Final

Remedial Investigation Report
Iron Mountain Road Ranges

Skeet Range, Parcel 69Q;
Range 19, Parcel 75Q;
Range 13, Parcel 71Q;
Range 12, Parcel 70Q;
Former Rifle Grenade Range at Skeet Range, Parcel 222Q-X;
and
Former Rifle Grenade Range
North of Washington Ranges, Parcel 221Q-X

Volume IV of IV: Appendices H – K

Fort McClellan
Calhoun County, Alabama

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APPENDIX H

STATISTICAL AND GEOCHEMICAL EVALUATION OF METALS DATA

Site-to-Background Comparison for Metals in Soil, Sediment, Groundwater, and Surface Water at the Iron Mountain Road Ranges Fort McClellan, Calhoun County, Alabama

1.0 Introduction

This appendix provides the methodology and results of the site-to-background comparison of inorganic constituents in soil, sediment, groundwater, and surface water samples from the Iron Mountain Road Ranges, Fort McClellan, Calhoun County, Alabama. Site samples used in the comparison include 120 surface soil samples (0 to 0.5 and 0 to 1 foot below ground surface [bgs]) collected from March 2000 through May 2003; 37 subsurface soil samples (various depths ranging from 1 to 9 feet bgs) collected in March 2000, April 2001, and February 2008; 9 sediment samples collected in April 2000; 6 unfiltered groundwater samples collected in October and November 2001; and 9 unfiltered surface water samples collected in April 2000. All of the site sediment, groundwater, and surface water samples were analyzed for the full suite of 23 target analyte list (TAL) metals, including aluminum, iron, and manganese. Only 51 surface soil samples and 17 subsurface soil samples were analyzed for TAL metals. Sixty-nine surface soil samples and twenty subsurface soil samples were analyzed only for lead; these samples are referred to in this report as "non-TAL" samples.

A three-tiered site-to-background comparison methodology has been established for the Fort McClellan project (Shaw Environmental, Inc., 2005). The site-to-background comparison consists of two statistical evaluations (Tiers 1 and 2), followed by geochemical evaluation (Tier 3). In the first step of the comparison, the maximum detected concentration (MDC) of each element is compared to two times the arithmetic mean (2x mean) of the background data (Science Applications International Corporation [SAIC], 1998). Any element that has an MDC greater than two times the background mean is carried forward for Tier 2 evaluation, which includes the hot measurement test and the Wilcoxon rank sum (WRS) test. Any element that fails either the hot measurement test or the WRS test is then carried forward for geochemical evaluation, to determine if the elevated site concentration(s) have a natural source.

The following sections provide the methodology and results of the site-to-background comparison for the Iron Mountain Road Ranges. The Fort McClellan installation-wide work plan (IT Corporation, 2002) also provides details on the site-to-background comparison methodology. The methodology has been slightly modified since the work plan was issued,

pursuant to the technical memorandum dated March 14, 2005 (Shaw Environmental, Inc., 2005) and agreements reached during Fort McClellan's Base Realignment and Closure Cleanup Team (BCT) meetings. The 2005 technical memorandum is included as an attachment to this appendix. It should be noted that the site soil sample collection methodology, analytical results, and sample location map are provided within the body of the remedial investigation report and are not reproduced in this appendix.

Background distributions and screening values have been established for TAL metals in surface soil, subsurface soil, sediment, groundwater, and surface water at Fort McClellan (SAIC, 1998; IT Corporation, 2002), and they are used in the following comparison.

2.0 Comparison Methodology

This section describes the statistical and geochemical evaluation techniques that were employed in the site-to-background comparison for the Iron Mountain Road Ranges. Descriptive statistics for the background data set are provided in the background study report (SAIC, 1998) and the February 2002 installation-wide work plan (IT Corporation, 2002).

2.1 Statistical Procedures

Contamination can be caused by a variety of processes that yield different spatial distributions of elevated contaminant concentrations. Slight but pervasive contamination can occur from non-point-source releases and can result in slight increases in contaminant concentrations in a large percentage of samples. Localized, or "hot-spot," contamination can result in elevated concentrations in a small percentage of the total number of site samples. No single, two-sample statistical comparison test is sensitive to both of these modes of contamination. For this reason, the use of multiple simultaneous tests is recommended for a valid and complete comparison of site versus background distributions (U.S. Environmental Protection Agency [EPA], 1989, 1992, 1994, and 2006; U.S. Navy, 2002).

2.1.1 Tier 1

In the first step of the background screening process, the MDC of each element in the site data set is compared to the corresponding 2x mean value in the background data set (SAIC, 1998). Elements for which the site MDC does not exceed this background screening value are considered to be present at background concentrations, and thus they are not considered site-related chemicals. Elements for which the site MDC exceeds this background screening value undergo further evaluation (Tier 2).

Table 1 lists the 2x mean values for the Fort McClellan background data set. It should be noted that 100 percent of the background groundwater samples are nondetect for chromium, nickel, and selenium, and 100 percent of the background surface water samples are nondetect for cobalt, mercury, and selenium. Two-times-the-background mean values are lacking for these elements (SAIC, 1998); accordingly, the corresponding site data are carried forward for Tier 2 evaluation, as long as site detections are present.

2.1.2 Tier 2

The WRS test is sensitive to slight but pervasive contamination but is not sensitive to localized or more extreme hot-spot situations. The background threshold comparison, or "hot measurement test," is effective in identifying localized contamination but is not sensitive to slight but pervasive contamination. The WRS test and hot measurement test are thus complementary. Both tests are nonparametric, meaning that they do not require that assumptions be made regarding the type of distribution (normal, lognormal, etc.), and they are valid for a wide variety of distributional shapes. In addition to the quantitative WRS and hot measurement tests, box-and-whisker plots are used to visually compare the site and background distributions and to properly interpret the results of the WRS test.

Analytes that fail either of the quantitative comparison tests are subject to a geochemical evaluation to determine if the elevated concentrations are most likely due to natural processes. The hot measurement test, WRS test, and box plots are described below.

Hot Measurement Test. The hot measurement test consists of comparing each site measurement with a concentration value that is representative of the upper limit of the background distribution (EPA, 1994). Ideally, a site sample with a concentration above the background screening value would have a low probability of being a member of the background distribution, and may be an indicator of contamination. It is important to select such a background screening value carefully so that the probability of falsely identifying site samples as contaminated or uncontaminated is minimized.

The 95th upper tolerance limit (UTL) is recommended as a screening value for normally or lognormally distributed analytes, and the 95th percentile is recommended as a screening value for nonparametrically distributed analytes (EPA, 1989, 1992, and 1994). On average, roughly five percent of uncontaminated site samples are expected to exceed the background screening value. Site samples with concentrations above these values are not necessarily contaminated, but should be considered suspect.

To perform the test, each analyte's site MDC is compared to the background 95th UTL or 95th percentile, in accordance with the type of background distribution. If the site MDC exceeds the background screening value, then that analyte will undergo a geochemical evaluation. If the MDC does not exceed the background screening value, then that indicates that hot-spot contamination is not present. Table 2 lists the background 95th UTLs and background 95th percentiles for TAL metals in Fort McClellan surface soil, subsurface soil, sediment, groundwater, and surface water. These background screening values are also provided and discussed in the installation-wide work plan (IT Corporation, 2002).

Wilcoxon Rank Sum Test. The WRS test has been recommended for use in site-to-background comparisons (EPA, 2000 and 2006; U.S. Navy, 2002). In this report, the WRS test is performed when the site and background data sets each contain less than 50 percent nondetects (i.e., measurements reported as not detected below the laboratory reporting limit). The WRS test is not performed on data sets containing 50 percent or more nondetects. The medians of such data sets are unknown, and hence the test lacks sufficient power to yield reliable results. Likewise, the WRS test is not performed on data sets of size $n < 4$; in such cases, the test lacks sufficient power to identify differences between the two samples.

The WRS test compares two data sets of size n and m ($n > m$), and tests the null hypothesis that the samples were drawn from populations with distributions having the same medians. To perform the test, the two sets of observations are pooled and arranged in order from smallest to largest. Each observation is assigned a rank; that is, the smallest is ranked 1, the next largest is ranked 2, and so on up to the largest observation, which is ranked ($n + m$). If ties occur between or within samples, each one is assigned the midrank. Next, the sum of the ranks of smaller data set m is calculated. Then the test statistic Z is determined,

$$Z = \frac{W - m(m + n + 1)/2}{\sqrt{mn(m + n + 1)/12}}$$

Where:

W = Sum of the ranks of the smaller data set
m = Number of data points in smaller group
n = Number of data points in larger group.

This test statistic Z is used to find the two-sided significance. For example, if the test statistic yields a probability of a Type I error (p-level) less than 0.05, then there is a statistically

significant difference between the medians at the 95 percent confidence level. A Type I error involves rejecting the null hypothesis when it is true. If the p-level is greater than 0.05, then there is no reasonable justification to reject the null hypothesis at the 95 percent confidence level. It can therefore be concluded that the medians of the two data sets are similar and can be assumed to be drawn from the same population.

At the request of EPA Region 4 and as confirmed during the May 2007 BCT meeting, the Fort McClellan WRS tests are performed at a significance level (α) of 0.20. If the p-level is less than 0.20, then the medians of the two distributions are significantly different at the 80 percent confidence level. This can occur if the site data are shifted higher or lower than the background data. If the site data are shifted higher relative to background, then contamination may be indicated, and the analyte in question will be carried on for geochemical evaluation. However, if the site data are shifted lower relative to background, then contamination is not indicated. If the p-level is greater than 0.20, then pervasive site contamination is not suspected.

Box Plots. The box-plot comparison is a quick, robust graphical method to visualize and compare two or more groups of data, and is recommended in EPA guidance (EPA, 1989 and 1992). Box-and-whisker plots provide a summary view of the entire data set, including the overall location and degree of symmetry. The box encloses the central 50 percent of the data points so that the top of the box represents the 75th percentile and the bottom of the box represents the 25th percentile. The median of the data set is represented by a small box within the larger box. The upper whisker extends outward from the box to the maximum point, and the lower whisker extends to the minimum point. Nondetect results are set equal to one-half of the reporting limit for plotting purposes.

For each analyte, box plots of site and background data are placed side by side to visually compare the distributions and qualitatively determine whether the data sets are similar or distinct. Accordingly, the box plots are a necessary adjunct to the WRS test. As described previously, the WRS test may indicate that the medians of the site and background data sets are significantly different. Examination of the box plots will confirm whether that difference is caused by site data that are shifted higher or lower relative to background.

2.2 Geochemical Evaluation

Statistical site-to-background comparisons for trace elements in environmental media commonly have high false-positive error rates. A large number of background samples is required to adequately characterize the upper tails of most trace element distributions, which are typically right-skewed and span a wide range of concentrations, but such a large background data set is

not always feasible. There are also concerns regarding the statistical validity of comparing site data from a small parcel with facility-wide background data that typically display higher variance than the site data. Higher false-positive error rates are expected if the site sample size is greater than the background sample size. The presence of estimated concentrations and nondetects with differing reporting limits can also cause statistical comparison tests to fail.

Statistical tests consider only the absolute concentrations of individual elements, and they disregard the interdependence of element concentrations and the geochemical mechanisms controlling element behavior. However, it is well established that trace elements naturally associate with specific minerals in soil and sediment (and specific suspended minerals in groundwater and surface water), and the preferential enrichment of a sample with these minerals will result in elevated trace element concentrations. It is thus important to be able to identify these naturally high concentrations and distinguish them from potential contamination.

If an analyte fails either of the Tier 2 statistical tests described in Section 2.1.2, then a geochemical evaluation is performed to determine if the elevated concentrations are caused by natural processes. Recent publications indicate that geochemical evaluations are assuming a larger role in environmental investigations (e.g., EPA, 1995; Barclift, *et al*., 2000; U.S. Navy, 2002 and 2003; Myers and Thorbjornsen, 2004; Thorbjornsen and Myers, 2007a, 2007b, and 2008). A properly executed geochemical evaluation can distinguish between naturally high element concentrations versus contamination, and it can identify the specific samples that may contain some component of site-related contamination.

Geochemical evaluation of inorganic data is not a new concept, and it is based in part on the well-understood processes of trace element adsorption that are described in the literature (e.g., Gulledge and O'Connor, 1973; McKenzie, 1980; Electric Power Research Institute [EPRI], 1984; Hem, 1985; EPRI, 1986; Belzile and Tessier, 1990; Bowell, 1994; Manceau, 1995; Stumm and Morgan, 1996; Sullivan and Aller, 1996; Drever, 1997; Belzile *et al*., 2000; Nickson *et al*., 2000; Kabata-Pendias, 2001; Lai and Chen, 2001; Emmanuel and Erel, 2002; Munk *et al*., 2002; Roddick-Lanzilotta *et al*., 2002; Smedley and Kinniburgh, 2002; Cornell and Schwertmann, 2003; Welch and Stollenwerk, 2003). These papers, texts, and monographs provide the technical basis for the geochemical evaluations performed for the Fort McClellan project. This fundamental research has been applied in numerous peer-reviewed papers that employ correlation plots of trace elements versus specific major elements. The aims of these applied-science papers are to determine the likely mechanisms controlling element concentrations and identify potentially contaminated samples (e.g., Windom *et al*., 1989; Hanson *et al*., 1993; Daskalakis and O'Connor, 1995; Schiff and Weisberg, 1997; Barclift *et al*., 2000; Kuss *et al*.,

2001; Chen *et al*., 2002; El Bilali *et al*., 2002; Mostafa *et al*., 2004). In some cases, these papers use the same types of analytical data that are obtained during the Fort McClellan investigations and typical environmental investigations at other sites.

2.2.1 Geochemical Evaluation Methodology for Soil and Sediment

Trace elements naturally associate with specific minerals in soil and sediment, and geochemical evaluations are predicated on these known associations. For example, in most uncontaminated oxic soils, arsenic exhibits an almost exclusive association with iron oxide minerals (Bowell, 1994; Schiff and Weisberg, 1997). Arsenic exists in oxic soil pore fluid as oxyanions such as $HAsO_4^{-2}$ and $H_2AsO_4^{-}$ (Brookins, 1988), and these negatively charged species have a strong affinity to adsorb on iron oxides, which tend to maintain a net positive surface charge (EPRI, 1986). (In this report, the term "iron oxide" encompasses oxides, hydroxides, oxyhydroxides, and hydrous oxides of iron.) This association is expressed as a positive correlation between arsenic concentrations and iron concentrations for uncontaminated samples: soil samples with a low percentage of iron oxides will contain proportionally lower arsenic concentrations, and soil samples that are enriched in iron oxides will contain proportionally higher arsenic concentrations. Although there is variability in the absolute concentrations of arsenic and iron in soil at a site, the As/Fe ratios of the samples will be relatively constant if no contamination is present (Daskalakis and O'Connor, 1995). Samples that contain excess arsenic from a contaminant source (e.g., arsenic-bearing compounds such as arsenical herbicides) will exhibit anomalously high As/Fe ratios compared to the uncontaminated samples.

To perform the geochemical evaluation, correlation plots are constructed to explore the elemental associations and identify potentially contaminated samples. The detected concentrations of the trace element of interest (dependent variable) are plotted against the detected concentrations of the reference element (independent variable), which represents the mineral to which the trace element may be adsorbed. In the case of arsenic, the arsenic concentrations for a given set of samples would be plotted on the y-axis, and the corresponding iron concentrations would be plotted on the x-axis. If no contamination is present, then the samples will exhibit a common trend and consistent As/Fe ratios, and the samples with the highest arsenic concentrations will lie on this trend. This indicates that the elevated arsenic is due to the preferential enrichment of iron oxides in those samples and that the arsenic has a natural source. If, however, the samples with high arsenic concentrations have low or moderate iron concentrations (anomalously high As/Fe ratios), then they will lie above the trend established by the other samples. This would indicate that the anomalous samples contain excess arsenic beyond that which can be explained by the natural iron oxide content, and such samples may contain a component of contamination.

The reference elements against which trace elements are evaluated reflect the affinity that the trace elements have for specific minerals. The concentrations of iron, aluminum, and manganese serve as qualitative indicators of the amounts of iron oxide, clay, and manganese oxide minerals in the soil samples. Along with arsenic, selenium and vanadium are present in oxic soil pore fluid as anions and have an affinity to adsorb on iron oxides, which tend to maintain a net positive surface charge. Concentrations of arsenic, selenium, or vanadium in a set of samples can be evaluated through comparison to the corresponding iron concentrations. Barium, cadmium, lead, and zinc are typically present in soil as divalent cations and have an affinity to adsorb on clay minerals, which tend to maintain a net negative surface charge. Concentrations of barium, cadmium, lead, or zinc can be evaluated through comparison to the corresponding aluminum concentrations. Manganese oxides have a strong affinity to adsorb barium, cobalt, and lead (Kabata-Pendias, 2001), so concentrations of these elements can be compared to the corresponding manganese concentrations, as long as there is enough manganese present in the soil to form discrete manganese oxides.

It is important to note that some trace elements have very strong affinities for a particular type of mineral, whereas other elements will partition themselves among several minerals. For instance, vanadium has a particularly strong affinity for iron oxides, so correlation coefficients for vanadium versus iron in uncontaminated samples are usually very high, and this is expressed on a correlation plot as a consistent trend with little to no scatter. In contrast, chromium forms several coexisting aqueous species with different charges [$Cr(OH)_2^+$, $Cr(OH)_3^0$, and $Cr(OH)_4^-$] that will adsorb on several different types of minerals, including clays and iron oxides. This behavior will yield lower correlation coefficients for chromium versus iron or chromium versus aluminum relative to the coefficients observed for vanadium versus iron, and more scatter may be observed on the correlation plots. Some elements are more selective than others with respect to adsorption on specific mineral surfaces, and this selectivity is dependent on site-specific conditions, including soil pH, redox conditions, and concentrations of competing elements.

It should be noted that the geochemical evaluations rely in part on professional judgment. Samples that plot off the background trend on a correlation plot are certainly suspect, but because all uncertainty cannot be eliminated from the evaluation, such plots cannot be construed as definitive proof of contamination. Unless otherwise noted, anomalous samples are flagged as suspect, and their results should be used as a basis for further investigation, risk assessment, or remediation, as appropriate.

Ratio Plots. Site samples with a trace element present as a contaminant will exhibit anomalously high trace-versus-major element ratios compared to background trace-versus-major element ratios. These elevated ratios may not always be apparent in log-log correlation plots, especially at the upper range of concentrations. Therefore, ratio plots, which depict trace element concentrations on the y-axis and trace/major element ratios on the x-axis, are employed in conjunction with correlation plots in those cases where it is not immediately apparent which site samples have anomalously high elemental ratios on the correlation plots. The ratio plots permit easy identification of samples with anomalously high elemental ratios relative to background, and they have high resolution over the entire concentration range. The presence of an anomalously high elemental ratio is not definitive proof of site-related contamination; however, such samples are discussed in the text and, unless otherwise noted, are flagged as representing potential site-related contamination. This is a conservative approach.

It is important to note that there is natural variability, as well as analytical uncertainty, in the elemental ratios of uncontaminated soil samples. Trace/major element ratios are calculated from two uncertain analytical results, so the resulting uncertainties in the ratios can produce some scatter in the points on a ratio plot. This is especially true when estimated ("J"-qualified) analytical results are used. This can be seen on many of the plots that show more scatter of the points at the lower end of the concentration range, where analytical uncertainties are higher and analytical results are reported with fewer significant figures.

On ratio plots, vertical trends should be expected only in those cases where the trace element adsorption is a linear process, where the trace element concentrations are controlled exclusively by adsorption on a given mineral type, and where the variances of the reference and trace element concentrations are similar. Nonvertical trends are much more common in ratio plots, however, because adsorption processes often are not linear, trace elements often have affinities for more than one type of sorptive surface, and the reference and trace element concentrations usually possess different variances. Nonlinear adsorption of a trace element on mineral surfaces will manifest itself as a curve rather than a straight line on a correlation plot and as a nonvertical trend on a ratio plot. In addition, the presence of competing ions in soil and differences in pH and redox conditions among the sample locations can add to the natural variability of elemental ratios.

Ratio plots may also be prepared for the major elements (e.g., aluminum versus Al/Fe ratios). However, adsorption is not the dominant process controlling major element concentrations. For example, aluminum and iron concentrations covary largely because they are controlled by the abundance of fine-grained minerals in the samples. The plots thus reflect physical effects rather

than chemical effects such as adsorption. Constant ratios are not necessarily observed for major versus major elements.

2.2.2 Geochemical Evaluation Methodology for Groundwater and Surface Water

Trace element behavior in groundwater and surface water is more complex than in soil and sediment because it is subject to a wider range of pH and redox conditions, and trace elements are more sensitive to the presence of natural complexing ligands (chloride, hydroxyl, sulfate, phosphate, etc.) and organic contaminants in aqueous systems. Although there are more dimensions to interpretation of the data, more parameters are available to aid in the interpretation. These additional parameters include pH, dissolved oxygen (DO), oxidation-reduction potential (ORP), filtered/unfiltered ratios, turbidity, specific conductivity, organic compound concentrations, etc.

Elevated concentrations of inorganic constituents in surface water samples may be due to naturally high dissolved concentrations, the presence of suspended particulates in the samples, reductive dissolution, or contamination resulting from site activities. The effects of suspended particulates and reductive dissolution are discussed below.

Effects of Suspended Particulates. Under natural conditions, metals concentrations are commonly controlled through adsorption on suspended particulates. The most common suspended particulates in surface water samples are clay minerals, hydrous aluminum oxides ($Al_2O_3 \bullet nH_2O$), and aluminum hydroxides [$Al(OH)_3$], hereafter referred to as "clays"; and iron oxide (Fe_2O_3), hydrous iron oxide, iron hydroxide [$Fe(OH)_3$], and iron oxyhydroxide ($FeO \bullet OH$) minerals, hereafter referred to as "iron oxides." Aluminum is a primary component of all clay minerals, which have low solubilities over the neutral pH range (6 to 8). Measured concentrations of aluminum greater than approximately 1 milligram per liter (mg/L) indicate the presence of suspended clay minerals (Hem, 1985; Stumm and Morgan, 1996); the higher the aluminum concentration, the greater the mass of suspended clay minerals in the sample. Iron oxides also have very low solubilities under oxic neutral-pH conditions, but they are redox-sensitive. Measured iron concentrations above approximately 1 mg/L under neutral-pH and moderate to oxidizing redox conditions indicate the presence of suspended iron oxides (Hem, 1985).

The same concepts involved in the evaluation of soil and sediment data also apply to groundwater and surface water data, although pH and redox conditions need to be carefully considered. Samples containing trace elements adsorbed on suspended clay particulates should show a positive correlation with aluminum concentrations, and samples containing trace

elements adsorbed on suspended iron oxides should show a positive correlation with iron concentrations. These correlations are evaluated by generating x-y plots of the concentrations of an elevated trace metal versus aluminum or iron (depending on the trace element). Divalent cations such as barium, lead, and zinc have an affinity to adsorb on clay surfaces, which tend to maintain a net negative charge (EPRI, 1984; Brookins, 1988). Concentrations of barium, lead, or zinc in a set of samples can be evaluated through comparison to the corresponding aluminum concentrations. Under oxidizing conditions, elements such as arsenic, selenium, and vanadium are usually present as oxyanions and have a strong affinity to adsorb on iron oxide surfaces, which tend to maintain a net positive charge (Pourbaix, 1974; Hem, 1985; Brookins, 1988; Bowell, 1994). Concentrations of arsenic, selenium, or vanadium can be evaluated through comparison to the corresponding iron concentrations. Chromium can exist as a mixture of aqueous species with different charges [$Cr(OH)_2^+$, $Cr(OH)_3^o$, and $Cr(OH)_4^-$], depending on pH (EPRI, 1984), so it can be distributed on several different types of sorptive surfaces, including clay and iron oxide minerals.

As an example geochemical evaluation for groundwater or surface water, the detected concentrations of zinc would be plotted on the y-axis, and the corresponding detected concentrations of aluminum would be plotted on the x-axis. A trend with a positive slope (positive correlation) indicates that the zinc in those samples is associated with suspended clay minerals at a relatively constant ratio and that the zinc is natural. A sample that plots above this trend contains excess zinc beyond that which can be explained by the suspended clay content and may contain a component of contamination.

Ratio plots are also a useful tool for interpreting the relationship between trace and major elements and for identifying anomalous samples that may contain a component of contamination. Ratio plots display trace element concentrations on the y-axis and trace/major element ratios on the x-axis, and they are employed in conjunction with correlation plots in those cases where it is not immediately apparent which site samples have anomalously high elemental ratios on the correlation plots. However, ratio plots must be used with care when depicting aqueous data, and they should only be used for samples from oxidizing waters. For samples from low-redox areas, redox-sensitive elements (such as arsenic, iron, and manganese) are expected to display a higher degree of scatter on correlation plots and, hence, a wider range of ratios on ratio plots.

In addition to the evaluation of trace-versus-major element correlations, the effects of suspended particulates can be assessed via the evaluation of element-versus-turbidity correlations, element-versus-total suspended solids (TSS) correlations, and the comparison of filtered versus unfiltered splits. Evaluations of turbidity and TSS measurements provide additional lines of evidence that

support the conclusions drawn from the evaluation of trace-versus-major element correlations. However, turbidity and TSS measurements are qualitative and cannot distinguish between suspended iron oxides, clay minerals, and natural organic material. Consequently, they do not provide the mechanistic information afforded by the correlations of trace elements versus aluminum or trace elements versus iron. Comparisons of filtered versus unfiltered splits of samples are highly informative and permit the identification of elements that are present as suspended particulates versus those that are in true solution.

Effects of Reductive Dissolution. Iron oxides and manganese oxides concentrate several trace elements such as arsenic, selenium, and vanadium on mineral surfaces, as discussed above. In soils and sedimentary aquifers, these elements are almost exclusively associated with iron and manganese oxide minerals and grain coatings, as long as the redox conditions are moderate to oxidizing.

The release of organic contaminants such as jet fuel, gasoline, or chlorinated solvents can establish local reducing environments caused by microbial degradation of the organic compounds. The establishment of local reducing conditions can drive the dissolution of iron and manganese oxides, which become soluble as the redox potential drops below a threshold value. Dissolution of these oxide minerals can mobilize the trace elements adsorbed on the oxide surfaces, which is a process termed "reductive dissolution." Several investigations have documented the mobilization of arsenic, selenium, and other trace elements under locally reducing redox conditions (Sullivan and Aller, 1996; Nickson *et al.*, 2000; Belzile *et al.*, 2000). Reducing conditions can also exist naturally in groundwaters and surface waters that are associated with swamp or wetland environments.

Evidence for reductive dissolution includes high Fe/Al ratios and correlation between elevated trace elements (arsenic, selenium, and vanadium in particular) versus lower redox conditions. Low redox conditions can be identified by local depressions in ORP or DO measurements or by the presence of reducing gases such as hydrogen, methane, ethane, or ethene. Anaerobic microbes can also reduce sulfate to sulfide and nitrate to ammonia, resulting in local depressions in sulfate and nitrate concentrations and local detections of sulfide and ammonia. In areas impacted by chlorinated solvents, additional evidence for the establishment of anaerobic reducing conditions is the presence of *cis*-1,2-dichloroethene and/or vinyl chloride, which are reductive dechlorination products resulting from the microbial degradation of trichloroethene or tetrachloroethene under anaerobic conditions.

3.0 Results of the Site-to-Background Comparison for the Iron Mountain Road Ranges

This section presents the results of the site-to-background comparison for 23 TAL metals in surface soil, subsurface soil, sediment, groundwater, and surface water samples from the Iron Mountain Road Ranges. Tables 3 through 7 list the results of the statistical tests for each medium. Box plots are provided in Attachment 1, and geochemical correlation plots and ratio plots are included in Attachment 2.

3.1 Soil

The results of the statistical site-to-background comparison tests for surface soil and subsurface soil are summarized below, and the individual test results for each element are listed in Tables 3 and 4. The two soil intervals were combined for purposes of geochemical evaluation.

Surface Soil. One hundred percent of the site surface soil samples are nondetect for cadmium. Aluminum, barium, chromium, cobalt, iron, magnesium, manganese, mercury, sodium, thallium, and vanadium passed statistical comparison to background (Tier 1 or Tier 2; Table 3). The detected concentrations of these eleven elements are within their respective background ranges. Antimony, arsenic, beryllium, calcium, copper, lead, nickel, potassium, selenium, silver, and zinc failed statistical comparison to background (Tier 2) and required geochemical evaluation.

Subsurface Soil. One hundred percent of the site subsurface soil samples are nondetect for cadmium. Aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, magnesium, manganese, mercury, nickel, potassium, silver, sodium, thallium, vanadium, and zinc passed statistical comparison to background (Tier 1 or Tier 2; Table 4). The detected concentrations of these 17 elements are within their respective background ranges. Antimony, copper, iron, lead, and selenium failed statistical comparison to background (Tier 2) and required geochemical evaluation. Iron (along with aluminum) is evaluated first because it is one of the primary reference elements used to evaluate the other trace elements.

Aluminum – Geochemical Evaluation

Aluminum is the second most abundant element analyzed in the site soil samples, with a mean concentration of 7,220 mg/kg (approximately 0.7 weight percent). Aluminum is a primary component of common soil-forming minerals such as clays, feldspars, and micas. Aluminum also substitutes for ferric iron in iron oxide minerals, and can adsorb on iron oxide surfaces (Cornell and Schwertmann, 2003). Iron is the most abundant element analyzed in the site soil samples (mean concentration of 15,100 mg/kg, or 1.5 weight percent), and is mostly present as

iron oxides, which are common soil-forming minerals. Clays and iron oxides tend to exist as very fine particles, so both aluminum and iron are enriched in samples with finer grain sizes.

A plot of aluminum versus iron concentrations provides a qualitative indicator of the relative abundance of clay and iron oxide minerals in site soil (Figure 1). Site surface soil samples are represented by open triangles, site subsurface soil samples by filled triangles, and background soil samples by filled circles. For both soil intervals, most of the site samples exhibit aluminum and iron concentrations that are similar to that of the background samples. The samples with high aluminum concentrations also contain high iron and lie on the general background trend (Figure 1). This indicates that the Al/Fe ratios of the site and background samples are similar, and that the aluminum and iron have a natural source. It is important to note that clays and iron oxides adsorb specific trace elements (as discussed previously), so samples that plot on the upper end of the trend in Figure 1 are expected to contain proportionally higher concentrations of trace elements.

Antimony – Geochemical Evaluation

Antimony is geochemically similar to arsenic; like arsenic it has an affinity to adsorb on the surfaces of iron oxides, so a positive correlation between antimony and iron is expected for uncontaminated samples. The background samples form a common trend with a positive slope in a plot of antimony versus iron (Figure 2); the background samples with high antimony contain proportionally higher iron. This indicates that antimony in the background soil samples is associated with iron oxides at consistent ratios, and is natural.

Most of the site samples lie above the background trend in Figure 2 and to the right of the background samples in the ratio plot of Figure 3. Their anomalously high Sb/Fe ratios suggests that they contain excess antimony from a contaminant source. The Iron Mountain Road Ranges encompass several firing ranges, and lead is a known contaminant due to its presence in bullets and bullet fragments. Antimony is used as a hardening agent in bullets (Interstate Technology and Regulatory Council [ITRC], 2003), and is present in lead bullets at concentrations of 3 to 8 percent; elevated antimony concentrations, therefore, would be expected in soil samples from firing ranges. The correlation between antimony and lead in the site samples (Figure 4) and the presence of elevated antimony concentrations in samples with high lead indicate that lead and antimony are co-contaminants at the site.

The anomalous site samples identified in Figures 2 and 3 include multiple surface soil samples and one subsurface soil sample with antimony concentrations of 2.8 mg/kg and higher. These samples exhibit low to moderate iron content (as well as low to moderate aluminum and manganese), elevated lead, and anomalously high Sb/Fe ratios relative to background. They contain an excess amount of antimony that cannot be explained by natural processes, and are most likely contaminated (Table 8).

Arsenic – Geochemical Evaluation

As discussed previously, arsenic in oxic soil pore fluid is commonly present as oxyanions ($H_2AsO_4^-$, $HAsO_4^{2-}$) that have a strong affinity to adsorb on iron oxides, which tend to maintain a net positive surface charge. Positive correlations between arsenic and iron are typically observed for uncontaminated samples under those conditions. A plot of arsenic versus iron reveals a common trend for the background samples and most of the site samples (Figure 5).

Most of the site samples lie on the background trend in the correlation plot, which suggests that arsenic in these site samples is associated with iron oxides ratios consistent with those of the background samples, and that it is natural.

Another perspective on the data sets is provided in Figure 6, which displays the arsenic concentrations of the site and background samples (y-axis) versus their corresponding As/Fe ratios (x-axis). If a site sample contains excess arsenic from a contaminant source, then it will exhibit an anomalously high As/Fe ratio relative to background and will plot to the right of the background samples in Figure 6. Three site surface soil samples have As/Fe ratios that exceed the background range, which suggests that they may contain a component of arsenic contamination (Table 8).

Beryllium – Geochemical Evaluation

Beryllium concentrations in soil are commonly controlled through adsorption on iron oxides (Vesely, *et al*., 2002), so positive correlations between beryllium and iron concentrations are often observed for uncontaminated samples. A plot of beryllium versus iron is provided in Figure 7. The site and background samples form a common trend, and the Be/Fe ratios of the site samples are consistent with those of the background samples. These observations suggest a natural source for the beryllium detected in the site samples.

Calcium – Geochemical Evaluation

Calcium and magnesium have similar chemical properties, and magnesium often substitutes for calcium in minerals. Positive correlations between calcium and magnesium concentrations are thus commonly observed in uncontaminated soil samples. A plot of calcium versus magnesium is provided in Figure 8. The site and background samples with elevated calcium concentrations have proportionally higher magnesium and form a common trend with a positive slope. Calcium in these samples has a natural source.

Copper – Geochemical Evaluation

Copper in soil has an affinity to adsorb on the surfaces of minerals such as clays and iron oxide minerals (Kabata-Pendias, 2001). The background samples form a common trend with a positive slope in a plot of copper versus iron (Figure 9). Many of the site samples lie on the background trend, but many other site samples exhibit anomalously high Cu/Fe ratios and lie above the background trend in the correlation plot (Figure 9) and to the right of the background samples in the ratio plot (Figure 10). Copper, along with zinc, is a primary component of shell casings and jackets (ITRC, 2003), so copper contamination would be expected at firing-range sites such as the Iron Mountain Road Ranges. Lead is a known contaminant at firing ranges; a plot of copper versus lead reveals that the samples with elevated copper also have high lead content (Figure 11). This indicates that copper and lead are co-contaminants in site soil.

Many site samples have Cu/Fe ratios that are within the background range, and copper in these samples is most likely natural. However, the site soil samples with anomalously high Cu/Fe ratios relative to background (Figure 10) most likely contain a component of contamination (Table 8).

Lead – Geochemical Evaluation

Manganese oxides are a class of naturally occurring minerals that are common in soils and sediments (Post, 1999). They exist either as discrete mineral grains or as coatings on other minerals. As a result of their large surface areas and high negative surface charges, these minerals have a strong affinity to adsorb divalent cations such as Ba^{2+}, Co^{2+}, and Pb^{2+}. A soil sample that is naturally enriched in manganese oxides will have high concentrations of manganese and associated trace elements, such as lead.

A common trend with a positive slope is observed for the background samples and some of the site samples in a plot of lead versus manganese (Figure 12). Many site samples have Pb/Mn ratios that are within the background range, as seen in the ratio plot of Figure 13. It can be concluded that lead in these samples is associated with manganese oxides at ratios consistent with those of the background samples, and is natural. However, many other site soil samples contain elevated lead but only moderate manganese. The anomalously high Pb/Mn ratios of these samples suggest that they contain a component of contamination (Table 8).

It is important to note that 69 of the 120 surface soil samples and 20 of the 37 subsurface soil samples were analyzed only for lead, instead of the full suite of 23 TAL metals. These non-TAL samples could not be subjected to geochemical evaluation to determine if their lead concentrations have a natural source. The non-TAL samples with lead concentrations above the background screening values are listed in Table 9.

Nickel – Geochemical Evaluation

A plot of nickel versus manganese reveals a common trend with a positive slope for most of the background samples, and all of the site samples lie on this trend (Figure 14). The site samples with high nickel concentrations are also characterized by high manganese content, and they lie on the background trend. This suggests that nickel in the site samples is associated with manganese oxides at ratios consistent with those of the background samples, and that it is natural.

Potassium – Geochemical Evaluation

Potassium is a major element that is a common constituent of minerals such as clays, which also contain aluminum. Positive correlations between potassium and aluminum concentrations are often observed for uncontaminated soil samples. Most of the background samples form a common trend in a plot of potassium versus aluminum, and the site samples lie on this trend (Figure 15). The similarity between the site and background K/Al ratios suggests a natural source for the potassium detected in the site samples.

Selenium – Geochemical Evaluation

As noted previously, selenium is typically present in oxic soil pore fluid as oxyanions ($HSeO_3^-$, SeO_3^{2-}) and has an affinity to adsorb on iron oxides, which tend to maintain a net positive surface charge. Positive correlations between selenium and iron concentrations are thus expected for uncontaminated soil samples. However, selenium detections are often estimated concentrations below the reporting limit, and the uncertainty associated with such values means that weak correlations are often observed, even in uncontaminated samples.

Comparison to background is hindered because of the high percentage of nondetects in the background data set. The site surface soil samples form a common trend with a shallow positive slope in a plot of selenium versus iron, and one of the two background samples with detectable selenium lies on this trend (Figure 16). The samples with high selenium also contain proportionally higher iron, suggesting that the selenium in these samples is associated with iron oxides at a relatively constant ratio, and is natural. One site surface sample (0.592 J mg/kg) lies below the trend established by the other samples, but it is below the background maximum of 1.28 mg/kg. Furthermore, this concentration is an estimated value below the reporting limit of 1.31 mg/kg, and such values are highly uncertain. This uncertainty likely explains the lower Se/Fe ratio observed for this sample.

Silver – Geochemical Evaluation

A plot of detectable silver versus iron concentrations in the site and background samples is provided in Figure 17. The three site samples with detectable silver have higher concentrations than most of the background samples. However, two of these site samples exhibit Ag/Fe ratios that are similar to those of the background samples, which suggests that the silver has a natural source. The site sample with the highest silver concentration (HGG0004; 3.69 mg/kg), however, has only moderate iron (as well as only moderate aluminum and manganese), and lies well above the background trend in the correlation plot. This sample contains an excess amount of silver beyond that which can be explained by the reference element content, and it may contain a component of contamination (Table 8). A ratio plot is provided in Figure 18, and this plot confirms that only one site sample has a Ag/Fe ratio that exceeds the background ratio range.

Zinc – Geochemical Evaluation

Zinc in soils is commonly associated with clay minerals and hydrous iron and aluminum oxides (Kabata-Pendias, 2001), so positive correlations for zinc versus aluminum and zinc versus iron are expected for uncontaminated samples. A plot of zinc versus aluminum is provided in Figure 19. The background samples and many of the site samples form a common trend with a positive slope. Some of the site samples with high zinc also contain proportionally higher aluminum, and lie on the background trend. This suggests that zinc in these samples is associated with clays and other aluminum-bearing minerals at ratios consistent with those of the background samples, and is natural.

Several site samples exhibit anomalously high Zn/Al ratios and lie above the background trend in the correlation plot of Figure 19 and to the right of the background samples in Figure 20. Zinc, along with copper, is a primary component of shell casings and jackets (ITRC, 2003), so zinc contamination would be expected at firing-range sites such as the Iron Mountain Road Ranges. Lead is a known contaminant at firing ranges; a plot of zinc versus lead reveals that the samples with elevated zinc also have high lead content (Figure 21). This indicates that zinc and lead are co-contaminants in site soil. Table 8 identifies the soil samples that have anomalously high Zn/Al ratios and likely zinc contamination.

3.2 Sediment

One hundred percent of the site sediment samples are nondetect for cadmium, selenium, silver, and sodium. Aluminum, beryllium, calcium, chromium, cobalt, magnesium, mercury, potassium, vanadium, and zinc passed statistical comparison to background (Tier 1 or Tier 2;

Table 5). The detected concentrations of these ten elements are within their respective background ranges. Antimony, arsenic, barium, copper, iron, lead, manganese, nickel, and thallium failed statistical comparison to background (Tier 2) and required geochemical evaluation. Iron (along with aluminum) is evaluated first because it is one of the primary reference elements used to evaluate the trace elements of concern.

Aluminum and Iron – Geochemical Evaluation

Aluminum is the second most abundant element analyzed in the site sediment samples, with a mean concentration of 3,630 mg/kg (0.4 weight percent). Aluminum is a primary component of minerals such as clays, feldspars, and micas. Aluminum also substitutes for ferric iron in iron oxide minerals, and can adsorb on iron oxide surfaces (Cornell and Schwertmann, 2003). Iron is the most abundant element analyzed in the site sediment samples (mean concentration of 23,878 mg/kg; 2.4 weight percent), and is mostly present as iron oxides, which are common minerals in soil and sediment. Clays and iron oxides tend to exist as very fine particles, so both aluminum and iron are enriched in samples with finer grain sizes.

A plot of aluminum versus iron concentrations can be as a qualitative indicator of the relative abundance of clay and iron oxide minerals in site sediment (Figure 22). Site sediment samples are represented by filled triangles and background sediment samples are represented by filled circles. The site and background samples form a common trend with a positive slope, and the site samples have Al/Fe ratios that are similar to those of the background samples. This indicates that the aluminum in the site samples has a natural source. It is important to note that clays and iron oxides adsorb specific trace elements (as discussed in Section 2.2), so samples that plot on the upper end of the trend in Figure 22 are expected to contain proportionally higher concentrations of natural trace elements.

Antimony – Geochemical Evaluation

Antimony is geochemically similar to arsenic; like arsenic it has an affinity to adsorb on the surfaces of iron oxides, so a positive correlation between antimony and iron is expected for uncontaminated samples. The background samples and one of the site samples form a common trend with a positive slope in a plot of antimony versus iron (Figure 23). Antimony in these samples is most likely associated with iron oxides at consistent ratios and is natural.

Three site sediment samples lie above the background trend in the correlation plot (Figure 23) and to the right of the background samples in the ratio plot (Figure 24). Their anomalously high Sb/Fe ratios suggest they contain a component of antimony contamination. As discussed previously, the Iron Mountain Road Ranges encompass several firing ranges, and lead is a known contaminant due to its presence in bullets and bullet fragments. Antimony is used as a hardening agent in bullets (ITRC, 2003), and is present in lead bullets at concentrations of 3 to 8 percent; elevated antimony concentrations, therefore, would be expected in samples from firing ranges. The correlation between antimony and lead in the site samples (Figure 25) and the presence of elevated antimony concentrations in samples with high lead indicate that lead and antimony are co-contaminants at the site.

The anomalous site samples identified in Figures 23 and 24 contain antimony concentrations of 3.4 mg/kg and higher (samples HJ1002, HJ1006, and HJ1009). These samples exhibit low to moderate iron content (as well as low to moderate aluminum and manganese), elevated lead, and have anomalously high Sb/Fe ratios relative to background. They contain an excess amount of antimony that cannot be explained by natural processes, and are most likely contaminated (Table 8).

Arsenic – Geochemical Evaluation

A plot of arsenic versus manganese reveals a common trend with a positive slope for the site and background samples (Figure 26). The site sample with the highest arsenic concentration also contains the highest manganese concentration, and lies on the trend established by the other samples. These observations suggest that arsenic in the site samples is associated with manganese oxides at ratios consistent with those of the background samples, and is most likely natural.

Barium – Geochemical Evaluation

Manganese oxides are a class of naturally occurring minerals that are common in soils and sediments (Post, 1999). They exist either as discrete mineral grains or as coatings on other minerals. As a result of their large surface areas and high negative surface charges, these minerals have a strong affinity to adsorb divalent cations such as Ba^{2+}, Co^{2+}, and Pb^{2+}. A sample that is naturally enriched in manganese oxides will have high concentrations of manganese and associated trace elements, such as barium.

A plot of barium versus manganese reveals a common trend with a positive slope for the site and background samples (Figure 27). The site sample with the highest barium concentration also has the highest manganese, and it lies on the background trend. All of the site samples have Ba/Mn ratios that are within the background Ba/Mn ratio range, as seen in the ratio plot (Figure 28). This suggests that barium in the site samples is associated with manganese oxides at ratios consistent with those of the background samples, and that it is natural.

Copper – Geochemical Evaluation

Copper has an affinity to adsorb on the surfaces of minerals such as clays and iron oxide minerals (Kabata-Pendias, 2001). The background samples form a common trend with a positive slope in a plot of copper versus aluminum (Figure 29). Most of the site samples lie on the background trend, but two site samples exhibit anomalously high Cu/Al ratios; they lie above the background trend in the correlation plot (Figure 29) and to the right of the background samples in the ratio plot (Figure 30). Copper, along with zinc, is a primary component of shell casings and jackets (ITRC, 2003), so copper contamination would be expected at firing-range sites such as the Iron Mountain Road Ranges. Lead is a known contaminant at firing ranges; a plot of copper versus lead reveals that the samples with elevated copper also have high lead content (Figure 31). This indicates that copper and lead are co-contaminants in site sediment.

The two anomalous site samples identified in Figures 29 and 30 contain copper concentrations of 39.9 mg/kg and 73 mg/kg (samples HJ1002 and HJ1006, respectively). These samples exhibit only low to moderate aluminum content (as well as only moderate iron), elevated lead and antimony, and anomalously high Cu/Al ratios relative to background. They contain an excess

amount of copper that cannot be explained by natural processes, and are most likely contaminated (Table 8).

Lead – Geochemical Evaluation

As discussed in previously, manganese oxides have an affinity to adsorb divalent cations such as lead (Kabata-Pendias, 2001). A sample that is naturally enriched in manganese oxides will have high concentrations of manganese and associated trace elements, such as lead. The background samples and most of the site samples form a common trend with a positive slope in a plot of lead versus manganese (Figure 32). The lead in these samples is associated with manganese oxides at a relatively constant ratio, and is natural. The three site samples with the highest lead concentrations (247 mg/kg and higher; samples HJ1002, HJ1006, and HJ1009), however, contain only moderate manganese (as well as only moderate aluminum and iron) and lie above the background trend in the correlation plot of Figure 32. Their anomalously high Pb/Mn ratios can also be seen in the ratio plot of Figure 33. Elevated lead in these samples, which also contain anomalously high concentrations of copper and/or antimony, should be considered suspect. The Iron Mountain Road Ranges encompass several firing ranges, and thus lead is an expected contaminant due to its presence in bullets and bullet fragments (Table 8).

Manganese – Geochemical Evaluation

Manganese oxides are a class of naturally occurring minerals that are common in soils and sediments (Post, 1999). They exist either as discrete mineral grains or as coatings on other minerals. Iron oxides are also common soil-forming minerals, and the iron and manganese concentrations of soil and sediment samples can reflect the relative abundance of these minerals. In addition to being present in the form of manganese oxides, manganese (as the divalent cation Mn^{2+}) can adsorb on the surfaces of iron oxides and can replace Fe^{2+} and Mg^{2+} in silicate and oxide minerals (Kabata-Pendias, 2001; Cornell and Schwertmann, 2003). Figure 34 depicts manganese concentrations versus the corresponding iron concentrations in the site and background sediment samples. The site samples exhibit Mn/Fe ratios that are identical to those of the background samples, which indicates a natural source for their manganese detections.

Nickel – Geochemical Evaluation

Nickel is commonly present in soil and sediment as the cation (Ni^{2+}), which binds to hydroxyl groups (OH^-) on the surfaces of iron oxides. This adsorption affinity increases as the pH approaches neutrality (Cornell and Schwertmann, 2003). As a result of this behavior, positive correlations between nickel versus iron concentrations are often observed in uncontaminated samples. If a sample contains a high proportion of iron oxides, then it is expected to contain naturally high concentrations of iron and associated cations such as nickel. A plot of nickel versus iron reveals a common trend with a positive slope for the background samples (Figure 35). The site samples with high nickel concentrations are also characterized by high iron content and lie on the background trend. This suggests that nickel in the site samples is associated with iron oxides at ratios consistent with those of the background samples and is natural.

Thallium – Geochemical Evaluation

A plot of thallium versus manganese in the site and background samples is provided in Figure 36. The background samples form a weak trend with a shallow positive slope. The three site samples with detectable thallium lie above this trend, but they exhibit consistent Tl/Mn ratios, as seen in Figure 37. The site sample with the highest thallium concentration (2.7 mg/kg) also

contains the highest manganese concentration of both site and background data sets (2,830 J mg/kg). These observations suggest a natural source for the thallium in the site samples. It is important to note that two of the site concentrations are estimated values (0.71 J mg/kg) below the reporting limit, and such values are highly uncertain. In comparison, the background detections are all unestimated concentrations, ranging from 0.012 to 0.221 mg/kg, with a mean of 0.0634 mg/kg. Additionally, the site samples are most likely characterized by higher reporting limits relative to the background samples: the site reporting limits range from 1.2 to 1.5 mg/kg, with a mean of 1.34 mg/kg. Reporting limit data are unavailable for the background samples, but their low unestimated detections (which are one to two orders of magnitude below the site reporting limits) suggest that the background reporting limits are significantly lower than those of the site samples. The uncertainty associated with estimated concentrations and the difference in reporting limits likely explain why the site samples exhibit slightly higher Tl/Mn ratios relative to most of the background samples. However, the site Tl/Mn ratios are within the background ratio range (Figure 37), which suggests that the site samples do not contain excess thallium from a contaminant source.

Given the low, mostly estimated nature of the site concentrations and the difference in site versus background reporting limits, a difference in Tl/Mn ratios between the two data sets is expected. When there is an order of magnitude difference in reporting limits, estimated concentrations in the samples with higher reporting limits are expected to be higher than estimated concentrations in the samples with lower reporting limits.

3.3 Groundwater

One hundred percent of the site groundwater samples are nondetect for antimony, arsenic, cadmium, chromium, copper, mercury, nickel, silver, thallium, vanadium, and zinc. Aluminum, barium, beryllium, calcium, iron, lead, magnesium, potassium, selenium, and sodium passed statistical comparison to background (Tier 1 or Tier 2; Table 6). The detected concentrations of these ten elements are within their respective background ranges. Cobalt and manganese in the site data set failed statistical comparison to background (Tier 2) and required geochemical evaluation.

Field-measured pH readings for the site groundwater samples range from 4.81 to 7.74, with a median of 5.55 and mean of 5.75. These values indicate slightly acidic conditions at most of the groundwater sample locations. Field-measured DO readings range from 2.49 to 9.50 mg/L, with a median of 5.15 mg/L and mean of 5.80 mg/L, and ORP readings range from +55 to +311 millivolts (mV), with a median of +166 mV and mean of +169 mV. These values suggest oxidizing conditions at the sample locations. Turbidity measurements range from 3 to 999 nephelometric turbidity units (NTU), with a median of 7.6 NTU and mean of 179 NTU. Although one site sample (HJJ3001, from monitoring well HR-69Q-MW01) contained a significant mass of suspended particulates (turbidity of 999 NTU), most of the samples did not

(turbidity of 54 NTU or lower). It should be noted that field readings are not available for the background samples.

Aluminum and iron are discussed here because they are the primary reference elements used to evaluate cobalt and manganese. Aluminum was detected in five of the six unfiltered site groundwater samples, at concentrations ranging from 0.0644 J mg/L to 1.03 mg/L. As discussed previously, aluminum concentrations in excess of approximately 1 mg/L in neutral-pH groundwater indicate the presence of suspended clays. Some fraction of detected aluminum will be present in solution at a pH below about 4 and above 10 (Drever, 1997), but all of the site pH readings are either neutral or only slightly acidic (see the above discussion of field readings). Iron was detected in all six unfiltered site groundwater samples, at concentrations ranging from 0.0312 J mg/L to 3.54 mg/L. Iron concentrations in excess of approximately 1 mg/L in neutral-pH, moderate to oxidizing groundwater conditions indicate the presence of suspended iron oxides. Iron, unlike aluminum, is a redox-sensitive element, and its dissolved concentrations will increase under reducing conditions (reducing conditions can be natural, or they can be induced by the microbial degradation of chlorinated solvents and fuels). As noted above, the DO and ORP readings suggest oxidizing conditions at most sample locations. This suggests that iron in the site samples is present primarily as suspended iron oxides.

A plot of aluminum versus iron can be used as a qualitative indicator of the amount of suspended particulates in the groundwater samples, as well as an indicator of the redox conditions at the sample locations (Figure 38). A linear trend with a positive slope is typically observed when both elements are present in particulate form (as clays and iron oxides), with Al/Fe ratios close to 1. Such a trend is observed in Figure 38 for the site samples and the majority of background samples. The consistent Al/Fe ratios observed in the plot suggest that the aluminum and iron concentrations in the site samples have a natural source.

Cobalt – Geochemical Evaluation

Cobalt was detected in only one of the six site groundwater samples. Cobalt has an affinity to adsorb on the surfaces of manganese oxides under oxidizing conditions. A plot of cobalt versus manganese is provided in Figure 39. Comparison to background is hindered by the high percentage of nondetects in the background data set. The single site sample with detectable cobalt (HJJ3001, collected from well HR-69Q-MW01) has a higher concentration (0.0359 mg/L) than the background samples with detectable cobalt. However, this site sample also has high manganese, which suggests that the cobalt in sample HJJ3001 is associated with suspended particulates such as manganese oxides, and that it is natural. This conclusion is corroborated by the turbidity reading of 999 NTU, which indicates a high mass of suspended particulates in the sample. These observations suggest that the cobalt in the sample has a natural source.

Manganese – Geochemical Evaluation

Manganese was detected in five of the six site groundwater samples. Manganese behaves similarly to iron in that it is redox-sensitive and soluble only under reducing conditions. Reducing conditions can be natural, or they can be caused by the anaerobic degradation of chlorinated solvents or fuels. However, field readings for the site samples indicate oxidizing conditions at all of the sample locations, and VOCs were detected in only one site sample – and all three detections were estimated values below the reporting limit. Under these conditions, both manganese and iron are expected to be present primarily as suspended particulates. A plot of manganese versus iron is provided in Figure 40. Two of the site samples lie on the general background trend. The two site samples with the highest manganese concentrations (2.42 and 5.6 mg/L) lie slightly above the trend formed by the majority of background samples. However, these concentrations are below the background maximum of 5.82 mg/L, so any contamination, if present, would not be significant. None of the site samples exhibits excess manganese relative to background, suggesting a natural source for the manganese in the site samples.

3.4 Surface Water

One hundred percent of the site surface water samples are nondetect for antimony, arsenic, beryllium, cadmium, chromium, cobalt, mercury, nickel, selenium, silver, thallium, and vanadium. Aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc passed statistical comparison to background (Tier 1 or Tier 2; Table 7). The detected concentrations of these ten elements are within their respective background ranges. Lead in the site data set failed statistical comparison to background (Tier 2) and required geochemical evaluation.

Field-measured pH readings for the site surface water samples range from 3.93 to 8.03, with a median of 5.69 and mean of 5.66. These values indicate slightly acidic to neutral conditions at the sample locations. Field-measured DO readings range from 2.01 to 9.27 mg/L, with a median of 7.76 mg/L and mean of 6.75 mg/L, and ORP readings range from +70 to +265 mV, with a median of +120 mV and mean of +153 mV. These readings suggest oxidizing conditions at the sample locations. Turbidity measurements range from 2 to 201 NTU, with a median of 7 NTU and mean of 31.4 NTU. Although one sample was characterized by high turbidity (HJ2006; 201 NTU), most of the site samples did not contain a significant mass of suspended particulates (turbidity of 33 NTU or lower). It should be noted that field readings are not available for the background samples.

Aluminum and iron are discussed here because they are the primary reference elements used to evaluate lead. Aluminum was detected in all nine unfiltered site surface water samples, at concentrations ranging from an estimated 0.151 mg/L to 0.522 mg/L. As discussed previously, aluminum concentrations of approximately 1 mg/L or higher in neutral-pH surface water indicate

the presence of suspended clays. Some fraction of detected aluminum will be present in solution at a pH below about 4 and above 10 (Drever, 1997), but most of the site pH readings are either near-neutral or only slightly acidic (see the above discussion of field readings). Iron was detected in all nine unfiltered site surface water samples, at concentrations ranging from an estimated 0.0634 mg/L to 0.643 mg/L. Iron concentrations of approximately 1 mg/L or higher in neutral-pH, moderate to oxidizing groundwater conditions indicate the presence of suspended iron oxides. Iron, unlike aluminum, is a redox-sensitive element, and its dissolved concentrations will increase under reducing conditions (reducing conditions can be natural, or they can be induced by the microbial degradation of chlorinated solvents and fuels). As noted above, the DO and ORP readings suggest oxidizing conditions at most sample locations. This suggests that iron in the site samples is present primarily as suspended iron oxides.

A plot of aluminum versus iron can be used as a qualitative indicator of the amount of suspended particulates in the surface water samples, as well as an indicator of the redox conditions at the sample locations (Figure 41). A linear trend with a positive slope is typically observed when both elements are present in particulate form (as clays and iron oxides), with Al/Fe ratios close to 1. Such a trend is observed in Figure 41, in which it can also be seen that the Al/Fe ratios of the site samples are consistent with those of the background samples. These observations suggest that the aluminum and iron concentrations in the site samples have a natural source. The fact that the site samples have lower aluminum and iron concentrations than many background samples indicates that the site samples contain a relatively lower mass of suspended clays and iron oxides.

Lead – Geochemical Evaluation

Lead was detected in four of the nine site surface water samples. As noted previously, lead in natural waters has an affinity to adsorb on suspended clay particulates. A plot of lead versus aluminum is provided in Figure 42. Most of the background and site samples form a common trend with a positive slope, indicating that lead in these samples is associated with clay particulates at a relatively constant ratio, and is natural. Two site samples (HJ2006 and HJ2002) lie above this trend. However, the ratio plot reveals that both samples have Pb/Al ratios that are below the maximum background ratio (Figure 43). Site sample HJ2006, which contains the second-highest lead concentration in the site data set (0.0356 mg/L), contains relatively low aluminum but its Pb/Al ratio of 0.107 is well below the maximum background Pb/Al ratio of 0.404. Trace element behavior is more complex in groundwater and surface water than in soil because it is subject to a wider range of pH and redox conditions, and trace elements are more sensitive to the presence of natural complexing ligands (chloride, hydroxyl, sulfate, phosphate, etc.) in aqueous systems. Natural variability in elemental ratios is expected for aqueous media, and the Fort McClellan background surface water data set likely reflects this natural variability. The pH reading for site sample HJ2006 (sample location SAR-RC-SW/SD10) is 3.93, whereas the remaining eight site samples have pH readings of 4.35 to 8.03, with a median of 5.85 and mean of 5.88. Under the acidic conditions at location SAR-RC-SW/SD10, lead is not expected

to strongly adsorb to the surfaces of suspended clay minerals (because of increased competition for sorption sites from H^+ ions). The Pb/Al ratios in such waters are therefore not expected to be identical to ratios from samples reflecting circumneutral conditions; natural variability in the ratios is expected.

The site maximum of 0.0871 mg/L is observed in a sample (HJ2002) with low aluminum (as well as low iron), and this sample lies well above the background trend in the correlation plot (Figure 42). Elevated lead in this sample might reflect contamination (Table 8). Given that its Pb/Al ratio is consistent with background, this is a conservative assessment.

4.0 Summary

The methodology used to compare the site and background data sets for 23 elements in surface soil, subsurface soil, sediment, groundwater, and surface water consisted of a combination of statistical and geochemical evaluations. Tier 1 consisted of a comparison of the site MDC to two times the mean of the background data set. Elements passing this step were considered to be present at background concentrations. Any element failing the Tier 1 evaluation was carried forward for Tier 2 evaluation, which consisted of a hot measurement test, nonparametric two-sample WRS test, and box-and-whisker plots. Analytes that failed either of the Tier 2 statistical tests were subjected to geochemical evaluation to determine if the elevated concentrations could be explained by natural processes.

Tables 3 through 7 summarize the results of the Tiers 1 and 2 statistical tests. Table 8 lists the samples identified via geochemical evaluation as containing anomalously high element concentrations that may reflect site-related contamination. Table 9 lists the non-TAL surface and subsurface soil samples that could not be included in the geochemical evaluation and that contain lead concentrations above the corresponding background screening values.

Surface Soil. One hundred percent of the site surface soil samples are nondetect for cadmium. Aluminum, barium, chromium, cobalt, iron, magnesium, manganese, mercury, sodium, thallium, and vanadium passed statistical comparison to background (Tier 1 or Tier 2 evaluation). The detected concentrations of these eleven elements are within their respective background ranges. Antimony, arsenic, beryllium, calcium, copper, lead, nickel, potassium, selenium, silver, and zinc failed statistical comparison to background (Tier 2) and were subjected to geochemical evaluation. Geochemical evaluation indicates that all detected concentrations of beryllium, calcium, nickel, potassium, and selenium in the site surface soil samples are most likely natural.

Anomalously high concentrations of antimony, arsenic, copper, lead, silver, and zinc are present in 1 to 21 samples each and may contain a component of contamination (Table 8).

Sixty-nine surface soil samples were not analyzed for Al, Fe, and Mn and could not be included in the geochemical evaluation to determine if their lead concentrations have a natural source. Thirty-eight of these lead-only (non-TAL) samples have lead concentrations that exceed the background 95th UTL (63.8 mg/kg), and they may reflect site-related contamination (Table 9).

Subsurface Soil. One hundred percent of the site subsurface soil samples are nondetect for cadmium. Aluminum, arsenic, barium, beryllium, calcium, chromium, cobalt, magnesium, manganese, mercury, nickel, potassium, silver, sodium, thallium, vanadium, and zinc passed statistical comparison to background (Tier 1 or Tier 2 evaluation). The detected concentrations of these 17 elements are within their respective background ranges. Antimony, copper, iron, lead, and selenium failed statistical comparison to background (Tier 2) and were subjected to geochemical evaluation. Geochemical evaluation indicates that all detected concentrations of iron and selenium in the site subsurface soil samples are most likely natural. Anomalously high concentrations of antimony, copper, and lead are present in one to three samples each and may contain a component of contamination (Table 8).

Twenty subsurface soil samples were not analyzed for Al, Fe, and Mn and could not be included in the geochemical evaluation to determine if their lead concentrations have a natural source. Five of these lead-only (non-TAL) samples have lead concentrations that exceed the background 95th percentile (28.8 mg/kg), and they may reflect site-related contamination (Table 9).

Sediment. One hundred percent of the site sediment samples are nondetect for cadmium, selenium, silver, and sodium. Aluminum, beryllium, calcium, chromium, cobalt, magnesium, mercury, potassium, vanadium, and zinc passed statistical comparison to background (Tier 1 or Tier 2). The detected concentrations of these ten elements are within their respective background ranges. Antimony, arsenic, barium, copper, iron, lead, manganese, nickel, and thallium failed statistical comparison to background (Tier 2) and were subjected to geochemical evaluation. Geochemical evaluation indicates that all detected concentrations of arsenic, barium, iron, manganese, nickel, and thallium in the site sediment samples are most likely natural. Anomalously high concentrations of antimony, copper, and lead are present in two to three samples each and may contain a component of contamination (Table 8).

Groundwater. One hundred percent of the site groundwater samples are nondetect for antimony, arsenic, cadmium, chromium, copper, mercury, nickel, silver, thallium, vanadium, and

zinc. Aluminum, barium, beryllium, calcium, iron, lead, magnesium, potassium, selenium, and sodium passed statistical comparison to background (Tier 1 or Tier 2). The detected concentrations of these ten elements are within their respective background ranges. Cobalt and manganese in the site data set failed statistical comparison to background (Tier 2) and were subjected to geochemical evaluation. Geochemical evaluation indicates that all detected concentrations of cobalt and manganese in the site groundwater samples are most likely natural. The available data do not indicate inorganics contamination in the site groundwater samples.

Surface Water. One hundred percent of the site surface water samples are nondetect for antimony, arsenic, beryllium, cadmium, chromium, cobalt, mercury, nickel, selenium, silver, thallium, and vanadium. Aluminum, barium, calcium, copper, iron, magnesium, manganese, potassium, sodium, and zinc passed statistical comparison to background (Tier 1 or Tier 2). The detected concentrations of these ten elements are within their respective background ranges. Lead in the site data set failed statistical comparison to background (Tier 2) and was subjected to geochemical evaluation. Geochemical evaluation indicates that one surface water sample (HJ2002) contains an anomalously high lead concentration that might reflect contamination (Table 8). The other detected concentrations of lead in the site samples are most likely natural.

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TABLES

Table 1

Tier 1 2x Mean Background Screening Values for TAL Metals in Soil, Sediment, Groundwater, and Surface Water Fort McClellan, Calhoun County, Alabama

Element	Surface Soil mg/kg	Subsurface Soil mg/kg	Sediment mg/kg	Groundwater µg/L	Surface Water µg/L
Aluminum	16,306	13,591	8,593	2,335	5,259
Antimony	2	1.3	0.73	3.2	--
Arsenic	13.7	18.3	11.3	17.8	2.2
Barium	124	234	98.9	127.5	75.4
Beryllium	0.8	0.9	0.97	1.3	0.39
Cadmium	0.29	0.22	0.43	2.5	1.13
Calcium	1,723	637	1,112	56,493	25,166
Chromium	37	38.3	31.2	--	11.13
Cobalt	15.2	17.5	11.0	23.4	--
Copper	12.7	19.4	17.12	25.5	12.7
Iron	34,154	44,817	35,267	7,040	19,628
Lead	40.1	38.5	37.8	8	9
Magnesium	1,033	766	906	21,282	10,972
Manganese	1,579	1,355	712	580.5	565
Mercury	0.08	0.07	0.11	--	--
Nickel	10.3	12.9	13.02	--	22.5
Potassium	800	711	1,013	7,195	2,564
Selenium	0.48	0.47	0.72	--	--
Silver	0.36	0.24	0.32	4	--
Sodium	634	702	692	14,846	3,437
Thallium	3.4	1.4	0.13	1.5	2.5
Vanadium	58.8	65	40.9	17	15.2
Zinc	40.6	35	52.7	220	40.4

Source: Science Applications International Corporation, 1998, *Final Background Metals Survey Report, Fort McClellan, Anniston, Alabama* , July.

" -- " - Analyte not detected in the background groundwater data set (SAIC, 1998).

mg/kg - Milligram(s) per kilogram.

µg/L - Microgram(s) per liter.

TAL - Target analyte list.

Table 2

Background 95th UTLs and 95th Percentiles for TAL Metals in Soil, Sediment, Groundwater, and Surface Water Fort McClellan, Calhoun County, Alabama

Element	Surface Soil mg/kg	Subsurface Soil mg/kg	Sediment mg/kg	Groundwater µg/L	Surface Water µg/L
Aluminum	22,900	16,574	14,331	5,950	13,700
Antimony	< 7.14	< 7.14	0.878	< 10	< 10
Arsenic	25.42	54.9	28.4	< 117	3.40
Barium	193.8	320	190.6	472	115
Beryllium	1.189	2.19	1.826	< 5	0.40
Cadmium	< 1.2	0.620	0.787	< 6.78	< 5
Calcium	3,545	1,710	2,856	71,400	37,800
Chromium	64.4	53.4	63.27	< 16.8	< 16.8
Cobalt	32.5	54.7	29.07	20.2	< 25
Copper	22.5	34.2	36.79	207	50.6
Iron	55,399	41,800	70,845	22,000	118,000
Lead	63.8	28.8	76.4	< 43.4	22.1
Magnesium	2,160	2,270	2,440	22,000	50,536
Manganese	4,658	3,790	2,611	4,134	1,829
Mercury	0.125	0.094	0.137	< 0.243	< 0.243
Nickel	19.96	29.2	25.8	< 34.3	40.0
Potassium	1,830	1,420	2,300	16,000	4,251
Selenium	< 0.563	< 0.574	1.03	< 97.1	< 5
Silver	0.774	0.880	0.530	< 10	< 4.6
Sodium	451	588	547	49,028	5,580
Thallium	< 6.62	< 6.62	0.211	< 10	< 2
Vanadium	99.4	91.7	67.7	< 27.6	21.1
Zinc	73.7	85.0	122.9	1,155	45.6

Note: 95th UTLs are listed for elements with normal or lognormal background distributions. 95th percentiles are listed for elements with neither normal nor lognormal background distributions (i.e., those elements with nonparametric distributions). Please see the installation-wide work plan (IT Corporation, 2002).

mg/kg - Milligram(s) per kilogram.

µg/L - Microgram(s) per liter.

TAL - Target analyte list.

UTL - Upper tolerance limit.

Table 3

Summary of Tier 1 and Tier 2 Site-to-Background Comparison for Surface Soil
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

	Frequency	Tier 1		Tier 2 Evaluation				Carried Forward
	of	Evaluation[a]		Hot Measurement Test		Wilcoxon Rank Sum Test[b]		for Tier 3
Element	Detection	*n* > 2x mean	Result	*n* > Hm	Result	p-level[c]	Result	Geochemical Evaluation
Aluminum	51 / 51	0	Passed	NA	NA	NA	NA	
Antimony	24 / 51	13	Failed	9	Failed	< 0.001 (Site > BG)	Failed	Yes
Arsenic	46 / 51	6	Failed	3	Failed	0.288	Passed	Yes
Barium	51 / 51	0	Passed	NA	NA	NA	NA	
Beryllium	30 / 51	10	Failed	2	Failed	< 0.001 (Site > BG)	Failed	Yes
Cadmium	0 / 51	NA	NA	NA	NA	NA	NA	
Calcium	50 / 51	2	Failed	1	Failed	0.335	Passed	Yes
Chromium	51 / 51	0	Passed	NA	NA	NA	NA	
Cobalt	48 / 51	1	Failed	0	Passed	0.502	Passed	
Copper	51 / 51	31	Failed	25	Failed	< 0.001 (Site > BG)	Failed	Yes
Iron	51 / 51	0	Passed	NA	NA	NA	NA	
Lead	120 / 120	79	Failed	69	Failed	< 0.001 (Site > BG)	Failed	Yes
Magnesium	51 / 51	0	Passed	NA	NA	NA	NA	
Manganese	51 / 51	1	Failed	0	Passed	0.931	Passed	
Mercury	36 / 51	3	Failed	0	Passed	NA	NA	
Nickel	51 / 51	6	Failed	0	Passed	0.012 (Site > BG)	Failed	Yes
Potassium	47 / 51	2	Failed	0	Passed	0.020 (Site > BG)	Failed	Yes
Selenium	6 / 51	6	Failed	8	Failed	NA	NA	Yes
Silver	2 / 51	2	Failed	1	Failed	NA	NA	Yes
Sodium	10 / 51	0	Passed	NA	NA	NA	NA	
Thallium	12 / 51	0	Passed	NA	NA	NA	NA	
Vanadium	51 / 51	0	Passed	NA	NA	NA	NA	
Zinc	51 / 51	15	Failed	7	Failed	< 0.001 (Site > BG)	Failed	Yes

Hm - Background 95th upper tolerance limit (or background 95th percentile). See Table 2 for values.

NA - Not applicable.

[a] Tier 1 evaluation consists of a comparison of the site maximum detected concentration to two times the background mean. Performed in accordance with the technical memorandum entitled "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3," dated 14 March 2005, by K. Thorbjornsen, J. Myers, and P. Goetchius (Shaw Environmental).

[b] The Wilcoxon rank sum test is not performed on data sets containing 50% or more nondetects.

[c] Relative positions of site and background (BG) medians are provided in parentheses for p-levels < 0.20. See box plots.

Table 4

Summary of Tier 1 and Tier 2 Site-to-Background Comparison for Subsurface Soil
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

	Frequency	**Tier 1**		**Tier 2 Evaluation**				Carried Forward
	of	**Evaluation[a]**		Hot Measurement Test		Wilcoxon Rank Sum Test[b]		for Tier 3
Element	Detection	*n* > 2x mean	Result	*n* > Hm	Result	p-level[c]	Result	Geochemical Evaluation
Aluminum	17 / 17	0	Passed	NA	NA	NA	NA	
Antimony	3 / 17	2	Failed	1	Failed	NA	NA	Yes
Arsenic	16 / 17	1	Failed	0	Passed	0.560	Passed	
Barium	17 / 17	0	Passed	NA	NA	NA	NA	
Beryllium	7 / 17	1	Failed	0	Passed	NA	NA	
Cadmium	0 / 17	NA	NA	NA	NA	NA	NA	
Calcium	15 / 17	0	Passed	NA	NA	NA	NA	
Chromium	17 / 17	1	Failed	0	Passed	0.147 (Site < BG)	Passed	
Cobalt	15 / 17	0	Passed	NA	NA	NA	NA	
Copper	17 / 17	1	Failed	1	Failed	0.942	Passed	Yes
Iron	17 / 17	1	Failed	1	Failed	0.006 (Site < BG)	Passed	Yes
Lead	37 / 37	7	Failed	11	Failed	0.026 (Site > BG)	Failed	Yes
Magnesium	16 / 17	0	Passed	NA	NA	NA	NA	
Manganese	17 / 17	0	Passed	NA	NA	NA	NA	
Mercury	13 / 17	0	Passed	NA	NA	NA	NA	
Nickel	17 / 17	2	Failed	0	Passed	0.524	Passed	
Potassium	14 / 17	0	Passed	NA	NA	NA	NA	
Selenium	1 / 17	1	Failed	1	Failed	NA	NA	Yes
Silver	1 / 17	1	Failed	0	Passed	NA	NA	
Sodium	1 / 17	0	Passed	NA	NA	NA	NA	
Thallium	2 / 17	0	Passed	NA	NA	NA	NA	
Vanadium	17 / 17	0	Passed	NA	NA	NA	NA	
Zinc	17 / 17	2	Failed	0	Passed	0.301	Passed	

Hm - Background 95th upper tolerance limit (or background 95th percentile). See Table 2 for values.
NA - Not applicable.

[a] Tier 1 evaluation consists of a comparison of the site maximum detected concentration to two times the background mean. Performed in accordance with the technical memorandum entitled "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3," dated 14 March 2005, by K. Thorbjornsen, J. Myers, and P. Goetchius (Shaw Environmental).

[b] The Wilcoxon rank sum test is not performed on data sets containing 50% or more nondetects.

[c] Relative positions of site and background (BG) medians are provided in parentheses for p-levels < 0.20. See box plots.

Table 5

Summary of Tier 1 and Tier 2 Site-to-Background Comparison for Sediment
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

	Frequency of	Tier 1 Evaluation[a]		Tier 2 Evaluation				Carried Forward for Tier 3
				Hot Measurement Test		Wilcoxon Rank Sum Test[b]		
Element	Detection	*n* > 2x mean	Result	*n* > Hm	Result	p-level[c]	Result	Geochemical Evaluation
Aluminum	9 / 9	0	Passed	NA	NA	NA	NA	
Antimony	4 / 9	4	Failed	4	Failed	NA	NA	Yes
Arsenic	9 / 9	2	Failed	1	Failed	0.095 (Site > BG)	Failed	Yes
Barium	9 / 9	1	Failed	1	Failed	0.342	Passed	Yes
Beryllium	6 / 9	2	Failed	0	Passed	NA	NA	
Cadmium	0 / 9	NA	NA	NA	NA	NA	NA	
Calcium	9 / 9	1	Failed	0	Passed	0.208	Passed	
Chromium	9 / 9	1	Failed	0	Passed	0.421	Passed	
Cobalt	9 / 9	2	Failed	0	Passed	0.600	Passed	
Copper	9 / 9	2	Failed	2	Failed	0.037 (Site > BG)	Failed	Yes
Iron	9 / 9	1	Failed	0	Passed	0.140 (Site > BG)	Failed	Yes
Lead	9 / 9	5	Failed	4	Failed	0.021 (Site > BG)	Failed	Yes
Magnesium	9 / 9	0	Passed	NA	NA	NA	NA	
Manganese	9 / 9	1	Failed	1	Failed	0.491	Passed	Yes
Mercury	5 / 9	0	Passed	NA	NA	NA	NA	
Nickel	9 / 9	1	Failed	1	Failed	0.514	Passed	Yes
Potassium	9 / 9	0	Passed	NA	NA	NA	NA	
Selenium	0 / 9	NA	NA	NA	NA	NA	NA	
Silver	0 / 9	NA	NA	NA	NA	NA	NA	
Sodium	0 / 9	NA	NA	NA	NA	NA	NA	
Thallium	3 / 9	3	Failed	3	Failed	NA	NA	Yes
Vanadium	9 / 9	1	Failed	0	Passed	0.315	Passed	
Zinc	9 / 9	1	Failed	0	Passed	0.298	Passed	

Hm - Background 95th upper tolerance limit (or background 95th percentile). See Table 2 for values.

NA - Not applicable.

[a] Tier 1 evaluation consists of a comparison of the site maximum detected concentration to two times the background mean. Performed in accordance with the technical memorandum entitled "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3," dated 14 March 2005, by K. Thorbjornsen, J. Myers, and P. Goetchius (Shaw Environmental).

[b] The Wilcoxon rank sum test is not performed on data sets containing 50% or more nondetects.

[c] Relative positions of site and background (BG) medians are provided in parentheses for p-levels < 0.20. See box plots.

Table 6

Summary of Tier 1 and Tier 2 Site-to-Background Comparison for Groundwater
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

	Frequency	Tier 1		Tier 2 Evaluation				Carried Forward
	of	Evaluation[a]		Hot Measurement Test		Wilcoxon Rank Sum Test[b]		for Tier 3
Element	Detection	*n* > 2x mean	Result	*n* > Hm	Result	p-level[c]	Result	Geochemical Evaluation
Aluminum	5 / 6	0	Passed	NA	NA	NA	NA	
Antimony	0 / 6	NA	NA	NA	NA	NA	NA	
Arsenic	0 / 6	NA	NA	NA	NA	NA	NA	
Barium	5 / 6	1	Failed	0	Passed	0.941	Passed	
Beryllium	1 / 6	1	Failed	0	Passed	NA	NA	
Cadmium	0 / 6	NA	NA	NA	NA	NA	NA	
Calcium	6 / 6	0	Passed	NA	NA	NA	NA	
Chromium	0 / 6	NA	NA	NA	NA	NA	NA	
Cobalt	1 / 6	1	Failed	1	Failed	NA	NA	Yes
Copper	0 / 6	NA	NA	NA	NA	NA	NA	
Iron	5 / 6	0	Passed	NA	NA	NA	NA	
Lead	2 / 6	0	Passed	NA	NA	NA	NA	
Magnesium	6 / 6	0	Passed	NA	NA	NA	NA	
Manganese	5 / 6	2	Failed	1	Failed	0.183 (Site > BG)	Failed	Yes
Mercury	0 / 6	NA	NA	NA	NA	NA	NA	
Nickel	0 / 6	NA	NA	NA	NA	NA	NA	
Potassium	4 / 6	0	Passed	NA	NA	NA	NA	
Selenium	1 / 6	NA[d]	Failed	NA	NA	NA	NA	
Silver	0 / 6	NA	NA	NA	NA	NA	NA	
Sodium	3 / 6	0	Passed	NA	NA	NA	NA	
Thallium	0 / 6	NA	NA	NA	NA	NA	NA	
Vanadium	0 / 6	NA	NA	NA	NA	NA	NA	
Zinc	0 / 6	NA	NA	NA	NA	NA	NA	

Hm - Background 95th upper tolerance limit (or background 95th percentile). See Table 2 for values.

NA - Not applicable.

[a] Tier 1 evaluation consists of a comparison of the site maximum detected concentration to two times the background mean. Performed in accordance with the technical memorandum entitled "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3," dated 14 March 2005, by K. Thorbjornsen, J. Myers, and P. Goetchius (Shaw Environmental).

[b] The Wilcoxon rank sum test is not performed on data sets containing 50% or more nondetects.

[c] Relative positions of site and background (BG) medians are provided in parentheses for p-levels < 0.20. See box plots.

[d] Element is 100 percent nondetect in the background data set. Site data are therefore carried forward for Tier 2 evaluation.

Table 7

Summary of Tier 1 and Tier 2 Site-to-Background Comparison for Surface Water
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

	Frequency	Tier 1		Tier 2 Evaluation				Carried Forward
	of	Evaluation[a]		Hot Measurement Test		Wilcoxon Rank Sum Test[b]		for Tier 3
Element	Detection	*n* > 2x mean	Result	*n* > Hm	Result	p-level[c]	Result	Geochemical Evaluation
Aluminum	2 / 9	0	Passed	NA	NA	NA	NA	
Antimony	0 / 9	NA	NA	NA	NA	NA	NA	
Arsenic	0 / 9	NA	NA	NA	NA	NA	NA	
Barium	9 / 9	0	Passed	NA	NA	NA	NA	
Beryllium	0 / 9	NA	NA	NA	NA	NA	NA	
Cadmium	0 / 9	NA	NA	NA	NA	NA	NA	
Calcium	9 / 9	0	Passed	NA	NA	NA	NA	
Chromium	0 / 9	NA	NA	NA	NA	NA	NA	
Cobalt	0 / 9	NA	NA	NA	NA	NA	NA	
Copper	1 / 9	0	Passed	NA	NA	NA	NA	
Iron	9 / 9	0	Passed	NA	NA	NA	NA	
Lead	4 / 9	2	Failed	2	Failed	NA	NA	Yes
Magnesium	9 / 9	0	Passed	NA	NA	NA	NA	
Manganese	9 / 9	0	Passed	NA	NA	NA	NA	
Mercury	0 / 9	NA	NA	NA	NA	NA	NA	
Nickel	0 / 9	NA	NA	NA	NA	NA	NA	
Potassium	9 / 9	0	Passed	NA	NA	NA	NA	
Selenium	0 / 9	NA	NA	NA	NA	NA	NA	
Silver	0 / 9	NA	NA	NA	NA	NA	NA	
Sodium	9 / 9	0	Passed	NA	NA	NA	NA	
Thallium	0 / 9	NA	NA	NA	NA	NA	NA	
Vanadium	0 / 9	NA	NA	NA	NA	NA	NA	
Zinc	5 / 9	0	Passed	NA	NA	NA	NA	

Hm - Background 95th upper tolerance limit (or background 95th percentile). See Table 2 for values.

NA - Not applicable.

[a] Tier 1 evaluation consists of a comparison of the site maximum detected concentration to two times the background mean. Performed in accordance with the technical memorandum entitled "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3," dated 14 March 2005, by K. Thorbjornsen, J. Myers, and P. Goetchius (Shaw Environmental).

[b] The Wilcoxon rank sum test is not performed on data sets containing 50% or more nondetects.

[c] Relative positions of site and background (BG) medians are provided in parentheses for p-levels < 0.20. See box plots.

Table 8

Samples With Anomalously High Element Concentrations
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

Medium	Location	Sample	Date	Element(s)
Surface Soil	HR-221Q-GP01	NB0001	2-Apr-01	Antimony, Copper, Lead
Surface Soil	HR-69Q-DEP01	HJJ0003	20-Aug-01	Copper, Lead
Surface Soil	HR-69Q-SS01	HJJ0001	15-Aug-01	Antimony, Copper, Lead
Surface Soil	HR-70Q-SS01	HEE0001	16-Aug-01	Antimony, Copper, Lead
Surface Soil	HR-70Q-SS01	RW0001	13-May-03	Antimony, Arsenic, Copper, Lead
Surface Soil	HR-70Q-SS02	HEE0002	16-Aug-01	Antimony, Copper, Lead
Surface Soil	HR-71Q-SS01	HFF0001	16-Aug-01	Arsenic, Copper, Lead
Surface Soil	HR-75Q-SS01	HGG0001	15-Aug-01	Antimony, Copper, Lead, Zinc
Surface Soil	HR-75Q-SS02	HGG0002	15-Aug-01	Copper, Lead
Surface Soil	HR-75Q-SS03	HGG0004	15-Aug-01	Antimony, Copper, Lead, Silver, Zinc
Surface Soil	SAR-69-SS11	RW0021	12-May-03	Antimony, Arsenic, Copper, Lead
Surface Soil	SAR-69-SS29	HJ0032	18-Mar-00	Lead
Surface Soil	SAR-69-SS32	HJ0035	18-Mar-00	Antimony, Lead
Surface Soil	SAR-69-SS39	HJ0055	18-Mar-00	Copper
Surface Soil	SAR-70-SS12	HE0013	17-Mar-00	Antimony, Lead
Surface Soil	SAR-70-SS12	RW0024	8-May-03	Lead
Surface Soil	SAR-70-SS15	HE0018	17-Mar-00	Copper, Zinc
Surface Soil	SAR-71-SS05	RW0005	8-May-03	Copper, Lead
Surface Soil	SAR-71-SS09	RW0006	8-May-03	Lead
Surface Soil	SAR-71-SS20	HF0025	17-Mar-00	Antimony, Copper, Lead
Surface Soil	SAR-71-SS21	HF0028	17-Mar-00	Copper, Lead
Surface Soil	SAR-75-SS20	HG0030	18-Mar-00	Copper, Lead
Surface Soil	SAR-RC-DEP08	HJ1004	1-Apr-00	Antimony, Copper, Lead
Subsurface Soil	SAR-71-SS20	HF0026	17-Mar-00	Lead
Subsurface Soil	SAR-71-SS21	HF0030	17-Mar-00	Lead
Subsurface Soil	SAR-75-SS19	HG0028	18-Mar-00	Antimony, Copper, Lead
Sediment	SAR-RC-SW/SD06	HJ1002	1-Apr-00	Antimony, Copper, Lead
Sediment	SAR-RC-SW/SD10	HJ1006	1-Apr-00	Antimony, Copper, Lead
Sediment	SAR-RC-SW/SD13	HJ1009	1-Apr-00	Antimony, Lead
Surface Water	SAR-RC-SW/SD06	HJ2002	1-Apr-00	Lead

Note: Not listed above are soil samples that were analyzed only for lead; they could not be included in the geochemical evaluation to determine whether their lead concentrations have a natural source. Thirty-eight of the "non-TAL" surface samples and five of the "non-TAL" subsurface soil samples have lead concentrations that exceed the background 95th upper tolerance limit (surface soil) or background 95th percentile (subsurface soil). The elevated lead in these samples should be considered suspect (Table 9).

Table 9

Non-TAL Samples With Lead Concentrations Above Background Screening Values
Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

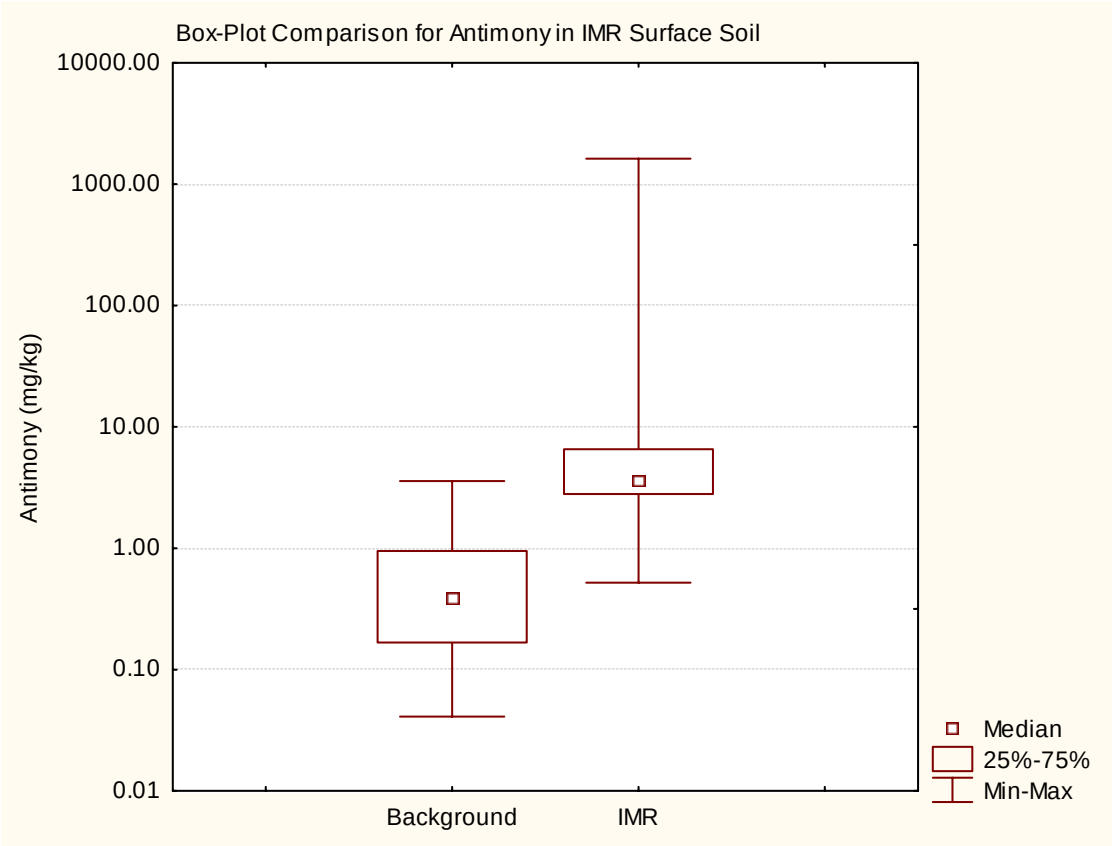
Medium	Location	Sample	Date
Surface Soil	HR-221Q-GP01E	NB0012	17-May-02
Surface Soil	HR-221Q-GP01N	NB0010	17-May-02
Surface Soil	HR-221Q-GP01S	NB0011	17-May-02
Surface Soil	HR-221Q-GP01W	NB0013	17-May-02
Surface Soil	SAR-69-SS11	HJ0012	18-Mar-00
Surface Soil	SAR-69-SS13	HJ0015	18-Mar-00
Surface Soil	SAR-69-SS14	HJ0016	18-Mar-00
Surface Soil	SAR-69-SS17	HJ0019	18-Mar-00
Surface Soil	SAR-69-SS18	HJ0020	18-Mar-00
Surface Soil	SAR-69-SS20	HJ0023	18-Mar-00
Surface Soil	SAR-69-SS22	HJ0025	18-Mar-00
Surface Soil	SAR-69-SS33	HJ0036	18-Mar-00
Surface Soil	SAR-69-SS34	HJ0039	18-Mar-00
Surface Soil	SAR-69-SS35	HJ0042	18-Mar-00
Surface Soil	SAR-69-SS36	HJ0046	18-Mar-00
Surface Soil	SAR-70-SS06	HE0007	17-Mar-00
Surface Soil	SAR-70-SS08	HE0009	17-Mar-00
Surface Soil	SAR-70-SS16	HE0021	17-Mar-00
Surface Soil	SAR-71-SS04	HF0004	17-Mar-00
Surface Soil	SAR-71-SS05	HF0005	17-Mar-00
Surface Soil	SAR-71-SS06	HF0006	17-Mar-00
Surface Soil	SAR-71-SS07	HF0008	17-Mar-00
Surface Soil	SAR-71-SS08	HF0009	17-Mar-00
Surface Soil	SAR-71-SS09	HF0010	17-Mar-00
Surface Soil	SAR-71-SS10	HF0012	17-Mar-00
Surface Soil	SAR-71-SS11	HF0013	17-Mar-00
Surface Soil	SAR-71-SS12	HF0014	17-Mar-00
Surface Soil	SAR-71-SS15	HF0017	17-Mar-00
Surface Soil	SAR-71-SS16	HF0018	17-Mar-00
Surface Soil	SAR-71-SS18	HF0020	17-Mar-00
Surface Soil	SAR-75-SS01	HG0001	17-Mar-00
Surface Soil	SAR-75-SS02	HG0002	17-Mar-00
Surface Soil	SAR-75-SS04	HG0004	17-Mar-00
Surface Soil	SAR-75-SS07	HG0008	18-Mar-00
Surface Soil	SAR-75-SS09	HG0010	17-Mar-00
Surface Soil	SAR-75-SS15	HG0016	17-Mar-00
Surface Soil	SAR-75-SS16	HG0017	17-Mar-00
Surface Soil	SAR-75-SS18	HG0022	18-Mar-00
Subsurface Soil	SAR-69-SS35	HJ0044	18-Mar-00
Subsurface Soil	SAR-69-SS35	HJ0045	18-Mar-00
Subsurface Soil	SAR-69-SS36	HJ0047	18-Mar-00
Subsurface Soil	SAR-70-SS16	HE0024	17-Mar-00
Subsurface Soil	SAR-75-SS18	HG0024	18-Mar-00

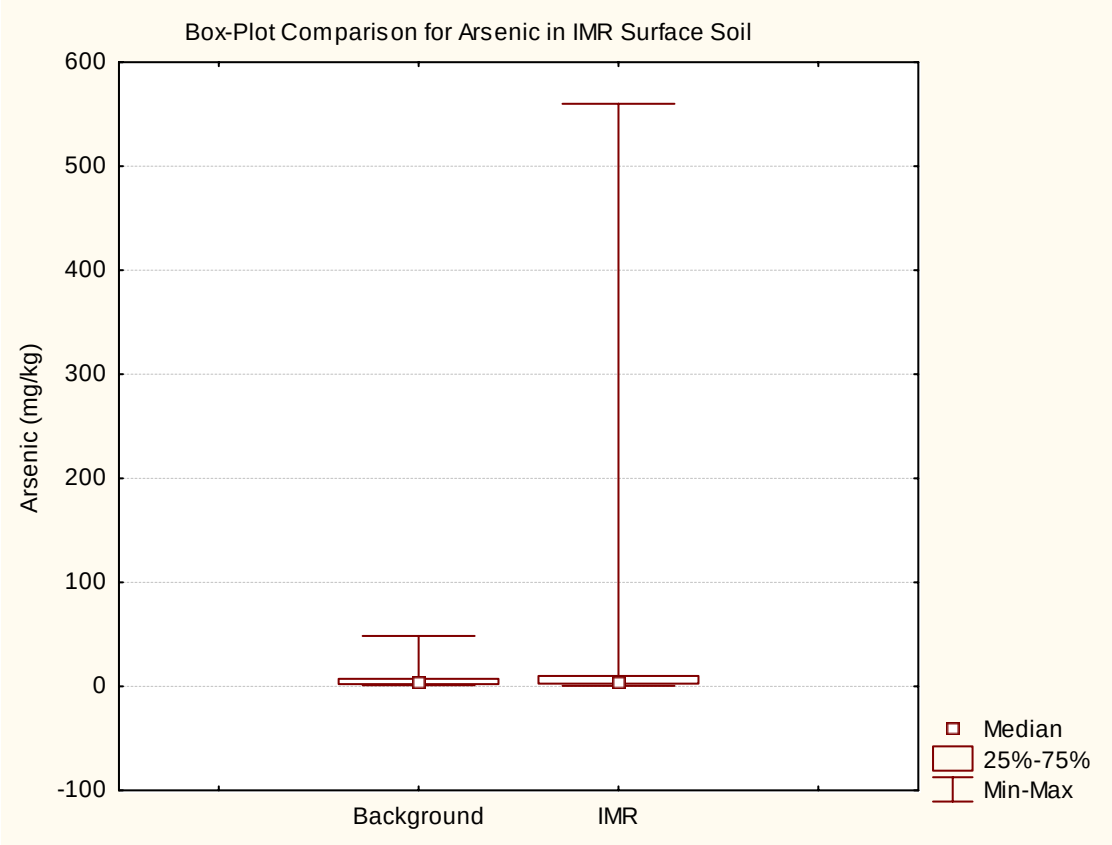
Note: The background screening value consists of the 95th upper tolerance limit (surface soil) or 95th percentile (subsurface soil).
TAL - Target analyte list.

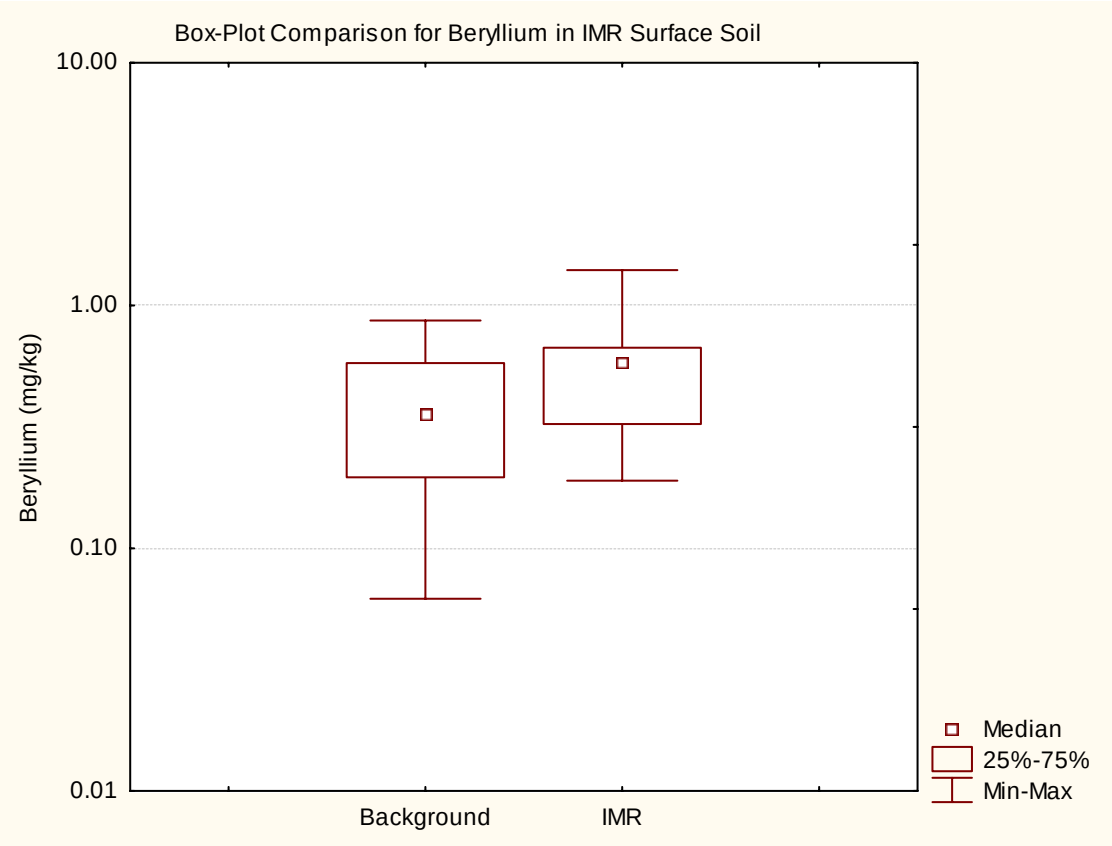
ATTACHMENT 1

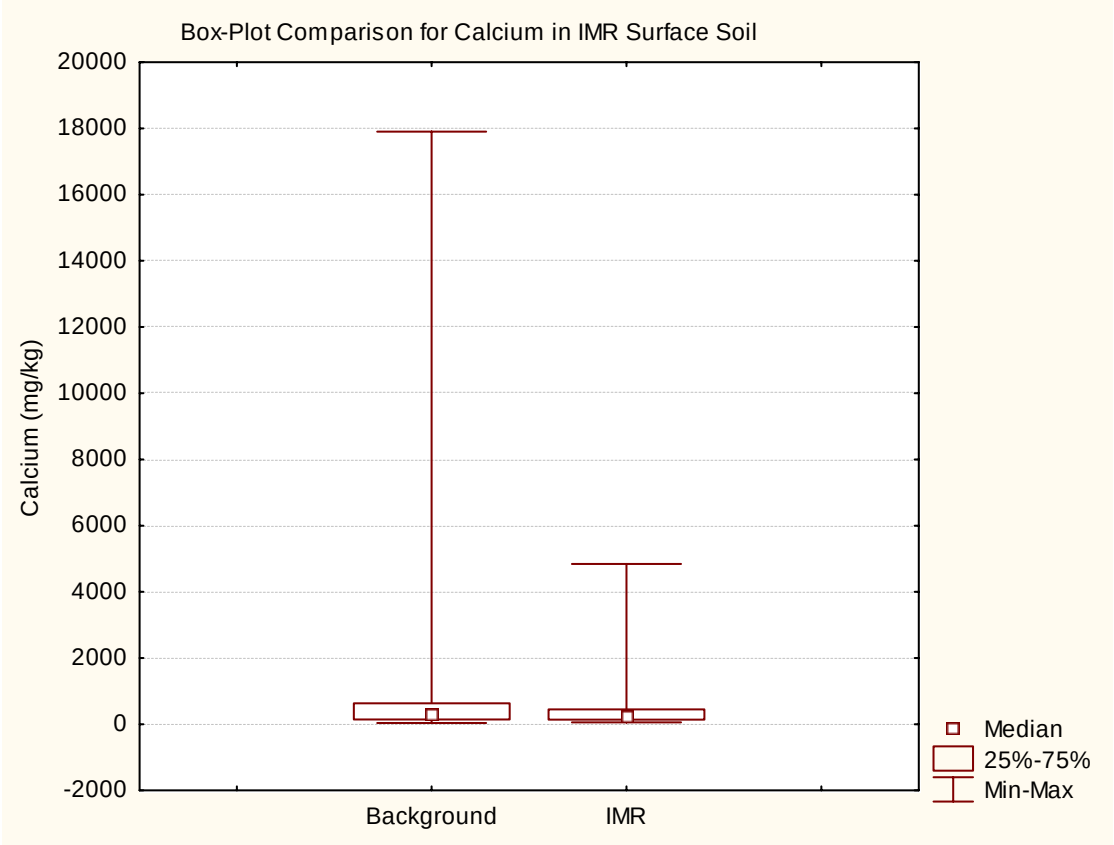
BOX PLOTS

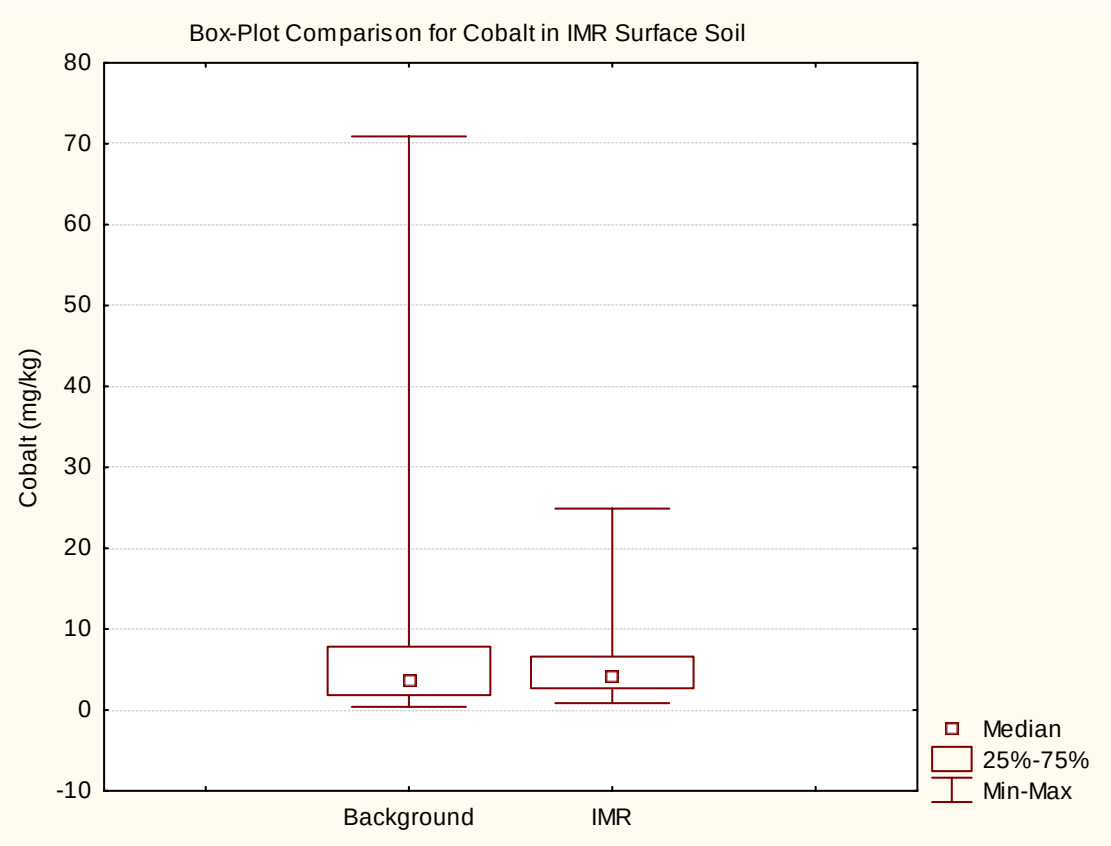
SURFACE SOIL BOX PLOTS

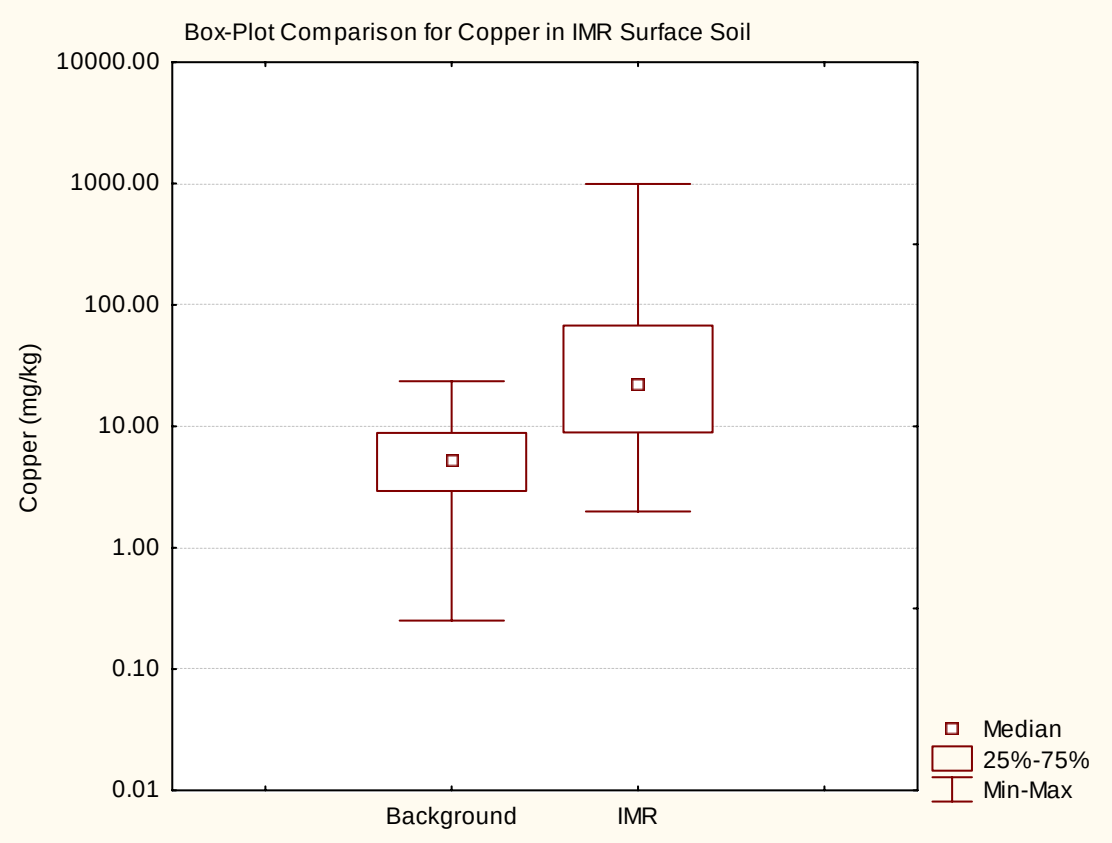

Box-Plot Comparison for Antimony in IMR Surface Soil
Antimony (mg/kg)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
Background
IMR
Median
25%-75%
Min-Max

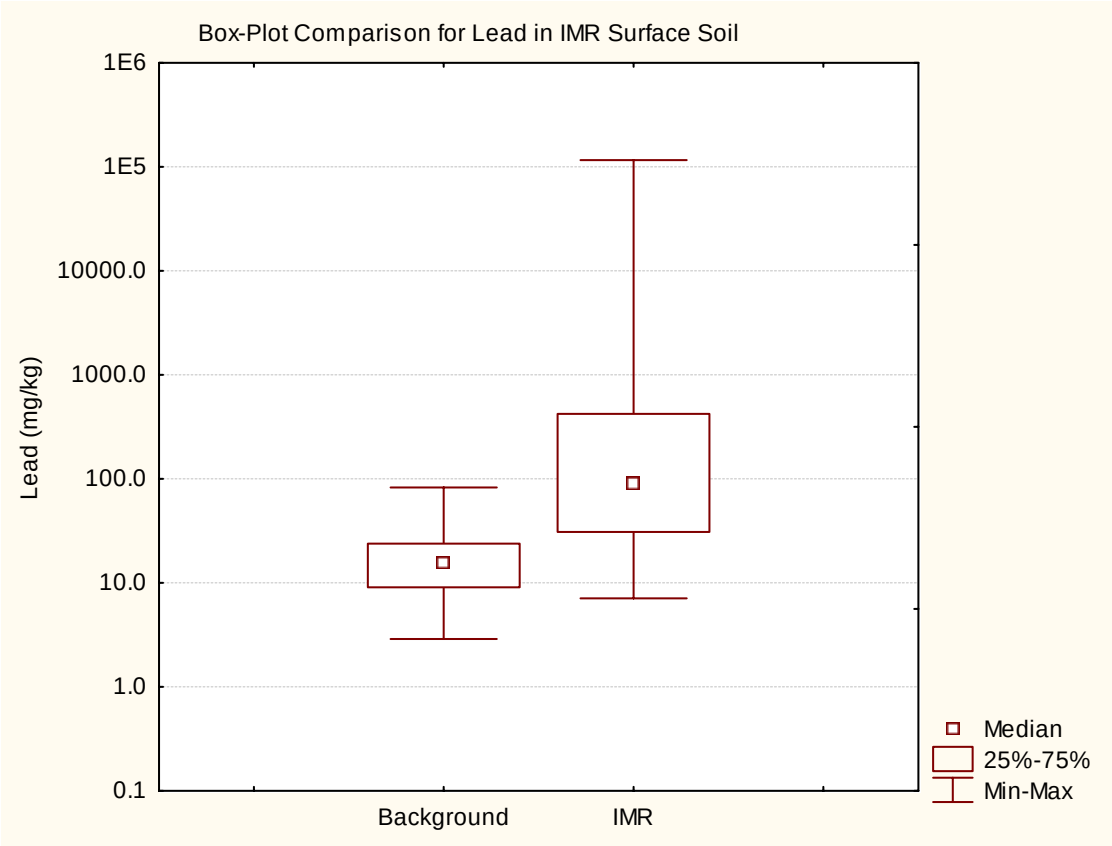

Box-Plot Comparison for Arsenic in IMR Surface Soil
Arsenic (mg/kg)
600
500
400
300
200
100
0
-100
Background
IMR
Median
25%-75%
Min-Max

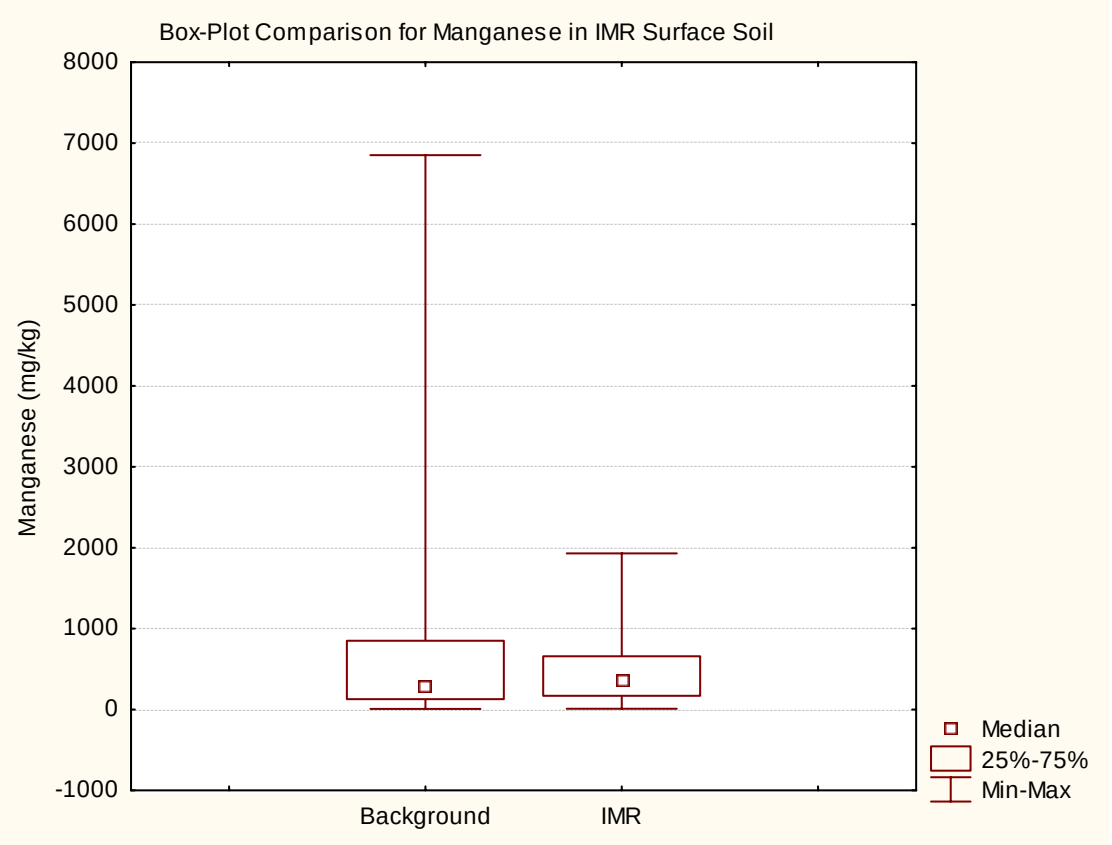

Box-Plot Comparison for Beryllium in IMR Surface Soil
10.00
1.00
0.10
0.01
Beryllium (mg/kg)
Background
IMR
Median
25%-75%
Min-Max

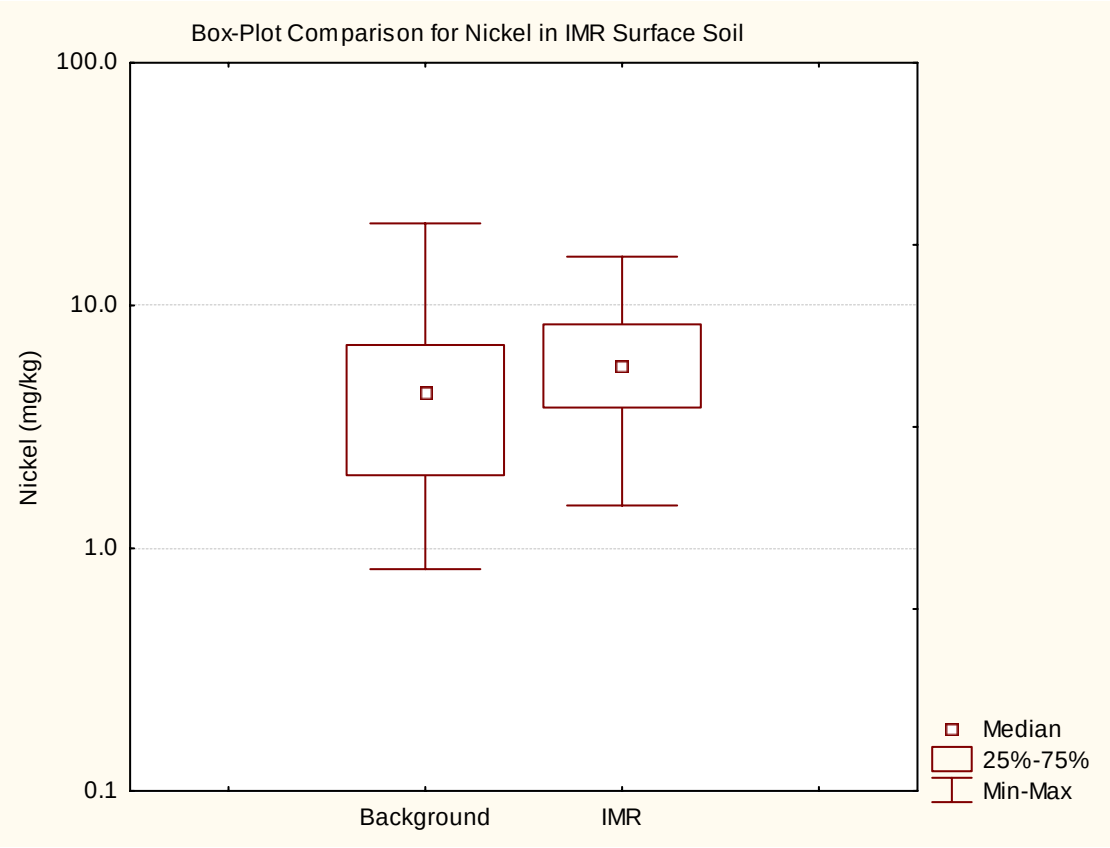

Box-Plot Comparison for Calcium in IMR Surface Soil
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Calcium (mg/kg)
Background
IMR
Median
25%-75%
Min-Max

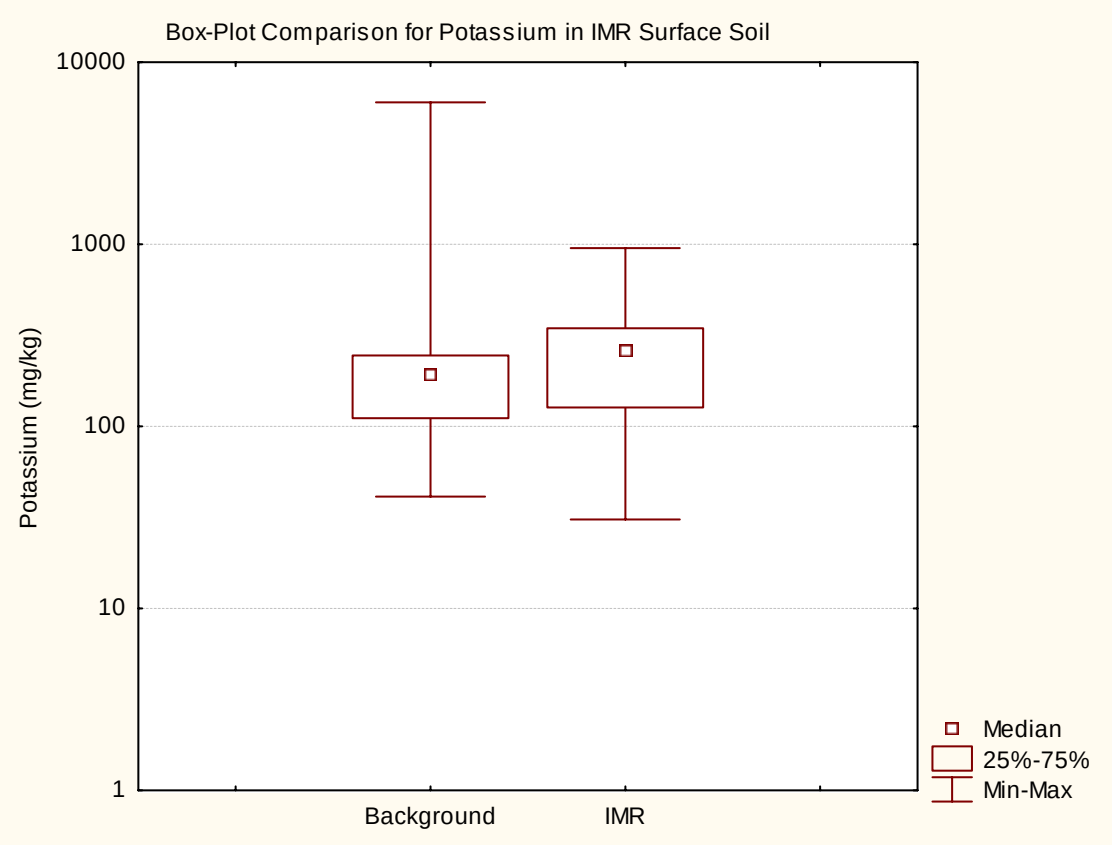

Box-Plot Comparison for Cobalt in IMR Surface Soil
Cobalt (mg/kg)
80
70
60
50
40
30
20
10
0
-10
Background
IMR
Median
25%-75%
Min-Max

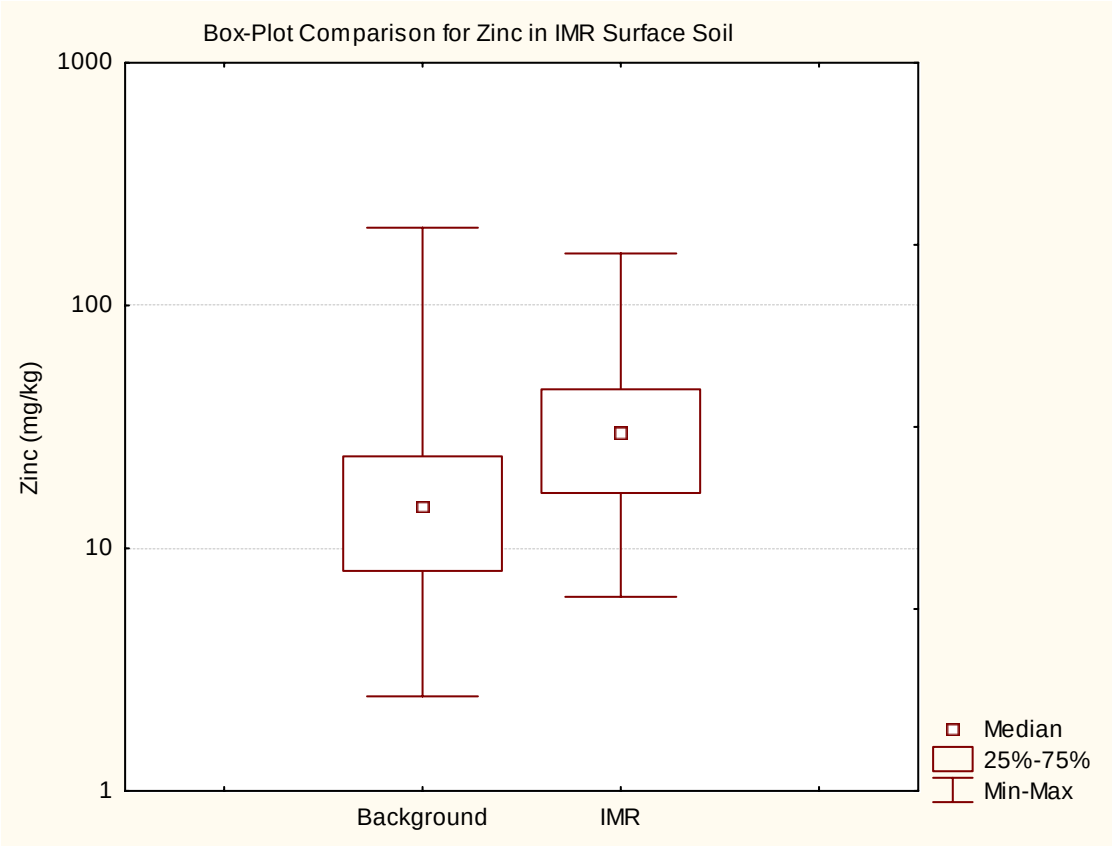

Box-Plot Comparison for Copper in IMR Surface Soil
Copper (mg/kg)
10000.00
1000.00
100.00
10.00
1.00
0.10
0.01
Background
IMR
Median
25%-75%
Min-Max


Box-Plot Comparison for Lead in IMR Surface Soil
Lead (mg/kg)
1E6
1E5
10000.0
1000.0
100.0
10.0
1.0
0.1
Background
IMR
Median
25%-75%
Min-Max

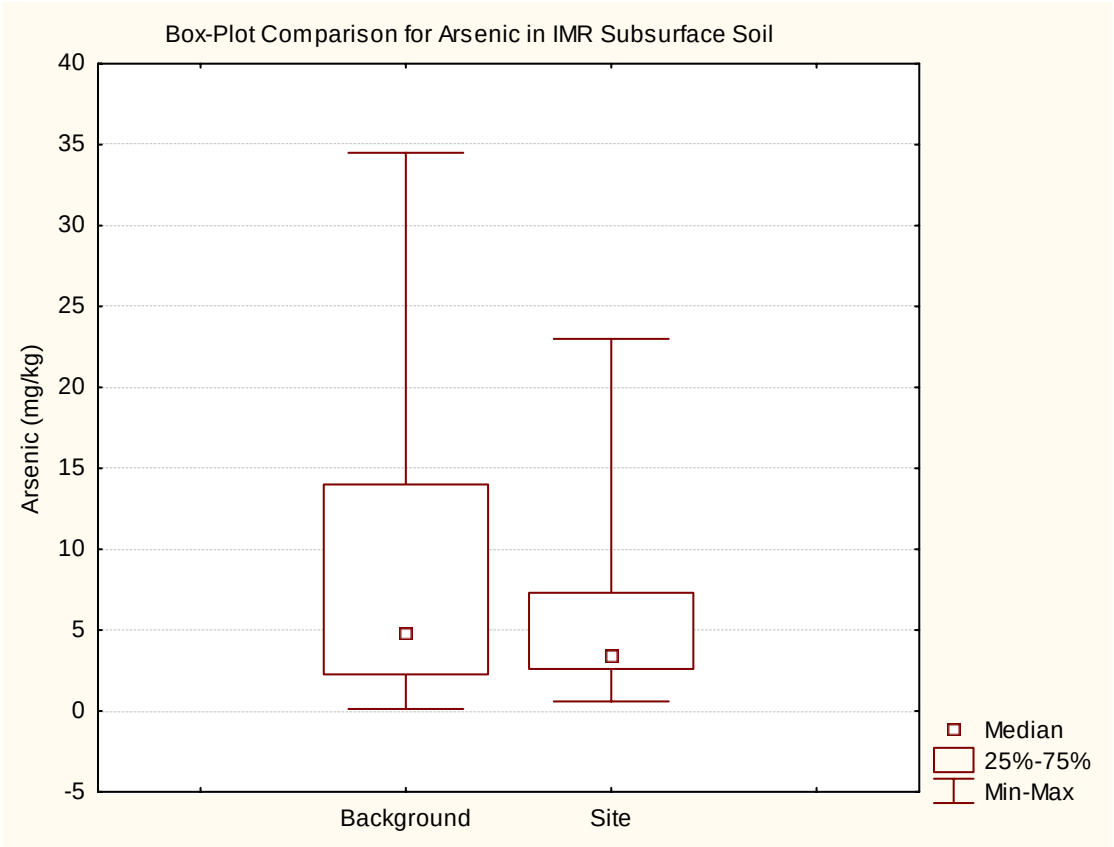

Box-Plot Comparison for Manganese in IMR Surface Soil
Manganese (mg/kg)
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Background
IMR
Median
25%-75%
Min-Max

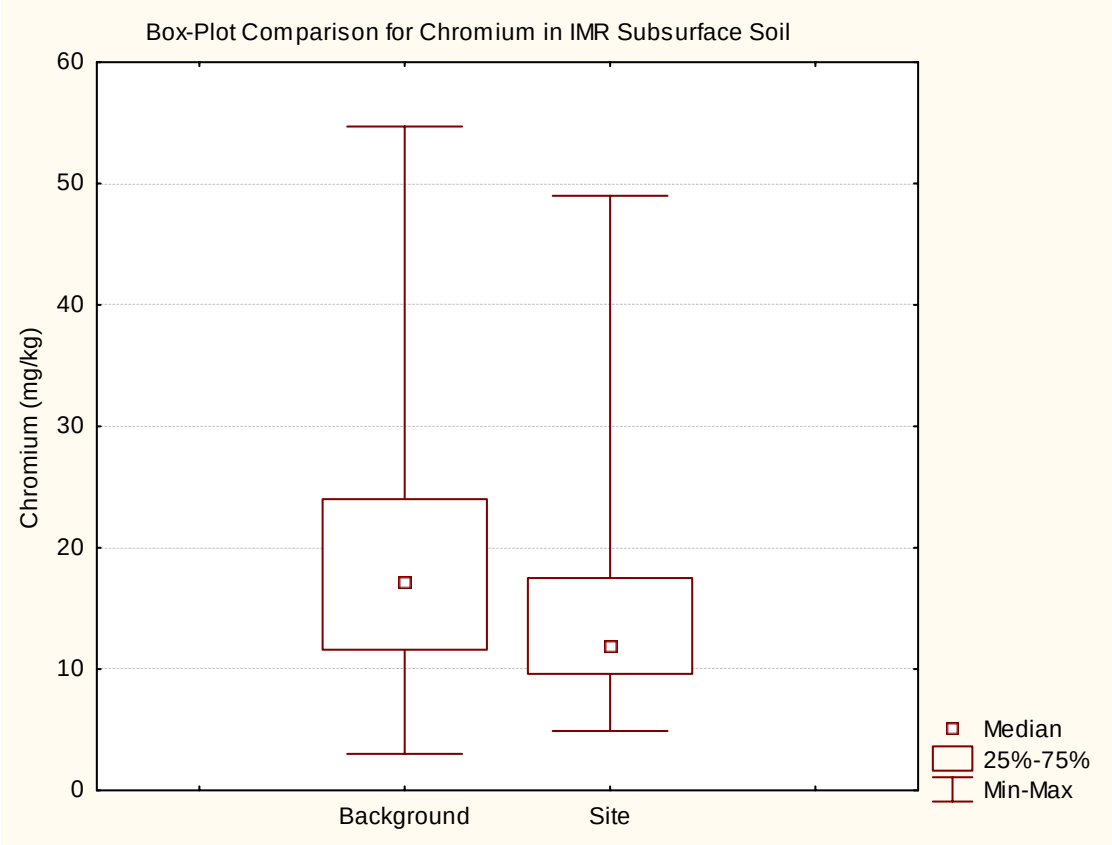

Box-Plot Comparison for Nickel in IMR Surface Soil
100.0
10.0
1.0
0.1
Nickel (mg/kg)
Background
IMR
Median
25%-75%
Min-Max

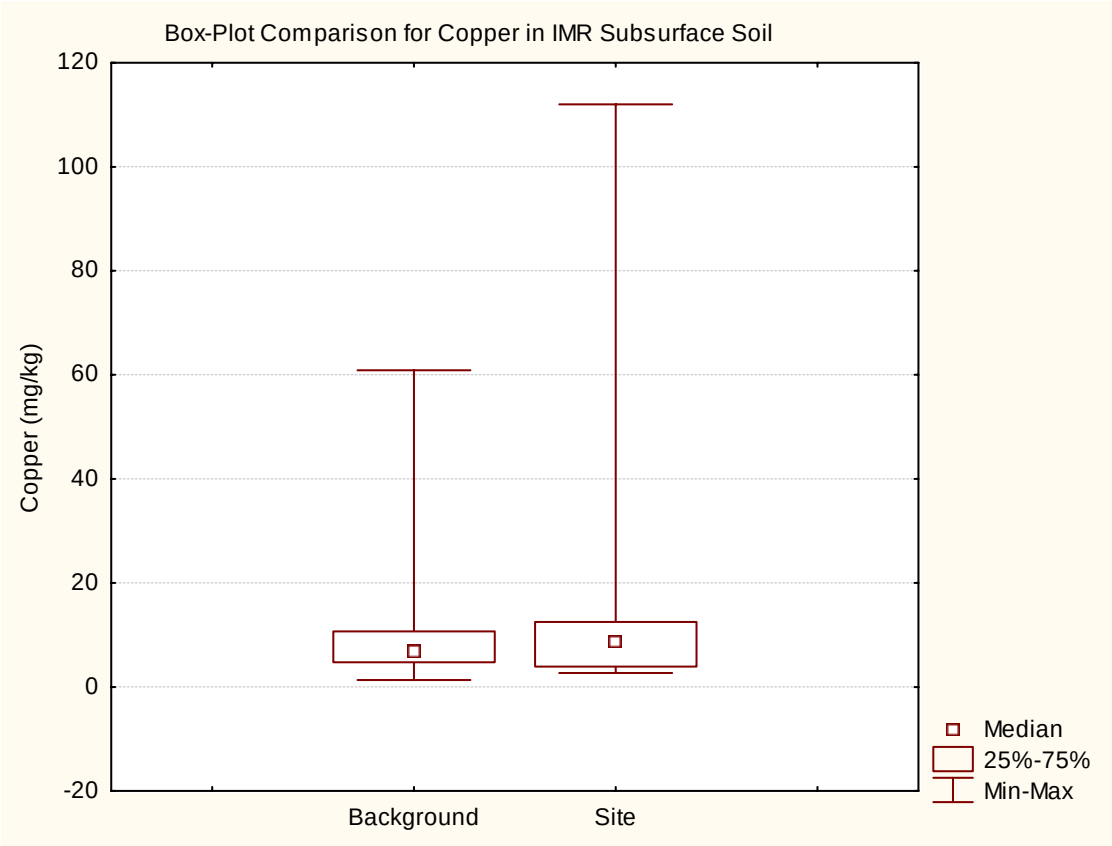

Box-Plot Comparison for Potassium in IMR Surface Soil
10000
1000
100
10
1
Potassium (mg/kg)
Background
IMR
Median
25%-75%
Min-Max

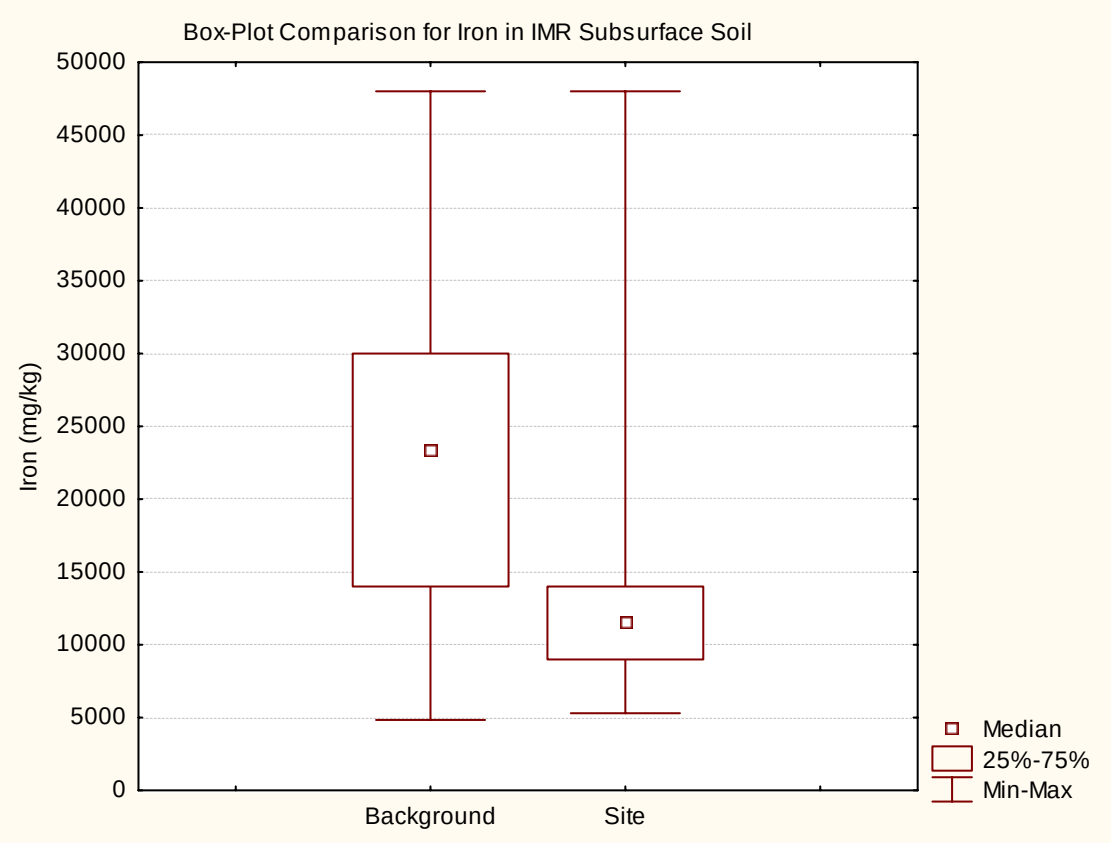

Box-Plot Comparison for Zinc in IMR Surface Soil
1000
100
10
1
Zinc (mg/kg)
Background
IMR
Median
25%-75%
Min-Max

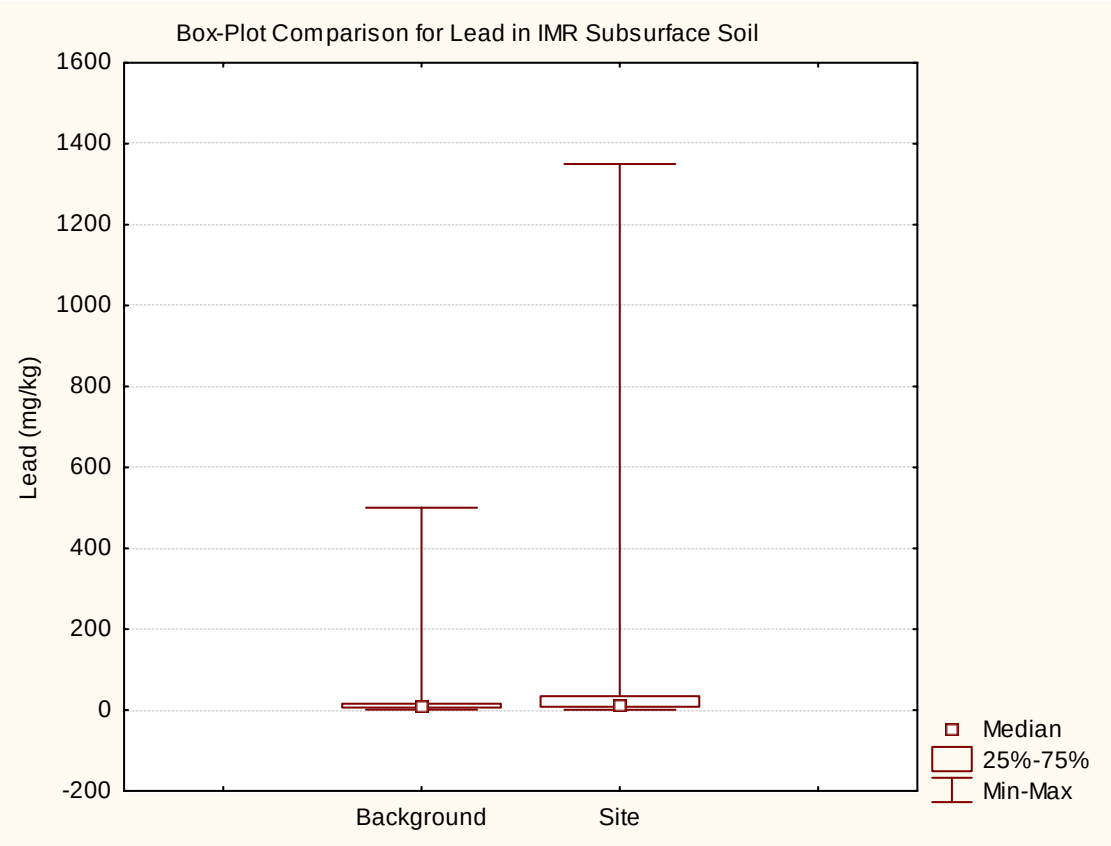
SUBSURFACE SOIL BOX PLOTS

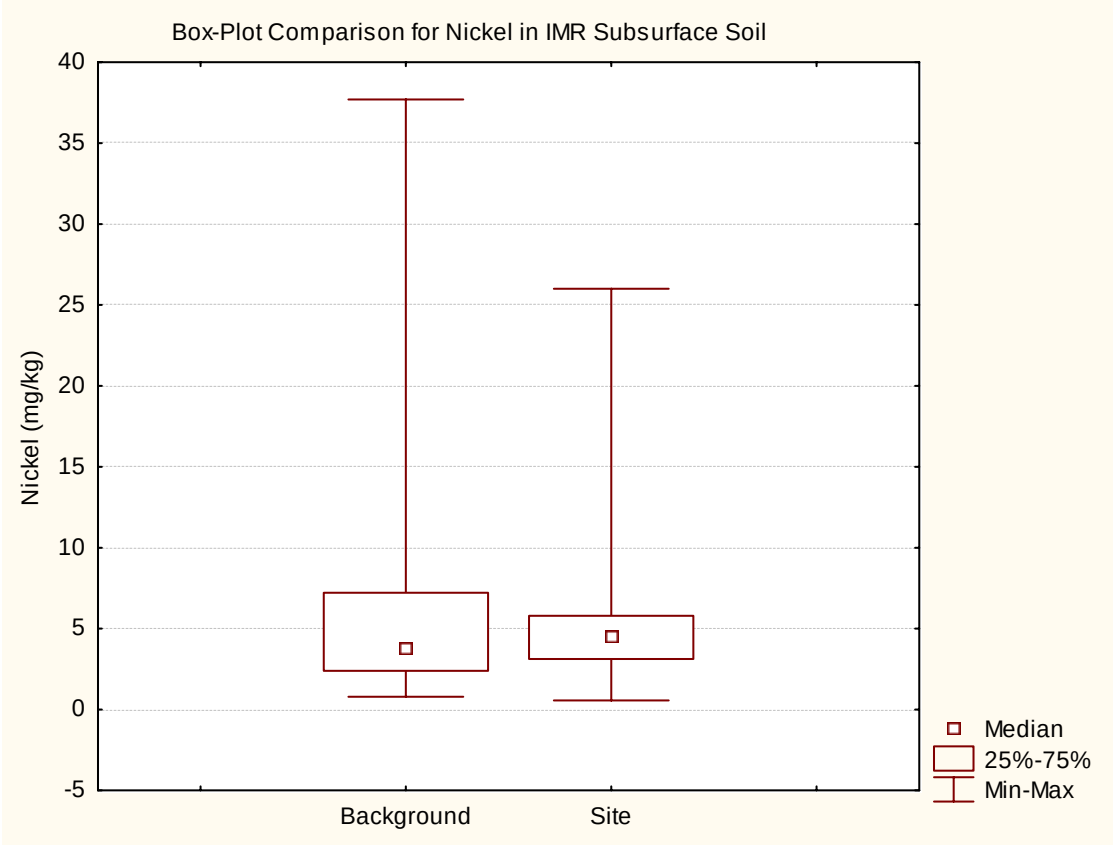

Box-Plot Comparison for Arsenic in IMR Subsurface Soil
Arsenic (mg/kg)
40
35
30
25
20
15
10
5
0
-5
Background
Site
Median
25%-75%
Min-Max

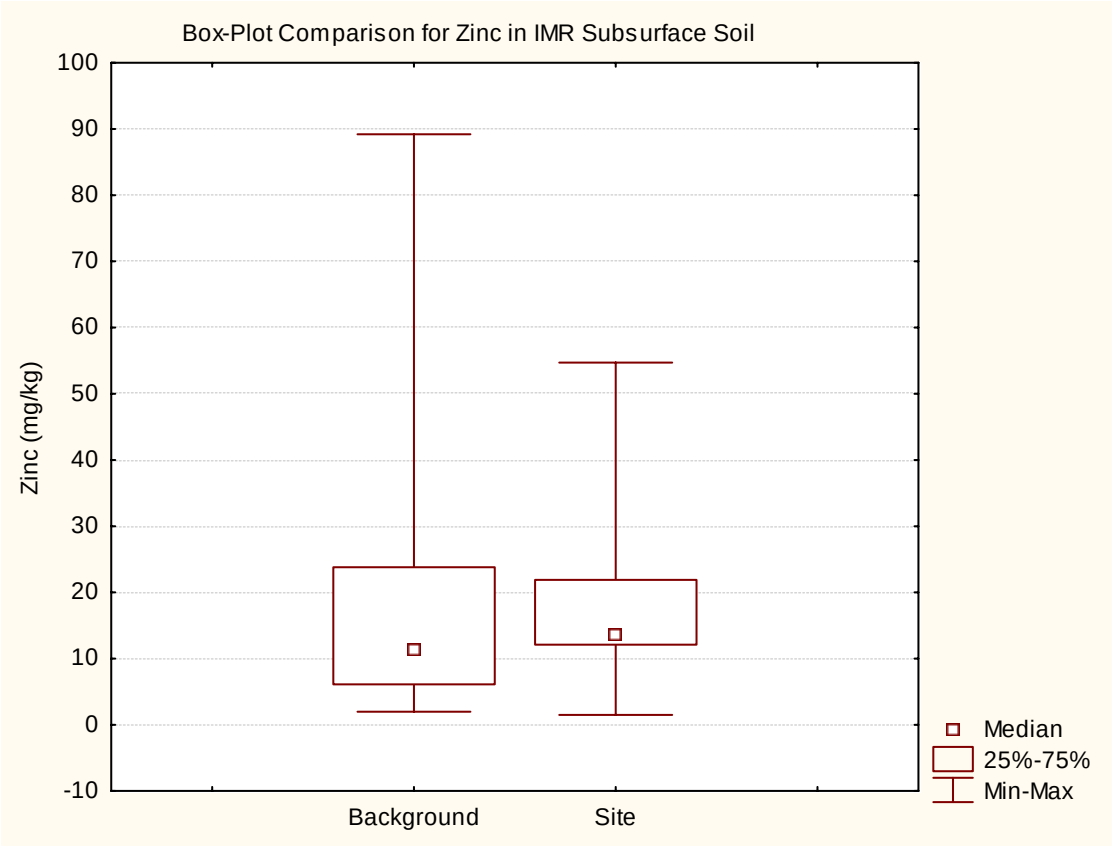

Box-Plot Comparison for Chromium in IMR Subsurface Soil
Chromium (mg/kg)
60
50
40
30
20
10
0
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Copper in IMR Subsurface Soil
Copper (mg/kg)
120
100
80
60
40
20
0
-20
Background
Site
Median
25%-75%
Min-Max

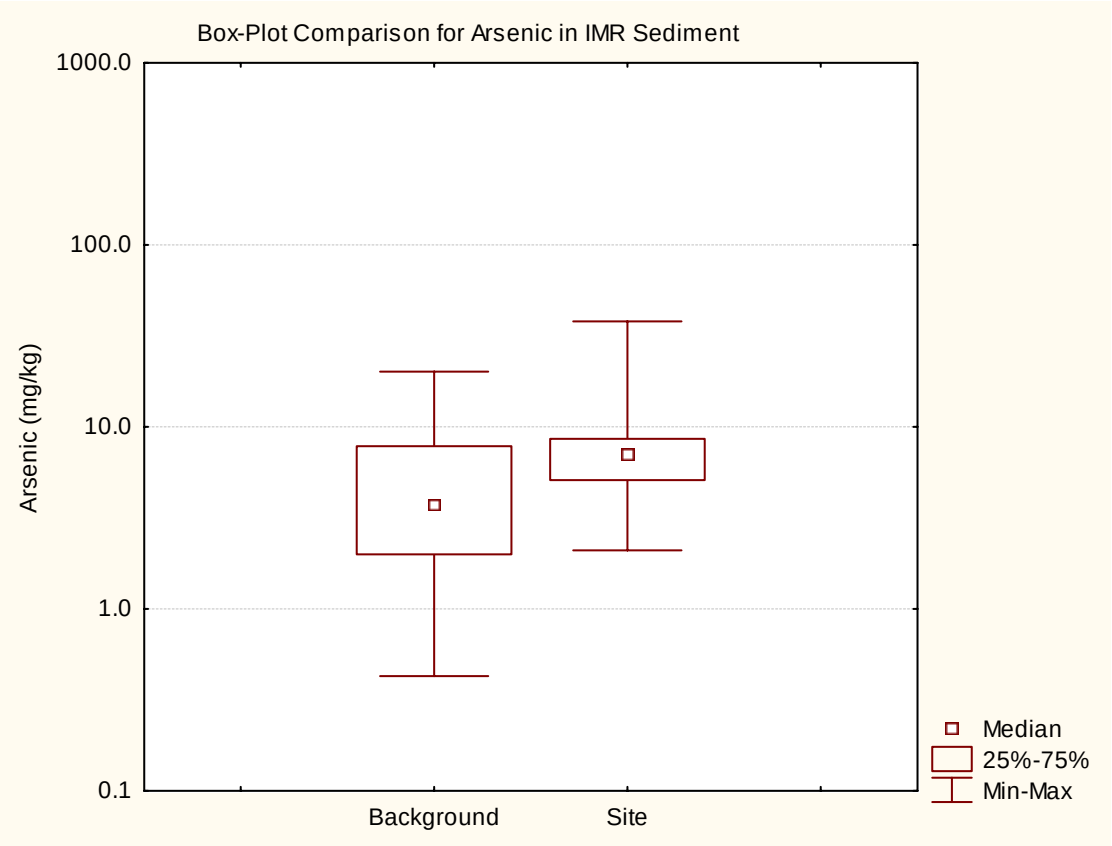

Box-Plot Comparison for Iron in IMR Subsurface Soil
Iron (mg/kg)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
Background
Site
Median
25%-75%
Min-Max

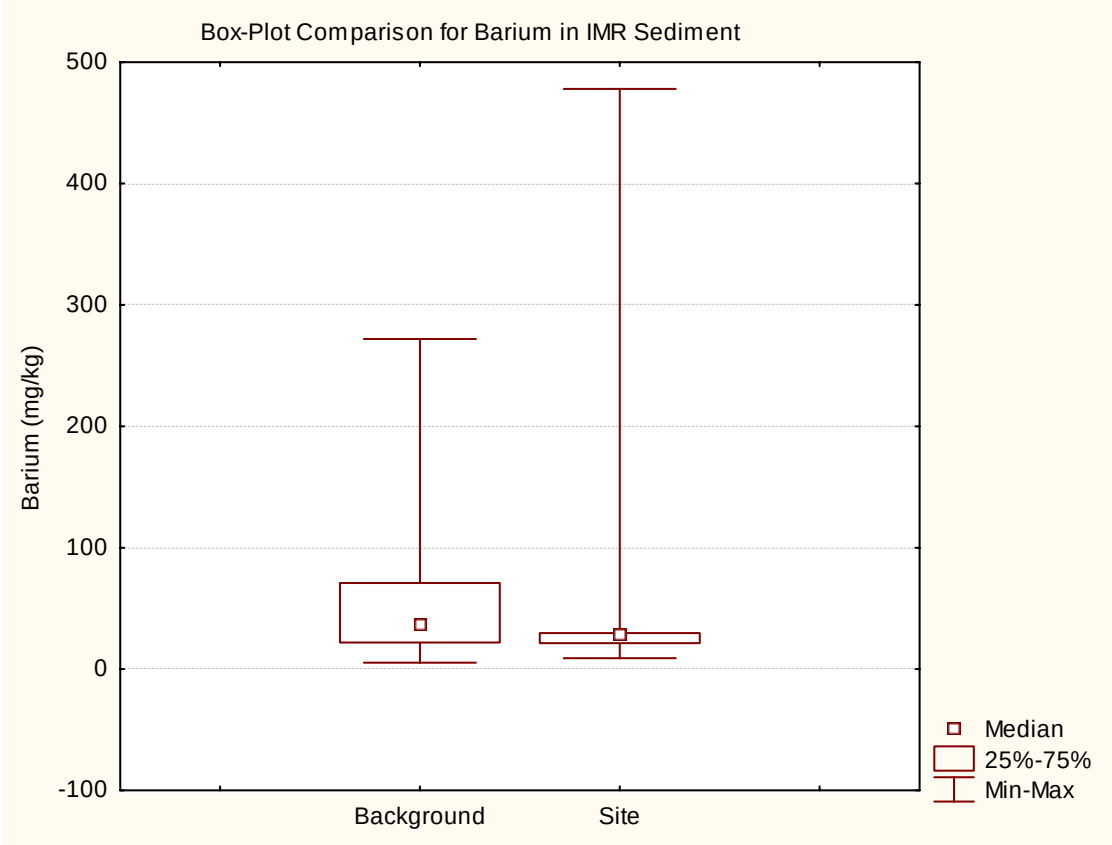

Box-Plot Comparison for Lead in IMR Subsurface Soil
Lead (mg/kg)
1600
1400
1200
1000
800
600
400
200
0
-200
Background
Site
Median
25%-75%
Min-Max

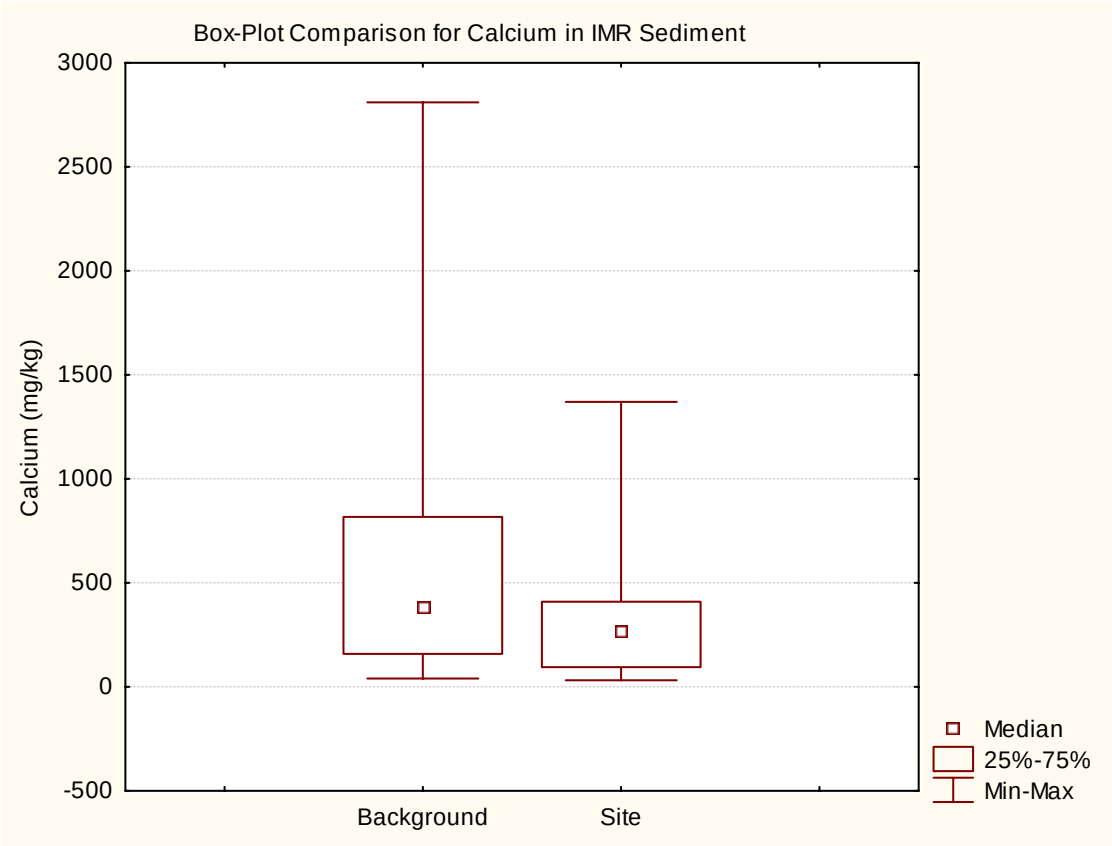

Box-Plot Comparison for Nickel in IMR Subsurface Soil
Nickel (mg/kg)
40
35
30
25
20
15
10
5
0
-5
Background
Site
Median
25%-75%
Min-Max

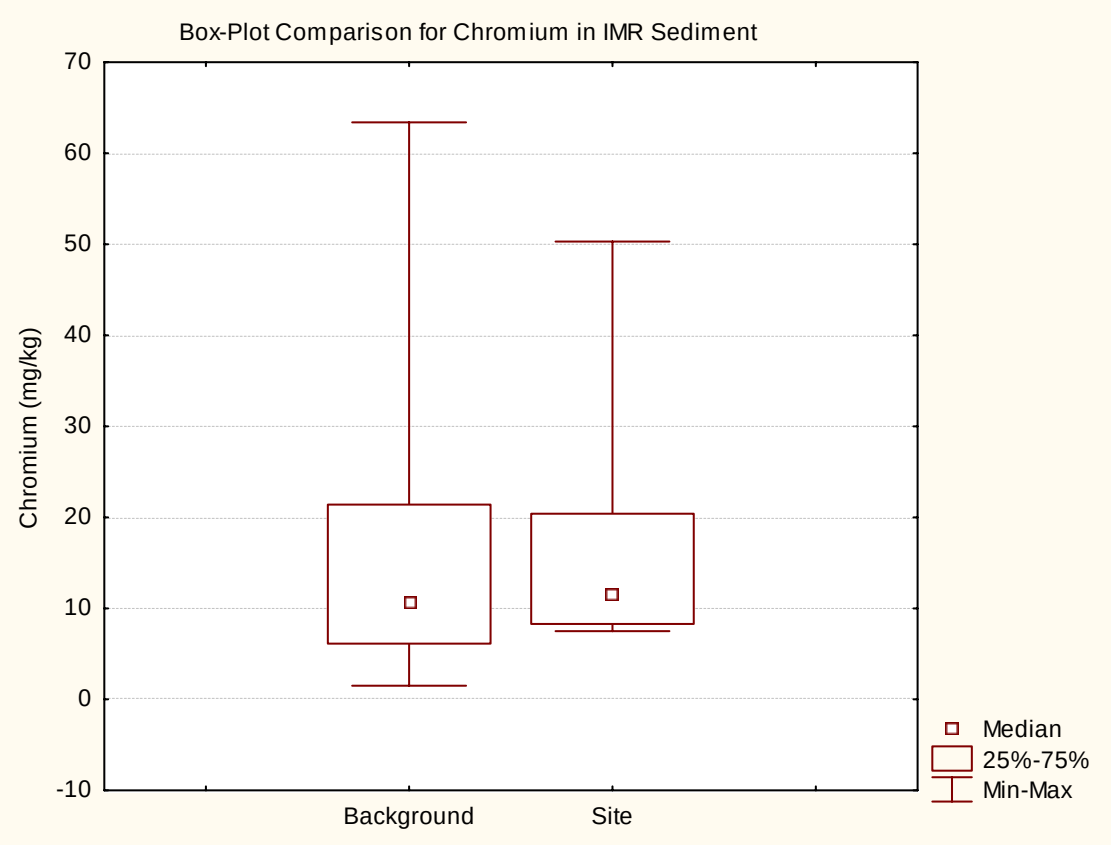

Box-Plot Comparison for Zinc in IMR Subsurface Soil
Zinc (mg/kg)
100
90
80
70
60
50
40
30
20
10
0
-10
Background
Site
Median
25%-75%
Min-Max

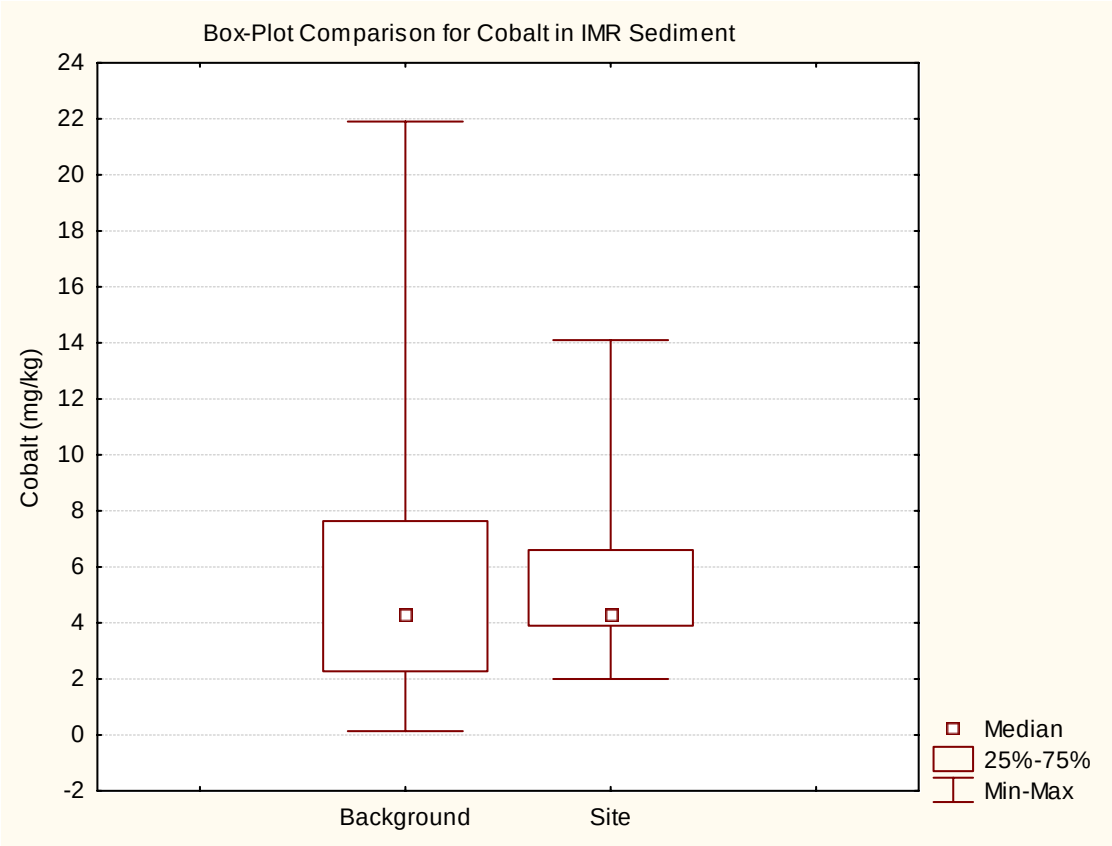
SEDIMENT BOX PLOTS

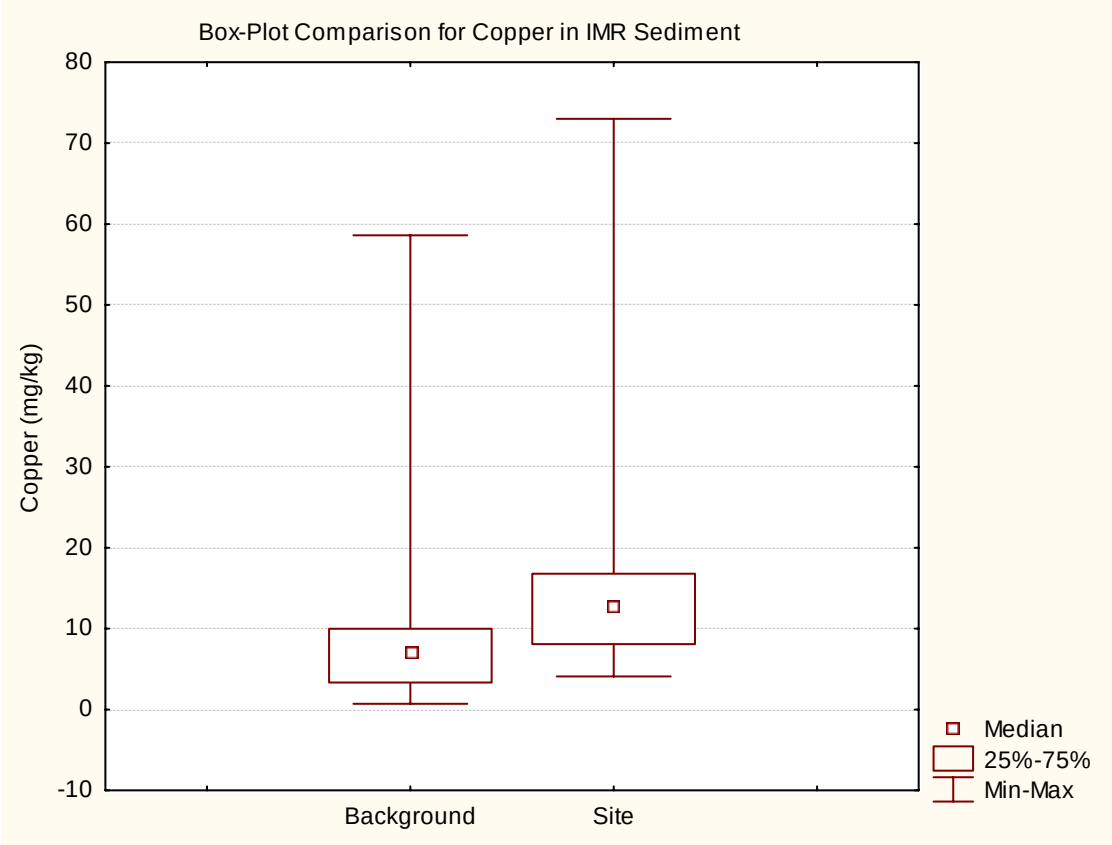

Box-Plot Comparison for Arsenic in IMR Sediment
1000.0
100.0
10.0
1.0
0.1
Arsenic (mg/kg)
Background
Site
Median
25%-75%
Min-Max

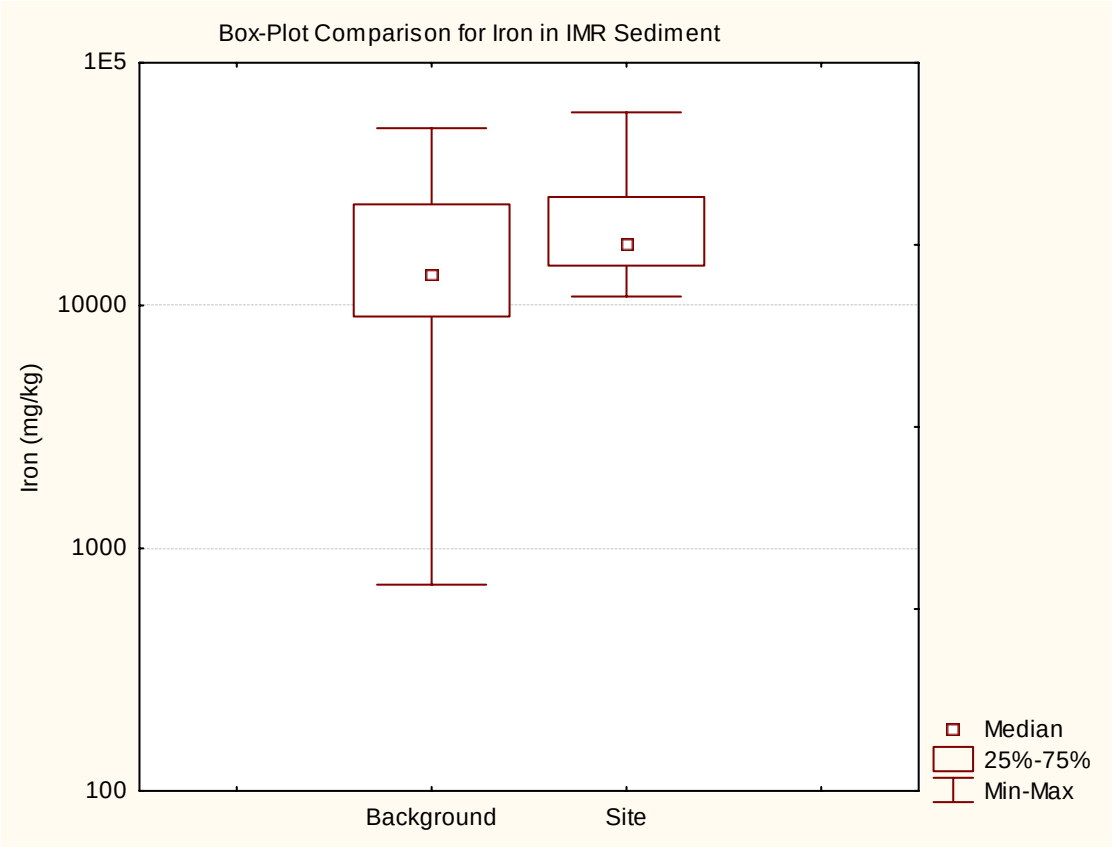

Box-Plot Comparison for Barium in IMR Sediment
500
400
300
200
100
0
-100
Barium (mg/kg)
Background
Site
Median
25%-75%
Min-Max

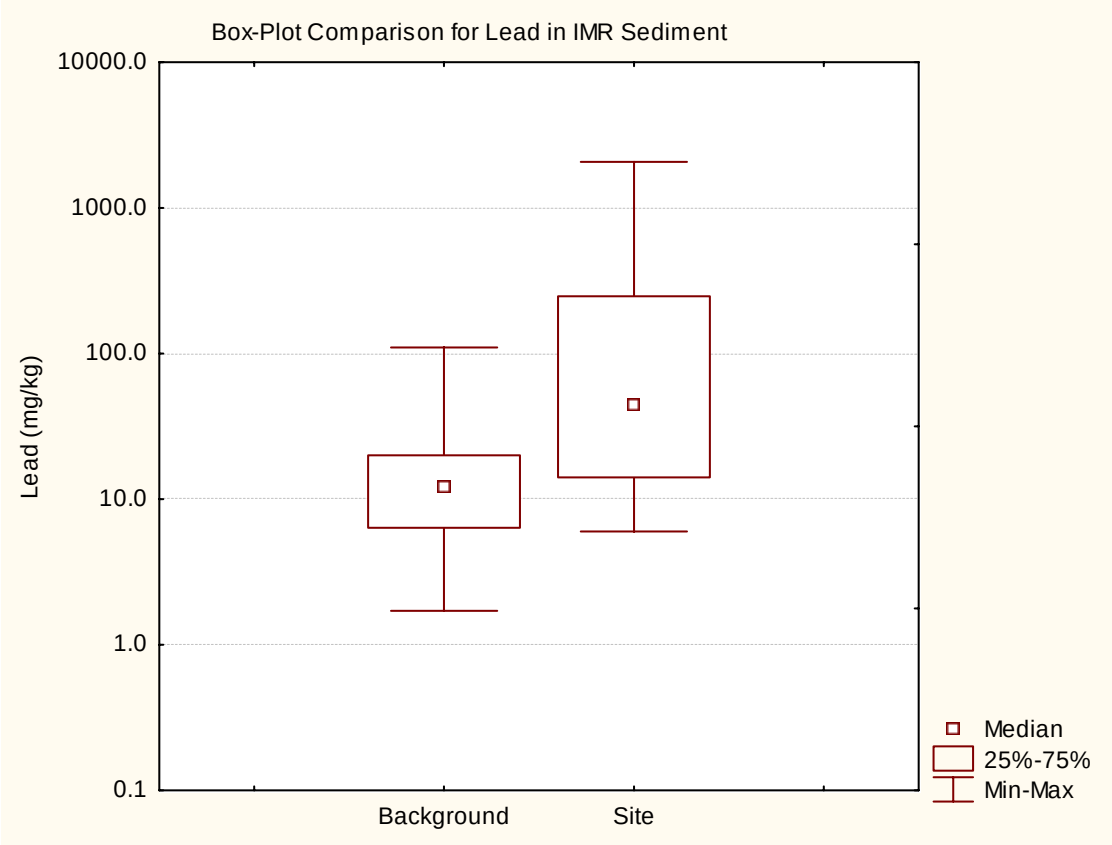

Box-Plot Comparison for Calcium in IMR Sediment
Calcium (mg/kg)
3000
2500
2000
1500
1000
500
0
-500
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Chromium in IMR Sediment
Chromium (mg/kg)
70
60
50
40
30
20
10
0
-10
Background
Site
Median
25%-75%
Min-Max

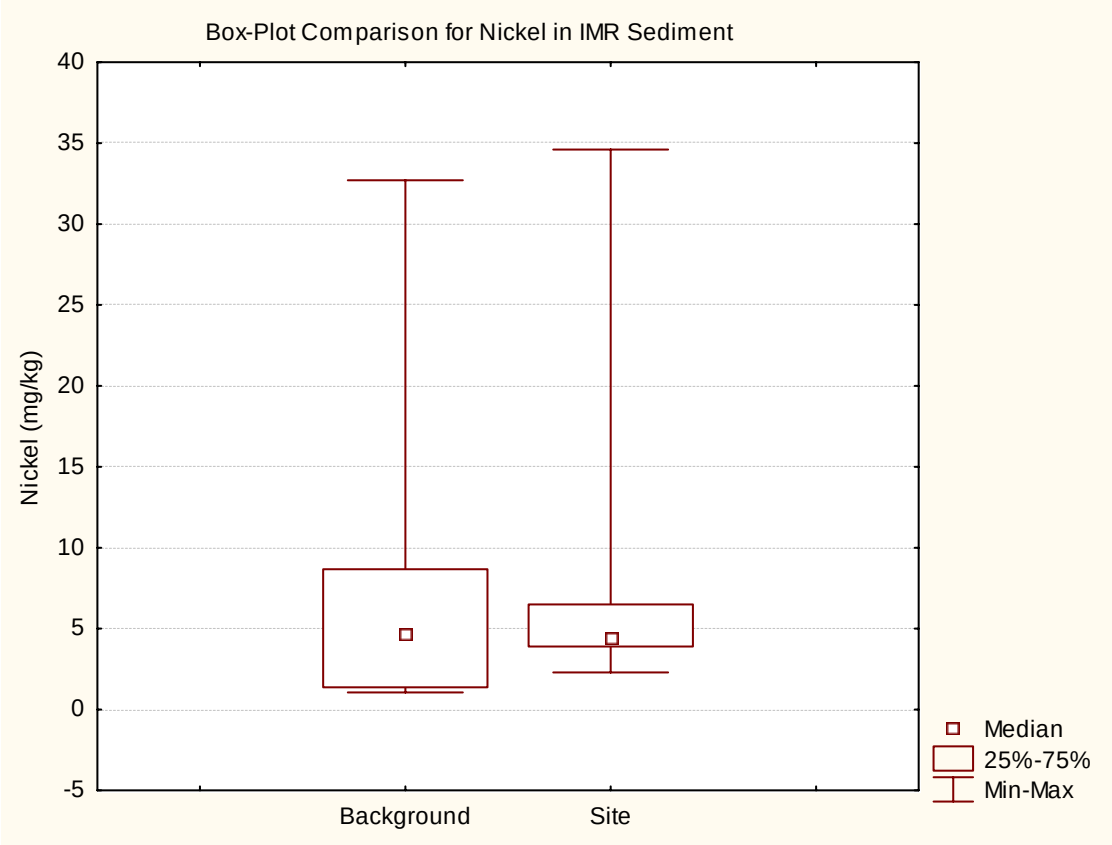

Box-Plot Comparison for Cobalt in IMR Sediment
Cobalt (mg/kg)
24
22
20
18
16
14
12
10
8
6
4
2
0
-2
Background
Site
Median
25%-75%
Min-Max

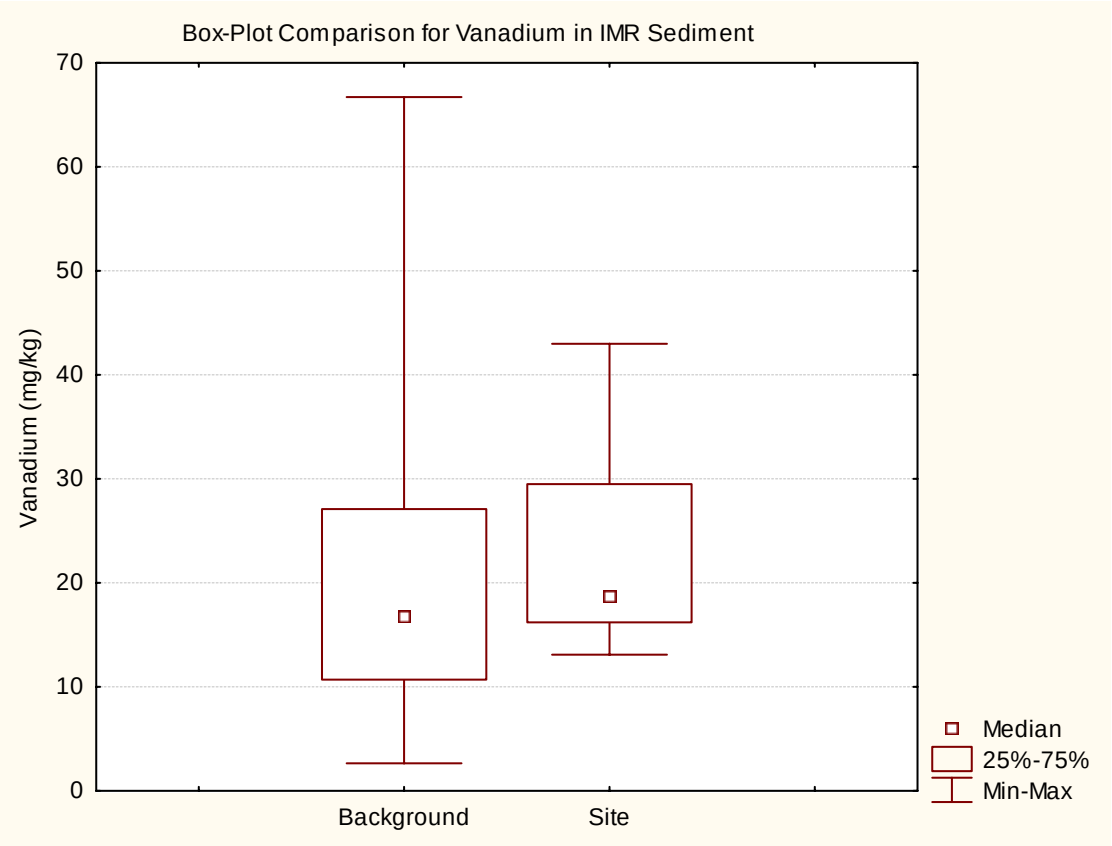

Box-Plot Comparison for Copper in IMR Sediment
Copper (mg/kg)
80
70
60
50
40
30
20
10
0
-10
Background
Site
Median
25%-75%
Min-Max

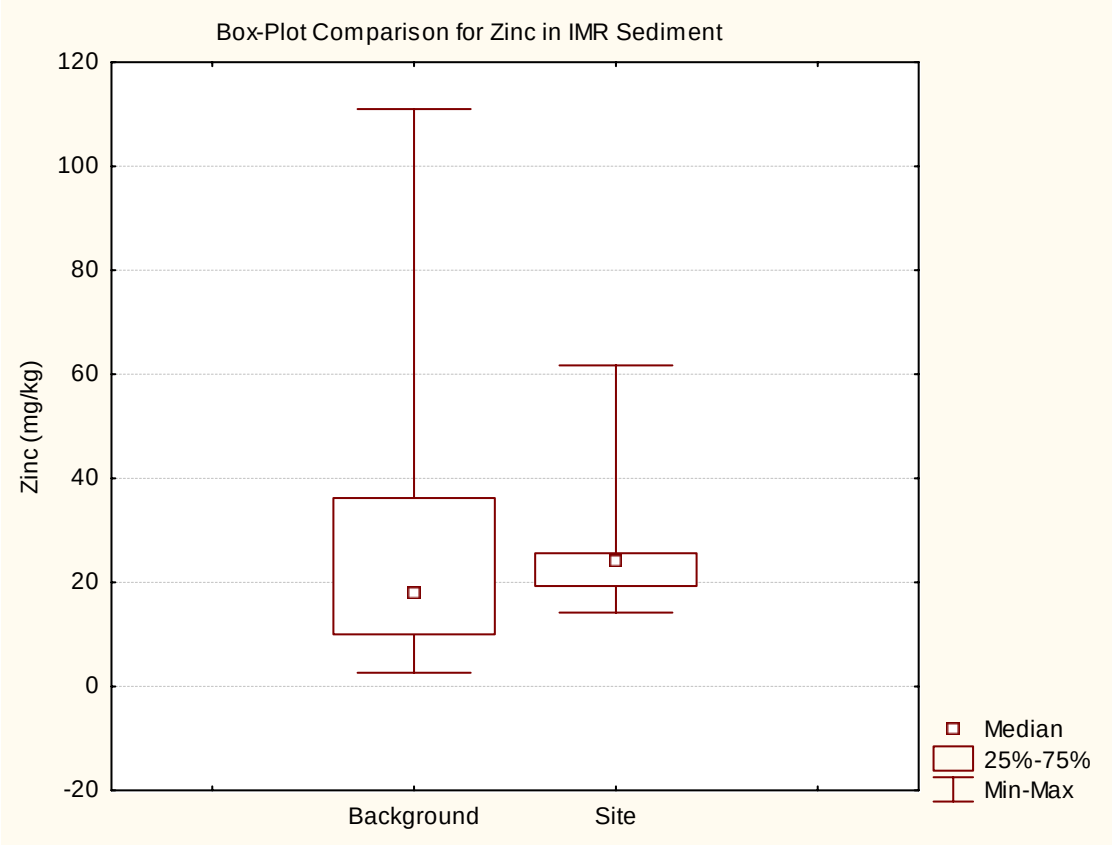

Box-Plot Comparison for Iron in IMR Sediment
1E5
10000
1000
100
Iron (mg/kg)
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Lead in IMR Sediment
10000.0
1000.0
100.0
10.0
1.0
0.1
Lead (mg/kg)
Background
Site
Median
25%-75%
Min-Max

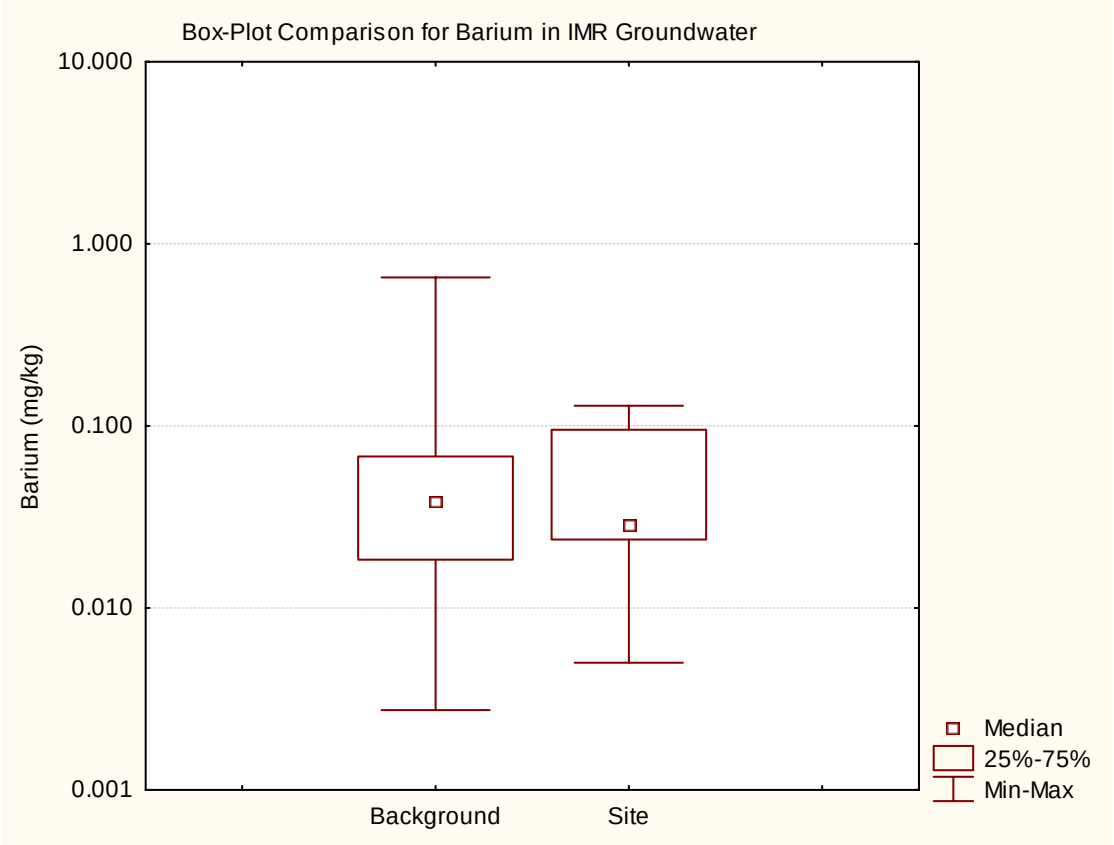
Box-Plot Comparison for Manganese in IMR Sediment
Manganese (mg/kg)
3000
2500
2000
1500
1000
500
0
-500
Background
Site
Median
25%-75%
Min-Max

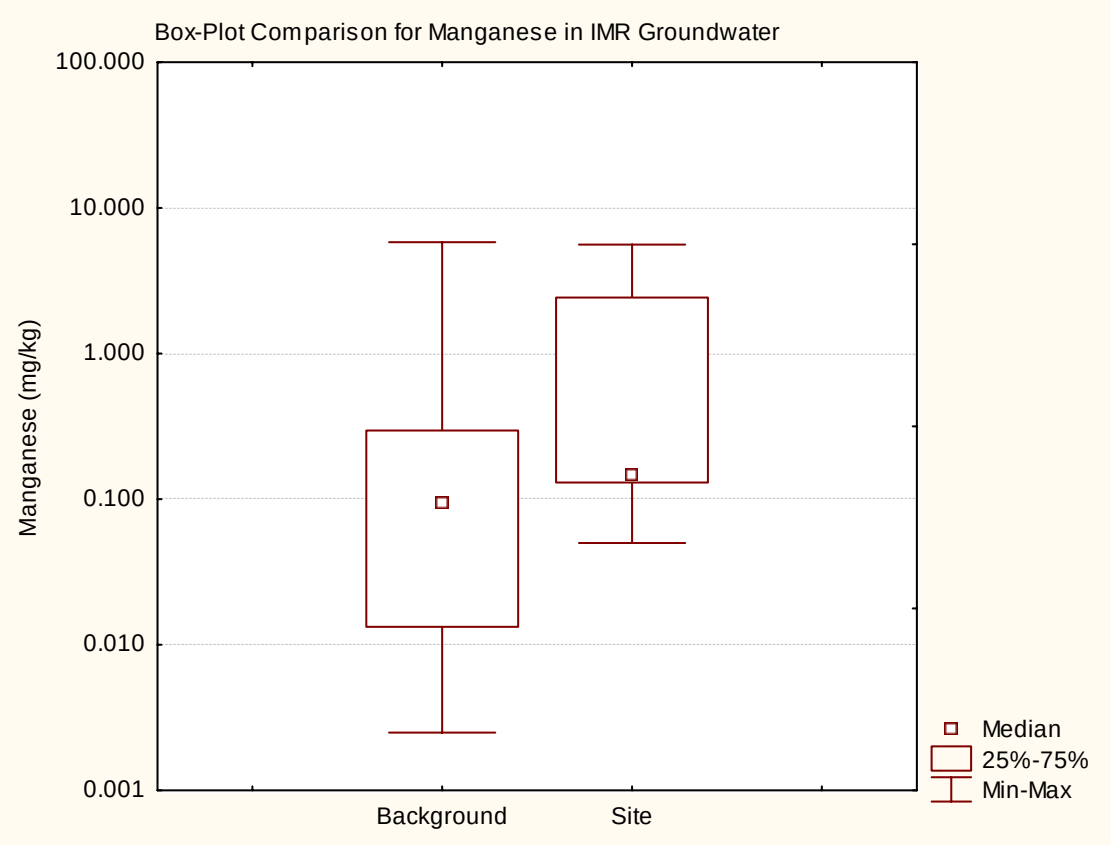

Box-Plot Comparison for Nickel in IMR Sediment
Nickel (mg/kg)
40
35
30
25
20
15
10
5
0
-5
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Vanadium in IMR Sediment
Vanadium (mg/kg)
70
60
50
40
30
20
10
0
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Zinc in IMR Sediment
Zinc (mg/kg)
120
100
80
60
40
20
0
-20
Background
Site
Median
25%-75%
Min-Max

GROUNDWATER BOX PLOTS


Box-Plot Comparison for Barium in IMR Groundwater
10.000
1.000
0.100
0.010
0.001
Barium (mg/kg)
Background
Site
Median
25%-75%
Min-Max


Box-Plot Comparison for Manganese in IMR Groundwater
100.000
10.000
1.000
0.100
0.010
0.001
Manganese (mg/kg)
Background
Site
Median
25%-75%
Min-Max

ATTACHMENT 2

GEOCHEMICAL CORRELATION PLOTS AND RATIO PLOTS

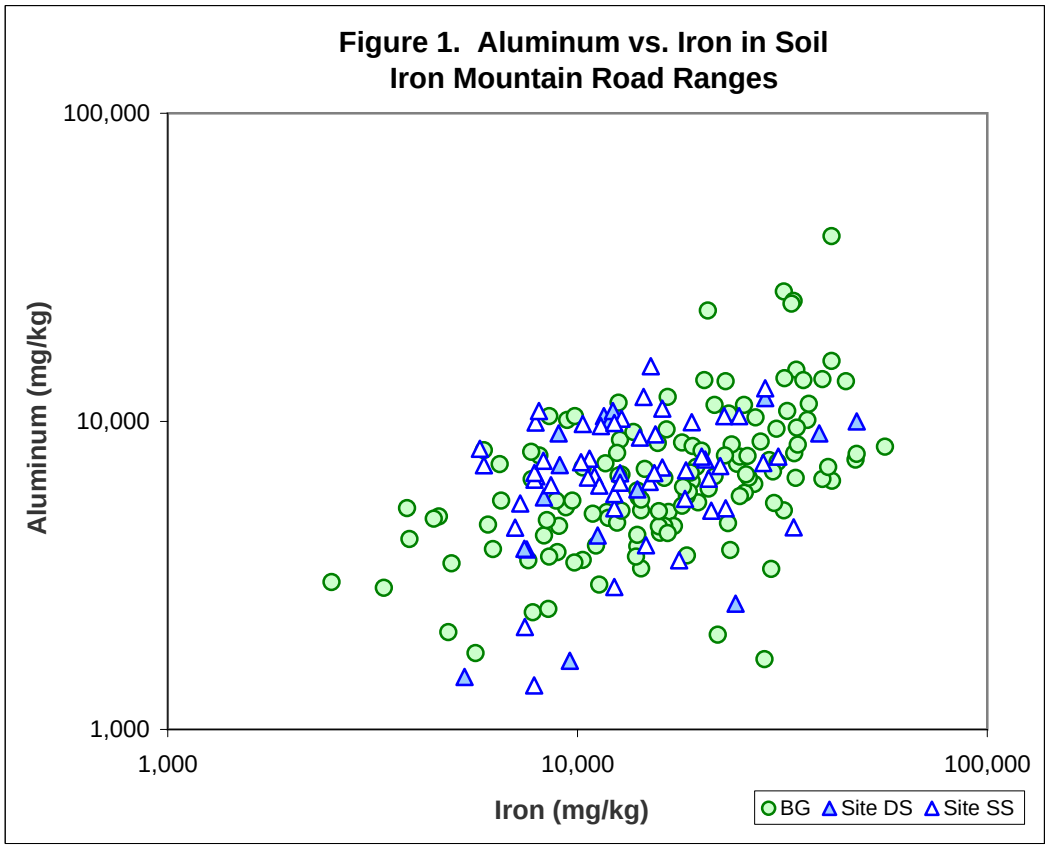


Figure 1. Aluminum vs. Iron in Soil
Iron Mountain Road Ranges
100,000
10,000
1,000
Aluminum (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site DS
Site SS

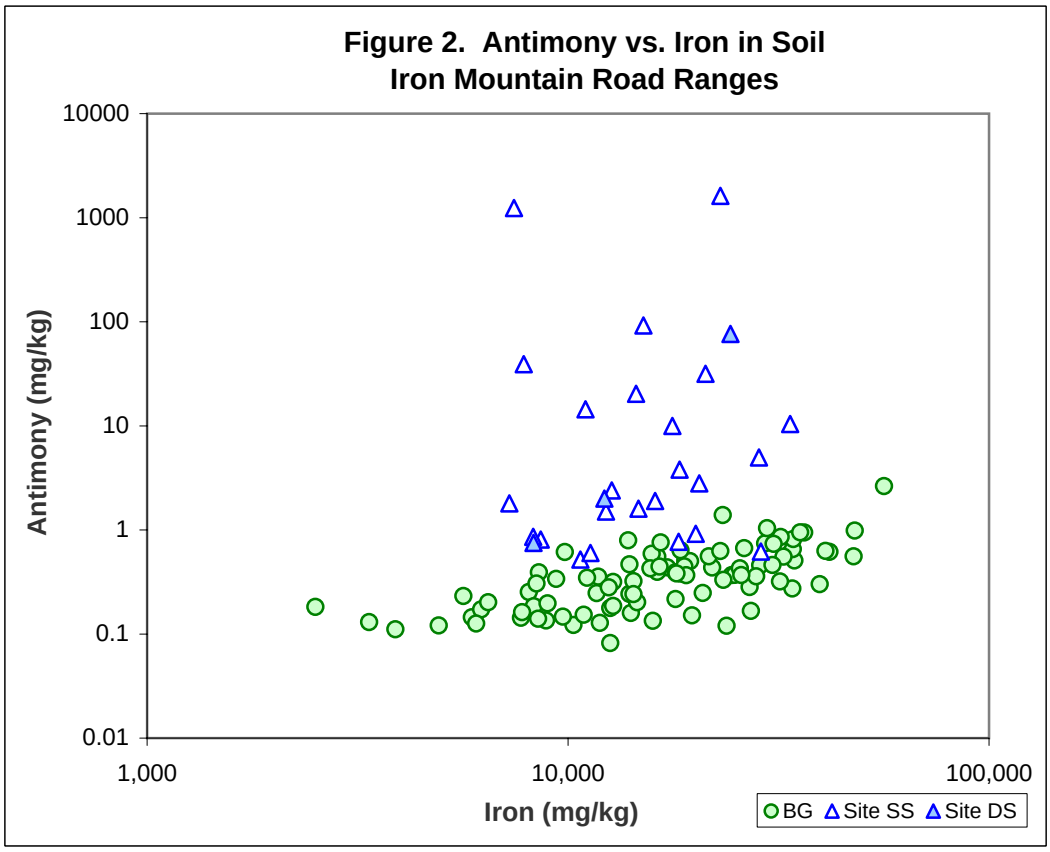


Figure 2. Antimony vs. Iron in Soil
Iron Mountain Road Ranges
10000
1000
100
10
1
0.1
0.01
Antimony (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

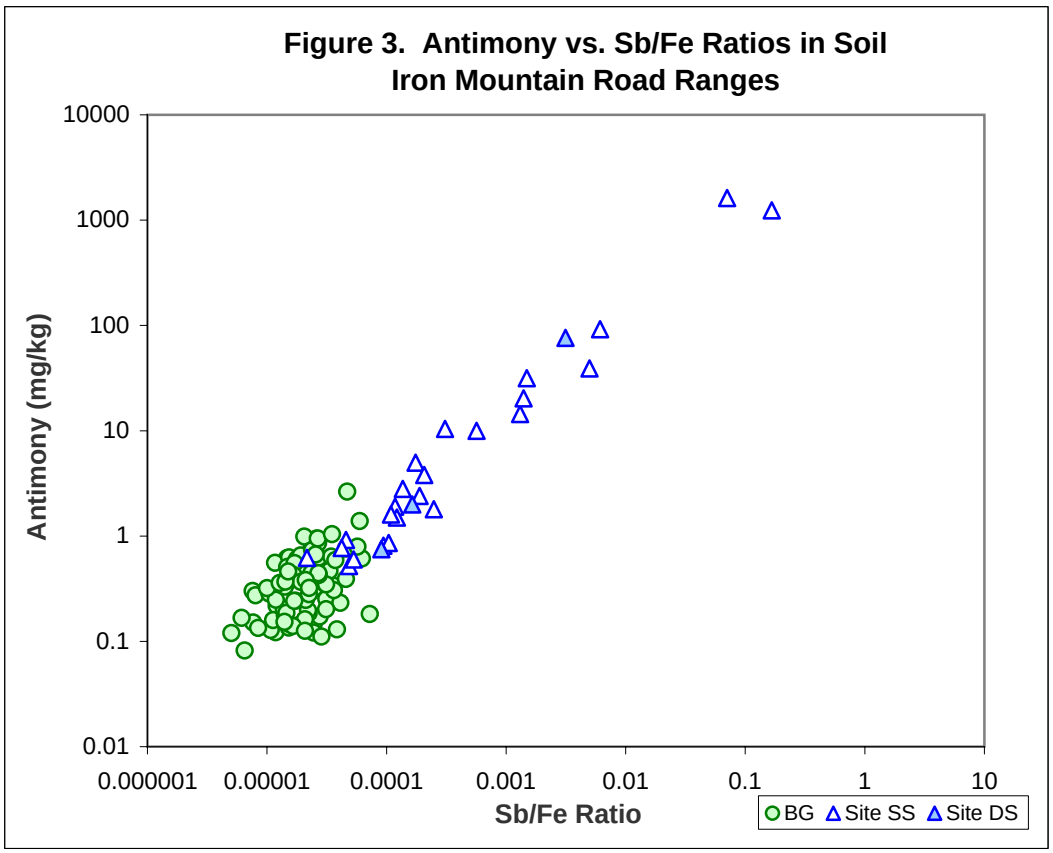


Figure 3. Antimony vs. Sb/Fe Ratios in Soil
Iron Mountain Road Ranges
Antimony (mg/kg)
10000
1000
100
10
1
0.1
0.01
0.000001
0.00001
0.0001
0.001
0.01
0.1
1
10
Sb/Fe Ratio
BG
Site SS
Site DS

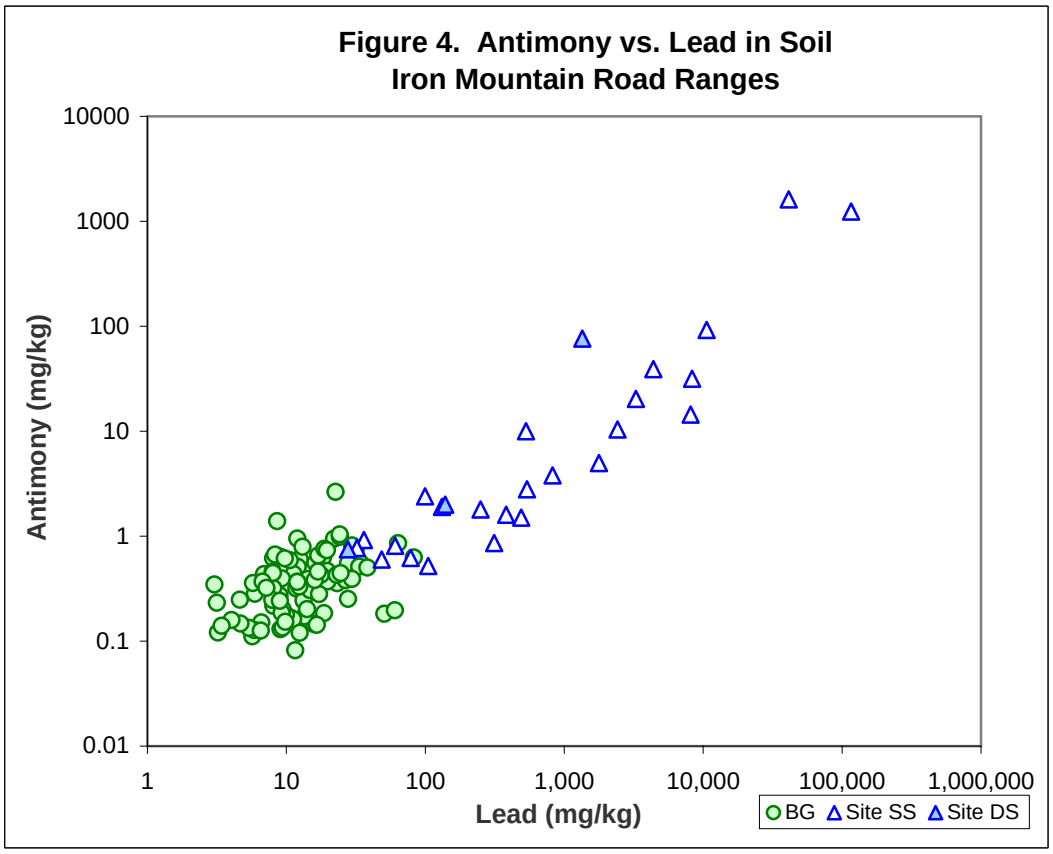


Figure 4. Antimony vs. Lead in Soil
Iron Mountain Road Ranges
Antimony (mg/kg)
10000
1000
100
10
1
0.1
0.01
1
10
100
1,000
10,000
100,000
1,000,000
Lead (mg/kg)
BG
Site SS
Site DS

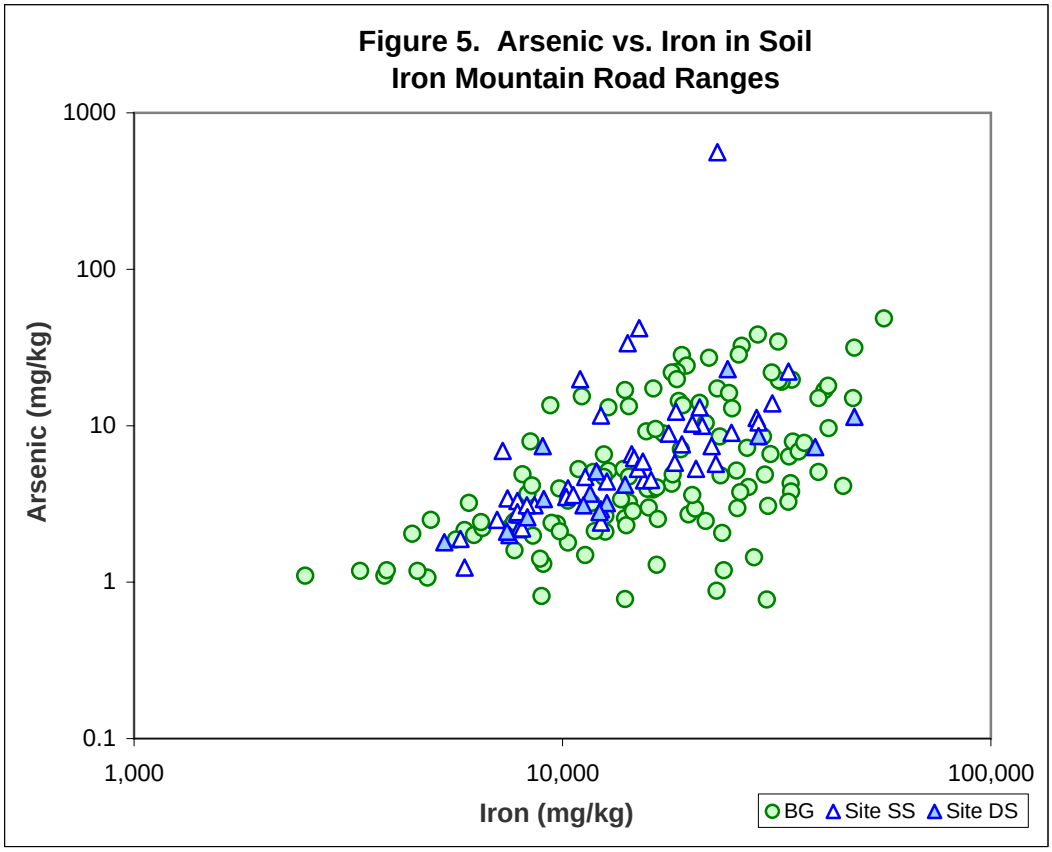


Figure 5. Arsenic vs. Iron in Soil
Iron Mountain Road Ranges
1000
100
10
1
0.1
Arsenic (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

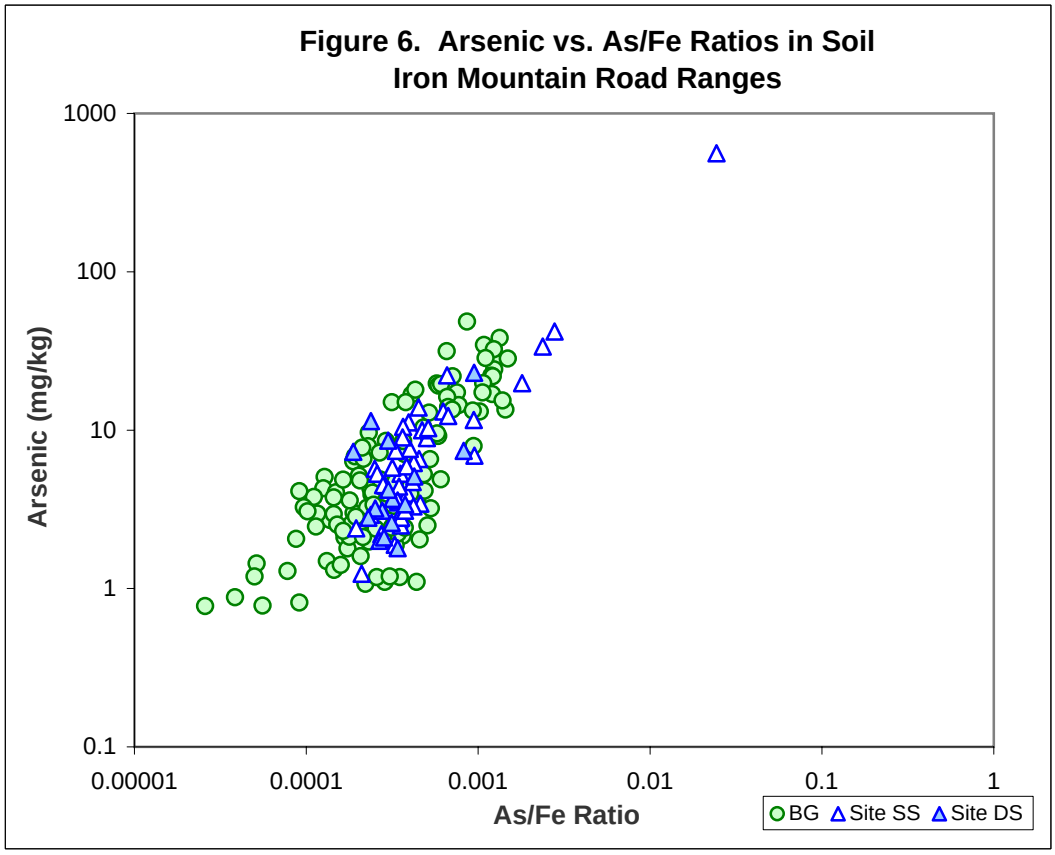


Figure 6. Arsenic vs. As/Fe Ratios in Soil
Iron Mountain Road Ranges
1000
100
10
1
0.1
Arsenic (mg/kg)
0.00001
0.0001
0.001
0.01
0.1
1
As/Fe Ratio
BG
Site SS
Site DS

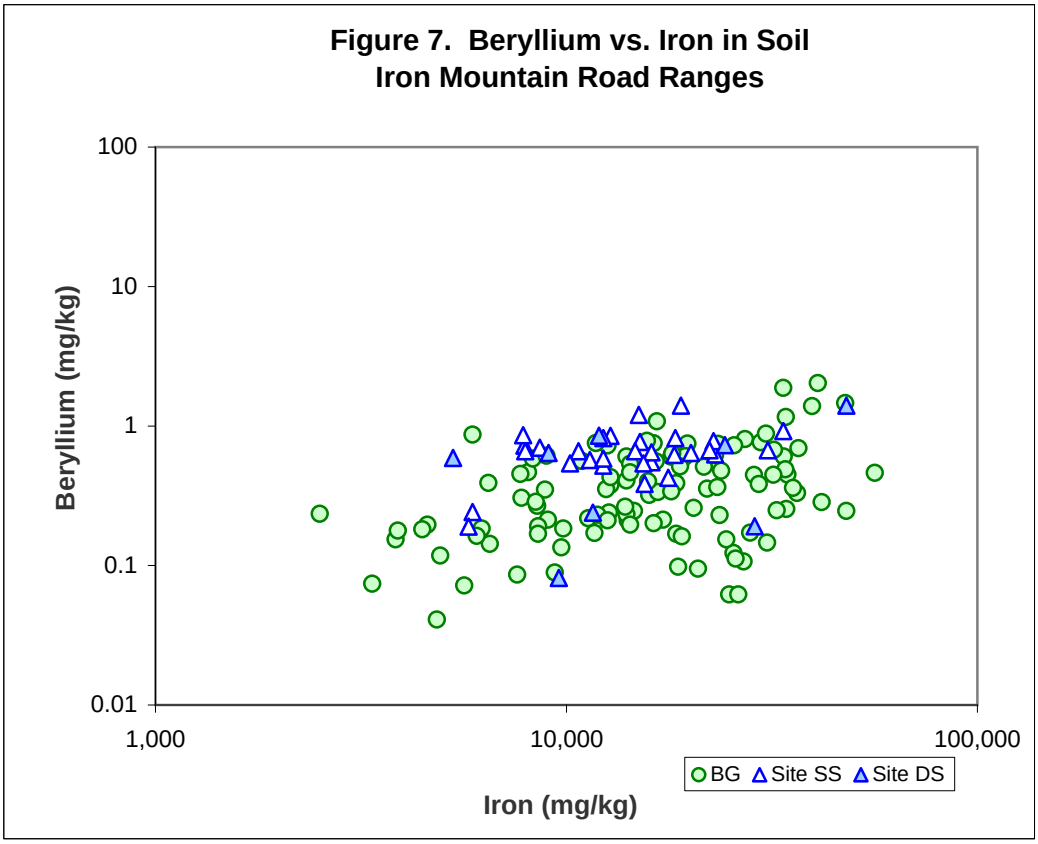


Figure 7. Beryllium vs. Iron in Soil
Iron Mountain Road Ranges
100
10
1
0.1
0.01
Beryllium (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

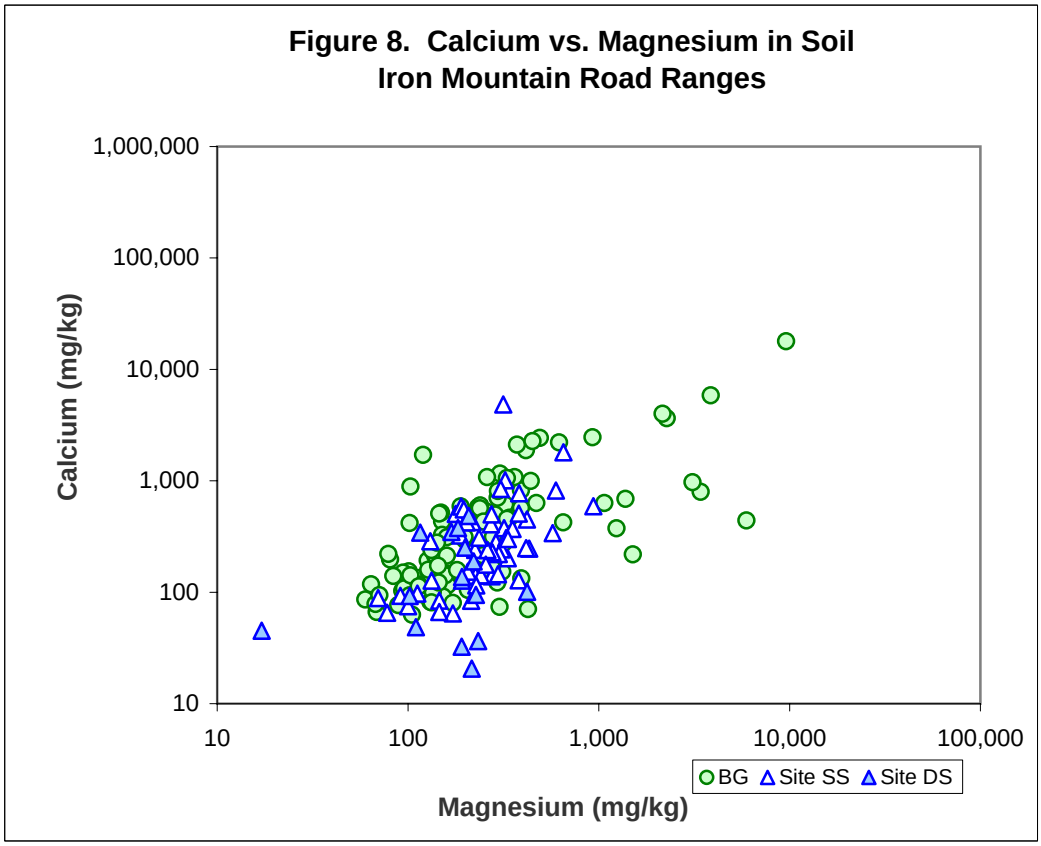


Figure 8. Calcium vs. Magnesium in Soil
Iron Mountain Road Ranges
1,000,000
100,000
10,000
1,000
100
10
Calcium (mg/kg)
10
100
1,000
10,000
100,000
Magnesium (mg/kg)
BG
Site SS
Site DS

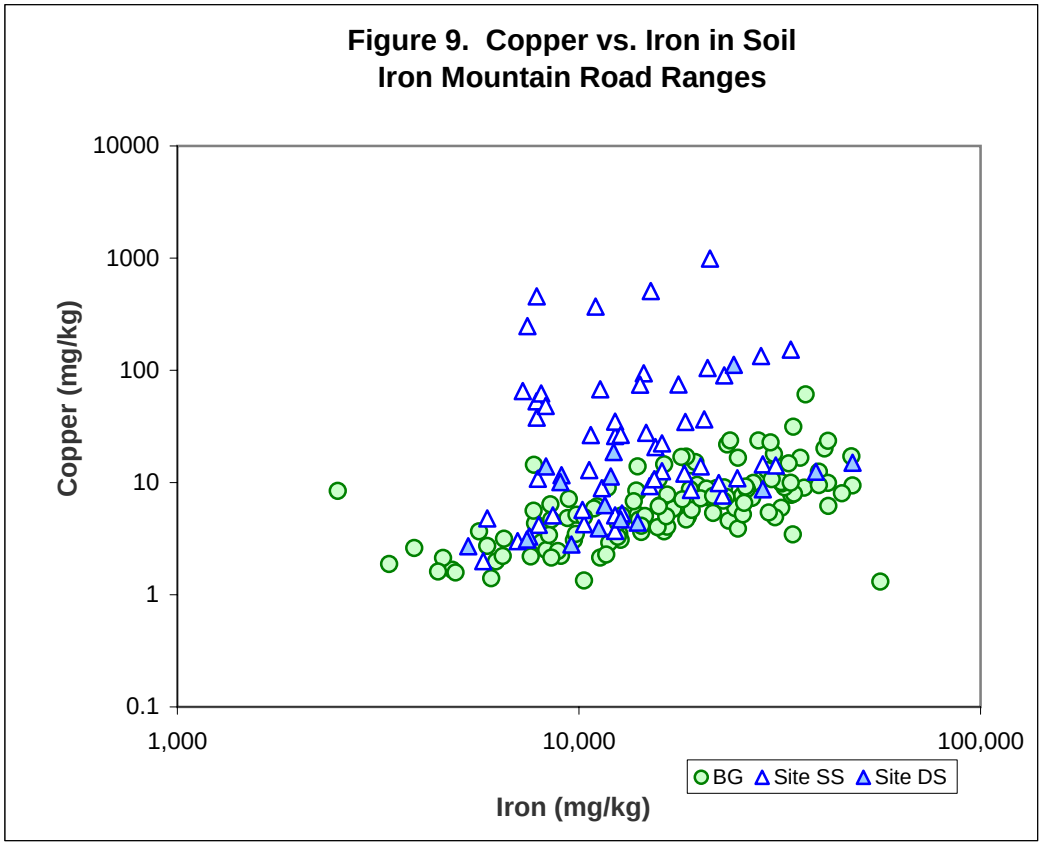


Figure 9. Copper vs. Iron in Soil
Iron Mountain Road Ranges
10000
1000
100
10
1
0.1
Copper (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

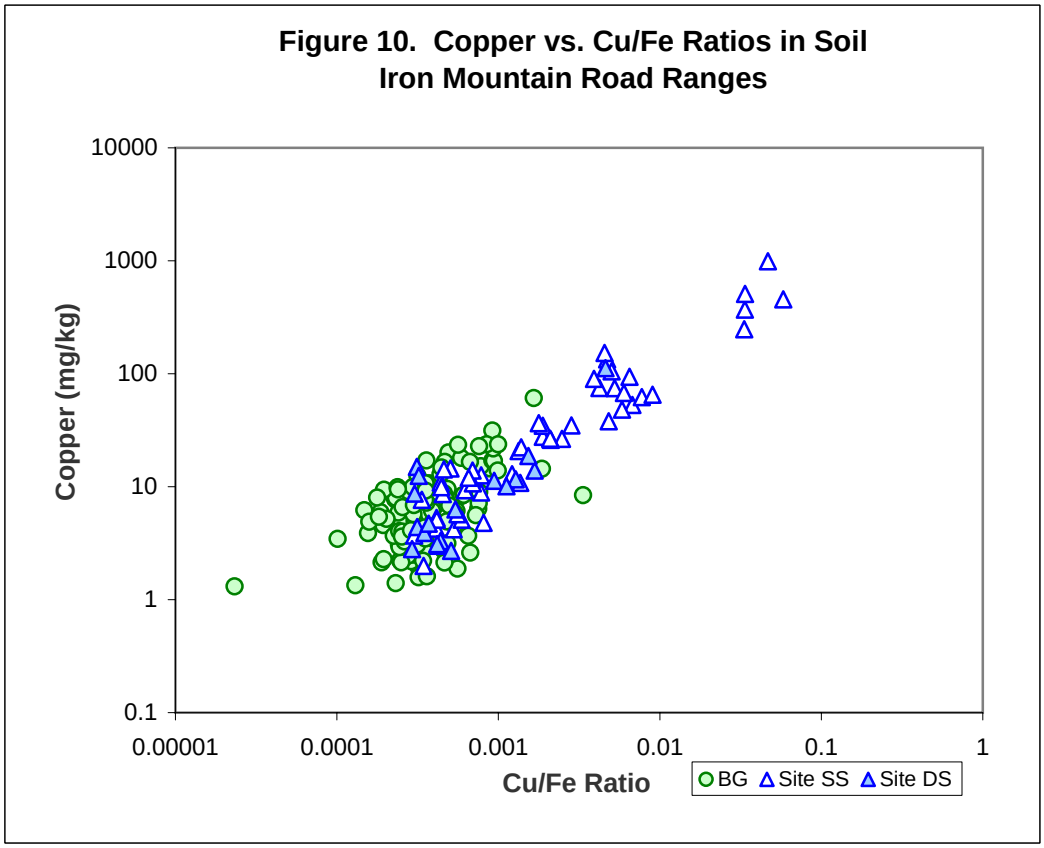


Figure 10. Copper vs. Cu/Fe Ratios in Soil
Iron Mountain Road Ranges
10000
1000
100
10
1
0.1
Copper (mg/kg)
0.00001
0.0001
0.001
0.01
0.1
1
Cu/Fe Ratio
BG
Site SS
Site DS

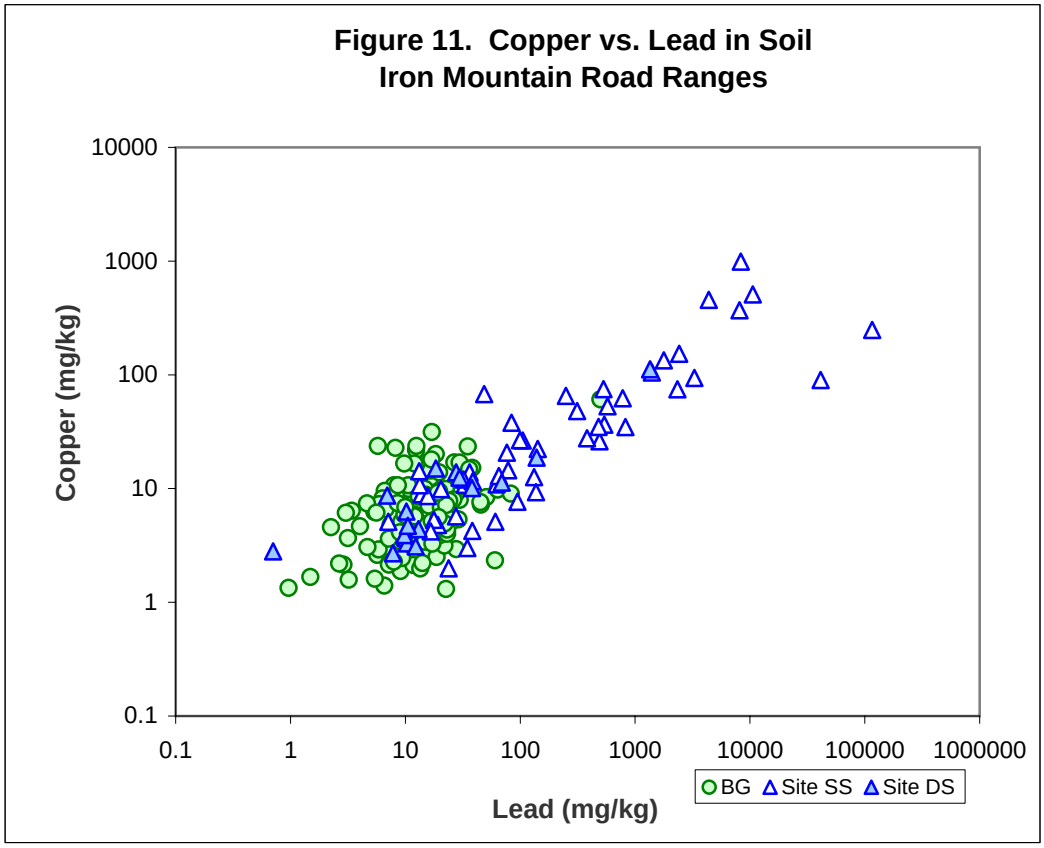


Figure 11. Copper vs. Lead in Soil
Iron Mountain Road Ranges
Copper (mg/kg)
10000
1000
100
10
1
0.1
0.1
1
10
100
1000
10000
100000
1000000
Lead (mg/kg)
BG
Site SS
Site DS

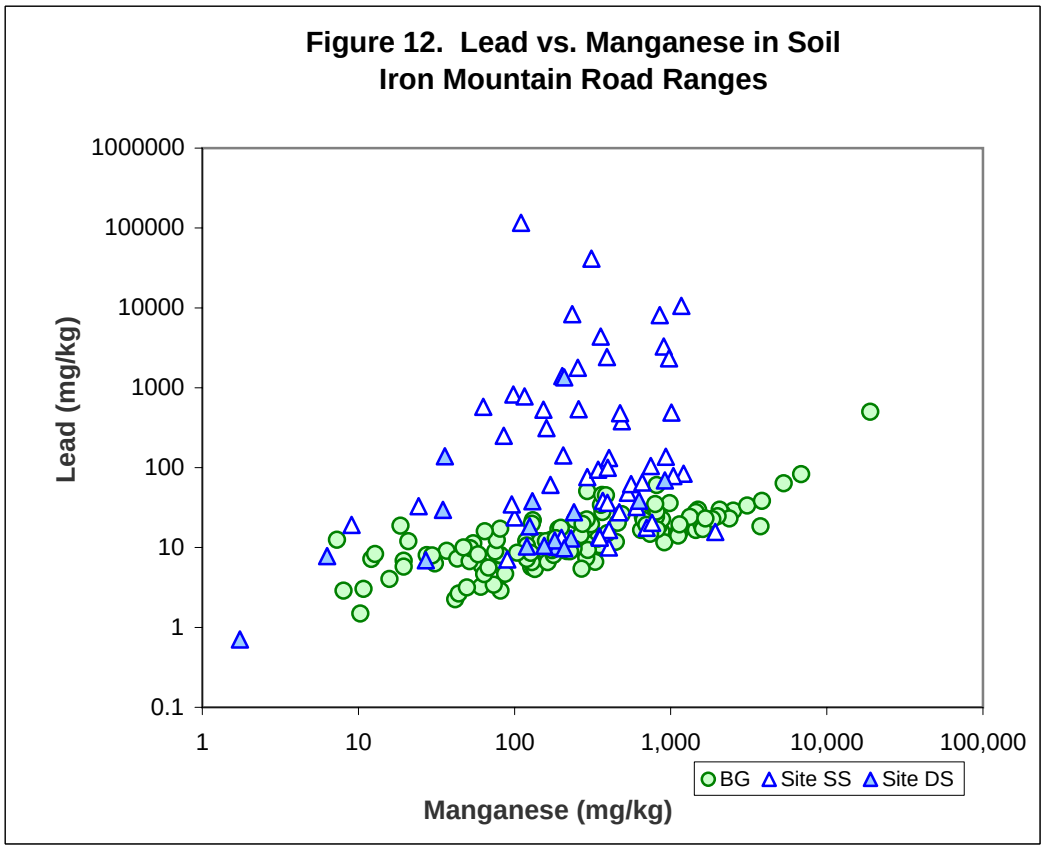


Figure 12. Lead vs. Manganese in Soil
Iron Mountain Road Ranges
Lead (mg/kg)
1000000
100000
10000
1000
100
10
1
0.1
1
10
100
1,000
10,000
100,000
Manganese (mg/kg)
BG
Site SS
Site DS

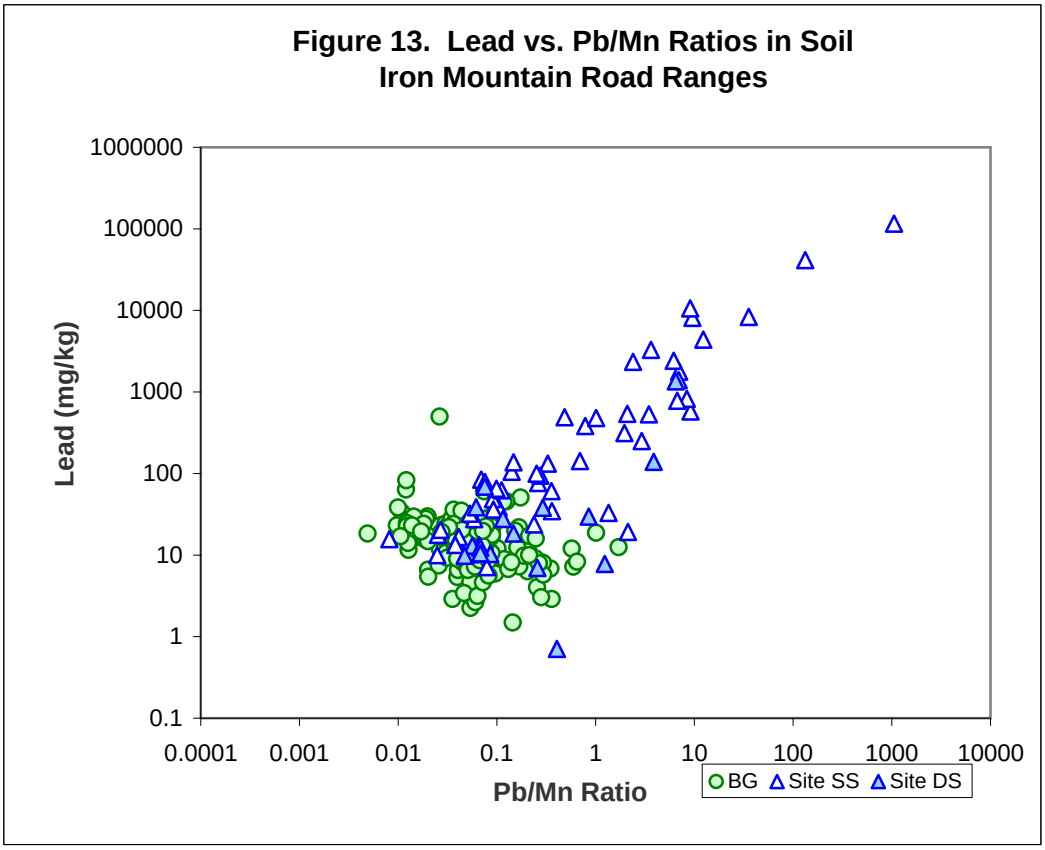


Figure 13. Lead vs. Pb/Mn Ratios in Soil
Iron Mountain Road Ranges
Lead (mg/kg)
1000000
100000
10000
1000
100
10
1
0.1
0.0001
0.001
0.01
0.1
1
10
100
1000
10000
Pb/Mn Ratio
BG
Site SS
Site DS

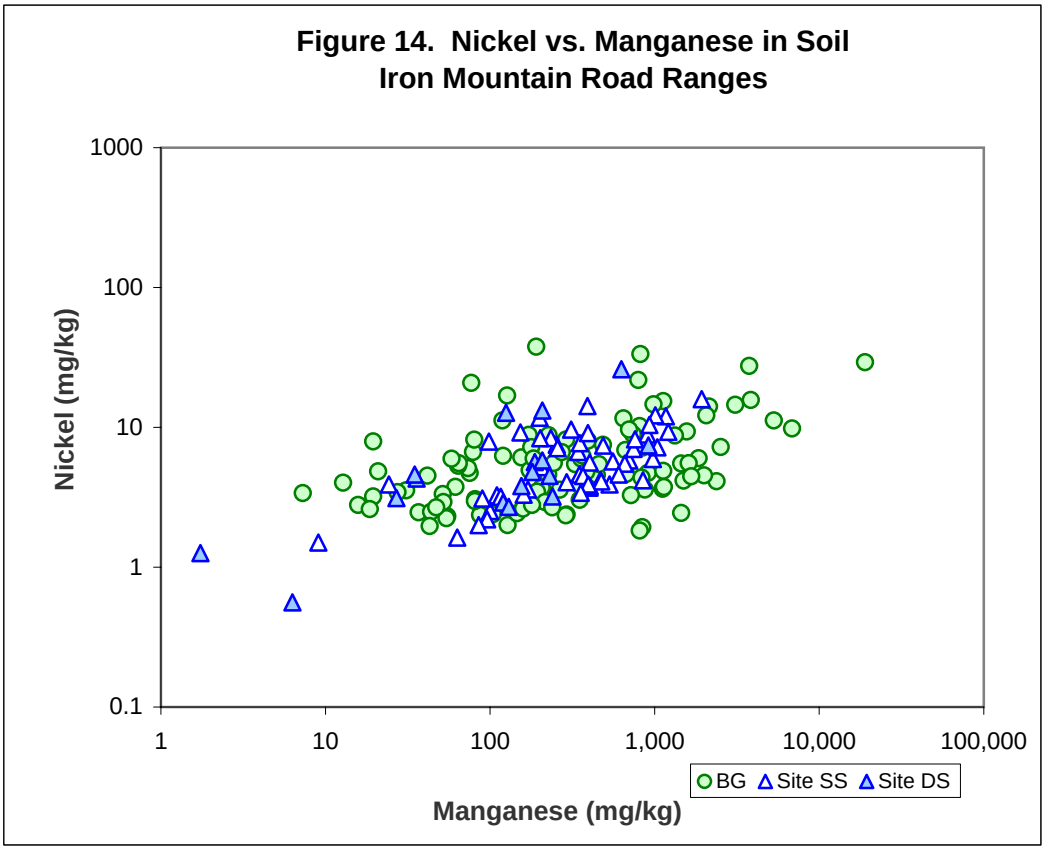


Figure 14. Nickel vs. Manganese in Soil
Iron Mountain Road Ranges
Nickel (mg/kg)
1000
100
10
1
0.1
1
10
100
1,000
10,000
100,000
Manganese (mg/kg)
BG
Site SS
Site DS

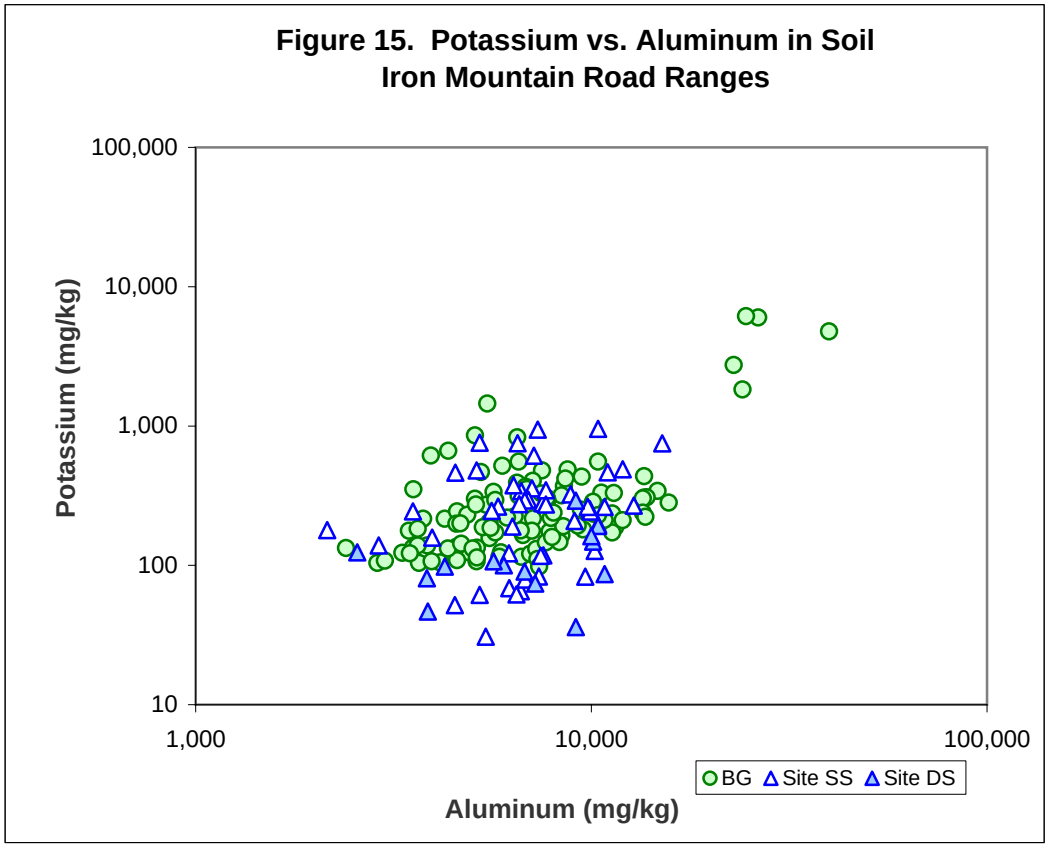


Figure 15. Potassium vs. Aluminum in Soil
Iron Mountain Road Ranges
100,000
10,000
1,000
100
10
Potassium (mg/kg)
1,000
10,000
100,000
Aluminum (mg/kg)
BG
Site SS
Site DS

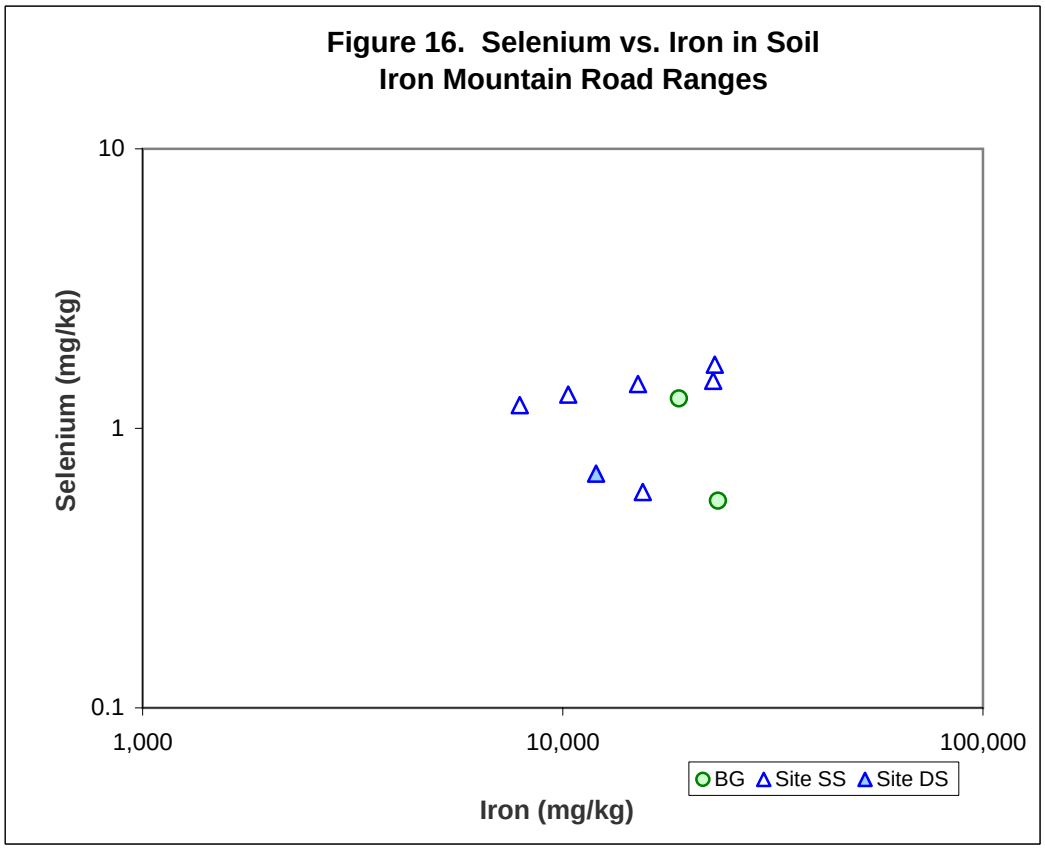


Figure 16. Selenium vs. Iron in Soil
Iron Mountain Road Ranges
10
1
0.1
Selenium (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

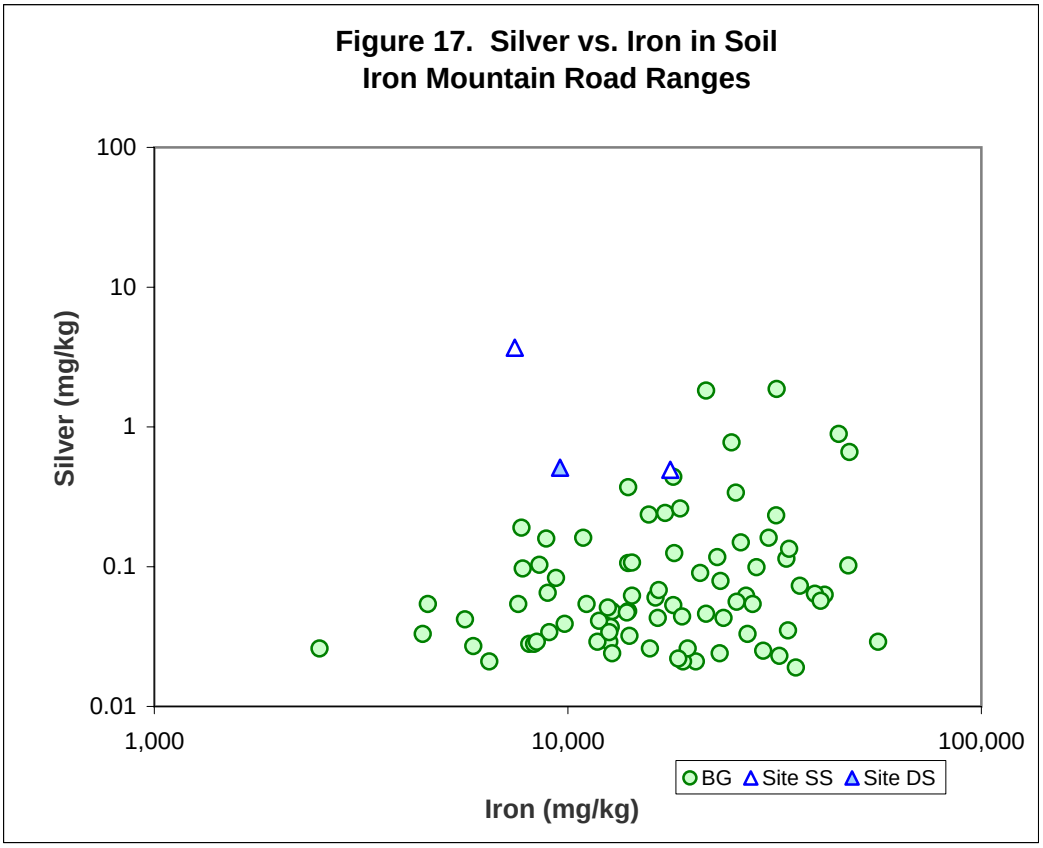


Figure 17. Silver vs. Iron in Soil
Iron Mountain Road Ranges
100
10
1
0.1
0.01
Silver (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site SS
Site DS

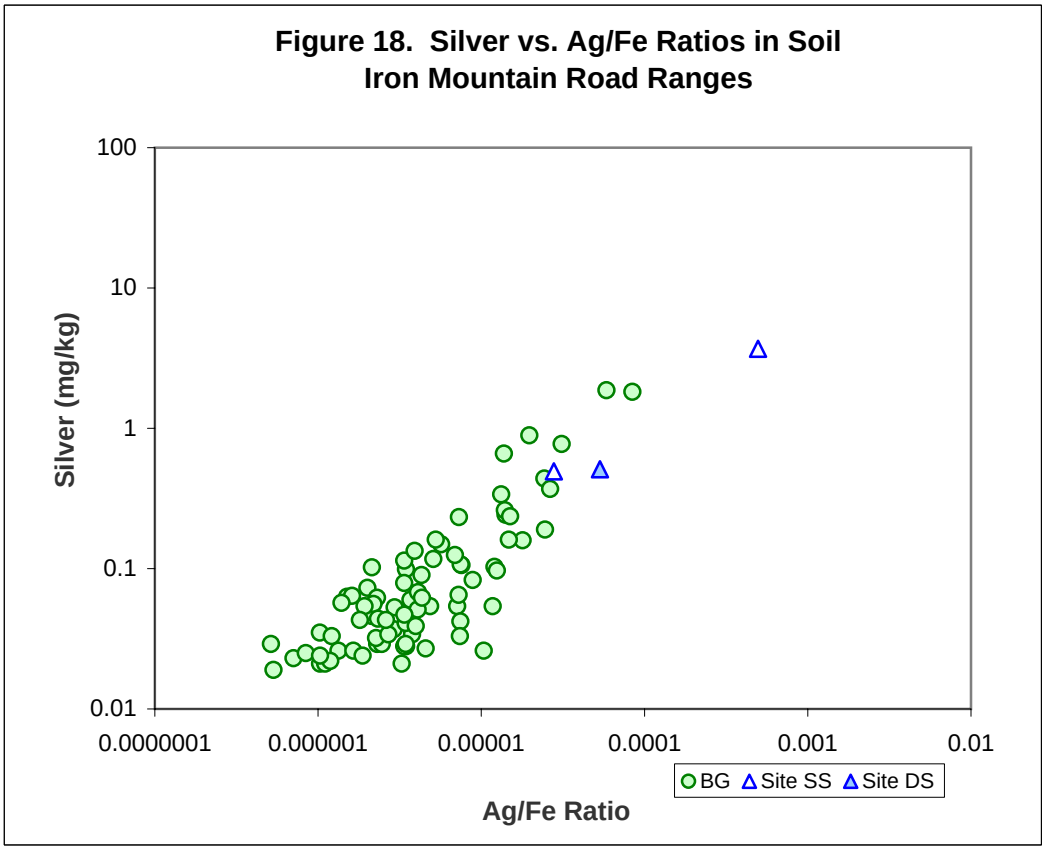


Figure 18. Silver vs. Ag/Fe Ratios in Soil
Iron Mountain Road Ranges
100
10
1
0.1
0.01
Silver (mg/kg)
0.0000001
0.000001
0.00001
0.0001
0.001
0.01
Ag/Fe Ratio
BG
Site SS
Site DS

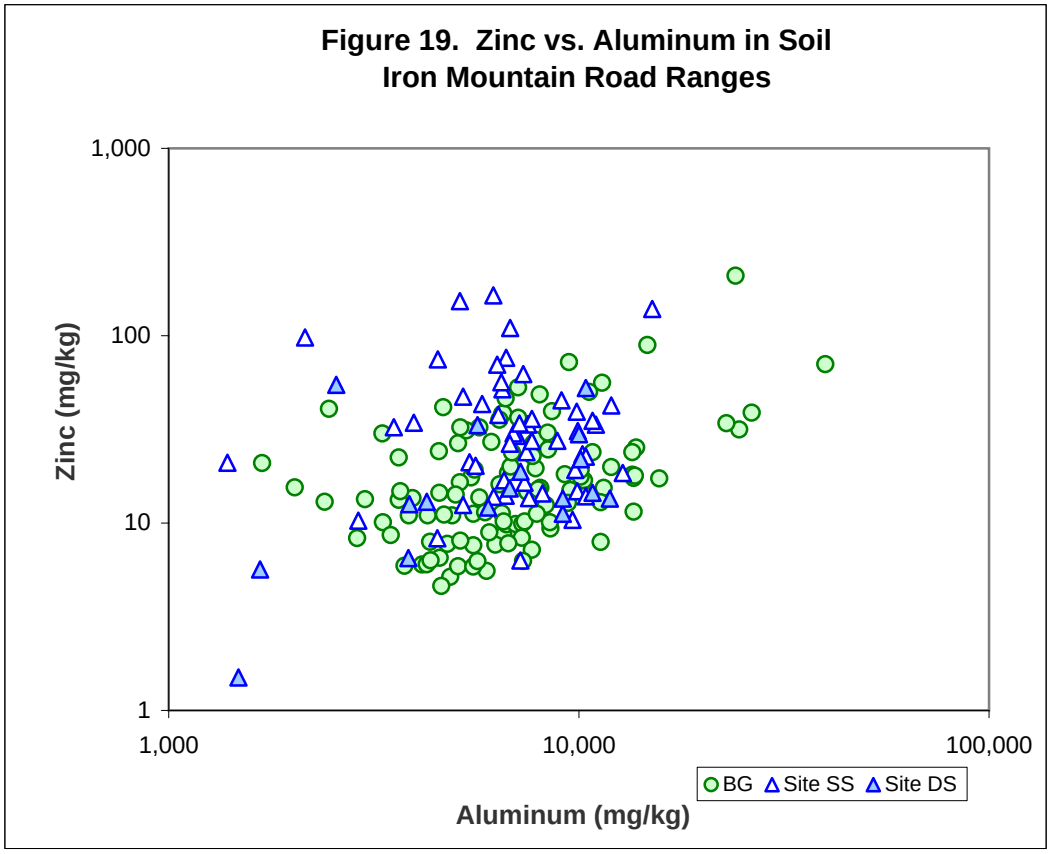


Figure 19. Zinc vs. Aluminum in Soil
Iron Mountain Road Ranges
1,000
100
10
1
Zinc (mg/kg)
1,000
10,000
100,000
Aluminum (mg/kg)
BG
Site SS
Site DS

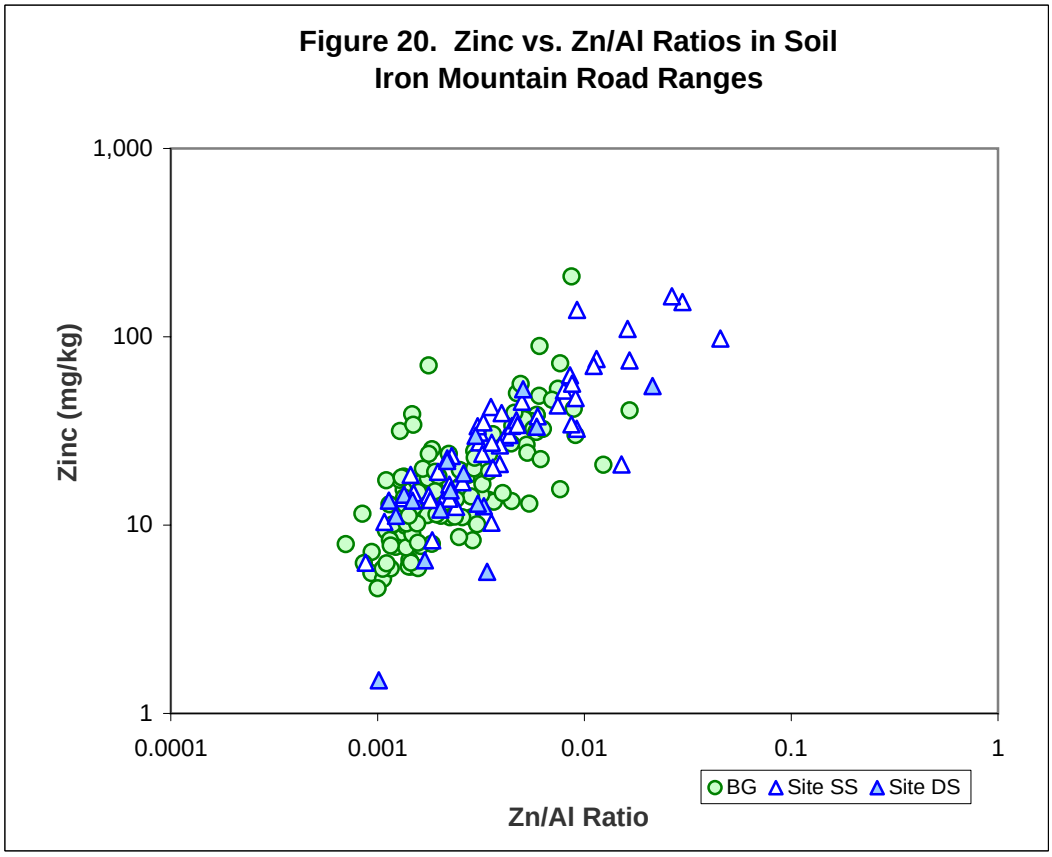


Figure 20. Zinc vs. Zn/Al Ratios in Soil
Iron Mountain Road Ranges
1,000
100
10
1
Zinc (mg/kg)
0.0001
0.001
0.01
0.1
1
Zn/Al Ratio
BG
Site SS
Site DS

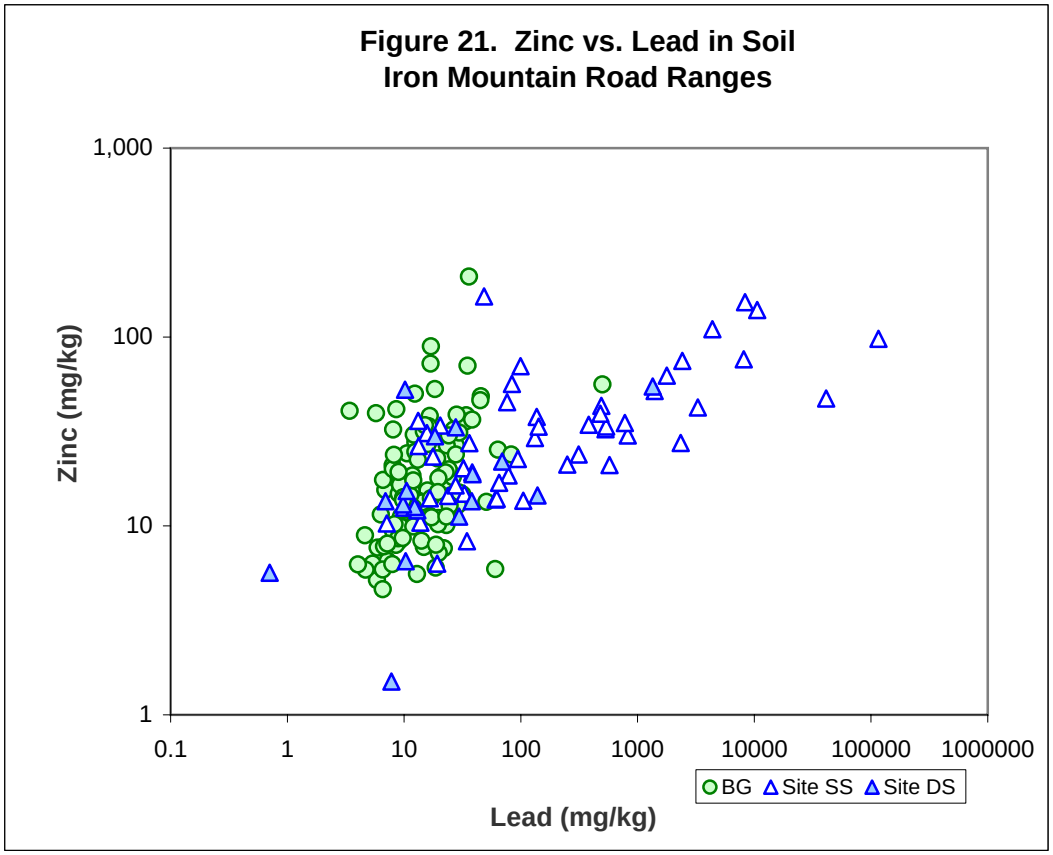


Figure 21. Zinc vs. Lead in Soil
Iron Mountain Road Ranges
1,000
100
10
1
Zinc (mg/kg)
0.1
1
10
100
1000
10000
100000
1000000
Lead (mg/kg)
BG
Site SS
Site DS

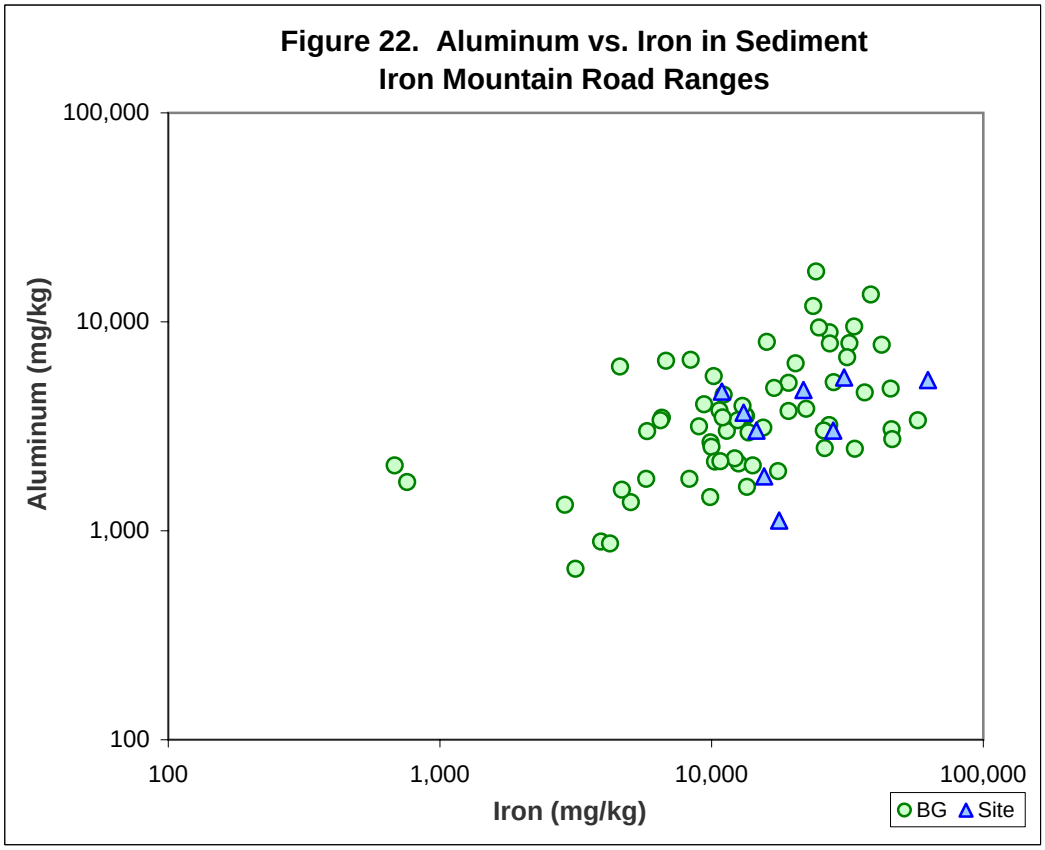


Figure 22. Aluminum vs. Iron in Sediment
Iron Mountain Road Ranges
Aluminum (mg/kg)
100,000
10,000
1,000
100
100
1,000
10,000
100,000
Iron (mg/kg)
BG
Site

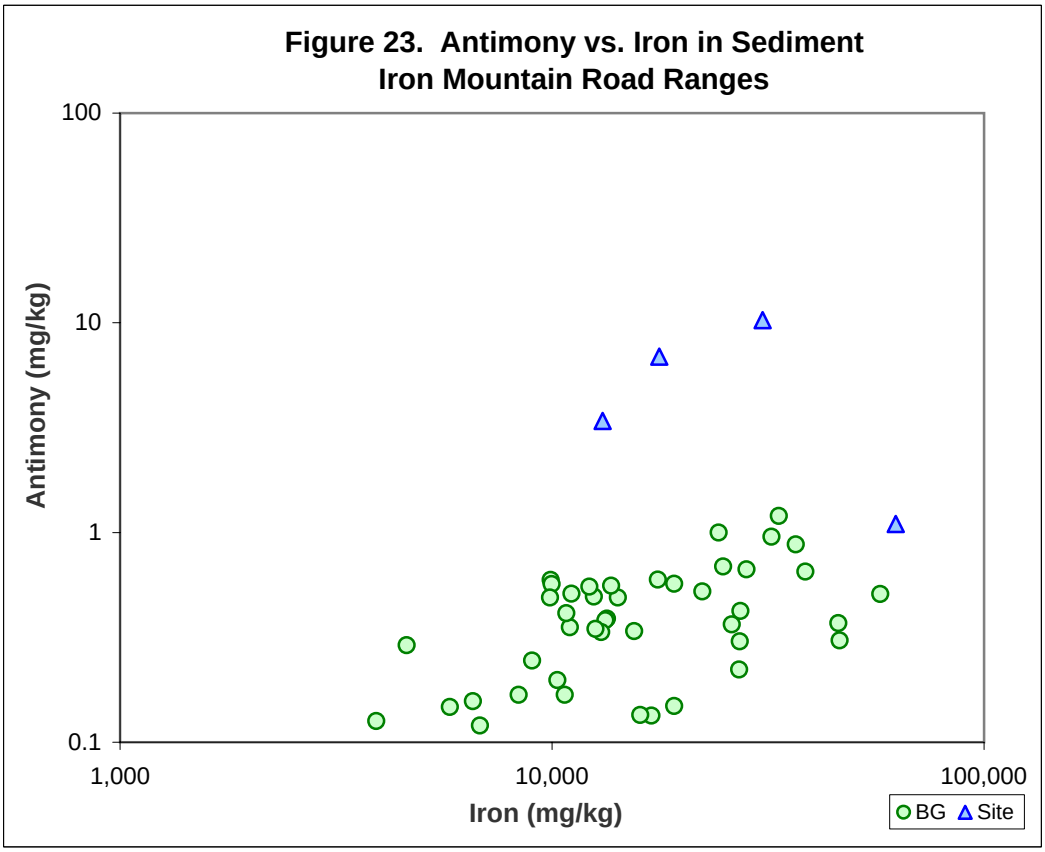


Figure 23. Antimony vs. Iron in Sediment
Iron Mountain Road Ranges
Antimony (mg/kg)
100
10
1
0.1
1,000
10,000
100,000
Iron (mg/kg)
BG
Site

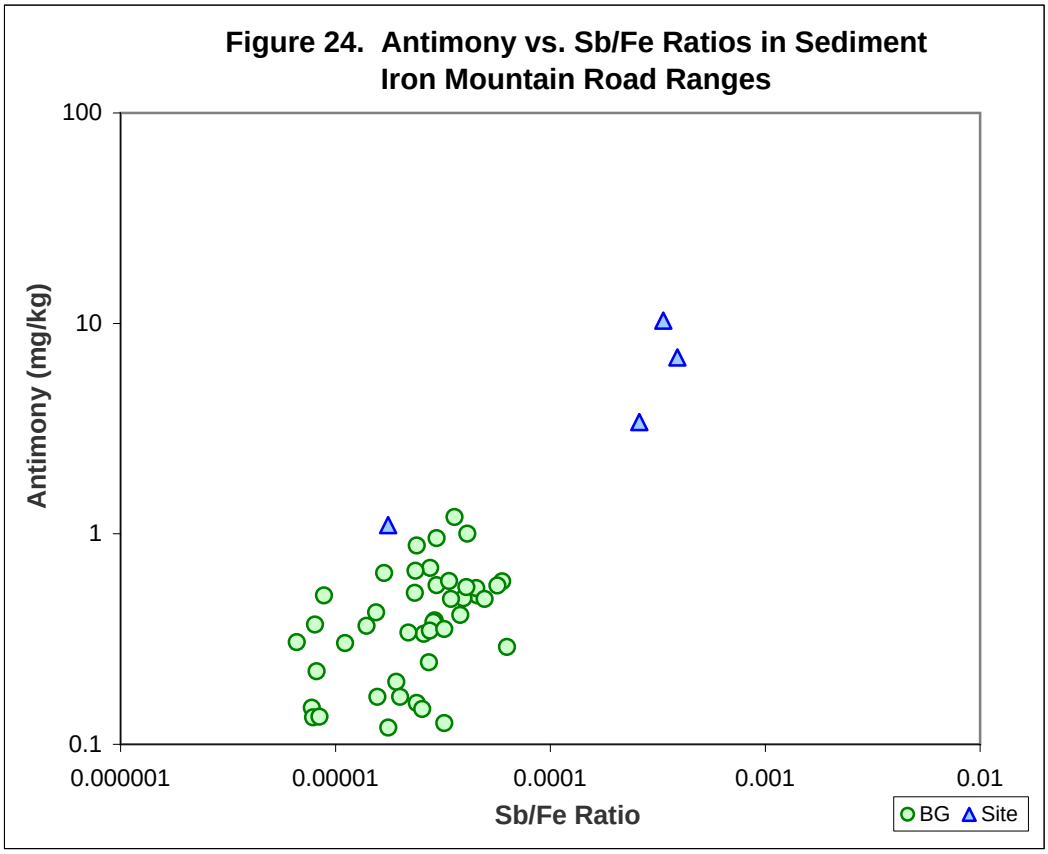


Figure 24. Antimony vs. Sb/Fe Ratios in Sediment
Iron Mountain Road Ranges
Antimony (mg/kg)
100
10
1
0.1
0.000001
0.00001
0.0001
0.001
0.01
Sb/Fe Ratio
BG
Site

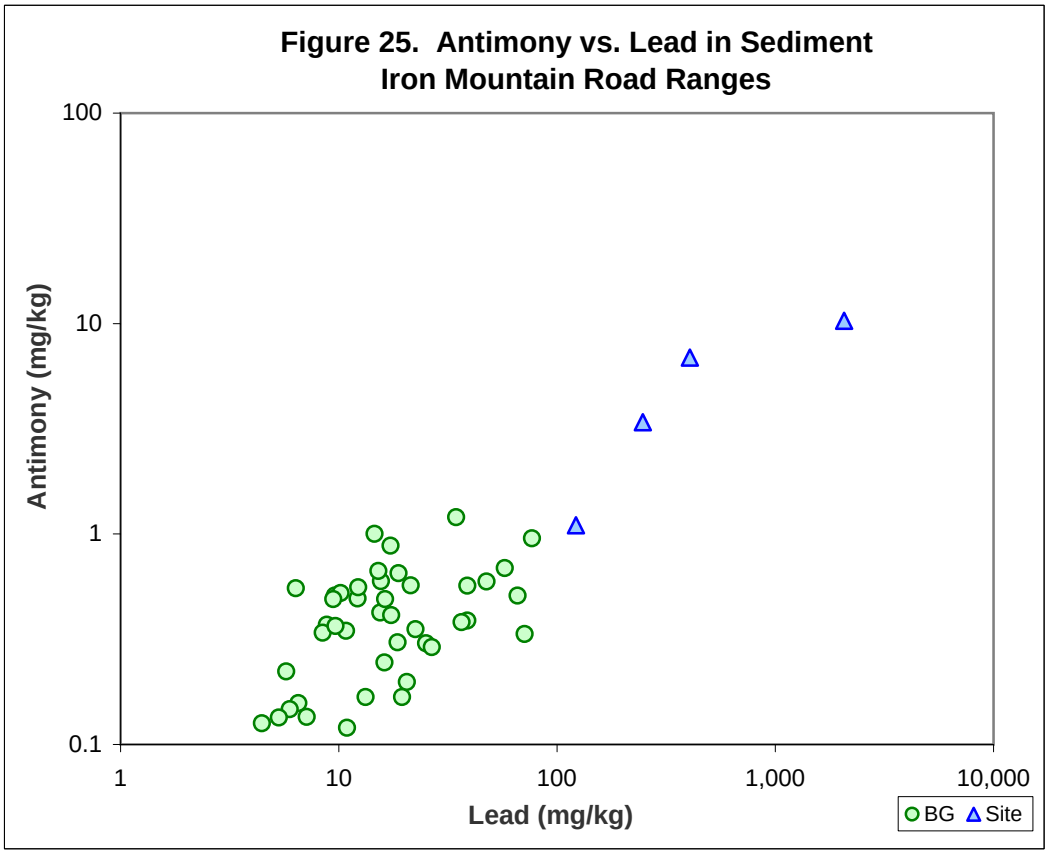


Figure 25. Antimony vs. Lead in Sediment
Iron Mountain Road Ranges
Antimony (mg/kg)
100
10
1
0.1
1
10
100
1,000
10,000
Lead (mg/kg)
BG
Site

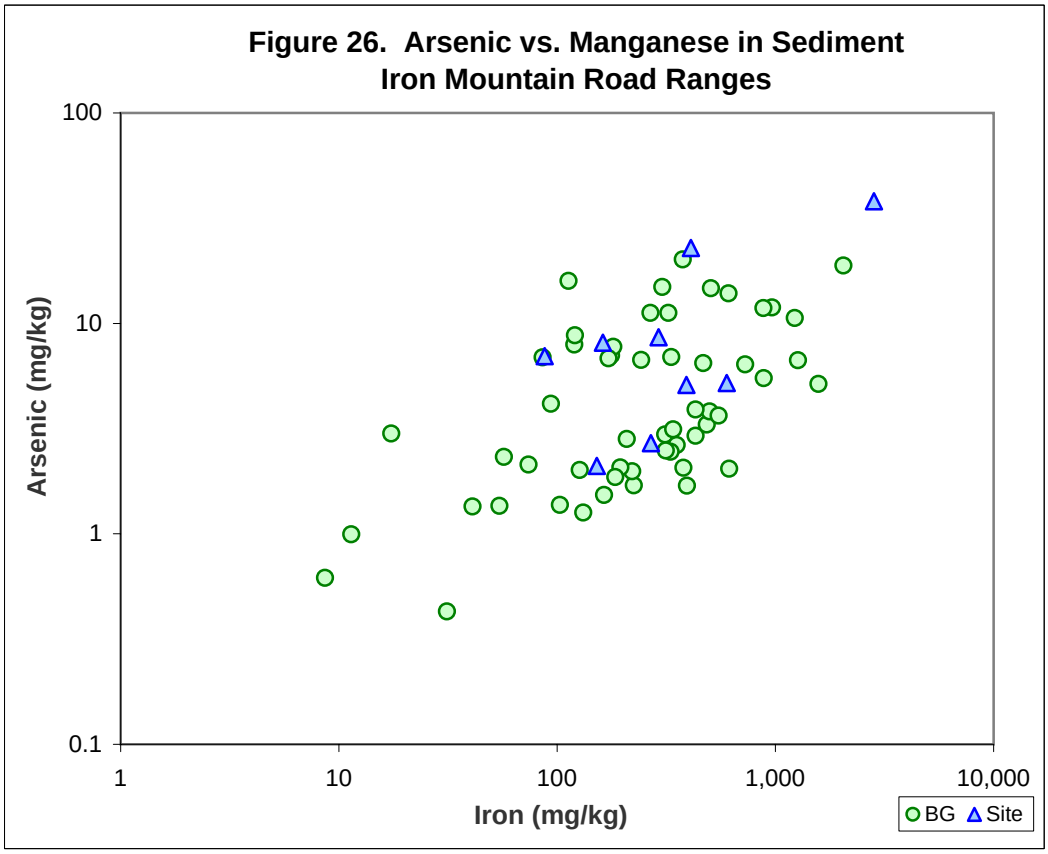


Figure 26. Arsenic vs. Manganese in Sediment
Iron Mountain Road Ranges
Arsenic (mg/kg)
100
10
1
0.1
1
10
100
1,000
10,000
Iron (mg/kg)
BG
Site

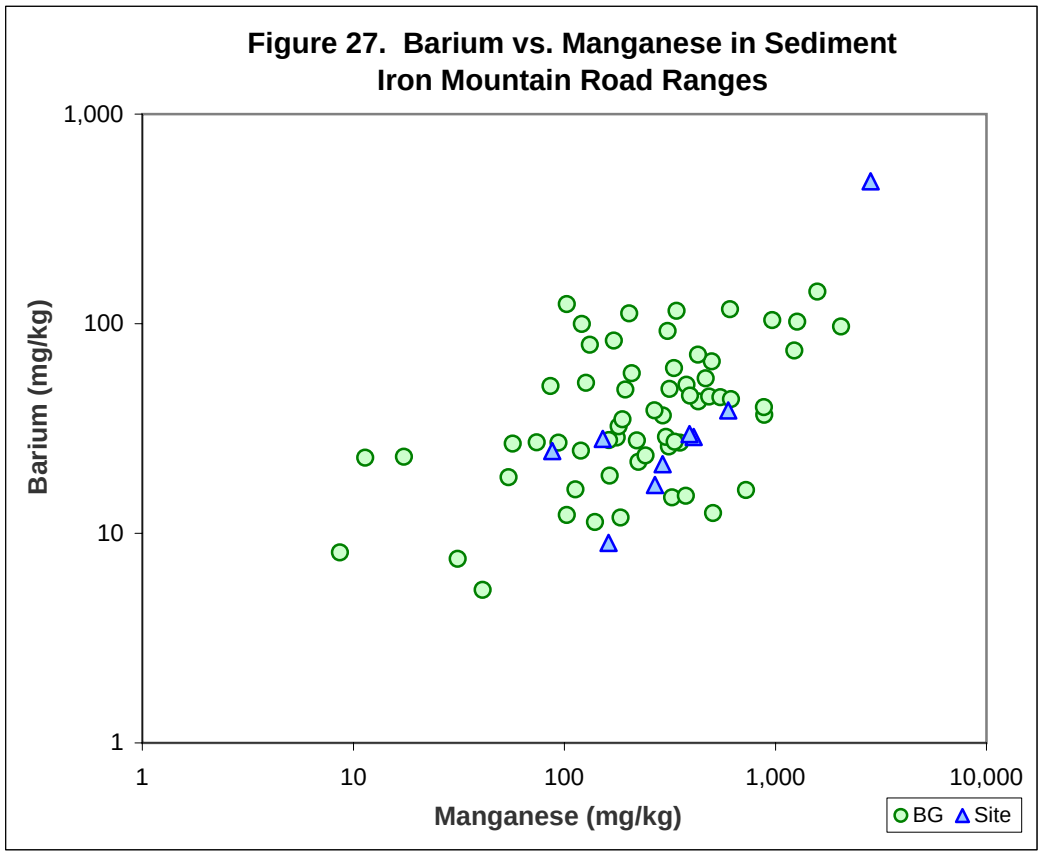


Figure 27. Barium vs. Manganese in Sediment
Iron Mountain Road Ranges
Barium (mg/kg)
1,000
100
10
1
1
10
100
1,000
10,000
Manganese (mg/kg)
BG
Site

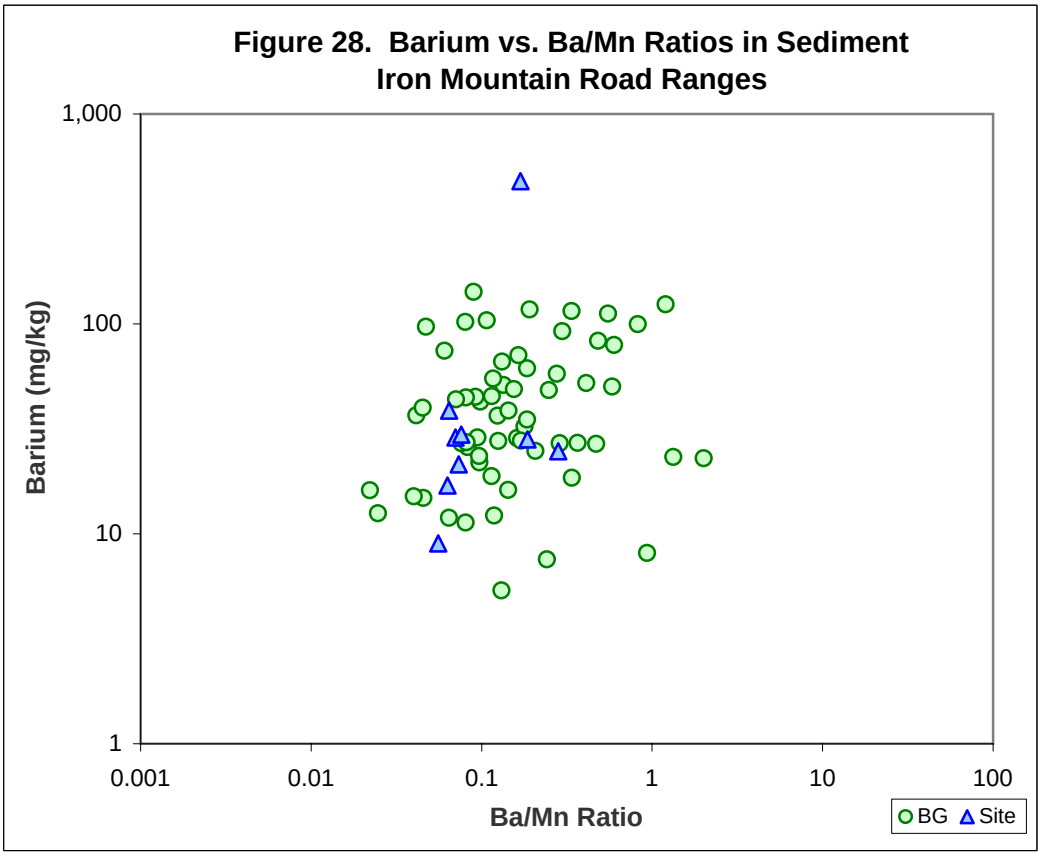


Figure 28. Barium vs. Ba/Mn Ratios in Sediment
Iron Mountain Road Ranges
1,000
100
10
1
Barium (mg/kg)
0.001
0.01
0.1
1
10
100
Ba/Mn Ratio
BG
Site

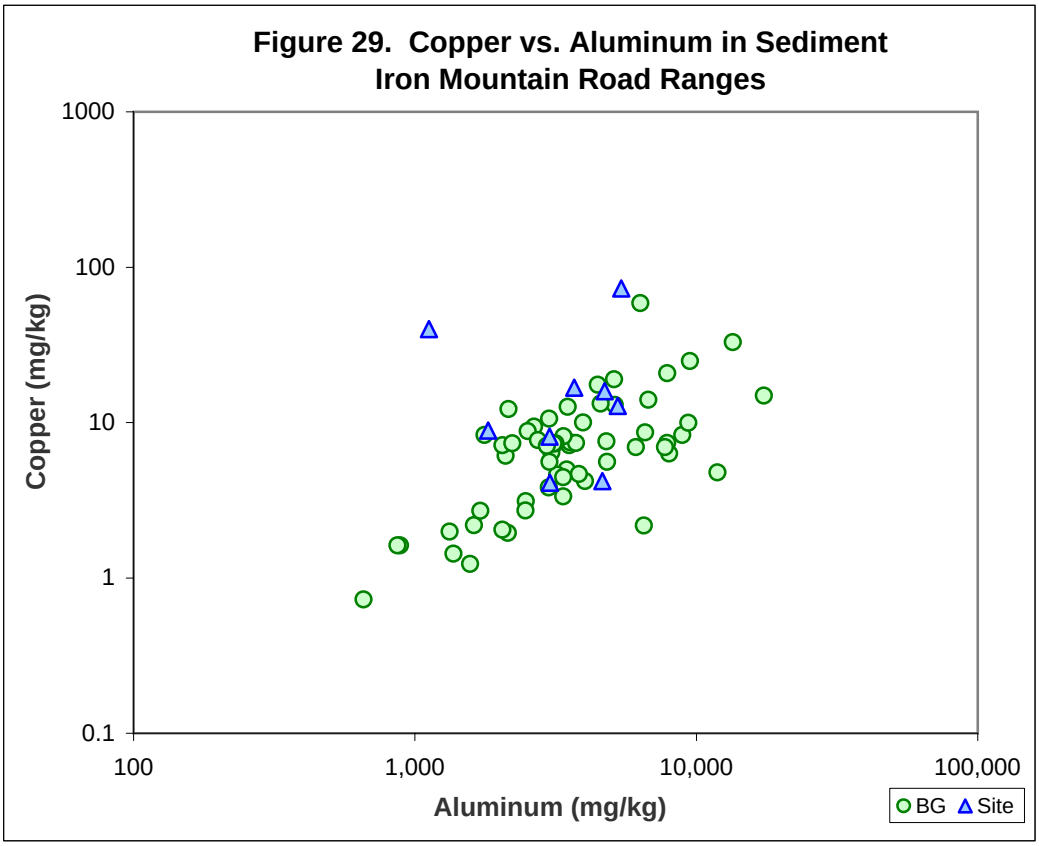


Figure 29. Copper vs. Aluminum in Sediment
Iron Mountain Road Ranges
1000
100
10
1
0.1
Copper (mg/kg)
100
1,000
10,000
100,000
Aluminum (mg/kg)
BG
Site

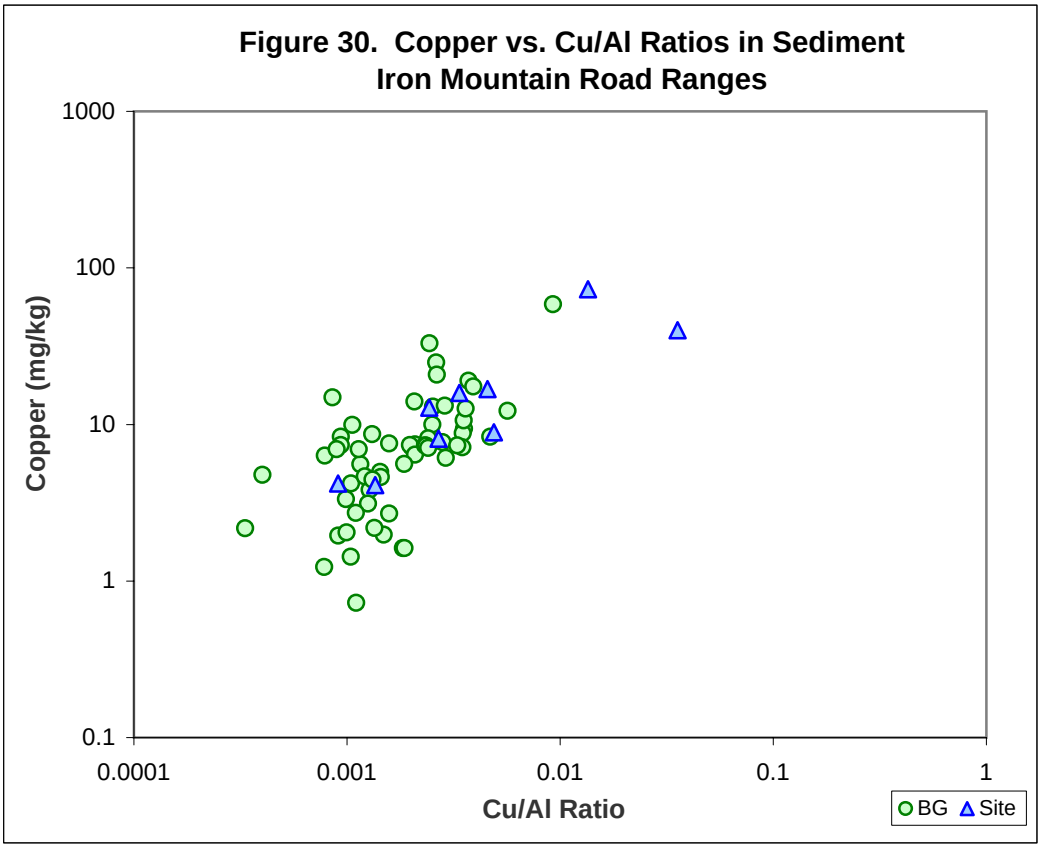


Figure 30. Copper vs. Cu/Al Ratios in Sediment
Iron Mountain Road Ranges
1000
100
10
1
0.1
Copper (mg/kg)
0.0001
0.001
0.01
0.1
1
Cu/Al Ratio
BG
Site

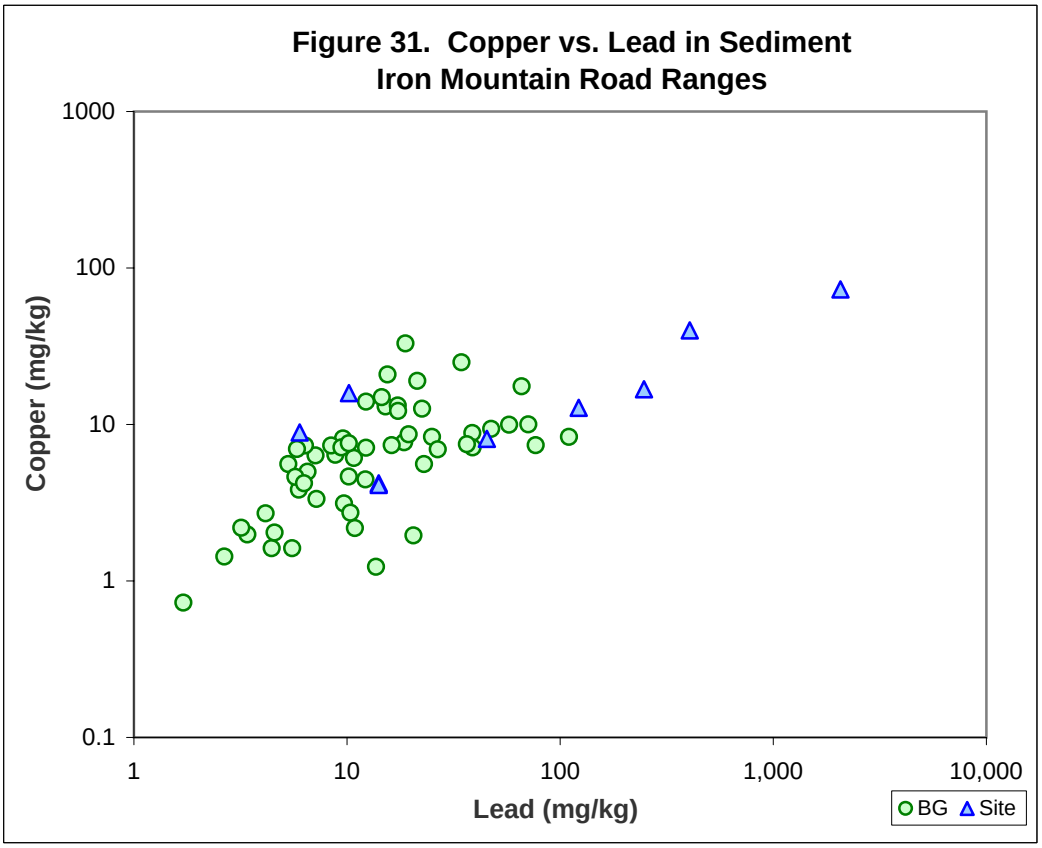


Figure 31. Copper vs. Lead in Sediment
Iron Mountain Road Ranges
1000
100
10
1
0.1
Copper (mg/kg)
1
10
100
1,000
10,000
Lead (mg/kg)
BG
Site

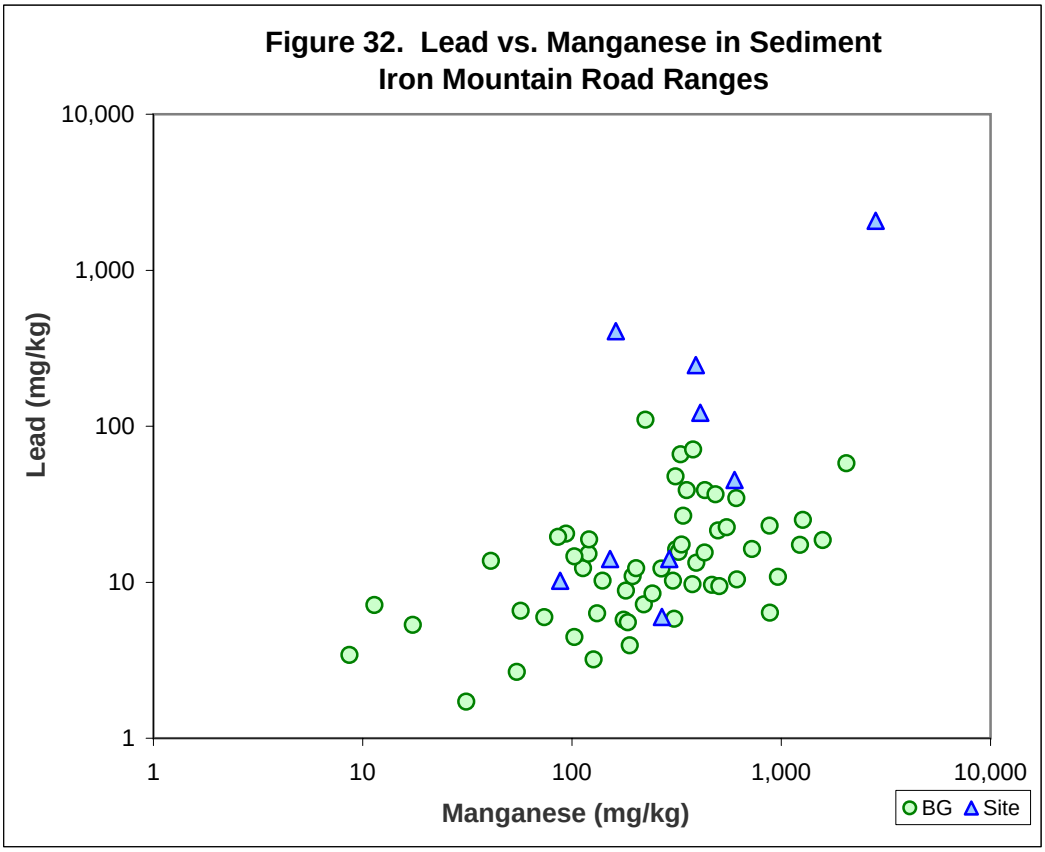


Figure 32. Lead vs. Manganese in Sediment
Iron Mountain Road Ranges
10,000
1,000
100
10
1
Lead (mg/kg)
1
10
100
1,000
10,000
Manganese (mg/kg)
BG
Site

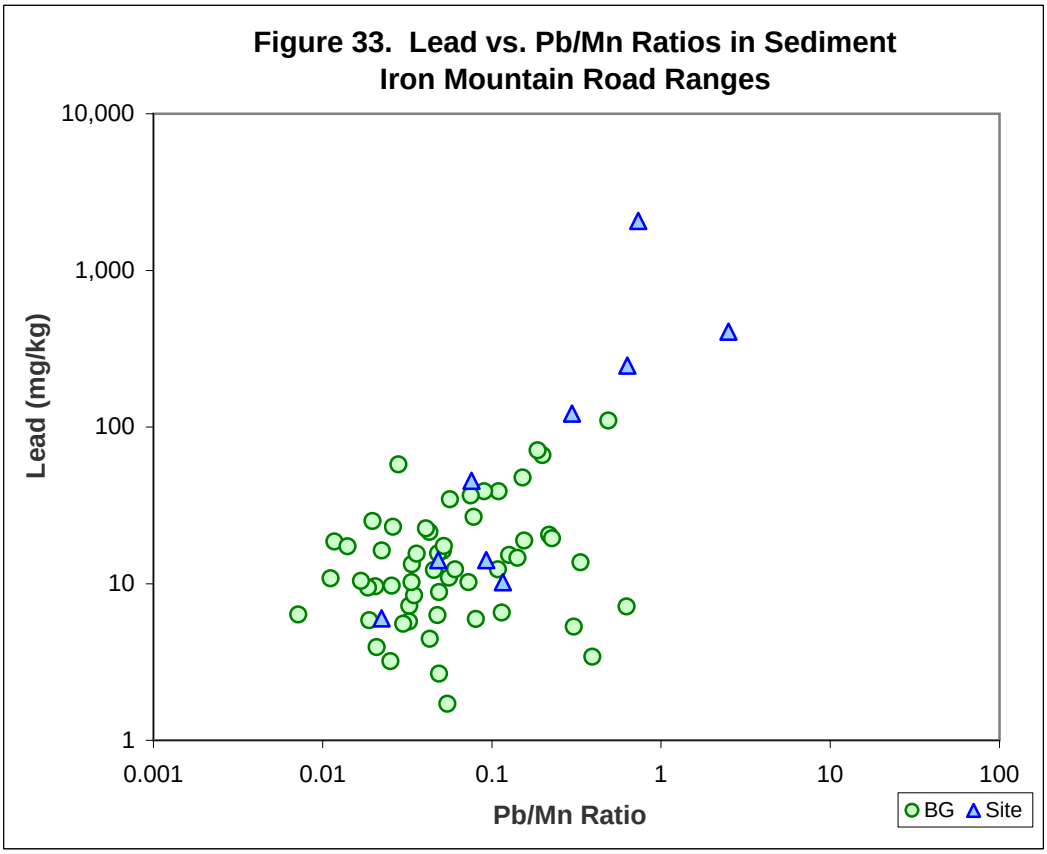


Figure 33. Lead vs. Pb/Mn Ratios in Sediment
Iron Mountain Road Ranges
10,000
1,000
100
10
1
Lead (mg/kg)
0.001
0.01
0.1
1
10
100
Pb/Mn Ratio
BG
Site

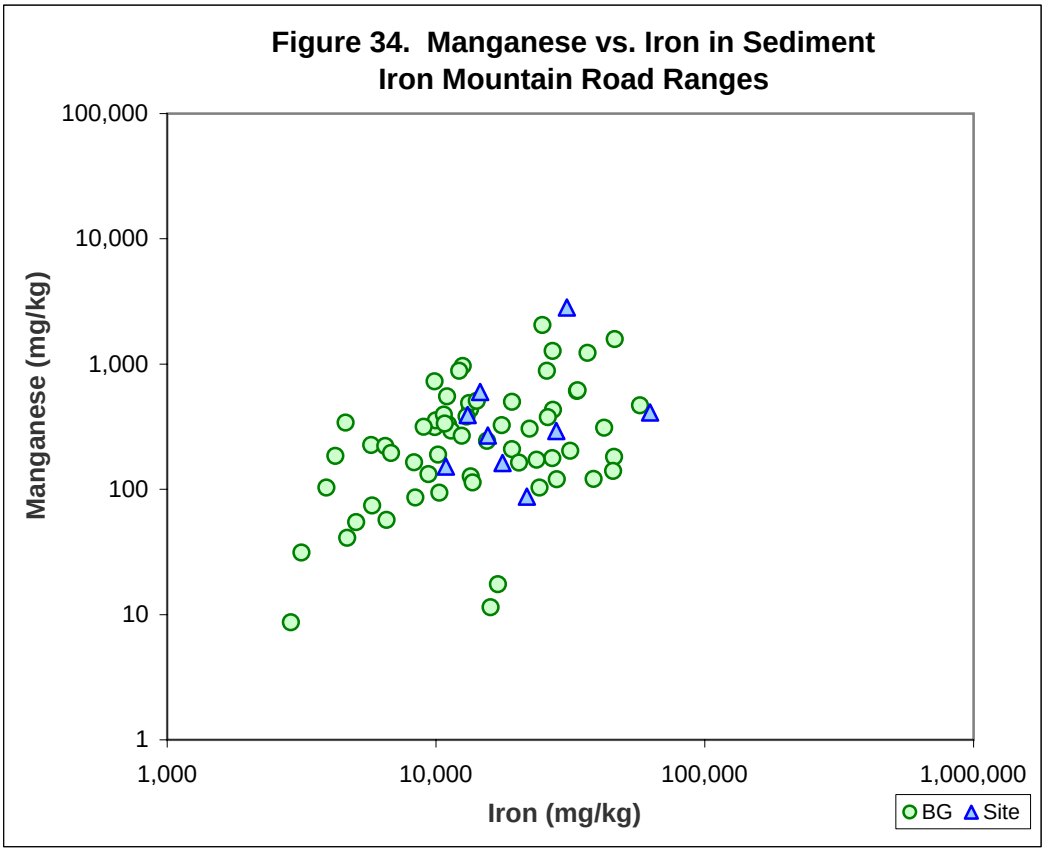


Figure 34. Manganese vs. Iron in Sediment
Iron Mountain Road Ranges
100,000
10,000
1,000
100
10
1
Manganese (mg/kg)
1,000
10,000
100,000
1,000,000
Iron (mg/kg)
BG
Site

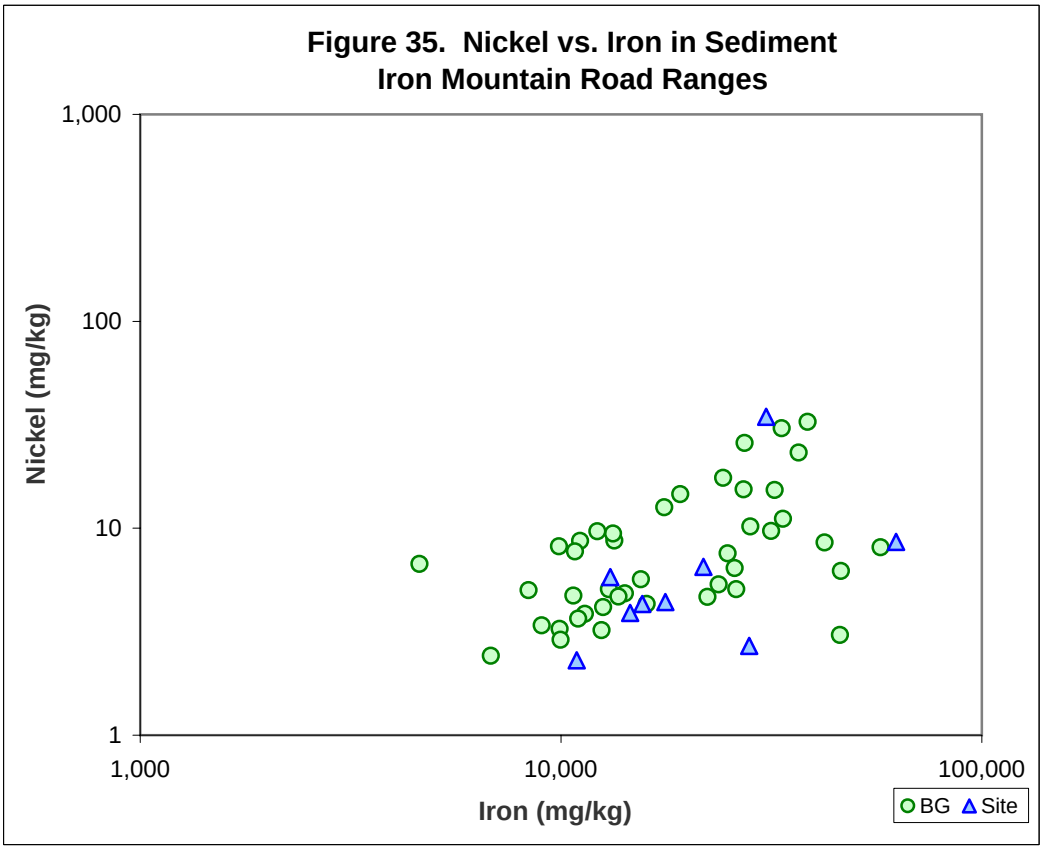


Figure 35. Nickel vs. Iron in Sediment
Iron Mountain Road Ranges
1,000
100
10
1
Nickel (mg/kg)
1,000
10,000
100,000
Iron (mg/kg)
BG
Site

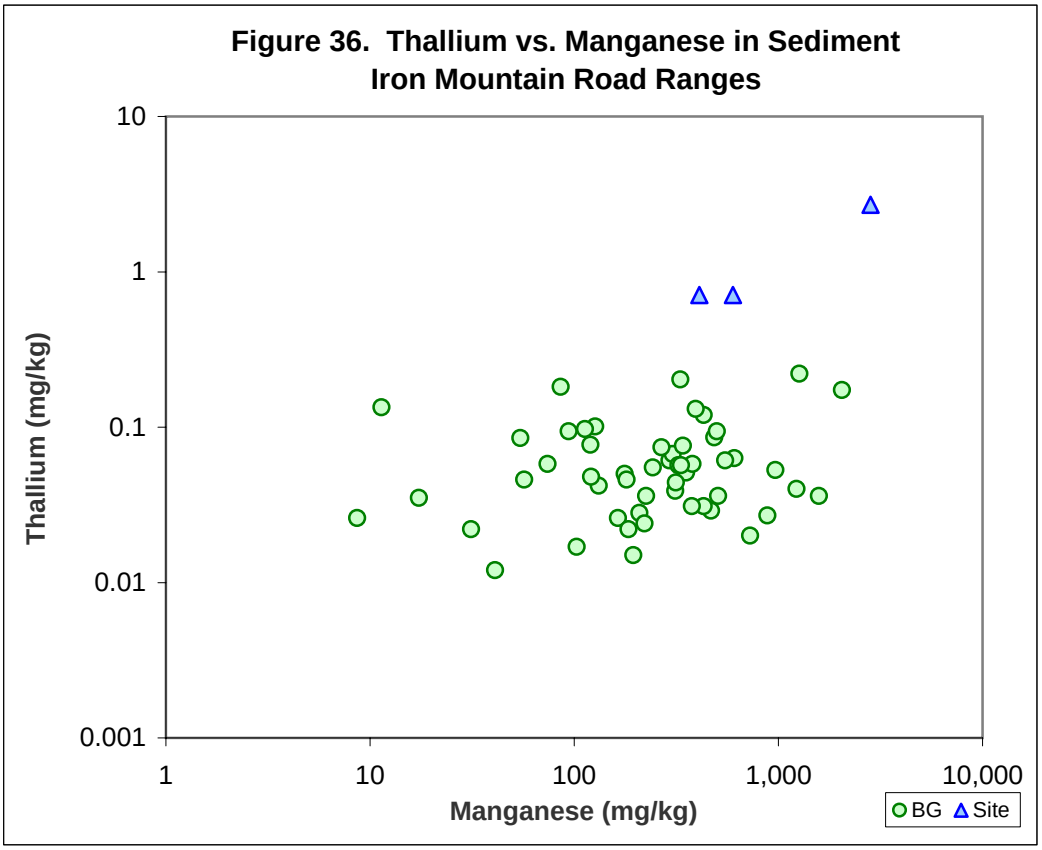


Figure 36. Thallium vs. Manganese in Sediment
Iron Mountain Road Ranges
Thallium (mg/kg)
10
1
0.1
0.01
0.001
1
10
100
1,000
10,000
Manganese (mg/kg)
BG
Site

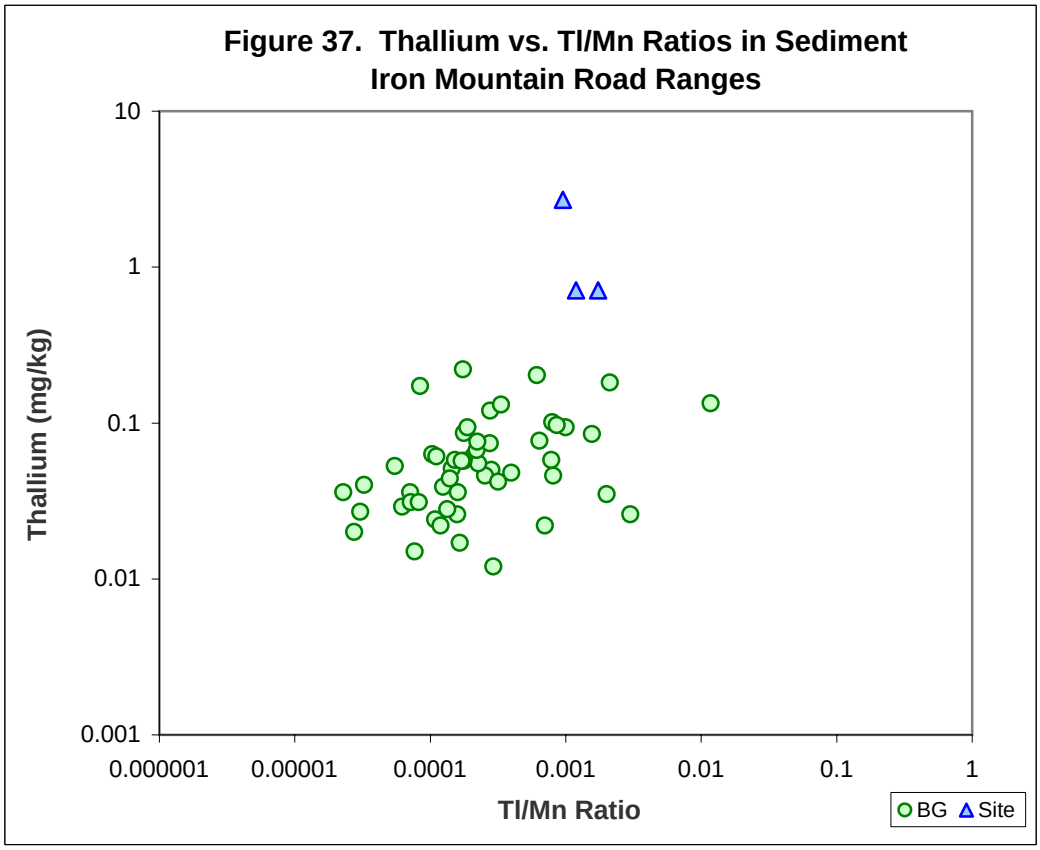


Figure 37. Thallium vs. Tl/Mn Ratios in Sediment
Iron Mountain Road Ranges
Thallium (mg/kg)
10
1
0.1
0.01
0.001
0.000001
0.00001
0.0001
0.001
0.01
0.1
1
Tl/Mn Ratio
BG
Site

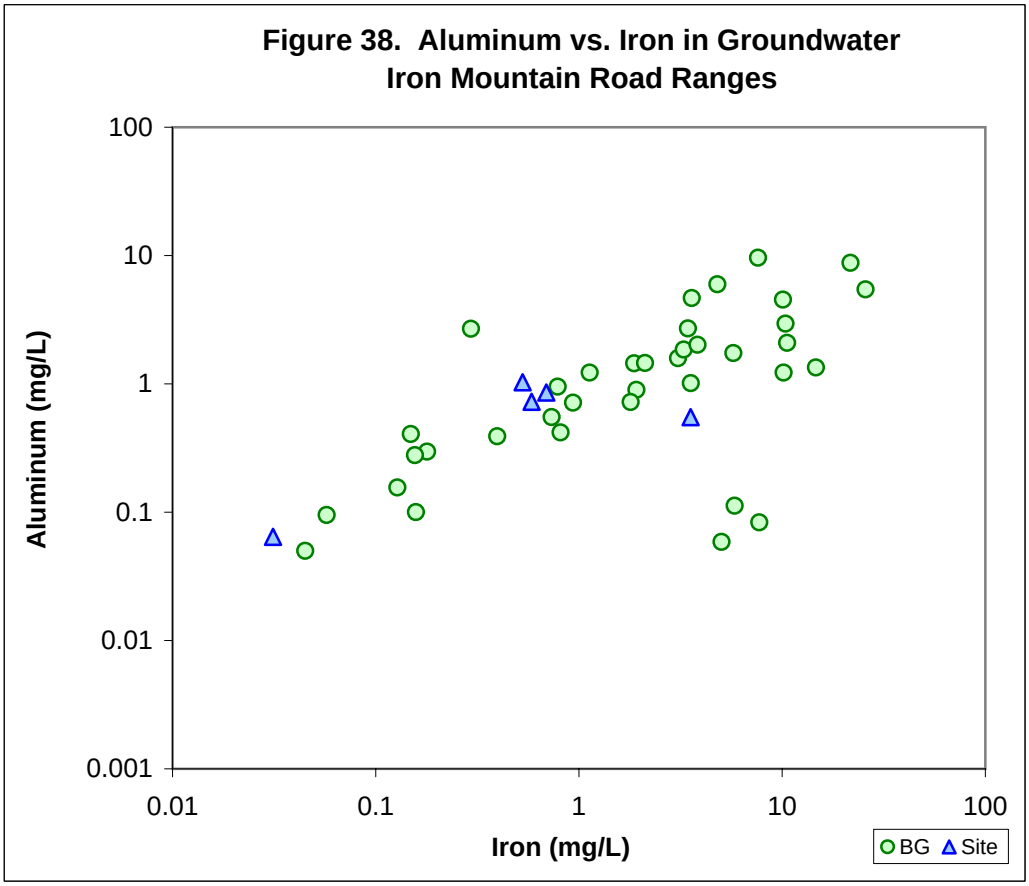


Figure 38. Aluminum vs. Iron in Groundwater
Iron Mountain Road Ranges
Aluminum (mg/L)
100
10
1
0.1
0.01
0.001
0.01
0.1
1
10
100
Iron (mg/L)
BG
Site

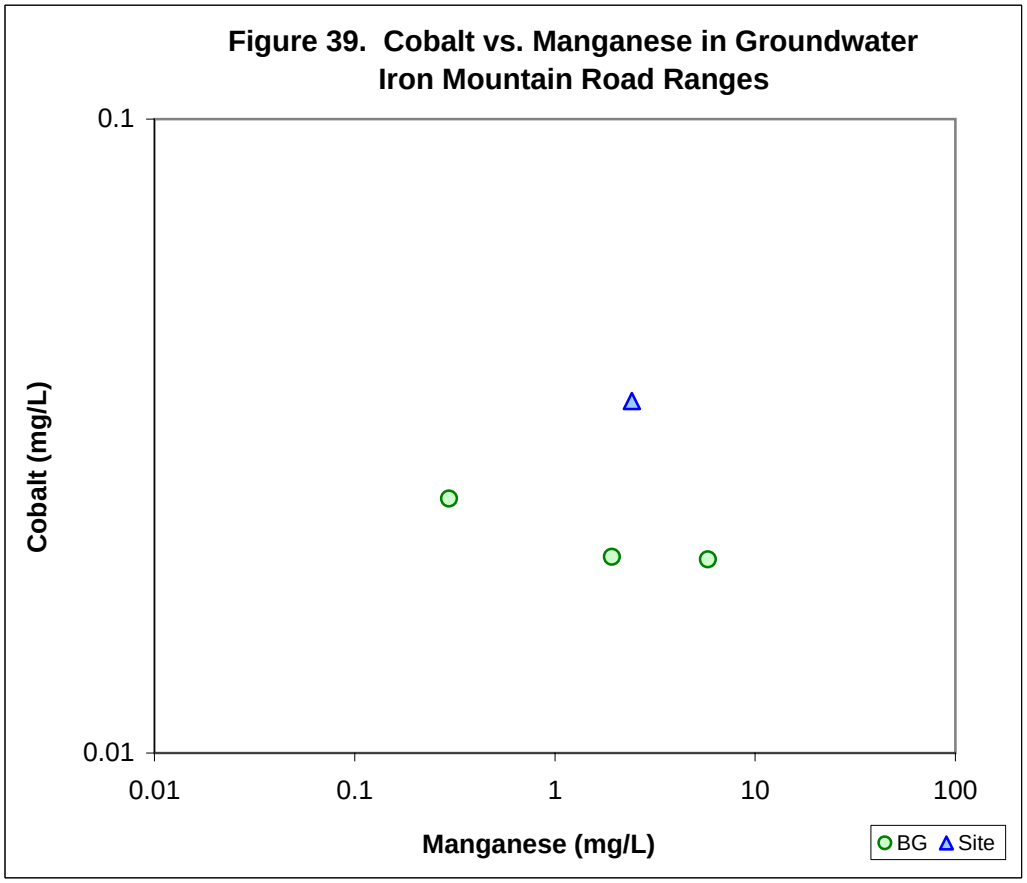


Figure 39. Cobalt vs. Manganese in Groundwater
Iron Mountain Road Ranges
Cobalt (mg/L)
0.1
0.01
0.01
0.1
1
10
100
Manganese (mg/L)
BG
Site

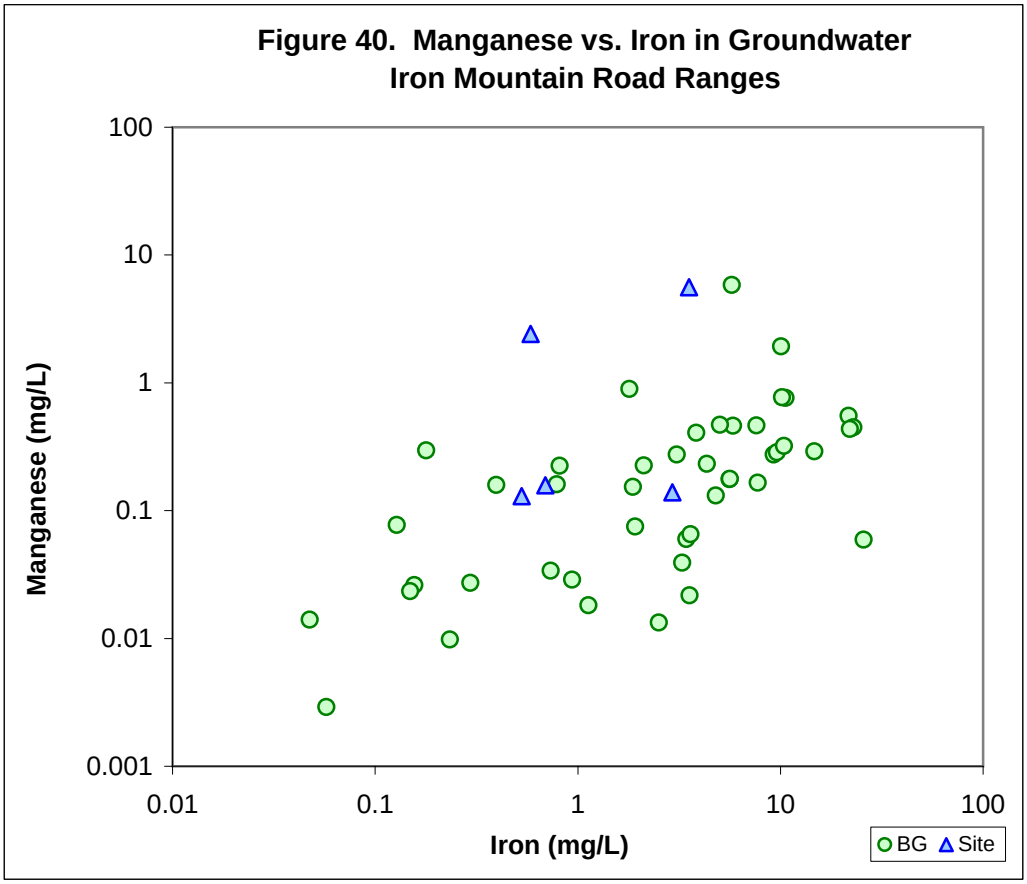


Figure 40. Manganese vs. Iron in Groundwater
Iron Mountain Road Ranges
Manganese (mg/L)
100
10
1
0.1
0.01
0.001
0.01
0.1
1
10
100
Iron (mg/L)
BG
Site

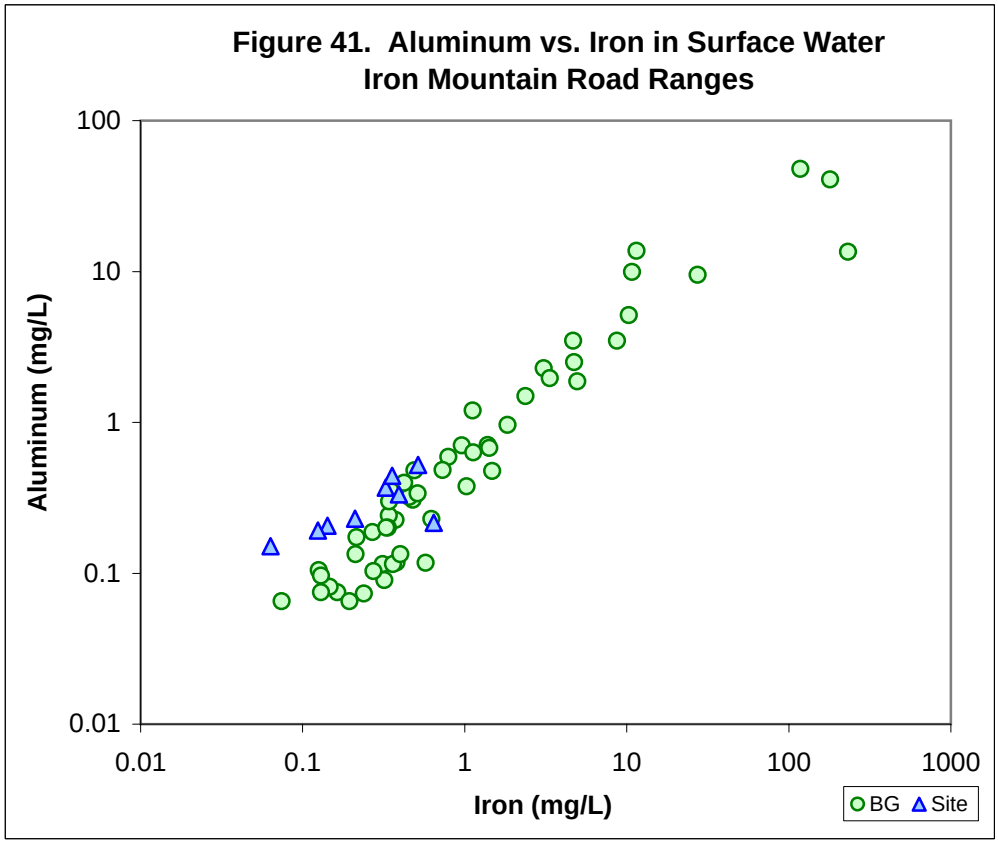


Figure 41. Aluminum vs. Iron in Surface Water
Iron Mountain Road Ranges
Aluminum (mg/L)
100
10
1
0.1
0.01
0.01
0.1
1
10
100
1000
Iron (mg/L)
BG
Site

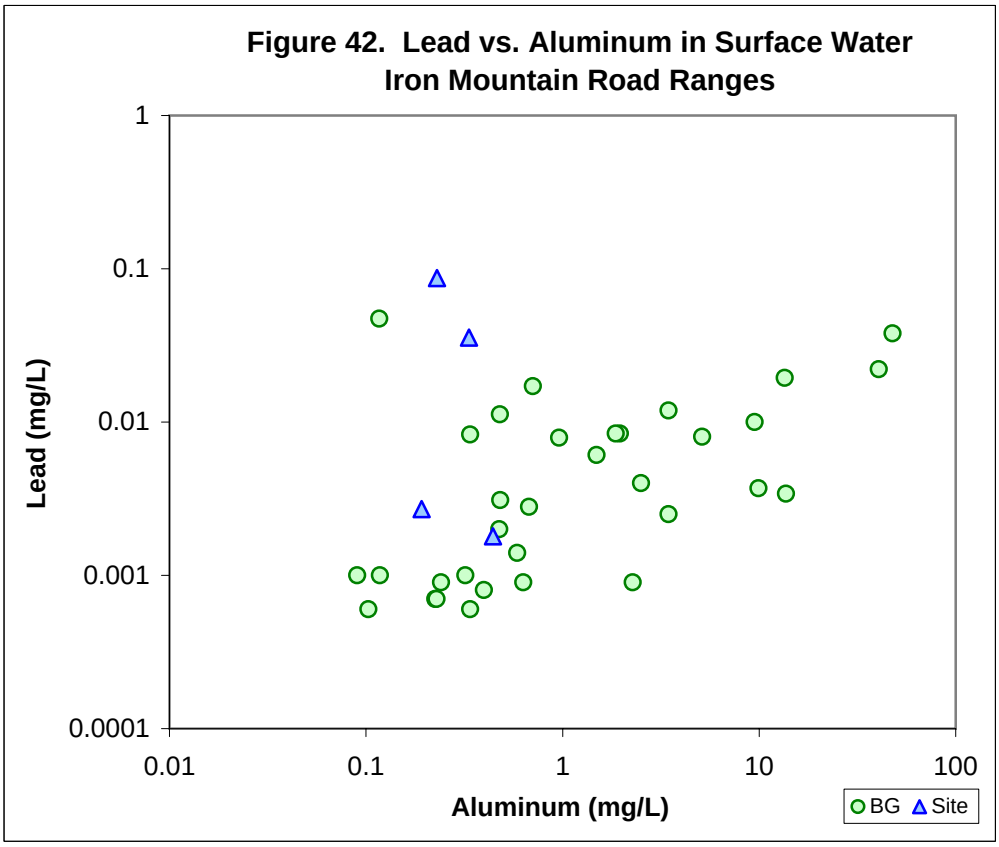


Figure 42. Lead vs. Aluminum in Surface Water
Iron Mountain Road Ranges
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.01
0.1
1
10
100
Aluminum (mg/L)
BG
Site

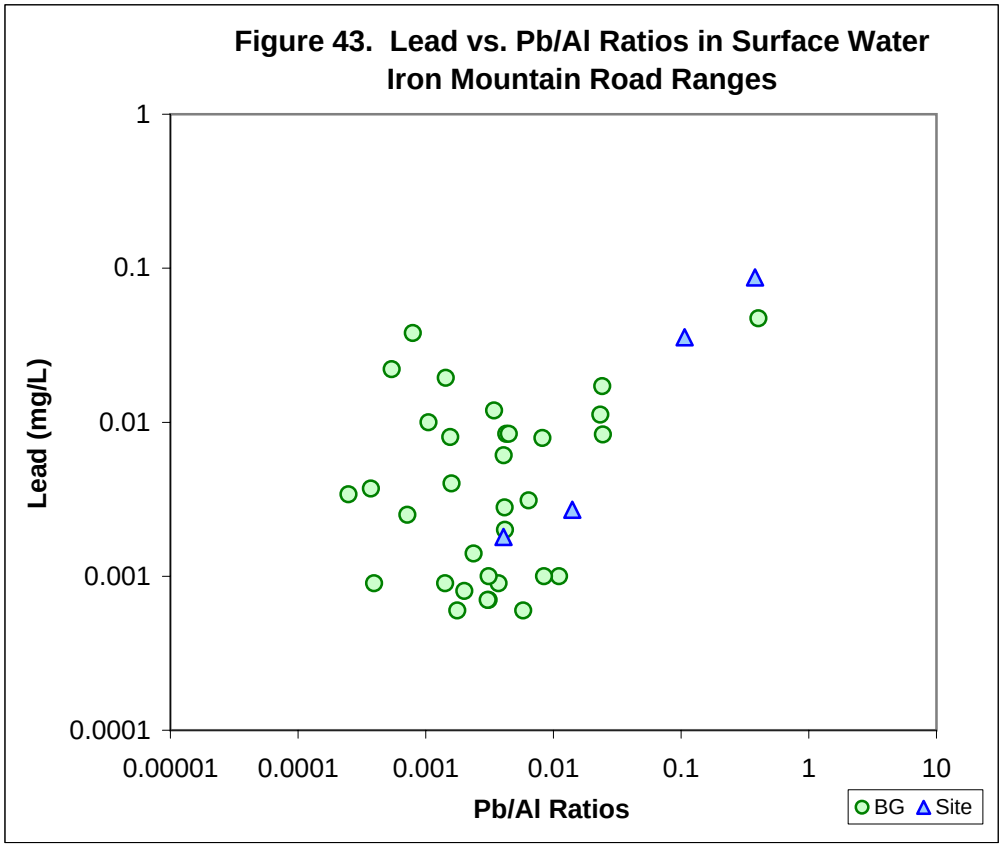


Figure 43. Lead vs. Pb/Al Ratios in Surface Water
Iron Mountain Road Ranges
Lead (mg/L)
1
0.1
0.01
0.001
0.0001
0.00001
0.0001
0.001
0.01
0.1
1
10
Pb/Al Ratios
BG
Site

ATTACHMENT 3

MARCH 2005 TECHNICAL MEMORANDUM: "SELECTING SITE-RELATED CHEMICALS FOR HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENTS FOR FTMC: REVISION 3"

Shaw Environmental & Infrastructure, Inc.

Shaw The Shaw Group Inc.™

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Knoxville, TN 37923-4799
Phone: 865-690-3211
Fax: 865-690-3626

Memorandum

Date: 14 March 2005

To: Ft. McClellan Project File

From: Karen Thorbjornsen, Jonathan Myers, and Paul Goetchius

RE: Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 3

This memo describes the protocol for site-to-background comparisons performed to select site-related chemicals at Fort McClellan (FTMC). It represents modifications to the original protocol set forth in the 28 April 2003 and 24 June 2003 technical memos.

Background screening is performed to differentiate between elements that have elevated concentrations due to natural processes versus elements that have elevated concentrations due to releases from site activities. The original protocol, which used the Slippage test, has been shown to provide an unacceptably high false-negative error rate due to the highly right-skewed nature of trace element distributions in many FTMC site data sets. The identification of exactly which site samples exhibit anomalously high elemental ratios on geochemical correlation plots was also an issue of concern. This memo reflects agreement reached between the Army (via USACE and Shaw E & I) and EPA Region 4 during the project meeting on 25 January 2005 in Atlanta, Georgia. The modifications to the methodology include the substitution of the hot measurement test for the Slippage test during the Tier 2 evaluation, and the addition of ratio plots to identify samples with anomalously high elemental ratios during the Tier 3 evaluation. The ratio plots are used in conjunction with the correlation plots when conducting the Tier 3 evaluation.

Background screening will be performed as a multi-tiered process, as follows:

Tier 1: *(Tier 1 remains unchanged from the 28 April 2003 memo.)* The maximum detected concentration (MDC) of site data is compared with the background screening criterion (BSC). Chemicals for which the MDC of site data does not exceed the BSC are considered to be present at background concentrations, are not selected as site-related chemicals and are not considered further in the risk assessment. Chemicals for which the MDC of site data exceeds the BSC are carried forward to Tier 2.

Tier 2: Tier 2 consists of two complementary statistical tests: (a) The hot measurement test is performed as the test of upper tails. This test consists of comparison of the site MDC to the background 95 UTL (for lognormally and normally distributed analytes) or the background 95th percentile (for nonparametric

distributions). (b) The Wilcoxon rank sum test is performed to compare the central tendencies of the site and background distributions, for those analytes with less than 50 percent nondetects in both the site and background data sets. The background data are provided in the installation-wide background study report (SAIC, 1998). Metals that fail either of these statistical tests are then subjected to the Tier 3 evaluation. "Failure" of a statistical test means that the site data are shown to be elevated with respect to background.

Tier 3: Tier 3 consists of a geochemical evaluation to determine whether concentrations of site metals are naturally occurring or elevated due to contamination. Geochemical evaluations are based on the natural association between a trace element and one or more specific soil-forming minerals that concentrate that trace element. The correlation of the trace element of interest with a major element representing the abundance of the specific mineral that concentrates the trace element is evaluated. The selection of the major reference element is dependent on a number of general and site-specific factors as discussed below.

Some elements, under certain environmental conditions, display exclusive associations with specific reference elements. For instance, in oxic, neutral-pH soils, arsenic, selenium, and vanadium are almost exclusively associated with iron oxides, so iron is usually used as a reference element for these trace elements (Bowell, 1994; Schiff and Weisberg, 1997). The reason for this association is well understood, and is based on aqueous speciation and surface chemistry effects. These three elements are present in oxic soil pore fluid as negatively charged oxyanions ($HAsO_4^{-2}$, $HSeO_3^-$, $H_2VO_4^-$) (Pourbaix, 1974; EPRI, 1986; Brookins, 1988). Iron oxides maintain a positive surface charge that strongly attracts these oxyanions, resulting in the observed linear correlations (Bowell, 1994).

Cadmium, nickel, lead, and zinc exist in the pore fluid of most soils as positively charged divalent cations (Cd^{+2}, Ni^{+2}, Pb^{+2}, Zn^{+2}) (Brookins, 1988; Pourbaix, 1974). These trace elements have a strong affinity to adsorb on clay minerals which maintain a negative surface charge (EPRI, 1984). These elements are usually evaluated against aluminum, which is a major component of all clay minerals.

Chromium can be present in soil pore fluid as a mixture of aqueous species with different charges such as $Cr(OH)_2^+$, $Cr(OH)_3^o$, and $Cr(OH)_4^-$, depending on the pH of the pore fluid (EPRI, 1984). The positive, neutral, and negative charges on these species result in the distribution of chromium on several different types of sorptive surfaces, including clay and iron oxide minerals. Higher soil pH conditions will favor the anionic Cr species which adsorb on iron oxides, and lower soil pH conditions will favor the cationic Cr species which preferentially adsorb on clay minerals.

Manganese oxides have a specific affinity to adsorb barium, cobalt, and lead (Kabata-Pendias, 2001). In most soils, the manganese concentrations are too low for it to form discrete manganese oxide minerals. However, in oxic, manganese-rich soils, minerals such as pyrolusite (MnO_2) and nsutite ($MnO_{1.9}$) will form that strongly adsorb Ba, Co, and Pb. Under reducing, low CO_2

conditions, the minerals $MnO{\bullet}OH$, Mn_2O_3 and Mn_3O_4 will form, which also concentrate these trace elements. Under reducing, high CO_2 conditions however, Mn will be present as rhodochrosite ($MnCO_3$) which does not have as strong adsorptive properties as the Mn-oxides (EPRI, 1984).

Soils that contain fragments of limestone often show linear correlations between barium, cadmium, cobalt, nickel, strontium, lead, and zinc versus calcium. This is because these divalent metals readily substitute for calcium in calcite ($CaCO_3$) and dolomite [$(Ca,Mg)CO_3$], which are the major minerals present in limestone. This association is also common in arid regions where the divalent metals co-precipitate with calcite and gypsum ($CaSO_4{\bullet}2H_2O$) in caliche horizons.

Arkosic soils that contain unweathered fragments of feldspar have very different trace/major element associations, reflecting the mineralogy of the primary igneous or metamorphic source material. For instance, beryllium is associated with alkali feldspars which all contain sodium, potassium and aluminum, so the correlations of beryllium versus those major elements would be evaluated.

Total organic carbon is a good reference element for mercury, which has a strong affinity for adsorption on natural organic material. Mercury often shows better correlations with total organic carbon than with inorganic reference elements.

In reducing environments such as swamps, bogs, and wetlands where organic content is high, anaerobic sulfate-reducing conditions can become established. Under these conditions, trace elements such as arsenic, cadmium, nickel, lead, and zinc will co-precipitate with iron as sulfide minerals. These trace metals in this environment would be expected to be correlated with iron and sulfide in soil samples.

Care must be taken in the selection of reference elements to ensure that those elements are themselves not directly or indirectly impacted by contamination. Aluminum is usually a good reference element because it is not sensitive to redox conditions, and direct aluminum contamination is rare. A further advantage of aluminum is its low solubility over the neutral pH range, but it does become soluble at pH conditions below 4 and above 9. The release of strong acids or bases will leach aluminum from soil and solubilize aluminum in groundwater, so evaluation of the pH conditions is important.

Examining the correlation between iron versus aluminum in soil is an important tool in geochemical evaluations. Both elements tend to concentrate in the finer grain size fractions as oxide and clay minerals, respectively. Concentrations of iron and aluminum may vary from sample to sample by orders of magnitude reflecting differences in grain size, but they are usually present at a fixed ratio. Site samples that plot off of the trend established by the background samples and exhibit anomalously high Fe/Al ratios, may have some excess component of iron, suggesting contamination from rust, machine shop sweepings, ferric chloride sludge, etc. If iron contamination is identified in some samples, then those samples should be identified as such and removed from the evaluation, or an alternate reference element should be selected.

Iron and manganese in groundwater are subject to reductive dissolution effects which should be evaluated before they are used as reference elements. The release of organic contaminants such as hydrocarbon fuels or chlorinated solvents can establish local reducing environments caused by anaerobic microbial degradation of the organic compounds. The establishment of local reducing conditions can drive the dissolution of iron and manganese oxides, which become soluble as the redox potential drops below a threshold value. Dissolution of these oxide minerals can mobilize the trace elements that were adsorbed on the oxide surfaces, which is a process termed "reductive dissolution." Several investigations have documented the mobilization of arsenic, selenium, and other trace elements under locally reducing redox conditions (Sullivan and Aller, 1996; Nickson, et al., 2000; Belzile, et al., 2000).

Evidence for reductive dissolution would be a correlation between elevated trace elements (arsenic, selenium, and vanadium in particular) versus lower redox conditions. Low redox conditions can be identified in groundwater by local depressions in oxidation-reduction potential or dissolved oxygen measurements; the presence of detectable ferrous iron; or the presence of reducing gases such as hydrogen, methane, ethane, or ethene. Anaerobic microbes can also reduce sulfate to sulfide and nitrate to ammonia, resulting in local depressions in sulfate and nitrate concentrations, and local detections of sulfide and ammonia. In areas impacted by chlorinated solvents, additional evidence for the establishment of anaerobic reducing conditions is the presence of dichloroethene and/or vinyl chloride, which are reductive dechlorination products resulting from the microbial degradation of trichloroethene or tetrachloroethene under anaerobic conditions.

An additional technique that is used to identify the presence of local reducing conditions in groundwater is a correlation plot of iron versus aluminum. These two elements are usually highly correlated in oxic groundwater because they are both insoluble and tend to be present as suspended particulates at a fairly constant ratio. If local reducing conditions are present, then samples from those areas will have a higher Fe/Al ratio than oxic areas because iron becomes soluble under reducing conditions but aluminum does not. Results can be independently confirmed by evaluating manganese versus aluminum because manganese and iron have similar redox behavior.

All available laboratory and field data are examined to determine if there is a local reducing environment that is driving the dissolution of iron and manganese oxides, as this effect may cause erroneous geochemical evaluation results if this process is not taken into account. Field measurements of oxidation-reduction potential, and concentrations of dissolved oxygen, ferrous iron, and sulfide are useful in identifying natural or contaminant-induced changes in redox conditions that may alter elemental ratios. Data are also evaluated for pH anomalies and the presence of organic contaminants that may alter the geochemical environment.

Ratio Plots. Site samples with a trace element present as a contaminant will exhibit anomalously high trace-versus-major element ratios compared to background trace-versus-major element ratios. These elevated ratios may not

always be apparent in log-log correlation plots, especially at the upper range of concentrations. Therefore, ratio plots – which depict trace element concentrations on the y-axis and trace/major element ratios on the x-axis – are employed in conjunction with correlation plots in those cases where it is not immediately apparent which site samples have anomalously high elemental ratios on the correlation plots. The ratio plots permit easy identification of samples with anomalously high elemental ratios relative to background, and they have high resolution over the entire concentration range.

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APPENDIX I

STREAMLINED HUMAN HEALTH RISK ASSESSMENT

APPENDIX I-1

PRO UCL OUTPUT

General UCL Statistics for Data Sets with Non-Detects (Surface Soil)

User Selected Options	
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

Antimony

General Statistics			
Number of Valid Samples	51	Number of Detected Data	24
Number of Unique Samples	24	Number of Non-Detect Data	27
		Percent Non-Detects	52.94%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.52	Minimum Detected	-0.654
Maximum Detected	1620	Maximum Detected	7.39
Mean of Detected	129.3	Mean of Detected	1.712
SD of Detected	405	SD of Detected	2.248
Minimum Non-Detect	3.4	Minimum Non-Detect	1.224
Maximum Non-Detect	6.9	Maximum Non-Detect	1.932
Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	42
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	9
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	82.35%
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Lilliefors Test Statistic	0.354	Lilliefors Test Statistic	0.859
5% Lilliefors Critical Value	0.916	5% Lilliefors Critical Value	0.916
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	62.12	Mean	1.243
SD	282	SD	1.602
95% DL/2 (t) UCL	128.3	95% H-Stat (DL/2) UCL	23.92
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE yields a negative mean		Mean in Log Scale	0.993
		SD in Log Scale	1.738
		Mean in Original Scale	61.77
		SD in Original Scale	282.1
		95% Percentile Bootstrap UCL	132.5
		95% BCA Bootstrap UCL	165.6
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	0.228	Data do not follow a Discernable Distribution (0.05)	
Theta Star	567.5		
nu star	10.94		
A-D Test Statistic	3.589	Nonparametric Statistics	
5% A-D Critical Value	0.882	Kaplan-Meier (KM) Method	
K-S Test Statistic	0.882	Mean	61.61
5% K-S Critical Value	0.196	SD	279.4
Data not Gamma Distributed at 5% Significance Level		SE of Mean	39.96
		95% KM (t) UCL	128.6
Assuming Gamma Distribution		95% KM (z) UCL	127.3
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	127.8
Minimum	0.52	95% KM (bootstrap t) UCL	1273
Maximum	1620	95% KM (BCA) UCL	141.6
Mean	136.8	95% KM (Percentile Bootstrap) UCL	134
Median	95.28	95% KM (Chebyshev) UCL	235.8
SD	275.9	97.5% KM (Chebyshev) UCL	311.2
k star	0.419	99% KM (Chebyshev) UCL	459.2
Theta star	326.4		
Nu star	42.76	Potential UCLs to Use	
AppChi2	28.76	99% KM (Chebyshev) UCL	459.2
95% Gamma Approximate UCL	203.4		
95% Adjusted Gamma UCL	205.7		

Note: DL/2 is not a recommended method.

Arsenic

General Statistics			
Number of Valid Samples	46	Number of Unique Samples	44
Raw Statistics		Log-transformed Statistics	
Minimum	1.24	Minimum of Log Data	0.215
Maximum	560	Maximum of Log Data	6.328
Mean	19.93	Mean of log Data	1.844
Median	5.5	SD of log Data	1.019
SD	81.78		
Coefficient of Variation	4.103		
Skewness	6.685		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.207	Shapiro Wilk Test Statistic	0.865
Shapiro Wilk Critical Value	0.945	Shapiro Wilk Critical Value	0.945
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	40.18	95% H-UCL	15.21
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	18.53
95% Adjusted-CLT UCL	52.46	97.5% Chebyshev (MVUE) UCL	22.02
95% Modified-t UCL	42.16	99% Chebyshev (MVUE) UCL	28.88
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.525	Data do not follow a Discernable Distribution (0.05)	
Theta Star	37.98		
nu star	48.28		
Approximate Chi Square Value (.05)	33.33	Nonparametric Statistics	
Adjusted Level of Significance	0.0448	95% CLT UCL	39.77
Adjusted Chi Square Value	32.93	95% Jackknife UCL	40.18
		95% Standard Bootstrap UCL	40.04
Anderson-Darling Test Statistic	6.799	95% Bootstrap-t UCL	211
Anderson-Darling 5% Critical Value	0.809	95% Hall's Bootstrap UCL	117.1
Kolmogorov-Smirnov Test Statistic	0.307	95% Percentile Bootstrap UCL	43.95
Kolmogorov-Smirnov 5% Critical Value	0.138	95% BCA Bootstrap UCL	56.73
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	72.49
		97.5% Chebyshev(Mean, Sd) UCL	95.24
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	139.9
95% Approximate Gamma UCL	28.87		
95% Adjusted Gamma UCL	29.22		
Potential UCL to Use		Use 99% Chebyshev (Mean, Sd) UCL	139.9

Copper

General Statistics			
Number of Valid Samples	51	Number of Unique Samples	50
Raw Statistics		Log-transformed Statistics	
Minimum	1.99	Minimum of Log Data	0.688
Maximum	991	Maximum of Log Data	6.899
Mean	80.18	Mean of log Data	3.229
Median	22.3	SD of log Data	1.45
SD	169.1		
Coefficient of Variation	2.108		
Skewness	3.907		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Lilliefors Test Statistic	0.322	Lilliefors Test Statistic	0.12
Lilliefors Critical Value	0.124	Lilliefors Critical Value	0.124
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	119.9	95% H-UCL	128.7
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	150.1
95% Adjusted-CLT UCL	133	97.5% Chebyshev (MVUE) UCL	185
95% Modified-t UCL	122	99% Chebyshev (MVUE) UCL	253.6
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.524	Data appear Lognormal at 5% Significance Level	
Theta Star	153		
nu star	53.45		
Approximate Chi Square Value (.05)	37.66	Nonparametric Statistics	
Adjusted Level of Significance	0.0453	95% CLT UCL	119.1
Adjusted Chi Square Value	37.27	95% Jackknife UCL	119.9
		95% Standard Bootstrap UCL	119.4
Anderson-Darling Test Statistic	2.68	95% Bootstrap-t UCL	156.5
Anderson-Darling 5% Critical Value	0.811	95% Hall's Bootstrap UCL	149.9
Kolmogorov-Smirnov Test Statistic	0.174	95% Percentile Bootstrap UCL	122.7
Kolmogorov-Smirnov 5% Critical Value	0.131	95% BCA Bootstrap UCL	132.1
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	183.4
		97.5% Chebyshev(Mean, Sd) UCL	228
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	315.7
95% Approximate Gamma UCL	113.8		
95% Adjusted Gamma UCL	115		
Potential UCL to Use		Use 95% H-UCL	128.7

Aldrin

General Statistics			
Number of Valid Samples	15	Number of Detected Data	3
Number of Unique Samples	3	Number of Non-Detect Data	12
		Percent Non-Detects	80.00%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0012	Minimum Detected	-6.725
Maximum Detected	0.034	Maximum Detected	-3.381
Mean of Detected	0.0122	Mean of Detected	-5.559
SD of Detected	0.0189	SD of Detected	1.888
Minimum Non-Detect	0.0011	Minimum Non-Detect	-6.812
Maximum Non-Detect	0.0014	Maximum Non-Detect	-6.571
Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	13
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	2
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	86.67%
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.755	Shapiro Wilk Test Statistic	0.784
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.00292	Mean	-7.055
SD	0.0086	SD	1.056
95% DL/2 (t) UCL	0.00683	95% H-Stat (DL/2) UCL	0.00224
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-10.95
		SD in Log Scale	3.308
		Mean in Original Scale	0.00245
		SD in Original Scale	0.00874
		95% Percentile Bootstrap UCL	0.0069
		95% BCA Bootstrap UCL	0.00925
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Lognormal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	0.57	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	0.0034
5% K-S Critical Value	N/A	SD	0.00818
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.00259
		95% KM (t) UCL	0.00796
Assuming Gamma Distribution		95% KM (z) UCL	0.00765
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.00712
Minimum	N/A	95% KM (bootstrap t) UCL	0.384
Maximum	N/A	95% KM (BCA) UCL	N/A
Mean	N/A	95% KM (Percentile Bootstrap) UCL	0.034
Median	N/A	95% KM (Chebyshev) UCL	0.0147
SD	N/A	97.5% KM (Chebyshev) UCL	0.0196
k star	N/A	99% KM (Chebyshev) UCL	0.0291
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	97.5% KM (Chebyshev) UCL	0.0196
95% Gamma Approximate UCL	N/A		
95% Adjusted Gamma UCL	N/A		
Note: DL/2 is not a recommended method.			

Benzo(a)anthracene

General Statistics			
Number of Valid Samples	42	Number of Detected Data	3
Number of Unique Samples	3	Number of Non-Detect Data	39
		Percent Non-Detects	92.86%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.07	Minimum Detected	-2.659
Maximum Detected	0.88	Maximum Detected	-0.128
Mean of Detected	0.345	Mean of Detected	-1.755
SD of Detected	0.464	SD of Detected	1.412
Minimum Non-Detect	0.18	Minimum Non-Detect	-1.715
Maximum Non-Detect	0.235	Maximum Non-Detect	-1.448
Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	41
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	1
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	97.62%
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.763	Shapiro Wilk Test Statistic	0.804
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.117	Mean	-2.266
SD	0.121	SD	0.35
95% DL/2 (t) UCL	0.149	95% H-Stat (DL/2) UCL	0.13
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-2.459
		SD in Log Scale	0.705
		Mean in Original Scale	0.115
		SD in Original Scale	0.134
		95% Percentile Bootstrap UCL	0.151
		95% BCA Bootstrap UCL	0.176
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Lognormal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	0.554	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	0.0961
5% K-S Critical Value	N/A	SD	0.123
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.0239
		95% KM (t) UCL	0.136
Assuming Gamma Distribution		95% KM (z) UCL	0.135
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.132
Minimum	N/A	95% KM (bootstrap t) UCL	0.244
Maximum	N/A	95% KM (BCA) UCL	0.88
Mean	N/A	95% KM (Percentile Bootstrap) UCL	0.88
Median	N/A	95% KM (Chebyshev) UCL	0.2
SD	N/A	97.5% KM (Chebyshev) UCL	0.245
k star	N/A	99% KM (Chebyshev) UCL	0.334
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	95% KM (BCA) UCL	0.88
95% Gamma Approximate UCL	N/A		
95% Adjusted Gamma UCL	N/A		
Note: DL/2 is not a recommended method.			

Benzo(a)pyrene

General Statistics			
Number of Valid Samples	42	Number of Detected Data	3
Number of Unique Samples	3	Number of Non-Detect Data	39
		Percent Non-Detects	92.86%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.073	Minimum Detected	-2.617
Maximum Detected	1.9	Maximum Detected	0.642
Mean of Detected	0.714	Mean of Detected	-1.249
SD of Detected	1.028	SD of Detected	1.691
Minimum Non-Detect	0.18	Minimum Non-Detect	-1.715
Maximum Non-Detect	0.235	Maximum Non-Detect	-1.448
Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	41
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	1
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	97.62%
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.79	Shapiro Wilk Test Statistic	0.928
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.144	Mean	-2.23
SD	0.278	SD	0.469
95% DL/2 (t) UCL	0.216	95% H-Stat (DL/2) UCL	0.144
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	-2.117
		SD in Log Scale	0.865
		Mean in Original Scale	0.189
		SD in Original Scale	0.292
		95% Percentile Bootstrap UCL	0.275
		95% BCA Bootstrap UCL	0.329
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Normal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	0.411	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	0.164
5% K-S Critical Value	N/A	SD	0.275
Data not Gamma Distributed at 5% Significance Level		SE of Mean	0.0656
		95% KM (t) UCL	0.274
Assuming Gamma Distribution		95% KM (z) UCL	0.272
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.296
Minimum	N/A	95% KM (bootstrap t) UCL	0.344
Maximum	N/A	95% KM (BCA) UCL	1.9
Mean	N/A	95% KM (Percentile Bootstrap) UCL	N/A
Median	N/A	95% KM (Chebyshev) UCL	0.45
SD	N/A	97.5% KM (Chebyshev) UCL	0.574
k star	N/A	99% KM (Chebyshev) UCL	0.817
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	95% KM (t) UCL	0.274
95% Gamma Approximate UCL	N/A	95% KM (Percentile Bootstrap) UCL	N/A
95% Adjusted Gamma UCL	N/A		
Note: DL/2 is not a recommended method.			

Dibenz(a,h)anthracene

General Statistics			
Number of Valid Samples	42	Number of Unique Samples	12
Raw Statistics		Log-transformed Statistics	
Minimum	0.18	Minimum of Log Data	-1.715
Maximum	0.41	Maximum of Log Data	-0.892
Mean	0.205	Mean of log Data	-1.597
Median	0.195	SD of log Data	0.132
SD	0.0356		
Coefficient of Variation	0.174		
Skewness	4.913		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.488	Shapiro Wilk Test Statistic	0.609
Shapiro Wilk Critical Value	0.942	Shapiro Wilk Critical Value	0.942
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.214	95% H-UCL	0.212
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.222
95% Adjusted-CLT UCL	0.218	97.5% Chebyshev (MVUE) UCL	0.23
95% Modified-t UCL	0.214	99% Chebyshev (MVUE) UCL	0.246
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	45.83	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.00446		
nu star	3850		
Approximate Chi Square Value (.05)	3707	Nonparametric Statistics	
Adjusted Level of Significance	0.0443	95% CLT UCL	0.214
Adjusted Chi Square Value	3702	95% Jackknife UCL	0.214
		95% Standard Bootstrap UCL	0.213
Anderson-Darling Test Statistic	4.429	95% Bootstrap-t UCL	0.226
Anderson-Darling 5% Critical Value	0.746	95% Hall's Bootstrap UCL	0.25
Kolmogorov-Smirnov Test Statistic	0.234	95% Percentile Bootstrap UCL	0.215
Kolmogorov-Smirnov 5% Critical Value	0.136	95% BCA Bootstrap UCL	0.221
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.228
		97.5% Chebyshev(Mean, Sd) UCL	0.239
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.259
95% Approximate Gamma UCL	0.212		
95% Adjusted Gamma UCL	0.213		
Potential UCL to Use		Use 95% Student's-t UCL	0.214
		or 95% Modified-t UCL	0.214

General UCL Statistics for Full Data Sets in (Subsurface Soil)

User Selected Options			
Full Precision	OFF		
Confidence Coefficient	95%		
Number of Bootstrap Operations			2000

Antimony

General Statistics			
Number of Valid Samples	17	Number of Detected Data	3
Number of Unique Samples	3	Number of Non-Detect Data	14
		Percent Non-Detects	82.35%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.75	Minimum Detected	-0.288
Maximum Detected	76.3	Maximum Detected	4.335
Mean of Detected	26.35	Mean of Detected	1.58
SD of Detected	43.26	SD of Detected	2.435
Minimum Non-Detect	3.3	Minimum Non-Detect	1.194
Maximum Non-Detect	5.95	Maximum Non-Detect	1.783
Note: Data have multiple DLs - Use of KM Method is recommended		Number treated as Non-Detect	16
For all methods (except KM, DL/2, and ROS Methods),		Number treated as Detected	1
Observations < Largest ND are treated as NDs		Single DL Non-Detect Percentage	94.12%
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.762	Shapiro Wilk Test Statistic	0.901
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	6.372	Mean	0.861
SD	18.03	SD	0.954
95% DL/2 (t) UCL	14.01	95% H-Stat (DL/2) UCL	5.249
Maximum Likelihood Estimate(MLE) Method	N/A	Log ROS Method	
MLE method failed to converge properly		Mean in Log Scale	0.502
		SD in Log Scale	1.205
		Mean in Original Scale	6.026
		SD in Original Scale	18.14
		95% Percentile Bootstrap UCL	14.71
		95% BCA Bootstrap UCL	19.49
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Lognormal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	0.45	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	5.782
5% K-S Critical Value	N/A	SD	17.64
Data not Gamma Distributed at 5% Significance Level		SE of Mean	5.261
		95% KM (t) UCL	14.97
Assuming Gamma Distribution		95% KM (z) UCL	14.44
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	13.6
Minimum	N/A	95% KM (bootstrap t) UCL	85.25
Maximum	N/A	95% KM (BCA) UCL	76.3
Mean	N/A	95% KM (Percentile Bootstrap) UCL	N/A
Median	N/A	95% KM (Chebyshev) UCL	28.72
SD	N/A	97.5% KM (Chebyshev) UCL	38.64
k star	N/A	99% KM (Chebyshev) UCL	58.13
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	99% KM (Chebyshev) UCL	58.13
95% Gamma Approximate UCL	N/A		
95% Adjusted Gamma UCL	N/A		

Note: DL/2 is not a recommended method.

Benzo(a)pyrene

General Statistics			
Number of Valid Samples	13	Number of Unique Samples	5
Raw Statistics		Log-transformed Statistics	
Minimum	0.185	Minimum of Log Data	-1.687
Maximum	0.25	Maximum of Log Data	-1.386
Mean	0.197	Mean of log Data	-1.628
Median	0.19	SD of log Data	0.0853
SD	0.0182		
Coefficient of Variation	0.0924		
Skewness	2.364		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.687	Shapiro Wilk Test Statistic	0.716
Shapiro Wilk Critical Value	0.866	Shapiro Wilk Critical Value	0.866
Data not Normal at 5% Significance Level		Data not Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	0.206	95% H-UCL	N/A
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	0.217
95% Adjusted-CLT UCL	0.209	97.5% Chebyshev (MVUE) UCL	0.226
95% Modified-t UCL	0.206	99% Chebyshev (MVUE) UCL	0.243
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	108.7	Data do not follow a Discernable Distribution (0.05)	
Theta Star	0.00181		
nu star	2826		
Approximate Chi Square Value (.05)	2704	Nonparametric Statistics	
Adjusted Level of Significance	0.0301	95% CLT UCL	0.205
Adjusted Chi Square Value	2687	95% Jackknife UCL	0.206
		95% Standard Bootstrap UCL	0.205
Anderson-Darling Test Statistic	1.405	95% Bootstrap-t UCL	0.215
Anderson-Darling 5% Critical Value	0.732	95% Hall's Bootstrap UCL	0.235
Kolmogorov-Smirnov Test Statistic	0.304	95% Percentile Bootstrap UCL	0.206
Kolmogorov-Smirnov 5% Critical Value	0.236	95% BCA Bootstrap UCL	0.208
Data not Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	0.219
		97.5% Chebyshev(Mean, Sd) UCL	0.228
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	0.247
95% Approximate Gamma UCL	0.206		
95% Adjusted Gamma UCL	0.207		
Potential UCL to Use		Use 95% Student's-t UCL	0.206
		or 95% Modified-t UCL	0.206

General UCL Statistics for Data Sets with Non-Detects (Groundwater)

User Selected Options	
Full Precision	OFF
Confidence Coefficient	95%
Number of Bootstrap Operations	2000

2-Nitrotoluene

General Statistics			
Number of Valid Samples	6	Number of Detected Data	3
Number of Unique Samples	3	Number of Non-Detect Data	3
		Percent Non-Detects	50.00%
Raw Statistics		Log-transformed Statistics	
Minimum Detected	0.0012	Minimum Detected	-6.725
Maximum Detected	0.0039	Maximum Detected	-5.547
Mean of Detected	0.0026	Mean of Detected	-6.062
SD of Detected	0.00135	SD of Detected	0.603
Minimum Non-Detect	2.00E-04	Minimum Non-Detect	-8.517
Maximum Non-Detect	2.00E-04	Maximum Non-Detect	-8.517
UCL Statistics			
Normal Distribution Test with Detected Values Only		Lognormal Distribution Test with Detected Values Only	
Shapiro Wilk Test Statistic	0.996	Shapiro Wilk Test Statistic	0.955
5% Shapiro Wilk Critical Value	0.767	5% Shapiro Wilk Critical Value	0.767
Data appear Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
DL/2 Substitution Method		DL/2 Substitution Method	
Mean	0.00135	Mean	-7.636
SD	0.00161	SD	1.766
95% DL/2 (t) UCL	0.00268	95% H-Stat (DL/2) UCL	0.00648
Maximum Likelihood Estimate(MLE) Method		Log ROS Method	
Mean	0.00263	Mean in Log Scale	-7.05
SD	0.0011	SD in Log Scale	1.203
95% MLE (t) UCL	0.00354	Mean in Original Scale	0.00148
95% MLE (Tiku) UCL	0.00391	SD in Original Scale	0.0015
		95% Percentile Bootstrap UCL	0.00246
		95% BCA Bootstrap UCL	0.00255
Gamma Distribution Test with Detected Values Only		Data Distribution Test with Detected Values Only	
k star (bias corrected)	N/A	Data appear Normal at 5% Significance Level	
Theta Star	N/A		
nu star	N/A		
A-D Test Statistic	0.285	Nonparametric Statistics	
5% A-D Critical Value	N/A	Kaplan-Meier (KM) Method	
K-S Test Statistic	N/A	Mean	0.0019
5% K-S Critical Value	N/A	SD	0.00105
Data not Gamma Distributed at 5% Significance Level		SE of Mean	5.24E-04
		95% KM (t) UCL	0.00296
Assuming Gamma Distribution		95% KM (z) UCL	0.00276
Gamma ROS Statistics using Extrapolated Data		95% KM (jackknife) UCL	0.00316
Minimum	N/A	95% KM (bootstrap t) UCL	0.0028
Maximum	N/A	95% KM (BCA) UCL	0.0039
Mean	N/A	95% KM (Percentile Bootstrap) UCL	0.0039
Median	N/A	95% KM (Chebyshev) UCL	0.00419
SD	N/A	97.5% KM (Chebyshev) UCL	0.00517
k star	N/A	99% KM (Chebyshev) UCL	0.00712
Theta star	N/A		
Nu star	N/A	Potential UCLs to Use	
AppChi2	N/A	95% KM (t) UCL	0.00296
95% Gamma Approximate UCL	N/A	95% KM (Percentile Bootstrap) UCL	0.0039
95% Adjusted Gamma UCL	N/A		

Note: DL/2 is not a recommended method.

General UCL Statistics for Data Sets with Non-Detects (Sediment)

User Selected Options			
Full Precision	OFF		
Confidence Coefficient	95%		
Number of Bootstrap Operations	2000		

Arsenic

General Statistics			
Number of Valid Samples	9	Number of Unique Samples	9
Raw Statistics		Log-transformed Statistics	
Minimum	2.1	Minimum of Log Data	0.742
Maximum	38	Maximum of Log Data	3.638
Mean	11.07	Mean of log Data	1.996
Median	7	SD of log Data	0.925
SD	11.81		
Coefficient of Variation	1.067		
Skewness	1.888		
Relevant UCL Statistics			
Normal Distribution Test		Lognormal Distribution Test	
Shapiro Wilk Test Statistic	0.735	Shapiro Wilk Test Statistic	0.945
Shapiro Wilk Critical Value	0.829	Shapiro Wilk Critical Value	0.829
Data not Normal at 5% Significance Level		Data appear Lognormal at 5% Significance Level	
Assuming Normal Distribution		Assuming Lognormal Distribution	
95% Student's-t UCL	18.38	95% H-UCL	31.42
95% UCLs (Adjusted for Skewness)		95% Chebyshev (MVUE) UCL	25.38
95% Adjusted-CLT UCL	20.18	97.5% Chebyshev (MVUE) UCL	31.77
95% Modified-t UCL	18.8	99% Chebyshev (MVUE) UCL	44.31
Gamma Distribution Test		Data Distribution	
k star (bias corrected)	0.987	Data appear Gamma Distributed at 5% Significance Level	
Theta Star	11.21		
nu star	17.77		
Approximate Chi Square Value (.05)	9.222	Nonparametric Statistics	
Adjusted Level of Significance	0.0231	95% CLT UCL	17.54
Adjusted Chi Square Value	7.957	95% Jackknife UCL	18.38
		95% Standard Bootstrap UCL	17.08
Anderson-Darling Test Statistic	0.522	95% Bootstrap-t UCL	38.15
Anderson-Darling 5% Critical Value	0.737	95% Hall's Bootstrap UCL	59.3
Kolmogorov-Smirnov Test Statistic	0.274	95% Percentile Bootstrap UCL	17.71
Kolmogorov-Smirnov 5% Critical Value	0.285	95% BCA Bootstrap UCL	19.82
Data appear Gamma Distributed at 5% Significance Level		95% Chebyshev(Mean, Sd) UCL	28.22
		97.5% Chebyshev(Mean, Sd) UCL	35.64
Assuming Gamma Distribution		99% Chebyshev(Mean, Sd) UCL	50.22
95% Approximate Gamma UCL	21.32		
95% Adjusted Gamma UCL	24.71		
Potential UCL to Use		Use 95% Approximate Gamma UCL	21.32

APPENDIX I-2

SSSL DERIVATION FOR THE INDOOR WORKER

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Memorandum

Date: 24 January 2008
To: FTMC Human Health Risk Assessment File
CC:

From: Paul F. Goetchius, DVM
Senior Toxicologist/Risk Assessor

RE: EXPOSURE SCENARIO AND SITE-SPECIFIC SCREENING LEVELS FOR THE INDOOR WORKER AT FT. McCLELLAN

The Alabama Department of Environmental Management (ADEM) review of several Fort McClellan (FTMC) Remedial Investigation Reports (RI) and the October 2007 meeting held at FTMC to resolve the ADEM comments revealed the need to include an indoor worker as an additional receptor for commercial/industrial exposure to soil. The groundskeeper scenario is currently included to assess the upper bound on long-term exposure to soil, and the construction worker scenario is included to assess the upper bound on more intense but shorter-term exposure. A reasonable exposure domain for a construction worker could be small, reflecting activity (e.g., erecting a building or installing underground utilities) on an area perhaps less than an acre. A reasonable exposure domain for a groundskeeper, on the other hand, could be many acres, and it is generally assumed that an entire parcel or site under investigation comprises a single exposure domain for the groundskeeper. The indoor worker receptor is introduced as a plausible scenario for evaluating long-term exposure to a smaller exposure domain, since an indoor worker may be expected to occupy a single building or a small cluster of buildings on a campus.

The indoor worker proposed by EPA (2002) serves as the primary guidance for the indoor worker receptor scenario developed herein. Although the environmental medium of concern is soil, exposure to groundwater hypothetically developed as a potable source is included to permit estimating cumulative risk across all plausible exposure media.

The indoor worker is assumed to be a 70-kg adult with an expected lifetime of 70 years (25550 days) who works on site 250 days per year for 25 years (EPA, 2002). His soil incidental ingestion rate is assumed to be 50 mg/day. Dermal exposure and inhalation exposure to fugitive dust are assumed to be toxicologically insignificant. EPA (2002) recommends for the indoor worker using the same exposure assumptions for drinking water consumption that are used for residential exposure to cover for the potential for contaminated groundwater to migrate off site into nearby residential areas. At FTMC, however, the potential for off-site migration of groundwater is addressed by the future residential scenario, which evaluates exposure to groundwater hypothetically developed as a

potable source. Therefore, the EPA (1991) recommendation for drinking water consumption for site workers of 1 L/day is adopted for this evaluation. The exposure assumptions for the indoor worker are summarized below:

Exposure Variable	Value
Body weight (BW) (kg)	70
Exposure frequency (EF) (days/year)	250
Exposure duration (ED) (years)	25
Soil incidental ingestion rate (IRso) (mg/day)	50
Fraction exposed to contaminated soil (FIso) (unitless)	1
Drinking water consumption rate (DW) (L/day)	1
Fraction exposed to contaminated groundwater (FIgw) (unitless)	1
Averaging time, cancer risk (ATc) (days)	25550
Averaging time, noncancer effects (ATn) (days)	9125

The equations for estimating SSSLs for exposure to chemicals in soil are, based on cancer risk:

$$SSSL_{SLIWc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{IRso \bullet SFo} \qquad \text{Eq. 1}$$

and based on noncancer hazard:

$$SSSL_{SLIWn} = \frac{THQ \bullet BW \bullet ATn \bullet (1/FIso) \bullet (1/EF) \bullet (1/ED) \bullet CF1}{IRso / RfDo} \qquad \text{Eq. 2}$$

where, based on cancer risk:

$SSSL_{SLIWc}$ = cancer-based site-specific screening level for soil, indoor worker (mg/kg, calculated)
TR = target cancer risk (unitless, 1E-6)
BW = body weight (kg)
ATc = averaging time for cancer risk (25550 days)
FIso = fraction exposed to contaminated soil (unitless,1)
EF = exposure frequency (250 days/year)
ED = exposure duration (25 years)
CF1 = conversion factor (1E+6 mg/kg)
IRso = soil incidental ingestion rate (50 mg/day)
SFo = oral cancer slope factor (per mg/kg-day),

and additional variables based on noncancer hazard:

$SSSL_{SLIWn}$ = noncancer-based site-specific screening level for soil, indoor worker (mg/kg, calculated)
THQ = target hazard quotient (unitless, 1)
ATn = averaging time for noncancer hazard (9125 days)
RfDo = oral reference dose (mg/kg-day).

The equations for estimating SSSLs for exposure to chemicals in groundwater hypothetically developed as a source of drinking water are, based on cancer risk:

$$SSSL_{GWIWc} = \frac{TR \bullet BW \bullet ATc \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{DW \bullet SFo} \qquad \text{Eq. 3}$$

and based on noncancer hazard:

$$SSSL_{GWIWn} = \frac{THQ \bullet BW \bullet ATn \bullet (1/FIgw) \bullet (1/EF) \bullet (1/ED)}{DW / RfDo} \qquad \text{Eq. 4}$$

where, variables not defined above, based on cancer risk:

$SSSL_{GWIWc}$= cancer-based site-specific screening level for groundwater, indoor worker (mg/L, calculated)
FIgw = fraction exposed to contaminated groundwater (unitless,1)
DW = drinking water consumption rate (1 L/day),

and additional variables not defined above based on noncancer hazard:

$SSSL_{GWIWn}$= noncancer-based site-specific screening level for groundwater, indoor worker (mg/L, calculated).

Equations 1 through 4 pertain to chemicals other than lead.

The ADEM comments mentioned in Section 1.0 include the request to revise the cleanup level for lead in soil for the groundskeeper and construction worker from 880 mg/kg to 800 mg/kg. Since the indoor worker evaluation would accompany but not substitute for the groundskeeper and construction worker evaluations, and since the groundskeeper and construction worker are both more intensely exposed to soil, the cleanup level for lead in soil of 800 mg/kg is adopted as sufficiently protective for the indoor worker.

The EPA (2006) action level for lead in drinking water of 1.5E-2 mg/L is adopted as the cleanup level for lead in groundwater hypothetically developed as a potable source.

References

U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

U.S. Environmental Protection Agency (EPA), 1991, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual Supplemental Guidance, Standard Default Exposure Factors***, Interim Final, Office of Solid Waste and Emergency Response, OSWER Directive: 9285.6-03.

APPENDIX I-3

UPDATED SSSLs

Appendix I-3

T-24A Ranges RI

Comments that have been resolved:
1,2,3,5,8,10,11,14,16,18,19,20,22,24,26,27,29,30,35,38,39,41,42,44,46,47,49,51,52,53, 54,55,56,57,58,59,61,62,63,64,66,67,68,70,71,72,76,79,80,85,86,87,92,95,98,99,100,101, 102,104,105,106,107,108,109,111,114,115,116,117,118,119,120,122,123

Please add the responses from these comments to the text:
21,23,28,36,37,40,82,110,112,113,124,125

Evaluation of responses for unresolved comments:

Comment 75: **<u>Page 6-1, Section 6.0</u>. In addition to a review of toxicity data to ensure that values are up-to-date, exposure parameter assumptions used to calculate SSSLs should be updated to reflect current guidance. Significant changes have been made since the 1992 references with respect to dermal guidance. The most current United States Environmental Protection Agency (USEPA) recommended values for parameters, including but not limited to skin surface area (SA) and adherence factors (AFs), should be used. For example, the current guidance recommends the use of an AF of 0.2 mg/cm^2 for a child, yet an AF of 0.07 mg/cm^2 was assumed for a resident. Also, an SA of 1,800 cm^2 was assumed for the child residential receptor, but the current USEPA-recommended value is 2,800 cm^2. Please update all exposure parameters to reflect current guidance for all receptors. Also, SSSLs do not address vapor intrusion from groundwater into overlying structures. Please address this exposure pathway in the risk assessment for future residential and commercial exposure scenarios.**

Response 75: It must be remembered that the SSSLs are *site-specific* screening levels, and as such reflect agreement regarding exposure variables between ADEM, EPA Region 4 and the Army as documented in the approved installation-wide work plan. For example, the AF of 0.07 mg/cm^2 for the resident was specifically requested by the EPA reviewer. Agreed, however, that the EPA (2004) model for dermal uptake from water has been revised. The SSSLs have been revised to incorporate the newer EPA (2004) model.

Agree that the SSSLs do not address vapor intrusion into overlying buildings. The protocol for vapor intrusion evaluation approved by ADEM and EPA Region 4 for Redstone Arsenal (RSA) will be adapted to FTMC. Adaptation will involve substituting site-specific soil physical characteristics if available for those specific to RSA; otherwise, model defaults will be used.

Reference:

U.S. Environmental Protection Agency (EPA), 2004b, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, July, including errata @ http://www.epa.gov/oswer/riskassessment/ragse/index.htm accessed 18 October 2007.

Evaluation: *ADEM requests the use of current guidance values unless site-specific data is available that supports the use of a different value. In order to protect public health and the environment, as guidances are updated, the SSSLs and risk assessment methodology should also be updated. Just as the SSSLs were revised to address the revision to the model for dermal uptake from water, the soil SSSLs should be revised to incorporate the most current recommended input parameter values.*

Response to Evaluation: Agreed; the variables for exposure to soil will be revised to reflect the latest guidance, which is EPA (2002) Supplemental SSL guidance and the EPA (2004) dermal guidance. Accordingly, the following will change:

- **Resident:** AF for the child will be changed from 0.07 to 0.2 mg/cm^2, and SA for the child will be changed from 1800 to 2800 cm^2. SA for the adult will change from 5250 cm^2 to 5700 cm^2. The changes in SA and AF necessitate changing the age-adjusted dermal factor from 2520 cm^2-years/kg-day to 360 mg-year/kg-day as per the 2002 Supplemental SSL guidance. Equation 5.7 of the August 1998 final Installation-Wide Work Plan, the derivation of the cancer-based SSSL for residential soil, will be revised to accommodate these changes as follows:

$$SSSL_{SLRESc} = \frac{TR \bullet ATc \bullet (1/FIso) \bullet (1/EF) \bullet CF1}{(IFadj \bullet SFo) + (DSadj \bullet ABS \bullet SFd)}$$

where:

$SSSL_{SLRESc}$	=	cancer-based site-specific screening level for soil, resident (mg/kg, calculated)
TR	=	target cancer risk (unitless, 1E-6)
ATc	=	averaging time, cancer (days)
FIso	=	fraction exposed to contaminated medium (unitless)
EF	=	exposure frequency (days/year)
CF1	=	conversion factor 1E+6 mg/kg)
IF adj	=	age-adjusted soil incidental ingestion factor (mg-years//kg-day)
SFo	=	oral cancer slope factor (per mg/kg-day)
DSadj	=	age-adjusted soil dermal uptake factor (mg-years/kg-day, assuming one event per day)

ABS = dermal absorption factor (unitless)
SFd = dermal cancer slope factor (per mg/kg-day).

- **Groundskeeper (see outdoor worker in SSL Supplemental Guidance):** EF for the groundskeeper will be changed from 250 to 225 days/year, AF will be changed from 0.01 to 0.2 mg/cm^2, and SA will be changed from 5250 to 3300 cm^2.

- **Construction worker:** Soil incidental ingestion will change from 200 mg/day to 330 mg/day, AF will change from 0.1 to 0.3 mg/cm^2, and SA will be changed from 5250 to 3300 cm^2.

The other receptor scenarios (e.g., residential site user, highway worker, National Guardsperson) were developed as site-specific receptors to capture the specific characteristics and designated future uses of the FTMC facility. Furthermore, no ADEM or EPA guidance currently exists for these scenarios. Therefore, the exposure assumptions for these receptors will not be revised.

In addition, ABS and GAF were updated according to the 2004 dermal guidance. Also, Kp, FA and tau were updated to reflect the 2004 dermal guidance values for uptake for water. When data were not available values for the water uptake parameters were calculated from the 2004 guidance methodology, using MW and log K_{ow} values from EPA (2007). For simplicity it was assumed that steady state was not reached.

References:

U.S. Environmental Protection Agency (EPA), 2007, ***Estimation Program Interface (EPI) Suite Version 3.20***, Software for estimating physical properties, February, available at http://www.epa.gov/oppt/exposure/pubs/episuitedl.htm.

U.S. Environmental Protection Agency (EPA), 2004, ***Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Final***, Office of Superfund Remediation and Technology Innovation, Washington, DC, EPA/540/R/99/005, OSWER 9285.7-02EP, July, including errata @ http://www.epa.gov/oswer/riskassessment/ragse/index.htm accessed 18 October 2007.

U.S. Environmental Protection Agency (EPA), 2002, ***Supplemental Guidance for Developing Soil Screening Levels for Superfund Sites***, Office of Solid Waste and Emergency Response, OSWER 9355.4-24, December.

APPENDIX I-4

CLEANUP LEVEL FOR LEAD IN SURFACE WATER

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Memorandum

Date: 31 March 2009
To: FTMC Human Health Risk Assessment File
CC:

From: Paul F. Goetchius, DVM
Senior Toxicologist/Risk Assessor

RE: HUMAN HEALTH RISK ASSESSMENT ISSUES FOR FORT McCLELLAN

Alabama Department of Environmental Management (ADEM) review of several Remedial Investigation Reports (RI) for Fort McClellan (FTMC) generated several similar comments on the Streamlined Risk Assessments (SRA) contained therein. The resolution of these comments during the October 2007 meeting at FTMC requires several changes to the SRAs.

Please note: a memo with the same title as above was written on 4 March 2008 addressing all the issues that require revisions to the SRAs, as follows:

- *Include an indoor worker as an additional receptor. This issue is addressed in Appendix J-1 of the RI report.*

- *Include a young child recreational site user as an additional receptor. Discussion during a 12-13 December 2008 meeting concluded that this receptor was not necessary if it is clarified that the youth recreational site user would be more highly exposed than the young child. Clarification to this effect was added to the introductory material in Section 6.0.*

- *Use the Integrated Exposure Uptake Biokinetic blood lead model (IEUBK) to develop a cleanup level for lead in soil for the young child recreational site user. This is no longer relevant; please see previous bullet.*

- *Use the IEUBK to develop a cleanup level for lead in surface water for the young child recreational site user. Please see previous bullet; a cleanup level for lead in surface water was not developed for the young child recreational site user. However, the adult blood lead model (ABLM) was used to develop a cleanup level for lead in surface water for the youth recreational site user.*

This memo is a contraction of the 4 March 2008 memo limited to the development of a cleanup level for lead in surface water for the youth recreational site user.

Develop a Cleanup Level for Lead in Surface Water for Recreational Site User

Originally the Army had developed a cleanup level for the *youth* recreational site user by adjusting the tap water action level for lead to reflect the differences in exposure between residential consumption of tap water and the youth recreational site user consumption of surface water. ADEM determined that the method of adjustment was inappropriate, and requested that the IEUBK be used to develop a cleanup level for lead in surface water for the *young child* recreational site user. However, as discussed above, there is no plausible pathway by which the young child recreational site user would be exposed to surface water by ingestion. Therefore, the IEUBK cannot be used to develop a cleanup level for lead in surface water for the young child recreational site user.

EPA (2003a), however, provides sufficient guidance for estimation of a cleanup level for lead in surface water for the *youth* recreational site user. EPA (2003a) notes that the Adult Blood Lead Model (ALM) (EPA, 2003b) can be applied to this age group.

The ALM consists of several algorithms that can be used, modified or rearranged to accomplish any of several purposes. Equation 1 of the ALM is intended to estimate the central tendency blood lead concentration of a female adult of child-bearing age ($PbB_{Y,CT}$) resulting from exposure to lead in soil at a secondary location (e.g., work place), in addition to the contribution to blood lead from background sources (e.g., residence). Modifying the ALM to estimate a cleanup level for lead in surface water involves the following:

- Add another term to the ALM to reflect the contribution to blood lead from ingestion exposure to surface water during recreational site use.

- Locate a more receptor-specific central-tendency estimate of background blood lead concentration than the default provided by EPA (2003b) to reflect the contribution to blood lead from exposure at the residence and other background sources.

- Choose appropriate reasonable maximum exposure (RME) values for the exposure terms in the model so that these terms reasonably reflect the contribution to blood lead from exposure to site soil and surface water during recreational site use.

It is necessary in this exercise to preserve an RME approach to managing uncertainty, which is to say that the final estimate should reflect the maximum exposure that the receptor may reasonably be expected to experience, theoretically the 90th to 95th percentile on exposure, but not the worst case (EPA, 1989, 1991, 1993). EPA (1989, 1991) generally recommends that this is accomplished by choosing reasonable high-end values for exposure concentration, ingestion or contact rate, and exposure frequency, while choosing central tendency values for the other variables included in an exposure equation. Choosing unnecessarily high values for the central tendency variables will cause the final result to exceed the intent of the RME and to become

unnecessarily restrictive. The use of the ALM for this purpose is particularly susceptible to this problem for the following reasons:

- There are more variables multiplied together in the exposure terms of the ALM than in most risk models, providing more opportunities for concatenation – i.e., to multiplicatively inflate the final result beyond the intent of the RME. The problem is exacerbated in this case because the surface water term added to the model to address simultaneous exposure to soil and surface water repeats the high-end exposure assumptions applied to soil ingestion (e.g., ingestion rate and EF – see Equation 3).

- The cleanup level for lead in soil of 6500 mg/kg (EPA, 2003c) is selected as the concentration of lead in soil for determining a cleanup level for surface water. This implies that the recreational site user is continually exposed to soil containing lead at 6500 mg/kg, which will almost invariably be greater than the 90th to 95th percentile on exposure intended by the RME approach. Data are not available with which to refine this value to reflect an average concentration of lead in soil, which would be the appropriate RME value to use. Because this level of exposure is very unlikely, it imparts a strongly conservative bias to the ALM in the development of a cleanup level for surface water.

As explained by Cogliano (1997), the summation of multiple RME terms, as in this effort to develop a cleanup level for lead in surface water, yields final results that are often totally implausible. For this reason, each variable in the ALM must be scrutinized carefully and refined where possible.

Equation 3 in EPA (2003b) can be adapted to estimate a safe or goal blood lead concentration for a youth based on the interrelationships between maternal blood lead levels, background exposure and fetal blood lead level, assuming similarities between youth and adults, as follows:

$$PbB_{Y,CTg} = \frac{PbB_{F,g}}{GSD_{i,A}^{SND} \bullet R} \qquad \text{Eq. 1}$$

where:

$PbB_{Y,CTg}$ = blood lead concentration, youth, central tendency, goal (µg/dL)
$PbB_{F,g}$ = blood lead concentration, fetus, 95th percentile, goal (10 µg/dL [EPA, 2003b])
$GSD_{i,A}$ = geometric standard deviation of blood lead concentrations within a similarly exposed population (1.7 unitless, see below)
SND = standard normal deviate to estimate 95th percentile blood lead concentration from lognormal distribution of blood lead concentrations (1.654 unitless [EPA, 2003b])
R = proportionality constant between maternal and fetal blood lead concentrations at birth (0.9 unitless [EPA, 2003b]).

It is assumed that the $GSD_{i,A}$ for a youth would be the comparable to that for an adult. The $GSD_{i,A}$ reflects the variation between individuals exposed to the same levels of lead in media at the site. EPA (2003b) recommends a value of 2.2 for a very heterogeneous population, such as might be experienced by adults of both sexes over a wide geographic area included in a national survey. They note, however, that $GSD_{i,A}$ values of 1.6 to 1.8 are more typical for a somewhat more homogeneous population, such as adult women exposed predominantly to a single source (e.g., a waste site or active mine site). The latter seems more relevant to recreational site use at FTMC – the population of concern is young women exposed simultaneously to surface water and soil at a given site. EPA (2003b) recommends a value for $GSD_{i,A}$ of 1.8, the upper end of the range, as a default value for a more homogeneous population. Given the unusually high conservatism imparted by the assumed soil concentration of 6500 mg/kg, the midpoint of the range for the homogeneous population, 1.7, is chosen as the $GSD_{i,A}$ for this evaluation.

From the foregoing, a value for $PbB_{Y,CTg}$ can be estimated as follows:

$$PbB_{Y,CTg} = \frac{10}{1.7^{1.645} \bullet 0.9} = 4.64 \qquad \text{Eq. 2}$$

Equation 1 of the ALM relates $PbB_{Y,CT}$ to background exposures integrated with secondary exposure to lead in soil at another location (e.g., recreational site). Assuming similarity between youth and adults, the model can be applied to a youth recreational site user to relate $PbB_{Y,CT}$ to background exposures and lead in soil at an FTMC site during recreational site use. Equation 1 can also be modified to integrate other sources of exposure to lead provided the requisite exposure and biokinetic variable values are available or can be reasonably estimated. For the purpose of this exercise, exposure to surface water is included, and Equation 1 of the ALM is modified as follows:

$$PbB_{Y,CT} = PbB_{Y,B} + \left(\frac{PbS \bullet BKSF \bullet GAFs \bullet IRso \bullet FIso \bullet EF}{T \bullet CF3} \right) + \left(\frac{PbW \bullet BKSF \bullet GAFw \bullet IRsw \bullet EF}{T} \right) \qquad \text{Eq. 3}$$

where:

$PbB_{Y,CT}$	=	blood lead concentration, youth, central tendency (µg/dL)
$PbB_{Y,B}$	=	blood lead concentration, youth, central tendency, from background exposures (1.0 µg/dL, see below)
PbS	=	concentration of lead in site soil (6500 mg/kg [µg/g], see above)

BKSF	=	biokinetic slope factor: increase in blood lead concentration per unit increase in systemic lead uptake (0.4 µg/dL per µg/day, see below)
GAFs	=	gastrointestinal (GI) absorption fraction for ingested lead in soil and dust (unitless, see below)
IRso	=	soil incidental ingestion rate (100 mg/day, Text Table 2)
FIso	=	fraction exposed to contaminated soil (0.25, Text Table 2)
EF	=	exposure frequency (104 days/year, Text Table 2)
T	=	assumed averaging time (365 days/year)
CF3	=	conversion factor (1E+3 mg/g)
PbW	=	concentration of lead in surface water (µg/L)
GAFw	=	GI absorption fraction for ingested lead in surface water (unitless, see below)
IRsw	=	surface water consumption rate (1 L/day, Text Table 2).

EPA (2003b) provides a default range for adult background blood levels of 1.7 to 2.2 µg/dL. More recent data show that blood lead levels in youth are generally somewhat lower than those in adults, and values in females, the more sensitive members of the population, are generally lower than those in males (CDC, 2005). Also, blood lead levels in the general population have been decreasing since the data on which EPA (2003b) based their recommendations were published in 1994. Therefore, the value for $PbB_{Y,B}$ of 1.0 µg/dL, the geometric mean for 3125 female subjects, age 6 through 19 years, including whites, blacks and Mexican-Americans, measured during 1999 to 2002 (CDC, 2005), is considered more timely and relevant, and is adopted for this exercise.

BKSF, the relationship of blood lead concentration to lead uptake, physiologically operates independently from the extent of GI absorption (GAF). However, a default value for BKSF was extrapolated from the interplay of BKSF and assumptions regarding GAF because the former is extremely difficult to measure independently. Based on the blood lead levels measured in adult males and assumptions regarding the uptake of lead from water, EPA (2003b) estimated values for BKSF ranging from 0.36 to 0.45 µg/dL per µg/day. Bowers et al. (1994) applied different assumptions to the same data set and estimated a value for BKSF of 0.375 µg/dL per µg/day.

EPA (2003b) recommends a default value for BKSF of 0.4 µg/dL per µg/day as being within the range they calculated from the study in male adults and as being consistent with the value estimated by Bowers et al. (1994) from the same data. Females generally have lower blood lead levels than males at all age ranges (CDC, 2005); however, the reason is unclear. Possibilities include differences in ingestion rate, particularly when normalized to BW, the extent of GI absorption, or gender-specific differences in BKSF. Given the uncertainty about a more realistic value for BKSF, the EPA (2003b) default value of 0.4 µg/dL per µg/day will be used in this exercise. However, to compensate for the inability to refine BKSF, an effort will be made to refine GAF beyond the default provided by EPA (2003b).

A large amount of literature, some of which has been reviewed by EPA (2003b) and Bowers et al. (1994) indicates a great amount of variation in the GI absorption of lead. Possibly the most recent and comprehensive synthesis of the available data is the Agency for Toxic Substances and Disease Registry (ATSDR) *Toxicological Profile for Lead* (ATSDR, 2007). EPA (2003b) bases

their recommendation for GAFs on measurements of GAFw and application of a relative bioavailability factor (RBF) to reflect the lesser absorption of lead from soil compared with water. Therefore, GAFw is discussed before GAFs.

GI absorption of water-soluble forms of lead ranges from 3 to approximately 60 percent, depending largely on age and physiological state (i.e., eating or fasting), but also on several other factors (ATSDR, 2007). The very young absorb lead more efficiently (absolute values of 40 to 50 percent) than adults (absolute values of 3 to 10 percent); however, the data suggest that children upwards of 6 years old absorb lead to the same extent as adults. The presence of food in the GI tract reduces the absorption of water-soluble forms of lead; uptake is greatest (up to approximately 60 percent) following an extended fast, and least (approximately 2 to 10 percent [Bowers et al., 1994]) when lead is administered during a meal. Most youth recreational site users probably will not consume meals while on site; however, neither will they be participating in an extended fast.

Probably the most defensible and accurate study of GI absorption comes from a series of toxicokinetic studies in rats reviewed by ATSDR (2007). In these studies, a GAFw of 0.15 was estimated by comparing blood lead concentrations following oral and intravenous administration of lead acetate, which is highly soluble in water.

Recommendations for GAFw for the ALM vary. EPA (2003b) recommends a GAFw of 0.2, a weight-of-evidence determination to account for variation in food intake, lead intake, lead form and particle size. O'Flaherty (1993) recommends 8 percent (0.08) as a reasonable value for GI absorption of lead from food and water that works well for predicting blood lead levels. Bowers (1997) reviewed the literature and estimated a time-weighted average over a day (i.e., lead administered during and at various times before and after a meal) of 11 to 12 percent (GAFw of 0.11 to 0.12). Bowers (1997) recommended a range of 8 to 12 percent to the Georgia Industry Environmental Coalition for use in the Georgia Adult Lead Model (GALM) (GA EPD, 2007). (The GALM is essentially identical to the EPA [2003b] ALM but includes an additional term for drinking water consumption.) The default GAFw in the GALM is 0.2, which is the same as the EPA (2003b) default. A GAFw of 0.15, the value derived from the toxicokinetic study in rats, is chosen for this evaluation as being based on the most defensible methodology for determining GI uptake and generally consistent with the various recommendations described in this paragraph.

As stated above, EPA (2003b) based their recommendation for GAFs on the application of an RBF to the GAFw. EPA (2003b) reviewed studies of RBF as follows:

- The RBF of lead in soil from a mining area compared with soluble lead in immature swine was 0.6 to 0.8.

- The RBF of lead from a large variety of soils from mining sites and smelters compared with soluble lead in adult rats ranged from 0.09 to 0.4.

- An RBF of 0.5 was estimated from a study in which 6 fasted human volunteers were given a single dose of lead-contaminated soil.

The usefulness of the foregoing studies is limited by lack of experimental detail; i.e., it is uncertain how GI absorption was estimated and how the RBF was estimated. Furthermore, the usefulness of the study in humans is compromised because youth recreational site users are unlikely to be participating on a regular basis in an extended fast.

Probably the best estimates of RBF are those from the toxicokinetic studies in rats reviewed by ATSDR (2007) mentioned above on which the GAFw was based. In these studies, soil samples containing mine waste providing lead at concentrations of 1.62, 4.05, 19.5 or 78.2 mg/kg were fed to rats for 30 days. Blood lead levels were measured and compared with those obtained from oral administration of lead acetate. RBFs varied from 0.121 to 0.268 with an average of approximately 0.18. There appeared to be no gender-specific differences, but statistical analysis was not reported by ATSDR (2007). The average RBF of 0.18 multiplied by the GAFw of 0.15 defended above yields a GAFs of 0.03, which is adopted for this exercise.

Substitution of the documented variable values defended above in Equation 3 allows simplification as follows:

$$PbB_{Y,CT} = 1.0 + \left(\frac{6500 \bullet 0.4 \bullet 0.03 \bullet 100 \bullet 0.25 \bullet 104}{365 \bullet 1000}\right) + \left(\frac{PbW \bullet 0.4 \bullet 0.15 \bullet 1 \bullet 104}{365}\right) \quad \text{Eq. 4}$$

$$PbB_{Y,CT} = 1.0 + 0.556 + PbW \bullet 0.017 \quad \text{Eq. 5}$$

Substituting the value for $PbB_{Y,CTg}$ of 4.64 µg/dL for $PbB_{Y,CT}$ and rearranging Equation 5 permits solving for PbW as follows:

$$4.64 = 1.556 + PbW \bullet 0.017 \quad \text{Eq. 6}$$

$$PbW = 3.08 / 0.017 = 181 \mu g/L$$

Rounded to two significant figures, the cleanup level for lead in surface water for the recreational site user is 180 µg/L.

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LEAD MODEL FOR WINDOWS Version 1.0

==========

Model Version: 1.0 Build 264
User Name:
Date:
Site Name:
Operable Unit:
Run Mode: Research

==========

The time step used in this model run: 1 - Every 4 Hours (6 times a day).

****** Air ******

Indoor Air Pb Concentration: 30.000 percent of outdoor.
Other Air Parameters:

Age	Time Outdoors (hours)	Ventilation Rate (m^3/day)	Lung Absorption (%)	Outdoor Air Pb Conc (ug Pb/m^3)
.5-1	1.000	2.000	32.000	0.100
1-2	2.000	3.000	32.000	0.100
2-3	3.000	5.000	32.000	0.100
3-4	4.000	5.000	32.000	0.100
4-5	4.000	5.000	32.000	0.100
5-6	4.000	7.000	32.000	0.100
6-7	4.000	7.000	32.000	0.100

****** Diet ******

Age	Diet Intake(ug/day)
.5-1	3.160
1-2	2.600
2-3	2.870
3-4	2.740
4-5	2.610
5-6	2.740
6-7	2.990

****** Drinking Water ******

Water Consumption:

Age	Water (L/day)
.5-1	0.200
1-2	0.500
2-3	0.520
3-4	0.530
4-5	0.550
5-6	0.580
6-7	0.590

Drinking Water Concentration: 4.000 ug Pb/L

****** Soil & Dust ******

Multiple Source Analysis Used
Average multiple source concentration: 290.000 ug/g

Mass fraction of outdoor soil to indoor dust conversion factor: 0.700
Outdoor airborne lead to indoor household dust lead concentration: 100.000
Use alternate indoor dust Pb sources? No

Age	Soil (ug Pb/g)	House Dust (ug Pb/g)
.5-1	400.000	290.000
1-2	400.000	290.000
2-3	400.000	290.000
3-4	400.000	290.000
4-5	400.000	290.000
5-6	400.000	290.000
6-7	400.000	290.000

****** Alternate Intake ******

Age	Alternate (ug Pb/day)
.5-1	0.000
1-2	0.000
2-3	0.000
3-4	0.000
4-5	0.000
5-6	0.000
6-7	0.000

****** Maternal Contribution: Infant Model ******

Maternal Blood Concentration: 2.500 ug Pb/dL

****
CALCULATED BLOOD LEAD AND LEAD UPTAKES:
****

Year	Air (ug/day)	Diet (ug/day)	Alternate (ug/day)	Water (ug/day)
.5-1	0.021	1.416	0.000	0.358
1-2	0.034	1.146	0.000	0.882
2-3	0.062	1.286	0.000	0.932
3-4	0.067	1.247	0.000	0.965
4-5	0.067	1.223	0.000	1.031
5-6	0.093	1.298	0.000	1.099
6-7	0.093	1.425	0.000	1.124

Year	Soil+Dust (ug/day)	Total (ug/day)	Blood (ug/dL)
.5-1	7.758	9.554	5.1
1-2	12.126	14.189	5.8
2-3	12.325	14.605	5.4
3-4	12.511	14.789	5.2
4-5	9.545	11.865	4.2
5-6	8.685	11.175	3.6
6-7	8.250	10.892	3.2

Geo Mean = 4.611
GSD = 1.600
% Above = 4.978

APPENDIX J

BASELINE ECOLOGICAL RISK ASSESSMENT FOR IRON MOUNTAIN AND BAINS GAP ROAD RANGES

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List of Acronyms

AET	apparent effects threshold
asl	above sea level
ASTM	American Society for Testing and Materials
AUF	area use factor
B	both locations
BAF	bioaccumulation factor
BERA	Baseline Ecological Risk Assessment
BGR	Bains Gap Road
BTV	background threshold value
CL	community loss
COPC	constituents of potential ecological concern
CPOM	course particulate organic matter
DQO	data quality objective
EPA	U.S. Environmental Protection Agency
EPT	Ephemeroptera, Plecoptera and Trichoptera
ESV	ecological screening value
FBI	Family Biotic Index
FTMC	Fort McClellan
HQ	hazard quotient
I	impact location
IMR	Iron Mountain Road
IT	IT Corporation
kg/kg/day	kilogram per kilogram per day
L/kg/day	liters per kilogram per day
LOEC	lowest observable effect concentration
MDCC	maximum detected constituent concentration
mg/kg	milligrams per kilogram
mg/kg-day	milligrams per kilogram per day
mg/L	milligrams per liter
mm	millimeter
NOAEL	no-observed-adverse-effects-level
NOEC	no observable effect concentration
R	reference location

List of Acronyms *(Continued)*

RBRG	risk-based remedial goal
Shaw	Shaw Environmental, Inc.
SINA	Special Interest Natural Area
SLERA	Screening-Level Ecological Risk Assessment
USACE	U.S. Army Corps of Engineers
USFWS	U.S Fish and Wildlife Service

1.0 Introduction

This Baseline Ecological Risk Assessment (BERA) utilizes the results of the Screening Level Ecological Risk Assessments (SLERA) conducted for the Iron Mountain Road (IMR) and Bains Gap Road (BGR) ranges at Fort McClellan (FTMC) (IT Corporation [IT], April 2002a and May 2002b) and builds upon the information presented in the Problem Formulation and Study Design reports for these two groups of small arms ranges (Shaw Environmental, Inc. [Shaw], November 2002a and b and April 2003). The methods used in this BERA are consistent with the guidelines set forth in U.S. Environmental Protection Agency's (EPA) *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments* (EPA, 1997) and *Amended Guidance on Ecological Risk Assessment at Military Bases: Process Considerations, Timing of Activities, and Inclusion of Stakeholders* (EPA Region 4, 2000).

2.0 Screening-Level Ecological Risk Assessment Summary

SLERAs were completed for both the IMR and BGR ranges. The SLERAs for these two groups of small arms ranges indicated that constituents of potential ecological concern were present in one or more environmental media at these sites. The following sections summarize the findings of the SLERAs completed at the IMR and BGR ranges.

2.1 Environmental Setting at the Iron Mountain Road Ranges

The terrestrial habitat at the IMR ranges fall into two general categories: "cleared" areas and forested areas. The cleared areas are those areas that were formerly maintained as lawns or mowed fields. Since maintenance activities have ceased in these areas, pioneer species are now colonizing these ranges. Typically, the species most likely to colonize these areas are the "weed" species that tend to be vigorous pioneer plants that grow and spread rapidly. The first of the pioneer species to invade these abandoned areas are the grasses and herbaceous species. These formerly maintained grassy areas are classified as being in an early old field successional state. Over time, the grass and herbaceous species will be followed by shrubs and small trees. The early old field successional areas at the IMR ranges are dominated by various grasses and herbs, including dock *(Rumex spp.)*, clover *(Trifolium spp.)*, vetch *(Astragalus spp.)*, milkweed *(Ascelepias spp.)*, bed straw *(Galium spp.)*, ox-eye daisy *(Chrysanthemum leucanthemum)*, and Johnson grass *(Sorghum halepense)*. Other old field herbaceous species occurring at the IMR ranges are black raspberry *(Rubus occidentalis)*, poison ivy *(Toxicodendron radicans)*, smooth sumac (*Rhus glabra)*, green briar (*Smilax rotundiflora)*, Japanese honeysuckle *(Lonicera japonica)*, fox grape *(Vitus labrusca)*, and multifloral rose *(Rosa multiflora)*.

The forested areas outside of the cleared areas are best characterized as mixed deciduous/ coniferous forest. With the exception of the forest stand around the Skeet Range, these rich and relatively unaltered forested regions represent the large safety fans across the Main Post. The cover species typically found in the forested areas surrounding the IMR ranges include scrub pine *(Pinus virginiana)*, loblolly pine *(Pinus taeda),* white oak *(Quercus alba)*, post oak *(Quercus stellata)*, chestnut oak *(Quercus prinus)*, southern red oak *(Quercus falcata)*, wild black cherry *(Prunus serotina)*, hackberry *(Celtis occidentalis)*, black walnut *(Juglans nigra)*, and flowering dogwood *(Cornus florida)*. These mixed deciduous/coniferous forests exhibit sparse, shade-tolerant undergrowth species such as Virginia creeper *(Parthenocissus quinquefolia)*, Christmas fern *(Polystrichum acrotichoides)*, and poison ivy *(Toxicodendron radicans)*. Descriptions of the habitat at each of the small arms ranges at IMR are presented in the following sections.

2.1.1 Skeet Range Habitat

The Skeet Range consists of two main habitat types. The cleared area encompasses approximately two acres at and adjacent to the firing lines. The habitat in this area is dominated by grasses and early old field successional species. In the past, this area was maintained lawn with concrete walkways throughout. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Scrub pine (*Pinus virginiana*) saplings have also begun to encroach on this cleared area. The forested areas surrounding the cleared area at the Skeet Range can be characterized as mixed deciduous/coniferous forest. Scrub pine and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type, as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various songbirds were observed on site.

Remount Creek, which runs along the western boundary of the Skeet Range, and its tributaries, which generally run east-to-west across the Skeet Range, exhibit mostly gravel and cobble substrate with very little organic matter. Remount Creek is narrow and shallow (less than 5 feet across and less than 6 inches deep) when there is water present. This ephemeral creek and its tributaries are dry during significant portions of the year, and the presence or absence of water is highly dependent upon the volume of precipitation. During dry periods, the creek may be entirely dry for significant portions of the year (6 to 8 months). The ephemeral nature of Remount Creek and its tributaries in this area limits their ability to support many aquatic organisms (e.g., large fish) and other organisms that rely on aquatic species for food (e.g., piscivores). Remount Creek and its tributaries may support semi-aquatic species (e.g., amphibians) and provide a breeding ground for some small fish species during the periods when water is present.

Remount Creek in the vicinity of the Skeet Range has historically been identified as a moderate to low quality foraging area for the federally listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Remount Creek has been identified as a gray bat foraging area because it allegedly provides habitat for aquatic insects, which are fed upon by the gray bat. However, Remount Creek is dry during significant portions of the year, which precludes the presence of aquatic insects during those dry periods. Additionally, construction of the Eastern Bypass within and adjacent to the Remount Creek corridor has eliminated a significant portion of the tree and shrub canopy that formerly covered Remount Creek. Because the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging, the elimination of significant portions of the forest in this area would negatively affect its foraging

habits. Based on the ephemeral nature of Remount Creek in this area and the elimination of significant portions of the forest canopy, the creek may no longer provide adequate foraging habitat for the gray bat.

2.1.2 Range 19 Habitat

The total site, including the extensive forested range fan, encompasses 1,529 acres. The main study area is limited to approximately 5 to 7 acres. The study area of Range 19 consists almost entirely of maintained lawn, mowed fields, unvegetated soil, and roadways. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Scrub pine saplings (*Pinus virginiana*) have also begun to encroach into these previously maintained areas. The embankment on the eastern side of the site is almost completely void of vegetation, due to the fact that soil was historically scraped and graded along this embankment for maintenance purposes when the ranges were active. The area surrounding the cleared areas of Range 19 can be characterized as mixed deciduous/coniferous forest. Scrub pine and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type, as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various songbirds were observed on site.

Remount Creek is dry for significant periods of time over most of the distance that it passes along the western boundary of Range 19 (approximately 1,000 feet). The presence of small pools of water (one to two feet in length) in this portion of Remount Creek may be due to groundwater discharge. The creek is narrow and shallow (less than 3 feet across and less than 6 inches deep) when water is present and has a variable substrate of mud and leaf litter interspersed with areas of sand and gravel. Again, the presence of water in Remount Creek adjacent to Range 19 is highly dependent upon significant precipitation.

The portion of Remount Creek adjacent to Range 19 has historically been classified as low quality foraging habitat for the federally listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This classification has not taken into account the impacts on Remount Creek habitat resulting from construction of the Eastern Bypass.

2.1.3 Range 13 Habitat

The total area of Range 13, including the range safety fan, encompasses 549 acres. The main study area is limited to approximately 5 acres, which are described herein as the cleared areas. The cleared area of Range 13 is dominated by grasses and early successional species. In the past, this area consisted of maintained lawn, mowed field, unvegetated soil, and roadways. Since

maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Scrub pine saplings (*Pinus virginiana*) have also begun to encroach into these previously maintained areas. The forested areas surrounding the cleared area at Range 13 can be characterized as mixed deciduous/coniferous forest. Scrub pine and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type, as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various songbirds were observed on site.

Remount Creek, along the 800 foot length that runs adjacent to the western boundary of Range 13, exhibits sections of very slow moving water (zero to 6 inches deep) and areas which are completely dry. Similar to Range 19, the presence of small, intermittent areas of water (less than one foot to several feet in length) may be due to groundwater discharge. The creek is narrow (less than 3 feet across) and shallow (less than 6 inches deep), when water is present, and has a variable substrate of mud and leaf litter interspersed with areas of sand and gravel. Again, the presence of water in Remount Creek adjacent to Range 13 is highly dependent upon significant precipitation.

The portion of Remount Creek adjacent to Range 13 has historically been classified as low quality foraging habitat for the Federally endangered gray bat (*Myotis grisescens*) (Garland, 1996). This classification has not taken into account the impacts on Remount Creek habitat resulting from construction of the Eastern Bypass.

2.1.4 Range 12 Habitat

The total area of Range 12, including the range safety fan, encompasses 311 acres. The main study area is limited to approximately 5 acres, which are described herein as the cleared areas. The cleared area of Range 12 is dominated by grasses and early successional species. In the past, this area consisted of maintained lawn, mowed field, and roadways. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Scrub pine saplings (*Pinus virginiana*) have also begun to encroach into these previously maintained areas. The forested areas surrounding the cleared area at Range 12 can be characterized as mixed deciduous/ coniferous forest. Scrub pine and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type, as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. White-tailed deer, wild turkey, gray squirrel, and various songbirds were observed on site.

Along the 400-foot length of Remount Creek that runs adjacent to the western boundary of Range 12, the creek exhibits sections of very slow-moving water (zero to 6 inches deep) and areas which are completely dry. Similar to Range 19, the presence of small, intermittent areas of water (less than one foot to several feet in length) may be due to groundwater discharge. The creek is narrow and shallow (less than 3 feet across and less than 6 inches deep) when water is present and has a variable substrate of mud and leaf litter interspersed with areas of sand and gravel. Again, the presence of water in Remount Creek adjacent to Range 12 is highly dependent upon significant precipitation.

The portion of Remount Creek adjacent to Range 12 has historically been classified as low quality foraging habitat for the federally listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This classification has not taken into account the impacts on Remount Creek habitat resulting from construction of the Eastern Bypass.

2.1.5 Remount Creek Habitat

In the vicinity of the IMR ranges, Remount Creek is a small, ephemeral stream that flows (when water is present) from south to north. The physical characteristics of Remount Creek and the surrounding land use vary along its length, from its headwaters at Yahou Lake to its confluence with Cane Creek near the west-northwest boundary of the Main Post. The headwaters of Remount Creek are formed by the discharge from Yahou Lake and its tributaries, approximately 0.75 mile south of Range 12. Remount Creek runs in a northerly direction along the topographic low formed by gently sloping hills to the east and west of the creek. Most of the length of Remount Creek between Yahou Lake and the IMR ranges runs through the Eastern Bypass corridor. Virtually all of the trees in the bypass corridor have been clear-cut and all of the vegetation removed. The entire area has been covered with mulch that was created by "chipping" the vegetation that was cut down. The land surrounding Remount Creek adjacent to Ranges 12 and 13 is characteristic of the clear-cut areas associated with the Eastern Bypass corridor. It is likely that portions of the creek adjacent to the IMR ranges will be significantly altered (e.g., rerouted, culverted) as a result of construction of the Eastern Bypass.

Immediately north of the Skeet Range, Remount Creek flows through a culvert under the old parade grounds/athletic fields and then through the grounds of the Cane Creek Golf Course until its confluence with Cane Creek in the west-northwestern corner of the Main Post.

The ecological value of Remount Creek is greatest as it flows through the Cane Creek Golf Course and intersects Cane Creek. It is in this stretch (downstream of the IMR ranges) that the creek may support foraging of insectivorous mammals and a functional aquatic ecosystem.

Remount Creek and its tributaries in the vicinity of the IMR ranges may support semi-aquatic species (e.g., amphibians) and provide a breeding ground for some small fish species during the periods when water is present.

2.2 Environmental Setting at the Bains Gap Road Ranges

The terrestrial habitat occurring at the BGR ranges is very similar to the habitat at the IMR ranges and falls into two general categories: "cleared" areas and forested areas. The "cleared" areas are those areas that were formerly maintained as lawns or mowed fields. These areas represent the locations where range activities were most prevalent. Since maintenance activities have ceased in these areas, pioneer species are colonizing these areas. Typically, the species most likely to colonize these areas are the "weed" species that tend to be vigorous pioneer plants that grow and spread rapidly. The first of the pioneer species to invade these abandoned areas are the grasses and herbaceous species. These formerly maintained grassy areas are classified as being in an early old field successional state. Over time, these grass and herbaceous species will be followed by shrubs and small trees. The early old field successional areas at the BGR ranges are dominated by various grasses and herbs including *Rumex spp.* (dock), *Trifolium spp.* (clover), *Astragalus spp.* (vetch), *Ascelepias spp.* (milkweed), *Galium spp.* (bed straw), *Chrysanthemum leucanthemum* (ox-eye daisy), and *Sorghum halepense* (Johnson grass). Other old field herbaceous species occurring at the BGR ranges are *Rubus occidentalis* (black raspberry), *Toxicodendron radicans* (poison ivy), *Rubus glabra* (smooth sumac), *Smilax rotundiflora* (green brier), *Lonicera japonica* (Japanese honeysuckle), *Vitus labrusca* (fox grape), and *Rosa multiflora* (multiflora rose). Loblolly pine (*Pinus taeda)* saplings have also begun to encroach on the formerly maintained grassy areas of the BGR ranges.

The forested areas outside of the "cleared" areas are best characterized as mixed deciduous/ coniferous forest. The canopy species typically found in the forested areas surrounding the BGR ranges include yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), black gum (*Nyssa sylvatica*), shortleaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), white oak (*Quercus alba*), and northern red oak *(Quercus rubra*). The dominant understory species of this area are red maple (*Acer rubrum*), flowering dogwood (*Cornus florida*), witch hazel (*Hamamelis virginia*), sweetgum (*Liquidambar styraciflua*), wild black cherry (*Prunus serotina*), hackberry (*Celtis occidentalis*), black walnut (*Juglans nigra*), and sourwood (*Oxydendrum arboreum*). The shrub layer is dominated by mountain laurel (*Kalmia latifolia*), southern low blueberry *(Vaccinium pallidum*), southern wild raisin (*Viburnum nudum*), Virginia creeper (*Parthenocissus quinquefolia*), Christmas fern (*Lystrichum acrotichoides*), poison ivy (*Toxicodendron radicans*), and yellowroot (Xanthorhiza simplicissima). Numerous muscadine grape (*Vitis rotundifolia*) vines are also present in this area.

Terrestrial species that may inhabit the area of the BGR ranges include opossum, short-tailed shrew, raccoon, white-tail deer, red fox, coyote, gray squirrel, striped skunk, a number of species of mice and rats (e.g., white-footed mouse, eastern harvest mouse, cotton mouse, eastern wood rat, and hispid cotton rat), and eastern cottontail.

Approximately 200 avian species reside at FTMC at least part of the year (U.S. Army Corps of Engineers [USACE], 1998). Common species expected to occur in the vicinity of the BGR ranges include northern cardinal (*Cardinalis cardinalis*), northern mockingbird (*Mimus polyglottus*), warblers *(Dendroica spp.*), indigo bunting (*Passerina cyanea*), red-eyed vireo (*Vireo olivaceus*), American crow (*Corvus brachyrhynchos*), bluejay (*Cyanocitta cristata*), several species of woodpeckers (*Melanerpes spp., Picoides spp.*), and Carolina chickadee (*Parus carolinensis*). Game birds present in the vicinity of the BGR ranges may include northern bobwhite (*Colinus virginianus*), mourning dove (*Zenaida macroura*), and eastern wild turkey (*Meleagris gallopavo*). Woodland hawks (e.g., sharp-shinned hawk) were observed in this area during the ecological investigation (September, 2000) and are expected to use this area for a hunting ground. A variety of other raptors (e.g., red-tailed hawk, barred owl, and great horned owl) could also use portions of this area for a hunting ground, particularly the fringe areas where the forested areas abut roads and cleared areas. Due to the presence of Cane Creek, piscivorous bird species may also be present in the vicinity of the BGR ranges. These piscivorous birds may include great blue heron (*Ardea herodias*), green-backed heron (*Butorides striatus*), and belted kingfisher (*Ceryle alcyon*).

In general, the terrain at FTMC supports large numbers of amphibians and reptiles. Jacksonville State University has prepared a report titled *Amphibians and Reptiles of Fort McClellan, Calhoun County, Alabama* (Cline and Adams, 1997). The report indicated that surveys in 1997 found 16 species of toads and frogs, 12 species of salamanders, 5 species of lizards, 7 species of turtles, and 17 species of snakes. Typical inhabitants of the area surrounding the BGR ranges are copperhead (*Agkistrodon contortix*), king snake (*Lampropeltis getulus*), black racer (*Coluber constrictor*), fence lizard (*Sceloporour undulatus*), and six-lined racerunner (*Cnemidophorous sexlineatus*).

Descriptions of the habitats at each of the ranges on BGR are presented in the following sections.

2.2.1 Range 21 Habitat

The entire area of Range 21, including the extensive safety fan is approximately 2,249 acres. The study area of Range 21 is approximately 15 acres in size and is topographically relatively

flat. It is bounded on the north by BGR, on the east and south by mixed deciduous/coniferous forest, and on the west by Range 22. A soil berm separates Range 21 from Range 22 to the west. The study area of Range 21 is almost entirely comprised of formerly maintained lawn, mowed fields, and non-vegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 21 remain non-vegetated, with large areas of bare soil.

The forested areas to the east and south of Range 21 are best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants.

Cane Creek flows east-to-west across Range 21 towards Range 22 and through a large concrete culvert beneath the soil berm that separates Range 21 from Range 22 to the west. Several small tributaries also flow across the southern portion of Range 21 and along the eastern and western boundaries of Range 21. Cane Creek is relatively narrow (4 to 6 feet) and shallow (0.5 to 1.0 feet) along its length within Range 21, with steep embankments approximately four feet high. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought. The vegetative canopy of the Cane Creek corridor within Range 21 is characterized by low-level shrubs and tree saplings (less than 8 feet high) that form a low, dense canopy over the creek. This vegetation extends less than six feet from the creek bed itself. Thus this vegetative canopy is narrow, low and dense. Because Cane Creek bisects Range 21 between the firing line and several of the target areas, vegetation along Cane Creek was previously maintained at a low level so that the target areas would not be obstructed.

The portion of Cane Creek that flows through Range 21 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. Due to historical maintenance activities along Cane Creek, the forest canopy has been eliminated and has only recently been replaced by low-lying shrubs and saplings. Thus, the currently

existing vegetative cover along the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

2.2.2 Range 22 Habitat

The total area of Range 22, including the extensive safety fan, comprises 1,810 acres. The main study area of Range 22 is approximately 12.5 acres and is topographically relatively flat. A rocky, soil berm forms the southern boundary of the main study area. Range 22 is bounded on the north by BGR, on the east by Range 21, on the south by mixed deciduous/coniferous forest, and on the east by Range 27. A soil berm separates Range 22 from Range 27 to the west. The study area of Range 22 is comprised almost entirely of formerly maintained lawns, mowed fields, and non-vegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 22 remain non-vegetated, with large areas of bare soil.

The forested area south of Range 22 is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants.

Cane Creek flows east-to-west across Range 22 towards Range 27. A small tributary that originates southeast of Range 22 flows into Cane Creek at Range 22. Another small tributary that originates north of Range 22 flows into Cane Creek between Ranges 22 and 27. Cane Creek is relatively narrow (4 to 6 feet) and shallow (0.5 to 1.0 feet) along its length within Range 22. The northern bank of Cane Creek is relatively steep and approximately four feet high. The southern bank of Cane Creek is very steep and rises significantly to an elevation of approximately 330 above the firing line elevation. This southern bank effectively forms the impact zone for the majority of Range 22. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought.

The vegetation adjacent to Cane Creek within Range 22 is sporadic, and where it is present is best characterized by low-level shrubs and tree saplings (less than 8 feet high). This vegetation

extends less than six feet from the creek bed to the north. On the southern side of the creek, the bank rises steeply and is largely devoid of vegetation. Because Cane Creek flows along the southern boundary of the impact zone, vegetation along Cane Creek was previously maintained at a low level so that the target areas would not be obstructed.

The portion of Cane Creek that flows through Range 22 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. Due to historical maintenance activities along Cane Creek, the forest canopy has been eliminated and has only recently been replaced by low-lying shrubs and saplings. Thus, the currently existing vegetative cover along the northern border of the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

2.2.3 Range 24 Upper Habitat

The total area of Range 24 Upper is approximately 11 acres, and there is no defined safety fan. The main study area of Range 24 Upper is on a south-facing slope immediately south of BGR. It is bounded on the north by BGR, on the east and south by mixed deciduous /coniferous forest, and on the west by Range 21. The northern half of the site slopes from an elevation of approximately 1,050 feet above sea level (asl) to 975 feet asl. This south-facing hillside is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants. At the base of this slope is a cleared area that is best characterized as oldfield, early successional habitat. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these areas. Significant portions of the southern half of Range 24 Upper remain non-vegetated, with large areas of bare soil.

Two small, ephemeral tributaries of Cane Creek occur at the base of the slope and in the cleared area south of the hill at Range 24 Upper. These tributaries only have water after significant rainfall events and are dry most of the year. Their substrates are cobbles and boulders and there are very few areas with sandy deposits. These tributaries run east-to-west across Range 24 Upper and join west of the range to form a portion of the headwaters of Cane Creek. These

tributaries have not been identified as being capable of supporting gray bat habitat (Garland, 1996).

2.2.4 Range 27 Habitat

The total area of Range 27, including the extensive safety fan, comprises 954 acres. The main study area of Range 27 is approximately 16 acres and is topographically relatively flat. A rocky, soil berm forms the southern boundary of the main study area. Range 27 is bounded on the north by BGR, on the east by Range 22, and on the south and west by mixed deciduous/coniferous forest. A soil berm separates Range 27 from Range 22 to the east. The study area of Range 27 is comprised almost entirely of formerly maintained lawns, mowed fields, and unvegetated soil. Since maintenance activities have ceased, the grasses have grown uncontrolled and early successional species have intruded. Various grasses and herbaceous species dominate this habitat type. Loblolly pine (*Pinus taeda)* saplings have also begun to encroach into these previously maintained areas. Significant portions of Range 27 remain unvegetated, with large areas of bare soil.

The forested area south of Range 27 is best characterized as mixed deciduous/coniferous forest. Scrub pine, loblolly pine, white oak, and southern red oak dominate this habitat. There are minimal understory or herbaceous layers in this forest type as fallen leaves and pine needles form a thick mat that precludes the germination of smaller plants.

Cane Creek flows east-to-west across the southern boundary of Range 27. A small tributary that originates southeast of Range 27, flows into Cane Creek at Range 27. Cane Creek is relatively narrow (4 to 6 feet) and shallow (0.5 to 1.0 feet) along its length within Range 27. The northern bank of Cane Creek is gently sloping to a height of approximately three feet. The southern bank of Cane Creek is very steep and rises significantly to an elevation of approximately 330 above the firing line elevation. This southern bank effectively forms the impact zone for the majority of Range 27. The substrate of Cane Creek is mostly boulders and cobbles with a few small depositional areas with sand substrate. The water level in Cane Creek is highly variable, depending on the amount of precipitation received by the local watershed. Cane Creek is a perennial creek, and as such, maintains water flow even during periods of drought.

The vegetation adjacent to Cane Creek within Range 27 is sporadic, ranging from areas completely void of vegetation to areas with relatively mature forest canopy. The western portion of the Cane Creek corridor at Range 27 is mostly void of vegetation, while the eastern portion exhibits mature forest vegetation. On the southern side of the creek, the bank rises steeply and

the vegetation is mostly brush and weed species for a distance of approximately 50 feet until it transitions to a mixed deciduous/coniferous forest.

The portion of Cane Creek that flows through Range 27 has been identified as low-quality foraging habitat for the Federally-listed endangered gray bat (*Myotis grisescens*) (Garland, 1996). This section of Cane Creek has been identified as a gray bat foraging area because it provides habitat for aquatic insects, which are fed upon by the gray bat. However, the gray bat requires continuous cover while traveling to and from its foraging habitats and while foraging. The forest canopy along the Cane Creek corridor at Range 27 is sporadic and not continuous. Thus, the currently existing vegetative cover along the Cane Creek corridor may not provide the cover favored by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

2.2.5 Cane Creek Habitat

Cane Creek in the vicinity of the BGR ranges is a perennial stream that flows east-to-west across the ranges at BGR. The physical characteristics of Cane Creek at the BGR ranges are relatively consistent; however, they differ both upstream and downstream of the BGR ranges. The BGR ranges lie within an east-west trending valley that is formed by Jones Hill, Mount Tylo, and several unnamed hills north of the ranges, and Marcheta Hill and several unnamed hills south of the ranges. Upstream (one-half to three-quarters of a mile east) of the BGR ranges, the headwaters of Cane Creek are formed by several small tributaries that are created by surface runoff and seeps from the hills north, south, and east of the ranges. These headwater streams are small ephemeral streams with boulder and cobble substrate that carry runoff during storm events, but are dry during significant portions of the year. The headwater areas are relatively undeveloped portions of Main Post and are almost entirely mixed deciduous/coniferous forest.

Downstream (west) of the BGR ranges, Cane Creek continues to flow in a westerly direction across the developed portion of Main Post (including the Cane Creek golf course) and off-site along the west-northwest boundary of the Main Post.

In general, the portion of Cane Creek that flows through the BGR ranges is a low-gradient perennial stream with widths ranging from 4 to 10 feet and depths ranging from 0.5 to 2.0 feet. The banks of Cane Creek are steep (4 to 8 feet) and exhibit erosional features characteristic of occasional high velocity flow (i.e., during significant storm events). The substrate of Cane Creek is mostly cobbles and boulders. There is very little evidence of organic matter present as substrate in Cane Creek in the vicinity of the BGR ranges. In fact, large sections of the creek bed in this area are made up of exposed bedrock.

The vegetation surrounding Cane Creek at the BGR ranges is variable. Because Cane Creek bisects these ranges, routine maintenance activities have historically controlled/eliminated the vegetation along the creek banks. Since maintenance activities have ceased, vegetative species have begun to re-colonize the creek banks. Therefore, weeds, low-lying shrubs, and tree saplings dominate the creek banks. The areas directly north of Cane Creek is best characterized as old field early successional habitat and the areas directly south of Cane Creek is mixed deciduous / coniferous forest, except for Range 21. Cane Creek flows through the center of Range 21; therefore, the habitat on both the north and south sides of Cane Creek at Range 21 is characterized as old field, early successional.

The headwaters of Cane Creek are formed by runoff from the hills north, east, and south of the BGR ranges. There also appears to be localized contribution to the creek flow from groundwater where the potentiometric surface exceeds the creek bed surface. The flow contribution from groundwater varies according to the amount of precipitation, with an increase when precipitation raises the potentiometric surface. The contribution of groundwater to the flow of Cane Creek appears to be low in the eastern portion of Cane Creek with an increase in groundwater contribution to Cane Creek flow towards the western ranges (e.g., Range 22 and Range 27). Flow in Cane Creek is highly variable, depending on precipitation in the surrounding watershed.

Although relatively shallow (less than two feet deep) over its entire length at the BGR ranges, Cane Creek has the potential to support a variety of amphibious species and some small fish species. Bullfrog *(Rana catesbeiana)* and leopard frog (*Rana sphenocephala*) are examples of amphibians that may be found in Cane Creek in the vicinity of the BGR ranges. Fish species that may be found in Cane Creek in the vicinity of the BGR ranges include blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), stoneroller (*Campostoma anomalum*), striped shiner (*Luxilus chrysocephalus*), and various darters (*Etheostoma spp.*). The shallow nature of Cane Creek limits its ability to support many aquatic organisms (e.g., large fish) and other organisms that rely on aquatic species for food (e.g., piscivores). Larger fish species are not expected to inhabit Cane Creek due to its shallow nature.

Cane Creek, in the area of the BGR ranges, has been identified as providing low quality foraging habitat for the Federally endangered gray bat (*Myotis grisescens*) (Garland, 1996). Two major requirements for gray bat foraging habitat are contiguous forest cover and habitat for aquatic insects (one of the gray bat's preferred dietary items). Although aquatic insects may be present in Cane Creek at the BGR ranges, the forest canopy is sporadic, and may not provide the cover

required by gray bats. In the future, growth of a high canopy of trees along the Cane Creek corridor may improve the gray bat foraging habitat potential.

2.2.6 Wetland/Seep Habitat

The wetland/seep habitat present in the vicinity of the BGR Ranges is limited to the area south of Range 21. This area is known as the Marcheta Hill Orchid Seep Special Interest Natural Area (SINA). SINA at FTMC consist of those biological communities that harbor federal, candidate, or state-listed species, or those habitats containing single or groups of unique or unusual species. Additional information regarding each individual SINA and their management practices at FTMC is presented in the *Endangered Species Management Plan for Fort McClellan, Alabama* (Garland, 1996). The only SINA that could potentially be impacted by activities (both past and future) at the BGR ranges is the Marcheta Hill Orchid Seep SINA, as it is located directly adjacent to Range 21.

The spring seepage to the west of Marcheta Hill constitutes one of the more important SINAs on Main Post at FTMC. The boundary of the wetland seep is approximately 7.2 acres; however, the integrity of the adjacent watershed is critical to the maintenance of this seep. The area is located directly south of Range 21. This wetland is the largest forested seepage on the installation and contains two federal candidate 2 species: white fringeless orchid (*Plantanthera integrilabia*) and Diana butterfly (*Speyeria diana*). The population of white fringeless orchid is particularly significant with over 250 individuals recorded. Additional plants on the ANHP tracking list include rose pink (*Sabatia capitata*) and soapwort gentian (*Gentiana saponaria*).

The ecological significance of this wetland has been recognized for several years. "Do Not Disturb Endangered Species Area" signs have been posted along the wetland's boundary. The continuation of the existing fire regime is considered the most critical management requirement. According to verbal accounts, this area experienced a wildfire at least once every two years while the facility was active. Many of these wildfires were due to the training activities that took place at Range 21. In order to insure this fire frequency in the future, the management plan for this area prescribes that a burn will be instituted if the area has not experienced a fire by March 1 of the second year.

2.3 Potential Receptors at the Iron Mountain Road and Bains Gap Road Ranges

The ecological receptors expected to occur in terrestrial ecosystems at the IMR and BGR ranges are similar and are discussed below. The aquatic receptors expected to occur at these ranges are somewhat different and these differences are also discussed in the following sections. Ecological receptors may be exposed to constituents in soils via direct and/or secondary (indirect) exposure

pathways. Direct exposure pathways include soil ingestion, dermal absorption, and inhalation of constituents of potential ecological concern (COPEC) adsorbed to fugitive dust. Significant exposure via dermal contact is limited to organic constituents that are lipophilic and can penetrate epidermal barriers. Mammals are less susceptible to exposure via dermal contact with soils because their fur prevents skin from coming into direct contact with soil. However, soil ingestion may occur while grooming, preening, burrowing, or consuming plants, insects, or invertebrates resident in soil. Exposure via inhalation of fugitive dust is limited to constituents present in surface soils at areas that are devoid of vegetation. The inherent moisture content of the soil and the frequency of soil disturbance also play important roles in the amount of fugitive dust generated at a particular site.

Ecological receptors could be exposed to constituents in surface water via direct contact or through consumption of water. Aquatic organisms inhabiting contaminated waters would be in constant contact with the COPECs.

Constituents present in sediment may result from erosion or adsorption of water-borne constituents onto sediment particles. If sediment is present in an area that is periodically inundated with water, then previous exposure pathways for soils would be applicable during dry periods. Water overlying sediments prevents constituents from being carried by wind erosion. Because the majority of the constituents detected in sediment are inorganic compounds that are not prone to volatilization, volatilization from sediments is not an important fate mechanism. Therefore, inhalation of constituents originating from the sediment is not a significant exposure pathway. Exposure via dermal contact may occur, especially for benthic organisms and wading birds or other animals that may use Remount Creek (IMR ranges) or Cane Creek (BGR ranges) as a feeding area. Some aquatic organisms consume sediment and ingest organic material from the sediment. Inadvertent ingestion of sediments may also occur as the result of feeding on benthic organisms and plants.

While constituents in soils may leach into groundwater, environmental receptors will not come into direct contact with constituents in groundwater since there is no direct exposure route. The only potential exposure pathways for ecological receptors to groundwater would be via surface water exposure routes. Potential exposure to groundwater-related constituents is expected to be insignificant compared to other exposure pathways (i.e., exposure to constituents in surface water as a result of surface runoff) since groundwater discharge to Cane Creek is expected to be localized and sporadic.

Groundwater discharge to the ground surface via seeps is also a potential exposure pathway for a number of different organisms in the vicinity of the BGR ranges. Specifically, the area south of Range 21 is dominated by groundwater seeps and is known as the Marcheta Hill Orchid Seep Special Interest Natural Area (SINA). This SINA is described in detail in the *Endangered Species Management Plan for Fort McClellan, Alabama* (Garland, 1996). These groundwater seep areas could be used by various animals as a source of drinking water and they also provide unique habitat for a number of plant and animal species. Semi-aquatic organisms (e.g., amphibians) could utilize these seeps as breeding grounds as they are inundated during portions of the year when precipitation is heavy and maintain vegetation that is characteristic of saturated soils throughout the year.

Secondary (indirect) exposure pathways involve constituents that are transferred through different trophic levels of the food chain and may be bioaccumulated and/or bioconcentrated. This may include constituents bioaccumulated from soil into plant tissues or into terrestrial species ingesting soils. These plants or animals may, in turn, be consumed by animals at higher trophic levels. Sediment-borne COPECs may bioaccumulate into aquatic organisms, aquatic plants, or animals which frequent surface waters and then be passed through the food chain to impact organisms at higher trophic levels.

Potential ecological receptors at the IMR and BGR ranges fall into two general categories: terrestrial and aquatic. Within these two general categories there are several major feeding guilds that could be expected to occur at the IMR and BGR ranges: herbivores, invertivores, omnivores, carnivores, and piscivores. All of these feeding guilds have the potential to be directly exposed to various combinations of surface soil and surface water and sediment in Remount Creek or Cane Creek and their tributaries via various activities (e.g., feeding, drinking, grooming, bathing, etc.). These feeding guilds may also be exposed to site-related chemicals via food web transfers.

As discussed above, ingestion of COPECs in soil, surface water, and sediment are the pathways that pose the greatest potential for exposure for ecological receptors at the IMR and BGR ranges. Dermal absorption and inhalation exposures are expected to be insignificant. Food web transfers of COPECs are also possible exposure pathways for ecological receptors at the IMR and BGR ranges, although none of the COPECs at these ranges have high bioconcentration or biomagnification potential.

Potentially complete exposure pathways are depicted in the Site Conceptual Model (SCM) for the IMR and BGR ranges as presented in Figure 2-1, and are described in the following sections for the various feeding guilds expected to occur at these ranges.

2.3.1 Herbivorous Feeding Guild

The major route of exposure for herbivores is through ingestion of plants that may have accumulated contaminants from the soil, surface water, or sediment. The vegetation at the formerly maintained areas of the IMR and BGR ranges is mainly grasses and sedges, which are remnants of the maintained grass that was present when these ranges were operational. Since terrestrial herbivores by definition are grazers and browsers, they could be exposed to chemicals that have accumulated in the vegetative tissues of plants at these sites. Terrestrial herbivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while grazing or grooming or during other activities.

Typical herbivorous species that could be expected to occur at the IMR or BGR ranges and are commonly used as sentinel species in ecological risk assessment include eastern cottontail (*Sylvilagus floridanus*), eastern gray squirrel (*Sciurus carolinensis*), pine vole (*Pitymys pinetorum*), whitetail deer (*Odocoileus virginianus*), and wild turkey (*Meleagris gallopavo*).

Aquatic herbivores, such as muskrat (*Ondatra zibethicus*) and mallard (*Anas platyrhynchos*), could be exposed to site-related constituents in surface water and/or sediment in Remount Creek or Cane Creek. However, aquatic herbivores are not expected to routinely occur at Remount Creek in the vicinity of the IMR ranges, due to the ephemeral nature of the creek in this area.

2.3.2 Invertivorous Feeding Guild

Invertivores specialize in eating insects and other invertebrates. As such, they may be exposed to site-related chemicals that have accumulated in insects and other invertebrates. Invertivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while probing for insects or grooming or during other activities. Ingestion of soil while feeding is potentially a major exposure pathway for terrestrial invertivores, since much of their food (e.g., earthworms and other invertebrates) lives on or below the soil surface.

Typical terrestrial invertivorous species that could be expected to occur at the IMR or BGR ranges and are commonly used as sentinel species in ecological risk assessment include American woodcock (*Philohela minor*), carolina wren (*Thryothorus ludovicianus*), shorttail shrew (*Blarina brevicauda*), and eastern mole (*Scalopus aquaticus*). Aquatic invertivores (those species that live in water) could include the wood duck (*Aix sponsa*) and blacknose dace

(*Rhinichthys atratulus*). However, aquatic invertivores are not expected to routinely occur at Remount Creek in the vicinity of the IMR ranges due to the ephemeral nature of the creek in this area.

Invertivores that feed on emergent aquatic insects but do not live in the water have the potential to feed in the vicinity of the IMR and BGR ranges. These riparian invertivores could be exposed to site-related chemicals in sediment through the ingestion of emergent aquatic insects that live in the sediment of Remount Creek or Cane Creek. Aquatic insects could accumulate site-related chemicals from the sediment and could potentially be ingested by invertivores that feed in the vicinity of the IMR or BGR ranges. Typical riparian invertivores that feed on emergent aquatic insects include the little brown bat (*Myotis lucifugus*) and the marsh wren (*Cistothorus palustris*).

2.3.3 Omnivorous Feeding Guild

Omnivores consume both plant and animal material in their diet, depending upon availability. Therefore, they could be exposed to chemicals that have accumulated in the vegetative tissues of plants at these ranges and also to chemicals that may have accumulated in smaller animal tissues that the omnivores prey upon. They may also be exposed to surface water through ingestion of water in Remount Creek or Cane Creek. Omnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding or grooming or during other activities.

Typical omnivorous species that may occur at the IMR or BGR ranges and are commonly used as sentinel species in ecological risk assessment include red fox (*Vulpes vulpes*), white-footed mouse (*Peromyscus leucopus*), and American robin (*Turdus migratorius*).

Aquatic omnivores, such as raccoon (*Procyon lotor*) and creek chub (*Semotilus atromaculatus*), could be exposed to COPECs in surface water and sediment in Remount Creek or Cane Creek. However, aquatic omnivores are not expected to routinely occur at Remount Creek in the vicinity of the IMR ranges due to the ephemeral nature of the creek in this area.

2.3.4 Carnivorous Feeding Guild

Carnivores are meat-eating animals and are, therefore, exposed to site-related chemicals through consumption of prey animals that may have accumulated contaminants in their tissues. Carnivores are quite often top predators in a local food web and are often subject to exposure to contaminants that have bioaccumulated in lower trophic level organisms or biomagnified through the food web. Food web exposures for carnivores are based on the consumption of prey animals that have accumulated COPECs from various means. Smaller herbivores, omnivores,

invertivores, and other carnivores may consume soil, surface water, sediment, plant, and animal material as food and accumulate COPECs in their tissues. Subsequent ingestion of these prey animals by carnivorous animals would expose them to COPECs. Carnivores may also be exposed to site-related chemicals in soil through incidental ingestion of soil while feeding or grooming or during other activities. Most inorganic compounds are not accumulated in animal tissues to any great extent (Shugart, 1991; U.S. Army Environmental Hygiene Agency, 1994), and the COPECs at the IMR and BGR ranges do not significantly bioconcentrate or biomagnify in higher trophic levels organisms. Therefore, food web exposures to these chemicals are expected to be minimal.

Typical carnivorous species that could occur at the IMR or BGR ranges and are commonly used as sentinel species in ecological risk assessment include red-tailed hawk (*Buteo jamaicensis*), black vulture (*Coragyps atratus*), and bobcat (*Lynx rufus*).

Because Remount Creek (IMR ranges) and Cane Creek (BGR ranges) are narrow and shallow, they do not have the capability to support large aquatic carnivores on a full-time basis. Carnivorous fish such as largemouth bass (*Micropterus salmoides*) and spotted gar (*Lepisosteus oculatus*) are not expected to occur in Remount Creek or Cane Creek due to the habitat restrictions. Carnivorous mammals such as the mink (*Mustela vison*) may feed along Remount Creek or Cane Creek during certain periods of the year when significant water is present in these creeks, but most likely would not live adjacent to these creeks because of the creeks' inability to support large individual fish or other aquatic species.

2.3.5 Piscivorous Feeding Guild

Piscivores are specialists that feed mostly on fish. Therefore, they may be exposed to site-related chemicals that have accumulated in small fish that may inhabit Remount Creek or Cane Creek. They may also be exposed to surface water and sediment in these creek systems through ingestion of drinking water and during feeding. Although Remount Creek (IMR ranges) is dry during certain periods of the year, it does exhibit flowing and/or standing water during portions of the year and could be utilized for drinking purposes. Cane Creek (BGR ranges) is a perennial creek and as such, has flowing water throughout the year. Therefore, it is expected that Cane Creek could be utilized for drinking purposes by a number of different species. Although piscivorous species could be expected to visit the areas around Remount Creek and Cane Creek during certain periods of the year when the flow in these creeks is significant, they would not be expected to live near the IMR or BGR ranges due to the fact that these creeks are not large enough and do not provide suitable habitat to support larger fish species (piscivore's main food source).

Food web exposures for piscivores are based on the consumption of fish that have accumulated COPECs from surface water and sediment. Forage fish may consume surface water, sediment, benthic invertebrates, aquatic plants, and planktonic material as food and accumulate COPECs in their tissues. Subsequent ingestion of these forage fish by piscivorous animals would expose them to COPECs. However most inorganic compounds are not accumulated in fish tissues to any great extent. Therefore, food web exposures to these chemicals are expected to be minimal.

Typical piscivorous species that could occur near the IMR or BGR and are commonly used as sentinel species in ecological risk assessment include great blue heron (*Ardea herodias*) and belted kingfisher (*Ceryle alcyon*). Larger piscivorous fish species (e.g., small mouth bass, spotted gar) and piscivorous mammals (e.g., mink) are not expected to occur in the creek systems at the IMR or BGR ranges due to the habitat limitations of Remount Creek and Cane Creek and the inability of these creeks to support larger fish and other aquatic species.

2.3.6 Threatened and Endangered Species

Four species listed as threatened or endangered by the U.S Fish and Wildlife Service (USFWS) have been recorded at FTMC. These threatened and endangered species are as follows:

- Gray bat (*Myotis grisescens*);
- Blue shiner (*Cyprinella caerules*);
- Mohr's Barbara buttons (*Marshallia mohrii*); and
- Tennessee yellow-eyed grass (*Xyris tennesseensis*).

The only federally listed species that has the potential to occur in the vicinity of the IMR or BGR ranges is the gray bat (Garland, 1996). The other federally listed species occur at Pelham Range or Choccolocco Creek.

Gray bat summer foraging habitat is found primarily over open water of rivers and reservoirs. They apparently do not forage over sections of rivers or reservoirs that have lost their normal woody vegetation along the banks (USFWS, 1982). Gray bats usually follow wooded corridors from their summer caves to the open water areas used as foraging sites. Forested areas surrounding and between caves, as well as over feeding habitats, are clearly advantageous to gray bat survival, as the cover provides increased protection from predators such as screech owls. In addition, surveys have demonstrated that reservoirs and rivers that have been cleared of their adjacent forest canopy are avoided as foraging areas by gray bats (USFWS, 1982).

The gray bat is entirely insectivorous, and surveys have shown that gray bats feed almost exclusively on mayflies at certain times of the year (Mount, 1986). Therefore, gray bats could be exposed to site-related constituents that have accumulated in aquatic insects from Remount Creek or Cane Creek. Because gray bats are flying mammals and the IMR and BGR ranges do not provide roosting habitat, no other exposure pathways are complete for the gray bat.

Mist net surveys were conducted on and adjacent to FTMC in 1995. Gray bats were captured along both Choccolocco Creek (east of FTMC Main Post) and Cane Creek on Pelham Range (west of FTMC Main Post) during these mist net surveys (Garland, 1996). These preliminary data suggest that these major stream corridors at FTMC may provide at least a minimum foraging habitat for gray bats. However, gray bat surveys have not been conducted on Remount Creek in the vicinity of the IMR ranges or Cane Creek in the vicinity of the BGR ranges.

Although not officially listed by USFWS as threatened or endangered, two species that are candidates for federal listing are known to occur at the Marcheta Hill Orchid Seep SINA located directly south of Range 21 (BGR ranges); the white fringeless orchid (*Plantanthera integrilabia*) and the Diana butterfly (*Speyeria diana*). The white fringeless orchid occurs in bogs and seepages along wooded stream banks and ravines from the coastal plain of Mississippi through Alabama, Georgia, Tennessee, Kentucky, the Carolinas, and Virginia. The plant was recorded within two SINAs on Main Post: Marcheta Hill Orchid Seep and Cave Creek Seep (Garland, 1996).

The other candidate species that is known to occur at the Marcheta Hill Orchid Seep is the Diana butterfly (*Speyeria diana*). Habitat affinity for this butterfly includes wet, rich forested valleys and mountainsides, and relatively undisturbed forests, especially near streams (Garland, 1996).

2.4 Constituents of Potential Ecological Concern

The SLERAs conducted for the IMR and BGR ranges initially identified a number of COPECs in surface soil, surface water, and sediment by calculating screening-level hazard quotients (HQ) (HQ_{screen}). HQ_{screen} values were developed via a three-step process as follows:

- Comparison of maximum detected constituent concentrations (MDCC) to ecological screening values (ESV);
- Identification of essential macronutrients; and
- Comparison to naturally occurring background concentrations.

A constituent was initially identified as a COPEC in the SLERA if all of the following conditions were met:

- The MDCC exceeded the ESV;
- The MDCC was 10 times the background threshold value (BTV) if the constituent is a macronutrient; and
- The MDCC exceeded the BTV for inorganics.

If a constituent in a given environmental medium did not meet all of these conditions, then it was not considered a COPEC at the IMR or BGR ranges and was not considered for further assessment. Identification of a constituent as a COPEC in the SLERA simply indicated that further assessment of that particular constituent in a given environmental medium was deemed appropriate and did not imply that that particular constituent posed a definite risk to ecological receptors.

Additional lines of evidence were used to refine the list of COPECs that would be assessed in the BERA for these ranges. These additional lines of evidence included frequency of detection, magnitude of the calculated HQ, association with known U.S. Army activities at the ranges and bioaccumulation and toxicity potential. The COPECs identified for surface soil, surface water, sediment, and groundwater at the IMR and BGR ranges are presented in Tables 2-1 and 2-2, respectively.

2.4.1 COPECs at the IMR Ranges

The following sections summarized the COPECs that were identified in surface soil, surface water, and sediment at the IMR ranges.

2.4.1.1 COPECs in Surface Soil

Antimony, copper, lead, and zinc were frequently detected in surface soil at all of the IMR ranges at concentrations that exceeded their respective ESVs. The highest concentrations of these four constituents were found in locations that are associated with small arms use (i.e., soil berms that are the impact areas). Thus, it was concluded that these constituents are site related and could be considered COPECs in surface soil at all of the IMR ranges.

2.4.1.2 COPECs in Surface Water

Lead was the only COPEC detected in surface water from Remount Creek and its tributaries in the vicinity of the IMR ranges. Four surface water samples from the Skeet Range exhibited lead

concentrations that were greater than the ESV. Surface water samples from the other IMR ranges did not exhibit elevated concentrations of any constituent. Since lead was identified as a COPEC in surface soil and is associated with small arms training activities, it has been identified as a COPEC in surface water at the IMR ranges, although the extent of lead contamination in surface water appears to be limited to the Skeet Range.

2.4.1.3 COPECs in Sediment

Arsenic, barium, copper, lead, manganese, and thallium were identified as COPECs in sediment from Remount Creek and its tributaries in the vicinity of the IMR ranges. These constituents of potential concern were detected at elevated concentrations only in samples from the ditches and tributaries at the Skeet Range.

2.4.1.4 COPECs in Groundwater

Surface water ESVs were used to assess groundwater at the IMR ranges in order to determine the potential for impacts to aquatic organisms from groundwater if groundwater intrusion to Remount Creek and its tributaries does occur.

During the course of field investigations at the IMR ranges, surface water was not consistently observed flowing through the stream channel adjacent to the study area. During the majority of field observations, the stream channel was largely dry, with some small pools of surface water (estimated 2 to 4 feet in diameter) observed in depressions in the stream channel.

During soil boring and well installation activities, groundwater was encountered at depths ranging from 15 to 88 feet below ground surface. Based on a comparison of the approximate elevations at which groundwater was encountered during drilling to the elevation of the Remount Creek streambed, it appears that groundwater in the residuum at the IMR ranges does not contribute substantially to surface water flow within Remount Creek. Furthermore, comparing the static water levels from both January 2002 and November 2001 on either side of the creek to the location and elevation of Remount Creek, it appears that the potentiometric surface is below the base of the creek bed. This suggests that Remount Creek is not being fed by the residuum groundwater under base flow conditions. However, it does not rule out the possibility that during periods of heavy rainfall, residuum may become saturated locally and temporarily discharge to the surface water in Remount Creek.

None of the constituents detected in groundwater at elevated concentrations relative to surface water ESVs were detected in surface water at elevated concentrations. In fact, the only constituent detected in surface water at elevated concentrations (lead) was not found in

groundwater at elevated concentrations. Ecological receptors have the potential to be exposed to groundwater only through surface water exposure pathways. Although there may be groundwater/surface water interchange during periods of high precipitation, there does not appear to be a significant exchange of contaminants between the two media.

Based on the extremely low concentrations of the constituents detected in groundwater, the infrequency of detection, and the fact that none of the groundwater constituents was detected at elevated concentrations in surface water at the IMR ranges, it was concluded that there are no COPECs in groundwater at the IMR ranges.

2.4.1.5 Summary of COPECs at the IMR Ranges

The COPECs that were identified in the SLERA and formed the basis for the BERA at the IMR ranges are the following:

- ***Surface Soil***: antimony, copper, lead, and zinc
- ***Surface Water***: lead
- ***Sediment***: arsenic, barium, copper, lead, manganese, and thallium.

2.4.2 COPECs at the BGR Ranges

The following sections summarized the COPECs that were identified in surface soil, surface water, and sediment at the BGR ranges.

2.4.2.1 COPECs in Surface Soil

Antimony, copper, lead, and zinc were frequently detected in surface soil at all of the BGR ranges at concentrations that exceeded their respective ESVs. The highest concentrations of these four constituents were found in locations that are associated with small arms use at these ranges (i.e., soil berms that are the impact areas). Thus, it was concluded that these constituents were site-related and were considered COPECs in surface soil at all of the BGR ranges.

2.4.2.2 COPECs in Surface Water

Surface water from Cane Creek and its tributaries in the vicinity of the BGR ranges exhibited elevated concentrations of copper and lead in a number of samples. In addition, 3 out of 24 surface water samples exhibited elevated concentrations of cobalt with respect to the ESV (HQ_{screen} = 3.04). Two out of 24 surface water samples exhibited slightly elevated concentrations of thallium (HQ_{screen} = 1.88). Based on the relative infrequency of detection of cobalt and thallium, and the fact that the maximum detected concentrations of these two

inorganic compounds only slightly exceeded their respective ESVs, it was concluded that cobalt and thallium are not COPECs in surface water at the BGR ranges.

2.4.2.3 COPECs in Sediment

Sediment from Cane Creek and its tributaries exhibited elevated concentrations of copper and lead in a number of samples collected from the 0 to 6 inch depth increment. Barium, iron, manganese, and thallium do not have ESVs, but they were detected in several samples at slightly elevated concentrations relative to their BTVs. Barium was detected in 4 of 21 samples at elevated concentrations, iron was detected in 2 of 21 samples at elevated concentrations, manganese was detected in 2 of 21 samples at elevated concentrations, and thallium was detected in 1 of 21 samples at elevated concentrations, relative to background. Because barium and manganese were detected at concentrations greater than their respective BTVs and they do not have ESVs, they were retained as COPECs in sediment. Thallium was also retained as a sediment COPEC because it was detected at concentrations that exceeded its BTV and it has the potential to bioaccumulate in lower tropic levels organisms.

2.4.2.4 COPECs in Groundwater

The rationale for assessing groundwater at the BGR ranges using surface water ESVs was to determine the potential for impacts to aquatic organisms from groundwater intrusion to Cane Creek and its tributaries. Aluminum, barium, copper, iron, and manganese were detected at concentrations in groundwater that exceeded their surface water ESVs. Aluminum was detected in two samples out of twelve at concentrations that exceeded the BTV. Barium, copper, and iron were detected in one of fifteen samples at concentrations that exceeded their respective BTVs. Manganese was detected in four of sixteen samples at concentrations that exceeded its BTV.

It is important to note that if groundwater intrusion into surface water bodies is occurring at the BGR ranges, the surface water samples would incorporate the groundwater that may be introduced to the surface water bodies. As such, screening the surface water samples using the surface water ESVs includes any introduction of groundwater constituents that may be taking place.

Based on the relative infrequency of detection of these inorganic constituents, the fact that the maximum detected concentrations only slightly exceeded their respective BTVs, and the fact that groundwater/surface water interactions do not appear to be significant at the BGR ranges, it was concluded that there are no COPECs in groundwater at the BGR ranges.

2.4.2.5 Summary of COPECs at the BGR Ranges

In order to focus on the constituents that are most prevalent at the BGR ranges and have the greatest potential to pose adverse ecological effects to local ecological communities and populations, the initial list of COPECs was scrutinized using additional lines of evidence. These additional lines of evidence included frequency of detection, magnitude of the HQ_{screen} value, association with Army activities, bioaccumulation and toxicity potential. Based on these additional lines of evidence, the COPECs that were identified at the BGR ranges are the following:

- ***Surface Soil:*** antimony, copper, lead, and zinc
- ***Surface Water:*** copper and lead
- ***Sediment:*** barium, copper, lead, manganese, and thallium.

3.0 Assessment and Measurement Endpoints

Assessment and measurement endpoints are the basis of the Study Design phase of the BERA and define the ecological values that require protection and the methodologies by which those ecological values are measured, respectively. The following sections describe the assessment endpoints that have been identified for the IMR and BGR ranges, the risk hypotheses, and the corresponding measurement endpoints.

3.1 Assessment Endpoints

An assessment endpoint is "an explicit expression of the environmental value that is to be protected" (EPA, 1992). Assessment endpoints focus the risk assessment on particular valuable components of the ecosystem(s) that could be adversely affected by contaminants at a site.

Assessment endpoints for the BERA for the IMR and BGR ranges were selected based on the ecosystems, communities, and species present at the IMR and BGR ranges. Selection of the assessment endpoints was dependent upon the following factors:

- The COPECs, their characteristics, and their concentrations at the IMR and BGR ranges
- The mechanisms of toxicity of the COPECs to different groups of organisms
- Ecologically relevant receptors that are potentially sensitive or highly exposed to the COPECs
- The presence of complete exposure pathways contributing to potential risk.

The assessment endpoints that were identified for the IMR and BGR ranges are presented in the following sections.

3.1.1 Terrestrial Assessment Endpoints

Given the overall goal of protecting the integrity and quality of the terrestrial old field ecosystems at the IMR and BGR ranges, the terrestrial assessment endpoints focus on critical community niches within the old field system. The ecological receptors with the potential for the greatest exposure to COPECs at the IMR and BGR ranges were determined to be invertivorous and omnivorous small mammals and birds. Additionally, the terrestrial invertebrate community has the potential for significant exposure to COPECs. These ecological communities formed the basis for the assessment endpoints described herein.

The terrestrial invertebrate community forms a critical link in many terrestrial food webs and constitutes a food source for many omnivorous and invertivorous birds and mammals. Terrestrial invertebrates also perform an important function in the degradation of organic matter in soil through their bioturbative activities. Terrestrial invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. The assessment endpoint that was identified with respect to the terrestrial invertebrate community is the following:

- Maintenance of a healthy terrestrial invertebrate community at the IMR and BGR ranges.

Herbivorous, omnivorous, and invertivorous birds that feed on the ground (gallinaceous) have the potential to ingest and retain lead bullet fragments that remain on the ground surface at the IMR and BGR ranges. Ingestion and retention of lead fragments has the potential to induce adverse health effects in these birds. The assessment endpoint that was identified with respect to these gallinaceous birds is the following:

- Maintenance of healthy populations of gallinaceous and other ground-feeding birds at the small arms ranges at FTMC.

Invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the IMR and BGR ranges, mainly through ingestion of terrestrial invertebrates that may have accumulated COPECs in their tissues. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs due to their feeding habits, these species also form an important food group for higher trophic level organisms. The assessment endpoint that was identified with respect to the terrestrial invertivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of terrestrial invertivorous small mammals and birds at the IMR and BGR ranges.

Omnivorous mammals and birds were identified as having significant potential for exposure to COPECs at the IMR and BGR ranges, mainly because a portion of their diet includes terrestrial invertebrates that may have accumulated COPECs in their tissues. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs due to their feeding habits, these species also form an important food group for higher trophic level organisms. The assessment endpoint that was identified with respect to the terrestrial omnivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of terrestrial omnivorous small mammals and birds at the IMR and BGR ranges.

The assessment endpoints that have been identified for the IMR and BGR ranges are summarized in Table 3-1.

3.1.2 Aquatic Assessment Endpoints

The overall goal of the aquatic assessment endpoints is the protection of the integrity and quality of the semi-aquatic ecosystem in Remount Creek at the IMR ranges and the aquatic ecosystem in Cane Creek at the BGR ranges. The aquatic assessment endpoints focus on critical community niches within these semi-aquatic and aquatic ecosystems. The ecological receptors with the potential for the greatest exposure to COPECs in these ecosystems are those populations and communities that live in direct contact with the surface water and sediment within Remount and Cane Creeks and those feeding guilds that utilize these creek systems as a major food source. These ecological communities formed the basis for the aquatic assessment endpoints described herein.

The benthic invertebrate community forms a critical link in many aquatic food webs and constitutes a food source for many aquatic and riparian omnivorous and invertivorous birds and mammals. Aquatic benthic invertebrates also perform an important function in the degradation of organic material in sediment. Aquatic benthic invertebrates may also accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the aquatic benthic invertebrate community was identified as an important ecological resource at the BGR ranges. The assessment endpoint that was identified with respect to the aquatic benthic invertebrate community is the following:

- Maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges.

The aquatic water-column invertebrate community forms a critical link in many aquatic food webs. Aquatic water-column invertebrates may accumulate COPECs in their tissues and act as a conduit for the transfer of COPECs to higher trophic level organisms in the food chain. For these reasons, the aquatic water-column invertebrate community was identified as an important ecological resource at the BGR ranges. The assessment endpoint that was identified with respect to the aquatic water-column invertebrate community is the following:

- Maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges.

Aquatic vertebrates (e.g., finfish) are top predators/consumers in many aquatic ecosystems similar to that found at Cane Creek at the BGR ranges. As such, finfish have the potential to be exposed to COPECs that may have accumulated in benthic and/or water-column invertebrates, as well as aquatic plants and other food items in Cane Creek. Finfish could also act as a food source for piscivorous animals that utilize Cane Creek for a hunting/fishing ground. The assessment endpoint that was identified with respect to the aquatic vertebrate (e.g., finfish) community is the following:

- Maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges.

Riparian invertivorous mammals and birds were identified as having significant potential for exposure to COPECs at the BGR ranges, mainly through ingestion of aquatic benthic invertebrates that may have accumulated COPECs in their tissues. In order to differentiate the invertivores that feed mainly on terrestrial invertebrates from those that feed mainly on aquatic invertebrates, this latter group is termed "riparian invertivores" for this assessment. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs in sediment due to their feeding habits, these species also form an important food group for higher trophic level organisms (i.e., raptors). The assessment endpoint that was identified with respect to the riparian invertivorous mammal and bird feeding guild is the following:

- Maintenance of healthy populations and communities of riparian invertivorous small mammals and birds at the BGR ranges.

The assessment endpoints that have been identified for the aquatic and semi-aquatic ecosystems at the IMR and BGR ranges are summarized in Table 3-1.

3.2 Risk Hypotheses

The risk hypotheses in a BERA are questions about the relationships among the assessment endpoints and the predicted responses at a given site. The risk hypotheses are based on the assessment endpoints and provide a basis for developing the study design. The most basic question applicable to most sites is whether site-related contaminants are causing or have the potential to cause adverse effects on the assessment endpoints. Using this basic premise, risk hypotheses were developed for the assessment endpoints identified in the previous section.

3.2.1 Terrestrial Risk Hypothesis

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of a healthy terrestrial invertebrate community" was determined to be the following:

- Survival of terrestrial invertebrates exposed to surface soil collected from the BGR ranges is significantly different from that of terrestrial invertebrates exposed to soil from a non-impacted reference area.

This risk hypothesis will identify differences in terrestrial invertebrate survivability when exposed to on-site soils and off-site reference soils in laboratory toxicity tests.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations of gallinaceous and other ground-feeding birds" was determined to be the following:

- Calculated probabilities of birds ingesting and retaining lead bullet fragments are statistically and biologically significant in local bird populations.

This risk hypothesis will identify if the probabilities of birds ingesting lead bullet fragments at the IMR and BGR ranges are statistically and biologically significant.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of terrestrial invertivorous small mammals and birds" was determined to be the following:

- Calculated HQs using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors (AUF) indicate statistically significant risk potential to terrestrial invertivorous small mammals or birds.

This risk hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of terrestrial omnivorous small mammals and birds" was determined to be the following:

- Calculated HQs using measured body burdens of COPECs in earthworms, site-specific diet composition, and AUFs indicate statistically significant risk potential to terrestrial omnivorous small mammals or birds.

This risk hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values.

Table 3-1 presents risk hypotheses for each of the terrestrial assessment endpoints. It is important to note that the hypotheses are expressed as a positive response in order to minimize the likelihood of Type II statistical errors (i.e., a false negative decision) at a standard confidence level of $p = 0.05$.

3.2.2 Aquatic Risk Hypotheses

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges" is the following:

- Survival and growth of aquatic benthic invertebrates exposed to sediment collected from the BGR ranges is statistically significantly different from that of aquatic benthic invertebrates exposed to sediment from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic benthic invertebrate survivability and growth when exposed to on-site sediments from Cane Creek and off-site reference sediments in laboratory toxicity tests.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges" was determined to be the following:

- Survival and growth of aquatic water-column invertebrates exposed to surface water collected from Cane Creek at the BGR ranges is statistically significantly different from that of aquatic water-column invertebrates exposed to surface water from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic water-column invertebrate survivability and growth when exposed to on-site surface water from Cane Creek and off-site reference surface water in laboratory toxicity tests.

The environmental concern associated with this risk hypothesis is whether contaminants in surface water at the IMR ranges preclude the presence of a normal, functioning population of aquatic water column invertebrates. The repercussions of having contaminant-induced adverse effects on the aquatic invertebrate population are the inability of the aquatic habitat to support

higher trophic level organisms. This risk hypothesis will help determine whether surface water at the IMR ranges has been, or is being, adversely affected by site-related contaminants such that the ability of the surface water bodies at the IMR ranges to support aquatic communities is being compromised.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges" was determined to be the following:

- Survival and growth of aquatic vertebrates (e.g., finfish) exposed to surface water collected from Cane Creek at the BGR ranges is statistically significantly different from that of aquatic vertebrates exposed to surface water from a non-impacted reference stream.

This risk hypothesis will identify differences in aquatic vertebrate survivability and growth when exposed to on-site surface water from Cane Creek and off-site reference surface water in laboratory toxicity tests.

The risk hypothesis that was identified as being appropriate to address the assessment endpoint of "maintenance of healthy local populations and communities of riparian invertivorous mammals and birds" was determined to be the following:

- Calculated HQs using modeled COPEC concentrations in aquatic insects, site-specific diet composition, and AUFs indicate statistically significant risk potential to riparian invertivorous mammals or birds.

This risk hypothesis will determine whether calculated daily doses of COPECs exceed feeding guild-specific toxicity reference values and will determine if COPECs in surface water and/or sediment have the potential to be transferred through the riparian food chain via aquatic insects.

Table 3-1 presents risk hypotheses for each of the aquatic assessment endpoints. It is important to note that the hypotheses are expressed as a positive response in order to minimize the likelihood of Type II statistical errors (i.e., a false negative decision) at a standard confidence level of $p = 0.05$.

3.3 Measurement Endpoints

A measurement endpoint is "a measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint" and is a measure of biological effects (e.g., mortality, reproduction, growth) (EPA, 1992). Measurement endpoints are frequently numerical

expressions of observations (e.g., toxicity test results, community diversity measures) that can be compared statistically to a control or reference site to detect adverse responses to site contaminants. The measurement endpoints that have been selected for the IMR and BGR ranges are presented in the following sections.

3.3.1 Terrestrial Measurement Endpoints

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of a healthy terrestrial invertebrate community" is the following:

- Statistical comparison of earthworm survival and growth rates between earthworms exposed to soils exhibiting a gradient of COPEC concentrations from the BGR and IMR ranges to earthworms exposed to soils from a non-impacted reference location.

Additionally, in order to estimate the bioavailability of the COPECs in soil at the IMR and BGR ranges, and to provide data for the other assessment endpoints, COPEC concentrations in tissues of earthworms exposed to soils from within the IMR and BGR ranges and a non-impacted reference location will be determined.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of healthy populations of gallinaceous and other ground-feeding birds at the small arms ranges at FTMC" is the following:

- Calculation of the probability of bobwhite quail and wild turkeys ingesting and retaining a lead bullet fragment from the IMR or BGR ranges.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of a healthy local population of small terrestrial invertivorous mammals and birds" is the following:

- Calculation of HQs for invertivorous mammal (shorttail shrew) and invertivorous bird (American woodcock) using measured earthworm tissue concentrations of COPECs and modeled terrestrial vegetation concentrations of COPECs.

The measurement endpoint that has been identified to address the assessment endpoint of "maintenance of a healthy local population of small terrestrial omnivorous mammals and birds" is the following:

- Calculation of HQs for omnivorous mammal (white-footed mouse) and omnivorous bird (American robin) using measured earthworm tissue

concentrations of COPECs and modeled terrestrial vegetation concentrations of COPECs.

These measurement endpoints will provide the necessary data to answer the risk hypotheses for the terrestrial ecosystems at the IMR and BGR ranges. An important factor in assessing these measurement endpoints is an understanding of the degree of impairment to a biological attribute that is understood to be biologically or ecologically significant. Statistically significant differences in population survivability, growth, reproduction, or HQs values that cannot be related to biological or ecological significance should not be interpreted as indicating a population or community is at risk. However, for this risk assessment, the measurement endpoints and data quality objectives (DQO) are assumed to relate to natural communities and populations at the IMR and BGR ranges, recognizing that the test species are surrogates for natural communities at FTMC.

Table 3-1 presents the measurement endpoints corresponding to each assessment endpoint and risk hypothesis for the terrestrial ecosystems at the IMR and BGR ranges at FTMC.

3.3.2 Aquatic Measurement Endpoints

The measurement endpoints that were identified to address the assessment endpoint of "maintenance of healthy aquatic benthic invertebrate populations and communities in Cane Creek at the BGR ranges" are the following:

- Comparison of survival and growth of the benthic amphipod *Chironomus riparius* exposed to "on-site" sediment to survival and growth of *Chironomus riparius* exposed to sediment from a reference stream.

- Comparison of the benthic community assemblage from Cane Creek adjacent to the BGR ranges with the benthic community assemblages from a reference stream using RBPII methodology.

The measurement endpoint that was identified to address the assessment endpoint of "maintenance of healthy aquatic water-column invertebrate populations and communities in Cane Creek at the BGR ranges" is the following:

- Comparison of survival and reproduction of the water flea *Ceriodaphnia dubia* exposed over 7 days to "on-site" surface water (Cane Creek and tributaries) to survival and reproduction of *Ceriodaphnia dubia* exposed over 7-days to surface water from a reference stream.

The measurement endpoint that was identified to address the assessment endpoint of "maintenance of healthy aquatic vertebrate (e.g., finfish) populations and communities in Cane Creek at the BGR ranges" is the following:

- Comparison of survival and growth of the fathead minnow *Pimephales promelas* exposed over 7-days to "on-site" surface water to survival and growth of *Pimephales promelas* exposed over 7-days to surface water from a reference stream.

The measurement endpoint that was identified to address the assessment endpoint of "maintenance of healthy populations and communities of riparian invertivorous small mammals and birds at the BGR ranges" is the following:

- Calculation of HQs for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) using modeled tissue concentrations of COPECs in emergent benthic invertebrates.

These measurement endpoints will provide the necessary data to answer the risk hypotheses for the aquatic ecosystems at the IMR and BGR ranges. An important factor in assessing these measurement endpoints is an understanding of the degree of impairment to a biological attribute that is understood to be biologically or ecologically significant. Statistically significant differences in population survivability, growth, reproduction, or HQ values that cannot be related to biological or ecological significance should not be interpreted as indicating a population or community is at risk. However, for this risk assessment, the measurement endpoints and DQOs are assumed to relate to natural communities and populations at the IMR and BGR ranges, recognizing that the test species are surrogates for natural communities at FTMC.

Table 3-1 presents the measurement endpoints corresponding to each aquatic assessment endpoint and risk hypothesis.

4.0 Data Quality Objectives

DQO are "qualitative and quantitative statements that clarify study objectives, define the appropriate type of data, and specify tolerable levels of potential decision errors that will be used as the basis for establishing the quality and quantity of data needed to support decisions" (EPA, 2000a).

Based on the findings of the SLERAs and Problem Formulations conducted for the IMR and BGR ranges, the objectives of this BERA were identified as the following:

- Collect site-specific data to address bioavailability and bioaccumulation potentials in lower trophic level organisms that form the basis of the terrestrial and aquatic food webs at the IMR and BGR ranges.
- Collect site-specific data to address the existence and level of site-specific toxicity to terrestrial and aquatic receptors resulting from exposure to the COPECs.
- Determine the concentrations of the COPECs within the surface soils, surface water, and sediment at the IMR and BGR ranges at which the ecological receptors are at risk.
- Provide data of sufficient quality to develop a technically defensible characterization of risk at the IMR and BGR ranges for use by risk managers in their acceptance or rejection of present and future ecological risks posed by the COPECs in surface soil, surface water, and sediment and, if necessary, develop ecologically-based cleanup criteria.

The following decisions require site-specific data in order to address the issues identified in the objectives presented above.

- Determine if the COPECs at the IMR and BGR ranges are available for bio-uptake (i.e., bioavailable) in terrestrial or aquatic systems.
- Determine what levels of COPECs in soil, sediment, and surface water promote acute or chronic toxicity to terrestrial and aquatic receptors.
- Determine if the COPECs bioaccumulate in the tissues of terrestrial invertebrates (e.g., earthworms) or benthic invertebrates, and if so, to what extent.
- Determine the probability of gallinaceous and other ground-feeding birds ingesting and retaining a lead bullet fragment at the IMR and BGR ranges.

- Determine whether the tissue burdens of COPECs in terrestrial invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize terrestrial invertebrates as a major food source.

- Determine whether benthic communities within Cane Creek are adversely affected by exposure to COPECs in surface water and sediment.

- Determine whether the concentrations of COPECs in emergent benthic invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize emergent benthic invertebrates as a major food source.

- Develop constituent-specific cleanup goals for soil, surface water, or sediment if the BERA concludes that there is the potential for unacceptable ecological risk.

The information required to support the decisions that were identified in the Problem Formulations for the IMR and BGR ranges and summarized above include the following:

- Surface soil concentrations of the four soil COPECs (parts per million) within the three different "binding capacity" soils ("low", "medium", and "high");

- Earthworm mortality based on earthworm LC_{50} (lethal concentration killing 50 percent of the test population) data (parts per million) for each of the three different "binding capacity" soils ("low", "medium", and "high");

- Bio-uptake and accumulation potential based on the ratio of soil COPEC concentrations to earthworm tissue concentrations within each of the three different "binding capacity" soils ("low", "medium", and "high");

- Lead bullet fragment densities in the surface soil at the IMR and BGR ranges.

- Number of ingested and retained lead fragments necessary to induce adverse effects in birds.

- Preferred size ranges for particles retained in birds' crops.

- Retention times for particles retained in birds' crops.

- Projected dose estimates of the four soil COPECs in the terrestrial invertivorous shorttail shrew and American woodcock, as well as the omnivorous American robin and white-footed mouse (mg COPEC per unit of body mass per day);

- Estimated levels of concern to the invertivorous shorttail shrew and American woodcock as well as the omnivorous American robin and white-footed mouse based on modeled HQ values (estimated total daily dose/literature-based effect value);

- Sediment concentrations of barium, copper, lead, manganese, and thallium;
- Surface water concentrations of lead and copper;
- *Chironomus riparius* mortality based on exposure to various COPEC concentrations in sediment and derivation of sediment LC_{50} values;
- Bio-uptake and accumulation potential based on the ratio of sediment COPEC concentrations in Cane Creek to *Chironomus sp.* tissue concentrations;
- Fathead minnow (*Pimephales promelas*) and water flea (*Ceriodaphnia dubia*) acute and sub-chronic responses to Cane Creek surface water;
- Projected dose estimates of the COPECs in the riparian invertivorous little brown bat and marsh wren (mg COPEC per unit of body mass per day);
- Estimated levels of concern to the riparian invertivorous little brown bat and marsh wren based on modeled HQ values (estimated total daily dose/literature-based effect value); and
- Benthic invertebrate community structure as determined by rapid bioassessment measurements.

These data will be used to help determine whether COPECs in surface soil, sediment, and surface water at the IMR and BGR ranges are, or will, present significant risk to ecological receptors. If ecological risks are predicted using the information presented above, then this information will also be used to determine the concentrations of COPECs in surface soil, sediment, and surface water that are protective of the terrestrial and aquatic receptors at the IMR and BGR ranges.

The objective in developing specific decision rules is to construct theoretical "if…then…" statements relative to the ecological habitats, populations and COPECs at the IMR and BGR ranges. These statements can then be used by risk managers in deciding whether to accept or reject the characterized risk and, if necessary, in generating ecological based cleanup goals. The decision rules for the IMR and BGR ranges BERA include the following:

- If COPECs in soils from the BGR and IMR ranges cause acute earthworm toxicity which is statistically greater than earthworm toxicity in soils from a "reference" site, then there is the potential for unacceptable risks to terrestrial invertebrate receptors at the IMR and BGR ranges.
- If earthworms exposed to soils from the BGR and IMR ranges demonstrate statistically higher tissue concentrations of COPECs than earthworms exposed to

"reference" soils, then there is the potential for significant COPEC accumulation in terrestrial invertebrate tissues.

- If the probability of birds ingesting and retaining a lead bullet fragment is statistically and biologically significant, then there is the potential for ecological risk to gallinaceous and other ground-feeding birds at the IMR or BGR ranges.

- If calculated doses of COPECs for terrestrial invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the IMR and BGR ranges.

- If calculated doses of COPECs for terrestrial omnivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the IMR and BGR ranges.

- If, based on the collective evaluation of the lines-of-evidence, COPECs are determined to pose unacceptable risks to terrestrial receptors at the IMR or BGR ranges, then remedial goals for soil will be developed using the data collected during the BERA.

- If COPECs within the Cane Creek surface water cause acute or chronic toxicity to fathead minnows or *Ceriodaphnids* which are statistically greater than toxicity from reference waters, then there is the potential for risk to water column receptors at the IMR and BGR ranges.

- If COPECs within the Cane Creek sediments cause acute toxicity to the benthic invertebrate *Chironomus sp.*, which is statistically greater than toxicity from reference sediments, then there is the potential for risk to emergent benthic invertebrates at the BGR ranges.

- If chironomids exposed to sediment from Cane Creek demonstrate statistically higher tissue concentrations of COPECs than chironomids exposed to "reference" sediment, then there is the potential for significant COPEC accumulation in benthic invertebrate tissue.

- If the benthic community assemblage in Cane Creek at the BGR ranges is significantly different than the benthic community assemblage in a non-impacted reference stream, then there is the potential for risk to the Cane Creek benthic ecosystem.

- If calculated doses of COPECs for riparian invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to riparian invertivorous mammals or birds at the IMR and BGR ranges

It is important to consider the role of background concentrations of COPECs when developing specific decision rules. It is possible that naturally-occurring concentrations of certain inorganic

constituents in environmental media could result in a determination of unacceptable risk. Therefore, background will be considered within the context of each of the aforementioned decision rules.

Additionally, it is possible that benthic macroinvertebrate assemblages in on-site creek stretches could potentially exhibit metrics indicative of a "higher quality" environment than those found in the reference stream. This type of result is interpreted in the risk assessment as the on-site creek stretch being un-impacted in comparison to the reference stream.

5.0 Site Investigation Results

Site investigation tasks included the following:

- Collection of surface soil samples;
- Collection of surface water samples;
- Collection of sediment samples; and
- Survey of Cane Creek benthic invertebrates.

These site investigation tasks were conducted in May and June 2003. The results of the site investigation are presented in the following sections. Analysis and interpretation of the results are presented in Chapter 6.0, Risk Characterization.

5.1 Results of Abiotic Sampling and Analysis

Surface soil, surface water, and sediment samples were collected from the IMR and BGR ranges, and Cane Creek in order to conduct toxicity and bioaccumulation studies. These samples were also subjected to chemical analysis to determine the concentrations of COPECs present and aid in risk characterization. The following sections describe the results of the abiotic sampling conducted in conjunction with this BERA.

5.1.1 Surface Soil Sampling and Results

Because the terrestrial assessment endpoints are highly dependent upon the bioavailability of the COPECs in soil, a study was conducted during the design phase of the IMR and BGR BERA to determine the binding capacity of the soils found at the IMR and BGR ranges. It was assumed that soils with similar physical and chemical binding capacities would exhibit similar bioavailabilities for a given COPEC, regardless of where the soil and COPEC were located (i.e., regardless of what range the soil or COPEC were found on). Eight surface soil samples were collected from the IMR ranges (Parcels 69Q, 70Q, 71Q, and 75Q) and the BGR ranges (Parcels 77Q, 78Q, 80Q, and 85Q). The surface soil samples were collected from five soil mapping units (U.S. Department of Agriculture, 1961): Anniston and Allen gravelly loams, Anniston ad Allen stony loams, Stony Rough Land Sandstone; Jefferson stony fine sandy loam, and Jefferson gravelly fine sandy loam. Figure 5-1 shows the locations of the surface soil samples used for the binding capacity analysis and the soil mapping units associated with these samples.

The surface soil samples were laboratory analyzed for the following physical and chemical characteristics:

- Texture
- pH
- Phosphate
- Total organic carbon
- Total carbonate
- Cation exchange capacity
- Iron oxyhydroxide content
- Total metals concentrations (aluminum, barium, cadmium, calcium, chromium, copper, iron, lead, magnesium, manganese, nickel, potassium, silicon, sodium, and titanium).

These physical and chemical analyses were conducted on "whole" surface soil samples. Sieving was not conducted prior to analysis. Table 5-1 presents the results of the analyses conducted on the eight surface soils from the IMR and BGR ranges. To determine the relative metal-binding capacity of the soils present at the sample locations, the analytical results for pH, cation exchange capacity, total organic carbon, texture (used in conjunction with the physical description recorded by the sampler at the time of sample collection), and total lead concentrations were used. Lead was used in this analysis because it is a significant COPEC at all of the IMR and BGR ranges and has been used to identify areas of contamination at all of these ranges.

Based on the analysis of the results, the relative metal-binding capacities of the soils present at the sample locations were divided into three categories: low, medium, and high. The low, medium, and high metal-binding capacities were then assigned to the soil mapping units present at the ranges. The table below lists the relative metal-binding capacity assigned to each soil mapping unit.

Metal-Binding Capacity	Soil Mapping Unit
Low	Stony Rough Land Sandstone
	Anniston and Allen stony loams
	Anniston and Allen gravelly loams
Medium	Jefferson gravelly fine sandy loam
High	Jefferson stony fine sandy loam

These three "soil types," based on metal-binding capacity, were used in the Study Design (Shaw, 2003a) to identify sample locations and COPEC concentration gradients.

For this BERA, a total of 23 surface soil samples were collected from the IMR and BGR ranges per the methodologies set forth in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a). Six soil samples were collected from each of the high, medium, and low metal binding capacity soil types present at these ranges. Additionally, one reference soil sample was collected from high binding capacity soil, one reference sample was collected from medium binding capacity soil and three reference soils were collected from the three soil mapping units that make up the low binding capacity soil at these ranges. These 23 surface soil samples were utilized for earthworm toxicity testing and bioaccumulation analysis as described in later sections of this report. These surface soil samples were also subjected to chemical analysis. The results of the chemical analysis of these 23 surface soil samples are presented in Table 5-2.

Surface soil samples were collected from locations representative of the full range of lead concentrations present in soils at the IMR and BGR ranges. Sample locations were identified in the field using XRF technology. The results of the 23 surface soil samples collected for this BERA were combined with the results of the previous investigations at the IMR and BGR ranges to form a database of 120 surface soil samples for the IMR ranges and 191 surface soil samples for the BGR ranges.

The results of the surface soil sampling at the IMR ranges indicated that antimony, beryllium, copper, lead, magnesium, mercury, nickel, potassium, selenium, silver, and zinc were present in surface soil samples at statistically elevated concentrations compared to background. However, geochemical evaluation of the data indicated that all detected concentrations of beryllium, magnesium, mercury, nickel, potassium, and selenium in surface soil were naturally occurring. Numerous surface soil samples had anomalously high concentrations of antimony, copper, lead, and zinc. One surface soil sample (HR-75Q-SS03) out of 120 samples exhibited an anomalously high concentration of silver (3.69 milligrams per kilogram [mg/kg]) compared to background. These data correspond extremely well with the results of the SLERA for the IMR ranges in that the SLERA identified antimony, copper, lead, and zinc in surface soil as COPECs.

The results of the surface soil sampling at the BGR ranges indicated that aluminum, antimony, barium, beryllium, cadmium, copper, iron, lead, magnesium, mercury, potassium, selenium, silver, and zinc were present in surface soil samples at statistically elevated concentrations compared to background. However, geochemical evaluation of the data indicated that all

detected concentrations of aluminum, barium, beryllium, iron, magnesium, and potassium is surface soil were naturally occurring. Numerous surface soil samples had anomalously high concentrations of antimony, copper, lead, and zinc. One surface soil sample (HR-80Q-GP06) exhibited an anomalously high concentration of cadmium (1.3 mg/kg) and one surface soil sample (HR-85Q-SS02) exhibited anomalously high concentrations of selenium and silver (2.85 mg/kg and 2.74 mg/kg, respectively) relative to background. These data correspond well with the results of the SLERA for the BGR ranges in that the SLERA identified antimony, copper, lead, and zinc in surface soil as COPECs.

5.1.2 Surface Water Sampling and Results

A total of eleven surface water samples were collected from Cane Creek and it's tributaries at the BGR ranges per the methodologies set forth in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a). Ten surface water samples were collected from Cane Creek and its tributaries and one surface water sample was collected from a reference site located on the tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to the Main Post. These eleven surface water samples were used for the fathead minnow and ceriodaphnid toxicity tests described in later sections of this report. These surface water samples were also subjected to chemical analysis and were analyzed for total recoverable metals. The results of the chemical analysis of these eleven surface water samples are presented in Table 5-3. Surface water samples were not collected from Remount Creek at the IMR ranges specifically for this BERA due to the ephemeral nature of Remount Creek at the IMR ranges.

The results of the 11 surface water samples collected for this BERA were combined with the results of the previous investigations at the IMR and BGR ranges. Although no surface water samples were collected at the IMR ranges specifically for this BERA, surface water samples collected as part of the remedial investigation at the IMR ranges indicated that lead in surface water at the IMR ranges was statistically elevated compared to background.

Geochemical evaluation also indicated lead was a COPEC in surface water at the IMR ranges. The SLERA for the IMR ranges identified lead as the only COPEC in surface water.

Copper, lead, potassium, and thallium were detected in surface water samples from the BGR ranges at concentrations that were statistically elevated compared to background. Geochemical evaluation of the data indicated that potassium and thallium were naturally occurring. Copper and lead were detected in numerous surface water samples at anomalously high concentrations. The SLERA for the BGR ranges also identified copper and lead as COPECs in surface water.

5.1.3 Sediment Sampling and Results

A total of eleven sediment samples were collected from Cane Creek and it's tributaries at the BGR ranges per the methodologies set forth in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a). Ten sediment samples were collected from Cane Creek and it's tributaries and one surface water sample was collected from a reference site located on the tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to the Main Post. These eleven sediment samples were used for chironomid toxicity testing and bioaccumulation analysis described in later sections of this report. These sediment samples were also subjected to chemical analysis. The results of the chemical analysis of these 11 sediment samples are presented in Table 5-4. As was the case for surface water at the IMR ranges, sediment samples were not collected from Remount Creek at the IMR ranges specifically for this BERA due to the ephemeral nature of Remount Creek at the IMR ranges.

The results of the 11 sediment samples collected for this BERA were combined with the results of the previous investigations at the IMR and BGR ranges. Antimony, arsenic, copper, iron, lead, and thallium were found to be statistically elevated in sediment samples from the IMR ranges compared to background. Geochemical evaluation indicated that arsenic, iron, and thallium were naturally occurring, but several sediment samples exhibited anomalously high concentrations of antimony, copper, and lead. The SLERA for the IMR ranges identified copper and lead as COPECs in sediment.

Antimony, copper, lead, potassium, selenium, silver, and thallium were found to be statistically elevated in sediment samples from the BGR ranges compared to background. However, geochemical evaluation indicated that potassium, selenium, silver, and thallium were naturally occurring. A number of sediment samples from the BGR ranges exhibited anomalously high concentrations of antimony, copper, and lead. The SLERA for the BGR ranges identified barium, copper, lead, manganese, and thallium as COPECs in sediment.

5.2 Results of Earthworm Toxicity and Bioaccumulation Tests

Surface soil from twenty-three sampling locations within the IMR and BGR ranges was used for toxicity and bioaccumulation testing using the earthworm *Eisenia fetida*. Six soil samples were collected from each of the high, medium, and low binding capacity soils present at these small arms ranges. Additionally, one reference soil sample was collected from high binding capacity soil, one reference sample was collected from medium binding capacity soil and three reference

soils were collected from the three soil mapping units that make up the low binding capacity soil at these ranges.

The test procedures utilized in the performance of the 28-day earthworm toxicity and bioaccumulation tests were based upon those procedures described in *Protocols for Short-Term Toxicity Screening of Hazardous Waste Sites* (EPA, 1989) and *Conducting Laboratory Soil Toxicity or Bioaccumulation Tests with the Lumbricid Earthworm Eisenia fetida* (American Society for Testing and Materials [ASTM], 1999). A detailed description of the testing protocols and results is presented in Attachment 1.

Each soil sample was replicated ten times. Five replicates were used to assess survival, growth, and as tissue for bioaccumulation assessment. Five replicates were used for additional worm tissue for bioaccumulation assessment only. Each test chamber contained ten worms and constituted a replicate. The number of live and dead worms was enumerated at day 14 of the study and at the termination of the test (day 28). Mortality was assessed by emptying the soil onto a tray and sorting worms from the soil. Worms were considered dead if they did not respond to a gentle touch to their anterior end. At the termination of the test, surviving worms were rinsed of soil, blotted dry, weighed by replicate, and placed into labeled zip-lock bags, then frozen prior to shipment to the analytical laboratory for tissue analysis. Worms were not purged of their gut contents prior to analysis.

Day 14 survival ranged from 0% in site samples RW0010 and RW0018 to 100% in site samples RW0001, RW0004, RW0006, RW0008ref, RW0009ref, RW0015, RW0023ref, and RW0025. There was 100% survival in the laboratory control and 99% survival in the pooled reference sites. Statistically significant differences between laboratory control and reference sites and on-site samples were identified at the P = 0.05 level. The term "biologically significant" refers to the fact that although a site sample may exhibit effects that are statistically different than the laboratory control samples or reference location, the effect may not be significant in a biological system that normally exhibits a wide range of variability with respect to survival, growth, and other parameters. Often, an effect exhibited by 20 percent or less of a given population is considered to be within the normal variability of a biological system and is not considered biologically significant (Suter, 2000). Site samples RW0002, RW0010, RW0012, RW0013, RW0018, and RW0019 were significantly reduced for survival compared to the laboratory control and the pooled reference sites. Survival in sample RW0002 was 80 percent and may not be biologically significant. Sample RW0024 exhibited 92 percent survival, which was statistically less than the pooled reference samples but not the laboratory control, and is not considered biologically significant. Day 14 survival is presented in Table 5-5.

Day 28 survival ranged from 0% in site samples RW0002, RW0010, RW0013, and RW0018 to 100% in site samples RW0006, RW0008ref, RW0009ref, RW00015, RW0023ref, and RW0025. There was 100% survival in the laboratory control and 99% survival in the pooled reference sites. Site samples RW0001, RW0002, RW0005, RW0010, RW0012, RW0013, RW0017, RW0018, and RW0019 were significantly reduced for survival as compared to the laboratory control and the pooled reference sites. However, survival in sample RW0005 was 82 percent and may not be biologically significant. Day 28 survival is presented in Table 5-5. The locations of the soil samples used in the earthworm toxicity tests and the results of the 28-day earthworm survival test are presented in Figure 5-2.

All samples showed a loss in weight since no feed was added during the test (Table 5-5). Percent weight loss ranged from –16 percent in site sample RW0022 to –100 percent in site samples RW0002, RW0010, RW0013, and RW0018. Percent weight loss in the laboratory control was –25 percent. Percent weight loss in the reference sites ranged from –8% in reference site RW0007 to –23% in reference site RW0009. Weight loss in the on-site soil samples was differentiated from weight loss in the reference soil samples by using Dunnett's Multi-Comparison T-Test. Site samples with statistically significant survival effects were removed from statistical analysis for weight change. Site samples RW0004, RW0005, and RW0021 were significantly reduced for percent weight loss as compared to the pooled reference sites. The laboratory control was also significantly reduced for percent weight loss as compared to the pooled reference site samples. Weight loss encountered in the control was typical of studies conducted where no food is added during the test. Earthworm weight change was found to be the most sensitive endpoint in the soil toxicity tests. The locations of the soil samples used in the earthworm toxicity tests and the results of the 28-day earthworm growth test are presented in Figure 5-3.

After the 28-day exposure period, live and dead worms were enumerated. Surviving worms were rinsed of soil, blotted dry, weighed, placed into zip-lock bags, and shipped to the analytical laboratory for tissue analysis. Worms were not purged of their gut contents prior to analysis. Earthworm tissues from 18 of the 23 samples were analyzed for metal content. Five of the samples exhibited complete mortality; therefore, no living earthworms remained for tissue analysis. The results of the earthworm tissue analysis for the soil COPECs (antimony, copper, lead, and zinc) are presented in Table 5-6. Antimony concentrations in earthworm tissues ranged from ND in ten samples to 7.36 mg/kg in sample HR-70Q-SS01. Copper in earthworm tissues ranged from 8.91 mg/kg in sample LMBC-REF1-SS to 127 mg/kg in sample HR-70Q-SS01. Lead in earthworm tissues ranged from 10.4 mg/kg in sample LMBC-REF1-SS to 2650 mg/kg in

sample HR-70Q-SS01. Zinc in earthworm tissues ranged from 51 mg/kg in sample MMBC-REF-SS to 132 mg/kg in sample HR-70Q-SS01. The highest concentrations of all of the soil COPECs were detected in the same earthworm tissue sample (HR-70Q0SS01) although the corresponding surface soil sample did not exhibit the highest concentrations of any of the soil COPECs.

The locations of the surface soil samples and the corresponding earthworm survival and growth rates are presented in Figures 5-2 and 5-3, respectively.

5.3 Results of Surface Soil Particle Size Analysis

Surface soil samples were collected from the same 18 locations as the soil samples collected for earthworm toxicity testing. Six soil samples were collected from each of the high, medium, and low binding capacity soils present at the IMR and BGR ranges. Soil was collected from a one foot-by-one foot square area to a depth of one inch. Soil samples for particle size analysis were then placed in a zip-lock bag and shipped to the Shaw geotechnical laboratory in Knoxville, Tennessee. Details of the sampling and analysis procedure are presented in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a).

The methodology used to separate the bullet fragments from the native material followed the methodology described by Peddicord and La Kind (2000). In order to separate the bulk soil samples into particle ranges containing bullet and non-bullet fractions and determine the number of particles of each fraction in each size range, the following procedure was followed:

1. Bulk soil samples were split to obtain test specimens.

2. The test specimens were oven-dried at 105°C+/-5 to constant weight.

3. Test specimens were weighed, then soaked overnight in water.

4. Test specimens were wet-washed over sieves: 4.75 millimeter (mm) (#4) test sieve, 4 mm test sieve, 2.8 mm (#7) test sieve, 2.2 mm test sieve, and 0.8 mm test sieve.

5. Material retained on the #4 sieve was set aside. Particles passing the 2.8 mm sieve but retained on the 2.2 mm sieve were set aside.

6. Particles retained on the 2.8 mm and 0.8 mm sieves were sorted initially by using a water spray to "float" the less dense native material from the bullet particles. This

step primarily removed organic material from the bullet and native mineral particles.

7. Material retained on the 4.0 mm, 2.8 mm and 0.8 mm sieves after wet-washing was oven-dried.

8. Material retained on the 4.0 mm test sieve was segregated visually into bullet and non-bullet fractions. Each particle was measured using digital calipers. Particles coarser than 4.2 mm were included in the previously sorted > 4.75 mm fraction. Particles finer than 4.2 mm were placed into the 2.8 mm fraction.

9. The washed and dried 2.8 mm and 0.8 mm portions were hand-sorted to remove bullet material from the native particles.

10. Bullet particles from the 2.8 mm and 0.8 mm fractions were counted and weighed. Native, non-bullet particles were also counted and weighed.

11. Where the number of particles was large, an aliquot of the particles was counted (e.g. 50) and weighed. Aliquots were used mainly for non-bullet fractions in the 0.8 mm to 2.2 mm size range.

12. During the first round of testing, bullet and non-bullet particle volumes and densities were determined from composites of several bullet and non-bullet fractions (individual fractions were too small to obtain good results). These steps were not repeated for the second round of testing because the soils, except one, were the same for each round (also, this data was not needed in order to calculate the numbers of lead and non-lead particles in the samples submitted for testing).

In order to enumerate the number of bullet and non-bullet particles present in each soil sample within the two particle size ranges, the following process was followed:

1. The dry weight of the test specimen was divided by the dry weight of the total sample submitted for testing (sampled 144 cubic inches of soil) to determine the percentage of sample represented by the test specimen.

2. Where aliquots of particles were counted, the weight of counted particles was divided by the number of counted particles to obtain the average particle weight. The total weight of all particles was divided by the average particle weight to obtain the number of particles for that size and class of particle.

3. The number of bullet particles recovered within the 2.8 mm to 4.2 mm range was multiplied by the inverse of the test specimen percentage to arrive at the number of particles contained in the total test sample. The number of bullet particles recovered within the 0.8 mm to 2.2 mm range was found by the same method.

4. The number of non-bullet particles recovered within the 2.8 mm to 4.2 mm range was determined by multiplying the number of particles in the respective fraction

by the inverse of the test specimen percentage to arrive at the number of particles contained in the total test sample. The number of non-bullet particles recovered within the 0.8 mm to 2.2 mm range was found by the same method.

5. The percentage of bullet particles for each size was found by dividing the number of bullet particles by the sum of the number of bullet particles and the number of non-bullet particles and multiplying the result by 100. The percentage of non-bullet particles was found by subtracting the percentage of bullet particles from 1 and multiplying the result by 100.

It is important to note that the separation technique used in the particle size analysis only distinguished between "native" and "non-native" material. It did not definitively identify the "non-native" material as lead particles.

The results of the soil particle size analysis are presented in Table 5-7. The data presented in Table 5-7 indicate that bullet-related particles within the two size ranges of interest (0.8 to 2.2 mm and 2.8 to 4.2 mm) are found at various percentages in soils from both the IMR and BGR ranges.

5.4 Results of Fathead Minnow Survival and Growth Tests

Surface water samples from ten locations along Cane Creek at the BGR ranges were used for toxicity testing using the fathead minnow *Pimephales promelas*. A reference sample was also collected from the unnamed tributary to Choccolocco Creek that flows in an easterly direction along BGR, east of the Bains Gap gate to the Main Post.

The test procedures utilized in the performance of the 7-day fathead minnow toxicity tests were based upon those procedures described in *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (EPA, 2002). A detailed description of the testing protocols and results is presented in Attachment 2.

Each site sample was replicated four times with 10 fathead minnows per replicate chamber. Minnows were fed *ad libitum* three times daily with newly hatched brine shrimp (*Artemia* sp.) and supplemented the first two days with rotifers (*Brachionus plicatilis*). Survival was recorded daily for each replicate. All samples were monitored for 7 days. At the end of the seven days the surviving fish were anesthetized, placed into pre-weighed aluminum containers, and blotted dry. They were then dried for up to 24 hours at 80-100°C, cooled to room temperature in a dessicator, re-weighed, and total dry weights recorded. Average dry weights per organism were determined for statistical comparisons. Fathead minnow test data are presented in Attachment 2.

A summary of the survival percentages of fathead minnows is presented in Table 5-8. Survival percentages ranged from 78% in sample RW2005 to 100% in sample RW2011. Survival in the reference sample (RW2012ref) and the laboratory control was 98% and 99%, respectively. Site sample RW2005 was the only sample that was statistically reduced for survival compared to the reference site RW2012ref. However, with only a 20 percent reduction in survival compared to the reference sample, this difference may not be biologically significant.

Dry weight data for fathead minnows are summarized in Table 5-8. Mean dry weights per fish ranged from 0.0004 grams in sample RW2002 to 0.0011grams in sample RW2006. The mean dry weight of the laboratory control was 0.0010 grams and the reference site RW2012ref was 0.0011 grams. There was no significant difference between the control and reference site. Site samples RW2001, RW2002, RW2004, RW2005, and RW2007 had statistically reduced dry weights compared to both the laboratory control and the reference sample.

The locations of the surface water samples used in the fathead minnow toxicity tests and the corresponding fathead minnow survival and growth rates are presented in Figures 5-4 and 5-5, respectively.

5.5 Results of Daphnid Survival and Reproduction Tests

Surface water samples from ten locations along Cane Creek at the BGR ranges were used for toxicity testing using the water flea *Ceriodaphnia dubia*. A reference sample was also collected from the unnamed tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to the Main Post.

The test procedures utilized in the performance of the 7-day Ceriodaphnid toxicity tests were based upon those procedures described in *Short Term Methods for Estimating the Chronic Toxicity of Effluents and Receiving Waters to Freshwater Organisms* (EPA, 2002). A detailed description of the testing protocols and results is presented in Attachment 2.

Each site sample was replicated 10 times and the laboratory control was replicated 20 times. At test initiation, one *Ceriodaphnia dubia* neonate (less than 24 hours old) was added to each of the test and control beakers. All beakers were monitored daily for survival of *C. dubia* and the production of young. Test solutions were renewed daily. The criterion for test acceptability was mean survival of >80% in the control(s), an average of 15 or more young per surviving female in the control solutions, and production of at least three broods in 60% of the surviving control organisms. *Ceriodaphnia dubia* test data are presented in Attachment 2.

A summary of the survival percentages of *Ceriodaphnia dubia* is presented in Table 5-8. Survival percentages ranged from 0 percent in samples RW2001, RW2002, RW2004, RW2005, and RW2007 to 100 percent in sample RW2008. Survival in the reference sample, RW2012ref was 80 percent and the laboratory control was 95 percent. There was no significant difference in the survival of the laboratory control and the reference site. Site samples RW2001, RW2002, RW2004, RW2005, RW2007, RW2010, and RW2011 exhibited statistically lower survival (α=0.05) than both the laboratory control and the reference sample.

Mean reproduction data *Ceriodaphnia dubia* are summarized in Table 5-8. Reproduction ranged from 0 young produced in samples RW2001, RW2002, RW2004, RW2005, and RW2007 (0% survival) to 53.0 neonates in sample RW2008. Mean reproduction of the laboratory control and reference sample were 58.6 and 30.4 neonates, respectively. The reference site mean reproduction was significantly reduced (α=0.05) as compared to the laboratory control. Other than the five samples that had no survival after seven days, there was no statistically significant reduction in reproduction for the site samples compared to the reference site.

The locations of the surface water samples used in the ceriodaphnid toxicity tests and the corresponding daphnid survival and reproduction rates are presented in Figures 5-6 and 5-7, respectively.

5.6 Results of Midge Survival, Growth, and Bioaccumulation Tests

Sediment samples from ten locations along Cane Creek at the BGR ranges were used for toxicity testing using the larval midge *Chironomus riparius*. A reference sample was also collected from the unnamed tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to the Main Post.

The test procedures utilized in the performance of the 10-day midge toxicity tests were based upon those procedures described in *Methods for Measuring the Toxicity and Bioaccumulation of Sediment-Associated Contaminants with Freshwater Invertebrates* (ASTM, 1995) and *Standard Test Methods for Measuring the Toxicity of Sediment-Associated Contaminants with Fresh Water Invertebrates* (EPA, 2000b). A detailed description of the testing protocols and results is presented in Attachment 3.

Sediment samples for all screening toxicity tests were replicated eight times with 10 organisms per replicate chamber. The test chambers were 0.5-L glass jars containing approximately 100 ml of sediment and approximately 400 mL of overlying water. The overlying water was laboratory freshwater prepared by blending well water with well water treated by reverse-osmosis to

produce water with a hardness of 160 to 180 mg/L as $CaCO_3$. The overlying water was renewed using an automated system that provided approximately two volume additions per day per replicate chamber. The animals were fed approximately 1 mL of a prepared invertebrate food daily. The number of live and dead animals in each test chamber were enumerated at test termination (day 10) by sieving the sediment through a No. 35 (500-µm) and/or No. 40 (425-µm) sieve. Animals were considered dead if they did not respond to a gentle physical stimulus. Ash-free dry weights were measured by placing animals into an ashed and pre-tarred weigh boat and dried at 60-90 °C for 24 hours. Weigh boats were placed into a dessicator to cool and then re-weighed. Weigh boats were then placed into a muffle furnace at approximately 550 °C for 2.5 hours. Weigh boats were allowed to cool in a dessicator and then re-weighed.

The test procedures utilized in the performance of the 10-day midge bioaccumulation test were based upon those general procedures described above. Each control and site sample was replicated four times using 11.3-L aquaria with base dimensions of 15.8 by 30.5 cm. These base dimensions yielded a surface area of 482 cm^2. Approximately 300 1-3 day post hatch *C. riparius* larvae were added to each replicate. This rate, 1.6 cm^2 per organism, is similar to that suggested by OECD Guideline 218 (OECD, 2002). The overlying water was renewed using the same automated renewal system discussed above. One to two centimeters of control or site sample sediment was added to each aquarium the day prior to the addition of test organisms. Live animals in each test chamber were removed at test termination (day 10) by sieving the sediment through a No. 35 (500-µm) or No. 40 (425-µm) sieve. Once larvae were collected they were placed into labeled polyethylene bottles and placed in a cooler with dry ice. Upon completion of the animal collection, the samples were stored in a freezer until being shipped to the analytical laboratory for analysis.

A summary of the midge survival percentages is presented in Table 5-9. Midge survival ranged from 4 percent in sample RW1001 to 46 percent in sample RW1011. Survival in the laboratory control and reference site was 82 and 33 percent, respectively. Percent survival in site samples RW1001 and RW1005 were significantly reduced compared to the reference site. However, due to the low survival in the reference site sample, these results should be used with caution. The overall low survival in the site and reference samples may be due to the coarse grain size and the low organic content of he sediment samples. Survival data for the larval midge test are located in Attachment 3.

A summary of the ash-free dry weight measurements of midge are presented in Table 5-9. Ash free dry weight ranged from 0.0002 grams in sample RW1002 to 0.0006 grams in samples RW1007, RW1009, and RW1011. Ash free dry weight in the laboratory control and the

reference site was 0.0003 and 0.0010 grams, respectively. Ash-free dry weight in site samples RW1001, RW1002, RW1004, RW1005, RW1006, RW1007, and RW1008 were significantly reduced compared to the reference site. The ash-free dry weight in the laboratory control was also significantly reduced compared to the reference site.

The surviving organisms in the 1.3 liter aquaria were utilized solely for generation of tissue for chemical analysis. The number of surviving organisms was estimated for analytical use only. Chironomid tissue samples were analyzed for metals content. The concentrations of sediment COPECs (arsenic, barium, copper, lead, manganese, and thallium) detected in chironomid tissues are presented in Table 5-10. Arsenic concentrations in chironomid tissues ranged from 0.337 mg/kg in sample SAR-77-SD23 to 5.38 mg/kg in sample HR-85Q-SD02. Barium concentrations in chironomid tissues ranged from 15.2 mg/kg in sample SAR-85-SD08 to 113 mg/kg in sample HR-80Q-SD06. Copper concentrations in chironomid tissues ranged from 30.4 mg/kg in sample REFST-SD to 617 mg/kg in sample SAR-85-SD02. Lead concentrations in chironomid tissues ranged from 20.5 mg/kg in sample REFST-SD to 2880 mg/kg in sample SAR-78-SD10. Manganese concentrations in chironomid tissues ranged from 27.7 mg/kg in sample SAR-77-SD25 to 383 mg/kg in sample HR-80Q-SD03. Thallium was only detected in one chironomid tissue sample (HR-78Q-SD01), although it was not detected in any of the corresponding sediment samples.

The locations of the sediment samples used in the chironomid toxicity tests and the corresponding chironomid survival and growth rates are presented in Figures 5-8 and 5-9, respectively.

5.7 Results of Benthic Community Analysis

Benthic community assemblages in Cane Creek and a reference location were assessed using the methodologies presented in *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, 2nd Edition* (Barbour, et al., 1999). Benthic macroinvertebrate samples, which were co-located with the sediment samples, were collected from 10 locations from Cane Creek and its tributaries within BGR ranges, and one reference location. The benthic macroinvertebrate sample locations are presented on Figure 9-5 of the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a) and are the same locations that were used for collection of sediment for chironomid toxicity testing presented in Figures 5-8 and 5-9. The specific sampling locations were determined in the field, based on available invertebrate habitat and field observations. Concurrent with benthic invertebrate sampling, physical characteristics

of the stream and water quality parameters were also documented. All surface water, sediment, and benthic invertebrate sampling was conducted June 9 through June 12, 2003.

Sample location HR-80Q-SD03 is located on a tributary of Cane Creek in the eastern portion of Range 24-Upper at the BGR ranges. This sample location is the farthest upstream sampling location at the BGR ranges. The stream is 3 to 4 feet wide and approximately 6 inches deep at this sampling location. There are 2-feet high stream banks on either side of the creek with signs of moderate erosion. The forest canopy is complete at this sampling location and the dominant forest species is dogwood (*Cornus sp.*). The stream substrate is comprised of the following types: 20% bedrock, 20% boulder, 40% cobbles, 15% gravel, and 5% sand. The water temperature at this sampling location was measured to be 19.2 °C, the dissolved oxygen was 9.01 mg/L, and the pH was 5.89.

Sample location HR-80Q-SD06 is located on a tributary of Cane Creek located south of the Range 24-Upper study area in the headwaters of Cane Creek. The stream is 2 to 3 feet wide and approximately 4 to 6 inches deep at this sampling location. This section of stream is located within a 50-feet wide flat floodplain with signs of moderate erosion. The forest canopy is complete at this sampling location and the dominant forest species is alder (*Alnus sp.*). The stream substrate is comprised of the following types: 20% boulder, 40% cobble, 35% gravel, and 5% sand. The water temperature at this sampling location was measured to be 19.9 °C, the dissolved oxygen was 7.85 mg/L, and the pH was 5.87.

Sample location SAR-77-SD23 is located on a tributary to Cane Creek in the southern portion of Range 21. The stream is 2 to 3 feet wide and 6 inches deep at this sampling location. This section of stream has no significant banks and is characteristic of a braided stream, with numerous channels and pools, and signs of moderate erosion. The forest canopy is low and dense with alder (*Alnus sp.*) and red maple (*Acer rubrum*) the dominant tree species. The stream substrate is comprised of the following types: 75% sand and 25% silt. The water temperature at this sampling location was measured to be 19 °C, the dissolved oxygen was 8.53 mg/L, and the pH was 5.49.

Sample location SAR-77-SD25 is located on a tributary to Cane Creek in the southwestern portion of Range 21. The stream is approximately 2 to 3 feet wide and 6 inches deep at this sampling location. There is a low, dense forest canopy dominated by alder (*Alnus sp.*) and red maple (*Acer rubrum*). There are also numerous rooted emergent plants in the stream channel dominated by rushes, arrowweed, and polygonium. The stream substrate at this sampling

location is made up of the following types: 5% cobble, 5% gravel, 15% sand, and 75% silt. The water temperature at this sampling location was measured to be 19.8 °C, the dissolved oxygen was 8.43 mg/L, and the pH was 5.83.

Sample location HR-78Q-SD01 is located on the main channel of Cane Creek in the central portion of Range 22. Cane Creek is approximately 6 to 8 feet wide at this location and approximately 6 inches deep. There is a 4 to 5 feet high bank on the north bank and a high, steep hillside with no vegetation on the southern bank, with signs of significant erosion. The canopy is partially open at this sample location with red maple (*Acer rubrum*) the dominant tree species. The stream substrate at this sampling location is made up of the following types: 30% boulder, 50% cobble, 15% gravel, and 5% sand. The water temperature at this sampling location was measured to be 23.1 °C, the dissolved oxygen was 8.42 mg/L, and the pH was 6.21.

Sample location SAR-78-SD10 is located on Cane Creek in the west-central portion of Range 22. Cane Creek is approximately 6 to 8 feet wide at this location and approximately 6 inches deep. There are 5 to 6 feet high banks on both sides of Cane Creek at this location with moderate signs of erosion. There is a low, dense canopy over Cane Creek at this location which is dominated by alder (*Alnus sp.*). There is a significant brown "algae" floc on all of the substrate at this sample location. The stream substrate at this sampling location is made up of the following types: 25% boulder, 40% cobble, 30% gravel, and 5% sand. The water temperature at this sampling location was measured to be 24.1 °C, the dissolved oxygen was 8.33 mg/L, and the pH was 6.66.

Sample location SAR-85-SD08 is located on Cane Creek in the northeast portion of Range 27. Cane Creek is approximately 10 to 12 feet wide and 6 inches to 1 foot deep at this sampling location. There are 4 feet high steep banks with signs of moderate erosion on both sides of Cane Creek at this location. There is a low, partly open canopy dominated by alder (*Alnus sp.*) over Cane Creek at this location. There is a significant brown "algae" floc on all of the substrate at this sample location. The stream substrate at this sampling location is made up of the following types: 30% boulder, 40% cobble, 20% gravel, and 10% sand. The water temperature at this sampling location was measured to be 23.5 °C, the dissolved oxygen was 8.39 mg/L, and the pH was 6.73.

Sample location SAR-85-SD05 is located on Cane Creek in the central portion of Range 27. Cane Creek is approximately 6 feet wide and 4 to 8 inches deep at this sampling location. There are 4 feet high steep banks with signs of moderate erosion on either side of Cane Creek at this

sampling location. There is a low, partly shaded canopy over Cane Creek at this location which is dominated by alder (*Alnus sp.*). There is a significant brown "algae" floc on all of the substrate at this sample location. The stream substrate at this sampling location is made up of the following types: 20% boulder, 40% cobble, 30% gravel, and 10% sand. The water temperature at this sampling location was measured to be 23 °C, the dissolved oxygen was 8.62 mg/L, and the pH was 6.69.

Sample location HR-85Q-SD02 is located on the small tributary/drainage swale in the northern portion of the Range 27 study area. This small tributary is approximately 2 feet wide and 6 inches deep. There are no significant banks along this tributary as the area is mostly flat with moderate signs of erosion. There is a mostly open canopy along this tributary which is dominated by sedges and rushes along it's length. The substrate at this sampling location is made up of the following types: 80% sand and 20% silt. The water temperature at this sampling location was measured to be 20.3 °C, the dissolved oxygen was 7.2 mg/L, and the pH was 6.73.

Sample location SAR-85-SD02 is located on Cane Creek in the western portion of Range 27. Cane Creek is 8 to 10 feet wide and 6 inches to 1 foot deep at this sampling location. The southern bank of Cane Creek at this location is approximately 4 feet high with significant signs of erosion. The northern bank is made up of cobbles and boulders gradually sloping to the creek. There is no canopy at this location as Cane Creek is completely open with no vegetation along its banks. There is a significant brown "algae" floc on all of the substrate at this sample location. The substrate at this sampling location is made up of the following types: 20% bedrock, 20% boulder, 40% cobble, 15% gravel, and 5% sand. The water temperature at this sampling location was measured to be 19.6 °C, the dissolved oxygen was 9.02 mg/L, and the pH was 5.75.

The surface water and sediment reference sample location is located on a tributary of Choccolocco Creek which is east of the Bains Gap Road gate. This reference creek originates in the mountains east of the BGR ranges and runs in an easterly direction towards Choccolocco Creek. This reference creek is approximately 6 to 8 feet wide and 6 inches to 1 foot deep. There are 2 to 3 feet high banks on both sides of this creek with moderate signs of erosion. The forest along this reference stream forms a complete canopy and is made up mature hardwoods (i.e. oaks [*Quercus sp.*] and tulip trees [*Leriodendron tulipifera]*) and numerous dogwoods (*Cornus sp.*). The substrate at this sampling location is made up of the following types: 10% bedrock, 25% boulder, 40% cobble, 20% gravel, and 5% sand. The water temperature at this sampling location was measured to be 19.8 °C, the dissolved oxygen was 9.22 mg/L, and the pH was 6.08.

Additionally, stream habitat was assessed by using field data sheets adapted from *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, 2nd Edition* (Barbour, et al., 1999). These field data sheets are presented in Attachment 4. The stream habitat in Cane Creek and its tributaries at the BGR ranges was characterized as being sub-optimal to poor. There was no apparent trend in stream habitat quality with regard to sampling location. The results of the stream habitat assessment are summarized in Table 5-11

Benthic macroinvertebrate samples were collected in accordance with the procedures specified in Appendix B of the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a). Two benthic macroinvertebrate samples were collected at each location, a riffle/run sample and a course particulate organic matter (CPOM) sample. The riffle/run sample was collected with a kick net; and consisted of a composite sample collected from two areas; one from an area of relatively fast current velocity (riffle), and the other from an area of relatively slow current (run). The CPOM sample was hand collected from a depositional area of the creek and consisted of a composite of a variety of leaves, twigs, bark, and other organic matter. All samples were placed into appropriate containers and preserved with buffered 10 percent formalin solution.

Benthic macroinvertebrate samples were processed in the Shaw laboratory in Knoxville, TN as indicated in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a). All samples for benthic invertebrate analysis were analyzed in total (i.e., samples were not "split" into sub-samples) because the abundance of invertebrates was relatively low, less than 100 organisms per sample. All benthic macroinvertebrates were identified to Family using both compound and dissecting microscopes based on the information provided in Merritt and Cummins (1984), Peckarsky, et al. (1990) and Pennak (1989 and 1978). All of the invertebrates identified in a sample were counted and placed into a glass vial containing 95 percent ethanol. The vial containing the invertebrates from each sample was labeled with the sample location code.

Using the raw benthic data, a numerical value was calculated for each metric. Calculated values were then compared to values derived from the reference site. Each metric was then assigned a score according to the comparability (percent similarity) of calculated and reference values. Scores for the eight metrics were then totaled and compared to the total metric score for the reference location. The percent comparison between the total scores provides a final evaluation of biological condition. Although some of the metrics included in the Rapid Bioassessment Protocol (RBP) were originally developed to assess the impacts of organic pollutants on benthic

invertebrate communities, their utility in assessing the impacts of other stressors on benthic invertebrate communities is also widely recognized. Certain metrics are more specific to organic pollutants (e.g. Hilsenhoff FBI) than some of the other metrics that are equally useful for organic and inorganic pollutants (e.g. Community Similarity Index). The use of multiple metrics to assess the biologic condition of a given stream reach serves to de-emphasize any given metric and instead relies on the overall score produced by all of the metrics combined. In this way, no single stream characteristic or group of organisms is provided more "weight" than another characteristic or group of organisms. Furthermore, each metric is given a score based on the percent comparability to a reference location. By comparing all of the on-site metrics to the metrics at a reference location, the biologic condition of a given on-site stream reach is normalized to the reference location and the specific stressor(s) that affects the biologic condition is not identified, nor is it critical to this assessment technique.

A summary of the benthic macroinvertebrates which were collected during this survey are shown in Table 5-12. The metrics used to evaluate the benthic macroinvertebrate data and their significance are described below and summarized in Table 5-13.

Metric 1: Taxa Richness. Taxa richness is calculated by counting the number of taxa present in each sample. Taxa richness reflects the health of the community through a measurement of the variety of taxa present. In general, taxa richness increases with increasing water quality, habitat diversity, and/or habitat suitability. Taxa richness ranged from 1 at sample location SAR-85-SW/SD08 to 8 at REFST.

Metric 2: Modified Family Biotic Index. This index, developed by Hilsenhoff (1988), summarizes the tolerances of the benthic arthropod community to organic pollutants with a single value. Tolerance values used in the calculation of the Family Biotic Index (FBI) were obtained from Hilsenhoff (1988) and Bode (1988). The FBI is calculated by multiplying the number of organisms in each taxon by the tolerance value for that taxon, summing the products, and dividing by the total number of organisms in the sample as follows:

$$FBI = \Sigma \frac{x_i t_i}{n}$$

where:

x_i	=	number of individuals within a taxon;
t_i	=	tolerance value of a given taxon; and
n	=	total number of organisms in the sample.

Values for the FBI range from 0 to 10 with higher values corresponding to greater levels of organic pollution as shown in the following:

Family Biotic Index	Water Quality	Degree of Organic Pollution
3.5	Excellent	Organic pollution unlikely
3.51-4.5	Very good	Possible slight organic pollution
4.51-5.5	Good	Some organic pollution probable
5.51-6.5	Fair	Fairly substantial pollution likely
6.51-7.5	Fairly poor	Substantial pollution likely
7.51-8.5	Poor	Very substantial pollution likely
8.51-10	Very poor	Severe organic pollution likely

The FBI ranged from 2.27 at sample location SAR-85-SW/SD02 to 8 at sample location SAR-85-SW/SD08. The FBI score at the reference site was 4.8.

Metric 3: Ratio of Scraper and Filtering Collector Functional Feeding Groups. The relative abundance of scrapers and filtering collectors in the riffle/run habitat is an indicator of the food sources available. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Functional feeding group designations for the taxa identified will be obtained from Merritt and Cummins (1984) and Barbour, et al., (1999). This metric is calculated by dividing the relative abundance of scrapers by the relative abundance of filter feeding organisms.

The ratio of scrapers and filterers was only calculable at two sites, SAR-77-SW/SD23 and REFST, with values of 0.125 and 0.14, respectively. This index was not calculable at the remaining nine sites because no scraper-feeding invertebrates were present at these sites.

Metric 4: Ratio of EPT and Chironomidae Abundances. The ratio of Ephemeroptera, Plecoptera and Trichoptera (EPT) and chironomidae abundance is calculated by dividing the relative abundance of EPT taxa by the relative abundance of chironomidae. The ratio of EPT to chironomidae will indicate if there is an even distribution between the pollution sensitive EPT taxa and more pollution tolerant chironomidae. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups EPT. Skewed populations having a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive insect groups may indicate environmental stress.

The ratio of EPT and Chironomidae at the eight sample locations that had both Ephemeroptera, Plecoptera, Trichoptera and Chironomidae ranged from 0.07 at SAR-77-SW/SD25 to 4.5 at REFST. Chironomidae were not present at SAR-85-SW/SD02 and HR-80Q-SW/SD06; therefore, this index could not be calculated for these two locations. This index also could not be calculated at SAR-85-SW/SD08 because no EPT taxa were present at this site.

Metric 5: Percent Contribution of Dominant Taxon. The percent contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few species would indicate environmental stress. The percent contribution of the dominant taxon is calculated by dividing the abundance of the taxon which is numerically dominant by the total number of organisms in the sample. A low percent contribution of the dominant family indicates a balanced community. Factors influencing this percentage include environmental stress, habitat quality, and life histories of the organisms collected in the sample.

The percent contribution of the dominant taxon ranged from 100 at sample location SAR-85-SW/SD08 to 25 at location HR-78Q-SW/SD01. The numerically dominant organisms at SAR-85-SW/SD08 were Chironomidae. Perlodidae and Tanypodinae were numerically dominant at location HR-78Q-SW/SD01.

Metric 6: EPT Index. The EPT Index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This value summarizes taxa richness within the insect orders that are generally considered to be pollution sensitive. The EPT index usually increases with increasing water quality.

The EPT index ranged from 0 at SAR-85-SW/SD08, to 5 at REFST.

Metric 7: Community Similarity Index. This index evaluates the benthic populations at specific locations relative to populations present at the reference location. The Community Loss Index measures the loss of benthic species between a reference station and the station of comparison. It is an index of dissimilarity with values increasing as the degree of dissimilarity from the reference station increases. The community loss (CL) index is calculated by subtracting the number of taxa common to both locations (B) from the number of taxa present at the reference location (R), divided by the number of taxa present at the potential impact location (I), as follows:

$$CL = \frac{R - B}{I}$$

The community similarity index ranged from 7 at sample location SAR-85-SW/SD08 to 0.57 at location SAR-77-SW/SD23.

Metric 8: Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected. The abundance of the shredder function group relative to the abundance of all other functional groups allows evaluation of potential impairment as indicated by the CPOM-based shredder community. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily absorbed to the CPOM and either affect the microbial communities colonizing the CPOM or the shredders directly. The ratio of the relative abundance of shredders to the abundance of all other functional feeding groups is calculated by dividing the relative abundance of shredders by the total number of organisms in a given sample. The abundance of shredders in comparison to other functional feeding groups can be influenced by climate, seasonality, and vegetation within the riparian zone, as well as levels of toxicants adsorbed to CPOM while in the riparian zone, or adsorption of toxicants to the CPOM while it is in the water.

No shredder feeding organisms were found at locations SAR-85-SW/SD02, HR-85Q-SW/SD02, SAR-85-SW/SD08, SAR-78-SW/SD10, and HR-80Q-SW/SD03; therefore, this index was not calculable at these sites. The ratio of shredders and total organisms at the remaining sites ranged from 0.01 at SAR-77-SW/SD25 to 0.78 at REFST.

6.0 Risk Characterization

This Risk Characterization analyzes and interprets the data collected during the Site Investigation in terms of ecological exposures and effects, and estimates the potential for ecological risks. In the case of toxicity tests, the data interpretation attempts to relate effects observed in the toxicity tests to measured exposure concentrations of COPECs in the environmental samples. The result of this interpretation is the determination of toxicity values that relate COPEC concentrations to potential effects. The following toxicity values are developed within the subsequent sections that describe the results of the toxicity tests:

- ***Apparent Effects Threshold*** – The concentration at and above which effects are always observed. Since all samples with concentrations of a COPEC at or above the apparent effects threshold (AET) have observed effects, there is good evidence that the COPEC, or another co-occurring COPEC or stressor, may be causing the observed effects.

- ***No Observable Effect Concentration*** – The highest concentration at and below which effects are never observed. Since all samples with COPEC concentrations at or below the no observable effect concentration (NOEC) have no observable effects, there is strong evidence that the COPEC is not toxic at levels at or below the NOEC under those environmental conditions.

- ***Lowest Observable Effect Concentration*** – The lowest concentration at which an adverse effect is observed. Often some samples with concentrations between the AET and NOEC are toxic and other samples are not toxic. The lowest observable effect concentration (LOEC) is the lowest concentration of the COPEC in this range that has an observed effect. However, since some samples with COPEC concentrations above the LOEC are not toxic, the evidence that the COPEC is the cause of the observed effect is not as strong. The effects may or may not be related to the COPEC.

A useful parameter to evaluate with regard to these toxicity values is predictability. Predictability is essentially the ability to correctly predict that concentrations above the toxicity value are toxic and that concentrations below the toxicity value are not toxic. The results of samples that are incorrectly predicted are either false positives (i.e., samples that were predicted to be toxic but were found to be non-toxic) or false negatives (i.e., samples that were predicted to be non-toxic but were found to be toxic). By definition, the AET has no false negatives and the LOEC (or NOEC) has no false positives. This terminology will be used in the following sections describing the toxicity tests conducted as part of the Site Investigation.

The following sections describe the results of this BERA with respect to the assessment endpoints and decision rules presented in the *Baseline Ecological Risk Assessment Problem Formulation and Study Design for the Bains Gap Road Ranges* (Shaw, April 2003a) and summarized in the Chapter 4 of this report.

6.1 Terrestrial Ecosystems

Four assessment endpoints have been identified for the terrestrial ecosystems at the IMR and BGR ranges. These assessment endpoints are the following:

- Maintenance of a healthy terrestrial invertebrate community
- Maintenance of healthy populations of gallinaceous and other ground-feeding birds at the small arms ranges at FTMC
- Maintenance of healthy local populations and communities of terrestrial invertivorous small mammals and birds
- Maintenance of healthy local populations and communities of terrestrial omnivorous small mammals and birds.

Four decision rules have been defined pertaining to terrestrial ecosystems at the IMR and BGR ranges and have been designed to answer specific questions related to the terrestrial ecosystem assessment endpoints. The results of the Site Investigation and subsequent risk characterization are described herein with respect to each of these decision rules.

6.1.1 Earthworm Survival and Growth

The decision rule pertaining to earthworm survival and growth states that "If COPECs in soils from the BGR and IMR ranges cause acute earthworm toxicity which is statistically greater than earthworm toxicity in soils from a "reference" site, then there is the potential for unacceptable risks to terrestrial invertebrate receptors at the IMR and BGR ranges."

The results of the earthworm toxicity testing indicate that concentrations of COPECs in some surface soil samples result in earthworm survival that is statistically reduced compared to the survival of earthworms exposed to reference site soil. After 14-days of exposure statistically reduced earthworm survival was reported in the following soil samples:

- SAR-85-SS37 RW0002 (BGR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)

- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges).

After 28 days of exposure, statistically-reduced survival was reported in the following soil samples:

- HR-70Q-SS01 RW0001 (IMR ranges)
- SAR-85-SS37 RW0002 (BGR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)
- SAR-85-SS17 RW0017 (BGR (Ranges)
- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges).

There was no apparent correlation between soil type (binding capacity) and earthworm survival.

The results of the earthworm toxicity testing indicate that concentrations of COPECs in surface soil result in earthworm growth (as measured by weight change) that is statistically reduced compared to the growth of earthworms exposed to reference site soil. Statistically-reduced growth was reported in the following soil samples:

- HR-70Q-SS01 RW0001 (IMR ranges)
- SAR-85-SS37 RW0002 (BGR Ranges)
- SAR-85-SS34 RW0004 (BGR Ranges)
- SAR-71-SS05 RW0005 (IMR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)
- SAR-85-SS17 RW0017 (BGR (Ranges)
- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges)
- SAR-69-SS11 RW0021 (IMR Ranges).

There was no apparent correlation between soil type (binding capacity) and earthworm survival. Earthworm survival and growth results are summarized in Table 5-5.

The 28-day earthworm survival results as a function of the COPEC concentrations in soil are presented in Figures 6-1 through 6-4. The correlations between copper and survival and zinc and survival were both strong (Pearson's correlation coefficients r were 0.83 and 0.80, respectively). The correlation between antimony and survival was very weak (r = 0.04). The correlation

between lead and survival was fairly high (r = 0.66) but the soil sample with the highest concentration of lead (41,300 mg/kg) showed no observable effect on survival. The AETs, based on 28-day earthworm survival, for antimony, copper, lead, and zinc are >1,620 mg/kg, 509 mg/kg, 15,600 mg/kg, and 139 mg/kg, respectively. The NOECs and LOECs, based on 28-day earthworm survival, are 6.7 mg/kg and 17.9 mg/kg for antimony, 127 mg/kg and 334 mg/kg for copper, 779 mg/kg and 2,310 mg/kg for lead, and 47.3 and 63.9 mg/kg for zinc. These toxicity values are presented in Table 6-1.

The weight loss results as a function of the COPEC concentrations in soil are presented in Figures 6-5 through 6-8. The correlations of weight loss with copper, lead, and zinc were relatively strong (r = 0.88 for copper, r = 0.82 for lead, and r = 0.83 for zinc). Antimony concentrations in soil were inversely correlated with weight loss; thus, there is no evidence to suspect that antimony is responsible for the observed effects. The AETs, based on weight loss, for copper, lead, and zinc are 334 mg/kg, 6,820 mg/kg, and 72.8 mg/kg, respectively. The NOECs and LOECs, based on weight loss, are 61.4 mg/kg and 62.2 mg/kg for copper, 760 mg/kg and 779 mg/kg for lead, and 33.5 mg/kg and 35.1 mg/kg for zinc. These toxicity values are presented in Table 6-1.

Table 6-1 also presents the relative predictability of the AETs and LOECs for copper, lead, and zinc. The AETs for copper and zinc had fairly good predictability with only 2 and 3 false negatives each. The predictability of the lead AET was weaker with 6 false negatives. The LOECs for copper and lead also had good predictability with only 1 and 2 false positives, respectively. The predictability of the zinc LOEC was weaker with 4 false positives.

It is also helpful to examine the range of concentrations tested over which results were mixed, showing both toxic and non-toxic responses. For copper, this range was 62.2 mg/kg to 127 mg/kg, spanning only a factor of 2. For lead, on the other hand, this range was 770 mg/kg to 4,660 mg/kg, spanning a factor of 6. The difference in the ranges is reflective of the greater correlation between copper concentrations in soil and observed adverse effects and lead concentrations in soil and observed adverse effects.

Additionally, these toxicity values can be compared to generic screening benchmarks from the literature. Efroymson, et al. (1997) developed screening benchmarks as conservative estimates of soil concentrations below which adverse effects are not expected. These screening benchmarks for copper, lead, and zinc are reported as 60 mg/kg, 500 mg/kg, and 200 mg/kg, respectively. The generic screening benchmarks for copper and lead are, as expected based on their conservative nature, below but similar to the LOECs developed herein, whereas the generic

screening benchmark for zinc is well above the LOEC. This, along with the predictability of the toxicity values, provides the strongest evidence that lead and/or copper are responsible for the observed toxicity in the earthworm tests.

6.1.2 Earthworm Bioaccumulation

The decision rule pertaining to accumulation of COPECs from surface soil by earthworms states that "If earthworms exposed to soils from the BGR and IMR ranges demonstrate statistically higher tissue concentrations of COPECs than earthworms exposed to "reference" soils, then there is the potential for significant COPEC accumulation in terrestrial invertebrate tissues.

Data collected as part of the Site Investigation indicate that copper, lead, and zinc may accumulate in earthworm tissues, albeit at lower concentrations than ambient soil concentrations. The data suggest that antimony is not accumulated appreciably in earthworm tissues. A summary of the COPEC concentrations in soil and earthworm tissues is presented in Table 5-6.

The earthworm tissue COPEC concentrations as a function of the soil COPEC concentrations are presented in Figure 6-9 for antimony, Figure 6-10 for copper, Figure 6-11 for lead, and Figure 6-12 for zinc. These figures help relate the potential bioavailability of the COPECs in soil to the toxicity test results. The correlations between tissue concentrations and soil concentrations were strongest for copper and lead ($r = 0.95$). The correlation between soil and earthworm tissue concentrations for zinc were somewhat weaker ($r = 0.88$), but still relatively strong. Though lead depicted a fairly good correlation, the highest soil concentration tested resulted in a much lower concentration in the earthworm tissue than predicted. This lack of bioavailability in the sample may explain the relative absence of toxic effects in the sample with the highest lead soil concentrations. Antimony in earthworm tissue did not show a strong correlation and the weak correlation was also inverse, providing additional evidence that antimony is not likely responsible for the observed effects.

In order to define the relationship between soil concentrations and earthworm tissue concentrations of COPECs, the data were plotted for each of the soil COPECs (antimony, copper, lead, and zinc) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of copper, lead, and zinc in soil and earthworm tissues fit the data best. As suggested earlier, the data for antimony do not suggest any correlation between soil concentrations and earthworm concentrations. The graphs depicting the soil-to-earthworm bioaccumulation factors (BAF) for antimony, copper, lead, and zinc are presented in Figures 6-9 through 6-12, respectively. The best fit regression models of the natural log

transformed data for copper, lead, and zinc represent the site-specific soil-to-earthworm BAFs and are summarized below:

Surface Soil COPEC	Site-Specific Soil-to-Earthworm BAF
Antimony	NA
Copper	y = 0.4673 x + 1.4266
Lead	y = 1.1088 x – 0.5168
Zinc	y = 0.321 x + 3.1208

where: y = natural logarithm of terrestrial invertebrate tissue concentration
x = natural logarithm of soil concentration

As stated previously, there is no clear relationship between antimony concentrations in soil and earthworm tissues. An important consideration in the calculation of these regression models is the fact that for lead, only data from soil samples exhibiting lead concentrations less than 2,310 mg/kg were used in the regression analysis. It was assumed that soil exhibiting lead concentrations greater than 2,310 mg/kg would adversely impact the endpoints established for the earthworm toxicity tests and that including these high soil concentrations in the regression only serves to skew the result. Eliminating these data points from the regression analysis provided better resolution in the range of data where the critical endpoints are most likely impacted (i.e. where NOAELs and LOAELs are established).

These soil-to-earthworm BAFs were used in the terrestrial food web model to estimate the transfer of COPECs from surface soil to terrestrial invertebrates.

6.1.3 Terrestrial Food Web Exposures

Two decision rules pertaining to terrestrial food web exposures to surface soil-related COPECs were summarized in Chapter 5. The first decision rule pertaining to terrestrial food web exposures is "if calculated doses of COPECs for terrestrial invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the IMR and BGR ranges." The second decision rule pertaining to terrestrial food web exposures is "if calculated doses of COPECs for terrestrial omnivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to terrestrial invertivorous mammals or birds at the IMR and BGR ranges."

In order to assess the potential risks to various terrestrial-based feeding guilds from soil-related constituents, a food web was constructed. Based on the fact that the COPECs in surface soil at the IMR and BGR ranges (antimony, copper, lead, and zinc) do not bioconcentrate or

biomagnify appreciably through the food chain and do not accumulate appreciably in plant tissues (Kabata-Pendias and Pendias, 1992), the terrestrial ecological receptors with the potential for the greatest exposure to COPECs were determined to be invertivorous and omnivorous small mammals and birds. Herbivores were considered to have a lower exposure potential to COPECs because the COPECs do not accumulate appreciably in plant tissues, the herbivores' main food source. Carnivores were determined to have lower exposure potential to COPECs because the COPECs do not biomagnify in the food chain and would not be expected to occur at elevated concentrations in prey animal tissues. Additionally, carnivores in general have larger home ranges which would tend to minimize their exposures to COPECs at the IMR and BGR ranges. Likewise, piscivores were determined to have lower exposure potential to COPECs because the COPECs do not bioconcentrate or biomagnify in fish tissue to any appreciable extent and fish are not readily found in Remount Creek at the IMR ranges or Cane Creek at the BGR ranges. Therefore, the terrestrial food web model focused on the protection of the terrestrial omnivorous and invertivorous feeding guilds present at the IMR and BGR ranges.

Daily doses of COPECs for terrestrial invertivorous and omnivorous small mammals and birds were calculated using standard exposure algorithms. These algorithms incorporated species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and also utilize site-specific AUF. Additionally, site-specific soil-to-earthworm BAFs were used to calculate COPEC concentrations in the invertebrate portion of the food of the terrestrial invertivorous and omnivorous small mammals and birds. Literature-derived BAFs were used to estimate COPEC concentrations in the terrestrial vegetation portions of the receptor species' diets.

In order to calculate COPEC exposures, indicator species that represent the feeding guilds of interest were identified. For this risk assessment, the small terrestrial invertivorous mammal was represented by the shorttail shrew (*Blarina brevicauda*) and the terrestrial invertivorous bird was represented by the American woodcock (*Philohela minor*). The small terrestrial omnivorous mammal was represented by the white-footed mouse (*Peromyscus leucopus*) and the terrestrial omnivorous bird was represented by the American robin (*Turdus migratorius*). Natural history parameters for these indicator species (Table 6-2) were used in combination with site-specific exposure parameters to estimate exposures to terrestrial invertivorous and omnivorous small mammals and birds at the IMR and BGR ranges.

The algorithm that was used to estimate exposures to COPECs by terrestrial invertivorous and omnivorous small mammals and birds was the following:

$$TDD_{wildlife} = \left[\left(IR_{food} \times f_{worm} \times C_{worm}\right) + \left(IR_{food} \times f_{veg} \times C_{veg}\right) + \left(IR_{water} \times C_{water}\right) + \left(IR_{food} \times f_{soil} \times C_{soil} \times BF_{soil}\right)\right] \rangle$$

where:

$TDD_{wildlife}$	=	total daily dose of COPEC received by omnivorous or invertivorous mammals or birds through ingestion (mg/kg/day)
IR_{food}	=	ingestion rate of food by receptor species (kilogram per kilogram [kg/kg]/day)
f_{worm}	=	fraction of daily diet comprised of invertebrates (percent)
C_{worm}	=	concentration of COPEC in invertebrate tissue (mg/kg)
f_{veg}	=	fraction of daily diet comprised of vegetation (percent)
C_{veg}	=	concentration of COPEC in terrestrial vegetation (mg/kg)
IR_{water}	=	ingestion rate of water by omnivorous mammals or birds (liters per kilogram per day [L/kg/day])
f_{water}	=	fraction of drinking water from the BGR ranges (percent)
C_{water}	=	concentration of COPEC in drinking water (milligram per liters [mg/L])
f_{soil}	=	fraction of daily diet comprised of soil (percent)
BF_{soil}	=	Bioavailable fraction of COPECs in incidentally ingested soil (fraction)
C_{soil}	=	concentration of COPEC in soil (mg/kg)
AUF	=	area use factor (fraction of site used by receptor species (percent).

The natural history (food web model input) parameters for the surrogate indicator species are described in the following sections.

6.1.3.1 Terrestrial Omnivorous Mammal Model Parameters

The surrogate species used in the terrestrial food web model to assess omnivorous mammals was the white-footed mouse (*Peromyscus leucopus*). The home range for white-footed mice ranges from one-half to one and one-half acres in size (Burt and Grossenheider, 1976). For the terrestrial food web model, the mean (one acre) of this range was used as the foraging area. The contaminated area of the IMR and BGR ranges was assumed to be 15 acres; therefore, the Area Use Factor (AUF) for the white-footed mouse in the terrestrial food web model was 1.0. Body weights for white-footed mice range from 14 to 31 grams (Burt and Grossenheider, 1976). The mean of this range (22.5 grams) was used as the representative body weight for white-footed mice in the terrestrial food web model. USEPA (1993) reports a water ingestion rate of 0.19 g/g/day for deer mice (*Peromyscus maniculatus*) based on two studies conducted in laboratories. Since water ingestion rates for white-footed mice were not readily available and the body weights for white-footed mice and deer mice are very similar, the water ingestion rate for deer mice (0.19 g/g/day) was used in the terrestrial food web model. Similarly, the food ingestion rate for deer mice was used in the terrestrial food web model. The food ingestion rates reported by USEPA (1993) for adult male and female non-breeding and lactating deer mice ranged from

0.18 to 0.45 g/g/day. The mean of this range is 0.2683 g/g/day (wet weight). The weighted average moisture content of the white-footed mouse diet (invertebrates and vegetation) has been estimated to be 53.9 percent. Taking this moisture content into account, the food ingestion rate for the white-footed mouse was estimated to be 0.1237 g/g/day (dry weight). The estimated percent of soil in the white-footed mouse diet is less than two percent (USEPA, 1993). For the terrestrial food web model, it was assumed that two percent (0.00247 g/g/day, dry weight) of the white-footed mouse diet was made up of soil. These input parameters are summarized in Table 6-2 and were used to estimate total daily exposures to COPECs for omnivorous mammals.

6.1.3.2 Terrestrial Omnivorous Bird Model Parameters

The surrogate species used in the terrestrial food web model to assess omnivorous birds was the American robin (*Turdus migratorius*). The territory size for adult male and female robins is reported to range from 0.11 to 0.42 hectares (USEPA, 1993). The mean of this range (0.61 acres) was used as the foraging area for American robins in the terrestrial food web model. The contaminated area of the IMR and BGR ranges was assumed to be 15 acres; therefore, the AUF for the American robin in the terrestrial food web model was 1.0. Body weights for adult male and female robins in New York and Pennsylvania was reported to range from 77.3 grams to 86.2 grams (USEPA, 1993). The mean of this range (81 grams) was used to represent the body weight of American robins in the terrestrial food web model. USEPA (1993) reports an estimated water ingestion rate of 0.14 g/g/day for adult male and female American robins. This estimated water ingestion rate was used in the terrestrial food web model. The food ingestion rate for free-living adult male and female American robins in California is reported to be 0.89 g/g/day (wet weight) (USEPA, 1993). The weighted average moisture content of the American robin diet (invertebrates and vegetation) has been estimated to be 79.6 percent. Taking this moisture content into account, the food ingestion rate for the American robin was estimated to be 0.1816 g/g/day (dry weight). Soil ingestion rates for American robins were not readily available; therefore, the soil ingestion rate of 2 percent of the diet reported for other birds (USEPA, 1993) was assumed to be representative of American robins. Assuming two percent of the robin's diet is made up of soil, the soil ingestion rate was estimated to be 0.00363 g/g/day (dry weight). These input parameters are summarized in Table 6-2 and were used to estimate total daily exposures to COPECs for omnivorous birds.

6.1.3.3 Terrestrial Invertivorous Mammal Model Parameters

The surrogate species used in the terrestrial food web model to assess invertivorous mammals was the short-tailed shrew (*Blarina brevicauda*). The home range for adult male and female short-tailed shrew in a Manitoba bog was reported to be 0.964 acres (USEPA, 1993). This home range was used for the short-tailed shrew in the terrestrial food web model. The contaminated

area of the IMR and BGR ranges was assumed to be 15 acres; therefore, the AUF for the short-tailed shrew in the terrestrial food web model was 1.0. Body weights for adult male and female short-tailed shrews in New Hampshire and Pennsylvania were reported to range from 15 to 19.2 grams. The mean of this range (16.8 grams) was used as the body weight for short-tailed shrews in the terrestrial food web model. The water ingestion rate used in the terrestrial food web model for short-tailed shrews (0.223 g/g/day) was the water ingestion rate reported by USEPA (1993) for adult male and female short-tailed shrews in an Illinois laboratory. Food ingestion rates for adult male and female short-tailed shrews in a Wisconsin laboratory were reported to range from 0.49 to 0.62 g/g/day (wet weight), with a mean value of 0.555 g/g/day (wet weight). The weighted average moisture content of the short-tailed shrew's diet has been estimated to be 83.8 percent. Taking the moisture content of the shrew's diet into consideration, the food ingestion rate for the short-tailed shrew that was used in the terrestrial food web model was 0.0899 g/g/day (dry weight). Soil ingestion rates for short-tailed shrews were not readily available; therefore, the soil ingestion rate of 2.4 percent of the diet reported for meadow voles (USEPA, 1993) was assumed to be representative of short-tailed shrews. Assuming 2.4 percent of the shrew's diet is made up of soil, the soil ingestion rate was estimated to be 0.00216 g/g/day (dry weight). These input parameters are summarized in Table 6-2 and were used to estimate total daily exposures to COPECs for invertivorous mammals.

6.1.3.4 Terrestrial Invertivorous Bird Model Parameters

The surrogate species used in the terrestrial food web model to assess invertivorous birds was the American woodcock (*Scolopax minor*). The home range for adult male and female American woodcocks in Pennsylvania and Wisconsin ranges from 7.7 to 182 acres (USEPA, 1993). The mean of this range is 61.3 acres and is the home range for American woodcocks used in the terrestrial food web model. The contaminated area of the IMR and BGR ranges was assumed to be 15 acres; therefore, the AUF for the American woodcock in the terrestrial food web model was 0.24. Body weights for adult male and female American woodcocks range from 133 to 218 grams (USEPA, 1993). The mean of this range is 169.4 grams and is the value used to estimate the body weight of American woodcock in the terrestrial food web model. The water ingestion rate for adult male and female American woodcock estimated by USEPA (1993) is 0.1 g/g/day. This value was used as the water ingestion rate for American woodcock in the terrestrial food web model. The food ingestion rate for captive adult male and female American woodcocks in Louisiana fed earthworms was 0.77 g/g/day (wet weight) (USEPA, 1993). The weighted average moisture content of the American woodcock's diet has been estimated to be 80.3 percent. Taking the moisture content of the woodcock's diet into account, the food ingestion rate for the American woodcock that was used in the terrestrial food web model was 0.1517 g/g/day (dry weight). USEPA (1993) reports an estimated percent of soil in a woodcock's diet of 10.4

percent. Assuming 10.4 percent of a woodcock's diet is made up of soil, the soil ingestion rate was estimated to be 0.0158 g/g/day (dry weight). These input parameters are summarized in Table 6-2 and were used to estimate total daily exposures to COPECs for invertivorous birds.

Because portions of the receptor species' diets consist of vegetative material, COPEC concentrations in terrestrial plant matter needed to be estimated in order to calculate a total COPEC dose. The COPEC concentrations in terrestrial plant matter were estimated using the empirically-derived plant BCF values reported in Baes, et al., (1984) and recommended by EPA (1999). These plant BCFs were applied to the soil concentrations of COPECs to estimate concentrations of COPECs in terrestrial vegetative food material in the following manner:

$$C_{veg} = C_{soil} \times BCF_{veg}$$

where:

C_{veg}	=	COPEC concentration in terrestrial vegetation (mg/kg, dry weight);
C_{soil}	=	COPEC concentration in soil (mg/kg, dry weight); and
BCF_{veg}	=	soil-to-plant bioconcentration factor (unitless).

The soil ingestion rate for the receptor species is most often represented as a percentage of a receptor species' diet. In order to account for the methodology used in the estimation of the soil ingestion rates, the moisture content of the receptor species' diets must be accounted for. The relationship used to estimate the soil ingestion rates for the terrestrial invertivorous and omnivorous small mammals and birds that have been identified as receptors in this ecological risk assessment is as follows:

$$IR_{soil} = IR_{food} \times Diet_{soil}$$

where:

IR_{soil}	=	ingestion rate of soil (kg/kg/day, dry weight);
IR_{food}	=	ingestion rate of food (kg/kg/day, dry weight); and
$Diet_{soil}$	=	portion of diet that is soil (percent).

Potential exposures to soil COPECs due to incidental ingestion of soil took into account the reduced bioavailability of inorganic compounds found in soil matrices. The bioavailability of many inorganic compounds in soil ranges from one to ten percent. USEPA (1996) recommends an absorption factor for soluble lead of 0.2, and a relative bioavailability for lead of 0.6, resulting in a soil lead absorption factor of 0.12 (0.2 x 0.6 = 0.12). For this BERA, the relative bioavailability of lead in soil (0.6) was used to adjust the amount of all COPECs ingested via the

soil ingestion pathway in order to account for the reduced bioavailability of metals in ingested soil.

The moisture contents of the invertebrate and vegetative material in the receptor species' diets were referenced from the EPA's *Wildlife Exposure Factors Handbook* (EPA, 1993) and are as follows:

- Earthworms - 84%
- Fruit - 77%
- Roots/young grass - 82%
- Seeds - 9.3%
- Fruit/young grass - 78%.

The weighted-average moisture contents of the diets of the receptor species of interest are as follows:

		Percent Moisture	Weighted-Average Moisture Content
White-footed mouse:			
invertebrates	=	84%	53.9%
vegetation	=	43.6%	
American robin:			
invertebrates	=	84%	79.6%
vegetation	=	77%	
Shorttail shrew:			
invertebrates	=	84%	83.8%
vegetation	=	82%	
American woodcock:			
invertebrates	=	84%	80.3%
vegetation	=	9.3%	

It was also assumed that if a receptor species' diet contained multiple vegetative components, then the percentage of each vegetative component would be equal. For instance, the vegetative component of the shorttail shrew's diet was assumed to be comprised of 50 percent roots and 50 percent young grass.

Dietary composition of the indicator species was simplified for modeling purposes but incorporates the major food types for the different feeding guilds. It was assumed that food intake for invertivores is comprised almost entirely of terrestrial invertebrates (i.e., earthworms). It was also assumed that omnivores consume both plant and animal material, a portion of which consists of terrestrial invertebrates.

The AUFs for each of the indicator species take into account the home range and habitat requirements for each species and the size of the contaminated areas and viable habitat at the IMR and BGR ranges. The biological fate and transport properties that affect the exposure routes of the receptor species are summarized in Table 6-3 and the exposure point concentrations for the receptor species are summarized in Table 6-4.

The terrestrial food web model was executed with maximum and mean exposure point concentrations in order to estimate a range of potential terrestrial wildlife exposures. The food web model was executed with site-specific AUFs, site-specific soil-to-earthworm BAFs, and literature-derived values for the other input variables. Maximum and mean exposures for the receptor species in the terrestrial food web are summarized in Table 6-5 through Table 6-12. The avian and mammalian toxicity reference values used in the terrestrial food web model are presented in Tables 6-13 and 6-14, respectively.

Estimated maximum and mean exposures for the receptor species were compared to the toxicity reference values to estimate maximum and mean HQs for each receptor species. These calculated HQs are presented in Tables 6-15 through 6-22 and are summarized below.

	Maximum Exposure		*Mean Exposure*	
	NOAEL HQ	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**
White-footed Mouse:				
Antimony	348	34.8	26.7	2.67
Copper	12	9.32	1.73	1.35
Lead	337	33.7	51.5	5.15
Zinc	0.458	0.0149	0.284	0.00924
American Robin :				
Antimony	581	116	44.5	8.9
Copper	3.9	2.97	0.594	0.452
Lead	1460	498	222	75.8
Zinc	0.0767	0.00767	0.0484	0.00483
Short-tail Shrew :				
Antimony	270	27	20.7	2.07
Copper	2.87	2.23	0.71	0.553
Lead	789	78.9	119	11.9
Zinc	1.1	0.0356	0.704	0.0229
American Woodcock:				
Antimony	149	29.9	11.4	2.29
Copper	0.369	0.281	0.0855	0.0651
Lead	729	248	110	37.6
Zinc	0.0415	0.00414	0.0252	0.00252

The results of the food web model indicate that there are potential risks to terrestrial receptors at the IMR and BGR ranges from exposures to COPECs at these ranges. The risks to the terrestrial receptors based on maximum exposures are presented in Table 6-23 and the risks to terrestrial receptors based on mean exposures are presented in Table 6-24.

The terrestrial food web model was also executed in order to estimate soil concentrations of COPECs that would result in hazard quotients of one or lower. These estimated soil concentrations (assuming all of the conservatism inherent in the food web model) based on an HQ equal to 1.0 are presented in Table 6-25 and are summarized below.

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	**Soil Conc. Based on LOAEL TRV and HQ = 1.0** (mg/kg)
White-Footed Mouse :		
- antimony	4.67	46.7
- copper	267	350
- lead	205	1,680
- zinc	1,750	193,000
American Robin :		
- antimony	2.8	14
- copper	850	1,140
- lead	55	147
- zinc	39,000	555,000
Short-tailed Shrew :		
- antimony	6.01	60.1
- copper	820	1,185
- lead	100	800
- zinc	215	173,000
American Woodcock :		
- antimony	10.85	54.2
- copper	11,870	16,200
- lead	105.5	280
- zinc	46,500	550,000

6.1.4 Ingestion of Particulate Lead by Birds

Risks to birds from ingestion of particulate lead in soil at the small arms ranges at FTMC were assessed via a three-tier process as outlined in the technical memorandum entitled *Ecological Risk Assessment Methodology for Particulate Lead Ingestion at Fort McClellan* (Shaw, April 14, 2003b). Tier one of the process consisted of collecting soil samples from the IMR and BGR ranges and determining the particle size fractions present in surface soils at these ranges. The soil samples for particle analysis were separated and analyzed using a combination of sieving, water washing, and hand-sorting as described in detail in Attachment 5.

Of particular interest were the particle size ranges corresponding to the preferred grit sizes of the Northern Bobwhite Quail (*Colinus virginianus*) and Eastern Wild Turkey (*Meleagris gallopavo*). The Northern Bobwhite Quail prefers grit that ranges in size from 0.8 – 2.2 mm in diameter (Best and Gionfriddo, 1991) while the Eastern Wild Turkey prefers grit that ranges in size from 2.8 – 4.2 mm in diameter (extrapolated from the preferred grit size of ring-necked pheasant and normalized to the wild turkey body weight) (Best and Gionfriddo, 1991). These two bird species were identified by the FTMC ecological risk assessment subcommittee as surrogates for all of the bird species at FTMC because the grit sizes preferred by these two species represent a broad range of available grit and these two species are known to occur at FTMC. The results of the particle size analysis were summarized in Table 5-7 and indicate that the preferred particle sizes for both the bobwhite quail and wild turkey occur at both the IMR and BGR ranges.

In addition to particle size, particle shape and surface texture also play an important role in the selection and retention of particles by birds. Literature sources suggest that birds do not ingest oblong grit particles or particles with angular surface textures (Gionfriddo and Best, 1996; Best and Gionfriddo, 1994; Best and Gionfriddo, 1991). Particle shape and texture were not taken into account in this assessment; therefore, the results of this assessment are conservative.

The percent of the preferred particle size fractions that is made up of "particulate lead" is also presented in Table 5-7. It is important to note that the results of the particle size analysis indicate that there are significantly more particles in the 0.8 – 2.2 mm particle size fraction (size preferred by bobwhite quail) than in the 2.8 – 4.2 mm particle size fraction (size preferred by wild turkey) at the IMR and BGR ranges. There does not appear to be any significant difference between the particle size fractions present at the IMR and BGR ranges, indicating the surface soils are similar at the IMR and BGR ranges with regard to particle size. It is also important to note that the separation technique used in the particle size analysis only distinguished between "native" and "non-native" material. It did not definitively identify the "non-native" material as lead particles.

Tier 2 of the agreed upon particulate lead risk assessment process consisted of using the Peddicord and LaKind (2000) model to determine the risks from ingesting particulate lead, and also determining the density of lead particles that could remain in soil while maintaining the health of the bobwhite quail and wild turkey populations at FTMC. The model developed by Peddicord and LaKind for evaluating the probability that a bird will ingest a lead particle in it's lifetime is as follows:

$$P_t = 1 - (1 - P)^N$$

where:

P_t	=	probability that a bird will ingest at least one lead particle in it's lifetime;
N	=	number of particles selected and retained in a bird's gizzard in a lifetime;
	=	$Y \bullet (D_e / D_p)$;
Y	=	number of years a bird lives (years);
D_e	=	number of days per year a bird forages in the study area (days):
D_p	=	retention time for a lead particle in the gizzard (days);
P	=	probability that a single selected particle will be a lead particle;
	=	$S \bullet P_s + (1 - S) \bullet P_0$
S	=	fraction of foraging time that a bird spends within the study area;
P_s	=	fraction of grit-size particles on-site that is lead;
...P_0	=	fraction of grit-size particles off-site that is lead.

The following table presents the input parameters used in the Peddicord and LaKind model.

MODEL PARAMETER	RECEPTOR SPECIES	
	Northern Bobwhite Quail	Eastern Wild Turkey
Number of Years an Individual Lives (years)	5 [b]	6 [e]
Number of Days per Year an Individual Forages Within Study Area (days)	365 [d]	365 [d]
Retention Time for Lead Particle in Gizzard (days)	10 – 156 [c]	42 [c]
Fraction of Foraging Time Individual Spends Within Study Area (unitless fraction)		
• IMR Ranges	0.45	0.018
• BGR Ranges	1.0	0.054
Foraging Range (acres)	40 [a]	1,000 [a]
Fraction of Grit-Size Particles That Is Lead (percent)[f]	1.66	4.9
Unacceptable Population-Level Exposure (percent)	> 20	> 20

[a]Megalos, M.A., M.S. Mitchell, and E.J. Jones, 1995. Working With Wildlife. North Carolina State University.
[b]Northern Bobwhite Quail.com, 2003. Online database.
[c]Gionfriddo, J.P. and L.B. Best, 1999. Grit Use By Birds: A Review. In: Current Ornithology, Vol. 15, edited by V. Nolan, Jr., et al., Kluwer Academic / Plenum Publishers, New York.
[d]Based on the fact that these species are year-round residents of northern Alabama.
[e]McCullough, J., 2002. Wild Turkey (*Meleagris gallopavo*). University of Michigan.
[f]Percent is irrespective of particle shape and texture.

The Peddicord and LaKind model was executed with a range of values for the grit retention time because sensitivity analyses have indicated that this parameter is the most sensitive input parameter in this model. Grit retention is also variable based on the species of bird, grit shape and surface roughness, and numerous environmental conditions such as grit availability, food preferences, time of year, and other environmental factors. Gionfriddo and Best (1999) report

grit retention times for necropsied bobwhite quail ranging from 42 days to 270 days. A grit retention time of 10 days is recommended by USFWS (personal communication with Mark Huston, 2000?) based on studies conducted by McConnell (1968) which measured the rate of deterioration of lead shot in bobwhite quail. No noticeable deterioration was observed in shot expelled by quail after 1 to 3 days. Shot expelled after 10 days were half eroded and shot expelled after 22 days were one-sixth their original size. Based on these deterioration rates and the assumption that grit will be expelled and replaced when they are half eroded, USFWS has recommended a grit retention time of 10 days. The grit retention time of 83 days is based on the entire range of values presented by Gionfriddo and Best (1999) and USFWS. The arithmetic mean of the values reported by Gionfriddo and Best (1999) is 156 days. This value was used as the longest grit retention time in the Peddicord and LaKind model. The arithmetic mean of 156 days and 10 days is 83 days. This value was used as the "mean" grit retention time. The value suggested by USFWS (10 days) was used as the shortest grit retention time. Executing the model over a range of grit retention times also serves to incorporate many different bird species (other than the bobwhite quail and wild turkey which serve as surrogate receptor species) in the evaluation process.

The Peddicord and LaKind model was executed with the values summarized above to calculate two different results. The model was first used to calculate the probability that a bobwhite quail or wild turkey would ingest and retain a single lead particle in its crop during it's lifetime. It was assumed that quail and turkey would utilize the range areas and surrounding habitats randomly for foraging, with no regard to habitat quality. It was also assumed that the percent lead particles present in soil at the range areas was the mean of the percent lead particles determined by laboratory analysis and presented in Table 5-7 for the two size fractions. The percent lead particles at the range areas are summarized below:

- 0.8 – 2.2 mm (bobwhite quail) : 1.66 % lead particles
- 2.8 – 4.2 mm (wild turkey): 4.9 % lead particles.

In other words, within the preferred particle size range for bobwhite quail, 1.66 percent of the particles at the IMR and BGR ranges are lead and within the preferred particle size range for wild turkey, 4.9 percent of the particles at the IMR and BGR ranges are lead. These measured percentages of lead particles in the soil at the IMR and BGR ranges is very conservative because the soil samples for particle separation and enumeration were collected from areas of known high bullet fragment densities (e.g. range impact zones) and are not representative of the lead particle densities known to occur across the entire IMR or BGR range complexes or the foraging areas of the bobwhite quail or wild turkey. The lead bullet fragment densities are known to be

significantly lower in the majority of the areas of these range complexes. Therefore, the results of the Peddicord and LaKind probability model are highly conservative in this assessment.

The probabilities that a bobwhite quail would ingest and retain a lead particle were calculated to range from 8.4 percent to 74 percent at the IMR ranges and from 18 percent to 95 percent at the BGR ranges, depending upon the grit retention time. The probabilities that a wild turkey would ingest and retain a lead particle were calculated to be 4.5 percent at the IMR ranges and 12.9 percent at the BGR ranges. The calculated probabilities of bobwhite quail and wild turkeys ingesting and retaining a single lead particle are presented in Table 6-26.

The model equations were then re-arranged in order to solve for the number of lead particles that would result in a 20 percent probability of a bobwhite quail or wild turkey ingesting and retaining a single lead particle in it's crop during it's lifetime. An acceptable exposure level of 20 percent was based on the level of effect that is considered biologically significant and/or distinguishable for a given ecological community or population (Suter, 2000). Adverse effects to a population or community that occur at a frequency less than 20 percent are indistinguishable from the natural variability inherent in natural biological systems and are considered biologically insignificant.

It was also assumed that ingestion of a single lead particle by a bobwhite quail or wild turkey could result in adverse effects; therefore, the probability of a receptor ingesting and retaining a single lead particle is equal to the probability of a receptor experiencing adverse effects. The model resulted in a range of values for the fraction of grit-size particles on-site that is lead, depending upon the grit retention time. The fraction of grit-size particles on-site that is lead particles was then multiplied by the mean number of grit-size particles at each group of ranges to calculate the number of lead particles that would result in a 20 percent probability of a bobwhite quail or wild turkey ingesting and retaining a lead particle. The results of these calculations are presented in Table 6-26.

These results indicate that lead particle densities in soil that would result in a 20 percent probability of ingestion and retention by a bobwhite quail range from 24.6 to 846 fragments per square foot. Likewise, the results indicate that lead particle densities in soil that would result in a 20 percent probability of ingestion and retention by a wild turkey range from 68 to 204 fragments per square foot.

The results of the lead particle separation and enumeration summarized in Table 5-7 indicate that none of the areas sampled had lead particle densities that would result in adverse effects to wild

turkeys. At the lowest grit retention time (10 days) four of the five samples from the IMR ranges exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 83 days, two of the samples from the IMR ranges (HR-70Q-SS01 and SAR-71-SS09) exhibited lead particle densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 156 days, one sample from the IMR ranges (HR-70Q-SS01) exhibited lead particle densities that could pose adverse effects to bobwhite quail.

At the lowest grit retention time (10 days), nine of the thirteen samples from the BGR ranges exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 83 days, two of the samples from the BGR ranges (SAR-85-SS37 and HR-77Q-SS01) exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 156 days, only one sample (HR-77Q-SS01) from the BGR ranges exhibited a lead particle density that could pose adverse effects to bobwhite quail.

6.2 Aquatic Ecosystems

Four assessment endpoints have been identified for the aquatic ecosystems at the IMR and BGR ranges. These assessment endpoints are the following:

- Maintenance of a healthy aquatic benthic invertebrate community;
- Maintenance of a healthy aquatic water-column invertebrate community;
- Maintenance of healthy aquatic vertebrate (e.g. finfish) community; and
- Maintenance of healthy local populations and communities of riparian invertivorous mammals and birds.

Five decision rules have been defined pertaining to aquatic ecosystems at the IMR and BGR ranges and have been designed to answer specific questions related to the aquatic ecosystem assessment endpoints. The results of the Site Investigation and subsequent risk characterization are described herein with respect to each of these decision rules.

6.2.1 Fathead Minnow Survival and Growth

The decision rule pertaining to fathead minnow survival and growth states that "if COPECs within Cane Creek surface water cause acute or chronic toxicity to fathead minnows or Ceriodaphnids which are statistically greater than toxicity from reference waters, then there is the potential for risk to water column receptors at the IMR and BGR ranges."

Surface water concentrations of COPECs and the resultant fathead minnow toxicity data were summarized in Table 5-8. Fathead minnow survival rates as a function of COPEC concentrations in surface water are presented in Figures 6-13 and 6-14. The results of the fathead minnow toxicity testing indicate 7-day survival rates were reduced in one surface water sample that exhibited a lead concentration of 0.0462 mg/L and a copper concentration of 0.0608 mg/L. All of the other surface water samples exhibited fathead minnow survival rates that were statistically similar to the reference area sample. Therefore, the AET and LOEC, based on survival, are equivalent and are 0.0608 mg/L for copper and 0.0462 for lead. The NOECs are 0.0527 mg/L copper and 0.0422 mg/L for lead. These toxicity values are presented in Table 6-27.

Fathead minnow growth rates as a function of COPEC concentrations in surface water are presented in Figures 6-15 and 6-16. Fathead minnow growth was statistically reduced in surface water samples with copper concentrations as low as 0.0346 mg/L and with lead concentrations as low as 0.0306 mg/L. The five surface water samples that elicited adverse effects had the five highest concentrations of both copper and lead. Thus, the AET and LOEC, based on these endpoints, are equivalent and are 0.0346 mg/L for copper and 0.0306 for lead. The NOECs are 0.0129 mg/L for copper and 0.0105 mg/L for lead. These toxicity values are presented in Table 6-27.

It is interesting to note that all of the surface water samples that resulted in reduced fathead minnow survival or growth were collected from Cane Creek at Range 22 and Range 27. These two ranges are the two farthest downstream ranges at the BGR ranges. None of the surface water samples from locations further upstream on Cane Creek exhibited reduced fathead minnow survival or growth.

6.2.2 Ceriodaphnid Survival and Reproduction

The decision rule pertaining to ceriodaphnid survival and reproduction states that "if COPECs within Cane Creek surface water cause acute or chronic toxicity to fathead minnows or ceriodaphnids which are statistically greater than toxicity from reference waters, then there is the potential for risk to water column receptors at the IMR and BGR ranges."

Table 5-8 presented the surface water concentrations of COPECs and corresponding results of the ceriodaphnid toxicity tests. The results of the ceriodaphnid toxicity testing indicate that 7-day survival rates were reduced in two surface water samples (SAR-77-SW19 and SAR-77-SW20), both of which exhibited non-detectable levels of copper and one of which had a non-detectable level of lead and the other had a lead concentration of 0.00236 mg/L. Of the three

samples that had concentrations of lead in the interval between sample SAR-77-SW20, which had 0.00236 mg/L lead and sample SAR 78-SW12, which had 0.0306 mg/L lead, none of them induced any toxic effects: SAR-77-SW15 with 0.00357 mg/L lead, SAR-78-SW14 with 0.00762 mg/L lead, and SAR-78-SW13 with 0.0105 mg/L lead. The toxicity observed in SAR-77-SW20 with only 0.00236 mg/L lead, as well as the toxicity in SAR-77-SW19 with no detectable lead, was likely not due to lead, but other unknown factors. Copper, similarly had lower levels in the same three samples than any other of the other samples with toxicity except for SAR-77-12 and SAR-22-SW20, where copper was not detected. The available data are not conclusive as to the cause of the observed toxicity in samples SAR-77-SW19 and SAR-77-SW20. These toxicity test results indicate that a factor other than lead or copper in surface water may be the cause of reduced ceriodaphnid survival in these two samples. Figures 6-17 and 6-18 present the correlation between surface water concentrations of COPECs and ceriodaphnid survival.

The toxicity test results for ceriodaphnid reproduction are very similar to the test results for fathead minnow growth. Ceriodaphnid reproduction was statistically reduced in surface water samples with copper and lead concentrations as low as 0.0346 mg/L and 0.0306 mg/L, respectively. Reproduction was not evaluated for statistical significance in samples SAR-77-SW19 and SAR-77-SW20 because ceriodaphnid survival was significantly reduced in these two samples. The five surface water samples that elicited adverse reproductive effects had the five highest concentrations of both copper and lead. Thus, the AET and LOEC, based on reproductive endpoints, are equivalent and are 0.0346 mg/L for copper and 0.0306 for lead. The NOECs, based on reproductive endpoints, are 0.0129 mg/L for copper and 0.0105 mg/L for lead. The AETs for copper and lead, based on ceriodaphnid survival, are 0.0346 mg/L and 0.0306 mg/L, respectively. The NOECs based on ceriodaphnid survival are 0.0129 mg/L for copper and less than the detection limit for lead. The LOECs for copper and lead, based on ceriodaphnid survival, are 0.0346 mg/L and 0.00236 mg/L, respectively. These toxicity values are presented in Table 6-27. Figures 6-19 and 6-20 present the correlations between surface water COPECs and cerdiodaphnid reproduction.

Table 6-27 also presents the relative predictability of the AETs and LOECs for copper and lead. Since effects were observed in samples with the highest concentrations and no effects were observed in the lower concentrations, the predictability of the AET and LOEC were very good, with no false positives or false negatives based on the sample toxicity data.

Additionally, these toxicity values can be compared to generic screening benchmarks from the literature. EPA Region IV (2003a) has established screening benchmarks for surface water as conservative estimates of concentrations in surface water below which effects are not expected.

These benchmarks for copper and lead are both hardness dependent values. For a hardness of 50 mg/L as $CaCO_3$ the screening criteria are 0.0065 mg/L for copper and 0.0013 mg/L for lead. These values are below the AETs, LOECs, and NOECs determined from the site-specific toxicity tests and could reflect a difference in bioavailability of copper and lead in the surface water in Cane Creek.

All of the surface water samples that resulted in reduced ceriodaphnid reproduction were collected from Cane Creek at Ranges 21, 22, and 27. None of the surface water samples from locations further upstream on Cane Creek exhibited reduced ceriodaphnid reproduction.

6.2.3 Chironomid Survival and Growth

The decision rule pertaining to chironomid survival and growth states that "if COPECs within the Cane Creek sediments cause acute toxicity to the benthic invertebrate *Chironomus sp.*, which is statistically greater than toxicity from reference sediments, then there is the potential for risk to emergent benthic invertebrates at the IMR and BGR ranges."

The results of the 10-day chironomid survival test show that survival was statistically reduced in sediment samples with arsenic concentrations as low as 2.4 mg/kg, barium concentrations as low as 32.5 mg/kg, copper concentrations as low as 160 mg/kg, lead concentrations as low as 605 mg/kg, and manganese concentrations as low as 181 mg/kg. Thallium was not detected in any of the sediment samples collected for toxicity testing. Table 5-9 presented the concentrations of COPECs detected in sediment samples and the corresponding results from the chironomid toxicity tests.

The 10-day survival results, as functions of the COPEC concentrations in sediment, are presented in Figure 6-21 for arsenic, Figure 6-22 for barium, Figure 6-23 for copper, Figure 6-24 for lead, and Figure 6-25 for manganese. The correlations between copper in sediment and survival and lead in sediment and survival were strongest ($r = 0.60$ and 0.67, respectively). The correlations of arsenic, barium, and manganese in sediment and survival were weak ($r = 0.03$ for arsenic, $r = 0.29$ for barium, and $r = 0.06$ for manganese) and the correlations with arsenic and barium were inverse. For all of the sediment COPECs except copper, the sample with the highest sediment concentration showed no observable effect on survival. Due to the poor correlations between arsenic, barium, and manganese in sediment and survival, toxicity values were only derived for copper and lead. The AETs, based on survival, for copper and lead are 380 mg/kg and >1,730 mg/kg, respectively. The NOECs and LOECs, based on survival, are 126 mg/kg and 160 mg/kg for copper and 495 mg/kg and 605 mg/kg for lead. These toxicity values are presented in Table 6-28.

The results of the chironomid growth tests, presented as final dry weight as functions of the COPEC concentrations in sediment, are presented in Figure 6-26 for arsenic, Figure 6-27 for barium, Figure 6-28 for copper, Figure 6-29 for lead, and Figure 6-30 for manganese. The correlations between copper in sediment and growth and lead in sediment and growth were strongest ($r = 0.77$ for both copper and lead). The correlations of arsenic, barium, and manganese were weak ($r = 0.20$ for arsenic, $r = 0.07$ for barium, and $r = 0.07$ for manganese) and the correlation with barium in sediment and growth was inverse. For barium and manganese, the sample with the highest concentration also showed no observable effect on growth. Due to the poor correlations with arsenic, barium, and manganese, toxicity values were only derived for copper and lead. The AETs, based on growth, for copper and lead are 74.9 mg/kg and 432 mg/kg, respectively. The NOECs and LOECs, based on growth, are 9.06 mg/kg and 10.4 mg/kg for copper and 23.1 mg/kg and 76.7 mg/kg for lead. These toxicity values are presented in Table 6-28.

Table 6-28 also presents the relative predictability of the AETs and LOECs for copper and lead. The AETs for copper and lead had fairly good predictability with only 1 false negative each. The LOECs for copper and lead also had good predictability with only 1 false positive each. The range of mixed results for copper and lead were relatively narrow. The range for copper was 10.4 mg/kg to 18.6 mg/kg spanning a factor of less than 2 and the range for lead was 76.7 mg/kg to 247 mg/kg spanning a factor of 3 to 4.

Additionally, these toxicity values can be compared to generic screening benchmarks from the literature. EPA Region IV (2003b) has established generic screening benchmarks for freshwater sediment as conservative estimates of concentrations below which effects are not expected. These generic screening benchmarks for copper and lead are reported as 18.7 mg/kg and 30.2 mg/kg and are adapted from MacDonald (1994). The screening benchmark for copper is greater than the LOEC but less than the AET, whereas the screening benchmark for lead is less than but similar to the LOEC. This, along with the predictability of the toxicity values, provides the strongest evidence that lead and/or copper may be responsible for the observed toxicity in the sediment toxicity tests and that values between the LOEC and AET are most appropriate for site-specific screening values.

6.2.4 Chironomid Bioaccumulation

The decision rule pertaining to accumulation of sediment-associated COPECs by benthic invertebrates is "if chironomids exposed to sediment from Cane Creek demonstrate statistically

higher tissue concentrations of COPECs than chironomids exposed to reference sediment, then there is the potential for significant COPEC accumulation in benthic invertebrate tissue."

Chironomid bioaccumulation tests were conducted in order to assess the potential COPEC transfer from sediment to emergent benthic invertebrates and to estimate a sediment-to-benthic invertebrate bioaccumulation factor (BAF). These site-specific sediment-to-benthic invertebrate BAFs are used in the riparian food web model to assess the potential uptake of sediment COPECs in benthic invertebrates and the subsequent transfer of sediment COPECs to higher trophic level organisms that feed on benthic invertebrates (e.g. marsh wren and little brown bat).

Data collected as part of the Site Investigation indicate that arsenic, barium, copper, lead, and manganese may accumulate in chironomid tissues, albeit at lower concentrations than ambient sediment concentrations. Since thallium was not detected in any of the sediment samples used for toxicity testing/bioaccumulation study, accumulation of thallium in chironomid tissues was assumed to be negligible.

A summary of the COPEC concentrations in sediment samples and the corresponding chironomid tissue concentrations was presented in Table 5-10. The chironomid tissue COPEC concentrations as a function of the sediment COPEC concentrations are presented in Figure 6-31 for arsenic, Figure 6-32 for barium, Figure 6-33 for copper, Figure 6-34 for lead, and Figure 6-35 for manganese. These figures help relate the potential bioavailability of the COPECs in the sediment to the toxicity test results. The correlations between tissue concentrations and sediment concentrations were strongest for copper ($r = 0.86$), lead ($r = 0.92$), and manganese ($r = 0.7$). Although lead depicted a good correlation ($r = 0.92$), the highest sediment concentration tested resulted in a much lower concentration in the chironomid tissue than predicted. Arsenic and barium in chironomid tissue did not show strong correlations ($r = 0.27$ and 0.56, respectively), providing additional evidence that these constituents are not likely responsible for the observed effects in the toxicity tests.

In order to define the relationship between sediment concentrations and chironomid tissue concentrations of COPECs, the data were plotted for each of the sediment COPECs (arsenic, barium, copper, lead, and manganese) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of arsenic, barium, copper, lead, and manganese in sediment and chironomid tissues fit the data best. As presented earlier, although thallium was identified as a sediment COPEC, none of the sediment samples collected as part of this BERA exhibited any detectable concentrations of thallium. Therefore, it was not possible to

correlate sediment concentrations and chironomid tissue concentrations of thallium. The graphs depicting the sediment-to-chironomid BAFs for arsenic, barium, copper, lead, and manganese are presented in Figures 6-31 through 6-35, respectively. The best fit regression models of the natural log transformed data for arsenic, barium, copper, lead, and manganese represent the site-specific sediment-to-chironomid BAFs and are summarized below:

Sediment COPEC	Sediment-to-Chironomid BAF
Arsenic	y = 0.2095 x + 0.6143
Barium	y = 0.3665 x + 2.1605
Copper	y = 0.5117 x + 3.1964
Lead	y = 0.7772 x + 2.1714
Manganese	y = 0.6647 x + 1.4114
Thallium	NA

where: y = natural logarithm of benthic invertebrate tissue concentration
x = natural logarithm of sediment concentration

Thallium was not detected in any of the sediment samples or chironomid tissue samples; therefore, a sediment-to-chironomid BAF could not be calculated. These sediment-to-chironomid BAFs were used in the riparian food web model to estimate the transfer of COPECs from sediment to riparian invertivores.

6.2.5 Benthic Invertebrate Community Assemblages

As presented in the previous chapter, benthic invertebrate samples were collected from 10 locations in Cane Creek and its tributaries within the BGR ranges and one reference station. A riffle/run sample and a CPOM sample were collected from each sampling location. Using the raw benthic data, a numerical value was calculated for the eight metrics (measures of benthic macroinvertebrate community quality) described previously. Calculated values were then compared to values derived from the reference site. Each metric was then assigned a score of 6, 3 or 0 according to the comparability (percent similarity) of calculated and reference values (Plafkin et al., 1989). Scores for the eight metrics were then totaled and compared to the total metric score for the reference location. The percent comparison between the total scores provides a final evaluation of biological condition. The inclusion of an integrated multi-metric approach to benthic habitat integrity incorporates many components of benthic community structure, and therefore provides a more reliable assessment than obtainable with a single metric analysis.

A summary of the benthic macroinvertebrates which were collected during this survey was shown in Table 5-12. The individual metrics used to evaluate the benthic macroinvertebrate data

and their significance are described below. The values for the metrics, percent comparison to the reference location, and the habitat quality score are presented in Table 5-13.

6.2.5.1 Taxa Richness

Taxa richness was calculated by counting the number of taxa present in each sample. Taxa richness is an unambiguous and easily understandable indication of the biological health of a stream community, and reflects the health of the community through a measurement of the variety of taxa present. In general, taxa richness increases with increasing water quality, habitat diversity, and/or habitat suitability. Taxa richness for the Cane Creek drainage riffle/run samples ranged from 1 at sample location SAR-85-SW/SD08 to 7 at locations HR-85Q-SW/SD02, SAR-77-SW/SD25 and SAR-77-SW/SD23. Eight taxa were found at reference location REFST. Inclusion of taxa in the CPOM samples gives a range of 2 to 9 taxa for the Cane Creek and tributary locations, and 10 taxa for REFST.

All locations on Cane Creek and its tributaries had fewer taxa than the reference location. Low taxa richness (1 to 3 taxa present) was found at SAR-85-SW/SD02, SAR-85-SW/SD08, SAR-85-SW/SD10, SAR-80Q-SW/SD03, and SAR-80Q-SW/SD06. The taxa richness data indicate that benthic macroinvertebrate habitats in the drainage basin containing the BGR ranges may be of lower quality than the reference location.

6.2.5.2 Modified Family Biotic Index

This index, developed by Hilsenhoff (1988), summarizes the tolerances of the benthic arthropod community to organic pollutants with a single value. Tolerance values used in the calculation of the FBI were obtained from Hilsenhoff (1988) and Bode (1988). The FBI is calculated by multiplying the number of organisms in each taxon by the tolerance value for that taxon, summing the products, and dividing by the total number of organisms.

Values for the FBI range from 0 to 10 with higher values corresponding to greater levels of organic pollution as shown in the following table:

Family Biotic Index	Water Quality	Degree of Organic Pollution
3.5	Excellent	Organic pollution unlikely
3.51-4.5	Very good	Possible slight organic pollution
4.51-5.5	Good	Some organic pollution probable
5.51-6.5	Fair	Fairly substantial pollution likely
6.51-7.5	Fairly poor	Substantial pollution likely
7.51-8.5	Poor	Very substantial pollution likely
8.51-10	Very poor	Severe organic pollution likely

The FBI ranged from 2.27 at sample location SAR-85-SW/SD02 to 8 at sample location SAR-85-SW/SD08. The FBI score at the reference site was 4.8. Two locations had FBI values that indicated better water quality than the reference location. However, because the tolerance values of individual taxa are based on sensitivity to organic pollution, the FBI may not give completely consistent results with other types of stressors. Five of the ten locations in the Cane Creek drainage had a percent comparability to reference score of 6, and five locations had a score of 3. No location had a score of zero for the FBI metric.

6.2.5.3 Ratio of Scraper and Filtering Collector Functional Feeding Groups

The relative abundance of scrapers and filtering collectors in the riffle/run habitat is an indicator of the food sources available. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Functional feeding group designations for the taxa identified were obtained from Merritt and Cummins (1984) and Barbour, et al., (1999). This metric was calculated by dividing the relative abundance of scrapers by the relative abundance of filter feeding organisms.

The ratio of scrapers and filterers was only calculable at two sites, SAR-77-SW/SD23 and REFST, with values of 0.125 and 0.14, respectively. Location SAR-77-SW/SD23 received the maximum reference comparability score of 6 for the scraper/filterer ratio. This index was not calculable at the remaining nine sites because no scraper-feeding invertebrates were present at these sites. Because the scraper/filterer ratio was obtained at the reference location, all Cane Creek drainage locations where the ratio could not be calculated because of a lack of scraper feeding invertebrates received a score of zero.

6.2.5.4 Ratio of EPT and Chironomidae Abundances

The ratio of EPT and Chironomidae abundance is calculated by dividing the relative abundance of EPT taxa by the relative abundance of Chironomidae. The ratio of EPT to Chironomidae indicates if there is an even distribution between the pollution sensitive EPT taxa and more pollution tolerant Chironomidae. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups EPT. Skewed populations having a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive insect groups may indicate environmental stress.

The ratio of EPT and Chironomidae at the seven Cane Creek drainage sample locations that had both EPT taxa and Chironomidae ranged from 0.07 at SAR-77-SW/SD25 to 2.29 at SAR-77-

SW/SD23. The ratio was 4.5 at reference location REFST. Chironomidae were not present at SAR-85-SW/SD02 and HR-80Q-SW/SD06; therefore, this index could not be calculated for these two locations. This index also could not be calculated at SAR-85-SW/SD08 because no EPT taxa were present at this site. Locations HR-78Q-SW/SD01 on Cane Creek and tributary location SAR-77- SW/SD23 had EPT/Chironomidae percent comparability to reference scores of 3. All other locations in the Cane Creek drainage had a score of zero.

6.2.5.5 Percent Contribution of Dominant Taxon

The percent contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few species would indicate environmental stress. The percent contribution of the dominant taxon is calculated by dividing the abundance of the taxon which is numerically dominant by the total number of organisms in the sample. A low percent contribution of the dominant family indicates a balanced community and generally indicates a higher quality habitat. Factors influencing this percentage include environmental stress, habitat quality, and life histories of the organisms collected in the sample.

The percent contribution of the dominant taxon ranged from 100 at sample location SAR-85-SW/SD08 to 25 at location HR-78Q-SW/SD01. The numerically dominant organisms at SAR-85-SW/SD08 were Chironomidae, which was the only taxon found at this location. Perlodidae (stonefly larvae) and Tanypodinae (midge larvae) were numerically dominant at location HR-78Q-SW/SD01. Locations HR-78Q-SW/SD01 on Cane Creek had a lower dominant taxon percentage than the reference location, and had the maximum percent comparability to the reference score of 6. Locations SAR-85-SW/SD02 and SAR-85-SW/SD08 on Cane Creek, and tributary station SAR-77-SW/SD25 had percent comparability to reference scores of zero.

6.2.5.6 EPT Index

The EPT Index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This value summarizes taxa richness within the insect orders that are generally considered to be pollution sensitive. The EPT index usually increases with increasing water quality.

The EPT index for the Cane Creek drainage locations ranged from 0 at SAR-85-SW/SD08, to 3 at HR-78Q-SW/SD01. The EPT was 5 at reference location REFST. Although EPT taxa were present at 9 of 10 Cain Creek drainage sampling locations, the percent comparability to reference score was zero for all ten locations for the EPT Index.

6.2.5.7 Community Similarity Index

This index evaluates the benthic populations at on-site locations relative to populations present at the reference location. The Community Loss Index measures the loss of benthic species between a reference station and the location of comparison. It is an index of dissimilarity with values increasing as the degree of dissimilarity from the reference station increases. The community loss index is calculated by subtracting the number of taxa common to both locations from the number of taxa present at the reference location, divided by the number of taxa present at the potential impact location.

The community similarity index ranged from 7 at sample location SAR-85-SW/SD08 to 0.57 at location SAR-77-SW/SD23. Location SAR-85-SW/SD08 on Cane Creek had a percent similarity with reference score of zero. All other Cane Creek drainage locations had a percent similarity with reference score of 3.

6.2.5.8 Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected

The abundance of the shredder functional group relative to the abundance of all other functional groups allows evaluation of potential impairment as indicated by the CPOM-based shredder community. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily absorbed to the CPOM and either affect the microbial communities colonizing the CPOM or the shredders directly. The ratio of the relative abundance of shredders to the abundance of all other functional feeding groups is calculated by dividing the relative abundance of shredders by the total number of organisms in a given sample. The abundance of shredders in comparison to other functional feeding groups can be influenced by climate, seasonality, and vegetation within the riparian zone, as well as levels of toxicants adsorbed to CPOM while in the riparian zone, or adsorption of toxicants to the CPOM while it is in the water.

No shredder feeding organisms were found at locations SAR-85-SW/SD02, HR-85Q-SW/SD02, SAR-85-SW/SD08, SAR-78-SW/SD10, and HR-80Q-SW/SD03; therefore, this index was not calculable at these sites. The ratio of shredders and total organisms at the remaining sites within the Cane Creek drainage ranged from 0.01 at SAR-77-SW/SD25 to 0.57 at HR-80Q-SW/SD06. The ration was 0.78 at reference location REFST.

6.2.5.9 *Total Metric Scores and Bioassessment*

The percent comparison to reference for all eight metrics is presented in Table 5-13. These values are used to assess the benthic invertebrate habitat quality at each sampling location as shown in the following table, adapted form Plafkin, et al., 1989.

Percent Comparability to Reference Score[a]	Relative Benthic Invertebrate Community Assessment	Attributes
Greater Than 79 Percent	Non-impaired	Comparable to the best benthic invertebrate community to be expected for stream size and habitat quality
29 – 72 Percent	Moderately Impaired	Fewer species due to loss of intolerant taxa.
Less Than 21 Percent	Severely Impaired	Few taxa present. May have high numbers of individuals of tolerant taxa.

[a]Percentage values that are intermediate to the table ranges are interpreted using best professional judgment.

Most sampling locations within the Cane Creek drainage were evaluated as being moderately impaired relative to the reference location, with percentages ranging from 50% at SAR-77-SW/SD23 to 25% at SAR-78-SW/SD10, SAR-77-SW/SD25, and HR-80Q-SW/SD03. Location SAR-77-SW/SD23, which had the greatest similarity to the reference location, is on a Cane Creek tributary. Other tributary locations were less similar to the reference location, but no tributary location was found to be severely impaired. The Cane Creek tributary streams are known to be ephemeral, and may be dry for significant time intervals each year. This is likely to significantly impact the composition of the benthic community, and reduce the similarity to the reference stream, which is a perennial stream with at least some water flow throughout the year. Cane Creek is a perennial stream, and therefore the benthic community in Cane Creek is not likely to be impacted by drying of the substrate.

Two sampling locations were evaluated as severely impaired relative to the reference location. These were SAR-85-SW/SD02 and SAR-85-SW/SD08. Both of these sampling locations are on Cane Creek within Range 27 (Parcel 85Q). There are two other sampling locations at Range 27 that exhibited only moderate impairment. One of these locations, HR-85Q-SW/SD02, is on a small drainage ditch north of Cane Creek.

The other, SAR-85-SW/SD05, is located between the sampling locations where severe impairment was found. Therefore, there does not appear to be a pattern of increasing or decreasing benthic community impairment along Cane Creek. One possible reason for the benthic habitat in Cane Creek at the BGR ranges being classified as less than optimal could be

the fact that Cane Creek exhibits very high energy flows during storm events due to the fact that the creek bank confines the flow to a static width. This high energy flow tends to scour the cobble and boulder substrate and remove many of the benthic invertebrates that may have colonized this area. Strong storm events the month before the benthic invertebrate sampling (June 2003) most likely scoured the substrate of Cane Creek (and specifically Cane Creek at Range 27) and removed many of the benthic invertebrates that may have been present before the storms. Sampling locations SAR-85-SW/SD02 and SAR-85-SW/SD08 are in high energy areas of Cane Creek. The substrate in these areas is almost entirely cobbles and boulders, with no or very little organic substrate. Significant scouring of the substrate is evident in these two sampling locations. These physical constraints may limit the ability of many benthic invertebrates to colonize these areas.

Sediment analytical results for all sampling locations were reviewed for constituents that may have affected the benthic community in Cane Creek and its tributaries. All Cane Creek sampling locations, and tributary location SAR-77-SW/SD25 had concentrations of lead above both the ESV and the calculated BTVs. Only the tributary locations furthest upstream (HR-80Q-SW/SD03 and HR-80Q-SW/SD06) and the reference location did not have sediment lead concentrations above the ESV and the BTV. In addition to benthic invertebrate community structure and COPEC concentrations in sediment, the stream habitat was assessed and characterized as sub-optimal to poor in quality. There does not appear to be a clear correlation between COPEC concentrations in sediment, the biological condition of the benthic invertebrate community, and the stream habitat as summarized in Table 6-29.

The benthic macroinvertebrate community data and sediment sample analytical data indicate that the previously discussed impairment in benthic macroinvertebrate communities of Cane Creek and its tributaries are most likely due to a combination of habitat restrictions and the presence of site-related constituents, particularly lead.

6.2.6 Riparian Food Web Exposures

The decision rule pertaining to riparian food web exposures to sediment-related COPECs was summarized in Chapter 5 and is the following: "If calculated doses of COPECs for riparian invertivorous mammals or birds are greater than literature-derived toxicity reference values, then there is the potential for risk to riparian invertivorous mammals or birds at the IMR and BGR ranges."

In order to assess the potential risks to various riparian-based feeding guilds from sediment-related constituents, a riparian food web was constructed. Riparian invertivorous mammals and

birds were identified as having significant potential for exposure to COPECs at the IMR and BGR ranges, mainly through ingestion of aquatic benthic invertebrates that may have accumulated COPECs in their tissues. In order to differentiate the invertivores that feed mainly on terrestrial invertebrates from those that feed mainly on aquatic invertebrates, this latter group is termed "riparian invertivores" for this assessment. In addition to the fact that this feeding guild has the potential to be maximally exposed to COPECs in sediment due to their feeding habits, these species also form an important food group for higher trophic level organisms (i.e., raptors). Raptors may prey on flying invertivorous mammals (e.g., bats) and invertivorous birds (e.g., swallows, wrens) and thus become exposed to COPECs through ingestion of COPECs that have become incorporated into the prey species' tissues. For these reasons, riparian invertivorous mammals and birds were identified as being an important ecological resource at the IMR and BGR ranges.

Daily doses of COPECs for riparian invertivorous mammals and birds were calculated using standard exposure algorithms. These algorithms incorporated species-specific natural history parameters (i.e., feeding rates, water ingestion rates, dietary composition, etc.) and also utilize site-specific AUF. Additionally, the concentrations of COPECs in benthic invertebrates were calculated using the site-specific sediment-to-chironomid BAFs described previously.

In order to calculate COPEC exposures, indicator species that represent the feeding guilds of interest were identified. For this risk assessment, the riparian invertivorous mammal was represented by the little brown bat (*Myotis lucifugus*) and the riparian invertivorous bird was represented by the marsh wren (*Cistothorus palustris*). Natural history parameters for these indicator species (Table 6-30) were used in combination with site-specific exposure parameters to estimate exposures to riparian invertivorous mammals and birds at the IMR and BGR ranges.

The algorithm that was used to estimate exposures to COPECs by riparian invertivorous mammals and birds is the following:

$$TDD_{wildlife} = \left[\left(IR_{food} \times f_{insect} \times \left\langle C_{sed} \times BCF_{insect} \right\rangle\right) + \left(IR_{water} \times C_{water}\right)\right] \times AUF$$

where:

$TDD_{wildlife}$	=	total daily dose of COPEC received by riparian invertivorous mammals or birds through ingestion (mg/kg/day);
IR_{food}	=	ingestion rate of food by receptor species (kg/kg/day);
f_{insect}	=	fraction of daily diet comprised of benthic invertebrates (percent);
C_{sed}	=	concentration of COPEC in sediment (mg/kg);

IR_{water}	=	ingestion rate of water by invertivorous mammals or birds (L/kg/day);
f_{water}	=	fraction of drinking water from the BGR ranges (percent);
C_{water}	=	concentration of COPEC in drinking water (mg/L);
AUF	=	area use factor (fraction of site used by receptor species) (percent).

The natural history (food web model input) parameters for the surrogate indicator species are described in the following sections.

6.2.6.1 Riparian Invertivorous Mammal Model Parameters

The surrogate species used in the riparian food web model to assess invertivorous mammals was the little brown bat (*Myotis lucifugus*). University of Michigan students (2006) have estimated the foraging area of the little brown bat through the use of radiotelemetry. The results of their study indicated the foraging area of the little brown bat to be approximately 40 acres in size. The size of the available bat foraging habitat along Cane Creek and its tributaries at the BGR ranges was estimated to be approximately 16,400 linear feet, and approximately 50 feet wide, resulting in a total foraging habitat size of approximately 19 acres. Therefore, the Area Use Factor for the little brown bat was estimated to be approximately 0.5 at the BGR ranges. The size of the available bat foraging habitat along Remount Creek and its tributaries at the IMR ranges was estimated to be approximately 11,250 linear feet, and approximately 50 feet wide, resulting in a total foraging habitat size of approximately 13 acres. Therefore, the Area Use Factor for the little brown bat was estimated to be approximately 0.325 at the IMR ranges. Because these two range complexes were assessed within the context of a single BERA, the more conservative AUF of 0.5 was used in the riparian food web model. The body weights of adult male and female little brown bats range from 7 to 9 grams, with a mean of 8 grams. The mean body weight of 8 grams was used as the body weight for the little brown bat in the riparian food web model. The water ingestion rate for little brown bats was estimated using the allometric equation presented in Sample, et al. (1997). Assuming a mean body weight of 8 grams, the water ingestion rate for little brown bats was estimated to be 0.16 L/kg/day. The food ingestion rates for pregnant, lactating, and juvenile little brown bats in New Hampshire were reported by Anthony and Kunz (1977) to be 0.23, 0.48, and 0.29 g/g/day, respectively, with a mean value of 0.333 g/g/day. The average moisture content of aquatic isopods, amphipods, caldocerans, and insect larvae is 79 percent (USEPA, 1993). Taking the moisture content of the little brown bat's diet into consideration, the food ingestion rate for the little brown bat that was used in the riparian food web model was 0.0699 g/g/day (dry weight). Since little brown bats are assumed to feed exclusively on emergent benthic invertebrates (aerial insectivore), their potential exposures to sediment is expected to be negligible. These input parameters are summarized in Table 6-30 and were used to estimate total daily exposures to COPECs for invertivorous mammals.

6.2.6.2 *Riparian Invertivorous Bird Model Parameters*

The surrogate species used in the riparian food web model to assess invertivorous birds was the marsh wren (*Cistothorus palustris*). The size of an adult male marsh wren's territory ranges from 0.015 acres to 0.42 acres, with a mean value of 0.13 acres (USEPA, 1993). This value was used as the foraging area for the marsh wren in the riparian food web model. This foraging area results in an area use factor for the marsh wren of 1.0. Body weights for adult male and female marsh wrens range from 9.4 to 11.9 grams (USEPA, 1993), with a mean value of 10.38 grams. This mean value was used as the marsh wren's body weight in the riparian food web model. USEPA (1993) has estimated the water ingestion rate for marsh wrens to be 0.26 g/g/day for adult males and 0.28 g/g/day for adult females. The mean value (0.27 g/g/day) was used for the water ingestion rate for marsh wrens in the riparian food web model. Food ingestion rates for adult male and female free-living marsh wrens range from 0.67 to 0.99 g/g/day (wet weight) (USEPA, 1993), with a mean value of 0.873 g/g/day. The average moisture content of aquatic isopods, amphipods, caldocerans, and insect larvae is 79 percent (USEPA, 1993). Taking the moisture content of the marsh wren's diet into consideration, the food ingestion rate for the marsh wren that was used in the riparian food web model was 0.1833 g/g/day (dry weight). Since marsh wrens are assumed to feed exclusively on emergent benthic invertebrates (aerial insectivore), their potential exposures to sediment is expected to be negligible. These input parameters are summarized in Table 6-30 and were used to estimate total daily exposures to COPECs for invertivorous birds.

It was assumed that the receptor species' diets consist entirely of emergent benthic invertebrates; therefore, it was necessary to estimate or measure COPEC concentrations in benthic invertebrate tissues. For this assessment, the COPEC concentrations in benthic invertebrate tissue were calculated using the site-specific sediment-to-chironomid BAFs described previously. The total daily doses of COPECs received by the riparian invertivorous mammals and birds did not include the ingestion of soil or sediment as the receptors' diets are assumed to consist solely of emergent aquatic insects and the potential for exposure to site-related soil or sediment is minimal for these receptors.

The AUFs for each of the indicator species take into account the home range and habitat requirements for each species and the size of the contaminated areas and viable habitat at the IMR and BGR ranges. The biological fate and transport properties used to estimate the exposure point concentrations of COPECs and the calculated exposure point concentrations of COPECs are presented in Tables 6-31 and 6-32, respectively.

The riparian food web model was executed with site-specific surface water and sediment concentrations, site-specific AUFs, site-specific sediment-to-chironomid BAFs, and literature-derived values for the other input variables. The model was executed with both maximum and mean detected concentrations as the exposure point concentrations for surface water and sediment in order to calculate a range of potential risks to riparian receptors. The estimated maximum and mean doses received by the riparian receptor species are presented in Tables 6-33 through 6-36. The avian and mammalian toxicity reference values used to assess the toxicity of the COPECs are presented in Tables 6-37 and 6-38, respectively.

Estimated maximum and mean exposures for the receptor species were compared to the toxicity reference values to estimate maximum and mean HQs for each receptor species. The calculated HQs for the surface water and sediment COPECs are summarized below.

	Maximum Exposure		***Mean Exposure***	
	NOAEL HQ	**LOAEL HQ**	**NOAEL HQ**	**LOAEL HQ**
Little Brown Bat:				
Arsenic	0.0758	0.00758	0.0657	0.00657
Barium	0.482	0.0482	0.317	0.0317
Copper	1.49	1.16	0.846	0.659
Lead	12.6	1.26	5.15	0.515
Manganese	0.172	0.0534	0.0653	0.0202
Thallium	NA	NA	NA	NA
Marsh Wren :				
Arsenic	0.202	0.0673	0.175	0.0584
Barium	0.619	0.309	0.407	0.203
Copper	1.99	1.52	1.13	0.862
Lead	137	46.7	56.1	19.1
Manganese	0.0797	0.00797	0.0302	0.00302
Thallium	NA	NA	NA	NA

The results of the riparian food web model indicate that there is a potential risk to riparian invertivorous mammals and riparian invertivorous birds from food web exposure to copper and lead in sediment. None of the other COPECs in surface water or sediment (arsenic, barium, manganese, and thallium) indicated the potential for adverse affects from exposure to even the maximum detected concentrations. Tables 6-39 through 6-42 present the estimated HQs for the riparian receptor species assuming maximum and mean exposures. Summaries of the estimated maximum and mean HQs are presented in Tables 6-43 and 6-44, respectively.

The riparian food web model was also executed to determine the sediment concentrations of copper and lead that would result in HQs of one or lower. These calculated sediment concentrations represent concentrations of copper and lead that could remain in sediment and still be protective of riparian receptors. Sediment concentrations based on an HQ = 1.0 are not

calculated for arsenic, barium, manganese, or thallium because the riparian food web model did not indicate any risk to riparian wildlife species due to food web exposures to these COPECs. The estimated sediment concentrations based on HQs equal to 1.0 are presented in Table 6-45 and summarized below.

Riparian Receptor Species	Sediment Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Sediment Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)
Little Brown Bat :		
- Copper	175	287
- Lead	66	1,290
Marsh Wren :		
- Copper	99	169
- Lead	3.1	12.4

7.0 Uncertainty Analysis

There are numerous uncertainties that are inherent in the ecological risk assessment process. This BERA was designed to reduce the level of uncertainty that was present in the SLERA; however, some uncertainties remain. The following sections describe the uncertainties present in the various lines of evidence utilized in this BERA. The major uncertainties and their effects on the results of this BERA are summarized in Table 7-1.

It is important to note the difference between "ecological risk" and "ecological impact" and the uncertainties inherent in each of these different concepts. Ecological risk assessment is a predictive assessment that attempts to predict current or future ecological risks posed by stressors using predictive models, toxicity tests, site-specific and literature-based toxicity values, and other lines of evidence. Impact assessment, on the other hand, is a forensic assessment based on observations of reproductive success, population dynamics, and other ecological indicators to determine whether stressors have caused an observable adverse effect on local ecological populations and communities.

The baseline ecological risk assessment (BERA) that was conducted for the IMR and BGR ranges at FTMC is a risk assessment (not an impact assessment); therefore, the lines of evidence utilized in the risk assessment were assembled to provide risk managers with an understanding of potential current and future risks if no remedial measures were taken at the site. It is important to note that some elements of impact assessment were utilized in this risk assessment. The benthic macroinvertebrate community analysis is a classic example of the type of assessment that is conducted in an impact assessment. The benthic macroinvertebrate community that is currently present in Cane Creek was studied to determine if the community structure was different than that found in an un-impacted stream in the vicinity of FTMC. This benthic macroinvertebrate community analysis was used with other lines of evidence (e.g. surface water and sediment toxicity tests) to determine if the aquatic communities in Cane Creek were, or have the potential to be at some time in the future, adversely impacted by chemical stressors originating at the IMR or BGR ranges.

While the assessment of terrestrial ecosystems at the IMR and BGR ranges did not explicitly utilize impact assessment techniques, visual observations of denuded soil could be considered an element of impact assessment (the observation that certain areas of the IMR and BGR ranges do not currently support normal plant growth could be considered an expression of adverse impact to terrestrial plant growth).

The fact that more elements of impact assessment (e.g. population studies of existing bird and mammals) were not utilized as lines of evidence in the risk assessment for the IMR and BGR ranges could be considered a source of uncertainty in the risk assessment.

7.1 Uncertainties in COPEC Identification

Uncertainty is introduced into the COPEC identification process through the use of analytical methods that are unable to attain detection limits sufficiently low to resolve constituent concentrations below the ecological screening values. If an analytical method cannot achieve a detection limit below the ESV, then there is a possibility that a constituent may be present in a given sample, but not be detected. In such an instance, the analysis would result in a false negative result and could result in constituents being present in environmental media without being detected.

Although standard USEPA analytical methods were used for all of the analyses conducted on environmental samples from FTMC, there are instances where the reporting limits and/or method detection limits were greater than the ESVs for certain constituents in certain samples. Tables 7-2 through 7-5 present comparisons of the analytical reporting limits and method detection limits to ESVs for constituents that were not detected in surface soil, surface water, sediment and groundwater.

In general, the detection limits were sufficiently low to conclude that the constituents that were not detected were, in fact, not present in environmental samples from FTMC. There may be some instances in which the detection limits were not low enough to definitively conclude that these constituents were not present in environmental samples and these constituents are highlighted and bolded in Tables 7-2 through 7-5. Based on site usage and historical records, there is no reason to suspect that the constituents that were not detected would actually be present in environmental media. Therefore, although there is uncertainty with regard to the detection (or non-detection) of certain constituents in environmental samples due to elevated detection limits, it is unlikely that these uncertainties would significantly impact the selection of COPECs.

As is standard practice for all risk assessments conducted at FTMC by Shaw, data from " field duplicate" samples were not used in the ecological risk assessment. Data from field duplicate samples were used exclusively for QA/QC purposes. As all analytical data for environmental samples exhibits some degree of variability, the practice of not using data from duplicate samples introduces some uncertainty into the chemical database. Tables 6-36 through 6-39 in

the Human Health risk assessment show the data for site samples and their associated duplicate samples for surface soil, surface water, sediment, and groundwater. As presented in these tables, there is no pattern of higher or lower analytical results being associated with the regular site samples or the associated field duplicate samples. Therefore, there is some uncertainty associated with not including the field duplicate data in the dataset used in the risk assessment; however, this uncertainty is the same uncertainty associated with the normal variability of environmental samples. This uncertainty is expected to have minimal impact on the results of the SLERA and subsequent risk analyses.

One source of uncertainty that may impart a non-conservative bias on the COPEC identification process is the exclusion of certain metals determined to be present at concentrations comparable to naturally-occurring background concentrations from consideration as COPECs. The exclusion of chemicals from the list of COPECs based on comparison to naturally-occurring levels is currently performed via a three-tiered protocol (Shaw, 2005). However, the COPEC identification process for the IMR and BGR Ranges was completed in the SLERAs conducted for these two range complexes. The SLERAs for the IMR and BGR Ranges were completed in 2002 (IT, April 2002a and May 2002b) and the only background screening that was conducted at that time was a comparison of the maximum detected concentration of metals to two-times the arithmetic mean concentration of the constituent in the background data set, which was defined as the background screening value (BSV). Comparison of the maximum detected constituent concentration to the BSV is recommended by USEPA Region 4 for refining the list of COPECs (USEPA Region 4, 2000) and is generally considered to be sufficiently conservative so that the uncertainty associated with chemicals eliminated using this comparison is minimal. Table 7-6 summarizes the constituents that were eliminated from consideration as COPECs based on the comparison of the maximum detected constituent concentration to the BSV. The impact on the results of the SLERA and subsequent risk analyses through the implementation of the background screening process is likely minimal.

7.2 Uncertainties in Earthworm Survival and Growth Tests

There are several sources of uncertainty that are evident in the earthworm survival and growth tests. Because all of the on-site sample results were compared to the results from reference locations, it was critical to identify representative reference sites. For the earthworm tests, reference samples were collected from five different locations: one sample from high metal binding capacity soil, one sample from medium metal binding capacity soil, and three samples from low metal binding capacity soil (one sample from each of the three soil mapping units that make up the low metal binding capacity soil). Every effort was made to identify reference locations that were representative of the different soil types and samples were collected from

areas thought to be unaffected by Army activities. However, subtle differences in the soil chemistry or physical make-up may be present between the on-site soils and reference soils that could affect the toxicity of the soils or the ability of earthworms to accumulate chemicals from the soil.

One of the strengths of earthworm toxicity tests is that the tests directly relate earthworm toxicity to on-site soil. However, the main weakness of the earthworm toxicity test is that it does not identify the toxicant(s) that causes the adverse effect. Although the earthworm toxicity tests identified lead and copper as the major toxicants that induced the adverse effects in earthworms, there may be other chemicals or physical characteristics of the soil itself that may also contribute to the observed adverse effects (reduced survival and/or growth).

Another uncertainty inherent in the earthworm toxicity tests is the fact that all of the samples exhibited earthworm weight loss during the tests. This is due to the fact that food was not introduced to the test chambers during the duration of the tests. Since the soils at the IMR and BGR ranges are very low in natural organic matter, the lack of food for the earthworms during the tests could exacerbate the adverse effects caused by any chemical contaminants present in the soil.

As mentioned above, the soils at the IMR and BGR ranges are very low in natural organic matter. In fact many of the soils are identified by the USGS as "Stony Rough Land." These soils may not be conducive to earthworm survival. Therefore, the reduced survival and growth may be largely linked to the fact that these soils do not have enough natural organic material to support significant populations of earthworms. Additionally, the species of worms used in the toxicity tests (*Eisenia fetida*) may not be representative of the types of invertebrates that would be expected to live in soils in northern Alabama.

7.3 Uncertainties in Earthworm Bioaccumulation Test

Many of the uncertainties related to the earthworm survival and growth tests are also inherent in the earthworm bioaccumulation test. A significant source of uncertainty associated with the earthworm bioaccumulation test is the fact that the earthworms were not depurated before chemical analysis. Therefore, the gut contents of the earthworms were incorporated into the earthworm tissue chemical analysis. The fact that the earthworms were not depurated prior to chemical analysis could potentially over-estimate the earthworm tissue concentrations of COPECs significantly. This could also significantly increase the calculated soil-to-earthworm BAF.

Another source of uncertainty in the earthworm bioaccumulation test is the duration of the test (28 days). Although the 28-day exposure period is the standard test duration, earthworm tissues may not reach equilibrium with the surrounding soils in 28 days. This uncertainty could serve to underestimate earthworm tissue concentrations and subsequent bioaccumulation potential.

The presence of other chemicals in the soil and the physical characteristics of the soil may serve to enhance or inhibit the bioaccumulation of soil COPECs by earthworms. This uncertainty could serve to either over- or under-estimate the bioaccumulation potential of certain soil COPECs.

7.4 Uncertainties in Terrestrial Food Web Model

There are a number of uncertainties in food web models in general and specifically the terrestrial food web model used in this risk assessment. Uncertainty is introduced into the terrestrial food web model by using a single surrogate species to represent an entire feeding guild. Different species and individuals within a given species exhibit different feeding habits and susceptibilities to stressors. Likewise, the use of a single value to represent each exposure parameter (e.g., food ingestion rate, body weight, foraging area, etc.) is an over-simplification of a natural system with a great deal of natural variability in order to establish a useable model. Most of the receptor-specific input parameters are the mean of several values presented in the literature. Additionally, the terrestrial food web model utilized simplified feeding preferences in order to simplify the modeling process. Simplified transfer rates were used to estimate the transfer of contaminants from abiotic media (e.g., soil, surface water, and sediment) to food items for the receptors of interest. These transfer rates introduce an unknown level of uncertainty into the terrestrial food web model.

Another area of uncertainty in the terrestrial food web model is the use of a site-specific soil-to-invertebrate BAF to estimate the concentrations of soil COPECs in terrestrial invertebrates. The use of laboratory-derived BAFs to simulate the potential bioaccumulation that may take place in a natural ecosystem is fraught with uncertainties. Natural ecosystems are controlled by numerous factors that vary both temporally and spatially, whereas many of these factors are controlled and held constant within a laboratory testing regime. The use of a single species, in this case the earthworm (*Eisenia fetida*), in the laboratory bioaccumulation test as a surrogate for all terrestrial invertebrates is a necessary simplification of a broad and diverse ecological system. Other terrestrial invertebrates may accumulate soil COPECs to a greater or lesser degree than the test species used in this BERA. Therefore, the site-specific soil-to-invertebrate BAFs that are calculated using site-specific soil and earthworm tissue concentrations are point estimates of what in nature is a wide range of values. Use of these estimated soil-to-invertebrate BAFs in the

terrestrial food web model introduces a significant level of uncertainty to the calculated risks, and also to the estimated RBRGs based on terrestrial food web exposures.

The mammalian and avian toxicity reference values used to assess toxicity were based on literature values derived in laboratory toxicity tests using different species than the receptor species and also using a single toxicant, as opposed to a number of co-occurring toxicants as occurs at FTMC. Laboratory animals respond differently to toxicants than do wild animals and environmental conditions at the site may act to attenuate or exacerbate the toxicity of certain stressors to wild animals. The toxicity reference values used in the terrestrial food web were derived from no-observed-adverse-effects-levels (NOAEL); therefore, they represent doses at which no adverse effects occur in the test animals. NOAEL-based TRVs are the most protective values that could be used and result in very conservative risk estimates. Uncertainty factors are also used in the derivation of the NOAEL-based TRVs, introducing more uncertainty to these values.

The terrestrial food web model used in this risk assessment did not take into account the potential contribution of dermal absorption or inhalation to the total dose of contaminant received by a receptor. The relative contribution of contaminant dose from inhalation and dermal absorption is expected to be insignificant compared to the dose received through ingestion, particularly with respect to the COPECs (inorganics) assessed in this risk assessment. However, there is a certain level of uncertainty introduced into the assessment by not quantifying these potential exposures.

7.5 Uncertainties in Lead Particle Ingestion Model

There is a significant level of uncertainty with regard to grit selection by birds. Birds are known to ingest lead shot at skeet ranges which can result in mortality. Skeet ranges are known potential threats to avian receptors because of this. However, lead shot is round and smooth. Bullet fragments, for the most part, are not. Gionfriddo and Best, 1996, Best and Gionfriddo, 1994, and Best and Gionfriddo, 1991 extensively evaluated not just the size of grit ingested by birds but also the shape and surface textures of grit found in their crops. They found that birds typically utilize round, smooth grit particles (such as lead shot) rather than oblong or jagged particles (such as bullet fragments). Since the ranges at FTMC were used primarily for small arms weapons training (pistol and rifle), and bullet fragments are typically oblong and jagged rather than round and smooth, the assumption that all lead particles on FTMC small arms ranges within the appropriate size categories for use by quail and turkey are available for ingestion overestimates the amount of potential exposure. It is unknown if birds preferentially ingest or avoid lead bullet fragments as digestive grit or if they discriminate between lead shot and lead bullet fragments.

USACHPPM evaluated the lead particles in four samples collected from FTMC ranges following the methodology in Gionfriddo and Best 1996 and Best and Gionfriddo, 1991. Approximately 75% of the lead particles in two of the samples were out of either the shape or surface texture range for grit used by birds as reported in Gionfriddo and Best, 1996. Approximately 35% of the particles contained in the remaining two samples were also out of the reported shape and surface texture ranges. Therefore, between 35 % and 75 % of the lead fragments that fall within the proper size category for quail and turkey are not usable by avian receptors due to shape or surface texture. The assumption that each lead particle within the appropriate ingestible size classification can be utilized without considering shape and surface texture results in the over estimation of potential exposures, and therefore, risks attributable to lead particle ingestion.

Assumptions regarding the receptor species' home ranges are also a source of uncertainty in the lead particle ingestion assessment. The Pedicord and LaKind model assumed that quail spend 100% of their time on the lead grit contaminated portions of the ranges. The lead grit contaminated portions of the ranges are small relative to the total area of the range, and to the home range of the avian receptors evaluated. Therefore, assuming that quail spend all of their time on the lead grit contaminated portions of the ranges, primarily the steeply sloped berms, over estimates the potential these birds have of ingesting lead grit.

The assumptions used to estimate grit retention times for the bird species in this assessment (quail and turkey) have the potential to introduce significant uncertainty into the assessment. The Pedicord and LaKind model is very sensitive to grit retention time. Grit retention time is highly variable and is dependant on a number of factors including diet. Grit retention times are typically shorter when the avian consumes harder dietary items than when they consume softer dietary items due to grit wear. Dietary item preference and selection depends on breeding condition, season, and item availability. Published grit retention times for quail range from 10 days to 270 days. This results in an order of magnitude difference in the probability of a quail ingesting a lead particle, and a two order of magnitude difference in the acceptable lead particle density in soil.

The assumption that ingestion and retention of a single lead particle by a bird would induce toxic effects introduces a significant level of uncertainty into this assessment. It was assumed that if an avian receptor ingested one piece of lead, that exposure would result in mortality. While a number of studies indicate that the ingestion of one lead particle results in mortality, there are an equal number of studies that indicate the ingestion of more than one lead particle does not cause mortality.

Additional uncertainty is introduced into this assessment by the assumption that a 20 % probability of an individual bird ingesting and retaining a lead particle in it's crop is acceptable. It was assumed that if an individual bird had a 20% chance of ingesting a lead particle, the entire population would experience a 20% exposure, and therefore, experience adverse effects. It was further assumed that a bird population that experiences a 20% incidence of adverse effects would not experience a significant population-level effect (i.e., reduced population). This approach may or may not be protective of the avian receptor population at FTMC. Field population studies would be necessary to determine the level of individual exposures that would result in population-level effects.

7.6 Uncertainties in Fathead Minnow Survival and Growth Tests

There are several sources of uncertainty that are evident in the fathead minnow survival and growth tests. Because all of the on-site sample results were compared to the results from a reference location, it was critical to identify a representative reference site. For the fathead minnow tests, a reference sample was collected from a tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to Main Post. Every effort was made to identify a reference location that was similar to the on-site sampling locations with respect to stream gradient, substrate, and surrounding habitat. However, subtle differences in the surface water or sediment chemistry or physical make-up of the substrate may be present between the on-site sample locations and reference location that could affect the toxicity of the surface water to fathead minnows.

One of the strengths of fathead minnow toxicity test is that the test directly relates minnow survival and growth to on-site surface water. However, the main weakness of the fathead minnow toxicity test is that it does not identify the toxicant(s) that causes the adverse effect. Although the fathead minnow toxicity tests identified lead and copper as the major toxicants that most likely induced the adverse effects in fathead minnows, there may be other chemicals or physical characteristics of the surface water that may also contribute to the observed adverse effects (reduced survival and/or growth).

Because surface water samples were only analyzed for total metals, it is not known what percentage of the detected metals were dissolved. It is commonly recognized that the biologically available portion of the total metals in surface water is the dissolved portion. Since dissolved metals were not analyzed, there is a certain level of uncertainty with regard to the concentrations of dissolved metals in the surface water samples, and therefore, the concentrations of the supposed causative agents with regard to the adverse affects to the fathead minnows.

Another uncertainty in the fathead minnow toxicity tests is with respect to the species used for testing. Fathead minnows (*Pimephales promelas*) may be more or less sensitive to the surface water COPECs (copper and lead) than native minnow species and may not be representative of the types of minnows that would be expected to live in Cane Creek and its tributaries at FTMC.

The relatively short duration of the fathead minnow tests may also introduce a certain level of uncertainty. Although the fathead minnow tests were run for seven days, the growth endpoint was used to assess chronic exposures. The relatively short (7 days) exposure duration may not accurately assess chronic exposures for fathead minnows.

7.7 Uncertainties in Ceriodaphnid Survival and Reproduction Tests

There are several sources of uncertainty that are evident in the ceriodaphnid survival and reproduction tests. Because all of the on-site sample results were compared to the results from a reference location, it was critical to identify a representative reference site. For the ceriodaphnid tests, a reference sample was collected from a tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to Main Post (the same reference location used for all surface water and sediment toxicity tests and benthic community analyses). Every effort was made to identify a reference location that was similar to the on-site sampling locations with respect to stream gradient, substrate, and surrounding habitat. However, subtle differences in the surface water or sediment chemistry or physical make-up of the substrate may be present between the on-site sample locations and reference location that could affect the toxicity of the surface water to ceriodaphnids.

One of the strengths of ceriodaphnid toxicity test is that the test directly relates daphnid survival and reproduction to on-site surface water. However, the main weakness of the ceriodaphnid toxicity test is that it does not identify the toxicant(s) that causes the adverse effect. Although the ceriodaphnid toxicity tests identified lead and copper as the major toxicants that most likely induced the adverse effects in daphnids, there may be other chemicals or physical characteristics of the surface water that may also contribute to the observed adverse effects (reduced survival and/or reproduction).

Because surface water samples were only analyzed for total metals, it is not known what percentage of the detected metals were dissolved. It is commonly recognized that the biologically available portion of the total metals in surface water is the dissolved portion. Since dissolved metals were not analyzed, there is a certain level of uncertainty with regard to the

concentrations of dissolved metals in the surface water samples, and therefore, the concentrations of the supposed causative agents with regard to the adverse affects to ceriodaphnids.

Another uncertainty with respect to the ceriodaphnid toxicity tests results is the fact that 7-day ceriodaphnid survival was statistically reduced in surface water samples with non-detectable concentrations of copper and lead (the presumed causative agents). These results implicate a factor other than copper or lead as the cause of reduced survival. The observed reduction in ceriodapnid survival could be attributed to a number of factors including another chemical toxicant, laboratory testing procedures, sample handling, or a variety of other physical, chemical, or biological factors that were not the subject of this particular test protocol. Due to the uncertainties with the test results for ceriodaphnid survival, these test results were not used in the BERA weight-of-evidence assessment.

Another uncertainty in the ceriodaphnid toxicity tests is with respect to the species used for testing. Ceriodaphnia (*Ceriodaphnia dubia*) may be more or less sensitive to the surface water COPECs (copper and lead) than native species of water fleas and may not be representative of the types of water fleas that would be expected to live in Cane Creek and its tributaries at FTMC.

The relatively short duration of the tests on ceriodaphnids may also introduce a certain level of uncertainty. Although the ceriodaphnid tests were run for seven days, the reproductive endpoint was used to assess chronic exposures. The relatively short (7 days) exposure duration may not accurately assess chronic exposures for all surface water invertebrates.

7.8 Uncertainties in Chironomid Survival and Growth Tests

A number of uncertainties are inherent in the chrionomid survival and growth tests. Because all of the on-site sample results were compared to the results from a reference stream, it was critical to identify a representative reference site. For the chironomid tests, a reference sample was collected from a tributary to Choccolocco Creek that flows in an easterly direction along BGR, immediately east of the Bains Gap gate to Main Post (the same reference location used for all surface water and sediment toxicity tests and benthic community analyses). Every effort was made to identify a reference location that was similar to the on-site sampling locations with respect to stream gradient, substrate, and surrounding habitat. However, subtle differences in the surface water or sediment chemistry or physical make-up of the substrate may be present between the on-site sample locations and reference location that could affect the toxicity of the sediment to chironomids.

One of the strengths of chrionomid toxicity tests is that the tests directly relate chironomid toxicity to on-site sediment. However, the main weakness of the chironomid toxicity test is that it does not identify the toxicant(s) that causes the adverse effect. Although the chironomid toxicity tests identified lead and copper as the major toxicants that induced the adverse effects in chironomids, there may be other chemicals or physical characteristics of the sediment itself that may also contribute to the observed adverse effects (reduced survival and/or growth).

The sediment in Cane Creek at the BGR ranges is mostly gravel and cobbles, with interspersed areas of sand. The sediment is very low in natural organic matter. This sediment type may not be conducive to chironomid survival, as indicated by the low survival rates in all of the sediment samples including the reference location. The reduced survival and growth may be largely linked to the fact that these sediments do not have enough natural organic material to support significant populations of chironomids or other benthic invertebrates. The low overall survival of chironomids introduces a significant level of uncertainty into the sediment toxicity test results.

Additionally, the species of chironomids used in the toxicity tests (*Chironomus riparius*) may not be representative of the types of invertebrates that would be expected to live in the sediment of small streams in northern Alabama.

7.9 Uncertainties in Chironomid Bioaccumulation Test

There are several uncertainties that are evident in the chironomid bioaccumulation test. Based on the small size of individual chironomids and the volume requirements of the analytical laboratory, a large number of chironomids were required to conduct the required chemical analyses on the chironomid tissues. These volume requirements necessitated the use of non-standard sample volumes and test chambers. These variances from the standard testing protocols may have introduced some uncertainty into the results of the chironomid bioaccumulation test.

The fact that the on-site sediments were not conducive to chironomid survival or growth also hindered the bioaccumulation test. The on-site sediments are mostly gravel and cobble, with very low organic content. These sediments do not provide suitable habitat to support significant populations of chironomids or other benthic invertebrates. Therefore, bioaccumulation from these sediments by chironomids is expected to be minimal.

Another source of uncertainty in the chironomid bioaccumulation test is the duration of the test (10 days). Although the 10-day exposure period is the standard test duration, chironomid tissues may not reach equilibrium with the surrounding sediments in 10 days. This uncertainty could

serve to underestimate chironomid tissue concentrations and subsequent bioaccumulation potential.

7.10 Uncertainties in Benthic Invertebrate Community Analysis

There are a number of uncertainties inherent in assessing benthic invertebrate community structure using the RBP techniques. The RBP assessment provides a "snapshot" of the benthic community structure at the time of sampling. However, it does not provide an assessment of the benthos over time. As such, the assessment is subject to the environmental conditions at the time of sampling or just prior to sampling. For instance, Cane Creek in the vicinity of the BGR ranges is a high energy stream during periods of significant precipitation. A significant amount of scouring takes place during these rainfall events. If a significant rainfall event occurred just prior to sampling, the benthic community may be different that the community that occurs in the stream during normal flow conditions.

A significant level of uncertainty is introduced to the benthic invertebrate community analysis and the assessment of sediment toxicity as a whole by the fact that the benthic habitat at the BGR ranges was characterized as sub-optimal to poor in quality. The habitat quality may have a significant impact on the benthic community structure at the BGR ranges and the ability of the habitat to support a viable benthic community.

Another source of uncertainty in the RBP assessment is the fact that several of the metrics used to quantitatively assess the community structure are based on the assessment of organic pollutants. Since the COPECs in sediment at the IMR and BGR ranges are metals, some of the metrics used in the RBP technique may not be applicable.

Another source of uncertainty is the fact that the RBP technique identifies areas of impact regardless of the stressor that causes the impact. The RBP technique cannot differentiate between chemical, biological, physical, or other stressors.

Another area of uncertainty with regards to the benthic community analysis is the habitat quality in the areas surrounding the sampling locations. While the assessment of the key physical characteristics of the water body and surrounding land is critical to the overall evaluation of impairment, these characteristics can only be evaluated qualitatively, and as such, contain an unknown level of uncertainty. This fact is especially true when comparing on-site stream characteristics to a reference stream. Although a thorough effort was made to identify and sample a reference location from a stream with similar physical characteristics as Cane Creek at

the BGR ranges, subtle differences in the physical makeup of the stream or surrounding habitat may cause differences in the benthic invertebrate communities.

7.11 Uncertainties in Riparian Food Web Model

There are a number of uncertainties in food web models in general and specifically the riparian food web model used in this risk assessment. Uncertainty is introduced into the riparian food web model by using a single surrogate species to represent an entire feeding guild. Different species and individuals within a given species exhibit different feeding habits and susceptibilities to stressors. Likewise, the use of a single value to represent each exposure parameter (e.g., food ingestion rate, body weight, foraging area, etc.) is an over-simplification of a natural system with a great deal of natural variability in order to establish a useable model. Most of the receptor-specific input parameters are the mean of several values presented in the literature. Additionally, the riparian food web model utilized simplified feeding preferences in order to simplify the modeling process. In the case of the riparian food web model, the receptors were assumed to eat only emergent benthic invertebrates. Simplified transfer rates were used to estimate the transfer of contaminants from abiotic media (e.g., surface water and sediment) to food items for the receptors of interest. These transfer rates introduce an unknown level of uncertainty into the riparian food web model.

The mammalian and avian toxicity reference values used to assess toxicity were based on literature values derived in laboratory toxicity tests using different species than the receptor species and also using a single toxicant, as opposed to a number of co-occurring toxicants as occurs at FTMC. Laboratory animals respond differently to toxicants than do wild animals and environmental conditions at the site may act to attenuate or exacerbate the toxicity of certain stressors to wild animals. The toxicity reference values used in the riparian food web were derived from NOAEL; therefore, they represent doses at which no adverse effects occur in the test animals. NOAEL-based TRVs are the most protective values that could be used and result in very conservative risk estimates. Uncertainty factors are also used in the derivation of the NOAEL-based TRVs, introducing more uncertainty to these values.

8.0 Summary and Conclusions

SLERAs were completed for both the IMR and BGR ranges. The SLERAs for these two groups of small arms ranges indicated COPECs were present in various environmental media and that additional assessment was warranted to further identify and refine the potential ecological risks at these sites. In order to accomplish these tasks, a BERA was conducted for the IMR and BGR ranges.

8.1 BERA Summary

Due to the fact that the habitats present at the IMR and BGR ranges were very similar and the COPECs present at these ranges were also very similar, a single BERA was conducted to address the potential ecological risks at both the IMR and BGR ranges. The following sections describe the BERA that was conducted for the IMR and BGR ranges at FTMC.

8.1.1 Terrestrial Habitat at the IMR and BGR Ranges

The SLERAs for the IMR and BGR ranges indicated that the habitats and COPECs present at these two groups of ranges were similar. The terrestrial habitat at the IMR and BGR ranges fall into two general categories: "cleared" areas and forested areas. The cleared areas are those areas that were formerly maintained as lawns or mowed fields. Since maintenance activities have ceased in these areas, pioneer species are now colonizing these ranges. Typically, the species most likely to colonize these areas are the "weed" species that tend to be vigorous pioneer plants that grow and spread rapidly. The first of the pioneer species to invade these abandoned areas are the grasses and herbaceous species. These formerly maintained grassy areas are classified as being in an early old field successional state. Over time, the grass and herbaceous species will be followed by shrubs and small trees. The forested areas outside of the cleared areas are best characterized as mixed deciduous/coniferous forest. With the exception of the forest stand around the Skeet Range, these rich and relatively unaltered forested regions represent the large safety fans across the Main Post.

8.1.2 Remount Creek Habitat

In the vicinity of the IMR ranges, Remount Creek is a small, ephemeral stream that flows (when water is present) from south to north. The physical characteristics of Remount Creek and the surrounding land use vary along its length, from its headwaters at Yahou Lake to its confluence with Cane Creek near the west-northwest boundary of the Main Post. The headwaters of Remount Creek are formed by the discharge from Yahou Lake and its tributaries, approximately 0.75 mile south of Range 12. Remount Creek runs in a northerly direction along the topographic

low formed by gently sloping hills to the east and west of the creek. Most of the length of Remount Creek between Yahou Lake and the IMR ranges runs through the Eastern Bypass corridor. Virtually all of the trees in the bypass corridor have been clear-cut and all of the vegetation removed. The entire area has been covered with mulch that was created by "chipping" the vegetation that was cut down. The land surrounding Remount Creek adjacent to Ranges 12 and 13 is characteristic of the clear-cut areas associated with the Eastern Bypass corridor. It is likely that portions of the creek adjacent to the IMR ranges will be significantly altered (e.g., rerouted, culverted) as a result of construction of the Eastern Bypass.

Immediately north of the Skeet Range, Remount Creek flows through a culvert under the old parade grounds/athletic fields and then through the grounds of the Cane Creek Golf Course until its confluence with Cane Creek in the west-northwestern corner of the Main Post.

The ecological value of Remount Creek is greatest as it flows through the Cane Creek Golf Course and intersects Cane Creek. It is in this stretch (downstream of the IMR ranges) that the creek may support foraging of insectivorous mammals and a functional aquatic ecosystem. Remount Creek and its tributaries in the vicinity of the IMR ranges may support semi-aquatic species (e.g., amphibians) and provide a breeding ground for some small fish species during the periods when water is present.

8.1.3 Cane Creek Habitat

Cane Creek in the vicinity of the BGR ranges is a perennial stream that flows east-to-west across the ranges at BGR. The physical characteristics of Cane Creek at the BGR ranges are relatively consistent; however, they differ both upstream and downstream of the BGR ranges. The BGR ranges lie within an east-west trending valley that is formed by Jones Hill, Mount Tylo, and several unnamed hills north of the ranges, and Marcheta Hill and several unnamed hills south of the ranges. Upstream (one-half to three-quarters of a mile east) of the BGR ranges, the headwaters of Cane Creek are formed by several small tributaries that are created by surface runoff and seeps from the hills north, south, and east of the ranges. These headwater streams are small ephemeral streams with boulder and cobble substrate that carry runoff during storm events, but are dry during significant portions of the year. The headwater areas are relatively undeveloped portions of Main Post and are almost entirely mixed deciduous/coniferous forest.

Downstream (west) of the BGR ranges, Cane Creek continues to flow in a westerly direction across the developed portion of Main Post (including the Cane Creek golf course) and off-site along the west-northwest boundary of the Main Post.

In general, the portion of Cane Creek that flows through the BGR ranges is a low-gradient perennial stream with widths ranging from 4 to 10 feet and depths ranging from 0.5 to 2.0 feet. The banks of Cane Creek are steep (4 to 8 feet) and exhibit erosional features characteristic of occasional high velocity flow (i.e., during significant storm events). The substrate of Cane Creek is mostly cobbles and boulders. There is very little evidence of organic matter present as substrate in Cane Creek in the vicinity of the BGR ranges. In fact, large sections of the creek bed in this area are made up of exposed bedrock.

The vegetation surrounding Cane Creek at the BGR ranges is variable. Because Cane Creek bisects these ranges, routine maintenance activities have historically controlled/eliminated the vegetation along the creek banks. Since maintenance activities have ceased, vegetative species have begun to re-colonize the creek banks. Therefore, weeds, low-lying shrubs, and tree saplings dominate the creek banks. The areas directly north of Cane Creek is best characterized as old field early successional habitat and the areas directly south of Cane Creek is mixed deciduous / coniferous forest, except for Range 21. Cane Creek flows through the center of Range 21; therefore, the habitat on both the north and south sides of Cane Creek at Range 21 is characterized as old field, early successional.

8.1.4 Wetland/Seep Habitat

The wetland/seep habitat present in the vicinity of the BGR Ranges is limited to the area south of Range 21. This area is known as the Marcheta Hill Orchid Seep SINA. SINA at FTMC consist of those biological communities that harbor federal, candidate, or state-listed species, or those habitats containing single or groups of unique or unusual species. The only SINA that could potentially be impacted by activities (both past and future) at the BGR ranges is the Marcheta Hill Orchid Seep SINA, as it is located directly adjacent to Range 21.

The spring seepage to the west of Marcheta Hill constitutes one of the more important SINAs on Main Post at FTMC. The boundary of the wetland seep is approximately 7.2 acres; however, the integrity of the adjacent watershed is critical to the maintenance of this seep. The area is located directly south of Range 21. This wetland is the largest forested seepage on the installation and contains two federal candidate 2 species: white fringeless orchid (*Plantanthera integrilabia*) and Diana butterfly (*Speyeria diana*). The population of white fringeless orchid is particularly significant with over 250 individuals recorded. Additional plants on the ANHP tracking list include rose pink (*Sabatia capitata*) and soapwort gentian (*Gentiana saponaria*).

8.1.5 Threatened and Endangered Species

Four species listed as threatened or endangered by the USFWS have been recorded at FTMC. These threatened and endangered species are as follows:

- Gray bat (*Myotis grisescens*);
- Blue shiner (*Cyprinella caerules*);
- Mohr's Barbara buttons (*Marshallia mohrii*); and
- Tennessee yellow-eyed grass (*Xyris tennesseensis*).

The only federally listed species that has the potential to occur in the vicinity of the IMR or BGR ranges is the gray bat (Garland, 1996). The other federally listed species occur at Pelham Range or Choccolocco Creek.

Gray bat summer foraging habitat is found primarily over open water of rivers and reservoirs. They apparently do not forage over sections of rivers or reservoirs that have lost their normal woody vegetation along the banks (USFWS, 1982). Gray bats usually follow wooded corridors from their summer caves to the open water areas used as foraging sites. Forested areas surrounding and between caves, as well as over feeding habitats, are clearly advantageous to gray bat survival, as the cover provides increased protection from predators such as screech owls. In addition, surveys have demonstrated that reservoirs and rivers that have been cleared of their adjacent forest canopy are avoided as foraging areas by gray bats (USFWS, 1982).

The gray bat is entirely insectivorous, and surveys have shown that gray bats feed almost exclusively on mayflies at certain times of the year (Mount, 1986). Therefore, gray bats could be exposed to site-related constituents that have accumulated in aquatic insects from Remount Creek or Cane Creek. Because gray bats are flying mammals and the IMR and BGR ranges do not provide roosting habitat, no other exposure pathways are complete for the gray bat.

Mist net surveys were conducted on and adjacent to FTMC in 1995. Gray bats were captured along both Choccolocco Creek (east of FTMC Main Post) and Cane Creek on Pelham Range (west of FTMC Main Post) during these mist net surveys (Garland, 1996). These preliminary data suggest that these major stream corridors at FTMC may provide at least a minimum foraging habitat for gray bats. However, gray bat surveys have not been conducted on Remount Creek in the vicinity of the IMR ranges or Cane Creek in the vicinity of the BGR ranges.

Although not officially listed by USFWS as threatened or endangered, two species that are candidates for federal listing are known to occur at the Marcheta Hill Orchid Seep SINA located directly south of Range 21 (BGR ranges); the white fringeless orchid (*Plantanthera integrilabia*)

and the Diana butterfly (*Speyeria diana*). The white fringeless orchid occurs in bogs and seepages along wooded stream banks and ravines from the coastal plain of Mississippi through Alabama, Georgia, Tennessee, Kentucky, the Carolinas, and Virginia. The plant was recorded within two SINAs on Main Post: Marcheta Hill Orchid Seep and Cave Creek Seep (Garland, 1996).

The other candidate species that is known to occur at the Marcheta Hill Orchid Seep is the Diana butterfly (*Speyeria diana*). Habitat affinity for this butterfly includes wet, rich forested valleys and mountainsides, and relatively undisturbed forests, especially near streams (Garland, 1996).

8.1.6 COPECs Identified in SLERAs

The COPECs that were identified in the SLERA and formed the basis for the BERA at the IMR ranges are the following:

- ***Surface Soil***: antimony, copper, lead, and zinc
- ***Surface Water***: lead
- ***Sediment***: arsenic, barium, copper, lead, manganese, and thallium.

The COPECS that were identified in the SLERA at the BGR ranges are the following:

- ***Surface Soil***: antimony, copper, lead, and zinc
- ***Surface Water***: copper and lead
- ***Sediment***: barium, copper, lead, manganese, and thallium.

8.1.7 Assessment and Measurement Endpoints

Given the overall goal of protecting the integrity and quality of the terrestrial old field ecosystems at the IMR and BGR ranges, the terrestrial assessment endpoints focused on critical community niches within the old field system. The overall goal of the aquatic assessment endpoints was the protection of the integrity and quality of the semi-aquatic ecosystem in Remount Creek at the IMR ranges and the aquatic ecosystem in Cane Creek at the BGR ranges. The aquatic assessment endpoints focused on critical community niches within these semi-aquatic and aquatic ecosystems. The assessment endpoints, risk hypotheses, and measurement endpoints that were identified for the IMR and BGR ranges were summarized in Table 3-1.

8.1.8 Data Quality Objectives

Based on the findings of the SLERAs and Problem Formulations conducted for the IMR and BGR ranges, the objectives of this BERA were identified as the following:

- Collect site-specific data to address bioavailability and bioaccumulation potentials in lower trophic level organisms that form the basis of the terrestrial and aquatic food webs at the IMR and BGR ranges.

- Collect site-specific data to address the existence and level of site-specific toxicity to terrestrial and aquatic receptors resulting from exposure to the COPECs.

- Determine the concentrations of the COPECs within the surface soils, surface water, and sediment at the IMR and BGR ranges at which the ecological receptors are at risk.

- Provide data of sufficient quality to develop a technically defensible characterization of risk at the IMR and BGR ranges for use by risk managers in their acceptance or rejection of present and future ecological risks posed by the COPECs in surface soil, surface water, and sediment and, if necessary, develop ecologically-based cleanup criteria.

The following decisions required site-specific data in order to address the issues identified in the objectives presented above.

- Determine if the COPECs at the IMR and BGR ranges are available for bio-uptake (i.e., bioavailable) in terrestrial or aquatic systems.

- Determine what levels of COPECs in soil, sediment, and surface water promote acute or chronic toxicity to terrestrial and aquatic receptors.

- Determine if the COPECs bioaccumulate in the tissues of terrestrial invertebrates (e.g., earthworms) or benthic invertebrates, and if so, to what extent.

- Determine the probability of gallinaceous and other ground-feeding birds ingesting and retaining a lead bullet fragment at the IMR and BGR ranges.

- Determine whether the tissue burdens of COPECs in terrestrial invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize terrestrial invertebrates as a major food source.

- Determine whether benthic communities within Cane Creek are adversely affected by exposure to COPECs in surface water and sediment.

- Determine whether the concentrations of COPECs in emergent benthic invertebrates have the potential to pose adverse effects to higher trophic level organisms that utilize emergent benthic invertebrates as a major food source.

- Develop constituent-specific cleanup goals for soil, surface water, or sediment if the BERA concludes that there is the potential for unacceptable ecological risk.

These data were used to help determine whether COPECs in surface soil, sediment, and surface water at the IMR and BGR ranges are, or will, present significant risk to ecological receptors.

8.1.9 Results of Earthworm Toxicity Tests

After 14-days of exposure, statistically reduced earthworm survival was reported in the following soil samples:

- SAR-85-SS37 RW0002 (BGR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)
- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges).

After 28 days of exposure, statistically-reduced survival was reported in the following soil samples:

- HR-70Q-SS01 RW0001 (IMR ranges)
- SAR-85-SS37 RW0002 (BGR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)
- SAR-85-SS17 RW0017 (BGR (Ranges)
- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges).

There was no apparent correlation between soil type (binding capacity) and earthworm survival.

The results of the earthworm toxicity testing indicated that statistically-reduced growth rates were exhibited in the following soil samples:

- HR-70Q-SS01 RW0001 (IMR ranges)
- SAR-85-SS37 RW0002 (BGR Ranges)
- SAR-85-SS34 RW0004 (BGR Ranges)
- SAR-71-SS05 RW0005 (IMR Ranges)
- HR-77Q-SS01 RW0010 (BGR Ranges)
- SAR-78-SS34 RW0012 (BGR Ranges)
- SAR-77-SS33 RW0013 (BGR Ranges)
- SAR-85-SS17 RW0017 (BGR (Ranges)
- SAR-78-SS25 RW0018 (BGR Ranges)
- SAR-78-SS17 RW0019 (BGR Ranges)
- SAR-69-SS11 RW0021 (IMR Ranges).

The 14-day AETs, based on survival, for antimony, copper, lead, and zinc are >1,620 mg/kg, 711 mg/kg, 15,600 mg/kg, and 153 mg/kg, respectively. The NOECs and LOECs, based on 14-day survival rates, are 6.7 mg/kg and 17.9 mg/kg for antimony, 334 mg/kg and 393 mg/kg for copper, 779 mg/kg and 2,310 mg/kg for lead, and 47.3 and 63.9 mg/kg for zinc.

The 28-day AETs, based on survival, for antimony, copper, lead, and zinc are >1,620 mg/kg, 509 mg/kg, 15,600 mg/kg, and 139 mg/kg, respectively. The NOECs and LOECs, based on 28-day survival rates, are 6.7 mg/kg and 17.9 mg/kg for antimony, 127 mg/kg and 334 mg/kg for copper, 779 mg/kg and 2,310 mg/kg for lead, and 47.3 and 63.9 mg/kg for zinc.

Antimony concentrations in soil were inversely correlated with weight loss; thus, there is no evidence to suspect that antimony is responsible for the observed effects. The AETs, based on weight loss, for copper, lead, and zinc are 334 mg/kg, 6,820 mg/kg, and 72.8 mg/kg, respectively. The NOECs and LOECs, based on weight loss, are 61.4 mg/kg and 62.2 mg/kg for copper, 760 mg/kg and 779 mg/kg for lead, and 33.5 mg/kg and 35.1 mg/kg for zinc.

8.1.10 Results of Earthworm Bioaccumulation Test

The correlations between earthworm tissue concentrations and soil concentrations were strongest for copper and lead ($r = 0.95$). The correlation between soil and earthworm tissue concentrations for zinc were somewhat weaker ($r = 0.88$), but still relatively strong. Though lead depicted a fairly good correlation, the highest soil concentration tested resulted in a much lower concentration in the earthworm tissue than predicted. This lack of bioavailability in the sample may explain the relative absence of toxic effects in the sample with the highest lead soil concentrations. Antimony in earthworm tissue did not show a strong correlation and the weak correlation was also inverse, providing additional evidence that antimony is not likely responsible for the observed effects.

In order to define the relationship between soil concentrations and earthworm tissue concentrations of COPECs, the data were plotted for each of the soil COPECs (antimony, copper, lead, and zinc) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of copper, lead, and zinc in soil and earthworm tissues fit the data best. The best fit regression models of the natural log transformed data for copper, lead, and zinc represent the site-specific soil-to-earthworm BAFs and are summarized below:

Surface Soil COPEC	Site-Specific Soil-to-Earthworm BAF
Antimony	NA
Copper	y = 0.4673 x + 1.4266
Lead	y = 1.1088 x – 0.5168
Zinc	y = 0.321 x + 3.1208

As stated previously, there is no clear relationship between antimony concentrations in soil and earthworm tissues.

8.1.11 Results of Terrestrial Food Web Model

A terrestrial food web model was designed to assess the potential risks to various terrestrial-based feeding guilds from soil-related COPECs. The terrestrial food web model was executed with maximum and mean exposure point concentrations in order to estimate a range of potential terrestrial wildlife exposures. The food web model was executed with site-specific AUFs, site-specific soil-to-earthworm BAFs, and literature-derived values for the other input variables.

Estimated maximum and mean exposures for the receptor species were compared to the toxicity reference values to estimate maximum and mean HQs for each receptor species. The results of the terrestrial food web model indicate that there are potential risks to terrestrial receptors at the IMR and BGR ranges from exposures to antimony, copper, lead, and zinc.

The terrestrial food web model was also executed in order to estimate soil concentrations of COPECs that would result in hazard quotients of one or lower. These estimated soil concentrations (assuming all of the conservatism inherent in the food web model) based on an HQ equal to 1.0 are presented in Table 6-25 and are summarized below.

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)
White-Footed Mouse :		
- antimony	4.67	46.7
- copper	267	350
- lead	205	1,680
- zinc	1,500	145,000
American Robin :		
- antimony	2.8	14
- copper	850	1,140
- lead	55	147
- zinc	31,500	434,000
Short-tailed Shrew :		
- antimony	6.01	60.1
- copper	820	1,185

	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)
- lead	100	800
- zinc	215	173,000
American Woodcock :		
- antimony	10.85	54.2
- copper	11,870	16,200
- lead	105.5	280
- zinc	46,500	550,000

8.1.12 Results of Particulate Lead Ingestion Model

Risks to birds from ingestion of particulate lead in soil at the small arms ranges at FTMC were assessed via a three-tier process as outlined in the technical memorandum entitled *Ecological Risk Assessment Methodology for Particulate Lead Ingestion at Fort McClellan* (Shaw, April 14, 2003b). Tier one of the process consisted of collecting soil samples from the IMR and BGR ranges and determining the particle size fractions present in surface soils at these ranges. Of particular interest were the particle size ranges corresponding to the preferred grit sizes of the Northern Bobwhite Quail (*Colinus virginianus*) and Eastern Wild Turkey (*Meleagris gallopavo*). The Northern Bobwhite Quail prefers grit that ranges in size from 0.8 – 2.2 mm in diameter (Best and Gionfriddo, 1991) while the Eastern Wild Turkey prefers grit that ranges in size from 2.8 – 4.2 mm in diameter (extrapolated from grit size preferred by ring-necked pheasant and normalized to the wild turkey body weight) (Best and Gionfriddo, 1991). These two bird species were identified by the FTMC ecological risk assessment subcommittee as surrogates for all of the bird species at FTMC because the grit sizes preferred by these two species represent a broad range of available grit and these two species are known to occur at FTMC. The results of the particle size analysis indicate that the preferred particle sizes for both the bobwhite quail and wild turkey occur at both the IMR and BGR ranges.

Tier 2 of the agreed upon particulate lead risk assessment process consisted of using the Peddicord and LaKind (2000) model to determine the risks from ingesting particulate lead, and also determining the density of lead particles that could remain in soil while maintaining protectiveness of the bobwhite quail and wild turkey populations at FTMC.

The Peddicord and LaKind model was executed with a range of values for the grit retention time for the bobwhite quail because the literature provides a wide range of values for this parameter. Executing the model over a range of grit retention times also served to incorporate many different bird species (other than the bobwhite quail and wild turkey which serve as surrogate receptor species) in the evaluation process. Grit retention is also variable based on the species of

bird, grit shape and surface roughness, and numerous environmental conditions such as grit availability, food preferences, time of year, and other environmental factors. Gionfriddo and Best (1999) report grit retention times for necropsied bobwhite quail ranging from 42 days to 270 days. A grit retention time of 10 days is recommended by USFWS (personal communication with Mark Huston, 2000?) based on studies conducted by McConnell (1968) which measured the rate of deterioration of lead shot in bobwhite quail. No noticeable deterioration was observed in shot expelled by quail after 1 to 3 days. Shot expelled after 10 days were half eroded and shot expelled after 22 days were one-sixth their original size. Based on these deterioration rates and the assumption that grit will be expelled and replaced when they are half eroded, USFWS has recommended a grit retention time of 10 days. The grit retention time of 83 days is based on the entire range of values presented by Gionfriddo and Best (1999) and USFWS. The arithmetic mean of the values reported by Gionfriddo and Best (1999) is 156 days. This value was used as the longest grit retention time in the Peddicord and LaKind model. The arithmetic mean of 156 days and 10 days is 83 days. This value was used as the "mean" grit retention time. The value suggested by USFWS (10 days) was used as the shortest grit retention time.

The Peddicord and LaKind model was executed to calculate two different results. The model was first used to calculate the probability that a bobwhite quail or wild turkey would ingest and retain a single lead particle in it's crop during it's lifetime. The probabilities that a bobwhite quail would ingest and retain a lead particle were calculated to range from 8.4 percent to 74 percent at the IMR ranges and from 18 percent to 95 percent at the BGR ranges, depending upon the grit retention time. The probabilities that a wild turkey would ingest and retain a lead particle were calculated to be 4.5 percent at the IMR ranges and 12.9 percent at the BGR ranges.

The model equations were then re-arranged in order to solve for the number of lead particles that would result in a 20 percent probability of a bobwhite quail or wild turkey ingesting and retaining a single lead particle in it's crop during it's lifetime. An acceptable exposure level of 20 percent was based on the level of effect that is considered biologically significant and/or distinguishable for a given ecological community or population (Suter, 2000). Adverse effects to a population or community that occur at a frequency less than 20 percent are indistinguishable from the natural variability inherent in natural biological systems and are considered biologically insignificant.

It was also assumed that ingestion of a single lead particle by a bobwhite quail or wild turkey could result in adverse effects; therefore, the probability of a receptor ingesting and retaining a single lead particle is assumed to equal the probability of a receptor experiencing adverse effects.

These results indicate that lead particle densities in soil that would result in a 20 percent probability of ingestion and retention by a bobwhite quail range from 24.6 to 846 fragments per square foot. Likewise, the results indicate that lead particle densities in soil that would result in a 20 percent probability of ingestion and retention by a wild turkey range from 68 to 204 fragments per square foot.

The results of the lead particle separation and enumeration summarized in Table 5-6 indicate that none of the areas sampled had lead particle densities that would result in adverse effects to wild turkeys. At the lowest grit retention time (10 days) four of the five samples from the IMR ranges exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 83 days, two of the samples from the IMR ranges (HR-70Q-SS01 and SAR-71-SS09) exhibited lead particle densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 156 days, one sample from the IMR ranges (HR-70Q- SS01) exhibited lead particle densities that could pose adverse effects to bobwhite quail.

At the lowest grit retention time (10 days), nine of the thirteen samples from the BGR ranges exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 83 days, two of the samples from the BGR ranges (SAR-85-SS37 and HR-77Q-SS01) exhibited densities that could pose adverse effects to bobwhite quail. Assuming a grit retention time of 156 days, only one sample (HR-77Q-SS01) from the BGR ranges exhibited a lead particle density that could pose adverse effects to bobwhite quail.

8.1.13 Results of Fathead Minnow Toxicity Tests

The results of the fathead minnow toxicity testing indicated 7-day survival rates were reduced in one surface water sample that exhibited a lead concentration of 0.0462 mg/L and a copper concentration of 0.0608 mg/L. All of the other surface water samples exhibited fathead minnow survival rates that were statistically similar to the reference site sample. Therefore, the AET and LOEC, based on survival, are equivalent and are 0.0608 mg/L for copper and 0.0462 for lead. The NOECs are 0.0527 mg/L copper and 0.0422 mg/L for lead.

Fathead minnow growth was statistically reduced in surface water samples with copper concentrations as low as 0.0346 mg/L and with lead concentrations as low as 0.0306 mg/L. The five surface water samples that elicited adverse effects had the five highest concentrations of both copper and lead. Thus, the AET and LOEC, based on these endpoints, are equivalent and are 0.0346 mg/L for copper and 0.0306 for lead. The NOECs are 0.0129 mg/L for copper and 0.0105 mg/L for lead.

It is interesting to note that all of the surface water samples that resulted in reduced fathead minnow survival or growth were collected from Cane Creek at Range 22 and Range 27. These two ranges are the two farthest downstream ranges at the BGR ranges. None of the surface water samples from locations further upstream on Cane Creek exhibited reduced fathead minnow survival or growth.

8.1.14 Results of Ceriodaphnid Toxicity Tests

The results of the ceriodaphnid toxicity testing indicate that 7-day survival rates were reduced in two surface water samples (SAR-77-SW19 and SAR-77-SW20), both of which exhibited non-detectable levels of copper and one of which had a non-detectable level of lead and the other had a lead concentration of 0.00236 mg/L. Of the three samples that had concentrations of lead in the interval between sample SAR-77-SW20, which had 0.00236 mg/L lead and sample SAR 78-SW12, which had 0.0306 mg/L lead, none of them induced any toxic effects: SAR-77-SW15 with 0.00357 mg/L lead, SAR-78-SW14 with 0.00762 mg/L lead, and SAR-78-SW13 with 0.0105 mg/L lead. The toxicity observed in SAR-77-SW20 with only 0.00236 mg/L lead, as well as the toxicity in SAR-77-SW19 with no detectable lead, was likely not due to lead, but other unknown factors. Copper, similarly had lower levels in the same three samples than any other of the other samples with toxicity except for SAR-77-12 and SAR-22-SW20, where copper was not detected. The available data are not conclusive as to the cause of the observed toxicity in samples SAR-77-SW19 and SAR-77-SW20. The toxicity test results indicate that a factor other than lead or copper in surface water may be the cause of reduced ceriodaphnid survival in these two samples.

The toxicity test results for ceriodaphnid reproduction were very similar to the test results for fathead minnow growth. Ceriodaphnid reproduction was statistically reduced in surface water samples with copper and lead concentrations as low as 0.0346 mg/L and 0.0306 mg/L, respectively. Reproduction was not evaluated for statistical significance in samples SAR-77-SW19 and SAR-77-SW20 because ceriodaphnid survival was significantly reduced in these two samples. The five surface water samples that elicited adverse reproductive effects had the five highest concentrations of both copper and lead. Thus, the AET and LOEC, based on reproductive endpoints, are equivalent and are 0.0346 mg/L for copper and 0.0306 for lead. The NOECs, based on reproductive endpoints, are 0.0129 mg/L for copper and 0.0105 mg/L for lead. The AETs for copper and lead, based on ceriodaphnid survival, are 0.0346 mg/L and 0.0306 mg/L, respectively. The NOECs based on ceriodaphnid survival are 0.0129 mg/L for copper and less than the detection limit for lead. The LOECs for copper and lead, based on ceriodaphnid survival, are 0.0346 mg/L and 0.00236 mg/L, respectively.

As was the case with the fathead minnow data, all of the surface water samples that resulted in reduced ceriodaphnid reproduction were collected from Cane Creek at Ranges 21, 22, and 27. None of the surface water samples from locations further upstream on Cane Creek exhibited reduced ceriodaphnid reproduction.

8.1.15 Results of the Chironomid Toxicity Tests

The results of the 10-day chironomid survival test showed that survival was statistically reduced in sediment samples with arsenic concentrations as low as 2.4 mg/kg, barium concentrations as low as 32.5 mg/kg, copper concentrations as low as 160 mg/kg, lead concentrations as low as 605 mg/kg, and manganese concentrations as low as 181 mg/kg. Thallium was not detected in any of the sediment samples collected for toxicity testing.

For all of the sediment COPECs except copper, the sample with the highest sediment concentration showed no observable effect on survival. Due to the poor correlations between arsenic, barium, and manganese in sediment and survival, toxicity values were not derived for these metals. Significant correlations were only found for copper and lead in sediment and chironomid survival. The AETs, based on survival, for copper and lead were 380 mg/kg and >1,730 mg/kg, respectively. The NOECs and LOECs, based on survival, were 126 mg/kg and 160 mg/kg for copper and 495 mg/kg and 605 mg/kg for lead.

For barium and manganese, the sample with the highest concentration also showed no observable effect on growth. Due to the poor correlations with arsenic, barium, and manganese, toxicity values were not derived for these metals. Significant correlations were only found for copper and lead in sediment and chironomid growth. The AETs, based on growth, for copper and lead are 74.9 mg/kg and 432 mg/kg, respectively. The NOECs and LOECs, based on growth, are 9.06 mg/kg and 10.4 mg/kg for copper and 23.1 mg/kg and 76.7 mg/kg for lead.

8.1.16 Results of Chironomid Bioaccumulation Test

Data collected as part of the Site Investigation indicate that arsenic, barium, copper, lead, and manganese may accumulate in chironomid tissues, albeit at lower concentrations than ambient sediment concentrations. Since thallium was not detected in any of the sediment samples used for toxicity testing/bioaccumulation study, accumulation of thallium in chironomid tissues was assumed to be negligible.

The correlations between tissue concentrations and sediment concentrations were strongest for copper ($r = 0.86$), lead ($r = 0.92$), and manganese ($r = 0.7$). Although lead depicted a good correlation ($r = 0.92$), the highest sediment concentration tested resulted in a much lower

concentration in the chironomid tissue than predicted. Arsenic and barium in chironomid tissue did not show strong correlations (r = 0.27 and 0.56, respectively), providing additional evidence that these constituents are not likely responsible for the observed effects in the toxicity tests.

In order to define the relationship between sediment concentrations and chironomid tissue concentrations of COPECs, the data were plotted for each of the sediment COPECs (arsenic, barium, copper, lead, and manganese) and a number of different regression models were fitted to the data. The results of the analysis of different regression models suggested that the straight line regression of the natural log transformed concentrations of arsenic, barium, copper, lead, and manganese in sediment and chironomid tissues fit the data best. As presented earlier, although thallium was identified as a sediment COPEC, none of the sediment samples collected as part of this BERA exhibited any detectable concentrations of thallium. Therefore, it was not possible to correlate sediment concentrations and chironomid tissue concentrations of thallium. The graphs depicting the sediment-to-chironomid BAFs for arsenic, barium, copper, lead, and manganese are presented in Figures 6-31 through 6-35, respectively. The best fit regression models of the natural log transformed data for arsenic, barium, copper, lead, and manganese represent the site-specific sediment-to-chironomid BAFs and are summarized below:

Sediment COPEC	Sediment-to-Chironomid BAF
Arsenic	y = 0.2095 x + 0.6143
Barium	y = 0.3665 x + 2.1605
Copper	y = 0.5117 x + 3.1964
Lead	y = 0.7772 x + 2.1714
Manganese	y = 0.6647 x + 1.4114
Thallium	NA

Thallium was not detected in any of the sediment samples or chironomid tissue samples; therefore, a sediment-to-chironomid BAF could not be calculated.

8.1.17 Results of Benthic Invertebrate Community Analysis

Benthic invertebrate samples were collected from 10 locations in Cane Creek and its tributaries within the BGR ranges and one reference station. A riffle/run sample and a CPOM sample were collected from each sampling location. Using the raw benthic data, a numerical value was calculated for the eight metrics (measures of benthic macroinvertebrate community quality) described previously. Calculated values were then compared to values derived from the reference site. Each metric was then assigned a score of 6, 3 or 0 according to the comparability (percent similarity) of calculated and reference values (Plafkin et al., 1989). Scores for the eight metrics were then totaled and compared to the total metric score for the reference location. The percent comparison between the total scores provides a final evaluation of biological condition.

The inclusion of an integrated multi-metric approach to benthic habitat integrity incorporates many components of benthic community structure, and therefore provides a more reliable assessment than obtainable with a single metric analysis.

Taxa richness was calculated by counting the number of taxa present in each sample. Taxa richness is an unambiguous and easily understandable indication of the biological health of a stream community, and reflects the health of the community through a measurement of the variety of taxa present. Taxa richness for the Cane Creek drainage riffle/run samples ranged from 1 at sample location SAR-85-SW/SD08 to 7 at locations HR-85Q-SW/SD02, SAR-77-SW/SD25 and SAR-77-SW/SD23. Eight taxa were found at reference location REFST. Inclusion of taxa in the CPOM samples gives a range of 2 to 9 taxa for the Cane Creek and tributary locations, and 10 taxa for REFST.

All locations on Cane Creek and its tributaries had fewer taxa than the reference location. Low taxa richness (1 to 3 taxa present) was found at SAR-85-SW/SD02, SAR-85-SW/SD08, SAR-78-SW/SD10, HR-80Q-SW/SD03, and HR-80Q-SW/SD06. The taxa richness data indicate that benthic macroinvertebrate habitats in the drainage basin containing the BGR ranges may be of lower quality than the reference location. This fact is illustrated in Table 6-29 in which there is no clear relationship between COPEC concentration in the sediment, habitat quality, and benthic invertebrate community structure.

The Modified FBI, developed by Hilsenhoff (1988), summarizes the tolerances of the benthic arthropod community to organic pollutants with a single value. Tolerance values used in the calculation of the FBI were obtained from Hilsenhoff (1988) and Bode (1988). The FBI is calculated by multiplying the number of organisms in each taxon by the tolerance value for that taxon, summing the products, and dividing by the total number of organisms.

The FBI ranged from 2.27 at sample location SAR-85-SW/SD02 to 8 at sample location SAR-85-SW/SD08. The FBI score at the reference site was 4.8. Two locations had FBI values that indicated better water quality than the reference location. However, because the tolerance values of individual taxa are based on sensitivity to organic pollution, the FBI may not give completely consistent results with other types of stressors. Five of the ten locations in the Cane Creek drainage had a percent comparability to reference score of 6, and five locations had a score of 3. No location had a score of zero for the FBI metric.

The relative abundance of scrapers and filtering collectors in the riffle/run habitat is an indicator of the food sources available. The proportion of the two feeding groups is important because

predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Functional feeding group designations for the taxa identified were obtained from Merritt and Cummins (1984) and Barbour, et al., (1999). This metric was calculated by dividing the relative abundance of scrapers by the relative abundance of filter feeding organisms.

The ratio of scrapers and filterers was only calculable at two sites, SAR-77-SW/SD23 and REFST, with values of 0.125 and 0.14, respectively. Location SAR-77-SW/SD23 received the maximum reference comparability score of 6 for the scraper/filterer ratio. This index was not calculable at the remaining nine sites because no scraper-feeding invertebrates were present at these sites. Because the scraper/filterer ratio was obtained at the reference location, all Cane Creek drainage locations where the ratio could not be calculated because of a lack of scraper feeding invertebrates received a score of zero.

The ratio of EPT and Chironomidae abundance is calculated by dividing the relative abundance of EPT taxa by the relative abundance of Chironomidae. The ratio of EPT to Chironomidae indicates if there is an even distribution between the pollution sensitive EPT taxa and more pollution tolerant Chironomidae. Good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive groups EPT. Skewed populations having a disproportionate number of the generally tolerant Chironomidae relative to the more sensitive insect groups may indicate environmental stress.

The ratio of EPT and Chironomidae at the seven Cane Creek drainage sample locations that had both EPT taxa and Chironomidae ranged from 0.07 at SAR-77-SW/SD25 to 2.29 at SAR-77-SW/SD23. The ratio was 4.5 at reference location REFST. Chironomidae were not present at SAR-85-SW/SD02 and HR-80Q-SW/SD06; therefore, this index could not be calculated for these two locations. This index also could not be calculated at SAR-85-SW/SD08 because no EPT taxa were present at this site. Locations HR-78Q-SW/SD01 on Cane Creek and tributary location SAR-77- SW/SD23 had EPT/Chironomidae percent comparability to reference scores of 3. All other locations in the Cane Creek drainage had a score of zero.

The percent contribution of the numerically dominant taxon to the total number of organisms is an indication of community balance at the lowest positive taxonomic level. A community dominated by relatively few species would indicate environmental stress. The percent contribution of the dominant taxon is calculated by dividing the abundance of the taxon which is numerically dominant by the total number of organisms in the sample. A low percent

contribution of the dominant family indicates a balanced community and generally indicates a higher quality habitat. Factors influencing this percentage include environmental stress, habitat quality, and life histories of the organisms collected in the sample.

The percent contribution of the dominant taxon ranged from 100 at sample location SAR-85-SW/SD08 to 25 at location HR-78Q-SW/SD01. The numerically dominant organisms at SAR-85-SW/SD08 were Chironomidae, which was the only taxon found at this location. Perlodidae (stonefly larvae) and Tanypodinae (midge larvae) were numerically dominant at location HR-78Q-SW/SD01. Locations HR-78Q-SW/SD01 on Cane Creek had a lower dominant taxon percentage than the reference location, and had the maximum percent comparability to the reference score of 6. Locations SAR-85-SW/SD02 and SAR-85-SW/SD08 on Cane Creek, and tributary station SAR-77-SW/SD25 had percent comparability to reference scores of zero.

The EPT Index is the total number of distinct taxa within the orders Ephemeroptera, Plecoptera, and Trichoptera. This value summarizes taxa richness within the insect orders that are generally considered to be pollution sensitive. The EPT index usually increases with increasing water quality.

The EPT index for the Cane Creek drainage locations ranged from 0 at SAR-85-SW/SD08, to 3 at HR-78Q-SW/SD01. The EPT was 5 at reference location REFST. Although EPT taxa were present at 9 of 10 Cain Creek drainage sampling locations, the percent comparability to reference score was zero for all ten locations for the EPT Index.

The Community Similarity Index evaluates the benthic populations at on-site locations relative to populations present at the reference location. The Community Similarity Index measures the loss of benthic species between a reference station and the location of comparison. It is an index of dissimilarity with values increasing as the degree of dissimilarity from the reference station increases. The community similarity index is calculated by subtracting the number of taxa common to both locations from the number of taxa present at the reference location, divided by the number of taxa present at the potential impact location.

The community similarity index ranged from 7 at sample location SAR-85-SW/SD08 to 0.57 at location SAR-77-SW/SD23. Location SAR-85-SW/SD08 on Cane Creek had a percent similarity with reference score of zero. All other Cane Creek drainage locations had a percent similarity with reference score of 3.

The abundance of the shredder functional group relative to the abundance of all other functional groups allows evaluation of potential impairment as indicated by the CPOM-based shredder community. Shredders are sensitive to riparian zone impacts and are particularly good indicators of toxic effects when the toxicants involved are readily absorbed to the CPOM and either affect the microbial communities colonizing the CPOM or the shredders directly. The ratio of the relative abundance of shredders to the abundance of all other functional feeding groups is calculated by dividing the relative abundance of shredders by the total number of organisms in a given sample. The abundance of shredders in comparison to other functional feeding groups can be influenced by climate, seasonality, and vegetation within the riparian zone, as well as levels of toxicants adsorbed to CPOM while in the riparian zone, or adsorption of toxicants to the CPOM while it is in the water.

No shredder feeding organisms were found at locations SAR-85-SW/SD02, HR-85Q-SW/SD02, SAR-85-SW/SD08, SAR-78-SW/SD10, and HR-80Q-SW/SD03; therefore, this index was not calculable at these sites. The ratio of shredders and total organisms at the remaining sites within the Cane Creek drainage ranged from 0.01 at SAR-77-SW/SD25 to 0.57 at HR-80Q-SW/SD06. The ratio was 0.78 at reference location REFST.

The percent comparison to reference for all eight metrics was presented in table 5-13. These values were used to assess the benthic invertebrate habitat quality at each sampling location.

Most sampling locations within the Cane Creek drainage were evaluated as being moderately impaired relative to the reference location, with percentages ranging from 50% at SAR-77-SW/SD23 to 25% at SAR-78-SW/SD10, SAR-77-SW/SD25, and HR-80Q-SW/SD03. One possible reason for the benthic habitat in Cane Creek at the BGR ranges being classified as less than optimal could be the fact that Cane Creek exhibits very high energy flows during storm events due to the fact that the creek bank confines the flow to a static width. This high energy flow tends to scour the cobble and boulder substrate and remove many of the benthic invertebrates that may have colonized this area. Strong storm events the month before the benthic invertebrate sampling (June 2003) most likely scoured the substrate of Cane Creek (and specifically Cane Creek at Range 27) and removed many of the benthic invertebrates that may have been present before the storms.

Location SAR-77-SW/SD23, which had the greatest similarity to the reference location, is on a Cane Creek tributary. Other tributary locations were less similar to the reference location, but no tributary location was found to be severely impaired. The Cane Creek tributary streams are known to be ephemeral, and may be dry for significant time intervals each year. This is likely to

significantly impact the composition of the benthic community, and reduce the similarity to the reference stream, which is a perennial stream with at least some water flow throughout the year. Cane Creek is a perennial stream, and therefore the benthic community in Cane Creek is not likely to be impacted by drying of the substrate.

Benthic invertebrate communities at sample locations SAR-85-SD08 and SAR-85-SD02 (Range 27) exhibited the lowest percent comparison to the reference site and were considered as exhibiting "severe" biological condition. However, of these two samples, only sample location SAR-85-SD08 exhibited statistically significant adverse effects to chironomid survival and growth. Although both of these sample locations exhibited elevated concentrations of copper and lead compared to ESVs, other sample locations along Cane Creek at the BGR ranges exhibited higher copper and lead concentrations than those found at locations SAR-85-SD08 and SAR-85-SD02 and were considered only moderately impaired using the results of the Rapid Bioassessment metrics. There are two other sampling locations at Range 27 that exhibited only moderate impairment. One of these locations, HR-85Q-SW/SD02, is on a small drainage ditch north of Cane Creek. The other, SAR-85-SW/SD05, is located between the sampling locations where severe impairment was found. Therefore, there does not appear to be a pattern of increasing or decreasing benthic community impairment along Cane Creek and no clear relationship between sediment concentrations of COPECs and benthic community structure is readily apparent. Sampling locations SAR-85-SW/SD02 and SAR-85-SW/SD08 are in high energy areas of Cane Creek. The substrate in these areas is almost entirely cobbles and boulders, with no or very little organic substrate. Significant scouring of the substrate is evident in these two sampling locations. These physical constraints may limit the ability of many benthic invertebrates to colonize these areas.

In addition to benthic invertebrate community structure and COPEC concentrations in sediment, the stream habitat was assessed and characterized as sub-optimal to poor in quality. There does not appear to be a clear correlation between COPEC concentrations in sediment, the biological condition of the benthic invertebrate community, and the stream habitat as summarized in Table 6-29.

The benthic macroinvertebrate community data and sediment sample analytical data indicate that the previously discussed impairment in benthic macroinvertebrate communities of Cane Creek and its tributaries are most likely due to a combination of habitat restrictions and the presence of site-related constituents, particularly lead.

8.1.18 Results of Riparian Food Web Model

In order to assess the potential risks to various riparian-based feeding guilds from sediment-related constituents, a riparian food web was constructed. The riparian food web model was executed with site-specific surface water and sediment concentrations, site-specific AUFs, site-specific sediment-to-chironomid BAFs, and literature-derived values for the other input variables. The model was executed with both maximum and mean detected concentrations as the exposure point concentrations for surface water and sediment in order to calculate a range of potential risks to riparian receptors.

Estimated maximum and mean exposures for the receptor species were compared to the toxicity reference values to estimate maximum and mean HQs for each receptor species. The results of the model indicate that there is a potential risk to riparian invertivorous mammals and riparian invertivorous birds from indirect exposure to copper and lead in sediment in Cane Creek. None of the other COPECs in surface water or sediment (arsenic, barium, manganese, and thallium) indicated the potential for adverse affects from exposure to even the maximum detected concentrations.

The riparian food web model was also executed to determine the sediment concentrations of copper and lead that would result in HQs of one or lower. These calculated sediment concentrations represent concentrations of copper and lead that could remain in sediment and still be protective of riparian receptors. Sediment concentrations based on an HQ = 1.0 are not calculated for arsenic, barium, manganese, or thallium because the riparian food web model did not indicate any risk to riparian wildlife species due to food web exposures to these COPECs. The estimated sediment concentrations based on HQs equal to 1.0 are presented in Table 6-45 and summarized below.

Riparian Receptor Species	**Sediment Conc. Based on NOAEL TRV and HQ = 1.0** (mg/kg)	**Sediment Conc. Based on LOAEL TRV and HQ = 1.0** (mg/kg)
Little Brown Bat :		
- Copper	4,060	6,600
- Lead	530	10,200
Marsh Wren :		
- Copper	112	191
- Lead	3.33	13.3

8.2 BERA Conclusions

The results of this BERA indicate that one or more constituents in surface soil, surface water, and sediment have the potential to pose adverse effects to sensitive ecological receptors in the terrestrial and riparian ecosystems at the IMR and BGR ranges.

In order to identify site-specific concentrations of the COPECs that are protective of the sensitive receptors potentially present at the IMR and BGR ranges, the various lines of evidence collected during the BERA were analyzed. From the various lines of evidence were derived risk-based remedial goals (RBRG). These RBRGs are concentrations of COPECs in the various environmental media that are protective of the assessment endpoints described in Chapter 3 of this report. Because several lines of evidence were assessed for some of the assessment endpoints and COPECs, several RBRGs were also derived for these assessment endpoints and COPECs. The selection of the most reasonable or appropriate RBRG for a given endpoint or COPEC is a risk management decision and is not the province of this BERA.

8.2.1 Terrestrial Ecosystems

Earthworm toxicity tests (survival and growth endpoints) indicated that COPECs in soil at the IMR and BGR ranges may cause adverse effects in terrestrial invertebrates (e.g., reduced survival and/or growth). Additionally, the terrestrial food web model indicated that sensitive terrestrial receptors could experience adverse effects due to exposure to COPECs in soil at the IMR and BGR ranges through food web interactions. The results of the earthworm toxicity tests indicated that antimony is most likely not responsible for the observed effects in any of the earthworm tests. Adverse effects in earthworms (e.g., reduced growth) were observed at copper concentrations as low as 62.2 mg/kg, lead concentrations as low as 779 mg/kg, and zinc concentrations as low as 35.1 mg/kg. Copper, lead, and zinc were found to accumulate in the tissues of terrestrial invertebrates (earthworms) at minimal levels, such that the concentrations of COPECs were similar in soil and earthworm tissues.

The terrestrial food web model was used to predict soil concentrations that would be protective of the sensitive terrestrial feeding guilds found at these ranges. The food web model indicated that adverse effects to terrestrial receptors could be expected at antimony concentrations as low as 2.8 mg/kg, copper concentrations in soil as low as 267 mg/kg, lead concentrations as low as 55 mg/kg, and zinc concentrations as low as 215 mg/kg.

The calculated RBRGs for soil COPECs at the IMR and BGR ranges ranged from 2.8 to > 1,620 mg/kg for antimony, 61.4 to 16,200 mg/kg for copper, 55 to > 15,600 mg/kg for lead, and 33.5 to 550,000 mg/kg for zinc. The potential ecological RBRGs for surface soil at the IMR and BGR

ranges are summarized in Table 8-1. It is important to note that these soil RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of this BERA. Any number of other remedial goal options is available based on human health risk, ARARs, other ecological endpoints, and other rationale. It is a risk management decision as to which remedial option, if any, is most appropriate for a given site.

In order to assess the potential risks to birds from ingesting lead particles, the Peddicord and LaKind (2000) model was utilized. The probabilities that a bobwhite quail would ingest and retain a single lead particle were calculated to range from 8.4 percent to 74 percent at the IMR ranges and from 18 percent to 95 percent at the BGR ranges, depending on the grit retention time. The probability that a wild turkey would ingest and retain a single lead particle was calculated to be 4.5 percent at the IMR ranges and 12.9 percent at the BGR ranges. These results indicate that lead particle densities at the IMR and BGR ranges would not be expected to result in adverse effects to the wild turkey populations at these ranges (probability of ingesting and retaining a lead particle is less than 20%). However, lead particle densities in the impact areas of the IMR and BGR ranges could potentially pose a risk to the bobwhite quail populations at these ranges.

The Peddicord and LaKind (2000) model was also used to calculate lead particle densities that would result in a 20 percent probability of an individual turkey or bobwhite quail ingesting and retaining a single lead particle. These lead particle densities could be used as RBRGs for lead particles in surface soil and are presented in Table 6-26 and summarized below.

	Acceptable Lead Particle Density at the IMR Ranges (particles/ft^2)	**Acceptable Lead Particle Density at the BGR Ranges** (particles/ft^2)
Bobwhite Quail	55 - 846	25 - 381
Wild Turkey	205	68

The RBRGs for bobwhite quail were calculated assuming a grit retention time ranging from 10 days to 156 days. The large range in values for "acceptable lead particle densities for the bobwhite quail is attributable to the significant uncertainty and variability in the bobwhite quail's grit retention time. The RBRGs for wild turkeys were calculated assuming a grit retention time of 42 days (Gionfriddo and Best, 1999).

8.2.2 Riparian Ecosystems

Fathead minnow and ceriodaphnid toxicity tests indicated that COPEC concentrations in surface water at the BGR ranges may cause adverse effects in aquatic vertebrates (reduced fathead

minnow survival and growth) and aquatic invertebrates (reduced ceriodaphnid survival and reproduction). The toxicity tests indicated that copper and lead were the most likely causative agents in the observed adverse effects in the surface water toxicity tests. Adverse effects were observed in fathead minnows and ceriodaphnids at copper concentrations as low as 0.0346 mg/L and at non-detectable levels of lead.

The calculated RBRGs for surface water COPECs at the IMR and BGR ranges ranged from 0.0129 to 0.0608 mg/L for copper and non-detectable to 0.0462 mg/L for lead. The potential ecological RBRGs for surface water at the IMR and BGR ranges are summarized in Table 8-1. It is important to note that these surface water RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of this BERA. Any number of other remedial goal options is available based on human health risk, ARARs, ambient water quality criteria, and other rationale. It is a risk management decision as to which remedial option, if any, is most appropriate for a given site.

Chironomid toxicity tests (survival and growth endpoints) indicated that COPECs in sediment at the BGR ranges may cause adverse effects in benthic invertebrates (e.g., reduced chironomid survival and growth). Thallium was not detected in any sediment samples and was not considered to be a causative agent in the observed adverse effects. Arsenic, barium, and manganese concentrations in sediment were poorly correlated with chironomid survival and growth and were, therefore, not considered causative agents in the observed adverse effects. Adverse impacts were observed in chironomid survival and growth at copper concentrations as low as 10.4 mg/kg and lead concentrations as low as 76.7 mg/kg. Copper, lead, and manganese were found to accumulate in the tissues of benthic invertebrates (chironomids) at minimal levels, such that the concentrations of COPECs were similar in sediment and chironomid tissues. Arsenic, barium, and thallium did not exhibit any tendencies to bioaccumulate in chironomid tissues.

The riparian food web model indicated that sensitive riparian receptors could experience adverse effects due to exposure to copper and lead in sediment at the IMR and BGR ranges through food web interactions. Arsenic, barium, manganese, and thallium are unlikely to cause any adverse effects to sensitive riparian receptors through food web interactions.

The riparian food web model was also used to predict soil concentrations that would be protective of the sensitive riparian feeding guilds found at these ranges. The food web model indicated that adverse effects to riparian receptors could be expected at copper concentrations in sediment as low as 112 mg/kg and lead concentrations as low as 3.3 mg/kg.

The calculated RBRGs for sediment COPECs at the IMR and BGR ranges ranged from 9.06 to 6,600 mg/kg for copper and 3.33 to 10,200 mg/kg for lead. The potential ecological RBRGs for sediment at the IMR and BGR ranges are summarized in Table 8-1. It is important to note that these sediment RBRGs represent only those remedial goals resulting from the specific assessments conducted as part of this BERA. Any number of other remedial goal options is available based on human health risk, ARARs, and other rationale. It is a risk management decision as to which remedial option, if any, is most appropriate for a given site.

9.0 References

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TABLES

Table 2-1
Summary of COPECs at Iron Mountain Road Ranges
Fort McClellan, Calhoun County, Alabama

COPECs	Skeet Range Surface Soil	Range 12 Surface Soil	Range 13 Surface Soil	Range 19 Surface Soil	Remount Cr. & Tributaries Surface Water	Remount Cr. & Tributaries Sediment
antimony	X	X	X	X		
arsenic		O	O	O		X
barium						X
beryllium	O					O
cobalt	O					
copper	X	X	X	X		X
iron						O
lead	X	X	X	X	X	X
manganese	O					X
nickel						O
silver				O		
thallium						X
vanadium						O
zinc	X	X	X	X		
benzo(a)pyrene	O					
fluoranthene	O					
phenanthrene	O					
pyrene	O					
4,4'-DDT		O				

O - HQ_{screen} > 1.0, however additional lines of evidence indicate that this constituent is not a COPEC.

X - Constituent identified as a COPEC.

Table 2-2

Summary of COPECs at Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

COPECs	Range 21 Surface Soil	Range 22 Surface Soil	Range 24-Upper Surface Soil	Range 27 Surface Soil	Cane Creek & Tributaries Surface Water	Cane Creek & Tributaries Sediment	BGR Ranges Groundwater
aluminumn			O				O
antimony	X	X	X	X		O	
arsenic	O			O			
barium			O			X	O
beryllium		O	O	O			
chromium			O				
cobalt					O		
copper	X	X	X	X	X	X	O
iron			O			O	O
lead	X	X	X	X	X	X	
manganese			O	O		X	O
mercury			O				
selenium	O		O	O			
silver			O	O			
thallium					O	X	
zinc	X	X	X	X			
benzo(a)pyrene	O						
fluoranthene	O	O					
pyrene	O	O					
butylbenzyl phthalate				O			
4,4'-DDE	O						
4,4'-DDT		O					
MCPP			O				
aldrin			O				
alpha-BHC			O				
endrin			O				
2,4-dinitrotoluene						O	
trichlorofluoromethane						O	

O - HQ > 1.0; however, additional lines of evidence indicate that this constituent is not a COPEC
X - Constituent identified as a COPEC

Table 3-1

Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the Iron Mountain Road and Bains Gap Road Ranges Fort McClellan, Calhoun County, Alabama

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
Terrestrial Ecosystems :		
I. Maintenance of a healthy terrestrial invertebrate community.	I. Survival and growth of terrestrial invertebrates exposed to surface soil collected from the IMR and BGR ranges is statistically significantly different from that of invertebrates exposed to reference soil from non-impacted areas.	I. Statistical comparison of earthworm survival and growth rates between earthworms exposed to soils from the IMR and BGR ranges to earthworms exposed to reference site soils.
II. Maintenance of healthy local populations of gallinaceous and other ground-feeding birds.	II. Calculated probabilities of birds ingesting and retaining lead bullet fragments are statistically and biologically significant in local bird populations.	II. Calculation of the probability of bobwhite quail and wild turkeys ingesting and retaining a lead bullet fragment from the IMR or BGR ranges.
III. Maintenance of healthy local populations and communities of terrestrial invertivorous small mammals and birds.	III. Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant potential for risk to either terrestrial invertivorous small mammals or birds.	III. Calculation of hazard quotients for terrestrial invertivorous small mammal (shorttail shrew) and invertivorous bird (American woodcock) using measured earthworm tissue concentrations of COPECs.

Table 3-1

Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the Iron Mountain Road and Bains Gap Road Ranges Fort McClellan, Calhoun County, Alabama

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
IV. Maintenance of healthy local populations and communities of terrestrial omnivorous small mammals and birds.	IV. Calculated hazard quotients using measured body burdens of COPECs in earthworms, site-specific diet composition, and area use factors indicate statistically significant potential for risk to terrestrial omnivorous small mammals or birds.	IV. Calculation of hazard quotients for terrestrial omnivorous small mammal (white-footed mouse) and omnivorous bird (American robin) using measured earthworm tissue concentrations of COPECs and modeled vegetation concentrations of COPECs.
Aquatic Ecosystems :		
I. Maintenance of a healthy aquatic benthic invertebrate community.	I. Survival and growth of aquatic benthic invertebrates exposed to sediment collected from Cane Creek is statistically significantly different from that of benthic invertebrates exposed to sediment from non-impacted reference stream.	IA. Statistical comparison of survival and growth of *Chironomus sp.* exposed to sediment from Cane Creek to survival and growth of *Chironomus sp.* exposed sediment from reference stream. IB. Comparison of benthic community assemblage from Cane Creek with the benthic community assemblage from a reference stream using RBPII methodology and literature-based community assemblages.
II. Maintenance of a healthy aquatic water-column invertebrate community.	II. Survival and reproduction of aquatic water-column invertebrates exposed to surface water collected from Cane Creek is statistically significantly different from that of aquatic water-column invertebrates exposed to surface water from non-impacted reference stream.	II. Statistical comparison of survival and reproduction of *Ceriodaphnia dubia* exposed to surface water from Cane Creek to survival and growth of *Ceriodaphnia dubia* exposed surface water from reference stream.

Table 3-1

Assessment Endpoints, Risk Hypotheses, and Measurement Endpoints for the Iron Mountain Road and Bains Gap Road Ranges Fort McClellan, Calhoun County, Alabama

Assessment Endpoint	Risk Hypothesis	Measurement Endpoint
III. Maintenance of a healthy aquatic vertebrate (e.g., finfish) community.	III. Survival and growth of aquatic vertebrates exposed to surface water collected from Cane Creek is statistically significantly different from that of aquatic vertebrates exposed to surface water from non-impacted reference stream.	III. Statistical comparison of survival and growth of *Pimephales promelas* exposed to surface water from Cane Creek to survival and growth of *Pimephales promelas* exposed to surface water from reference stream.
IV. Maintenance of healthy local populations and communities of riparian invertivorous mammals and birds.	IV. Calculated hazard quotients using modeled COPEC concentrations in aquatic insects, site-specific diet composition, and area use factors indicate statistically significant potential for risk to either riparian invertivorous mammals or birds.	IV. Calculation of hazard quotients for riparian invertivorous mammal (little brown bat) and invertivorous bird (marsh wren) using modeled tissue concentrations of COPECs in emergent benthic invertebrates.

Table 5-1

Physical/Chemical Properties of Soil Related to Binding Capacity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Chemical Properties

Parameter	Sample Number and Soil Mapping Unit							
	69Q	70Q	71Q	75Q	77Q	78Q	80Q	85Q
	JSFSL	AASL	AASL	AAGL	JGFSL	SRLS	JGFSL	JSFSL
pH (s.u.)	6.3	4.7	4.1	4.1	5.1	5.9	5.7	5.3
Phosphate (mg/kg)	76	48	52	33	110	1000	180	38
Total Organic Carbon (mg/kg)	22000	22000	58000	15000	19000	52000	20000	18000
Total Carbonate (mg/kg)	53000	40000	82000	62000	16000	68000	47000	57000
Cation Exchange Capacity (meq Na/100 g)	26	20.5	42.7	25.8	13.8	27.7	26.6	27.7
Iron Oxyhydroxide Content (mg/kg)	1600	1300	1110	1310	893	751	579	1480
Total Aluminum (mg/kg)	5590	6490	4770	4300	3890	1820	2030	3880
Total Barium (mg/kg)	78.1	33.5	85.2	48.3	81.6	181	122	214
Total Cadmium (mg/kg)	<0.684	<0.676	1.48	1.23	2.42	2.52	2.66	1.42
Total Calcium (mg/kg)	1330	153	1010	616	562	3170	9000	1930
Total Chromium (mg/kg)	11.2	6.84	7.30	6.32	6.42	2.8	7.17	5.07
Total Copper (mg/kg)	12.6	64.5	454	234	657	3780	927	94.8
Total Iron (mg/kg)	12900	5100	5200	5260	9780	3000	8720	5900
Total lead (mg/kg)	122	348	4290	1170	4410	28200	10000	2480
Total Magnesium (mg/kg)	290	195	232	165	337	273	479	317
Total Manganese (mg/kg)	452	97.2	303	50.9	637	1290	397	817
Total Nickel (mg/kg)	8.37	1.66	1.76	<1.44	3.51	1.90	4.60	2.01
Total Potassium (mg/kg)	262	89.6	151	127	463	182	241	451
Total Silicon (mg/kg)	125.3	59.26	140.9	133.9	126.1	45.06	8.015	116.5
Total Sodium (mg/kg)	8.55	6.86	8.41	5.18	7.34	6.93	7.08	6.39
Total Titanium (mg/kg)	10.66	12.76	18.48	12.68	6.637	7.942	5.321	3.67

Soil Mapping Units:
- AAGL - Anniston and Allen gravelly loams
- AASL - Anniston and Allen stony loams
- SRLS - Stony rough land, sandstone
- JGFSL - Jefferson gravelly fine sandy loam
- JSFSL - Jefferson stoney fine sandy loam

s.u. - Standard unit.
mg/kg - Milligrams per kilogram.

Table 5-1

Physical/Chemical Properties of Soil Related to Binding Capacity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Physical Properties

Tyler Sieve	Diameter (mm)	Sample Number and Grain Size (percent finer)							
		69Q	70Q	71Q	75Q	77Q	78Q	80Q	85Q
		JSFSL	AASL	AASL	AAGL	JGFSL	SRLS	JGFSL	JSFSL
3"	75.0	100	100	100	100	100	100	100	100
1.5"	37.5	100	100	100	100	100	100	100	100
0.75"	19.0	100.0	93.2	100.0	96.2	100	97.3	93.6	96.5
0.375"	9.50	91.2	80.7	81.9	88.8	81.0	74.9	78.1	81.7
#4	4.75	88.6	68.5	60.9	79.6	72.1	48.8	62.3	73.7
#10	2.00	86.0	61.8	55.5	75.1	65.1	33.3	51.9	70.8
#20	0.850	83.2	59.2	52.8	71.9	59.9	25.5	45.7	67.1
#40	0.425	74.1	56.4	46.6	63.8	49.3	17.4	37.3	58.6
#60	0.250	64.2	53.3	39.7	54.4	40.2	12.5	29.7	48.5
#100	0.149	54.2	42.4	31.5	42.7	31.4	9.4	22.9	37.7
#140	0.106	46.4	31.2	25.0	34.1	25.4	8.0	19.4	30.9
#200	0.075	40.1	26.1	20.2	28.0	19.5	7.0	16.6	25.1
--	0.0478	37.6	25.0	--	26.6	17.9	--	--	--
--	0.0340	33.6	22.3	16.2	24.6	13.6	5.8	15.2	18.5
--	0.0226	29.7	19.1	13.7	22.6	11.9	4.8	12.1	16.6
--	0.0131	22.7	14.9	11.2	18.0	7.1	4.2	11.1	12.8
--	0.00931	18.0	12.8	9.1	13.3	6.5	3.9	8.6	8.9
--	0.00665	14.1	9.6	7.1	10.7	4.9	3.0	8.1	7.0
--	0.00473	11.0	6.4	5.6	9.3	3.8	2.1	6.6	5.1
--	0.00329	9.4	5.3	5.1	7.3	2.7	1.8	5.6	4.5
--	0.00138	5.5	3.7	3.0	5.3	2.2	1.8	4.0	3.2
% Gravel		11.4	32.5	39.1	10.4	27.9	51.2	37.7	26.3
% Sand		48.5	41.4	40.7	51.5	52.6	41.8	45.7	48.6
% Silt/Clay		40.1	26.1	20.2	28.0	19.5	7.0	16.6	25.1
USCS Code		SC	SM	SM	SM	SM	GP-GM	SM	SM

mm - Millimeter.
USCS - Universal Soil Classification System.
SC - clayey sand
SM - silty sand
GP-GM - poorly graded gravel - silty gravel

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				SAR-78-SS04				HR-70Q-SS01				HR-77Q-SS01				HR-80Q-GP06			
Sample Number:				RW0023				RW0001				RW0010				RW0025			
Sample Date:				9-May-03				13-May-03				7-May-03				12-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :																			
2,4-DB	mg/kg		0.1	ND				ND				ND				ND			
MCPP	mg/kg	NA	0.1	ND				ND				ND				ND			
PESTICIDES :																			
4,4'-DDD	mg/kg	NA	0.0025	0.0072			YES	ND				ND				0.0047	J		YES
4,4'-DDE	mg/kg	NA	0.0025	ND				ND				ND				0.0044	J		YES
4,4'-DDT	mg/kg	NA	0.0025	ND				0.0017	J			ND				0.0012	J		
Aldrin	mg/kg	NA	0.0025	ND				ND				0.00066	J			0.0023	J		
Dieldrin	mg/kg	NA	0.0005	ND				ND				ND				ND			
Endosulfan I	mg/kg	NA	0.11927	ND				ND				ND				ND			
Endosulfan II	mg/kg	NA	0.11927	ND				ND				ND				ND			
Endosulfan sulfate	mg/kg	NA	0.03578	0.0037	J			ND				ND				ND			
Endrin	mg/kg	NA	0.001	ND				ND				ND				0.0012	J		YES
Endrin aldehyde	mg/kg	NA	0.0105	ND				ND				ND				ND			
Heptachlor	mg/kg	NA	0.1	0.0028	J			0.0013	J			0.0014	J			0.0016	J		
Heptachlor epoxide	mg/kg	NA	0.15188	0.00054	J			0.0019	J			0.00021	J			ND			
Methoxychlor	mg/kg	NA	0.01988	ND				ND				0.005	J			ND			
alpha-BHC	mg/kg	NA	0.0025	ND				0.00071	J			0.00083	J			ND			
alpha-Chlordane	mg/kg	NA	0.1	ND				ND				0.00021	J			ND			
beta-BHC	mg/kg	NA	0.001	ND				ND				ND				0.0022	J		YES
gamma-BHC (Lindane)	mg/kg	NA	0.00005	ND				ND				ND				0.0016	J		YES
gamma-Chlordane	mg/kg	NA	0.1	ND				ND				ND				ND			
METALS :																			
Aluminum	mg/kg	16306	50	6550			YES	15100			YES	6250			YES	9770			YES
Antimony	mg/kg	1.99	3.5	ND				92.2	J	YES	YES	276	J	YES	YES	ND			
Arsenic	mg/kg	13.73	10	3.88				42		YES	YES	10.4	J		YES	2.76			
Barium	mg/kg	123.94	165	46.7				88.1				111				80.9			
Beryllium	mg/kg	0.8	1.1	ND				0.769	J			0.819	J	YES		0.5	J		
Calcium	mg/kg	1723	NA	33000		YES		591				284	J			395			
Chromium	mg/kg	37.04	0.4	10.6			YES	21.6			YES	7.22			YES	10.1			YES
Cobalt	mg/kg	15.15	20	2.41	J			10.7				5.13				2.58	J		
Copper	mg/kg	12.71	40	15.2		YES		509	J	YES	YES	3580	J	YES	YES	56.2	J	YES	YES
Iron	mg/kg	34154	200	10800			YES	15100			YES	18100			YES	11000			YES
Lead	mg/kg	40.05	50	49.9		YES		10600		YES	YES	20100		YES	YES	486		YES	YES
Magnesium	mg/kg	1033	440000	11200		YES		936				304				455			
Manganese	mg/kg	1579	100	191			YES	1170			YES	567			YES	659			YES
Mercury	mg/kg	0.08	0.1	ND				ND				ND				0.0374	J		
Nickel	mg/kg	10.33	30	4.24				12		YES		5.05				3.76			
Potassium	mg/kg	799.76	NA	864		YES		751				1190		YES		712			
Selenium	mg/kg	0.48	0.81	ND				1.44		YES	YES	0.627	B	YES		0.815	J	YES	YES
Sodium	mg/kg	634.28	NA	55.2	B			ND				39.4	J			26.8	B		
Vanadium	mg/kg	58.84	2	12.1			YES	20.4			YES	9.76			YES	12.4			YES
Zinc	mg/kg	40.64	50	39.6	J			139		YES	YES	281	J	YES	YES	28.1			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-78-SS04				HR-70Q-SS01				HR-77Q-SS01				HR-80Q-GP06			
			Sample Number:	RW0023				RW0001				RW0010				RW0025			
			Sample Date:	9-May-03				13-May-03				7-May-03				12-May-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :																			
Azinphosmethyl	mg/kg	NA	0.1	ND				ND				ND				ND			
PESTICIDES/PCBs :																			
Aroclor 1260	mg/kg	NA	0.02	0.03	J		YES	ND				0.027	J		YES	ND			
PH																			
pH	Std	NA	NA	7.48				6.28				5.69				4.9			
SEMIVOLATILE ORGANIC COMPOUNDS :																			
Benzo(a)anthracene	mg/kg	1.193	5.21	ND				ND				ND				ND			
Benzo(b)fluoranthene	mg/kg	1.659	59.8	ND				ND				ND				ND			
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93	ND				ND				ND				ND			
Chrysene	mg/kg	1.397	4.73	ND				ND				ND				ND			
Di-n-butyl phthalate	mg/kg	NA	200	ND				ND				ND				ND			
Fluoranthene	mg/kg	2.031	0.1	ND				ND				ND				ND			
N-Nitrosodiphenylamine	mg/kg	NA	20	ND				ND				ND				ND			
Pyrene	mg/kg	1.626	0.1	ND				ND				ND				ND			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	21100				16200				23700				24800			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	89.6	0.0041	J			0.017	J			ND				0.019	J		
Acetone	mg/kg	NA	2.5	0.072				0.23				0.15				0.42			
Chloromethane	mg/kg	NA	0.1	ND				0.0033	J			ND				ND			
N-Butylbenzene	mg/kg	NA	NA	ND				ND				ND				ND			
Toluene	mg/kg	NA	0.05	ND				ND				ND				ND			
Trichlorofluoromethane	mg/kg	NA	0.1	0.0014	B			ND				ND				0.0055	J		
p-Cymene	mg/kg	NA	NA	ND				ND				ND				ND			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				HR-80Q-MW02				SAR-85-SS24				SAR-69-SS37				SAR-70-SS09			
Sample Number:				RW0014				RW0007				RW0008				RW0009			
Sample Date:				7-May-03				9-May-03				12-May-03				13-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :																			
2,4-DB	mg/kg		0.1					ND				ND				ND			
MCPP	mg/kg	NA	0.1					ND				ND				ND			
PESTICIDES :																			
4,4'-DDD	mg/kg	NA	0.0025					ND				ND				ND			
4,4'-DDE	mg/kg	NA	0.0025	0.0092	J		YES	ND				ND				ND			
4,4'-DDT	mg/kg	NA	0.0025					ND				0.0096			YES	0.015	J		YES
Aldrin	mg/kg	NA	0.0025					0.004			YES	0.034	J		YES	ND			
Dieldrin	mg/kg	NA	0.0005	0.0047	J		YES	ND				ND				ND			
Endosulfan I	mg/kg	NA	0.11927	0.0015	J			ND				0.001	J			0.00088	J		
Endosulfan II	mg/kg	NA	0.11927					ND				ND				ND			
Endosulfan sulfate	mg/kg	NA	0.03578	0.001	J			ND				ND				ND			
Endrin	mg/kg	NA	0.001					ND				0.013	J		YES	0.014	J		YES
Endrin aldehyde	mg/kg	NA	0.0105					ND				0.0034	J			0.0028	J		
Heptachlor	mg/kg	NA	0.1	0.0015	J			0.0028				0.0054				0.004			
Heptachlor epoxide	mg/kg	NA	0.15188					ND				0.0046				ND			
Methoxychlor	mg/kg	NA	0.01988					ND				ND				ND			
alpha-BHC	mg/kg	NA	0.0025	0.0032	J		YES	0.0018	J			0.0056	J		YES	0.0022	J		
alpha-Chlordane	mg/kg	NA	0.1					0.0023	J			ND				ND			
beta-BHC	mg/kg	NA	0.001	0.0035			YES	0.0012	J		YES	ND				0.0079	J		YES
gamma-BHC (Lindane)	mg/kg	NA	0.00005	0.00026	J		YES	0.00072	J		YES	ND				0.003			YES
gamma-Chlordane	mg/kg	NA	0.1					ND				ND				ND			
METALS :																			
Aluminum	mg/kg	16306	50	8700			YES	9400			YES	9800			YES	10400			YES
Antimony	mg/kg	1.99	3.5	39.5	J	YES	YES	ND				ND				ND			
Arsenic	mg/kg	13.73	10	3.85				1.93				3.98				5.7			
Barium	mg/kg	123.94	165	283	J	YES	YES	84.7				46.2				121			
Beryllium	mg/kg	0.8	1.1	0.773	J			0.495	J			ND				0.779	J		
Calcium	mg/kg	1723	NA	6390	J	YES		299				246				508			
Chromium	mg/kg	37.04	0.4	8.53			YES	8.53			YES	21.3			YES	22.2			YES
Cobalt	mg/kg	15.15	20	9.86				8.37				4.19				2.27	J		
Copper	mg/kg	12.71	40	127		YES	YES	5.91				4.25	J			7.66	J		
Iron	mg/kg	34154	200	13100			YES	6130			YES	10300			YES	22800			YES
Lead	mg/kg	40.05	50	4660		YES	YES	16.5				38.3				94.4		YES	YES
Magnesium	mg/kg	1033	440000	571				514				432				381			
Manganese	mg/kg	1579	100	1360			YES	431			YES	367			YES	343			YES
Mercury	mg/kg	0.08	0.1					ND				0.0461	J			ND			
Nickel	mg/kg	10.33	30	5.47				5.78				4.49				6.67			
Potassium	mg/kg	799.76	NA	739				408	B			263	J			954		YES	
Selenium	mg/kg	0.48	0.81	0.838	B	YES	YES	ND				1.32		YES	YES	1.48		YES	YES
Sodium	mg/kg	634.28	NA	41	J			41.7	B			22.8	B			26.6	B		
Vanadium	mg/kg	58.84	2	12.8			YES	11.8			YES	20.5			YES	26.9			YES
Zinc	mg/kg	40.64	50	43.9		YES		18.3	J			19.2				22.6			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				HR-80Q-MW02				SAR-85-SS24				SAR-69-SS37				SAR-70-SS09			
Sample Number:				RW0014				RW0007				RW0008				RW0009			
Sample Date:				7-May-03				9-May-03				12-May-03				13-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :																			
Azinphosmethyl	mg/kg	NA	0.1					ND				ND				ND			
PESTICIDES/PCBs :																			
Aroclor 1260	mg/kg	NA	0.02					ND				ND				ND			
PH																			
pH	Std	NA	NA	5.49				4.92				4.42				5.01			
SEMIVOLATILE ORGANIC COMPOUNDS :																			
Benzo(a)anthracene	mg/kg	1.193	5.21					ND				ND				ND			
Benzo(b)fluoranthene	mg/kg	1.659	59.8					ND				ND				ND			
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93					ND				ND				ND			
Chrysene	mg/kg	1.397	4.73					ND				ND				ND			
Di-n-butyl phthalate	mg/kg	NA	200					ND				ND				ND			
Fluoranthene	mg/kg	2.031	0.1					ND				ND				ND			
N-Nitrosodiphenylamine	mg/kg	NA	20					ND				ND				ND			
Pyrene	mg/kg	1.626	0.1					ND				ND				ND			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	23100				13500				26800				25400			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	89.6					0.0068	J			0.019	J			0.014	J		
Acetone	mg/kg	NA	2.5	0.26				0.19				0.56				0.37			
Chloromethane	mg/kg	NA	0.1					ND				ND				ND			
N-Butylbenzene	mg/kg	NA	NA					ND				ND				0.0021	J		
Toluene	mg/kg	NA	0.05					ND				ND				0.0026	J		
Trichlorofluoromethane	mg/kg	NA	0.1					ND				0.0042	J			0.0039	J		
p-Cymene	mg/kg	NA	NA					ND				0.0014	J			0.022			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				HR-80Q-GP17				SAR-69-SS11				SAR-70-SS12				SAR-71-SS05			
Sample Number:				RW0016				RW0021				RW0024				RW0005			
Sample Date:				12-May-03				12-May-03				8-May-03				8-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :																			
2,4-DB	mg/kg		0.1	ND				ND				ND				ND			
MCPP	mg/kg	NA	0.1	2	J		YES	ND				ND				ND			
PESTICIDES :																			
4,4'-DDD	mg/kg	NA	0.0025	ND				ND				ND				ND			
4,4'-DDE	mg/kg	NA	0.0025	0.0029	J		YES	ND				ND				0.0043	J		YES
4,4'-DDT	mg/kg	NA	0.0025	0.0058	J		YES	0.0069			YES	ND				0.0051	J		YES
Aldrin	mg/kg	NA	0.0025	0.0079			YES	ND				ND				0.0014	J		
Dieldrin	mg/kg	NA	0.0005	ND				ND				0.0019	J		YES	0.00061	J		YES
Endosulfan I	mg/kg	NA	0.11927	ND				ND				ND				0.0014	J		
Endosulfan II	mg/kg	NA	0.11927	ND				ND				ND				ND			
Endosulfan sulfate	mg/kg	NA	0.03578	ND				ND				ND				0.0026	J		
Endrin	mg/kg	NA	0.001	0.003	J		YES	0.0054	J		YES	0.00055	J			0.0027	J		YES
Endrin aldehyde	mg/kg	NA	0.0105	0.0044	J			0.0025	J			ND				ND			
Heptachlor	mg/kg	NA	0.1	0.0024	J			0.0015	J			0.00084	J			0.0027	J		
Heptachlor epoxide	mg/kg	NA	0.15188	0.0025	J			ND				0.0015	J			0.0016	J		
Methoxychlor	mg/kg	NA	0.01988	ND				ND				ND				ND			
alpha-BHC	mg/kg	NA	0.0025	0.0013	J			0.00095	J			ND				ND			
alpha-Chlordane	mg/kg	NA	0.1	ND				ND				ND				0.0036	J		
beta-BHC	mg/kg	NA	0.001	0.0023	J		YES	ND				ND				0.01	J		YES
gamma-BHC (Lindane)	mg/kg	NA	0.00005	ND				ND				0.0038	J		YES	0.0023	J		YES
gamma-Chlordane	mg/kg	NA	0.1	ND				ND				ND				0.00034	J		
METALS :																			
Aluminum	mg/kg	16306	50	9960			YES	5220			YES	11000			YES	10800			YES
Antimony	mg/kg	1.99	3.5	ND				1620	J	YES	YES	ND				ND			
Arsenic	mg/kg	13.73	10	3.61				560		YES	YES	4.5				2.2			
Barium	mg/kg	123.94	165	87.8				38.3				73.1				59.3			
Beryllium	mg/kg	0.8	1.1	0.702	J			0.625	J			0.648	J			ND			
Calcium	mg/kg	1723	NA	160				242				249				228			
Chromium	mg/kg	37.04	0.4	9.11			YES	14.1			YES	16.4			YES	11			YES
Cobalt	mg/kg	15.15	20	5.39				5.59	J			5.32				1.93	J		
Copper	mg/kg	12.71	40	5.86	J			90	J	YES	YES	22.3		YES		62.2		YES	YES
Iron	mg/kg	34154	200	19500			YES	23000			YES	16100	J		YES	8050	J		YES
Lead	mg/kg	40.05	50	39.4				41300		YES	YES	142	J	YES	YES	779	J	YES	YES
Magnesium	mg/kg	1033	440000	450				310				416				277			
Manganese	mg/kg	1579	100	562			YES	311			YES	205			YES	116			YES
Mercury	mg/kg	0.08	0.1	ND				ND				0.0959	J	YES		ND			
Nickel	mg/kg	10.33	30	5.35				9.65				5.19				3.19			
Potassium	mg/kg	799.76	NA	1450		YES		759				465	J			263	J		
Selenium	mg/kg	0.48	0.81	1.57		YES	YES	1.69		YES	YES	0.784	B	YES		ND			
Sodium	mg/kg	634.28	NA	24.4	B			ND				37.6	J			45.6	J		
Vanadium	mg/kg	58.84	2	14.7			YES	24.7			YES	18.7			YES	15			YES
Zinc	mg/kg	40.64	50	20.3				47.3		YES		33.5				35.1			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	HR-80Q-GP17				SAR-69-SS11				SAR-70-SS12				SAR-71-SS05			
			Sample Number:	RW0016				RW0021				RW0024				RW0005			
			Sample Date:	12-May-03				12-May-03				8-May-03				8-May-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :																			
Azinphosmethyl	mg/kg	NA	0.1	ND				0.14			YES	ND				ND			
PESTICIDES/PCBs :																			
Aroclor 1260	mg/kg	NA	0.02	ND				ND				0.01	J			0.028	J		YES
PH																			
pH	Std	NA	NA	4.37				5.12				5.01				4.56			
SEMIVOLATILE ORGANIC COMPOUNDS :																			
Benzo(a)anthracene	mg/kg	1.193	5.21	ND				ND				ND				ND			
Benzo(b)fluoranthene	mg/kg	1.659	59.8	ND				ND				ND				ND			
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93	ND				ND				0.13	J			ND			
Chrysene	mg/kg	1.397	4.73	ND				ND				ND				ND			
Di-n-butyl phthalate	mg/kg	NA	200	ND				ND				0.091	J			ND			
Fluoranthene	mg/kg	2.031	0.1	ND				ND				ND				ND			
N-Nitrosodiphenylamine	mg/kg	NA	20	ND				ND				0.21	J			ND			
Pyrene	mg/kg	1.626	0.1	ND				ND				ND				ND			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	17200				12200				11100				30100			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	89.6	0.016	J			ND				ND				ND			
Acetone	mg/kg	NA	2.5	0.34				0.2				0.092				0.3			
Chloromethane	mg/kg	NA	0.1	ND				ND				ND				ND			
N-Butylbenzene	mg/kg	NA	NA	ND				ND				ND				ND			
Toluene	mg/kg	NA	0.05	ND				0.0019	J			ND				ND			
Trichlorofluoromethane	mg/kg	NA	0.1	0.0034	J			0.0025	J			0.0017	J			0.0048	J		
p-Cymene	mg/kg	NA	NA	ND				0.0081				ND				ND			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-71-SS09				SAR-77-SS16				SAR-77-SS33				SAR-77-SS50			
			Sample Number:	RW0006				RW0026				RW0013				RW0015			
			Sample Date:	8-May-03				7-May-03				7-May-03				12-May-03			
			Sample Depth (Feet):	0- .5				0- 1				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :																			
2,4-DB	mg/kg		0.1	0.025				ND				ND				ND			
MCPP	mg/kg	NA	0.1	ND				ND				ND				ND			
PESTICIDES :																			
4,4'-DDD	mg/kg	NA	0.0025	ND				ND				ND				ND			
4,4'-DDE	mg/kg	NA	0.0025	0.0085	J		YES	ND				0.0017	J			0.0014	J		
4,4'-DDT	mg/kg	NA	0.0025	ND				ND				0.0012	J			0.0027	J		YES
Aldrin	mg/kg	NA	0.0025	0.0012	J			0.0012	J			0.00079	J			0.008			YES
Dieldrin	mg/kg	NA	0.0005	ND				0.0018	J		YES	ND				0.0016	J		YES
Endosulfan I	mg/kg	NA	0.11927	ND				ND				ND				ND			
Endosulfan II	mg/kg	NA	0.11927	0.0028	J			ND				ND				ND			
Endosulfan sulfate	mg/kg	NA	0.03578	ND				ND				0.0012	J			ND			
Endrin	mg/kg	NA	0.001	0.0055			YES	ND				ND				0.0036	J		YES
Endrin aldehyde	mg/kg	NA	0.0105	ND				ND				ND				ND			
Heptachlor	mg/kg	NA	0.1	0.01	J			0.0016	J			0.0021	J			0.0049			
Heptachlor epoxide	mg/kg	NA	0.15188	0.0032	J			ND				ND				0.005	J		
Methoxychlor	mg/kg	NA	0.01988	ND				ND				ND				ND			
alpha-BHC	mg/kg	NA	0.0025	0.0018	J			0.0013	J			0.001	J			0.00038	J		
alpha-Chlordane	mg/kg	NA	0.1	0.0026	J			0.00033	J			ND				ND			
beta-BHC	mg/kg	NA	0.001	0.0027			YES	0.0051	J		YES	0.00054	J			0.00061	J		
gamma-BHC (Lindane)	mg/kg	NA	0.00005	0.0045	J		YES	ND				0.00034	J		YES	0.0017	J		YES
gamma-Chlordane	mg/kg	NA	0.1	ND				0.007				ND				ND			
METALS :																			
Aluminum	mg/kg	16306	50	9880			YES	15800			YES	9400			YES	7820			YES
Antimony	mg/kg	1.99	3.5	ND				6.71	J	YES	YES	35.4	J	YES	YES	ND			
Arsenic	mg/kg	13.73	10	2.92				5.21				4.96				1.27	B		
Barium	mg/kg	123.94	165	94.3				46.5	J			40.6	J			51.4			
Beryllium	mg/kg	0.8	1.1	0.584	J			ND				0.784	J			ND			
Calcium	mg/kg	1723	NA	424				280	J			142	J			214			
Chromium	mg/kg	37.04	0.4	8.44			YES	12.3			YES	12.3			YES	5.56			YES
Cobalt	mg/kg	15.15	20	2.74				3.93				3.22				1.83	J		
Copper	mg/kg	12.71	40	34.9		YES		61.4		YES	YES	908		YES	YES	14.6	J	YES	
Iron	mg/kg	34154	200	12300	J		YES	15600			YES	25000			YES	4890			YES
Lead	mg/kg	40.05	50	480	J	YES	YES	760		YES	YES	6860		YES	YES	156		YES	YES
Magnesium	mg/kg	1033	440000	203				566				376				409			
Manganese	mg/kg	1579	100	474			YES	590			YES	414			YES	135			YES
Mercury	mg/kg	0.08	0.1	ND				ND				ND				ND			
Nickel	mg/kg	10.33	30	4.11				6.68				4.32				2.84			
Potassium	mg/kg	799.76	NA	127	B			626				1480		YES		504	J		
Selenium	mg/kg	0.48	0.81	1.03	B	YES	YES	0.876	B	YES	YES	1.41	B	YES	YES	1.04	J	YES	YES
Sodium	mg/kg	634.28	NA	33.7	J			37.4	J			32.6	J			24.9	B		
Vanadium	mg/kg	58.84	2	17			YES	25.7			YES	18.5			YES	8.87			YES
Zinc	mg/kg	40.64	50	39.3				27.1				72.8		YES	YES	19.9			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				SAR-71-SS09				SAR-77-SS16				SAR-77-SS33				SAR-77-SS50			
Sample Number:				RW0006				RW0026				RW0013				RW0015			
Sample Date:				8-May-03				7-May-03				7-May-03				12-May-03			
Sample Depth (Feet):				0- .5				0- 1				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :																			
Azinphosmethyl	mg/kg	NA	0.1	ND				ND				ND				0.044			
PESTICIDES/PCBs :																			
Aroclor 1260	mg/kg	NA	0.02	0.021	J		YES	ND				0.02	J		YES	ND			
PH																			
pH	Std	NA	NA	4.68				4.84				4.74				4.5			
SEMIVOLATILE ORGANIC COMPOUNDS :																			
Benzo(a)anthracene	mg/kg	1.193	5.21	ND				0.074	J			ND				ND			
Benzo(b)fluoranthene	mg/kg	1.659	59.8	ND				0.15	J			ND				ND			
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93	ND				ND				ND				ND			
Chrysene	mg/kg	1.397	4.73	ND				0.12	J			ND				ND			
Di-n-butyl phthalate	mg/kg	NA	200	ND				ND				ND				ND			
Fluoranthene	mg/kg	2.031	0.1	ND				0.11	J		YES	ND				ND			
N-Nitrosodiphenylamine	mg/kg	NA	20	ND				ND				ND				ND			
Pyrene	mg/kg	1.626	0.1	ND				0.11	J		YES	ND				ND			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	40300				11500				26600				15300			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	89.6	ND				ND				ND				0.0091	J		
Acetone	mg/kg	NA	2.5	0.47	J			0.17				0.1				0.29			
Chloromethane	mg/kg	NA	0.1	ND				ND				ND				ND			
N-Butylbenzene	mg/kg	NA	NA	ND				ND				ND				ND			
Toluene	mg/kg	NA	0.05	ND				ND				ND				ND			
Trichlorofluoromethane	mg/kg	NA	0.1	ND				0.0026	B			ND				0.0041	J		
p-Cymene	mg/kg	NA	NA	ND				ND				ND				ND			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				SAR-78-SS17				SAR-78-SS25				SAR-78-SS34				SAR-85-SS02			
Sample Number:				RW0019				RW0018				RW0012				RW0022			
Sample Date:				7-May-03				12-May-03				9-May-03				6-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :																			
2,4-DB	mg/kg		0.1	ND								ND				ND			
MCPP	mg/kg	NA	0.1	1.2	J		YES					ND				ND			
PESTICIDES :																			
4,4'-DDD	mg/kg	NA	0.0025	ND								ND				ND			
4,4'-DDE	mg/kg	NA	0.0025	ND								ND				ND			
4,4'-DDT	mg/kg	NA	0.0025	ND								0.015	J		YES	ND			
Aldrin	mg/kg	NA	0.0025	ND								ND				ND			
Dieldrin	mg/kg	NA	0.0005	ND								ND				ND			
Endosulfan I	mg/kg	NA	0.11927	ND								ND				ND			
Endosulfan II	mg/kg	NA	0.11927	ND								ND				ND			
Endosulfan sulfate	mg/kg	NA	0.03578	ND								ND				0.00079	J		
Endrin	mg/kg	NA	0.001	ND								0.00086	J			ND			
Endrin aldehyde	mg/kg	NA	0.0105	ND								ND				ND			
Heptachlor	mg/kg	NA	0.1	0.0015	J			0.0014	J			0.0017	J			ND			
Heptachlor epoxide	mg/kg	NA	0.15188	ND								ND				ND			
Methoxychlor	mg/kg	NA	0.01988	ND								ND				ND			
alpha-BHC	mg/kg	NA	0.0025	ND				0.00079	J			ND				ND			
alpha-Chlordane	mg/kg	NA	0.1	ND								ND				0.0017	J		
beta-BHC	mg/kg	NA	0.001	ND								ND				0.00035	J		
gamma-BHC (Lindane)	mg/kg	NA	0.00005	ND								ND				ND			
gamma-Chlordane	mg/kg	NA	0.1	ND								ND				ND			
METALS :																			
Aluminum	mg/kg	16306	50	27300		YES	YES	2410			YES	11600			YES	8830			YES
Antimony	mg/kg	1.99	3.5	17.9	J	YES	YES	298	J	YES	YES	72.9		YES	YES	ND			
Arsenic	mg/kg	13.73	10	5.85				11.3			YES	17.4		YES	YES	80.1	J	YES	YES
Barium	mg/kg	123.94	165	34.7	J			20.2				23.4				64.7			
Beryllium	mg/kg	0.8	1.1	0.535	J							ND				0.614	J		
Calcium	mg/kg	1723	NA	194	J			67.1	J			357				974	J		
Chromium	mg/kg	37.04	0.4	23.6			YES	3.05			YES	23.7			YES	44.1		YES	YES
Cobalt	mg/kg	15.15	20	1.74	J			1.19	J			ND				4.32			
Copper	mg/kg	12.71	40	393		YES	YES	2280	J	YES	YES	1200		YES	YES	91.3	J	YES	YES
Iron	mg/kg	34154	200	28100			YES	9870			YES	22300			YES	13000			YES
Lead	mg/kg	40.05	50	2310		YES	YES	23100		YES	YES	15600		YES	YES	180	J	YES	YES
Magnesium	mg/kg	1033	440000	1050		YES		105	J			436				480			
Manganese	mg/kg	1579	100	50.8				178			YES	161			YES	385	J		YES
Mercury	mg/kg	0.08	0.1	ND								ND				ND			
Nickel	mg/kg	10.33	30	5.36				2.09	J			2.77				3.7			
Potassium	mg/kg	799.76	NA	2140		YES		601				1480		YES		900		YES	
Selenium	mg/kg	0.48	0.81	1.65	B	YES	YES	0.699	J	YES		0.869	B	YES	YES	0.821	B	YES	YES
Sodium	mg/kg	634.28	NA	38.8	J			22.7	B			49.1	B			55.2	J		
Vanadium	mg/kg	58.84	2	43.6			YES	5.18			YES	32.3			YES	14.7			YES
Zinc	mg/kg	40.64	50	63.9		YES	YES	229		YES	YES	153	J	YES	YES	71.5	J	YES	YES

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-78-SS17				SAR-78-SS25				SAR-78-SS34				SAR-85-SS02			
			Sample Number:	RW0019				RW0018				RW0012				RW0022			
			Sample Date:	7-May-03				12-May-03				9-May-03				6-May-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :																			
Azinphosmethyl	mg/kg	NA	0.1	ND								ND				ND			
PESTICIDES/PCBs :																			
Aroclor 1260	mg/kg	NA	0.02	ND								ND				ND			
PH																			
pH	Std	NA	NA	4.68				5.8				5.68				6.06			
SEMIVOLATILE ORGANIC COMPOUNDS :																			
Benzo(a)anthracene	mg/kg	1.193	5.21	ND								ND				ND			
Benzo(b)fluoranthene	mg/kg	1.659	59.8	ND								ND				ND			
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93	ND								ND				ND			
Chrysene	mg/kg	1.397	4.73	ND								ND				ND			
Di-n-butyl phthalate	mg/kg	NA	200	ND								ND				ND			
Fluoranthene	mg/kg	2.031	0.1	ND								ND				ND			
N-Nitrosodiphenylamine	mg/kg	NA	20	ND								ND				ND			
Pyrene	mg/kg	1.626	0.1	ND								ND				ND			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	10300				6000				17500				30500			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	89.6	ND								ND				ND			
Acetone	mg/kg	NA	2.5	0.043				0.064				0.042				0.098			
Chloromethane	mg/kg	NA	0.1	ND								ND				ND			
N-Butylbenzene	mg/kg	NA	NA	ND								ND				ND			
Toluene	mg/kg	NA	0.05	ND								ND				ND			
Trichlorofluoromethane	mg/kg	NA	0.1	0.0016	B							0.0017	B			0.0043	J		
p-Cymene	mg/kg	NA	NA	ND								ND				ND			

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				SAR-85-SS17				SAR-85-SS34				SAR-85-SS37			
Sample Number:				RW0017				RW0004				RW0002			
Sample Date:				13-May-03				6-May-03				6-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
HERBICIDES :															
2,4-DB	mg/kg		0.1	ND				ND							
MCPP	mg/kg	NA	0.1	ND				ND							
PESTICIDES :															
4,4'-DDD	mg/kg	NA	0.0025	ND				ND							
4,4'-DDE	mg/kg	NA	0.0025	0.0028	J		YES	0.0018	J						
4,4'-DDT	mg/kg	NA	0.0025	0.016			YES	0.0042	J		YES	0.0011	J		
Aldrin	mg/kg	NA	0.0025	ND				0.0013	J						
Dieldrin	mg/kg	NA	0.0005	ND				ND							
Endosulfan I	mg/kg	NA	0.11927	ND				ND							
Endosulfan II	mg/kg	NA	0.11927	ND				ND							
Endosulfan sulfate	mg/kg	NA	0.03578	ND				0.00057	J						
Endrin	mg/kg	NA	0.001	ND				0.002	J		YES	0.0052	J		YES
Endrin aldehyde	mg/kg	NA	0.0105	ND				ND				0.0019	J		
Heptachlor	mg/kg	NA	0.1	0.0061				0.0033	J						
Heptachlor epoxide	mg/kg	NA	0.15188	0.0022	J			0.0011	J						
Methoxychlor	mg/kg	NA	0.01988	ND				0.0052	J						
alpha-BHC	mg/kg	NA	0.0025	0.0022	J			ND				0.0011	J		
alpha-Chlordane	mg/kg	NA	0.1	ND				ND							
beta-BHC	mg/kg	NA	0.001	0.013	J		YES	0.0023	J		YES	0.0012	J		YES
gamma-BHC (Lindane)	mg/kg	NA	0.00005	0.0024	J		YES	0.0017	J		YES	0.00031	J		YES
gamma-Chlordane	mg/kg	NA	0.1	ND				ND							
METALS :															
Aluminum	mg/kg	16306	50	9260			YES	5530			YES	2090			YES
Antimony	mg/kg	1.99	3.5	63.3	J	YES	YES	112	J	YES	YES	187	J	YES	YES
Arsenic	mg/kg	13.73	10	5.16				9.13	J			10.7	J		YES
Barium	mg/kg	123.94	165	91.2				157		YES		166		YES	YES
Beryllium	mg/kg	0.8	1.1	ND				0.532	J						
Calcium	mg/kg	1723	NA	995				1530	J			2640	J	YES	
Chromium	mg/kg	37.04	0.4	6.38			YES	6.39			YES	2.17	J		YES
Cobalt	mg/kg	15.15	20	5.7				6.84							
Copper	mg/kg	12.71	40	334	J	YES	YES	508	J	YES	YES	711	J	YES	YES
Iron	mg/kg	34154	200	5890			YES	6860			YES	2200			YES
Lead	mg/kg	40.05	50	6820		YES	YES	14900	J	YES	YES	22600	J	YES	YES
Magnesium	mg/kg	1033	440000	539				357				124	J		
Manganese	mg/kg	1579	100	731			YES	782	J		YES	1100	J		YES
Mercury	mg/kg	0.08	0.1	ND				ND							
Nickel	mg/kg	10.33	30	4.8				5.04				2.41	B		
Potassium	mg/kg	799.76	NA	535	J			543	J			253	B		
Selenium	mg/kg	0.48	0.81	0.966	J	YES	YES	ND							
Sodium	mg/kg	634.28	NA	ND				34.8	J			27.5	J		
Vanadium	mg/kg	58.84	2	10.2			YES	9.4			YES	2.31	J		YES
Zinc	mg/kg	40.64	50	73.1		YES	YES	128	J	YES	YES	116	J	YES	YES

Table 5-2

Surface and Depositional Soil Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Sample Location:				SAR-85-SS17				SAR-85-SS34				SAR-85-SS37			
Sample Number:				RW0017				RW0004				RW0002			
Sample Date:				13-May-03				6-May-03				6-May-03			
Sample Depth (Feet):				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
OP PESTICIDES :															
Azinphosmethyl	mg/kg	NA	0.1	ND				ND							
PESTICIDES/PCBs :															
Aroclor 1260	mg/kg	NA	0.02	ND				ND				0.013	J		
PH															
pH	Std	NA	NA	5.48				6.24				6.15			
SEMIVOLATILE ORGANIC COMPOUNDS :															
Benzo(a)anthracene	mg/kg	1.193	5.21	ND				ND							
Benzo(b)fluoranthene	mg/kg	1.659	59.8	ND				ND							
Bis(2-Ethylhexyl)phthalate	mg/kg	NA	0.93	ND				ND							
Chrysene	mg/kg	1.397	4.73	ND				ND							
Di-n-butyl phthalate	mg/kg	NA	200	ND				ND							
Fluoranthene	mg/kg	2.031	0.1	ND				ND							
N-Nitrosodiphenylamine	mg/kg	NA	20	ND				ND							
Pyrene	mg/kg	1.626	0.1	ND				ND							
TOTAL ORGANIC CARBON :															
Total Organic Carbon	mg/kg	NA	NA	53100				39700				39600			
VOLATILE ORGANIC COMPOUNDS :															
2-Butanone	mg/kg	NA	89.6	0.029				ND							
Acetone	mg/kg	NA	2.5	ND				0.26				0.28			
Chloromethane	mg/kg	NA	0.1	ND				ND							
N-Butylbenzene	mg/kg	NA	NA	ND				ND							
Toluene	mg/kg	NA	0.05	ND				ND							
Trichlorofluoromethane	mg/kg	NA	0.1	0.0038	J			ND							
p-Cymene	mg/kg	NA	NA	ND				ND							

[a] BTV - Background. Concentration listed is two-times the arithmetic mean of background metals concentration (SAIC, 1998). For SVOCs, concentration listed is the background screening value for soils adjacent to asphalt (IT Corp., 2000), *Final Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan,* Calhoun County, Alabama, July.
[b] ecological screening value (ESV) as given in IT, 2000.
B - Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero).
J - Compound was positively identified; reported value is an estimated concentration.
mg/kg - Milligrams per kilogram.
NA - Not available.
ND - Not detected.
DV - Data validation qualifier.

Table 5-3

Surface Water Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	HR-85Q-SW/SD02				REFST				SAR-77-SW/SD15				SAR-77-SW/SD19			
			Sample Number:	RW2007				RW2012				RW2008				RW2010			
			Sample Date:	10-Jun-03				12-Jun-03				11-Jun-03				11-Jun-03			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
METALS :																			
Aluminum	mg/L	5.259	0.087	0.0744	B			0.0778	J			0.0648	B			0.078	J		
Barium	mg/L	0.07536	0.0039	0.0302			YES	0.0299			YES	0.0273			YES	0.0314			YES
Calcium	mg/L	25.166	116	1.63				0.741	J			1.07				0.499	J		
Copper	mg/L	0.0127	0.00654	0.0457		YES	YES	ND				0.00767	J		YES	ND			
Iron	mg/L	19.628	1	0.297	J			0.0755	J			0.112	J			0.205	J		
Lead	mg/L	0.00867	0.00132	0.0361		YES	YES	ND				0.00357	J		YES	ND			
Magnesium	mg/L	10.972	82	0.914	J			0.477	J			0.725	J			0.428	J		
Manganese	mg/L	0.56485	0.08	0.0298	J			0.00452	J			0.0101	J			0.0106	J		
Potassium	mg/L	2.564	53	1.12	J			1.36	J			1.12	J			1.25	J		
Sodium	mg/L	3.437	680	0.799	J			0.837	J			0.706	J			0.791	J		
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/L	NA	NA	1.24	J			ND				ND				ND			
VOLATILE ORGANIC COMPOUNDS :																			
Methylene chloride	mg/L	NA	1.93	0.00037	B			0.00036	B			0.00036	B			0.00036	B		

Table 5-3

Surface Water Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-77-SW/SD20				SAR-78-SW/SD12				SAR-78-SW/SD13			
			Sample Number:	RW2011				RW2004				RW2006			
			Sample Date:	11-Jun-03				10-Jun-03				10-Jun-03			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
METALS :															
Aluminum	mg/L	5.259	0.087	0.0852	J			0.058	B			0.0601	B		
Barium	mg/L	0.07536	0.0039	0.0303			YES	0.0249			YES	0.025			YES
Calcium	mg/L	25.166	116	0.503	J			0.982	J			0.939	J		
Copper	mg/L	0.0127	0.00654					0.0346		YES	YES	0.0129	J	YES	YES
Iron	mg/L	19.628	1	0.227	J			0.179	J			0.201	J		
Lead	mg/L	0.00867	0.00132	0.00236	J		YES	0.0306		YES	YES	0.0105		YES	YES
Magnesium	mg/L	10.972	82	0.432	J			0.643	J			0.659	J		
Manganese	mg/L	0.56485	0.08	0.0121	J			0.0104	J			0.00952	J		
Potassium	mg/L	2.564	53	1.26	J			1.14	J			1.17	J		
Sodium	mg/L	3.437	680	0.774	J			0.714	J			0.747	J		
TOTAL ORGANIC CARBON :															
Total Organic Carbon	mg/L	NA	NA					1.28	J			ND			
VOLATILE ORGANIC COMPOUNDS :															
Methylene chloride	mg/L	NA	1.93	0.00036	B			0.00035	B			0.00034	B		

Table 5-3

Surface Water Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-78-SW/SD14				SAR-85-SW/SD05				SAR-85-SW/SD07				SAR-85-SW/SD08			
			Sample Number:	RW2009				RW2001				RW2002				RW2005			
			Sample Date:	11-Jun-03				10-Jun-03				10-Jun-03				10-Jun-03			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
METALS :																			
Aluminum	mg/L	5.259	0.087	0.0718	B			0.0888	J		YES	0.0595	B			0.0673	B		
Barium	mg/L	0.07536	0.0039	0.028			YES	0.0277			YES	0.0304			YES	0.0339			YES
Calcium	mg/L	25.166	116	1.01				1.42				1.8				1.97			
Copper	mg/L	0.0127	0.00654	0.0106	J		YES	0.0436		YES	YES	0.0527		YES	YES	0.0608		YES	YES
Iron	mg/L	19.628	1	0.185	J			0.294	J			0.295	J			0.356	J		
Lead	mg/L	0.00867	0.00132	0.00762	J		YES	0.0321		YES	YES	0.0422		YES	YES	0.0462		YES	YES
Magnesium	mg/L	10.972	82	0.72	J			0.808	J			1.01				1.15			
Manganese	mg/L	0.56485	0.08	0.0103	J			0.0297	J			0.0359	J			0.0386	J		
Potassium	mg/L	2.564	53	1.2	J			0.995	J			1.2	J			1.41	J		
Sodium	mg/L	3.437	680	0.794	J			0.707	J			0.832	J			0.965	J		
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/L	NA	NA	ND				1.19	J			ND							
VOLATILE ORGANIC COMPOUNDS :																			
Methylene chloride	mg/L	NA	1.93	0.00037	B			0.00036	B			0.00037	B			0.00034	B		

[a] BTV - Background. Concentration listed is two-times the arithmetic mean of background metals concentration (SAIC, 1998).

[b] Ecological screening value (ESV) as given in IT Corporation (2000), *Final Human Health and Ecological Screening Values and PAH Background Summary Report. Fort McClellan. Calhoun County, Alabama*, July.

B - Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero).

J - Compound was positively identified; reported value is an estimated concentration.

mg/L - Milligrams per liter.

NA - Not available.

ND - Not detected.

DV - Data validation qualifier.

Table 5-4

Sediment Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	HR-78Q-SW/SD01				HR-80Q-SW/SD03				HR-80Q-SW/SD06				HR-85Q-SW/SD02			
			Sample Number:	RW1001				RW1010				RW1011				RW1009			
			Sample Date:	11-Jun-03				12-Jun-03				12-Jun-03				9-Jun-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
PESTICIDES :																			
Endrin	mg/kg		0.0033	ND				ND				ND				0.0016	J		
Endrin aldehyde	mg/kg	NA	3.2	ND				ND				ND				0.00073	J		
Heptachlor	mg/kg	NA	0.0006	ND				ND				ND				ND			
Heptachlor epoxide	mg/kg	NA	0.0006	ND				ND				ND				0.00088	J		YES
alpha-BHC	mg/kg	NA	0.006	0.0014	J			0.0011	J			0.0007	J			0.0013	J		
beta-BHC	mg/kg	NA	0.005	ND				ND				ND				ND			
gamma-BHC (Lindane)	mg/kg	NA	0.0033	ND				ND				ND				ND			
METALS :																			
Aluminum	mg/kg	8593	NA	7410	J			3950				8350				4190	J		
Antimony	mg/kg	0.73	12	ND				ND				ND				ND			
Arsenic	mg/kg	11.33	7.24	2.88				2.39				5.06				2.59			
Barium	mg/kg	98.91	NA	60.9				276		YES		137		YES		36			
Beryllium	mg/kg	0.97	NA	0.527	J			ND				0.934	J			ND			
Calcium	mg/kg	1111.51	NA	233				58.1	J			91.7	J			274			
Chromium	mg/kg	31.15	52.3	8.04				7.55				13.7				5.6			
Cobalt	mg/kg	11.01	50	4.66				5.54				8.28				ND			
Copper	mg/kg	17.12	18.7	160	J	YES	YES	7.1	J			9.06	J			18.6	J	YES	
Iron	mg/kg	35267	NA	14400				11500				28500				13600			
Lead	mg/kg	37.82	30.2	883	J	YES	YES	23.1				9.8				247	J	YES	YES
Magnesium	mg/kg	905.94	NA	354				168				394				218			
Manganese	mg/kg	712.31	NA	298				1110		YES		322				59.4			
Nickel	mg/kg	13.02	15.9	4.22				2.41	J			5.94				3.18	J		
Potassium	mg/kg	1013.48	NA	1140		YES		740				2440		YES		573	J		
Selenium	mg/kg	0.72	NA	ND				ND				0.668	J			ND			
Sodium	mg/kg	692.29	NA	40.7	J			39.6	J			53.6	J			42.4	J		
Vanadium	mg/kg	40.87	NA	15.1				9.55				19.3				9.47			
Zinc	mg/kg	52.74	124	19.5	J			7.64	J			15.2	J			39.5	J		
pH :																			
pH	Std	NA	NA	5.86				4.72				4.96				5.41			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	2480				1490				1180	J			7990			
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	0.13696	ND				ND				ND				ND			
Acetone	mg/kg	NA	0.45337	0.043	J			0.09	J			0.067	J			0.064	J		
Methylene chloride	mg/kg	NA	1.26	ND				0.0037	B			0.0023	B			ND			
Toluene	mg/kg	NA	0.67	ND				ND				ND				ND			
Trichlorofluoromethane	mg/kg	NA	0.00307	ND				ND				0.0014	J			ND			
p-Cymene	mg/kg	NA	NA	ND				ND				ND				ND			

Table 5-4

Sediment Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	REFST				SAR-77-SW/SD23				SAR-77-SW/SD25				SAR-78-SW/SD10			
			Sample Number:	RW1012				RW1008				RW1006				RW1002			
			Sample Date:	11-Jun-03				12-Jun-03				12-Jun-03				11-Jun-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
PESTICIDES :																			
Endrin	mg/kg		0.0033	ND				ND				ND				ND			
Endrin aldehyde	mg/kg	NA	3.2	ND				ND				ND				ND			
Heptachlor	mg/kg	NA	0.0006	ND				0.00076	J		YES	ND				ND			
Heptachlor epoxide	mg/kg	NA	0.0006	ND				ND				ND				ND			
alpha-BHC	mg/kg	NA	0.006	0.00061	J			0.0021	J			0.002	J			0.00049	J		
beta-BHC	mg/kg	NA	0.005	ND				ND				ND				ND			
gamma-BHC (Lindane)	mg/kg	NA	0.0033	ND				ND				0.0025	J			ND			
METALS :																			
Aluminum	mg/kg	8593	NA	4060				1320				17600		YES		4090	J		
Antimony	mg/kg	0.73	12	ND				ND				ND				8.44	J	YES	
Arsenic	mg/kg	11.33	7.24	1.3				ND				ND				6.22	J		
Barium	mg/kg	98.91	NA	43.8				33.4				301		YES		27			
Beryllium	mg/kg	0.97	NA	0.461	J			ND				ND				0.735	J		
Calcium	mg/kg	1111.51	NA	147				99.4	J			1220		YES		91.3	J		
Chromium	mg/kg	31.15	52.3	5.18				ND				12.5				15	J		
Cobalt	mg/kg	11.01	50	2.08	J			ND				ND				3.19	J		
Copper	mg/kg	17.12	18.7	2.6	J			10.4	J			271	J	YES	YES	202	J	YES	YES
Iron	mg/kg	35267	NA	11100				442				8710				35800	J	YES	
Lead	mg/kg	37.82	30.2	3.99				76.7		YES	YES	1730		YES	YES	967	J	YES	YES
Magnesium	mg/kg	905.94	NA	189				94.3	J			1140		YES		158			
Manganese	mg/kg	712.31	NA	131				19.9				91.1				184			
Nickel	mg/kg	13.02	15.9	2.95				ND				9.99	J			5.67	J		
Potassium	mg/kg	1013.48	NA	1050		YES		207	J			1760	J	YES		726			
Selenium	mg/kg	0.72	NA	ND				ND				3.49	J	YES		ND			
Sodium	mg/kg	692.29	NA	30.8	J			28.8	J			189	J			30.6	J		
Vanadium	mg/kg	40.87	NA	8.81				1.4	J			21.2				19.5	J		
Zinc	mg/kg	52.74	124	8.66	J			4.35	J			83.1	J	YES		19.5	J		
pH :																			
pH	Std	NA	NA	5.41				5.02				5.05				5.44			
TOTAL ORGANIC CARBON :																			
Total Organic Carbon	mg/kg	NA	NA	1020	J			8270				118000				1050	J		
VOLATILE ORGANIC COMPOUNDS :																			
2-Butanone	mg/kg	NA	0.13696	ND				ND				0.42	J		YES	ND			
Acetone	mg/kg	NA	0.45337	0.069	J			0.038	J			3.3	J		YES	0.081	J		
Methylene chloride	mg/kg	NA	1.26	0.0027	B			0.0036	B			0.027	B			0.0023	B		
Toluene	mg/kg	NA	0.67	ND				ND				0.091				ND			
Trichlorofluoromethane	mg/kg	NA	0.00307	ND				ND				ND				0.0025	J		
p-Cymene	mg/kg	NA	NA	ND				ND				0.1	J			ND			

Table 5-4

Sediment Sample Analytical Results
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

			Sample Location:	SAR-85-SW/SD02				SAR-85-SW/SD05				SAR-85-SW/SD08			
			Sample Number:	RW1007				RW1004				RW1005			
			Sample Date:	9-Jun-03				9-Jun-03				9-Jun-03			
			Sample Depth (Feet):	0- .5				0- .5				0- .5			
Parameter	Units	BTV[a]	ESV[b]	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV	Result	DV	>BTV	>ESV
PESTICIDES :															
Endrin	mg/kg		0.0033	ND				ND							
Endrin aldehyde	mg/kg	NA	3.2	ND				ND							
Heptachlor	mg/kg	NA	0.0006	ND				ND							
Heptachlor epoxide	mg/kg	NA	0.0006	ND				ND							
alpha-BHC	mg/kg	NA	0.006	0.0019	J			ND							
beta-BHC	mg/kg	NA	0.005	0.0014	J			ND							
gamma-BHC (Lindane)	mg/kg	NA	0.0033	ND				ND							
METALS :															
Aluminum	mg/kg	8593	NA	5120	J			3360	J			5190	J		
Antimony	mg/kg	0.73	12	ND				5.45	J	YES		6.41	J	YES	
Arsenic	mg/kg	11.33	7.24	2.08				1.54	B			2.4			
Barium	mg/kg	98.91	NA	35.6				17.9				32.5			
Beryllium	mg/kg	0.97	NA	ND				ND				0.571	J		
Calcium	mg/kg	1111.51	NA	146				57.2	J			112	J		
Chromium	mg/kg	31.15	52.3	6.17				5.49				7.54			
Cobalt	mg/kg	11.01	50	2.71	J			1.4	J			2.82			
Copper	mg/kg	17.12	18.7	126	J	YES	YES	74.9	J	YES	YES	380	J	YES	YES
Iron	mg/kg	35267	NA	13300				12800				18400			
Lead	mg/kg	37.82	30.2	495	J	YES	YES	432	J	YES	YES	605	J	YES	YES
Magnesium	mg/kg	905.94	NA	256				133				291			
Manganese	mg/kg	712.31	NA	197				114				181			
Nickel	mg/kg	13.02	15.9	2.83				2.43	J			4.95			
Potassium	mg/kg	1013.48	NA	906				622	J			1140		YES	
Selenium	mg/kg	0.72	NA	ND				ND							
Sodium	mg/kg	692.29	NA	31.5	J			28	J			39.7	J		
Vanadium	mg/kg	40.87	NA	12.7				10.5				12.9			
Zinc	mg/kg	52.74	124	15.2	J			10.1	J			21	J		
pH :															
pH	Std	NA	NA	5.05				5				5.41			
TOTAL ORGANIC CARBON :															
Total Organic Carbon	mg/kg	NA	NA	1170	J			370	J			770	J		
VOLATILE ORGANIC COMPOUNDS :															
2-Butanone	mg/kg	NA	0.13696	ND				ND							
Acetone	mg/kg	NA	0.45337	0.05	J			0.044				0.074			
Methylene chloride	mg/kg	NA	1.26	ND				0.0031	B			0.0031	B		
Toluene	mg/kg	NA	0.67	ND				ND							
Trichlorofluoromethane	mg/kg	NA	0.00307	0.0033	J		YES	0.0021	J						
p-Cymene	mg/kg	NA	NA	ND				ND							

[a] BTV - Background. Concentration listed is two times the arithmetic mean of background metals concentration (SAIC, 1998).

[b] Ecological screening value (ESV) as given in IT Corporation (2000),
Final Human Health and Ecological Screening Values and PAH Background Summary Report, Fort McClellan, Calhoun County, Alabama, July.

B - Analyte detected in laboratory or field blank at concentration greater than the reporting limit (and greater than zero).

J - Compound was positively identified; reported value is an estimated concentration.

mg/kg - Milligrams per kilogram.

NA - Not available.

ND - Not detected.

DV - Data validation qualifier.

Table 5-5

Surface Soil COPEC Concentrations and Earthworm Toxicity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Antimony Conc. in Surface Soil (mg/kg - dry wt.)	Copper Conc. in Surface Soil (mg/kg - dry wt.)	Lead Conc. in Surface Soil (mg/kg - dry wt.)	Zinc Conc. in Surface Soil (mg/kg - dry wt.)	Toxicity Test Endpoints		
						14-Day Earthworm Survival (percent)	28-Day Earthworm Survival (percent)	Earthworm Growth (% wt. change)
ARTIFICIAL LABORATORY SOIL	ABC CONTROL							
HR-70Q-SS01-SS-RW0001-REG	RW0001	92.2	509	10600	139	100	24 *	-87 *
SAR-85-SS37-SS-RW0002-REG	RW0002	187	711	22600	116	80 *	0 *	-100 *
SAR-85-SS34-SS-RW0004-REG	RW0004	112	508	14900	128	100	96	-49 *
SAR-71-SS05-SS-RW0005-REG	RW0005	ND	62.2	779	35.1	98	82	-55 *
SAR-71-SS09-SS-RW0006-REG	RW0006	ND	34.9	480	39.3	100	100	-23
LMBC-REF1-SS-RW0007-REG	RW0007	ND	5.91	16.5	18.3	98	98	-8
LMBC-REF2-SS-RW0008-REG	RW0008	ND	4.25	38.3	19.2	100	100	-10
LMBC-REF3-SS-RW0009-REG	RW0009	ND	7.66	94.4	22.6	100	100	-23
HR-77Q-SS01-SS-RW0010-REG	RW0010	276	3580	20100	281	0 *	0 *	-100 *
SAR-78-SS34-SS-RW0012-REG	RW0012	72.9	1200	15600	153	62 *	2 *	-99 *
SAR-77-SS33-SS-RW0013-REG	RW0013	35.4	908	6860	72.8	36 *	0 *	-100 *
HR-80Q-MW02-SS-RW0014-REG	RW0014	39.5	127	4660	43.9	98	98	-20
SAR-77-SS50-SS-RW0015-REG	RW0015	ND	14.6	156	19.9	100	100	-22
MMBC-REF-SS-RW0016-REG	RW0016	ND	5.86	39.4	20.3	98	98	-17
SAR-85-SS17-SS-RW0017-REG	RW0017	63.3	334	6820	73.1	96	65 *	-67 *
SAR-78-SS25-SS-RW0018-REG	RW0018	298	2280	23100	229	0 *	0 *	-100 *
SAR-78-SS17-SS-RW0019-REG	RW0019	17.9	393	2310	63.9	73 *	2 *	-99 *
SAR-69-SS11-SS-RW0021-REG	RW0021	1620	90	41300	47.3	94 [a]	96 [a]	-37 *
SAR-85-SS02-SS-RW0022-REG	RW0022	ND	93.1	180	71.5	98	96	-16
HMBC-REF-RW0023-REG	RW0023	ND	15.2	49.9	39.6	100	100	-16
SAR-70-SS12-SS-RW0024-REG	RW0024	ND	22.3	142	33.5	92	98	-19
HR-80Q-GP06-SS-RW0025-REG	RW0025	ND	56.2	486	28.1	100	100	-18
SAR-77-SS16-SS-RW0026-REG	RW0026	6.71	61.4	760	27.1	98	98	-20

* - Significant difference in survival or weight change between reference sites and on-site samples.

[a] - 8 living worms were found on day-14 and 9 living worms were found on day-28 of the toxicity test. One living worm was apparently missed when counting day-15 survival rates.

Table 5-6

COPEC Concentrations
in Soil and Earthworm Tissues
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Antimony Conc. in Surface Soil (mg/kg - dry wt.)	Antimony Conc. in Earthworm Tissue (mg/kg - dry wt.)	Copper Conc. in Surface Soil (mg/kg - dry wt.)	Copper Conc. in Earthworm Tissue (mg/kg - dry wt.)	Lead Conc. in Surface Soil (mg/kg - dry wt.)	Lead Conc. in Earthworm Tissue (mg/kg - dry wt.)	Zinc Conc. in Surface Soil (mg/kg - dry wt.)	Zinc Conc. in Earthworm Tissue (mg/kg - dry wt.)
ARTIFICIAL LABORATORY SOIL	ABC CONTROL		ND		9.75		3.8		50.2
HR-70Q-SS01-SS-RW0001-REG	RW0001	92.2	7.36	509	127	10600	2650	139	132
SAR-85-SS37-SS-RW0002-REG	RW0002	187	NA	711	NA	22600	NA	116	NA
SAR-85-SS34-SS-RW0004-REG	RW0004	112	2.46	508	80.7	14900	1140	128	81.2
SAR-71-SS05-SS-RW0005-REG	RW0005	ND	ND	62.2	19.5	779	1070	35.1	83.2
SAR-71-SS09-SS-RW0006-REG	RW0006	ND	ND	34.9	19.4	480	372	39.3	73.8
LMBC-REF1-SS-RW0007-REG	RW0007	ND	ND	5.91	8.91	16.5	10.4	18.3	55
LMBC-REF2-SS-RW0008-REG	RW0008	ND	ND	4.25	9.46	38.3	43.5	19.2	60.4
LMBC-REF3-SS-RW0009-REG	RW0009	ND	ND	7.66	11.6	94.4	68.3	22.6	59.6
HR-77Q-SS01-SS-RW0010-REG	RW0010	276	NA	3580	NA	20100	NA	281	NA
SAR-78-SS34-SS-RW0012-REG	RW0012	72.9	NA	1200	NA	15600	NA	153	NA
SAR-77-SS33-SS-RW0013-REG	RW0013	35.4	NA	908	NA	6860	NA	72.8	NA
HR-80Q-MW02-SS-RW0014-REG	RW0014	39.5	7.24	127	49.6	4660	1100	43.9	67
SAR-77-SS50-SS-RW0015-REG	RW0015	ND	ND	14.6	11.8	156	442	19.9	61
MMBC-REF-SS-RW0016-REG	RW0016	ND	ND	5.86	9.43	39.4	51.9	20.3	51
SAR-85-SS17-SS-RW0017-REG	RW0017	63.3	3.01	334	62.9	6820	1210	73.1	86.2
SAR-78-SS25-SS-RW0018-REG	RW0018	298	NA	2280	NA	23100	NA	229	NA
SAR-78-SS17-SS-RW0019-REG	RW0019	17.9	3.87	393	50.1	2310	1300	63.9	92.4
SAR-69-SS11-SS-RW0021-REG	RW0021	1620	3.92	90	35.1	41300	781	47.3	79.2
SAR-85-SS02-SS-RW0022-REG	RW0022	ND	5.03	93.1	61.6	180	283	71.5	97.5
HMBC-REF-RW0023-REG	RW0023	ND	ND	15.2	16.2	49.9	29.4	39.6	73.5
SAR-70-SS12-SS-RW0024-REG	RW0024	ND	ND	22.3	15.6	142	73.1	33.5	72.4
HR-80Q-GP06-SS-RW0025-REG	RW0025	ND	ND	56.2	20.8	486	619	28.1	67.5
SAR-77-SS16-SS-RW0026-REG	RW0026	6.71	5.15	61.4	39.8	760	792	27.1	70

ND - Not Detected

NA - Not Analyzed due to complete mortality in this sample

Table 5-7

Summary of Grit-Size Particle Analysis
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

			2.8 mm to 4.2 mm Particle Size Fraction					0.8 mm to 2.2 mm Particle Size Fraction				
Range	Sample Location	Sample Identification	Particles Per Gram Soil	Total No. Particles in Gross Sample	No. Lead Particles in Gross Sample	Percent Lead Particles	Percent Non-Lead Particles	Particles Per Gram Soil	Total No. Particles in Gross Sample	No. Lead Particles in Gross Sample	Percent Lead Particles	Percent Non-Lead Particles
IMR	HR-70Q-SS01	RW0001R	0.023	1,672	126.4	7.56	92.44	0.266	22,525	1436.7	6.38	93.62
BGR	SAR-85-SS37	RW0002	0.013	453	18.2	4.02	95.98	0.180	11,817	246.2	2.08	97.92
BGR	SAR-85-SS34	RW0004	0	NC	0	0	100	0.013	10,012	36.3	0.36	99.64
IMR	SAR-71-SS05	RW0005	0.009	317	15.0	4.73	95.27	0.035	6,080	58.2	0.96	99.04
IMR	SAR-71-SS09	RW0006	0.018	923	44.3	4.80	95.20	0.301	29,361	744.8	2.54	97.46
BGR	HR-77Q-SS01	RW0010	0.005	1,247	10.0	0.80	99.20	0.288	72,184	637.0	0.88	99.12
BGR	SAR-78-SS34	RW0012	0	NC	0	0	100	0.002	3,644	6.2	0.17	99.83
BGR	SAR-77-SS33	RW0013	0.019	1,573	47.5	3.02	96.98	0.059	33,044	148.3	0.45	99.55
BGR	HR-80Q-MW02	RW0014	0.001	348	1.9	0.56	99.44	0.007	5,077	13.4	0.26	99.74
BGR	SAR-77-SS50	RW0015	0.003	49	4.2	8.57	91.43	0.022	2,279	35.7	1.56	98.44
BGR	SAR-85-SS17	RW0017	0.001	87	2.3	2.64	97.36	0.008	4,319	15.4	0.36	99.64
BGR	SAR-78-SS25	RW0018	0.001	3,823	5.8	0.15	99.85	0.025	75,946	100.8	0.13	99.87
BGR	SAR-78-SS17	RW0019	0.003	309	7.2	2.33	97.67	0	26,049	163.5	0.63	99.37
IMR	SAR-69-SS11	RW0021	0.010	24	10.9	45.83	54.17	0.151	1,597	166.4	10.42	89.58
BGR	SAR-85-SS02	RW0022	0	NC	0	0	100	0.083	3,064	71.7	2.34	97.66
IMR	SAR-70-SS12	RW0024	0	NC	0	0	100	0	NC	0	0	100
BGR	HR-80Q-GP06	RW0025	0.007	398	12.8	3.22	96.78	0.025	15,392	46.4	0.30	99.70
BGR	SAR-77-SS16	RW0026	0	NC	0	0	100	0	NC	0	0	100
Site-Wide Average			0.009	863	24	4.90	95.10	0.10	20,149	245	1.66	98.34

NC - Not Counted because no bullet fragments were identified in this sample.

Table 5-8

Surface Water COPEC Concentrations and Fathead Minnow and Ceriodaphnid Toxicity Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Copper Conc. in Surface Water (mg/L)	Lead Conc. in Surface Water (mg/L)	Toxicity Test Endpoints			
				7-Day Fathead Minnow Survival (percent)	7-Day Fathead Minnow Growth (grams - dry wt.)	7-Day Ceriodaphnid Survival (percent)	7-Day Ceriodaphnid Reproduction (young/adult)
SAR-85-SW/SD05-SW-RW2001-REG	RW2001	0.0436	0.0321	90	0.0006 *	0 *	0 *
SAR-85-SW/SD07-SW-RW2002-REG	RW2002	0.0527	0.0422	85	0.0004 *	0 *	0 *
SAR-78-SW/SD12-SW-RW2004-REG	RW2004	0.0346	0.0306	93	0.0005 *	0 *	0 *
SAR-85-SW/SD08-SW-RW2005-REG	RW2005	0.0608	0.0462	78 *	0.0005 *	0 *	0 *
SAR-78-SW/SD13-SW-RW2006-REG	RW2006	0.0129	0.0105	95	0.0011	90	46.7
HR-85Q-SW/SD02-SW-RW2007-REG	RW2007	0.0457	0.0361	93	0.0007 *	0 *	0 *
SAR-77-SW/SD15-SW-RW2008-REG	RW2008	0.00767	0.00357	98	0.001	100	53
SAR-78-SW/SD14-SW-RW2009-REG	RW2009	0.0106	0.00762	98	0.001	90	41.9
SAR-77-SW/SD19-SW-RW2010-REG	RW2010	ND	ND	85	0.0009	40 *	26.3 [a]
SAR-77-SW/SD20-SW-RW2011-REG	RW2011	ND	0.00236	100	0.0009	50 *	22.7 [a]
REFST-SW-RW2012-REG	RW2012Ref	ND	ND	98	0.0011	80	30.4

* - Significant difference in survival, weight, or young per adult between reference site and on-site samples. reference site and on-site samples

ND - Not Detected

[a] - Ceriodaphnid reproduction was not evaluated for statistical significance in these samples because survival was significantly reduced.

Table 5-9

Sediment COPEC Concentrations and Chironomid Toxicity
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Arsenic Conc. in Sediment (mg/kg-dry wt.)	Barium Conc. in Sediment (mg/kg-dry wt.)	Copper Conc. in Sediment (mg/kg-dry wt.)	Lead Conc. in Sediment (mg/kg-dry wt.)	Manganese Conc. in Sediment (mg/kg-dry wt.)	Thallium Conc. in Sediment (mg/kg-dry wt.)	Toxicity Test Endpoints	
								10-Day Chironomid Survival (percent)	Chironomid Ash-Free Dry Weight (grams)
HR-78Q-SW/SD01-SD-RW1001-REG	RW1001	2.88	60.9	160	883	298	ND	4 *	0.0004 *
SAR-78-SW/SD10-SD-RW1002-REG	RW1002	6.22	27	202	967	184	ND	18	0.0003 *
SAR-85-SW/SD05-SD-RW1004-REG	RW1004	1.54	17.9	74.9	432	114	ND	15	0.0004 *
SAR-85-SW/SD08-SD-RW1005-REG	RW1005	2.4	32.5	380	605	181	ND	10 *	0.0003 *
SAR-77-SW/SD25-SD-RW1006-REG	RW2006	ND	301	271	1730	91.1	ND	24	0.0004 *
SAR-85-SW/SD02-SD-RW1007-REG	RW2007	2.08	35.6	126	495	197	ND	20	0.0006 *
SAR-77-SW/SD23-SW-RW1008-REG	RW1008	ND	33.4	10.4	76.7	19.9	ND	21	0.0005 *
HR-85Q-SW/SD02-SD-RW1009-REG	RW1009	2.59	36	18.6	247	59.4	ND	20	0.0006
HR-80Q-SW/SD03-SD-RW1010-REG	RW1010	2.39	276	7.1	23.1	1110	ND	16	0.0005
HR-80Q-SW/SD06-SD-RW1011-REG	RW1011	5.06	137	9.06	9.8	322	ND	46	0.0006
REFST-SD-RW1012-REG	RW1012ref	1.3	43.8	2.6	3.99	131	ND	33	0.001

* - Significant difference in survival or weight between reference site and on-site samples.

ND - Not Detected

Table 5-10

COPEC Concentrations in Sediment and Midge Tissue Fort McClellan, Calhoun County, Alabama

Sample Name	Sample ID	Arsenic Conc. in Sediment (mg/kg-dry wt.)	Arsenic Conc. in Midge Tissue (mg/kg-dry wt.)	Barium Conc. in Sediment (mg/kg-dry wt.)	Barium Conc. in Midge Tissue (mg/kg-dry wt.)	Copper Conc. in Sediment (mg/kg-dry wt.)	Copper Conc. in Midge Tissue (mg/kg-dry wt.)	Lead Conc. in Sediment (mg/kg-dry wt.)	Lead Conc. in Midge Tissue (mg/kg-dry wt.)	Manganese Conc. in Sediment (mg/kg-dry wt.)	Manganese Conc. in Midge Tissue (mg/kg-dry wt.)	Thallium Conc. in Sediment (mg/kg-dry wt.)	Thallium Conc. in Midge Tissue (mg/kg-dry wt.)
HR-78Q-SW/SD01-SD-RW1001-REG	RW1001	2.88	2.28	60.9	24.4	160	408	883	1360	298	54.4	ND	3.43
SAR-78-SW/SD10-SD-RW1002-REG	RW1002	6.22	2.8	27	28.3	202	471	967	2880	184	280	ND	ND
SAR-85-SW/SD05-SD-RW1004-REG	RW1004	1.54	2.49	17.9	21.3	74.9	365	432	1710	114	80.6	ND	ND
SAR-85-SW/SD08-SD-RW1005-REG	RW1005	2.4	1.42	32.5	15.2	380	335	605	990	181	128	ND	ND
SAR-77-SW/SD25-SD-RW1006-REG	RW1006	ND	1.34	301	37.5	271	164	1730	681	91.1	27.7	ND	ND
SAR-85-SW/SD02-SD-RW1007-REG	RW1007	2.08	2.01	35.6	35.6	126	617	495	2780	197	228	ND	ND
SAR-77-SW/SD23-SW-RW1008-REG	RW1008	ND	0.337	33.4	44.6	10.4	110	76.7	486	19.9	29.5	ND	ND
HR-85Q-SW/SD02-SD-RW1009-REG	RW1009	2.59	5.38	36	27	18.6	128	247	753	59.4	57.1	ND	ND
HR-80Q-SW/SD03-SD-RW1010-REG	RW1010	2.39	2.12	276	76.2	7.1	83.6	23.1	62.7	1110	383	ND	ND
HR-80Q-SW/SD06-SD-RW1011-REG	RW1011	5.06	2.02	137	113	9.06	35.8	9.8	45.1	322	261	ND	ND
REFST-SD-RW1012-REG	RW1012ref	1.3	1.47	43.8	80.8	2.6	30.4	3.99	20.5	131	321	ND	ND

Table 5-11

Benthic Invertebrate Habitat Assessment
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Location	Habitat Parameter										
	Epifaunal Substrate / Available Cover	Embeddedness	Velocity / Depth Regime	Sediment Deposition	Channel Flow Status	Channel Alteration	Frequency Of Riffles or Bends	Bank Stability [a]	Vegetative Protection [a]	Riparian Vegetative Zone Width [a]	AVERAGE SAMPLE LOCATION SCORE
SAR-85-SD02	13	13	13	18	17	18	13	11	18	18	**15.2** (Sub-Optimal)
HR-85Q-SD02	2	0	2	2	6	6	2	18	18	4	**6.0** (Poor)
SAR-85-SD05	13	13	13	16	17	18	13	14	18	18	**15.3** (Sub-Optimal)
SAR-85-SD08	14	15	11	16	17	18	16	12	18	18	**15.5** (Sub-Optimal)
SAR-78-SD10	16	16	13	16	16	16	16	14	14	6	**14.3** (Sub-Optimal)
HR-78Q-SD01	16	16	11	16	16	16	17	9	7	4	**12.8** (Sub-Optimal)
SAR-77-SD25	7	3	4	3	17	11	4	16	18	6	**8.9** (Poor)
SAR-77-SD23	5	2	7	5	16	16	8	16	16	14	**10.5** (Poor)
HR-80Q-SD03	17	16	14	16	16	17	17	18	10	4	**14.5** (Sub-Optimal)
HR-80Q-SD06	14	16	11	14	14	16	16	16	4	4	**12.5** (Sub-Optimal)
BGR-BERA-REF-SED	16	16	16	15	15	16	17	16	16	4	**14.7** (Sub-Optimal)
AVERAGE HABITAT SCORE :	**12.1**	**11.5**	**10.5**	**12.5**	**15.2**	**15.3**	**12.6**	**14.5**	**14.3**	**9.1**	

Notes :

[a] - Total score for both stream banks.

Habitat Condition Score:

20 - 16 = Optimal

15 - 11 = Sub-Optimal

10 - 6 = Marginal

5 - 0 = Poor

Table 5-12

Benthic Invertebrate Identification Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Class	Order	Family	Common Name	Pollution Tolerance Value	Life Stage	Functional Feeding Group [c]	SAR-85-SW/SD02		HR-85Q-SW/SD02		SAR-85-SW/SD05		SAR-85-SW/SD08	
							riffle/run	CPOM	riffle/run	CPOM	riffle/run	CPOM	riffle/run	CPOM
Oligochaeta	Tubificida	Tubificidae	tubifex worm	10 [a]	adult	gatherer/collector			1					
	Lumbriculida	Lumbriculidae	worm	NA	adult	gatherer/collector								
Insecta	Ephemeroptera	Heptageniidae	mayfly	4 [b]	nymph	scraper								
	Odonata	Cordulegastridae	dragonfly	3 [b]	nymph	predator	1		1					
		Gomphidae	dragonfly	1 [b]	nymph	predator								
		Calopterygidae	damselfly	5 [b]	nymph	predator								
	Plecoptera	Perlodidae	stonefly	2 [b]	nymph	predator	9							
		Peltoperlidae	stonefly	NA	nymph	shredder								
	Hemiptera	Gerridae	water strider	NA	adult	predator								
	Trichoptera	Hydropsychidae	caddisfly	4 [b]	larva	filterer/collector	1		1	1	1			
		Limniphilidae	caddisfly	4 [b]	larva	shredder								
		Philopotamidae	caddisfly	3 [b]	larva	filterer/collector								
	Coleoptera	Elmidae	beetle	4 [b]	larva	gatherer/collector					1			
	Diptera	not determined	fly	NA	larva	NA								
		Tabanidae	horsefly	6 [b]	larva	predator			1					
		Tipulidae	cranefly	3 [b]	larva	shredder					1			
		Tanypodinae	midge	6 [b]	larva	predator			4		4	1		2
		Chironominae	midge	8 [b]	larva	gatherer/collector		15	2		1		1	4
		Ptychopteridae	phantom cranefly	NA	larva	gatherer/collector								
		Simuliidae	blackfly	6 [b]	larva	filterer/collector			1					
Crustacea	Isopoda	Asellidae	isopod	8 [a]	adult	gatherer/collector								
	Decapoda	Cambaridae	crayfish	6 [a]	juvenile	shredder					1			
						TOTAL INDIVIDUALS	11	15	11	1	9	1	1	6

[a] Bode, R.W., 1988. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. New York State Department of Environmental Conservation.
[b] Hilsenhoff, W.L., 1988. Rapid Field Assessment of Organic Pollution with a Family Level Biotic Index. *Journal of the North American Benthological Society*, Vol. 7(1): 65-68
[c] Merritt, R.W. and K.W. Cummins (eds.), 1984. *An Introduction to the Aquatic Insects of North America, 2nd ed*. Kendall/Hunt Publishing Company, Dubuque, IA.
NA - not available

Table 5-12

Benthic Invertebrate Identification Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Class	Order	Family	Common Name	Pollution Tolerance Value	Life Stage	Functional Feeding Group [c]	SAR-78-SW/SD10		HR-78Q-SW/SD01		SAR-77-SW/SD25		SAR-77-SW/SD23	
							riffle/run	CPOM	riffle/run	CPOM	riffle/run	CPOM	riffle/run	CPOM
Oligochaeta	Tubificida	Tubificidae	tubifex worm	10 [a]	adult	gatherer/collector							13	2
	Lumbriculida	Lumbriculidae	worm	NA	adult	gatherer/collector					1			
Insecta	Ephemeroptera	Heptageniidae	mayfly	4 [b]	nymph	scraper							2	
	Odonata	Cordulegastridae	dragonfly	3 [b]	nymph	predator					1	3	1	
		Gomphidae	dragonfly	1 [b]	nymph	predator			1		1			
		Calopterygidae	damselfly	5 [b]	nymph	predator						1		
	Plecoptera	Perlodidae	stonefly	2 [b]	nymph	predator			2			2		2
		Peltoperlidae	stonefly	NA	nymph	shredder				1				
	Hemiptera	Gerridae	water strider	NA	adult	predator	1							
	Trichoptera	Hydropsychidae	caddisfly	4 [b]	larva	filterer/collector	1	3	1		4	1	16	
		Limniphilidae	caddisfly	4 [b]	larva	shredder			1	1	1			
		Philopotamidae	caddisfly	3 [b]	larva	filterer/collector								
	Coleoptera	Elmidae	beetle	4 [b]	larva	gatherer/collector								
	Diptera	not determined	fly	NA	larva	NA								
		Tabanidae	horsefly	6 [b]	larva	predator								
		Tipulidae	cranefly	3 [b]	larva	shredder			1				1	
		Tanypodinae	midge	6 [b]	larva	predator		2	2		19	27		
		Chironominae	midge	8 [b]	larva	gatherer/collector		2		11	51	38	7	
		Ptychopteridae	phantom cranefly	NA	larva	gatherer/collector								1
		Simuliidae	blackfly	6 [b]	larva	filterer/collector				8				
Crustacea	Isopoda	Asellidae	isopod	8 [a]	adult	gatherer/collector							1	
	Decapoda	Cambaridae	crayfish	6 [a]	juvenile	shredder								
						TOTAL INDIVIDUALS	2	7	8	21	78	72	41	5

[a] Bode, R.W., 1988. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. New York Sta
[b] Hilsenhoff, W.L., 1988. Rapid Field Assessment of Organic Pollution with a Family Level Biotic Index. *Journal of the*
[c] Merritt, R.W. and K.W. Cummins (eds.), 1984. *An Introduction to the Aquatic Insects of North America, 2nd ed*. Ke
NA - not available

Table 5-12

Benthic Invertebrate Identification Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Class	Order	Family	Common Name	Pollution Tolerance Value	Life Stage	Functional Feeding Group [c]	HR-80Q-SW/SD03		HR-80Q-SW/SD06		REFST	
							riffle/run	CPOM	riffle/run	CPOM	riffle/run	CPOM
Oligochaeta	Tubificida	Tubificidae	tubifex worm	10 [a]	adult	gatherer/collector						
	Lumbriculida	Lumbriculidae	worm	NA	adult	gatherer/collector						
Insecta	Ephemeroptera	Heptageniidae	mayfly	4 [b]	nymph	scraper					2	
	Odonata	Cordulegastridae	dragonfly	3 [b]	nymph	predator						
		Gomphidae	dragonfly	1 [b]	nymph	predator						
		Calopterygidae	damselfly	5 [b]	nymph	predator						
	Plecoptera	Perlodidae	stonefly	2 [b]	nymph	predator	3				1	
		Peltoperlidae	stonefly	NA	nymph	shredder			19	4	1	38
	Hemiptera	Gerridae	water strider	NA	adult	predator						
	Trichoptera	Hydropsychidae	caddisfly	4 [b]	larva	filterer/collector		4	19	1	10	
		Limniphilidae	caddisfly	4 [b]	larva	shredder						
		Philopotamidae	caddisfly	3 [b]	larva	filterer/collector					4	
	Coleoptera	Elmidae	beetle	4 [b]	larva	gatherer/collector						
	Diptera	not determined	fly	NA	larva	NA					1	2
		Tabanidae	horsefly	6 [b]	larva	predator						
		Tipulidae	cranefly	3 [b]	larva	shredder						
		Tanypodinae	midge	6 [b]	larva	predator	1	2				1
		Chironominae	midge	8 [b]	larva	gatherer/collector	3				4	1
		Ptychopteridae	phantom cranefly	NA	larva	gatherer/collector						
		Simuliidae	blackfly	6 [b]	larva	filterer/collector						2
Crustacea	Isopoda	Asellidae	isopod	8 [a]	adult	gatherer/collector			21	2	2	5
	Decapoda	Cambaridae	crayfish	6 [a]	juvenile	shredder						
						TOTAL INDIVIDUALS	7	6	59	7	25	49

[a] Bode, R.W., 1988. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. New York Sta
[b] Hilsenhoff, W.L., 1988. Rapid Field Assessment of Organic Pollution with a Family Level Biotic Index. *Journal of the*
[c] Merritt, R.W. and K.W. Cummins (eds.), 1984. *An Introduction to the Aquatic Insects of North America, 2nd ed*. Ke
NA - not available

Table 5-13

Rapid Bioassessment Metric Results
Fort McClellan, Calhoun County, Alabama

Sample Location	Metric								Total Score[c]	Percent Comparison to Reference Site	Biological Condition[d]
	Taxa Richness[e]	Modified Family Biotic Index[f]	Ratio of Scrapers and Filterers[e]	Ratio of EPT and Chironomidae[e]	Percent Contribution of Dominant Taxon[g]	EPT Index[e]	Community Similarity Index[h]	Ratio of Shredders and Total Organisms[e]			
SAR-85-SW/SD02	3	2.27	0	0	82	2	2	0			
% COMPARISON TO REFERENCE	38	100	0	0	82	40	-	0			
score[d]	0	6	0	0	0	0	3	0	9	19	severe
HR-85Q-SW/SD02	7	6.27	0	0.17	36	1	0.86	0			
% COMPARISON TO REFERENCE	88	77	0	3.7	36	20	-	0			
score[d]	6	3	0	0	3	0	3	0	15	32	moderate
SAR-85-SW/SD05	6	5.4	0	0.2	44	1	1	0.11			
% COMPARISON TO REFERENCE	75	89	0	4.4	44	20	-	14			
score[d]	3	6	0	0	3	0	3	0	15	32	moderate
SAR-85-SW/SD08	1	8	0	0	100	0	7	0			
% COMPARISON TO REFERENCE	13	60	0	0	100	0	-	0			
score[d]	0	3	0	0	0	0	0	0	3	6	severe
SAR-78-SW/SD10	2	4	0	0.5	50	1	3.5	0			
% COMPARISON TO REFERENCE	25	100	0	11	50	20	-	0			
score[d]	0	6	0	0	3	0	3	0	12	25	moderate
HR-78Q-SW/SD01	6	3.5	0	2	25	3	1	0.09			
% COMPARISON TO REFERENCE	75	100	0	44	25	60	-	12			
score[d]	3	6	0	3	6	0	3	0	21	44	moderate
SAR-77-SW/SD25	7	7	0	0.07	65	2	0.86	0.01			
% COMPARISON TO REFERENCE	88	69	0	1.6	65	40	-	1.3			
score[d]	6	3	0	0	0	0	3	0	12	25	moderate
SAR-77-SW/SD23	7	6.63	0.125	2.29	39	1	0.57	0.02			
% COMPARISON TO REFERENCE	88	72	89	51	39	20	-	2.5			
score[d]	6	3	6	3	3	0	3	0	24	50	moderate
HR-80Q-SW/SD03	3	5.14	0	0.75	43	1	2	0			
% COMPARISON TO REFERENCE	38	93	0	17	43	20	-	0			
score[d]	0	6	0	0	3	0	3	0	12	25	moderate
HR-80Q-SW/SD06	3	6.1	0	0	36	2	1.7	0.57			
% COMPARISON TO REFERENCE	38	79	0	0	36	40	-	73			
score[d]	0	3	0	0	3	0	3	6	15	31	moderate
REFST	8	4.8	0.14	4.5	40	5	NA	0.78			
score[d]			6	6	6	6	6	6	48	100	NA

Notes

[a] Index not calculable, no Chironomidae in sample.

[b] Shredders were not present in the CPOM sample, but were present in the riffle/run sample. Data from riffle/run sample used in calculation.

[c] Sum of all metrics.

[d] Obtained from Figure 6.2.3 (Barbour, et al., 1989).

[e] Score is a ratio of study site to reference site x 100.

[f] Score is a ratio of reference site to study site x 100.

[g] Scoring criteria evaluate actual percent contribution, not percent comparability to reference station.

[h] Range of values obtained. The comparison to reference is incorporated into this calculation.

Table 6-1

Site Specific Soil Toxicity Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

	Apparent Effects Threshold (AET) (mg/kg)	No Observable Effect Concentration (NOEC) (mg/kg)	Lowest Observable Effect Concentration (LOEC) (mg/kg)	Uncertainty Range (mg/kg)	Relative Predictability of AET		Relative Predictability of LOEC	
					False Positives	False Negatives	False Positives	False Negatives
14-Day Earthworm Survival								
Antimony	>1,620	6.7	17.9	17.9 - 1,620				
Copper	711	334	393	393 - 711				
Lead	15,600	779	2,310	2,310 - 15,600				
Zinc	153	47.3	63.9	63.9 - 153				
28-Day Earthworm Survival								
Antimony	>1,620	6.7	17.9	17.9 - 1,620				
Copper	509	127	334	334 - 509				
Lead	15,600	779	2,310	2,310 - 15,600				
Zinc	139	47.3	63.9	63.9 - 128				
28-Day Earthworm Weight Loss								
Antimony	Not Applicable - Antimony inversely related to toxic effects							
Copper	334	61.4	62.2	62.2 - 127	0	2	1	0
Lead	6,820	760	779	770 - 4,660	0	6	2	0
Zinc	72.8	33.5	35.1	35.1 - 71.50	0	3	4	0

Table 6-2

Terrestrial Foodweb Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
White-Footed Mouse	*Peromyscus leucopus*	Omnivorous Mammal	1 (b)	0.0225 (b)	0.19 (a)	0.1237 (a)	0.00247 (a)	0.254 0.746	Terrestrial Invertebrates Terrestrial Vegetation
American Robin	*Turdus migratorius*	Omnivorous Bird	0.61 (a)	0.081 (a)	0.14 (a)	0.1816 (a)	0.00363 (c)	0.375 0.625	Terrestrial Invertebrates Terrestrial Vegetation
Short-Tailed Shrew	*Blarina brevicauda*	Invertivorous Mammal	0.964 (a)	0.0168 (a)	0.223 (a)	0.0899 (a)	0.00216 (a)	0.887 0.113	Terrestrial Invertebrates Terrestrial Vegetation
American Woodcock	*Scolopax minor*	Invertivorous Bird	61.3 (a)	0.169 (a)	0.1 (a)	0.1517 (a)	0.0158 (a)	0.950 0.050	Terrestrial Invertebrates Terrestrial Vegetation

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a

b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.

c Assumed value based on soil ingestion values for other birds presented in USEPA (1993).

Soil ingestion rates (dry weight) were calculated using the following relationship: $IR_{soil} = IR_{food} \times Diet_{soil}$

where:

IR_{soil} = ingestion rate of soil (kg/kg/day, dry weight);

IR_{food} = food ingestion rate (kg/kg/day, dry weight); and

$Diet_{soil}$ = percentage of diet that is soil (percent).

Table 6-3

Biological Fate and Transport Properties for the Constituents of Potential Ecological Concern in the Terrestrial Foodweb Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituents of Potential Ecological Concern	CAS Number	Molecular Weight	Henry's Law Constant (atm/m^3-$mole^{-1}$)	Octanol-Water Partition Coefficient (log K_{ow}) (M_{oct}/M_{water})	Organic Carbon Partition Coefficient (log K_{oc}) (L/kg)	Soil to Plant BAF (unitless)	Soil to Invertebrate BAF (unitless)
Inorganic Constituents :							
Antimony	7440-36-0	121.75	0.00E+00	NA	NA	0.2 [1]	0.22 [1]
Copper	7440-50-8	63.55	0.00E+00	NA	NA	0.4 [1]	$e^{0.4673 \, Ln(x) + 1.4266}$ [2]
Lead	7439-92-1	207.2	0.00E+00	NA	NA	0.045 [1]	$e^{1.1088 \, Ln(x) - 0.5168}$ [2]
Zinc	7440-66-6	65.39	0.00E+00	NA	NA	1.2E-12 [1]	$e^{0.321 \, Ln(x) + 3.1208}$ [2]

NOTES :

1) USEPA, 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*.

2) Calculated using site-specific soil and earthworm tissue data.

Table 6-4

Exposure Point Concentrations for the
Constituents of Potential Ecological Concern in the Terrestrial Foodweb
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituents Of Potential Ecological Concern	Constituent Concentration													
	Surface Water		Surface Soil [a]		Seeds, Grass, & Fruit [a]		Fruit [a]		Roots & Young Grass [a]		Seeds [a]		Terrestrial Invertebrates [a]	
	Max. Conc. (mg/L)	Mean Conc. (mg/L)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)
Inorganic Constituents :														
Antimony	ND	ND	1.62E+03	1.24E+02	3.24E+02	2.48E+01	3.24E+02	2.48E+01	3.24E+02	2.48E+01	3.24E+02	2.48E+01	3.56E+02	2.73E+01
Copper	6.08E-02	2.70E-02	3.58E+03	4.79E+02	1.43E+03	1.92E+02	1.43E+03	1.92E+02	1.43E+03	1.92E+02	1.43E+03	1.92E+02	1.91E+02	7.45E+01
Lead	4.62E-02	1.96E-02	4.13E+04	7.48E+03	1.86E+03	3.37E+02	1.86E+03	3.37E+02	1.86E+03	3.37E+02	1.86E+03	3.37E+02	7.83E+04	1.18E+04
Zinc	ND	ND	2.81E+02	7.48E+01	3.37E-10	8.98E-11	3.37E-10	8.98E-11	3.37E-10	8.98E-11	3.37E-10	8.98E-11	1.38E+02	9.05E+01

Table 6-5

Maximum Constituent Exposures
for White-Footed Mouse
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS				MAXIMUM CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.62E+03	ND	3.56E+02	3.24E+02	2.40E+00	NA	1.12E+01	2.99E+01	4.35E+01
Copper	3.58E+03	6.08E-02	1.91E+02	1.43E+03	5.31E+00	1.16E-02	5.99E+00	1.32E+02	1.43E+02
Lead	4.13E+04	4.62E-02	7.83E+04	1.86E+03	6.12E+01	8.78E-03	2.46E+03	1.72E+02	2.69E+03
Zinc	2.81E+02	ND	1.38E+02	3.37E-10	4.16E-01	NA	4.35E+00	3.11E-11	4.77E+00

Table 6-6

Maximum Constituent Exposures
for American Robin
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS				MAXIMUM CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg-day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.62E+03	ND	3.56E+02	3.24E+02	3.53E+00	NA	2.43E+01	3.68E+01	6.46E+01
Copper	3.58E+03	6.08E-02	1.91E+02	1.43E+03	7.80E+00	8.51E-03	1.30E+01	1.63E+02	1.83E+02
Lead	4.13E+04	4.62E-02	7.83E+04	1.86E+03	9.00E+01	6.47E-03	5.33E+03	2.11E+02	5.63E+03
Zinc	2.81E+02	ND	1.38E+02	3.37E-10	6.12E-01	NA	9.43E+00	3.83E-11	1.00E+01

Table 6-7

Maximum Constitient Exposures
for Short-Tailed Shrew
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS				MAXIMUM CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.62E+03	ND	3.56E+02	3.24E+02	2.10E+00	NA	2.84E+01	3.29E+00	3.38E+01
Copper	3.58E+03	6.08E-02	1.91E+02	1.43E+03	4.64E+00	1.36E-02	1.52E+01	1.45E+01	3.44E+01
Lead	4.13E+04	4.62E-02	7.83E+04	1.86E+03	5.35E+01	1.03E-02	6.24E+03	1.89E+01	6.32E+03
Zinc	2.81E+02	ND	1.38E+02	3.37E-10	3.64E-01	NA	1.10E+01	3.43E-12	1.14E+01

Table 6-8

Maximum Constituent Exposures
for American Woodcock
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS				MAXIMUM CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.62E+03	ND	3.56E+02	3.24E+02	3.69E+00	NA	1.23E+01	5.90E-01	1.66E+01
Copper	3.58E+03	6.08E-02	1.91E+02	1.43E+03	8.15E+00	1.46E-03	6.59E+00	2.61E+00	1.73E+01
Lead	4.13E+04	4.62E-02	7.83E+04	1.86E+03	9.40E+01	1.11E-03	2.71E+03	3.38E+00	2.81E+03
Zinc	2.81E+02	ND	1.38E+02	3.37E-10	6.39E-01	NA	4.79E+00	6.14E-13	5.43E+00

Table 6-9

Mean Constituent Exposures
for White-Footed Mouse
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS				MEAN CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg - day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.24E+02	ND	2.73E+01	2.48E+01	1.84E-01	NA	8.58E-01	2.29E+00	3.33E+00
Copper	4.79E+02	2.70E-02	7.45E+01	1.92E+02	7.10E-01	5.13E-03	2.34E+00	1.77E+01	2.07E+01
Lead	7.48E+03	1.96E-02	1.18E+04	3.37E+02	1.11E+01	3.72E-03	3.70E+02	3.11E+01	4.12E+02
Zinc	7.48E+01	ND	9.05E+01	8.98E-11	1.11E-01	NA	2.84E+00	8.28E-12	2.96E+00

Table 6-10

Mean Constituent Exposures
for American Robin
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS				MEAN CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg-day)	Surface Water (mg/kg-day)	Terrestrial Invertebrates (mg/kg-day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.24E+02	ND	2.73E+01	2.48E+01	2.70E-01	NA	1.86E+00	2.82E+00	4.95E+00
Copper	4.79E+02	2.70E-02	7.45E+01	1.92E+02	1.04E+00	3.78E-03	5.07E+00	2.18E+01	2.79E+01
Lead	7.48E+03	1.96E-02	1.18E+04	3.37E+02	1.63E+01	2.74E-03	8.02E+02	3.82E+01	8.57E+02
Zinc	7.48E+01	ND	9.05E+01	8.98E-11	1.63E-01	NA	6.17E+00	1.02E-11	6.33E+00

Table 6-11

Mean Constituent Exposures
for Short-Tailed Shrew
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS				MEAN CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.24E+02	ND	2.73E+01	2.48E+01	1.61E-01	NA	2.18E+00	2.52E-01	2.59E+00
Copper	4.79E+02	2.70E-02	7.45E+01	1.92E+02	6.21E-01	6.02E-03	5.94E+00	1.95E+00	8.52E+00
Lead	7.48E+03	1.96E-02	1.18E+04	3.37E+02	9.70E+00	4.37E-03	9.39E+02	3.42E+00	9.52E+02
Zinc	7.48E+01	ND	9.05E+01	8.98E-11	9.69E-02	NA	7.22E+00	9.12E-13	7.32E+00

Table 6-12

Mean Constituent Exposures
for American Woodcock
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS				MEAN CONSTITUENT DOSES				
	Soil (mg/kg)	Surface Water (mg/L)	Terrestrial Invertebrates (mg/kg)	Terrestrial Vegetation (mg/kg)	Soil (mg/kg - day)	Surface Water (mg/kg - day)	Terrestrial Invertebrates (mg/kg - day)	Terrestrial Vegetation (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :									
Antimony	1.24E+02	ND	2.73E+01	2.48E+01	2.82E-01	NA	9.44E-01	4.52E-02	1.27E+00
Copper	4.79E+02	2.70E-02	7.45E+01	1.92E+02	1.09E+00	6.48E-04	2.58E+00	3.49E-01	4.02E+00
Lead	7.48E+03	1.96E-02	1.18E+04	3.37E+02	1.70E+01	4.70E-04	4.07E+02	6.13E-01	4.25E+02
Zinc	7.48E+01	ND	9.05E+01	8.98E-11	1.70E-01	NA	3.13E+00	1.63E-13	3.30E+00

Table 6-13

Avian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents :										
Antimony	Red-winged Blackbird	Mortality	100	900	0.111	3	100	180	0.556	3
Copper	1-Day old chicks	Growth & Mortality	46.97	1	46.97	2	61.72	1	61.72	2
Lead	American Kestrel & Japanese Quail	Reproduction	3.85	1	3.85	5	11.3	1	11.30	1
Zinc	Leghorn hen	Reproduction	130.9	1	130.9	4	130.9	0.1	1310	4

NOTES :

1) Edens, F., W.E. Benton, S.J. Bursian, and G.W. Morgan, 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, Coturnix coturnix japonica." *Toxicol. Appl. Pharmacol*., 38: 307-314.
2) Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus, 1960. "The Tolerance of Growing Chickens for Dietary Copper." Poultry Science, Vol. 39, pp. 713-719.
3) Schafer, E.W., W.A. Bowles, and J. Hurlbut, 1983. The Acute Oral Toxicity, Repellency, and Hazard Potential of 998 Chemicals to One or More Species of Wild and Domestic Birds. *Arch. Environ Contam. Toxicol*. 12(3): 355-382. As cited in: Hazardous Substances Databank. January 1995.
4) Stahl, J.L., J.L. Greger, and M.E. Cook, 1990. "Breeding-Hen and Progeny Performance When Hens are Fed Excessive Dietary Zinc." Poultry Science, Vol. 69, pp. 259-263.
5) Pattee, O.H., 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Arch. Environ. Contam. Toxico*l., 13: 213-218.

Table 6-14

Mammalian Toxicity Reference Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents :										
Antimony	Mouse	Longevity	1.25	10	0.125	5	1.25	1	1.25	5
Copper	Mink	Reproduction	12	1	12	1	15.4	1	15.4	1
Lead	Rat	Reproduction	8	1	8	2	80	1	80	2
Zinc	Mouse & Rat	Growth & Reproduction	104	10	10.4	3	320	1	320	4

NOTES :

1) Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano, 1982. "Effects of Supplemental Dietary Copper on Growth, Reproductive Performance, and Kit Survival of Standard Dark Mink and the Acute Toxicity of Copper to Mink." Journal of Animal Science, Vol. 55, pp. 337-343.
2) Azar, A. H.J. Trochimowicz, and M.E. Maxwell, 1973. "Review of Lead Studies in Animals Carried Out at Haskell Laboratory: Two-Year Feeding Study and Response to Hemorrhage Study." *In: Environmental Health Aspects of Lead: Proceedings, International Symposium*. D. Barth, et al., eds. Commission of Europen Communities, pp. 199-210.
3) Maita, K., M. Hirano, K. Mitsumori, K. Takabashi, and Y. Shirasu, 1981. "Subacute Toxicity Studies with Zinc Sulfate in Mice and Rats. " *Journal of Pesticide Science*, Vol. 6, pp. 327-336.
4) Schlicker, S.A. and D.H. Cox, 1968. "Maternal Dietary Zinc, and Development and Zinc, Iron, and Copper Content of the Rat Fetus." *J. Nutr.*, 95:: 287-294.
5) Schroeder, H.A., M. Mitchener, J.J. Balassa, M. Kanisawa, and A.P. Nason, 1968. "Zirconium, Niobium, Antimony, and Fluorine, in Mice: Effects on Growth, Survival, and Tissue Levels." *J. Nutr.*, 95: 95-101.

Table 6-15

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for White-Footed Mouse
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	4.35E+01	1.25E-01	1.25E+00	3.48E+02	3.48E+01	Yes
Copper	1.43E+02	1.20E+01	1.54E+01	1.20E+01	9.32E+00	Yes
Lead	2.69E+03	8.00E+00	8.00E+01	3.37E+02	3.37E+01	Yes
Zinc	4.77E+00	1.04E+01	3.20E+02	4.58E-01	1.49E-02	No

Table 6-16

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for American Robin
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	6.46E+01	1.11E-01	5.56E-01	5.81E+02	1.16E+02	Yes
Copper	1.83E+02	4.70E+01	6.17E+01	3.90E+00	2.97E+00	Yes
Lead	5.63E+03	3.85E+00	1.13E+01	1.46E+03	4.98E+02	Yes
Zinc	1.00E+01	1.31E+02	1.31E+03	7.67E-02	7.67E-03	No

Table 6-17

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for Short-Tailed Shrew
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	3.38E+01	1.25E-01	1.25E+00	2.70E+02	2.70E+01	Yes
Copper	3.44E+01	1.20E+01	1.54E+01	2.87E+00	2.23E+00	Yes
Lead	6.32E+03	8.00E+00	8.00E+01	7.89E+02	7.89E+01	Yes
Zinc	1.14E+01	1.04E+01	3.20E+02	1.10E+00	3.56E-02	Yes

Table 6-18

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for American Woodcock
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	1.66E+01	1.11E-01	5.56E-01	1.49E+02	2.99E+01	Yes
Copper	1.73E+01	4.70E+01	6.17E+01	3.69E-01	2.81E-01	No
Lead	2.81E+03	3.85E+00	1.13E+01	7.29E+02	2.48E+02	Yes
Zinc	5.43E+00	1.31E+02	1.31E+03	4.15E-02	4.14E-03	No

Table 6-19

Comparison of Mean Constituent Exposures
with Toxicity Reference Values for White-Footed Mouse
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	3.33E+00	1.25E-01	1.25E+00	2.67E+01	2.67E+00	Yes
Copper	2.07E+01	1.20E+01	1.54E+01	1.73E+00	1.35E+00	Yes
Lead	4.12E+02	8.00E+00	8.00E+01	5.15E+01	5.15E+00	Yes
Zinc	2.96E+00	1.04E+01	3.20E+02	2.84E-01	9.24E-03	No

Table 6-20

Comparison of Mean Constituent Exposures with Toxicity Reference Values for American Robin Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	4.95E+00	1.11E-01	5.56E-01	4.45E+01	8.90E+00	Yes
Copper	2.79E+01	4.70E+01	6.17E+01	5.94E-01	4.52E-01	No
Lead	8.57E+02	3.85E+00	1.13E+01	2.22E+02	7.58E+01	Yes
Zinc	6.33E+00	1.31E+02	1.31E+03	4.84E-02	4.83E-03	No

Table 6-21

Comparison of Mean Constituent Exposures with Toxicity Reference Values for Short-Tailed Shrew Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	2.59E+00	1.25E-01	1.25E+00	2.07E+01	2.07E+00	Yes
Copper	8.52E+00	1.20E+01	1.54E+01	7.10E-01	5.53E-01	No
Lead	9.52E+02	8.00E+00	8.00E+01	1.19E+02	1.19E+01	Yes
Zinc	7.32E+00	1.04E+01	3.20E+02	7.04E-01	2.29E-02	No

Table 6-22

Comparison of Mean Constituent Exposures with Toxicity Reference Values for American Woodcock Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Antimony	1.27E+00	1.11E-01	5.56E-01	1.14E+01	2.29E+00	Yes
Copper	4.02E+00	4.70E+01	6.17E+01	8.55E-02	6.51E-02	No
Lead	4.25E+02	3.85E+00	1.13E+01	1.10E+02	3.76E+01	Yes
Zinc	3.30E+00	1.31E+02	1.31E+03	2.52E-02	2.52E-03	No

Table 6-23

Summary of Terrestrial Food Web Hazard Quotients
Assuming Maximum Exposure Point Concentrations
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum White-Footed Mouse Hazard Quotients		Maximum American Robin Hazard Quotients		Maximum Short-Tail Shrew Hazard Quotients		Maximum American Woodcock Hazard Quotients	
	NOAEL-Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients
Inorganic Constituents :								
Antimony	3.48E+02	3.48E+01	5.81E+02	1.16E+02	2.70E+02	2.70E+01	1.49E+02	2.99E+01
Copper	1.20E+01	9.32E+00	3.90E+00	2.97E+00	2.87E+00	2.23E+00	3.69E-01	2.81E-01
Lead	3.37E+02	3.37E+01	1.46E+03	4.98E+02	7.89E+02	7.89E+01	7.29E+02	2.48E+02
Zinc	4.58E-01	1.49E-02	7.67E-02	7.67E-03	1.10E+00	3.56E-02	4.15E-02	4.14E-03

- Indicates a HQ value greater than 1.0.

Table 6-24

Summary of Terrestrial Food Web Hazard Quotients
Assuming Mean Exposure Point Concentrations
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean White-Footed Mouse Hazard Quotients		Mean American Robin Hazard Quotients		Mean Short-Tail Shrew Hazard Quotients		Mean American Woodcock Hazard Quotients	
	NOAEL-Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients
Inorganic Constituents :								
Antimony	2.67E+01	2.67E+00	4.45E+01	8.90E+00	2.07E+01	2.07E+00	1.14E+01	2.29E+00
Copper	1.73E+00	1.35E+00	5.94E-01	4.52E-01	7.10E-01	5.53E-01	8.55E-02	6.51E-02
Lead	5.15E+01	5.15E+00	2.22E+02	7.58E+01	1.19E+02	1.19E+01	1.10E+02	3.76E+01
Zinc	2.84E-01	9.24E-03	4.84E-02	4.83E-03	7.04E-01	2.29E-02	2.52E-02	2.52E-03

- Indicates a HQ value greater than 1.0.

Table 6-25

Risk-Based Remedial Goals for Terrestrial Food Web Exposures
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Receptor	Surface Soil COPECs							
	Antimony		Copper		Lead		Zinc	
	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Soil Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)
White-footed Mouse	4.67	46.7	267	350	205	1,680	1,750	193,000
American Robin	2.8	14	850	1,140	55	147	39,000	555,000
Short-tailed Shrew	6.01	60.1	820	1,185	100	800	215	173,000
American Woodcock	10.85	54.2	11,870	16,200	105.5	280	46,500	550,000

Notes :
Risk-based remedial goals were calculated based on an HQ = 1.0.

Table 6-26

Calculated Risks and Lead Particle Densities
Protective of
Bobwhite Quail and Wild Turkey
Fort McClellan, Calhoun County, Alabama

Location	Northern Bobwhite Quail			Eastern Wild Turkey		
	Grit Retention Time (days)	Probability of Bobwhite Quail Ingesting Lead Particle	Acceptable Lead Particle Density [1] (fragments/ft^2)	Grit Retention Time (days)	Probability of Wild Turkey Ingesting Lead Particle	Acceptable Lead Particle Density [1] (fragments/ft^2)
IMR Ranges :	10	0.7455	54.60	42	0.045	204.53
	83	0.152	452.14			
	156	0.084	846.26			
BGR Ranges :	10	0.9529	24.58	42	0.129	68.26
	83	0.3079	203.50			
	156	0.1778	380.82			

NOTES :

[1] Acceptable bullet fragment densities calculated using the input parameters summarized in letter report to Doyle Brittain (USEPA Region 4) from Ron Levy (U.S. Army) dated 18 September, 2003.

number of grit-size particles (turkey) per sample at the IMR and BGR ranges range from 24 to 3,823; mean = 863.

number of grit-size particles (bobwhite) per sample at the IMR and BGR ranges range from 1,597 to 75,946; mean = 20,149.

mean percent lead particles in 0.8 - 2.2 mm size range (bobwhite) at IMR and BGR ranges = 1.66%

mean percent lead particles in 2.8 - 4.2 mm size range (turkey) at IMR and BGR ranges = 4.9%

Table 6-27

Site Specific Surface Water Toxicity Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

	Apparent Effects Threshold (AET) (mg/L)	No Observable Effect Concentration (NOEC) (mg/L)	Lowest Observable Effect Concentration (LOEC) (mg/L)	Uncertainty Range (mg/L)	Relative Predictability of AET		Relative Predictability of LOEC	
					False Positives	False Negatives	False Positives	False Negatives
7-Day Fathead Minnow Survival								
Copper	0.0608	0.0527	0.0608	NA				
Lead	0.0462	0.0422	0.0462	NA				
7-Day Fathead Minnow Growth								
Copper	0.0346	0.0129	0.0346	NA	0	0	0	0
Lead	0.0306	0.0105	0.0306	NA	0	0	0	0
7-Day Ceriodaphnid Reproduction								
Copper	0.0346	0.0129	0.0346	NA	0	0	0	0
Lead	0.0306	0.0105	0.0306	NA	0	0	0	0
7-Day Ceriodaphnid Survival								
Copper	0.0346	0.0129	0.0346	NA	0	0	0	0
Lead	0.0306	ND	0.00236	NA	0	0	0	0

Table 6-28

Site Specific Sediment Toxicity Values
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

	Apparent Effects Threshold (AET) (mg/kg)	No Observable Effect Concentration (NOEC) (mg/kg)	Lowest Observable Effect Concentration (LOEC) (mg/kg)	Uncertainty Range (mg/kg)	Relative Predictability of AET		Relative Predictability of LOEC	
					False Positives	False Negatives	False Positives	False Negatives
10-Day Chironomid Survival								
Arsenic	Not Applicable - Weak and/or inverse correlations							
Barium	Not Applicable - Weak and/or inverse correlations							
Copper	380	126	160	160 - 271				
Lead	>1,730	495	605	605 - 1,730				
Manganese	Not Applicable - Weak and/or inverse correlations							
10-Day Chironomid Growth								
Arsenic	Not Applicable - Weak and/or inverse correlations							
Barium	Not Applicable - Weak and/or inverse correlations							
Copper	74.9	9.06	10.4	10.4 - 18.6	0	1	1	0
Lead	432	23.1	76.7	76.7 - 247	0	1	1	0
Manganese	Not Applicable - Weak and/or inverse correlations							

Table 6-29

Benthic Invertebrate Community Bioassessment Results and Sediment COPEC Concentrations
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Sample Location	Rapid Bioassessment		Sediment COPEC Concentrations (mg/kg)						Benthic Habitat Assessment
	Score	Biological Condition	Arsenic	Barium	Copper	Lead	Manganese	Thallium	
SAR-85-SD02	9	severely impaired	2.08	35.6	126 *	495 *	197	ND	Sub-Optimal
HR-85Q-SD02	15	moderately impaired	2.59	36	18.6	247 *	59.4	ND	Poor
SAR-85-SD05	15	moderately impaired	1.54	17.9	74.9 *	432 *	114	ND	Sub-Optimal
SAR-85-SD08	3	severely impaired	2.4	32.5	380 *	605 *	181	ND	Sub-Optimal
SAR-78-SD10	12	moderately impaired	6.22	27	202 *	967 *	184	ND	Sub-Optimal
HR-78Q-SD01	21	moderately impaired	2.88	60.9	160 *	883 *	298	ND	Sub-Optimal
SAR-77-SD25	12	moderately impaired	ND	301 *	271 *	1730 *	91.1	ND	Poor
SAR-77-SD23	24	moderately impaired	ND	33.4	10.4	76.7 *	19.9	ND	Poor
HR-80Q-SD03	12	moderately impaired	2.39	276 *	7.1	23.1	1110 *	ND	Sub-Optimal
HR-80Q-SD06	15	moderately impaired	5.06	137 *	9.06	9.8	322	ND	Sub-Optimal
BGR-BERA-REF-SED	48	NA	1.3	43.8	2.6	3.99	131	ND	Sub-Optimal

Notes:
Values shown with shading and an asterisk exceed the ESV and/or the background threshold value
Ecological screening values: barium = NA, lead = 30.2 mg/kg, copper = 18.7 mg/kg, manganese = NA
Calculated background threshold values: barium = 98.9 mg/kg, copper = 17.1 mg/kg, lead = 37.8 mg/kg, manganese = 712 mg/kg

Table 6-30

Riparian Foodweb Indicator Species Life History Parameters
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Common Name	Scientific Name	Feeding Guild	Foraging Area (acres)	Area Use Factor (unitless)	Body Weight (kg)	Water Ingestion Rate (L/kg/day)	Food Ingestion Rate (kg/kg/day-dry wt.)	Soil / Sediment Ingestion Rate (kg/kg/day-dry wt.)	Dietary Fraction	Dietary Component
Little Brown Bat	*Myotis lucifugus*	Invertivorous Mammal	40 (c)	0.5	0.0080 (b)	0.16 (e)	0.0699 (d)	NA	1.0	Aquatic Emergent Invertebrates
Marsh Wren	*Cistothorus palustris*	Invertivorous Bird	0.13 (a)	1.0	0.01038 (a)	0.27 (a)	0.1833 (a)	NA	1.0	Aquatic Emergent Invertebrates

Notes:

All of the values presented in this table represent arithmetic mean values if more than one value was presented in the referenced source.

a USEPA, 1993. *Wildlife Exposure Factors Handbook*. EPA/600/R-93/187a
b Burt, W.H. and R.P. Grossenheider. *Mammals, Peterson Field Guide*.
c University of Michigan, 2006. *Spatial Foraging Habits of the Little Brown Bat (Myotis lucifugus) and Northern Long-Eared Bat (Myotis septentrionalis)*.
d Anthony and Kunz, 1977. Feeding Strategies of the Little Brown bat, *Myotis lucifugus*, in Southern New Hampshire.
e Sample, et al., 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants.

Table 6-31

Biological Fate and Transport Properties for the Constituents of Potential Ecological Concern in the Riparian Foodweb Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituents of Potential Ecological Concern	CAS Number	Molecular Weight	Henry's Law Constant (atm/m^3-$mole^{-1}$)	Octanol-Water Partition Coefficient (log K_{ow}) (M_{oct}/M_{water})	Organic Carbon Partition Coefficient (log K_{oc}) (L/kg)	Sediment to Plant BAF (unitless)	Sediment to Invertebrate BAF (unitless)
Inorganic Constituents :							
Arsenic	7440-38-2	74.92	0.00E+00	NA	NA	0.036 [1]	$e^{0.2095 Ln(x) + 0.6143}$ [3]
Barium	7440-39-3	137.33	0.00E+00	NA	NA	0.15 [1]	$e^{0.3665 Ln(x) + 2.1605}$ [3]
Copper	7440-50-8	63.55	0.00E+00	NA	NA	0.4 [1]	$e^{0.5117 Ln(x) + 3.1964}$ [3]
Lead	7439-92-1	207.2	0.00E+00	NA	NA	0.045 [1]	$e^{0.7772 Ln(x) + 2.1714}$ [3]
Manganese	7439-96-5	54.94	0.00E+00	NA	NA	0.250 [2]	$e^{0.6647 Ln(x) +1.4114}$ [3]
Thallium	7440-28-0	204.38	0.00E+00	NA	NA	0.004 [1]	0.22 [1]

NOTES :

1) USEPA, 1999. *Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities*.

2) Baes, C.F., R.D. Sharp, A.L. Sjoreen, and R.W. Shor, 1984. "A Review and Analysis of Parameters for Assessing Transport of Environmentally Released Radionuclides Through Agriculture." U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge TN. ORNL-5786.

3) Calculated using site-specific sediment and chironomid tissue data.

Table 6-32

Exposure Point Concentrations for the
Constituents of Potential Ecological Concern in the Riparian Foodweb
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituents Of Potential Ecological Concern	Constituent Concentration					
	Surface Water		Sediment		Aquatic Invertebrates	
	Max. Conc. (mg/L)	Mean Conc. (mg/L)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)	Max. Conc. (mg/kg)	Mean Conc. (mg/kg)
Inorganic Constituents :						
Arsenic	ND	ND	6.22E+00	3.15E+00	2.71E+00	2.35E+00
Barium	3.39E-02	2.90E-02	3.01E+02	9.57E+01	7.03E+01	4.62E+01
Copper	6.08E-02	2.70E-02	3.80E+02	1.26E+02	5.11E+02	2.90E+02
Lead	4.62E-02	1.96E-02	1.73E+03	5.47E+02	2.88E+03	1.18E+03
Manganese	3.86E-02	1.83E-02	1.11E+03	2.58E+02	4.34E+02	1.64E+02
Thallium	ND	ND	ND	ND	NA	NA

Table 6-33

Maximum Constituent Exposures
for Little Brown Bat
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS			MAXIMUM CONSTITUENT DOSES			
	Sediment (mg/kg)	Surface Water (mg/L)	Aquatic Invertebrates (mg/kg)	Sediment (mg/kg-day)	Surface Water (mg/kg - day)	Aquatic Invertebrates (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :							
Arsenic	6.22E+00	ND	2.71E+00	NA	NA	9.48E-02	9.48E-02
Barium	3.01E+02	3.39E-02	7.03E+01	NA	2.71E-03	2.46E+00	2.46E+00
Copper	3.80E+02	6.08E-02	5.11E+02	NA	4.86E-03	1.79E+01	1.79E+01
Lead	1.73E+03	4.62E-02	2.88E+03	NA	3.70E-03	1.01E+02	1.01E+02
Manganese	1.11E+03	3.86E-02	4.34E+02	NA	3.09E-03	1.52E+01	1.52E+01
Thallium	ND	ND	NA	NA	NA	NA	0.00E+00

Table 6-34

Maximum Constituent Exposures
for Marsh Wren
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MAXIMUM EXPOSURE POINT CONCENTRATIONS			MAXIMUM CONSTITUENT DOSES			
	Sediment (mg/kg)	Surface Water (mg/L)	Aquatic Invertebrates (mg/kg)	Sediment (mg/kg-day)	Surface Water (mg/kg-day)	Aquatic Invertebrates (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :							
Arsenic	6.22E+00	ND	2.71E+00	NA	NA	4.97E-01	4.97E-01
Barium	3.01E+02	3.39E-02	7.03E+01	NA	9.15E-03	1.29E+01	1.29E+01
Copper	3.80E+02	6.08E-02	5.11E+02	NA	1.64E-02	9.36E+01	9.36E+01
Lead	1.73E+03	4.62E-02	2.88E+03	NA	1.25E-02	5.28E+02	5.28E+02
Manganese	1.11E+03	3.86E-02	4.34E+02	NA	1.04E-02	7.95E+01	7.95E+01
Thallium	ND	ND	NA	NA	NA	NA	0.00E+00

Table 6-35

Mean Constituent Exposures
for Little Brown Bat
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS			MEAN CONSTITUENT DOSES			
	Sediment (mg/kg)	Surface Water (mg/L)	Aquatic Invertebrates (mg/kg)	Sediment (mg/kg-day)	Surface Water (mg/kg - day)	Aquatic Invertebrates (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :							
Arsenic	3.15E+00	ND	2.35E+00	NA	NA	8.22E-02	8.22E-02
Barium	9.57E+01	2.90E-02	4.62E+01	NA	2.32E-03	1.61E+00	1.62E+00
Copper	1.26E+02	2.70E-02	2.90E+02	NA	2.16E-03	1.01E+01	1.02E+01
Lead	5.47E+02	1.96E-02	1.18E+03	NA	1.57E-03	4.12E+01	4.12E+01
Manganese	2.58E+02	1.83E-02	1.64E+02	NA	1.46E-03	5.74E+00	5.75E+00
Thallium	ND	ND	NA	NA	NA	NA	0.00E+00

NA - Not Applicable. It is assumed that the little brown bats' diet consists entirely of emergent aquatic invertebrates and the potential for exposure to sediment is minimal.

Table 6-36

Mean Constituent Exposures
for Marsh Wren
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	MEAN EXPOSURE POINT CONCENTRATIONS			MEAN CONSTITUENT DOSES			
	Sediment (mg/kg)	Surface Water (mg/L)	Aquatic Invertebrates (mg/kg)	Sediment (mg/kg-day)	Surface Water (mg/kg-day)	Aquatic Invertebrates (mg/kg-day)	TOTAL (mg/kg - day)
Inorganic Constituents :							
Arsenic	3.15E+00	ND	2.35E+00	NA	NA	4.31E-01	4.31E-01
Barium	9.57E+01	2.90E-02	4.62E+01	NA	7.83E-03	8.46E+00	8.47E+00
Copper	1.26E+02	2.70E-02	2.90E+02	NA	7.29E-03	5.32E+01	5.32E+01
Lead	5.47E+02	1.96E-02	1.18E+03	NA	5.29E-03	2.16E+02	2.16E+02
Manganese	2.58E+02	1.83E-02	1.64E+02	NA	4.94E-03	3.01E+01	3.01E+01
Thallium	ND	ND	NA	NA	NA	NA	0.00E+00

NA - Not Applicable. It is assumed that the marsh wrens' diet consists entirely of emergent aquatic invertebrates and the potential for exposure to sediment is minimal.

Table 6-37

Avian Toxicity Reference Values for Riparian Food Web
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents :										
Arsenic	Brown-headed cowbird	NOAEL	2.46	1	2.46	6	7.38	1	7.38	6
Barium	1-Day old chicks	Mortality	208.26	10	20.83	3	416.53	10	41.65	3
Copper	1-Day old chicks	Growth & Mortality	46.97	1	46.97	2	61.72	1	61.72	2
Lead	American Kestrel & Japanese Quail	Reproduction	3.85	1	3.85	7	11.3	1	11.30	1
Manganese	Japanese quail	Growth	997	1	997	4	997	0.1	9970	4
Thallium	Starling	Mortality	35	100	0.350	5	35	10	3.5	5

NOTES :

1) Edens, F., W.E. Benton, S.J. Bursian, and G.W. Morgan, 1976. "Effect of Dietary Lead on Reproductive Performance in Japanese Quail, Coturnix coturnix japonica." *Toxicol. Appl. Pharmacol*., 38: 307-314.

2) Mehring, A.L., J.H. Brumbaugh, A.J. Sutherland, and H.W. Titus, 1960. "The Tolerance of Growing Chickens for Dietary Copper." Poultry Science, Vol. 39, pp. 713-719.

3) Johnson, D., A.L. Mehring, and H.W. Titus, 1960. "Tolerance of Chickens for Barium." *Proc. Soc. Exp. Biol. Med.*, 104: 436-438.

4) Laskey, J.W. and F.W. Edens, 1985. "Effects of Chronic High-Level Manganese Exposure on Male Behavior in Japanese Quail (*Coturnix coturnix japonica*)." *Poultry Sci*., 64: 579-584.

5) Schafer, E.W., 1972. "The Acute Oral Toxicity of 369 Pesticidal, Pharmaceutical, and Other Chemicals to Wild Birds." *Toxicological and Applied Pharmacology*, Vol. 21, pp. 315-330.

6) U.S. Fish and Wildlife Service, 1969. Bureau of Sport Fisheries and Wildlife. Publication 74, pp. 56-57.

7) Pattee, O.H., 1984. "Eggshell Thickness and Reproduction in American Kestrels Exposed to Chronic Dietary Lead." *Arch. Environ. Contam. Toxicol*., 13: 213-218.

Table 6-38

Mammalian Toxicity Reference Values for Riparian Food Web
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Toxicity Test Receptor	Toxicity Test Endpoint	NOAEL-Based Toxicity Reference Values				LOAEL-Based Toxicity Reference Values			
			Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.	Dose (mg/kg/day)	Uncertainty Factor	TRV (mg/kg/day)	Ref.
Inorganic Constituents :										
Arsenic	Dog	Chronic NOAEL	1.25	1	1.25	6	1.25	0.1	12.5	6
Barium	Rat	Growth, Hypertension	5.1	1	5.1	3	5.1	0.1	51	3
Copper	Mink	Reproduction	12	1	12	1	15.4	1	15.4	1
Lead	Rat	Reproduction	8	1	8	2	80	1	80	2
Manganese	Rat	Reproduction	88	1	88	4	284	1	284	4
Thallium	Rat	Reproduction	1.31	100	0.0131	5	1.31	10	0.131	5

NOTES :

1) Aulerich, R.J., R.K. Ringer, M.R. Bleavins, and A. Napolitano, 1982. "Effects of Supplemental Dietary Copper on Growth, Reproductive Performance, and Kit Survival of Standard Dark Mink and the Acute Toxicity of Copper to Mink." Journal of Animal Science, Vol. 55, pp. 337-343.

2) Azar, A. H.J. Trochimowicz, and M.E. Maxwell, 1973. "Review of Lead Studies in Animals Carried Out at Haskell Laboratory: Two-Year Feeding Study and Response to Hemorrhage Study." *In: Environmental Health Aspects of Lead: Proceedings, International Symposium*. D. Barth, et al., eds. Commission of Europen Communities, pp. 199-210.

3) Perry, H.M., E.F. Perry, M.N. Erlanger, and S.J. Kopp, 1983. "Cardiovascular Effects of Chronic Barium Ingestion." *In: Proc. 17th Annual Conf. Trace Substances in Environ. Healith*, Vol. 17, University of Missouri Press, Columbia, MO.

4) Laskey, J.W., G.L. Rehnberg, J.F. Hein, and S.D. Carter, 1982. "Effects of Chronic Manganese (Mn_3O_4) Exposure on Selected Reproductive Parameters in Rats." J. Toxicol. Environ. Health, 9: 677-687.

5) Formigli, L., R. Scelsi, P. Poggi, C. Gregotti, A. DiNucci, E. Sabbioni, L. Gottardi, and L. Manzo, 1986. "Thallium-Induced Testicular Toxicity in the Rat." *Environ. Res*., 40: 531-539.

6) Byron, W.R., G.W. Bierbower, J.B. Brouwer, and W.H. Hansen, 1967. "Pathological Changes in Rats and Dogs from Two-Year Feeding of Sodium Arsenite or Sodium Arsenate." *Toxicology and Applied Pharmacology*, Vol. 10, pp. 132-147.

Table 6-39

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for Little Brown Bat
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Arsenic	9.48E-02	1.25E+00	1.25E+01	7.58E-02	7.58E-03	No
Barium	2.46E+00	5.10E+00	5.10E+01	4.82E-01	4.82E-02	No
Copper	1.79E+01	1.20E+01	1.54E+01	1.49E+00	1.16E+00	**YES**
Lead	1.01E+02	8.00E+00	8.00E+01	1.26E+01	1.26E+00	**YES**
Manganese	1.52E+01	8.80E+01	2.84E+02	1.72E-01	5.34E-02	No
Thallium	0.00E+00	1.31E-02	1.31E-01	NA	NA	No

Table 6-40

Comparison of Maximum Constituent Exposures
with Toxicity Reference Values for Marsh Wren
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Arsenic	4.97E-01	2.46E+00	7.38E+00	2.02E-01	6.73E-02	No
Barium	1.29E+01	2.08E+01	4.17E+01	6.19E-01	3.09E-01	No
Copper	9.36E+01	4.70E+01	6.17E+01	1.99E+00	1.52E+00	**YES**
Lead	5.28E+02	3.85E+00	1.13E+01	1.37E+02	4.67E+01	**YES**
Manganese	7.95E+01	9.97E+02	9.97E+03	7.97E-02	7.97E-03	No
Thallium	0.00E+00	3.50E-01	3.50E+00	NA	NA	No

Table 6-41

Comparison of Mean Constituent Exposures
with Toxicity Reference Values for Little Brown Bat
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Mammalian NOAEL (mg/kg-day)	Mammalian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Arsenic	8.22E-02	1.25E+00	1.25E+01	6.57E-02	6.57E-03	No
Barium	1.62E+00	5.10E+00	5.10E+01	3.17E-01	3.17E-02	No
Copper	1.02E+01	1.20E+01	1.54E+01	8.46E-01	6.59E-01	No
Lead	4.12E+01	8.00E+00	8.00E+01	5.15E+00	5.15E-01	**YES**
Manganese	5.75E+00	8.80E+01	2.84E+02	6.53E-02	2.02E-02	No
Thallium	0.00E+00	1.31E-02	1.31E-01	NA	NA	No

Table 6-42

Comparison of Mean Constituent Exposures with Toxicity Reference Values for Marsh Wren Iron Mountain Road and Bains Gap Road Ranges BERA Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Constituent Exposure (mg/kg-day)	Avian NOAEL (mg/kg-day)	Avian LOAEL (mg/kg-day)	NOAEL Hazard Quotient	LOAEL Hazard Quotient	Constituent Of Ecological Concern ?
Inorganic Constituents :						
Arsenic	4.31E-01	2.46E+00	7.38E+00	1.75E-01	5.84E-02	No
Barium	8.47E+00	2.08E+01	4.17E+01	4.07E-01	2.03E-01	No
Copper	5.32E+01	4.70E+01	6.17E+01	1.13E+00	8.62E-01	**YES**
Lead	2.16E+02	3.85E+00	1.13E+01	5.61E+01	1.91E+01	**YES**
Manganese	3.01E+01	9.97E+02	9.97E+03	3.02E-02	3.02E-03	No
Thallium	0.00E+00	3.50E-01	3.50E+00	NA	NA	No

Table 6-43

Summary of Riparian Food Web Hazard Quotients
Assuming Maximum Exposure Point Concentrations
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Maximum Little Brown Bat Hazard Quotients		Maximum Marsh Wren Hazard Quotients	
	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients
Inorganic Constituents :				
Arsenic	7.58E-02	7.58E-03	2.02E-01	6.73E-02
Barium	4.82E-01	4.82E-02	6.19E-01	3.09E-01
Copper	1.49E+00	1.16E+00	1.99E+00	1.52E+00
Lead	1.26E+01	1.26E+00	1.37E+02	4.67E+01
Manganese	1.72E-01	5.34E-02	7.97E-02	7.97E-03
Thallium	NA	NA	NA	NA

- Indicates a HQ value greater than 1.0.

Table 6-44

Summary of Riparian Food Web Hazard Quotients
Assuming Mean Exposure Point Concentrations
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Constituent Of Potential Ecological Concern	Mean Little Brown Bat Hazard Quotients		Mean Marsh Wren Hazard Quotients	
	NOAEL Hazard Quotients	LOAEL Hazard Quotients	NOAEL Hazard Quotients	LOAEL Hazard Quotients
Inorganic Constituents :				
Arsenic	6.57E-02	6.57E-03	1.75E-01	5.84E-02
Barium	3.17E-01	3.17E-02	4.07E-01	2.03E-01
Copper	8.46E-01	6.59E-01	1.13E+00	8.62E-01
Lead	5.15E+00	5.15E-01	5.61E+01	1.91E+01
Manganese	6.53E-02	2.02E-02	3.02E-02	3.02E-03
Thallium	NA	NA	NA	NA

- Indicates a HQ value greater than 1.0.

Table 6-45

Risk-Based Remedial Goals for Riparian Food Web Exposures
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Receptor	Sediment COPECs			
	Copper		Lead	
	Sediment Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Sediment Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)	Sediment Conc. Based on NOAEL TRV and HQ = 1.0 (mg/kg)	Sediment Conc. Based on LOAEL TRV and HQ = 1.0 (mg/kg)
Little Brown Bat	175	287	66	1,290
Marsh Wren	99	169	3.1	12.4

Notes :
Risk-based remedial goals were calculated based on a HQ = 1.0.

Table 7-1

Baseline Ecological Risk Assessment Uncertainty Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Risk Assessment Method	Uncertainty	Effect on Risk Estimate	Potential Magnitude of Effect
COPEC Identification	1) Some analytical detection limits greater than ESVs	Under-Estimate	Low
	2) Field duplicate sample data not used in ecological risk assessment	Unknown	Low
	3) Elimination of metals from list of COPECs via comparison to background	Under-Estimate	Low
Earthworm Survival and Growth Test	1) Potential physical and chemical differences between on-site soils and reference soils	Unknown	High
	2) Toxicity test does not directly identify causative agents	Unknown	Low
	3) Significant weight loss in all tests treatment because no food provided during test	Unknown	Low
	4) Ability of un-impacted soils to support a viable earthworm population at FTMC	Over-Estimate	High
	5) Earthworm species used in toxicity tests (*Eisenia fetida*) may not be representative of invertebrates at FTMC	Unknown	High
Earthworm Bioaccumulation Test	1) Potential physical and chemical differences between on-site soils and reference soils	Unknown	High
	2) Presence of other chemicals in soil and physical characteristics of soil may enhance or inhibit bioaccumulation of COPECs	Unknown	High
	3) Ability of un-impacted soils to support a viable earthworm population at FTMC	Over-Estimate	High
	4) Earthworm species used in toxicity tests (*Eisenia fetida*) may not be representative of invertebrates at FTMC	Unknown	High
	5) Test duration (28 days) may not be sufficient for worm tissues to reach equilibrium with soil	Under-Estimate	Moderate
	6) Earthworms not depurated prior to chemical analysis	Over-Estimate	High
Terrestrial Food Web Model	1) Single surrogate species to represent an entire feeding guild	Unknown	High
	2) Single point estimate to represent each exposure parameter	Unknown	Moderate
	3) Simplified feeding preferences to represent complex feeding behavior	Unknown	High
	4) Simplified transfer rates to estimate COPEC transfer from abiotic media to food items	Unknown	High
	5) Literature-based toxicity reference values may not represent on-site conditions	Unknown	High
	6) Dermal and inhalation exposures not assessed	Under-Estimate	Low
Lead Particle Ingestion Model	1) Lead bullet fragment shape and texture not considered in exposure estimates	Over-Estimate	High
	2) Limited information regarding the ingestion of lead bullet fragments as digestive grit	Over-Estimate	High
	3) Bird foraging ranges and areal extent of lead bullet contamination conservatively estimated	Under-Estimate	High
	4) Grit retention times highly variable	Over-Estimate	Moderate
	5) Assumed that ingestion and retention of a single bullet fragment resulted in mortality	Under-Estimate	Moderate
	6) Assumed adverse impact to 20% of bird population would not adversely impact entire population	Unknown	High

Table 7-1

Baseline Ecological Risk Assessment Uncertainty Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Risk Assessment Method	Uncertainty	Effect on Risk Estimate	Potential Magnitude of Effect
Fathead Minnow Survival and Growth Test	1) Potential physical and chemical differences between on-site surface water and reference site surface water	Unknown	Low
	2) Toxicity test does not directly identify causative agents	Over-Estimate	High
	3) Surface water samples analyzed for total metals, but toxicity more closely related to dissolved metals	Unknown	High
	4) Fish species used in toxicity tests (Pimephales promelas) may not be representative of fish species at FTMC	Under-Estimate	Moderate
	5) Test exposure period may not accurately assess long-term chronic exposures	Unknown	High
Ceriodaphnid Survival and Reproduction Test	1) Potential physical and chemical differences between on-site surface water and reference site surface water	Unknown	Low
	2) Toxicity test does not directly identify causative agents	Over-Estimate	High
	3) Surface water samples analyzed for total metals, but toxicity more closely related to dissolved metals	Unknown	High
	4) Ceriodaphnid species used in toxicity tests (Ceriodaphnia dubia) may not be representative of aquatic invertebrate species at FTMC	Under-Estimate	Moderate
	5) Test exposure period may not accurately assess long-term chronic exposures	Unknown	High
Chironomid Survival and Growth Test	1) Potential physical and chemical differences between on-site sediment and reference site sediment	Unknown	Low
	2) Toxicity test does not directly identify causative agents	Over-Estimate	High
	3) Toxicity test results indicate un-impacted sediment may not support a viable benthic invertebrate community at FTMC	Unknown	High
	4) Chironomid species used in toxicity tests (*Chironomus riparius*) may not be representative of benthic invertebrate species at FTMC	Under-Estimate	Moderate
	5) Test exposure period may not accurately assess long-term chronic exposures	Unknown	Low
Chironomid Bioaccumulation Test	1) The large number of chironomids necessary to achieve the required tissue volume necessitated the use of non-standard sample volumes and test chambers	Unknown	Moderate
	2) On-site sediments were not conducive to chironomid survival; therefore, bioaccumulation was difficult to measure	Under-Estimate	Moderate
	3) Test duration (10 days) may not be sufficient for chironomid tissues to reach equilibrium with sediment	Unknown	Moderate

Table 7-1

Baseline Ecological Risk Assessment Uncertainty Summary
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Risk Assessment Method	Uncertainty	Effect on Risk Estimate	Potential Magnitude of Effect
Benthic Invertebrate Community Analysis	1) The assessment technique (RBP-II) provides a snapshot of the benthic community structure, but does not address temporal changes	Unknown	Low
	2) Several of the metrics used to assess community structure are based on the assessment of organic pollutants	Over-Estimate	Moderate
	3) Assessment technique identifies areas of impact regardless of stressor (i.e., biological, chemical, physical, etc.)	Unknown	Moderate
	4) Benthic habitat quality was characterized as sub-optimal to poor; therefore, benthic community structure may not be a descriminating factor in the assessment of sediment	Unknown	High
	5) Applicability of benthic community analysis to Remount Creek is uncertain	Unknown	Moderate
	6) Surrounding land use is important in the assessment but can only be qualitatively described	Unknown	High
Riparian Food Web Model	1) Single surrogate species to represent an entire feeding guild	Unknown	Moderate
	2) Single point estimate to represent each exposure parameter	Unknown	High
	3) Simplified feeding preferences to represent complex feeding behavior	Unknown	High
	4) Simplified transfer rates to estimate COPEC transfer from abiotic media to food items	Unknown	High
	5) Literature-based toxicity reference values may not represent on-site conditions	Unknown	High

Table 7-2

Soil Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Surface Soil: Range of Reporting Limits (mg/kg) minimum	Surface Soil: Range of Reporting Limits (mg/kg) maximum	Surface Soil: Range of Method Detection Limits (mg/kg) minimun	Surface Soil: Range of Method Detection Limits (mg/kg) maximum
Metals :					
Cadmium	1.60E+00	NA	NA	NA	NA
Thallium	1.00E+00	1.10E+00	5.63E+00	4.80E-01	***1.71E+00***
Herbicides :					
2,2-Dichloropropanoic Acid	NA	2.30E-02	5.60E-02	4.50E-03	1.30E-02
2,4,5-T	1.00E-01	1.20E-02	2.80E-02	5.80E-03	1.40E-02
2,4,5-TP	1.00E-01	1.20E-02	2.80E-02	5.50E-03	1.40E-02
2,4-D	1.00E-01	1.20E-02	2.80E-02	4.40E-03	1.40E-02
2,4-DB	1.00E-01	2.20E-02	2.50E-02	6.60E-03	9.40E-03
Dicamba	1.00E-01	2.30E-02	5.60E-02	6.30E-03	1.50E-02
Dichloroprop	1.00E-01	1.20E-02	2.80E-02	5.10E-03	1.40E-02
Dinoseb	1.00E-01	1.20E-02	2.80E-02	1.90E-03	4.60E-03
MCPA	1.00E-01	2.30E+00	5.60E+00	***2.00E-01***	***5.10E-01***
Polychlorinated Biphenyls :					
Aroclor 1016	2.00E-02	4.60E-02	1.10E-01	1.80E-02	***4.40E-02***
Aroclor 1221	2.00E-02	4.60E-02	1.10E-01	2.00E-02	***5.00E-02***
Aroclor 1232	2.00E-02	4.60E-02	1.10E-01	1.30E-02	***3.20E-02***
Aroclor 1242	2.00E-02	4.60E-02	1.10E-01	1.70E-02	***4.20E-02***
Aroclor 1248	2.00E-02	4.60E-02	1.10E-01	9.50E-03	***2.30E-02***
Aroclor 1254	2.00E-02	4.60E-02	1.10E-01	9.60E-03	***2.30E-02***
Aroclor 1260	2.00E-02	4.60E-02	1.10E-01	9.50E-03	***2.30E-02***
Organochlorine Pesticides :					
4,4'-DDD	2.50E-03	4.40E-03	4.90E-03	1.10E-03	1.20E-03
4,4'-DDE	2.50E-03	4.40E-03	4.90E-03	1.00E-03	1.10E-03
Aldrin	2.50E-03	2.20E-03	2.50E-03	5.30E-04	8.10E-04
alpha-BHC	2.50E-03	2.20E-03	2.50E-03	2.10E-04	2.50E-04
alpha-Chlordane	1.00E-01	2.30E-03	5.60E-03	1.90E-04	4.70E-04
beta-BHC	1.00E-03	2.20E-03	2.50E-03	4.20E-04	4.60E-04
delta-BHC	9.94E+00	2.30E-03	5.60E-03	2.80E-04	1.50E-03
Dieldrin	5.00E-04	4.40E-03	4.90E-03	3.70E-04	4.10E-04
Endosulfan I	1.19E-01	2.20E-03	2.50E-03	8.10E-04	9.00E-04
Endosulfan II	1.19E-01	4.40E-03	4.90E-03	3.80E-04	6.90E-04
Endosulfan sulfate	3.58E-02	4.40E-03	4.90E-03	4.40E-04	4.90E-04
Endrin	1.00E-03	4.40E-03	4.90E-03	3.70E-04	4.10E-04
Endrin aldehyde	1.05E-02	4.40E-03	4.90E-03	3.70E-04	4.10E-04
Endrin ketone	1.05E-02	4.60E-03	1.10E-02	5.00E-04	1.20E-03
gamma-BHC (Lindane)	5.00E-05	2.20E-03	2.50E-03	***2.90E-04***	***3.30E-04***
gamma-Chlordane	1.00E-01	2.20E-03	2.50E-03	2.30E-04	2.60E-04
Heptachlor	1.00E-01	2.20E-03	2.50E-03	2.50E-04	3.60E-04
Heptachlor epoxide	1.52E-01	2.20E-03	2.50E-03	1.80E-04	2.10E-04
Methoxychlor	1.99E-02	2.30E-02	5.60E-02	3.00E-03	9.80E-03
Toxaphene	1.19E-01	4.60E-02	1.10E-01	9.60E-03	2.30E-02
Organophosphate Pesticides :					
Azinphosmethyl	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Bolstar	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Chlorpyrifos	1.00E-01	7.70E-02	1.90E-01	2.50E-02	6.20E-02
Coumaphos	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02

Table 7-2

Soil Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Surface Soil: Range of Reporting Limits (mg/kg) minimum	Surface Soil: Range of Reporting Limits (mg/kg) maximum	Surface Soil: Range of Method Detection Limits (mg/kg) minimun	Surface Soil: Range of Method Detection Limits (mg/kg) maximum
Demeton	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Diazinon	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Dichlorvos	1.00E-01	7.70E-02	1.90E-01	4.30E-02	1.00E-01
Dimethoate	1.00E-01	7.70E-02	1.90E-01	2.30E-02	5.60E-02
Disulfoton	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Ethoprop	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Famphur	1.00E-01	7.70E-02	1.90E-01	3.20E-02	7.90E-02
Fensulfothion	1.00E-01	7.70E-02	1.90E-01	3.00E-02	7.30E-02
Fenthion	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Malathion	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Merphos	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Methyl Parathion	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Mevinphos	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Naled	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Parathion	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Phorate	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Ronnel	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Stirophos	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Sulfotep	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Thionazin	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Tokuthion	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Trichloronate	1.00E-01	3.80E-02	9.30E-02	1.80E-02	4.50E-02
Nitroaromatic Compounds :					
1,3,5-Trinitrobenzene	3.76E-01	2.50E-01	4.00E-01	5.70E-02	1.70E-01
1,3-Dinitrobenzene	6.55E-01	2.50E-01	4.00E-01	3.00E-02	6.30E-02
2,4,6-Trinitrotoluene	NA	2.50E-01	4.00E-01	4.50E-02	9.00E-02
2,4-Dinitrotoluene	1.28E+00	2.50E-01	4.00E-01	4.50E-02	9.00E-02
2,6-Dinitrotoluene	3.28E-02	2.50E-01	4.00E-01	***7.90E-02***	***1.30E-01***
2-Amino-4,6-dinitrotoluene	NA	2.50E-01	4.00E-01	8.50E-02	1.20E-01
2-Nitrotoluene	NA	2.50E-01	4.00E-01	9.90E-02	1.40E-01
3-Nitrotoluene	NA	2.50E-01	4.00E-01	1.10E-01	1.50E-01
4-Amino-2,6-dinitrotoluene	NA	2.50E-01	4.00E-01	6.60E-02	9.00E-02
HMX	NA	4.00E-01	5.00E-01	1.70E-01	1.80E-01
Nitrobenzene	1.31E+00	2.50E-01	4.00E-01	4.50E-02	2.00E-01
p-Nitrotoluene	NA	2.50E-01	4.00E-01	9.00E-02	1.10E-01
RDX	NA	4.00E-01	5.00E-01	1.10E-01	1.70E-01
Tetryl	NA	4.00E-01	6.50E-01	9.10E-02	3.80E-01
Semivolatile Organic Compounds :					
1,2,4-Trichlorobenzene	1.00E-02	3.80E-01	9.30E-01	***9.60E-02***	***2.40E-01***
1,2-Dichlorobenzene	1.00E-02	3.80E-01	9.30E-01	***9.20E-02***	***2.20E-01***
1,3-Dichlorobenzene	1.00E-02	3.80E-01	9.30E-01	***6.80E-02***	***1.70E-01***
1,4-Dichlorobenzene	1.00E-02	3.80E-01	9.30E-01	***8.20E-02***	***2.00E-01***
2,4,5-Trichlorophenol	4.00E+00	3.80E-01	9.30E-01	6.50E-02	1.60E-01
2,4,6-Trichlorophenol	1.00E+01	7.30E-01	1.80E+00	8.60E-02	2.10E-01
2,4-Dichlorophenol	2.00E+01	3.80E-01	9.30E-01	7.70E-02	1.90E-01
2,4-Dimethylphenol	1.00E-02	3.80E-01	9.30E-01	***7.00E-02***	***1.70E-01***
2,4-Dinitrophenol	2.00E+01	7.30E-01	1.80E+00	4.20E-02	1.00E-01

Table 7-2

Soil Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Surface Soil: Range of Reporting Limits (mg/kg) minimum	Surface Soil: Range of Reporting Limits (mg/kg) maximum	Surface Soil: Range of Method Detection Limits (mg/kg) minimun	Surface Soil: Range of Method Detection Limits (mg/kg) maximum
2,4-Dinitrotoluene	1.28E+00	3.80E-01	9.30E-01	8.40E-02	2.10E-01
2,6-Dinitrotoluene	3.28E-02	3.80E-01	9.30E-01	***7.00E-02***	***1.70E-01***
2-Chloronaphthalene	1.00E+00	3.80E-01	9.30E-01	7.90E-02	1.90E-01
2-Chlorophenol	7.00E+00	3.80E-01	9.30E-01	6.70E-02	1.60E-01
2-Methylnaphthalene	NA	3.80E-01	9.30E-01	8.00E-02	2.00E-01
2-Methylphenol	5.00E-01	3.80E-01	9.30E-01	5.90E-02	1.40E-01
2-Nitroaniline	3.16E+00	7.30E-01	1.80E+00	6.50E-02	1.60E-01
2-Nitrophenol	7.00E+00	3.80E-01	9.30E-01	7.60E-02	1.90E-01
3,3'-Dichlorobenzidine	6.46E-01	7.30E-01	1.80E+00	6.20E-02	1.50E-01
3-Nitroaniline	2.19E+01	7.30E-01	1.80E+00	7.10E-02	1.70E-01
4,6-Dinitro-2-methylphenol	NA	7.30E-01	1.80E+00	9.60E-02	2.40E-01
4-Bromophenyl phenyl ether	NA	3.80E-01	9.30E-01	7.30E-02	1.80E-01
4-Chloro-3-methylphenol	NA	3.80E-01	9.30E-01	7.30E-02	1.80E-01
4-Chloroaniline	2.00E+01	3.80E-01	9.30E-01	9.60E-02	2.40E-01
4-Chlorophenyl phenyl ether	NA	3.80E-01	9.30E-01	7.60E-02	1.90E-01
4-Methylphenol	5.00E-01	3.80E-01	9.30E-01	6.30E-02	1.50E-01
4-Nitroaniline	3.16E+00	3.80E-01	9.30E-01	9.60E-02	2.40E-01
4-Nitrophenol	7.00E+00	7.30E-01	1.80E+00	9.60E-02	2.40E-01
Acenaphthene	2.00E+01	3.80E-01	9.30E-01	7.80E-02	1.90E-01
Acenaphthylene	6.82E+02	3.80E-01	9.30E-01	8.70E-02	2.10E-01
Anthracene	1.00E-01	3.80E-01	9.30E-01	6.60E-02	***1.60E-01***
Benzo(a)anthracene	5.21E+00	3.80E-01	9.30E-01	5.40E-02	1.30E-01
Benzo(a)pyrene	1.00E-01	3.80E-01	9.30E-01	5.30E-02	***1.30E-01***
Benzo(b)fluoranthene	5.98E+01	3.80E-01	9.30E-01	7.50E-02	1.80E-01
Benzo(ghi)perylene	1.19E+02	3.80E-01	9.30E-01	4.80E-02	1.20E-01
Benzo(k)fluoranthene	1.48E+02	3.80E-01	9.30E-01	5.70E-02	1.40E-01
Bis(2-Chloroethoxy)methane	NA	3.80E-01	9.30E-01	8.00E-02	2.00E-01
Bis(2-Chloroethyl)ether	2.37E+01	3.80E-01	9.30E-01	7.00E-02	1.70E-01
Bis(2-Chloroisopropyl)ether	NA	3.80E-01	9.30E-01	8.20E-02	2.00E-01
Bis(2-Ethylhexyl)phthalate	9.26E-01	3.80E-01	9.30E-01	5.90E-02	1.50E-01
Butyl benzyl phthalate	2.39E-01	3.80E-01	9.30E-01	4.90E-02	1.20E-01
Carbazole	NA	3.80E-01	9.30E-01	5.70E-02	1.40E-01
Chrysene	4.73E+00	3.80E-01	9.30E-01	5.50E-02	1.30E-01
Dibenz(a,h)anthracene	1.84E+01	3.80E-01	9.30E-01	5.30E-02	1.30E-01
Dibenzofuran	NA	3.80E-01	9.30E-01	7.80E-02	1.90E-01
Diethyl phthalate	1.00E+02	3.80E-01	9.30E-01	8.10E-02	2.00E-01
Dimethyl phthalate	2.00E+02	3.80E-01	9.30E-01	8.00E-02	1.90E-01
Di-n-butyl phthalate	2.00E+02	3.80E-01	9.30E-01	6.00E-02	1.50E-01
Di-n-octyl phthalate	7.09E+02	3.80E-01	9.30E-01	8.10E-02	2.00E-01
Fluoranthene	1.00E-01	3.80E-01	9.30E-01	6.30E-02	***1.50E-01***
Fluorene	1.22E+02	3.80E-01	9.30E-01	9.00E-02	2.20E-01
Hexachlorobenzene	2.50E-03	3.80E-01	9.30E-01	***5.70E-02***	***1.40E-01***
Hexachlorobutadiene	3.98E-02	3.80E-01	9.30E-01	***6.20E-02***	***1.50E-01***
Hexachlorocyclopentadiene	1.00E+01	3.80E-01	9.30E-01	7.20E-02	1.80E-01
Hexachloroethane	5.96E-01	3.80E-01	9.30E-01	7.60E-02	1.80E-01
Indeno(1,2,3-cd)pyrene	1.09E+02	3.80E-01	9.30E-01	5.40E-02	1.30E-01
Isophorone	1.39E+02	3.80E-01	9.30E-01	7.60E-02	1.80E-01

Table 7-2

Soil Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Surface Soil: Range of Reporting Limits (mg/kg) minimum	Surface Soil: Range of Reporting Limits (mg/kg) maximum	Surface Soil: Range of Method Detection Limits (mg/kg) minimun	Surface Soil: Range of Method Detection Limits (mg/kg) maximum
Naphthalene	1.00E-01	3.80E-01	9.30E-01	7.80E-02	***1.90E-01***
Nitrobenzene	4.00E+01	3.80E-01	9.30E-01	8.40E-02	2.10E-01
N-Nitroso-di-n-propylamine	NA	3.80E-01	9.30E-01	8.30E-02	2.00E-01
N-Nitrosodiphenylamine	2.00E+01	3.80E-01	9.30E-01	5.70E-02	1.40E-01
Pentachlorophenol	2.00E-03	7.30E-01	1.80E+00	***7.90E-02***	***1.90E-01***
Phenanthrene	1.00E-01	3.80E-01	9.30E-01	5.80E-02	***1.40E-01***
Phenol	5.00E-02	3.80E-01	9.30E-01	***6.50E-02***	***1.60E-01***
Pyrene	1.00E-01	3.80E-01	9.30E-01	6.00E-02	***1.50E-01***
Volatile Organic Compounds :					
1,1,1,2-Tetrachloroethane	1.00E-01	4.50E-03	2.10E-02	4.50E-04	2.10E-03
1,1,1-Trichloroethane	1.00E-01	4.50E-03	2.10E-02	4.30E-04	2.00E-03
1,1,2,2-Tetrachloroethane	1.00E-01	4.50E-03	2.10E-02	2.80E-04	1.30E-03
1,1,2-Trichloroethane	1.00E-01	4.50E-03	2.10E-02	1.00E-03	4.90E-03
1,1-Dichloroethane	1.00E-01	4.50E-03	2.10E-02	4.40E-04	2.10E-03
1,1-Dichloroethene	1.00E-01	4.50E-03	2.10E-02	4.60E-04	2.20E-03
1,1-Dichloropropene	1.00E-01	4.50E-03	2.10E-02	9.80E-04	4.60E-03
1,2,3-Trichlorobenzene	1.00E-02	4.50E-03	2.10E-02	4.40E-04	2.00E-03
1,2,3-Trichloropropane	1.00E-01	4.50E-03	2.10E-02	5.10E-04	2.40E-03
1,2,4-Trichlorobenzene	1.00E-02	4.50E-03	2.10E-02	5.60E-04	2.60E-03
1,2,4-Trimethylbenzene	1.00E-01	4.50E-03	2.10E-02	2.70E-04	1.30E-03
1,2-Dibromo-3-Chloropropane	1.00E-01	9.00E-03	1.20E-02	1.00E-03	1.40E-03
1,2-Dibromoethane	1.23E+00	4.50E-03	2.10E-02	5.70E-04	2.70E-03
1,2-Dichlorobenzene	1.00E-02	4.50E-03	2.10E-02	2.70E-04	1.30E-03
1,2-Dichloroethane	4.00E-01	4.50E-03	2.10E-02	8.00E-04	3.80E-03
1,2-Dichloropropane	7.00E+02	4.50E-03	2.10E-02	3.50E-04	1.60E-03
1,2-Dimethylbenzene	1.00E-01	4.50E-03	2.10E-02	2.50E-04	1.20E-03
1,3,5-Trimethylbenzene	1.00E-01	4.50E-03	2.10E-02	3.90E-04	1.80E-03
1,3-Dichlorobenzene	1.00E-02	4.50E-03	2.10E-02	2.70E-04	1.30E-03
1,3-Dichloropropane	7.00E+02	4.50E-03	2.10E-02	6.10E-04	2.90E-03
1,4-Dichlorobenzene	1.00E-02	4.50E-03	2.10E-02	3.10E-04	1.40E-03
2-Butanone	8.96E+01	1.80E-02	2.10E-02	2.40E-03	2.90E-03
2-Hexanone	1.26E+01	1.80E-02	8.50E-02	1.70E-03	8.10E-03
4-Methyl-2-pentanone	4.43E+02	1.80E-02	8.50E-02	1.50E-03	6.90E-03
Benzene	5.00E-02	4.50E-03	2.10E-02	3.10E-04	1.50E-03
Bromobenzene	1.00E-01	4.50E-03	2.10E-02	3.30E-04	1.50E-03
Bromochloromethane	1.00E-01	4.50E-03	2.10E-02	7.30E-04	3.40E-03
Bromodichloromethane	1.00E-01	4.50E-03	2.10E-02	3.30E-04	1.50E-03
Bromoform	1.59E+01	4.50E-03	2.10E-02	3.00E-04	1.40E-03
Bromomethane	NA	5.30E-03	6.20E-03	2.70E-03	3.10E-03
Carbon disulfide	9.40E-02	4.50E-03	2.10E-02	2.50E-04	1.20E-03
Carbon tetrachloride	1.00E+03	4.50E-03	2.10E-02	3.90E-04	1.90E-03
Chlorobenzene	5.00E-02	4.50E-03	2.10E-02	2.20E-04	1.10E-03
Chloroethane	1.00E-01	9.00E-03	4.20E-02	2.90E-03	1.30E-02
Chloroform	1.00E-03	4.50E-03	2.10E-02	4.00E-04	***1.90E-03***
Chloromethane	1.00E-01	4.50E-03	2.10E-02	2.30E-03	1.10E-02
Cis-1,2-Dichloroethene	1.00E-01	4.50E-03	2.10E-02	2.20E-04	1.10E-03
Cis-1,3-Dichloropropene	1.00E-01	4.50E-03	2.10E-02	3.00E-04	1.40E-03

Table 7-2

Soil Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Surface Soil: Range of Reporting Limits (mg/kg) minimum	Surface Soil: Range of Reporting Limits (mg/kg) maximum	Surface Soil: Range of Method Detection Limits (mg/kg) minimun	Surface Soil: Range of Method Detection Limits (mg/kg) maximum
Cumene	NA	4.50E-03	2.10E-02	4.20E-04	2.00E-03
Dibromochloromethane	1.00E-01	4.50E-03	2.10E-02	5.20E-04	2.40E-03
Dibromomethane	1.23E+00	4.50E-03	2.10E-02	7.20E-04	3.40E-03
Dichlorodifluoromethane	1.00E-01	9.00E-03	4.20E-02	2.50E-03	1.20E-02
Ethylbenzene	5.00E-02	4.50E-03	2.10E-02	2.90E-04	1.40E-03
Hexachlorobutadiene	3.98E-02	4.50E-03	2.10E-02	4.60E-04	2.20E-03
m,p-Xylenes	5.00E-02	9.00E-03	4.20E-02	6.60E-04	3.10E-03
Methylene chloride	2.00E+00	9.30E-03	9.30E-03	1.30E-03	1.30E-03
Naphthalene	1.00E-01	9.00E-03	4.20E-02	2.90E-03	1.30E-02
N-Butylbenzene	NA	4.50E-03	2.10E-02	2.20E-04	1.10E-03
N-Propylbenzene	NA	4.50E-03	2.10E-02	2.20E-04	1.10E-03
o-Chlorotoluene	1.00E-01	4.50E-03	2.10E-02	4.70E-04	2.20E-03
p-Chlorotoluene	1.00E-01	4.50E-03	2.10E-02	3.70E-04	1.70E-03
p-Cymene	NA	4.40E-03	5.30E-03	2.20E-04	2.60E-04
sec-Butylbenzene	NA	4.50E-03	2.10E-02	2.70E-04	1.20E-03
sec-Dichloropropane	7.00E+02	4.50E-03	2.10E-02	3.60E-04	1.70E-03
Styrene	1.00E-01	4.50E-03	2.10E-02	4.60E-04	2.20E-03
tert-Butylbenzene	NA	4.50E-03	2.10E-02	2.20E-04	1.10E-03
Tetrachloroethene	1.00E-02	4.50E-03	2.10E-02	3.30E-04	1.60E-03
Toluene	5.00E-02	4.50E-03	2.10E-02	4.90E-04	2.30E-03
Trans-1,2-Dichloroethene	1.00E-01	4.50E-03	2.10E-02	3.00E-04	1.40E-03
Trans-1,3-Dichloropropene	1.00E-01	4.50E-03	2.10E-02	4.70E-04	2.20E-03
Trichloroethene	1.00E-03	4.50E-03	2.10E-02	2.80E-04	***1.30E-03***
Trichlorofluoromethane	1.00E-01	4.40E-03	5.30E-03	2.40E-04	2.80E-04
Vinyl chloride	1.00E-02	4.50E-03	2.10E-02	2.10E-03	9.90E-03

Method detection limits that exceed the ESV are shown in bold font and shaded.

[a] Ecological Screening Values (ESV) presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000)..

mg/kg - milligram per kilogram

NA - Not Available

Table 7-3

Surface Water Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) mnaximum
Metals :					
Antimony	1.60E-01	1.00E-01	1.00E-01	2.75E-02	5.00E-02
Beryllium	5.30E-04	1.00E-03	1.00E-02	***6.00E-04***	***1.00E-03***
Cadmium	6.60E-04	1.00E-02	1.00E-02	***4.20E-03***	***5.00E-03***
Chromium	1.10E-02	1.00E-02	2.00E-02	4.70E-03	6.00E-03
Cobalt	3.00E-03	2.00E-02	2.00E-02	***9.10E-03***	***1.10E-02***
Mercury	1.20E-05	5.00E-04	5.00E-04	***1.18E-04***	***1.18E-04***
Nickel	8.77E-02	2.00E-02	2.00E-02	8.90E-03	1.50E-02
Silver	1.20E-05	1.00E-02	2.00E-02	***4.50E-03***	***1.00E-02***
Vanadium	1.90E-02	1.00E-02	2.00E-02	3.80E-03	5.00E-03
Zinc	5.89E-02	2.00E-02	1.00E-01	5.80E-03	2.70E-02
Herbicides :					
2,2-Dichloropropanoic Acid	NA	4.00E-04	4.00E-04	7.80E-05	7.80E-05
2,4,5-T	NA	4.00E-04	4.00E-04	1.60E-04	1.60E-04
2,4,5-TP	3.27E-01	4.00E-04	4.00E-04	1.80E-04	1.80E-04
2,4-D	NA	4.00E-04	4.00E-04	1.50E-04	1.50E-04
2,4-DB	NA	4.00E-04	4.00E-04	2.20E-04	2.20E-04
Dicamba	NA	8.00E-04	8.00E-04	5.60E-04	5.60E-04
Dichloroprop	NA	4.00E-04	4.00E-04	1.60E-04	1.60E-04
Dinoseb	3.90E-04	4.00E-04	4.00E-04	3.90E-05	3.90E-05
MCPA	NA	2.00E-01	2.00E-01	6.30E-03	6.30E-03
MCPP	NA	2.00E-01	2.00E-01	8.20E-03	8.20E-03
Polychlorinated Biphenyls :					
Aroclor 1016	1.40E-05	9.50E-04	9.90E-04	***5.40E-04***	***5.60E-04***
Aroclor 1221	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Aroclor 1232	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Aroclor 1242	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Aroclor 1248	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Aroclor 1254	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Aroclor 1260	1.40E-05	9.50E-04	9.90E-04	***2.40E-04***	***2.50E-04***
Organochlorine Pesticides :					
4,4'-DDD	6.40E-06	1.90E-04	2.00E-04	***3.00E-05***	***3.20E-05***
4,4'-DDE	1.05E-02	1.90E-04	2.00E-04	2.80E-05	3.00E-05
4,4'-DDT	1.00E-06	1.90E-04	2.00E-04	***1.80E-05***	***1.90E-05***
Aldrin	3.00E-04	9.50E-05	9.90E-05	1.00E-05	1.10E-05
alpha-BHC	5.00E+00	9.50E-05	9.90E-05	7.60E-06	7.90E-06
alpha-Chlordane	4.30E-06	9.50E-05	9.90E-05	***4.80E-06***	***4.90E-06***
beta-BHC	5.00E+01	9.50E-05	9.90E-05	1.20E-05	1.30E-05
delta-BHC	6.67E-01	9.50E-05	9.90E-05	1.10E-05	1.20E-05
Dieldrin	1.90E-06	1.90E-04	2.00E-04	***7.30E-05***	***7.60E-05***
Endosulfan I	5.60E-05	9.50E-05	9.90E-05	2.40E-05	2.50E-05
Endosulfan II	5.60E-05	1.90E-04	2.00E-04	9.50E-06	9.90E-06
Endosulfan sulfate	2.23E-03	1.90E-04	2.00E-04	1.00E-05	1.10E-05
Endrin	2.30E-06	1.90E-04	2.00E-04	***9.50E-06***	***9.90E-06***
Endrin aldehyde	1.50E-04	1.90E-04	2.00E-04	9.50E-06	9.90E-06
Endrin ketone	1.50E-04	1.90E-04	2.00E-04	1.00E-05	1.10E-05
gamma-BHC (Lindane)	8.00E-05	9.50E-05	9.90E-05	7.60E-06	7.90E-06
gamma-Chlordane	4.30E-06	9.50E-05	9.90E-05	***4.80E-06***	***4.90E-06***
Heptachlor	3.80E-06	9.50E-05	9.90E-05	***7.60E-06***	***7.90E-06***
Heptachlor epoxide	3.80E-06	9.50E-05	9.90E-05	***4.80E-06***	***4.90E-06***
Methoxychlor	3.00E-05	9.50E-04	9.90E-04	***7.90E-05***	***8.20E-05***

Table 7-3

Surface Water Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) mnaximum
Toxaphene	2.00E-07	2.80E-03	3.00E-03	***1.20E-03***	***1.30E-03***
Organophosphate Pesticides :					
Azinphosmethyl	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Bolstar	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Chlorpyrifos	4.10E-05	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Coumaphos	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Demeton	1.00E-04	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Diazinon	4.30E-05	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Dichlorvos	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Dimethoate	4.12E-02	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Disulfoton	4.02E-05	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Ethoprop	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Famphur	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Fensulfothion	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Fenthion	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Malathion	1.00E-04	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Merphos	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Methyl Parathion	1.30E-05	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Mevinphos	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Naled	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Parathion	1.30E-05	1.00E-03	1.00E-03	***5.00E-04***	***5.00E-04***
Phorate	3.62E-03	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Ronnel	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Stirophos	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Sulfotep	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Thionazin	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Tokuthion	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Trichloronate	NA	1.00E-03	1.00E-03	5.00E-04	5.00E-04
Nitroaromatic Compounds :					
1,3,5-Trinitrobenzene	1.10E-02	4.00E-04	4.00E-04	1.90E-04	1.90E-04
1,3-Dinitrobenzene	2.00E-02	4.00E-04	4.00E-04	1.10E-04	1.10E-04
2,4,6-Trinitrotoluene	9.00E-02	4.00E-04	4.00E-04	1.40E-04	1.40E-04
2,4-Dinitrotoluene	2.30E-01	4.00E-04	4.00E-04	1.40E-04	1.40E-04
2,6-Dinitrotoluene	4.20E-02	4.00E-04	4.00E-04	1.90E-04	1.90E-04
2-Amino-4,6-dinitrotoluene	2.00E-02	4.00E-04	4.00E-04	1.70E-04	1.70E-04
3-Nitrotoluene	NA	6.00E-04	6.00E-04	2.90E-04	2.90E-04
4-Amino-2,6-dinitrotoluene	NA	4.00E-04	4.00E-04	2.10E-04	2.10E-04
HMX	3.30E-01	4.00E-04	4.00E-04	1.90E-04	1.90E-04
Nitrobenzene exp	7.40E-01	4.00E-04	4.00E-04	1.10E-04	1.10E-04
p-Nitrotoluene	NA	6.00E-04	6.00E-04	2.50E-04	2.50E-04
RDX	1.90E-01	4.00E-04	4.00E-04	1.70E-04	1.70E-04
Tetryl	NA	4.00E-04	4.00E-04	1.50E-04	1.50E-04
Semivolatile Organic Compounds :					
1,2,4-Trichlorobenzene	4.49E-02	9.40E-03	1.00E-02	3.40E-03	3.70E-03
1,2-Dichlorobenzene	1.58E-02	9.40E-03	1.00E-02	4.30E-03	4.70E-03
1,3-Dichlorobenzene	5.02E-02	9.40E-03	1.00E-02	4.10E-03	4.50E-03
1,4-Dichlorobenzene	1.12E-02	9.40E-03	1.00E-02	4.30E-03	4.60E-03
2,4,5-Trichlorophenol	6.30E-02	9.40E-03	1.00E-02	4.00E-03	4.30E-03
2,4,6-Trichlorophenol	3.20E-03	9.40E-03	1.00E-02	***4.50E-03***	***4.90E-03***
2,4-Dichlorophenol	3.65E-02	9.40E-03	1.00E-02	4.20E-03	4.50E-03

Table 7-3

Surface Water Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) mnaximum
2,4-Dimethylphenol	2.12E-02	9.40E-03	1.00E-02	4.20E-03	4.50E-03
2,4-Dinitrophenol	6.20E-03	1.90E-02	2.00E-02	5.50E-03	6.00E-03
2,4-Dinitrotoluene	3.10E-01	1.90E-02	2.00E-02	5.90E-03	6.40E-03
2,6-Dinitrotoluene	4.20E-02	1.90E-02	2.00E-02	5.90E-03	6.40E-03
2-Chloronaphthalene	3.96E-04	9.40E-03	1.00E-02	***4.50E-03***	***4.90E-03***
2-Chlorophenol	4.38E-02	9.40E-03	1.00E-02	4.40E-03	4.70E-03
2-Methylnaphthalene	3.30E-01	9.40E-03	1.00E-02	3.80E-03	4.10E-03
2-Methylphenol	4.89E-01	9.40E-03	1.00E-02	3.30E-03	3.50E-03
2-Nitroaniline	NA	1.90E-02	2.00E-02	5.40E-03	5.80E-03
2-Nitrophenol	3.50E+00	9.40E-03	1.00E-02	4.40E-03	4.80E-03
3,3'-Dichlorobenzidine	9.98E-02	9.40E-03	1.00E-02	3.90E-03	4.20E-03
3-Nitroaniline	NA	9.40E-03	1.00E-02	4.50E-03	4.90E-03
4,6-Dinitro-2-methylphenol	NA	1.90E-02	2.00E-02	6.10E-03	6.60E-03
4-Bromophenyl phenyl ether	1.50E-03	1.90E-02	2.00E-02	***6.40E-03***	***7.00E-03***
4-Chloro-3-methylphenol	3.00E-04	9.40E-03	1.00E-02	***4.40E-03***	***4.80E-03***
4-Chloroaniline	5.00E-02	9.40E-03	1.00E-02	4.30E-03	4.70E-03
4-Chlorophenyl phenyl ether	NA	9.40E-03	1.00E-02	4.90E-03	5.30E-03
4-Methylphenol	4.89E-01	9.40E-03	1.00E-02	3.70E-03	4.00E-03
4-Nitroaniline	NA	9.40E-03	1.00E-02	4.50E-03	4.90E-03
4-Nitrophenol	8.28E-02	9.40E-03	1.00E-02	4.80E-03	5.20E-03
Acenaphthene	1.70E-02	9.40E-03	1.00E-02	4.40E-03	4.80E-03
Acenaphthylene	4.84E+00	9.40E-03	1.00E-02	4.60E-03	5.00E-03
Anthracene	2.90E-05	9.40E-03	1.00E-02	***4.50E-03***	***4.90E-03***
Benzo(a)anthracene	8.39E-04	9.40E-03	1.00E-02	***4.00E-03***	***4.30E-03***
Benzo(a)pyrene	1.40E-05	9.40E-03	1.00E-02	***3.90E-03***	***4.20E-03***
Benzo(b)fluoranthene	9.07E-03	9.40E-03	1.00E-02	3.60E-03	3.90E-03
Benzo(ghi)perylene	7.64E-03	9.40E-03	1.00E-02	4.00E-03	4.40E-03
Benzo(k)fluoranthene	5.60E-06	9.40E-03	1.00E-02	***4.50E-03***	***4.90E-03***
Bis(2-Chloroethoxy)methane	1.10E+01	9.40E-03	1.00E-02	4.40E-03	4.80E-03
Bis(2-Chloroethyl)ether	2.38E+00	9.40E-03	1.00E-02	4.80E-03	5.20E-03
Bis(2-Chloroisopropyl)ether	NA	9.40E-03	1.00E-02	5.10E-03	5.50E-03
Bis(2-Ethylhexyl)phthalate	3.00E-04	1.90E-02	2.00E-02	***9.30E-03***	***1.00E-02***
Butyl benzyl phthalate	2.20E-02	9.40E-03	1.00E-02	3.70E-03	4.00E-03
Carbazole	NA	9.40E-03	1.00E-02	4.70E-03	5.10E-03
Chrysene	3.30E-05	9.40E-03	1.00E-02	***3.80E-03***	***4.10E-03***
Dibenz(a,h)anthracene	1.60E-06	9.40E-03	1.00E-02	***4.40E-03***	***4.80E-03***
Dibenzofuran	2.00E-02	9.40E-03	1.00E-02	4.50E-03	4.90E-03
Diethyl phthalate	5.21E-01	1.90E-02	2.00E-02	5.40E-03	5.90E-03
Dimethyl phthalate	3.30E-01	1.90E-02	2.00E-02	5.20E-03	5.70E-03
Di-n-butyl phthalate	9.40E-03	9.40E-03	1.00E-02	4.50E-03	4.90E-03
Di-n-octyl phthalate	3.00E-02	9.40E-03	1.00E-02	4.30E-03	4.70E-03
Fluoranthene	3.98E-02	9.40E-03	1.00E-02	5.00E-03	5.40E-03
Fluorene	3.90E-03	9.40E-03	1.00E-02	***4.60E-03***	***5.00E-03***
Hexachlorobenzene	3.68E-03	1.90E-02	2.00E-02	***5.20E-03***	***5.60E-03***
Hexachlorobutadiene	9.30E-04	9.40E-03	1.00E-02	***3.60E-03***	***3.90E-03***
Hexachlorocyclopentadiene	7.00E-05	9.40E-03	1.00E-02	***4.70E-03***	***5.10E-03***
Hexachloroethane	9.80E-03	9.40E-03	1.00E-02	3.80E-03	4.10E-03
Indeno(1,2,3-cd)pyrene	4.31E-03	9.40E-03	1.00E-02	3.70E-03	4.00E-03
Isophorone	1.17E+00	9.40E-03	1.00E-02	4.40E-03	4.70E-03
Naphthalene	6.20E-02	9.40E-03	1.00E-02	4.00E-03	4.40E-03

Table 7-3

Surface Water Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) mnaximum
Nitrobenzene	2.70E-01	9.40E-03	1.00E-02	4.80E-03	5.20E-03
N-Nitroso-di-n-propylamine	NA	9.40E-03	1.00E-02	4.60E-03	5.00E-03
N-Nitrosodiphenylamine	5.85E-02	9.40E-03	1.00E-02	4.50E-03	4.80E-03
Pentachlorophenol	1.30E-02	1.90E-02	2.00E-02	6.10E-03	6.60E-03
Phenanthrene	6.30E-03	1.90E-02	2.00E-02	5.40E-03	5.80E-03
Phenol	2.56E-01	9.40E-03	1.00E-02	3.90E-03	4.20E-03
Pyrene	3.00E-04	9.40E-03	1.00E-02	***4.50E-03***	***4.80E-03***
Volatile Organic Compounds :					
1,1,1,2-Tetrachloroethane	2.40E+00	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,1,1-Trichloroethane	5.28E-01	1.00E-03	1.00E-03	1.30E-04	1.30E-04
1,1,2,2-Tetrachloroethane	2.40E-01	1.00E-03	1.00E-03	2.80E-04	2.80E-04
1,1,2-Trichloroethane	9.40E-01	1.00E-03	1.00E-03	2.30E-04	2.30E-04
1,1-Dichloroethane	4.70E-02	1.00E-03	1.00E-03	1.20E-04	1.20E-04
1,1-Dichloroethene	3.03E-01	1.00E-03	1.00E-03	1.50E-04	1.50E-04
1,1-Dichloropropene	2.44E-01	1.00E-03	1.00E-03	2.20E-04	2.20E-04
1,2,3-Trichlorobenzene	6.92E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2,3-Trichloropropane	1.21E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,2,4-Trichlorobenzene	4.49E-02	1.00E-03	1.00E-03	2.00E-04	2.00E-04
1,2,4-Trimethylbenzene	NA	1.00E-03	1.00E-03	1.40E-04	1.40E-04
1,2-Dibromoethane	2.25E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,2-Dichlorobenzene	1.58E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,2-Dichloroethane	2.00E+00	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2-Dichloropropane	5.25E-01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2-Dimethylbenzene	NA	1.00E-03	1.00E-03	1.20E-04	1.20E-04
1,3,5-Trimethylbenzene	NA	1.00E-03	1.00E-03	1.50E-04	1.50E-04
1,3-Dichlorobenzene	5.02E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,3-Dichloropropane	5.21E-01	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,4-Dichlorobenzene	1.12E-02	5.00E-03	5.00E-03	1.40E-04	1.40E-04
2-Hexanone	1.71E+00	1.00E-02	1.00E-02	1.00E-03	1.00E-03
4-Methyl-2-pentanone	3.68E+00	1.00E-02	1.00E-02	1.00E-03	1.00E-03
Benzene	5.30E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Bromobenzene	NA	1.00E-03	1.00E-03	1.60E-04	1.60E-04
Bromochloromethane	1.10E+01	1.00E-03	1.00E-03	1.40E-04	1.40E-04
Bromodichloromethane	1.10E+01	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Bromoform	2.93E-01	1.00E-03	1.00E-03	2.20E-04	2.20E-04
Bromomethane	NA	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Carbon disulfide	8.40E-02	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Carbon tetrachloride	3.52E-01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Chlorobenzene	1.95E-01	1.00E-03	1.00E-03	1.20E-04	1.20E-04
Chloroethane	2.30E+02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Chloroform	2.89E-01	1.00E-03	1.00E-03	1.20E-04	1.20E-04
Chloromethane	5.50E+00	1.00E-03	1.00E-03	4.00E-04	4.00E-04
Cis-1,2-Dichloroethene	1.16E+01	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Cis-1,3-Dichloropropene	2.44E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Cumene	NA	1.00E-03	1.00E-03	1.60E-04	1.60E-04
Dibromochloromethane	6.40E+00	1.00E-03	1.00E-03	1.90E-04	1.90E-04
Dibromomethane	2.25E-02	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Dichlorodifluoromethane	1.10E+01	1.00E-03	1.00E-03	4.20E-04	4.20E-04
Ethylbenzene	4.53E-01	1.00E-03	1.00E-03	1.10E-04	1.10E-04
Hexachlorobutadiene	9.30E-04	1.00E-03	1.00E-03	1.90E-04	1.90E-04

Table 7-3

Surface Water Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) mnaximum
m,p-Xylenes	1.17E-01	2.00E-03	2.00E-03	2.40E-04	2.40E-04
Methylene chloride	1.93E+00	2.00E-03	2.00E-03	1.20E-04	1.20E-04
Naphthalene	6.20E-02	1.00E-03	1.00E-03	2.70E-04	2.70E-04
N-Butylbenzene	NA	1.00E-03	1.00E-03	1.40E-04	1.40E-04
N-Propylbenzene	NA	1.00E-03	1.00E-03	1.50E-04	1.50E-04
o-Chlorotoluene	NA	1.00E-03	1.00E-03	1.90E-04	1.90E-04
p-Chlorotoluene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
p-Cymene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
sec-Butylbenzene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
sec-Dichloropropane	5.21E-01	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Styrene	5.60E-02	1.00E-03	1.00E-03	1.10E-04	1.10E-04
tert-Butylbenzene	NA	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Tetrachloroethene	8.40E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Toluene	1.75E-01	1.00E-03	1.00E-03	1.20E-04	1.20E-04
Trans-1,2-Dichloroethene	1.35E+00	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Trans-1,3-Dichloropropene	2.44E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Trichloroethene	2.19E+01	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Trichlorofluoromethane	1.10E+01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Vinyl chloride	9.20E-03	1.00E-03	1.00E-03	2.50E-04	2.50E-04

Method detection limits that exceed the ESV are shown in bold font and shaded.

[a] Ecological Screening Values (ESV) presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000)..

mg/L - milligram per liter

NA - Not Available

Table 7-4

Sediment Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Range of Reporting Limits (mg/kg) minimum	Range of Reporting Limits (mg/kg) maximum	Range of Method Detection Limits (mg/kg) minimum	Range of Method Detection Limits (mg/kg) maximum
Metals :					
Cadmium	1.00E+00	6.11E-01	1.41E+00	2.38E-01	6.20E-01
Mercury	1.30E-01	1.22E-01	1.42E-01	3.04E-02	3.55E-02
Herbicides :					
2,2-Dichloropropanoic Acid	NA	2.40E-02	2.80E-02	4.70E-03	1.30E-02
2,4,5-T	NA	1.20E-02	1.40E-02	6.10E-03	7.10E-03
2,4,5-TP	7.35E+00	1.20E-02	1.40E-02	5.80E-03	6.80E-03
2,4-D	NA	1.20E-02	1.40E-02	6.10E-03	7.10E-03
2,4-DB	NA	2.40E-02	2.80E-02	9.30E-03	1.10E-02
Dicamba	NA	2.40E-02	2.80E-02	6.60E-03	7.70E-03
Dichloroprop	NA	1.20E-02	1.40E-02	5.90E-03	6.80E-03
Dinoseb	1.18E-02	1.20E-02	1.40E-02	2.00E-03	2.40E-03
MCPA	NA	2.40E+00	2.80E+00	2.50E-01	4.70E-01
Polychlorinated Biphenyls :					
Aroclor 1016	3.30E-02	4.90E-02	5.70E-02	1.00E-02	2.20E-02
Aroclor 1221	6.70E-02	4.90E-02	5.70E-02	1.50E-02	2.50E-02
Aroclor 1232	3.30E-02	4.90E-02	5.70E-02	1.40E-02	***3.70E-02***
Aroclor 1242	3.30E-02	4.90E-02	5.70E-02	1.00E-02	2.10E-02
Aroclor 1248	3.30E-02	4.90E-02	5.70E-02	1.00E-02	1.20E-02
Aroclor 1254	3.30E-02	4.90E-02	5.70E-02	1.00E-02	1.20E-02
Aroclor 1260	3.30E-02	4.90E-02	5.70E-02	1.00E-02	1.20E-02
Organochlorine Pestcides :					
4,4'-DDD	3.30E-02	4.90E-03	5.70E-03	1.20E-03	1.40E-03
4,4'-DDE	3.30E-02	4.90E-03	5.70E-03	1.10E-03	1.30E-03
4,4'-DDT	3.30E-02	4.90E-03	5.70E-03	6.50E-04	9.00E-04
Aldrin	2.00E-03	2.40E-03	2.80E-03	5.80E-04	9.20E-04
alpha-Chlordane	1.70E-03	2.40E-03	2.80E-03	2.00E-04	2.40E-04
beta-BHC	5.00E-03	2.40E-03	2.80E-03	4.60E-04	5.30E-04
delta-BHC	7.15E+01	2.40E-03	2.80E-03	2.90E-04	3.40E-04
Dieldrin	3.00E-03	4.90E-03	5.70E-03	4.10E-04	4.80E-04
Endosulfan I	1.75E-04	2.40E-03	2.80E-03	***8.90E-04***	***1.00E-03***
Endosulfan II	1.04E-04	4.90E-03	5.70E-03	***4.20E-04***	***4.90E-04***
Endosulfan sulfate	3.46E-02	4.90E-03	5.70E-03	4.90E-04	5.70E-04
Endrin	3.30E-03	4.90E-03	5.70E-03	4.00E-04	4.70E-04
Endrin aldehyde	3.20E+00	4.90E-03	5.70E-03	4.00E-04	4.70E-04
Endrin ketone	3.20E+00	4.90E-03	5.70E-03	5.30E-04	6.10E-04
gamma-BHC (Lindane)	3.30E-03	2.40E-03	2.80E-03	2.20E-04	3.80E-04
gamma-Chlordane	1.70E-03	2.40E-03	2.80E-03	2.30E-04	2.90E-04
Heptachlor	6.00E-04	2.40E-03	2.80E-03	2.70E-04	3.80E-04
Heptachlor epoxide	6.00E-04	2.40E-03	2.80E-03	2.00E-04	2.40E-04
Methoxychlor	3.59E-03	2.40E-02	2.80E-02	***4.20E-03***	***4.90E-03***
Toxaphene	1.09E-04	4.90E-02	5.70E-02	***1.00E-02***	***1.20E-02***
Organophosphate Pesticides :					
Azinphosmethyl	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Bolstar	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Chlorpyrifos	NA	8.10E-02	9.50E-02	2.70E-02	3.10E-02
Coumaphos	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Demeton	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Diazinon	1.90E-03	4.00E-02	4.70E-02	***1.90E-02***	***2.30E-02***
Dichlorvos	NA	8.10E-02	9.50E-02	4.50E-02	5.20E-02
Dimethoate	1.90E-01	8.10E-02	9.50E-02	2.40E-02	2.80E-02
Disulfoton	3.24E-01	4.00E-02	4.70E-02	1.90E-02	2.30E-02

Table 7-4

Sediment Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Range of Reporting Limits (mg/kg) minimum	Range of Reporting Limits (mg/kg) maximum	Range of Method Detection Limits (mg/kg) minimum	Range of Method Detection Limits (mg/kg) maximum
Ethoprop	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Famphur	1.78E-03	8.10E-02	9.50E-02	***3.40E-02***	***4.00E-02***
Fensulfothion	NA	8.10E-02	9.50E-02	3.20E-02	3.70E-02
Fenthion	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Malathion	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Merphos	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Methyl Parathion	7.55E-04	4.00E-02	4.70E-02	***1.90E-02***	***2.30E-02***
Mevinphos	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Naled	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Parathion	3.40E-04	4.00E-02	4.70E-02	***1.90E-02***	***2.30E-02***
Phorate	8.61E-04	4.00E-02	4.70E-02	***1.90E-02***	***2.30E-02***
Ronnel	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Stirophos	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Sulfotep	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Thionazin	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Tokuthion	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Trichloronate	NA	4.00E-02	4.70E-02	1.90E-02	2.30E-02
Nitroaromatic Compounds :					
1,3,5-Trinitrobenzene	2.40E-03	4.00E-01	4.00E-01	***5.70E-02***	***5.70E-02***
1,3-Dinitrobenzene	6.70E-03	4.00E-01	4.00E-01	***6.30E-02***	***6.30E-02***
2,4,6-Trinitrotoluene	9.20E-02	4.00E-01	4.00E-01	8.30E-02	8.30E-02
2,6-Dinitrotoluene	2.06E-02	4.00E-01	4.00E-01	***1.30E-01***	***1.30E-01***
2-Amino-4,6-dinitrotoluene	NA	4.00E-01	4.00E-01	1.20E-01	1.20E-01
2-Nitrotoluene	NA	4.00E-01	4.00E-01	9.90E-02	9.90E-02
3-Nitrotoluene	NA	4.00E-01	4.00E-01	1.10E-01	1.10E-01
4-Amino-2,6-dinitrotoluene	NA	4.00E-01	4.00E-01	6.60E-02	6.60E-02
HMX	4.70E-03	4.00E-01	4.00E-01	***1.70E-01***	***1.70E-01***
Nitrobenzene exp	4.88E-01	4.00E-01	4.00E-01	5.30E-02	5.30E-02
p-Nitrotoluene	NA	4.00E-01	4.00E-01	9.50E-02	9.50E-02
RDX	1.30E-02	4.00E-01	4.00E-01	***1.30E-01***	***1.30E-01***
Tetryl	NA	4.00E-01	4.00E-01	9.10E-02	9.10E-02
Semivolatile Organic Compounds :					
1,2,4-Trichlorobenzene	6.40E-02	4.00E-01	4.70E-01	***1.00E-01***	***1.20E-01***
1,2-Dichlorobenzene	5.00E-02	4.00E-01	4.70E-01	***9.60E-02***	***1.10E-01***
1,3-Dichlorobenzene	1.70E-01	4.00E-01	4.70E-01	7.20E-02	8.30E-02
1,4-Dichlorobenzene	1.20E-01	4.00E-01	4.70E-01	8.60E-02	1.00E-01
2,4,5-Trichlorophenol	8.56E-02	4.00E-01	4.70E-01	6.90E-02	8.00E-02
2,4,6-Trichlorophenol	8.48E-02	7.70E-01	8.90E-01	***9.10E-02***	***1.10E-01***
2,4-Dichlorophenol	1.34E-01	4.00E-01	4.70E-01	8.20E-02	9.50E-02
2,4-Dimethylphenol	3.05E-01	4.00E-01	4.70E-01	7.40E-02	8.60E-02
2,4-Dinitrophenol	1.33E-03	7.70E-01	8.90E-01	***4.40E-02***	***5.20E-02***
2,4-Dinitrotoluene-svoc	7.51E-02	4.00E-01	4.70E-01	***8.90E-02***	***1.00E-01***
2,6-Dinitrotoluene svoc	2.06E-02	4.00E-01	4.70E-01	***7.40E-02***	***8.60E-02***
2-Chloronaphthalene	4.17E-01	4.00E-01	4.70E-01	8.30E-02	9.70E-02
2-Chlorophenol	1.17E-02	4.00E-01	4.70E-01	***7.10E-02***	***8.30E-02***
2-Methylnaphthalene	3.30E-01	4.00E-01	4.70E-01	8.50E-02	9.80E-02
2-Methylphenol	6.30E-02	4.00E-01	4.70E-01	6.20E-02	***7.20E-02***
2-Nitroaniline	2.00E-04	7.70E-01	8.90E-01	***6.90E-02***	***8.00E-02***
2-Nitrophenol	7.77E-03	4.00E-01	4.70E-01	***8.00E-02***	***9.30E-02***
3,3'-Dichlorobenzidine	2.82E-02	7.70E-01	8.90E-01	***6.50E-02***	***7.60E-02***
3-Nitroaniline	2.00E-04	7.70E-01	8.90E-01	***7.50E-02***	***8.70E-02***
4,6-Dinitro-2-methylphenol	NA	7.70E-01	8.90E-01	1.00E-01	1.20E-01

Table 7-4

Sediment Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Range of Reporting Limits (mg/kg) minimum	Range of Reporting Limits (mg/kg) maximum	Range of Method Detection Limits (mg/kg) minimum	Range of Method Detection Limits (mg/kg) maximum
4-Bromophenyl phenyl ether	1.55E+00	4.00E-01	4.70E-01	7.70E-02	8.90E-02
4-Chloro-3-methylphenol	NA	4.00E-01	4.70E-01	7.70E-02	8.90E-02
4-Chloroaniline	1.46E-01	4.00E-01	4.70E-01	1.00E-01	1.20E-01
4-Chlorophenyl phenyl ether	6.56E-01	4.00E-01	4.70E-01	8.00E-02	9.30E-02
4-Methylphenol	6.70E-01	4.00E-01	4.70E-01	6.60E-02	7.70E-02
4-Nitroaniline	2.00E-04	4.00E-01	4.70E-01	***1.00E-01***	***1.20E-01***
4-Nitrophenol	7.78E-03	7.70E-01	8.90E-01	***1.00E-01***	***1.20E-01***
Acenaphthene	3.30E-01	4.00E-01	4.70E-01	8.20E-02	9.60E-02
Acenaphthylene	3.30E-01	4.00E-01	4.70E-01	9.10E-02	1.10E-01
Anthracene	3.30E-01	4.00E-01	4.70E-01	7.00E-02	8.10E-02
Benzo(a)anthracene	3.30E-01	4.00E-01	4.70E-01	5.70E-02	6.60E-02
Benzo(a)pyrene	3.30E-01	4.00E-01	4.70E-01	5.60E-02	6.50E-02
Benzo(b)fluoranthene	6.55E-01	4.00E-01	4.70E-01	7.90E-02	9.20E-02
Benzo(ghi)perylene	6.55E-01	4.00E-01	4.70E-01	5.10E-02	5.90E-02
Benzo(k)fluoranthene	6.55E-01	4.00E-01	4.70E-01	6.00E-02	7.00E-02
Bis(2-Chloroethoxy)methane	NA	4.00E-01	4.70E-01	8.50E-02	9.80E-02
Bis(2-Chloroethyl)ether	2.12E-01	4.00E-01	4.70E-01	7.40E-02	8.60E-02
Bis(2-Chloroisopropyl)ether	NA	4.00E-01	4.70E-01	8.60E-02	1.00E-01
Bis(2-Ethylhexyl)phthalate	1.82E-01	4.00E-01	4.70E-01	6.30E-02	7.30E-02
Butyl benzyl phthalate	4.19E+00	4.00E-01	4.70E-01	5.20E-02	6.00E-02
Carbazole	NA	4.00E-01	4.70E-01	6.10E-02	7.00E-02
Chrysene	3.30E-01	4.00E-01	4.70E-01	5.80E-02	6.70E-02
Dibenz(a,h)anthracene	3.30E-01	4.00E-01	4.70E-01	5.60E-02	6.50E-02
Dibenzofuran	1.52E+00	4.00E-01	4.70E-01	8.20E-02	9.50E-02
Diethyl phthalate	8.04E-03	4.00E-01	4.70E-01	***8.50E-02***	***9.90E-02***
Dimethyl phthalate	2.50E-02	4.00E-01	4.70E-01	***8.40E-02***	***9.80E-02***
Di-n-butyl phthalate	1.11E-01	4.00E-01	4.70E-01	6.30E-02	7.30E-02
Di-n-octyl phthalate	4.06E+01	4.00E-01	4.70E-01	8.50E-02	9.90E-02
Fluoranthene	3.30E-01	4.00E-01	4.70E-01	6.60E-02	7.70E-02
Fluorene	3.30E-01	4.00E-01	4.70E-01	9.40E-02	1.10E-01
Hexachlorobenzene	2.00E-02	4.00E-01	4.70E-01	***6.00E-02***	***7.00E-02***
Hexachlorobutadiene	1.38E+00	4.00E-01	4.70E-01	6.50E-02	7.60E-02
Hexachlorocyclopentadiene	9.01E-01	4.00E-01	4.70E-01	7.60E-02	8.90E-02
Hexachloroethane	2.23E+00	4.00E-01	4.70E-01	8.00E-02	9.30E-02
Indeno(1,2,3-cd)pyrene	6.55E-01	4.00E-01	4.70E-01	5.70E-02	6.60E-02
Isophorone	4.22E-01	4.00E-01	4.70E-01	8.00E-02	9.30E-02
Naphthalene	3.30E-01	4.00E-01	4.70E-01	8.20E-02	9.60E-02
Nitrobenzene	4.88E-01	4.00E-01	4.70E-01	8.90E-02	1.00E-01
N-Nitroso-di-n-propylamine	NA	4.00E-01	4.70E-01	8.70E-02	1.00E-01
N-Nitrosodiphenylamine	1.55E-01	4.00E-01	4.70E-01	6.00E-02	7.00E-02
Pentachlorophenol	6.90E-01	7.70E-01	8.90E-01	8.40E-02	9.70E-02
Phenanthrene	3.30E-01	4.00E-01	4.70E-01	6.20E-02	7.20E-02
Phenol	2.73E-02	4.00E-01	4.70E-01	***6.90E-02***	***8.00E-02***
Pyrene	3.30E-01	4.00E-01	4.70E-01	6.40E-02	7.40E-02
Volatile Organic Compounds :					
1,1,1,2-Tetrachloroethane	1.09E-02	5.20E-03	7.10E-03	5.20E-04	7.10E-04
1,1,1-Trichloroethane	1.70E-01	5.20E-03	7.10E-03	5.00E-04	6.80E-04
1,1,2,2-Tetrachloroethane	9.40E-01	5.20E-03	7.10E-03	3.30E-04	4.40E-04
1,1,2-Trichloroethane	6.74E-01	5.20E-03	7.10E-03	1.20E-03	1.60E-03
1,1-Dichloroethane	5.75E-04	5.20E-03	7.10E-03	5.10E-04	***6.90E-04***
1,1-Dichloroethene	2.09E-01	5.20E-03	7.10E-03	5.40E-04	7.30E-04
1,1-Dichloropropene	2.96E-03	5.20E-03	7.10E-03	1.10E-03	1.50E-03

Table 7-4

Sediment Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Range of Reporting Limits (mg/kg) minimum	Range of Reporting Limits (mg/kg) maximum	Range of Method Detection Limits (mg/kg) minimum	Range of Method Detection Limits (mg/kg) maximum
1,2,3-Trichlorobenzene	6.40E-02	5.20E-03	7.10E-03	5.10E-04	6.90E-04
1,2,3-Trichloropropane	8.35E-03	5.20E-03	7.10E-03	5.90E-04	8.00E-04
1,2,4-Trichlorobenzene	6.40E-02	5.20E-03	7.10E-03	6.50E-04	8.80E-04
1,2,4-Trimethylbenzene	NA	5.20E-03	7.10E-03	3.20E-04	4.30E-04
1,2-Dibromo-3-Chloropropane	2.00E-02	1.00E-02	1.40E-02	1.20E-03	1.60E-03
1,2-Dibromoethane	1.24E-02	5.20E-03	7.10E-03	6.70E-04	9.00E-04
1,2-Dichlorobenzene	5.00E-02	5.20E-03	7.10E-03	3.10E-04	4.20E-04
1,2-Dichloroethane	5.42E-02	5.20E-03	7.10E-03	9.30E-04	1.30E-03
1,2-Dichloropropane	3.52E-01	5.20E-03	7.10E-03	4.10E-04	5.50E-04
1,2-Dimethylbenzene	NA	5.20E-03	7.10E-03	2.90E-04	3.90E-04
1,3,5-Trimethylbenzene	NA	5.20E-03	7.10E-03	4.50E-04	6.10E-04
1,3-Dichlorobenzene	1.70E-01	5.20E-03	7.10E-03	3.10E-04	4.30E-04
1,3-Dichloropropane	3.52E-01	5.20E-03	7.10E-03	7.10E-04	9.60E-04
1,4-Dichlorobenzene	1.20E-01	5.20E-03	7.10E-03	3.60E-04	4.80E-04
2-Hexanone	1.01E+00	2.10E-02	2.80E-02	2.00E-03	2.70E-03
4-Methyl-2-pentanone	5.44E-01	2.10E-02	2.80E-02	1.70E-03	2.30E-03
Benzene	5.70E-02	5.20E-03	7.10E-03	3.60E-04	4.90E-04
Bromobenzene	NA	5.20E-03	7.10E-03	3.80E-04	5.20E-04
Bromochloromethane	NA	5.20E-03	7.10E-03	8.50E-04	1.20E-03
Bromodichloromethane	1.13E-03	5.20E-03	7.10E-03	3.80E-04	5.10E-04
Bromoform	9.96E-01	5.20E-03	7.10E-03	3.40E-04	4.60E-04
Bromomethane	NA	5.20E-03	7.10E-03	2.70E-03	3.60E-03
Carbon disulfide	1.34E-01	5.20E-03	7.10E-03	2.90E-04	4.00E-04
Carbon tetrachloride	3.57E-02	5.20E-03	7.10E-03	4.60E-04	6.20E-04
Chlorobenzene	6.19E-02	5.20E-03	7.10E-03	2.60E-04	3.50E-04
Chloroethane	5.86E+01	1.00E-02	1.40E-02	3.30E-03	4.50E-03
Chloroform	2.70E-02	5.20E-03	7.10E-03	4.70E-04	6.30E-04
Chloromethane	7.85E-05	5.20E-03	7.10E-03	***2.60E-03***	***3.60E-03***
Cis-1,2-Dichloroethene	2.09E-01	5.20E-03	7.10E-03	2.60E-04	3.50E-04
Cis-1,3-Dichloropropene	2.96E-03	5.20E-03	7.10E-03	3.50E-04	4.70E-04
Cumene	NA	5.20E-03	7.10E-03	4.90E-04	6.60E-04
Dibromochloromethane	2.68E-01	5.20E-03	7.10E-03	6.10E-04	8.20E-04
Dibromomethane	1.24E-02	5.20E-03	7.10E-03	8.30E-04	1.10E-03
Dichlorodifluoromethane	1.33E-03	1.00E-02	1.40E-02	***2.90E-03***	***3.90E-03***
Ethylbenzene	3.60E+00	5.20E-03	7.10E-03	3.40E-04	4.60E-04
Hexachlorobutadiene	1.38E+00	5.20E-03	7.10E-03	5.40E-04	7.30E-04
m,p-Xylenes	2.50E-02	1.00E-02	1.40E-02	7.70E-04	1.00E-03
Methylene chloride	1.26E+00	1.20E-02	1.20E-02	1.80E-03	1.80E-03
Naphthalene	3.46E-02	1.00E-02	1.40E-02	3.30E-03	4.50E-03
N-Butylbenzene	NA	5.20E-03	7.10E-03	2.60E-04	3.50E-04
N-Propylbenzene	NA	5.20E-03	7.10E-03	2.60E-04	3.50E-04
o-Chlorotoluene	NA	5.20E-03	7.10E-03	5.50E-04	7.50E-04
p-Chlorotoluene	NA	5.20E-03	7.10E-03	4.30E-04	5.80E-04
p-Cymene	NA	5.20E-03	7.10E-03	2.60E-04	3.50E-04
sec-Butylbenzene	NA	5.20E-03	7.10E-03	3.10E-04	4.20E-04
sec-Dichloropropane	NA	5.20E-03	7.10E-03	4.20E-04	5.70E-04
Styrene	4.45E-01	5.20E-03	7.10E-03	5.30E-04	7.20E-04
tert-Butylbenzene	NA	5.20E-03	7.10E-03	2.60E-04	3.50E-04
Tetrachloroethene	1.96E-01	5.20E-03	7.10E-03	3.90E-04	5.20E-04
Toluene	6.70E-01	5.20E-03	7.10E-03	5.70E-04	7.70E-04
Trans-1,2-Dichloroethene	2.09E-01	5.20E-03	7.10E-03	3.50E-04	4.70E-04
Trans-1,3-Dichloropropene	2.96E-03	5.20E-03	7.10E-03	5.50E-04	7.40E-04

Table 7-4

Sediment Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	ESV [a] (mg/kg)	Range of Reporting Limits (mg/kg) minimum	maximum	Range of Method Detection Limits (mg/kg) minimum	maximum
Trichloroethene	1.80E-01	5.20E-03	7.10E-03	3.30E-04	4.50E-04
Vinyl chloride	2.00E-03	5.20E-03	7.10E-03	***2.50E-03***	***3.30E-03***

Method detection limits that exceed the ESV are shown in bold font and shaded.

[a] Ecological Screening Values (ESV) presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000)..

mg/kg - milligram per kilogram

NA - Not Available

Table 7-5

Groundwater Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	Surface Water ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) maximum
Metals :					
Antimony	1.60E-01	1.00E-01	1.00E-01	5.00E-02	5.00E-02
Arsenic	1.90E-01	1.00E-02	1.00E-02	1.70E-03	1.70E-03
Beryllium	5.30E-04	1.00E-02	1.00E-02	***1.00E-03***	***1.00E-03***
Cadmium	6.60E-04	1.00E-02	1.00E-02	***5.00E-03***	***5.00E-03***
Chromium	1.10E-02	2.00E-02	2.00E-02	6.00E-03	6.00E-03
Cobalt	3.00E-03	2.00E-02	2.00E-02	***1.10E-02***	***1.10E-02***
Lead	1.32E-03	1.00E-02	1.00E-02	1.30E-03	1.30E-03
Mercury	1.20E-05	5.00E-04	5.00E-04	***1.18E-04***	***1.18E-04***
Nickel	8.77E-02	2.00E-02	2.00E-02	1.50E-02	1.50E-02
Selenium	5.00E-03	1.00E-02	1.00E-02	2.70E-03	2.70E-03
Silver	1.20E-05	2.00E-02	2.00E-02	***1.00E-02***	***1.00E-02***
Thallium	4.00E-03	1.00E-02	1.00E-02	3.70E-03	3.70E-03
Vanadium	1.90E-02	2.00E-02	2.00E-02	5.00E-03	5.00E-03
Nitroaromatics :					
1,3,5-Trinitrobenzene	1.10E-02	4.00E-04	1.00E-03	1.90E-04	2.00E-04
1,3-Dinitrobenzene	2.00E-02	4.00E-04	1.00E-03	1.10E-04	2.00E-04
2,4,6-Trinitrotoluene	9.00E-02	4.00E-04	1.00E-03	1.40E-04	2.00E-04
2,4-Dinitrotoluene	2.30E-01	4.00E-04	1.00E-03	1.40E-04	2.00E-04
2,6-Dinitrotoluene	4.20E-02	4.00E-04	1.00E-03	1.90E-04	2.00E-04
3-Nitrotoluene	NA	6.00E-04	1.00E-03	2.00E-04	2.90E-04
HMX	3.30E-01	4.00E-04	1.00E-03	1.90E-04	2.00E-04
Nitrobenzene	7.40E-01	4.00E-04	1.00E-03	1.10E-04	2.00E-04
p-Nitrotoluene	NA	6.00E-04	1.00E-03	2.00E-04	2.50E-04
RDX	1.90E-01	4.00E-04	1.00E-03	1.70E-04	2.00E-04
Tetryl	NA	4.00E-04	1.00E-03	1.50E-04	2.00E-04
Perchlorate Compound :					
Perchlorate	NA	5.00E-03	5.00E-03	8.09E-04	8.09E-04
Semivolatile Organic Compounds :					
1,2,4-Trichlorobenzene	4.49E-02	9.50E-03	1.00E-02	3.50E-03	3.70E-03
1,2-Dichlorobenzene	1.58E-02	9.50E-03	1.00E-02	4.40E-03	4.60E-03
1,3-Dichlorobenzene	5.02E-02	9.50E-03	1.00E-02	4.20E-03	4.40E-03
1,4-Dichlorobenzene	1.12E-02	9.50E-03	1.00E-02	4.30E-03	4.50E-03
2,4,5-Trichlorophenol	6.30E-02	9.50E-03	1.00E-02	4.00E-03	4.20E-03
2,4,6-Trichlorophenol	3.20E-03	9.50E-03	1.00E-02	***4.60E-03***	***4.80E-03***
2,4-Dichlorophenol	3.65E-02	9.50E-03	1.00E-02	4.20E-03	4.40E-03
2,4-Dimethylphenol	2.12E-02	9.50E-03	1.00E-02	4.20E-03	4.40E-03
2,4-Dinitrophenol	6.20E-03	1.90E-02	2.00E-02	5.60E-03	5.90E-03
2,4-Dinitrotoluene	3.10E-01	1.90E-02	2.00E-02	5.90E-03	6.20E-03
2,6-Dinitrotoluene	4.20E-02	1.90E-02	2.00E-02	6.00E-03	6.30E-03
2-Chloronaphthalene	3.96E-04	9.50E-03	1.00E-02	***4.50E-03***	***4.80E-03***
2-Chlorophenol	4.38E-02	9.50E-03	1.00E-02	4.40E-03	4.70E-03
2-Methylnaphthalene	3.30E-01	9.50E-03	1.00E-02	3.80E-03	4.00E-03
2-Methylphenol	4.89E-01	9.50E-03	1.00E-02	3.30E-03	3.50E-03
2-Nitroaniline	NA	1.90E-02	2.00E-02	5.40E-03	5.70E-03
2-Nitrophenol	3.50E+00	9.50E-03	1.00E-02	4.40E-03	4.70E-03
3,3'-Dichlorobenzidine	9.98E-02	9.50E-03	1.00E-02	3.90E-03	4.10E-03
3-Nitroaniline	NA	9.50E-03	1.00E-02	4.60E-03	4.80E-03
4,6-Dinitro-2-methylphenol	NA	1.90E-02	2.00E-02	6.10E-03	6.50E-03
4-Bromophenyl phenyl ether	1.50E-03	1.90E-02	2.00E-02	***6.50E-03***	***6.80E-03***
4-Chloro-3-methylphenol	3.00E-04	9.50E-03	1.00E-02	***4.50E-03***	***4.70E-03***
4-Chloroaniline	5.00E-02	9.50E-03	1.00E-02	4.40E-03	4.60E-03
4-Chlorophenyl phenyl ether	NA	9.50E-03	1.00E-02	5.00E-03	5.20E-03

Table 7-5

Groundwater Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	Surface Water ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) maximum
4-Methylphenol	4.89E-01	9.50E-03	1.00E-02	3.70E-03	3.90E-03
4-Nitroaniline	NA	9.50E-03	1.00E-02	4.60E-03	4.80E-03
4-Nitrophenol	8.28E-02	9.50E-03	1.00E-02	4.90E-03	5.10E-03
Acenaphthene	1.70E-02	9.50E-03	1.00E-02	4.50E-03	4.70E-03
Acenaphthylene	4.84E+00	9.50E-03	1.00E-02	4.60E-03	4.90E-03
Anthracene	2.90E-05	9.50E-03	1.00E-02	***4.60E-03***	***4.80E-03***
Benzo(a)anthracene	8.39E-04	9.50E-03	1.00E-02	***4.00E-03***	***4.20E-03***
Benzo(a)pyrene	1.40E-05	9.50E-03	1.00E-02	***3.90E-03***	***4.10E-03***
Benzo(b)fluoranthene	9.07E-03	9.50E-03	1.00E-02	3.60E-03	3.80E-03
Benzo(ghi)perylene	7.64E-03	9.50E-03	1.00E-02	4.10E-03	4.30E-03
Benzo(k)fluoranthene	5.60E-06	9.50E-03	1.00E-02	***4.60E-03***	***4.80E-03***
Bis(2-Chloroethoxy)methane	1.10E+01	9.50E-03	1.00E-02	4.40E-03	4.70E-03
Bis(2-Chloroethyl)ether	2.38E+00	9.50E-03	1.00E-02	4.80E-03	5.10E-03
Bis(2-Chloroisopropyl)ether	NA	9.50E-03	1.00E-02	5.20E-03	5.40E-03
Bis(2-Ethylhexyl)phthalate	3.00E-04	1.90E-02	2.00E-02	***9.40E-03***	***9.90E-03***
Butyl benzyl phthalate	2.20E-02	9.50E-03	1.00E-02	3.70E-03	3.90E-03
Carbazole	NA	9.50E-03	1.00E-02	4.70E-03	5.00E-03
Chrysene	3.30E-05	9.50E-03	1.00E-02	***3.80E-03***	***4.00E-03***
Dibenz(a,h)anthracene	1.60E-06	9.50E-03	1.00E-02	***4.40E-03***	***4.70E-03***
Dibenzofuran	2.00E-02	9.50E-03	1.00E-02	4.50E-03	4.80E-03
Diethyl phthalate	5.21E-01	1.90E-02	2.00E-02	5.50E-03	5.70E-03
Dimethyl phthalate	3.30E-01	1.90E-02	2.00E-02	5.30E-03	5.50E-03
Di-n-butyl phthalate	9.40E-03	9.50E-03	1.00E-02	4.60E-03	4.80E-03
Di-n-octyl phthalate	3.00E-02	9.50E-03	1.00E-02	4.30E-03	4.60E-03
Fluoranthene	3.98E-02	9.50E-03	1.00E-02	5.00E-03	5.30E-03
Fluorene	3.90E-03	9.50E-03	1.00E-02	***4.60E-03***	***4.90E-03***
Hexachlorobenzene	3.68E-03	1.90E-02	2.00E-02	***5.30E-03***	***5.50E-03***
Hexachlorobutadiene	9.30E-04	9.50E-03	1.00E-02	***3.70E-03***	***3.90E-03***
Hexachlorocyclopentadiene	7.00E-05	9.50E-03	1.00E-02	***4.80E-03***	***5.00E-03***
Hexachloroethane	9.80E-03	9.50E-03	1.00E-02	3.80E-03	4.00E-03
Indeno(1,2,3-cd)pyrene	4.31E-03	9.50E-03	1.00E-02	3.80E-03	3.90E-03
Isophorone	1.17E+00	9.50E-03	1.00E-02	4.40E-03	4.60E-03
Naphthalene	6.20E-02	9.50E-03	1.00E-02	4.10E-03	4.30E-03
Nitrobenzene	2.70E-01	9.50E-03	1.00E-02	4.80E-03	5.10E-03
N-Nitroso-di-n-propylamine	NA	9.50E-03	1.00E-02	4.70E-03	4.90E-03
N-Nitrosodiphenylamine	5.85E-02	9.50E-03	1.00E-02	4.50E-03	4.80E-03
Pentachlorophenol	1.30E-02	1.90E-02	2.00E-02	6.10E-03	6.40E-03
Phenanthrene	6.30E-03	1.90E-02	2.00E-02	5.40E-03	5.70E-03
Phenol	2.56E-01	9.50E-03	1.00E-02	3.90E-03	4.10E-03
Pyrene	3.00E-04	9.50E-03	1.00E-02	***4.50E-03***	***4.70E-03***
Volatile Organic Compounds :					
1,1,1,2-Tetrachloroethane	2.40E+00	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,1,1-Trichloroethane	5.28E-01	1.00E-03	1.00E-03	1.30E-04	1.30E-04
1,1,2,2-Tetrachloroethane	2.40E-01	1.00E-03	1.00E-03	2.80E-04	2.80E-04
1,1,2-Trichloroethane	9.40E-01	1.00E-03	1.00E-03	2.30E-04	2.30E-04
1,1-Dichloroethane	4.70E-02	1.00E-03	1.00E-03	1.20E-04	1.20E-04
1,1-Dichloroethene	3.03E-01	1.00E-03	1.00E-03	1.50E-04	1.50E-04
1,1-Dichloropropene	2.44E-01	1.00E-03	1.00E-03	2.20E-04	2.20E-04
1,2,3-Trichlorobenzene	6.92E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2,3-Trichloropropane	1.21E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,2,4-Trichlorobenzene	4.49E-02	1.00E-03	1.00E-03	2.00E-04	2.00E-04
1,2,4-Trimethylbenzene	NA	1.00E-03	1.00E-03	1.40E-04	1.40E-04
1,2-Dibromoethane	2.25E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04

Table 7-5

Groundwater Reporting Limits and Method Detection Limits of Nondetect Results Compared to ESVs
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Chemical	Surface Water ESV [a] (mg/L)	Range of Reporting Limits (mg/L) minimum	Range of Reporting Limits (mg/L) maximum	Range of Method Detection Limits (mg/L) minimum	Range of Method Detection Limits (mg/L) maximum
1,2-Dichlorobenzene	1.58E-02	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,2-Dichloroethane	2.00E+00	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2-Dichloropropane	5.25E-01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,2-Dimethylbenzene	NA	1.00E-03	1.00E-03	1.20E-04	1.20E-04
1,3,5-Trimethylbenzene	NA	1.00E-03	1.00E-03	1.50E-04	1.50E-04
1,3-Dichlorobenzene	5.02E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
1,3-Dichloropropane	5.21E-01	1.00E-03	1.00E-03	1.60E-04	1.60E-04
1,4-Dichlorobenzene	1.12E-02	5.00E-03	5.00E-03	1.40E-04	1.40E-04
2-Hexanone	1.71E+00	1.00E-02	1.00E-02	1.00E-03	1.00E-03
4-Methyl-2-pentanone	3.68E+00	1.00E-02	1.00E-02	1.00E-03	1.00E-03
Benzene	5.30E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Bromobenzene	NA	1.00E-03	1.00E-03	1.60E-04	1.60E-04
Bromochloromethane	1.10E+01	1.00E-03	1.00E-03	1.40E-04	1.40E-04
Bromoform	2.93E-01	1.00E-03	1.00E-03	2.20E-04	2.20E-04
Bromomethane	NA	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Carbon disulfide	8.40E-02	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Carbon tetrachloride	3.52E-01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Chlorobenzene	1.95E-01	1.00E-03	1.00E-03	1.20E-04	1.20E-04
Chloroethane	2.30E+02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Chloromethane	5.50E+00	1.00E-03	1.00E-03	4.00E-04	4.00E-04
Cis-1,2-Dichloroethene	1.16E+01	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Cis-1,3-Dichloropropene	2.44E-02	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Cumene	NA	1.00E-03	1.00E-03	1.60E-04	1.60E-04
Dibromomethane	2.25E-02	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Dichlorodifluoromethane	1.10E+01	1.00E-03	1.00E-03	4.20E-04	4.20E-04
Ethylbenzene	4.53E-01	1.00E-03	1.00E-03	1.10E-04	1.10E-04
Hexachlorobutadiene	9.30E-04	1.00E-03	1.00E-03	1.90E-04	1.90E-04
m,p-Xylenes	1.17E-01	2.00E-03	2.00E-03	2.40E-04	2.40E-04
Methylene chloride	1.93E+00	2.00E-03	2.00E-03	1.20E-04	1.20E-04
Naphthalene	6.20E-02	1.00E-03	1.00E-03	2.70E-04	2.70E-04
N-Butylbenzene	NA	1.00E-03	1.00E-03	1.40E-04	1.40E-04
N-Propylbenzene	NA	1.00E-03	1.00E-03	1.50E-04	1.50E-04
o-Chlorotoluene	NA	1.00E-03	1.00E-03	1.90E-04	1.90E-04
p-Chlorotoluene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
p-Cymene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
sec-Butylbenzene	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
sec-Dichloropropane	NA	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Styrene	5.60E-02	1.00E-03	1.00E-03	1.10E-04	1.10E-04
tert-Butylbenzene	NA	1.00E-03	1.00E-03	1.30E-04	1.30E-04
Tetrachloroethene	8.40E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Toluene	1.75E-01	1.00E-03	1.00E-03	1.20E-04	1.20E-04
Trans-1,2-Dichloroethene	1.35E+00	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Trans-1,3-Dichloropropene	2.44E-02	1.00E-03	1.00E-03	1.80E-04	1.80E-04
Trichloroethene	2.19E+01	1.00E-03	1.00E-03	1.50E-04	1.50E-04
Trichlorofluoromethane	1.10E+01	1.00E-03	1.00E-03	1.70E-04	1.70E-04
Vinyl chloride	9.20E-03	1.00E-03	1.00E-03	2.50E-04	2.50E-04

Method detection limits that exceed the ESV are shown in bold font and shaded.

[a] Ecological Screening Values (ESV) presented in *Human Health and Ecological Screening Values and PAH Background Summary Report* (IT, 2000)..

mg/L - milligram per liter

NA - Not Available

Table 7-6

Constituents Eliminated From COPEC Consideration
Based on Background Comparison
Iron Mountain Road and Bains Gap Road Ranges
Fort McClellan, Calhoun County, Alabama

Iron Mountain Road Ranges

	Aluminum	Arsenic	Barium	Chromium	Iron	Lead	Manganese	Thallium	Vanadium
Skeet Range Surface Soil	•	•		•	•			•	•
Range 12 Surface Soil	•			•	•		•		•
Range 13 Surface Soil	•			•	•		•		•
Range 19 Surface Soil	•			•	•		•	•	•
Surface Water	•		•				•		
Sediment	•								
Groundwater	•					•			

Bains Gap Road Ranges

	Aluminum	Arsenic	Barium	Beryllium	Chromium	Cobalt	Iron	Lead	Manganese	Thallium	Vanadium
Range 21 Surface Soil	•				•		•		•		•
Range 22 Surface Soil	•	•			•		•		•	•	•
Range 24-Upper Surface Soil		•									•
Range 27 Surface Soil	•				•		•				•
Surface Water	•		•				•		•		
Sediment	•			•							•
Groundwater						•		•			

Table 8-1

Summary of Potential Ecological Risk-Based Remedial Goals
Iron Mountain Road and Bains Gap Road Ranges BERA
Fort McClellan, Calhoun County, Alabama

Measurement Endpoints	Soil COPECs			
	Antimony (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)
Terrestrial Invertebrate Survival and Growth :				
28-Day Earthworm Survival NOEC	6.7	127	779	47.3
28-Day Earthworm Survival LOEC	17.9	334	2,310	63.9
28-Day Earthworm Survival AET	>1,620	509	15,600	139
28-Day Earthworm Growth NOEC	NA	61.4	760	33.5
28-Day Earthworm Growth LOEC	NA	62.2	779	35.1
28-Day Earthworm Growth AET	63.3	334	6,820	72.8
Terrestrial Food Web Exposures :				
White-Footed Mouse NOAEL	4.67	267	205	1,750
White-Footed Mouse LOAEL	46.7	350	1,680	193,000
American Robin NOAEL	2.8	850	55	39,000
American Robin LOAEL	14	1,140	147	555,000
Short-Tailed Shrew NOAEL	6.01	820	100	215
Short-Tailed Shrew LOAEL	60.1	1,185	800	173,000
American Woodcock NOAEL	10.85	11,870	105.5	46,500
American Woodcock LOAEL	54.2	16,200	280	550,000
Soil RBRG Range :	2.8 - >1,620	61.4 - 16,200	55 - >15,600	33.5 - 555,000

NA - Antimony concentrations in soil were poorly correlated with measured earthworm growth; therefore, it was determined that antimony was not a causative agent in reduced earthworm growth.