

APPENDIX H

**STATISTICAL AND GEOCHEMICAL
EVALUATIONS OF SITE METALS DATA**

STATISTICAL

Statistical Comparison of Site and Background Data Range 30, Firing Line Area, Parcels 88Q, 102Q, and 106Q-X Fort McClellan, Alabama

1.0 Introduction

This report provides the Tier 1 and Tier 2 (Shaw E&I, 2003) site-to-background comparison results for Range 30, Firing Line Area, Parcels 88Q, 102Q, and 106Q-X, Fort McClellan, in Calhoun County, Alabama. In the first step of the comparison, the maximum detected concentration (MDC) of each element is compared to two times the arithmetic mean of the background data (SAIC, 1998). Any metal that has an MDC greater than the background screening value is carried forward for Tier 2 evaluation, which includes the Slippage Test and the Wilcoxon Rank Sum Test (WRS). If either or both of these statistical test cannot be done, the evaluation will include the Hot Measurement Test.

The methodology and results of the Tier 1 and Tier 2 comparisons are summarized in Tables 1 through 5, and described in more detail in the following sections. Site samples used in the site-to-background comparison include 40 surface soil samples (0 to 1 foot below ground surface [bgs]), 33 subsurface soil (2.5 to 4 feet bgs), 5 groundwater samples, 2 sediment samples, and 2 surface water samples that were collected at the site.

Background distributions and screening values have been established for target analyte list metals in surface soil, subsurface soil, groundwater, sediment, and surface water for Fort McClellan (SAIC, 1998).

2.0 Comparison Methodology

This section describes the statistical techniques that were employed in the Range 30 site-to-background comparison.

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,

Table 1

**Summary of Tier 1 and Tier 2 Site to Background Comparison for Surface Soil
Range 30, Firing Line Area (Parcels 88Q, 102Q, and 106Q-X)
Fort McClellan, Calhoun County, Alabama**

Metals	Frequency of Detection	Tier 1 Evaluation ^a	Slippage Test ^b	Wilcoxon Rank Sum Test ^b	Hot Measurement Test ^{b,c}	Carried Forward for Tier 3 Geochemical Evaluation
Aluminum	40 / 40	Failed	Passed	Failed	NA	Yes
Antimony	0 / 40	NA	NA	NA	NA	
Arsenic	40 / 40	Passed	NA	NA	NA	
Barium	40 / 40	Failed	Passed	Failed	NA	Yes
Beryllium	32 / 40	Failed	Passed	Failed	NA	Yes
Cadmium	0 / 40	NA	NA	NA	NA	
Calcium	40 / 40	Failed	Passed	Failed	NA	Yes
Chromium	40 / 40	Failed	Passed	Passed	NA	
Cobalt	32 / 40	Passed	NA	NA	NA	
Copper	40 / 40	Failed	Passed	Failed	NA	Yes
Iron	40 / 40	Failed	Passed	Passed	NA	
Lead	40 / 40	Failed	Passed	Failed	NA	Yes
Magnesium	40 / 40	Failed	Passed	Failed	NA	Yes
Manganese	40 / 40	Failed	Passed	Failed	NA	Yes
Mercury	37 / 40	Failed	Passed	NA ^d	Failed	Yes
Nickel	39 / 40	Failed	Passed	Failed	NA	Yes
Potassium	40 / 40	Failed	Passed	Failed	NA	Yes
Selenium	1 / 40	Failed	Passed	NA ^d	Failed	Yes
Silver	0 / 40	NA	NA	NA	NA	
Sodium	38 / 40	Passed	NA	NA	NA	
Thallium	0 / 40	NA	NA	NA	NA	
Vanadium	40 / 40	Failed	Passed	Passed	NA	
Zinc	34 / 40	Failed	Passed	Failed	NA	Yes

NA = not applicable

a Tier 1 evaluation per **Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC, Revision 2**, Technical Memorandum, 24 June 2003 by Paul Goetchius.

b Part of Tier 2 evaluation per the above referenced memo.

c Performed only when the Slippage test and/or Wilcoxon Rank Sum (WRS) test cannot be performed.

d WRS test is not performed on data sets containing 50% or more nondetects.

Table 2

Summary of Tier 1 and Tier 2 Site to Background Comparison for Subsurface Soil, Range 30
Firing Line Area (Parcels 88Q, 102Q, and 106Q-X)
Fort McClellan, Calhoun County, Alabama

Metals	Frequency of Detection	Tier 1 Evaluation ^a	Slippage Test ^b	Wilcoxon Rank Sum Test ^b	Hot Measurement Test ^{b,c}	Carried Forward for Tier 3 Geochemical Evaluation
Aluminum	33 / 33	Failed	Failed	Failed	NA	Yes
Antimony	1 / 33	Failed	NA ^c	NA ^e	Passed	
Arsenic	33 / 33	Passed	NA	NA	NA	
Barium	33 / 33	Failed	Passed	Failed	NA	Yes
Beryllium	24 / 33	Failed	Passed	Failed	NA	Yes
Cadmium	0 / 33	NA	NA	NA	NA	
Calcium	31 / 33	Passed	NA	NA	NA	
Chromium	33 / 33	Failed	Passed	Passed	NA	
Cobalt	28 / 33	Failed	Passed	Passed	NA	
Copper	33 / 33	Passed	NA	NA	NA	
Iron	33 / 33	Passed	NA	NA	NA	
Lead	33 / 33	Failed	Passed	Failed	NA	Yes
Magnesium	33 / 33	Failed	Passed	Failed	NA	Yes
Manganese	33 / 33	Failed	Passed	Failed	NA	Yes
Mercury	28 / 33	Failed	Passed	NA ^e	Failed	Yes
Nickel	31 / 33	Passed	NA	NA	NA	
Potassium	33 / 33	Failed	Passed	Failed	NA	Yes
Selenium	3 / 33	Failed	NA ^c	NA ^e	Failed	Yes
Silver	1 / 33	Failed	NA ^c	NA ^e	Failed	Yes
Sodium	32 / 33	Passed	NA	NA	NA	
Thallium	0 / 33	NA	NA	NA	NA	
Vanadium	33 / 33	Passed	NA	NA	NA	
Zinc	29 / 33	Failed	Passed	Failed	NA	Yes

NA = not applicable

a Tier 1 evaluation per **Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC, Revision 2**, Technical Memorandum, 24 June 2003 by Paul Goetchius.

b Part of Tier 2 evaluation per the above referenced memo.

c Performed only when the Slippage test and/or Wilcoxon Rank Sum (WRS) test cannot be performed.

d Slippage test is not performed on data sets for which the maximum background value is a nondetect.

e WRS test is not performed on data sets containing 50% or more nondetects.

Table 3

Summary of Tier 1 and Tier 2 Site to Background Comparison for Groundwater
Range 30, Firing Line Area (Parcels 88Q, 102Q, and 106Q-X)
Fort McClellan, Calhoun County, Alabama

Metals	Frequency of Detection	Tier 1 Evaluation ^a	Slippage Test ^b	Wilcoxon Rank Sum Test ^b	Hot Measurement Test ^{b,c}	Carried Forward for Tier 3 Geochemical Evaluation
Aluminum	2 / 5	Passed	NA	NA	NA	
Antimony	0 / 5	NA	NA	NA	NA	
Arsenic	0 / 5	NA	NA	NA	NA	
Barium	4 / 5	Passed	NA	NA	NA	
Beryllium	0 / 5	NA	NA	NA	NA	
Cadmium	0 / 5	NA	NA	NA	NA	
Calcium	2 / 5	Passed	NA	NA	NA	
Chromium	0 / 5	NA	NA	NA	NA	
Cobalt	0 / 5	NA	NA	NA	NA	
Copper	0 / 5	NA	NA	NA	NA	
Iron	5 / 5	Passed	NA	NA	NA	
Lead	0 / 5	NA	NA	NA	NA	
Magnesium	3 / 5	Passed	NA	NA	NA	
Manganese	5 / 5	Passed	NA	NA	NA	
Mercury	0 / 5	NA	NA	NA	NA	
Nickel	0 / 5	NA	NA	NA	NA	
Potassium	3 / 5	Passed	NA	NA	NA	
Selenium	1 / 5	Failed	NA ^d	NA ^e	Passed	
Silver	0 / 5	NA	NA	NA	NA	
Sodium	3 / 5	Passed	NA	NA	NA	
Thallium	0 / 5	NA	NA	NA	NA	
Vanadium	0 / 5	NA	NA	NA	NA	
Zinc	0 / 5	NA	NA	NA	NA	

NA = not applicable

a Tier 1 evaluation per **Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC, Revision 2**, Technical Memorandum, 24 June 2003 by Paul Goetchius.

b Part of Tier 2 evaluation per the above referenced memo.

c Performed only when the Slippage test and/or Wilcoxon Rank Sum (WRS) test cannot be performed.

d Slippage test is not performed on data sets for which the maximum background value is a nondetect.

e WRS test is not performed on data sets containing 50% or more nondetects.

Table 4

**Summary of Tier 1 and Tier 2 Site to Background Comparison for Sediment
Range 30, Firing Line Area (Parcels 88Q, 102Q, and 106Q-X)
Fort McClellan, Calhoun County, Alabama**

Metals	Frequency of Detection	Tier 1 Evaluation ^a	Slippage Test ^b	Wilcoxon Rank Sum Test ^b	Hot Measurement Test ^{b,c}	Carried Forward for Tier 3 Geochemical Evaluation
Aluminum	2 / 2	Failed	Passed	NA ^d	Passed	
Antimony	0 / 2	NA	NA	NA	NA	
Arsenic	2 / 2	Passed	NA	NA	NA	
Barium	2 / 2	Passed	NA	NA	NA	
Beryllium	2 / 2	Passed	NA	NA	NA	
Cadmium	0 / 2	NA	NA	NA	NA	
Calcium	2 / 2	Passed	NA	NA	NA	
Chromium	2 / 2	Passed	NA	NA	NA	
Cobalt	2 / 2	Passed	NA	NA	NA	
Copper	2 / 2	Passed	NA	NA	NA	
Iron	2 / 2	Passed	NA	NA	NA	
Lead	2 / 2	Passed	NA	NA	NA	
Magnesium	2 / 2	Passed	NA	NA	NA	
Manganese	2 / 2	Passed	NA	NA	NA	
Mercury	1 / 2	Passed	NA	NA	NA	
Nickel	2 / 2	Passed	NA	NA	NA	
Potassium	2 / 2	Passed	NA	NA	NA	
Selenium	2 / 2	Passed	NA	NA	NA	
Silver	0 / 2	NA	NA	NA	NA	
Sodium	0 / 2	NA	NA	NA	NA	
Thallium	0 / 2	NA	NA	NA	NA	
Vanadium	2 / 2	Passed	NA	NA	NA	
Zinc	2 / 2	Passed	NA	NA	NA	

NA = not applicable

a Tier 1 evaluation per **Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC, Revision 2**, Technical Memorandum, 24 June 2003 by Paul Goetchius.

b Part of Tier 2 evaluation per the above referenced memo.

c Performed only when the Slippage test and/or Wilcoxon Rank Sum (WRS) test cannot be performed.

d WRS test is not performed on data sets with sample sizes less than 5.

Table 5

Summary of Tier 1 and Tier 2 Site to Background Comparison for Surface Water
 Range 30, Firing Line Area
 (Parcels 88Q, 102Q, and 106Q-X)
 Fort McClellan, Calhoun County, Alabama

Metals	Frequency of Detection	Tier 1 Evaluation ^a	Slippage Test ^b	Wilcoxon Rank Sum Test ^b	Hot Measurement Test ^{b,c}	Carried Forward for Tier 3 Geochemical Evaluation
Aluminum	2 / 2	Failed	Passed	NA ^e	Passed	
Antimony	0 / 2	NA	NA	NA	NA	
Arsenic	2 / 2	Failed	Passed	NA ^e	Passed	
Barium	2 / 2	Passed	NA	NA	NA	
Beryllium	0 / 2	NA	NA	NA	NA	
Cadmium	0 / 2	NA	NA	NA	NA	
Calcium	2 / 2	Passed	NA	NA	NA	
Chromium	1 / 2	Failed	NA ^d	NA ^e	Passed	
Cobalt	0 / 2	NA	NA	NA	NA	
Copper	1 / 2	Failed	Passed	NA ^e	Passed	
Iron	2 / 2	Passed	NA	NA	NA	
Lead	2 / 2	Failed	Passed	NA ^e	Failed	Yes
Magnesium	2 / 2	Passed	NA	NA	NA	
Manganese	2 / 2	Passed	NA	NA	NA	
Mercury	0 / 2	NA	NA	NA	NA	
Nickel	0 / 2	NA	NA	NA	NA	
Potassium	2 / 2	Failed	Passed	NA ^e	Passed	
Selenium	0 / 2	NA	NA	NA	NA	
Silver	0 / 2	NA	NA	NA	NA	
Sodium	2 / 2	Passed	NA	NA	NA	
Thallium	1 / 2	Failed	Passed	NA ^e	Failed	Yes
Vanadium	2 / 2	Failed	Passed	NA ^e	Failed	Yes
Zinc	1 / 2	Failed	Passed	NA ^e	Failed	Yes

NA = not applicable

a Tier 1 evaluation per **Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC, Revision 2**, Technical Memorandum, 24 June 2003 by Paul Goetchius.

b Part of Tier 2 evaluation per the above referenced memo.

c Performed only when the Slippage test and/or WRS test cannot be performed.

d Slippage test is not performed on data sets for which the maximum background value is a nondetect.

e WRS test is not performed on data sets with sample sizes less than 5.

the use of several simultaneous tests is recommended for a valid and complete comparison of site versus background distributions (U.S. Environmental Protection Agency [EPA], 1989, 1992, and 1994; U.S. Navy, 2002).

Analytes that fail the Tier 1 and Tier 2 comparisons are subject to a geochemical evaluation to determine if the elevated concentrations are due to natural processes or if they represent potential contamination.

2.1.1 Tier 1

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

2.1.2 Tier 2

Slippage Test. The nonparametric Slippage test is designed to detect a difference between the upper tails of two distributions, and has been recommended for use in site-to-background comparisons to identify potential localized, or hot-spot, contamination (U.S. Navy, 2002). The test is performed by counting the number (K) of detected concentrations in the site data set that exceed the maximum background measurement, and then comparing this number to a critical value (K_c), which is a function of the number of background samples and the number of site samples. If $K > K_c$, then potential contamination is indicated and the analyte will be subjected to geochemical evaluation. If $K \leq K_c$, then localized contamination is not suspected.

Critical values tables for site and background data sets up to size $n = 50$ are provided in U.S. Navy (2002). Critical values for larger data sets are calculated using the test statistic provided in Rosenbaum (1954). In this report, the Slippage test is performed at the 95 percent confidence level. The test cannot be performed if the maximum background value is a nondetect, because the actual concentration in that sample is unknown.

Wilcoxon Rank Sum Test. The nonparametric WRS test is designed to detect a difference between the medians of two data sets, and has been recommended for use in site-to-background comparisons to identify slight but pervasive contamination (EPA, 2000; 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 will not be performed on data sets containing 50 percent or more nondetects. The medians of such data sets are unknown, and hence the test results would lack sufficient power to yield reliable results.

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 mid-rank. 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 instance, if the test statistic yields a probability of a Type I error (p-level) less than 0.2, then there is a statistically significant difference between the medians at the 80 percent confidence level. A Type I error involves rejecting the null hypothesis when it is true. If the p-level is greater than 0.2, then there is no reasonable justification to reject the null hypothesis at the 80 percent confidence level. It can therefore be concluded that the medians of the two data sets are similar, and it can be assumed to be drawn from the same population.

If the p-level is less than 0.2, 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 0.2, then pervasive site contamination is not suspected.

Box Plots. A quick, robust graphical method recommended by the EPA to visualize and compare two or more groups of data is the box plot comparison (EPA, 1989 and 1992). These 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 small box within the larger box represents the median of the data set. 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.

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 (95th 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). 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 threshold value, then hot-spot contamination is not indicated.

2.1.3 Geochemical Evaluation

If an analyte fails either of the statistical tests described above, then a geochemical evaluation is performed to determine if the elevated concentrations are caused by natural processes. The methodology and results of the geochemical evaluation are provided in Appendix H.

3.0 Results of the Site-to-Background Comparisons

This section presents the results of the site-to-background comparisons for 23 TAL metals in the Range 30 surface soil, subsurface soil, groundwater, sediment, and surface water samples. Tables 1 through 5 summarize the Tier 1 and Tier 2 test results for each media as discussed in the following sections. Statistical test results are discussed in detail below. Box plots are also discussed below and are provided in Attachment 1.

3.1 Surface Soil

Twenty-three TAL metals were evaluated in the Range 30 surface soil. Four metals (antimony, cadmium, silver, and thallium) had no detected concentrations in surface soil. No further discussion of these metals is included.

Three metals (arsenic, cobalt, and sodium) had no detected concentrations above their respective background screening values, passing the Tier 1 evaluation. These metals are considered within the range of background and will not be tested or discussed any further.

The remaining 16 metals underwent Tier 2 evaluation. The statistical test results and box plots are discussed in detail below.

Table 1 summarizes the Tier 1 and Tier 2 test results for surface soil.

Aluminum

Tier 1 Evaluation

Twenty-two site samples exceed the background screening value of 16,306 milligrams per kilogram (mg/kg).

Slippage Test

The critical value, K_c , for aluminum is 3. Aluminum has no site samples exceeding the maximum background measurement ($K=0$). Because $K < K_c$, aluminum passes the Slippage test.

WRS Test

The WRS test p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

Box plots for the site and background data sets are provided in Figure 1-1. The site minimum and interquartile range are higher than the corresponding background values. The site maximum is less than that of background.

Conclusion

Because aluminum in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Barium

Tier 1 Evaluation

Four site samples exceed the background screening value of 123.94 mg/kg.

Slippage Test

K_c for barium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, barium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-1). The site maximum is slightly less than background.

Conclusion

Because barium in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Beryllium

Tier 1 Evaluation

Four site samples exceed the background screening value of 0.8 mg/kg.

Slippage Test

The critical value, K_c is 4, and 4 site samples exceed the maximum background measurement. Because $K \leq K_c$, beryllium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-2).

Conclusion

Because beryllium in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Calcium

Tier 1 Evaluation

One site sample exceeds the background screening value of 1,723 mg/kg.

Slippage Test

K_c for calcium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, calcium passes the Slippage test.

WRS Test

The p-level of 0.153 indicates weak agreement between the site and background distributions.

Box Plot

The site minimum and interquartile range are slightly higher than the corresponding background values (Figure 1-2). The site maximum is lower than that of background.

Conclusion

Because calcium in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Chromium

Tier 1 Evaluation

One site sample exceeds the background screening value of 37.04 mg/kg.

Slippage Test

K_c for chromium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, chromium passes the Slippage test.

WRS Test

The p-level of 0.819 indicates excellent agreement between the site and background distributions.

Box Plot

The site and background medians are similar (Figure 1-3). The site minimum and 25th percentile are higher than the corresponding background values, and the site maximum and 75th percentiles are lower than that of background.

Conclusion

Chromium in surface soil is considered to be within the range of background.

Copper

Tier 1 Evaluation

Six site samples exceed the background screening value of 12.71 mg/kg.

Slippage Test

K_c for copper is 3, and 2 site samples exceed the maximum background measurement. Because $K < K_c$, copper passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-3).

Conclusion

Because copper in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Iron

Tier 1 Evaluation

One site sample exceeds the background screening value of 34,154 mg/kg.

Slippage Test

K_c for iron is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, iron passes the Slippage test.

WRS Test

The p-level of 0.64 indicates a strong agreement between the site and background distributions.

Box Plot

The site and background medians are similar (Figure 1-4). The site minimum and 25th percentile are higher than the corresponding background values. The site maximum and 75th percentile are lower than that of background.

Conclusion

Iron in surface soil is considered to be within the range of background.

Lead

Tier 1 Evaluation

Two site samples exceed the background screening value of 40.05 mg/kg.

Slippage Test

K_c for lead is 3, and two site samples exceed the maximum background measurement. Because $K < K_c$, lead passes the Slippage test.

WRS Test

The p-level of 0.062 indicates weak agreement between the site and background distributions.

Box Plot

The site median is slightly higher than that of background (Figure 1-4). The site minimum, 25th percentile and maximum are higher than that of background. The site and background 75th percentiles are the same.

Conclusion

Because lead in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Magnesium

Tier 1 Evaluation

Two site samples exceed the background screening value of 1,033 mg/kg.

Slippage Test

K_c for magnesium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, magnesium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-5). The site maximum is lower compared to that of background.

Conclusion

Because magnesium in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Manganese

Tier 1 Evaluation

Five site samples exceed the background screening value of 1,579 mg/kg.

Slippage Test

The critical value, K_c , for manganese is 3. No detects in site samples exceed the maximum background measurement. Because $K < K_c$, manganese passes the Slippage test.

WRS Test

The p-level of 0.032 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum, 25th percentile, and median are higher than their respective background values (Figure 1-5). The site 75th percentile is just slightly elevated compared to that of background, and the site maximum is less than the corresponding background value.

Conclusion

Because manganese in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Mercury

Tier 1 Evaluation

Seven site samples exceed the background screening value of 0.08 mg/kg.

Slippage Test

K_c for mercury is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, mercury passes the Slippage test.

WRS Test

The WRS test was not performed because the background data set has more than 50 percent nondetects.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-6). The site maximum is less than that of background. The shape and location of the background box plot are influenced by the percentage of nondetects (66 percent), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC exceeds the background 95th percentile of 0.125 mg/kg.

Conclusion

Because mercury in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Nickel

Tier 1 Evaluation

Five site samples exceed the background screening value of 10.33 mg/kg.

Slippage Test

K_c for nickel is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, nickel passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-6). The site maximum is slightly less than that of background.

Conclusion

Because nickel in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Potassium

Tier 1 Evaluation

Nine site samples exceed the background screening value of 799.76 mg/kg.

Slippage Test

K_c for potassium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, potassium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-7), and the site maximum is less than that of background.

Conclusion

Because potassium in surface soil failed statistical comparison to background, it is carried forward for Tier 3 geochemical evaluation.

Selenium

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.48 mg/kg.

Slippage Test

K_c for selenium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, selenium passes the Slippage test.

WRS Test

No WRS test was performed because the site and background data sets contain more than 50 percent nondetects.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-7), and the site maximum is less than that of background. The shape and location of the background and site box plots are influenced by the high percentage of nondetects (99 percent and 97 percent, respectively), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC exceeds the background 95th percentile of 0.563 mg/kg.

Conclusion

Because selenium in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Vanadium

Tier 1 Evaluation

One site sample exceeds the background screening value of 58.84 mg/kg.

Slippage Test

K_c for vanadium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, vanadium passes the Slippage test.

WRS Test

The p-level of 0.497 indicates very good agreement between the site and background distributions.

Box Plot

The site and background medians are similar (Figure 1-8). The site minimum and 25th percentile are higher than the corresponding background values, and the site 75th percentile and maximum are lower than the corresponding background values.

Conclusion

Vanadium in surface soil is considered to be within the range of background.

Zinc

Tier 1 Evaluation

Three site samples exceed the background screening value of 40.64 mg/kg.

Slippage Test

K_c for zinc is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, zinc passes the Slippage test.

WRS Test

The p-level of 0.007 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and maximum are lower than the corresponding background values (Figure 1-8). The site interquartile range is higher than that of background.

Conclusion

Because zinc in surface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

3.2 Subsurface Soil

Twenty-three TAL metals were evaluated in Range 30, subsurface soil. Two metals, cadmium and thallium, had no detected concentrations. No further discussion of these metals is included.

Seven metals (arsenic, calcium, copper, iron, nickel, sodium, and vanadium) had no detected concentrations above the background screening values, passing the Tier 1 evaluation these metals are considered within the range of background. No further testing or discussion of these metals is included.

The remaining 14 metals underwent Tier 2 evaluation. The statistical tests and box plots are discussed in detail below.

Table 2 summarizes the Tier 1 and Tier 2 test results for subsurface soil.

Aluminum

Tier 1 Evaluation

Twenty-five site samples exceed the background screening value of 13,591 mg/kg.

Slippage Test

The critical value, K_c , for aluminum is 3. Eight site samples exceed the maximum background measurement. Because $K > K_c$, aluminum fails the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

Box plots for the site and background data sets are provided in Figure 1-9. The site minimum, interquartile range, and maximum are higher than that of background.

Conclusion

Because aluminum in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Antimony

Tier 1 Evaluation

One site sample exceeds the background screening value of 1.31 mg/kg.

Slippage Test

The maximum result in background is a nondetect, so the Slippage test is not done.

WRS Test

The WRS test was not performed because the site data set has more than 50 percent nondetects.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-9). The shape and location of the site box plot are influenced by the high percentage of nondetects (97 percent), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC for antimony is less than the background 95th Percentile of 7.14 mg/kg.

Conclusion

Based on statistical comparison to background, antimony in subsurface soil is considered to be within the range of background.

Barium

Tier 1 Evaluation

One site sample exceeds the background screening value of 233.62 mg/kg.

Slippage Test

K_c for barium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, barium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-10). The site maximum is significantly lower than that of background.

Conclusion

Because barium in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Beryllium

Tier 1 Evaluation

Three site samples exceed the background screening value of 0.86 mg/kg.

Slippage Test

K_c for beryllium is 4, and no site samples exceed the maximum background measurement. Because $K < K_c$, beryllium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum, 25th percentile, and median are significantly higher than the corresponding background values (Figure 1-10). The site median and 75th percentile are higher than the corresponding background values, and the site maximum is slightly lower than that of background.

Conclusion

Because beryllium in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Chromium

Tier 1 Evaluation

Two site samples exceed the background screening value of 38.25 mg/kg.

Slippage Test

K_c for chromium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, chromium passes the Slippage test.

WRS Test

The p-level of 0.32 indicates a good agreement between the site and background distributions.

Box Plot

The site median, 75th percentile, and maximum are lower than the corresponding background values (Figure 1-11). The site minimum and 25th percentile are higher than that of background.

Conclusion

Chromium in subsurface soil is considered to be within the range of background.

Cobalt

Tier 1 Evaluation

One site sample exceeds the background screening value of 17.54 mg/kg.

Slippage Test

K_c for cobalt is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, cobalt passes the Slippage test.

WRS Test

The p-level of 0.23 indicates a good agreement between the site and background distributions.

Box Plot

The site median is slightly higher than that of background (Figure 1-11). The site minimum and 25th percentile are higher than the corresponding background values, and the site 75th percentile and maximum are lower than that of background.

Conclusion

Cobalt in subsurface soil is considered to be within the range of background.

Lead

Tier 1 Evaluation

One site sample exceeds the background screening value of 38.53 mg/kg.

Slippage Test

K_c for lead is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, lead passes the Slippage test.

WRS Test

The p-level of 0.108 indicates a weak agreement between the site and background distributions.

Box Plot

The site median is slightly higher than that of background (Figure 1-12). The site minimum and 25th percentile are higher than the corresponding background values, and the site maximum is lower than that of background. The site and background 75th percentiles appear to be the same.

Conclusion

Because lead in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Magnesium

Tier 1 Evaluation

Ten site samples exceed the background screening value of 766.24 mg/kg.

Slippage Test

K_c for magnesium is 3, and one site sample exceeds the maximum background measurement. Because $K < K_c$, magnesium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-12). The site maximum is less than that of background.

Conclusion

Because magnesium in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Manganese

Tier 1 Evaluation

Three site samples exceed the background screening value of 1,355 mg/kg.

Slippage Test

K_c for manganese is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, manganese passes the Slippage test.

WRS Test

The p-level of 0.059 indicates a weak agreement between the site and background distributions.

Box Plot

The site minimum is significantly higher than that of background, and the site interquartile range is slightly higher than that of background (Figure 1-13). The site maximum is less than that of background.

Conclusion

Because manganese in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Mercury

Tier 1 Evaluation

Eleven site samples exceed the background screening value of 0.07 mg/kg.

Slippage Test

K_c for mercury is 3, and two site samples exceed the maximum background measurement. Because $K < K_c$, mercury passes the Slippage test.

WRS Test

The WRS test was not performed because the background data set has more than 50 percent nondetects.

Box Plot

The site minimum, interquartile range, and maximum are higher than that of the corresponding background values (Figure 1-13). The shape and location of the background box plot are influenced by the percentage of nondetects (53 percent), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC exceeds the background 95th percentile of 0.094 mg/kg.

Conclusion

Because mercury in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Potassium

Tier 1 Evaluation

Twenty-five site samples exceed the background screening value of 710.74 mg/kg.

Slippage Test

K_c for potassium is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, potassium passes the Slippage test.

WRS Test

The p-level < 0.001 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-14). The site maximum is less than that of background.

Conclusion

Because potassium in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Selenium

Tier 1 Evaluation

Three site samples exceed the background screening value of 0.47 mg/kg.

Slippage Test

The maximum result in background is a nondetect, so the Slippage test is not done.

WRS Test

The WRS test was not performed because the background and site data sets are more than 50 percent nondetect.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-14). The shape and location of the background and site box plots are influenced by the high percentage of nondetects (98 percent and 91 percent, respectively), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC exceeds the background 95th percentile of 0.574 mg/kg.

Conclusion

Because selenium in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Silver

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.24 mg/kg.

Slippage Test

The maximum result in background is a nondetect, so the Slippage test is not done.

WRS Test

The WRS test was not performed because the site data set has more than 50 percent nondetects.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-15). The shape and location of the site box plot are influenced by the high percentage of nondetects (97 percent), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC exceeds the background 95th percentile of 0.88 mg/kg.

Conclusion

Because silver in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Zinc

Tier 1 Evaluation

One site sample exceeds the background screening value of 34.86 mg/kg.

Slippage Test

K_c for zinc is 3, and no site samples exceed the maximum background measurement. Because $K < K_c$, zinc passes the Slippage test.

WRS Test

The p-level of 0.0145 indicates a significant difference between the site and background distributions.

Box Plot

The site minimum and maximum are lower than the corresponding background values (Figure 1-15). The site interquartile range is higher than that of background.

Conclusion

Because zinc in subsurface soil failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

3.3 Groundwater

This section presents the results of the site-to-background comparisons for 23 metals in unfiltered groundwater samples.

Fourteen metals (antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, nickel, silver, thallium, vanadium, and zinc) had no detected results in the site samples and are not discussed any further.

Eight metals had no detected concentrations that exceeded their respective background screening values, passing the Tier 1 evaluation. These metals (aluminum, barium, calcium, iron, magnesium, manganese, potassium, and sodium) are considered to be within the range of background, and will not be included in any further evaluation or discussion.

The remaining metal, selenium, underwent Tier 2 evaluation. The results of the statistical tests are discussed in detail below and summarized in Table 3. Box plots are provided in Attachment 1.

Selenium

Tier 1 Evaluation

There is no background screening value for selenium, and one site sample has a detected result.

Slippage Test

The maximum background value for selenium is a nondetect, so the Slippage test was not performed.

WRS Test

The WRS test was not performed because the site and background data sets contain 50 percent or more nondetects.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-16). The site maximum is lower than that of background. The shape and location of the background and site box plots are influenced by the high percentage of nondetects (100 percent and 80 percent, respectively), and the replacement values of one-half the reporting limit, rather than detected concentrations.

Hot Measurement Test

The site MDC of selenium is less than the background 95th percentile of 0.0971 mg/L.

Conclusion

Selenium in groundwater is considered to be within the range of background.

3.4 Sediment

This section presents the results of the site-to-background comparisons for 23 TAL metals for the Range 30 sediment samples. Five metals (antimony, cadmium, silver, sodium, and thallium) had no detected concentrations in sediment. No further discussion of these elements is included.

Seventeen metals (arsenic, barium, beryllium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, vanadium, and zinc) had no site samples exceeding their respective background screening values. Because these metals passed the Tier 1 evaluation, they are considered to be within the range of background and will not be tested or discussed any further.

The remaining metal, aluminum, underwent Tier 2 evaluation and is discussed in detail below.

Table 4 summarizes the Tier 1 and Tier 2 results for sediment.

Aluminum

Tier 1 Evaluation

Two site samples exceed the background screening value of 8,593 mg/kg.

Slippage Test

The critical value, K_c , for aluminum is 1, and no site samples exceed the maximum background measurement. Because $K < K_c$, aluminum passes the Slippage test.

WRS Test

The WRS test was not done because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-16). The site maximum is lower to that of background.

Hot Measurement Test

The site MDC of aluminum is less than the background 95th UTL of 14,331 mg/kg.

Conclusion

Aluminum in sediment is considered to be within the range of background.

3.5 Surface Water

This section presents the results of the site-to-background comparisons for the 23 metals tested in surface water samples from Range 30. Eight metals (antimony, beryllium, cadmium, cobalt, mercury, nickel, selenium, and silver) had no detected concentrations in the site samples and are not discussed any further.

Six metals (barium, calcium, iron, magnesium, manganese, and sodium) had no detected concentrations exceeding their respective background screening values. These metals are considered within the range of background based on the Tier 1 evaluation, and will not be tested or discussed further.

The remaining nine metals (aluminum, arsenic, chromium, copper, lead, potassium, thallium, vanadium, and zinc) underwent Tier 2 evaluation. The results of these tests are discussed in detail below. Box plots are provided in Attachment 1.

Aluminum

Tier 1 Evaluation

Two site samples exceed the background screening value of 5.259 mg/L.

Slippage Test

K_c for aluminum is 1, and no site samples exceed the maximum background measurement. Because $K < K_c$, aluminum passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-17). The site maximum is lower than that of background.

Hot Measurement Test

The site MDC of aluminum is less than the background 95th percentile of 13.7 mg/L.

Conclusion

Aluminum in surface water is considered to be within the range of background.

Arsenic

Tier 1 Evaluation

Two site samples exceed the background screening value of 0.00217 mg/L.

Slippage Test

The critical value, K_c , for arsenic is 1. No site samples exceed the maximum background measurement. Because $K < K_c$, arsenic passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-17). The site maximum is less than that of background.

Hot Measurement Test

The site MDC for arsenic is less than the background 95th percentile of 0.0034 mg/L.

Conclusion

Arsenic in surface water is considered to be within the range of background.

Chromium

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.01113 mg/L.

Slippage Test

The maximum background value for chromium is a nondetect, so the Slippage test was not performed.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-18). The site maximum is less than that of background.

Hot Measurement Test

The site MDC for chromium is less than the background 95th percentile of 0.0168 mg/L.

Conclusion

Chromium in surface water passes the Tier 2 evaluation and is considered to be within the range of background.

Copper

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.0127 mg/L.

Slippage Test

K_c for copper is 1, and no site samples exceed the maximum background measurement. Because $K < K_c$, copper passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-18). The site maximum is less than that of background.

Hot Measurement Test

The site MDC for copper is less than the background 95th percentile of 0.0506 mg/L.

Conclusion

Copper in surface water passes the Tier 2 evaluation and is considered to be within the range of background.

Lead

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.00867 mg/L.

Slippage Test

K_c for lead is 1, and 1 site sample exceeds the maximum background measurement. Because $K \leq K_c$, lead passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-19).

Hot Measurement Test

The site MDC for lead exceeds the background 95th percentile of 0.0221 mg/L.

Conclusion

Because lead in surface water failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Potassium

Tier 1 Evaluation

One site sample exceeds the background screening value of 2.564 mg/L.

Slippage Test

K_c for potassium is 1, and no site samples exceed the maximum background value. Because $K < K_c$, potassium passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-19). The site maximum is lower than that of background.

Hot Measurement Test

The site MDC of potassium is less than the background 95th UTL of 4.251 mg/L.

Conclusion

Potassium in surface water passed the Tier 2 evaluation and is considered to be within the range of background.

Thallium

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.00249 mg/L.

Slippage Test

K_c for thallium is 1, and 1 site sample exceeds the maximum background value. Because $K \leq K_c$, potassium passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum, interquartile range, and maximum are higher than the corresponding background values (Figure 1-20).

Hot Measurement Test

The site MDC of thallium exceeds the background 95th percentile of 0.002 mg/L.

Conclusion

Because thallium in surface water failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Vanadium

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.01521 mg/L.

Slippage Test

K_c for vanadium is 1, and no site samples exceed the maximum background value. Because $K < K_c$, vanadium passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-20). The site maximum is lower than that of background.

Hot Measurement Test

The site MDC of vanadium exceeds the background 95th percentile of 0.0211 mg/L.

Conclusion

Because vanadium in surface water failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

Zinc

Tier 1 Evaluation

One site sample exceeds the background screening value of 0.04035 mg/L.

Slippage Test

K_c for zinc is 1, and no site samples exceed the maximum background value. Because $K < K_c$, zinc passes the Slippage test.

WRS Test

The WRS test is not included because the site sample size is less than 5.

Box Plot

The site minimum and interquartile range are higher than the corresponding background values (Figure 1-21). The site maximum is lower than that of background.

Hot Measurement Test

The site MDC of zinc exceeds the background 95th percentile of 0.0456 mg/L.

Conclusion

Because zinc in surface water failed statistical comparison to background, it will be carried forward for Tier 3 geochemical evaluation.

4.0 Summary and Conclusions

The statistical methodology used to compare site data from Range 30, Firing Line Area (Parcels 88Q, 102Q, and 106Q-X) and the background data for 23 elements in surface soil, subsurface soil, groundwater, sediment, and surface water includes a comparison of the site MDC to the background screening value (Tier 1 evaluation). Analytes that failed this comparison were

subjected to the Slippage test and Wilcoxon rank sum test, and box-and-whisker plots were prepared to visually compare the two data sets and properly interpret the WRS test results. If the Slippage test and/or the WRS test could not be performed, the Hot Measurement test was included as part of the Tier 2 statistical evaluation. Analytes that underwent Tier 2 evaluation and failed any component of the statistical site-to-background comparison are carried forward for Tier 3 geochemical evaluation to determine if natural processes can explain the elevated concentrations.

Tables 1 through 5 summarize the comparison test results and the metals carried forward for geochemical evaluation.

5.0 References

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ATTACHMENT 1

Figure 1-1

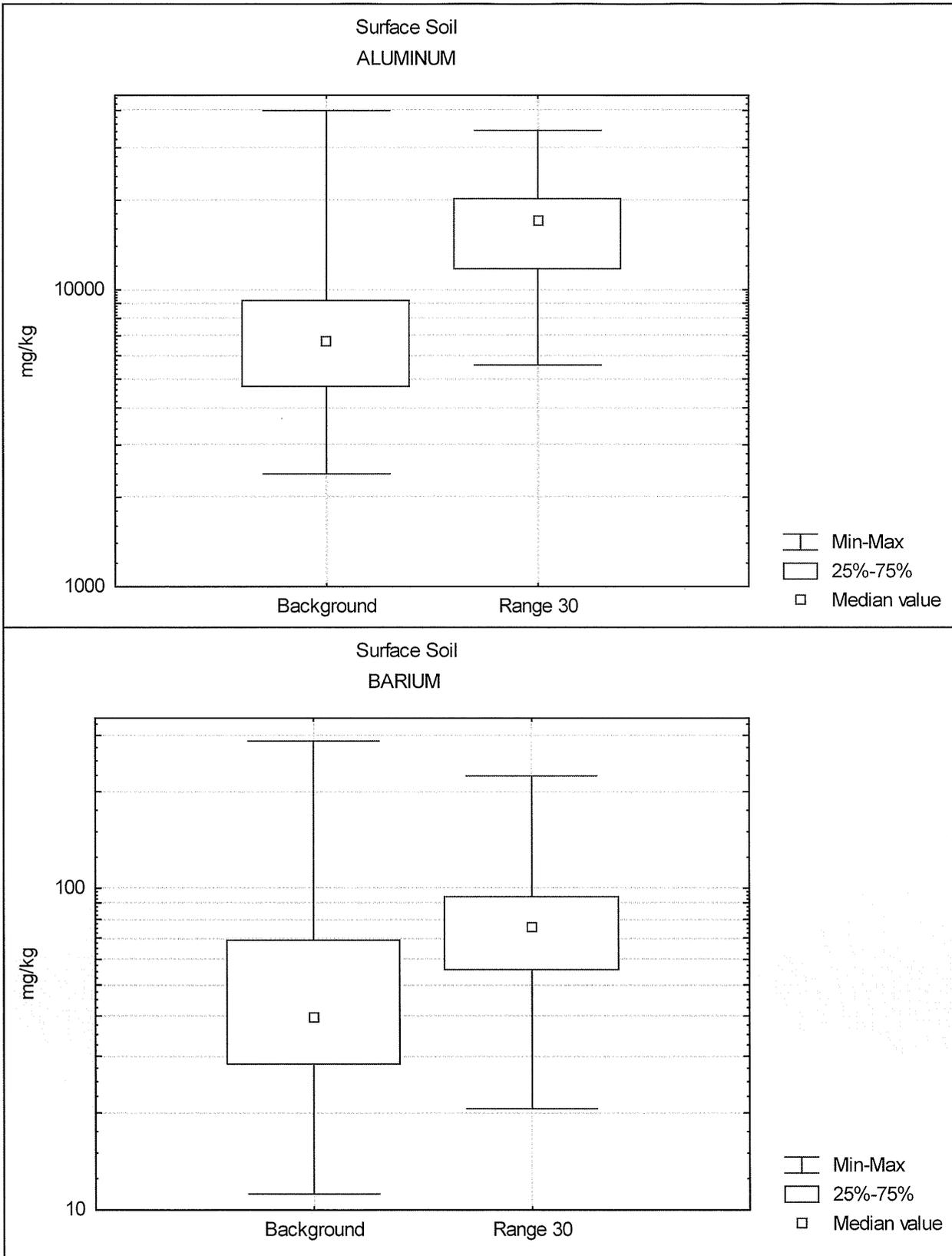


Figure 1-2

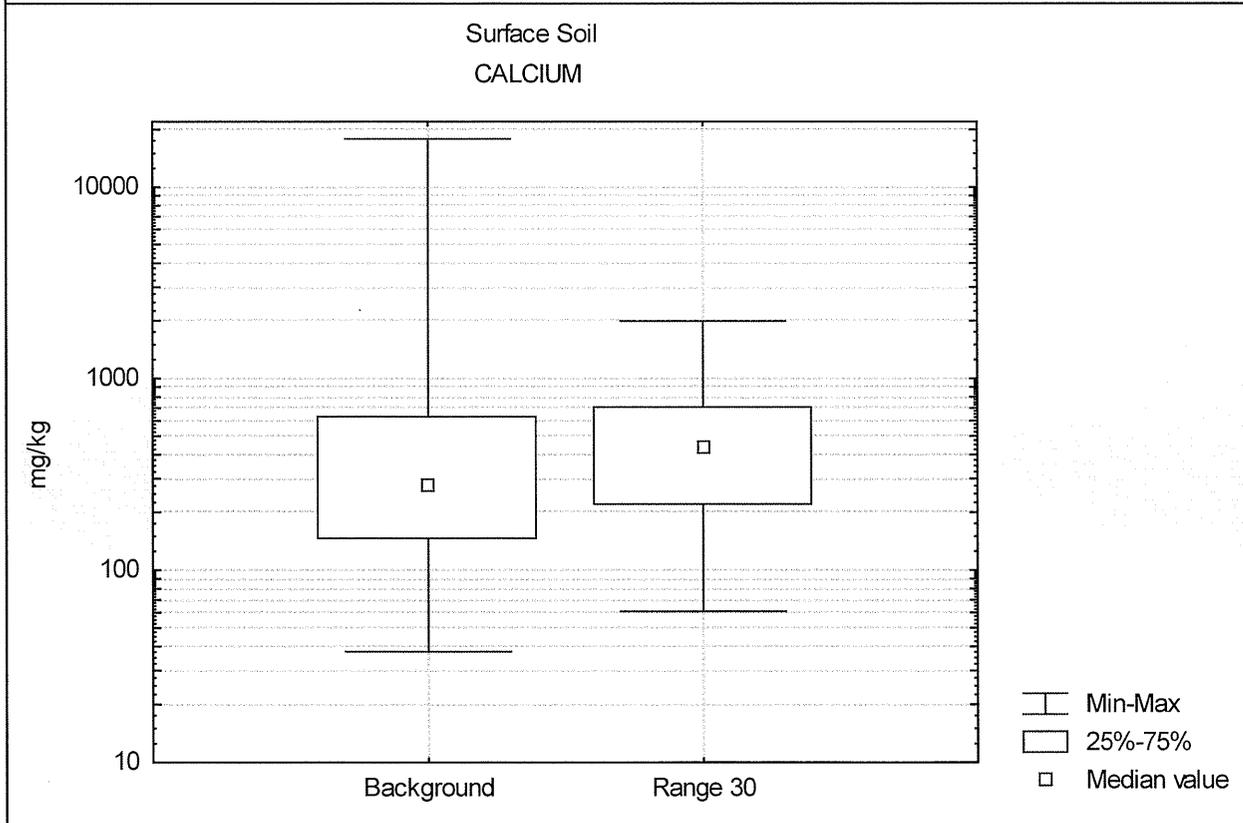
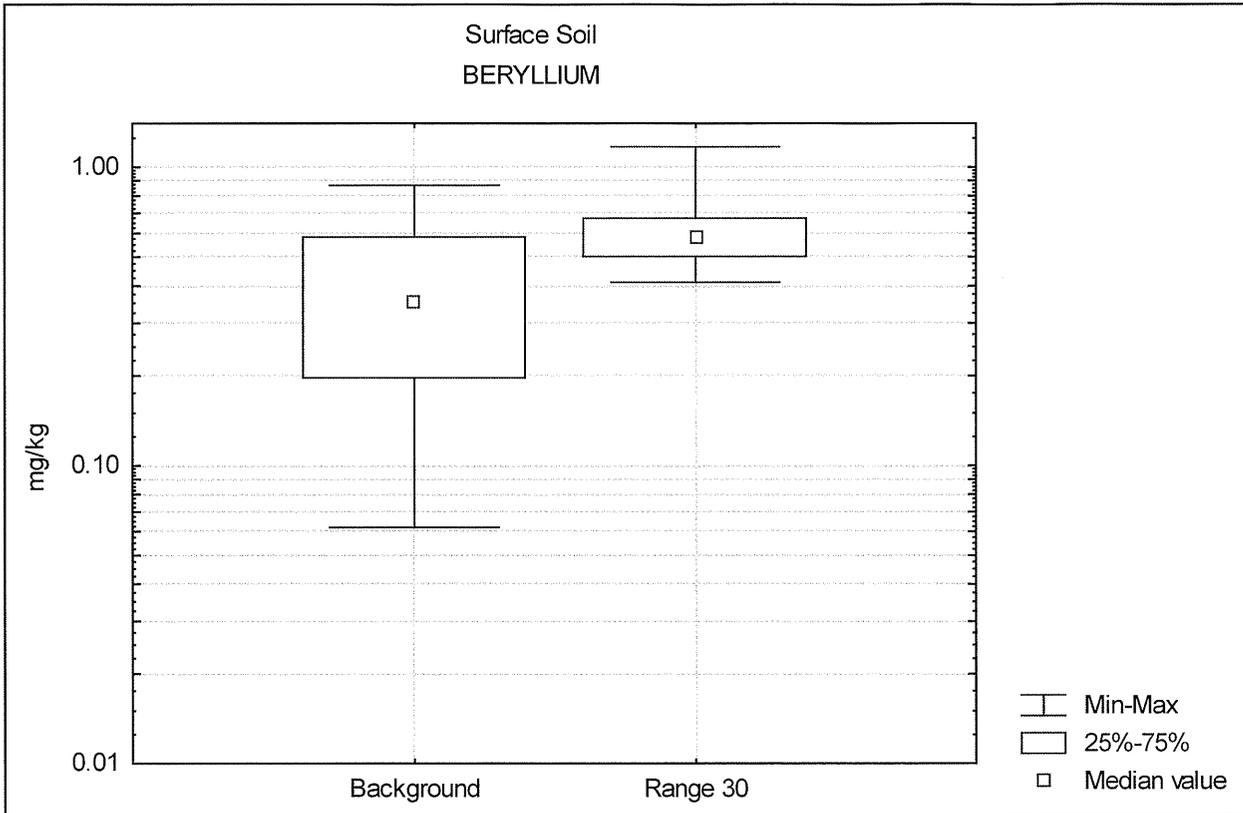


Figure 1-3

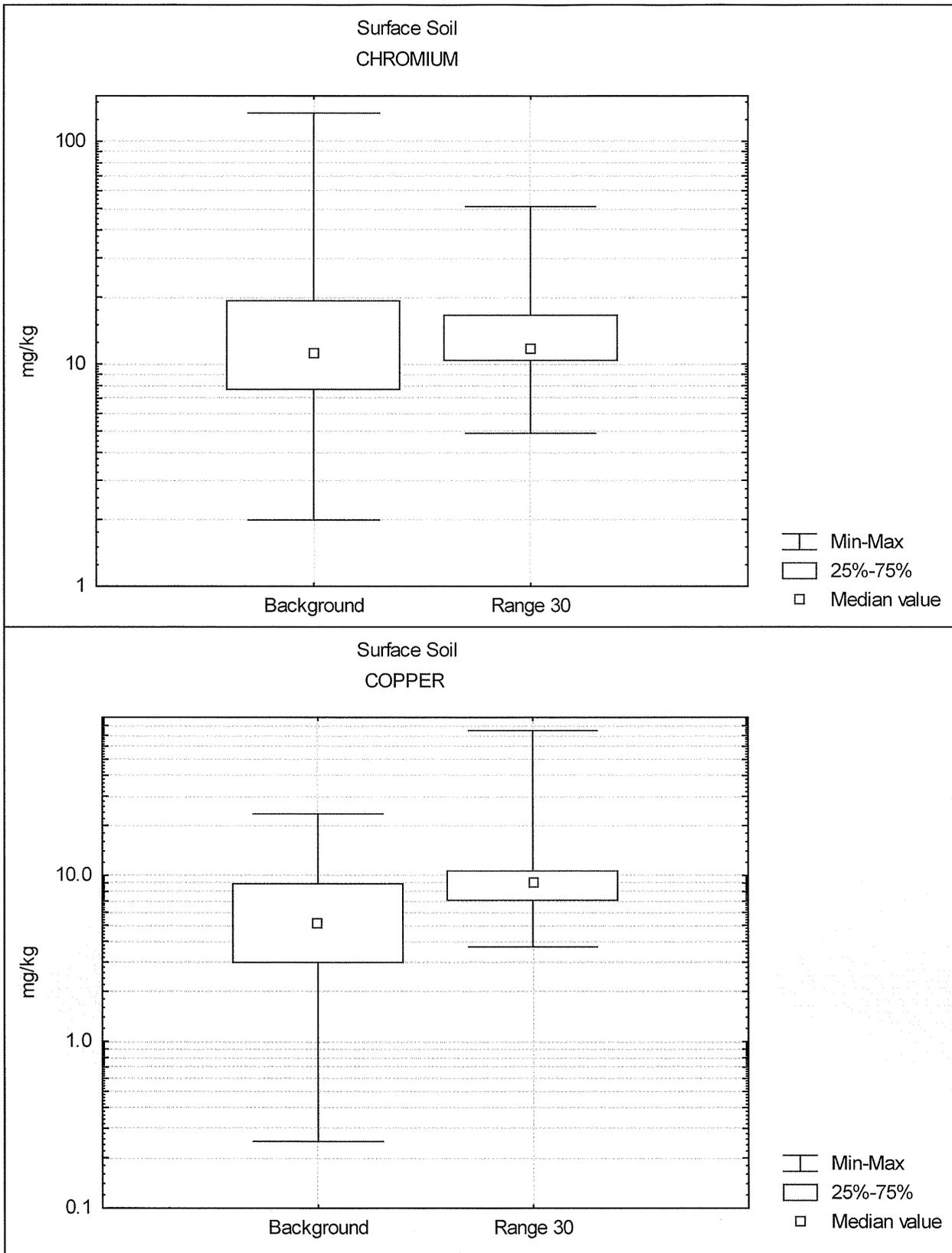


Figure 1-4

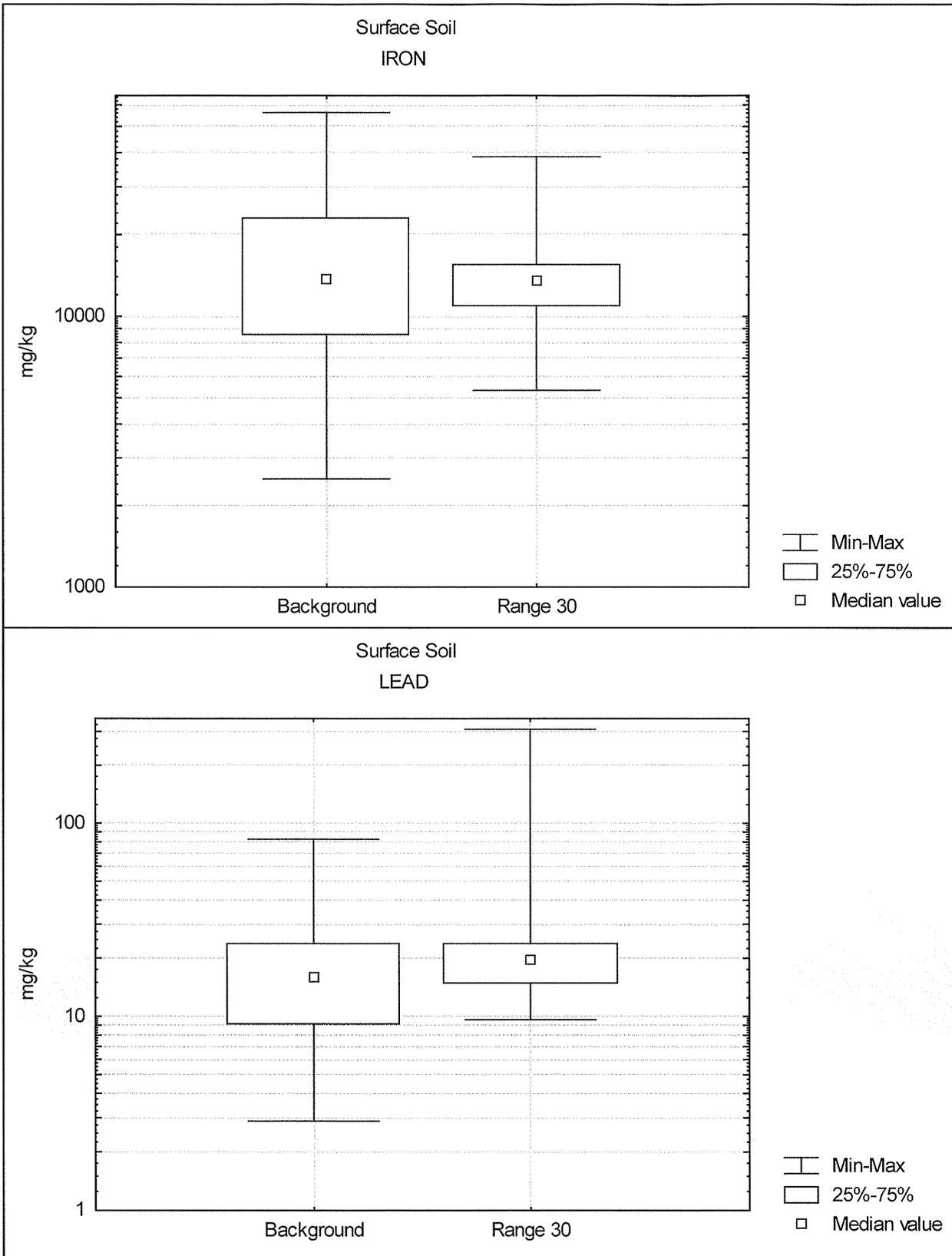


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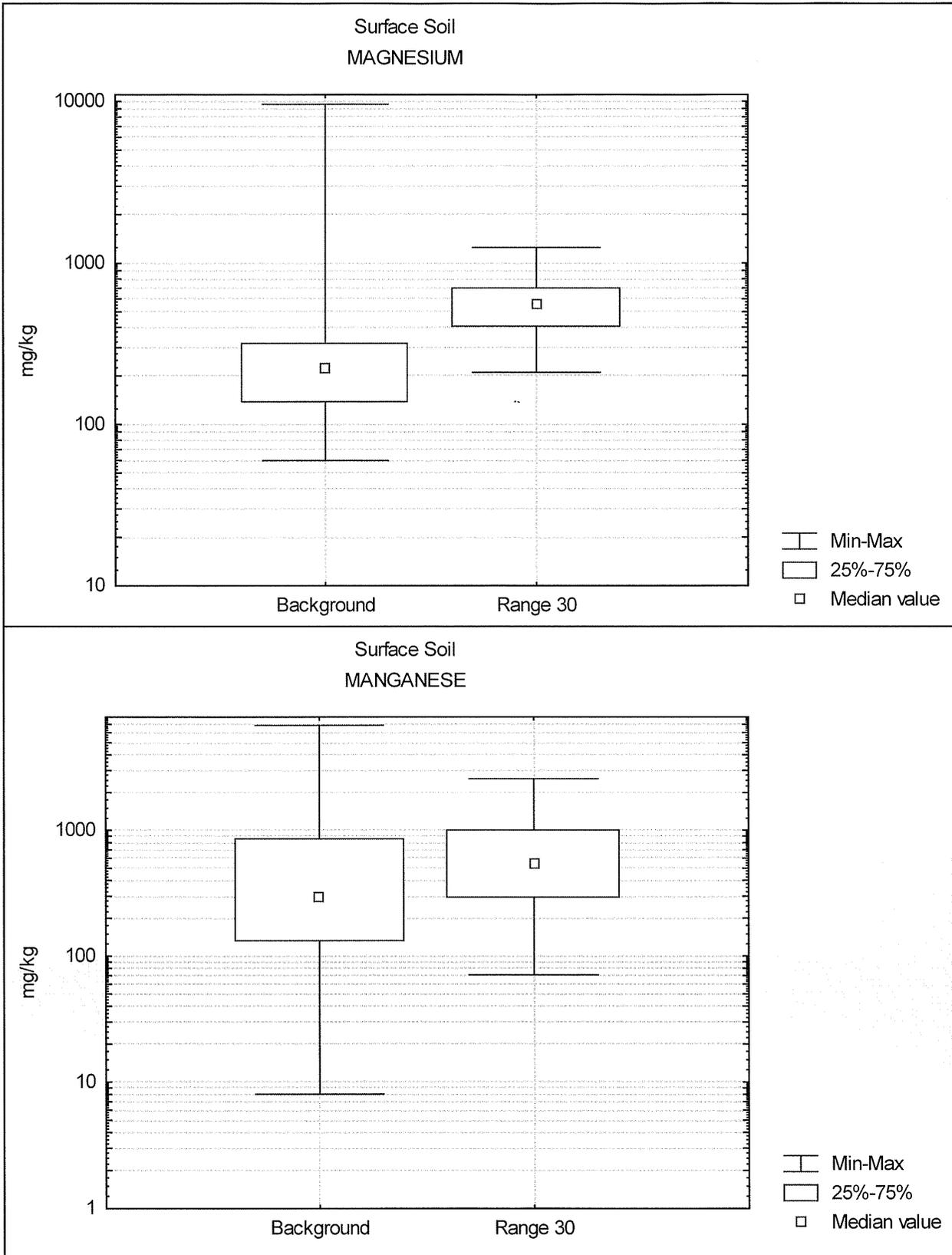


Figure 1-6

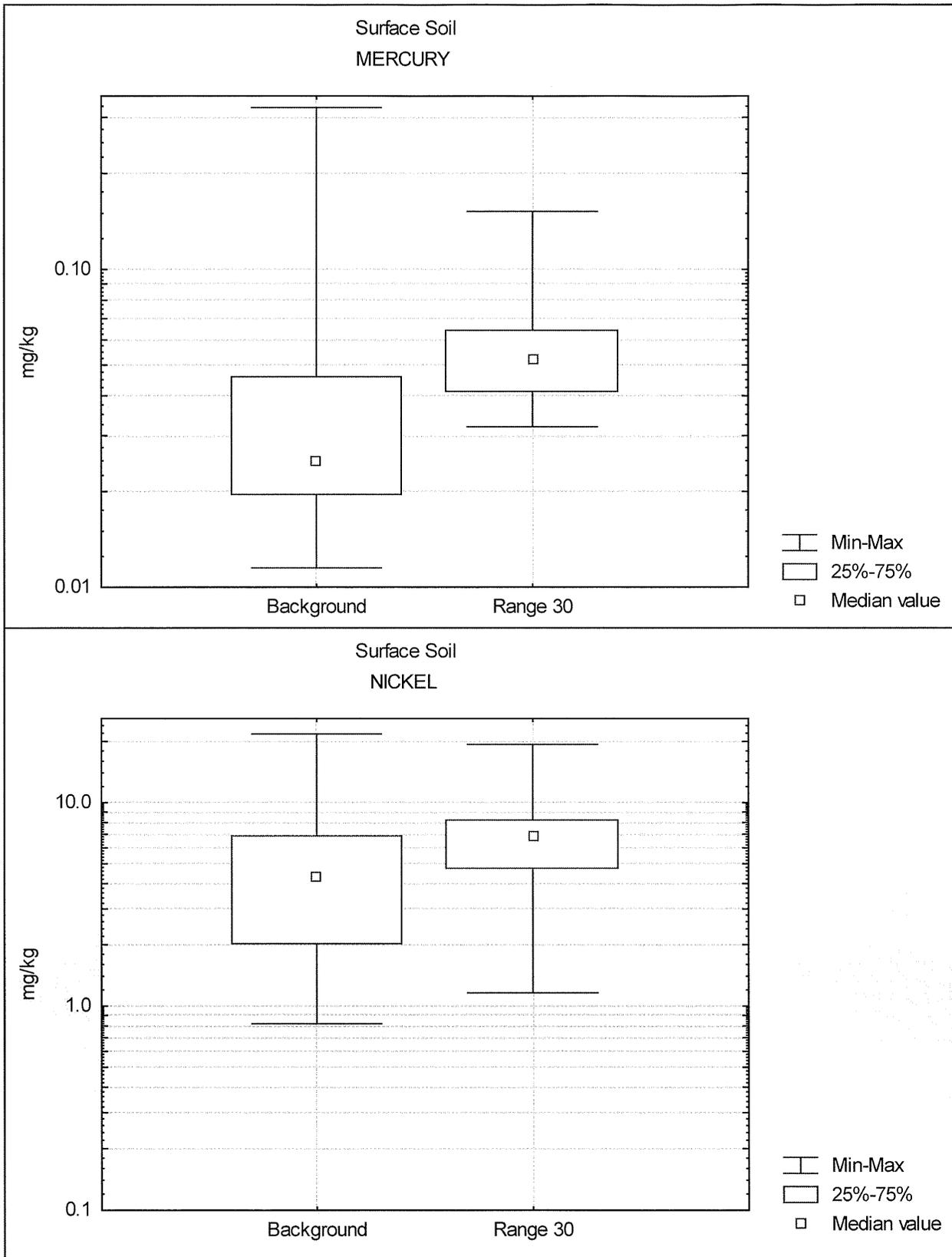


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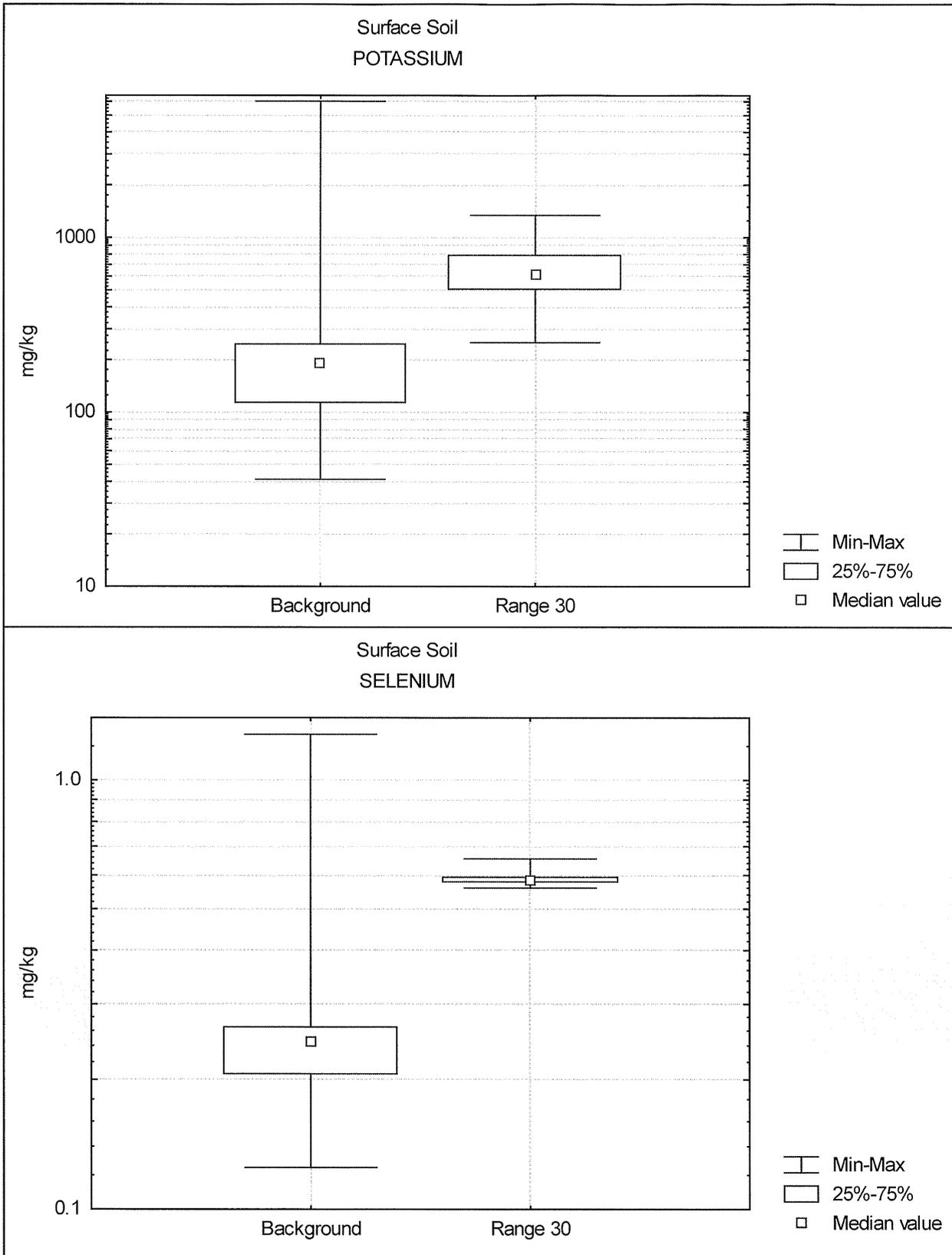


Figure 1-8

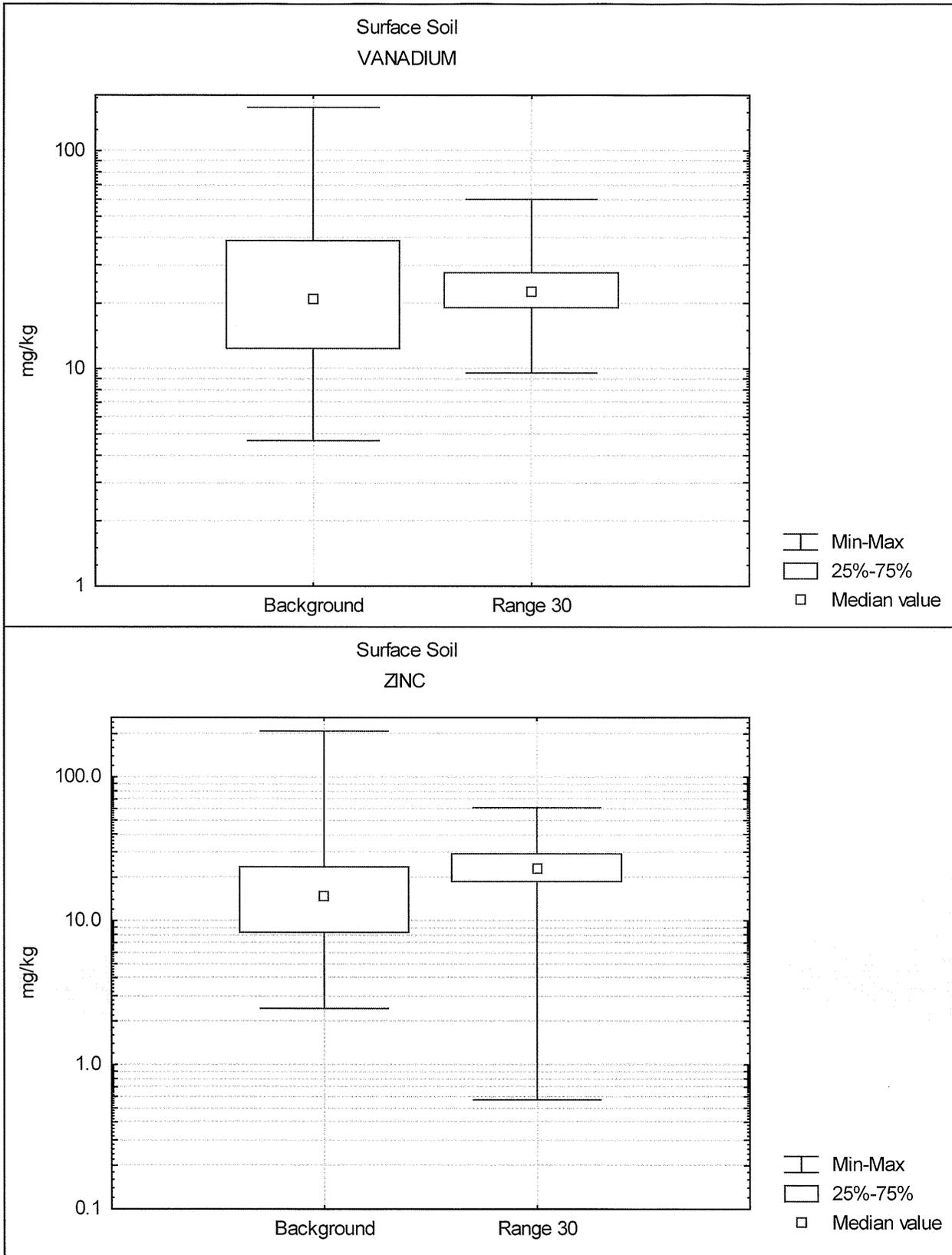


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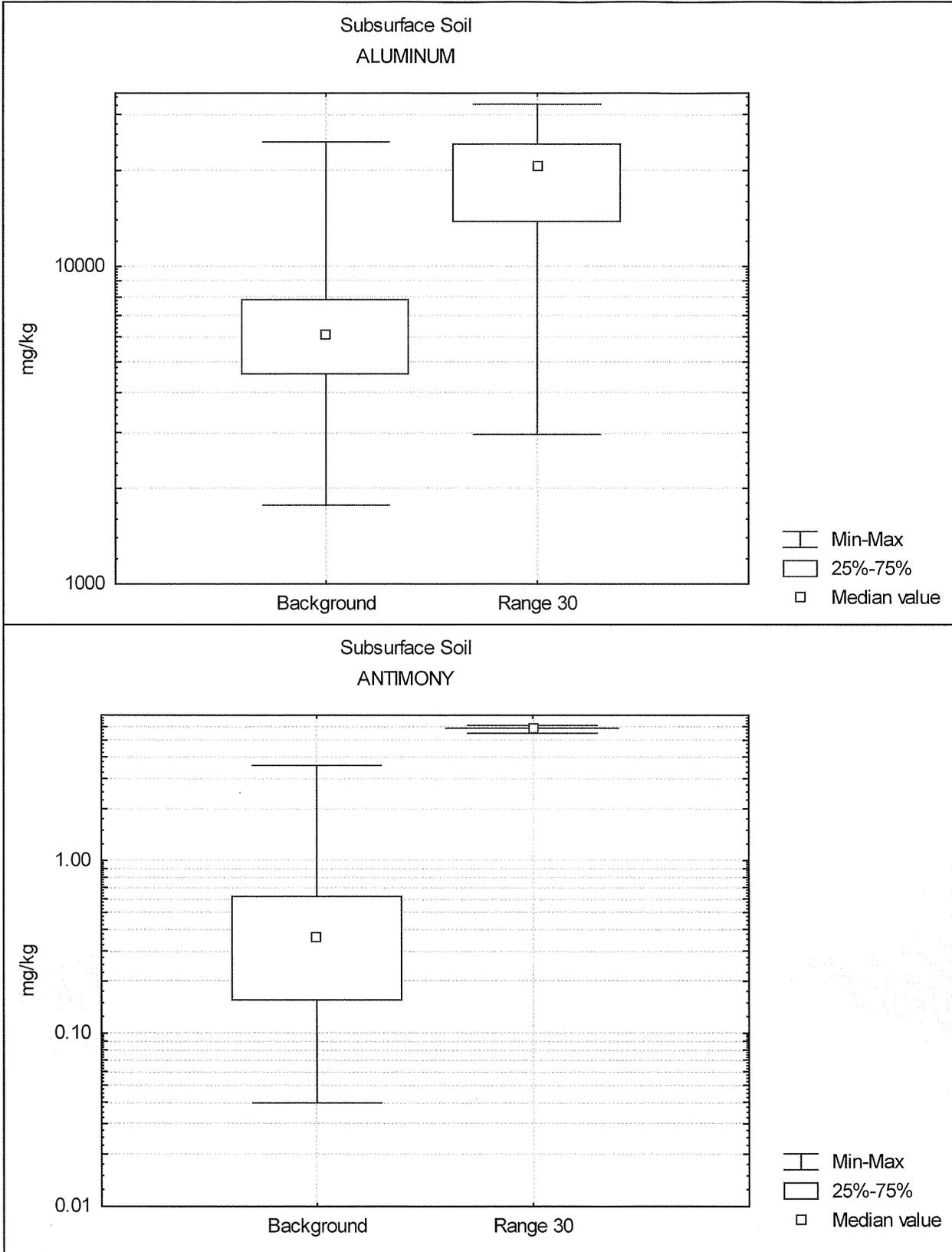


Figure 1-10

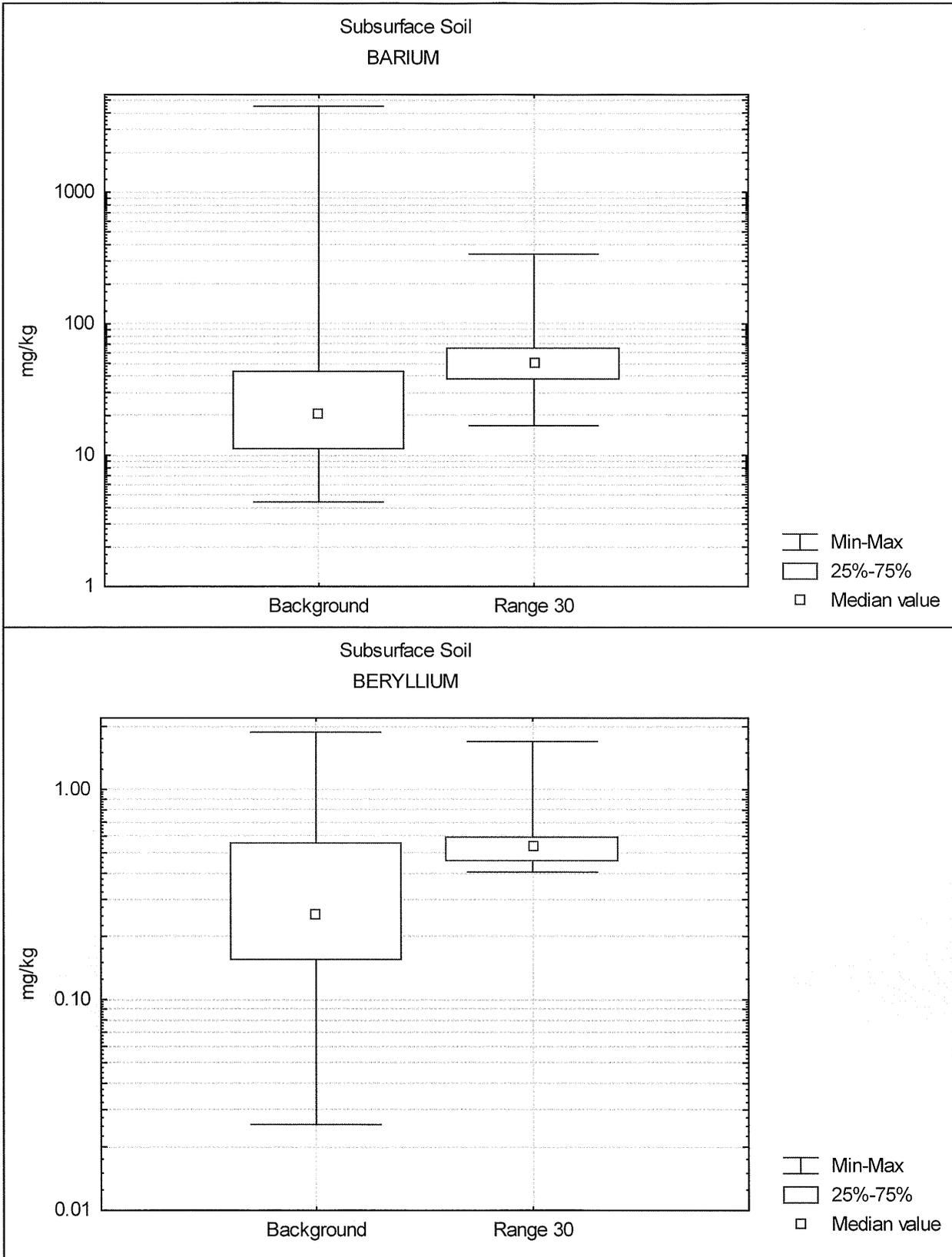


Figure 1-11

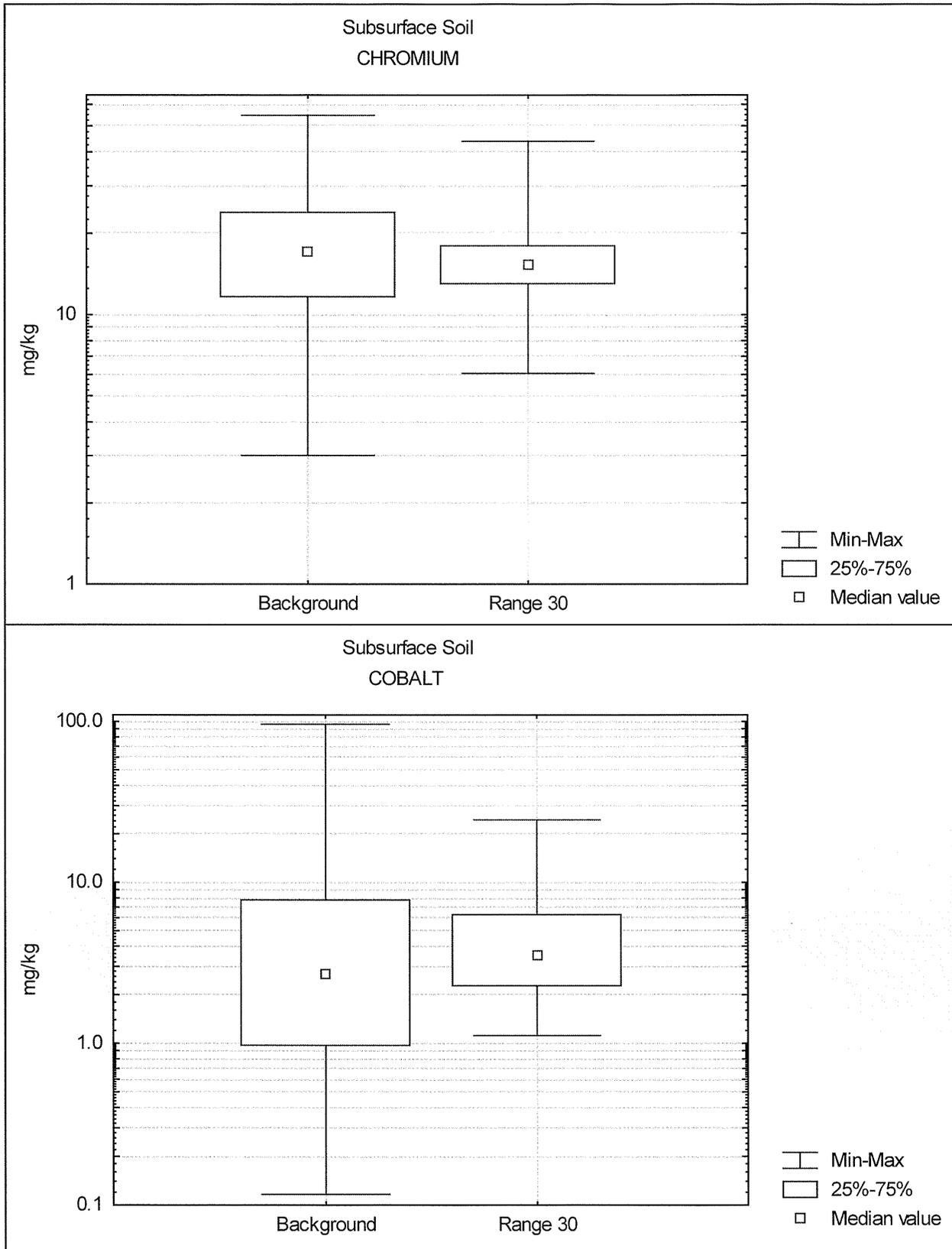


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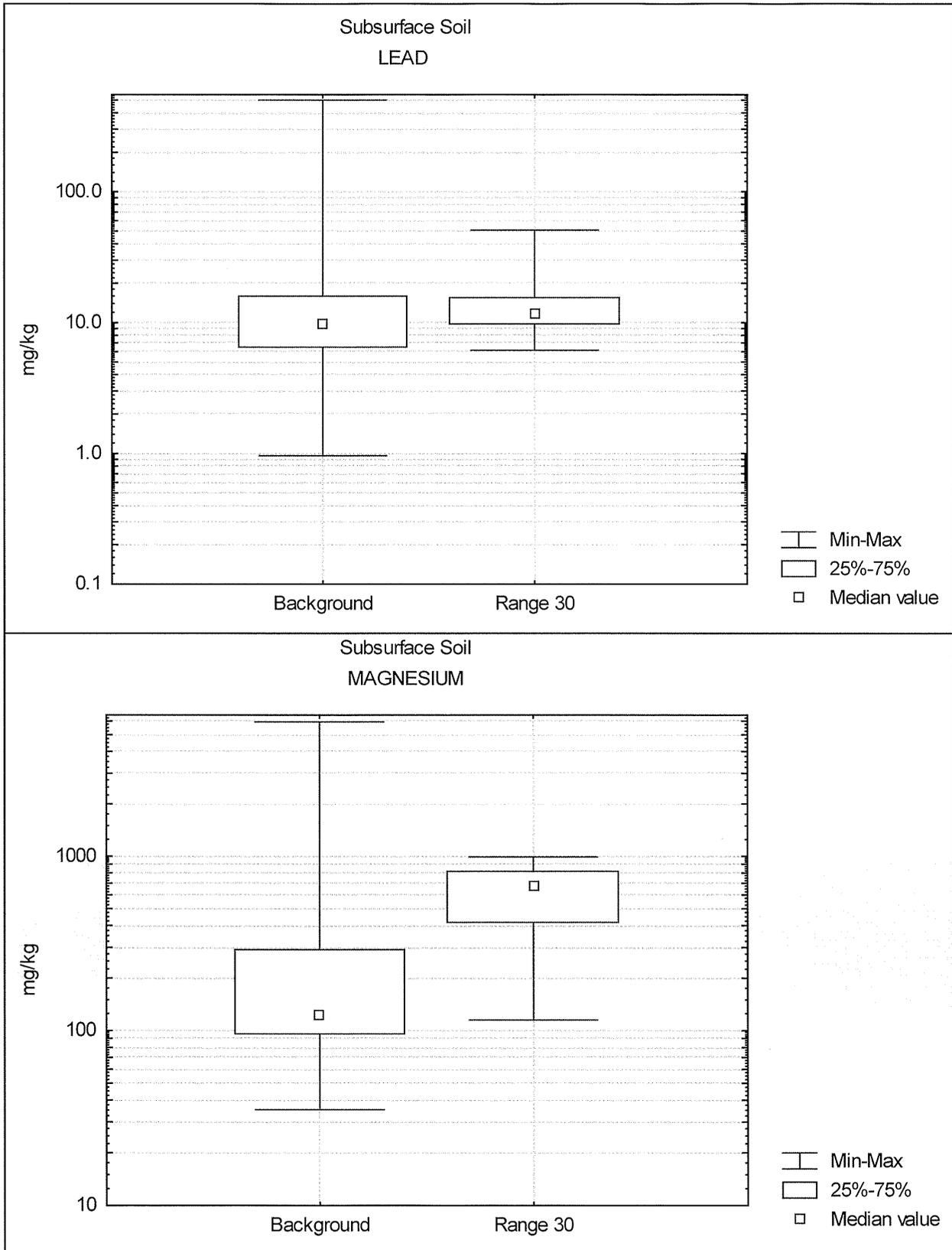


Figure 1-13

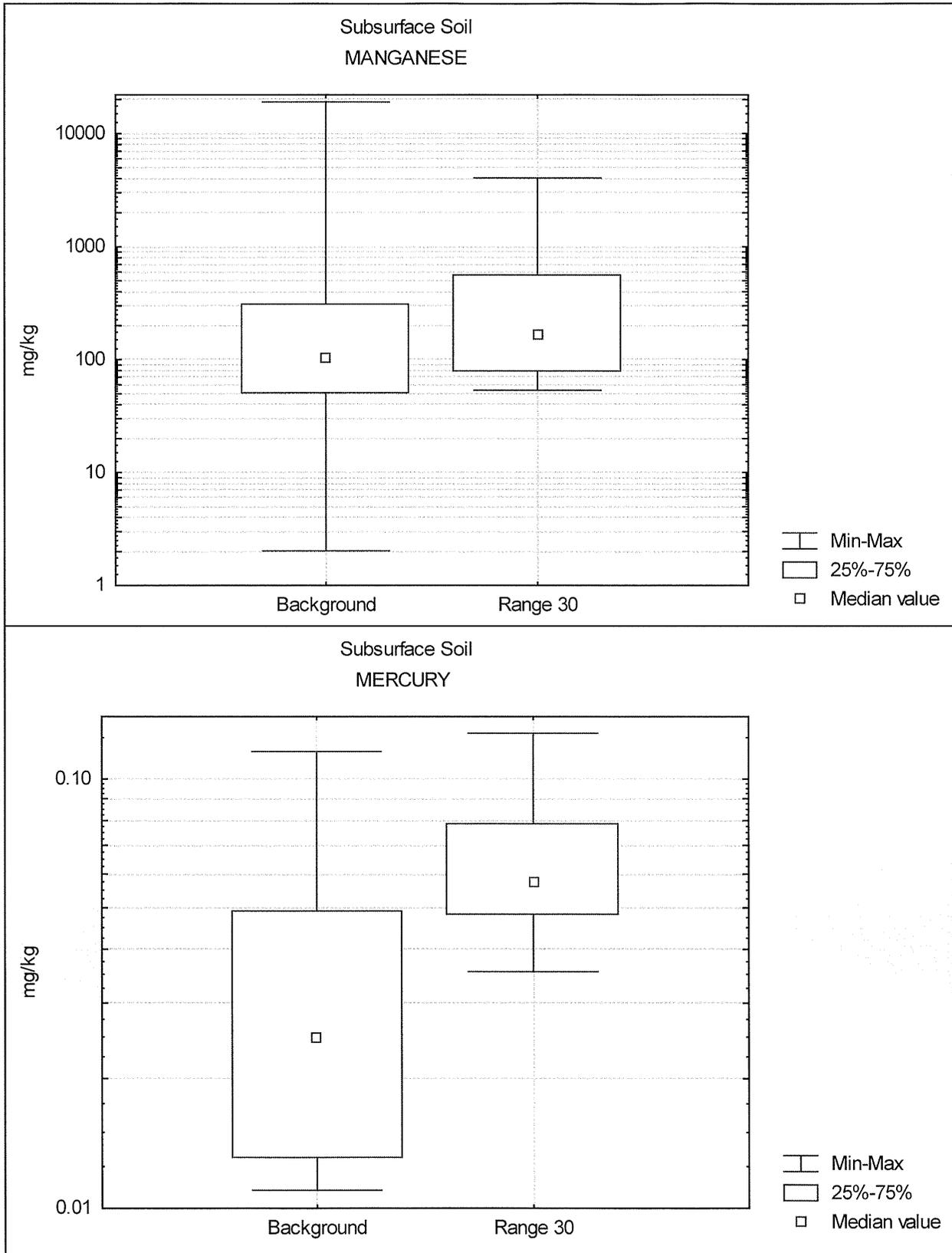


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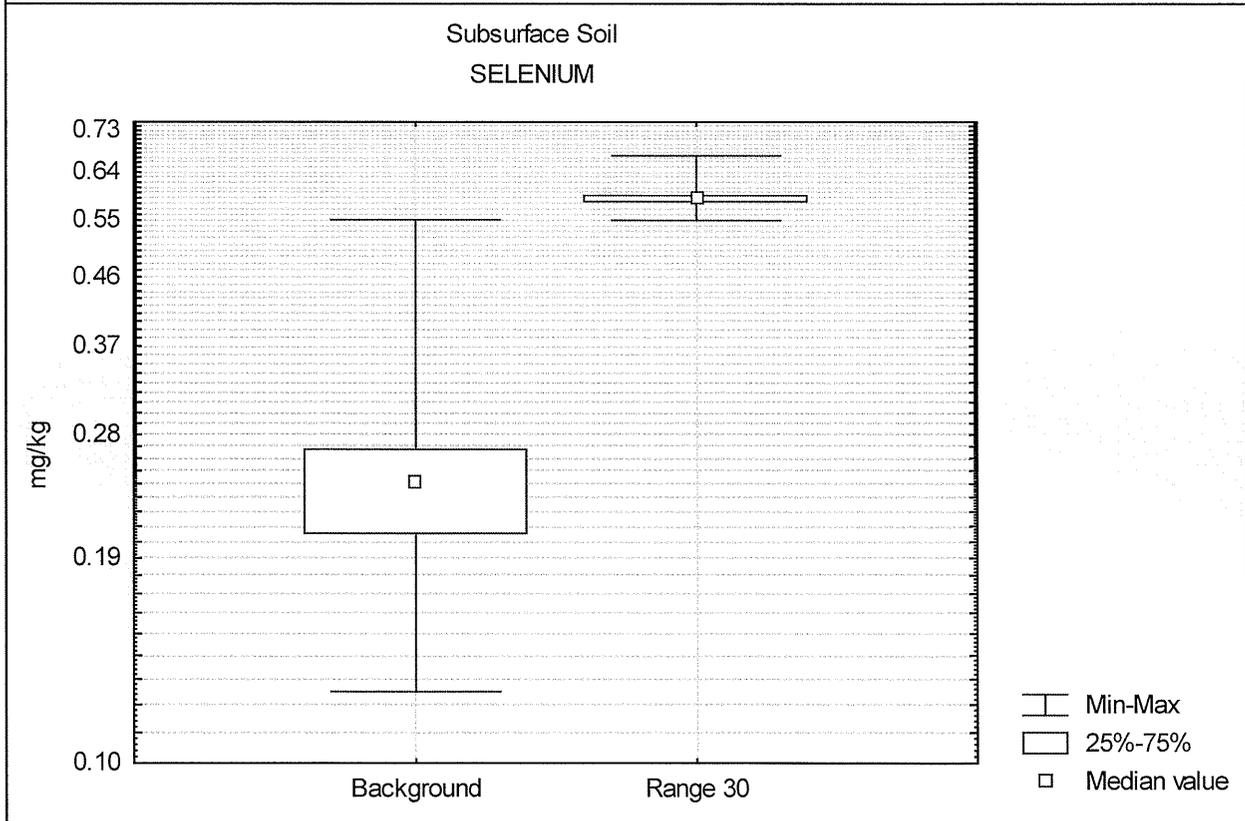
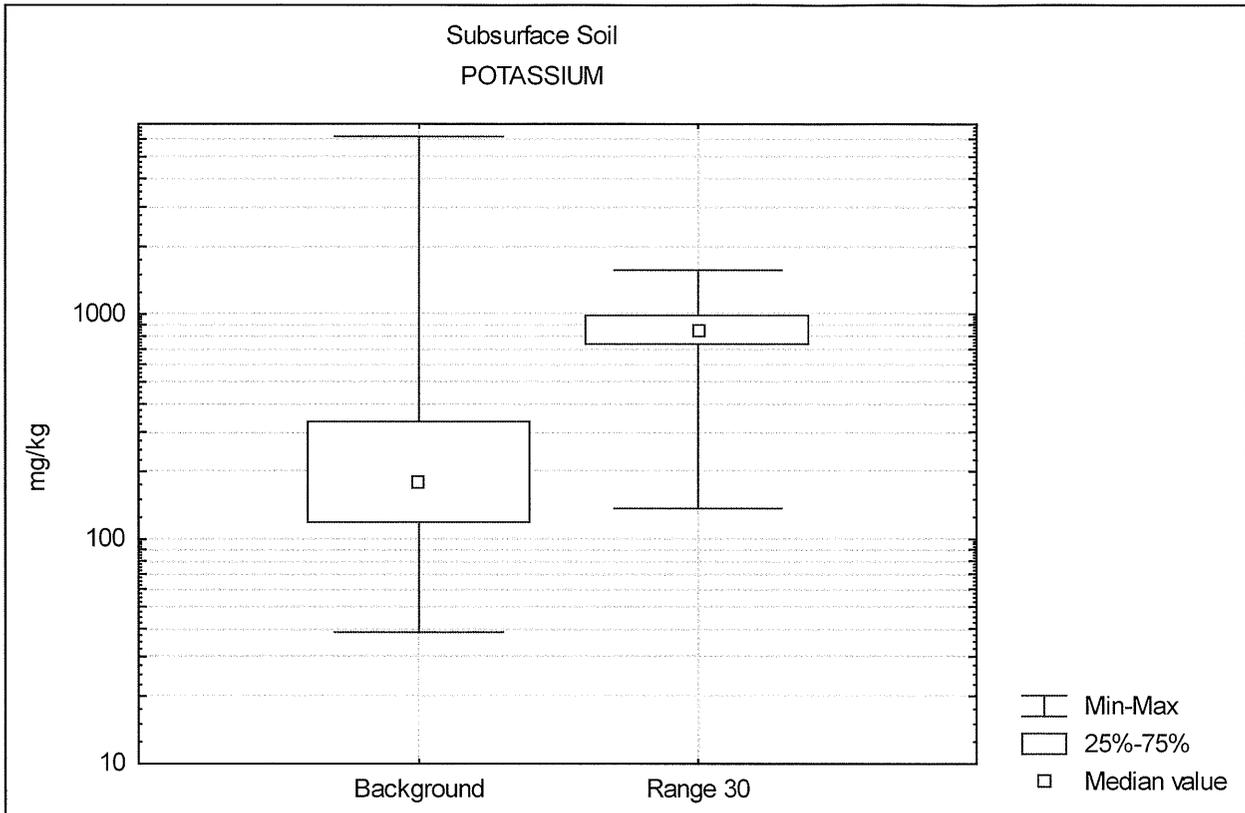


Figure 1-15

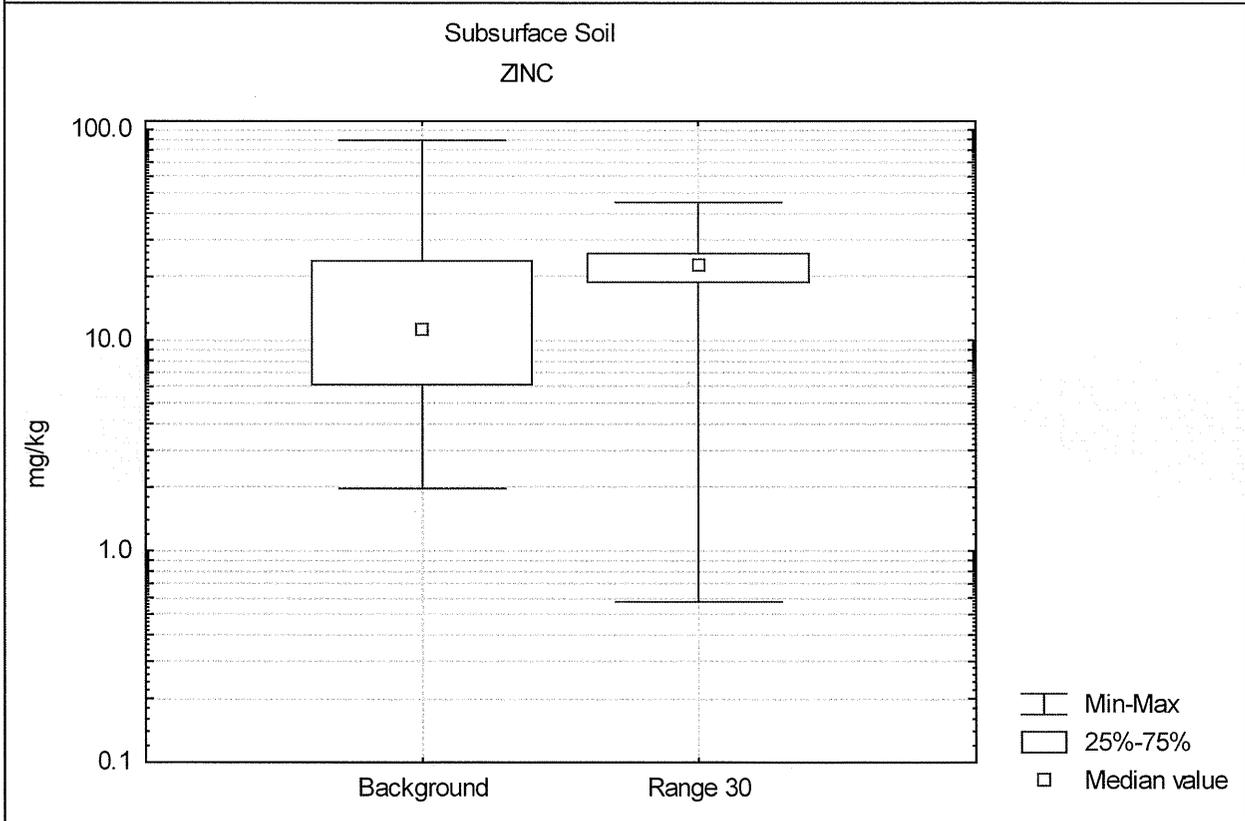
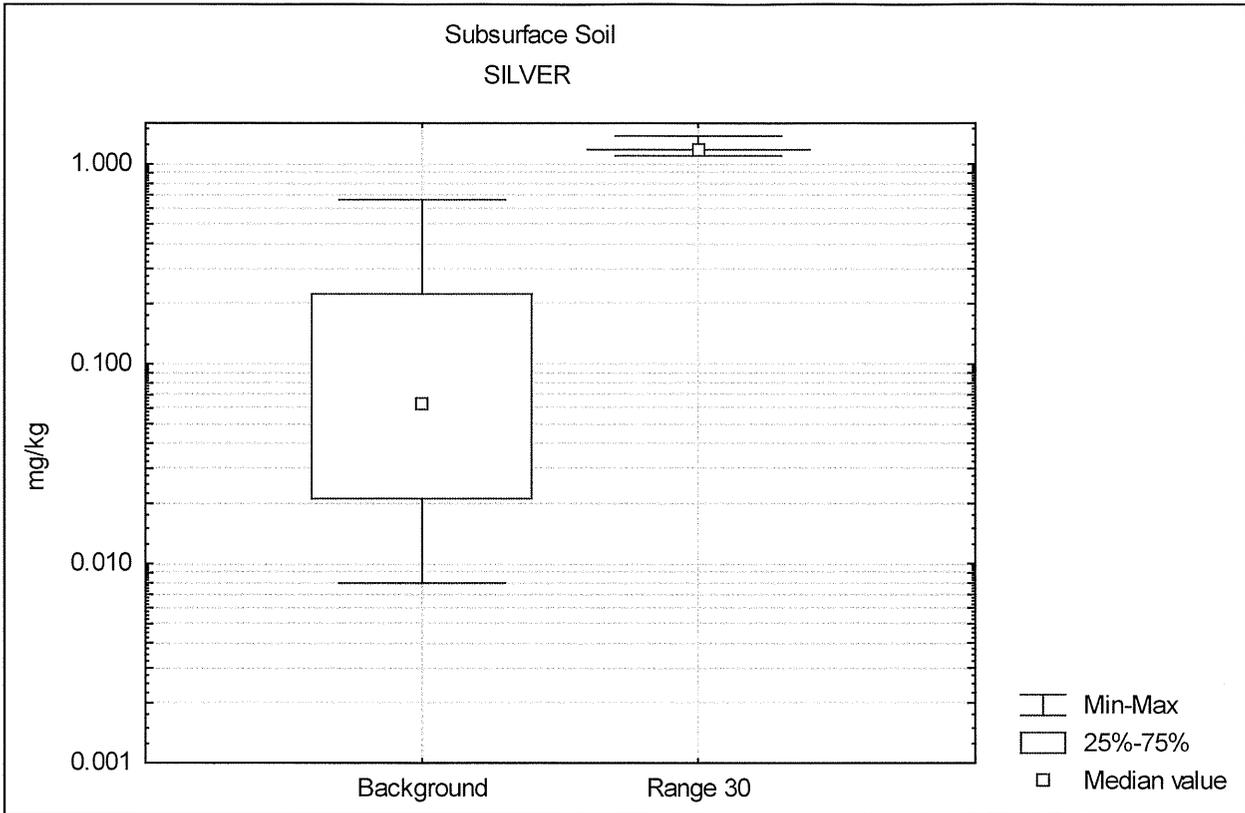


Figure 1-16

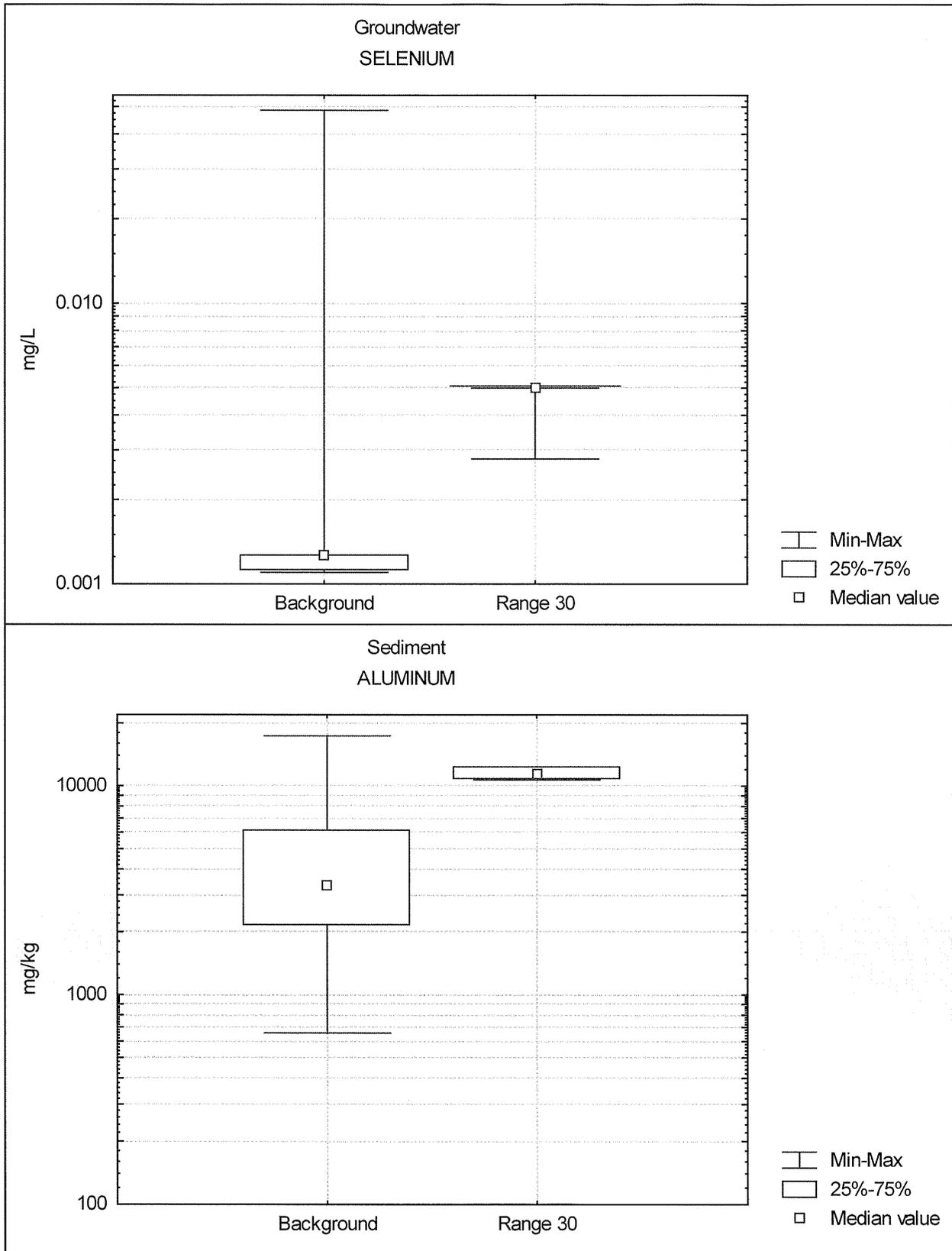


Figure 1-17

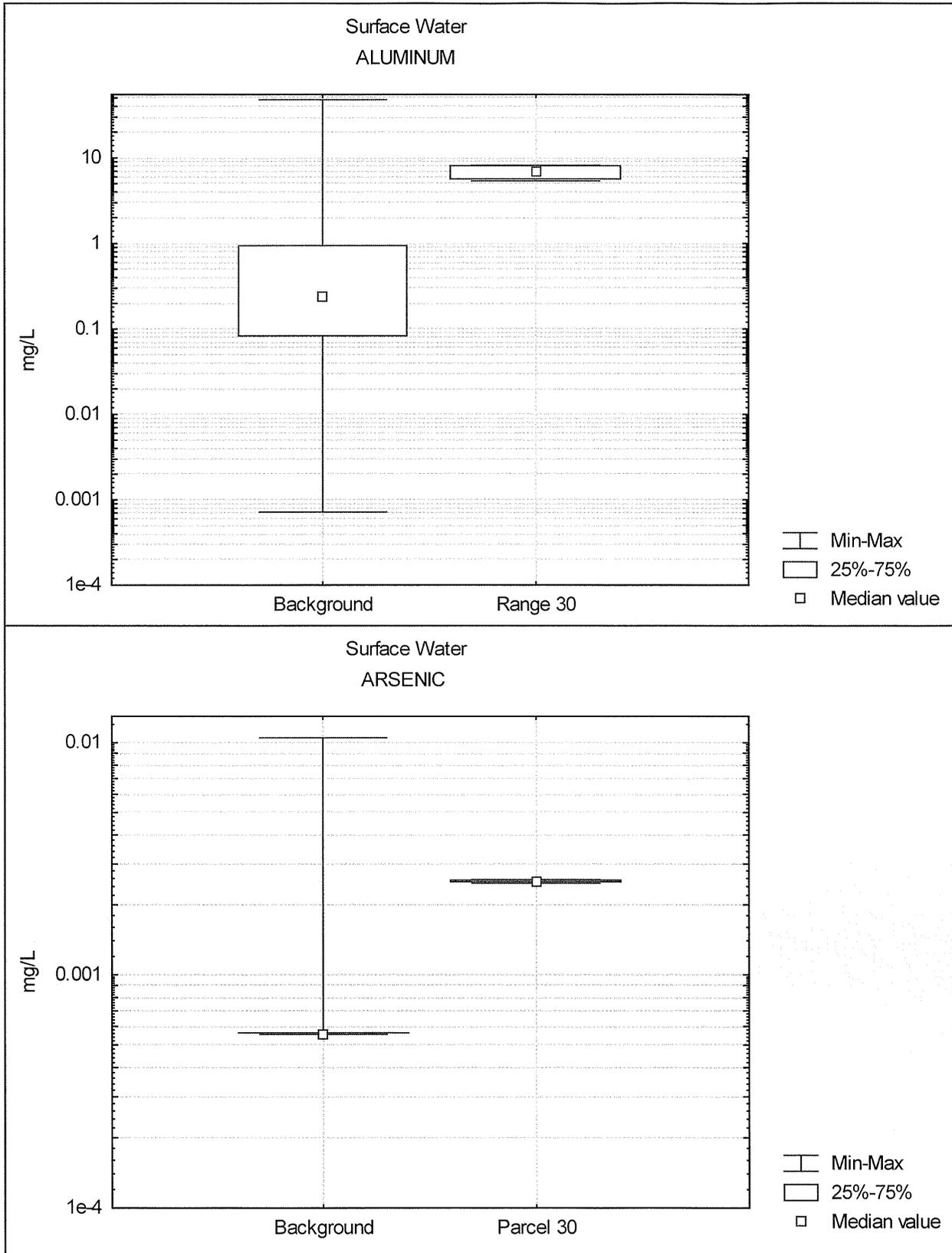


Figure 1-18

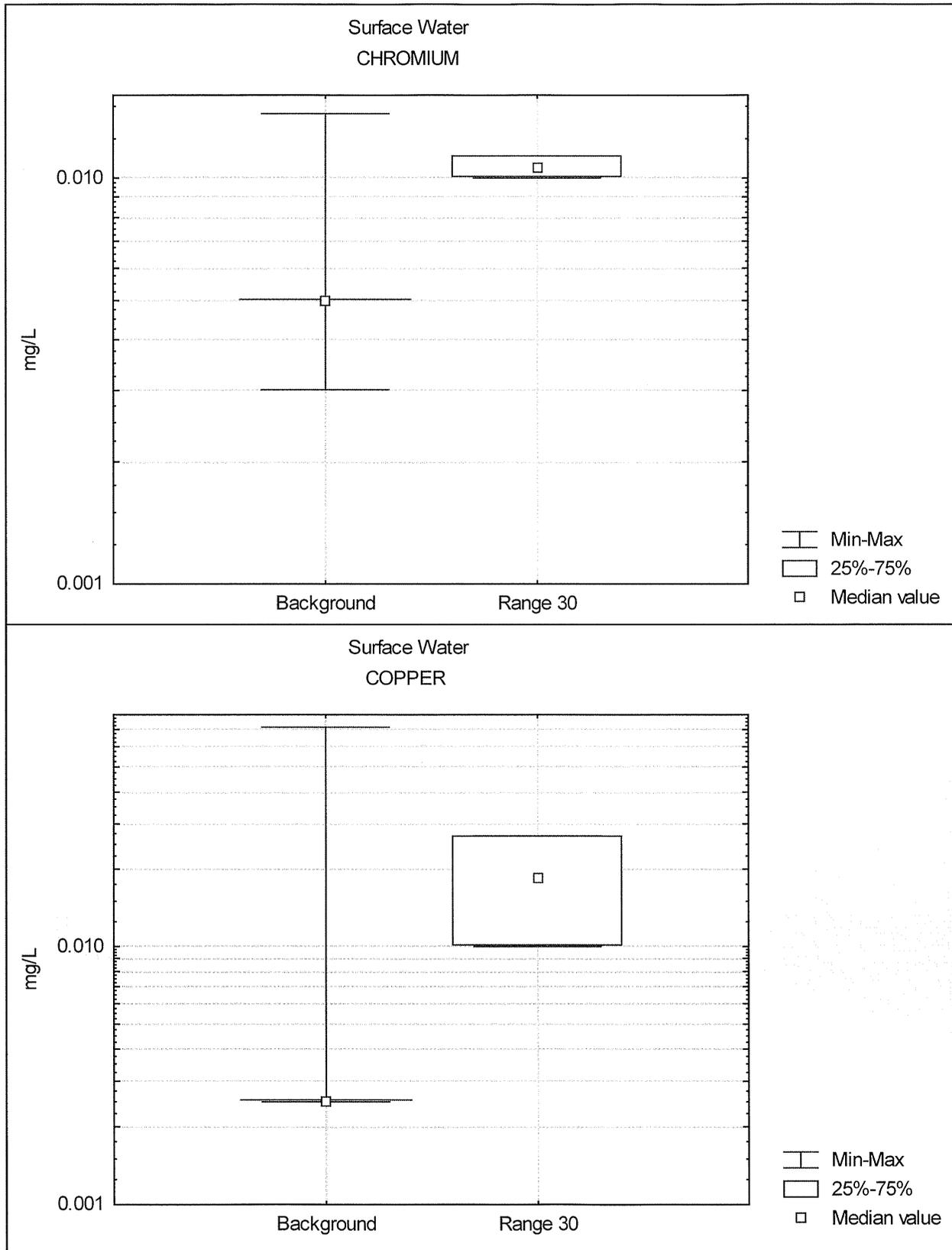


Figure 1-19

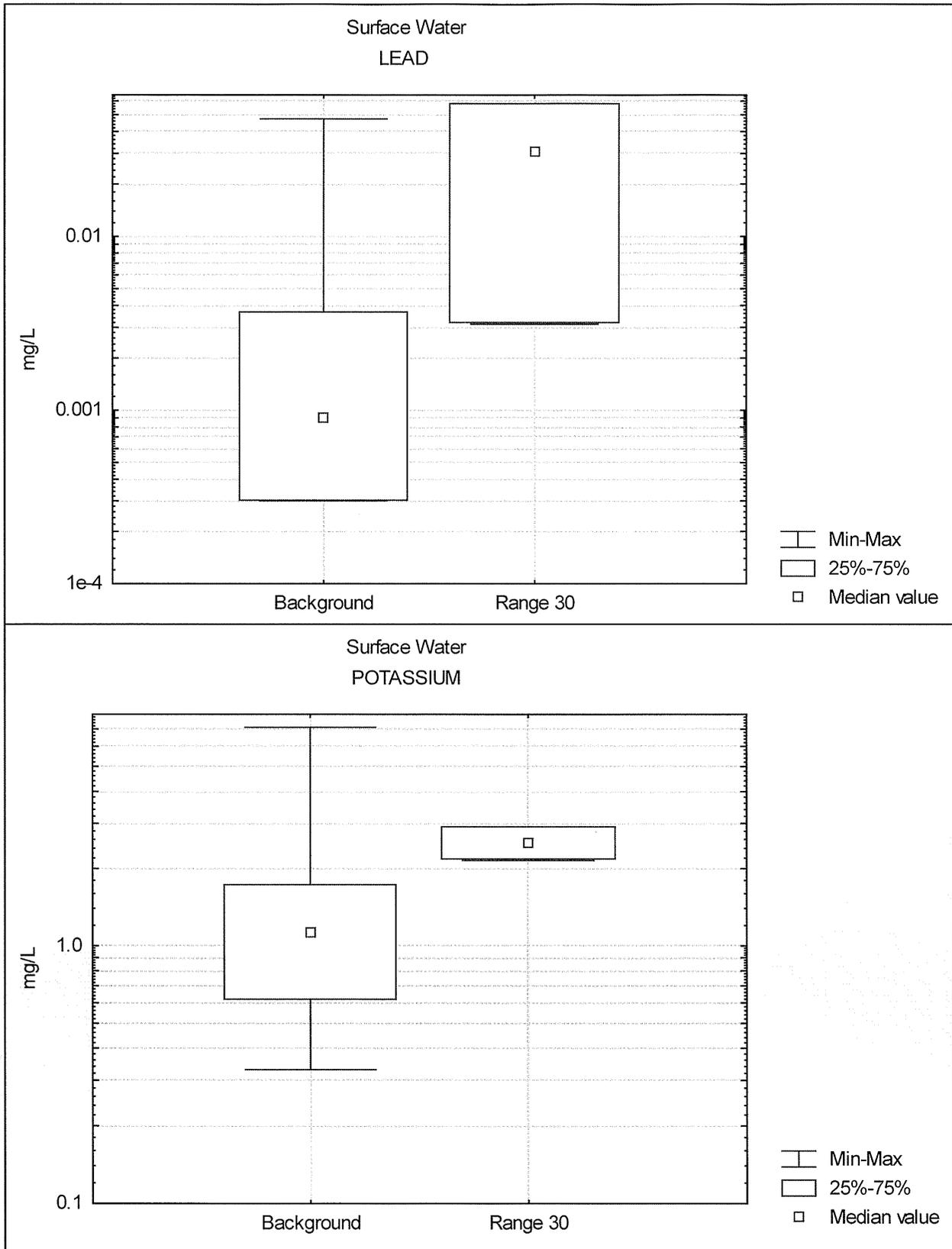


Figure 1-20

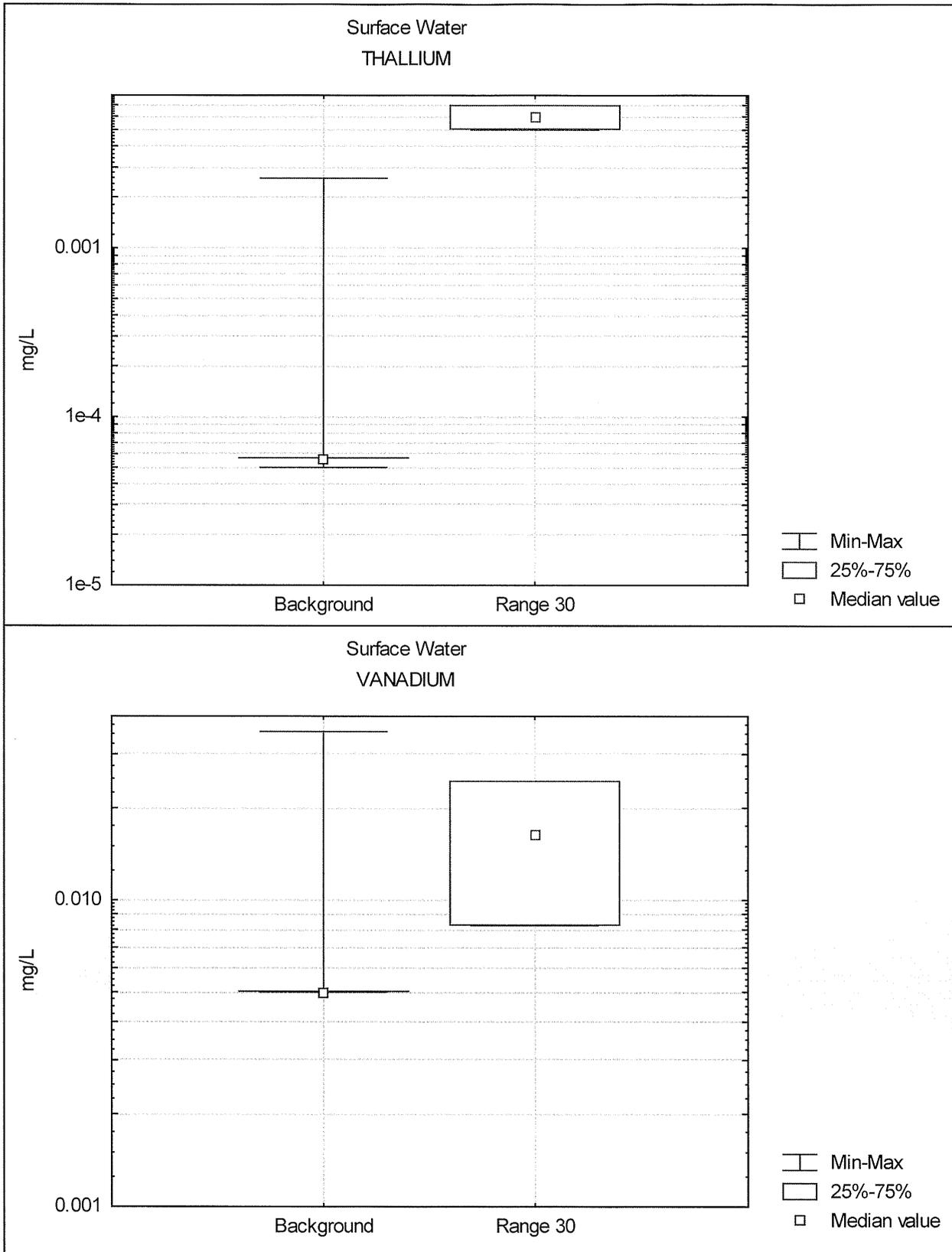
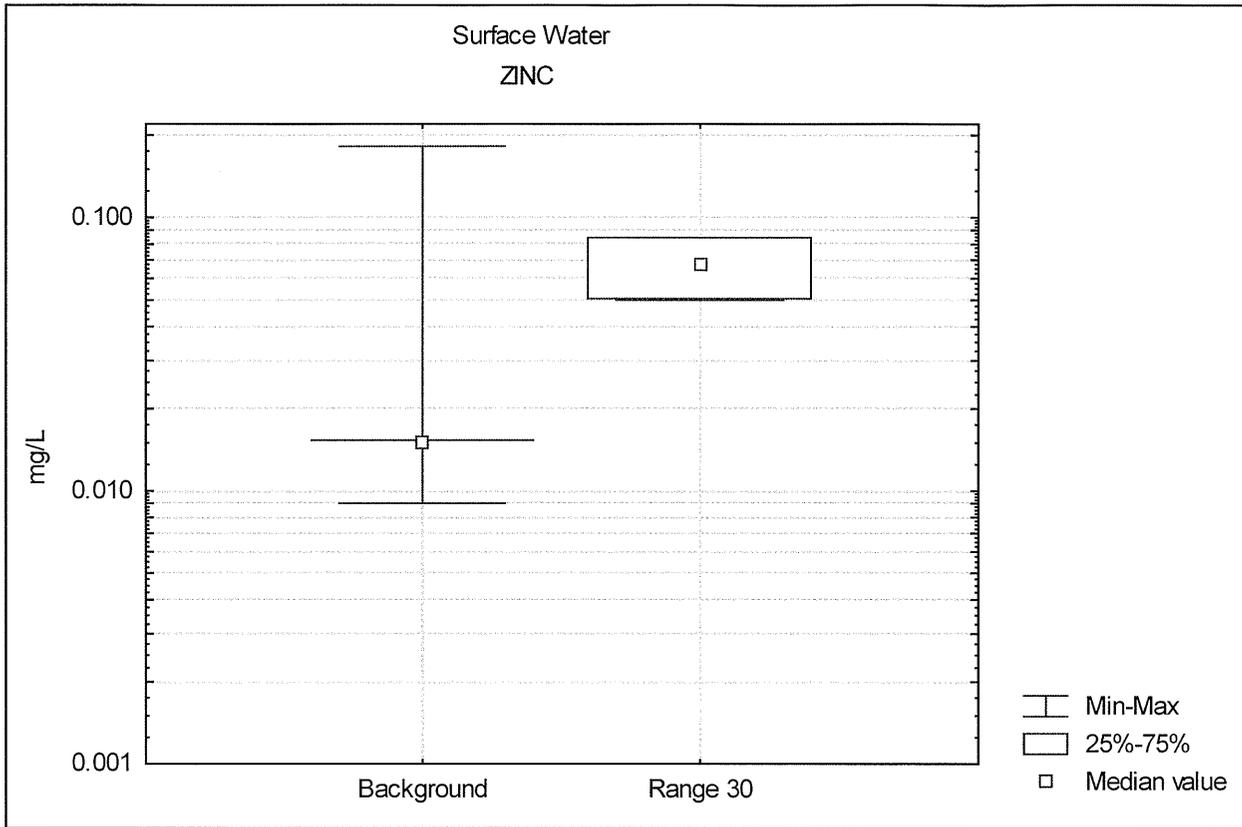


Figure 1-21



GEOCHEMICAL

Geochemical Evaluation of Metals in Soil and Surface Water Range 30 Firing Line Area, Parcels 88Q, 102Q, and 106Q-X Fort McClellan, Alabama

1.0 Introduction

This report provides the results of a geochemical evaluation of inorganic constituents in soil and groundwater samples from Range 30 Firing Line Area, Parcels 88Q, 102Q, 106Q-X, Fort McClellan, Calhoun County, Alabama. Thirteen elements in soil and four elements in surface water failed statistical comparison to background. A geochemical evaluation was performed to determine if the elevated concentrations are naturally occurring or if they contain a component of contamination.

Site samples included in the evaluation consist of 40 surface soil samples (0 to 1 foot below ground surface [bgs]) collected from January through March 2002; 33 subsurface soil samples (2.5 to 4 feet bgs) collected in January and February 2002; and 2 unfiltered surface water samples collected in March 2002. All of the site samples were analyzed for the full list of 23 target analyte list (TAL) metals. Installation-wide background data for TAL metals in soil and surface water are provided in the background study report (Science Applications International Corporation, 1998) and are used in the following evaluation.

2.0 Geochemical Evaluation Methodology

Naturally occurring trace element concentrations in environmental media commonly exceed regulatory screening criteria. For example, trace element distributions in uncontaminated soil tend to have very large ranges (two to three orders of magnitude are not uncommon), and are highly right-skewed, resembling lognormal distributions. These trace elements are naturally associated with specific soil-forming minerals, 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 statistical comparison to background as described in the “Statistical Comparison of Site and Background Data for Range 30,” then a geochemical evaluation is performed to determine if the elevated concentrations are caused by natural processes. The importance of geochemical evaluations in distinguishing between site and background data sets has been recognized in the industry (U.S. Environmental Protection Agency, 1995; Barclift, *et*

al., 2000; U.S. Navy, 2002; Myers and Thorbjornsen, 2004). When properly evaluated, geochemistry can provide mechanistic explanations for apparently high, yet naturally occurring, constituents. Anomalous samples that may represent contamination can also be readily distinguished from uncontaminated samples. This section describes the geochemical evaluation techniques that were employed in the site-to-background comparisons for Range 30.

It should be noted that the geochemical evaluations rely in part on professional judgment and qualitative assessment is a necessary part of the process. Samples that plot off the linear 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. However, anomalous samples should be flagged as suspect and their results used as a basis for further investigation, risk assessment, or remediation, as appropriate. The combination of statistical evaluations (Tiers 1 and 2) and geochemical evaluation (Tier 3) as presented in this appendix is effective in reducing the occurrences of decision errors relative to consideration of statistics or geochemistry alone.

2.1 Soil and Sediment

The geochemical evaluation is based on the natural associations of trace elements with specific minerals in the soil or sediment matrix. As an example, arsenic in most uncontaminated oxic soils is almost exclusively associated with iron oxide minerals (Bowell, 1994; Schiff and Weisberg, 1997). (The term “iron oxide” is used here to include oxides, hydroxides, oxyhydroxides, and hydrous oxides of iron.) This association of arsenic with iron oxides is a result of the adsorptive behavior of this particular trace metal in an oxic soil environment. Arsenic is present in oxic soil pore fluid as negatively charged oxyanions (HAsO_4^{-2} , H_2AsO_4^-) (Brookins, 1988). These anions have strong affinities to adsorb on the surfaces of iron oxides, which maintain a strong positive surface charge (Electric Power Research Institute, 1986). If a soil sample has a high percentage of iron oxides, then it is expected to have a proportionally higher concentration of arsenic.

The absolute concentrations of arsenic and iron can vary by several orders of magnitude at a site, but the arsenic/iron ratios in the samples are usually quite constant as long as no contamination is present (Daskalakis and O'Connor, 1995). If a sample has some naturally occurring arsenic plus additional arsenic from an herbicide or some other source, then it will have an anomalously high ratio relative to the other uncontaminated samples. These ratios thus serve as a powerful technique for identifying contaminated samples.

The evaluation includes the generation of plots in which detected arsenic concentrations in a set of samples are plotted on the y-axis, and the corresponding detected iron concentrations are plotted on the x-axis. The slope of a best-fit line through the samples is equal to the average arsenic/iron background ratio. If the samples with the highest arsenic concentrations plot on the same linear trend as the other samples, then it is most probable that the elevated concentrations are natural, and are caused by the preferential enrichment of iron oxides in those samples. If the site samples with elevated arsenic concentrations plot above the trend displayed by the uncontaminated samples, then there is evidence that those samples have an excess contribution of arsenic, and contamination may be indicated.

Each trace element is associated with one or more minerals in the soil matrix. Vanadium and selenium, along with arsenic, form anionic species in solution and are associated with iron oxides, which maintain a positive surface charge. Divalent metals such as barium, cadmium, lead, and zinc tend to form cationic species in solution and are attracted to clay mineral surfaces, which maintain a negative surface charge. These trace elements would be evaluated against aluminum, which is a major component of clay minerals. Manganese oxides also have an affinity to adsorb divalent cations such as barium, cobalt, and lead (Kabata-Pendias, 2001). These trace elements would be evaluated against manganese.

2.2 Groundwater and Surface Water

Elevated concentrations of inorganic constituents in groundwater and 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. This section discusses the major geochemical processes considered during the evaluation of groundwater and surface water analytical data.

Effects of Suspended Particulates. The presence of trace elements adsorbed on suspended particulates can greatly increase trace element concentrations as reported by an analytical laboratory. These adsorbed trace elements are not in true solution, and can be removed by settling or filtration. The same concepts involved in the evaluation of soil and sediment data also apply to groundwater and surface water data: 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).

The most common suspended particulates in groundwater samples are clay minerals; hydrous aluminum oxides ($\text{Al}_2\text{O}_3 \cdot n\text{H}_2\text{O}$) and hydroxides $[\text{Al}(\text{OH})_3]$; and iron oxide (Fe_2O_3), iron hydroxide $[\text{Fe}(\text{OH})_3]$, and iron oxyhydroxide ($\text{FeO} \cdot \text{OH}$) minerals, collectively referred to as “iron oxides.” All clay minerals contain aluminum and have low solubilities over a neutral pH range of 6 to 8. Measured concentrations of aluminum in excess of ~1 milligram per liter (mg/L) indicate the presence of suspended clay minerals (Hem, 1985; Stumm and Morgan, 1996), with higher aluminum concentrations being a qualitative indicator of the mass of suspended clay minerals. Iron also has a very low solubility under neutral pH and moderate to oxidizing redox conditions, so that measured iron concentrations in excess of ~1 mg/L under these conditions indicate the presence of suspended iron oxides (Hem, 1985).

The presence of suspended clay or iron oxides in groundwater samples has particular importance in the interpretation of trace element concentrations. Most clay particles maintain a negative surface charge under neutral pH conditions, and have a strong tendency to adsorb positively charged (cationic) aqueous species. Iron oxides display the opposite behavior, maintaining a positive surface charge under neutral pH conditions, and have a strong tendency to adsorb negatively charged (anionic) aqueous species.

Barium, lead, and zinc are usually present in groundwater as divalent cations and thus tend to concentrate on clay surfaces (EPRI, 1984; Brookins, 1988). Arsenic, selenium, and vanadium are usually present under oxidizing conditions as oxyanions, and thus tend to concentrate on iron oxide surfaces (Bowell, 1994; Hem, 1985; Pourbaix, 1974; Brookins, 1988).

Chromium can be present in groundwater as a mixture of aqueous species with different charges, depending on pH (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.

As an example, the concentrations of zinc (y-axis) would be plotted against aluminum (x-axis). If all of the samples display a common linear trend, then it is most likely that the zinc concentrations are due to the presence of suspended clay minerals in the samples. The slope of a best-fit line through the points is equal to the average zinc/aluminum ratio. If some samples plot above the linear trend established by the other samples, then those samples have an anomalously high zinc/aluminum ratio, and most likely contain excess zinc that cannot be explained by these natural processes.

Alternative techniques for assessing the effects of suspended particulates on trace element concentrations are the evaluation of correlations of trace element concentrations versus turbidity, and comparison of analyses of filtered versus unfiltered splits of samples. Turbidity measurements are qualitative, and do not distinguish between suspended clay minerals, iron oxides, and natural organic material, so this approach lacks the resolution provided by trace element versus aluminum or trace element versus iron correlations.

If the concentrations of trace elements in unfiltered samples are correlated with aluminum or iron, then they are most likely adsorbed to the surfaces of suspended particulates. If these correlations are linear, then the elevated concentrations are most likely natural.

Effects of Reductive Dissolution. Iron 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 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 by local depressions in oxidation-reduction potential (ORP) or dissolved oxygen (DO) measurements, 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 *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 Geochemical Evaluation for Multiple Elements in Soil

This section presents the results of the geochemical evaluation of aluminum, barium, beryllium, calcium, copper, lead, magnesium, manganese, mercury, nickel, potassium, selenium, and zinc in soil samples from Range 30. Correlation plots are provided in Attachment 1.

Aluminum

Aluminum is the most abundant element analyzed in the site soil samples, with a mean concentration of 18,121 mg/kg (1.8 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, 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. The site soil boring logs note that clay or clay and silt are the predominant soil types in many of the sampled intervals, which indicates that the site samples contain a high percentage of fine-grained material.

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, the site samples exhibit slightly higher aluminum concentrations than most of the background samples and lie on or slightly above the general background trend (Figure 1). However, the site samples are generally linear, indicating that Al/Fe ratios in the site samples are relatively constant. These observations suggest that the site samples are enriched in clays and other aluminum-bearing minerals relative to the background samples, and that the aluminum has a natural source. It is important to note that clays and iron oxides adsorb specific trace elements (as discussed in Section 2.1), so samples that plot on the upper end of the trend in Figure 1 are expected to contain proportionally higher concentrations of trace elements.

Conclusion

Aluminum detected in the site soil samples is naturally occurring.

Barium

Manganese oxides have an affinity to adsorb divalent cations such as barium and cobalt (Kabata-Pendias, 2001). If a soil sample contains a high proportion of manganese oxides, then it is expected to contain high concentrations of manganese and associated trace elements. The site and background samples form a collinear trend in a plot of barium versus manganese (Figure 2). The site samples with the highest barium concentrations also contain the highest manganese

concentrations, and lie on the trend established by the other samples. These observations indicate that barium in the site samples is associated with manganese oxides at a relatively constant ratio, and is natural.

Conclusion

Barium detected in the site soil samples is naturally occurring.

Beryllium

The site and background samples form a common linear trend in a plot of beryllium versus manganese ($R^2 = 0.56$ and 0.89 for the site surface and subsurface intervals) (Figure 3). The site samples with the highest beryllium concentrations also have proportionally higher manganese, and lie on the trend established by the other samples. Beryllium in the site samples is associated with manganese oxides at a relatively constant ratio, and is natural.

Conclusion

Beryllium detected in the site soil samples is naturally occurring.

Calcium

Calcium and magnesium have similar chemical properties, and magnesium often substitutes for calcium in minerals. A plot of magnesium versus calcium is provided in Figure 4. The background samples exhibit a generally linear trend with a positive slope, and the site samples lie on this trend. This indicates that the site samples exhibit Mg/Ca ratios consistent with those of the background samples, and that the calcium has a natural source.

Conclusion

Calcium detected in the site soil samples is naturally occurring.

Copper

Copper in soil has an affinity to adsorb on the surfaces of minerals such as clays and iron oxides (Kabata-Pendias, 2001). The background samples and most of the site samples form a common linear trend with a positive slope in a plot of copper versus iron (Figure 5). Most of the site samples with high copper concentrations also exhibit proportionally higher iron, and lie on the background trend. Copper in these samples has a natural source. Surface soil samples PQ0046 (from location HR-88Q-GP24) and PQ0050 (HR-88Q-MW01), however, contain elevated copper concentrations (75 and 28.1 mg/kg, respectively) but only moderate iron (as well as only moderate aluminum), and lie above the background trend. These two samples contain excess copper beyond that which be explained by natural processes, and may contain a component of contamination.

Conclusion

Copper concentrations in samples PQ0046 and PQ0050 are anomalously high and may contain a component of contamination. Copper detected in the other surface soil samples and all of the subsurface soil samples is naturally occurring.

Lead

Manganese oxides in soil have a strong affinity to adsorb divalent cations such as barium and lead (Kabata-Pendias, 2001). Samples that contain a high percentage of manganese oxides will contain elevated manganese concentrations and proportionally higher lead. A common linear trend with a positive slope is observed for the background samples and most of the site samples in a plot of lead versus manganese (Figure 6). Lead in these samples is associated with manganese oxides at a relatively constant ratio, and is natural. Surface soil samples PQ0006 (from location HR-88Q-GP03) and PQ0046 (HR-88Q-GP24), however, contain elevated lead concentrations (89.8 and 308 mg/kg, respectively) but only moderate manganese (as well as only moderate amounts of the other reference elements aluminum and iron), and lie above the background trend. These two samples contain excess copper beyond that which be explained by natural processes, and may contain a component of contamination.

Conclusion

Lead concentrations in surface soil samples PQ0006 and PQ0046 are anomalously high and most likely contain a component of contamination. Lead detected in the other surface soil samples and all of the subsurface soil samples is naturally occurring.

Magnesium

Magnesium is a common component of minerals such as clays and micas, which contain aluminum as a primary constituent. A plot of magnesium versus aluminum reveals a generally linear trend for most of the background samples (Figure 7). The site samples are highly linear ($R^2 = 0.84$ and 0.91 for the surface and subsurface intervals, respectively); the samples with the highest magnesium concentrations also exhibit the highest aluminum content, and lie on the background trend. These observations indicate that magnesium in the site samples is associated with aluminum-bearing minerals at a nearly constant ratio, and is natural.

Conclusion

Magnesium detected in the site soil samples is naturally occurring.

Manganese

As discussed previously, manganese oxides are common in soil and have an affinity to adsorb specific trace elements such as barium, cobalt, and lead. A positive correlation is thus expected between manganese and associated trace elements in uncontaminated soil samples. The positive correlations observed for barium vs. manganese and beryllium vs. manganese, and the absence of outliers plotting off the linear trends on the correlation plots, indicate a natural source for these two elements (Figures 2 and 3).

Conclusion

Manganese in the site soil samples is naturally occurring.

Mercury

Mercury concentrations in soil are commonly controlled through organic complex formation (Kabata-Pendias, 2001), so poor correlations between mercury and iron or mercury and aluminum are often observed, even in uncontaminated soil samples. A plot of mercury versus aluminum is provided in Figure 8. The site samples with high mercury also have high aluminum

and lie on the general background trend; this indicates that the mercury in these samples is associated with clays at ratios consistent with those of the background samples, and is natural. Some of the site samples with low mercury concentrations lie slightly below the background trend, but these concentrations are well below the background maximum of 0.322 mg/kg. It is important to note that 63 of the 65 site detections are estimated concentrations below the reporting limit, and that such values are highly uncertain. This uncertainty contributes to the weak correlation observed for the site samples.

Conclusion

Mercury detected in the site soil samples is naturally occurring.

Nickel

Nickel has an affinity to sorb on clays (Kabata-Pendias, 2001), so a positive correlation between nickel and aluminum would be expected for uncontaminated samples. A plot of nickel versus aluminum reveals a generally linear trend with a positive slope for the background samples (Figure 9). The site samples are highly linear ($R^2 = 0.86$ and 0.87 for the surface and subsurface intervals) and lie on the background trend. This observations indicate that nickel in the site samples is associated with clays at a nearly constant ratio, and is natural.

Conclusion

Nickel detected in the site soil samples is naturally occurring.

Potassium

Potassium is a major element that is a common constituent of minerals such as clays, which also contain aluminum. Most of the background samples form a generally linear trend in a plot of potassium versus aluminum, and the site samples lie on this trend (Figure 10). The site samples with high potassium also have proportionally higher aluminum, and lie on the trend established by the other samples. This indicates that potassium in the site samples is associated with clays and other aluminum-bearing minerals at a relatively constant ratio, and that the potassium is natural.

Conclusion

Potassium detected in the site soil samples is naturally occurring.

Selenium

As explained in Section 2.1, selenium has a strong affinity to adsorb on iron oxides in oxic soils, so a positive correlation between selenium and iron is expected for uncontaminated soil samples. Comparison to background is hindered because of the high percentage of nondetects in the background data set. The site samples form a linear trend with a shallow positive slope in a plot of selenium versus iron (Figure 11). The site selenium concentrations exhibit low variability, ranging from 0.632 to 0.674 mg/kg. All four site detections are estimated values below the reporting limit (the reporting limits range from 1.16 to 1.19 mg/kg), and such values are highly uncertain. This uncertainty likely explains why the linear site trend exhibits a shallow slope. One of the two background samples with detectable selenium lies on the site trend, and all four site detections are well below the background maximum of 1.28 mg/kg. These observations suggest a natural source for selenium in the site samples.

Conclusion

Selenium detected in the site soil samples is naturally occurring.

Zinc

Zinc commonly substitutes for magnesium in silicate minerals (Kabata-Pendias, 2001), so a positive correlation between zinc and magnesium would be expected for uncontaminated samples. A plot of zinc versus magnesium is provided in Figure 12. The site and background samples form a common linear trend with a positive slope. The site samples with the highest zinc also contain proportionally higher magnesium, and lie on the linear trend. This indicates a natural source for zinc in the site samples.

Conclusion

Zinc detected in the site soil samples is naturally occurring.

4.0 Results of the Geochemical Evaluation for Multiple Elements in Surface Water

This section presents the results of the geochemical evaluation of lead, thallium, vanadium, and zinc in the two unfiltered surface water samples from Range 30. Correlation plots are provided in Attachment 1.

Field-measured pH readings for surface water samples PQ2001 (HR-88Q-SW/SD01) and PQ2003 (HR-88Q-SW/SD02) are 5.33 and 5.77 standard units, respectively, indicating slightly acidic conditions in site surface water. Field-measured DO readings are 11.3 and 10.45 mg/L, and ORP readings are +385 and +305 mV. These readings suggest oxidizing conditions at the sample locations. Turbidity measurements are 462 and 144 NTU, indicating that the site samples contained a significant mass of suspended particulates. It should be noted that field readings are not available for the background samples.

Lead

Lead was detected in both of the site surface water samples. Lead in natural waters has an affinity to adsorb on the surfaces of suspended clays, so a positive correlation between lead and aluminum is expected for uncontaminated samples. A plot of lead versus aluminum reveals a generally linear trend with a positive slope for most of the background samples and site sample PQ2003, which contains the lower of the two site lead concentrations (0.00313 J mg/L) (Figure 13). This indicates that lead in these samples is associated with suspended particulates such as clays at a relatively constant ratio, and is natural. Site sample PQ2001 (collected from sample location HR-88Q-SW/SD01) contains elevated lead (0.058 mg/L) but only moderate aluminum (as well as moderate iron), and lies slightly above the background trend. These observations suggest that there may be a component of contamination in this sample.

It should be noted that pH data for the background samples are unavailable for comparative purposes. The solubility of lead increases at low pH, and the pH of sample PQ2001 is slightly acidic; if this low pH is natural, then the higher Pb/Al ratio of sample PQ2001 would be expected and would not necessarily reflect anthropogenic input or impact.

Conclusion

The lead concentration in surface water sample PQ2001 is anomalously high and may contain a component of contamination.

Thallium

Thallium was detected at an estimated concentration in one of the two surface water samples (PQ2003). Comparison to background is hindered by the high percentage of nondetects in the background samples. A plot of thallium versus iron is provided in Figure 14. The site sample contains a higher thallium concentration than the background sample, but it also exhibits proportionally higher iron (as well as detectable aluminum). Field readings for this sample indicate oxidizing conditions, so the iron is expected to be present primarily as suspended particulates, which – like clays – have an affinity to sorb specific trace elements. Additionally, this sample was shown to contain lead and vanadium concentrations that were associated with suspended particulates at ratios consistent with background, and which are natural (see the Lead and Vanadium evaluations). All of these observations suggest that the thallium detected in sample PQ2003 is associated with suspended particulates such as iron oxides, and is natural.

Conclusion

Thallium detected in the site surface water samples is naturally occurring.

Vanadium

Vanadium was detected in both of the site surface water samples. As discussed previously, under natural conditions vanadium is present in waters primarily as oxyanions and its concentrations are often controlled by adsorption on iron oxides. The site and background samples form a common linear trend with a positive slope in a plot of vanadium versus iron (Figure 15). This indicates that vanadium in the site samples is associated with suspended iron oxides at ratios consistent with those of the background samples, and is natural.

Conclusion

Vanadium detected in the site surface water samples is naturally occurring.

Zinc

Zinc was detected in one of the two site surface water samples. As discussed in Section 2.2, barium, lead, and zinc are usually present in natural waters as divalent cations and have an affinity to adsorb on clay surfaces, which maintain a negative surface charge. A plot of zinc versus aluminum is provided in Figure 16. The background samples and single site sample (PQ2001) with detectable zinc form a common linear trend with a positive slope; the samples with the highest zinc concentrations exhibit proportionally higher aluminum and lie on this trend. Sample PQ2001 contains only a moderate amount of zinc relative to the background samples (0.0843 mg/L, which is below the mean value of 0.087 mg/L for the background detections) as well as a proportional amount of aluminum, and lies in the center of the linear background trend.

These observations indicate that zinc in the site and background samples is associated with suspended clays at a relatively constant ratio, and is natural.

Conclusion

Zinc detected in the site surface water samples is naturally occurring.

5.0 Summary

This section summarizes the results of the geochemical evaluations of selected elements in soil and surface water samples from Range 30.

Soil. Geochemical evaluation indicates that all of the aluminum, barium, beryllium, calcium, magnesium, manganese, mercury, nickel, potassium, selenium, and zinc concentrations detected in the Range 30 surface and subsurface soil samples are naturally occurring. Concentrations of copper in surface soil samples PQ0046 (location HR-88Q-GP24) and PQ0050 (HR-88Q-MW01), and concentrations of lead in surface soil samples PQ0046 and PQ0006 (HR-88Q-GP03) are anomalously high and may contain a component of contamination. All of the copper and lead concentrations detected in the subsurface soil samples are naturally occurring.

Surface Water. Geochemical evaluation indicates that detected concentrations of thallium, vanadium, and zinc in the Range 30 surface water samples are naturally occurring. The lead concentration in sample PQ2001 (location HR-88Q-SW/SD01) is anomalously high relative to the reference element concentrations, and may contain a component of contamination.

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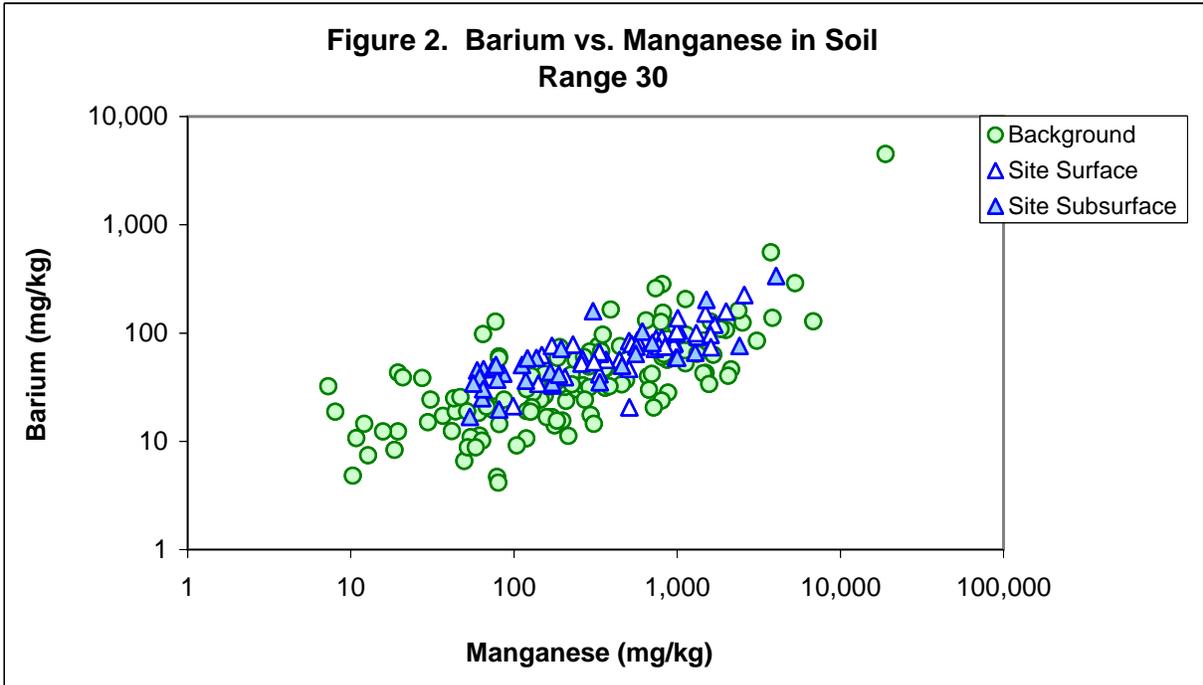
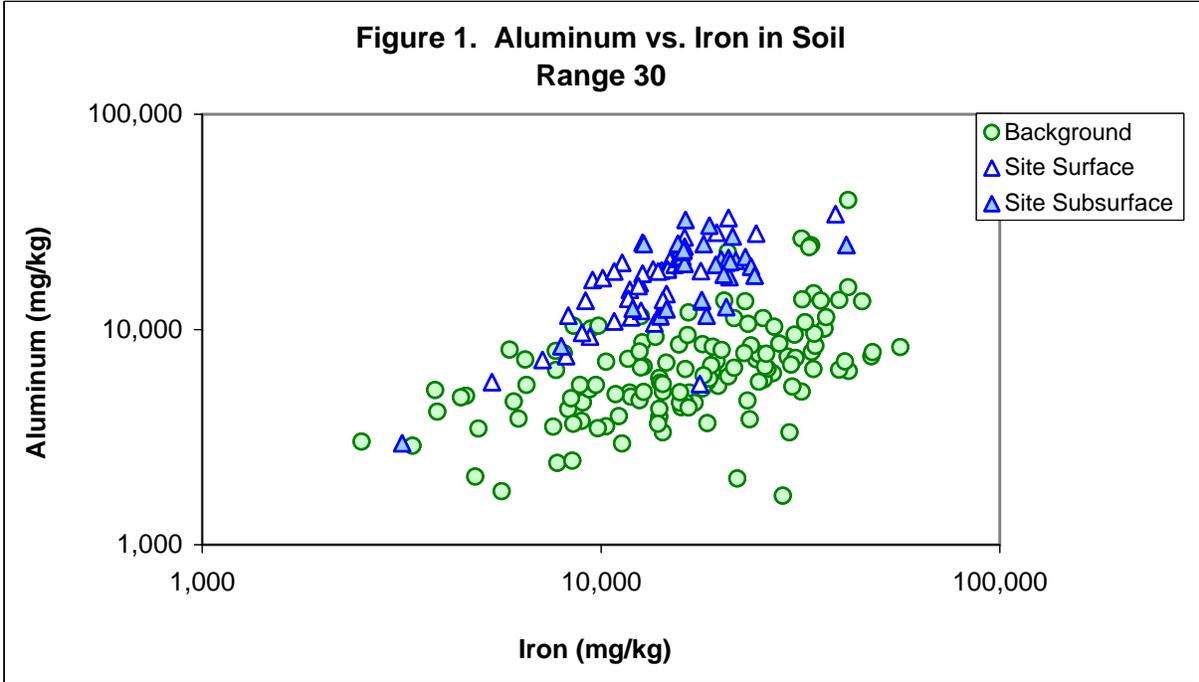
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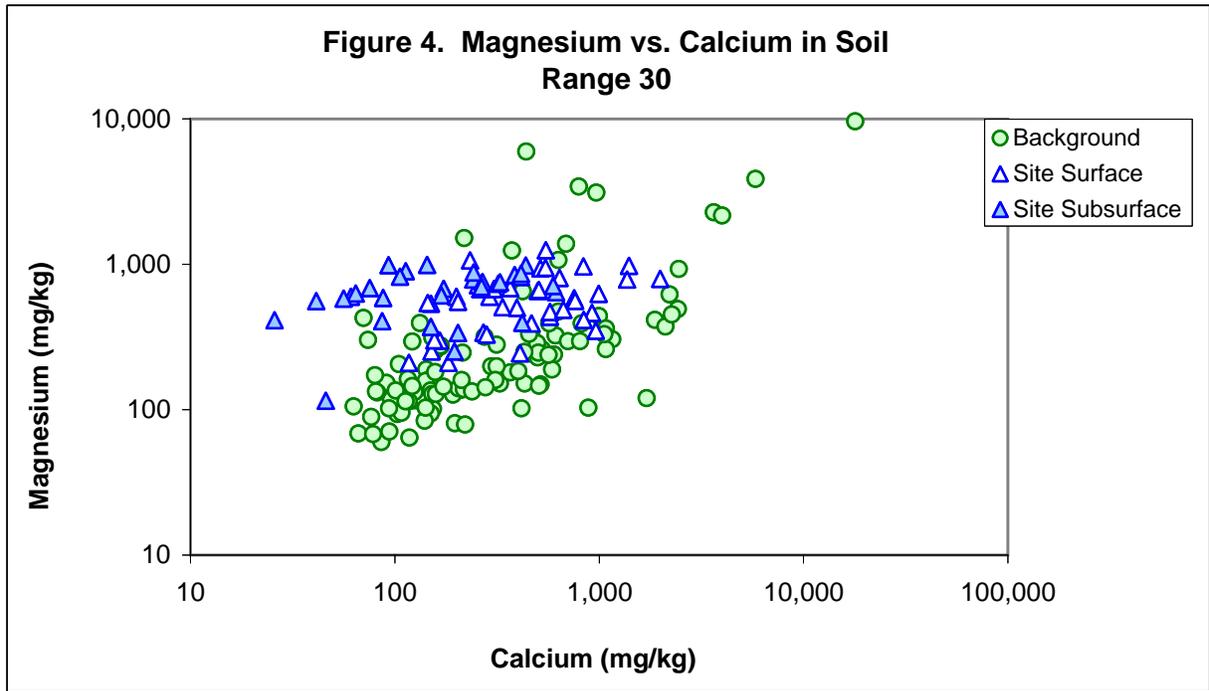
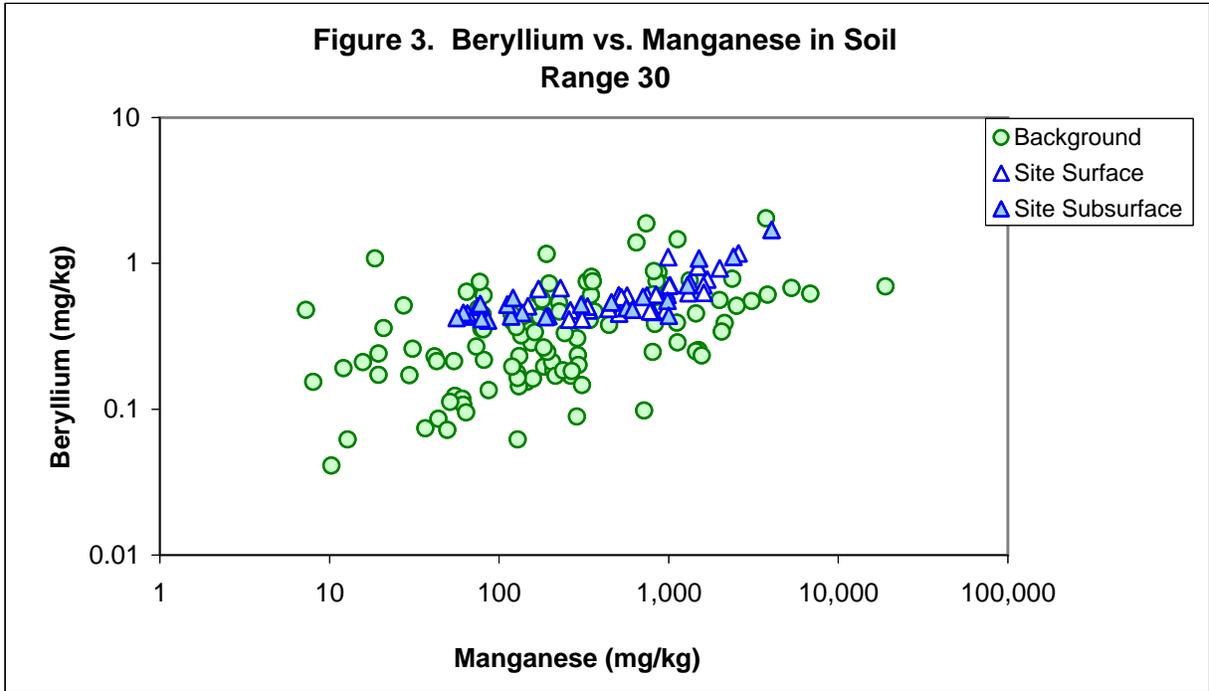
Sullivan, K. A. and R. C. Aller, 1996, "Diagenetic Cycling of Arsenic in Amazon Shelf Sediments," *Geochimica et Cosmochimica Acta*, Vol. 60, No. 9, pp. 1465-1477.

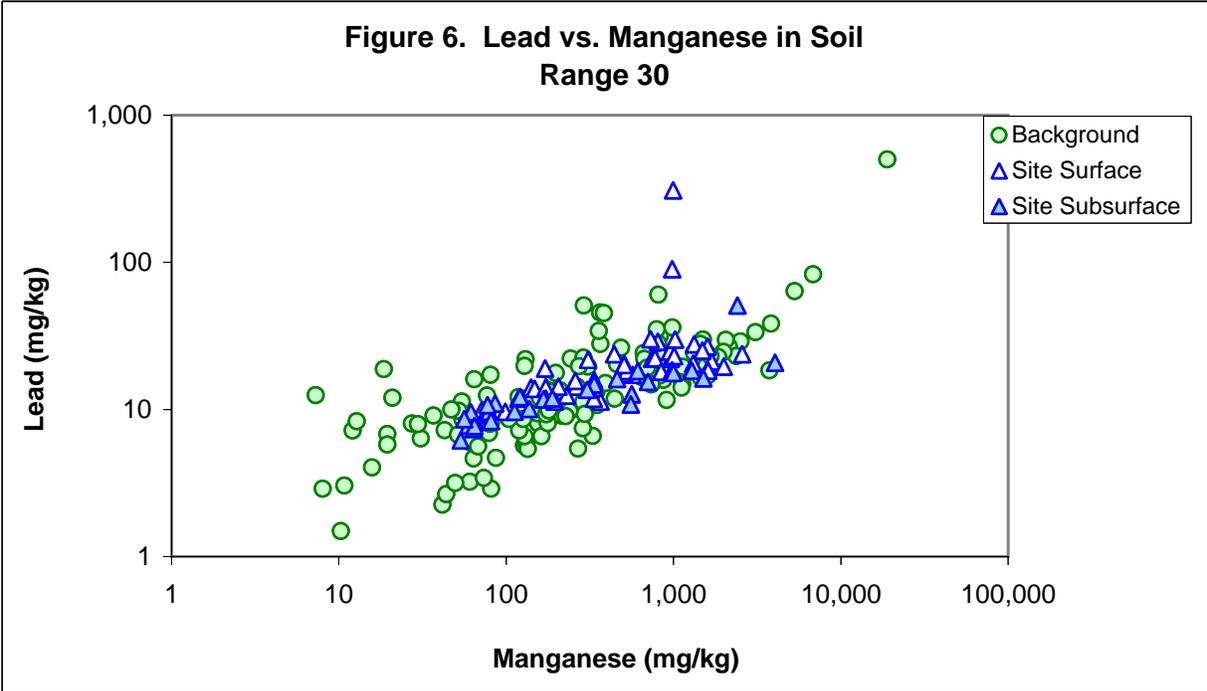
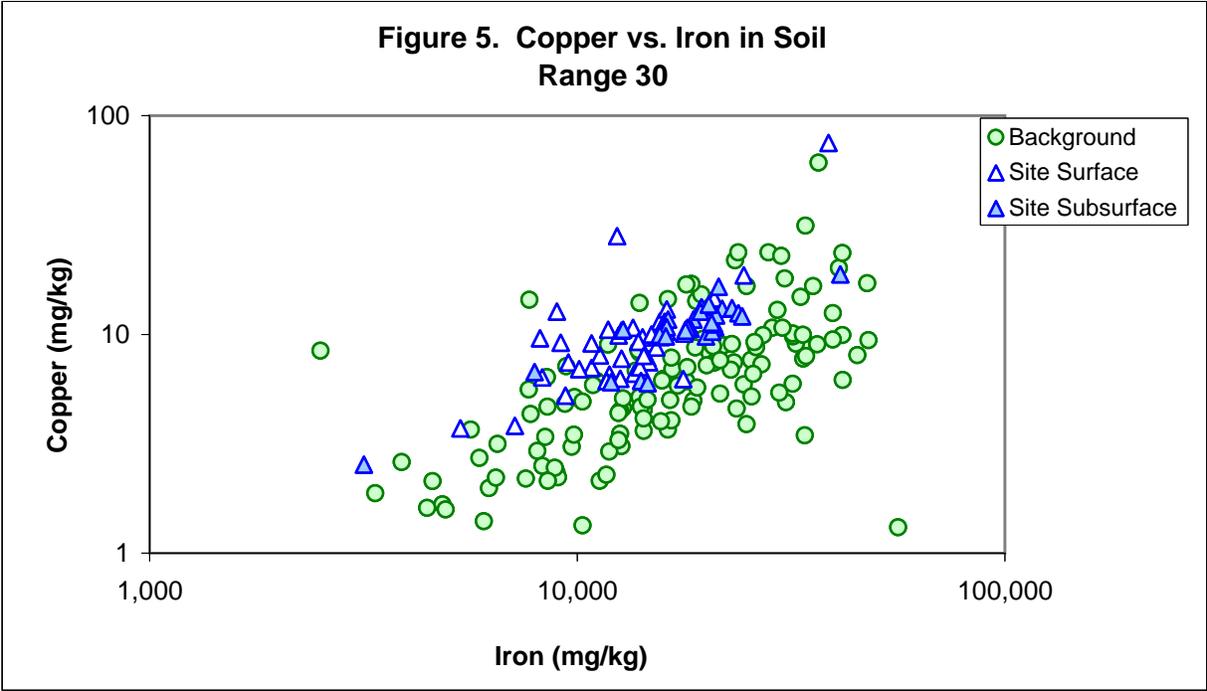
U.S. Environmental Protection Agency, 1995, *Determination of Background Concentrations of Inorganics in Soils and Sediments at Hazardous Waste Sites*, Office of Research and Development, EPA/540/S-96/500, December.

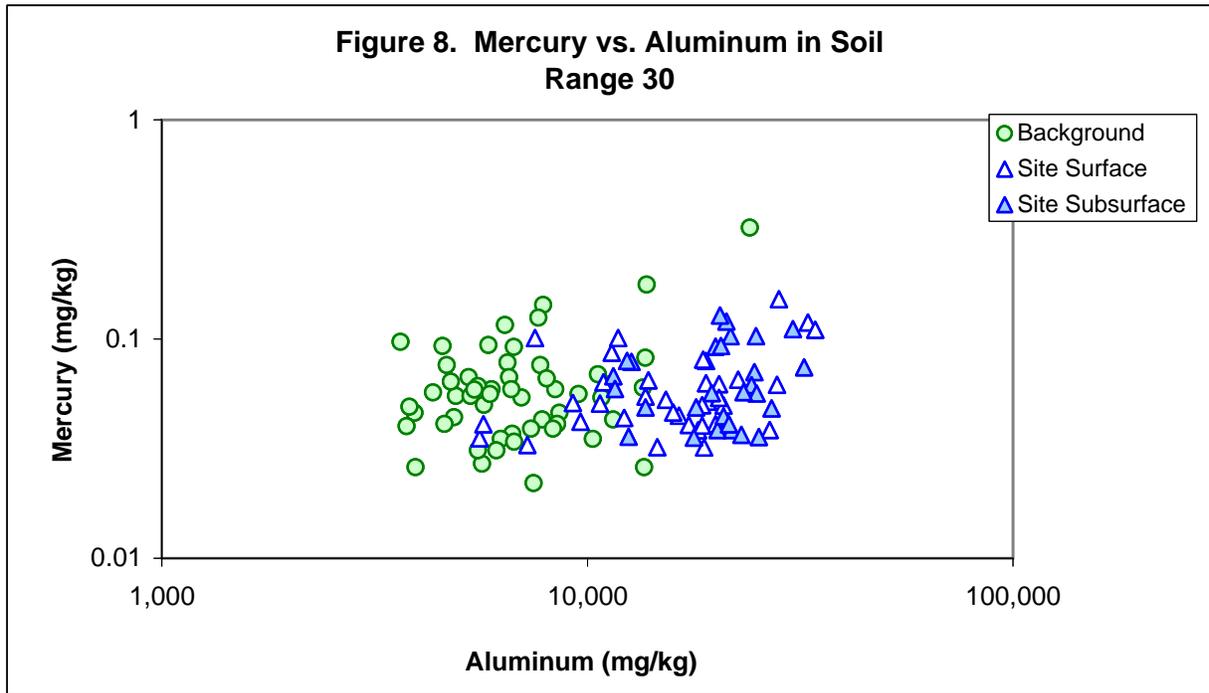
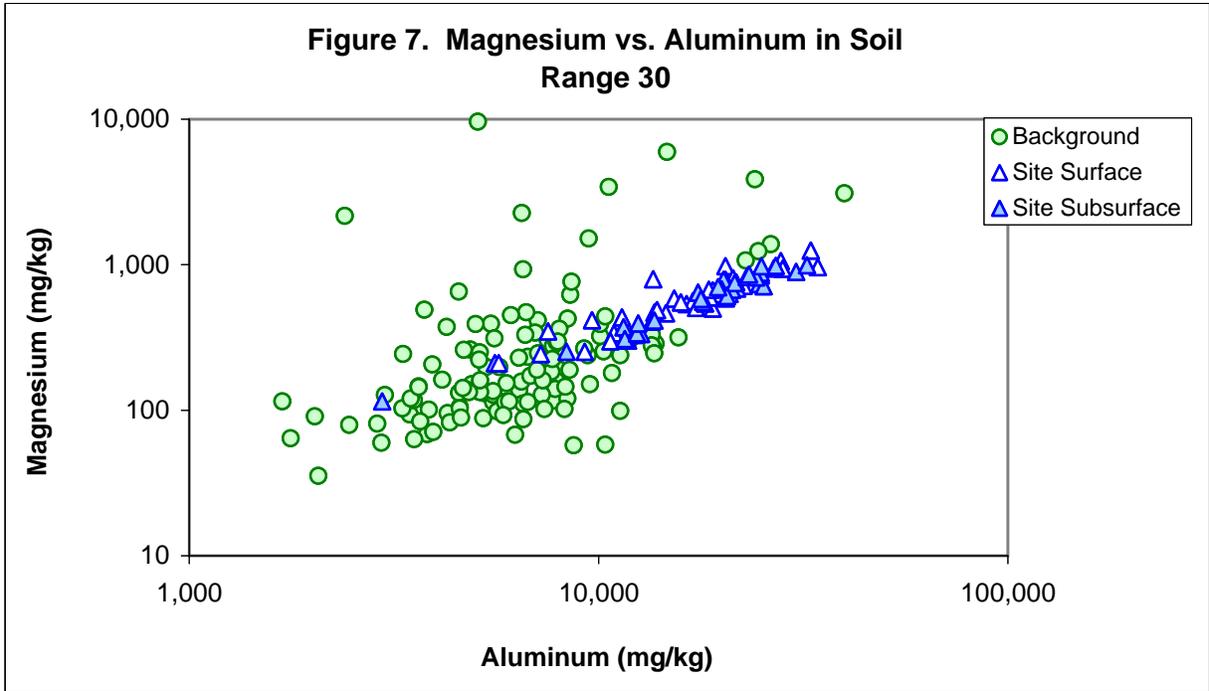
U.S. Navy, 2002, *Guidance for Environmental Background Analysis, Volume 1: Soil*, NFESC User's Guide UG-2049-ENV, Naval Facilities Engineering Command, Washington, D.C., April.

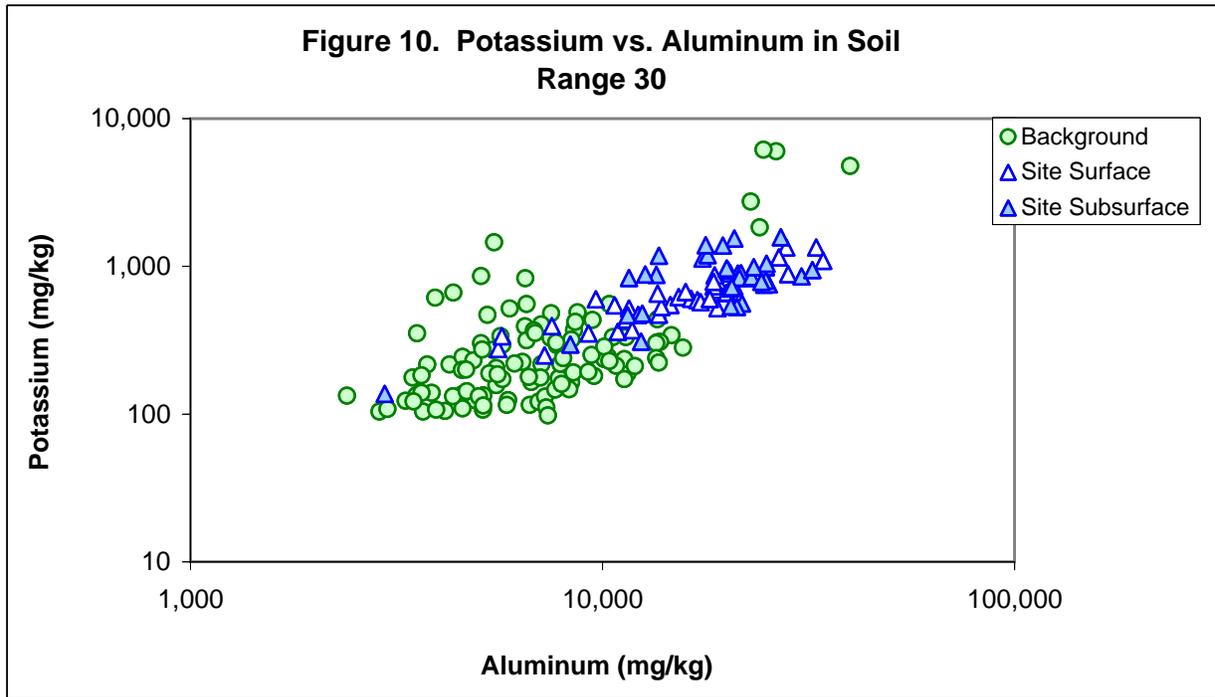
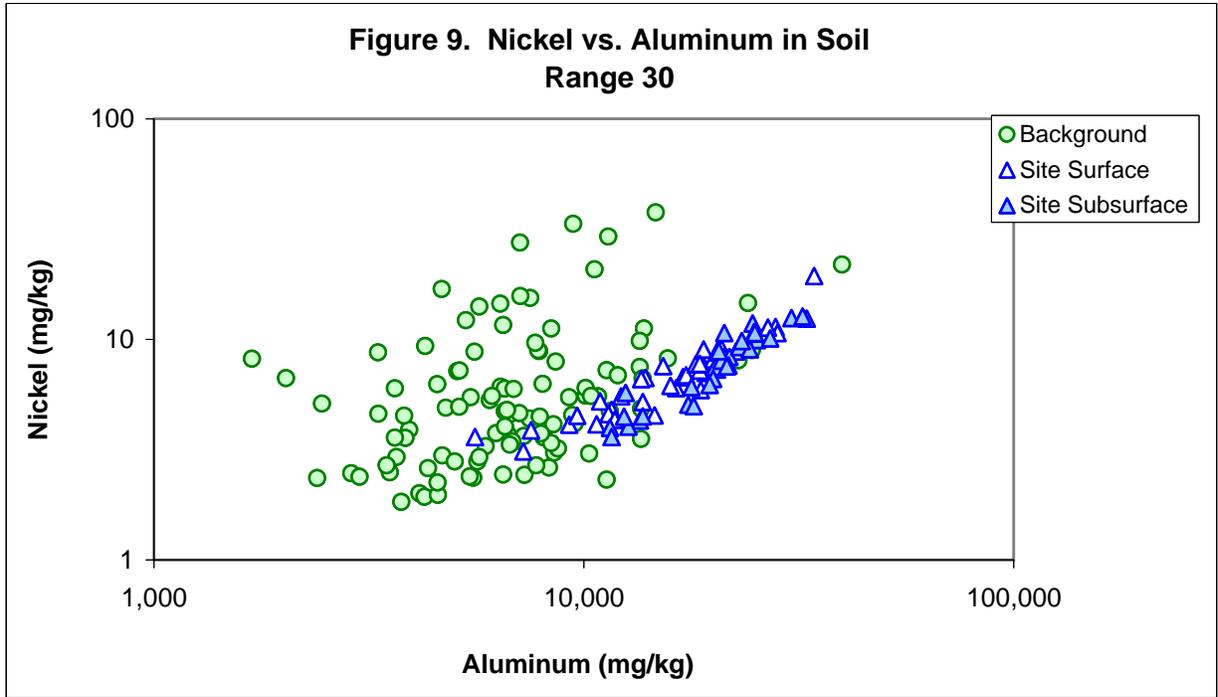
ATTACHMENT 1

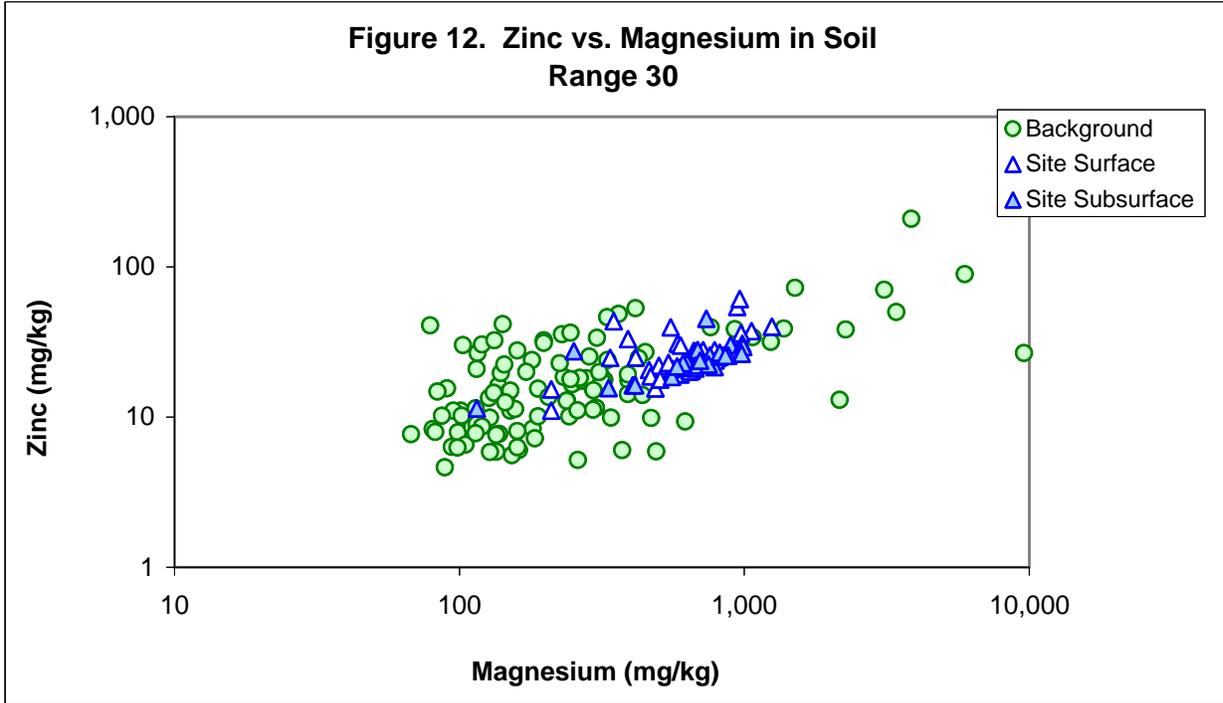
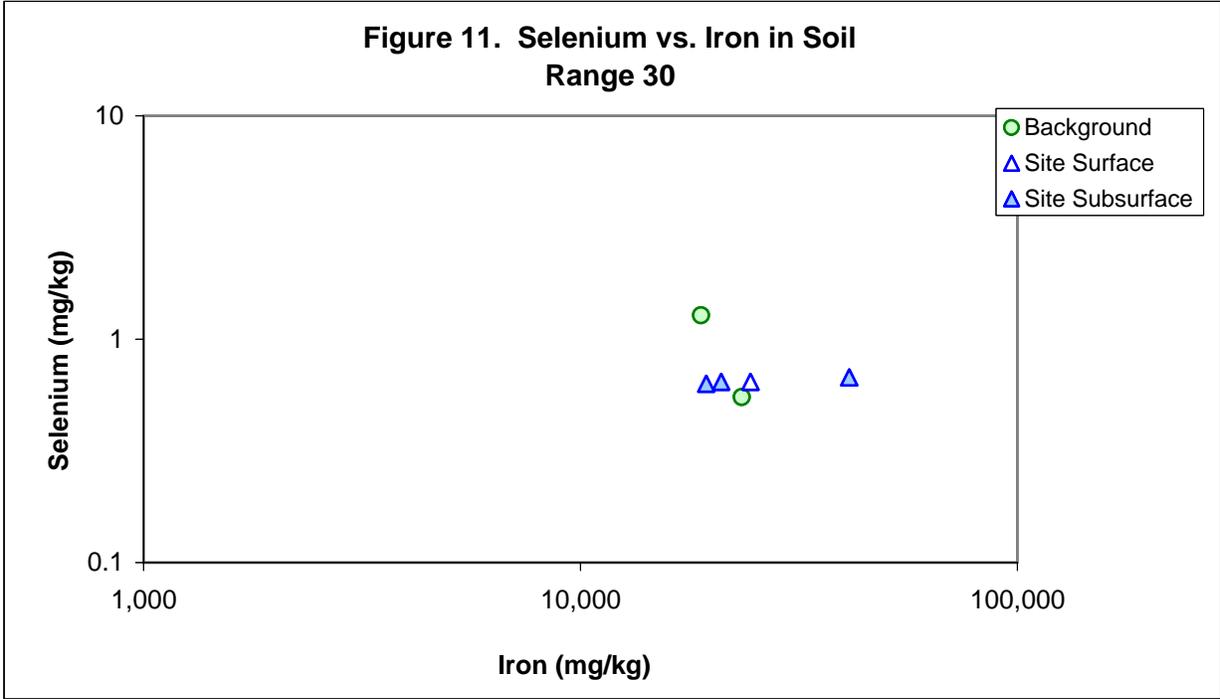


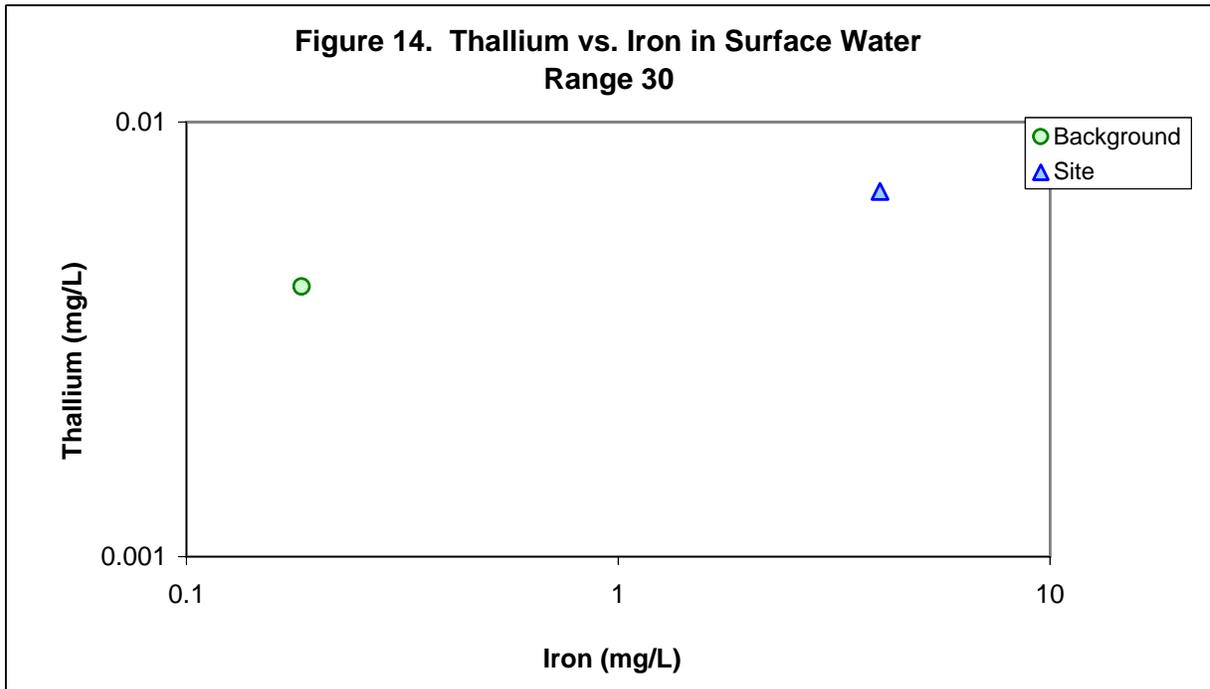
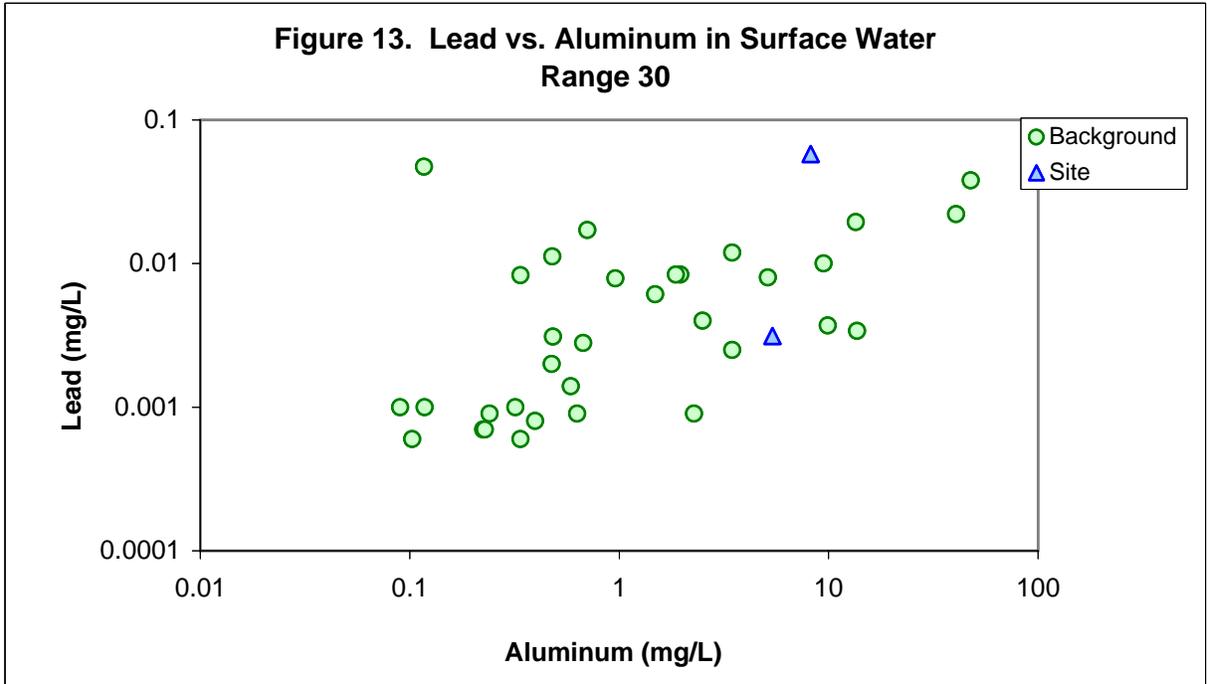


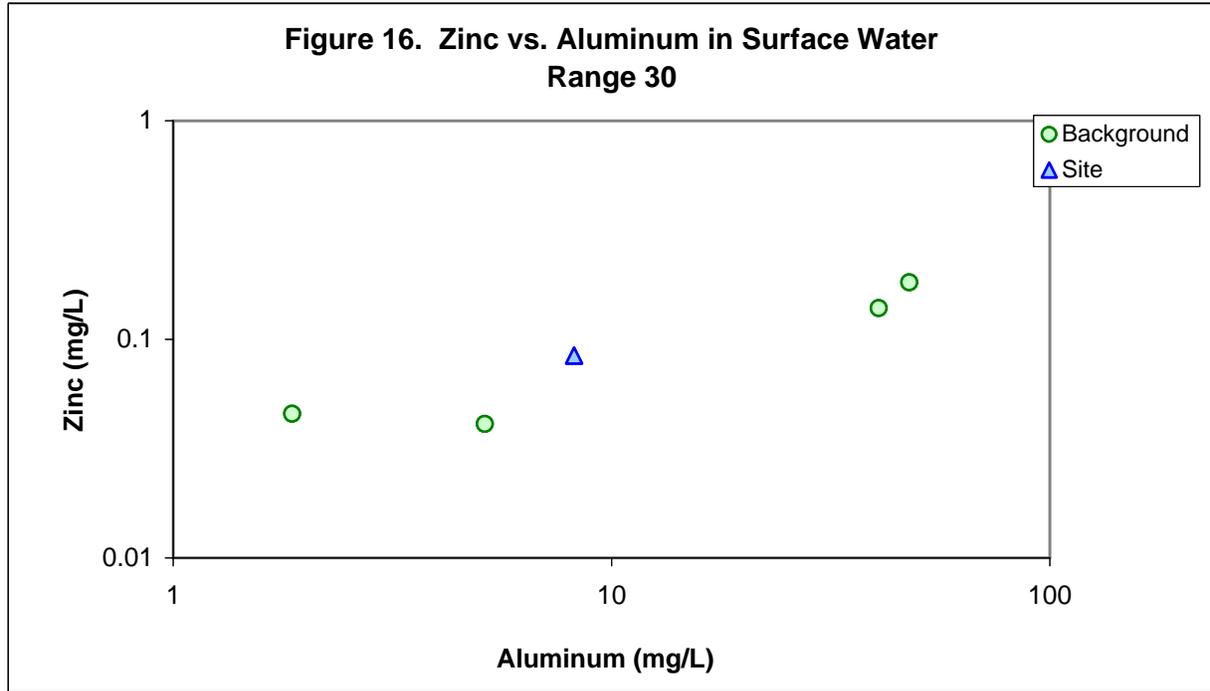
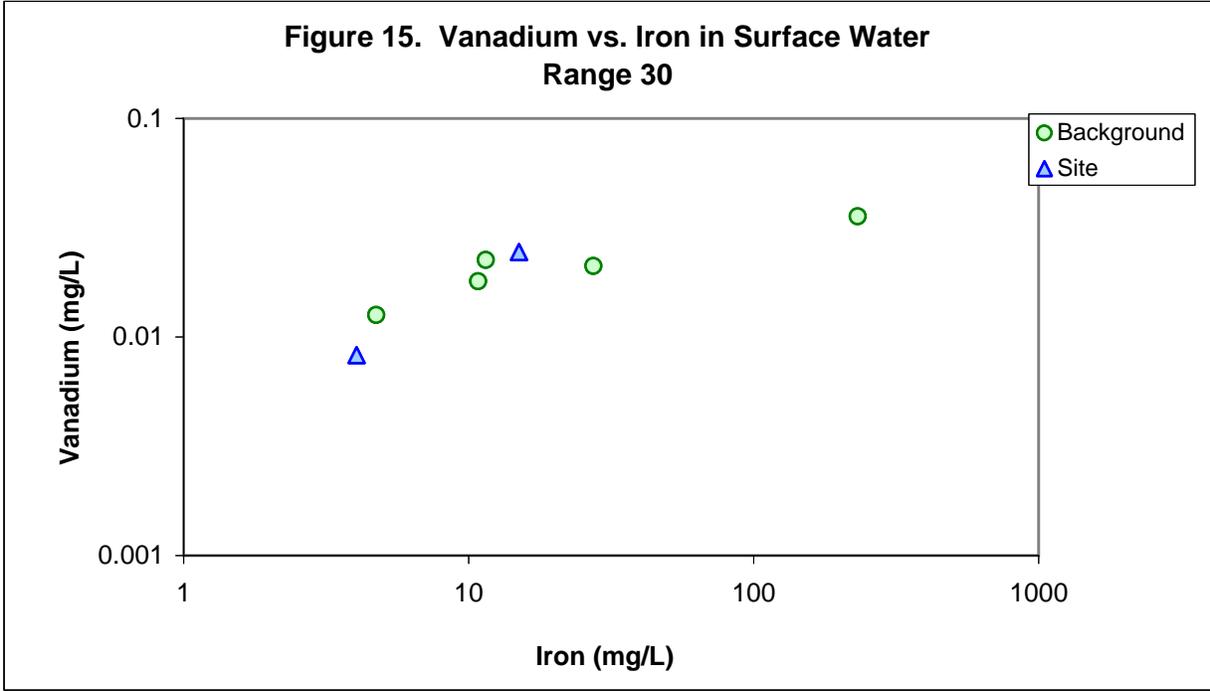












RESPONSE TO COMMENTS

**Response to Alabama Department of Environmental Management Comments
Draft Site Investigation Report
Range 30, Confidence Course (Firing Line) (Parcel 88Q); Former Rifle/Machine
Gun Range (Parcel 102Q); Former Grenade Range/Area (Parcel 106Q-X); Tank
Sub-Caliber/Carbine Transition/Machine Gun Range (OA-08); Grenade Court (OA-15);
and Unnamed Small Arms Range
Fort McClellan, Calhoun County, Alabama**

*Comment from Stephen A. Cobb, Chief, Governmental Hazardous Waste Branch, Land Division,
dated January 28, 2003.*

Comment 1: The Alabama Department of Environmental Management (ADEM or the Department) and the Environmental Protection Agency (EPA) have reviewed Fort McClellan's submittal of the above referenced *Site Investigation Report*. ADEM concurs with EPA's comments attached for your review and response. Please submit responses to the Department within 45 days from receipt of this letter.

Response 1: Comment noted.

**Response to U.S. Environmental Protection Agency Comments
Draft Site Investigation Report
Range 30 Confidence Course (Firing Line), Parcel 88Q,
Former Rifle/Machine Gun Range, Parcel 102Q,
Former Grenade Range/Area, Parcel 106Q-X,
Tank Sub-Caliber/Carbine Transition/Machine Gun Range (OA-08),
Grenade Court (OA-15), Unnamed Small Arms Range
Fort McClellan, Calhoun County, Alabama
August 2002**

Comments from Doyle T. Brittain, U.S. Environmental Protection Agency, Senior Remedial Project Manager, dated September 26, 2002.

General Comments

Comment 1: The evaluation and selection of COPCs in this document eliminated constituents as COPCs based on comparison to the range of background concentrations of each individual constituent. While this form of comparison is appropriate for consideration in Step 3a of the ERA process, it is not appropriate for inclusion in a Site Investigation Report. Many constituents were eliminated based on this incorrectly applied approach and these constituents should be re-included as COPCs and carried forward for further evaluation.

Response 1: Site metals data were re-evaluated in accordance with the new background screening protocol agreed to by the BCT in March 2003. The three-tiered process consists of statistical testing and geochemical evaluation to select site-related metals. The background screening methodology is described in the technical memorandum "Selecting Site-Related Chemicals for Human Health and Ecological Risk Assessments for FTMC: Revision 2," (Shaw Environmental, Inc., 2003).

Specific Comments

Comment 1: Page ES-1, Last Paragraph. This paragraph discusses a surface water sample which was turbid and states that an elevated lead concentration was likely the result of this turbidity. If this is the case, the sediment sample from this location would also have exhibited elevated lead concentrations. This apparent inconsistency should be addressed.

Response 1: Comment noted. Agree that it is reasonable to expect a positive correlation between surface water results and sediment results in collocated samples from shallow, stagnant water bodies where the water column above the sediment is static. However, this stream was flowing at the time of sample collection. Thus, the correlation between the two sets of results becomes less certain. It

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Fort McClellan, Calhoun County, Alabama
August 2002**

should be noted that the lead result (0.058 mg/L), although elevated, was within the same order of magnitude as both the SSSL (0.015 mg/L) and the upper background range (0.047 mg/L). It is possible that naturally occurring background levels of lead (approximately 38 mg/kg for sediment) were sufficient to cause the surface water lead result.

Comment 2: Page ES-2 and Elsewhere. The statement is made that *IT recommends “No Further Action” and unrestricted land reuse with regard to hazardous, toxic, and radioactive waste at Range 30, Confidence Course (Firing Line), Parcel 88Q, Former Rifle/Machine Gun Range, Parcel 102Q, Former Grenade Range/Area, Parcel 106Q-X, Tank Sub-Caliber/Carbine Transition/Machine Gun Range (OA-08), Grenade Court (OA-15), Unnamed Small Arms Range”*. This statement is disconcerting to EPA. Why would such a statement be made? No information has been brought to EPA’s attention that toxic (under the EPA regulatory definition of toxic) or radioactive substances have been handled at this site. The only substances that EPA is aware of having been handled at this site fit the EPA regulatory definition of hazardous. The subject report deals only with hazardous substances. Based on the information brought to EPA’s attention, the following two comments are made. If substances have been used that fit the EPA regulatory definition of a toxic or radioactive substance, EPA requests that they be brought to our attention. If not, EPA asks that such statements not be included in this or any other document regarding environmental investigation and remediation at Fort McClellan.

Response 2: Agree. The text was revised to indicate “...with regard to CERCLA-related hazardous substances...”

Comment 3: Page 1-2, Last complete Paragraph. This paragraph states that the study area was limited to an approximately 24 acre area and did not include the range fans for this area. A short statement about the range fans being covered under a separate investigation should be added here.

Response 3: Agree. The text was revised per comment.

Response to U.S. Environmental Protection Agency Comments
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Fort McClellan, Calhoun County, Alabama
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- Comment 4:** Page 1-5, First Paragraph. This paragraph discusses area OA-08. This area should be identified on Figure 103. In addition, four of the areas identified on Figure 1-3 are not discussed in the text. These inconsistencies should be addressed.
- Response 4:** Disagree. Area OA-08 is shown on Figure 1-3 and all areas shown on the figure are discussed or mentioned in the text.
- Comment 5:** Page 3-2, Second Complete Paragraph. This paragraph states that subsurface soil samples were collected at a depth of 3 to 4 feet below ground surface. The third complete paragraph states that subsurface soil samples were collected continuously to 12 feet and that the deepest sample above the saturated zone was submitted for analysis. This inconsistency should be addressed.
- Response 5:** Agree. The text was revised to indicate that "...samples were collected continuously to 4 feet below ground surface..."
- Comment 6:** Page 3-4, Third Paragraph. This paragraph discusses a turbid groundwater sample and states that the sample was allowed to settle and then decanted prior to shipment to the laboratory. Since samples for volatile compounds are collected in preserved vials, an explanation should be provided as to how samples for volatile compound analyses were collected.
- Response 6:** Agree the text is confusing. Groundwater samples (including those for VOC analysis) were collected following standard procedures in the SAP; however, only the sample fraction for metals analysis was decanted. The text was revised for clarification.
- Comment 7:** Figure 4-1. This figure shows the groundwater elevation map prepared for this site. The groundwater elevation provided for HR-88Q-NW3 appears to be inconsistent with the rest of the figure. This elevation (728.53) is higher than that at the nearest up gradient well (728.13) and at the down gradient well (728.03). This inconsistency should be resolved.

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Tank Sub-Caliber/Carbine Transition/Machine Gun Range (OA-08),
Grenade Court (OA-15), Unnamed Small Arms Range
Fort McClellan, Calhoun County, Alabama
August 2002**

Response 7: Disagree that an inconsistency exists. Agree that the groundwater elevation for HR-88Q-MW03 is *slightly* higher (approximately 6 inches) than in adjacent wells. It is possible that a slight mounding of groundwater occurs in the vicinity of HR-88Q-MW03. This may be in response to the slight increase in topography shown by the closed 760-foot contour to the east of the well. However, the figure simply shows that the water table in this area of the site is very flat. The calculated hydraulic gradient across this area of the site (north of Falcon Road) is approximately 0.001 ft/ft.

Comment 8: **Page 5-1, Section 5.0, Line 12. This line states that metals concentrations exceeding the SSSLs and ESVs were subsequently compared to metals screening values to determine if the metals concentrations are within natural background concentrations. As written, it is difficult to determine what background screening was utilized (i.e., 2 times the mean background concentration, range of background, or additional statistical comparison). The text should be clarified to state that the only comparison to background that was performed for the elimination of COPCs was the comparison of the maximum concentration of each respective constituent to two times that constituent's mean background concentration.**

Response 8: See response to General Comment No. 1.

Comment 9: **Page 5-1, Section 5.1, Line 31. The text states that these metals concentrations, however, were within the range of background values. Based on this text and other text found in this section, it appears that constituents are being eliminated as COPCs based on methods that are appropriate in Step 3a of an ERA, not for inclusion in a site investigation. COPCs should be carried forward if they exceed either the SSSL or ESV and 2 times mean background. Therefore, any constituent eliminated as a COPC based on any other form of analysis than that stated above (i.e., being within the range of background), is not appropriate at this time and should be re-included into the document as a COPC.**

Response 9: See response to General Comment No. 1.