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**To:** Shannon Harbour, NDEP

**RE:** Technical Memorandum: Background Evaluation for Metals in Shallow Soils in  
Remediation Zone A and Remediation Zone D

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We have prepared these materials to facilitate our discussion during the conference call scheduled for Wednesday, April 14<sup>th</sup>. These materials present the results of background comparisons for metals in shallow soil (i.e., starting depths from 0 to 10 feet below ground surface [fbgs]) using the data collected in Remediation Zones (RZ) A and D. The purpose of this conference call is to discuss some issues that arose during the background comparisons for this subset of the RZs. The aim of this discussion is to ensure that there is agreement on a consistent approach going forward to streamline Tronox's preparation and NDEP's review of the remaining background evaluations. We propose to have a separate discussion regarding the background comparisons for radionuclides, including secular equilibrium, for all of the RZs.

Preliminary background comparisons have been provided to NDEP in prior data summary meetings; however, the new delineation of RZs warranted additional analysis. These materials summarize the methods used and the implications for identifying chemicals of potential concern (COPCs) in each of these areas. RZ-A is presented, as no remediation is planned in this area. RZ-D is presented because the pre-confirmation sampling plan indicates that additional soil samples will be analyzed for arsenic. The results of the background evaluation for RZ-D, however, indicate that further collection of samples for arsenic analysis may not be needed. The background comparisons for RZ-B, RZ-C, and RZ-E will be conducted after the results for the pre-confirmation samples have been received. Complete background evaluations will be included in the Human Health Risk Assessment (HRA) prepared for each RZ, per the HRA work plan.

### **Evaluation of Site Concentrations Relative to Background Conditions**

Consistent with USEPA guidance (1989, 1992b,c), site data for metals were evaluated relative to background concentrations to identify those that are not elevated above naturally occurring levels and can, therefore, be eliminated from further quantitative evaluation in the health risk assessment. This evaluation was based on a combination of exploratory data analysis (EDA)



and appropriate statistical methods (USEPA 2002c), each of which is discussed further below. When the weight-of-evidence of the EDA and results of the statistical analyses indicated that a particular chemical is within background levels, then the chemical was not identified as a COPC.

### **Background Datasets**

Site soil concentrations were compared to background levels using the existing soils background data presented in the *Background Shallow Soil Summary Report, BMI Complex and Common Area Vicinity* (BRC and TIMET 2007), which includes both the Environ (2003) dataset and the BRC/TIMET dataset collected in 2005. Specifically, only the subset of shallow background data identified as being from sediments derived from the McCullough Range were used, based on the recommendation from NDEP (NDEP 2009e). These samples were collected at 0, 5, and 10 fbgs.

### **Site Data**

Site data collected from locations within each RZ at sample starting depths between 0 and 10 fbgs were included in this evaluation. Samples were generally collected from 0.5 to 2 fbgs and from 10 to 11.5 fbgs, although a few samples were collected at 2.5, 5, 7, and 9 fbgs due to location-specific sampling obstacles. Field duplicates and site samples were treated as independent samples, on the basis of preliminary evaluation indicating that the variance of the duplicates was similar to the variance of the site samples, in consultation with NDEP guidance (NDEP 2008c; Paul Black, *personal communic.* Nov. 11, 2009). Finally, non-detect results were set equal to one-half of the limit of detection for purposes of this evaluation. The Sample Quantitation Limit (SQL) was used as the detection limit for both the site and background data sets as per NDEP guidance (NDEP 2008d).

### **Exploratory Data Analysis**

EDA was performed using summary statistics (*Guidance on the Development of Summary Statistics Tables for the BMI Plant Sites and Common Areas Projects, Henderson, Nevada, NDEP, 2008b*) and quantile-quantile plots and side-by-side box-and-whisker plots to qualitatively evaluate whether the Site and background data are representative of a single population. The summary statistics for the Site and background data are presented in separate tables for RZ-A and RZ-D; the plots are included in Appendices A and B.

### **Statistical Comparisons**

The computer statistical software program Guided Interactive Statistical Decision Tools (GiSdT<sup>®</sup>; Neptune and Company 2007) was used to perform all statistical comparisons. Specifically, statistical background comparisons were performed using the Quantile test, Slippage test, *t*-test, and Wilcoxon Rank Sum test with Gehan modification. The *t*-test is parametric, which assumes that the data are normally distributed. In contrast, the Wilcoxon Rank Sum test, Quantile test, and Slippage test are non-parametric, which do not require an assumption of whether the data are normally or lognormally distributed (USEPA 2002c; NDEP, 2009c). These non-parametric tests are described further below.



- The Wilcoxon Rank Sum test performs a test for a difference between the sum of the ranks for two populations. This is a non-parametric method for assessing differences in the centers of the distributions that relies on the relative rankings of data values. Knowledge of the precise form of the population distributions is not necessary. The Wilcoxon Rank Sum test has less power than the two-sample *t*-test when the data are normally distributed, but the assumptions are not as restrictive. The GiSdT<sup>®</sup> version of the Wilcoxon Rank Sum test uses the Mantel approach for ranking the data, which is equivalent to using the Gehan ranking system. The Gehan ranking system is used to rank non-detects with the rest of the data (NDEP, 2009c).
- The Quantile test addresses tail effects which are not addressed in the Wilcoxon Rank Sum test. The Quantile test looks for differences in the right tails (upper-end of the data set) rather than central tendency like the Wilcoxon Rank Sum test. The Quantile test was performed using a defined quantile = 0.80 (Paul Black, *personal communic.* Oct. 7, 2009).
- The Slippage test looks for a shift to the right in the extreme right-tail of the background data set versus the extreme right-tail of the site data set. This test determines, for each metal and radionuclide, if the number of site concentrations that are greater than the maximum background concentration is greater than would be expected statistically if the site and background distributions are the same.

For most metals, comparisons between site data and the background dataset were based on the combined data for all depth intervals in each dataset, as recommended in BRC's Background Soil Summary Report (BRC/TIMET 2007). For the remaining metals, the site and background data were subdivided by depth interval as follows, as also recommend in the Background Soil Summary Report (BRC/TIMET 2007):

- Chromium(total), chromium(VI), iron, manganese, potassium, sodium, and zinc – site data collected between 0 and 2 fbgs were compared to background data collected at 0 fbgs and site data collected between 2 and 10 fbgs were compared to background data collected at 5 and 10 fbgs
- Lead – site data collected between 0 and 2 fbgs were compared to background data collected at 0 fbgs, site data collected between 2 and 6 fbgs were compared to background data collected at 5 fbgs, and site data collected between 6 and 10 fbgs were compared to background data collected at 10 fbgs.
- Uranium – site data collected between 0 and 6 fbgs were compared to background data collected at 0 and 5 fbgs and site data collected between 6 and 10 fbgs were compared to background data collected at 10 fbgs.

Finally, an alpha = 0.05 is typically used to evaluate a statistically significant result (USEPA, 2002c). However, as more tests are performed, it is more likely that a statistically significant result will be obtained purely by chance. Given the use of multiple statistical tests, an alpha = 0.025 was selected as a reasonable significance level for determining if Site data are different than background (NDEP, 2009c). Generally, any chemical that resulted in a *p*-value less than 0.025 in one of four tests will be retained for further consideration in the COPC selection



process. Additionally, because these tests are set up with one-sided hypotheses, not only are differences between the two samples able to be detected, a directional determination can be made as well (e.g., Site is greater than background).

**Results for RZ-A**

The background and site data for RZ-A are summarized in Table 1, including number of detections, total number of samples, percent detections, minimum detected value, maximum detected value, median, mean, and standard deviation (NDEP, 2008b); quantile-quantile and box and whisker plots are included in Attachment A. Consistent with NDEP guidance, the median, mean and standard deviation are based solely on detected values (NDEP, 2008b). The results for the four statistical tests (p-values) are also included in the table, as well as a determination as to whether the site data are greater than background. It is important to note that many of the p-values for multiple tests are close to or equal to one, suggesting that the site data are lower than background. In addition, there are several chemicals for which there is low frequency of detection (less than 25%) in the site or background data set. Finally, chemicals for which only one p-value was less than 0.025 are noted on the Table. Based on these results, the chemicals identified as being greater than background in RZ-A are listed in the following table, along with any comments as to how the elevated levels might be explained by the conceptual site model (CSM).

<b>Metals Greater than Background</b>	<b>Relation to Conceptual Site Model</b>
Antimony	Very low detection frequency in the site dataset. One detected value much greater than maximum detected background concentration (RSAT5-0.5B). No explicit relation to CSM for RZ-A.
Boron	Elevated concentrations detected in samples collected within LOU 62 (State Industries, Inc. Site including Impoundments and Catch Basin). Borax (hydrated sodium borate) was identified as a known constituent of the process waste stored in the impoundments (ENSR/AECOM, 2008c).
Cadmium	Very low detection frequency in background dataset. No explicit relation to CSM for RZ-A.
Copper	One detected value much greater than maximum detected background concentration (RSAT5-0.5B). No explicit relation to CSM for RZ-A.
Iron	Elevated concentrations detected in samples collected within LOU 62. Iron identified as a known constituent of the process waste stored in the impoundments (ENSR/AECOM, 2008c).
Lead	Elevated above background only for data collected between 6



	and 10 fbg; however, highest detected site concentrations detected in samples collected between 0 and 6 fbg. One of two highest concentrations detected in a sample collected within LOU 62; the other was detected in sample collected from RSAT5-0.5B. No explicit relation to CSM for RZ-A .
Molybdenum	One detected value much greater than maximum detected background concentration (RSAT5-0.5). No explicit relation to CSM for RZ-A.
Platinum	Very low detection frequency in background data set; maximum detected concentration in site data below maximum detected concentration in background data. No explicit relation to CSM for RZ-A.
Potassium	Elevated above background only for data collected between 2 and 10 fbg; maximum detected concentration in site data below maximum detected concentration in background data for this depth interval. No explicit relation to CSM for RZ-A.
Selenium	Low frequency of detection in site data set. No explicit relation to CSM for RZ-A.
Silver	Low frequency of detection in both site and background data sets. Two highest detected site concentrations from samples collected within LOU 62. No explicit relation to CSM for RZ-A.
Sodium	Highest detected site concentrations from samples collected within LOU 62. Potentially associated with borax (hydrated <u>sodium</u> borate) that was identified as a known constituent of the process waste stored in the impoundments (ENSR/AECOM, 2008c).
Tin	Very low detection frequency in site dataset. Highest detected concentration in site data below maximum detected concentration in background data. No explicit relation to CSM for RZ-A.
Titanium	Maximum detected site concentration is only slightly higher than maximum detected background concentrations (1080 vs. 1010 mg/kg). No explicit relation to CSM for RZ-A.
Tungsten	Not detected in background data set. No explicit relation to CSM for RZ-A.
Uranium	Elevated above background only for data collected between 6 and 10 fbg; maximum detected concentration in site data below maximum detected concentration in background data for



	this depth interval. No explicit relation to CSM for RZ-A.
Vanadium	Maximum detected concentration in site data below maximum detected concentration in background data. No explicit relation to CSM for RZ-A.

All of these chemicals were evaluated further in the COPC selection process, regardless of whether the elevated concentrations could be related to the CSM for this RZ. For purposes of this technical memorandum, further evaluation of the COPCs is limited to direct contact pathways. A separate evaluation is being conducted to address the potential leaching of these chemicals and impact to groundwater.

The final two columns in Table 1 are the NDEP worker basic comparison level (BCL: NDEP 2009a), and the number of samples in which the detected concentration exceeds 10% of the BCL. Of the metals present in soil at RZ-A at concentrations greater than background, the maximum detected concentration of antimony, boron, cadmium, copper, molybdenum, selenium, silver, tin, titanium, tungsten, uranium, and vanadium are below 10% of their respective BCLs; therefore, these metals were not identified as COPCs. BCLs are not available for platinum, potassium, or sodium, nor are there any available toxicity criteria or applicable surrogate criteria; therefore, these chemicals also were not identified as COPCs. The maximum concentrations of the remaining metals, i.e., iron and lead, are greater than 10% of their respective BCLs; therefore, iron and lead were identified as COPCs for RZ-A and will be further evaluated in the human health risk assessment.

**Results for RZ-D**

The background and site data for RZ-D are summarized in Table 2, including number of detections, total number of samples, percent detections, minimum detected value, maximum detected value, median, mean, and standard deviation (NDEP, 2008b); quantile-quantile and box and whisker plots are included in Appendix B. The results for the four statistical tests (p-values) are also included in the table, as well as a determination as to whether the site data are greater than background. As with RZ-A, many of the p-values for multiple tests are close to or equal to one, suggesting that the site data are lower than background. In addition, there are several chemicals for which there is low frequency of detection (less than 25%) in the site or background data set. Finally, chemicals for which only one p-value was less than 0.025 are noted on the table. Based on these results, the chemicals identified as being greater than background in RZ-D are listed in the following table, along with any comments as to how the elevated levels might be explained by the conceptual site model (CSM).

<b>Metals Greater than Background</b>	<b>Relation to Conceptual Site Model</b>
Antimony	Low detection frequency in site dataset. Maximum detected site concentration only slightly higher than maximum detected



	background concentration. No explicit relation to the CSM for RZ-D.
Boron	Highest detected site concentrations collected near Former Trade Effluent Ponds (RSAJ2-0.5B) and WC East and West Ponds (RSAJ5-0.5B). Boron was identified as a known or potential constituent associated with the WC East and West Ponds.
Cadmium	Very low detection frequency in background dataset. Maximum detected site concentration less than 5 times maximum detected background concentration. No explicit relation to CSM for RZ-D.
Chromium (VI)	Not detected in background dataset. Elevated above background only for data collected between 0 and 2 fbg. Highest detected site concentrations collected near Former Trade Effluent Ponds (RSAJ2-0.5B). Chromium (VI) was identified as a known or potential constituent associated with the Former Trade Effluent Ponds.
Copper	Very few site data concentrations greater than maximum detected background concentration. Highest detected site concentrations (less than 3 times maximum detected background concentration) collected near WC East and West Ponds (SA201-0.5B) and AP Plant Area Old D-1 Building Washdown (SA179-0.5B). No explicit relation to the CSM for RZ-D.
Iron	Elevated above background only for data collected between 2 and 10 fbg; maximum detected concentration in site data below maximum detected concentration in background data for this depth interval. No explicit relation to CSM for RZ-D.
Lead	Very few site data concentrations greater than maximum detected background concentration. Highest detected site concentrations (less than 3 times maximum detected background concentration) collected near WC East and West Ponds (RSAK7-0.5B). No explicit relation to CSM for RZ-D.
Magnesium	Highest detected site concentrations collected near Former Trade Effluent Ponds (RSAJ3-0.5B) and WC East and West Ponds (RSAJ5-0.5B). Magnesium was identified as a known or potential constituent associated with the WC East and West Ponds.



Manganese	Elevated above background only for data collected between 0 and 2 fbg. Highest detected site concentrations collected near Former Trade Effluent Ponds (RSAJ3-0.5B) and WC East and West Ponds (RSAJ8-0.5B). Manganese was identified as a known or potential constituent associated with the WC East and West Ponds.
Potassium	One detected value in site data much greater than maximum detected background concentration in sample collected near Former Trade Effluent Ponds (RSAJ2-0.5B). No explicit relation to CSM for RZ-D.
Selenium	Very low detection frequency in site dataset. Maximum detected site concentration only 2 times higher than maximum detected background concentration. No explicit relation to CSM for RZ-D.
Silver	Highest detected site concentrations collected near Former Trade Effluent Ponds (SA201-10B, SA202-10B). No explicit relation to CSM for RZ-D.
Sodium	Highest detected site concentrations detected near Former Trade Effluent Ponds and WC East and West Ponds (multiple samples). Sodium chlorate production wastes associated with the Former Trade Effluent Ponds.
Tin	Very low detection frequency in site dataset. Maximum detected site concentration detected near Former Trade Effluent Ponds (RSAK8-10B). No explicit relation to CSM for RZ-D.
Titanium	Highest detected site concentrations only slightly higher than maximum detected background concentrations (1220, 1070, 1060 vs. 1010 mg/kg). No explicit relation to CSM for RZ-D.
Tungsten	Not detected in background data set. Maximum detected site concentration detected near Former Trade Effluent Ponds (RSAK8-10B). No explicit relation to CSM for RZ-D.
Uranium	Highest detected site concentrations less than 4 times higher than the maximum detected background concentrations for each depth interval. No explicit relation to CSM for RZ-D.
Vanadium	Maximum detected site concentration less than 2 times higher than maximum detected background concentration. No explicit relation to CSM for RZ-D.





The final two columns in Table 2 are the NDEP worker basic comparison level (BCL: NDEP 2009a), and the number of samples in which the detected concentration exceeds 10% of the BCL. Of the metals present in soil at RZ-D at concentrations greater than background, the maximum detected concentration of antimony, boron, cadmium, chromium(VI), copper, selenium, silver, tin, titanium, tungsten, uranium, and vanadium are below 10% of their respective BCLs; therefore, these metals were not identified as COPCs. BCLs are not available for potassium or sodium, nor are there any available toxicity criteria or applicable surrogate criteria; therefore, these chemicals also were not identified as COPCs. The maximum concentrations of the remaining metals, i.e., iron, lead, magnesium, and manganese are greater than 10% of their respective BCLs; therefore, iron, lead, magnesium, and manganese were identified as COPCs for RZ-D and will be further evaluated in the human health risk assessment.



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