BLOOD LEAD AND ENVIRONMENTAL MONITORING STUDY FOR RICO, COLORADO

PHASE II
Data Sumary Report and Trend Analysis

Submitted to
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February 13, 2007

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Phase II
Data Summary Report
and Trend Analysis

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ACRONYMS AND ABBREVIATIONS

ANOVA	analysis of variance
CDC	U.S. Centers for Disease Control and Prevention
CDPHE	Colorado Department of Public Health and the Environment
DL	detection limit
EDTA	ethylenediaminetetraacetic acid
EPA	U.S. Environmental Protection Agency
FOD	frequency of detection
HVS3	high volume small surface sampler
NHANES	National Health and Nutrition Examination Study
OSHA	Occupational Safety and Health Administration
QAPP	quality assurance project plan
SAP	sampling and analysis plan
XRF	X-ray fluorescence
ZPP	erythrocyte zinc protoporphyrin

EXECUTIVE SUMMARY

In 2006, Integral Consulting Inc. conducted a two-phase blood lead and environmental monitoring study in the town of Rico, Colorado: Phase I was performed in May and Phase II in September. The study objectives were to 1) further characterize current blood lead levels for Rico residents and identify factors influencing exposures, and 2) understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels. This report presents results from Phase II of the study and an analysis of the results from both Phases I and II. Full results from the Phase I May sampling event were provided in the Phase I data summary report (Integral 2006a). Complete details of the study design and sampling plan were described in the work plan (Integral 2006b), sampling and analysis plan (SAP) (Integral 2006c), and SAP addendum (Integral 2006d).

The high participation rate (67 percent and 63 percent of all eligible households for Phases I and II, respectively) and the high rate of re-participation (82 percent) for the Phase II sampling event support the overall conclusion that the measured levels of lead in blood and environmental media are representative of exposures to permanent Rico residents at this time.

BLOOD LEAD CHARACTERIZATION

During the Phase II September sampling event, blood lead levels were measured for 112 individuals from 62 households. Resulting blood lead is characterized as follows:

- Blood lead levels for the 12 children less than 7 years old who participated in this study ranged from 1.9 μg/dL to 7.0 μg/dL, with a geometric mean[1] blood lead of 2.6 μg/dL.
- Among the 8 older children (7–18 years of age), blood lead levels ranged from <1.0 μg/dL to 3.0 μg/dL, with a geometric mean blood lead of 1.5 μg/dL.
- For the 92 adults blood lead levels ranged from <1.0 μg/dL to 14 μg/dL[2], with a geometric mean blood lead of 1.9 μg/dL.

[1] The geometric mean is a measure of central tendency that is typically used to report blood lead data. This summary statistic is useful for skewed data in which the measurement scale is not linear. The geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if an average arithmetic mean were calculated.
[2] The individual with the highest blood lead value had known occupational exposure to lead-containing materials. Lead levels in this participant's soil were below current remediation action levels.

- The geometric mean blood lead levels for Rico can be compared to those reported by the National Health and Nutrition Examination Study (NHANES) for the general U.S. population from 1999–2002 (CDC 2005). In children ages 1 to 5 the national value was 1.9 μg/dL compared to a value of 2.6 μg/dL for the 12 children tested in Rico; however, due to the small number of children tested it is not clear if this difference is statistically significant. For older age groups, geometric mean blood lead levels in Rico were slightly higher than national values.

In September 2006, no individuals had blood lead levels above the U.S. Centers for Disease Control and Prevention (CDC) and Colorado Department of Public Health and the Environment (CDPHE) risk management levels of 10 μg/dL for children and 25 μg/dL for adults. In contrast, three individuals (two children and one adult) exceeded a level of concern during Phase I in May 2006. The two children had provided heel prick blood samples and when retested via venipuncture by their personal physician, were below the risk management level of 10 μg/dL. The adult with elevated blood lead had known occupational exposure to lead-containing materials. Two of these three individuals were retested in September and did not exceed the levels of concern.

Trends in blood lead by age and gender were similar for the spring and fall. For both phases, geometric mean blood lead was highest in children ages 0 to 6 compared to other age groups. Blood lead levels were also significantly higher in males compared to females. Self-reported information on occupational history was also associated with gender. This suggests that differences in blood lead by gender may be explained by greater occupational exposure to soil and other potential sources of lead for men. Overall, for subjects participating in both phases of the study, there was no significant association between blood lead levels and season.

HOUSEDUST SEASONAL CHANGES

We hypothesized that lead concentrations in house dust might be higher following the summer months in which contact with soil was expected to be greater. However, no significant difference in levels of lead in house dust was found between the two phases of the study. Ongoing yard soil remediation activities and drier than normal late winter weather may, in part, explain the lack of difference.

As remediation efforts have continued through 2006, the proportion of residences with remediated yards participating in the study increased from Phase I to Phase II of the study. During the first phase of the study, 18 percent of residences participating in the study had been remediated, whereas during the second phase of the study 35 percent of residences participating in the study had either undergone or were currently undergoing

remediation. As more time passes, lead concentrations in house dust from homes with previously remediated yards is expected to decrease.

EXPOSURES INFLUENCING BLOOD LEAD

An evaluation of blood lead and potential exposure sources and routes, including concentrations of lead in environmental media and all recorded behavior and activity factors, was conducted to provide information about changes in exposures over time and with season. For children ages 0 to 6, based on the September data, no statistically significant relationships were found between blood lead levels and any of the potential predictor variables. As reported in the Phase I data summary report (Integral 2006a), the most predictive model based on May data included gender, levels of lead in house dust, and the presence of paint in exterior surfaces. The most significant factor in the model was concentrations of lead in house dust. This model approached statistical significance[3] and indicates that house dust may constitute a source of exposure contributing to blood lead. However, no statistical relationship was established between blood lead and any potential predictors of blood lead during the second phase of study. We believe the relatively small number of children providing blood, and the low levels and small range of blood lead, limited the ability to statistically detect relationships for this age group.

Based on data collected in September, the most significant model developed to predict blood lead levels in older children and adults (ages 7+) included both lead levels in house dust and potential occupational lead exposure (including self-reported exposure to soil and to other potential sources of lead). As reported in the Phase I data summary report (Integral 2006a) the most predictive model based on the May data included only gender. As there were no significant differences within subjects in blood lead with time or in concentrations of lead in house dust with time, differences in the predictive factors between the two phases of the study are likely not attributable to seasonal variations. Instead, the differences likely reflect the preciseness with which mathematical models were able to identify predictive factors utilizing the improved questionnaire data obtained in September.

Taken together, predictive models for both children ages 0 to 6 and older children and adults (ages 7+) indicate that concentrations of lead in house dust are a potential source of exposure contributing to blood lead. Additionally, occupational exposure to sources of lead is another factor shown to influence blood lead in adults.

[3] $p = 0.07$. For this report $\alpha < 0.05$ was defined as significant.

1 INTRODUCTION

The town of Rico, Colorado has been the location of a variety of mining and mineral processing activities for more than a century. These activities were driven by the presence of a highly mineralized ore body at ground surface. Both the presence of the ore body and associated mining and processing activities led to elevated metal concentrations in Townsite soils. Of the metals, only lead is present in sufficient concentrations to present a potential health risk (SEH 2004).

An evaluation of potential human health risks from lead in Rico soils was recently completed to support a voluntary cleanup plan application submitted by Atlantic Richfield Company and others (Integral 2006e). The human health risk assessment was conducted in 2005 and 2006 to quantify potential human exposures to lead in soil and to identify health-protective risk-based concentrations to guide soil remediation activities (Integral 2006e). In accordance with standard risk assessment practice, exposure to lead is assessed using mathematical models to estimate blood lead levels.

The risk assessment concluded that, prior to remediation, anywhere from 3.7 to 65.1 percent of Rico properties had soil lead concentrations that could cause a greater than 5 percent risk of exceeding the target blood lead level for children of 10 μg/dL. Due to the predicted potential for blood lead levels to exceed the target blood lead level, a program of cleaning up residential soils in Rico is continuing under the oversight of Colorado Department of Public Health and the Environment (CDPHE).

This blood lead study was undertaken independently of the soil cleanup program at the request of Rico residents to provide them with more complete characterization of blood lead levels for Rico and information regarding factors that may influence exposures to lead in Rico soil. Specifically, the objectives of this study were to:

1. Further characterize current blood lead levels for Rico residents and identify factors influencing exposures.
2. Understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels.

In order to understand the factors that may influence exposures to lead, blood lead samples were linked with co-located samples of environmental media (e.g., yard soil,

house dust, drinking water, and paint). Due to the small population in Rico,[4] a single sampling event was not anticipated to provide a comprehensive characterization of blood lead and lead exposures in the community. Repeated sampling allowed for a more robust understanding of current blood lead. Blood and environmental sampling occurred in May and was repeated in September, when soil exposures had the potential to increase. The specific sampling times chosen were expected to provide an understanding of seasonal variability in exposures.

This report presents results from Phase II of the Blood Lead and Environmental Monitoring Study, conducted in September 2006, and provides an analysis of the results from both Phases I and II. Full results from the May sampling event were provided in the Phase I Data Summary Report (Integral 2006a). The study design and sampling plan were described in the work plan (Integral 2006b), sampling and analysis plan (SAP) (Integral 2006c), and SAP addendum (Integral 2006d).

Sixty-two households[5] and 143 individuals participated in the September field event. This compares with 66 households and 118 individuals that participated in the May field event. Blood lead samples were collected from the majority of individuals participating in both field events. Environmental media samples including dust, water, and paint were collected during one or both field events. Levels of lead in water and paint were not expected to change over the course of the two field events; therefore, these media were generally not re-sampled during the second phase of sampling. Levels of lead in house dust were anticipated to change with seasons; therefore, samples were obtained in both May and September. This sampling scheme allowed for the analysis to rely on samples that were temporally representative of levels of lead in environmental media. Previously collected soil data were also incorporated into the analysis. Exposure questionnaires were administered during both phases of the study. A comprehensive discussion of the sampling completed during Phase II is included in Section 3.0.

Fifty-four of the households participating[6] and 84 individuals providing blood samples in May also participated in September. Residents who participated in both the sampling events allowed for "within-group" comparisons. This type of comparison allows for participants to act as their own control, so fewer participants are needed to detect statistically significant differences.

[4] The projected 2004 Rico population was approximately 220 permanent residents. Just under 220 water hook-ups to buildings in town (including commercial and industrial buildings) are present, suggesting a population of less than 200 permanent residents in 2006.
[5] Two of the 62 households participating (at which 3 participating individuals resided) provided blood samples and answers to questionnaires only. Environmental media samples were not obtained for these households.
[6] Environmental media were not sampled at one of the 54 households re-participating in the study. A single resident at this household provided a blood sample and answers to the questionnaire only.

2 BACKGROUND

This section presents background information relevant to this study, including a discussion of the site setting and population, a summary of yard soil remediation efforts during 2005 and 2006, and an overview of prior blood screening. A conceptual site model and a discussion of the temporal and seasonal trends of environmental and blood lead levels are also included. The majority of information contained in this section is included in Section 3.0 of the Phase I data summary report (Integral 2006a) and is provided here for ease of reference. Relevant information obtained from the spring 2006 sampling event and related to ongoing remediation activities is also included here.

2.1 SITE SETTING AND POPULATION

The Rico Townsite is located in the southwest part of the San Juan Mountains where very steep mountain slopes and sloping tributary stream valleys abruptly descend upon the gently to moderately sloping, and relatively narrow, Dolores River Valley. Elevations in the Townsite area generally range from over 12,000 feet at the crest of the surrounding mountain peaks to about 8,700 feet in the Dolores River Valley (SEH 2004). The elevation along the main street in the Townsite is greater than 8,800 feet.

The population size projected in 2004 was approximately 220 permanent residents (USCB 2006a), with additional residents during the summer. Census data from 2000 (USCB 2006b), reported the median age of Townsite residents as 35.4 years. In the year 2000 children under 5 years of age made up 5.4 percent of the population, and 3.4 percent of the population was over the age of 65. Men and women made up 59 percent and 41 percent of the town's population, respectively. The population could be described as homogenous, as 92.7 percent was of a single race (White) and over 80 percent was between 18 and 65 years of age (USCB 2006b).

Statistics from Phase I of this study indicate that more children under the age of 5 currently reside in Rico than indicated in the 2000 census data. Seventeen children under the age of 6 participated in the first phase of the study, and additional non-participating children were noted. This statistic suggests that currently greater than 8 percent of the permanent population of Rico are children under the age of 6.

2.2 PHASED YARD SOIL REMEDIATION EFFORTS

Remediation of the yards of homes in the Town of Rico was conducted in 2004 and 2005 with cleanup activities concluding by October 2005, and beginning again in the summer of 2006. Throughout the soil remediation efforts, homes were targeted based on high lead

concentrations. During the first phase of remediation, 35 yards with greater than 1,300 mg/kg lead in soil were targeted for remediation. A new action level of 1,100 mg/kg lead in soil was used to target additional yards for remediation during the summer of 2006. Approximately 31 properties were remediated during the summer of 2006.[7] The cleanup history of individual properties was considered in evaluating blood lead data.

2.3 PRELIMINARY RICO BLOOD LEAD SCREENING

Blood lead testing of a small number of Rico residents was conducted in April and June of 2004 by the Dolores County Health Department. A total of 33 residents participated in the April sampling event, and 16 participated in the June event. Due to the need to maintain confidentiality of the blood lead results, it is not known if individual residents were sampled in both April and June.

The work plan for this study (Integral 2006b) presents a detailed description of the 2004 preliminary blood lead screening. In summary, all measured blood lead levels were below the U.S. Centers for Disease Control and Prevention (CDC) and CDPHE blood lead level of concern of 10 μg/dL. Measured blood lead levels ranged from below the detection limit (1 μg/dL) to 8.8 μg/dL. Blood lead levels were highest in the youngest age group, which is consistent with other populations. For all age categories, average blood lead levels were higher in June than in April. The consistency of this trend, while not conclusive due to the small number of samples, suggested that exposures to lead in soil and dust might increase in the summer after the snow melts and the soil dries.

Due to low participation rates, the data collected during the preliminary blood lead screening were limited in their ability to provide results which are statistically significant. In addition, since it is unknown whether any individuals were included in both sampling events, statements about temporal trends must be tempered due to the potential for confounding. Examination of the relationships between concentrations of lead in environmental media and in blood was not part of the 2004 blood screening.

2.4 CONCEPTUAL SITE MODEL

A conceptual site model describing the ways in which people may be exposed to lead-containing media was developed for the Rico Townsite risk assessment (Integral 2006e) and provides the basis for the environmental sampling for this study. The conceptual site model is presented here as Figure 2-1. The conceptual site model graphically describes the ways in which residents, indoor workers, outdoor workers, and visitors within the

[7] Summer 2006 remediation efforts included three to four properties for which soil removal occurred in summer 2005, but for which remediation was not completed until 2006.

study area may come in contact with lead in soil. It also depicts the pathways by which lead in outdoor soil and dust may be transferred to other areas or media. Generally, lead in soil has relatively low mobility, which limits its transport to groundwater. Lead is not volatile, but may enter air in dust particles that are eroded from the open land and yard soil into air by wind or mechanical forces. The latter may include traffic on dirt roads. Lead in soil may contribute to indoor dust due to settling of airborne soil particles or by transport of soil into buildings on shoes or pets. Theoretically, lead could also be transferred from soil into homegrown garden vegetables.

Previous investigations of exposures to lead from soil at former mining and smelting sites in the Rocky Mountains have demonstrated that inhalation of resuspended soil particulates is an insignificant exposure pathway. These investigations have also shown that ingestion of homegrown vegetables does not contribute to increased exposure to lead in these communities, many of which have short growing seasons similar to that in Rico. For direct contact with lead in soil and dust, incidental ingestion is the primary exposure route, with dermal absorption being insignificant (the dermal pathway is not included in U.S. Environmental Protection Agency (EPA) lead exposure models). Consequently, site-specific exposure pathways of significance include incidental ingestion of soil and dust.

Other "background" sources of lead include lead in drinking water and paint. Lead pipes were used in interior plumbing in the early 1900s and after copper and galvanized steel pipes began to replace lead pipes, lead was still found in solder and flux used to join pipes. Lead also may be found in faucet fixtures.[8] In addition, homes built prior to 1980 are likely to contain lead-based paint. As the paint ages, particularly if the surface is not well maintained, chips will flake off and become incorporated into house dust, which may be inhaled by residents or ingested via hand-to-mouth contact. Children will sometimes chew on painted surfaces, such as windowsills and railings, resulting in consumption of paint chips. In addition, aging paint can flake or wear off of exterior and interior house surfaces, contributing to lead content in soil around the house and in indoor dust. This conceptual site model is the basis for the environmental sampling for this study.

2.5 TEMPORAL TRENDS IN BLOOD AND ENVIRONMENTAL LEAD LEVELS

Average blood lead levels for the nation's population as a whole have declined dramatically since the 1970s. This decline in blood lead levels is attributed to multiple factors including the removal of lead from gasoline, paint, plumbing, and soldered cans. The mean blood lead level of persons aged 1 to 74 years dropped 78 percent, from 12.8 to 2.8 μg/dL between 1976 and 1991, and mean blood lead levels for children aged

[8] Chrome-plated brass fixtures and fittings contained up to 30 percent lead until 1988 and up to 8 percent lead until 1998.

1 to 5 years declined 77 percent, from 13.7 to 3.2 μg/dL for non-Hispanic white children and 72 percent, from 20.2 to 5.6 μg/dL, for non-Hispanic black children (Pirkle et al. 1994). Since 1991, blood lead levels have continued to decline, albeit more slowly. The National Health and Nutrition Examination Survey (NHANES) reports geometric mean blood lead of 2.7 μg/dL in children ages 1 to 5 for 1991–1994, and 1.9 μg/dL for 1999–2002. Similarly, blood lead levels have decreased in older individuals. Geometric mean blood lead in individuals 6 to 19 years of age was 1.7 μg/dL for 1991–1994, and 1.1 μg/dL for 1999–2002. Geometric mean lead levels in individuals 20 to 59 years of age were 2.2 μg/dL for 1991—1994 and 1.5 μg/dL for 1999–2002 (CDC 2005) (Table 2-1).

The percentage of individuals with blood lead exceeding the CDC and CDPHE risk management level of 10 μg/dL for children has also decreased between the study periods of 1991–1994 and 1999–2002. From 1991–1994, 2.2 percent of individuals surveyed had blood lead levels greater than 10 μg/dL, compared to only 0.7 percent of individuals exceeding this threshold in 1999–2002 (Table 2-2). Declines were found across population subgroups defined by age, sex, and race/ethnicity.

As with national blood lead trends, the prevalence of elevated childhood blood lead has decreased in Colorado in recent years. Statewide prevalence of elevated blood lead levels (≥10 μg/dL) in children has dropped from 5 percent in 1996 to 1 percent in 2004 (CDPHE 2005). However, despite these decreases, elevated blood lead levels remain more common nationwide among low-income children, urban children, and those living in older housing (Pirkle et al. 1994; Pirkle et al. 1998).

2.6 SEASONAL TRENDS IN BLOOD AND ENVIRONMENTAL LEAD LEVELS

Large-scale studies of lead exposure in children have demonstrated seasonal variations in environmental-lead measurements and blood lead levels. An overview of these studies conducted by USEPA (1995, 1996), Laidlaw et al. (2005), and Yiin et al. (2000) are detailed in the work plan (Integral 2006b). The studies attribute seasonal fluctuations in blood lead to confirmed seasonal variations in environmental samples and differences in exposure levels.

In Rico, the ground is frozen or snow covered for 6 or 7 months each year. Consequently, contact with outdoor soil is minimized during that time. In addition, house dust lead concentrations have been hypothesized to increase in the summer. Changes in house dust lead concentrations is likely, in part, due to increased outdoor activity leading to tracking of soil from outdoors to indoors via pathways including foot traffic from humans and indoor/outdoor dogs.

While exposure to lead in exterior paint, lead in yard soil, and lead in house dust would be expected to be reduced during the winter, lead exposures from drinking water and indoor lead-based paint would not be expected to be influenced by season. Overall, the expectation for this study was that increased summertime blood lead levels, if found, would implicate incidental ingestion of yard soil and house dust as the primary exposure pathways. The suggested seasonal variation in exposure via these pathways provides the basis for the repeated blood lead and environmental sampling in this study.

3 FIELD EVENT SUMMARY

This section describes the Phase II sampling scheme, recruitment of study participants, field sampling protocol, an overview of laboratory analysis, and deviations from the work plan (Integral 2006b). Additionally, in order to aid in the interpretation of temporal data, a limited description of the first phase sampling event is presented. For example, instances in which sampling differed between the two field events are highlighted. An in-depth account of the Phase I field event is presented in the Phase I data summary report (Integral 2006a).

For the second phase of study, environmental and blood samples were collected from participating Townsite residents in September 2006. House dust was collected from 60 residences, and drinking water samples were collected from 12 of these participating residences that had not been previously sampled, or required follow-up from the May sampling. At most homes, previously measured soil concentrations were available and used in this analysis. A blood sample was collected from at least one individual from each of the 60 residences at which house dust samples were obtained. An additional three residents (from two residences) provided blood samples; however, environmental samples were not collected from their place of residence. A total of 112 blood samples were collected. Questionnaires were administered to all adults providing blood samples. Questionnaires for children providing blood samples were completed by a parent or adult resident. In addition, individuals at some residences chose not to have their blood sampled but elected to provide answers to the questionnaire. Questionnaire results were obtained for a total of 143 individuals.

3.1 SAMPLING SCHEME

The two sampling events were planned for times of year at which differences in exposure and transfer pathways, including contact with lead in soil and tracking of lead in soil into residences, were hypothesized to be most distinct. Phase I of the study was planned for the time of year directly following the winter, snow-covered months. The second phase of the study was planned for the end of summer, a time of year when contact with outdoor soil and tracking of soil into residences was expected to be greater.

3.2 RECRUITMENT OF PARTICIPANTS

Children and adults living year-round in the town of Rico were eligible for this study. As described in Section 1, collection of longitudinal data was planned to allow for a more robust understanding of current blood lead levels and the understanding of seasonal and

temporal variability in exposures. For this reason, Phase I participants were the primary focus for Phase II recruiting.

Recruitment of participants for Phase II began approximately 2 weeks prior to the scheduled field event. Integral staff called residents to remind them of the Phase II event and to schedule appointments for residents who were willing to participate and ready to schedule a sampling time. Upon arrival to Rico, Integral staff visited unscheduled homes a minimum of three times at various times of the day and made additional phone call attempts to contact residents.

At the time of the call or visit, for any residents willing to participate in the study, the recruiting team scheduled a date and time for the environmental sampling and blood draw. Residents were also given the opportunity to schedule a consultation visit to review their results from the spring sampling event. If the resident was not the owner of the property, the landlord's contact information was collected in order to obtain consent for the environmental sampling. If the resident was unsure about participating, the team scheduled a follow-up visit with the resident.

3.3 FIELD SAMPLING

This section presents an overview of the confidentiality and consent agreement, field sampling protocol, and the exposure questionnaire administered during the September 2006 field sampling event. A brief overview of laboratory procedures is presented in Section 3.4. Standard operating procedures, quality assurance plans, detailed sample collection methods, and the exposure questionnaire are described in detail in the SAP and quality assurance project plan (QAPP) and addenda to each (Integral 2006c,d,f,g). Detailed descriptions of all sample handling and analysis protocols (e.g., sampling labels, sample custody and tracking procedures, sample preservation, field documentation, and sample packaging and shipping procedures) can also be found in the SAP and SAP Addendum (Integral 2006c,d). Any deviations from those plans are described in Section 3.5.

3.3.1 Confidentiality and Consent

A confidentiality and consent form was signed by each homeowner participating in the study. Phase I participants also were asked to sign a consent form for the Phase II event. The consent forms used in Phase II sampling are presented in the SAP addendum (Integral 2006d). A consent form was signed by each adult from whom blood was sampled. Parents of minors signed consent forms if their children were participating in the blood draw. In cases where study participants were renters, as opposed to homeowners, both the participating renter and owner were required to sign the consent

forms to permit residential sampling. In instances where the landlord declined to participate, renters could choose to have only their blood drawn. Environmental sampling and blood draws occurred after a signed copy of the confidentiality and consent form was obtained. A copy of the signed form was provided to the residents, and, if applicable, owners; one copy was kept by the sampling team for retention in the project file.

3.3.2 Blood Sampling

Blood samples may be obtained by either venipuncture or finger or heel prick (utilizing capillary tubes). Blood samples were collected from adults and most children via venipuncture by trained phlebotomists. A heel prick (capillary) sample was collected from infants and small children in cases where the phlebotomists and/or parents determined the venipuncture sample would be too difficult to obtain or uncomfortable for the child to provide. Venipuncture samples are considered more reliable than capillary samples because a larger sample size is more easily obtained and potential contamination of the sample is minimized.

All sample collection equipment and supplies were provided by the analytical laboratory conducting blood lead analyses and were certified as lead-free. Phlebotomists collected venous blood samples using a standard vacutainer needle or butterfly needle and vacutainer tube containing an anticoagulant, ethylenediaminetetraacetic acid (EDTA). The samples were labeled according to the sample nomenclature provided in Attachment B of the SAP (Integral 2006c). Integral staff retained custody of the blood samples and were responsible for shipment of samples to the analytical laboratory.

Phlebotomists collected capillary samples by puncturing the child's foot with an automated heel incision device and collecting blood squeezed from the foot in a pediatric sample tube containing EDTA. To reduce the potential for environmental contamination of heel prick samples, phlebotomists thoroughly cleaned the entire bottom surface of the child's foot to remove dust and dirt that could potentially enter the pediatric sample tube during sample collection. Contamination of capillary samples can be difficult to avoid because blood is captured in tubes by capturing droplets of blood formed at the puncture wound, and it is usually difficult to hold the foot still as young children or infants will resist when their foot is held still and squeezed to obtain blood.

3.3.3 House Dust Sampling

At each residence, one composite house dust sample was collected using a high volume small surface sampler (HVS3) manufactured by CS3, Inc. A detailed description of the HVS3 is included in the SAP (Integral 2006c). At each home, dust was collected from high-traffic areas where residents, and particularly children, were expected to spend a

significant portion of their time. At least three locations, preferably a main living space, interior of the entrance way and, in homes with children, a child's bedroom, were included in each composite sample. The exact area sampled varied by the housekeeping practices and floor types in individual homes. A minimum area of 0.25 m by 0.25 m was sampled at each of the three composite locations. Additional areas were sampled as needed to ensure sufficient sample mass of 1 g of dust.

Sample labeling and storage protocol are presented in the SAP and SAP Addendum (Integral 2006c,d). Quality control measures, including decontamination procedures are described in detail in the QAPP and QAPP Addendum (Integral, 2006f,g).

3.3.4 Drinking Water Sampling

Because concentrations of lead found in drinking water are not expected to change significantly with time or season, water samples were generally not collected from Phase I participants during Phase II. However, for a few homes with lead levels above EPA's drinking water standard of 15 μg/L during Phase I, participants were asked if their water could be tested again during Phase II. Additionally, water was resampled at a few residences for which there was reason to suspect that results obtained as part of the Phase I study were not representative of true concentrations of lead in the given type of water. For example, several residents did not conform to instructions provided for collecting first-draw samples; therefore, the results from these samples may not have accurately represented levels of lead in this type of water. Additionally, one resident asked Integral to collect a first-draw sample as their sample from May had mistakenly not been recovered. During the Phase II sampling event, water was resampled at three residences. Water samples were additionally obtained from seven newly participating households, and two households participating in Phase I sampling for which no water samples were initially obtained.

For the residences described above, up to four drinking water samples were collected from the primary drinking water faucet at each residence. The first water sample was collected in a pre-labeled sample container from the cold water faucet 10 minutes following a 3-minute purge by Integral staff. Instructions were provided for residents on collection of the second sample. The second water sample was collected by residents the following morning after allowing water to stand in the pipes overnight. This "first-draw" water sample was recovered by Integral staff on the day it was collected. In cases where residents used a filter on the primary drinking water faucet, samples were collected both from the filtered faucet and an additional, non-filtered faucet.

When possible, Integral staff determined the composition of plumbing under the kitchen sink at each residence sampled. Details of methods used to identify pipe composition are included in the SAP (Integral 2006c). Details of quality control and assurance measures,

including sample custody, duplicate, matrix spike, and reference sample analyses, accuracy, and completeness are found in the QAPP and QAPP addendum (Integral 2006f,g).

3.3.5 Paint Analysis

Lead levels in paint are not expected to change over a season; therefore, no paint analysis was conducted in Phase II. For seven residences joining the study in Phase II, and three residences for which no lead levels in paint were obtained during the first phase of study, lead in paint was estimated using the age of the house,[9] a parameter that was ascertained by the study questionnaire. This approach was necessary because the instrument used to measure lead in paint during Phase I was not available during Phase II. Five houses constructed prior to 1980 were assumed to contain lead in interior and exterior surfaces, while five houses constructed after 1980 were assumed to contain no lead in interior or exterior surfaces. The significant relationship between lead in paint and age of a house, established as part of the Phase I analysis, provides the basis for this surrogate approach (Integral 2006a). Potential implications of this surrogate approach are explored using summary statistics for age of house from the Phase I and Phase II Questionnaire results in Section 4.4.3.

3.3.6 Exposure Questionnaire

An interview eliciting information on factors that might affect potential for lead exposure was administered at each participating residence. The interview during the Phase II event included questions regarding the participants' residential duration in Rico, the residents' home and its condition (e.g., age of the house; interior/exterior paint; repainting, sanding, stripping, and refinishing activities); condition of the exterior of the home (e.g., bare areas in the yard); activities and behaviors of all residents (e.g., time spent recreating at the Dolores River Corridor and the Silver Creek Canyon; shoe removal upon entering the house; gardening); occupational histories of all residents; and general demographic information (e.g., age and gender).

As a result of the Phase I sampling event, several changes were made to the administration of the questionnaire and the questionnaire itself. During the second phase of the study, each participating resident of a household was instructed to answer questions related to that individuals' activities and behavior, as opposed to the first phase in which participants were instructed to answer questions for all members of the household combined. In some instances only one resident of a given household was able to spend the time necessary to participate in the questionnaire. In these cases the participating resident provided answers for other household residents who had provided

[9] One household joining the study in Phase II did not provide information on the age of their residence.

a blood sample. Additionally, some residents who elected not to have blood sampled participated in the questionnaire.

In addition, the specific information ascertained within, and the form of some questions included in the exposure questionnaire from Phase I were revised for Phase II. Questions deemed irrelevant to lead exposure (e.g., race and level of education of participants; use of household pesticides) were removed, and exposure-related questions were refined. Questions to ascertain information on activities including gardening, landscaping, and household shoe removal behavior were added. More quantitative information on time spent recreating along the Dolores River Corridor and around the Silver Creek Canyon was also gathered. Questions related to occupational history were changed to more explicitly determine information on specific sources of exposure. The complete questionnaires for Phases I and II can be found in Attachment D of the work plan (Integral 2006b), and SAP addendum (Integral 2006d).

3.4 DESCRIPTION OF LABORATORY PROCEDURES

Laboratory analysis of lead in drinking water, household dust, and blood was conducted. Blood samples were analyzed for lead and several blood parameters useful in interpretation of blood lead data (i.e., erythrocyte zinc protoporphyrin (ZPP), hematocrit, and hemoglobin).

Laboratory instrumental analyses of samples collected during the course of this investigation were performed by laboratories that have established protocols and quality assurance procedures that meet or exceed EPA, Occupational Safety and Health Administration (OSHA), and CDC guidelines. Standard analyses employed EPA, OSHA, or CDC-approved or recommended methods if available, as well as associated quality assurance procedures. Detailed descriptions of laboratory analysis and procedures are presented in the SAP, QAPP, and the addenda for each (Integral 2006c,d,f,g).

3.5 DEVIATIONS FROM WORK PLAN/SAMPLING AND ANALYSIS PLAN

This section presents deviations from the field sampling protocol and laboratory analysis presented in the work plan, SAP, and QAPP. Few deviations from the original sampling plan documents occurred; deviations by sample type are presented below. Deviations from Phase I of the study are also noted here, if these deviations could impact interpretation of the results for the analysis of trends across time.

3.5.1 Recruitment of Participants

Only full-time residents were eligible for this study. However, during Phase II sampling, one household of non-full-time residents participated in the study. The residents in this household reported spending between 1 and 2 weeks of every month in Rico. Since these residents reported living in Rico approximately half-time and because they were interested in participating, they were included in Phase II.

3.5.2 Blood Samples

During the first phase of the study, the analytical laboratory, Quest Diagnostics, initially reported a detection limit for lead in blood of 3 μg/dL although the QAPP (Integral 2006f) specified a detection limit of 1 μg/dL. Ultimately a final detection limit of 1.4 μg/dL was obtained, which is considered sufficiently low to allow for evaluation of seasonal fluctuations in blood lead levels. Quest Diagnostics verified the validity of the lowered limit by performing a series of serial dilutions of their calibration standards.

During the second phase of the study, blood lead results were initially reported as whole numbers with only one significant figure. MedTox subsequently reanalyzed a portion of the samples to report concentrations to the nearest tenth. A detection limit of 1.0 μg/dL was used for the Phase II analysis of blood. MedTox reporting is discussed in Appendix A of this report.

Field duplicates of blood samples were not collected as part of either Phase I or Phase II sampling. The QAPP states that duplicate analysis will occur for "1 in every 20 samples or once per sample delivery group, whichever is greater;" however, field duplicate blood samples were not collected to avoid unnecessary burden to study participants. Following review of internal quality control/quality assurance records from Quest Diagnostics and MedTox, this deviation is not thought to impact the reliability of the data.

3.5.3 Environmental Samples

House dust samples obtained during the first phase of study were not weighed by the laboratory before or after being sieved. This data gap prevented calculation of lead loading for residences. Lead loading is a measure of lead per unit area. Because reasonable assumptions regarding dust ingestion are often violated in homes with high dust mass per unit area, this measure is useful when evaluating exposure pathways for blood lead. The majority of homes in this study did not appear to have dust loadings high enough to necessitate alternate lead measurements. However, samples were weighed and dust loading was evaluated in the September sampling event.

Field blanks were not collected for water samples in either Phase I or Phase II because no sampling equipment was used that could potentially contaminate samples.

As described in Sections 3.3.4 and 3.3.5, water and paint were not analyzed at all participating residents during Phase II as these media are not expected to vary seasonally.

3.5.4 Exposure Questionnaire

Changes to the questionnaire are detailed in Section 3.3.6. A complete questionnaire administered in Phase II can be found in SAP addendum (Integral 2006d)

4 RESULTS

This section provides an overview of the results for the second phase of this study. The presentation of results obtained during the first phase is limited to those relevant for comparative purposes. Detailed results for the first phase of the study are documented in the Phase I data summary report (Integral 2006a). A brief description of the study population for the Phase II study is presented below, followed by a discussion of data validation, an overview of the samples that were collected, and basic summary statistics (e.g., average, median, and maximum values). Data analysis and interpretation is presented in Section 5.

4.1 DESCRIPTION OF STUDY POPULATION

An overview of study participation for the Phase II sampling event is provided in Table 4-1. Overall, 62 (63 percent) of the eligible parcels/households participated in the study. Fifty-four of the households participating in May also participated in September. Based on May enrollment, and excluding a single household that relocated from Rico prior to September, the rate of re-participation was 83 percent.[10] Additionally, 8 new households participated in the Phase II study. The number of participants from each household ranged from 1 to 5, and averaged 2.3.

The total number of study participants, grouped by age and gender, are provided in Tables 4-2 and 4-3. Adults over 18 years in age comprised 74 percent of the study population. Participation of males and females was approximately equal.

4.2 DATA VALIDATION

Data generated in the field and at the laboratories were verified and validated according to criteria and procedures described in the project QAPP (Integral 2006f). The resulting Data Quality Summary is provided as Appendix A.

Quality assurance of data was performed using USEPA (2002) guidelines for inorganic data, but in the context of data quality objectives specified in the QAPP. Data qualifiers defined in USEPA (2002) guidelines were applied to the project data.

[10] There are various reasons why 17 percent of households did not participate again: several were out of town during the second sampling event, several were not able to be scheduled, and one did not receive results for the first field event due to exceedence time and therefore declined to participate during the second phase.

The following laboratory deliverables were reviewed during data validation:

- The case narratives discussing analytical problems (if any) and laboratory procedures
- Chain-of-custody documentation
- Method blank results to assess laboratory contamination
- Results for laboratory duplicate analyses to assess analytical precision
- Results for matrix spike and laboratory control samples to assess accuracy
- Analytical results for analyses performed.

Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with EPA data validation guidelines (USEPA 2002) and the quality control requirements included in the analytical methods (Integral 2006f).

Data qualified as estimated were used for all intended purposes and have been appropriately qualified in the project database. Any limitation of data qualified as estimated has been included in the quality assurance report. No data were rejected.

4.3 OVERVIEW OF SAMPLES COLLECTED

Blood samples were collected from 112 individuals. Of these samples, 16 could not be analyzed for hemoglobin and hematocrit, and 15 could not be analyzed for ZPP due to small sample sizes or exceedances of hold time.

As described in Section 3.3, during the second phase of the study, lead was sampled in environmental media, including house dust, and, in a limited number of cases, water. Dust samples were collected from 60 of the 62 households included in the study. Water was sampled at seven of the eight newly participating residences[11] and two residences participating in Phase I for which water samples were not obtained. Water was resampled at three residences at which water samples were collected during the first phase of the study. Four of the 12 residences at which water was sampled had a filtered water tap. From these residences four filtered, purged samples, and two filtered, first-draw samples were collected.

Questionnaire results were gathered from all 62 households and for all 143 individuals participating in the study. As some individuals elected only to participate in the questionnaire portion of the study and did not provide blood samples, a larger number of results for individual activity and behavior factors was obtained compared to blood data.

[11] A single newly participating residence in the Phase II study did not provide environmental media samples. At this residence, only blood samples and questionnaire results for two residents were obtained.

4.4 DESCRIPTION OF BLOOD, ENVIRONMENTAL AND QUESTIONNAIRE RESULTS

This section describes the blood data (i.e., lead concentrations and pertinent blood characteristics), environmental data (i.e., soil, house dust, and drinking water) and questionnaire data (i.e., household characteristics and participant behaviors). Summary statistics and distributions of the datasets are provided as listed in Table 4-4. This information was also used in Section 5 to support more detailed statistical analyses to determine potential sources of lead exposure and to evaluate changes in lead levels and potential sources of exposure over time.

4.4.1 Blood Data Summary

For the 12 children younger than 7 years of age, blood lead levels ranged from 1.9 μg/dL to 7 μg/dL (Table 4-5). For the 8 older children, blood lead levels ranged from <1.0 μg/dL[12] to 3.0 μg/dL, while the range for adults was <1.0 μg/dL to 14 μg/dL (Table 4-5). All individuals exhibited blood lead levels lower than the CDC and CDPHE's risk management levels of 10 μg/dL for children and 25 μg/dL for adults. The maximum individual level (14 μg/dL) was collected from an individual reporting contact with lead-containing materials while working, which likely explains the observed blood lead level.

Blood lead levels for groups of people are typically reported as a geometric mean because this statistic better represents average levels.[13] For all ages combined the geometric mean was 1.9 μg/dL (Table 4-5). Geometric mean blood lead levels were 2.6 μg/dL for the 0 to 6 year age group, 1.5 μg/dL for older children and 1.9 μg/dL for adults. Geometric mean blood lead concentrations were higher in males (2.3 μg/dL) as compared to females (1.6 μg/dL) (Table 4-6). All blood lead results are presented in Appendix A.

The geometric mean blood lead levels for Rico can be compared to those reported by the NHANES for the general U.S. population from 1999–2002 (Table 2-1). In children ages 1 to 5, the national value was 1.9 μg/dL compared to a value of 2.6 μg/dL for the 12 children tested in Rico; however, due to the small number of children tested in Rico it is not clear if

[12] Detectable levels of lead were present in 99 percent of the samples. The higher frequency of detection compared to the Phase I study (Phase I, FOD Blood Lead; 74%) is likely due to the lower analytical detection limits for Phase II (1.0 μg/dL vs. 1.4 μg/dL).

[13] The geometric mean is a measure of central tendency, computed as: $G = (x_1 * x_2 * ... * x_n)^{1/n}$ where n is the sample size. This summary statistic is useful for skewed data in which the measurement scale is not linear. The geometric mean, unlike an arithmetic mean, tends to dampen the effect of very high or low values, which might bias the mean if an average arithmetic mean were calculated. This report presents geometric means for lead in blood lead and environmental media. As these measures do not follow a linear scale, this summary measure is expected to give a clearer indication of central tendency. Arithmetic means are reported in Section 4 Tables 4-5 to 4-9.

this difference is statistically significant. For older age groups, geometric mean blood lead levels in Rico were slightly higher than national values. The percentage of children exceeding the risk management level of 10 μg/dL in Rico, CO was lower compared to the NHANES data. While no children participating in this study exceeded the 10 μg/dL threshold during Phase II, 1.6 percent of children ages 1 to 5 surveyed in the 1999–2001 NHANES did exceed the threshold.

As described in the work plan (Integral 2006b), blood samples were also analyzed for several blood parameters potentially useful in interpretation of blood lead data (i.e., erythrocyte zinc protoporphyrin, hematocrit, and hemoglobin). Due to the generally low blood lead levels in Rico residents, these parameters were not found to be useful in interpretation of blood lead levels found in this study (Integral 2006a). Summary statistics for these parameters are included in Table 4-7.

4.4.2 Environmental Media Data Summary

Environmental samples and select questionnaire results were assessed for individual households enrolled in the study. Tables 4-8 and 4-9 show summary statistics for environmental samples. Summary statistics for house dust are based on samples collected during Phase II sampling in September 2006. Lead was found at detectable levels in all house dust samples. The mass of house dust samples, each collected over a known area, was used to calculate lead loading, a measure of lead in dust per square meter area. Sample mass was obtained for 59 of the dust samples, and lead loading calculated for these residences (Table 4-8).

Summary statistics for water shown in Table 4-9 include the combined results for May and September, providing a more comprehensive representation of lead concentrations in water than the summary presented in the Phase I report. None of the water samples described here were above EPA's drinking water standard of 15μg/L, with the exception of one sample collected from a nonpotable water source.[14] Lead concentrations in the main drinking water source for newly participating and re-sampled households during Phase II were compared to samples obtained during Phase I (Table 4-9). Lead in water from Phase I sampling ranged from below the level of detection of 0.009 μg/L to 2.0 μg/L and had a geometric mean of 0.317 μg/L. Lead in water from the 12 newly obtained water samples ranged from 0.182 to 5.56 μg/L with a geometric mean of 1.24 μg/L. The implications of the slightly higher water lead concentrations in the Phase II samples on the analysis of the association between lead in water and blood lead is examined in Section 5.3.1.

[14] This water sample was collected from a residence although the water is not used for human consumption. The water sample is therefore not included in the summary statistics presented in Tables 4-8 and 4-9, or in any subsequent analysis including water.

As described in Section 3.3.5, no testing of lead in paint was conducted during Phase II. For the seven newly participating households in Phase II and the three households from Phase I without paint lead testing data, the age of house was used as a surrogate for the presence of lead-based paint. The significant relationship between lead in paint and age of house, established as part of the Phase I analysis, provided the basis for this surrogate approach. Twenty of the houses (i.e., 30 percent) included in the analysis establishing the relationship between age of house and the presence of lead in paint were built prior to 1980. For this group, the geometric mean age of house for those built prior to 1980 was 80 years. Five of the 10 houses (i.e., 50 percent) for which the surrogate approach was employed were built prior to 1980, and were therefore assumed to potentially have interior and exterior lead paint. The geometric mean age of houses constructed prior to 1980 for this group was 72 years. Summary statistics for houses included in the analysis establishing the statistically significant relationship between age of house and the presence of lead-based paint were similar to statistics for the 10 houses to which the surrogate approach was applied.

4.4.3 Exposure Questionnaire Data Summary

Residents were asked about household factors that could be associated with lead exposure and activities that could cause increased contact with soil and other potential sources of lead. Results for questionnaire items that had the potential to demonstrate trends with the environmental media or blood lead data are discussed below and presented in Tables 4-10 through 4-13. These factors were retained for consideration in further statistical analyses.

Remediation history and age of the house are two critical factors in assessing potential exposures. Yard remediation obviously will reduce potential exposure to lead in soil, while houses built prior to 1980 are more likely to have leaded paint outside and/or inside. Thirty-five percent of the households sampled reported that their yard had been remediated by Atlantic Richfield Company in either 2005 or 2006 (Table 4-10). The age of houses ranged from less than 1 to 125 years (Table 4-11). Forty-two houses (72 percent) were built prior to 1980. The geometric mean age of houses built prior to 1980 was 85 years.

The number of indoor/outdoor dogs owned at a given residence and whether residents of a household remove footwear before entering the house were also retained, as these factors have the potential to influence the amount of yard soil that is tracked into the home. The number of dogs per household ranged between 0 and 3, with 40 of the 62 households having one or more dogs (Table 4-12). Thirty-two participating households (52 percent) reported that all individuals residing in the house remove their shoes before entering or at the entrance of the residence (Table 4-10).

Residents were asked about activities that could lead to increased exposure to soil and other potential sources of lead. Fifty-three participants (37 percent) and 38 participants (27 percent) responded positively to taking part in gardening and landscaping, respectively. Thirty-three participating adults (31 percent) reported working in occupations with potential exposure to soil and 14 (13 percent) reported that they had potential for occupational exposure to other sources of lead (Table 4-13a).

To assess potential for exposure to lead in soils elsewhere in the community, residents were asked about their local recreational habits, and specifically how much time they spend recreating along the Dolores River Corridor and along the Silver Creek Canyon roads and trails. Recreational habits were examined separately by season to investigate changes corresponding to the presence or absence of snow-cover. A greater number of individuals reported spending no time recreating at the Dolores River Corridor and around the Silver Creek Canyon area during the winter months (87 individuals [61 percent] and 103 individuals [72 percent], respectively) compared to the summer months (65 individuals [45 percent] and 67 individuals [47 percent], respectively).

Additionally, the number of individuals who reported spending greater than 4 hours per week in the defined areas was greater in the summer months as compared to the winter months (Table 4-13b). Overall, the number of individuals recreating along either the Dolores River Corridor or along Silver Creek Canyon was greater in the summer season as compared to the winter season (Table 4-13a).

4.5 EVALUATION OF DISTRIBUTIONS

Data distributions were evaluated for blood lead, environmental media, and age of house. Distribution evaluation is necessary to determine the type of statistical analysis required. If data are normally distributed, certain characteristics of the data set can be accurately estimated based on indicators such as mean and standard deviation. If data are lognormally distributed, a log-transformation can be employed and the data can be treated as if they were normal. If a data set is not normally distributed and cannot be transformed to fit a normal distribution, nonparametric statistical methods are required, which make fewer assumptions about the inherent spread of the data.

Evaluations of distributions for blood data are based on data points from each individual, whereas the evaluation of distributions for environmental media samples and age of house are based on data points for each household. Table 4-14 contains results from

statistical tests for normality (Shapiro-Wilk's W test and Chi Square test[15]). Because each statistical test utilizes different methods and depends on different assumptions, the sensitivity and robustness of any statistical test will be influenced by differences in the data, such as the number of samples and the presence of outliers. For this reason the results of the statistical tests are viewed together in a weight-of-evidence approach in order to ascertain the data distribution. For these tests, *p*-values less than 0.05 indicate that the data are not considered to be normally distributed. As shown in Table 4-14, log-transformed data provided higher *p*-values than non-transformed data did. This indicates that when data was log-transformed it more closely fit a normal distribution as compared to the non-transformed data.

Data for the blood analytes (i.e., hematocrit, hemoglobin, and lead) and environmental media samples (i.e., lead concentration in house dust, lead per area in house dust, lead concentration in yard soil, lead concentration in water) exhibited tendencies towards lognormal distributions. The statistical tests for ZPP did not indicate that the distribution of this parameter fit well to either a normal or log-normal distribution. However, ZPP concentrations from Phase I of this study tended towards a log-normal distribution. Thus, ZPP was log-transformed for this analysis so it could be included in the statistical analysis along with other transformed data. Blood lead and environmental media were transformed to the natural logarithm for further statistical analysis.

[15] The Shapiro Wilk's test for normality calculates a *W* statistic that tests whether a random sample, x_1, x_2, …. x_n comes from a normal distribution. The *W* statistic is calculated as a function of ordered sample values (x_1…. x_n), and constants generated from the means, variances, and covariances of the order statistics of a sample of size n from a normal distribution. The Chi Square test for normality divides the range of data into a number of intervals. The number of points that falls into each specified interval is compared to the expected number given a normal distribution.

5 ANALYSIS OF FACTORS THAT COULD AFFECT BLOOD LEAD LEVELS

This section presents the analysis of results obtained from the September sampling event and an analysis of trends across time using results obtained from both the May and September sampling events. The analysis of the September data aimed to characterize blood lead levels, identify exposure and activity factors that are predictive of blood lead, and assess potential seasonal fluctuations in blood lead through comparison with data collected May. The analyses of the September sampling event and the examination of trends across time support the two objectives of this study: 1) further characterize blood lead levels for Rico residents, and 2) understand seasonal fluctuations in blood lead levels in order to characterize the potential contribution of the soil contact exposure pathway to blood lead levels.

Due to the relatively low levels and small range of blood lead measured in the Rico population, it was anticipated that multiple interactions and potential confounders would need to be analyzed in order for any true predictive relationships to be observed. In order to accomplish this, the analysis was approached systematically. First, relationships between lead in environmental media were analyzed. Next, relationships between blood lead levels and individual parameters, including concentrations of lead in environmental media and behavior and activity factors, were examined separately. Finally, these individual analyses were used to develop full models that included all potential sources and confounders, allowing us to understand factors influencing blood lead and the interactions among these factors[16]. By employing this approach, the sensitivity of the model was increased and the potential to mask or falsely predict true relationships was minimized.

For the examination of trends across time and the effects of seasonality, blood lead levels, lead in environmental media, and the relationships between these parameters are compared between the Phase I and Phase II study periods. The presentation of trends is limited to analyses that will provide meaningful information about temporal and seasonal influences on exposures contributing to blood lead.

[16] Unless otherwise noted, all samples were included in summary statistics and statistical analyses. For cases in which outliers were not included, the source of the sample was either not an exposure source (e.g., water from a single residence at which only bottled water is consumed was removed from the summary statistics and analyses evaluating the relationship between lead in water and blood lead), or was not a major contributor to the transfer pathway being evaluated (e.g., a single residence that had a known source of lead in house dust other than yard soil was removed from the statistical analysis evaluating the relationship between lead in yard soil and lead in house dust). Inclusion of these samples in the analyses would preclude true associations from being detected.

This section presents results for analysis of the September data and an analysis of trends across time using May and September data. A discussion of blood lead levels (Phase II and temporal trends), lead in environmental media (Phase II and temporal trends), relationships between individual environmental media, activity factors, and blood lead (Phase II only), and overall predictive models (Phase II and temporal trends) are included below. Table 5-1 provides a summary of all statistical analyses performed. For all analyses, samples with lead concentrations below the detection limit (DL) were assumed to contain concentrations at half of the DL (USEPA 1989).

5.1 BLOOD LEAD

Broad trends in blood lead with age and gender in this study were consistent with national trends. There were no significant trends in blood lead levels of individuals between phases of the study. These findings are described below.

Results from other scientific studies and the Phase I analysis of this study have shown higher levels of blood lead in young children compared to adults (CDC 2005, Integral 2006a). Behavior patterns, such as hand-to-mouth activity and time spent on low lying surfaces, differ between young children and older children and adults. This general pattern was repeated in Phase II. Although there were several high outlying blood lead levels in adults (age > 18), the overall distribution of blood lead in children (ages 0 to 6) was higher than in older children (ages 7 to 18) and adults (ages >18). However, differences in blood lead with age (age groups 0 to 6, 7 to 18, and > 18 years), were not statistically significant (analysis of variance [ANOVA]; n = 112, $p = 0.11$; Figure 5-1a). It is possible that a true difference in blood lead could not to be detected statistically because of the relatively small number of children during the second phase of the study (i.e., 12 children participated in the second phase compared to 17 in the first phase).

Analysis of Phase II data showed a significant relationship between gender and blood lead. Log-transformed blood lead levels were significantly higher in males compared to females (independent *t*-test; n = 112, $p < 0.01$; Figure 5-1b). Differences in behavior and environments, including occupational differences (e.g., frequency of work in construction which could result in greater exposure to soil), represent potential differences in exposure between males and females. This trend is consistent with national data (CDC 2005), and was consistent across both phases of the study.

The within-subject relationship between Phase I and Phase II blood lead was analyzed. Comparing levels of blood lead for the same individual at two time points allows for within-group variation to be removed and results in a more sensitive statistical test. This statistical test can more definitively detect a true change in blood lead levels for

individuals with time. Within subjects, no significant difference in blood lead with time was found (dependent t-test; n = 94, p = 0.18; Figure 5-2a-c).

5.2 LEAD IN ENVIRONMENTAL MEDIA

This section examines the relationship between levels of lead in environmental media from the Phase II sampling event and a presents an analysis of temporal trends of lead in environmental media using results from Phase I and Phase II.

As described previously, levels of lead in house dust were anticipated to change due to increased tracking of yard soil into residences over the summer. Analysis of the relationship between yard soil (pre-remediation samples) and Phase II house dust samples is provided (Section 5.2.1), followed by a temporal analysis of the relationship from Phase I and Phase II (Section 5.2.2) below.

As described in Section 3.3.5, lead in paint was not anticipated to change between the two phases of the study. It is not anticipated that the relationship between lead in different water samples (i.e., purged and first-draw, and filtered and unfiltered) would change between the two studies. Additionally, the small number of water samples obtained for some water sample types (i.e., only two filtered, first-draw water samples were obtained) did not allow for a complete characterization of within-house water samples to be completed. A characterization of lead in water and paint is summarized briefly in Section 5.3.1 and presented in entirety in the Phase I data summary report (Integral 2006a).

5.2.1 Lead in Yard Soil and House Dust, Phase II

The relationship between the log-transformed concentrations of lead in yard soil and house dust was examined. Yard soil sampling was completed prior to the 2005 soil remediation activities, whereas sampling for house dust took place in September 2006. Thirty-five homes were remediated in 2005, and 31 were remediated between July and October 2006. Twenty-two of the 62 residences participating in this study underwent yard soil remediation prior to the blood lead sampling event. For these 22 residences, the soil sampling results presented in this report represent pre-remediation conditions, while lead concentrations in house dust represent post-remediation conditions

Analyses were conducted both for the total data set of 62 residences and with the 22 previously remediated residences excluded, to eliminate potential confounding. Both of these analyses were considered to be of interest because of the possibility that house dust could continue to reflect the impact of yard soil for some time after the completion of remediation. For both the total data set (i.e., all houses in the study) and for non-remediated residences only, average lead levels were higher in yard soil compared to

house dust (Table 4-8). For all residences sampled in Phase II, geometric mean lead in yard soil was 551 mg/kg (n = 56) while geometric mean lead in house dust was 345 mg/kg (n = 60).

In the analysis of all residences, lead levels in yard soil were significantly correlated with corresponding concentrations in house dust (Pearson's correlation; n = 54; $r^2 = 0.34$; $p < 0.01$; Figure 5-3a)[17] . The relationship between lead in house dust and lead in yard soil is described by the equation: $y = e^{3.182 + 0.4122 \ln x}$. This significant correlation suggests that yard soil is an important contributor to lead loading in indoor dust. In homes with remediated yards, the current lead levels in soil are much lower than they were prior to soil removal. Therefore, the potential for remediation to impact the observed relationship between lead in yard soil and house dust in this data set was examined by evaluating the correlation with the remediated residences excluded. Excluding these residences slightly improved the correlation (Pearson's correlation; n = 33, $r^2 = 0.37$, $p < 0.01$; Figure 5-3b) and with this exclusion, lead concentrations in yard soil were found to predict 37 percent of the variability in lead concentrations in house dust. The relationship between lead in house dust and lead in yard soil for non-remediated yards is described by the linear equation: $y = e^{2.7053 + 0.4954 \ln x}$.

Lead levels in soil and house dust from residences that were remediated were compared to lead levels in soil from the non-remediated residences. Geometric mean lead in soil from remediated and non-remediated yards was 1,245 mg/kg (n = 21) and 338 mg/kg (n = 35), respectively (Table 4-8). Since yards with higher concentrations of lead were targeted for remediation, this observed trend was expected. The statistical significance of the relationship was confirmed by independent t-test results (n = 56, $p < 0.01$; Figure 5-4a). The difference in lead concentrations found in dust of residences with remediated and non-remediated yards was smaller than the difference in lead in soil between these two groups of houses. Geometric mean lead in house dust from remediated and non-remediated yards was 461 mg/kg and 292 mg/kg, respectively (Table 4-8; Figure 5-4b).[17] The strong relationship between lead concentrations in yard soil and house dust suggests that lead concentrations in house dust were likely even higher prior to remediation, although the magnitude of the concentration change is unknown due to a lack of pre-remediation dust samples for those homes. It is anticipated that as more time passes, lead concentrations in house dust from homes with previously remediated yards should continue to decrease.

A measure of lead loading was calculated as a function of the concentration of lead measured in house dust per square meter. Some environmental studies have shown that lead loading has a stronger correlation with measures of exposure than concentrations of

[17] A single residence that had a known source of lead in house dust other than yard soil was removed from the statistical analysis.

lead (Malcoe et al. 2002). In this study, as expected, the measure of lead loading was closely correlated with blood lead (Pearson's correlation; n = 101, $p < 0.01$). However, the concentration of lead in house dust and the concentration of lead per unit area were also highly correlated (Pearson's correlation; n = 59, $p < 0.01$). Due to the correlation between these two factors, lead loading was not included in subsequent analysis of the overall association between lead in environmental media and blood lead. Including both variables in the overall model would potentially confound any true association between lead in house dust and blood lead. Because lead loading was not measured during the first study phase, the choice to include lead concentration in the analysis of the overall associations allowed for more comprehensive comparisons through time.

5.2.2 Temporal Trends in Lead Concentrations in House Dust

Considering only houses that were sampled in both phases of the study, the geometric mean lead in house dust was 332 mg/kg for the first phase of the study and 324 mg/kg for the second phase of the study (n = 51). A within-residence comparison of lead concentrations in house dust between the sampling events was conducted in order to analyze changes in levels of lead in house dust with time. Within residences no significant difference in concentrations of lead in house dust was found (dependent t-test; n = 51, $p = 0.64$; Figure 5-5).

To account for the potential of remediation status to confound this relationship, a within-residence comparison was conducted analyzing only house dust lead concentrations from residences with non-remediated yards. Considering only houses that were sampled in both phases of the study and were not remediated at the time of the second sampling event, the geometric mean lead in house dust was 279 mg/kg for the first phase of the study and 273 mg/kg for the second phase of the study (n=32). For this constrained analysis, no significant difference was measured across phases of the study (dependent t-test; n = 32, $p = 0.77$). The results were contrary to the expectation that September dust samples would contain higher concentrations of lead than those obtained during May.

Because of observations by the residents that the sampling periods followed "atypical" winter and summer conditions in Rico, meteorological data from 2006 was compared to historical data.[18] Based on the comparison between historical and 2006 data, the months between January and April were drier than normal; average precipitation measured for Telluride from January through April 2006 totaled only 1.6 inches, whereas historical (1971–2001) averages for the same 4-month period totaled 7.4 inches and 9.3 inches for Telluride and Rico, respectively. Overall average precipitation for Telluride during the

[18] 2006 meteorological data for Telluride, CO, located about 25 miles from Rico, CO was compared to historical data (1971–2001) for Telluride, CO and Rico, CO. The limited variability in levels of precipitation from historical records for Telluride, CO and Rico, CO supported the extrapolation of 2006 data from Telluride as a surrogate for 2006 levels for Rico, CO.

summer period for May through August 2006 was comparable to historical data for Telluride and Rico (Table 5-2).

It is anticipated that with a drier than normal spring, residential exposures to dust may have been higher than normal. The deviations from expected "typical" levels of precipitation may, in part, explain the low degree of variation observed in lead concentrations in house dust over the two-phase study.

As remediation efforts have continued through 2006, the proportion of residences with remediated yards participating in the study increased from Phase I to Phase II of the study. During the first phase of study, the yards of 12 of the 66 (18 percent) residences participating in the study had been remediated. In September 2006, at the time of the second phase of study, the yards of 22 of the 62 (35 percent) residences participating in the study had either undergone or were currently undergoing remediation.

5.3 BLOOD LEAD AND PREDICTIVE RELATIONSHIPS

This section examines the relationships between blood lead levels and various demographic factors, levels of lead in environmental media, and behavior/activity factors. As described previously, individual relationships were analyzed separately and used to develop an overall model predictive of blood lead. The results presented here focus on analysis of Phase II data. However, in order to accurately develop models predictive of blood lead, the results of the Phase I analysis were also considered, and briefly summarized here in the context of the decision for their inclusion in the final model. The initial evaluation of individual parameters did not include potential confounders including the household effect, age, and gender, but was conducted to provide a baseline for further analysis.

5.3.1 Media-Specific Associations with Blood Lead Levels

The relationship between blood lead levels and lead concentrations in individual media, including yard soil and house dust, was analyzed. The relationship between blood lead and concentrations of lead in yard soil is described by the following equation: $y = e^{0.433 + .025 \ln x}$; however, the linear regression establishing this relationship was not statistically significant ($n = 102$, $p = 0.65$).

Unlike lead in yard soil, a significant relationship between blood lead and concentrations of lead in house dust was found (simple logarithmic regression; $n = 109$, $p < 0.01$; Figure 5-6). Individuals residing in houses with higher concentrations of lead in house dust had increased levels of blood lead.

The association between blood lead and lead concentrations in drinking water was also evaluated. Analysis of Phase I samples demonstrated no significant association between blood lead and lead concentrations in drinking water (Integral 2006a), and therefore it was anticipated that this relationship would remain insignificant in the Phase II analysis. However, due to the observed differences in concentrations of lead in water obtained during the two sampling events (described in Section 4.4.2), this relationship was re-evaluated using the combined water samples obtained in Phase I and Phase II sampling.

In order to evaluate this relationship, the water sample taken from the source that was more likely to represent the main drinking water source at a given residence was chosen to represent resident exposure. "Purged" water samples were obtained from faucets after allowing the water to run for 3 minutes. Because drinking water is likely to be obtained from the tap throughout the day, these purged water samples were assumed to more likely represent drinking water exposure compared to first-draw samples (which were collected after water had been allowed to stand in the pipes overnight). In the case that a household had a filtered tap, it was assumed that this would be their primary source of water. For these residences, lead concentrations from the filtered, purged water sample were compared to levels of blood lead. For households without a filtered system, the concentration of lead in the unfiltered, purged water sample was compared to levels of blood lead. A simple regression of log-transformed blood lead and representative water yielded an insignificant association (n = 108; $p = 0.929$)[19]. Additionally, in order to evaluate any uncertainty associated with using water samples from Phase I to predict blood lead measured during Phase II, an analysis of the relationship between lead in water obtained in Phase II only and blood lead was conducted. No significant association between Phase II water samples and blood lead was found (simple linear regression; n = 18; $p = 0.869$). These analyses confirm the results found in Phase I sampling that concentrations of lead in water are not a significant contributor to blood lead.

Relationships between blood lead and the presence of lead in interior and exterior paint were not included as part of the Phase II analysis. Analysis of Phase I data revealed that blood lead was significantly higher in individuals residing in houses in which lead was detected in exterior surfaces compared to houses in which either no lead was detected in paint or no painted exterior surfaces were present. Blood lead was also higher in individuals residing in houses in which lead was detected in interior paint; however, this relationship was not statistically significant. Lead was detected in only a small number of residences and when present, was often detected below several layers of paint (Integral 2006a). Thus despite the potential significance of lead in paint for individual exposures,

[19] Water from a single residence that does not have a well or receive water from the public water supply is not included in this analysis. All water consumed at this house is bottled; other water needs at this residence are supplied by cistern. Therefore, there is no household water source that is consumed by the residents.

community-wide exposures are not expected to be significantly influenced by lead in paint.

5.3.2 Behavior and Activity Associations with Blood Lead Levels

The relationship between blood lead levels and behavior and activity factors was analyzed, including participation in gardening or landscaping; the number of indoor/outdoor dogs in a household; whether individuals in a household removed footwear prior to entering the house; and reported time spent recreating in other areas of the community with potential for exposure to lead in soil. The relationship between blood lead levels and potential for exposure to lead through occupational exposure was also evaluated for individuals older than 18 years of age.

Blood lead levels were not significantly different in individuals reporting participation in gardening activities compared to those reporting no participation (independent t-test; n = 112, $p = 0.35$). Similarly, no significant relationship was found between blood lead and self-reported participation in landscaping activities (independent t-test; n = 112, $p = 0.21$). As current levels of lead in yard soil of non-remediated yards are expected to be greater than in yards that have undergone remediation, it was anticipated that these habits may have greater potential to influence blood lead in individuals with non-remediated yards. However, in an analysis constrained to residents with non-remediated yards only, blood lead levels in individuals reporting participation in gardening, and participation in landscaping were not significantly different from those reporting no participation in gardening and landscaping, respectively (independent t-test, n = 64, p = 0.44 [gardening]; independent *t*-test, n = 64; $p = 0.7$ [landscaping]).

Factors that may influence concentrations of lead in houses, including the number of indoor/outdoor dogs, and whether individuals of a household remove footwear prior to entering the residence, were investigated. Concentrations of lead in house dust were significantly lower in residences in which questionnaire results reported all individuals of a household removing footwear prior to entering the residence (geometric mean, 281 mg/kg; n = 31) compared to those that did not (geometric mean, 430 mg/kg; n = 29) (independent t-test; n = 59, $p = 0.05$; Figure 5-7a).[20] Geometric mean blood lead was higher in residents who did not remove their shoes prior to entering the house (2.1 µg/dL, n = 51) compared to residents who did remove shoes prior to entering the house (1.7 µg/dL, n = 61). The measured difference was statistically significant (independent t-test; n = 112, $p = 0.05$; Figure 5-7b).

[20] A single residence that had a known source of lead in house dust other than yard soil was removed from the statistical analysis.

No significant association was found between lead concentration in house dust and the number of indoor/outdoor dogs owned per household (n = 60, $p = 0.87$). Additionally, no significant difference in the concentration of lead in house dust in homes with indoor/outdoor dogs and without indoor/outdoor dogs was found (independent t-test; n = 60, $p = 0.45$).

Time spent in the primary recreational areas within the community was also examined. No significant associations between blood lead and positive responses for time spent recreating along the Dolores River Corridor and around the Silver Creek Canyon during the winter or summer were found.[21] In order to evaluate the cumulative effect associated with recreating within these two areas with potential for exposure to lead in soil, individual responses to time spent at each location during a given season were aggregated. Blood lead levels in individuals who spent no time recreating were compared to those who spent any time recreating during a given season. Geometric mean blood lead was slightly higher for those who indicated summer recreation activities compared to those who did not (2.0 μg/dL, n = 88 vs. 1.6 μg/dL, n = 24). The relationship

between summer activity and blood lead approached statistical significance [22] (independent t-test; n = 112, $p = 0.07$; Figure 5-8). However, given the uncertainties about the levels of lead present in soils in these areas and uncertainties in self-reported recreational behavior information, no firm conclusion regarding the role of recreational behavior on blood lead levels can be made. No significant difference in blood lead levels was found in individuals who reported positively and negatively for spending time recreating during the winter (independent t-test; n = 111, $p = 0.8$).

The association between occupational exposure to soil and occupational exposure to other potential sources of lead was evaluated in individuals 18 years of age and older. Blood lead levels were significantly higher in individuals reporting occupational exposure to soil (geometric mean, 2.4 μg/dL, n = 27) compared to those reporting no occupational exposure to soil (geometric mean, 1.7 μg/dL, n = 65) (independent t-test; n = 92, $p < 0.01$; Figure 5-9a). A significant relationship between blood lead and self-reported exposure to other potential sources of lead was also found (independent t-test; n = 92, $p = 0.05$;

[21] The specified areas, the Dolores River Corridor and around Silver Creek Canyon, are defined as having potential for exposure to lead in soil. Although sampling completed along the River Corridor is not comprehensive, available data suggest that only a few remaining hot spots and some elevated levels along the old railroad bed along the river remain. Although the Silver Creek area encompasses former mining areas, this area has largely been capped; therefore, potential exposures to lead found in mining waste are reduced.

[22] The *p*-level represents the probability of error that is involved in accepting the observed result as valid, or as "representative of the population." For example, a *p*-level of 0.05 indicates that there is a 5% probability that the relation between the variables in the sample occurs only by chance and does not represent a true association. For this study a *p*-level of < 0.05 is treated as statistically significant; *p*-levels of 0.05-0.1 are described as "approaching statistical significance." These do not indicate a definitive association, however, given certain statistical limitations including the relatively small data set and small range of blood lead levels.

Figure 5-9b). Geometric mean blood lead was 2.5 μg/dL (n = 13) in adults reporting occupational exposure to other potential sources of lead, and 1.8 μg/dL (n = 79) in those reporting no exposure to other potential sources of lead. Gender was also significantly related to occupational history; participants reporting occupational exposure to soil (independent t-test; n = 106, $p < 0.01$) and participants reporting occupational exposure to other sources of lead (n = 106, $p < 0.01$) were significantly more likely to be male than female.

5.4 OVERALL ASSOCIATIONS

Results from the individual assessments of associations were considered collectively in order to determine major predictors of blood lead levels. Specifically, relationships between blood lead and 1) age and gender, 2) environmental media, and 3) activity and behavior factors were evaluated.[23] Comparison of the results of the overall models developed using results from the May and September sampling events can provide information about how different exposures and factors may change over time, and with season.

The full models, developed via a multiple linear regression using log-transformed data, provide more power than the partial models described above. Multiple regression is an attempt to consider the simultaneous influence of several variables on the response variable at once. The multivariate model may reveal relationships that are hidden in the simple univariate models described above.

As evidenced by the Phase I and Phase II analysis, blood lead levels in children ages 0 to 6 are greater than blood lead for other age groups (Integral 2006a). Plausible explanations for differences in significant exposure pathways for each age group exist and findings within the scientific peer-reviewed literature support the potential for differential exposure by age group. Therefore, the final analyses of combined predictors of blood lead were conducted separately for children 0 to 6 years of age and older children and adults.

5.4.1 Development of Phase II Overall Models

In order to evaluate associations between environmental media and blood lead, it is imperative to include all potentially significant factors in an overall model. Several factors included in the Phase I analysis (e.g., the presence or absence of lead in interior and exterior paint) were not included in the simple univariate models for the Phase II

[23] The effect of household was additionally accounted for in the model. The inclusion of measures specific to individuals and measures specific to the household in the same model may create a statistical artifact that can confound any true relationship between predictive factors and blood lead. To counter-balance this effect, a factor to account for the household was included in each of the models.

analysis, presented in Section 5.3. Determination of the factors to be included in the multivariate models were, therefore, based on the findings of both Phase I and Phase II results.

For each of the defined age groups, a backwards multiple regression was conducted, including log-transformed blood lead; log-transformed concentrations of lead in house dust;[24] the presence of lead-based paint in interior and exterior surfaces;[25] summer recreation at either Dolores River Corridor or up Silver Creek Canyon; and household shoe removal behavior. For the older age group, ages 7+, occupational history including self-reported occupational exposure to soil and occupational exposure to other potential sources of lead were included in the model. For individuals ages 7 to 18, for whom no occupational history would be expected, all indicators of occupational history were coded as negative in the model.

Given the small sample size of only 8 individuals ages 7 to 18 providing blood samples in this study, a separate evaluation of this group would lack the statistical power needed to identify factors predictive of blood lead. As many activity factors are similar between older children (ages 7 to 18) and adults (ages 18+) this grouping is not anticipated to have a large impact on the overall model results. However, given the fact that blood lead levels are expected to decline with age, including individuals for whom occupational exposure status is not relevant in a model in which occupational exposure status is being evaluated may "dilute" the impact of occupational exposure in the overall model. Given the relatively small sample size of older children (ages 7 to 18) compared to adults (ages 18+) the impact of this artifact is not anticipated to significantly affect the results.

Full details of the predictive models developed from Phase I data can be found in the Phase I data summary report (Integral 2006a).

[24] Lead loading per unit area was significantly associated with blood lead levels. However, this factor is also significantly correlated with lead concentration. Including two highly correlated variables in a single statistical model can lead to confounding. Therefore, since lead concentrations, but not lead loading, were available for the Phase I sampling event, lead loading is excluded from models evaluating overall associations.

[25] Because lead-based paint testing was not conducted in 10 homes, lead-based paint was assumed to be present or absent based on the age of the house. Any bias or error that may have been introduced by the assumed lead-based paint status for the homes is not expected to significantly affect the findings of this study due to the similarities in 1) the distributions of houses constructed prior to and following 1980, 2) the age of houses constructed prior to 1980 that were tested for lead-based paint, and 3) the group of homes used to establish the relationship between the age of the house and the presence of lead on which actual lead-based testing was conducted. In addition, any exposure to lead present in paint was anticipated to be minimal based on the analysis of the Phase I data.

5.4.2 Results of the Overall Models

The differences in sampling protocols preclude the direct comparison of the overall models developed as part of the Phase I and Phase II analyses. For example, during the second phase of the study, more comprehensive and quantitative activity and behavior information was obtained via the questionnaire. Although these changes to the questionnaire allowed for more accurate and precise relationships to be established during the second phase of study, they limit the direct comparison of overall models developed as part of the Phase I and Phase II analyses.

For each phase of the study, the final analyses of combined predictors of blood lead were analyzed separately for children 0 to 6 years of age and older children and adults. For children ages 0 to 6, an analysis of all data resulting from the September sampling event did not find any statistically significant correlations between environmental lead levels or behavior and activity patterns. The factor with the highest correlation, while not statistically significant (n = 12, $p = 0.11$), was summer recreational activity (e.g., self-reported time spent along the Dolores River Corridor or in Silver Creek Canyon). It is likely that the relatively small number of children providing blood limited the ability to detect relationships for this study.

For young children 0 to 6 years of age, the most predictive model developed based on the May data included gender, concentrations of lead in house dust, and the presence of exterior paint. The model approached statistical significance (n = 15, $p = 0.07$) and explained 32 percent of the observed variability in blood lead. The most significant factor in the model was lead concentrations in house dust. The results of the model suggested that, of the exposure sources and pathways investigated in this study, lead in house dust was the most significant source of exposure to young children. As no statistically significant relationships were found between blood lead levels in children ages 0 to 6 and any of the potential predictor variables (i.e., concentrations of lead in environmental media or activity factors), definitive statements of the influence of temporal trends on children's lead exposures cannot be made.

This same analysis was also conducted for older children and adults (ages 7+). Based on the September data, the most predictive model included concentrations of lead in house dust, self-reported occupational soil contact, and self-reported occupational contact to other potential sources of lead (n = 96, $p < 0.01$). This model indicates that all of these factors should be considered as potentially significant exposures that may influence blood lead levels. In contrast, gender was the only significant predictor of blood lead (n = 82, $p < 0.01$) for the May data set.

The most predictive models for older children and adults (ages 7+) differed by study phase. The addition of occupation as a significant predictor of lead exposure using the

September data may be due to the improved questionnaire. Whereas interpretation of results from the first questionnaire depended on making assumptions about whether individuals within a certain occupation were likely to come into contact with lead, the questionnaire used for the second phase of study directly elicited information on exposure to specific sources of lead. The significant association between gender and blood lead found using the May data set was likely an imprecise surrogate for occupational exposure. Another possibility is that occupational exposure also increased during the summer.

Predictive factors for older children and adults (ages 7+) included in other slightly less, yet still statistically significant models, included summer recreational activity and household shoe removal behavior. These factors should, therefore, also be considered as potentially important to influencing blood lead.

No significant seasonal difference was found in either within-subject blood lead or lead in house dust; therefore, seasonal variation is probably not responsible for the increased association between blood lead and lead in dust in the September data set compared to the lack of association in the May data set. Instead, this difference likely reflects the preciseness with which mathematical models were able to detect predictive factors. Data obtained from improved questionnaires used in September were likely able to remove lingering confounding among variables that may not have been teased out with the questionnaire results obtained during the spring.

6 DISCUSSION AND CONCLUSIONS

All individuals had blood lead levels lower than the CDC and CDPHE's risk management levels of 10 μg/dL for children and 25 μg/dL for adults. This included two of the three participants whose blood lead levels were elevated[26] at the time of the spring sampling. The maximum individual level (14 μg/dL) was collected from an individual reporting contact with lead-containing materials while working, which likely explains the observed blood lead level. Geometric mean blood lead levels for participants in the September event were 2.6 μg/dL for the 0 to 6 year age group, 1.5 μg/dL for older children and 1.9 μg/dL for adults. For the 12 children younger than 7 years of age, blood lead levels ranged from 1.9 μg/dL to 7 μg/dL. For the 8 older children, blood lead levels ranged from <1.0 μg/dL[27] to 3.0 μg/dL, while the range for adults was <1.0 μg/dL to 14 μg/dL.

Due to the small population of Rico and the relatively low levels and small range of blood lead measured in residents, as well as ongoing yard remediation efforts, relationships between blood lead levels and environmental media and behavior and activity factors are difficult to separately identify and evaluate. The systematic, stepwise approach utilized for the statistical analysis, the revised study questionnaire administered during Phase II sampling, and the two-phase sampling scheme employed in this study all helped characterize any true predictive relationships. Overall, the findings of this two-phase study found no significant difference in blood lead, concentrations of lead in environmental media, or exposure pathways contributing to blood lead between May and September phases of the study.

The results from the overall statistical models used to determine factors predictive of blood lead for Phase I and II sampling were not identical. Although seasonal influences might account for some differences in results, the differences in sampling and analytical detections, as well as in the questionnaire and its administration, also likely contributed to differences in results. Characterization of relationships must, therefore, use the body of sampling results, statistical tests employed, and scientific knowledge.

[26] During the first phase of the study, two children (who provided heel prick blood samples) in the 0 to 6 year age group, and one adult, exhibited blood lead levels above the CDC and CDPHE's risk management levels of 10 μg/dL and 25 μg/dL for children and adults, respectively. The children, were referred to the CDPHE's Lead Poisoning Prevention Program and were retested by their personal physician. For both children, results of the second samples, collected via venipuncture, were below the risk management level of 10 μg/dL. The adult with elevated blood lead had known exposures to lead containing materials. Lead levels in this participant's soil were below current remediation action levels.

[27] Detectable levels of lead were present in 99 percent of the samples. The higher frequency of detection compared to the Phase I study (Phase I, FOD Blood Lead; 74 percent) is likely due to the lower analytical detection limits for Phase II (1.0 μg/dL vs. 1.4 μg/dL).

As there was no significant difference within subjects in blood lead with time, and no significant difference in concentrations of lead in house dust with time, differences in the predictive factors resulting from the models from the two phases of the study are likely not attributable to seasonal variations. Instead, the differences likely reflect the preciseness with which mathematical models were able to identify predictive factors. Data obtained from improved questionnaires used in September were likely able to remove confounding effects associated with the less refined questionnaire results obtained in the spring.

Taken together, predictive models for both children ages 0 to 6 and older children and adults (ages 7+) indicate that concentrations of lead in house dust are a source of exposure contributing to lead in blood. The self-reported removal of shoes prior to entering the residence was associated with lower blood levels. In contrast, summer recreation around the Dolores River Corridor and/or the Silver Creek Canyon area were identified as activities associated with slightly higher blood lead levels. However, it should be noted that uncertainties with the lead levels in soils in the specified recreation areas and in self-reported activity information preclude definitive conclusions regarding the influence of recreational activities on blood lead. Additionally, in adults, occupational exposures to sources of lead are another factor shown to influence blood lead.

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FIGURES

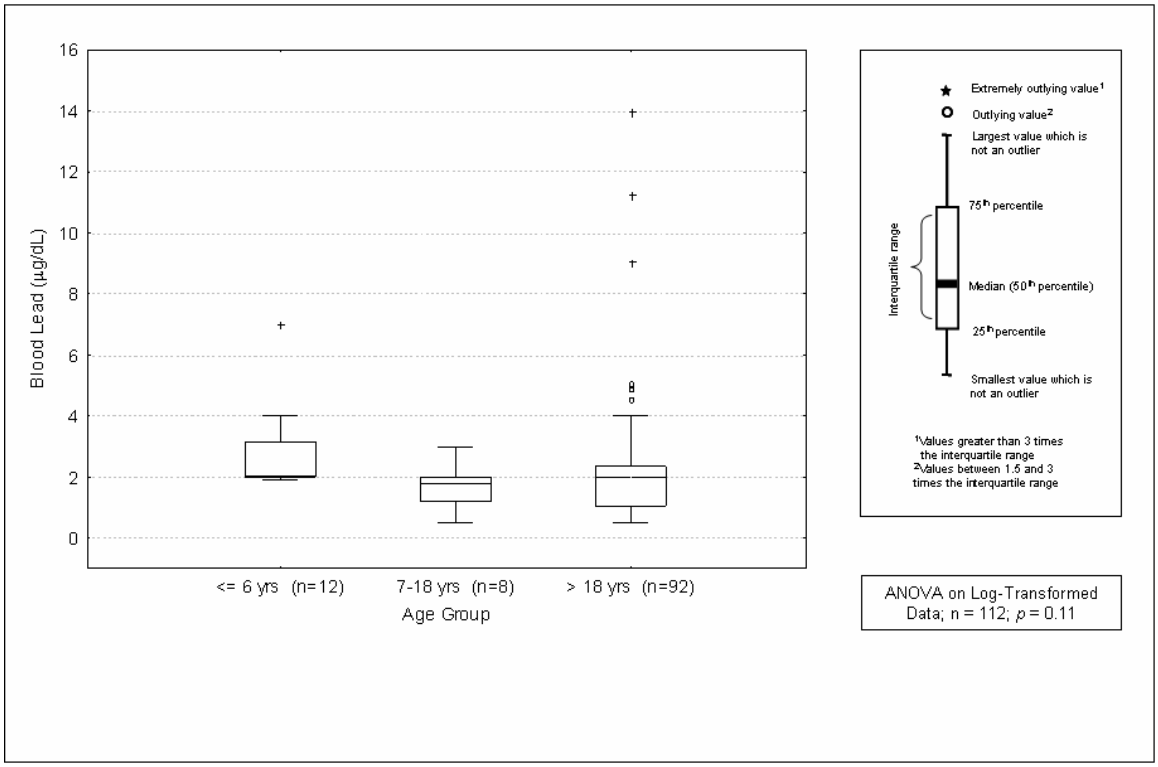


Figure 5-1a. Blood Lead Levels by Age Group, Phase II.

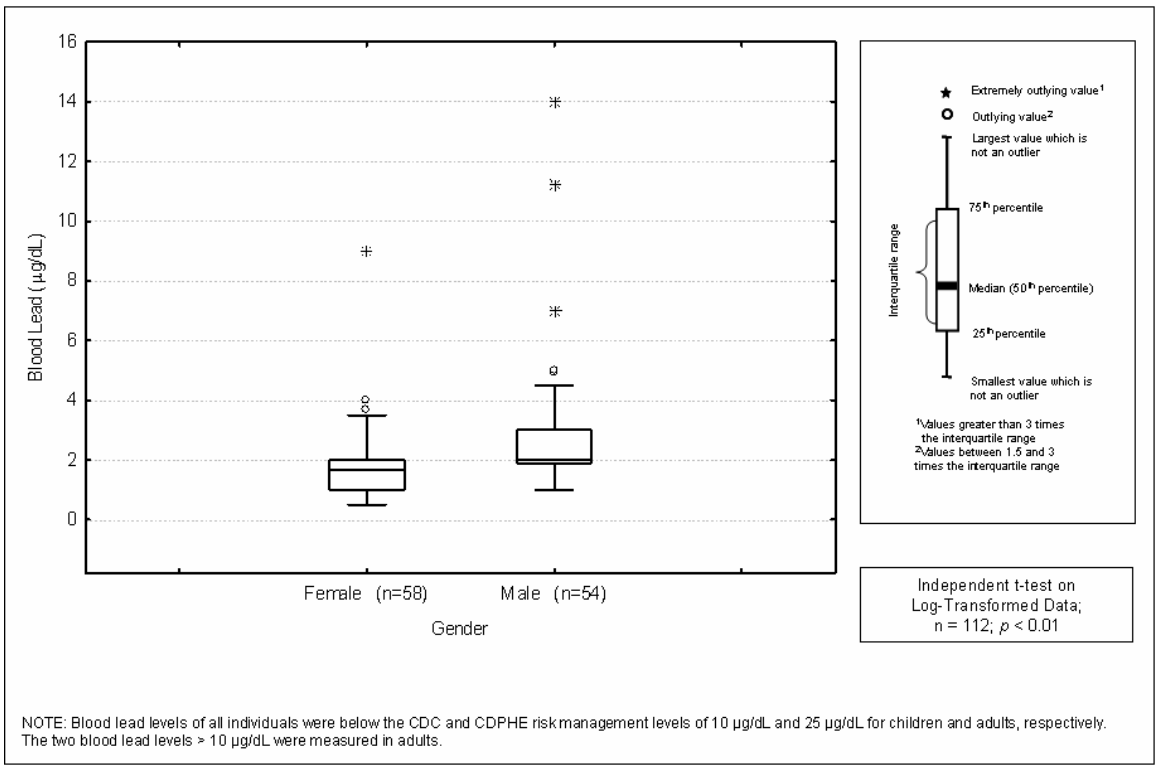
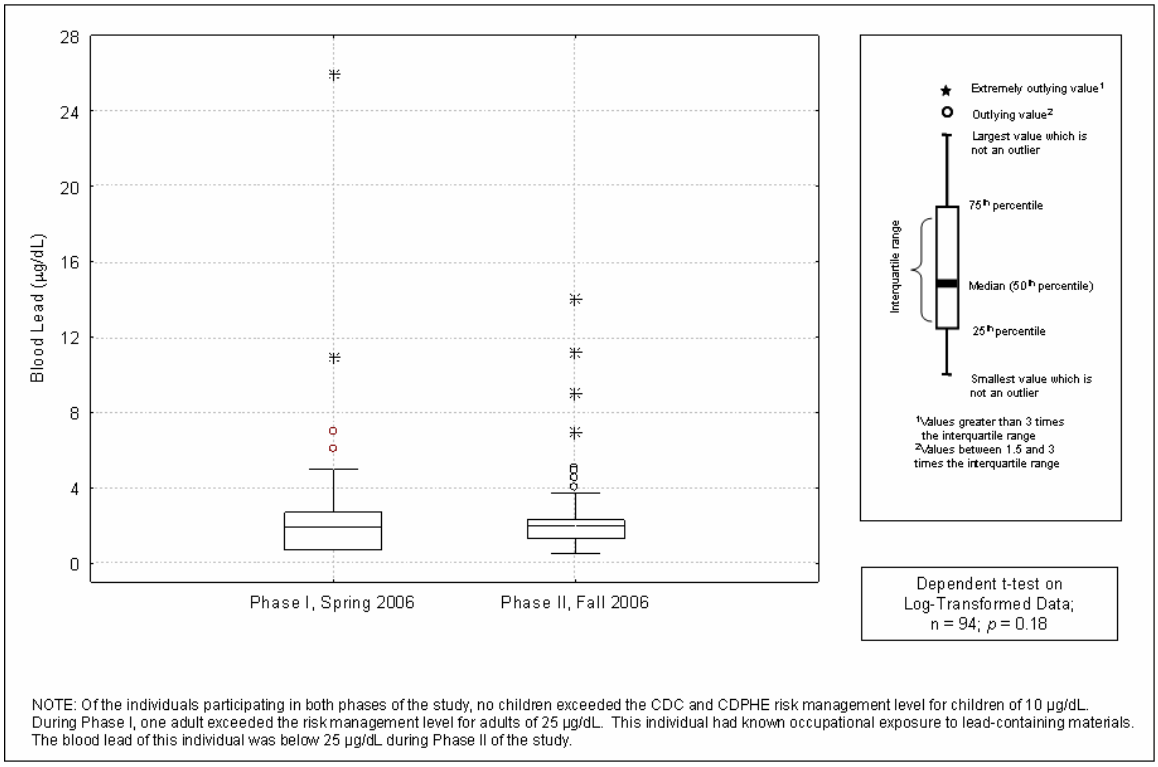
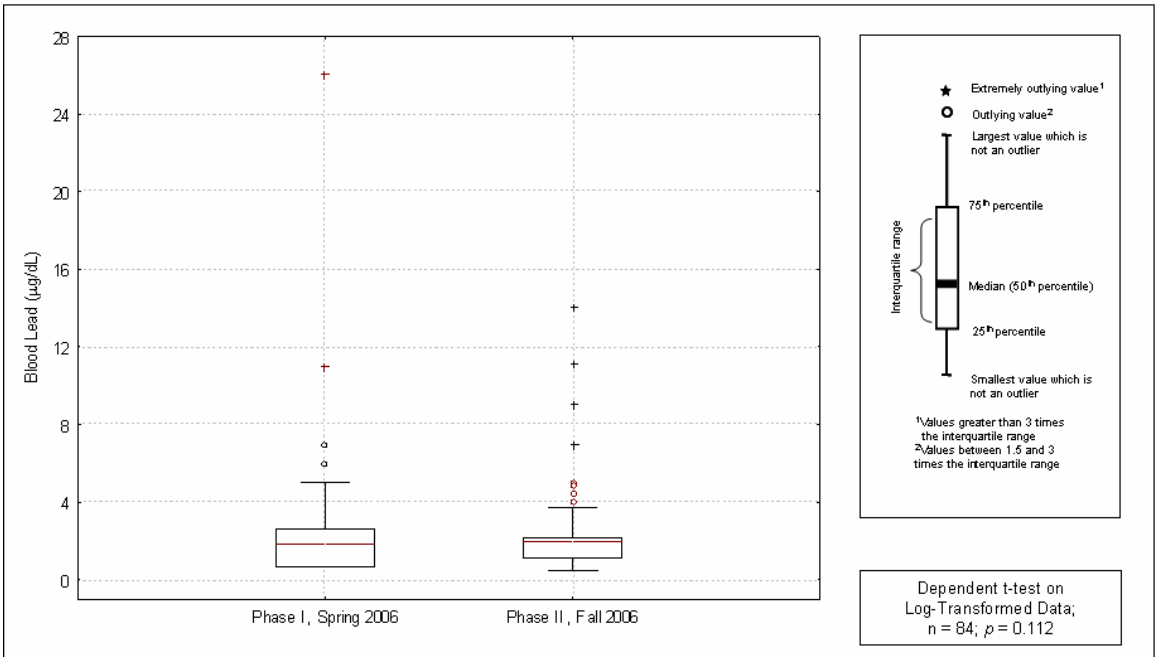


Figure 5-1b. Blood Lead Levels by Gender, Phase II.



NOTE: Of the individuals participating in both phases of the study, no children exceeded the CDC and CDPHE risk management level for children of 10 µg/dL. During Phase I, one adult exceeded the risk management level for adults of 25 µg/dL. This individual had known occupational exposure to lead-containing materials. The blood lead of this individual was below 25 µg/dL during Phase II of the study.

Figure 5-2a. Variation in Blood Lead between Phase I and Phase II Events, Individual Subjects Participating in Both Phases Only.



NOTE: During Phase I, one adult exceeded the CDC and CDPHE risk management level for adults of 25 µg/dL. This individual had known occupational exposure to lead-containing materials. The blood lead of this individual was below 25 µg/dL during Phase II of the study.

Figure 5-2b. Variation in Blood Lead in Older Children and Adults (Ages 7+) between Phase I and Phase II Events, Individual Subjects Participating in Both Phases Only.

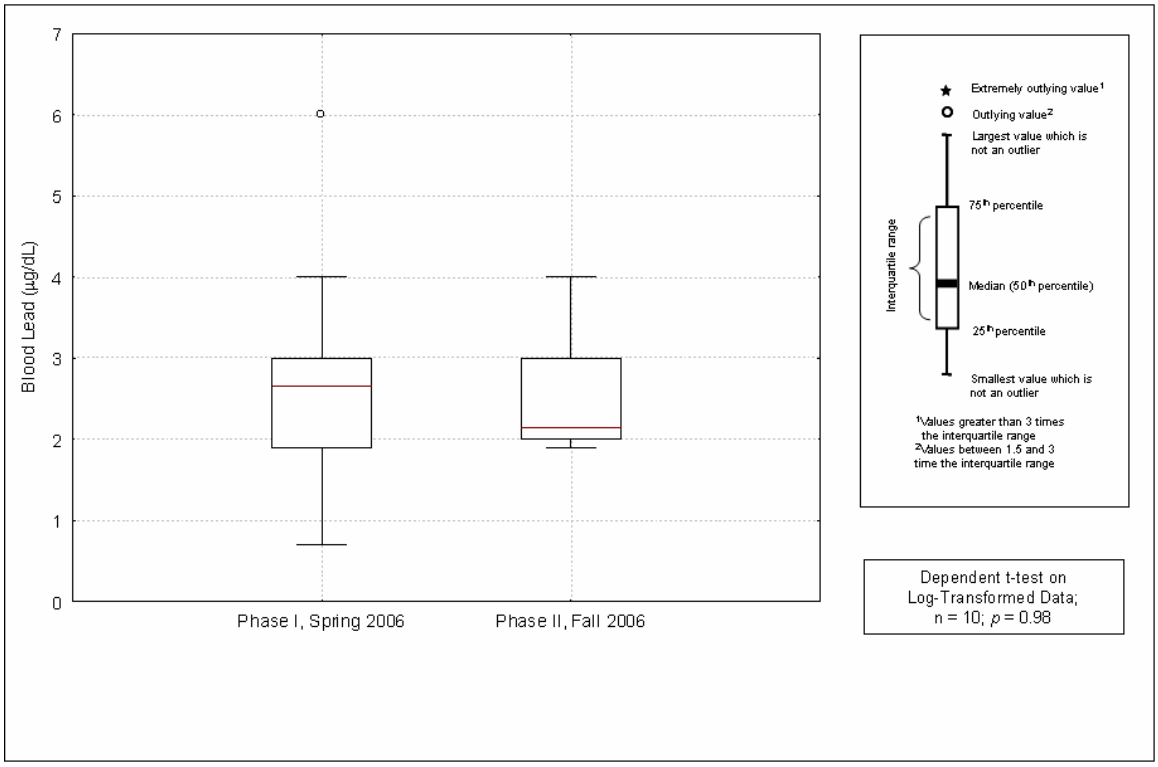


Figure 5-2c. Variation in Blood Lead in Children (Ages 0-6) between Phase I and Phase II Events, Individual Subjects Participating in Both Phases Only.

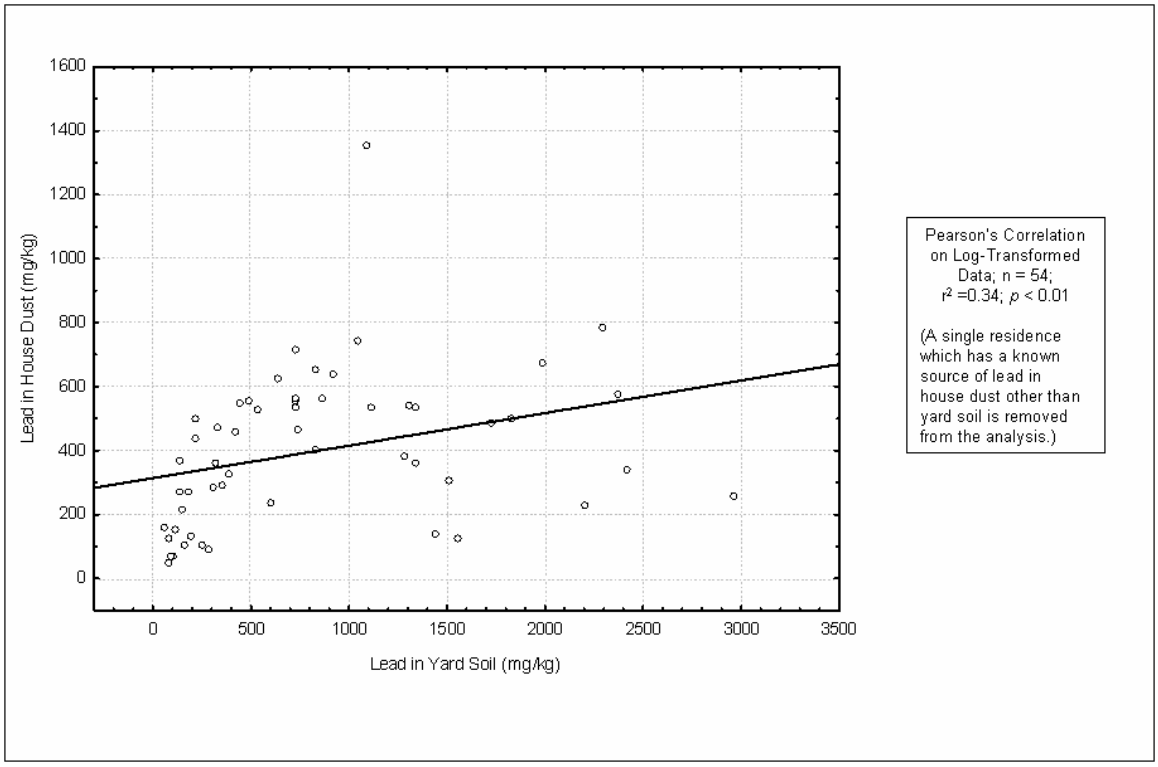


Figure 5-3a. Relationship between Yard Soil and Phase II House Dust Lead Concentrations.

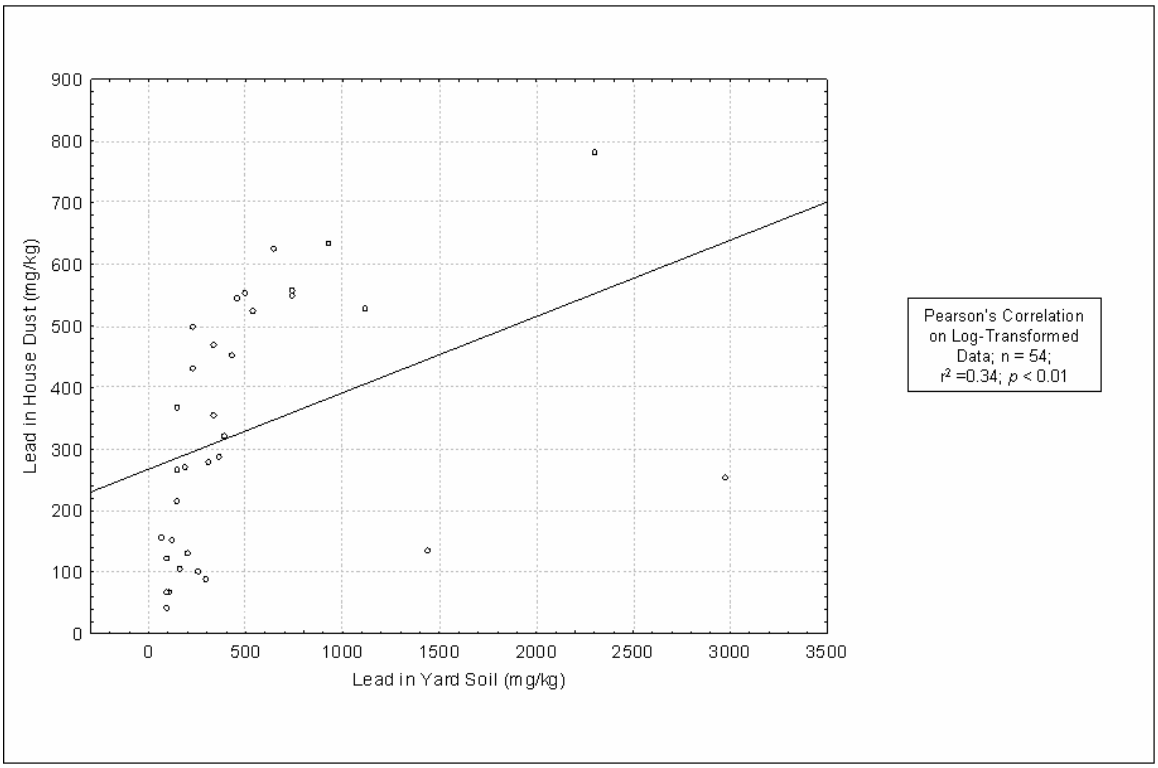


Figure 5-3b. Relationship between Yard Soil and Phase II House Dust Lead Concentrations, Excluding Residences that Were Subsequently Remediated.

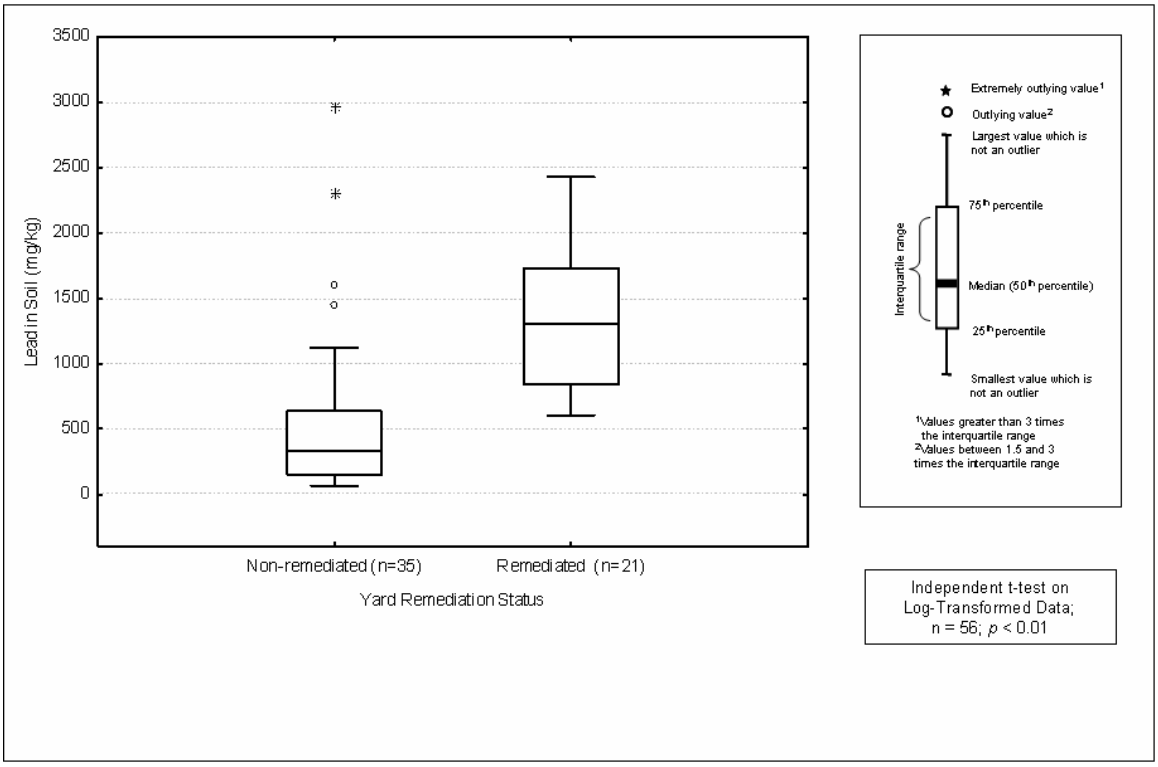


Figure 5-4a. Comparison of Lead Concentrations in Yard Soil in Remediated and Non-Remediated Yards (Prior to Cleanup).

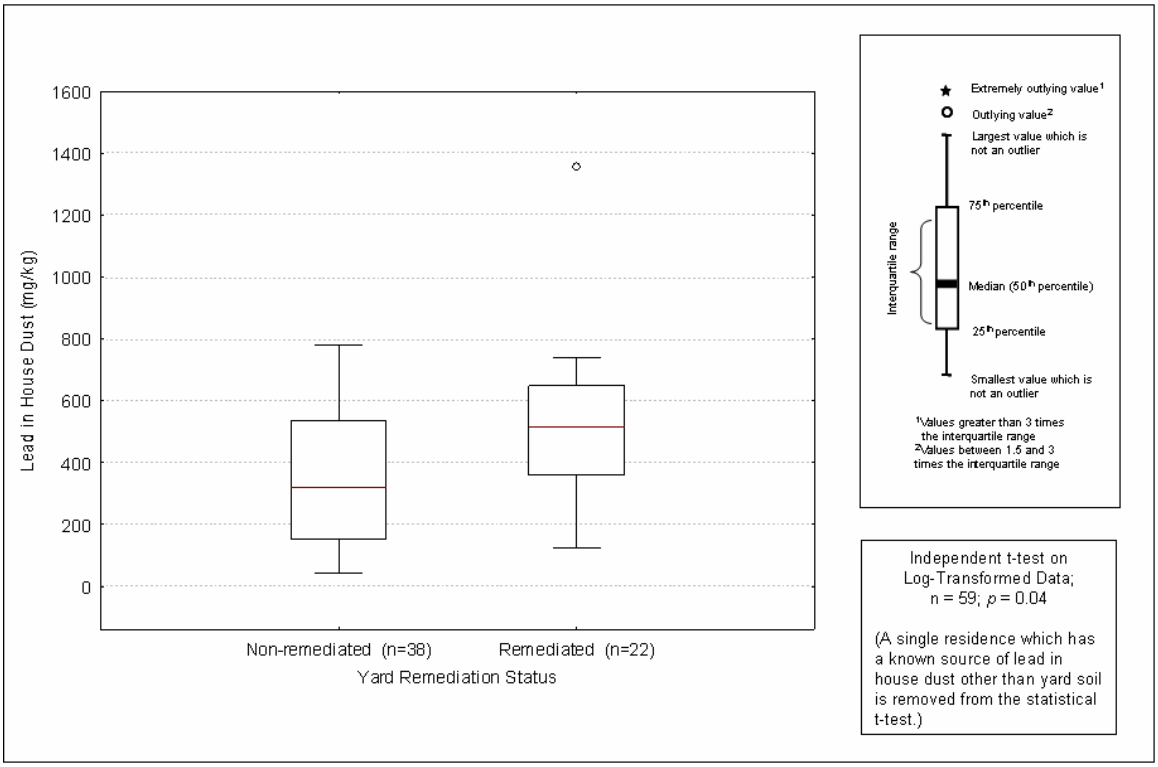


Figure 5-4b. Comparison of Lead Concentrations in Phase II House Dust in Residences with Remediated Yards (Following Cleanup) and Non-Remediated Yards.

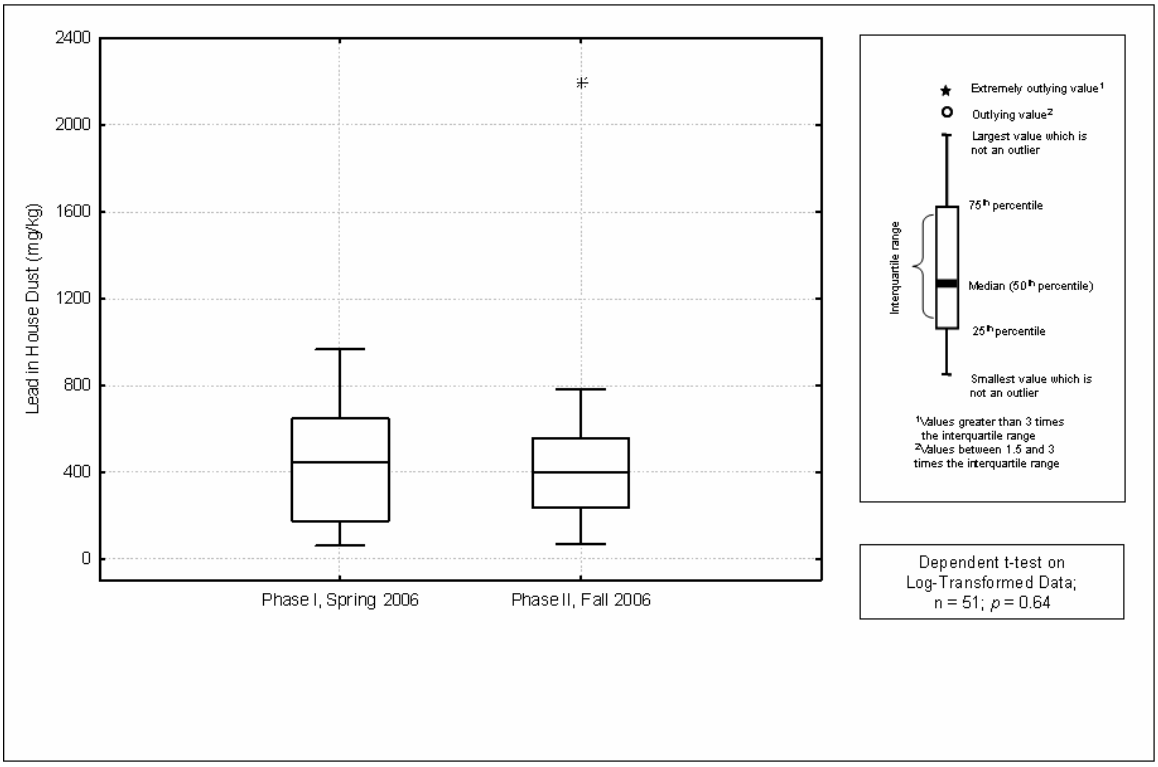


Figure 5-5. Variation in Concentrations of Lead in House Dust between Phase I and Phase II Events, Residences Participating in Both Phases Only.

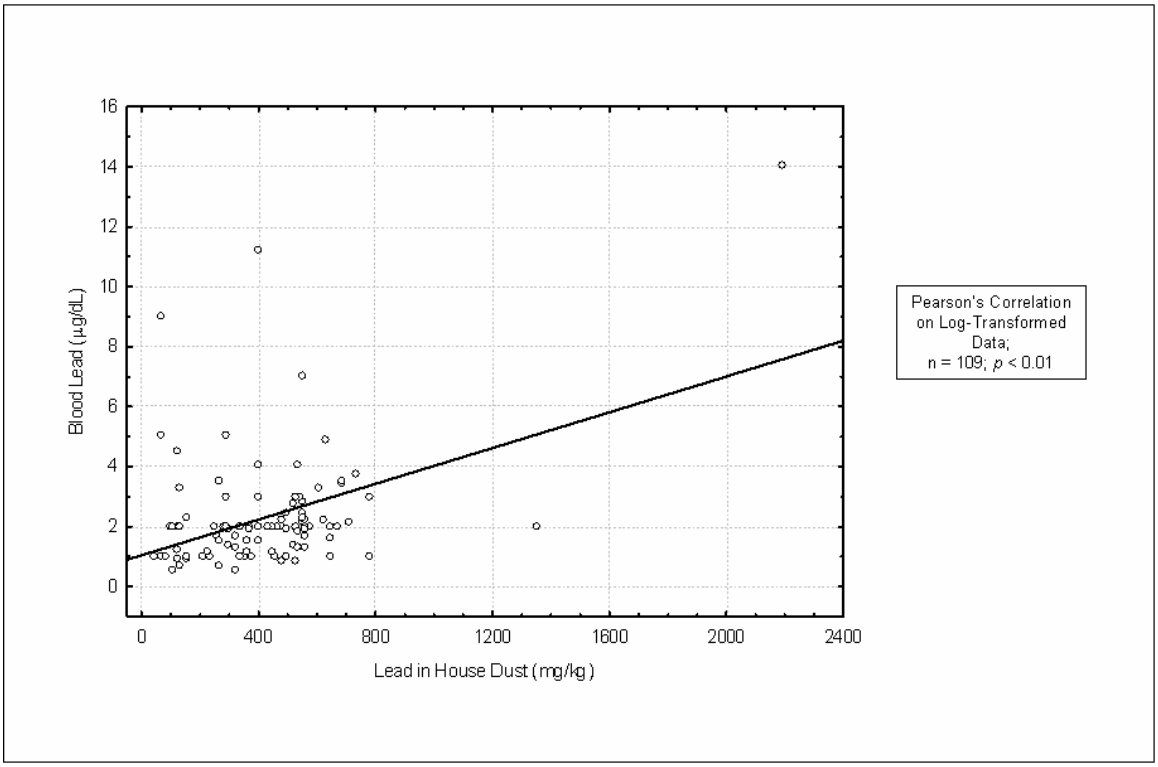


Figure 5-6. Relationship between House Dust Lead Concentrations and Blood Lead, Phase II.

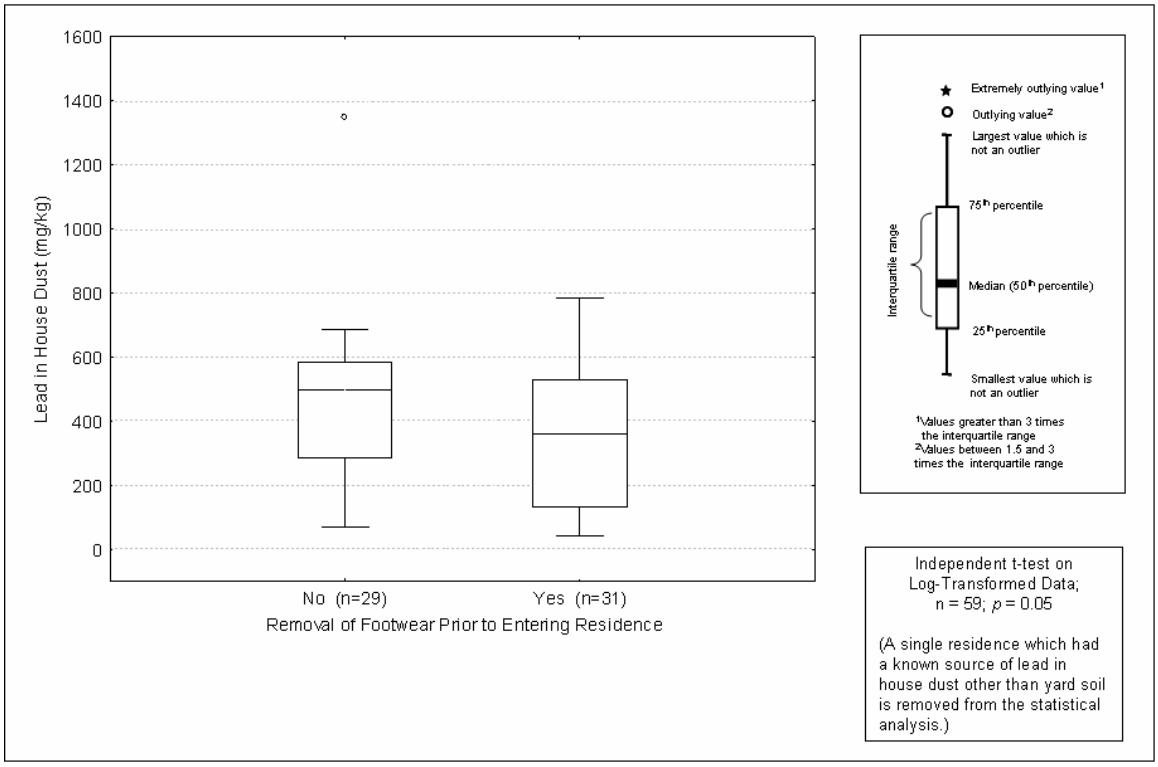


Figure 5-7a. Comparison of Phase II Lead Concentrations in House Dust in Residences by Household Shoe Removal Behavior.

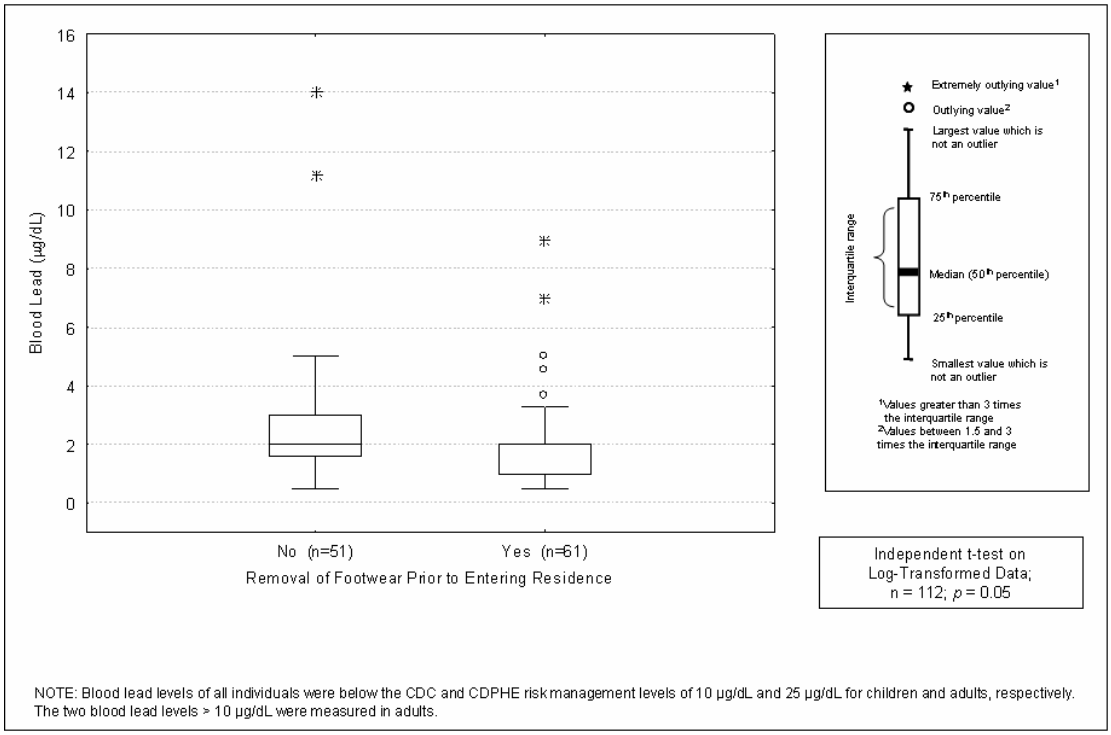


Figure 5-7b. Comparison of Phase II Blood Lead for Individuals by Household Shoe Removal Behavior.

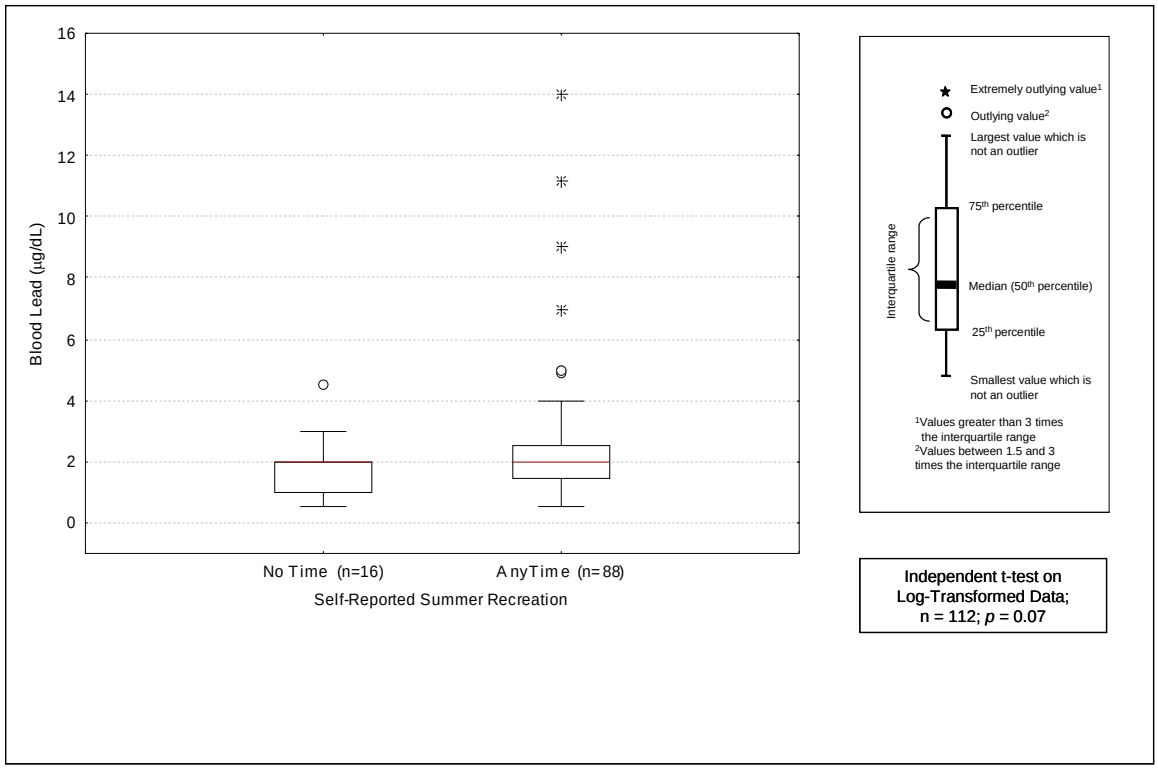


Figure 5-8. Comparison of Phase II Blood Lead in Individuals Reporting No Time and Any Time Spent Recreating along the Dolores River Corridor and around Silver Creek Canyon during the Summer Season.

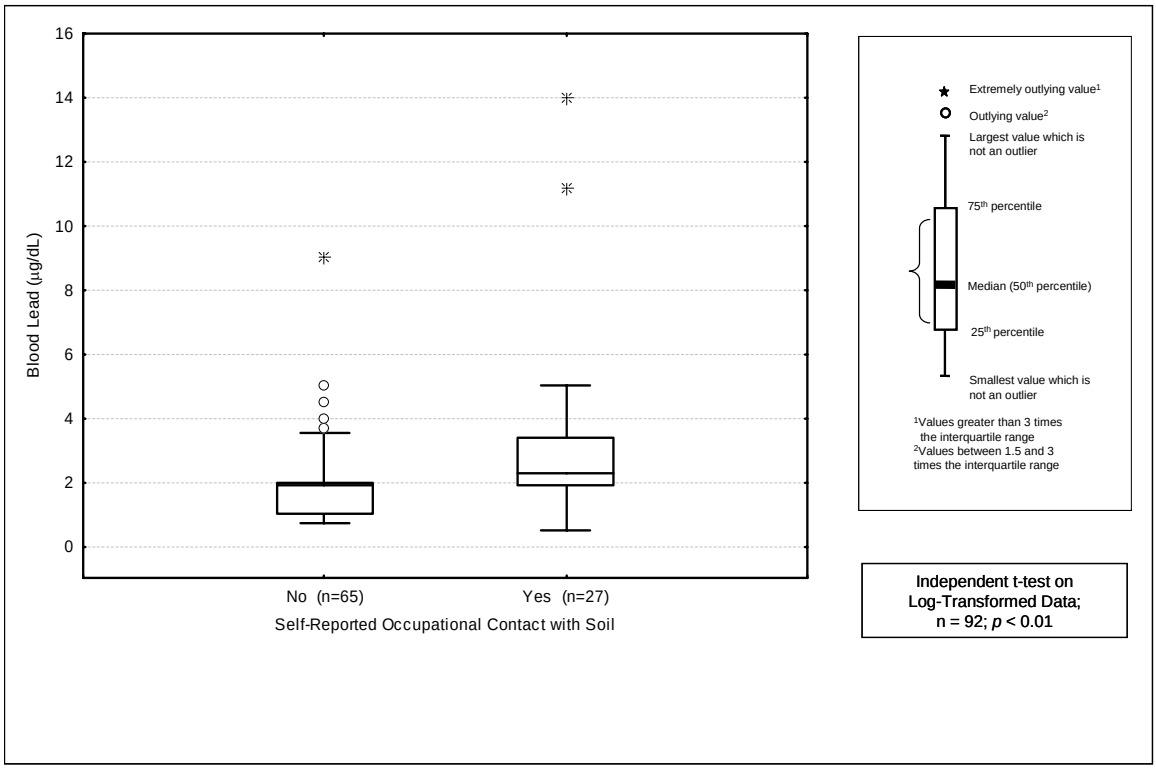


Figure 5-9a. Comparison of Phase II Blood Lead in Adults (Age 18+) by Self-Reported Occupational Contact with Soil.

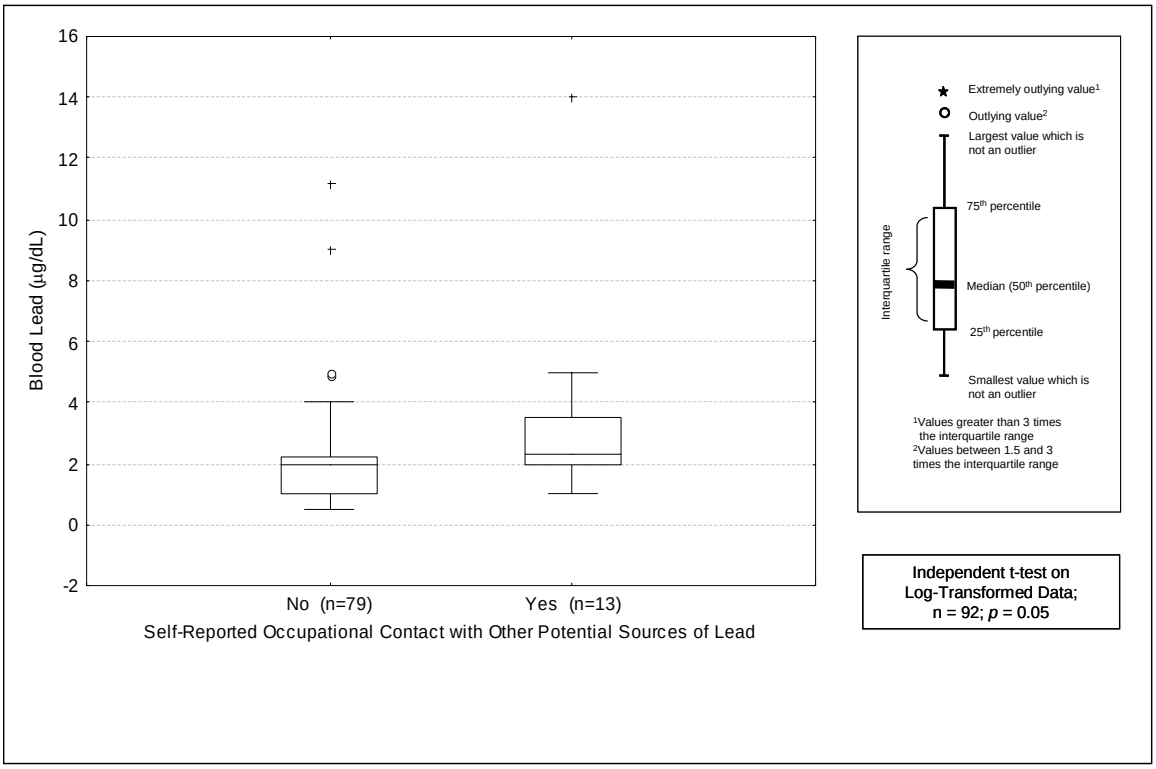


Figure 5-9b. Comparison of Phase II Blood Lead in Adults (Age 18+) by Self-Reported Occupational Contact with Sources of Lead (Other than Soil).

TABLES

Table 2-1. Geometric Means of Blood Lead Levels by Age Group—
NHANES 1991–1994 and 1999–2002.

			Geometric Mean Blood Lead (μg/dL)	
Study Period	Age	No. in Sample	All Racial/Ethnic Groups	White, Non-Hispanic
1991–1994	1–5	2,392	2.7	2.3
	6–19	2,960	1.7	1.5
	20–59	5,596	2.2	2.1
	≥60	2,524	3.4	3.3
	All Ages	13,472	2.3	2.2
1999–2002	1–5	1,610	1.9	1.8
	6–19	6,283	1.1	1.1
	20–59	5,876	1.5	1.5
	≥60	3,056	2.2	2.2
	All Ages	16,825	1.6	1.5

Source: CDC (2005)

Notes: NHANES = National Health and Nutrition Examination Study

Table 2-2. Percentage of Persons with Blood Lead Levels Exceeding 10 μg/dL, by Age Group—
NHANES 1991–1994 and 1999–2002.

			Percent Individuals ≥ 10 μg/dL	
Study Period	Age	No. in Sample	All Racial/Ethnic Groups	White, Non-Hispanic
1991–1994	1–5	2,392	4.4	2.3
	6–19	2,960	1.3	0.6
	20–59	5,596	1.7	1.1
	≥60	2,524	3.6	3.0
	All Ages	13,472	2.2	1.5
1999–2002	1–5	1,610	1.6	1.3
	6–19	6,283	0.2	0.2
	20–59	5,876	0.7	0.6
	≥60	3,056	0.8	0.4
	All Ages	16,825	0.7	0.5

Source: CDC (2005)

Notes: NHANES = National Health and Nutrition Examination Study

Table 4-1. Summary of Participating Households.

Eligible Households Identified	98
Households Participating	62
Environmental media sampled	60
Only blood drawn	2
Sampled for both Phase I and Phase II Study	54
New participation (Phase II Study only)	8
Individuals Participating per Household	
Average	2.3
Minimum	1
Maximum	5

Table 4-2. Study Participants by Age.

Age Group (years)[a]	Number Participating	Number Providing Blood Samples
0–6	24	12
7–18	13	8
Adult (> 18)	106	92

Notes:

[a] Age is age at time of study, defined as September 15, 2006.

Table 4-3. Study Participants by Gender.

Gender	Number Participating	Number Providing Blood Samples
Female	74	58
Male	69	54

Table 4-4. Summary of Within-Variable Statistical Evaluations.

Variable	Evaluation	Statistical Test	Section of Text
Age	Descriptive statistics	--	4.1
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Gender	Descriptive statistics	--	4.1
Blood lead	Descriptive statistics	--	4.4.1
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
ZPP	Descriptive statistics	--	4.4.1
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Hematocrit	Descriptive statistics	--	4.4.1
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Hemoglobin	Descriptive statistics	--	4.4.1
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Lead in soil	Descriptive statistics	--	4.4.2
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Lead in house dust	Descriptive statistics	--	4.4.2
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Lead per area in house dust	Descriptive statistics	--	4.4.2
	Analysis of distribution	Shapiro Wilk's W test, Chi Square test	4.5
Lead in water	Descriptive statistics	--	4.4.2
Recreation activity	Descriptive statistics	--	4.4.3
Gardening/landscaping activity	Descriptive statistics	--	4.4.3
Occupational exposure	Descriptive statistics	--	4.4.3
Number of indoor/outdoor dogs	Descriptive statistics	--	4.4.3
Household behavior - removal of shoes	Descriptive statistics	--	4.4.3
Yards remediated	Descriptive statistics	--	4.4.3
Age of house	Descriptive statistics	--	4.4.3

Notes:

-- = not applicable
ZPP = erythrocyte zinc protoporphyrin

Table 4-5. Blood Lead Data by Age Group.

Age Group (years)	Number	Mean (μg/dL)	Standard Deviation (μg/dL)	Geometric Mean (μg/dL)	Minimum (μg/dL)	Median (μg/dL)	Maximum (μg/dL)
0–6	12	2.8	1.5	2.6	1.9	2.1	7.0
7–18	8	1.7	0.7	1.5	< 1.0	1.8	3.0
Adult (> 18)	92	2.3	2.0	1.9	< 1.0	2.0	14
All	112	2.3	1.9	1.9	< 1.0	2.0	14

Notes:

All non-detects were included as 1/2 the Detection Limit (DL); DL Blood Lead = 1.0 μg/dL.

Table 4-6. Blood Lead Data by Gender.

Gender	Number	Mean (μg/dL)	Standard Deviation (μg/dL)	Geometric Mean (μg/dL)	Minimum (μg/dL)	Median (μg/dL)	Maximum (μg/dL)
Female	58	1.9	1.3	1.6	< 1.0	1.7	9.0
Male	54	2.8	2.3	2.3	1.0	2.0	14
All	112	2.3	1.9	1.9	< 1.0	2.0	14

Notes:

All non-detects were included as 1/2 the Detection Limit (DL); DL Blood Lead = 1.0 μg/dL.

Table 4-7. Summary Statistics for Blood Data.

Parameter	Units	Number	FOD (%)	Mean	Standard Deviation	Geometric Mean	Minimum	Median	Maximum
Blood Lead	μg/dL	112	99	2.3	1.9	1.9	< 1.0	2.0	14
Hematocrit	%	96	100	47.0	3.9	46.9	37.2	47.1	56.3
Hemoglobin	gm/dL	96	100	15.8	1.4	15.7	11.8	15.8	18.7
ZPP	μg/dL	97	100	42	12	40	8.0	41	99

Notes:

FOD = frequency of detection. All non detects were included as 1/2 the Detection Limit (DL); DL Blood Lead = 1.0 μg/dL.

ZPP = erythrocyte zinc protoporphyrin

Table 4-8. Lead Levels Measured in Environmental Media.

Parameter	Units	Number	FOD (%)	Mean	Standard Deviation	Geometric Mean	Minimum	Median	Maximum
Soil	mg/kg	56	100	851	727	551	65	683	2969
Soil, non-remediated yards only	mg/kg	35	100	549	644	338	65	329	2969
Soil, remediated yards only	mg/kg	21	100	1355	567	1245	604	1308	2427
House dust	mg/kg	60	100	440	327	345	43	442	2190
House dust, non-remediated yards only	mg/kg	38	100	397	360	292	43	339	2190
House dust, remediated yards only	mg/kg	22	100	515	250	461	124	515	1350
Lead in dust per area	mg/m^2	59	--	4.1	8.4	2.0	0.09	2.3	61
Lead in dust per area, non-remediated yards only	mg/m^2	37	--	3.0	3.3	1.6	0.09	2.0	16
Lead in dust per area, remediated yards only	mg/m^2	22	--	6.8	13	2.7	0.12	2.4	61
Purged filtered water	µg/L	16	94	0.425	0.837	0.111	< 0.009	0.0733	3.35
Purged unfiltered water	µg/L	59	100	1.06	1.01	0.794	0.193	0.735	5.56
First-draw filtered water	µg/L	13	92	0.785	1.21	0.192	< 0.009	0.174	4.08
First-draw unfiltered water	µg/L	57	100	2.93	2.65	2.00	0.268	1.87	11.4

Notes:

FOD = frequency of detection. All non-detects were included as 1/2 the Detection Limit (DL); DL for water samples = 0.009 µg/L.

-- = not applicable

Lead in dust per area is calculated as a function of the concentration of lead in dust, the sample area, and the sample mass obtained.

Soil data are from Summer 2005 sampling, prior to yard remediation activities.

Water data are from Phase I and Phase II sampling.

Water from a single residence that does not have a well or receive water from the public water supply is not included in summary statistics. All water consumed at this house is bottled; other water needs at this residence are supplied by cistern. Therefore, there is no household water source that is consumed by the residents.

Table 4-9. Lead Levels Measured in Water, Phase I and Phase II Comparison.

Sample[a]	Units	Number	FOD (%)	Mean	Standard Deviation	Geometric Mean	Minimum	Median	Maximum
Purged drinking water, combined data[b]	µg/L	59	98	0.812	0.915	0.433	< 0.009	0.6150	5.56
Purged drinking water, Phase I sampling only	µg/L	61	98	0.552	0.458	0.317	< 0.009	0.445	2.07
Purged drinking water, Phase II sampling only[c]	µg/L	12	100	1.80	1.50	1.24	0.182	1.69	5.56

Notes:

FOD = frequency of detection. All non-detects were included as 1/2 the Detection Limit (DL); DL for water samples = 0.009 µg/L.

[a] Purged drinking water refers to the sample taken from the source that was most likely to represent the main drinking water source at a given residence. In the case that a household had a filtered tap, this source was assumed to be their primary water source. For those residents lead concentrations from the filtered, purged water are presented. For households without a filtered system, the concentration of lead in the unfiltered purged water sample is presented.

[b] Combined data includes residences that participated in Phase Iand Phase II sampling events only.

[c] "Phase II sampling only" consists of 7 newly participating residences, 2 re-participating residences for which water was not obtained in Phase I, and 3 residences at which water was re-sampled.

Water from a single residence that does not have a well or receive water from the public water supply is not included in summary statistics. All water consumed at this house is bottled; other water needs at this residence are supplied by cistern. Therefore, there is no household water source that is consumed by the residents.

Table 4-10. Questionnaire Results for Household Behavior and Yard Remediation.[a]

Parameter[b]	Number	Yes	No
Remove shoes when entering house	62	32	30
Yard remediated	62	22	40

Notes:

[a] Results are counts.

[b] Parameters are self-reported.

Table 4-11. Questionnaire Results for Age of House.

Parameter	Number	Mean (years)	Geometric Mean (years)	Minimum (years)	Median (years)	Maximum (years)
Age of house	60	33	16	0.5	13	125

Table 4-12. Questionnaire Results for Number of Indoor/Outdoor Dogs.[a]

Number of Dogs	Number of Households Reporting
0	22
1	28
2	10
3	2
Total Households	62

Notes:

[a] Results are counts.

Table 4-13a. Questionnaire Results for Individual Activities.

Activity	Number	Yes	No
Summer recreation activity[a]	143	104	39
Winter recreation activity[a]	142	72	70
Occupational contact with soil[b]	106	33	73
Occupational contact with other possible sources of lead[b]	106	14	92
Gardening	143	53	90
Landscaping	143	38	105

Notes: All results are counts.

"No" indicates 0 hours reported; "Yes" indicates any reported time spent in the areas.

[a] Seasonal recreational activity is determined from reported activity in the Dolores River Corridor and Silver Creek Canyon area, on a seasonal basis.

[b] Only Adults (Age 18+) included in summary statistics for occupational exposures.

Table 4-13b. Questionnaire Results for Recreational Activities.

Recreational Activity	Number	0 (hours/week)	0.25–1 (hours/week)	> 1–2 (hours/week)	> 2–4 (hours/week)	> 4 (hours/week)
Dolores River Corridor—summer season	143	65	28	18	22	10
Dolores River Corridor—winter season	143	87	26	13	12	5
Silver Creek Canyon area—summer season	143	67	42	14	10	10
Silver Creek Canyon area—winter season	142	103	20	4	12	3

Note: Time spent recreating is self-reported.

Table 4-14. Results of Statistical Tests for Normality.

Variable	Statistical *p*-values	
	Shapiro Wilk's W Test	Chi Square Test
Non-transformed Data		
Blood lead	< 0.05	< 0.05
Hematrocrit	0.743	< 0.05[a]
Hemoglobin	0.644	< 0.05
ZPP	< 0.05	< 0.05
Lead in house dust	< 0.05	< 0.05
Lead per area in house dust	< 0.05	< 0.05
Lead in soil	< 0.05	< 0.05
Lead in purged unfiltered water	< 0.05	< 0.05
Lead in first-draw filtered water	< 0.05	< 0.05[a]
Lead in first-draw unfiltered water	< 0.05	< 0.05
Lead in purged filtered water	< 0.05	< 0.05[a]
Log-transformed Data		
Log-transformed blood lead	< 0.05	< 0.05
Log-transformed hematocrit	0.259	0.99863[a]
Log-transformed hemoglobin	0.082	1.000[a]
Log-transformed ZPP	< 0.05	< 0.05
Log-transformed lead in house dust	< 0.05	< 0.05
Log transformed lead per area in house dust	0.723	0.483
Log-transformed lead in soil	0.053	0.384
Log-transformed lead in purged unfiltered water	0.424	0.085
Log-transformed lead in first-draw filtered water	0.925	0.8142[a]
Log-transformed lead in first-draw unfiltered water	0.650	0.890
Log-transformed lead in purged filtered water	0.546	0.57913[a]

Notes:

ZPP = erythrocyte zinc protoporphyrin

A *p*-value less than 0.05 indicates that the null hypothesis, that there is no difference between the actual distribution of the data and a normal distribution, can be rejected. Larger *p*-values indicate a closer fit to normality.
Log-transformed values are the natural logarithm of individual data points.

[a] STATISTICA (version 7) yields no result if the expected bin frequency is less than or equal to five. In that case, the reported result is based on a Chi Square test that does not combine bin categories.

Table 5-1. Summary of Between-Variable Statistical Evaluations.

Evaluation Category	Relationship Evaluated	Statistical Test	Section of Text
Blood and demographics	Blood lead and age	ANOVA	5.1
Blood and demographics	Blood lead and gender	Independent t-test	5.1
Blood and time/season	Blood lead with time	Dependent t-test	5.1
Between environmental media	Lead in yard soil and house dust	Pearson's correlation	5.2.1
Environmental media and other parameters	Lead in yard soil and house dust; within non-remediated yards	Independent t-test	5.2.1
Environmental media and other parameters	Yard remediation and lead in house dust	Independent t-test	5.2.1
Environmental media and other parameters	Yard remediation and lead in yard soil	Independent t-test	5.2.1
Between environmental media	Lead in housedust and lead per unit area	Pearson's correlation	5.2.1
Environmental media and time/season	House dust with time	Dependent t-test	5.2.2
Environmental media and time/season	House dust with time; within non-remediated yards	Dependent t-test	5.2.2
Blood and environmental media	Blood lead and lead in yard soil	Simple linear regression	5.3.1
Blood and environmental media	Blood lead and lead in house-dust	Simple linear regression	5.3.1
Blood and environmental media	Blood lead and lead in water	Simple linear regression	5.3.1
Blood and behavior/activity	Blood lead and recreation activity	Independent t-test	5.3.2
Blood and behavior/activity	Blood lead and gardening/landscaping activity	Independent t-test	5.3.2
Blood and behavior/activity	Blood lead and gardening/landscaping activity; within non- remediated yards	Independent t-test	5.3.2
Blood and behavior/activity	Blood lead levels and occupational history	Independent t-test	5.3.2
Blood and behavior/activity	Blood lead and number of indoor/outdoor dogs owned	Pearson's correlation	5.3.2
Blood and behavior/activity	Blood lead and household footwear removal behavior	Independent t-test	5.3.2
Other; overall associations	Blood lead and environmental media and gender, ages 0–6	Multiple linear regression	5.4
Other; overall associations	Blood lead and environmental media and gender, ages 7+	Multiple linear regression	5.4

Notes:

ANOVA = analysis of variance

Table 5-2. Comparison of 2006 Precipitation to Historical Data.[a]

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.
Precipitation in Telluride: 2006	0.3	0.4	0.8	0.2	0.5	0.2	4.0	2.6	2.4	2.0
Average Precipitation in Telluride: 1971–2001	1.7	1.6	2.1	2.1	2.0	1.3	2.3	2.7	2.4	2.0
Average Precipitation in Rico: 1971–2001	2.4	2.5	2.6	1.9	1.7	1.4	2.8	2.9	2.4	2.1

Sources: WRCC (2006a,b)

Notes:

[a] Precipitation in inches.

APPENDIX A

DATA QUALITY SUMMARY

BLOOD LEAD AND ENVIRONMENTAL MONITORING PROGRAM FOR RICO TOWNSITE

Appendix A
Data Quality Summary

Prepared for

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February 13, 2007

CONTENTS

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ACRONYMS AND ABBREVIATIONS

CAS	Columbia Analytical Services
DQOs	data quality objectives
MDL	method detection limit
MRL	method reporting limit
QAPP	quality assurance project plan
RPD	relative percent difference
USEPA	U.S. Environmental Protection Agency
ZPP	zinc protoporphyrin

1 INTRODUCTION

This report summarizes the data quality of analyses performed on house dust, drinking water, and blood samples collected during the Blood Lead and Environmental Monitoring Study for the Rico Townsite, located in Rico, Colorado. Samples were collected September 5-15, 2006. A detailed description of the Rico Blood Lead and Environmental Monitoring sampling is included in the project Work Plan (Integral 2006a).

All samples were analyzed for total lead. In addition, house dust samples were analyzed for total solids, and blood samples were analyzed for hemoglobin, hematocrit, and zinc protoporphyrin (ZPP). All samples were analyzed according to the sample preparation and analytical procedures in the project Quality Assurance Project Plan (QAPP; Appendix C, Integral 2006a), and QAPP Addendum (Integral 2006b).

House dust and drinking water samples were analyzed by Columbia Analytical Services (CAS), Kelso, WA. Blood samples were analyzed by MedTox Laboratories Inc, St. Paul, MN. All samples were prepared and analyzed by methods detailed in Table 1 (QAPP Addendum, Integral 2006b).

2 DATA QUALITY AND USABILITY

Data generated in the field and at the laboratories were verified and validated according to the criteria and procedures described in the project QAPP (Appendix C, Integral 2006a). Data quality and usability were evaluated based on the results of the data validation and the data quality objectives (DQOs) for the Rico data (Table 1; Appendix C, Integral 2006a).

Results reported by the laboratories were 100 percent complete. No results were rejected (assigned an R qualifier) during the quality assurance review. Therefore, the completeness after data validation was 100 percent, which exceeded the standard environmental investigation quality assurance completeness goal of 95 percent.

2.1 DATA VALIDATION

Data validation was conducted by Integral Consulting, Inc. as described in the project QAPP (Appendix C; Integral 2006a). Data verification and validation was performed using U.S. Environmental Protection Agency (USEPA 2002a,b) data validation guidelines for inorganic data, but in the context of data quality objectives specified in the project QAPP. Data qualifiers defined in USEPA (2002a,b) guidelines were applied to the project data.

The following laboratory deliverables were reviewed during data validation:

- The case narratives discussing analytical problems (if any) and laboratory procedures
- Chain-of-custody documentation
- Method blank results to assess laboratory contamination
- Results for field and laboratory duplicate analyses to assess analytical precision
- Results for matrix spike and laboratory control samples to assess accuracy
- Analytical results for analyses performed.

Data qualifiers were assigned during data validation if applicable control limits were not met, in accordance with the USEPA data validation guidelines (USEPA 2002b) and the quality control requirements included in the analytical methods (Table 3-1; Appendix C, Integral 2006a and Table 1, Integral 2006b).

2.2 DATA QUALITY

The discussion below includes a comparison of the reported detection limits to the detection limits specified in the project QAPP (Appendix C; Integral 2006a) and QAPP Addendum (Integral 2006b), followed by a summary of the qualified data for each parameter group and any limitations to the usability of the data.

2.2.1 Reported Detection Limits

Data for the Rico Blood Lead and Environmental Monitoring Study were reported to the method detection limit (MDL) in most cases. In several cases, the MDL and method reporting limit (MRL) were elevated at the laboratory or during data validation because matrix interference or the presence of another analyte interfered with the quantification of a given analyte. MDLs and MRLs were also elevated when results were restated as undetected during data validation because of possible sample contamination, as indicated by the presence of target analytes in an associated method blank or equipment blank.

MedTox reported blood lead results as whole number values; Integral requested that results be recalculated to show at least one decimal place. MedTox was able to retrieve a portion of the total blood lead results and report them with the additional decimal place.

2.2.2 Field Quality Control Samples

Field replicates were collected to assess the variability of the results. Field replicate samples were generated by collecting an additional sample at a designated location or from a study participant, processing this sample separately in the same manner as the original sample, and submitting the replicate as a separate sample for analysis at the laboratories.

The comparability of the replicate results was assessed by calculating the relative percent difference (RPD) of the results. Because there is no standard control limit for comparison of field replicate results, an RPD of 50 was established as a conservative target control limit for detected results greater than 5 times the reporting limit. Greater variability is expected for results within 5-10 times the reporting limit because the background signal variations (i.e., "noise") are greater relative to the lower analyte levels. The precision of the results is acceptable. None of the results were qualified based solely on the field replicate results.

2.2.2.1 Summary of Qualified Data

Selected data not meeting the data quality criteria were qualified as undetected or estimated during validation, in accordance with the QAPP. Data qualified as undetected (U qualified) are usable for all intended purposes. Data qualified as estimated (J qualified) are usable for all intended purposes, with the knowledge that these data may be less precise or less accurate than unqualified data. Validated analytical results of the Rico biomonitoring samples are presented in Tables 1-3. One result for total lead in drinking water (Table 2; Sample ARR-FB-04-F1) was qualified as estimated (J qualified) based on the result being between the MRL and MDL.

The precision and accuracy of the Rico Blood Lead and Environmental Monitoring Study data was acceptable. The completeness of the Rico Blood Lead and Environmental Monitoring Study data was 100%. Overall, the data quality was acceptable and meets the objectives and goals set forth for this project.

3 REFERENCES

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USEPA. 2002a. Guidance on environmental data verification and validation. EPA AQ/G-8. U.S. Environmental Protection Agency, Office of Environmental Information, Washington, DC.

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TABLES

Table 1. Rico Biomonitoring Study - House Dust Analytical Results.

Sample ID	Sample Type	Date Collected	Pre-sieve Mass (g)	Post-sieve Mass (g)	Total Lead (mg/kg)	Total Solids (percent)
ARR-HD-R01-F1	N	9/14/2006	4.9	2.7	153	96.5
ARR-HD-R07-F1	N	9/8/2006	2.8	1.6	382	97.2
ARR-HD-R08-F1	N	9/5/2006	116	79.3	669	99.0
ARR-HD-R09-F1	N	9/15/2006	3.3	2.2	356	97.3
ARR-HD-R09-F1-D	FD	9/15/2006	3.7	2.2	355	97.7
ARR-HD-R101-F1	N	9/10/2006	22.7	19.3	684	96.5
ARR-HD-R107-F1	N	9/13/2006	0.70	0.34	1350	93.0
ARR-HD-R108-F1	N	9/8/2006	6.2	5.7	539	98.7
ARR-HD-R109-F1	N	9/12/2006	14.8	12.0	459	98.4
ARR-HD-R110-F1	N	9/13/2006	6.5	4.8	42.9	96.6
ARR-HD-R11-F1	N	9/6/2006	2.1	1.6	253	97.4
ARR-HD-R12-F1	N	9/12/2006	7.9	3.5	481	97.8
ARR-HD-R13-F1	N	9/13/2006	6.6	5.3	782	97.4
ARR-HD-R14-F1	N	9/7/2006	11.5	8.1	300	98.8
ARR-HD-R15-F1	N	9/11/2006	5.8	3.3	738	97.6
ARR-HD-R16-F1	N	9/5/2006	7.8	6.2	236	97.0
ARR-HD-R17-F1	N	9/7/2006	15.5	12.1	625	97.6
ARR-HD-R19-F1	N	9/14/2006	15.9	14.5	335	97.4
ARR-HD-R20-F1	N	9/14/2006	14.1	10.5	530	98.5
ARR-HD-R21-F1	N	9/7/2006	6.1	4.6	710	97.4
ARR-HD-R24-F1	N	9/9/2006	3.3	3.0	524	98.5
ARR-HD-R26-F1	N	9/7/2006	3.3	2.2	131	97.5
ARR-HD-R27-F1	N	9/6/2006	29.1	26.0	248	97.3
ARR-HD-R27-F1-D	FD	9/6/2006	29.5	25.0	294	96.8
ARR-HD-R29-F1	N	9/6/2006	6.5	4.9	215	99.0
ARR-HD-R31-F1	N	9/13/2006	3.4	1.8	2190	96.4
ARR-HD-R32-F1	N	9/7/2006	5.4	4.7	266	98.5
ARR-HD-R33-F1	N	9/10/2006	35.3	33.1	398	98.1
ARR-HD-R34-F1	N	9/12/2006	19.2	13.3	368	99.0
ARR-HD-R35-F1	N	9/5/2006	9.3	8.0	258	97.9
ARR-HD-R36-F1	N	9/7/2006	29.7	27.0	609	98.3
ARR-HD-R37-F1	N	9/11/2006	1.9	0.78	226	98.2
ARR-HD-R40-F1	N	9/6/2006	5.2	3.0	497	97.6
ARR-HD-R43-F1	N	9/7/2006	5.7	4.8	360	98.0
ARR-HD-R46-F1	N	9/10/2006	6.6	5.4	303	97.4
ARR-HD-R46-F1-D	FD	9/10/2006	5.1	4.4	340	97.8
ARR-HD-R48-F1	N	9/14/2006	6.1	4.6	468	98.9
ARR-HD-R51-F1	N	9/7/2006	12.5	11.4	545	98.2
ARR-HD-R52-F1	N	9/11/2006	23.2	17.5	648	99.1
ARR-HD-R54-F1	N	9/7/2006	6.4	4.7	632	97.1
ARR-HD-R55-F1	N	9/11/2006	7.2	4.7	553	93.0
ARR-HD-R56-F1	N	9/11/2006	4.3	2.4	529	99.3
ARR-HD-R57-F1	N	9/8/2006	7.8	3.9	573	98.3
ARR-HD-R58-F1	N	9/10/2006	15.9	13.7	124	99.2
ARR-HD-R60-F1	N	9/10/2006	8.2	6.5	557	97.5
ARR-HD-R61-F1	N	9/11/2006	9.0	3.5	500	98.7
ARR-HD-R62-F1	N	9/8/2006	2.3	1.5	135	96.8

Table 1. Rico Biomonitoring Study - House Dust Analytical Results.

Sample ID	Sample Type	Date Collected	Pre-sieve Mass (g)	Post-sieve Mass (g)	Total Lead (mg/kg)	Total Solids (percent)
ARR-HD-R63-F1	N	9/5/2006	9.2	8.4	530	97.7
ARR-HD-R64-F1	N	9/6/2006	8.5	7.1	534	98.2
ARR-HD-R67-F1	N	9/15/2006	6.8	5.1	68.5	98.3
ARR-HD-R70-F1	N	9/8/2006	9.2	8.4	551	98.2
ARR-HD-R71-F1	N	9/7/2006	10.8	9.6	556	97.5
ARR-HD-R75-02-F1	N	9/8/2006	47.4	6.3	973	98.2
ARR-HD-R75-F1	N	9/8/2006	11.8	8.5	558	98.5
ARR-HD-R82-F1	N	9/6/2006	1.8	1.8	452	97.4
ARR-HD-R84-F1	N	9/12/2006	4.1	3.3	280	97.6
ARR-HD-R85-F1	N	9/8/2006	5.9	3.9	288	97.8
ARR-HD-R86-F1	N	9/11/2006	9.0	6.7	123	97.7
ARR-HD-R88-F1	N	9/14/2006	5.0	3.6	86.7	97.9
ARR-HD-R89-F1	N	9/11/2006	1.9	0.81	105	97.2
ARR-HD-R92-F1	N	9/6/2006	18.0	16.2	69.1	96.8
ARR-HD-R93-F1	N	9/14/2006	22.3	19.4	101	98.2
ARR-HD-R94-F1	N	9/6/2006	30.3	23.8	155	99.1
ARR-HD-R97-F1	N	9/13/2006	6.8	3.0	432	97.4

Notes:

FD = field duplicate
N = normal environmental sample

Table 2. Rico Biomonitoring Study - Drinking Water Analytical Results.

Sample ID	Sample Type	Date Collected	Total Lead (ug/L)
ARR-FB-01-F1	N	9/10/2006	0.941
ARR-FB-02-F1	N	9/12/2006	1.05
ARR-FB-03-F1	N	9/12/2006	6.33
ARR-FB-04-F1	N	9/12/2006	0.019 J
ARR-WF-R107-F1-01	N	9/13/2006	2.77
ARR-WF-R107-F1-02	N	9/12/2006	0.927
ARR-WF-R108-02-F1	N	9/8/2006	3.35
ARR-WF-R108-F1	N	9/8/2006	2.13
ARR-WF-R109-F1-01	N	9/12/2006	1.77
ARR-WF-R109-F1-02	N	9/12/2006	0.439
ARR-WF-R31-F1	N	9/13/2006	1.66
ARR-WF-R32-F1	N	9/7/2006	2.37
ARR-WF-R36-F1	N	9/7/2006	1.11
ARR-WF-R40-F1	N	9/13/2006	2.02
ARR-WF-R51-F1	N	9/7/2006	0.323
ARR-WF-R55-F1	N	9/10/2006	1.5
ARR-WF-R55-F1-D	FD	9/10/2006	1.95
ARR-WF-R62-01-F1	N	9/8/2006	5.32
ARR-WF-R62-02-F1	N	9/8/2006	0.182
ARR-WF-R85-F1	N	9/8/2006	5.56
ARR-WF-R8-F1	N	9/14/2006	1.91
ARR-WS-R107-F1-01	N	9/14/2006	3.76
ARR-WS-R107-F1-02	N	9/14/2006	2.44
ARR-WS-R108-F1	N	9/9/2006	5.94
ARR-WS-R109-01-F1	N	9/13/2006	9.58
ARR-WS-R109-02-F1	N	9/13/2006	0.762
ARR-WS-R110-F1	N	9/14/2006	6.03
ARR-WS-R31-F1	N	9/13/2006	8.15
ARR-WS-R32-F1	N	9/8/2006	4.15
ARR-WS-R36-F1	N	9/8/2006	1.55
ARR-WS-R51-F1	N	9/8/2006	1.18
ARR-WS-R55-F1	N	9/10/2006	4.14
ARR-WS-R62-F1	N	9/8/2006	8.14
ARR-WS-R85-F1	N	9/9/2006	7.64
ARR-WS-R88-F1	N	9/15/2006	4.92

Notes:

FD = field duplicate
N = normal environmental sample

Table 3. Rico Biomonitoring Study - Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
ARRWB2402F1,N		NA	15.7	50.5	1.4	42
ARR-WB-R101-01F1,N		9/10/2006	15.7	47.6	3.4	44
ARR-WB-R101-02F1,N		9/10/2006	17.3	52.6	3.5	45
ARRWBR10802F1,N		9/8/2006	16.6	47.2	1.8	38
ARRWBR108D1F1,N		9/8/2006	15.7	46	1.3	42
ARRWBR1401F1,N		9/7/2006	15.3	45	1.4	35
ARRWBR1402F1,N		9/7/2006	16.6	49.6	1.9	32
ARRWBR1701F1,N		9/10/2006	15.4	47.4	2.2	36
ARRWBR20101F1,N		9/7/2006	16.1	47.5	2.1	47
ARRWBR2401F1,N		NA	16.3	50.5	2.7	45
ARR-WB-R26-01-F1,N		9/7/2006	15.8	45.1	0.7	50
ARR-WB-R26-02-F1,N [a]		9/7/2006	--	--	3.3	--
ARR-WB-R27-01-F1,N		9/6/2006	15.7	49.2	3.5	43
ARR-WB-R32-01-F1,N		9/7/2006	12.8	38.2	0.7	47
ARR-WB-R32-02-F1,N		9/7/2006	16.1	47.3	1.5	37
ARR-WB-R33-01-F1,N		9/10/2006	16	48.6	11.2	35
ARR-WB-R35-01-F1,N		9/6/2006	14.1	45.2	1.7	43
ARR-WB-R35-02-F1,N		9/6/2006	17.4	53.3	1.7	30
ARR-WB-R36-01-F1,N		NA	17.9	56.3	3.3	41
ARR-WB-R40-01-F1,N		9/6/2006	17.8	55.4	2.4	37
ARR-WB-R43-01-F1,N		9/7/2006	15.5	45.9	1.5	39
ARRWBR4302F1,N		9/7/2006	16.9	49	1.1	33
ARR-WB-R46-03-F1,N		9/10/2006	15.7	47.1	0.5	26
ARR-WB-R51-01-F1,N [b]		9/7/2006	--	--	3	NA
ARR-WB-R54-01-F1,N		9/7/2006	NA	NA	4.9	36
ARR-WB-R58-01-F1,N		9/10/2006	14.2	42.3	1.2	47
ARR-WB-R58-03-F1,N [a]		9/10/2006	--	--	2	--
ARR-WB-R60-01-F1,N		9/10/2006	14.2	43.7	1.9	19
ARR-WB-R60-02-F1,N		9/10/2006	14.9	46.4	2	8
ARR-WB-R61-01-F1,N		9/11/2006	17.2	48.8	1.9	39
ARR-WB-R61-02-F1,N		9/11/2006	15	42.7	1.0	30
ARR-WB-R62-03-F1,N		9/10/2006	17.9	51.4	2.0	15
ARR-WB-R70-01-F1,N [c]		9/8/2006	NA	NA	2.1	--
ARRWBR7101F1,N		9/7/2006	15	45.3	2.4	38
ARRWBR7102F1,N		9/7/2006	16.1	47	2.8	30
ARRWBR7103,N		9/7/2006	12.3	37.2	7	39
ARR-WB-R75-01-F1,N		9/8/2006	14.7	42.7	2.2	43
ARR-WB-R82-01-F1,N		9/7/2006	15.1	47.1	1.1	42
ARR-WB-R94-01-F1,N		9/6/2006	16.4	51.5	2.3	39
ARR-WB-RTS-02-F1,N		9/8/2006	16.7	48.8	1.7	43
N,ARR-R11-WB-D1F1		9/14/2006	15.3	46.9	2	99
N,ARR-R88-WB-02-F1		9/14/2006	15.8	46.8	1	36
N,ARR-WB R07-01-F1		9/8/2006	16.8	53	1	31
N,ARR-WB-R01-01-F1		9/14/2006	14.6	44.8	1	43
N,ARR-WB-R07-03-F1		9/8/2006	16.4	52.2	1	35
N,ARR-WB-R08-01-F1 [d]		9/5/2006	--	--	2	--
N,ARR-WB-R08-02-F1 [d]		9/5/2006	--	--	2	--
N,ARR-WB-R09-01-F1		9/15/2006	15.7	47.1	1	60

Table 3. Rico Biomonitoring Study - Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
N,ARR-WB-R107-01F1		9/13/2006	17.2	47.2	2	40
N,ARR-WB-R109-01-F1		9/12/2006	18.7	54.5	1	39
N,ARR-WB-R110-01F1		9/13/2006	14.8	44.7	1	49
N,ARR-WB-R11-01-F1 [d]		9/6/2006	--	--	2	--
N,ARR-WB-R11102-F1		9/14/2006	16.4	48.3	3	49
N,ARR-WB-R12-01-F1		9/12/2006	15.2	43.8	0.8	48
N,ARR-WB-R12-02-F1		9/12/2006	14.3	41.5	2.2	41
N,ARR-WB-R12-03-F1		9/12/2006	14.1	41.1	2.2	48
N,ARR-WB-R12-04-F1		9/12/2006	14.8	42.8	2	34
N,ARR-WB-R13-01-F1		9/13/2006	16.1	47.9	3	38
N,ARR-WB-R13-02-F1		9/13/2006	14.9	43.6	1	43
N,ARRWBR1501F1		9/11/2006	16.7	49.5	3.7	37
N,ARR-WB-R16-01-F1 [d]		9/5/2006	--	--	1	--
N,ARR-WB-R16-02-F1 [d]		9/5/2006	--	--	1	--
N,ARR-WB-R19-01-F1		9/14/2006	13.4	39.4	1	63
N,ARR-WB-R19-03-F1		9/14/2006	13.8	40.5	2	46
N,ARR-WB-R20-01-F1		9/14/2006	16.2	47.7	2	43
N,ARR-WB-R20-02-F1		9/14/2006	16.4	46.7	3	50
N,ARR-WB-R23-01-F1		9/12/2006	15.6	46.5	2	51
N,ARRWBR2901F1 [d]		9/6/2006	--	--	1	--
N,ARR-WB-R31-01-F1		9/13/2006	17.8	52.5	14	34
N,ARR-WB-R33-02-F1		9/10/2006	15.6	47	1.5	64
N,ARR-WB-R33-03-F1		9/10/2006	15.2	46.1	2.0	38
N,ARR-WB-R33-04-F1		9/10/2006	13.5	40.6	4	49
N,ARR-WB-R33-05-F1		9/10/2006	14.2	45.4	3	46
N,ARR-WB-R34-01-F1		9/12/2006	16.3	49.1	2	45
N,ARR-WB-R34-02-F1		9/12/2006	18	49.2	1.9	43
N,ARR-WB-R34-03-F1		9/12/2006	15.2	42.4	1.9	36
N,ARR-WB-R37-01-F1		9/11/2006	16.5	48.7	1.1	36
N,ARR-WB-R46-01-F1		9/10/2006	16.1	47.3	1.7	63
N,ARR-WB-R46-02-F1		9/10/2006	17.4	52	1.3	54
N,ARR-WB-R48-01-F1		9/14/2006	14.6	44.9	2	48
N,ARR-WB-R52-01		9/11/2006	14.6	42.7	2	48
N,ARR-WB-R52-02-F1		9/11/2006	15.4	44.8	1.6	34
N,ARR-WB-R52-03		9/11/2006	15.7	45.4	1	39
N,ARR-WB-R55-01-F1		9/10/2006	18.6	53.5	2.3	54
N,ARR-WB-R56-01-F1		9/11/2006	16.3	48.8	0.8	37
N,ARR-WB-R57-01-F1		9/8/2006	11.8	39.6	2	78
N,ARR-WB-R57-02-F1		9/8/2006	17	51.8	2	31
N,ARR-WB-R57-03-F1		9/8/2006	14.5	44.4	2	35
N,ARR-WB-R58-02-F1		9/10/2006	16.7	49.3	2	53
N,ARR-WB-R60-04-F1		9/10/2006	17	51.3	1.3	42
N,ARR-WB-R62-01-F1		9/8/2006	17.3	53.1	2	52
N,ARR-WB-R63-02-F1 [b]		9/5/2006	--	--	3	NA
N,ARR-WB-R64-01-F1 [d]		9/6/2006	--	--	4	--
N,ARR-WB-R64-02-F1 [d]		9/6/2006	--	--	4	--
N,ARR-WB-R82-02-F1 [d]		9/6/2006	--	--	2	--
N,ARR-WB-R84-01-F1		9/12/2006	17.1	48.7	2	40

Table 3. Rico Biomonitoring Study - Blood Lead Analytical Results.

Sample ID	Sample Type	Date Collected	Hemoglobin (g/dL)	Hematocrit (%)	Blood Lead (µg/dL)	ZPP (µg/dL)
N,ARR-WB-R85-01-F1		9/8/2006	14.7	45.7	2	36
N,ARR-WB-R85-02-F1		9/8/2006	14.5	44.8	2	26
N,ARR-WB-R85-03-F1		9/8/2006	14.9	45.7	3	26
N,ARR-WB-R85-04-F1		9/8/2006	17.1	52.4	5	34
N,ARR-WB-R86-01-F1		9/11/2006	16.5	50.1	0.9	40
N,ARR-WB-R86-02-F1		9/11/2006	15.8	46.6	4.5	42
N,ARR-WB-R87-01-F1		9/15/2006	14.6	40.8	9	43
N,ARR-WB-R87-02-F1		9/15/2006	18	51.4	5	63
N,ARR-WB-R88-01-F1		9/14/2006	16.3	46.5	1	32
N,ARR-WB-R89-01-F1		9/11/2006	13.3	38.6	< 1.0 U	55
N,ARR-WB-R89-02-F1		9/13/2006	17.3	49.2	2.0	36
N,ARR-WB-R92-01-F1 [d]		9/6/2006	--	--	1	--
N,ARR-WB-R93-01-F1		9/14/2006	15.4	45.6	2	36
N,ARR-WB-R93-02-F1		9/14/2006	17.3	50.1	2	33
N,ARR-WB-R94-02-F1		9/6/2006	14.2	45.5	0.9	46
N,ARR-WB-R97-01-F1		9/13/2006	16.3	48.3	2	60

Notes:

[a] Capillary Sample - Insufficient volume to conduct hemoglobin and hematocrit analyses and speciment type was unsuitable for ZPP analysis.

[b] No analytical results for hemoglobin and hematocrit based on the age of the speciment. No analytical results for ZPP.

[c] Capillary Sample - No analytical results for ZPP; specimen type is unsuitable for analysis.

[d] Testing for hemoglobin, hematocrit, and ZPP not performed due to the age of the specimen.

NA = not available

-- = Data requested but not available due to reasons stated in footnotes.