PUBLIC SCHOOLS ASBESTOS SAMPLING SUMMARY REPORT LIBBY, MONTANA, SUPERFUND SITE

July 2, 2010

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APPROVAL PAGE

This *Public Schools Asbestos Sampling Summary Report for the Libby Asbestos Superfund Site* has been reviewed by EPA and is approved for external release and distribution.

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ACRONYMS AND ABBREVIATIONS

95UCL	95% upper confidence limit of the sample mean
ABS	Activity-Based Sampling
Ago	Area of grid opening
cc	cubic centimeters
C	Chrysotile
CSF	Close Support Facility
DQO	Data Quality Objective
DQA	Data Quality Assessment
EDD	Electronic Data Deliverable
EDS	Energy Dispersive Spectroscopy
EF	Exposure Frequency
EFA	Effective area of the filter
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
ET	Exposure Time
FSDS	Field Sample Data Sheet
IUR	Inhalation Unit Risk
L	liters
LA	Libby Amphibole Asbestos
LFO	Libby Field Office
NAM	Non-Asbestos Material
ND	Non-Detect
OA	Other Amphibole-type Asbestos
OU	Operable Unit
PE	Performance Evaluation
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscopy Equivalent
PLM	Polarized Light Microscopy
PLM-VE	Polarized Light Microscopy using Visual Area Estimation
QC	Quality Control
s/cc	structures per cubic centimeter
SAED	Selected Area Electron Diffraction
SAP	Sampling and Analysis Plan
SOP	Standard Operating Procedure
SPP	Soil Preparation Plan
TEM	Transmission Electron Microscopy
Tr	Trace
TWF	Time Weighting Factor
VIP	Visual Inspection Point

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EXECUTIVE SUMMARY

Introduction

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from this mine contains varying levels of a form of asbestos referred to as Libby Amphibole (LA). Starting in 2000, the U.S. Environmental Protection Agency (EPA) began a range of cleanup actions at the Site to reduce or eliminate sources of LA exposure to residents and workers. One part of this effort focused on schools, and a number of investigations and cleanup actions have been performed at schools in Libby.

To investigate whether indoor and outdoor cleanup actions to date at Libby schools are sufficient to protect the health of students and staff, EPA designed and performed a series of investigations to characterize the level of LA exposures and risk that remain. This document summarizes the results of these investigations.

Indoor Air Investigation

Program Description

The purpose of the indoor air sampling program was to characterize the level of LA in indoor air at each school during normal school operations (i.e., when students and staff are present). Air concentrations were measured using transmission electron microscopy (TEM). Concentrations were determined both for total LA structures, and for phase contrast microscopy equivalent (PCME) structures. PCME structures are used to evaluate human cancer risk.

A total of 10 indoor air samples were collected from each school using stationary monitors. Sampling locations were selected to provide adequate spatial representativeness for each school. Typical locations included:

- Four classrooms
- Lunch room/cafeteria
- Gymnasium
- Four hallways

Each sample was a composite representing two days of normal school activities.

Major Findings

Most indoor air samples (48 out of 50) were non-detect for total LA. The typical analytical sensitivity was approximately 0.0006 cc^{-1}. The two samples with detects for total LA were reported at Libby Elementary School (0.00059 total LA s/cc) and Libby Middle School (0.00051 total LA s/cc). Neither of those samples contained any PCME LA structures.

Outdoor Activity-Based Sampling Program

Program Description

The purpose of the outdoor air activity-based sampling (ABS) program was to characterize exposures of students and maintenance staff to residual asbestos released from soil to air during routine outdoor activities. Outdoor air samples were collected using personal air monitors.

Areas for study were chosen based on interviews conducted in 2009 with school administrators to determine the most heavily used areas. Areas selected for characterizing student exposures focused on locations used for outdoor play or sports activities, while outdoor maintenance workers were assumed to be exposed over most of the school grounds.

The assessment focused on several standardized activities considered to be examples of typical disturbances based on interviews with the school administrators:

- Students playing soccer, football, baseball, and Frisbee®
- Students swinging on a swing set
- Students walking/running over various ground materials (i.e., playground, field, sand)
- Maintenance workers digging and raking various ground materials (e.g., playground, field, sand), and sweeping hard surfaces
- Maintenance workers mowing school lawns

Major Findings

Most outdoor air samples (58 of 63) were non-detect for total LA. Analytical sensitivities for non-detect samples ranged from 0.0019 to 0.0235 cc^{-1}. LA was detected in five samples from four different schools, with total LA air concentrations ranging from 0.0022 to 0.039 LA s/cc. Four of the five samples with LA contained PCME LA structures, with concentrations ranging from 0.0022 to 0.039 PCME LA s/cc.

Screening Level Risk Evaluation

Approach

EPA used the indoor and outdoor air data described above to perform a screening level evaluation of cancer risk to students, teachers, and maintenance staff at each school. These calculations were performed using the method currently recommended by EPA for evaluating risk of cancer from inhalation exposure to asbestos. EPA has not yet developed national guidance for evaluating the risk of non-cancer effects from inhalation exposure to asbestos, so non-cancer risks were not assessed. EPA is currently working to strengthen methods for evaluating cancer risk and to derive a method for estimating non-cancer risk. Therefore, the risk estimates presented here should be considered screening level, and may be re-calculated in the future as new methods and data become available.

Results

For indoor air, screening level risk estimates to students and teachers ranged from < 2E-06 to < 8E-06. As noted earlier, no PCME structures were observed in any indoor sample, so all risks are conservative estimates based on the average analytical sensitivity.

Screening level risk estimates for outdoor exposures of students and maintenance workers ranged from 3E-08 to a maximum of < 2E-05. As above, in many cases, no PCME structures were detected in any outdoor ABS air samples, so many risk values are conservative estimates based on the average analytical sensitivity.

The combined risk to students from school-related exposures for an individual who progresses from preschool through high school in Libby was < 2E-05. The combined risk to a maintenance worker that mowed the lawns at all five of the schools in Libby was < 2E-05.

Conclusion

The objective of the schools monitoring program was to determine if residual LA at schools in Libby poses risks to students, teachers or maintenance staff that are within acceptable bounds, or if further cleanup actions at schools are needed. Based on the data collected from the indoor and outdoor sampling programs, it is concluded that residual risks from indoor exposures and outdoor exposures, both alone and in combination, are within or below EPA's acceptable risk range of 1E-04 to 1E-06, and that further cleanup actions are not needed.

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1 INTRODUCTION

1.1 Site Background

Libby is a community in northwestern Montana that is located near a large open-pit vermiculite mine. Vermiculite from this mine contains varying concentrations of a form of asbestos referred to as Libby Amphibole (LA). Historic mining, milling, and processing operations at the Site, as well as bulk transfer of mining-related materials, tailings, and waste to locations throughout Libby Valley, are known to have resulted in releases of vermiculite and LA to the environment that have caused a range of adverse health effects in exposed people, including not only workers at the mine and processing facilities (Amandus and Wheeler 1987, McDonald et al. 1986, 2004, Whitehouse 2004, Sullivan 2007), but also in residents of Libby (Peipins et al. 2003, Noonan et al. 2006, Whitehouse et al. 2008).

Starting in 2000, the U.S. Environmental Protection Agency (EPA) began a range of cleanup actions at the Libby Asbestos Site to reduce or eliminate sources of LA exposure to residents and workers. One part of this effort focused on schools, both indoors and outdoors. Results of previous indoor investigations and cleanup actions at schools in Libby are summarized in the *Final Sampling and Analysis Plan for Stationary Air Collection at the Libby Public Schools* (EPA 2008b), while results of previous outdoor investigations and cleanup actions are described in the *Final Sampling and Analysis Plan Libby Public Schools – Activity Based Outdoor Air Exposures* (EPA 2009).

To investigate whether the indoor and outdoor cleanup actions taken to date at Libby schools are sufficient to protect the health of students and staff, EPA designed and performed a series of investigations to characterize the level of LA exposures remaining. These investigations included the following Libby schools:

- Kootenai Valley Head Start (formerly Plummer Elementary School) – 263 Indian Head Road
- Libby Elementary School (formerly Asa Wood Elementary School) – 700 Idaho Avenue
- Libby Middle School – 101 Ski Road
- Libby High School – 150 Education Way
- Libby Administration Building – 724 Louisiana Avenue

Figure 1-1 shows the locations of the schools that were evaluated. (Note: The former McGrade Elementary School is no longer utilized by the public school system and was not sampled as part of these investigations.)

At each school, samples of indoor air and outdoor air were collected and analyzed for LA. The Indoor Air sampling program (EPA 2008b) was conducted in December, 2008. This study measured LA in indoor air during regular school use. The Outdoor Activity-Based Sampling (ABS) program (EPA 2009) took place between July and September, 2009. This study measured LA in outdoor air during scripted activities that are representative of outdoor activities by students and school maintenance workers.

1.2 Purpose of This Document

This document summarizes the results of the indoor and outdoor air sampling studies at schools in Libby, and uses the data to estimate the residual exposure and risk from LA. These findings will be used by EPA to determine whether additional cleanup actions are needed at one or more schools to ensure protectiveness from potential LA exposure.

1.3 Document Organization

In addition to this introduction, this report is organized as follows:

Section 2 The section presents a summary of sample analysis and data reduction methods.

Section 3 The section presents a summary of the data on LA in indoor air.

Section 4 The section presents a summary of the data on LA in outdoor ABS air and associated data on LA in soil.

Section 5 The section presents a screening risk evaluation for students, teachers, and maintenance staff exposed to LA in indoor and/or outdoor air at schools.

Section 6 The section presents results of the data quality assessment, including a summary of program audits, modifications, data verification efforts, evaluation of quality control samples, and overall data adequacy.

Section 7 The section provides full citations for all analytical methods, site-related documents, and scientific publications referenced in this document.

All referenced tables, figures, and appendices are provided at the end of this document (or are provided electronically on the enclosed CD).

2 SAMPLE ANALYSIS METHODS AND DATA REDUCTION

2.1 Analysis of Air Samples

2.1.1 Sample Preparation

If air samples were not overloaded with particulates[1], filters were prepared for analysis by transmission electron microscopy (TEM) in accord with the direct preparation method provided in ISO 10312 (ISO 1995).

If air samples were overloaded, samples were prepared indirectly (either with or without ashing, as determined by the analyst) in accord with Standard Operating Procedure (SOP) EPA-LIBBY-08. In brief, in an indirect preparation, rinsate or ashed residue from the original filter is suspended in water and sonicated, and an aliquot of this water is applied to a second filter which is then used to prepare a set of TEM grids. If there was no loose material present in the air cassette or adhering to the cowl, the indirect preparation method was performed as specified in ISO 13794, except that the total solution volume was increased from 40 mL to 100 mL, and a portion of the original filter was retained. If there was loose material present in the air cassette or adhering to the cowl, the indirect preparation procedure was performed as specified in ASTM D-5755, except that an ashing of the primary filter was included.

2.1.2 Sample Analysis

Air samples were analyzed by TEM in basic accord with the counting and recording rules specified in ISO 10312 (ISO 1995), and the project-specific counting rule modifications specified in the Indoor and Outdoor School Sampling and Analysis Plans (SAPs) (EPA 2008b, 2009). In brief, when a sample is analyzed by TEM, the analyst records the size (length, width) and mineral type of each individual asbestos structure that is observed which has a length greater than or equal to 0.5 μm and an aspect ratio (length:width) ≥ 3:1. Mineral type is determined by Selected Area Electron Diffraction (SAED) and Energy Dispersive Spectroscopy (EDS), and each structure is assigned to one of the following four categories – LA, other amphibole-type asbestos (OA), chrysotile (C), or non-asbestos material (NAM).

All countable structures (including non-LA asbestos types) were recorded on the site-specific Libby laboratory bench sheets and electronic data deliverable (EDD) spreadsheets.

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[1] Overloaded is defined as >25% obscuration on the majority of the grid openings (see Libby Laboratory Modification #LB-000016 and SOP EPA-LIBBY-08).

Examination of TEM grid openings continues until one of the analysis stopping rules is achieved. The analysis stopping rules are specified in the appropriate SAPs (EPA 2008b, 2009).

2.1.3 Calculation of Air Concentration Values

The concentration of LA in air in a given sample is given by:

$$\text{Air Concentration (s/cc)} = N \cdot S$$

where:

N = Number of structures observed in the sample
S = Sensitivity (cc^{-1}) for the sample

For air, the sensitivity is calculated as:

$$S = \frac{EFA}{GO \cdot Ago \cdot V \cdot 1000 \cdot F}$$

where:

S	=	Sensitivity for air (cc^{-1})
EFA	=	Effective area of the filter (mm^2)
GO	=	Number of grid openings examined
Ago	=	Area of a grid opening (mm^2)
V	=	Volume of air passed through the filter (L)
1000	=	Conversion factor (cc/L)
F	=	Fraction of primary filter deposited on secondary filter (indirect preparation only)

2.1.4 Units of Concentration

For the purposes of this report, air concentrations are based on countable LA structures only. Two alternative estimates of concentration are used in this report:

- Total LA. This measure includes all LA structures that satisfy the TEM counting rules specified in the SAP (length > 0.5 µm, aspect ratio ≥ 3:1).

- PCME LA. This measure includes only a sub-set of the total LA structures that satisfy the counting rules used in Phase Contrast Microscopy (PCM). These structures are referred as PCM-equivalent (PCME). In the PCM method (NIOSH 7400), a fiber is counted if it has a length of 5 µm or longer and an aspect ratio of at least 3:1. Although there is no thickness rule, particles thinner than about 0.25 um are not usually detectable by PCM. Hence, the counting rules for PCME are: length ≥ 5 μm, width > 0.25 μm, aspect ratio ≥ 3:1.

For the purposes of estimating potential human health risk (see Section 5), the concentration of asbestos in air must be expressed in units of PCM or PCME s/cc. This is because the current risk model for estimation of cancer risk from inhalation exposure to asbestos (EPA 2008a) is based on cumulative exposure expressed as PCM s/cc-yrs. The concentration of PCM structures in an air sample could be measured directly using phase contrast microscopy, but EPA believes it is better to measure the concentration of total LA fibers using TEM, and then to count the number of structures observed in TEM that meet the counting requirements for PCM (i.e., PCME).

In this report, tabular summaries of air concentrations are reported both as total LA s/cc and PCME LA s/cc.

2.2 Analysis of Soil Samples

2.2.1 Sample Preparation

Soil samples collected as part of the outdoor program were prepared for analysis in accord with SOP ISSI-LIBBY-01 as specified in the CDM Close Support Facility (CSF) Soil Preparation Plan (SPP) (CDM 2004). In brief, each soil sample is dried and sieved through a ¼ inch screen. Particles retained on the screen (if any) are referred to as the “coarse” fraction. Particles passing through the screen are referred to as the “fine” fraction, and this fraction is ground by passing it through a plate grinder. The resulting material is referred to as the “fine ground” fraction. The fine ground fraction is split into four equal aliquots; one aliquot is submitted for analysis and the remaining aliquots are archived at the CSF.

2.2.2 Sample Analysis

Soil samples collected as part of the outdoor program were analyzed using polarized light microscopy (PLM). The coarse fractions were examined using stereomicroscopy, and any particles of asbestos (confirmed by PLM) were removed and weighed in accord with SRC-LIBBY-01 (referred to as “PLM-Grav”). The fine ground aliquots were analyzed using a Libby-specific PLM method using visual area estimation, as detailed in SOP SRC-LIBBY-03. For convenience, this method is referred to as “PLM-VE”.

PLM-VE is a semi-quantitative method that utilizes site-specific LA reference materials to allow assignment of fine ground samples into one of four “bins”, as follows:

- *Bin A (ND):* non-detect
- *Bin B1 (Trace):* LA detected at levels lower than the 0.2% LA reference material
- *Bin B2 (<1%):* LA detected at levels lower than the 1% LA reference material but higher than the 0.2% LA reference material
- *Bin C:* LA detected at levels greater than or equal to the 1% LA reference material

Of the 41 soil samples collected during the outdoor program, 18 samples had a coarse fraction. All 18 of these coarse fraction samples were reported as non-detect (ND) for LA when analyzed by PLM-Grav. Therefore, this report discusses only the PLM-VE results for the fine ground fraction.

2.3 Evaluation of Soil by Visual Inspection for Vermiculite

At the time of soil sample collection for PLM analysis, the sampling team performed a visual inspection of the displaced soil at each visual inspection point (VIP) in accord with SOP CDM-LIBBY-06 to determine if visible vermiculite was present. Vermiculite from Libby generally contains LA (EPA 2004). Consequently, the presence of visible vermiculite in soil at the Libby Site has been taken as a potentially useful indicator of the presence of LA. Available data indicate that there is a relation between the level of visible vermiculite in soil and the level of LA observed in air when the soil is disturbed (EPA 2010), although the strength of the relationship varies somewhat between different methods for characterizing the level of soil contamination.

In this study, there were 30 VIPs for each outdoor ABS area, as well as an additional 2 VIPs collected at the sub-locations where digging occurred. At each VIP, a semi-quantitative estimate (none, low, moderate[2], high) of the amount of visible vermiculite present was noted. A count of the number of VIPs assigned to each visible vermiculite ranking (e.g., 2-none, 20-low, 7-moderate, 1-high) was recorded on the Field Sample Data Sheet (FSDS) for the corresponding soil composite sample.

There are several alternative ways that this visual inspection data can be used to characterize the level of vermiculite contamination (and presumptive LA contamination) in an ABS area. This report uses a "weighted score" approach. In this approach, both the frequency of vermiculite detection and the qualitative level of vermiculite observed are considered. This is achieved by assigning a weighting factor to each visible ranking level, where the weighting factors are intended to represent the relative amounts of vermiculite at each level. As presented in SOP CDM-LIBBY-06, the guidelines for assigning a visible ranking level to a VIP are as follows:

[2] The visual inspection SOP CDM-LIBBY-06 uses the terminology "intermediate" to refer to the "moderate" classification. For the purposes of this document, the term "moderate" is retained to correspond with the accompanying ABS field sampling data sheets.

Observation	Level
No flakes of vermiculite are detected	None
A maximum of a few flakes of vermiculite are observed	Low
Vermiculite is easily observed, but is less than 50% of the sample	Moderate
The sample is 50% or more vermiculite	High

Based on these descriptions, the weighting factors that were used in this evaluation are as follows:

Visible Vermiculite Level (L_i)	Weighting factor (W_i)
None	0
Low	1
Moderate	3
High	10

The visible score is then the weighted sum of the observations for the area:

$$Score = \frac{\sum_{i=1}^{30} Count(L_i) \cdot W_i}{30}$$

This value can range from zero (all VIPs are “none”) to a maximum of 10 (all VIPs are “high”). For example, an ABS area with 1 “low” VIP and 29 “none” VIPs would receive a value of 1/30 = 0.033, while an ABS area with 25 “moderate” VIPs and 5 “high” VIPs receive a score of (25·3 + 5·10) / 30 = 4.17.

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3 INDOOR AIR SAMPLING SUMMARY AND EVALUATION

3.1 Study Design

The purpose of the indoor air sampling program was to characterize exposure of students, teachers, and staff to LA under normal conditions when school is in session. Detailed information on the indoor air study design and program-specific data quality objectives (DQOs) are provided in the Indoor Air Schools SAP (EPA 2008b). As discussed in EPA (2008b), there are two strategies for collecting air samples. In the first strategy, the air is collected using a pump worn by an individual, and the sampling cassette is placed in the breathing zone of the individual. This is referred to as personal air sampling. In the second strategy, the sampling pump is held on a fixed support, and the sampling cassette is placed at a height that is typical of what would be expected for a person engaged in normal activities in the general area of the sampler. This is referred to as stationary air sampling. In general, personal air samplers are preferred, because they measure the level of LA in actual breathing zone air, and these values often tend to be somewhat higher than observed in stationary samples. However, the magnitude of the difference depends on the level of source disturbance. When source disturbance is minimal, stationary and personal samples are expected to yield generally similar results.

For sampling indoor air in Libby schools, use of personal air monitors worn by students or teachers was considered, but was not judged to be appropriate or feasible, since this would be extremely disruptive to classroom operations. Therefore, only stationary air samples were collected. As noted above, the use of stationary monitors may tend to yield somewhat lower results than personal air monitors, but because the level of human disturbance of source materials in a typical classroom setting is likely to be low, it is expected that the difference, if any, will not be substantial.

To ensure spatial representativeness of stationary indoor air samples, samples were collected from multiple locations within each school building, based on a field inspection conducted in June 2008. Ten locations were selected per school building, generally including:

- Four classrooms
- Lunch room/cafeteria
- Gymnasium
- Four hallways

In each sampling location, the sampling cassette was placed at a level corresponding to the breathing zone of the students occupying the room. For example, in a classroom where students are usually seated at desks, the cassette was placed at the height of the face of a seated student. Conversely, in the gymnasium and hallways, the cassettes were placed at the height of a standing student.

To help ensure that all samples were representative of average exposure conditions, each sample was collected over a period of two days. Sampling occurred only during the times that each location is typically used by students. That is, during extended periods when classroom or common areas (e.g., gymnasium, cafeteria) were vacant, sampling pumps were turned off until students returned. Hallways and other areas (e.g., library) that are used intermittently throughout the day were sampled for the entire school day. Sampling continued over two sequential days. Because it is not expected that there will be large variations over time in a school setting, it was assumed that two-day composite samples generated at each location would ensure adequate temporal representativeness.

All indoor air samples were submitted to one of the subcontracted Libby laboratories for asbestos analysis. As noted above, each laboratory used TEM in accord with the ISO 10312 method (ISO 1995) counting protocols, with all applicable Libby site-specific laboratory modifications as specified in the Indoor Air Schools SAP (EPA 2008b). The target analytical sensitivity for all indoor air samples was 0.0006 cc^{-1}.

3.2 Results

As noted above, the concentration of LA was measured in indoor air at 10 different locations at each of the five Libby schools. At each location, a single two-day composite air sample was collected that represented indoor activities. This procedure resulted in a total of 50 indoor air samples collected.

At Libby High School, one of the sample cassettes appeared to have been tampered with on the first day, so a new cassette was used on the second day. The cassette that was tampered with was not used.

Appendix A presents a summary of the results for all air samples collected and analyzed as part of the indoor air sampling program. Detailed results (including raw structure information) for all indoor air samples are provided in Appendix H. Table 3-1 summarizes the LA results for indoor air, stratified by school and sampling location. As shown, 48 of 50 indoor air samples did not report any LA structures (typical analytical sensitivity for these samples was about 0.0006 cc^{-1}). For the two samples that were detect, only one total LA structure was observed in each sample (neither structure ranked as a PCME structure). No other types of asbestos were observed during sample analysis.

Further evaluation of these data is presented in the Screening Level Risk Evaluation in Section 5.

4 OUTDOOR AIR ACTIVITY-BASED SAMPLING SUMMARY AND EVALUATION

4.1 Study Design

The purpose of the outdoor air ABS program was to characterize exposures of students and maintenance staff to asbestos during routine outdoor activities conducted at public schools in Libby. This program included the collection and analysis of personal air samples representing the exposure of people who engage in activities that disturb outdoor soil at schools, as well as collection and analysis of associated soil samples. Detailed information on the outdoor air study design and program-specific DQOs are provided in the Outdoor Air Schools SAP (EPA 2009).

4.1.1 Outdoor Activity Scenarios and Sampling Locations

Outdoor activity scenarios for students and maintenance staff were selected based on interviews with school administrators. At each school, the administrators identified outdoor areas that were most commonly used by students or maintenance staff for typical outdoor behaviors. For students, this included:

- Playing sports (soccer, football, baseball, and Frisbee®) in designated sports areas (older students)
- Swinging on a swing set and playing on other equipment in designated play areas (younger students)
- Walking/running over various ground materials (i.e., playground, field, sand)

For outdoor maintenance workers, this included:

- Digging and raking on school grounds, as well as manual sweeping of blacktop play areas and sidewalks
- Power sweeping parking lots
- Mowing and edging school lawns

Outdoor sampling locations were selected based on interviews conducted with the school administrators to determine the most heavily used areas at each school. In general, school maintenance workers are expected to be exposed over most of the school grounds, while the students are most likely to be exposed in areas intended for play or sports activities. Therefore, one to three distinct areas were selected at each school for conducting student scenarios, while maintenance worker scenarios took place across the school grounds. The power sweeping scenario was performed in the parking lots at two schools (Libby Administration Building and Libby High School), and lawn mowing occurred at all schools.

Figures 4-1 through 4-5 depict the locations where the sampling occurred for each type of activity scenario. Table 4-1 provides details regarding the scenario areas and activities per school. For each activity scenario, three sampling rounds occurred between July 30-September 11, 2009, as shown in Table 4-2.

4.1.2 Sample Collection and Analysis

4.1.2.1 Soil Sampling

Table 4-3 lists the soil sampling locations evaluated as part of the Outdoor Schools sampling program.

One 30-point composite soil sample was collected from each scenario area during the first and third of the three sampling events. Scenario areas that were covered by asphalt, concrete, or gravel (without fine-grained soil) were not sampled. To represent scenario areas that span the entire school, composite samples were only collected from those areas not previously included in the smaller scenario subareas (e.g., the school-wide soil sample did not contain the same composite point locations as the soil sample collected from the soccer field). At the time of sample collection, visual vermiculite inspection results were recorded for each of the 30 VIPs.

In addition, a 2-point composite soil sample was collected from each of the smaller digging activity locations for each sampling event. At the time of sample collection, visual vermiculite inspection results were recorded for each of the 2 VIPs.

All soil samples collected as part of the outdoor ABS program were sampled in accord with SOP CDM-LIBBY-05, and were prepared and submitted for asbestos analysis by PLM as described above.

4.1.2.2 Outdoor ABS Air Sampling

Outdoor ABS air sampling was performed by EPA contractors in accordance with requirements specified in the Outdoor Air Schools SAP (EPA 2009). Because release of LA from soil to air is suspected to be diminished in cases where the soil is wet, a field evaluation of soil moisture content was performed prior to all ABS events. If the soil moisture deficiency was less than 50%, sampling did not occur.

The student and maintenance worker ABS scripts are provided in Appendix B. Each ABS event occurred over a two-hour time interval, subdivided by the number of representative activities, as shown in Table 4-1. During student scenarios, three samplers engaged in the prescribed activities to more closely simulate the exposures that might occur when several children are at play in close proximity to each other. Of these three samples, one was submitted for analysis and two were held in archive for use in case additional data or analyses were needed. During maintenance worker scenarios, only one sampler engaged in the prescribed activities. Sampling times were divided approximately equally between morning and afternoon. For each scenario at each location, the prescribed activities were performed three separate times, resulting in three different sampling rounds. The target analytical sensitivity for all outdoor air samples was 0.003 cc^{-1}.

4.2 Results

4.2.1 ABS Air

Appendix C presents a summary of the results for all samples analyzed as part of the outdoor air sampling program. Detailed results (including raw structure information) for all outdoor air samples are provided in Appendix H. Table 4-2 summarizes the LA results for outdoor air, stratified by school and outdoor activity. As shown, 58 of 63 outdoor air samples did not report any LA structures (analytical sensitivities for these samples ranged from 0.0019 to 0.0235 cc^{-1}). Five samples from four different schools had detectable levels of LA, with total LA air concentrations ranging from 0.0022 to 0.039 total LA s/cc. Four of the five LA structures observed ranked as PCME structures. No other forms of asbestos were observed during sample analysis.

Further evaluation of these data is presented in the Screening Level Risk Evaluation in Section 5.

4.2.2 Soil

Table 4-4 summarizes the results for soil, stratified by school and sampling location. As shown, PLM-VE results for LA were non-detect (ND) or trace (Tr) for all soil composite samples. Visible levels of vermiculite were observed in only six composite soil samples. In all cases, the level of visible vermiculite was ranked as “low” (i.e., just one or two flakes). The overall frequency of VIPs with visible vermiculite was 7/810 = 0.9%.

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5 SCREENING LEVEL RISK EVALUATION

This section presents a screening level evaluation of the risks associated with the levels of LA that have been observed in outdoor and indoor air at Libby schools. The risk calculations are considered screening level because toxicity values needed for quantification of site-specific cancer risk and non-cancer hazard from inhalation exposure to LA are still under development by EPA. The calculations presented here are based on the best methods currently available, but may be revised as new data become available and as LA-specific cancer potency factors and non-cancer toxicity values are developed.

These risk calculations are only for exposures that occur at the schools. Exposure of students and staff at Libby schools by exposure pathways that occur outside the school environment are not considered in this document, but will be considered by EPA in the baseline human health risk assessment for Operable Unit 4 (OU4) and in final risk management decision-making at the Libby Site.

5.1 Non-Cancer Risk

Inhalation exposure to asbestos increases the risk of non-cancer effects (asbestosis, pleural changes) in humans (EPA 1986, ATSDR 2001). At present, no approved method is available for quantifying risks of non-cancer effects. Therefore, risks of non-cancer effects are not evaluated in this document. This is an important source of uncertainty because numerous studies of former Libby workers and area residents provide evidence that exposure to LA results in an increased incidence of non-cancer adverse effects. It is not presently known whether exposure levels that protect against cancer risk will also protect against non-cancer risk from asbestos.

5.2 Cancer Risk Model

EPA has developed a method for estimating excess lifetime cancer risk due to inhalation exposure to asbestos. The basic equation used to estimate excess lifetime cancer risk is (EPA 2008a):

$$Risk = EPC \cdot TWF \cdot IUR_{a,d}$$

where:

Risk = Probability of developing cancer due to the asbestos exposure being evaluated

EPC = Exposure Point Concentration of asbestos in inhaled air (PCM or PCME s/cc)

TWF = Time Weighting Factor to account for less than continuous exposure (unitless)

$IUR_{a,d}$ = Inhalation Unit Risk $(s/cc)^{-1}$. This is the excess cancer risk per PCM s/cc in inhaled air for a continuous exposure beginning at age "a" and continuing for duration "d" years.

The level of cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, EPA considers excess cancer risks that are below about 1E-06 (one in one million) to be so small as to be negligible, and risks above 1E-04 (one in ten thousand) to be sufficiently large that some sort of response is recommended. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (EPA 1991), although this is evaluated on a case-by-case basis, and EPA may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action. Note that risk management decisions generally consider the sum of all the risks to an individual contributed by differing exposure scenarios, rather than simply evaluating each one independently.

5.3 Inputs to the Equation

5.3.1 Exposure Point Concentration (EPC)

An exposure point is a location where exposure and risk are to be evaluated, and an exposure point concentration (EPC) is an estimate of the long-term average concentration of LA in air at that location, expressed as PCM or PCME s/cc. For indoor air, each school was treated as an exposure point. For outdoor exposures, each ABS study area was treated as an exposure point.

Ideally, the EPC used in the risk calculations for each exposure location would be the true average concentration within the exposure area, averaged across the exposure duration "d". However, the true average concentration at a location can only be approximated from a finite set of measurements, and the observed sample mean might be either higher or lower than the true mean.

To minimize the chances of underestimating the true level of exposure and risk, EPA generally recommends that risk calculations be based on the 95% upper confidence limit (95UCL) of the sample mean (EPA 1992), and has developed a software application (ProUCL) to assist with the calculation of UCL values (EPA 2007a). However, the equations and functions in ProUCL assume that all of the concentration values in a data set are accurate, and that measurement error is negligible. In the case of asbestos, measurements of concentration in air are subject to random Poisson measurement error during the TEM analysis, with the relative magnitude of the error tending to increase as the number of asbestos structures observed decreases. Thus, application of ProUCL to asbestos data sets may not yield reliable estimates of the 95UCL, especially when counts are small.

Because the 95UCL cannot presently be calculated with confidence, risk calculations presented in this report utilize the sample mean only. The sample mean is an unbiased estimate of the true concentration, but the true concentration may be either higher or lower. However, the potential magnitude of the difference between the sample mean and the true mean cannot presently be quantified.

Note that, when computing the mean of a set of air samples, all samples with a count of zero PCME LA structures are evaluated using a value of zero (EPA 2008a). This is important, because assigning any value greater than zero to such samples will tend to bias the sample mean high (EPA 1999).

A special case arises when all of the samples in a data set have a count of zero. The calculated mean of the data set is zero, but the true concentration may be greater than zero. In this report, data sets with all zero counts are evaluated by calculating the mean analytical sensitivity, and assigning a concentration that is less than one structure times the mean sensitivity. For example, if the mean sensitivity were 0.001 cc^{-1}, the EPC would be reported as < 0.001 s/cc. Although not statistically rigorous, this value may reasonably be thought of as a conservative "upper bound" on the true mean.

5.3.1.1 <u>EPCs for Indoor Air</u>

As noted earlier (see Table 3-1), all indoor air results were non-detect for PCME LA. Therefore, the EPC for indoor air at each school was characterized based on the mean sensitivity of air samples collected at each school, as described above. Table 5-1 presents the EPCs for indoor air used to evaluate risk from indoor exposures at schools.

5.3.1.2 <u>EPCs for Outdoor Air</u>

For outdoor exposures during soil disturbance activities, EPCs were computed as the average of the ABS air concentrations across receptor-specific activities and across time (three sampling rounds) (see Table 4-1). This is because the goal is to estimate the long-term average exposure concentration over many years of various types of outdoor activities at schools. Table 5-2 presents school-specific and receptor-specific EPCs for outdoor air used to evaluate risk from outdoor exposures at schools.

5.3.2 Time-Weighting Factor (TWF)

The value of the TWF describes the average fraction that exposure occurs in the time interval being evaluated. The general equation is (EPA 2008a):

$$TWF = ET/24 \cdot EF/365$$

where:

ET = Average exposure time (hrs/day) on days when exposure is occurring
EF = Average exposure frequency (days/year) in years when exposure is occurring

For example, if a person were exposed to asbestos 10 hours per day for 200 days per year, the value of TWF would be:

$$TWF = 10/24 \cdot 200/365 = 0.228$$

All exposure parameters are based on interviews with school administrators at each school. Both the indoor and outdoor exposure assumptions were developed to be representative of the entire year, which includes extreme variations in weather.

Table 5-3 provides the site-specific data provided by school officials on indoor exposure parameters by students and teachers, along with the resulting indoor TWF values. Table 5-4 provides the site-specific data provided by school officials on the outdoor exposure parameters for students and maintenance workers at each school, along with the resulting outdoor TWF values.

5.3.3 Inhalation Unit Risk (IUR)

$IUR_{a,d}$ is the lifetime excess cancer risk per PCM(E) fiber/cc in air for a specified exposure scenario that begins at age "a" and lasts for duration "d" years. EPA (2008a) presents a table of IUR values for a wide range of differing values of *a* and *d*, and also provides equations for calculating $IUR_{a,d}$ for any values of *a* and *d* that may not be present in the table.

Table 5-5 summarizes the values of *a* and *d* used for each exposure group (students, teachers, maintenance staff, and lawn mowers), along with the corresponding values of $IUR_{a,d}$.

5.4 Results

5.4.1 Results by School

Table 5-6 summarizes the inputs and the resulting screening level cancer risk estimates for each receptor at each school for indoor air, outdoor air, and indoor and outdoor air combined.

For indoor air, risk estimates range from < 2E-06 to < 8E-06. As noted earlier, no PCME LA structures were observed in any sample, so these estimates are based on the mean analytical sensitivity, which may be thought of as a conservative "upper bound" on the true concentration.

Screening level risk estimates for outdoor exposures range from 3E-08 to a maximum of < 2E-05. As above, in many cases, no PCME LA structures were detected in any ABS air samples, so many risk estimates are upper bound values.

5.4.2 Results Summed Across Schools

The total risk to students from school-related exposures may be estimated by summing the risks to students across all of the schools they attend. For a student who progresses from Kootenai Valley Head Start through the Libby Elementary, Middle and High School, the total combined risk is < 2E-05.

Similarly, the risk that would apply if the same individual mowed the lawns at all five of the schools in Libby may be estimated by summing risk from lawn mowing across all schools. The resulting value is < 2E-05.

5.4.3 Risk Summary

Excess cancer risk from inhalation exposure to LA at Libby schools is within or below EPA's acceptable risk range (1E-04 to 1E-06) for students, teachers, and staff at all schools.

5.5 Uncertainties in Risk Estimates

Although EPA has used the best available science to evaluate potential risks from LA asbestos at the schools, there are number of sources of uncertainty in the risk calculations presented in this report. The most important of these include:

- Uncertainty in true long-term average LA concentrations in air.
  Concentrations of LA in ABS air (especially outdoor ABS air) are inherently variable, so estimates of mean exposure concentrations are subject to uncertainty arising from random variation between individual samples ("sampling uncertainty"). This sampling uncertainty is compounded by the effect of analytical measurement error. That is, for each air sample collected, the number of asbestos structures observed during the analysis is a random variable that is characterized by the Poisson distribution:

  $$Count_{observed} \sim \text{POISSON}\ (Concentration_{true} \cdot \text{Volume Analyzed})$$

  For example, if the true quantity ($Concentration_{true}$ * Volume Analyzed) were 3.72, then the probability of observing a specified number of structure counts during the TEM analysis would be as follows:

Count	Probability
0	2.4%
1	9.0%
2	16.8%
3	20.8%
4	19.3%
5	14.4%
6	8.9%
7	4.7%
8	2.2%

In general, the relative magnitude of the uncertainty due to Poisson variation tends to be largest for small counts, and decreases as count increases. The overall uncertainty in a measured concentration is the combination of the sampling error and the Poisson measurement error. However, the magnitude of the potential error cannot be estimated because appropriate statistical methods are not yet available to calculate the 95UCL.

In the special case of a data set where all samples had a count of zero, the concentration is reported as less than one structure times the mean analytical sensitivity, and risk is based on that reported concentration value. This approach is likely to be conservative, and actual risks are likely lower than reported.

- Uncertainty due to indirect sample preparation. During TEM analysis of air samples collected during this project, 27 of the air filters out of 114 samples were overloaded with particulates. In accord with the Schools SAPs (EPA 2008b, EPA 2009), these filters were prepared for TEM analysis using an indirect preparation method with ashing per SOP EPA-LIBBY-08. This is a potential source of uncertainty because, at least in the case of chrysotile asbestos, indirect preparation may tend to increase structure counts due to dispersion of bundles and clusters (Hwang and Wang 1983; HEI-AR 1991; Breysse 1991). However, for amphibole asbestos, the effects of indirect preparation are generally much smaller (Bishop et al. 1978, Sahle and Laszlo 1996, Harris 2009). The expectation that indirect preparation is a relatively minor source of uncertainty in estimates of LA concentration is supported by a Libby-specific study conducted in 2005 (EPA 2007b).

- Uncertainty in human exposure patterns. Risk calculations require knowledge of the duration, frequency, and age at which exposure occurs. Exposure parameters for students and staff were provided to EPA by school officials, so these parameters are believed to be reasonable and site-specific. However, the true parameters for any individual may be either higher or lower than the values assumed, so risks to individuals may vary from the values reported.

- Uncertainty in the cancer exposure-response relationship. Available data from studies in both animals and humans suggest that the risk of cancer from inhalation exposure to asbestos may depend in part on the type of asbestos (chrysotile vs. amphibole) and on the dimensions (length and width) of the inhaled fibers. Evaluations performed to date suggest that amphibole asbestos is somewhat more potent than chrysotile (e.g., Hodgson and Darnton 2000; Berman and Crump 2008a, b), although quantification of the difference remains difficult. The current EPA method for estimating cancer risk is based on a set of epidemiological studies in which some workers were exposed to chrysotile and other workers were exposed to amphibole (mainly amosite and crocidolite). Consequently, the current EPA potency estimates may be somewhat low for use at a site such as Libby where exposure is to amphibole asbestos only. It is also important to note that the current EPA method for estimating cancer risk is based on the best estimates of the cancer potency factors for lung cancer and mesothelioma, and that the true value of the potency factors might be up to 10-times higher or lower than the best estimates (EPA 1986). Consequently, true risks might be up to 10-times higher or lower than the values reported here.

- Uncertainty in age-dependent factors. In some cases, children are more susceptible to the effects of a toxic chemical than adults. In the case of asbestos, the existing risk models do predict higher risks to children than adults (assuming equal exposures). However, the potency factors used to support these risk calculations are all based on studies in adults, and it is unknown whether or not age-dependent differences in physiology might increase childhood susceptibility to asbestos.

- Lack of an approved method for assessing non-cancer risks. As noted above, EPA has not yet developed national guidance for evaluating the risk of non-cancer effects from inhalation exposure to asbestos. However, numerous studies of former workers and area residents provide evidence that exposure to LA results in an increased incidence of non-cancer adverse effects. It is not presently known whether exposure levels that protect against cancer risk will also protect against non-cancer risk from asbestos.

- Uncertainty associated with cumulative exposures. As noted above, most students and staff at schools in Libby may be exposed to LA not only at schools but at other locations as well. EPA will consider the total cumulative risks to individuals in the final risk management decision process for the Libby Site.

Because of these uncertainties, all risk values presented here should be considered to be approximate, and actual risks may be either higher or lower than estimated. However, despite the uncertainties, the results strongly support the conclusion that risks are at the low end of EPA's acceptable risk range.

5.6 Conclusions

The primary objective of the schools monitoring program was to determine if residual LA at schools poses risks to students, staff or maintenance workers that are within acceptable bounds, or if further cleanup actions at schools are needed. Based on the data collected from the Indoor and Outdoor Schools sampling programs, it is concluded that residual risks from indoor exposure and outdoor exposure at schools, both alone and in combination, are within or below EPA's acceptable risk range, and that further cleanup actions are not needed. As mentioned above, EPA will consider the total cumulative risks to individuals in the final risk management decision process for the Site.

6 DATA QUALITY ASSESSMENT

Data quality assessment (DQA) is the process of reviewing existing data to establish the quality of the data and to determine if any data quality limitations may influence data interpretation (EPA 2006). Data quality may be evaluated by a variety of metrics, as described below.

6.1 Audits

6.1.1 Field Audits

Field audits are conducted to evaluate the day-to-day activities of field personnel and ensure all processes and procedures are performed in accord with the applicable field guidance documents (or approved Libby Field Office [LFO] modification forms) and that all sample collection is correct and consistent. All aspects of data documentation and sample collection, as well as sample handling, custody, and shipping are evaluated. If any issues are identified, field personnel are notified and re-trained on the correct procedures.

A field audit was performed on September 18, 2009, during the collection of outdoor ABS samples at Libby Middle School (101 Ski Road). The detailed results of this audit are provided in Appendix D. No deficiencies were observed or noted during the field audit.

6.1.2 Laboratory Audits

Laboratory audits are conducted to evaluate laboratory personnel to ensure that samples are handled and analyzed in accord with the program-specific documents and analytical method requirements (or approved Libby laboratory modification forms) and that reported analytical results are correct and consistent. All aspects of sample handling, preparation, and analysis are evaluated. If any issues are identified, laboratory personnel are notified and retrained.

A series of laboratory audits was performed in the Summer/Fall of 2008 to evaluate all of the Libby laboratories. No critical deficiencies were noted during the laboratory audits that would be expected to impact data quality.

6.2 Modifications

During any sampling program, deviations from the original SAP may occur and/or it may be necessary to modify procedures identified in the original SAP to optimize sample collection. At the Libby Site, all field and laboratory modifications are recorded in site-specific modification forms. These forms provide a standardized format for tracking procedural changes in sample collection and analysis and allow project managers to assess potential impacts on the quality of the data being collected.

During the Schools sampling programs, only one new modification (LFO-000146) was instituted beyond those already identified and accepted in the Indoor and Outdoor Schools SAPs (EPA 2008b, 2009). Table 6-1 lists all applicable field and laboratory modifications associated with the Schools sampling programs and summarizes their potential impacts on the quality and usability of the data. As shown, none of these modifications are expected to negatively impact data quality or usability.

Appendix E provides copies of all applicable field and laboratory modifications associated with the Schools sampling programs.

6.3 Data Verification

At the time of the Schools sampling programs[3], sample and analytical electronic data were stored and maintained in the Libby2 Database (referred to as the Libby2DB) which was housed on a SQL server at EPA Region 8 in Denver, Colorado. The Libby2DB has a number of built-in quality control checks to identify unexpected or unallowable data values during upload into the database. Any issues identified by these automatic upload checks are resolved by consultation with the analytical laboratory before entry of the data into the database. After entry of the data into the database, several additional data verification steps are taken to ensure the data are recorded and entered correctly.

To ensure that the Libby2DB accurately reflects the original hard copy documentation, all data downloaded from the database are examined to identify data omissions, unexpected values, or apparent inconsistencies. In addition, 100% of all indoor air sample results and approximately 10% of all outdoor air sample results underwent a detailed verification. In brief, verification involves comparing the data for a sample in the Libby2DB to information on the original hard copy FSDS form and on the original hard copy analytical bench sheets for that sample. Any omissions or apparent errors identified during the verification are submitted to the field teams and/or analytical laboratories for resolution and rectification in the Libby2DB and in the hard copy documentation.

6.3.1 Field Sample Data Sheet (FSDS) Review

FSDS forms were reviewed for all 50 indoor air samples as part of the data verification effort. Only one error was found. In this one case, it was determined (based on input

[3] EPA is in the process of transitioning to a new data management system, referred to as Scribe.net. In the future, sample and analytical electronic data will be stored and maintained the Libby Data Warehouse which is populated by Scribe.net and housed on the EPA network.

from the field team) that the recorded address was incorrect on the FSDS form. Because this information was correct in the database, results for this location were not impacted.

A subset of the FSDS forms for outdoor air and soil samples were also reviewed as part of the data verification effort. A total of 7 air sample and 5 soil sample FSDS forms were reviewed. No errors were identified.

Appendix F presents a summary of the findings of the FSDS review for both indoor and outdoor samples.

6.3.2 TEM Review

All 50 indoor air TEM analyses were reviewed as part of the data verification effort. Only one discrepancy was found in one analysis. The analyst incorrectly applied Libby Laboratory Modification #LB-000066. This modification requires TEM analysts to note information on the levels (presence/absence) of the sodium and potassium peaks observed in the EDS spectrum for the recorded LA structure in the EDD comment field. This type of error is not deemed to be critical for this report (i.e., did not influence the reported air concentration).

A subset of the outdoor air TEM analyses (7/50 samples) were reviewed as part of the data verification effort. Only one error was found. A duplicate record was found in the database (i.e., the analysis EDD was uploaded twice). The duplicate record has been excluded for the dataset summarized in this report.

Appendix F presents a summary of the findings of the TEM analysis review for both indoor and outdoor samples.

6.3.3 PLM Data Review

Five of 41 PLM analyses of outdoor soil samples were selected for review. No discrepancies were found between the hard copy reports and the Libby2DB.

6.4 Quality Control Sample Summary

A number quality control (QC) samples were collected as part of the Schools programs to help characterize the accuracy and precision of the data obtained. QC samples included both field-based samples (which are submitted blind to the laboratories) and laboratory-based samples.

A detailed evaluation of these QC samples is provided in Appendix G. Based on the results of the QC evaluation presented in Appendix G, it is concluded that:

- Inadvertent contamination of air or soil field samples with LA is not of significant concern, either in the field or the laboratory.

- For TEM analysis of air samples, precision is generally good, as indicated by high agreement rates between field samples and field duplicates, between original and re-preparation analyses, and between original and recount analyses (samples where the same grid openings are evaluated twice).

- PLM precision for soil samples is generally good, as indicated by high concordance rates between field samples and matched field duplicates and laboratory duplicates.

- PLM accuracy for soil samples is generally good, as indicated by the absence of any strongly discordant results when analyzing performance evaluation (PE) samples. However, there is a higher than expected frequency of results for PE samples that are weakly discordant when compared to the nominal value, with a consistent tendency for the results to be biased high.

6.5 Data Adequacy Evaluation

Data adequacy is evaluated by comparing the data obtained to the DQOs and the sampling and analysis requirements specified in project planning documents (EPA 2008b, 2009).

6.5.1 TEM Air Data

6.5.1.1 <u>Spatial and Temporal Representativeness</u>

Outdoor

In accord with the Outdoor Schools SAP, outdoor samples were collected from representative exposure locations at all schools in Libby. Based on this, the Outdoor Schools ABS data collected are considered to be spatially representative.

ABS samples were collected during the time of year (July-September) that is expected to represent the high-end of the LA-releasability range in Libby. Because releasability from soil to air in the summer may be higher than at other times of year when the ground is frozen or snow-covered (typically November through March), concentration values may be biased somewhat high compared to year-long averages.

Indoor

Samples were collected from all five Libby public schools in December of 2008. Multiple locations were sampled within each school building from rooms and hallways that are representative of typical school conditions. Samples were also collected during the time in which the location was thought to be typically used by students. Based on this, the Indoor Schools data collected are deemed to be spatially and temporally representative.

6.5.1.2 Sample Completeness

Completeness is defined as the fraction of planned samples that were successfully collected and analyzed. As described above, for outdoor samples, it was expected that 3-9 samples would be collected from each school for each typical scenario, only 3 of which would be analyzed. For indoor samples, it was expected that 10 samples would be collected from each school. As seen in Table 3-1 (indoor) and Table 4-2 (outdoor), the number of results expected was achieved for all schools.

6.5.1.3 Sample Duration

Outdoor

As specified in the Outdoor Schools SAP, each soil disturbance activity was planned to span a 2-hour time interval. Actual sampling times for outdoor ABS samples ranged from 1.4 hours to 2.3 hours, with an average of 2.1 hours. Only two samples out of 63 had sampling times less than the target duration (2 hours), with values of 1.4 and 1.7 hours. Although less than the target, these sampling durations are both considered to be long enough to ensure temporal representativeness. Based on this, it is concluded that all outdoor ABS samples met temporal representativeness goals.

Indoor

As specified in the Indoor Schools SAP, sampling was to occur on two sequential days for 2 to 8 hours/day (4 to 16 hours total). Actual sampling times for indoor ABS samples ranged from a minimum of 6.7 hours to a maximum of 15.9 hours, with an average of 13.0 hours. Based on this, it is concluded that all indoor ABS samples met temporal representativeness goals.

6.5.1.4 Analytical Sensitivity

Outdoor

As specified in the Outdoor Schools SAP, the target analytical sensitivity for all outdoor air samples was 0.003 cc^{-1}. Table 4-2 summarizes the analytical sensitivities achieved for all outdoor Schools air samples. As seen, about 79% of all samples achieved the target sensitivity of 0.003 cc^{-1}. When samples did not achieve the target sensitivity, it was because the sample needed to be prepared indirectly due to overloading on the filter. In these samples, the TEM analysis was stopped because an area of at least 0.5

mm^2 was analyzed. The consequence of not achieving the analytical sensitivity is that the concentration estimates for these samples have somewhat higher uncertainty than would have been achieved if the samples had been analyzed until the analytical sensitivity was achieved. However, it is not expected that this leads to any bias in the data, so the overall impact on data quality is not expected to be significant.

Indoor

As specified in the Indoor Schools SAP, the target analytical sensitivity for all indoor air samples was 0.0006 cc^{-1}. Table 3-1 summarizes the analytical sensitivities achieved for all indoor Schools air samples. As seen, the analytical sensitivity achieved was close to the target of 0.0006 cc^{-1} in all cases.

6.5.2 Soil Samples

Sample Completeness

Based on the Outdoor Schools SAP, a 30-point soil composite sample was to be collected from each scenario area during the first and third of the three sampling events. In addition, a 2-point composite sample was to be collected from each digging activity location for each sampling event. Each sampling point was to be visually inspected for vermiculite.

The Outdoor Schools program was able to collect and perform PLM analyses and visible inspections for all of the target number of soil samples (i.e., 100% completeness).

6.6 Data Quality Conclusions

Taken together, these results indicate that TEM and PLM data collected at the Libby site as part of the Schools program are of acceptable quality, and are considered to be reliable and appropriate for use without qualification.

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