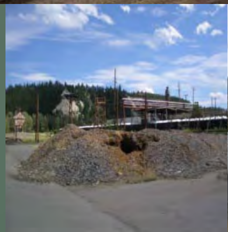
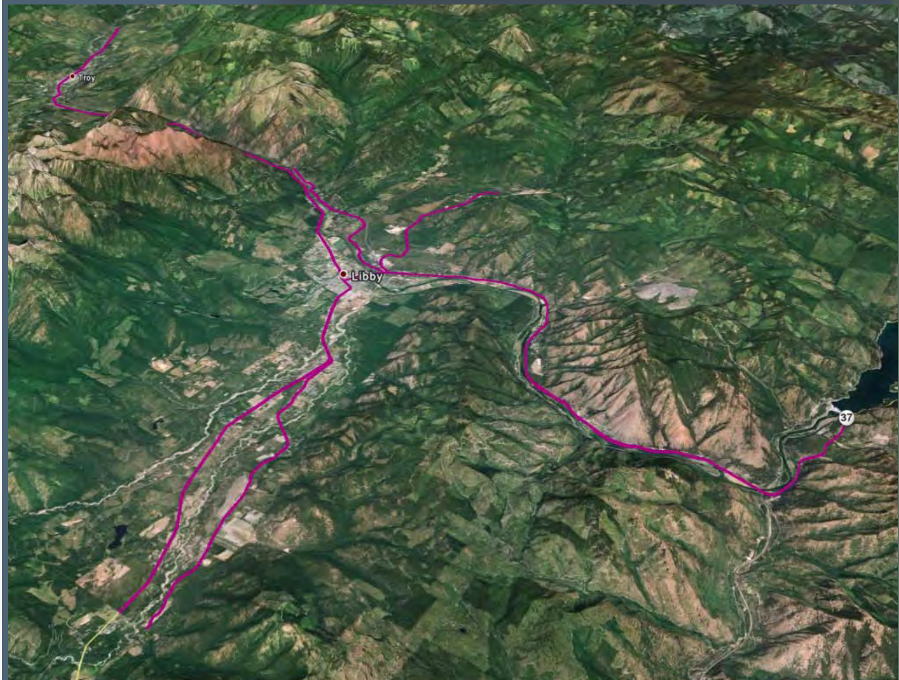
DRAFT Remedial Investigation Report

Operable Unit 8
Libby Asbestos National Priorities List Site

Libby, Montana

April 2012





EPA United States
Environmental Protection Agency
"...to protect human health and to safeguard the natural environment..."

DRAFT
Remedial Investigation Report

Operable Unit 8
Local and State Highways in Libby and Troy
Libby Asbestos National Priorities List Site
Libby, Montana

April 2012

Prepared for
US Environmental Protection Agency

by

HDR Engineering, Inc.
and
TechLaw, Inc.

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LIST OF ACRONYMS

ABS	Activity-Based Sampling
AM	Amosite
ATSDR	Agency for Toxic Substances and Disease Registry
ATV	All Terrain Vehicle
bgs	below ground surface
CSF	Close Support Facility
COC	Chain of Custody
CSM	Conceptual Site Model
DQA	Data Quality Assessment
DQOs	Data Quality Objectives
ED	Exposure Duration
EDD’s	Electronic Data Deliverables
EF	Exposure frequency
EPA	U.S. Environmental Protection Agency
EPC	Exposure point concentration
ERT	Emergency Response Team
ESAT	Environmental Services Assistance Team
ET	Exposure Time
FSDS	Field sample data sheet
Ft	Feet
Ft/day	Feet per day
HAEC	Human Airway Epithelial Cells
HHRA	Human Health Risk Assessment
HI	Hazard Index
HQ	Hazard Quotient
IRIS	Integrated Risk Information System
ISO	International Organization for Standardization
IUR	Inhalation Unit Risk
LA	Libby Amphibole
MCE	Mixed Cellulose Ester
MDOT	Montana Department of Transportation
NAS	National Academy of Sciences
ND	Non-Detect
NPL	National Priority List
OUs	Operable Units
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscopy Equivalent
PLM	Polarized light microscopy
PLM-VE	Polarized Light Microscopy – Visual Estimation
QAPP	Quality Assurance Project Plan
RfC	Reference Concentration
RI	Remedial Investigation
ROW	Right-Of-Way
s/cc	structures per cubic centimeter

SAP	Sampling and Analysis Plan
SERAS	Scientific, Engineering, Response and Analytical Services Program
SH2	State Highway 2
SH37	State Highway 37
SOPs	Standard Operating Procedures
TEM	Transmission Electron Microscopy
TWF	Time Weighting Factor
UCL	Upper confidence limit
μm	micrometer

EXECUTIVE SUMMARY

Overview

This Remedial Investigation (RI) Report describes the nature and extent of Libby amphibole (LA) asbestos and associated human health risks at Operable Unit 8 (OU8) of the Libby Asbestos National Priority List (NPL) Site (the Site).

Operable Unit 8 is also referred to as state and local highways and includes segments of roadway right-of-way (ROW) in and within 30 miles of Libby (Figure ES-1).

Asbestos found at the Libby mine contains a variety of different amphibole types. Because there are presently insufficient toxicological data to distinguish between the different forms, the Environmental Protection Agency (EPA) evaluates all of the mine-related amphibole asbestos types together. This mixture is referred to as LA. Most of the mining operations in Libby were not focused on asbestos, as it was not particularly valuable. However, vermiculite, the main ore extracted and processed at the mine, often contained asbestos and therefore, vermiculite mining acted as a carrier to spread asbestos throughout Libby. Raw vermiculite ore was estimated to contain up to 26% LA.

Asbestos exposure in humans may cause both cancer and non-cancer effects. Among them are:

Non-Cancer Effects:

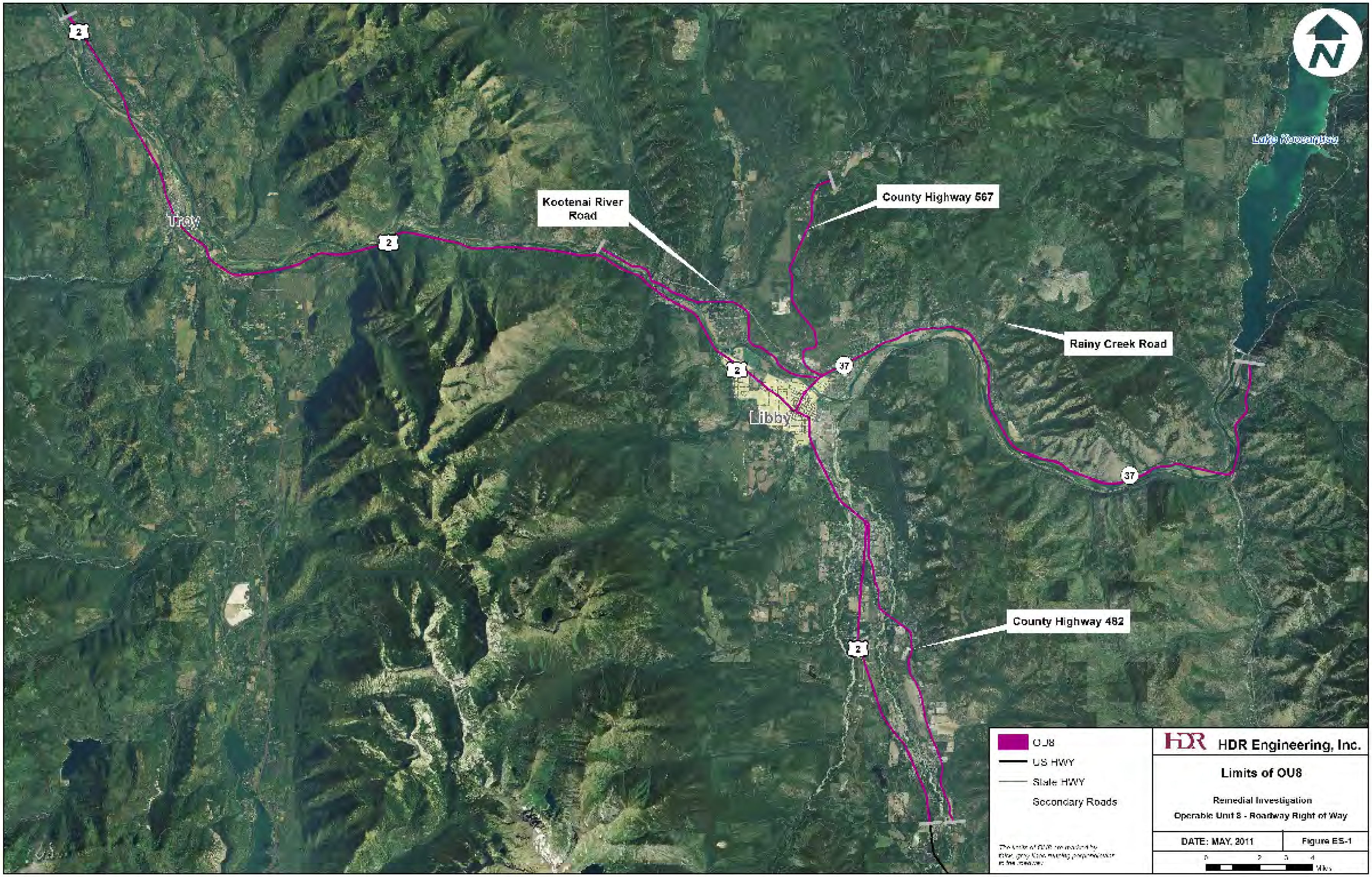
- Asbestosis
- Pleural Abnormalities

Cancer Effects:

- Lung cancer
- Mesothelioma

People who visit or work at OU8 may be exposed to LA by incidental ingestion of contaminated soil or dust and by inhalation of air that contains LA fibers. Of these two pathways, inhalation exposure is considered to be of greater concern.

The amount of LA fibers released to air will vary depending upon the level of LA in the source material (e.g., outdoor soil) and the intensity and duration of the disturbance activity. Because of this, predicting LA levels in air associated with disturbance activities based only on measured LA levels in source material is extremely difficult. Therefore, the most direct way to determine potential exposures from inhalation is to measure, through sampling and analysis, the concentration of LA in air during a specific activity that disturbs a source material. For convenience, this is referred to as activity-based sampling (ABS).


Troy
Kootenai River Road
County Highway 567
Lake Koocanusa
Rainy Creek Road
Libby
County Highway 482
2
37
OU8
US HWY
State HWY
Secondary Roads
HDR Engineering, Inc.
Limits of OU8
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MAY, 2011
Figure ES-1
Miles

Site Investigations

Investigations of portions of roadway ROW were conducted by EPA in 2003 and 2005, prior to the establishment of OU8. The most relevant investigations included collection of soil samples along US Highway 2 between Libby and Rainy Creek Road (Figure ES-1). Once OU8 was established in 2009, EPA conducted extensive sampling of soil and air during 2010 and 2011 including the following media-specific sampling:

- Soils
  - ➢ Surface – composite samples collected from as much as 6-inches below ground surface.
- Air
  - ➢ Personal air samples – collected using a sampling pump and filter located in the breathing zone of an individual (or mounted on equipment) while performing various outdoor activities.
  - ➢ Stationary air samples – collected using a stationary sampling pump and filter placed in a location that acts as a surrogate for a personal air sample.

Soil samples were collected and analyzed for LA in order to determine the distribution of LA (and visible vermiculite) along roadway ROWs. This information was used to, among other things, determine whether ABS sampling was performed over a range of LA levels and visible vermiculite conditions.

In most cases, one composite soil sample was created from ten aliquots collected for every 1,000 ft of ROW. A total of 485 field (non-QC) composite soil samples was collected from July 7 to September 10, 2010. Of these, 397 contained no detectable LA and the remaining 88 samples contained trace levels of LA.

Visible vermiculite was not observed in composite soil samples with the exception of those collected along the far eastern end of State Highway 37 (Figure ES-1). In this area, more than ten samples contained visible vermiculite. However, polarized light microscopy results for these samples were non-detect to trace for LA, which is typical of the rest of the OU. It is not clear why vermiculite was noted by visual inspection but LA was not detected by laboratory analyses.

ABS air samples were collected in association with the following activities:

Recreational Activities

- Riding all terrain vehicles (ATV) with a lead and following ATV.

Montana Department of Transportation (MDOT) Maintenance Activities

- Rotomilling of asphalt pavement
- Grass cutting and brush hogging in ROWs.

All ATV, brush hogging and grass cutting ABS sampling during the 2010-2011 OU8 Field Program was conducted along Hwy 37 between Libby and Rainy Creek Road (Figure ES-1). This portion of roadway was selected for ABS based on the presence of LA and visible vermiculite in surface soils as determined during investigations in 2003 and 2005. Samplers were mounted on the front and back of the grass cutting and brush hogging equipment as well as on the “following” ATV.

Rotomilling ABS sampling was performed along Hwy 37 in downtown Libby as part of regularly scheduled maintenance work conducted by the MDOT. The general area of interest (California Ave.) was selected because one of several core samples collected in California Ave. in March 2010 contained a trace (0.1%) of LA.

Rotomilling ABS consisted of samplers mounted on the moving rotomill as well as on a small front-end loader. In addition, stationary samplers were positioned on the sidewalk adjacent to the street where rotomilling operations were conducted. These samplers comprised the “inner perimeter” sampling stations.

In addition to the ABS sampling, several stationary air samplers were placed at various locations within downtown Libby but remote from the rotomilling operations. Samples collected from these locations are representative of ambient conditions and are referred to as “outer perimeter” samples.

Sample results are summarized below:

- Of the 34 ABS air samples associated with ATV riding, brush hogging and grass cutting, LA was detected in 8 samples. Of those, 7 were associated with brush hogging and one was found in association with ATV riding.
- Of the 10 ABS air samples collected from rotomilling equipment, no LA was detected.
- Of the 51 air samples collected from the inner perimeter, only one contained detectable LA.
- Of the 25 ambient air samples collected around downtown Libby, none contained detectable LA.

Risk Assessment

This risk assessment uses available data to estimate the current and future health risks to people who may inhale asbestos fibers while performing maintenance or recreational activities along the roads and highways in OU8, based on current conditions. The value of the exposure point concentration term is based on measurements of asbestos concentration levels in air.

Methods used to evaluate human health risks from asbestos are in basic accord with EPA guidelines for evaluating risks at Superfund sites, including recent guidance that has been specifically developed to support evaluations of exposure and risk from asbestos.

EPA has collected sufficient data to allow evaluation of exposure pathways that are thought to be most likely of potential concern in OU8. These pathways are the main focus of the risk assessment and include:

- Road construction activities include rotomilling and asphalt work.
- Maintenance activities adjacent to the roadways include grass cutting, road sweeping, ditch cleaning and brush hogging.
- ATV riders who may be exposed to asbestos fibers via inhalation along roadways.

Cancer risk and non-cancer hazard estimates for each site receptor are pending finalization of toxicity values for LA.

An ecological risk assessment is being developed for the mine site (OU3). EPA will build upon the information gathered during that ecological risk assessment to identify potential pathways and receptors to evaluate ecological risk at OU8. If ecological exposure pathways are identified at OU8 an ecological risk assessment will be performed.

1.0 INTRODUCTION

1.1 OVERVIEW AND REPORT ORGANIZATION

This Remedial Investigation (RI) Report describes the nature and extent of Libby amphibole (LA) asbestos and associated human health risks at Operable Unit 8 (OU8) of the Libby Asbestos National Priority List (NPL) Site (the Site). LA occurrence throughout the Site resulted from long time mining activities and the use and handling of materials which contained LA.

U.S. Environmental Protection Agency (EPA) has had a presence in Libby since 1999 and has completed a number of sampling activities and removal efforts. EPA determined there was imminent and substantial endangerment to public health from asbestos contamination in various types of source materials in and around Libby.

In light of evidence of human asbestos exposure and associated increase in health risks, it was recommended that EPA take appropriate steps to reduce or eliminate exposure pathways to these materials to protect area residents and workers. In 2002, Libby was classified as a NPL Site which, due to its large size, has been divided into eight Operable Units (OUs):

- OU1 – Former Export Plant
- OU2 – Former Screening Plant
- OU3 – Mine Site
- OU4 – Residential and commercial properties in and around Libby
- OU5 – Former Stimson Lumber Mill
- OU6 – Rail Line
- OU7 – Residential and commercial properties in and around Troy
- OU8 – US and Montana State highways and secondary highways in the vicinity of Libby and Troy, Montana.

Figure 1-1 presents a map showing the entire NPL area and boundaries of all OUs. This RI addresses OU8, which includes various State and local highways in the vicinity of Libby and Troy, Montana.

As determined by previous investigations conducted at the Site, LA is present in multiple environmental media. During 2003 and 2005 soil samples were collected along portions of State Highway 37 and were found to contain LA and visible vermiculite (CDM, 2005). During 2006 and 2007, soil and air samples were collected during routine maintenance activities performed by the Montana Department of Transportation (MDOT). LA was detected in some of those samples. In March 2010, five asphalt core samples were taken from California Street and US Highway 2 (in downtown Libby) and analyzed for asbestos. In one of the core samples, a trace (0.1%) of LA was detected indicating LA may be embedded in the roads in and around Libby (Lockheed Martin, 2010a). Based on this evidence, EPA established OU8 and began planning for the RI described in this report.

The RI Report is organized into the following major sections:

Section 1 – Introduction – This section describes the purpose of the RI and summarizes prior work and NPL Site history.

Section 2 – Site Characteristics – This section provides a brief description of Site setting, climate, geology, hydrogeology, and surface water hydrology.

Section 3 – Sampling and Analyses – This section discusses sample types and collection methods and analytical techniques.

Section 4 – Data Recording, Data Quality Assessment, and Data Selection – This section discusses the Libby database, quality control measures and how data were selected to produce the final OU8 data set used to describe the nature and extent of contamination and for calculation of health risk estimates.

Section 5 – Nature and Extent of LA – This section provides a description of the current type and extent of LA in surface soils and outdoor air.

Section 6 – Contaminant Fate and Transport – This section provides a qualitative discussion of LA contaminant migration routes and persistence in the environment.

Section 7 – Human Health Risk Assessment – This section presents the human health risk assessment.

Section 8 – Conclusions – This section presents general conclusions.

Section 9 – References – This section provides full references for all citations in the body of the report.

1.2 NPL SITE LOCATION & TOPOGRAPHY

The City of Libby, Montana is located in the northwest corner of the state, 35 miles east of Idaho and 65 miles south of the Canadian border (Figure 1-1). It is at an elevation of approximately 2,580 feet above mean sea level (msl). The source of LA, Vermiculite Mountain, is located approximately 7 miles northwest of Libby. The city has a total area of 1.3 square miles and lies in a valley carved by the Kootenai River and bounded by the Cabinet Mountains to the south.

Operable Unit No. OU8 consists of the right-of-way of the following State and local highway segments (See Figure 1-2):

- Montana State Highway 37 (SH37)
- Montana State Highway 2 (SH2)
- Kootenai River Road
- County Highway 482 (Farm to Market Road)
- County Highway 567 (Pipe Creek Road)

1.3 NPL SITE HISTORY

Libby is located near a large open-pit vermiculite mine on Vermiculite Mountain. Vermiculite is a mica-like mineral that can be processed for use as an insulating material or soil amendment and has been mined in Libby since 1919. It is estimated that the Libby mine was the source of over 70 percent of all vermiculite sold in the U.S. from 1919 to 1990. Over its lifetime, it employed more than 1,900 people. W. R. Grace bought the mine and processing facility in 1963 and operated it until 1990 (EPA, 2010a).

Vermiculite from this mine contains varying levels of amphibole asbestos, consisting primarily of winchite and richterite, with lower levels of tremolite, magnesioriebeckite, and possibly actinolite. Because existing toxicological data are not sufficient to distinguish differences in toxicity among these different forms, EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as Libby Amphibole asbestos. Historic mining, milling, and processing operations, 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. This has caused a range of adverse health effects in exposed people, including individuals who did not work at the mine or processing facilities.

EPA has been working in Libby since 1999 when an Emergency Response Team was sent to investigate local concern and news articles about asbestos-contaminated vermiculite. Since that time, EPA has been working closely with the community to clean up contamination and reduce risks to human health.

Based on health risks associated with asbestos, which include asbestosis, lung cancer and mesothelioma, EPA placed the Libby Asbestos Site on the NPL in October 2002.

Libby, Montana, which is the Lincoln County seat, has a population of less than 3,000, and 12,000 people live within a ten-mile radius. While Libby's economy is still largely supported by natural resources such as logging and mining, there are also many tourist and recreational opportunities in the area.

1.4 REGULATORY HISTORY

The following is a brief chronological summary of major regulatory actions taken at the Site.

- 1999 – Local concern alerts EPA to investigate asbestos in and around Libby, Montana
- 2002 – Libby Asbestos Site proposed for the NPL
- 2002 – Libby Asbestos Site formally added to the NPL
- 2009 – Operable Unit No. 8 added to the Site.

EPA has not entered into any enforcement agreements or issued any orders for investigation, removal, or remedial work at any part OU8. However, EPA has addressed some parts of OU8 along with the remedial actions for other OUs. EPA addressed the portion of Highway 37 adjacent to OU2 as part of the OU 2 removal and remedial actions. EPA will address the portion of Highway 37 adjacent to OU1 as part of the OU1 remedial action. These actions were not pursuant to any enforcement agreement or order. They were funded with special account money under the settlement EPA entered into with the only known Potentially Responsible Party for OUs 1, 2, and 8, W. R. Grace, in 2008. That agreement provided for a cash settlement of past and future response costs owed by W.R. Grace for the entire Libby NPL Site except OU3, the mine site.

1.5 PREVIOUS INVESTIGATIONS & REPORTS

Prior to the designation of OU8 as a Site Operable Unit, several investigations generated data from areas that lie within current OU8 boundaries. In addition, OU8-specific investigations were conducted in 2010 and 2011. Planning documents for these investigations and associated reports (if prepared) are listed below:

<u>Sampling and Analysis Plans</u>

- *Sampling and Analysis Plan/Quality Assurance Project Plan for Activity-Based Outdoor/Air Exposures, Operable Unit 8, Libby Asbestos Site, Libby, Montana, 2010 Sampling Events. Prepared by TechLaw. Revision Date July 15, 2010.*

<u>Sampling Investigation Results Reports (pre-OU8 designation) Containing Data Relevant to OU8</u>

- *Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4, Libby, Montana. Final Summary Report for the J. Neils Park and Montana State Highway 37 Investigations, Revision 1. Prepared By CDM. December 2005.*

- *Report of Findings, Potentially Asbestos-Containing Soil in MTD Rights-of-Way, Traction Sand and Road Aggregate Sources, Collected Road Sweepings, and Sampled*

Worker Air Space During Routine Maintenance Activities, Libby, Montana. Prepared By Tetra Tech, Inc., February 21, 2007.

- *Report of Findings, Sampled Worker Air Space during Routine Maintenance Activities, Libby, Montana. Prepared By Tetra Tech, Inc., July 19, 2007.*

<u>Sampling Investigation Results Reports Specific to OU8 (post-OU8 designation)</u>

- *Verification Summary Report for Operable Unit 8, Libby Asbestos Superfund Site (Based on Scribe database provided on 1/27/11), Prepared by SRC. February 1, 2011.*
- *Trip Report (on ABS activities), Libby Asbestos Site, Libby, Montana. Prepared by Lockheed Martin Scientific, Engineering, Response and Analytical Services. November 1, 2010.*
- *Trip Report (on Rotomilling ABS Activities and Ambient Air Sampling), Libby Asbestos Site, Libby, Montana. Prepared by Lockheed Martin Scientific, Engineering, Response and Analytical Services. June 24, 2011.*

2.0 SITE CHARACTERISTICS

Operable Unit 8 encompasses a large geographic area but is constrained to roadway rights-of-way (ROW). Therefore, an OU-specific detailed discussion of many site characteristics, such as geology, is impractical for linear features such as a roadway. In addition, the investigation of LA in OU8 is restricted to surface soil and air. Therefore, subsurface conditions are not relevant to the RI. As a result, the following discussion of Site characteristics is based on conditions in and around Libby where such information has been developed as a part of work in other OUs.

2.1 CLIMATE

Annual average precipitation in Libby is 24.7 inches, with an annual average of 105 inches of snowfall (WRCC, 2010). Precipitation and humidity in Libby are greatest during the winter months due to the presence of temperature-regulating Pacific air masses. In December and January, average temperatures range between 25-30 ºF. Occasionally, dry continental air masses occupy the Libby area for short periods of time during the winter, creating cold and less-humid conditions (CDM, 2009).

Fog is common in Libby during winter months and in early morning throughout the year. Summer months are drier than winter and are warm with occasional rainfall. The average July temperature ranges between 56-70 ºF, with an average high of 80 ºF (CDM, 2009).

Prevailing winds are from the west north-west and average approximately 6-7 miles per hour. Wind direction and velocities fluctuate depending on temperature variances caused by vertical relief in the area. Inversions often trap stagnant air in the Libby valley (CDM, 2009).

2.2 GEOLOGY

Regional geology in the Libby valley is comprised of lacustrine deposits underlain by Precambrian rocks. Surrounding mountains are formed by Precambrian rocks. Cliffs along the lower portion of the valley are formed by glacial lake bed deposits. The Kootenai River and Libby Creek cut through lacustrine and alluvial deposits and form a discontinuous sequence of gravel, sand, silt, and clay (EPA, 2010b).

Alluvial deposits extend from the surface to 190 feet (ft) below ground surface (bgs) and are comprised of sand, gravel, silt, clay and cobbles. Glacial till, which consists primarily of silt and clay with varying amounts of sand and gravel, underlies alluvial deposits. Deposits of glacial till are believed to be quite deep, occurring at depths exceeding 500 ft bgs (EPA, 2010b).

Soils in the Libby area typically are loamy soil composed of sand and silt with minor amounts of clay. Soil was formed by erosion of Precambrian rocks, downstream transport of clays by rivers and creeks, and organic matter from historically forested areas (CDM, 2009).

Site soils are a combination of historical soil modified in areas by human activities. These activities may include addition of vermiculite as a soil amendment, soil reworking for building construction, road and railroad operation, vermiculite processing and transport, and general site work.

2.3 HYDROLOGY AND HYDROGEOLOGY

Within OU8, portions of SH 2 and SH 37 follow the Kootenai River and runoff from these roadways discharges to the river. In addition, the portion of SH 2 south of Libby parallels Libby Creek. The Kootenai River originates in British Columbia, Canada, and flows through Montana and Idaho before returning to Canada and flowing into the Columbia River. Flows in the Kootenai River and Libby Creek are tied to runoff from the mountains surrounding Libby. Runoff peaks in spring when high-elevation snow begins to melt. Stream flow decreases in summer due to low precipitation and snowmelt flow moderation by high elevation lakes (CDM, 2009).

Based on investigations at the Libby Groundwater Site (a separate NPL Site within the Libby Asbestos NPL Site), the hydrogeology in the southeast portion of Libby consists of saturated alluvial deposits extending from the surface to approximately 190 ft bgs. These deposits have been sorted into three classifications: upper aquifer, intermediate zone, and lower aquifer. The upper aquifer contains high hydraulic conductivity material including silty gravel and sand with occasional interbedded clayey, silty deposits. It is unconfined and extends from the water table (5 to 30 ft bgs) to approximately 70 ft bgs. Hydraulic conductivity ranges from 100 to 1,000 feet per day (ft/day). The inferred groundwater flow direction is north-northwest towards the Kooteni River (EPA, 2010b).

The intermediate zone is comprised of low permeability deposits similar to the upper aquifer, but with a higher percentage of fine-grained material. Acting as a confining layer, the intermediate zone is 40 to 60 ft thick, extending from approximately 60-70 ft bgs to 110 ft bgs. The hydraulic conductivity of this layer is much lower than the upper aquifer at approximately 1 ft/day.

The lower aquifer extends from approximately 100 ft bgs to 190 ft bgs, and contains more low-permeability silt and clay layers than the upper aquifer. It is confined and under pressure, so water in wells screened in this aquifer rises to 14-26 ft bgs. Hydraulic conductivity of the lower aquifer ranges from 50 to 200 ft/day. The inferred groundwater flow direction is north-northwest towards the Kooteni River (EPA, 2010b).

3.0 SAMPLING AND ANALYSIS

Most analytical and other data relevant to OU8 were collected during 2010 and 2011, after OU8 was established. However, some data relevant to OU8 were collected prior to 2010 as part of the investigation of other OUs or Site-wide investigations. Table 3-1 summarizes all sampling events that generated data relevant to OU8.

The following sections describe sample types, sample collection and analytical methods. All sample media and associated analytical results are discussed in this section. However, certain data are excluded from the discussion of nature and extent of LA occurrence (Section 5) including:

- Data that were deemed irrelevant to the assessment of risk to human health. These include certain indoor dust and outdoor ambient air samples and street sweepings.
- Occupational Safety and Health Administration compliance monitoring data collected during field activities as part of field worker health and safety.

This was done to simplify and focus the description of nature and extent of LA occurrence to those measurements most relevant to the estimation of human health risks.

3.1 SAMPLE TYPES AND COLLECTION PROCEDURES

As shown in Table 3-1, the following media-specific sampling was conducted:

- Soils
  - ➢ Surface – composite samples collected from as much as 6-inches bgs.
- Air
  - ➢ Personal air samples – collected using a sampling pump and filter located in the breathing zone of an individual (or mounted on equipment) while performing various outdoor activities.
  - ➢ Stationary air samples – collected using stationary sampling pump and filter placed in a location that acts as a surrogate for a personal air sample.

Samples were collected, documented, and handled in accord with standard operating procedures (SOPs) as specified in the respective Sampling and Analysis Plans (SAPs) prepared for the various investigations summarized on Table 3-1. Additional details on the 2010 and 2011 Remedial Investigation Field Programs including the study design and data quality objectives (DQOs) is provided in the Quality Assurance Project Plan (QAPP; Lockheed Martin, 2010a).

Data documenting sample type, location, collection method, and collection date were recorded both in a field log book maintained by the field sampling team and on a field sample data sheet (FSDS) designed to facilitate data entry into the Libby site database, as described in Section 4.1.

All samples collected in the field were maintained under chain of custody during sample handling, preparation, shipment, and analysis.

3.1.1 Soil Samples

Composite soil samples were collected along both sides of the ROW from the following roadways in OU8 (See Figure 3-1):

- Montana State Highway 37 (SH37)
- Montana State Highway 2 (SH2)
- Kootenai River Road
- County Highway 482 (Farm to Market Road)
- County Highway 567 (Pipe Creek Road)

The soil samples were collected and analyzed for LA in order to determine the distribution of LA (and visible vermiculite) along roadway ROWs. This information was used to, among other things, determine whether air sampling (activity-based sampling (ABS); See section 3.1.2) was performed over a range of surface soil LA levels and visible vermiculite conditions.

In general, one soil aliquot was collected for every 100 feet (ft) of ROW. The aliquots were originally to be collected in locations of visible vermiculite. However, this biased sampling was not performed in most areas due to the absence of visible vermiculite in all locations except for Hwy 37 from Rainy Creek Road to the dam.

In most cases, one composite soil sample was created from the ten aliquots collected for every 1,000 ft of ROW. However, composite samples were created from as many as 30 to as few as 3 aliquots in sections of ROW where hard surfaces comprise much of the ROW. A total of 485 field (non-QC) composite soil samples were collected from July 7 to September 10, 2010.

Soil sample locations were recorded at the midpoint of each 1,000 foot segment of ROW from which each composite sample was collected. The locations of all composite samples are shown on Figure 3-1.

In addition to soil samples collected during 2010, composite samples consisting of three aliquots were collected in 2003 and 2005 (CDM, 2005) and referred to as “Legacy Data” throughout the remainder of this report. The Legacy Data were collected only between Libby and Rainy Creek Road along SH 37 and are not shown on Figure 3-1. However, the analytical results from these samples are presented and discussed in Section 5.0.

3.1.2 Air Samples

All air samples were collected by drawing a sample through a filter that traps asbestos and other particulate material on the face of the filter. Two main categories of air samples were collected:

1. Personal Air Samples - Sampling equipment worn by a person or affixed to operating equipment/vehicle.
2. Stationary Air Samples - Sampling equipment placed on a motionless surface.

Personal air sampling involved a variety of activities performed by the sampler generally involving operation of recreational or roadway maintenance equipment/vehicles. Such sampling is referred to in the remainder of this report as Activity-Based Sampling (ABS).

Air sampling for asbestos was conducted using Emergency Response Team (ERT) SOP #2015, *Asbestos Sampling.* The sampling train consisting of 0.8-micron (~m), 25-millimeter (mm) mixed cellulose ester (MCE) filter cassette connected to a sampling pump (Lockheed Martin, 2010b). For personal ABS sampling, participants were fitted with the appropriate sampling pump with the cassettes secured near the operator's breathing zone.

ABS Sampling

For the 2010 and 2011 OU8 RI field program, these activities included:

Recreational Activities

- Riding ATVs with a lead and following ATV.

MDOT Maintenance Activities

- Rotomilling of asphalt pavement
- Grass cutting and brush hogging in rights-of-way

All ABS sampling during the 2010-2011 OU8 Field Program was conducted along Hwy 37 between Libby and Rainy Creek Road (See Figure 3-1). This portion of roadway was selected for ABS (excluding rotomilling) based on the presence of LA and visible vermiculite in surface soils as determined during investigations conducted in 2003 and 2005 (CDM, 2005).

Rotomilling ABS sampling was performed along Hwy 37 as part of regularly scheduled maintenance work conducted by MDOT. The general area of interest (California Ave.) was selected because one of several core samples collected in California Ave. in March 2010 contained a trace (0.1%) of LA (Lockheed Martin, 2010a).

All ABS sampling other than rotomilling was performed in September or October in order to make measurements during the time of year where conditions are drier than most other months.

The effects of seasonal soil moisture has no effect on the results of asphalt rotomilling ABS sampling.

A summary of the ABS sampling procedures implemented during the 2010-2011 OU8 field program is provided below. Further details are provided in a QAPP (Lockheed Martin, 2010a) and ABS Trip Reports (Lockheed Martin, 2010b and 2011).

Brush Hogging

Brush hogging activities took place over three days in September 2010. A total of seven activities (scenarios) took place at seven locations at a rate of two to three per day. Each scenario was between approximately 60 and 200 minutes. During each scenario four air samples were collected at varying air flow rates. Two samples were collected at the front of the unit (tractor and implement) and two samples were collected on the back of the unit. In addition, a 30-point composite soil sample was collected to represent the seven locations where the brush hogging ABS was performed.

Grass Cutting

One grass cutting activity (scenario) was conducted at two locations over the course of two days in September 2010. Each scenario was approximately 150 minutes and involved the collection of four air samples. Two samples were collected at the front of the unit (tractor and implement) and two samples were collected on the back of the unit (at varying air flow rates). In addition, a 30-point composite soil sample was collected to represent the two locations where the grass cutting ABS was performed.

ATV Riding

Eight ATV riding activities (scenarios) took place at four locations over the course of four days in September 2010. Each scenario involved a lead and following ATV and was performed twice at each location during approximately 120 minutes. The ATVs maintained their relative positions at a distance of approximately 50 to 75 feet throughout each scenario. Two sampling pumps were placed on the lead ATV and two sampling pumps were placed on the following ATV resulting in the collection of four samples per scenario (32 samples total). In addition, a 30-point composite soil sample was collected to represent the three locations where the off-road ATV ABS was performed. One of the ATV scenarios involved riding on a paved surface and no soil sample was collected for that event.

Rotomilling

Rotomilling activities took place over three days in April 2011. Personal air samples were limited to those collected from the moving rotomill and skid steer (a small front end loader).

A total of 10 field personal air samples were collected. Eight were collected from the rotomilling machine and two were collected from the skid steer.

Additional samples associated with rotomilling were stationary and are discussed below.

Stationary Air Samples:

Stationary sampling included ambient air proximal to a person or piece of equipment conducting ABS activities. Such stationary air samples were collected to represent conditions in the breathing zone as a surrogate for a personal air sample. These are referred to as perimeter samples and typically monitor the perimeter of an ABS activity involving equipment operation that mobilizes dust into the air.

For the 2011 OU8 Field Program the following types of stationary air sampling were conducted:

- At fixed locations on both sides of the street where rotomilling operations were conducted. The samplers formed an inner perimeter around the rotomill spaced about a block (approximately 300 feet) apart.
- At selected locations up to 1,000 feet from California Ave., comprising an outer perimeter (also referred too as ambient air samples in the QAPP; Lockheed Martin, 2010a). These outer perimeter samples were initiated at the beginning of the day and completed at the end of each work day.

Overall, 76 stationary field air samples were collected at 38 locations (See Figure 3-2).

3.1.3 Quality Control Samples

Quality control samples type and collection frequency included:

<u>Soil Samples</u>

- Field duplicate soil samples were collected at a rate of one duplicate sample per 20 soil samples collected.
- Soil sample field blanks (blank sand) were collected at a rate of one field blank sample per 20 soil samples.

<u>Air Samples</u>

- One lot blank was analyzed for each new lot of MCE filter cassettes.
- One field blank was collected and submitted for analysis for each day of sampling for the duration of the ABS and rotomilling activities.
- Four perimeter field duplicates were collected and analyzed for each day of sampling (two collected at the high flow rate and two at the low flow rate).

- One ambient air field duplicate was collected over an 8-hour period at the high flow rate and analyzed each day for the duration of the rotomilling project.

An assessment of data quality is summarized in Section 4 and the full Data Quality Assessment Report is provided as Appendix A.

3.2 SAMPLE PREPARATION AND ANALYSIS

3.2.1 Soil

Polarized Light Microscopy (PLM)

Soil samples collected as part of the OU8 sampling programs were prepared for analysis in accord with SOP ISSI-LIBBY-01 as specified in the CDM Close Support Facility (CSF) Soil Preparation Plan (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 “coarse” fraction. Particles passing through the screen are referred to as fine fraction, and this fraction is ground by passing it through a plate grinder. Resulting material is referred to as “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.

Soil samples are analyzed using PLM whereby the analyst estimates the amount of asbestos in the sample (expressed as percent by weight) based on visual estimation techniques and by comparison to reference materials.

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”). 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):* detected at levels lower than the 0.2% LA reference material
- *Bin B2 (<1%):* 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

Visual Inspection

For soil samples, field teams also provide a semi-quantitative estimate of visible vermiculite present at soil sampling point(s). Visual inspection data can be used to characterize the level of vermiculite (and presumptive LA contamination) in an area and considers both frequency and level of vermiculite. This is achieved by assigning a weighting factor to each level, where weighting factors are intended to represent relative levels of vermiculite in each category.

As presented in SOP CDM-LIBBY-06, guidelines for assigning levels are as follows:

- None – No flakes of vermiculite observed within the soil sample.
- Low – A maximum of a few flakes of vermiculite observed within the soil sample.
- Moderate – Vermiculite easily observed throughout the soil sample, including the surface and contains <50% vermiculite.
- High – Vermiculite easily observed throughout the soil sample, including the surface and contains 50% or more vermiculite.

Based on these descriptions, weighting factors used to characterize magnitude of LA occurrence in soil are as follows:

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

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

$$Score = \frac{\sum_{i=1}^{30} L_i * W_i}{30}$$

This value can range from zero (all 30 points are "none") to a maximum of 10 (all 30 points are "high"). For example, an ABS area with 1 "low" point and 29 "none" points would receive a value of 1/30 = 0.033, while an ABS area with 24 "intermediate" points and 5 "high" would receive a score of (24·3 + 5·10) / 30 = 4.13.

In addition to the visual estimation method described above, field crews used a less sophisticated technique prior to implementation of SOP CDM-LIBBY-06 in 2006. This involved noting in the field the simple presence or absence of visible vermiculite in soil samples.

3.2.2 Air

In the past, the most common technique for measuring asbestos in air was phase contrast microscopy (PCM). In this technique, air is drawn through a filter and airborne particles become deposited on the face of the filter. All structures that have a length greater than 5 micrometers (um) and have an aspect ratio (the ratio of length to width) of 3:1 or more are counted as PCM fibers. The limit of resolution of PCM is about 0.25 um, so particles thinner than this are generally not observable.

A key limitation of PCM is that particle discrimination is based only on size and shape. Because of this, it is not possible to classify asbestos particles by mineral type, or even to distinguish between asbestos and non-asbestos particles. For this reason, nearly all samples of air collected in Libby are analyzed by transmission electron microscopy (TEM).

This method operates at higher magnification (typically about 20,000x) and hence is able to detect structures much smaller than can been seen by PCM. In addition, TEM instruments are fitted with accessories that allow each particle to be classified according to mineral type.

Air samples filters were directly prepared for analysis by TEM in accord with preparation methods provided in International Organization for Standardization (ISO) 10312 (ISO, 1995). In the case where filter cassettes were found to be overloaded, the filters were prepared for analysis in accordance with SOP EPA-Libby-08 (indirect prep). This indirect preparation method was employed for three samples associated with brush hogging and two samples associated with rotomilling. A discussion measurement uncertainty associated with indirect sample preparation is provided in Section 7.6.3.

Sample analysis was by TEM in basic accord with counting and recording rules specified in ISO 10312, and certain project-specific counting rule modifications including changing the recording rule to include structures with an aspect ratio $\geq$ 3:1.

For each countable structure particle identified, the analyst records structure-specific information (e.g., length, width, asbestos mineral type) which is then used to calculate air concentration in LA structures per cubic centimeter (s/cc).

4.0 DATA RECORDING, DATA QUALITY ASSESSMENT, AND DATA SELECTION

4.1 DATA RECORDING

All analytical results are stored and maintained in the OU8 Scribe Database. A copy of the database is available through EPA Region 8 records center (See Appendix B).

Standardized data entry spreadsheets (electronic data deliverables or EDDs) have been developed specifically for the Libby project to ensure consistency between laboratories in the presentation and submittal of analytical data. In general, a unique EDD has been developed for each type of analytical method. Each EDD provides the analyst with a standardized laboratory bench sheet and accompanying data entry form for recording analytical data. Data entry forms contain a variety of built-in quality control functions that improve accuracy of data entry and help maintain data integrity. These spreadsheets also perform automatic computations of analytical input parameters (e.g., sensitivity, dilution factors, and concentration), thus reducing the likelihood of analyst calculation errors.

Asbestos analytical data (soil and air) was reported by the analytical laboratory in the form of an EDD and a pdf of the Data Report via email. All asbestos analytical data was then uploaded into the OU8 Scribe Database by the Environmental Services Assistance Team (ESAT) Data Manager.

Hard copies of all analytical reports are stored in the Scientific, Engineering, Response and Analytical Services (SERAS) Program Central Files and electronic copies are stored on SERAS Local Area Network.

All sampling location identification numbers were given to EPA's ERT by ESAT prior to the sampling event. Field sampling data were recorded for each sample collected by ERT personnel on a sample log sheet and loaded into the OU8 Scribe Database. All samples and copies of sample log sheets were delivered to the EMSL/Libby laboratory. ERT/SERAS prepared all chain of custody forms prior to delivery of the samples to the laboratory.

Hard copies of all FSDSs, field log books, and chain of custody forms generated during the OU8 sampling program were transferred to the Sample Receiving Coordinator at CDMs Libby Montana Project Office.

4.2 DATA QUALITY ASSESSMENT

Data quality assessment (DQA) is the process of reviewing existing data to establish the quality of the data and to determine how any data quality limitations may influence data interpretation (EPA, 2006). The full DQA is provided as Appendix A and a summary is provided below.

A verification of a minimum of 10% of the TEM results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with SOP EPA-LIBBY-09 (rev 1). No discrepancies were discovered upon review of the original hand-written laboratory bench sheets to determine if the raw structure data were recorded in accord with ISO 10312 counting rules and SAP stopping rules. In addition, no errors were discovered when checks were performed to ensure that the data from the bench sheet were transferred into the OU8 Scribe Database without error or omission.

A verification of a minimum of 10% of the PLM-VE results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with draft Standard Operating Procedures for PLM verification. A review of the original laboratory PLM bench sheets and verification of the transfer of results from the bench sheets into the OU8 Scribe Database was performed. Because the issues identified are not likely to impact data interpretation, no future verification of PLM-VE results was recommended.

A verification of FSDS information for all 62 analyses selected for PLM-VE and TEM verification was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11. Several issues were discovered, some with the potential to impact data interpretation. The main issues involve discrepancies in the visible vermiculite information (number of aliquots vs. number of visible vermiculite observations) and sample date as well as omission of detailed pump information.

Discrepancies in the number of aliquots associated with visible vermiculite observations were limited to 4 samples out of 508. These visible vermiculite results (associated with sample HW-00129, HW-00130, HW-00133 and HW-0082) have been omitted from the remainder of the RI report.

In addition, the data quality assessment explains that detailed pump information was examined on the original FSDS and that the issue was limited to the lack pump information in the OU8 Scribe Database.

4.3 DATA SELECTION

Raw data for samples utilized in describing the occurrence of LA in OU8 soils and air (Section 5) as well as for use in the risk assessment (Section 7) were obtained via a subscription to the OU8 Scribe Database through Scribe.net. A copy of this database was obtained by HDR, Inc. on

December 16, 2012. A copy of the database is available through EPA Region 8 records center (See Appendix B).

Scribe queries were written to sort data by media, analytical method and to exclude quality control samples. The data set resulting from execution of the queries (excepting the four visible vermiculite results discussed in Section 4.2) was used to describe the nature and extent of LA occurrence and for calculation of human health risk estimates.

5.0 NATURE AND EXTENT OF LA

5.1 CONTAMINANTS OF CONCERN

The contaminant of concern at the Libby Site is asbestos. Asbestos is the generic name for the fibrous form of a broad family of naturally occurring poly-silicate minerals. Based on crystal structure, asbestos minerals are usually divided into two groups - serpentine and amphibole.

- Serpentine - The only asbestos mineral in the serpentine group is chrysotile. Chrysotile is the most widely used form of asbestos, accounting for about 90% of the asbestos used in commercial products (IARC, 1977). There is no evidence that chrysotile occurs in the Libby vermiculite deposit, although it may be present in some types of building materials in Libby.
- Amphibole – Five minerals in the amphibole group that occur in the asbestiform habit have found limited use in commercial products (IARC, 1977), including actinolite, amosite, anthophyllite, crocidolite, and tremolite.

At the Libby Site, the form of asbestos that is present in the vermiculite deposit is amphibole asbestos that for many years was classified as tremolite/actinolite (McDonald et al., 1986a, Amandus and Wheeler, 1987). More recently, the U.S. Geological Service performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from asbestos veins at the mine (Meeker et al., 2003). Using mineralogical naming rules recommended by Leake et al. (1997), the results indicate that asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, magnesioriebeckite and possibly actinolite.

Because mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because EPA does not find that there are toxicological data to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as LA.

5.2 LA IN SOIL

Surface Soil

Figure 5-1 illustrates LA occurrence in OU8 surface soils based on PLM results. A 4-color scheme is used to indicate the amount of LA present in a sample (additional detail on analytical reporting is provided in Appendix C):

- green = Bin A (non-detect)

- yellow = Bin B1 (trace)
- orange = Bin B2 (< 1%)
- red = Bin C (≥ 1%)

In this figure, composite samples collected during the 2010 field program are plotted as circles. Composite samples collected in 2003 and 2005 and referred to as “Legacy Data” are plotted as triangles (CDM, 2005). The Legacy Data was collected only between Libby and Rainy Creek Road along SH 37.

Of the 485 non-QC field composite samples, one (HW-00376) has no geographic information associated with it. Therefore, it is excluded from Figure 5-1. This sample contained no detectable LA.

Figure 5-2 illustrates vermiculite occurrence in surface soils based on visible vermiculite observations which utilized a semi-quantitative approach. Results are shown as squares and are color-coded based on the visible score (see Section 3.2.1):

- green = score of 0 (no visible vermiculite detected)
- yellow = score < 0.1
- orange = score 0.1 to < 0.3
- red = score > 0.3

One potential limitation to the approach for presenting visible score data is that the choice of cut-offs for use in color-coding is arbitrary. If other cut-offs were chosen, the appearance of the figures would be different. For example, the cutoff for red is 0.3 out of a possible score of 10. Nevertheless, the figures do provide a useful indication of the degree to which there is variation across OU8 and locations where higher than average levels have been observed.

Soil PLM results are generally non-detect to trace except between Libby and Rainy Creek Road where results are trace to <1% with a few non-detects. Relatively higher levels of LA in surface soils between Libby and the Rainy Creek Road is expected as ore trucks traveled this route during operation of the mine.

Visible vermiculite is limited to the eastern-most section of SH 37. This result is somewhat unexpected given that the occurrence of LA by PLM in soil in this area is typical of most of OU8. As discussed above, the cutoff for red as an indicator of the presence of visible vermiculite is arbitrary. In the case of the red colored results on the figure, most samples contained 10 aliquots, with a “low-level” of vermiculite noted in each aliquot.

The lack of visible vermiculite in surface soils between Libby and Rainy Creek Road is also unexpected given the presence of LA in these soils as measured by PLM (Figure 5-1). Further, vermiculite was observed in surface soils along this portion SH 37 in 2003 and 2005 (CDM, 2005). However, it is almost certain that the soils samples inspected in 2003, 2005 and 2010 were not co-located. Therefore, spatial variability in the occurrence of vermiculite in surface soils may account for some of the differences in field inspection results across sample events. Other differences likely arise from the inherently subjective nature of the vermiculite level category assignments, as well as variations in site conditions between rounds (e.g., cloud cover vs. sunshine, amount of ground cover, soil moisture, etc.).

5.3 LA IN AIR

ABS Air

As discussed in Section 7.2.1.2, the amount of LA fibers released to air will vary depending upon the level of LA in the source material (e.g., outdoor soil) and the intensity and duration of the disturbance activity. Because of this, predicting the LA levels in air associated with disturbance activities based only on measured LA levels in the source material is extremely difficult. Therefore, ABS is considered to be the most direct way to estimate potential exposures from inhalation of asbestos. ABS results for ATV riding, brush hogging and grass cutting are presented on Figure 5-3. ABS results for rotomilling are presented on Figure 5-4.

As seen on Figure 5-3, LA was not detected in air during grass cutting activities. However, LA was detected during ATV riding and brush hogging. Concentrations associated with these activities ranged between <0.0020 LA s/cc to 0.0180 s/cc. As discussed in Section 3.1.1, the area over which these ABS activities were performed was selected based on the presence of LA and visible vermiculite in surface soils during the 2003 and 2005 sample event (CDM, 2005).

As seen on Figure 5-4, LA was not detected in air samples collected from the rotomilling machine and skid steer (small front-end loader). Detection limits ranged from 0.0216 s/cc to 0.0025 s/cc.

Based on the surface soil PLM results (Section 5.2), the ABS air sampling was performed in that portion of OU8 with the highest levels of LA in soil. This suggests that the ABS air samples discussed in this section represents the worst case condition in the entire OU.

Human health risk estimates based on these measurements are provided in Section 7.

Stationary Air

As discussed in Section 3.1.2, stationary sampling included ambient air proximal to a person or piece of equipment conducting ABS activities. Such stationary air samples were collected to represent conditions in the breathing zone as a surrogate for a personal air sample (e.g., a person walking on the sidewalk during rotomilling operations on the adjacent street).

For the 2011 OU8 Field Program the following types of stationary air sampling were conducted:

- At fixed locations on both sides of the street where rotomilling operations were conducted. The samplers formed an inner perimeter around the rotomill spaced about a block (approximately 300 feet) apart.
- At selected locations up to 1,000 feet from California Ave., comprising an outer perimeter (also referred too as ambient air samples in the QAPP; Lockheed Martin, 2010a).

As seen on Figure 5-5, LA was detected in 1 of 52 inner perimeter field samples at a concentration of 0.0030 s/cc. Detection limits ranged from 0.0017 s/cc to 0.0247 s/cc.

As seen on Figure 5-6, LA was not detected in any outer perimeter (ambient) sample. Detection limits ranged from 0.0007 S/cc to 0.0.0010 s/cc.

Human health risk estimates based on these measurements are provided in Section 7.

6.0 CONTAMINANT FATE AND TRANSPORT

The source for LA detected in surface soils and an air sample associated with rotomilling may include:

- Vermiculite ore released from ore trucks by wind or other means during transport along state and local highways.
- Imported fill containing vermiculite mine wastes used during earthwork for roadway construction or maintenance.
- Naturally occurring LA (at background levels) in native soils in roadway ROW.
- Aggregate containing vermiculite mine wastes used to manufacture asphalt.
- Naturally occurring LA (at background levels) in aggregate used to manufacture asphalt.

Natural background levels of LA at the Site have not been established, although a study is underway that attempts to do this. Nevertheless, the relatively low levels and uniform distribution of LA in soils in roadway ROWs (excepting the portion of SH 37 between Libby and Rainy Creek Road), precludes elimination of natural background conditions as responsible for some of the LA detected in OU8.

The fate and transport of asbestos containing fibers is dependent on the type of host media (soil, water, air, etc.), land use, and site characteristics. Asbestos fibers (both serpentine and amphibole) are indefinitely persistent in the environment. According to the Agency for Toxic Substances and Disease Registry (ATSDR):

> *"Asbestos fibers are nonvolatile and insoluble, so their natural tendency is to settle out of air and water, and deposit in soil or sediment (EPA 1977, 1979c). However, some fibers are sufficiently small that they can remain in suspension in both air and water and be transported long distances. For example, fibers with aerodynamic diameters of 0.1–1 μm can be carried thousands of kilometers in air (Jaenicke 1980), and transport of fibers over 75 miles has been reported in the water of Lake Superior (EPA 1979c)."* In addition, *"they are resistant to heat, fire, and chemical and biological degradation"* (ATSDR, 2001).

The primary transport mechanisms for asbestos and asbestos containing material include:

- Suspension in air and transport via dispersion
- Suspension in water and transport downstream

Asbestos can become suspended in air when asbestos or asbestos containing material is disturbed. Wind, recreational activities, construction, and site work can disturb material outdoors.

Asbestos residence time in the air is determined primarily by particulate thickness; however it is influenced by other factors such as length and static charge. The average thickness of LA particles is 0.4 µm and ranges from approximately 0.1 to 1.0 µm. The suspension of LA in air is measured in “half times” which is the amount of time it will take 50% of LA particles to settle out of the air column. A particle with a thickness of 0.5 µm has a half time of approximately two hours, assuming the source of disturbance has been removed (CDM, 2009).

Larger particles will settle faster; a particle of 1 µm has a half time of about 30 minutes. Smaller LA particles may stay suspended for significantly longer. The typical half time for a 0.15 particle is close to 40 hours (CDM, 2009)

Activity-specific testing found that the half-time of LA suspended by dropping vermiculite on the ground was about 30 minutes. LA suspended from disturbing vermiculite insulation settled within approximately 24 hours (CDM, 2009).

Once suspended, LA moves by dispersion through air. LA concentration will be highest near the source and will decrease with increasing distance. In outdoor air, wind speed will determine direction and velocity of LA particle transport. Wind can cause the rapid dispersal of LA from the source of release.

In water, LA particles can be transported downstream with the current. As in air, larger particles tend to settle to the bottom more rapidly than smaller particles. Settled particles may be transported downstream with sediment (CDM, 2009).

LA is insoluble and therefore transport in solution will not occur in surface water, groundwater or from soils to water. Further, as a particle, LA is not expected to be mobilized from surface or near surface soils vertically through the soil column to the water table.

7.0 HUMAN HEALTH RISK ASSESSMENT

7.1 OVERVIEW

This section presents the human health risk assessment (HHRA) for OU8. Operable Unit 8 consists of state and local roadways in and near Libby and Troy, Montana. The roadways include Highway 37 between Rainy Creek Road and the Koocanusa Dam, Highway 2, and secondary Highways 260, 482, and 567.

As discussed previously, vermiculite from the Libby mine contains varying concentrations of LA. Releases of LA (in association with vermiculite) to the environment is known to have caused a range of adverse health effects in exposed populations, including workers at the mine and processing facilities (Amandus and Wheeler, 1987; McDonald et al., 1986a, 1986b, 2004; Whitehouse, 2004; Sullivan, 2007), and residents of Libby (Peipins et al., 2003; Noonan et al., 2006; Whitehouse et al., 2008).

This risk assessment uses available data to estimate the current and future health risks to people who may inhale asbestos fibers in the air while performing road construction and routine maintenance activities along the roads and highways or participating in recreational activities in OU8, based on current conditions. The road construction activities include rotomilling and asphalt work. Maintenance activities adjacent to the roadways include lawn mowing, road sweeping, ditch cleaning and brush hogging. The airborne dust generated from these activities may be contaminated with LA; therefore, persons performing the rotomilling and maintenance work and the residents of Libby may be exposed to LA through inhalation of ambient air, which could pose a risk of cancer and/or non-cancer health effects. Additionally, ATV users may be exposed to asbestos fibers via inhalation during recreational activities along the roadways and highways monitored during this investigation. The methods used to evaluate human health risks from asbestos are in accordance with EPA guidelines for evaluating risks at NPL sites (EPA, 1989), including recent guidance (EPA, 2008, 2009a, 2011a, 2011c) that has been specifically developed to support evaluations of exposure and risk from asbestos.

People exposed to asbestos at OU8 may also be exposed to asbestos at other locations in and around Libby, MT. While this HHRA focuses exclusively on risks related to road construction, routine maintenance, and ATV recreational activities at OU8, the cumulative risks from multiple exposure pathways and source areas that may occur throughout the Site will be addressed in the future.

An ecological risk assessment is being developed for the mine site (OU3). EPA will build upon the information gathered during that ecological risk assessment to identify potential pathways and receptors to evaluate ecological risk at OU8. If ecological exposure pathways are identified at OU8, an ecological risk assessment will be performed.

7.2 EXPOSURE ASSESSMENT

7.2.1 Conceptual Site Model

Figure 7-1 presents the Conceptual Site Model that summarizes how humans might be exposed to LA at OU8. The sections below discuss the exposed populations and exposure routes and pathways.

7.2.1.1 Exposed Populations

Based on the current and potential future land use at OU8, human receptors exposed on a regular basis include:

- Current/future adult maintenance workers (e.g. MDOT worker) conducting routine maintenance activities (e.g., mowing the grass, brush hogging, or rotomilling along roadways).
- Current/future child, adolescent, and adult recreational ATV users.

Given that OU8 consists of state and local roadways in and around Libby and Troy, Montana, buildings are not present and indoor exposure pathways are not applicable. Also, while automobiles drive on OU8 roadways, automobiles are not quantitatively evaluated in this HHRA. Automobile drivers and passengers traveling on roadways are anticipated to be minimally exposed to LA in air because typical automobile activity/traffic exposure durations are minimal. Finally, residents are not evaluated at OU8 since residences are not located within the OU8 boundaries and land use is not anticipated to change in the future.

7.2.1.2 Exposure Routes and Pathways

Human receptors that conduct maintenance work within, or otherwise access OU8, may be exposed to LA by incidental ingestion of contaminated media (e.g., soil, dust) and by inhalation of air that contains LA fibers. However, of these exposure pathways, inhalation exposure is the primary route of exposure. To the extent that incidental ingestion of LA may occur, the added risk from this pathway is expected to be insignificant compared to risks associated with the inhalation pathway; currently, toxicological criteria are not available to quantify ingestion exposure.

LA fibers may become airborne in a number of ways. This may include natural mechanisms such as entrainment of contaminated soil/dust in ambient air due to wind erosion or human activities that disturb contaminated sources such as indoor dust or outdoor soil. However, at OU8 indoor exposures are not applicable; only outdoor exposures are quantitatively evaluated. The amount of LA potentially inhaled varies depending on the concentration and fiber size of LA in the source, the intensity and duration of the disturbing force, and the activity level of potentially exposed populations. For the purposes of this risk evaluation a conservative adult inhalation rate of 20 m^3/day is assumed for all populations, including children and adolescents, and tailored to the exposure period, consistent with USEPA's *RAGS, Part F: Supplemental Guidance for Inhalation Risk Assessment* (USEPA, 2009a). Therefore, inhalation exposures focus on an evaluation based on the source material and disturbance activity. The exposures of concern for each of the exposed populations are as follows:

- Current or future maintenance workers working along roadways. Inhalation of LA in ambient air by adult maintenance workers may occur during routine maintenance activities along highway ROWs. LA may be released from the disturbance of outdoor soil from activities such as mowing the grass and brush hogging or from asphalt surfaces during rotomilling.
- Current or future recreational ATV users riding along roadways. Inhalation of LA in ambient air by child, adolescent, and adult recreational users may occur during ATV use due to disturbance of contaminated outdoor soil or dust along roadways. The associated risk evaluation assumes that children may ride ATVs with an accompanying parent.

Additionally, all individuals working in the vicinity of any roadwork may be exposed to ambient air. For example, those working in the town of Libby in local businesses along Highways 2 or 37 may be exposed to ambient air during road construction activities along these highways, as well as general bystanders. However, it is important to note that exposure assumptions for routine maintenance workers conducting ongoing work are more stringent than for intermittent exposures of local indoor business workers and general bystanders along OU8 roadways. Refer to Section 7.6, Uncertainty Analysis, for a discussion of uncertainties associated with exclusion of additional receptors from the quantitative evaluation.

The risk evaluation contained herein is predicated on the most relevant and conservative assessment basis applicable to OU8. Exposures associated with other receptor populations not specifically addressed in this assessment, such as people who visit OU8 on a less frequent basis (e.g., out-of-town visitors) will be lower than the exposures for the populations described above.

7.2.2 Approach for Characterizing Exposure

The amount of LA fibers released to ambient air at OU8 will vary depending upon the level of LA in outdoor soil (i.e., source material) and the intensity and duration of the disturbance activity. For outdoor exposures, a variety of meteorological (e.g., relative humidity, wind direction and speed) and source material conditions (e.g., soil moisture, vegetative cover) will also influence entrainment of dust and releases to air. Therefore, predicting LA levels in ambient air associated with disturbance activities based only on measured LA levels in source material is extremely difficult. The most direct way to determine potential exposures from inhalation is to measure the concentration of LA in air in association with a specific activity that disturbs the source material. The collection of ABS samples is essential in properly characterizing the level of airborne asbestos exposure which may be expected to occur when source material is disturbed (EPA, 2008).

EPA performed several ABS studies at the OU8 site in 2010 and 2011 to investigate the levels of LA in ambient air associated with a variety of activities under current conditions, including:

- Maintenance workers mowing the grass, brush hogging and rotomilling along OU8 roadways
- ATV users riding along OU8 roadways

Specifically, ABS data for ATV riding, grass mowing, and brush hogging were collected along a segment of Highway 37 between Libby and the intersection with Rainy Creek Road (Figure 5-3). ABS data for rotomilling (including ambient air sampling) were collected on Highway 37 between Highway 2 and East 2nd Street (Figures 5-4 thru 5-6). ABS data collection locations were determined based on visible vermiculite in surface soil (Figure 5-2) and PLM soil sampling results (Figure 5-1), as well as proximity to the town of Libby and actual locations of site activities (e.g., brush hogging, grass cutting, rotomilling, ATV riding).

Because it is cost prohibitive to evaluate risks by conducting outdoor ABS sampling along all segments/roadways in OU8, it is necessary to use the ABS data from limited portions of OU8 roadways to draw risk conclusions about areas that have not been studied by ABS. This was achieved by assessing the degree to which soil results from other areas are similar to the soil results for areas with ABS data. While ABS samples were not collected along the entirety of OU8, the locations that were sampled and their results represent a conservative estimate of potential source area concentrations and are appropriate for use in a conservatively-biased assessment of OU8 activity-based exposures.

A detailed description of the study design and DQOs for the ABS studies are provided in the *Sampling and Analysis Plan/Quality Assurance Project Plan for Activity-Based Outdoor Air Exposures, Operable Unit 8, Libby Asbestos Superfund Site, Libby, Montana* dated July 2010. Additional discussion of sample collection is provided in Section 3.

7.3 TOXICITY ASSESSMENT

The adverse effects of asbestos exposure in humans have been the subject of a large number of studies and publications. The following section provides a brief overview of the primary types of adverse health effects that have been observed in humans. More detailed reviews of the literature are provided in International Agency for Research on Cancer (IARC, 1977), World Health Organization (WHO, 2000), and Agency of Toxic Substances and Disease Registry (ATSDR, 2001, 2004).

7.3.1 Non-Cancer Effects

7.3.1.1 Asbestosis

Asbestosis is a chronic pneumoconiosis associated with inhalation exposure to asbestos. It is characterized by the gradual formation of scar tissue in the lung parenchyma. Initially the scarring may be minor and localized within the basal areas, but as the disease develops, the lungs may develop extensive diffuse alveolar and interstitial fibrosis (American Thoracic Society, 1986).

Build-up of scar tissue in the lung parenchyma results in a loss of normal elasticity in the lung which can lead to the progressive loss of lung function. The initial symptoms of asbestosis are shortness of breath, particularly during exertion. People with fully developed asbestosis tend to have increased difficulty breathing that is often accompanied by coughing or rales. In severe cases, impaired respiratory function can lead to death.

Asbestosis generally takes a long time to develop, with a latency period from 10 to 20 years.

Mossman and Churg (1998) suggest that latency is inversely proportional to exposure level. The disease may continue to progress long after exposure has ceased (ATSDR, 2001). The progression of the disease after cessation of exposure also appears to be related to the level and duration of exposure (American Thoracic Society, 2004).

7.3.1.2 Pleural Abnormalities

Exposure to asbestos may induce several types of abnormality in the pleura (the membrane surrounding the lungs).

- *Pleural effusions* are areas where excess fluid accumulates in the pleural space. Most pleural effusions last several months, although they may be recurrent.

- *Pleural plaques* are acellular collagenous deposits, often with calcification. Pleural plaques are the most common manifestations of asbestos exposure (ATSDR, 2001; American Thoracic Society, 2004).

- *Diffuse pleural thickening* is a non-circumscribed fibrous thickening of the visceral pleura with areas of adherence to the parietal pleura. Diffuse thickening may be extensive and cover a whole lobe or even an entire lung. Infolding of thickened visceral pleura may result in collapse of the intervening lung parenchyma (rounded atelectasis). Genevois et al. (1998) and Schwartz et al. (1991) report that diffuse pleural thickening may occur as a result of pleural effusions.

Pleural effusions and plaques are generally asymptomatic, although rarely they may be associated with decreased ventilatory capacity, fever, and pain (e.g., Bourbeau et al., 1990).

Diffuse pleural thickening can cause decreased ventilatory capacity (Baker et al., 1985; Churg 1986; Jarvholm and Larsson, 1988). Severe effects are rare, although Miller et al. (1983) reported on severe cases of pleural thickening that lead to death.

The latency period for pleural abnormalities is usually about 10 to 40 years (American Thoracic Society, 2004), although pleural effusions may occasionally develop as early as one year after first exposure (Epler and Gaensler, 1982).

7.3.1.3 Other Non-Cancer Effects

Some epidemiological studies provide evidence that chronic exposure to asbestos can increase the risk of several other types of non-cancer effects including cor pulmonale (right-sided heart failure), retroperitoneal fibrosis (a fibrous mass in the back of the abdomen that blocks the flow of urine from the kidneys to the bladder), depressed cell-mediated immunity (ATSDR, 2001), and autoimmune disease (Pfau et al., 2005; Noonan et al., 2006).

7.3.1.4 Observations of Non-Cancer Effects in People Exposed to LA

A number of studies have been performed to characterize the types of non-cancer effects that occur in people who have been exposed to LA. These studies are summarized below.

Amandus and Wheeler (1987), McDonald et al. (1986a, 1986b, 2004), and Sullivan (2007) studied the cause of death in workers exposed to LA while working at the vermiculite mine and mill at Libby. Each of these researchers reported that Libby workers were more likely to die of non-malignant respiratory disease (i.e., asbestosis, chronic obstructive pulmonary disease, pneumonia, tuberculosis and emphysema) compared to white males in the general U.S. population, supporting the conclusion that exposure to LA increases risk of non-malignant lung disease.

Armstrong et al. (1988), McDonald et al. (1986b) and Amandus et al. (1987) evaluated the prevalence of chest radiographic changes in workers exposed to LA while working at the vermiculite mine and mill at Libby. These researchers observed increased prevalence in pleural changes, including pleural calcification, pleural thickening and profusion of small opacities among exposed workers.

Rohs et al. (2007) studied the prevalence of pleural changes in the lungs of workers exposed to LA while working at a facility in Marysville, Ohio expanding Libby vermiculite for use as an inert carrier for lawn care products. Rohs et al. (2007) observed an increased incidence of pleural plaques, diffuse pleural thickening and interstitial changes (irregular opacities) in exposed workers. In addition, studies by Peipins et al. (2003), Muravov et al. (2005), and Whitehouse (2004) also observed increased incidence in pleural abnormalities of not only workers, but also household contacts of former employees of the Libby mine and residents of

Libby, MT environmentally exposed to LA. These findings support the conclusion that exposure to LA can induce pleural abnormalities.

7.3.2 Cancer Effects

Many epidemiological studies have reported increased mortality from cancer in asbestos workers, especially from lung cancer and mesothelioma. Based on these findings, and supported by extensive carcinogenicity data from animal studies, EPA has classified asbestos as a known human carcinogen (EPA, 1993).

7.3.2.1 Lung Cancer

Exposure to asbestos is associated with increased risk of developing all major histological types of lung carcinoma (adenocarcinoma, squamous cell carcinoma, and oat-cell carcinoma) (ATSDR, 2001). The latency period for lung cancer generally ranges from about 10 to 40 years (ATSDR, 2001). Early stages are generally asymptomatic, but as the disease develops, patients may experience coughing, shortness of breath, fatigue, and chest pain. Most lung cancer cases result in death. The risk of developing lung cancer from asbestos exposure is substantially higher in smokers than in non-smokers (Selikoff et al., 1968; Doll and Peto, 1985; ATSDR, 2001; NTP, 2005).

7.3.2.2 Mesothelioma

Mesothelioma is a tumor of the thin membrane that covers and protects the internal organs of the body including the lungs and chest cavity (pleura), and the abdominal cavity (peritoneum).

Exposure to asbestos is associated with increased risk of developing mesothelioma (ATSDR, 2001).

The latency period for mesothelioma is typically around 20-40 years (Lanphear and Buncher, 1992; ATSDR, 2001; Mossman et al., 1996; Weill et al., 2004). By the time symptoms appear, the disease is most often rapidly fatal (British Thoracic Society, 2001).

7.3.2.3 Other Cancers

A number of studies suggest asbestos exposure may increase risk of cancer at various gastrointestinal sites (EPA, 1986). National Academy of Sciences (NAS, 2006) reviewed evidence regarding the role of asbestos in gastrointestinal cancers primarily following occupational exposures (these are assumed to be primarily by the inhalation route). NAS concluded that data are “suggestive but insufficient” to establish that asbestos exposure causes stomach or colorectal cancer. Data on esophageal cancer are mixed and were regarded as “inadequate to infer the presence or absence of a causal relationship to asbestos exposure”.

Data on risks of gastrointestinal cancer following ingestion-only exposure are more limited.

Some researchers (e.g., Conforti et al., 1981; Kjaerheim et al., 2005) have reported a significant correlation between oral exposure to asbestos in drinking water and the risk of gastrointestinal cancer. However, WHO (1996) concluded that data are not adequate to support the hypothesis that an increased cancer risk is associated with the ingestion of asbestos in drinking water.

NAS (2006) reviewed available data on the relationship between asbestos exposure and laryngeal cancer and concluded that the data were "sufficient to infer a causal relationship between asbestos and laryngeal cancer." NAS (2006) concluded that data are "suggestive but not sufficient to infer a causal relationship between asbestos exposure and pharyngeal cancer."

Excess deaths from kidney cancer among persons with known exposure to asbestos have been reported by a number of researchers (e.g., Selikoff et al., 1979; Enterline et al., 1987; Puntoni et al., 1979). A review by Smith et al. (1989) evaluated these studies and concluded that asbestos should be regarded as a probable cause of human kidney cancer.

7.3.2.4 Observations of Cancer in People Exposed to LA

Amandus and Wheeler (1987), Amandus et al. (1987), McDonald et al. (1986a, 1986b, 2004), and Sullivan (2007) studied the cause of death in workers exposed to LA while working at the vermiculite mine and mill at Libby. All of these groups of researchers reported an increased incidence of lung cancer and mesothelioma in exposed workers, strongly supporting the conclusion that LA can cause increased risk of respiratory cancer when inhaled.

7.3.3 Role of Fiber Type and Size in Adverse Health Effects

All types of asbestos have been shown to induce asbestos-related disease in humans and animals; however, a number of researchers have proposed that not all forms of asbestos are equally toxic. Current research has focused on two key variables: mineral type (chrysotile versus various types of amphibole asbestos), and fiber size (length and width). Several researchers have used available human epidemiological data to investigate the relative potency of asbestos as a function of mineral type, and there is on-going debate regarding whether there is a difference in the relative cancer potencies of the various mineral types and sizes.

In particular, the carcinogenic potential of chrysotile asbestos relative to amphibole asbestos is a controversial issue. Various researchers (e.g., Hodgson and Darton, 2000; Mossman et al., 1990, McDonald and McDonald, 1997) propose that amphibole fibers are more potent inducers of mesothelioma and potentially lung cancer than chrysotile, based on lung burden studies, mechanistic studies, and various epidemiological data.

Studies on the importance of fiber size on toxicity come mainly from investigations in animals, particularly experiments conducted by Davis et al. (1978, 1980, 1985, 1986a, 1986b) and Davis and Jones (1988). These studies all utilized a common protocol in which groups of about 40 rats were exposed by inhalation for seven hours per day, five days per week for 224 days over one year and then observed for at least another year. A range of different test materials was evaluated, including crocidolite, Korean tremolite, four types of chrysotile, and three types of amosite. Each type of asbestos was tested at an airborne concentration of 10 mg/m3; several other concentrations were tested for some of the asbestos types. The original characterization of exposure materials in the studies by Davis et al. (1978, 1980, 1985, 1986a, 1986b) did not include comprehensive characterization of the distribution of the length and width of the suspended structures and did not include a count of structures thinner than 0.2 um. Because of these limitations, archived samples of the original stock samples were used to regenerate asbestos dust clouds (using the same equipment, procedures, and personnel as in the original studies) from which samples were taken and characterized more fully using TEM techniques (Berman et al., 1995).

Using these detailed particle size and type data, Berman et al. (1995) conducted statistical analyses of the rat lung tumor incidence data to identify which size categories were best correlated with increased incidence of disease. No mathematical model with a single explanatory variable provided an adequate description of the lung tumor incidence. In contrast, multivariate models which included concentrations of particles in different size categories did provide an adequate description of the lung tumor incidence data. Fitting began with a model with five length categories (<5, 5-10, 10-20, 20-40, > 40 um) and five thickness categories (<0.15, 0.15-0.3, 0.3-1.0, 1.0-5.0, and > 5 um).

By eliminating bins that had potency factors that were not statistically different from zero and combining bins that were not statistically different from each other, Berman et al. (1995) developed a final model with three length categories (<5, 5-40, and >40 um) and two width categories (<0.3 and > 5 um).

The relative bin-specific potency factors for this model are summarized below:

Relative Potency Estimates Based on Rat Data

Width (um)	Length (um)		
	< 5	5-40	> 40
≤ 0.3	0	0.0017	0.853
≥ 5.0	0	0	0.145

Adapted from Berman et al. 1995 by HDR in the September 2010 OU5 RI Report

As seen, fibers longer than 40 um accounted for 99.8% of the total potency, with most of that (85%) being contributed by fibers ≤ 0.3 um in diameter. Only a small contribution (<0.2%) was provided by fibers 5-40 um in length, and fibers less than 5 um did not contribute any observable potency. Further analysis of the available data in the context of the best-fitting model could not discern a difference in the lung-cancer-inducing potency of chrysotile and amphibole. Statistical analysis of the mesothelioma data indicated that amphibole potency was greater than chrysotile potency for equivalent size and shape particles (Berman et al., 1995).

More recently, research on “respirable” size fraction of asbestos particles to the overall toxicity of asbestos has been conducted although this is considered a data gap in the field of asbestos research (NIOSH, 2011). The amphibole class of asbestiform materials has a wide range of particle size distribution and the deposition of both spherical and elongate particles in the lung is size-dependent, with smaller particles having a greater probability of depositing in distal airways of the lung. Duncan et al. (2010) studied the cellular stress responses induced in primary human airway epithelial cells (HAEC) *in vitro* when exposed to a respirable size-fraction (≤2.5 um) of Libby amphibole ($LA_{2.5}$) to a similar size fraction of a reference amphibole sample amosite ($AM_{2.5}$). Unfractionated LA and amphibole AM, as well as the relative toxicity of a smaller size fraction with aerodynamic diameter (D_{ac}) of ≤ 2.5 um of each of the amphibole samples were also investigated. The responses were measured by gene expression changes of IL-8, COX-2, heme oxygenase (HO)-1, along with 84 other genes involved in cellular stress-responsive pathways. Results of the study indicated that small size fractions of LA and AM, which are believed to penetrate deeper into the lung, induced comparable epithelial cell production of pro-inflammatory cytokines as unfractionated LA and AM. Further, exposure to $AM_{2.5}$ resulted in a 4-10 fold greater induction in pro-inflammatory mediators compared to $LA_{2.5}$ after 24 hours of exposure.

The difference in observed toxicity for the size-fractionated samples could not be attributed to differences in mineral contamination between the two samples, total surface area, or oxidant generation. The study demonstrated that small amphibole particles could be taken up by HAEC and concluded that results of the investigation provide evidence of the ability of LA to induce epithelial injury and inflammation compared to well-characterized amphibole samples.

Studies on the importance of asbestos fiber dimension (length, width) on toxicity in humans are limited. Stayner et al. (2007) evaluated the role of fiber dimension on cancer and non-cancer disease in workers exposed to chrysotile. Both lung cancer and asbestosis were most strongly associated with exposure to thin fibers (< 0.25 um). Exposure to long fibers (> 10 um) was found to be a strong predictor of increased lung cancer risk, while results for asbestosis were inconsistent. No studies of this type have been located for workers exposed to amphibole.

However, Berman and Crump (2008) performed mathematical modeling of human exposure response data to a range of different asbestos types, and concluded that fibers < 10 um in length have very low carcinogenic potency compared to fibers longer than 10 um in length. Based on limited data on fiber width from either animal or human studies, Berman and Crump (2008) stated that the effect of fiber width on potency remains unclear although it is likely that fiber width will affect lung cancer and mesothelioma differently.

In addition to length and width, the impact of aspect ratio (length:width) on toxicity and health effects is an area of research that is still being investigated (NIOSH, 2011). Strum (2009) used a stochastic lung model to predict the deposition of variably shaped asbestos fibers in the human respiratory tract. The model focused on the computation of appropriate dynamic shape factors and resulting aerodynamic diameters of fibers with different aspect ratios. The aerodynamic diameter concept was implemented into a stochastic particle transport and deposition model which had previously been validated under numerous processes (Koblinger et al., 1990). Various deposition scenarios of fibers were computed and their values for estimation of health hazards were presented. The study indicated that the fiber aspect ratio (ß) had an insignificant influence on total deposition; and fibers with ß = 10 and ß = 100 differed by 2 to 10 percent (%). In contrast, for regional deposition the fiber diameter represented a controlling factor with fibrous particles with cylindrical diameter (d_p) = 0.1 um preferentially deposited in the bronchioles and alveoli, whereas fibers with d_p = 10 um exclusively accumulated in the extrathoracic region. Depositional behavior of fibers with d_p = 1 um was more complex, since the model indicated particle fractions deposited in all compartments of the lung. Results of the theoretical approach suggest that thin fibers with variable length tend to deposit in the pulmonary region of the lung, where they represent a risk for mesothelioma. The model indicated that thick fibers preferentially accumulate in the proximal bronchi, where they may induce bronchial lung cancer (adenocarcinoma).

7.4 QUANTIFICATION OF EXPOSURE AND RISK

The following section details the methodology by which the toxicity (i.e., constituent-specific dose-response information) and exposure (i.e., projected intake) assessments are integrated in the development of quantitative point estimates of carcinogenic risk and noncarcinogenic hazard.

7.4.1 Non-Cancer Risk

The basic equation for characterizing risk of a non-cancer effect from inhalation exposure to asbestos is as follows:

$$HQ = CE / RfC$$

where:

HQ = Hazard Quotient

CE = Cumulative exposure (PCM or PCM Equivalent (PCME) s/cc)

RfC = Reference concentration (PCM s/cc)

In May 2011, EPA hosted an interagency science consultation on the draft Integrated Risk Information System (IRIS) Toxicological Review of Libby Amphibole Asbestos and in August 2011, EPA released the External Review Draft for public review and comment. A public listening session was held on October 6, 2011. Final comments on the draft RfC were due on October 24, 2011 and no updates have been posted at the EPA website (EPA, 2011c). Following external peer review, the assessment will be revised, taking into consideration external peer review and public comments. The RfC will then be updated as appropriate and will undergo a final EPA internal review and a science discussion with other federal agencies and White House offices, and will be posted to the IRIS database (EPA, 2011c).

7.4.2 Cancer Risk

Excess lifetime risk of cancer (lung cancer plus mesothelioma) from exposure to asbestos in air is quantified based on the amount of asbestos inhaled and the duration over which exposure occurs. The basic equation is (EPA 2008):

$$Risk = EPC \cdot TWF \cdot IUR_{LA}$$

where:

Risk = Lifetime excess risk of cancer (lung cancer or mesothelioma) as a consequence of the site-related asbestos exposure.

EPC = Exposure point concentration of asbestos in air (PCM or PCME s/cc). The EPC is an estimate of the long-term average concentration of asbestos in inhaled air.

TWF = Time weighting factor. The value of the TWF term ranges from zero to one, and describes the average fraction of time that exposure occurs in the time interval being evaluated. The general equation is (EPA 2008):

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

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

IUR_{LA} = Inhalation unit risk (PCM s/cc)-1 for LA, which represents the upper-bound excess lifetime cancer risk estimated to result from continuous exposure at a concentration of 1 sLA/cc in air.

7.4.3 Exposure Point Concentrations

The value of the EPC term is based on TEM measurements of asbestos concentration levels in air (expressed as PCME LA s/cc) at the location of concern and for the exposure scenario of concern. Ideally, the EPC would be the true average concentration of LA in breathing zone air, averaged across the exposure period. However, the true average exposure concentration can only be approximated from a finite set of measurements, and the sample mean might be either higher or lower than the true mean.

To minimize the chances of underestimating the true amount 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 95UCL values (EPA, 2007a). However, the equations and functions in ProUCL are not designed for asbestos concentration data sets and application of ProUCL to asbestos data sets is not recommended (EPA, 2008). EPA is presently working to develop a new software application that will be appropriate for use with asbestos data sets, but the application is not yet available for use.

Because the 95UCL cannot presently be calculated with confidence, risk calculations presented in this report utilize the sample mean only (EPA, 2008). Because the sample mean may be either higher or lower than the true mean, the risk estimates presented here may be either higher or lower than the true risks.

In cases where the underlying data set for the EPC calculation is all non-detect, the calculated sample mean is zero. While a data set of this type provides good evidence that the true concentration is low, it is reasonable to assume the true mean value is not actually zero, although there is no reliable method for estimating what the true value might be (EPA, 2008).

It is important to note that rotomilling data collected from rotomilling equipment were all non-detect. These samples are indicative of exposures to a maintenance worker conducting rotomilling operations (i.e., a rotomill operator). However, while these data were non-detect, to be conservative, a maintenance worker/rotomiller was quantitatively evaluated in the HHRA using ABS data collected in the inner perimeter of the rotomilling study area. These data are representative of exposures to bystanders and other workers working in the study area and included some detections of LA in air.

The rotomilling EPC was calculated using inner perimeter ABS data only. Worker exposure assumptions were used to quantify risk and hazard for rotomilling activities.

7.4.4 Exposure Parameters

Not all individuals within a group will have equal exposures to asbestos. This is because different individuals will have differing values for exposure time (ET), exposure frequency (EF), and exposure period. To account for this variability, the HHRA evaluates a more realistic exposure scenario predicated on central tendency exposure parameter estimates, as well as an upper range exposure scenario for each site receptor.

Table 7-1 presents the exposure pathways and parameters used in the HHRA for each exposure scenario. The exposure parameters for recreational ATV users were based on professional judgment. The exposure parameters for outdoor maintenance workers were based on default values (EPA, 1991b, 2002, 2003), but were adjusted to focus on both a central tendency estimate and an upper range estimate. The rationale for the selected exposure parameters are provided in Table 7-1, as well as other HHRA tables.

7.5 RISK CHARACTERIZATION

The level of cancer risk that is of concern is a matter of personal, community, and regulatory judgment. In general, the EPA considers excess cancer risks that are below about 1E-06 (one in a million) to be so small as to be negligible, and risks above 1E-04 (one in ten thousand) to be sufficiently large that remediation or qualitative corrective action (e.g., land use restrictions) is desirable. Excess cancer risks that range between 1E-04 and 1E-06 are generally considered to be acceptable (EPA, 1991a), although this is evaluated on a case-by-case basis, considering the degree of conservatism and level of uncertainty inherent in the quantitative and qualitative assessments that comprise the risk evaluation. EPA may determine that risks lower than 1E-04 are not sufficiently protective and warrant remedial action. EPA has expressed a preference for cleanups achieving the protective end of the risk management range and considers 1E-06 as the point of departure for remedial decisions (EPA, 1991a). As noted previously, the risks calculated refer only to exposures that are assumed to occur in OU8. EPA will perform a risk assessment at a later date that considers cumulative risks from all site-related exposure pathways.

For noncancer health impacts risk is expressed as a Hazard Quotient (HQ), which is an indicator of the probability of potential risk of noncancer adverse health effects. The Hazard Index (HI) is equal to the sum of the HQs. Because LA is the only chemical evaluated at OU8, the HQ and HI are the same. An HI less than 1 indicates that it is unlikely for even sensitive populations to experience adverse health effects; an HI greater than 1 requires evaluation for potential risk management measures (EPA, 1989).

7.5.1 Risk to Adult Maintenance Workers

Pending finalization of toxicity values for LA.

7.5.2 Hazard to Adult Maintenance Workers

Pending finalization of toxicity values for LA.

7.5.3 Risks to Child, Adolescent and Adult Recreational ATV Users

Pending finalization of toxicity values for LA.

7.5.4 Hazard to Child, Adolescent and Adult Recreational ATV Users

Pending finalization of toxicity values for LA.

7.5.5 Risks from Outdoor Ambient Air

Pending finalization of toxicity values for LA.

7.5.6 Summary and Conclusions

Pending finalization of toxicity values for LA.

7.6 UNCERTAINTY ANALYSIS

There are a number of uncertainties that arise during the process of estimating human exposure and risk to asbestos. Such uncertainties limit the confidence in the estimated risks to recreational ATV users or roadway maintenance workers at OU8. The primary sources of uncertainty associated with this risk assessment are discussed below.

7.6.1 Uncertainty in LA Levels in Soil

As discussed previously, characterization of LA levels in soil is difficult. At present, the best available techniques are PLM-VE and visible inspection for vermiculite. However, both methods are subjective and are only semi-quantitative, and both tend to be somewhat variable between repeat analyses. Thus, the results of PLM or visible inspections analyses are inherently uncertain. In addition, because the relationship between LA levels in soil do not easily translate to air concentrations. Therefore, soil LA concentrations should not be relied upon for evaluating acute and chronic risks to receptors. Hence, the ABS approach was used to estimate potential health risk.

7.6.2 Uncertainty in LA Concentrations in Inhaled Air

Concentrations of LA in air are inherently variable, so estimates of mean exposure concentrations are subject to uncertainty arising from random variation between individual samples. This problem is especially marked for ABS samples, where very wide variability (3-4 orders of magnitude) may be observed within and between data sets. This high variability means that it is usually necessary to collect a large number of samples to ensure that the data are representative.

However, as noted above, only a limited number of ABS values are available for each ABS area, and these values may not be representative of the true long term average exposure concentration for soil disturbances in the OU. Consequently, the observed sample mean concentration may be either higher or lower than the true mean.

This uncertainty is further compounded by the effect of analytical measurement error. That is, for each air sample collected, the measured concentration value is a random variable that is characterized by the Poisson distribution:

$$C_{observed} \sim \text{POISSON}\ (C_{true} \cdot \text{Volume Analyzed}) / \text{Volume Analyzed}$$

As a consequence, the total variability (and hence uncertainty) in the measured concentration values is greater than the variability due to sampling variation alone. Consequently, risks calculated based on the mean may be either higher or lower than the true risk, but the magnitude of the potential error cannot be estimated because appropriate statistical methods are not yet available to calculate the 95UCL.

7.6.3 Uncertainty Arising from Use of an Indirect Preparation Technique

During TEM analysis of the ABS air samples, the analytical laboratory noted that some of the air filters were significantly overloaded with particulates. As a result, these samples were analyzed using an indirect preparation method after ashing in accordance with the Supplemental Remedial Investigation Quality Assurance Project Plan (EPA, 2005). For chrysotile asbestos, indirect preparation often tends to increase structure counts due to dispersion of bundles and clusters (Hwang and Wang, 1983; HEI-AR, 1991; Breysse 1991). For amphibole asbestos, the effects of indirect preparation are generally much smaller (Bishop et al., 1978; Sahle and Laszlo, 1996; Harris 2009). Based on this information, it is expected that the effect of indirect preparation on estimates of LA concentrations in air is likely to be minor.

This expectation is supported by a Libby-specific study conducted in 2005. This study compared the results for 31 samples analyzed for LA using both direct and indirect preparation methods (EPA, 2007b). Figure 7-2 presents the paired results from this study. For total LA (Panel A), some samples were statistically lower, some were not statistically different, and some were statistically higher when analyzed by an indirect method compared to a direct method. Although the difference was 10- to15-fold in a few samples, the average across all samples was about 3.3.

A similar pattern is observed when results are expressed as PCME s/cc (Panel B), although the differences tend to be smaller. In this case, the average ratio of indirect to direct concentration estimates is about 1.5. Based on these considerations, it is concluded that analysis of samples for

LA using an indirect preparation method may tend to overestimate exposure and risk somewhat, but that the magnitude of the error is not likely to exceed a factor of about 1.5-3.

7.6.4 Lack of an Approved Non-Cancer Inhalation RfC

Studies of former workers at the vermiculite mine and residents of Libby (Armstrong et al., 1988; McDonald et al., 1986a, 1986b; Amandus et al., 1987; Peipins et al., 2003; Muravov et al., 2005; Whitehouse 2004) provide strong evidence that exposure to LA results in an increased incidence of non-cancer adverse effects, and that these effects occur in some individuals who appear to have relatively low exposures. Similar results have been observed in workers at a plant in Ohio that utilized vermiculite from Libby to make lawn care products (Lockey et al. 1984, Rohs et al.2008).

While EPA has not yet developed national guidance for evaluating the risk of non-cancer effects from inhalation exposure to asbestos, EPA released a draft RfC for LA in May 2011. Using the draft RfC in the risk assessment could overestimate or underestimate hazard.

7.6.5 Uncertainty in Human Exposure Patterns

Risk from asbestos is strongly dependent not only on the level of exposure, but also on the time and frequency of exposure and on the age when exposure begins and ends. Exposure parameters for site users are based on profession judgment or EPA default values. There is some uncertainty with these exposure parameters, which may overestimate or underestimate uncertainty. To reduce uncertainty, risk and hazard estimates for each site receptor were determined using exposure parameters representative of upper range exposure and exposure parameters representative of a more central tendency exposure scenario.

7.6.6 Uncertainty in the Cancer Exposure-Response Relationship

Although the IRIS method is currently the only approach approved by EPA for estimating cancer risks from inhalation of asbestos (EPA 2008), there are some uncertainties and potential limitations to the use of this method, as follows:

- The potency factors derived by EPA (1986) are based on measures of exposure expressed as PCM fibers, without any distinction of mineral type (chrysotile, amphibole). However, there are a number of studies which suggest that mineral type may be an important determinant of potency, at least for mesothelioma. Because the potency factors are consensus values that are derived from studies that include occupational exposures to chrysotile alone, amphibole alone, and a mixture of amphibole and chrysotile, it is expected that the IRIS potency factors are intermediate between the values for amphibole and chrysotile. To the extent that amphibole is more potent that chrysotile, use of the IRIS potency factors may tend to underestimate risks in Libby, where the mineral form of concern is amphibole.
- To the extent that the particle size distributions vary between workplaces (i.e., the ratio is not constant between the concentration of PCM fibers and the concentrations of other size ranges with differing potencies), the IRIS approach cannot account for these differences, and may either underestimate or overestimate risk.
- The IRIS values are based on observations in workers, and may not address differences in susceptibility between different types of populations (e.g., children, the elderly).
- The IRIS values represent the central tendency estimates of the potency factors, not an upper bound on the values. Thus, the true potency factors might be either higher or lower than the values selected.
- The unit risks derived by EPA (1986) are based on mortality statistics from the 1970s. Thus, they may not be applicable to populations that are exposed to asbestos today. In particular, as life expectancy has increased, risks from asbestos exposure also tend to increase. Thus, risk estimates based on the IRIS method may be somewhat low.

7.6.7 Uncertainty Associated with Cumulative Exposures

People who live or work in Libby may be exposed to LA by a number of different pathways. Because this risk assessment evaluates only some of these pathways, the risk estimates presented here are likely to underestimate the total risks to site receptors. However, until risk assessments are completed for all potentially significant exposure pathways, the magnitude of the risks cannot be reliably estimated.

8.0 CONCLUSIONS

The RI reached the following general conclusions:

1. Approximately 80% of PLM results for surface soil samples collected as part of the OU8 remedial investigation field program are non-detect with the remainder containing trace amounts of LA. Some soil samples collected prior to the establishment of OU8 (legacy data) between the Libby Mine (Rainy Creek Road) and the town of Libby contained LA at levels between trace and 1%. Relatively higher levels of LA in surface soils between Libby and the Rainy Creek Road are expected as ore trucks traveled this route during operation of the mine.

2. Visible vermiculite is limited to the eastern-most section of SH 37. This result is somewhat unexpected given that the occurrence of LA by PLM in soil in this area is typical of most of OU8.

3. Predicting LA levels in air associated with disturbance activities based only on measured LA levels in soil is extremely difficult. Therefore, ABS is considered to be the most direct way to estimate potential exposures from inhalation of asbestos.

4. Exposure pathways that are thought to be most likely of potential concern in OU8 include exposure of ATV riders along roadway ROW and exposure of outdoor roadway maintenance workers performing grass cutting, brush hogging and rotomilling.

5. ABS air sampling was conducted to assess exposure to roadway maintenance workers and ATV riders. Air sampling pumps were affixed to ATVs and maintenance equipment during ABS sample events.

6. Air sampling associated with rotomilling also involved fixed sampling stations on both sides of the street where rotomilling operations were conducted (forming an inner perimeter). In addition, stationary air samples were collected at various locations up to 1,000 feet from the rotomill, comprising an outer perimeter.

7. Cancer risk estimates based on measured LA concentrations in air are pending finalization of toxicity values for LA.

8. Non-cancer health impacts are expressed as a Hazard Quotient (HQ), which indicates the potential for adverse health effects. HQs are pending finalization of toxicity values for LA.

9. An ecological risk assessment is being developed for the mine site (OU3). EPA will build upon the information gathered during that ecological risk assessment to identify potential

pathways and receptors to evaluate ecological risk at OU8. If ecological exposure pathways are identified at OU8, an ecological risk assessment will be performed.

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Tables

TABLE 3-1
Sampling Events Relevant to OU8

Location	Date	Investigation Description	Media Collected and Analyzed	Reason for Selecting Sample Location	Reference
Montana State Highway 37	2001	Exposures to cleanup workers and highway users during remediation activities	Air associated with vehicle and foot traffic	Opportunistic air sampling (sampler affixed to personnel and vehicles)	CDM, 2005
Montana State Highway 37	2003	Contaminant Screening Study, Libby Asbestos Site, Operable Unit 4	Surface soil (0-6") composite samples	Systematic surface soil sampling	CDM, 2005
Montana State Highway 37	2005	To resample the 2003 locations in the 0-1" interval	Surface soil (0-1") composite samples	Co-locate with 2003 locations.	CDM, 2005
Montana State Highway 37	2005	Assess exposure to individuals working on or near Hwy 37	Stationary air samples	Systematic air sampling along the same portion of Hwy 37 that was subjected to soil sampling in 2003	CDM, 2005
MDT Rights-of-Way within 5-miles of Libby	2006	Assessment to support MDT Industrial Hygene Policy	Activity-Based Air Samples (ABS) associated with MDT maintenance activities Traction sand and road aggregate Road sweepings Surface soil grab samples	Opportunistic air sampling (sampler affixed to personnel and equipment);opportunistic traction sand and aggregate sampling ; random road sweeping sampling; systematic soil sampling	Tetra Tech, Inc, 2007 a
Montana State Highway 37	2007	Assessment to support MDT Industrial Hygene Policy	ABS air samples associated with MDT maintenance activities	Opportunistic air sampling (sampler affixed to personnel and equipment)	Tetra Tech, Inc., 2007 b
OU8 State and Local Highway embankement	2010	Remedial Investigation Field Program	ABS Air samples asscoiated with recreational and MDT embankement maintenance activities; surface soil composite samples	ABS air samples collected between Libby and Rainy Creek Road (location along Hwy 37 where LA was detected during 2005 soil sample event); systematic soil sampling throughout OU8	EPA Scribe Database
OU8 State and Local Highway pavement	2011	Remedial Investigation Field Program	ABS Air samples associated with pavement rotomilling activities	Oppotunistic air sampling	EPA Scribe Database

TABLE 7-1
Exposure Pathways and Parameters Used in the Quantitative Evaluation

Exposure Pathways and Parameters	Acronym	Units	Upper Range Value	Central Tendency	Source
ATV User (Child)[1]					
Inhalation of Asbestos Fibers					
Exposure Parameters					
Exposure Time	ET	hours exposed/day	4	2	Professional Judgment [2]
Exposure Frequency	EF	days/year	184	90	184 days/year assumes daily exposure from April through September, during the warmer months of the year. 90 days/year assumes daily exposure for three summer months.
ATV User (Adolescent) [3]					
Inhalation of Asbestos Fibers					
Exposure Parameters					
Exposure Time	ET	hours exposed/day	4	2	Professional Judgment [4]
Exposure Frequency	EF	days/year	184	90	184 days/year assumes daily exposure from April through September, during the warmer months of the year. 90 days/year assumes daily exposure for three summer months.
ATV User (Adult) [5]					
Inhalation of Asbestos Fibers					
Exposure Parameters					
Exposure Time	ET	hours exposed/day	4	2	Professional Judgment[4]
Exposure Frequency	EF	days/year	184	90	184 days/year assumes daily exposure from April through September, during the warmer months of the year. 90 days/year assumes daily exposure for three summer months.
Maintenance Worker (Brush Hogging, Mowing, and Rotomilling) [6, 7]					
Inhalation of Asbestos Fibers					
Exposure Parameters					
Exposure Time	ET	hours exposed/day	8	8	Professional Judgment[6]
Exposure Frequency	EF	days/year	60	12	Upper range assumes three months of exposure working 5-day work weeks, 4 weeks per month, with weekends off. However, 12 days/year is likely more realistic of site exposures.[6]

Notes:

[1] Assumes 5 years of exposure at OU-8, starting at age 5 for six months out of the year, during the warmer months from April through September.

[2] Assumes that a child would accompany an adult during recreational activities (e.g., riding all terrain vehicles [ATVs]) along the highway at OU8.

[3] The risk calculation assumes 10 years of exposure at OU-8, starting at age 6 for six months out of the year, during warmer months from April through September. The hazard quotient calculation assumes 5 years of exposure at OU-8, starting at age 10 for six months out of the year, during warmer months from April through September.

[4] Assumes that a teenager or adult would walk, bicycle, or ride ATVs for 4 hours per day along the highway at OU-8. However, a more realistic estimate of exposure assumes 2 hours per day.

[5] Assumes 30 years exposure at OU-8, starting at age 20 for six months out of the year, during warmer months from April through September.

[6] An EF of 12 days per year considers approximately 240 miles of roadway spanning both sides of all OU8 state highways (~120 miles for one side of the highway) and assumes three days of brush hogging or rotomilling, to occur twice a year, and accounts for variability in brush hogging or rotomilling efficiency. Example (240 miles @ average mowing speed of 10 mph): 3 days mowing @ 8 hrs/day x 2 mowing operations/yr = 6 mowing days/yr. This estimate is doubled to account for 50% efficiency in operator differences, resulting in an effective exposure frequency of 12 days/year.

[7] Assumes 30 years exposure at OU-8, starting at age 20 for three months out of the year, during warmer months from June through August. Cancer risk and non-cancer hazard were estimated only for brush hogging activities; asbestos results were reported as non-detect for mowing activities, therefore cancer risk and hazard are not reported for the Maintenance Worker mowing scenario.

TABLE 7-2
Exposure Point Concentration Calculation for Maintenance Worker – Grass Cutting

Sample ID	Result (s/cc)	Activity	Sample Location[1]
HW-00650	0	Grass Cutting	Hwy 37 E Bridge to Riveredge ~mm 4.4 Front Low
HW-00652	0	Grass Cutting	Hwy 37 E Bridge to Riveredge ~mm 4.4 Back Low
HW-00654	0	Grass Cutting	Hwy 37 W Riveredge ~mm 4.4 to bridge Front Low
HW-00655	0	Grass Cutting	Hwy 37 W Riveredge ~mm 4.4 To Bridge Back High

EPC is zero as all data are non-detect. Quantification of risk and hazard are not applicable.

[1] - Description corresponds to location of sampling activity and where the sampler was located on the equipment (i.e., front, back, high, low)

TABLE 7-3
Exposure Point Concentration Calculation for Maintenance Worker – Brush Hogging

Sample ID	Result (s/cc)	Activity	Sample Location[1]
HW-00583	0	Brush hogging	Tractor Back ; Hi; MM2 to First driveway; Hwy 37 N
HW-00585	0	Brush hogging	Tractor Front; Hi; MM2 to First Driveway; Hwy 37 N
HW-00592	0.011958564	Brush hogging	Tractor Front; Hi; Drive across from Amerigas; Hwy 37 N
HW-00594	0.017797707	Brush hogging	Tractor Back; Hi; Driveway across from Amerigas; Hwy 37 N
HW-00596	0	Brush hogging	MM3 to ~MM3.5 on HWY 37 N Tractor Front Low
HW-00598	0	Brush hogging	MM3 to ~MM3.5 on HWY 37 N Tractor Back Low
HW-00608	0	Brush hogging	Hwy 37 East mm 3.5 to 3770 Hwy 37 Front High
HW-00610	0	Brush hogging	Hwy 37 East mm 3.5 to 3770 Hwy 37 Back High
HW-00613	0.015413709	Brush hogging	Hwy 37 E From 3770 To mm 4.5 Front High
HW-00615	0.008734435	Brush hogging	Hwy 37 E From 3770 To mm 4.5 Back High
HW-00626	0.017981411	Brush hogging	MM 4.5 to 4.0 Hwy 37 W Tractor Front High
HW-00628	0	Brush hogging	MM 4.5 to 4.0 Hwy 37 W Tractor Back High
HW-00630	0.002846538	Brush hogging	MM 4.5 to Rainey Creek Rd Hwy 37 E + W Sides Tractor Front High
HW-00632	0.011613876	Brush hogging	MM 4.5 to Rainey Creek Rd Hwy 37 E + W Sides Tractor Back High
AVERAGE	**6.17E-03**	**Exposure Point Concentration[2]**	

[1] - Description corresponds to location of sampling activity and where the sampler was located on the equipment (i.e., front, back, high, low)

[2] - The EPC is the concentration of asbestos structures in cubic centimeters of air (s/cc) for the specific activity being assessed

TABLE 7-4
Exposure Point Concentration Calculation for Maintenance Worker – Rotomilling

Inner Perimeter ABS Rotomilling Data - Results from General Vicinity (Not from Equipment)			
Sample ID	**Result (s/cc)**	**Activity**	**Sample Location[1]**
HW-00755	0	Rotomilling - Road Use Area	Block 1 East Side
HW-00757	0	Rotomilling - Road Use Area	Block 1 West Side
HW-00759	0	Rotomilling - Road Use Area	Block 2 East Side
HW-00761	0	Rotomilling - Road Use Area	Block 2 West Side
HW-00763	0	Rotomilling - Road Use Area	Block 3 East Side
HW-00765	0	Rotomilling - Road Use Area	Block 3 West Side
HW-00771	0	Rotomilling - Road Use Area	Block 4 West Side
HW-00773	0	Rotomilling - Road Use Area	Block 5 East Side
HW-00775	0	Rotomilling - Road Use Area	Block 5 West Side
HW-00777	0	Rotomilling - Road Use Area	Block 6 East Side
HW-00779	0	Rotomilling - Road Use Area	Block 6 West Side
HW-00781	0	Rotomilling - Road Use Area	Block 7 East Side
HW-00783	0	Rotomilling - Road Use Area	Block 7 West Side
HW-00787	0	Rotomilling - Road Use Area	Block 1 East Side
HW-00789	0	Rotomilling - Road Use Area	Block 1 West Side
HW-00791	0	Rotomilling - Road Use Area	Block 2 East Side
HW-00793	0	Rotomilling - Road Use Area	Block 2 West Side
HW-00797	0	Rotomilling - Road Use Area	Block 3 East Side
HW-00799	0	Rotomilling - Road Use Area	Block 3 West Side
HW-00801	0	Rotomilling - Road Use Area	Block 4 East Side
HW-00803	0	Rotomilling - Road Use Area	Block 4 West Side
HW-00805	0	Rotomilling - Road Use Area	Block 5 East Side
HW-00807	0	Rotomilling - Road Use Area	Block 5 West Side
HW-00809	0	Rotomilling - Road Use Area	Block 6 East Side
HW-00811	0	Rotomilling - Road Use Area	Block 6 West Side
HW-00813	0	Rotomilling - Road Use Area	Block 7 East Side
HW-00815	0	Rotomilling - Road Use Area	Block 7 West Side
HW-00828	0	Rotomilling - Road Use Area	Block 1 East Side Corner
HW-00830	0	Rotomilling - Road Use Area	Block 1 West Side Corner
HW-00832	0	Rotomilling - Road Use Area	Block 2 East Side Corner
HW-00834	0	Rotomilling - Road Use Area	Block 2 West Side Corner
HW-00836	0	Rotomilling - Road Use Area	Block 3 East Side Corner
HW-00838	0	Rotomilling - Road Use Area	Block 3 West Side Corner
HW-00840	0	Rotomilling - Road Use Area	Block 4 East Side Corner
HW-00842	0	Rotomilling - Road Use Area	Block 4 West Side Corner
HW-00844	0	Rotomilling - Road Use Area	Block 5 East Side Corner
HW-00846	0	Rotomilling - Road Use Area	Block 5 West Side Corner
HW-00848	0	Rotomilling - Road Use Area	Block 6 East Side Corner
HW-00850	0	Rotomilling - Road Use Area	Block 6 West Side Corner
HW-00854	0	Rotomilling - Road Use Area	Block 1 East Side Corner
HW-00856	0	Rotomilling - Road Use Area	Block 1 West Side Corner

(Continued)

TABLE 7-4

Exposure Point Concentration Calculation for Maintenance Worker – Rotomilling (Continued)

Inner Perimeter ABS Rotomilling Data - Results from General Vicinity (Not from Equipment)			
Sample ID	**Result (s/cc)**	**Activity**	**Sample Location[1]**
HW-00858	0	Rotomilling - Road Use Area	Block 2 East Side Corner
HW-00860	0.002973432	Rotomilling - Road Use Area	Block 2 West Side Corner
HW-00862	0	Rotomilling - Road Use Area	Block 3 East Side Corner
HW-00864	0	Rotomilling - Road Use Area	Block 3 West Side Corner
HW-00877	0	Rotomilling - Road Use Area	Block 4 East Side Corner
HW-00880	0	Rotomilling - Road Use Area	Block 4 West Side Corner
HW-00882	0	Rotomilling - Road Use Area	Block 5 East Side Corner
HW-00884	0	Rotomilling - Road Use Area	Block 5 West Side Corner
HW-00886	0	Rotomilling - Road Use Area	Block 6 East Side Corner
HW-00888	0	Rotomilling - Road Use Area	Block 6 West Side Corner
AVERAGE	**5.83E-05**	**Exposure Point Concentration[2]**	
Inner Perimeter ABS - Results on Equipment[3]			
Sample ID	**Result (s/cc)**	**Activity**	**Sample Location[1]**
HW-00752	0		Rotomill (Hwy 2 to W 5th (Hwy 37))
HW-00767	0		Rotomill
HW-00785	0		Rotomill
HW-00795	0		Rotomill
HW-00824	0		Rotomill
HW-00852	0		Rotomill
HW-00866	0		Skid Steer Rotomill
HW-00868	0		Rotomill
HW-00889	0		Skid Steer Rotomill
HW-00891	0		Rotomill
HW-00890	Overloaded[4]		

ABS - Activity Based Sampling

[1] - Description corresponds to location of sampler

[2] - The EPC is the concentration of asbestos structures in cubic centimeters of air (s/cc) for the specific activity being assessed

[3] - An EPC was not calculated as all data in this dataset were non-detect.

[4] - There are no results for this sample because filter was overloaded. Sample HW-00889, which was analyzed, is the parent sample to HW-00890.

TABLE 7-5
Exposure Point Concentration Calculation for Recreational ATV Users

Sample ID	Result (s/cc)	Activity	Sample Location[1]
HW-00588	0	ATV riding	ATV Lead; High; Pipe Creek Rd to Payne Machine entry; Hwy 37 N & S
HW-00590	0	ATV riding	ATV Follow; High; Hwy 37 N & S; Pipe Creek Rd to Payne Machine entry
HW-00600	0.002836723	ATV riding	MM2 to Rainey Creek Rd + Back Lead High
HW-00602	0	ATV riding	MM2 to Rainey Creek Rd + Back Hwy 37 Follow High
HW-00604	0	ATV riding	Hwy 37 mm 4.4 to 5.5 West Side Only Off Road Lead High
HW-00606	0	ATV riding	Hwy 37 mm 4.4 to 5.5 West Side Only Off Road Follow High
HW-00618	0	ATV riding	Hwy 37 mm 4.4 to 5.5 Off Road ONLY west Side Lead Low
HW-00620	0	ATV riding	Hwy 37 mm 4.4 to 5.5 Off Road ONLY west Side Follow Low
HW-00622	0	ATV riding	Hwy 37 Pipe Creek Rd to Rainey Creek Rd Pavement ONLY Lead High
HW-00624	0	ATV riding	Hwy 37 Pipe Creek Rd to Rainey Creek Rd Pavement ONLY Follow High
HW-00635	0	ATV riding	Hwy 37 MM2 to Rainey Creek Rd + Back Off Road Lead High
HW-00638	0	ATV riding	Hwy 37 MM2 to Rainey Creek Rd + Back Off Road Lead Low
HW-00645	0	ATV riding	Hwy 37 E + W Pipe Creek Rd to Payne Machinery Lead High
HW-00647	0	ATV riding	Hwy 37 E + W Pipe Creek Rd to Payne Machinery Follow High
HW-00657	0	ATV riding	Hwy 37 Pipe Creek Rd to Rainey Creek Rd + Back Pavement ONLY Lead High
HW-00659	0	ATV riding	Hwy 37 Pipe Creek Rd to Rainey Creek Rd + Back Pavement ONLY Follow High
AVERAGE	**1.77E-04**	**Exposure Point Concentration[2]**	

ATV - All terrain vehicle
[1] - Description corresponds to location of sampling activity and where the sampler was located on the equipment (i.e., front, back, high, low)
[2] - The EPC is the concentration of asbestos structures in cubic centimeters of air (s/cc) for the specific activity being assessed

TABLE 7-6
Maintenance Worker Inhalation of Asbestos in Air Cancer Risk Calculations (Upper Range)
Pending finalization of toxicity values for LA

TABLE 7-7

Maintenance Worker Inhalation of Asbestos in Air Cancer Risk Calculations (Central Tendency)

Pending finalization of toxicity values for LA

TABLE 7-8
Maintenance Worker Inhalation of Asbestos in Air Hazard Calculations (Upper Range)
Pending finalization of toxicity values for LA

TABLE 7-9
Maintenance Worker Inhalation of Asbestos in Air Hazard Calculations (Central Tendency)
Pending finalization of toxicity values for LA

TABLE 7-10
Recreational ATV User Inhalation of Asbestos in Air Cancer Risk Calculations (Upper Range)
Pending finalization of toxicity values for LA

TABLE 7-11
Recreational ATV User Inhalation of Asbestos in Air Cancer Risk Calculations (Central Tendency)
Pending finalization of toxicity values for LA

TABLE 7-12
Recreational ATV User Inhalation of Asbestos in Air Hazard Calculations (Upper Range)
Pending finalization of toxicity values for LA

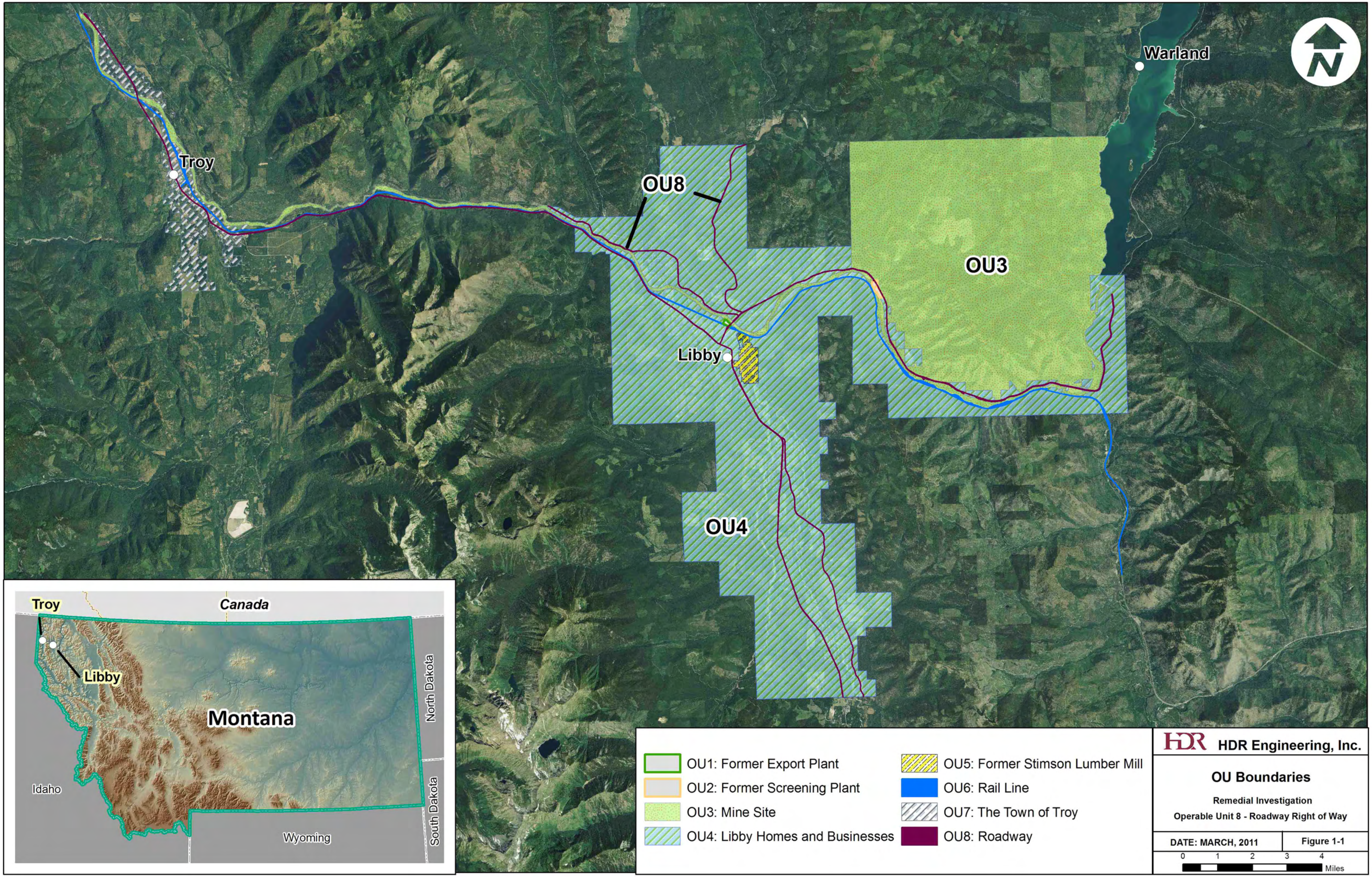
TABLE 7-13
Recreational ATV User Inhalation of Asbestos in Air Hazard Calculations (Central Tendency)
Pending finalization of toxicity values for LA

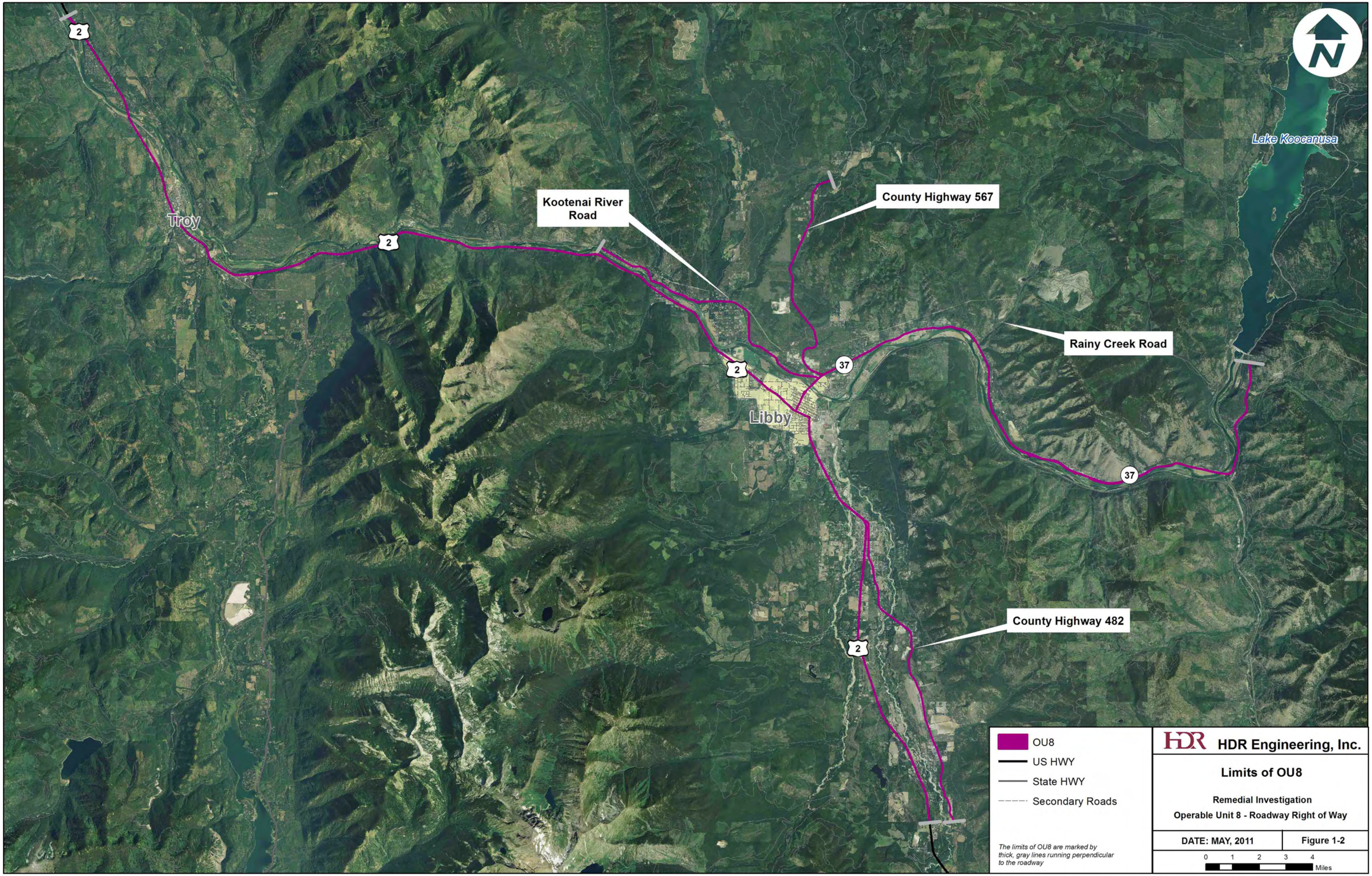
TABLE 7-14

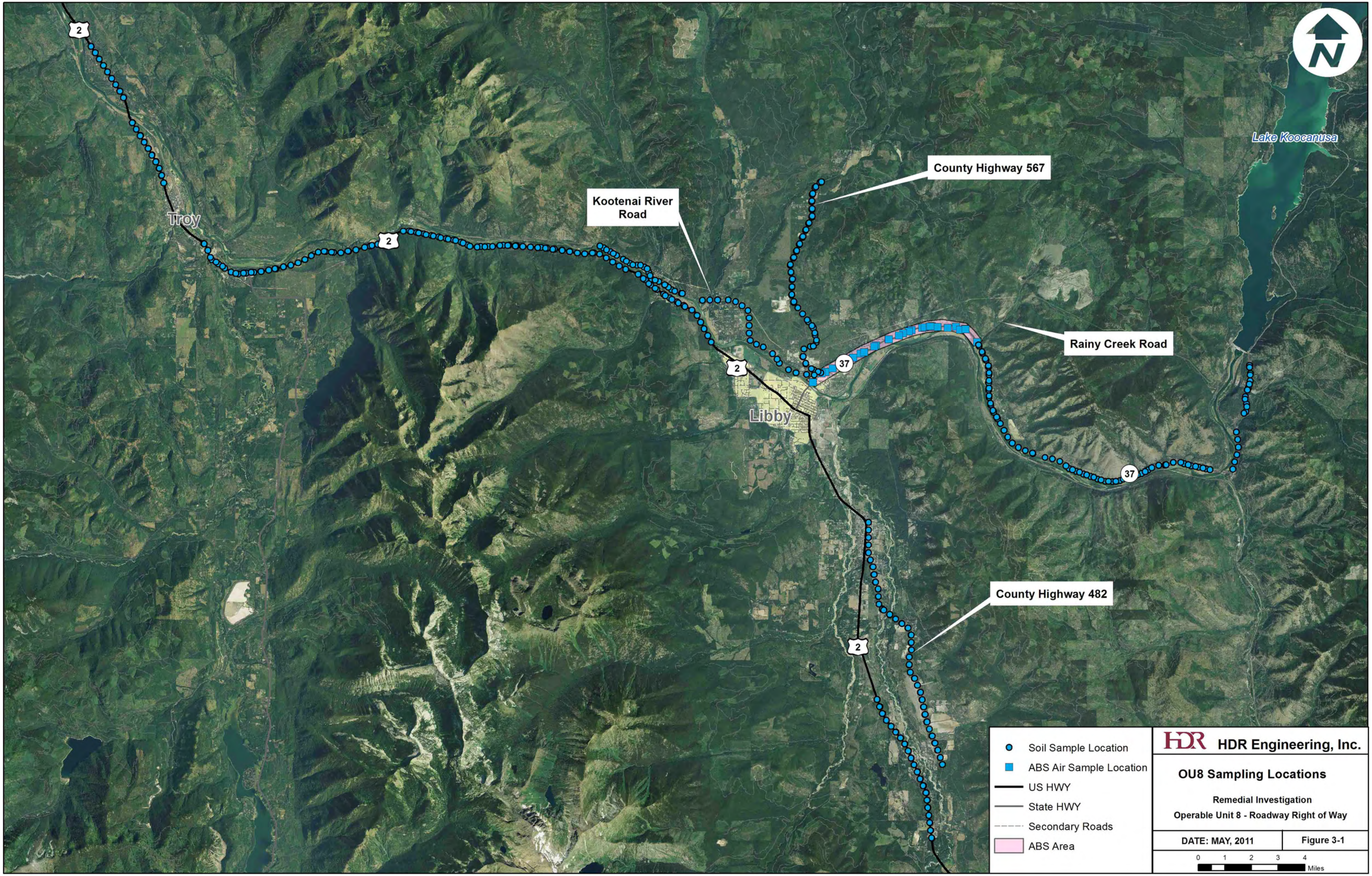
OU-8 Risk and Hazard Summary

Pending finalization of toxicity values for LA

Figures

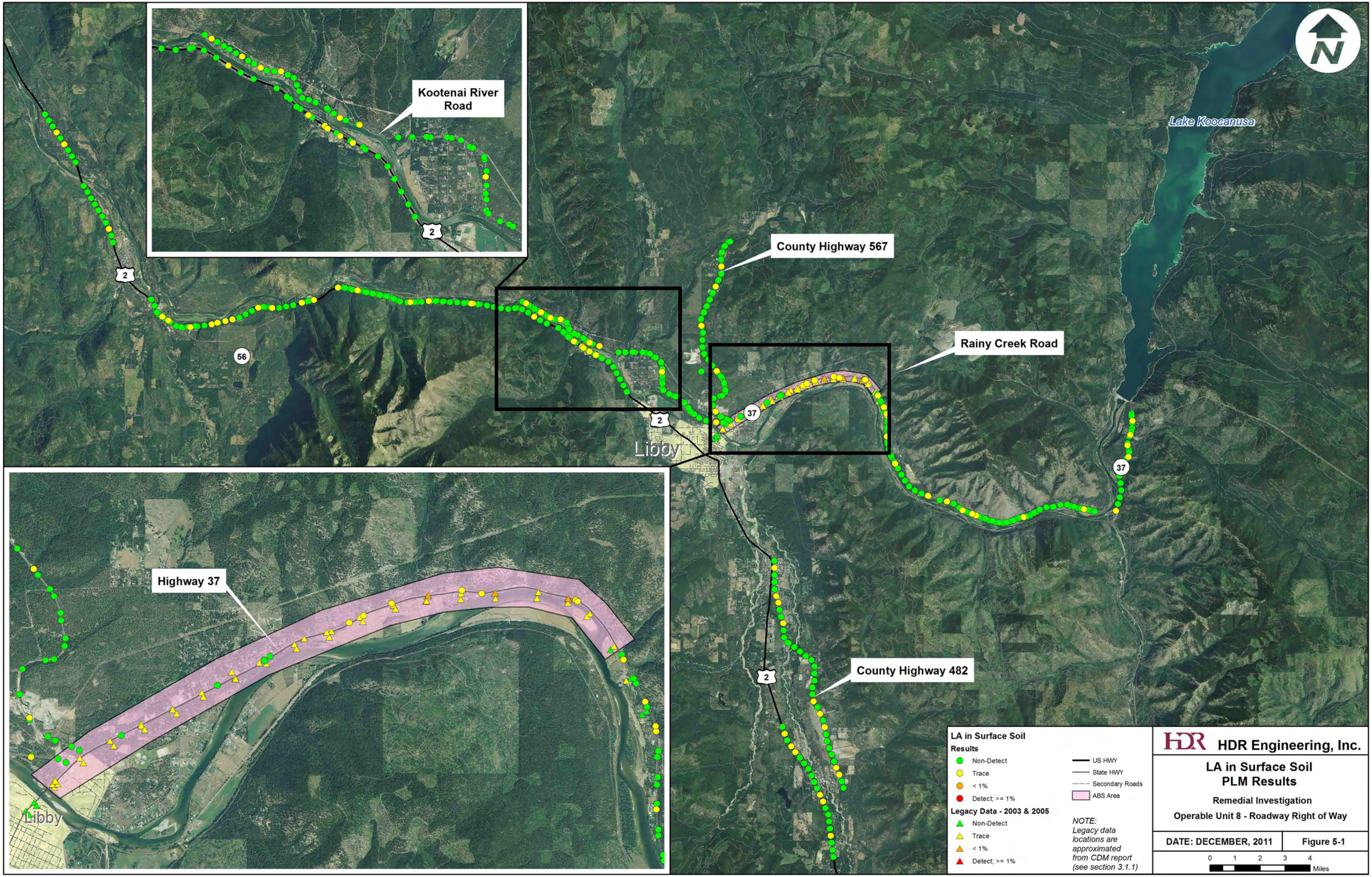

Warland
Troy
OU8
OU3
Libby
OU4
Troy
Canada
Libby
Montana
North Dakota
Idaho
South Dakota
Wyoming
OU1: Former Export Plant
OU2: Former Screening Plant
OU3: Mine Site
OU4: Libby Homes and Businesses
OU5: Former Stimson Lumber Mill
OU6: Rail Line
OU7: The Town of Troy
OU8: Roadway
HDR Engineering, Inc.
OU Boundaries
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MARCH, 2011
Figure 1-1
0 1 2 3 4
Miles


Troy
Kootenai River Road
County Highway 567
Lake Koocanusa
Rainy Creek Road
Libby
County Highway 482
2
37
OU8
US HWY
State HWY
Secondary Roads
The limits of OU8 are marked by thick, gray lines running perpendicular to the roadway
HDR Engineering, Inc.
Limits of OU8
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MAY, 2011
Figure 1-2
0 1 2 3 4
Miles

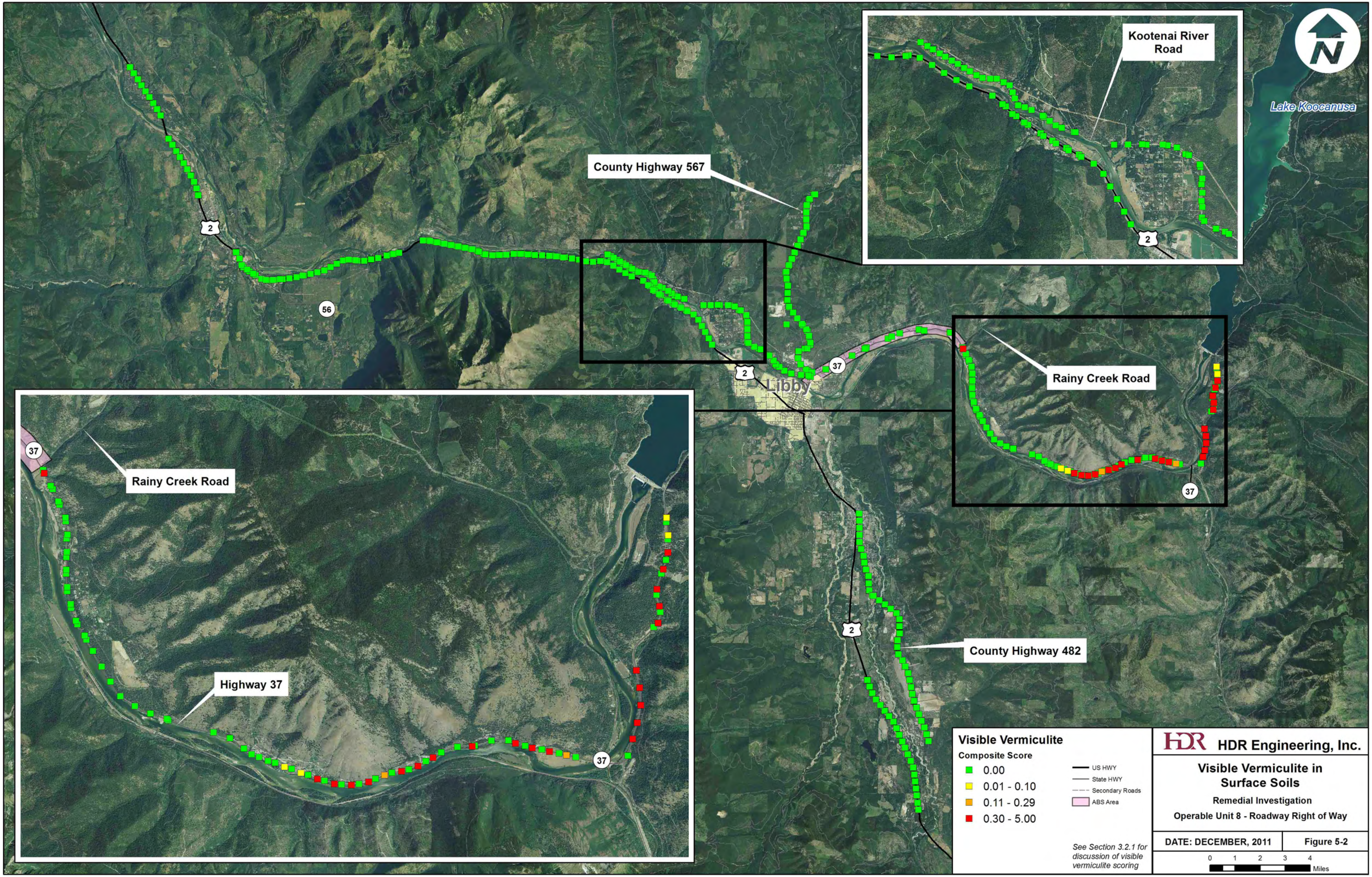


Troy
Libby
Lake Koocanusa
County Highway 567
Kootenai River Road
Rainy Creek Road
County Highway 482
Soil Sample Location
ABS Air Sample Location
US HWY
State HWY
Secondary Roads
ABS Area
HDR Engineering, Inc.
OU8 Sampling Locations
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: MAY, 2011
Figure 3-1
Miles

Kootenai River
37
2
E Commerce Way
W 2nd St
W 3rd St
W 4th St
E 5th St
Lincoln Blvd
W 6th St
E 6th St
E 8th St
W Oak St
Libby
Air Sample Locations
Inner-Perimeter
Outer-Perimeter
ABS measurement unit: LA structures per cubic centimeter (S/cc)
HDR
HDR Engineering, Inc.
Inner and Outer-Perimeter
Air Sample Locations
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 3-2
0
0.08
0.16
0.24
0.32
Miles



Kootenai River Road
County Highway 567
Lake Koocanusa
Rainy Creek Road
Libby
Highway 37
County Highway 482
2
56
37
LA in Surface Soil
Results
Non-Detect
Trace
< 1%
Detect; >= 1%
Legacy Data - 2003 & 2005
Non-Detect
Trace
< 1%
Detect; >= 1%
US HWY
State HWY
Secondary Roads
ABS Area
NOTE: Legacy data locations are approximated from CDM report (see section 3.1.1)
HDR Engineering, Inc.
LA in Surface Soil
PLM Results
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-1
0 1 2 3 4
Miles



HDR Engineering, Inc.

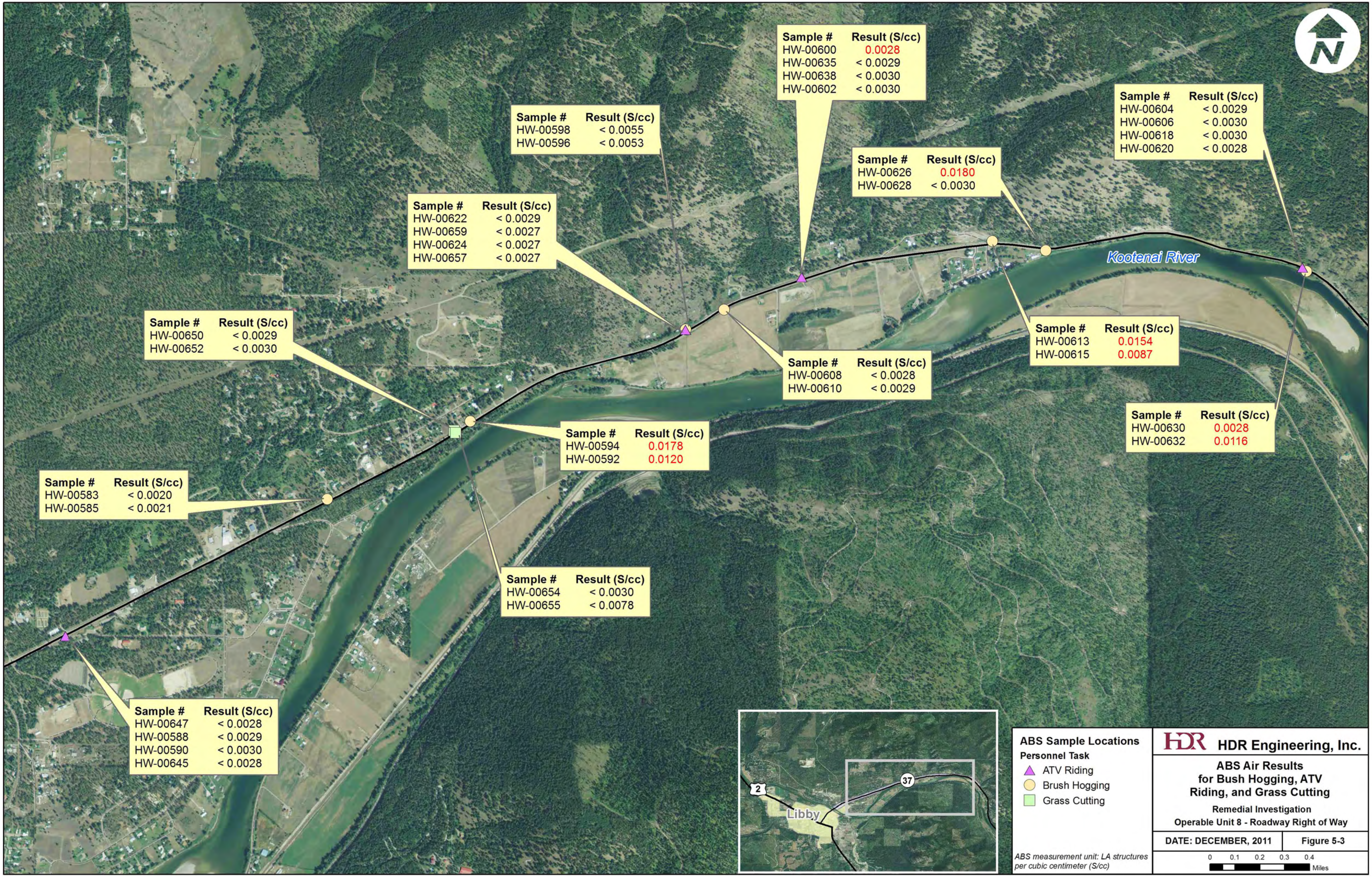
Visible Vermiculite in Surface Soils

Remedial Investigation

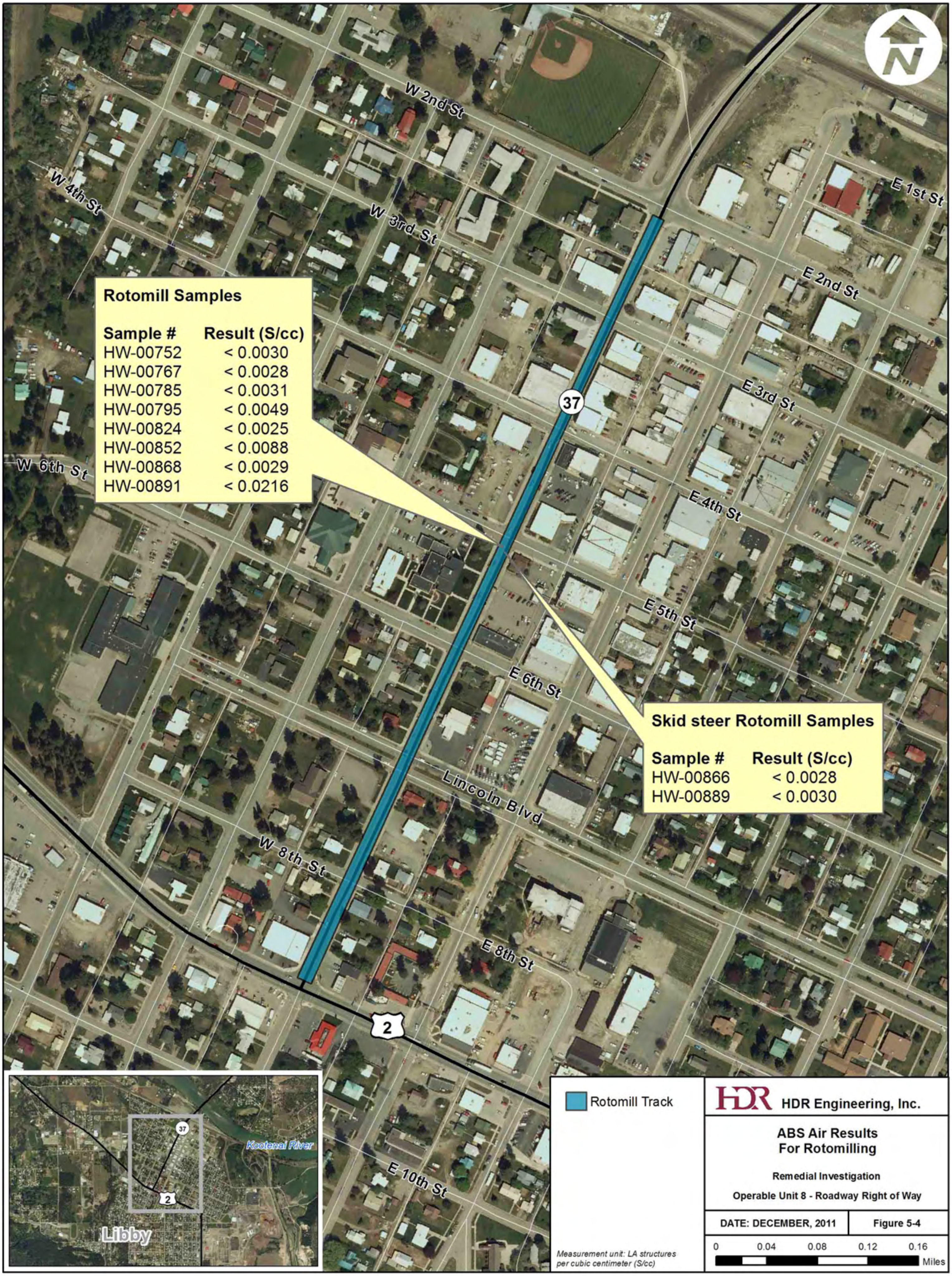
Operable Unit 8 - Roadway Right of Way

DATE: DECEMBER, 2011

Figure 5-2



Sample # Result (S/cc)
HW-00600 0.0028
HW-00635 < 0.0029
HW-00638 < 0.0030
HW-00602 < 0.0030
Sample # Result (S/cc)
HW-00604 < 0.0029
HW-00606 < 0.0030
HW-00618 < 0.0030
HW-00620 < 0.0028
Sample # Result (S/cc)
HW-00598 < 0.0055
HW-00596 < 0.0053
Sample # Result (S/cc)
HW-00626 0.0180
HW-00628 < 0.0030
Sample # Result (S/cc)
HW-00622 < 0.0029
HW-00659 < 0.0027
HW-00624 < 0.0027
HW-00657 < 0.0027
Kootenai River
Sample # Result (S/cc)
HW-00650 < 0.0029
HW-00652 < 0.0030
Sample # Result (S/cc)
HW-00613 0.0154
HW-00615 0.0087
Sample # Result (S/cc)
HW-00608 < 0.0028
HW-00610 < 0.0029
Sample # Result (S/cc)
HW-00630 0.0028
HW-00632 0.0116
Sample # Result (S/cc)
HW-00594 0.0178
HW-00592 0.0120
Sample # Result (S/cc)
HW-00583 < 0.0020
HW-00585 < 0.0021
Sample # Result (S/cc)
HW-00654 < 0.0030
HW-00655 < 0.0078
Sample # Result (S/cc)
HW-00647 < 0.0028
HW-00588 < 0.0029
HW-00590 < 0.0030
HW-00645 < 0.0028
N
2
37
Libby
ABS Sample Locations
Personnel Task
ATV Riding
Brush Hogging
Grass Cutting
ABS measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
ABS Air Results for Bush Hogging, ATV Riding, and Grass Cutting
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-3
0 0.1 0.2 0.3 0.4
Miles



W 2nd St
W 4th St
W 3rd St
E 1st St
E 2nd St
E 3rd St
W 6th St
E 4th St
E 5th St
E 6th St
Lincoln Blvd
W 8th St
E 8th St
E 10th St
37
2
Rotomill Samples
Sample # Result (S/cc)
HW-00752 < 0.0030
HW-00767 < 0.0028
HW-00785 < 0.0031
HW-00795 < 0.0049
HW-00824 < 0.0025
HW-00852 < 0.0088
HW-00868 < 0.0029
HW-00891 < 0.0216
Skid steer Rotomill Samples
Sample # Result (S/cc)
HW-00866 < 0.0028
HW-00889 < 0.0030
Kootenai River
Libby
Rotomill Track
HDR Engineering, Inc.
ABS Air Results
For Rotomilling
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-4
0 0.04 0.08 0.12 0.16
Miles
Measurement unit: LA structures per cubic centimeter (S/cc)


N
Sample # Result (S/cc)
HW-00850 < 0.0029
HW-00888 < 0.0028
Sample # Result (S/cc)
HW-00783 < 0.0027
HW-00815 < 0.0029
Sample # Result (S/cc)
HW-00779 < 0.0025
HW-00811 < 0.0025
Sample # Result (S/cc)
HW-00781 < 0.0053
HW-00813 < 0.0034
Sample # Result (S/cc)
HW-00846 < 0.0025
HW-00884 < 0.0028
Sample # Result (S/cc)
HW-00777 < 0.0026
HW-00809 < 0.0026
Sample # Result (S/cc)
HW-00775 < 0.0027
HW-00807 < 0.0025
Sample # Result (S/cc)
HW-00844 < 0.0247
HW-00882 < 0.0029
Sample # Result (S/cc)
HW-00842 < 0.0027
HW-00880 < 0.0028
Sample # Result (S/cc)
HW-00848 < 0.0029
HW-00886 < 0.0028
Sample # Result (S/cc)
HW-00771 < 0.0029
HW-00803 < 0.0027
Sample # Result (S/cc)
HW-00773 < 0.0028
HW-00805 < 0.0027
Sample # Result (S/cc)
HW-00838 < 0.0026
HW-00864 < 0.0029
Sample # Result (S/cc)
HW-00840 < 0.0028
HW-00877 < 0.0030
Sample # Result (S/cc)
HW-00765 < 0.0023
HW-00799 < 0.0027
Sample # Result (S/cc)
HW-00801 < 0.0028
Sample # Result (S/cc)
HW-00836 < 0.0027
HW-00862 < 0.0030
Sample # Result (S/cc)
HW-00834 < 0.0017
HW-00860 0.0030
Sample # Result (S/cc)
HW-00763 < 0.0028
HW-00797 < 0.0030
Sample # Result (S/cc)
HW-00761 < 0.0030
HW-00793 < 0.0025
Sample # Result (S/cc)
HW-00832 < 0.0028
HW-00858 < 0.0030
Sample # Result (S/cc)
HW-00830 < 0.0024
HW-00856 < 0.0029
Sample # Result (S/cc)
HW-00759 < 0.0028
HW-00791 < 0.0029
Sample # Result (S/cc)
HW-00757 < 0.0027
HW-00789 < 0.0029
Sample # Result (S/cc)
HW-00828 < 0.0025
HW-00854 < 0.0030
Sample # Result (S/cc)
HW-00755 < 0.0030
HW-00787 < 0.0030
W 2nd St
W 3rd St
W 4th St
W 6th St
E Commerce Way
E 5th St
37
Lincoln Blvd
W 8th St
E 6th St
E 8th St
2
E 10th St
W Oak St
Kootenai River
Libby
Stationary Air Sample Location
Measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
Inner-Perimeter (ABS) Rotomilling Air Results
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-5
0 0.05 0.1 0.15 0.2 Miles

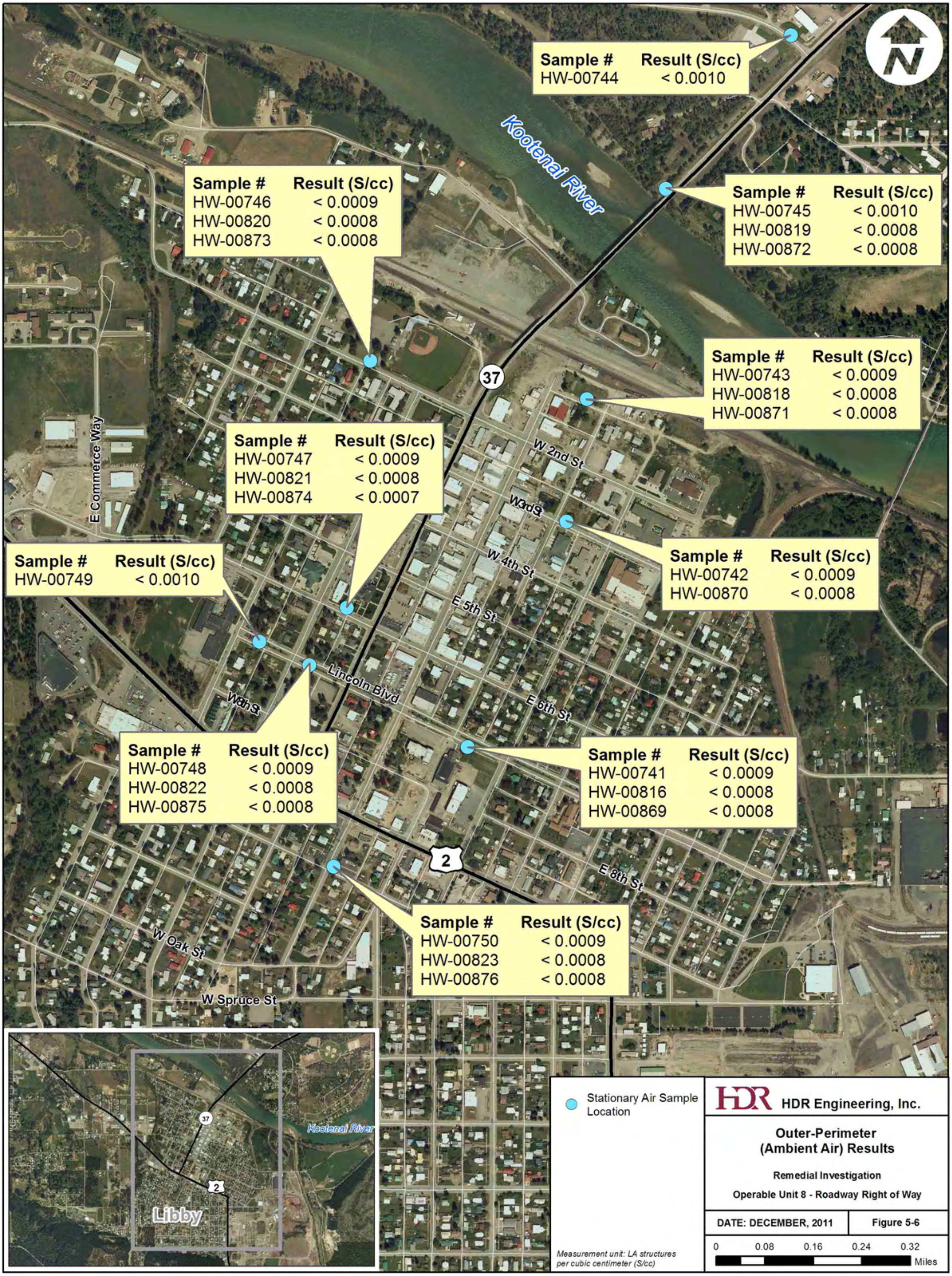
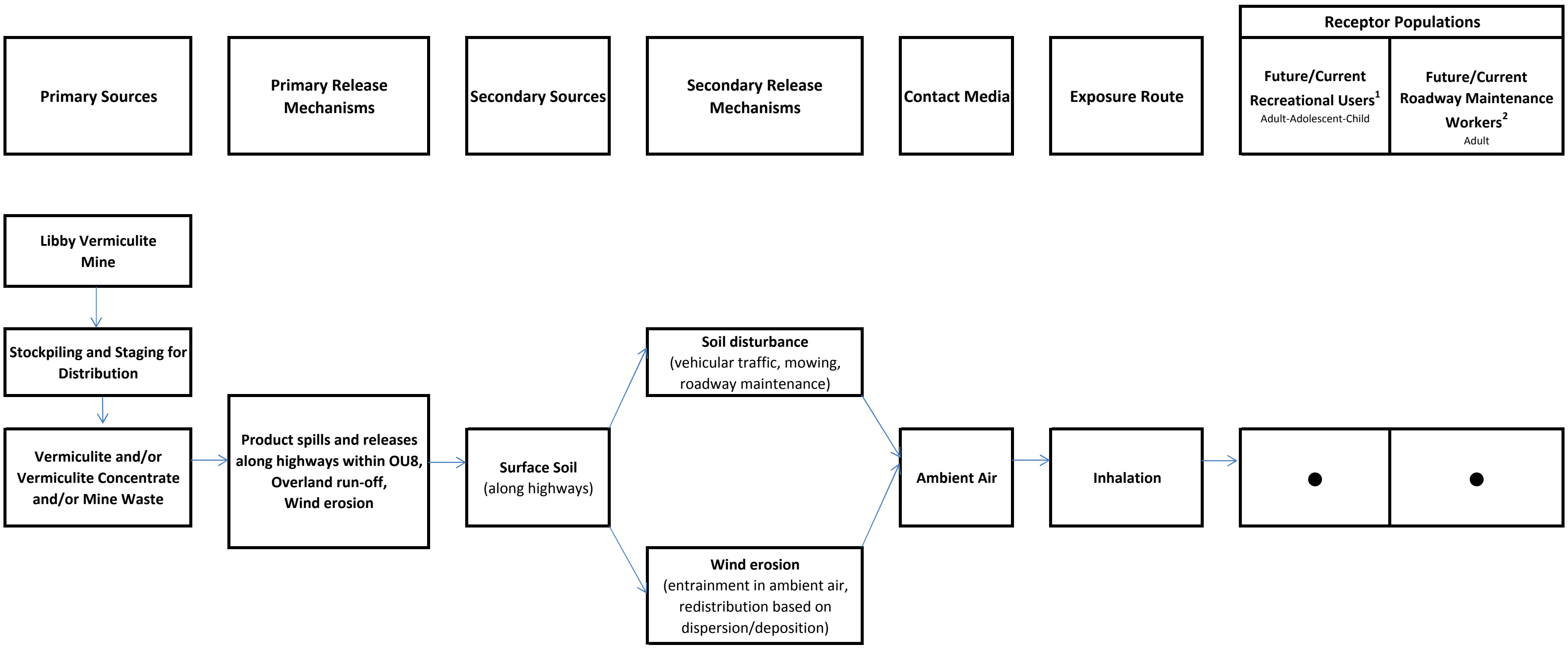

Sample # Result (S/cc)
HW-00744 < 0.0010
Kootenai River
Sample # Result (S/cc)
HW-00746 < 0.0009
HW-00820 < 0.0008
HW-00873 < 0.0008
Sample # Result (S/cc)
HW-00745 < 0.0010
HW-00819 < 0.0008
HW-00872 < 0.0008
Sample # Result (S/cc)
HW-00743 < 0.0009
HW-00818 < 0.0008
HW-00871 < 0.0008
37
Sample # Result (S/cc)
HW-00747 < 0.0009
HW-00821 < 0.0008
HW-00874 < 0.0007
E Commerce Way
W 2nd St
W 3rd St
W 4th St
E 5th St
Sample # Result (S/cc)
HW-00742 < 0.0009
HW-00870 < 0.0008
Sample # Result (S/cc)
HW-00749 < 0.0010
Lincoln Blvd
W 6th St
E 6th St
Sample # Result (S/cc)
HW-00748 < 0.0009
HW-00822 < 0.0008
HW-00875 < 0.0008
Sample # Result (S/cc)
HW-00741 < 0.0009
HW-00816 < 0.0008
HW-00869 < 0.0008
2
E 8th St
W Oak St
Sample # Result (S/cc)
HW-00750 < 0.0009
HW-00823 < 0.0008
HW-00876 < 0.0008
W Spruce St
Kootenai River
37
2
Libby
Stationary Air Sample Location
Measurement unit: LA structures per cubic centimeter (S/cc)
HDR Engineering, Inc.
Outer-Perimeter (Ambient Air) Results
Remedial Investigation
Operable Unit 8 - Roadway Right of Way
DATE: DECEMBER, 2011
Figure 5-6
0 0.08 0.16 0.24 0.32 Miles

Figure 7-1
Conceptual Site Model for Inhalation Exposures to Libby Amphibole Asbestos at OU8
State and Local Highways
Libby and Troy, Montana



Notes:

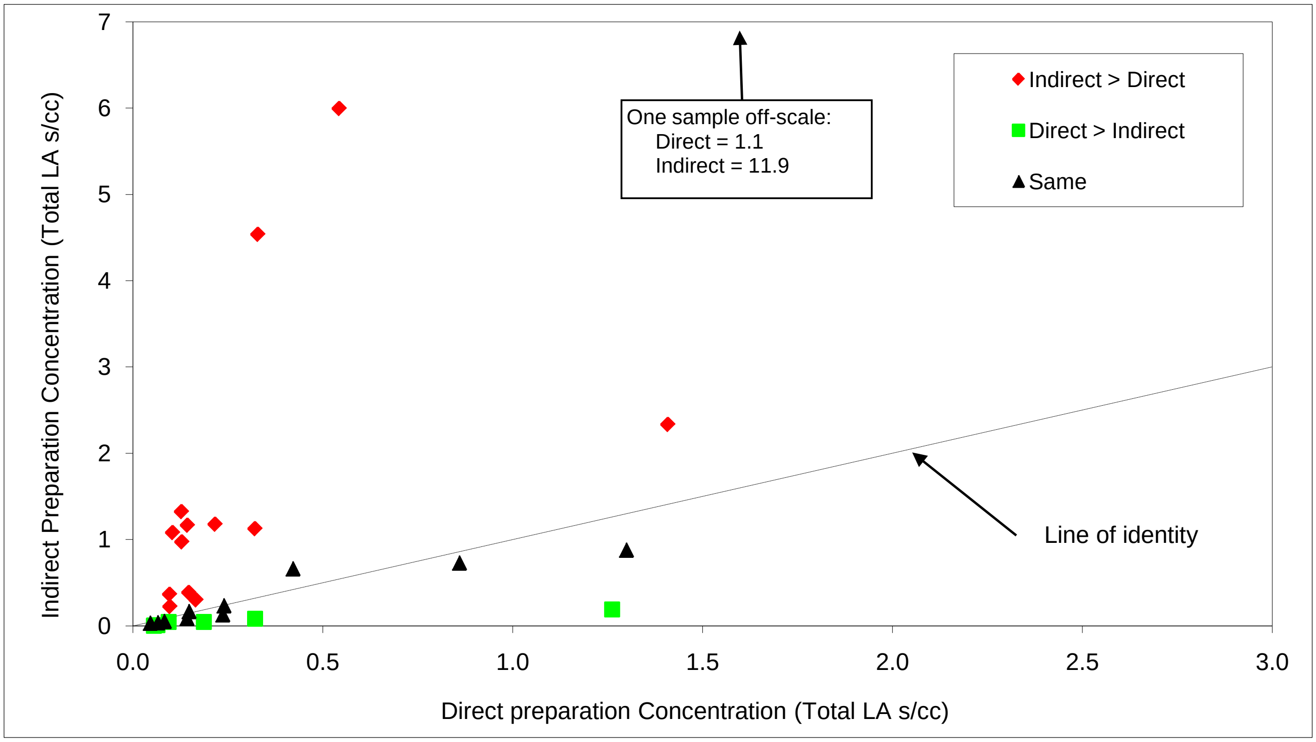
[1] Recreational activities assumed to include All Terrain Vehicle (ATV) use within accessible roadways at OU8.

[2] Roadway maintenance activities evaluated include mowing, rotomilling, and brush cutting.

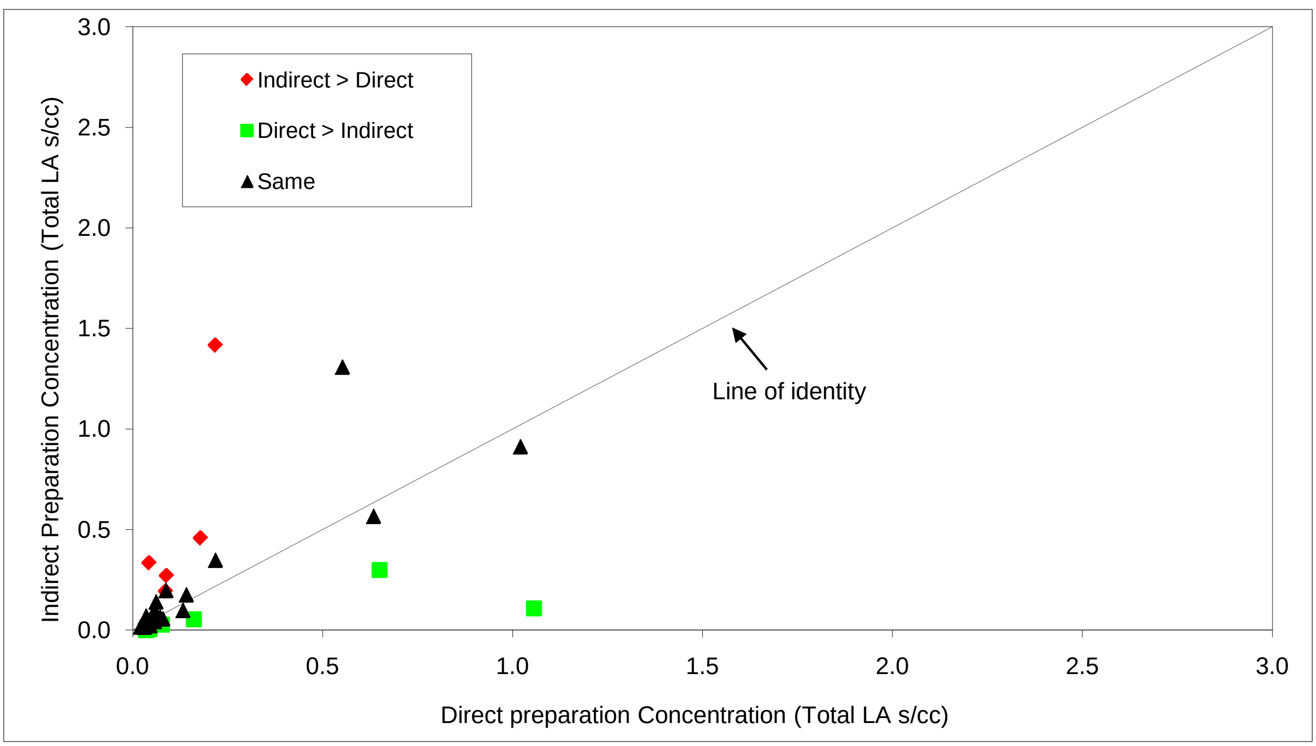
● Potentially complete exposure pathway

Figure 7-2
Comparison of Direct and Indirect TEM Results for 31 Air Samples from Libby

Panel A: Total LA



Panel B: PCME LA



Appendices

Appendix A
Data Quality Assessment

VERIFICATION SUMMARY REPORT

FOR OPERABLE UNIT 8

LIBBY ASBESTOS SUPERFUND SITE

(Based on Scribe database provided on 1/27/11)

Prepared for:

U.S. Environmental Protection Agency Region 8

1595 Wynkoop Street

Denver, Colorado 80202

Prepared by:

SRC, Inc.

Denver, CO

February 1, 2011

CONTENTS

ATTACHMENTS

TEM CONSISTENCY REVIEW AND DATA TRANSFER VERIFICATION REPORT

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 TEM Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of a minimum of 10% of the TEM results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with Standard Operating Procedure EPA-LIBBY-09 (rev 1). No discrepancies were discovered upon review of the original hand-written laboratory bench sheets to determine if the raw structure data were recorded in accord with ISO 10312 counting rules and SAP stopping rules. In addition, no errors were discovered when checks were performed to ensure that the data from the bench sheet were transferred into the Scribe Database without error or omission.

Recommendations for future review and verification: No future verification is recommended.

TEM-ISO 10312 SELECTION AND CONSISTENCY REVIEW RESULTS

Summary of available analyses:

Analyst, Lab	Number of TEM-ISO 10312 Analyses			Number of Analyses Selected for Review		
	Detect No	n-Detect	Total	Detect	Non-Detect	Total
E. Wyatt-Pescador, EMSL 27	8	26	34	2	2	4

	Goal	Actual
Selected Total	4	4
Selected Detects	2	2
Selected Non-Detects	2	2

Detailed summary of bench sheet consistency review –

Number of analyses reviewed: 4 (100% of total analyses selected)

If not all analyses could be reviewed, provide a brief explanation for why: N/A

Number of analyses with recording issues identified: 0 (0% of total analyses reviewed)

Types of recording issues identified (indicate the number of analyses):

_______ Reported structure types are inconsistent with ISO guidance

_______ Primary and/or total columns are not populated correctly

_______ NAM structures are recorded and not identified as non-countable

_______ Fibers recorded as countable do not meet aspect ratio criteria (LB-000016)

_______ Mineral class designation is missing or inconsistent

_______ Structure comments are inconsistent with LB-000066

_______ Structure comments are inconsistent with recorded data

_______ Structure attributes in the database do not match the bench sheet

Do the recording issues identified appear to be associated with a particular analyst or laboratory? Yes No

If yes, identify the analyst and/or laboratory: ______________________________

DATA TRANSFER VERIFICATION RESULTS

Number of analyses verified[1]: 4 (100% of total analyses selected)

Number of analyses with data transfer issues identified: 0 (0% of total analyses reviewed)

Types of data transfer issues identified:

_______ Incorrect/missing information on analysis details (e.g., lab job number, analysis date, filter status)

_______ F-factor calculation is incorrect or inputs are missing

_______ Air volume or dust area reported by laboratory is inconsistent with field value

_______ Number of grid openings counted is incorrect

_______ Sensitivity calculation is incorrect or inputs are missing

_______ Total number of countable LA structures is incorrect

Do the data transfer issues identified appear to be associated with a particular analyst or laboratory? Yes (No)

If yes, identify the analyst and/or laboratory: ____

____

Comments: No errors were discovered in the verification process.

ISSUE RESOLUTION AND STATUS

No resolutions are required. Attachments 1a and 1b contain the analyses that were verified and the information that was verified. Attachment 1a contains the analytical and results information and Attachment 1b contains the raw structure information.

[1] Only those analyses that have passed the bench sheet consistency review are included in the data transfer verification.

PLM CONSISTENCY REVIEW AND DATA TRANSFER VERIFICATION REPORT

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 PLM-VE Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of a minimum of 10% of the PLM-VE results was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11 in accord with draft Standard Operating Procedure for PLM verification. A review of the original laboratory PLM bench sheets and verification of the transfer of results from the bench sheets into the Scribe Database was performed.

Recommendations for future review and verification: Because the issues identified are not likely to impact data interpretation, no future verification is recommended.

PLM-VE SELECTION AND CONSISTENCY REVIEW RESULTS

Summary of available analyses:

Analyst, Lab	Number of PLM-VE Analyses			Number of Analyses Selected for Review		
	Detect	Non-Detect (Bin A)	Total	Detect	Non-Detect (Bin A)	Total
A. Goncalves, ESATR8	11	102	113	2	11	13
N. Fischer, ESATR8	18	96	114	2	10	12
N. MacDonald, ESATR8	14	105	119	2	11	13
T. Oliver, ESATR8	44	144	188	5	15	20
Total	87	447	534	11 47	58	

	Goal	Actual
Selected Total	58	58
Selected Detects	11	11
Selected Non-Detects	47	47

Detailed summary of bench sheet consistency review –

Number of analyses reviewed: 58 (100% of total analyses selected)

If not all analyses could be reviewed, provide a brief explanation for why: ________________________________

____

Number of analyses with recording issues identified: 0 (0% of total analyses reviewed)

Do the recording issues identified appear to be associated with a particular analyst or laboratory? Yes (No)

If yes, identify the analyst and/or laboratory: ____

____

DATA TRANSFER VERIFICATION RESULTS

Number of analyses verified[1]: 58 (100% of total analyses selected)

Number of analyses with data transfer issues identified: 5 (8.6% of total analyses verified)

Types of data transfer issues identified:

6 analyses had incorrect/missing information on analysis details (e.g., lab job number, analysis date)

Do the data transfer issues identified appear to be associated with a particular analyst or laboratory? (Yes) No

If yes, identify the analyst and/or laboratory: N. Fisher (ESATR8)

Comments: The lab sample IDs in Lab Job Number A101383 require revision throughout the lab job. In addition, the initials for the analyst in Lab Job Number A101373, Lab Sample IDs A101373-6 through -10 are unclear. They appear to be "ND", not "NF". Clarification on the benchsheets is required.

ISSUE RESOLUTION AND STATUS

The issues discovered in the verification process are summarized in the comments above and in Table 1 provided below. In addition, Attachment 2 contains a list of all analyses that were verified and the information that was verified.

Table 1. Summary of Issues

SampleNo	Lab Job Number	Verification Notes
HW-00087	A101373	Analyst's initials require clarification.
HW-00121	A101383	Lab Sample IDs are incorrect on benchsheets.

[1] Only those analyses that have passed the bench sheet consistency review are included in the data transfer verification.

Date: 2/1/11 Prepared by: Erin Kelly (SRC)

OU8 FSDS Data Verification

SUMMARY OF FINDINGS AND DATA QUALITY IMPLICATIONS

A verification of the sample information for analyses selected for PLM-VE and TEM verification was performed based on the OU8 Scribe Database provided by ESAT on 1/27/11. Several issues were discovered, some with the potential to impact data interpretation. The main issues discovered involve discrepancies in the visible vermiculite information and sample date as well as omission of detailed pump information.

Recommendations for future review and verification: Because some issues identified could potentially impact data interpretation, additional verification is at the discretion of the data managers.

FSDS SELECTION

A verification of all FSDS information for all 62 analyses selected for PLM-VE and TEM verification was performed.

DATA TRANSFER VERIFICATION RESULTS

Number of samples verified: 64 (100% of total analyses selected)

Number of samples with data transfer issues identified: 10 (15.6% of total samples verified)

Types of data transfer issues identified:

__1__ Sam ple Date

__3__ Location Type

__1__ LocationID

__3__ Location Description

__1__ Visible Vermiculite Information

__1__ Sam ple CompositeYN

__1__ Sam ple Aliquots

Comments: There were several data transfer issues that require clarification on the benchsheets and/or revision to the database. An inconsistency between the visible vermiculite information and the number of aliquots of the soil sample was one of the more important issues discovered. As a result, a review of this information as presented in the database was performed for all samples. There were 3 more samples that contained this inconsistency in the database. A review of the logbook notes is recommended in order to confirm the appropriate values for these fields. In addition, it was discovered in the verification process that the raw data for computing volume are not available in the database. Because only 4 air samples were verified during this effort, it was not inconvenient to verify this information manually based on the information contained in the FSDS forms. However, it is recommended that this information be collected electronically in future data collection efforts so that the raw data may be verified and also be available to data users that do not have the FSDS forms available to them.

ISSUE RESOLUTION AND STATUS

The issues discovered in the verification process are summarized in the comments above and in Table 1 provided below. In addition, Attachments 3a – 3c contain all samples that were verified and what information was verified. Attachment 3a contains the air FSDS verification, Attachment 3b contains the air pump information verification, and Attachment 3c contains the soil FSDS verification.

Table 1. Summary of Issues

Samp_No	Verification Notes
HW-00229	Sampling date is 7/28/10 on FSDS form.
HW-00129	Sample aliquots differ from number of vis verm observations.
HW-00130	Sample aliquots differ from number of vis verm observations.
HW-00133	Sample aliquots differ from number of vis verm observations.
HW-00082	Sample aliquots differ from number of vis verm observations.
HW-00087	FSDS has the location type as sampling location, not sampling point.
HW-00095	FSDS has the location type as sampling location, not sampling point.
HW-00639	Location description is null on FSDS form.
HW-00642	Location description is null on FSDS form.
HW-00644	Location description is null on FSDS form.
HW-00091	Sample composite in "N" on FSDS and "Y in database.
HW-00173	LocationID is "AD-OU8NA" in database and "NA" on FSDS form.
HW-00404	Sample Venue is not circled on FSDS form.

ATTACHMENT 1a. TEM VERIFICATION (Analytical and Results Information)

Samp_No	PersonnelTask	SampleQuantity	Analysis Quantity Analyzed	Analysis Date	AnalysisLabID	AnalysisAnalystName	AnalysisMethod	AnalysisLabJobNumber	AnalysisLabSampleID	AnalysisPrepMethod	AnalysisFilterStatus	Comments	AnalysisEFA	AnalysisGO Counted	AnalysisGO Chrys	AnalysisGO Size	AnalysisFFactor	ResultMineralClass	SENSITIVITY	STRUCTCNT	STRUCTCONC	Verifier's Initials	Verification Notes
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	CH	0.00200321	0	0	EK	
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	LA	0.00200321	0	0	EK	
HW-00583	Brush hoggin	192	192	10/8/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001351	271001351-0001	Direct	Analyzed		385	77	77	0.013	1	OA	0.00200321	0	0	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	CH	0.00296628	0	0	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	LA	0.00296628	6	0.01779771	EK	
HW-00594	Brush hoggin	384	384	9/27/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001129	271001129-0004	Direct	Analyzed		385	26	26	0.013	1	OA	0.00296628	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	CH	0.00296154	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	LA	0.00296154	0	0	EK	
HW-00606	ATV riding	400	400	10/14/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001354	271001354-0004	Direct	Analyzed		385	25	25	0.013	1	OA	0.00296154	0	0	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	CH	0.0029969	0	0	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	LA	0.0029969	6	0.01798141	EK	
HW-00626	Brush hoggin	366	366	10/25/10	EMSL27	E. Wyatt-Pescador	TEM-ISO	271001352	271001352-0004	Direct	Analyzed		385	27	27	0.013	1	OA	0.0029969	0	0	EK	

ATTACHMENT 1b. TEM VERIFICATION (Raw Structure Information)

StructureID	Samp_No	AnalysisID	Grid	GridOpening	Structure Type	Mineral Class	Primary	Total	Length	Width	AR	StructureComment	Verifier's Initials	Verification Notes
271001351-0001_ISO_D-1	HW-00583	271001351-0001_ISO_D	A1	E2	ND								EK	
271001351-0001_ISO_D-2	HW-00583	271001351-0001_ISO_D	A1	E4	ND								EK	
271001351-0001_ISO_D-3	HW-00583	271001351-0001_ISO_D	A1	E6	ND								EK	
271001351-0001_ISO_D-4	HW-00583	271001351-0001_ISO_D	A1	E8	ND								EK	
271001351-0001_ISO_D-5	HW-00583	271001351-0001_ISO_D	A1	E10	ND								EK	
271001351-0001_ISO_D-6	HW-00583	271001351-0001_ISO_D	A1	F1	ND								EK	
271001351-0001_ISO_D-7	HW-00583	271001351-0001_ISO_D	A1	F3	ND								EK	
271001351-0001_ISO_D-8	HW-00583	271001351-0001_ISO_D	A1	F5	ND								EK	
271001351-0001_ISO_D-9	HW-00583	271001351-0001_ISO_D	A1	F7	ND								EK	
271001351-0001_ISO_D-10	HW-00583	271001351-0001_ISO_D	A1	F9	ND								EK	
271001351-0001_ISO_D-11	HW-00583	271001351-0001_ISO_D	A1	G2	ND								EK	
271001351-0001_ISO_D-12	HW-00583	271001351-0001_ISO_D	A1	G4	ND								EK	
271001351-0001_ISO_D-13	HW-00583	271001351-0001_ISO_D	A1	G6	ND								EK	
271001351-0001_ISO_D-14	HW-00583	271001351-0001_ISO_D	A1	G8	ND								EK	
271001351-0001_ISO_D-15	HW-00583	271001351-0001_ISO_D	A1	G10	ND								EK	
271001351-0001_ISO_D-16	HW-00583	271001351-0001_ISO_D	A1	H1	ND								EK	
271001351-0001_ISO_D-17	HW-00583	271001351-0001_ISO_D	A1	H3	ND								EK	
271001351-0001_ISO_D-18	HW-00583	271001351-0001_ISO_D	A1	H5	ND								EK	
271001351-0001_ISO_D-19	HW-00583	271001351-0001_ISO_D	A1	H7	ND								EK	
271001351-0001_ISO_D-20	HW-00583	271001351-0001_ISO_D	A1	H9	ND								EK	
271001351-0001_ISO_D-21	HW-00583	271001351-0001_ISO_D	A1	I2	ND								EK	
271001351-0001_ISO_D-22	HW-00583	271001351-0001_ISO_D	A1	I4	ND								EK	
271001351-0001_ISO_D-23	HW-00583	271001351-0001_ISO_D	A1	I6	ND								EK	
271001351-0001_ISO_D-24	HW-00583	271001351-0001_ISO_D	A1	I8	ND								EK	
271001351-0001_ISO_D-25	HW-00583	271001351-0001_ISO_D	A1	I10	ND								EK	
271001351-0001_ISO_D-26	HW-00583	271001351-0001_ISO_D	A2	B2	ND								EK	
271001351-0001_ISO_D-27	HW-00583	271001351-0001_ISO_D	A2	B4	ND								EK	
271001351-0001_ISO_D-28	HW-00583	271001351-0001_ISO_D	A2	B6	ND								EK	
271001351-0001_ISO_D-29	HW-00583	271001351-0001_ISO_D	A2	B8	ND								EK	
271001351-0001_ISO_D-30	HW-00583	271001351-0001_ISO_D	A2	B10	ND								EK	
271001351-0001_ISO_D-31	HW-00583	271001351-0001_ISO_D	A2	C1	ND								EK	
271001351-0001_ISO_D-32	HW-00583	271001351-0001_ISO_D	A2	C3	ND								EK	
271001351-0001_ISO_D-33	HW-00583	271001351-0001_ISO_D	A2	C5	ND								EK	
271001351-0001_ISO_D-34	HW-00583	271001351-0001_ISO_D	A2	C7	ND								EK	
271001351-0001_ISO_D-35	HW-00583	271001351-0001_ISO_D	A2	C9	ND								EK	
271001351-0001_ISO_D-36	HW-00583	271001351-0001_ISO_D	A2	D2	ND								EK	
271001351-0001_ISO_D-37	HW-00583	271001351-0001_ISO_D	A2	D4	ND								EK	
271001351-0001_ISO_D-38	HW-00583	271001351-0001_ISO_D	A2	D6	ND								EK	
271001351-0001_ISO_D-39	HW-00583	271001351-0001_ISO_D	A2	D8	ND								EK	
271001351-0001_ISO_D-40	HW-00583	271001351-0001_ISO_D	A2	D10	ND								EK	
271001351-0001_ISO_D-41	HW-00583	271001351-0001_ISO_D	A2	E1	ND								EK	
271001351-0001_ISO_D-42	HW-00583	271001351-0001_ISO_D	A2	E3	ND								EK	
271001351-0001_ISO_D-43	HW-00583	271001351-0001_ISO_D	A2	E5	ND								EK	
271001351-0001_ISO_D-44	HW-00583	271001351-0001_ISO_D	A2	E7	ND								EK	
271001351-0001_ISO_D-45	HW-00583	271001351-0001_ISO_D	A2	E9	ND								EK	
271001351-0001_ISO_D-46	HW-00583	271001351-0001_ISO_D	A2	F2	ND								EK	
271001351-0001_ISO_D-47	HW-00583	271001351-0001_ISO_D	A2	F4	ND								EK	
271001351-0001_ISO_D-48	HW-00583	271001351-0001_ISO_D	A2	F6	ND								EK	
271001351-0001_ISO_D-49	HW-00583	271001351-0001_ISO_D	A2	F8	ND								EK	
271001351-0001_ISO_D-50	HW-00583	271001351-0001_ISO_D	A2	F10	ND								EK	
271001351-0001_ISO_D-51	HW-00583	271001351-0001_ISO_D	A2	G1	ND								EK	
271001351-0001_ISO_D-52	HW-00583	271001351-0001_ISO_D	A2	G3	ND								EK	
271001351-0001_ISO_D-53	HW-00583	271001351-0001_ISO_D	A2	G5	ND								EK	
271001351-0001_ISO_D-54	HW-00583	271001351-0001_ISO_D	A2	G7	ND								EK	
271001351-0001_ISO_D-55	HW-00583	271001351-0001_ISO_D	A2	G9	ND								EK	
271001351-0001_ISO_D-56	HW-00583	271001351-0001_ISO_D	A3	F9	ND								EK	
271001351-0001_ISO_D-57	HW-00583	271001351-0001_ISO_D	A3	F7	ND								EK	
271001351-0001_ISO_D-58	HW-00583	271001351-0001_ISO_D	A3	F5	ND								EK	
271001351-0001_ISO_D-59	HW-00583	271001351-0001_ISO_D	A3	F3	ND								EK	
271001351-0001_ISO_D-60	HW-00583	271001351-0001_ISO_D	A3	F1	ND								EK	
271001351-0001_ISO_D-61	HW-00583	271001351-0001_ISO_D	A3	E10	ND								EK	
271001351-0001_ISO_D-62	HW-00583	271001351-0001_ISO_D	A3	E8	ND								EK	
271001351-0001_ISO_D-63	HW-00583	271001351-0001_ISO_D	A3	E6	ND								EK	
271001351-0001_ISO_D-64	HW-00583	271001351-0001_ISO_D	A3	E4	ND								EK	
271001351-0001_ISO_D-65	HW-00583	271001351-0001_ISO_D	A3	E2	ND								EK	
271001351-0001_ISO_D-66	HW-00583	271001351-0001_ISO_D	A3	D9	ND								EK	
271001351-0001_ISO_D-67	HW-00583	271001351-0001_ISO_D	A3	D7	ND								EK	
271001351-0001_ISO_D-68	HW-00583	271001351-0001_ISO_D	A3	D5	ND								EK	
271001351-0001_ISO_D-69	HW-00583	271001351-0001_ISO_D	A3	D3	ND								EK	
271001351-0001_ISO_D-70	HW-00583	271001351-0001_ISO_D	A3	D1	ND								EK	
271001351-0001_ISO_D-71	HW-00583	271001351-0001_ISO_D	A3	C10	ND								EK	
271001351-0001_ISO_D-72	HW-00583	271001351-0001_ISO_D	A3	C8	ND								EK	
271001351-0001_ISO_D-73	HW-00583	271001351-0001_ISO_D	A3	C6	ND								EK	
271001351-0001_ISO_D-74	HW-00583	271001351-0001_ISO_D	A3	C4	ND								EK	
271001351-0001_ISO_D-75	HW-00583	271001351-0001_ISO_D	A3	C2	ND								EK	
271001351-0001_ISO_D-76	HW-00583	271001351-0001_ISO_D	A3	B9	ND								EK	
271001351-0001_ISO_D-77	HW-00583	271001351-0001_ISO_D	A3	B7	ND								EK	
271001129-0004_ISO_D-1	HW-00594	271001129-0004_ISO_D	B5	H9	ND								EK	
271001129-0004_ISO_D-2	HW-00594	271001129-0004_ISO_D	B5	H7	ND								EK	
271001129-0004_ISO_D-3	HW-00594	271001129-0004_ISO_D	B5	H5	F	LA	1	1	40.1	3.25	12.3384615	NaK; WRTA;	EK	
271001129-0004_ISO_D-4	HW-00594	271001129-0004_ISO_D	B5	H3	ND								EK	
271001129-0004_ISO_D-5	HW-00594	271001129-0004_ISO_D	B5	H1	ND								EK	
271001129-0004_ISO_D-6	HW-00594	271001129-0004_ISO_D	B5	D9	F	LA	2	2	84.5	1	84.5	NaK; WRTA;	EK	
271001129-0004_ISO_D-7	HW-00594	271001129-0004_ISO_D	B5	D7	ND								EK	

ATTACHMENT 1b. TEM VERIFICATION (Raw Structure Information)

StructureID	Samp_No	AnalysisID	Grid	GridOpening	Structure Type	Mineral Class	Primary	Total	Length	Width	AR	StructureComment	Verifier's Initials	Verification Notes
271001129-0004_ISO_D-8	HW-00594	271001129-0004_ISO_D	B5	D5	ND								EK	
271001129-0004_ISO_D-9	HW-00594	271001129-0004_ISO_D	B5	D3	ND								EK	
271001129-0004_ISO_D-10	HW-00594	271001129-0004_ISO_D	B5	D1	ND								EK	
271001129-0004_ISO_D-11	HW-00594	271001129-0004_ISO_D	B5	C8	ND								EK	
271001129-0004_ISO_D-12	HW-00594	271001129-0004_ISO_D	B5	C6	ND								EK	
271001129-0004_ISO_D-13	HW-00594	271001129-0004_ISO_D	B5	C4	F	LA	3	3	12.4	0.4	31	NaK; WRTA;	EK	
271001129-0004_ISO_D-14	HW-00594	271001129-0004_ISO_D	B6	G5	ND								EK	
271001129-0004_ISO_D-15	HW-00594	271001129-0004_ISO_D	B6	G3	ND								EK	
271001129-0004_ISO_D-16	HW-00594	271001129-0004_ISO_D	B6	G1	ND								EK	
271001129-0004_ISO_D-17	HW-00594	271001129-0004_ISO_D	B6	E9	ND								EK	
271001129-0004_ISO_D-18	HW-00594	271001129-0004_ISO_D	B6	E7	ND								EK	
271001129-0004_ISO_D-19	HW-00594	271001129-0004_ISO_D	B6	E5	F	LA	4	4	13.5	1	13.5	NaK; WRTA;	EK	
271001129-0004_ISO_D-20	HW-00594	271001129-0004_ISO_D	B6	E3	ND								EK	
271001129-0004_ISO_D-21	HW-00594	271001129-0004_ISO_D	B6	E1	ND								EK	
271001129-0004_ISO_D-22	HW-00594	271001129-0004_ISO_D	B6	C9	ND								EK	
271001129-0004_ISO_D-23	HW-00594	271001129-0004_ISO_D	B6	C7	ND								EK	
271001129-0004_ISO_D-24	HW-00594	271001129-0004_ISO_D	B6	C5	ND								EK	
271001129-0004_ISO_D-25	HW-00594	271001129-0004_ISO_D	B6	C3	F	LA	5	5	23.75	0.7	33.9285714	NaK; WRTA;	EK	
271001129-0004_ISO_D-26	HW-00594	271001129-0004_ISO_D	B6	C1	MD11		6						EK	
271001129-0004_ISO_D-27	HW-00594	271001129-0004_ISO_D	B6	C1	MF	LA		6	7	1.1	6.36363636	NaK; WRTA;	EK	
271001354-0004_ISO_D-1	HW-00606	271001354-0004_ISO_D	L4	F2	ND								EK	
271001354-0004_ISO_D-2	HW-00606	271001354-0004_ISO_D	L4	F4	ND								EK	
271001354-0004_ISO_D-3	HW-00606	271001354-0004_ISO_D	L4	F6	ND								EK	
271001354-0004_ISO_D-4	HW-00606	271001354-0004_ISO_D	L4	F8	ND								EK	
271001354-0004_ISO_D-5	HW-00606	271001354-0004_ISO_D	L4	F10	ND								EK	
271001354-0004_ISO_D-6	HW-00606	271001354-0004_ISO_D	L4	G1	ND								EK	
271001354-0004_ISO_D-7	HW-00606	271001354-0004_ISO_D	L4	G3	ND								EK	
271001354-0004_ISO_D-8	HW-00606	271001354-0004_ISO_D	L4	G5	ND								EK	
271001354-0004_ISO_D-9	HW-00606	271001354-0004_ISO_D	L4	G7	ND								EK	
271001354-0004_ISO_D-10	HW-00606	271001354-0004_ISO_D	L4	G9	ND								EK	
271001354-0004_ISO_D-11	HW-00606	271001354-0004_ISO_D	L4	H6	ND								EK	
271001354-0004_ISO_D-12	HW-00606	271001354-0004_ISO_D	L4	H8	ND								EK	
271001354-0004_ISO_D-13	HW-00606	271001354-0004_ISO_D	L4	H10	ND								EK	
271001354-0004_ISO_D-14	HW-00606	271001354-0004_ISO_D	L5	E9	ND								EK	
271001354-0004_ISO_D-15	HW-00606	271001354-0004_ISO_D	L5	E7	ND								EK	
271001354-0004_ISO_D-16	HW-00606	271001354-0004_ISO_D	L5	E5	ND								EK	
271001354-0004_ISO_D-17	HW-00606	271001354-0004_ISO_D	L5	E3	ND								EK	
271001354-0004_ISO_D-18	HW-00606	271001354-0004_ISO_D	L5	E1	ND								EK	
271001354-0004_ISO_D-19	HW-00606	271001354-0004_ISO_D	L5	D10	ND								EK	
271001354-0004_ISO_D-20	HW-00606	271001354-0004_ISO_D	L5	D8	ND								EK	
271001354-0004_ISO_D-21	HW-00606	271001354-0004_ISO_D	L5	D6	ND								EK	
271001354-0004_ISO_D-22	HW-00606	271001354-0004_ISO_D	L5	D4	ND								EK	
271001354-0004_ISO_D-23	HW-00606	271001354-0004_ISO_D	L5	D2	ND								EK	
271001354-0004_ISO_D-24	HW-00606	271001354-0004_ISO_D	L5	C3	ND								EK	
271001354-0004_ISO_D-25	HW-00606	271001354-0004_ISO_D	L5	C1	ND								EK	
271001352-0004_ISO_D-1	HW-00626	271001352-0004_ISO_D	J4	D9	ND								EK	
271001352-0004_ISO_D-2	HW-00626	271001352-0004_ISO_D	J4	D7	ND								EK	
271001352-0004_ISO_D-3	HW-00626	271001352-0004_ISO_D	J4	D5	F	LA	1	1	11.5	0.7	16.4285714	WRTA/NaK; F	EK	
271001352-0004_ISO_D-4	HW-00626	271001352-0004_ISO_D	J4	D3	MD10		2						EK	
271001352-0004_ISO_D-5	HW-00626	271001352-0004_ISO_D	J4	D3	MF	LA		2	4.75	0.25	19	WRTA/NaK; F	EK	
271001352-0004_ISO_D-6	HW-00626	271001352-0004_ISO_D	J4	D1	ND								EK	
271001352-0004_ISO_D-7	HW-00626	271001352-0004_ISO_D	J4	C10	ND								EK	
271001352-0004_ISO_D-8	HW-00626	271001352-0004_ISO_D	J4	C8	ND								EK	
271001352-0004_ISO_D-9	HW-00626	271001352-0004_ISO_D	J4	C6	ND								EK	
271001352-0004_ISO_D-10	HW-00626	271001352-0004_ISO_D	J4	C4	ND								EK	
271001352-0004_ISO_D-11	HW-00626	271001352-0004_ISO_D	J4	C2	ND								EK	
271001352-0004_ISO_D-12	HW-00626	271001352-0004_ISO_D	J4	B9	ND								EK	
271001352-0004_ISO_D-13	HW-00626	271001352-0004_ISO_D	J4	B7	ND								EK	
271001352-0004_ISO_D-14	HW-00626	271001352-0004_ISO_D	J4	B5	ND								EK	
271001352-0004_ISO_D-15	HW-00626	271001352-0004_ISO_D	J4	B3	F	LA	3	3	10	1.7	5.88235294	WRTA/NaK; F	EK	
271001352-0004_ISO_D-16	HW-00626	271001352-0004_ISO_D	J4	B1	ND								EK	
271001352-0004_ISO_D-17	HW-00626	271001352-0004_ISO_D	J5	E10	F	LA	4	4	7	0.25	28	WRTA/Nak; F	EK	
271001352-0004_ISO_D-18	HW-00626	271001352-0004_ISO_D	J5	E8	ND								EK	
271001352-0004_ISO_D-19	HW-00626	271001352-0004_ISO_D	J5	E6	ND								EK	
271001352-0004_ISO_D-20	HW-00626	271001352-0004_ISO_D	J5	E4	ND								EK	
271001352-0004_ISO_D-21	HW-00626	271001352-0004_ISO_D	J5	E2	ND								EK	
271001352-0004_ISO_D-22	HW-00626	271001352-0004_ISO_D	J5	D9	F	LA	5	5	6	0.2	30	WRTA/NaK; F	EK	
271001352-0004_ISO_D-23	HW-00626	271001352-0004_ISO_D	J5	D7	F	LA	6	6	7.75	0.4	19.375	WRTA/NaK	EK	
271001352-0004_ISO_D-24	HW-00626	271001352-0004_ISO_D	J5	D5	ND								EK	
271001352-0004_ISO_D-25	HW-00626	271001352-0004_ISO_D	J5	D3	ND								EK	
271001352-0004_ISO_D-26	HW-00626	271001352-0004_ISO_D	J5	D1	ND								EK	
271001352-0004_ISO_D-27	HW-00626	271001352-0004_ISO_D	J5	C4	ND								EK	
271001352-0004_ISO_D-28	HW-00626	271001352-0004_ISO_D	J5	C2	ND								EK	

ATTACHMENT 2. PLM-VE VERIFICATION

										Opitcal Property Data for Detected Samples									
SampleNo	Tag	Lab Job Number	AnalysisLabSampleID	Date Analyzed	AnalysisLabSampleID	AnalysisAppearance	LA	OA	C	FBRCOLOR	ELONG	PLEOCH	EXTINCT	RIALPHA	RIGAMMA	BIREF	HABIT	Verifier's Initials	Verification Notes
HW-00009	FG1	A101371	A101371-9	12/9/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00021	FG1	A101381	A101381-1	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00023	FG1	A101381	A101381-3	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00026	FG1	A101381	A101381-6	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00029	FG1	A101381	A101381-9	12/13/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00039	FG1	A101381	A101381-19	12/14/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.618	1.64	Medium	Prismatic	EK	
HW-00046	FG1	A101379	A101379-6	12/13/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00055	FG1	A101379	A101379-15	12/14/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00057	FG1	A101379	A101379-17	12/15/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00070	FG1	A101372	A101372-10	12/9/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00075	FG1	A101372	A101372-15	12/9/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00076	FG1	A101372	A101372-16	12/10/10	A. Goncalves	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.619	1.627	Low	Prismatic	EK	
HW-00080	FG1	A101372	A101372-20	12/10/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00083	FG1	A101373	A101373-3	12/9/10	N. Fischer	Brown soil, fine	Tr	ND	ND	Tan	Positive	No	Inclined	1.619	1.636	Medium	FIBER BUNDLE	EK	
HW-00087	FG1	A101373	A101373-7	12/9/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	analyst's initials unclear
HW-00091	FG1	A101373	A101373-11	12/9/10	N. MacDonald	Tan soil, fine	ND	ND	ND									EK	
HW-00094	FG1	A101373	A101373-14	12/9/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00095	FG1	A101373	A101373-15	12/9/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00104	FG1	A101382	A101382-4	12/13/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00121	FG1	A101383	A101383-1	12/14/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00129	FG1	A101383	A101383-9	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00132	FG1	A101383	A101383-12	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00137	FG1	A101383	A101383-17	12/15/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	lab sample id is incorrect on benchsheet.
HW-00150	FG1	A101384	A101384-10	12/15/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00151	FG1	A101384	A101384-11	12/15/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00161	FG1	A101385	A101385-1	12/18/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00168	FG1	A101385	A101385-8	12/18/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00173	FG1	A101385	A101385-13	12/20/10	T. Oliver	Tan soil, fine	ND	ND	ND									EK	
HW-00179	FG1	A101385	A101385-19	12/20/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00184	FG1	A101386	A101386-4	12/21/10	N. MacDonald	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.625	1.641	Medium	FIBER BUNDLE	EK	
HW-00195	FG1	A101386	A101386-15	12/21/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00200	FG1	A101386	A101386-20	12/21/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00206	FG1	A101387	A101387-6	12/17/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00208	FG1	A101387	A101387-8	12/17/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00216	FG1	A101387	A101387-16	12/20/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00218	FG1	A101387	A101387-18	12/20/10	A. Goncalves	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.635	1.641	Low	FIBER BUNDLE	EK	
HW-00229	FG1	A101388	A101388-9	12/17/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00231	FG1	A101388	A101388-11	12/17/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00240	FG1	A101388	A101388-20	12/20/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00243	FG1	A101389	A101389-3	12/21/10	T. Oliver	Brown soil, fine	Tr	ND	ND	GRAY	Positive	No	Inclined	1.617	1.638	Medium	FIBER BUNDLE	EK	
HW-00249	FG1	A101389	A101389-9	12/21/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00260	FG1	A101389	A101389-20	12/22/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00266	FG1	A101390	A101390-6	12/21/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00271	FG1	A101390	A101390-11	12/21/10	A. Goncalves	Brown soil, fine	ND	ND	ND									EK	
HW-00272	FG1	A101390	A101390-12	12/22/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00273	FG1	A101390	A101390-13	12/22/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00294	FG1	A101391	A101391-14	12/23/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00304	FG1	A101392	A101392-4	12/29/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00312	FG1	A101392	A101392-12	12/29/10	N. MacDonald	Brown soil, fine	ND	ND	ND									EK	
HW-00315	FG1	A101392	A101392-15	12/29/10	N. MacDonald	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.619	1.638	Medium	FIBER BUNDLE	EK	
HW-00347	FG1	A101394	A101394-7	12/29/10	N. Fischer	Brown soil, fine	ND	ND	ND									EK	
HW-00358	FG1	A101394	A101394-18	12/30/10	N. Fischer	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.619	1.635	Medium	Prismatic	EK	
HW-00382	FG1	A101396	A101396-2	12/30/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Colorless	Positive	No	Inclined	1.617	1.637	Medium	Prismatic	EK	
HW-00393	FG1	A101396	A101396-13	1/3/11	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00404	FG1	A101397	A101397-4	1/4/11	N. MacDonald	Tan soil, fine	ND	ND	ND									EK	
HW-00639	FG1	A101254	A101254-3	10/25/10	T. Oliver	Brown soil, fine	ND	ND	ND									EK	
HW-00642	FG1	A101254	A101254-6	10/25/10	T. Oliver	Brown soil, fine	Tr	ND	ND	Blue	Positive	No	Inclined	1.638	1.643	Low	FIBER BUNDLE	EK	
HW-00644	FG1	A101254	A101254-8	10/25/10	T. Oliver	Brown soil, fine	Tr	ND	ND	GRAY	Positive	No	Inclined	1.642	1.65	Low	FIBER BUNDLE	EK	

ATTACHMENT 3a. AIR FSDS VERIFICATION

Samp_No	Sample Venue	Sample Air Type	Personnel Task	SampleDate	Location	Sub_Location	Location Description	Sample Type	Sample Quantity	Sample Quantity Units	Sample Field Comments	Verifier's Initials	Verification Notes
HW-00583	Outdoor	PA-ABS	Brush hogging	07-Sep-10	XX-002392	Tractor Back ; Hi; MM2 to First driveway; Hwy 37 N	Right of Way - only	Field Sample	192	L		EK	Verifier manually checked volume; info not available in DB.
HW-00594	Outdoor	PA-ABS	Brush hogging	07-Sep-10	XX-002394	Tractor Back; Hi; Driveway across from Amerigas; Hwy 37 N	Right of Way - only	Field Sample	384	L		EK	Verifier manually checked volume; info not available in DB.
HW-00606	Outdoor	PA-ABS	ATV riding	08-Sep-10	XX-002397	Hwy 37 mm 4.4 to 5.5 West Side Only Off Road Follow Hi	Right of Way - only	Field Sample	400	L	Pump 10 for 28 mins then pump 2 for 12 mins	EK	Verifier manually checked volume; info not available in DB.
HW-00626	Outdoor	PA-ABS	Brush hogging	09-Sep-10	XX-002401	MM 4.5 to 4.0 Hwy 37 W Tractor Front Hi	Right of Way - only	Field Sample	366	L		EK	Verifier manually checked volume; info not available in DB.

ATTACHMENT 3b. AIR FSDS VERIFICATION (PUMP INFORMATION)

Panel A: Pump Information Data Entry

Samp_No	Start Flow	End Flow	Start_DateTime	Stop_DateTime	Vol Interval
HW-00583	3	3	9/7/10 9:40	9/7/10 10:44	192
HW-00594	3	3	9/7/10 10:53	9/7/10 12:00	201
HW-00594	3	3	9/7/10 12:23	9/7/10 13:24	183
HW-00606	10	10	9/8/10 8:59	9/8/10 9:27	280
HW-00606	10	10	9/8/10 10:37	9/8/10 10:49	120
HW-00626	3	3	9/9/10 9:00	9/9/10 11:02	366

Panel B: Volume Calculation

Samp_No	Volume	Verifier's Initials	Verification Notes
HW-00583	192	EK	
HW-00594	384	EK	
HW-00606	400	EK	
HW-00626	366	EK	

ATTACHMENT 3c. SOIL FSDS VERIFICATION

Samp_No	SampleDate	Sample Venue	LocationType	Location	Sub_Location	LocationDescription	Visible Vermiculite None	Low	Medium	High	Comments	SampleType	Sample CompositeYN	SampleAliquots	Samp_Depth	Samp_Depth_To	SampleField Comments	Verifier's Initials	Verification Notes
HW-00168	7/26/10	Outdoor	Sampling Point	XX-002072	South Shoulder East of Easy St	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00179	7/26/10	Outdoor	Sampling Point	XX-002081	South Shoulder at Quartz Creek Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00184	7/26/10	Outdoor	Sampling Point	XX-002086	South Shoulder near 2455 K. River Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00195	7/27/10	Outdoor	Sampling Point	XX-002095	North Shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00200	7/27/10	Outdoor	Sampling Point	XX-002100	North shoulder West of mile 1 marker	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00206	7/27/10	Outdoor	Sampling Point	XX-002106	North shoulder West of mile 2 marker	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00208	7/27/10	Outdoor	Sampling Point	XX-002108	North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00216	7/27/10	Outdoor	Sampling Point	XX-002114	North Shoulder 3803 Kootenai River Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00218	7/27/10	Outdoor	Sampling Point	XX-002116	North Shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00229	7/29/10	Outdoor	Sampling Point	XX-002127	North Shoulder by Cliffside Drive	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	Sampling date is 7/28/10 on FSDS form
HW-00231	7/28/10	Outdoor	Sampling Point	XX-002129	North Shoulder approaching end	Right of Way - only	8	0	0	0		Field Sample	Yes	8	0	3		EK	
HW-00104	7/23/10	Outdoor	Sampling Point	XX-002014	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00121	7/24/10	Outdoor	Sampling Point	XX-002029	Pipe Creek Rd (West Shoulder) South of Sanitary Lan	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00129	7/24/10	Outdoor	Sampling Point	XX-002036	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	6	0	3	No Grass	EK	Sample aliquots differ from number of vis verm observations.
HW-00130	7/24/10	Outdoor	Sampling Point	XX-002037	Pipe Creek Rd (West Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	7	0	3	no grass		Sample aliquots differ from number of vis verm observations.
HW-00132	7/24/10	Outdoor	Sampling Point	XX-002038	Pipe Creek Rd (West Shoulder) South of Power Statio	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00133	7/24/10	Outdoor	Sampling Point	XX-002039	Pipe Creek Rd (West Shoulder) North of 37	Right of Way - only	10	0	0	0	cut of grass	Field Sample	Yes	6	0	3	Out of Grass		Sample aliquots differ from number of vis verm observations.
HW-00137	7/24/10	Outdoor	Sampling Point	XX-002043	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00150	7/25/10	Outdoor	Sampling Point	XX-002056	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00151	7/25/10	Outdoor	Sampling Point	XX-002056	Pipe Creek Rd (East Shoulder)	Right of Way - only	10	0	0	0		Field Duplicat	Yes	10	0	3		EK	
HW-00161	7/25/10	Outdoor	Sampling Point	XX-002065	Pipe Creek Rd East Shoulder (Mile Marker 5) North of	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00312	7/30/10	Outdoor	Sampling Point	XX-002202	Begin N of Concrete Barriers	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00315	7/30/10	Outdoor	Sampling Point	XX-002205	N Bound 2 near Cedar Creek	Right of Way - only	7	0	0	0		Field Sample	Yes	7	0	3	Guard Rail	EK	
HW-00347	7/31/10	Outdoor	Sampling Point	XX-002233	South bound side	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00358	8/1/10	Outdoor	Sampling Point	XX-002244	Kootenai River Outfitters	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00382	8/2/10	Outdoor	Sampling Point	XX-002265	Coles Rd	Right of Way - only	10	0	0	0		Field Duplicat	Yes	10	0	3		EK	
HW-00393	8/3/10	Outdoor	Sampling Point	XX-002275	Begin N end of rail	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00240	7/28/10	Outdoor	Sampling Point	XX-002136	SE Bound Farm to Market near McKays St	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00243	7/28/10	Outdoor	Sampling Point	XX-002139	NW Bound Granny's Garden Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00249	7/28/10	Outdoor	Sampling Point	XX-002145	NW bound 1657 Farm to Market	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00260	7/29/10	Outdoor	Sampling Point	XX-002154	SE Bound Begin NW of Evans Rd	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00266	7/29/10	Outdoor	Sampling Point	XX-002160	SE Bound by Mine by Mile 3	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00271	7/29/10	Outdoor	Sampling Point	XX-002165	NW Bound Across from Mine	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00272	7/29/10	Outdoor	Sampling Point	XX-002166	SE Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00273	7/29/10	Outdoor	Sampling Point	XX-002167	SE Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00294	7/29/10	Outdoor	Sampling Point	XX-002186	SE Bound NW Corner of Meadowlark	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00304	7/30/10	Outdoor	Sampling Point	XX-002194	NW Bound	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00009	7/20/10	Outdoor	Sampling Point	XX-001929	Hwy 37 East of (south Shoulder) mile marker 7	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00021	7/21/10	Outdoor	Sampling Point	XX-001939	Hwy 37 (south Shoulder) West of mile marker 11	Right of Way - only	6	4	0	0	Small amo	Field Sample	Yes	10	0	3		EK	
HW-00023	7/21/10	Outdoor	Sampling Point	XX-001941	Hwy 37 (South Shoulder) West of 11501 Hwy 37	Right of Way - only	8	2	0	0	Small amo	Field Sample	Yes	10	0	3		EK	
HW-00026	7/21/10	Outdoor	Sampling Point	XX-001944	Hwy 37 (South shoulder) West of Mile marker 12	Right of Way - only	5	5	0	0	Small amo	Field Sample	Yes	10	0	3		EK	
HW-00029	7/21/10	Outdoor	Sampling Point	XX-001947	Hwy 37 (South Shoulder) (Mile Marker 13)	Right of Way - only	7	3	0	0	small amou	Field Sample	Yes	10	0	3		EK	
HW-00039	7/21/10	Outdoor	Sampling Point	XX-001956	Hwy 37 (South Shoulder)	Right of Way - only	5	5	0	0	Small amo	Field Sample	Yes	10	0	3		EK	
HW-00046	7/21/10	Outdoor	Sampling Point	XX-001962	Hwy 37 (South shoulder) West of mile post 17	Right of Way - only	9	1	0	0	Small amo	Field Sample	Yes	10	0	3		EK	
HW-00055	7/22/10	Outdoor	Sampling Point	XX-001969	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00057	7/22/10	Outdoor	Sampling Point	XX-001971	Highway 37 North shoulder East of River Bend	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00070	7/22/10	Outdoor	Sampling Point	XX-001983	Highway 37 north shoulder west of mile post 11	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00075	7/22/10	Outdoor	Sampling Point	XX-001987	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00076	7/23/10	Outdoor	Sampling Point	XX-001988	Highway 37 North shoulder West of 10000 Highway 3	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00080	7/23/10	Outdoor	Sampling Point	XX-001991	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00082	7/23/10	Outdoor	Sampling Point	XX-001993	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	7	0	3			Sample aliquots differ from number of vis verm observations.
HW-00083	7/23/10	Outdoor	Sampling Point	XX-001994	Highway 37 North shoulder East of National Forest Bo	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00087	7/23/10	Outdoor	Sampling Point	XX-001998	Highway 37 North shoulder mile marker 8	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	FSDS has the location type as sampling location, not sampling point.
HW-00094	7/23/10	Outdoor	Sampling Point	XX-002004	Highway 37 North shoulder	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	
HW-00095	7/23/10	Outdoor	Sampling Point	XX-002005	Highway 37 North shoulder; 6884-6814 Highway 37	Right of Way - only	10	0	0	0		Field Sample	Yes	10	0	3		EK	FSDS has the location type as sampling location, not sampling point.
HW-00639	9/9/10	Outdoor	Sampling Point	XX-002392	HWY 37 E SHOULDER MM 2 TO DRIVEWAY WITH F	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3	NO FIELD BL	EK	Location description is null on FSDS form
HW-00642	9/9/10	Outdoor	Sampling Point	XX-002395	HWY 37 E SHOULDER MM 3.0 TO ~MM 3.5	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3	NO FIELD BL	EK	Location description is null on FSDS form
HW-00644	9/9/10	Outdoor	Sampling Point	XX-002397	HWY 37 W SHOULDER MM 4.4 TO RAINEY CREEK	Right of Way - only	30	0	0	0		Field Sample	Yes	30	0	3		EK	Location description is null on FSDS form
HW-00091	7/23/10	NA	NA	AD-OU8NA	Field Blank (Sand)	NA						Field Blank	Yes	0	0	0		EK	Sample composite in "N" on FSDS and "Y in database.
HW-00173	7/26/10	NA	NA	AD-OU8NA	Field Blank	NA						Field Blank	No	0	0	0		EK	LocationID is "AD-OU8NA" in database and "NA" on FSDS form.
HW-00404	8/3/10	NA	NA	AD-OU8NA	Field Blank-Sand	NA						Field Blank	No	0	0	0		EK	Sample Venue is not circled on FSDS form.

Appendix B
EPA Scribe Database

(A copy of the Database may be requested by contacting the Region 8 EPA Records Center)

Appendix C
Asbestos Analysis Methods and Data Reduction Techniques

ASBESTOS ANALYSIS METHODS AND DATA REDUCTION TECHNIQUES

1 Asbestos Mineralogy

Asbestos is the generic name for the fibrous habit of a broad family of naturally occurring poly-silicate minerals. Based on crystal structure, asbestos minerals are usually divided into two groups: serpentine and amphibole.

- *Serpentine*: The only asbestos mineral in the serpentine group is chrysotile. Chrysotile is the most widely used form of asbestos, accounting for about 90% of the asbestos used in commercial products (IARC 1977). There is no evidence that chrysotile occurs in the Libby vermiculite deposit, although it may be present in some types of building materials in Libby.

- *Amphiboles*: Five minerals in the amphibole group that occur in the asbestiform habit have found limited use in commercial products (IARC 1977), including:

    - actinolite
    - amosite
    - anthophyllite
    - crocidolite
    - tremolite

At the Libby site, the form of asbestos that is present in the vermiculite deposit is an amphibole asbestos that for many years was classified as tremolite/actinolite (e.g., McDonald et al 1986a, Amandus and Wheeler 1987). More recently, the U.S. Geological Service (USGS) performed electron probe micro-analysis and X-ray diffraction analysis of 30 samples obtained from asbestos veins at the mine (Meeker et al. 2003). Using mineralogical naming rules recommended by Leake et al. (1997), the results indicate that the asbestos at Libby includes a number of related amphibole types. The most common forms are winchite and richterite, with lower levels of tremolite, actinolite, and magnesioriebeckite. Because the mineralogical name changes that have occurred over the years do not alter the asbestos material that is present in Libby, and because EPA does not find that there are toxicological data to distinguish differences in toxicity among these different forms, the EPA does not believe that it is important to attempt to distinguish among these various amphibole types. Therefore, EPA simply refers to the mixture as Libby Amphibole (LA) asbestos.

2 Measurement Techniques for Asbestos in Air

In the past, the most common technique for measuring asbestos in air was phase contrast microscopy (PCM). In this technique, air is drawn through a filter and airborne particles become deposited on the face of the filter. All structures that have a length greater than 5 um and have an aspect ratio (the ratio of length to width) of 3:1 or more are counted as PCM fibers. The limit of resolution of PCM is about 0.25 um, so particles thinner than this are generally not observable.

A key limitation of PCM is that particle discrimination is based only on size and shape. Because of this, it is not possible to classify asbestos particles by mineral type, or even to distinguish between asbestos and non-asbestos particles. For this reason, nearly all samples of air collected in Libby are analyzed by transmission electron microscopy (TEM). This method operates at higher magnification (typically about 20,000x) and hence is able to detect structures much smaller than can been seen by PCM. In addition, TEM instruments are fitted with accessories that allow each particle to be classified according to mineral type.

3 Transmission Electron Microscopy (TEM)

3.1 Sample Preparation

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

If air samples are deemed to be overloaded, samples are prepared indirectly (either with or without ashing as determined by the analyst) in accord with the procedures in SOP EPA-LIBBY-08. In brief, rinsate or ashed residue from the original filter is suspended in water and sonicated. An aliquot of this water is applied to a second filter which is then used to prepare a set of TEM grids. Reported air concentrations for indirectly prepared samples incorporate a dilution factor, or F-factor (see Section 3.4 below).

3.2 Sample Analysis

Air samples collected as part of the OU8 sampling programs were analyzed by TEM in basic accord with the counting and recording rules specified in ISO 10312 (ISO 1995), and certain project-specific counting rule modifications. These modifications included changing the recording rule to include structures with an aspect ratio ≥ 3:1.

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. 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 *Libby-class amphibole.* Structures having an amphibole SAED pattern and an elemental composition similar to the range of fiber types observed in ores from

[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).

the Libby mine (Meeker et al. 2003). This is a sodic tremolitic solid solution series of minerals including actinolite, tremolite, winchite, and richterite, with lower amounts of magnesio-arfedsonite and edenite/ferro-edenite.

OA *Other amphibole-type asbestos fibers.* Structures having an amphibole SAED pattern and an elemental composition that is not similar to fiber types from the Libby mine. Examples include crocidolite, amosite, and anthophyllite. There is presently no evidence that these fibers are associated with the Libby mine.

C *Chrysotile fibers.* Structures having a serpentine SAED pattern and an elemental composition characteristic of chrysotile. There is presently no evidence that these fibers are associated with the Libby mine.

NAM *Non-asbestos material.* These may include non-asbestos mineral fibers such as gypsum, glass, or clay, and may also include various types of organic and synthetic fibers derived from carpets, hair, etc.

For the purposes of this report, air concentrations are based on countable LA structures only (i.e., results for other amphibole-type asbestos and chrysotile are not discussed).

3.3 Estimation of PCME

For the purposes of computing risk estimates, it is necessary to utilize the results from a TEM analysis to estimate what would have been detected had the sample been analyzed by PCM. This is because available toxicity information is usually based on workplace studies that utilized PCM as the primary method for analysis. For convenience, structures detected under TEM that meet the recording rules for PCM (i.e., length > 5 um, width ≥ 0.25 um, aspect ratio ≥ 3:1) are referred to as PCM-equivalent (PCME) structures.

There are two alternative approaches available for expressing units of PCME s/cc. The first (and most direct) approach is to express the concentration of each sample in terms of the PCME structures observed in that sample. The second approach is to express the concentration of LA in each sample in terms of the total LA in that sample, and then multiply the total LA concentration by a value that represents the average fraction of total LA structures that meet PCME counting rules. For this evaluation, the first approach was followed.

In this document, all air concentrations will be reported in units of PCME LA s/cc.

3.4 Calculation of Air Concentrations

The concentration of LA in air is given by:

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

where:

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

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)

3.5 Estimating Confidence Bounds

For an Individual Sample

The uncertainty around a TEM estimate of asbestos concentration in a sample is a function of the number of structures observed during the analysis.

The 95% confidence interval around a count of N structures is given by:

LB = ½·CHIINV[0.025, 2N+1]
UB = ½·CHIINV[0.975, 2N+1]

where:

LB = Lower bound on the 95% confidence interval on N
UB = Upper bound on the 95% confidence interval on N
CHIINV = Inverse chi-squared cumulative distribution function
N = Number of structures observed

As N i ncreases, t he a bsolute w idth of t he c onfidence i nterval i ncreases, but t he r elative uncertainty [expressed as t he co nfidence i nterval (CI) di vided b y t he obs erved va lue (N)] decreases. This is illustrated in the table below.

Relationship Between Number of Structures Observed and Relative Uncertainty

Number of Structures Observed (N)	2.5% Lower Bound N (LB)	97.5% Upper Bound N (UB)	95% Confidence Interval Range (CI) [UB-LB]	Relative Uncertainty [CI/N]
0	0.00	2.51	2.51	+Infinity
1	0.11	4.67	4.57	457%
2	0.42	6.42	6.00	300%
3	0.84	8.01	7.16	239%
5	1.91	10.96	9.05	181%
10	5.14	17.74	12.60	126%
20	12.61	30.28	17.67	88%
50	37.54	65.35	27.81	56%
75	59.44	93.46	34.02	45%
100	81.82	121.08	39.26	39%

2.5% LB = 0.5 · CHIINV[0.975, (2 · N+1)]
97.5% UB = 0.5 · CHIINV[0.025, (2 · N+1)]

Using this approach, the equation for calculation of the upper and lower bounds on the air concentration of asbestos structures is:

Air Concentration (s/cc) = (LB or UB) · S

where:

LB or UB = Number of structures based on lower bound (LB) or upper bound (UB)
S = Sensitivity (cc^{-1} for air)

Across Multiple Samples

Calculation of the uncertainty bounds around the average of a group of asbestos samples is complicated by the fact that the between-sample variability in the measured concentration values includes the between-sample variability that arises from both analytical measurement error in individual samples and from between-sample temporal or spatial variability. EPA has not yet developed a method for calculating uncertainty bounds around the mean of asbestos data sets, so no uncertainty bounds are provided in this report for mean values (EPA, 2008[2]). However, it is important to recognize that the values are uncertain, and that actual values might be either higher or lower than reported.

4 Polarized Light Microscopy Analysis (PLM)

4.1 *Sample Preparation*

Soil samples collected as part of the OU8 sampling programs 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.

4.2 *Sample Analysis*

Soil samples collected at the Libby Site are 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

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[2] EPA. 2008. Framework for Investigating Asbestos-Contaminated Sites. Report prepared by the Asbestos Committee of the Technical Review Workgroup of the Office of Solid Waste and Emergency Response, U.S. Environmental protection Agency. OSWER Directive #9200.0-68.

"PLM-Grav"). Of the 508 soil field samples collected during these OU8 sampling program, only 4 samples had a coarse fraction.

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):* detected at levels lower than the 0.2% LA reference material
- *Bin B2 (<1%):* 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

5 Soil Visual Inspection

At the time of soil sample collection for PLM analysis, the sampling team performed a visual inspection of the displaced soil at each sampling point to determine if visible vermiculite was present in accord with SOP CDM-LIBBY-06. A semi-quantitative estimate (none, low, medium[3], high) of the amount of visible vermiculite present was noted for each sampling point. For composite samples, a count of the number of sampling points assigned to each visible vermiculite ranking was recorded on the Field Sample Data Sheet (FSDS) in the sample comments (e.g., 18 none [X], 6 low [L], 4 medium [M], 2 high [H]).

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 area.

<u>Option 1: Present/Absent</u>

The simplest strategy classifies an area either as "Vis –" if all sampling points in the composite were assigned a value of "none", or as "Vis +" if one or more of the sampling points were assigned a value of "low", "medium", or "high".

A potential limitation to this ranking strategy is that it does not account for differences in the amount or frequency of visible vermiculite detections. For example, an area with 1 "low" point

[3] The visual inspection SOP CDM-LIBBY-06 uses the terminology "intermediate" to refer to the "medium" classification. For the purposes of this document, the term "medium" is retained to correspond with the accompanying field documentation.

and 29 "none" points and an area with 24 "medium" points and 5 "high" points would both be ranked as "Vis +".

Option 2: Detection Frequency

In this approach, an area is assigned a value equal to the detection frequency by visible inspection. For example, an area with 1 "low" point and 29 "none" points would receive a value of 1/30 (3.3%), while an area with 24 "medium" points and 5 "high" points would receive a score of 29/30 (97%).

While this approach does account for the frequency of visible vermiculite, it does not consider the amount vermiculite observed. In other words, an ABS area with 5 "low" points and 25 "none" points would have the same detection frequency of 5/30 (17%) as an ABS area with 5 "high" points and 25 "none" points.

Option 3: Amount-Weighted Score

In this approach, both the frequency and the level of vermiculite are considered. This is achieved by assigning a weighting factor to each level, where the weighting factors are intended to represent the relative levels of vermiculite in each category. As presented in SOP CDM-LIBBY-06, the guidelines for assigning levels are as follows:

None =	No flakes of vermiculite detected observed within the inspection point.
Low =	A maximum of a few flakes of vermiculite observed within the inspection point.
Medium/High =	Vermiculite easily observed throughout the inspection point, including the surface. A ranking of High is reserved for samples that are 50% or more vermiculite. Others (<50%) are assigned a ranking of Medium.

Based on these descriptions, the weighting factors that were used to calculate scores are as follows:

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

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

$$Score = \frac{\sum_{i=1}^{x} L_i \cdot W_i}{x}$$

This value can range from zero (all points are "none") to a maximum of 10 (all points are "high"). For example, an area with 1 "low" point and 29 "none" points would receive a value of 1/30 = 0.033, while an area with 24 "medium" points and 5 "high" would receive a score of (24·3 + 5·10) / 30 = 4.13.

303 East 17th Avenue
Suite 700
Denver, CO 80203
p. (303) 764 - 1520
f. (303) 860 - 7139

2060 Briargate Parkway
Suite 120
Colorado Springs, CO 80920
p. (719) 272 - 8800
f. (719) 272 - 8801

419 Canyon Blvd.
Suite 316
Fort Collins, CO 80524
p. (970) 419 - 4388
f. (970) 419 - 4389

DRAFT Remedial Investigation Report

HDR

Operable Unit 8
Libby Asbestos National Priorities List Site

April 2012

EPA United States Environmental Protection Agency
"...to protect human health and to safeguard the natural environment..."