FINAL

2016 REMEDIAL INVESTIGATION REPORT ADDENDUM
OPERABLE UNIT 3
LIBBY ASBESTOS SUPERFUND SITE, LIBBY, MONTANA

SEPTEMBER 2018

Prepared for and with Oversight by:

W.R. Grace & Co.-Conn.

And

U.S. Environmental Protection Agency, Region 8
Denver, CO

Prepared by:

Stantec Consulting Services Inc.

1560 Broadway, Suite 1800

Denver, CO 80202

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PROJECT MANAGEMENT

TITLE AND APPROVAL SHEET – TO BE SIGNED FOR FINAL VERSION ONLY

Title: 2016 Remedial Investigation Report Addendum Operable Unit 3, Libby Asbestos Superfund Site, Libby, Montana

Approvals:

This 2016 Remedial Investigation Report Addendum is approved for implementation without conditions.

for ________________________ 9/26/2018

Christina Progess **Date**
U.S. Environmental Protection Agency
Region 8 Superfund Project Manager and Quality Assurance Manager, Libby OU3

________________________ 9/24/2018

Tony Penfold **Date**
W.R. Grace & Co.-Conn.
Remediation Manager

________________________ 9/24/2018

William Pickens, PG **Date**
Stantec Consulting Services, Inc.
Project Manager

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0	September 24, 2018	Submission of Final Report to Stakeholders

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LIST OF ACRONYMS AND ABBREVIATIONS

Ms/cm^2	million structures per square centimeter
Ms/g-dw	million structures per gram dry weight
ABS	Activity Based Sampling
AOC	Administrative Settlement Agreement and Order on Consent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chain of custody
CTP	Coarse Tailings Pile
CWA	Clean Water Act
EDD	electronic data deliverable
EPA	U.S. Environmental Protection Agency
EPC	Exposure Point Concentration
FS	Feasibility Study
FSDS	field sample data sheet
FSSR	Field Sampling Summary Report
Grace	W.R. Grace & Co.-Conn
GPS	global positioning system
HDPE	High Density Polyethylene
HEI	Hafferman Engineering, Inc.
HGM	hydrogeomorphic
HHRA	Human Health Risk Assessment
HQ	Hazard Quotient
H&S	Health & Safety
ID	identification number
ISO	Internal Organization for Standardization
KDC	Kootenai Development Company
KDID	Kootenai Development Impoundment Dam
LAA	Libby Amphibole Asbestos
MDEQ	Montana Department of Environmental Quality
MDNRC	Montana Department of Natural Resources and Conservation
MDSL	Montana Department of State Lands
MRWA	Montana Rapid Wetland Assessment
MWH	MWH Americas, Inc.
NIST	National Institute of Standards and Technology
NPL	National Priorities List
NVLAP	National Voluntary Laboratory Accreditation Program
OHWM	ordinary high water mark
OU3	Operable Unit 3
PCM	Phase Contrast Microscopy
PCME	Phase Contrast Microscopy-Equivalent
PLM-VE	Polarized Light Microscopy, Visual Area Estimation

PMF	probable maximum flood
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
QATS	Quality Assurance Technical Support
QC	Quality Control
RI	Remedial Investigation
RME	reasonable maximum exposures
ROM	Record of Modification
SAP/QAPP	Sampling and Analysis Plan/ Quality Assurance Project Plan
SOW	Statement of Work
Stantec	Stantec Consulting Services, Inc.
TEM	Transmission Electron Microscopy
US	United States
USACE	United States Army Corps of Engineers
WRP	Waste Rock Pile

1 INTRODUCTION

This report is an addendum to the *Remedial Investigation Report, Operable Unit 3 (OU3) Study Area, Libby Asbestos Superfund Site, Libby, Montana* (OU3 RI Report) [MWH Americas, Inc. (MWH), 2016a]. This addendum presents the results and conclusions for OU3 Remedial Investigation (RI) activities performed during 2016, after the OU3 RI Report was finalized. The 2016 activities were performed in support of the ongoing Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Study (FS) for OU3.

The RI activities conducted in 2016 and discussed in this report include the following:

- Supplemental tree bark and forest duff sampling;
- Inner wood sampling;
- Woodstove ash and hooking/skidding activity based sampling (ABS); and
- Wetlands delineation.

The data collected during the 2016 RI activities were used to inform the determination of a boundary for OU3, which is discussed herein. In addition, the newly collected ABS data were utilized by the United States Environmental Protection Agency (EPA) to prepare the document titled: *Final Addendum: Site-wide Human Health Risk Assessment* (HHRA Addendum) (EPA, 2018a), which is also summarized in this report. Additional background information about OU3 is also provided herein to augment the information provided in the OU3 RI Report.

The RI activities were conducted, and this RI Addendum was prepared, in accordance with the revised Statement of Work (SOW) dated December 2015 of the Administrative Settlement Agreement and Order on Consent (AOC) (Docket No. CERCLA-08-2007- 0012) between W.R. Grace & Co.-Conn (Grace) and the EPA (EPA, 2007 and EPA, 2015a).

2 ADDITIONAL BACKGROUND INFORMATION

The following additional background information is provided to more thoroughly describe the areas where former mining operations occurred within OU3 (referred to herein and in the RI Report as the Former Mine Area), provide additional details regarding previous and planned reclamation activities, and provide additional information regarding Libby Amphibole Asbestos (LAA) characteristics. It is anticipated that these additional details will support evaluation of remedial alternatives in the OU3 FS.

2.1 Former Mine Area Features

The primary features of the Former Mine Area are shown on **Figures 2-1** and **2-2,** and include the mined area (Vermiculite Mountain), Kootenai Development Impoundment Dam (KDID), Fine Tailings Impoundment located behind the KDID, Coarse Tailings Pile (CTP), Waste Rock Piles (WRPs), and areas impacted by releases from the mine, such as the haul road, and portions of the Kootenai River, creeks, and ponds. **Figure 2-1** is an interactive pdf showing photographs of the Former Mine Area features, which are viewable by clicking on the camera symbols on the figure. These photographs are also included in **Attachment A**. **Figure 2-2** shows the approximate features, areas and volumes of the various Former Mine Area. A brief description of the features are discussed below.

Mined Area (see Figure 2-1, Photo Nos. 12, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 29, 33). The mined area is approximately 504 acres, and refers to the higher-elevation, benched areas where vermiculite ore was extracted from Vermiculite Mountain. The mined area is generally vegetated with grasses and intermittent coniferous trees on most surfaces apart from the steeper slopes between benches. Soil excavated as part of remedial action from OUs 1, 2, 4, and 7 was transported and placed, spread, and revegetated for beneficial use at the northeast portion of the mined area. This beneficial reuse area comprises approximately 172 acres of the mined area.

Kootenai Development Impoundment Dam and Fine Tailings Impoundment (see Figure 2-1, Photo Nos. 3, 5, 7, 8, 11, 13 and 30). The KDID is a permitted 135-foot-tall earthen structure comprised of coarse mine tailings that was constructed across Upper Rainy Creek to store fine tailings produced during the wet milling of vermiculite. The volume of coarse tailings material in the KDID is approximately 1.2 million cubic yards, and the volume of fine tailings in the Fine Tailings Impoundment is approximately 3.2 million cubic yards. The Fine Tailings Impoundment behind the KDID occupies approximately 45 acres and receives inflow from both Upper Rainy Creek and Fleetwood Creek. The Fine Tailings Impoundment attenuates flowbehind the KDID and thus allows for settlement of suspended solids, including LAA, in the surface water. The surface area of the standing water in the impoundment typically ranges from about 10 to 25 acres depending on the time of year and is sometimes dry during late summer. A small embankment separates the KDID fine tailing impoundment from a small pond referred to as the upper tailings pond (UTP). The KDID and Fine Tailings Impoundment are thickly vegetated (except for the perennially submerged area of the impoundment). The vegetation stabilizes the tailings and embankment materials (resists erosion) and reduces potential for mobilization of LAA-containing fines during storm events.

The majority of flow through the impoundment discharges to Lower Rainy Creek through the KDID underdrain system, with a relatively small portion of the flow discharging during spring runoff via a principal spillway and chute located on the left abutment of the KDID. Options are currently being evaluated to improve the KDID's ability to safely pass the flow of the probable maximum flood (PMF): these options will voluntarily align the dam with current dam safety standards and tailing dam legislation.

Coarse Tailings Pile (see Figure 2-1, Photo No. 34): The CTP was used as a repository for coarse tailings generated during the dry milling of vermiculite. The CTP comprises an area of approximately 155 acres and is estimated to contain approximately 14.7 million cubic yards of material. The northwestern toe of the CTP is buttressed by the Fine Tailings Impoundment. The toe of the southwestern portion of the CTP was used as the primary borrow area for construction of the KDID (see **Figure 1-2**, Photo No. 13).

Waste Rock Piles (see Figure 2-1, Photo Nos. 18, 32 and 35): The WRPs are rock and overburden spoils that were placed off the south flank of Vermiculite Mountain during mining operations. The WRPs consist of a mixture of different overburden rock types (i.e., syenite, unaltered biotite, quartz, and other non-vermiculite materials). Three separate WRPs were deposited, varying in size and location and are referred to as the East, Central, and West WRPs. The West WRP is the largest, with approximately 28.2 million cubic yards and a maximum thickness of approximately 300 feet; the Central WRP is the smallest with approximately 1 million cubic yards and a maximum thickness of approximately 100 feet; and the East WRP is approximately 11.5 million cubic yards in volume with a maximum thickness of approximately 250 feet. The combined volume of the WRPs has been estimated to be approximately 40.7 million cubic yards.

Fleetwood Creek (see Figure 2-1, Photo No. 16): Fleetwood Creek flows along the toe of the CTP, and drains to the Fine Tailings Impoundment. Fleetwood Pond, a relatively shallow impoundment approximately 0.5 acre-feet in size, was formed as the CTP was deposited in the valley and tailing material impounded water by obstructing the creek.

Carney Creek (see Figure 2-1, Photo Nos. 18 and 35): Carney Creek flows along the south side of the former mine, and discharges into Lower Rainy Creek. Encroachment of the toe of the West WRP has pushed Carney Creek about 200 feet south and waste rock has dammed portions of the creek resulting in the formation of Carney Pond. Carney Pond is a relatively shallow pond, approximately 2 acre-feet in size (see **Figure 1-2**, Photo No. 35). Lower Carney Pond is approximately 0.5 acre-feet in size, and is located approximately 1,000 feet downstream of Carney Pond.

Lower Rainy Creek (see Figure 2-1, Photo Nos. 1, 2, 9 and 36): Lower Rainy Creek extends approximately 2.5 miles from the base of the KDID to its confluence with the Kootenai River. The Mill Pond is an impoundment in Lower Rainy Creek located approximately 0.5 mile downstream from the KDID that was formed by a human-made embankment, which is less than 10 feet high and approximately 490 feet long (see **Figure 1-2**, Photo Nos. 2 and 9). The impoundment volume is approximately 6 acre-feet. A lined spillway discharges flow from the Mill Pond back into Lower Rainy Creek. An area on the west side of Rainy Creek Road, to the southwest of the Mill Pond is referred to as the Amphitheater.

Kootenai River (see Figure 2-1, Photo No. 36): The Kootenai River receives flow from the Rainy Creek watershed, which includes the Former Mine Area, and the Fleetwood Creek and Carney Creek watersheds. On average, the flow from the approximately 17.3-square-mile Rainy Creek watershed represents about 0.03 percent of the total flow in the Kootenai River at its confluence with Lower Rainy Creek. The portion of the Kootenai River to be included in OU3 is currently being negotiated.

2.2 Mine Closure, Reclamation, and Other Historical Actions

The former vermiculite mine began operations in the 1920s and then was operated by Grace from approximately 1963 to 1990. In 1972, Grace received an operating permit (00010) under the Metal Mine Reclamation Act. A reclamation bond was issued by the Montana Department of State Lands (MDSL) for the entire permit area (1,200 acres) as part of the Reclamation Plan (MDSL, 1971). Under this permit, mined areas were reclaimed as they were mined out, and additional major reclamation efforts began after operations ceased in 1990. In summary, approximately 15 acres were reclaimed and released from bond in 1988, followed by 160 acres (which included the KDID and Impoundment) in 1994, and 900 acres were released from bond in 1997. A bond remains on 125 acres within the permit boundary, which includes portions of the CTP, an old landfill north of the West WRP, and a former solid waste landfill and borrow area (now located within the Beneficial Reuse Soil area) (MDSL, 1990). The former and current bonded areas are shown in **Figure 2-2**.

Activities completed within the mine permit area for bond release included the removal of mining structures and facilities; erosion control activities including land re-contouring and re-vegetation of disturbed areas; and Carney Pond sediment removal. Grace was presented with the "In Pursuit of Excellence" Award by the Montana Mining Association Board of Directors (The Pick & Shovel, 1993).

After 1997, Grace continued to perform reclamation activities as needed (e.g., continued erosion control and slope stability actions, removal activities, CERCLA removal actions, etc.). Details on the reclamation activities that have occurred following the mine closure in 1990 are included below. **Figure 2-3** shows a timeline that includes mine operation, closure, and reclamation activities.

2.2.1 Mining Structures and Facilities Removal

Following mine closure in 1990, Grace initiated the following activities for bond release:

- The on-site mill, where milling operations occurred, and the tramway, which was the mechanism used to transport concentrated vermiculite from the mill site to a load area, were removed.
- The decant system, which maintained reservoir elevations and limited fine tailing from being transported downstream of the dam was abandoned by pressure grouting. The downstream end of the decant pipe is currently visible with a welded steel cap and is visibly covered with concrete residue.
- The Upper Rainy Creek diversion and KDID operations emergency spillway half pipes were removed and the emergency spillway cut was backfilled.
- The current principal and auxiliary spillways were installed along with the installation of open standpipe piezometers (Schafer and Associates, 1992). The spillway and related reclamation work was completed following a Montana Environmental Policy Act review by relevant Montana agencies. The spillways convey flood-related inflows from the KDID impoundment safely downstream of the KDID embankment.

2.2.2 Erosion Control Activities

As described in the Bond Release Finding Memorandum issued by MDSL on August 31, 1994 (MDSL, 1994a), Grace performed various erosion related reclamation activities in the early-1990s to qualify for bond release including:

- Limited terracing of the WRPs
- Eliminating the stair-step mine benches, where practicable
- Scarifying the remaining mine benches and roadways
- Implementing erosion control measures on the mine area
- Hydroseeding various disturbed areas including the WRPs and CTP
- Planting trees
- Controlling weeds

Planting/Seeding. Grace planted approximately 10,000 deciduous trees and shrub species on the slopes of the WRPs and CTP, and approximately 10,000 conifers on the CTP and in other areas starting in 1990 through 1993. In addition, extensive hydroseeding was applied across the mine disturbed area during the same timeframe. In 1994, the MDSL observed that reclamation seedings had produced substantial stands of grass, with legumes growing the best, that wildlife were grazing in reclaimed areas, and that the old coarse tailings below the old mill and above the tailings impoundment had re-vegetated. Furthermore, the MDSL stated that “the post mine topography, vegetation and sediment control measures are effectively limiting sedimentation and release of asbestiform minerals in Rainy and Carney Creeks to background 1971 levels” (MDSL, 1994b). The effectiveness of these past mine reclamation activities for reduction of unacceptable risk associated with exposure to or migration of LAA, and any need for further remedial action, will be based on data collected as part of the OU3 RI and will be assessed as part of the FS.

In 2013, Grace planted approximately 7,000 additional trees to further stabilize the CTP, supplementing the plantings that had occurred in the early-1990s.

CTP Grading and Other Work. The following erosion-control activities have been performed by Grace on the CTP to address erosional features (e.g., rills and gullies) that develop as a result of large storm events:

- In 2012, logs that were used during an ABS event were placed horizontally in four erosion-prone areas to stabilize soils and control erosion. These areas were reseeded after log placement.
- In 2012, new, larger culverts were installed and the ditches were improved along the haul road to minimize surface water running across the road onto the CTP.
- In 2013, slash piles remaining from logging that occurred in the 1990s (estimated volume of 100 cubic yards) were chipped and spread on the CTP. This material was later covered as a result of the re-contouring efforts in 2015 and 2016 to improve the CTP drainage.
- In 2014, a slope stability investigation and hydrology analysis of the CTP was performed and repairs were made to the road and channels above the CTP to direct stormwater away

from the slopes (K. Hafferman of Hafferman Engineering, Inc., personal communication, March 17, 2017).

- In 2016, a series of stormwater collection and diversion channels were constructed across the face of the CTP to break surface flow and direct water away from the pile at more gentle slopes to limit erosion.

2.2.3 Carney Pond Sediment Removal

Lower Carney Pond is located to the southeast of the Mill Pond below the West WRP as shown on **Figures 2-1** and **2-2**. As part of mine reclamation, accumulated sediment in the pond was removed in 1994. According to the MDSL, the sediment material may have been spread over the Amphitheater area (see **Figure 2-2**) and re-seeded in 1995 (MDSL, 1995). A subsequent removal action occurred later at the Amphitheater and is described below.

2.2.4 Other Actions

In addition to the activities completed within the mine permit area for bond release, the following additional reclamation and site improvements have been performed:

- **Amphitheater Removal Action.** A field investigation conducted in October 2011 identified an area with LAA-containing material near the Amphitheater, located to the southwest of the Mill Pond (see **Figures 2-1** and **2-2**). To mitigate this potential source of LAA to Lower Rainy Creek, the EPA directed that LAA-containing material was to be excavated and transported to the Former Mine Area, where LAA-containing soil removed as part of various remedial efforts in OUs 1, 2, 4, and 7 had been placed (EPA, 2016a; see "Beneficial Reuse Soil" area shown in **Figures 2-1** and **2-2**). All excavated areas were regraded, covered with soil (originating from OU4) and reseeded. The Amphitheater removal action was performed during the fall of 2012 and summer of 2013. This work was completed under a CERCLA Non-Time-Critical Removal Action.

- **Beneficial Reuse Soil.** Since 2000, soils excavated from various remedial efforts in OUs 1, 2, 4, and 7 have been hauled to, and stockpiled at the Amphitheater per EPA requirement. When sufficient soil material accumulated, it was moved to the mined area where it was graded and planted with an OU3-specific seed mix developed by the Montana Department of Natural Resources and Conservation (MDNRC). The location of these soils is identified in **Figure 2-1**. These activities are ongoing.

- In a letter dated February 26, 2016 from EPA to Grace (EPA, 2016a) titled "Soil Placement for Libby Asbestos Site – Operable Unit 3", EPA states, "*the soil serves as an effective cover in this remote and highly contaminated area*." The letter also describes other action taken by EPA by stating, "*Similarly, EPA has worked cooperatively with Grace to make available soil removed from OUs 4 and 7 for use as fill material and a long-term cover to replace highly contaminated tailings excavated as part of the 2012-2013 Rainy Creek floodplain removal action*." Although EPA has acknowledged the effectiveness of the beneficial reuse soil as a cover material for the tailings piles in this letter, it is recognized that final determination of the effectiveness of reclamation activities or the suitability of reused soil as cover materials with respect to the CERCLA Remedial Action Objectives is still in development as part of the FS.

- **Logging on KDC Property.** It is estimated (from Google Earth historical imagery) that approximately 1,500 acres of forest were selectively logged on the KDC property during the early 1990s (between 1990 and 1995). Estimated areas where logging activities occurred within the KDC property boundary are shown on **Figure 2-4**. This estimate is based on the presence of logging roads, skid trails, logging landing sites, and the noticeable differences in the amount of vegetation (D. Schulte of Alder Gulch Natural Resources LLC, personal communication, March 19, 2017).
- **Access Control Points.** Grace and EPA have installed numerous gates throughout the Former Mine Area to control public access (see **Figure 2-2** for locations). For example, access gates are located at the main gate near the guard shack, on top of the dam, near Upper Rainy Creek on the haul road, and on Jackson Creek, at the Grace Property line. In addition, there is a USFS gate at the five-mile marker on Alexander Road.
- **Rainy Creek Road.** In 2001 and 2003, EPA paved approximately two miles of Rainy Creek Road from the junction of Montana Highway 37 and Rainy Creek Road to the Amphitheater (EPA, 2009) to reduce dust generation during haul truck transport of soils from OUs 1, 2, 4, and 7 to the Amphitheater (see **Figure 2-2**).
- **KDID Toe Drain Repairs.** In 2010, repairs were made by Grace to the outlets of Drains 2, 7 and 11 below the KDID. Repairs consisted of replacing short drain sections at the toe of the dam with high-density polyethylene (HDPE) pipe (Billmayer and Hafferman, Inc., 2013).
- **Fuels Management**. During the 2017 and 2018 field season, a significant amount of road clearing and fuel break creation was completed on the KDC property. This private fuel management work allows four-wheel drive firefighting vehicle access throughout the KDC property and, in the event of a wildfire, provides fuel breaks to reduce the potential size and severity of a wildfire.
  - 2017: A total of approximately 10 miles of roads were opened to a minimum 16 to 20-foot clearing width, with an additional 30-foot-wide buffer of material masticated on both sides of the roads. Additionally, 1.3 miles of a 60-foot-wide shaded fuel break was cleared along the Carney Creek ridge. Trees were masticated and scattered.
  - 2018: A second phase of fuels management was completed resulting in approximately 12 miles of additional road clearing and over 3 additional miles of ridgeline shaded fuel breaks on the KDC property. A buffer along Highway 37 on Grace property at the Rainy Creek Road entrance also was completed.

2.3 Libby Amphibole Asbestos Characteristics

Appendix B-1 of the OU3 RI Report presents a review of the available literature and data on the composition of amphibole and LAA associated with the former Zonolite Mine in Libby, Montana. The information was provided for use in the identification of mine-related amphibole asbestos as part of remedial investigation evaluations. **Attachment B** of this RI Addendum presents additional information to better define the compositional characteristics of the amphibole asbestos from the Rainy Creek Complex.

3 SUMMARY OF 2016 REMEDIAL INVESTIGATIONS

This section describes the sampling designs and sample collection details for the 2016 RI activities. The 2016 RI activities were performed in accordance with the following documents:

- Quality Assurance Project Plan: Libby Asbestos Superfund Site, Operable Unit 3, 2016 Tree Bark and Forest Duff Sampling [CDM Smith Federal Programs Corporation (CDM Smith), 2016a]
- Sampling and Analysis Plan/Quality Assurance Project Plan Libby Asbestos Superfund Site Operable Unit 3, Woodstove Ash and Hooking/Skidding Activity Based Sampling Investigation (MWH, 2016b)
- Quality Assurance Project Plan (QAPP) Addendum (Record of Modification LFM-OU3-01): Pilot Study to Compare LA Levels in Bark and Wood, Operable Unit 3, Libby Asbestos Superfund Site (CDM Smith, 2016b)
- Sampling and Analysis Plan / Quality Assurance Project Plan (SAP/QAPP) Wetland Delineation Operable Unit 3 Study Area Libby Asbestos Superfund Site (MWH, 2015)

Sampling methodologies, protocols, and analytical testing methods were presented in the above documents and are not repeated herein. The *2016 Field Sampling Summary Report, Libby Asbestos Superfund Site, Operable Unit 3, Libby, Montana* (2016 FSSR) (MWH, 2017a) was prepared for the work which contains specific information about the sampling events and field quality control.

3.1 Data Collection and Management

3.1.1 Sampling Overview

The following media were sampled in 2016:

- Duff from forested areas
- Tree bark from forested areas
- Inner wood from forested areas
- Woodstove ash
- Air (during woodstove ash and hooking/skidding ABS)

Sample totals per media and sample specifics including station information are presented on **Tables 3-1** and **3-2**, respectively. **Table 3-2** also includes the station identification numbers (ID), and station descriptions. Further detail on each sample event design and collection are presented below in **Sections 3.2** through **3.4**. Sample results are discussed in **Section 4.0** by media type.

3.1.2 OU3 Database

As described in Section 3.3 of the OU3 RI Report, all OU3-related analytical data are entered and maintained in the master OU3 project database (relational Microsoft Access® database), which is managed by CDM Smith. The 2016 data were entered into this relational database under the same guidance as previous datasets.

3.1.3 Excluded Datasets

No data sets were excluded from use (rejected) based on the results of validation. However, as discussed below in **Section 3.2**, the 2016 supplemental tree bark and duff results, which were collected to refine EPA's kriging models, have not yet been validated by EPA's Quality Assurance Technical Support (QATS) contractor. Upon reviewing the preliminary results for the supplemental tree bark and duff samples (see **Section 3.3** below), EPA decided that the continued analysis of the tree bark and duff samples collected as part of the 2016 supplemental sampling (BD16- station ID prefix and KG- index ID prefix as shown in **Attachment C**) should be placed on hold. Prior to the hold notice, a number of the samples had been analyzed. These preliminary results are included in this addendum for comparative purposes.

3.1.4 Analytical Methods

As described in Section 3.5 of the OU3 RI Report, the EPA has employed modifications to commercial asbestos test methods for various sample media collected in OU3. The analytical methods used to analyze the OU3 LAA samples by media are shown on Table 3-1 of the OU3 RI Report. For the 2016 sampling, Transmission Electron Microscopy (TEM) – in accordance with International Organization for Standardization (ISO) 10312.1995(E); referred to as TEM ISO, was the analytical method for all media.

3.1.5 Quality Assurance/Quality Control (QA/QC) Activities

Field QA Activities: Field quality assurance (QA) activities include processes and procedures that have been designed to confirm that field samples are collected and documented properly, and that issues/deficiencies associated with field data collection or sample processing are quickly identified and rectified. Field QA activities are included in the 2016 FSSR (MWH, 2017a) and summarized here:

- Prior to beginning the field activities, all field team members were required to read and become familiar with the applicable SAP/QAPPs, the applicable SOPs for sampling, documentation, decontamination, etc., and the project Health and Safety Plans.
- Readiness calls that included stakeholders and all field and management personnel were held to outline the project specifics and to answer any questions prior to conducting field activities.
- Health and safety (H&S) tailgate meetings were held each morning prior to mobilization on site with all field team members to discuss daily activities and any H&S related issues.
- EPA contractors from both HDR Inc. and CDM Smith were on site during the tree bark, duff sampling, and ABS activities to provide oversight and QA assistance.
- All samples were labeled and recorded on the appropriate chain-of-custody (COC) form and field sample data sheet (FSDS) as physical evidence of sample custody and control, and to capture sampling details.
- An EPA contractor from HDR Inc. was on site during the entire wetland delineation to provide oversight and QA assistance.
- Record of Modification (ROM) forms that modified the sampling approach and/or associated guidance were prepared to document changes to or deviations from the SAP/QAPPs and are included in the 2016 FSSR as attachments.

Field Audits: Field audits for the tree bark/forest duff sampling, and woodstove ash and hooking/skidding ABS were conducted during the H&S kickoff meeting by an EPA representative (Mike Cirian), and during the entire ABS field investigation by two EPA contractors, CDM Smith (Kris Beaudon or Dan Lauth) and HDR (Kyle Cark). The audits were performed to confirm that the SAP/QAPP and applicable SOPs were being followed during the field investigation and to alert the field team to potential data quality issues and/or deviations from the approved sampling methodologies. Quality or procedural issues were discussed in the field with all involved personnel and on follow-up calls with Stantec Consulting Services, Inc. (Stantec) and EPA. In the event of an identified deviation from the SAP/QAPP and/or SOPs, Stantec initiated a corrective action immediately.

Field audits for the wetland delineation activities were conducted during the H&S kickoff meeting by an EPA representative (Mike Cirian), and during the entire field evaluation by an EPA contractor, HDR (Kyle Cark). Field documentation validation was performed by HDR on the wetland delineation processes and procedures to evaluate overall data quality and to alert the Stantec wetland team to potential data quality issues. Quality or procedural issues were discussed immediately in the field with all involved personnel. No significant corrective actions were identified during the audits.

Data Verification: Data verification includes checking that results have been transferred correctly from the original hand-written, hard copy, field and analytical laboratory documentation to the OU3 project database. The goal of data verification is to identify and correct data reporting errors. For analytical laboratories that utilize the Libby-specific electronic data deliverable (EDD) spreadsheets, data checking of reported analytical results begins with automatic QC checks that have been built into the spreadsheets. Data verification was performed by CDM Smith staff familiar with project-specific data reporting, analytical methods, and investigation requirements. During data verification, any field documentation data issues identified by CDM Smith were relayed to Stantec for correction and form resubmittal so that sample collection information could be entered correctly into the OU3 database. The 2016 Supplemental Bark/Duff Study data were partially verified as a result of EPA's decision to not analyze all samples.

Laboratory QA Activities: Laboratories selected for analysis of samples for asbestos are part of the Libby analytical laboratory team. These laboratories have demonstrated experience and expertise in analysis of LAA in environmental media, and are part of an ongoing Libby-specific QA program designed to ensure accuracy and consistency of reported analytical results between laboratories. These laboratories are audited by the EPA QATS contractor, APTIM Federal Services, LLC (APTIM), and the National Institute of Standards and Technology (NIST)/National Voluntary Laboratory Accreditation Program (NVLAP) on a regular basis. Laboratory QA activities include processes and procedures designed to ensure data generated by an analytical laboratory are of high quality and any problems in sample preparation or analysis are quickly identified and rectified. A summary of the required laboratory QA procedures for each laboratory that analyzes samples from OU3 is included in Section 3.6 of the OU3 RI Report.

A detailed evaluation of the QC results for the 2016 ABS investigation was performed by APTIM including a formal data validation. The results of this evaluation are presented in the Annual QA/QC Summary Report (APTIM, 2016) (see **Attachment D**). The following summarizes the key components of the evaluation:

- No on-site audits of the Troy, MT soil preparation facility or asbestos laboratories used for analyzing OU3 samples were conducted in 2016.
- The 2016 Supplemental Bark/Duff Study data were not validated given EPA's request to hold these data.
- Data validation was performed to evaluate overall data quality and to assign data qualifiers, as appropriate, to alert data users of potential data quality issues within the subset of the data evaluated. Of the total 424 OU3 samples collected in 2016, 41 (~10%) were validated. The validated samples consisted of 30 field samples and 11 QC samples. The QC samples included seven laboratory blanks, two recount different analyses, one recount same analysis, and one re-preparation analysis. No qualifiers were applied to any of the 41 samples validated. The bench sheet/EDD information comparisons found that of the 41 samples validated, two samples and one laboratory blank contained minor discrepancies that have no impact on the sample results. No results were qualified during the data validation supporting the conclusion that reported data used in the HHRA Addendum are of high quality (EPA, 2018a, Appendix B).
- There are a variety of field quality control (QC) samples, preparation laboratory QC samples, and analytical laboratory QC analyses (see investigation-specific SAP/QAPPs for requirements), included as part of the sampling investigations performed at OU3. A more detailed summary of the QC results as evaluated by APTIM is as follows:
    - **Field Lot Blanks** – Lot blanks were collected for air samples only. During the 2016 ABS activities, two air filter lot blanks were analyzed by TEM and no asbestos structures were observed. Based on the lot blank results, the air filters used during the field sample collection did not contain asbestos.
    - **Field Blanks** – Field blanks were collected for air samples only. During the 2016 ABS activities, 12 field blanks were analyzed by TEM and no asbestos structures were observed. Based on the field blank results, the potential contamination was not introduced during sample collection, shipping and handling, or analysis.
    - **Field Duplicates** – Field duplicates were collected for ash, duff, tree bark, and inner wood samples. Of the 14 field duplicate pairs, 3 were ash, 6 were duff, 4 were tree bark, and one was an inner wood sample. The TEM results of the parent sample and the field duplicate sample are compared using the two Poisson rates method for comparison (Nelson, 1982). Because field duplicate samples are expected to have variability that is random and may be either small or large, there is no quantitative requirement for unanimity of field duplicates. Instead results provide information on the magnitude of this variability and its effect on data interpretation. All of the ash, duff, and inner wood duplicate samples yielded Poisson rates not statistically different, meaning the sampling results of these media were reproducible. Four of the seven tree bark duplicate pairs had Poisson rates that were statistically different. The statistical analysis shows that tree bark samples have more variability than samples of other media.
    - **Laboratory Blanks** – TEM blanks were represented by three blank types: laboratory blanks, drying blanks, and filtration blanks. A total of 116 TEM blank samples were analyzed. No asbestos structures were found in any of the TEM blank samples. The

results verify that asbestos contamination was not introduced during sample preparation and analysis in the TEM laboratories.

- **Laboratory Re-preparation Analysis** – A TEM re-preparation is the re-analysis of a sample from which new grids have been prepared using a different portion of the same field sample filter used to prepare the original grids. Re-preparation analyses provide information on analysis precision and within-filter variability. Re-preparation analyses are compared to the original analysis using the two Poisson rates ratio method for statistical comparison (Nelson, 1982). Three sample re-preparation analyses (one of each for ash, tree bark, and air) were performed; none were found to be statistically different from the original analyses. The results show good analysis precision and low within-filter variability.
- **Laboratory Recount Analyses** – A recount analysis is an intra-laboratory re-examination of the original TEM grid openings by the same and a different microscopist to verify the reproducibility of results within the laboratory. Recount analyses include recount same, recount different, and verified analyses. Recount analyses were compared with the original analyses on a grid-opening-by-grid-opening and structure-by-structure basis. Grid opening concordance is evaluated based on a comparison of total structure count. Structure concordance is evaluated based on a comparison of the assigned mineral classification and recorded structure dimensions. A total of 19 recount analyses were performed. When the same structure was observed and recorded, there was 100% agreement on the assigned mineral class, structure length, and structure width. By media, the concordance on structure count was good at 100% for duff and ash, good at 97% for air, and poor at 78% for tree bark. These results indicate that there is good result reproducibility within the same laboratory for duff, ash and air, but highlight the uncertainty about the structure count of tree bark samples (as was indicated by the field duplicates discussed above).
- **Laboratory Inter-laboratory Analyses** – Inter-laboratory analyses are recount analysis types in which grid openings are re-examined by a different laboratory than the one that performed the original analysis. Inter-laboratory analyses are compared in the same way as recount samples. Inter-laboratory analysis samples include four air samples, two tree bark samples, one ash sample, and one duff sample. With the exception of structure count, inter-laboratory analyses were all within the “good” or “acceptable” range for mineral class, structure length, and structure width. The concordance on structure count for all samples was poor at 33 – 67%. The TEM inter-laboratory analyses indicate that differences between structure count and recording procedures between the laboratories are evident. The discordances may be attributed to false negative results potentially caused by analyst error and/or misinterpretation, chemical variability among structures, tears in the file replicate causing the relocation of fibers, etc.

3.2 Supplemental Tree Bark and Forest Duff Sampling

3.2.1 Objectives

EPA initially identified a large OU3 Study Area to help delineate the extent of potential mine-related impacts. Potential risks to humans from exposures to LAA at the Libby Asbestos

Superfund Site, including exposures within the OU3 Study Area, were evaluated in the *Site-wide Human Health Risk Assessment* (Site-wide HHRA) (EPA, 2015b). The Site-wide HHRA concluded that inhalation risks associated with some activities that may take place within OU3 are potentially above a level of concern or may contribute to a cumulative[1] risk above an acceptable level. Following completion of the OU3 RI and Site-Wide HHRA, EPA delineated a different study area using kriging modeling to support the OU3 FS (EPA, 2016b). In brief, EPA identified preliminary LAA concentrations or "threshold levels" for tree bark and duff to represent unacceptable human-health risk based on an assumed linear correlation between LAA levels in source media (i.e., tree bark and duff) and airborne LAA concentrations when the source media are disturbed during specific activities. EPA then used the kriging results (based on the post-2007 to 2015 tree bark and duff datasets) to estimate the areas where LAA concentrations may exceed the preliminary threshold levels.

Kriging is a geostatistical procedure that generates an estimated surface from a scattered set of points using predictive algorithms. The magnitude of uncertainty in the estimated LAA concentrations increases as distance between the sampling locations increases. In some instances, EPA's kriging model estimates were considered uncertain due to a lack of post-2007 through 2015 sampling points. Other identified concerns with EPA's kriging approach included:

- EPA's *Framework for Investigating Asbestos-Contaminated Superfund Sites* (EPA, 2008) states that "[t]he relationship between the concentration of asbestos in a source material and the concentration of fibers in air that results when that source is disturbed is very complex and dependent on a wide range of variables. To date, no method has been found that reliably predicts the concentration of asbestos in air given the concentration of asbestos in the source." This conflicts with the assumed linear correlation between LAA concentrations in source media and LAA concentrations in air at OU3 that EPA used to establish the threshold values used in the kriging models.
- Although LAA concentrations in tree bark and duff generally decrease with distance from the mine, LAA concentrations in tree bark and duff are not normally distributed and do not follow a linear trend with regard to distance from the center of the former mine. This limits the viability of using kriging methods to predict media concentrations between data points.

The objective of the 2016 supplemental tree bark and forest duff sampling was to collect additional measurements of LAA concentrations in tree bark and duff to reduce uncertainties in EPA's kriging model estimates. The 2016 ABS activities discussed below in **Section 3.3** also were conducted with the objective of providing additional data to assess the relationship, if any, between LAA levels in source media (i.e., tree bark and duff) and airborne LAA concentrations when the source media is disturbed during specific activities. **Section 5.4** discusses the resultant OU3 Boundary and each line-of-evidence used to define the boundary, including the 2016 data.

3.2.2 Sampling Activities

The 2016 supplemental tree bark and forest duff sampling included collecting composite tree bark and/or duff samples at new sampling locations to fill spatial gaps in the data collected between 2007 and 2015. In addition, composite tree bark and/or duff samples were collected at four locations that had been previously sampled where the results appeared anomalous (i.e., isolated locations with elevated LAA concentrations compared to surrounding sampled locations). A total

[1] The sum of risks contributed by differing exposure scenarios.

of 29 tree bark samples were collected, 21 of which were analyzed. A total of 24 duff samples were collected, of which 17 were analyzed. Unanalyzed samples were archived.

The 2016 supplemental tree bark sampling locations (highlighted blue) are shown on **Figures 3-1** and **3-2** in conjunction with the tree bark sample locations from post-2007 through 2015 (not highlighted). The 2016 supplemental duff sampling locations (highlighted blue) are shown on **Figures 3-3** and **3-4** in conjunction with the duff sample locations from post-2007 through 2015 (not highlighted). Specific investigation-design information is included in the *Quality Assurance Project Plan: Libby Asbestos Superfund Site, Operable Unit 3, 2016 Tree Bark and Forest Duff Sampling* (CDM Smith, 2016a). **Table 3-1** presents the number of supplemental tree bark and duff samples analyzed. **Table 3-2** provides the supplemental tree bark and duff sampling locations by station ID and station description. The results of the 2016 supplemental tree bark and forest duff sampling are discussed in **Sections 4.1** and **4.2**, respectively.

3.3 Woodstove Ash and Hooking/Skidding Activity Based Sampling and Inner Wood Sampling

3.3.1 Objectives

The primary objectives of the 2016 woodstove ash and hooking/skidding ABS investigations were to:

- Better understand the relationship, if any, between LAA concentrations in tree bark with LAA concentrations in the air (and calculated HQs) when the tree bark was burned and the resulting woodstove ash was handled (residential exposure).
- Better understand the relationship, if any, between LAA concentrations in duff with LAA concentrations in the air (and calculated HQs) when the duff was disturbed by hooking/skidding activities (outdoor working exposures).
- Provide additional calculated HQ values associated with spatially arrayed locations to support delineation of risk-based boundaries for tree bark and duff. The 2016 ABS activities provided spatially distributed, calculated HQs that were used to identify, and define if applicable, risk-based areas of interest in lieu of kriging modeling.
- Obtain inner wood samples (from underneath the tree bark) to evaluate differences in LAA concentrations between the tree bark and the underlying inner wood. Understanding the difference, if any, between LAA concentrations in the tree bark and wood underneath the bark were intended to provide data to support the presumption that the primary mechanism of LAA transport is via airborne dispersion and deposition onto the outer surface of the bark.

3.3.2 Investigation Activities

A summary of the woodstove ash and hooking/skidding sampling and ABS activities, as well as the inner wood sampling, is presented below. Specific investigation-design information is included in the *Sampling and Analysis Plan/Quality Assurance Project Plan Libby Asbestos Superfund Site Operable Unit 3, Woodstove Ash and Hooking/Skidding Activity Based Sampling Investigation* (MWH, 2016b) and the *QAPP Addendum (Record of Modification LFM-OU3-01): Pilot Study to Compare LA Levels in Bark and Wood, Operable Unit 3, Libby Asbestos Superfund Site* (CDM Smith, 2016b).

The 2016 sampling activities included:

- Identifying two standing deadwood trees with intact tree bark from each of nine sample location areas[2] (ABS Areas A through I). The ABS areas are shown on **Figures 3-1** and **3-2** (see purple highlighted ABS areas).
- Collecting four, 5-point composite wood samples (from underneath the tree bark) from the standing deadwood trees at each of the ABS areas. The wood samples were collected from the standing deadwood trees to prevent possible cross-contamination with material on the forest floor.
- Felling the standing deadwood trees with intact tree bark from each of nine woodstove ash ABS sample areas. Sawing/splitting the felled tree into logs sized to fit into the woodstoves. Collecting the logs and placing them in plastic bags, sealing and labeling the bags, and transporting the bags with the firewood to the gravel pit near Lower Rainy Creek (shown on **Figures 2-1** and **2-2**) where the firewood could be burned in woodstoves.
- Collecting four, 5-point composite tree bark samples from the sawed/split logs sourced from each of the ABS areas. The tree bark samples were collected after the deadwood trees were felled, sawed, and split to mimic how firewood typically is collected.
- Burning the collected firewood in EPA-certified woodstoves. Each ABS area had a dedicated woodstove for burning firewood from that area.
- Sampling the resulting ash from each woodstove for LAA analysis, and collecting personal air samples during ash removal (i.e., ABS to simulate a person emptying woodstove ash). ABS air samples were collected from the breathing zone of the person removing ash from the woodstove over three 10-minute sampling events for each location. The remainder of the resultant ash material was sealed in a metal bucket and archived for potential future analysis.

The 2016 hooking/skidding ABS activities included:

- Identifying eight hooking/skidding ABS sample areas (ABS Areas A through H). The 2016 duff sample locations associated with the hooking/skidding ABS activities are shown on **Figures 3-3** and **3-4** (see purple highlighted ABS areas).
- Each sample area was divided into four approximately equal subsections where hooking/skidding was to be performed and one discrete duff sample was collected within each of the four subsections. Duff sample locations are shown on **Figures 3-3** and **3-4** by a single location representing the maximum LAA concentration detected in that ABS area.
- Felling trees for hooking/skidding within each hooking/skidding ABS area.
- Collecting personal air samples during simulated commercial logger hooking/skidding activities in the selected ABS areas. ABS air samples were collected every 30 minutes over a 2.5-hour hooking/skidding duration at each location.

[2] Locations, stations, areas are used interchangeably throughout this report to represent a designated place where sampling occurred.

Table 3-1 lists the number of tree bark and duff samples analyzed to support the 2016 woodstove ash ABS and hooking/skidding ABS activities. **Table 3-2** provides the tree bark and duff sampling locations by station ID and station description.

3.4 2016 Wetlands Delineation

3.4.1 Objectives

A wetlands and other waters of the United States (US) delineation study was performed during the late-spring of 2016. Wetlands and other waters of the US may, under certain circumstances, be considered jurisdictional waters and therefore protected under the Federal Clean Water Act of 1972 (CWA). The study was focused on the Former Mine Area of OU3 (see **Figure 3-5**). The study results are intended to inform the OU3 FS, which will evaluate potential impacts from remedial activities on jurisdictional or other wetland areas. The detailed study results of the 2016 wetlands evaluation, including maps and photos of each wetland area, are included in the *Final Wetland and Waters of the United States Delineation Report, Operable Unit 3 Study Area, Libby Asbestos Superfund Site, Libby, Montana* (Wetlands Report; MWH, 2017b).

3.4.2 Wetlands Delineation Activities

The 2016 wetlands delineation included a field survey to verify and map the wetlands within OU3 that were identified during a preliminary desktop study (refer to Section 2.10.2 of the OU3 RI Report). Specific methods and procedures are presented in the *Sampling and Analysis Plan/Quality Assurance Project Plan (SAP/QAPP) Wetland Delineation Operable Unit 3 Study Area Libby Asbestos Superfund Site* (MWH, 2015).

The 2016 wetland delineation activities included:

- Evaluating whether a water feature is a relatively permanent, standing, or continuously flowing body of water.
- Evaluating vegetation (structure, plant species, wetland indicator status, and percent cover), soils (texture, color, and presence of hydric indicators), and hydrology (primary and secondary indicators) on both sides of potential upland/wetland boundaries to identify features that met the United States Army Corps of Engineers (USACE) wetland criteria (USACE, 1987; USACE, 2010).
- Classifying wetlands and other water features according to the Cowardin (Cowardin *et al.,* 1979) and hydrogeomorphic (HGM) (Brinson, 1993) wetland classification systems, based on characteristics observed during the field evaluation.
- Evaluating delineated wetlands and other waters of the US (i.e., streams and ponds) to inform jurisdictional determination [including whether wetlands are adjacent to waters of the US, field indicators of ordinary high water mark (OHWM), and other physical characteristics] (USACE, 2014).
- Collecting additional field data used to evaluate wetland condition (quality/functionality) based on the Level 2 Montana Rapid Wetland Assessment (MRWA) method [Montana Department of Environmental Quality (MDEQ), 2005].

Data were documented on the appropriate field forms and the presumed wetland boundaries and sample points were mapped by collecting global positioning system (GPS) locations along the perimeter of each wetland.

4 RESULTS

This section describes the sampling results for the 2016 RI activities. Detailed summaries of the 2016 RI activities are included in the 2016 FSSR (MWH, 2017a). **Attachment C** contains the comprehensive raw analytical results for all media types discussed below.

The data summary tables and figures included in this RI addendum include both total and phase contrast microscopy-equivalent (PCME) LAA results. PCME LAA results are included in the discussions below for source media and resultant ash because the available toxicity values used for human health risk assessment are based on studies using Phase Contrast Microscopy (PCM) data. Additional discussion regarding LAA analytical methods is included in Section 3.5.1 of the OU3 RI Report (MWH, 2016a).

The HHRA Addendum (EPA, 2018a) incorporates the use of the newly established OU3 boundary to designate different exposure areas as a function of distance from the Former Mine Area (see **Sections 5.3 and 5.4** for discussions of the HHRA Addendum and the delineation of the OU3 boundary). The exposure areas evaluated in the HHRA Addendum include *within the OU3 boundary*, *outside the OU3 boundary [but within the National Priorities List (NPL) boundary[3]]*, and *outside the NPL boundary*. ABS air data from each ABS area were grouped together for the purposes of calculating Exposure Point Concentrations (EPCs) for each exposure area. For consistency with the HHRA Addendum, sampling stations for tree bark and wood, ash, and duff also were grouped into these exposure areas as presented below.

4.1 Tree Bark

The LAA results for the 2016 tree bark samples (which include the 2016 supplemental tree bark samples collected to refine EPA's kriging modeling, and the 2016 woodstove ash ABS tree bark samples) are summarized on **Table 4-1** (grouped by exposure area) and **Table 4-2** (grouped by station).

A total of seven stations were sampled and analyzed *within the OU3 Boundary* exposure area including BD16-18 and Areas A, C, D, E, F, and H. The PCME LAA concentrations at these stations ranged from 0 (non-detect[4]) to 0.29 million structures per square centimeter (Ms/cm^2), with an average concentration of 0.046 Ms/cm^2. The total LAA concentrations in tree bark ranged from 0 to 3.0 Ms/cm^2, with an average concentration of 0.35 Ms/cm^2. Nineteen stations were sampled and analyzed *outside of the OU3 Boundary (but within in the NPL boundary)* exposure area including 16 supplemental tree bark stations and Areas B, G, and I. The PCME LAA concentrations in tree bark at these stations ranged from 0 to 0.24 Ms/cm^2, with an average concentration of 0.031 Ms/cm^2. The total LAA concentrations in tree bark ranged from 0 to 1.0 Ms/cm^2, with an average concentration of 0.16 Ms/cm^2. Four stations were sampled and analyzed *outside of the NPL boundary* exposure area, all of which were supplemental tree bark stations. No PCME LAA concentrations were detected at these stations. The total LAA concentrations in

[3] As shown on Figure 3-1, the area between the blue boundary (OU3 boundary) and the within the outermost boundary of the dashed area is considered outside of the OU3 boundary but within the NPL boundary.

[4] A LAA concentration of zero, or non-detect, does not necessarily mean that no LAA is present in the sample. It is recognized that even when an analysis is reported as non-detect, the 95% upper confidence limit (UCL) on the Poisson distribution for a count of zero structures is 2.996 structures. This fact is supported by results where source medium LAA concentrations were zero but corresponding ABS air results had detections indicating that achieved sensitivities are not always adequate.

tree bark ranged from 0 to 0.24 Ms/cm^2, with an average concentration of 0.088 Ms/cm^2. **Table 4-2** shows summary statistics for each individual station by exposure area (i.e., minimum and maximum of all samples by station, and the mean for each station).

The maximum PCME LAA results for the 2016 tree bark samples are shown on **Figure 3-1** along with the maximum PCME LAA results for the post-2007 through 2015 tree bark samples. The maximum total LAA results for the 2016 tree bark samples are shown on **Figure 3-2** along with the maximum total LAA results for the post-2007 through 2015 tree bark samples. The sample locations have colored highlighting on **Figures 3-1** and **3-2** to differentiate the sampling programs as follows: the 2016 supplemental tree bark samples have blue highlighting, the 2016 woodstove ash ABS tree bark samples have purple highlighting, and the post-2007 through 2015 tree bark samples have no highlighting.

As shown on **Figures 3-1** and **3-2**, a subset of the 2016 supplemental tree bark samples were analyzed before EPA directed that the remaining samples not be analyzed, and that the analyzed results not be validated in accordance with the QAPP (CDM Smith, 2016a). EPA made this decision because the 2016 ABS results did not support a discernible and predictable relationship between LAA levels in source media (i.e., tree bark) and airborne LAA concentrations. Moreover, calculated HQs for the woodstove ash[5] removal ABS in each of the 2016 ABS areas were all less than or equal to 0.6. EPA's decision to discontinue analysis of the remaining 2016 supplemental tree bark samples also considered the high cost and long durations associated with LAA analysis and validation processes. All 2016 supplemental tree bark samples have been archived for future analyses, if deemed necessary.

4.2 Inner Wood

The results of the inner wood samples (from underneath the tree bark) collected during the 2016 woodstove ash ABS activities are summarized on **Table 4-3**. PCME LAA was non-detect in eight of the nine inner wood samples and total LAA was non-detect in seven of the nine inner wood samples.

Attachment E summarizes the average LAA concentrations for the inner wood and outer tree bark samples for each ABS area. Each tree bark result was pooled across four tree bark samples. PCME LAA structures were observed in tree bark samples from seven ABS areas (not including Area B and Area I), with average concentrations ranging from 0.0 to 0.36 Ms/g-dw, while eight of the nine inner wood samples were reported as non-detect for PCME LAA. Total LAA structures were observed in tree bark samples from all nine ABS areas, with average concentrations ranging from 0.023 to 2.4 million structures per gram-dry weight (Ms/g-dw), while seven of the nine inner wood samples were reported as non-detect for total LAA. When LAA was detected for both PCME and total LAA, inner wood concentrations were lower than the corresponding tree bark concentrations. When tree bark and inner wood concentrations were compared using the Poisson ratio comparison test (Nelson, 1982) for total LAA structures, the difference in concentrations was statistically significant for 5 of the 9 samples (i.e., the difference in concentrations is more than would be expected as a consequence of analytical uncertainty due to Poisson counting error). In addition, the graphical comparisons of the LAA concentrations in tree bark and inner wood for PCME and total LAA (included in **Attachment E**) show that all of the ABS area pairings have tree

[5] The trees from which tree bark was sampled were the source of the resultant woodstove ash by area.

bark concentrations that are higher than the corresponding inner wood concentration (except in Area B and Area I where no PCME LAA was detected in tree bark and inner wood).

4.3 Woodstove Ash

The results for the woodstove ash samples collected during the 2016 woodstove ash ABS activities, and from the 2012 woodstove ash study, are summarized on **Table 4-4** (grouped by exposure area) and **Table 4-5** (grouped by station).

A total of seven stations (including one station from 2012 referred to as Area 1) were sampled and analyzed *within the OU3 Boundary* exposure area. The PCME LAA concentrations at these stations ranged from 0 to 30 Ms/g-dw, with an average concentration of 4.1 Ms/g-dw. The total LAA concentrations ranged from 0 to 52 Ms/g-dw, with an average concentration of 7.2 Ms/g-dw. Four stations were sampled and analyzed *outside of the OU3 Boundary (but within in the NPL boundary)* exposure area including the 2012 location near Flower Creek. The PCME LAA concentrations at these stations ranged from 0 to 9.8 Ms/g-dw, with an average concentration of 0.81 Ms/g-dw. The total LAA concentrations ranged from 0 to 9.8 Ms/g-dw, with an average concentration of 1.0 Ms/g-dw. Only one station was sampled and analyzed *outside of the NPL boundary* exposure area (the 2012 location near Bear Creek). Both the PCME and total LAA concentrations at this station ranged from 0 to 3.3 Ms/g-dw, with an average concentration of 1.8 Ms/g-dw. **Table 4-5** shows summary statistics for each individual station by exposure area (i.e., minimum and maximum of all samples by station, and the mean for each station).

4.4 Duff[6]

The LAA results for the 2016 duff samples (which include the 2016 supplemental duff samples and the 2016 hooking/skidding ABS duff samples) are summarized on **Table 4-6** (grouped by exposure area) and **Table 4-7** (grouped by station).

A total of seven stations were sampled and analyzed *within the OU3 Boundary* exposure area including BD16-18 and Areas A, C, D, E, F and H. The PCME LAA concentrations at these stations ranged from 0 to 4.6 Ms/g-dw, with an average concentration of 0.68 Ms/g-dw. The total LAA concentrations ranged from 0 to 9.1 Ms/g-dw, with an average concentration of 1.6 Ms/g-dw. Eleven stations were sampled and analyzed *outside of the OU3 Boundary (but within in the NPL boundary)* exposure area including nine supplemental duff stations, Area B, and Area G. The PCME LAA concentrations at these stations ranged from 0 to 12 Ms/g-dw, with an average concentration of 2.3 Ms/g-dw. The total LAA concentrations ranged from 0 to 27 Ms/g-dw, with an average concentration of 4.3 Ms/cm^2. Three stations were sampled and analyzed *outside of the NPL boundary* exposure area, all of which were supplemental duff stations. The PCME LAA concentrations at these stations ranged from 0 to 10 Ms/g-dw, with an average concentration of 3.4 Ms/g-dw. The total LAA concentrations ranged from 0 to 46 Ms/g-dw, with an average concentration of 16 Ms/g-dw. **Table 4-7** shows summary statistics for each individual

[6] Although duff was identified as the source material to be sampled during the hooking/skidding study (MWH, 2015), it is recognized that duff and soil act as source materials. The resulting duff LAA concentrations compared to the hooking/skidding HQ values suggest that soil may be the more important source medium contributing to airborne LAA concentrations when soil/duff disturbances occur. The HHRA Addendum (EPA, 2018) references both soil and duff as source media for the hooking/skidding scenario.

station by exposure area (i.e., minimum and maximum of all samples by station, and the mean for each station).

The maximum PCME LAA results for the 2016 duff samples are shown on **Figure 3-3** along with the PCME LAA results for the post-2007 through 2105 duff samples. The maximum total LAA results for the 2016 duff samples are shown on **Figure 3-4** along with the maximum total LAA results for the post-2007 through 2015 duff samples. The sample locations have colored highlighting on **Figures 3-3** and **3-4** to differentiate the sampling programs as follows: the 2016 supplemental duff samples have blue highlighting, the 2016 hooking/skidding ABS duff samples have purple highlighting, and the post-2007 through 2015 duff sample have no highlighting.

As shown on **Figures 3-3** and **3-4**, a subset of the 2016 supplemental duff samples were analyzed before EPA directed that the remaining samples not be analyzed, and that the analyzed results not be validated in accordance with the QAPP (CDM Smith, 2016a). EPA's decisions regarding sample analysis and validation are discussed above in **Section 4.1**. All 2016 supplemental duff samples have been archived for future analyses, if deemed necessary.

4.5 ABS Air Data

The unadjusted (see **Section 5.1**) LAA results for the 2016 ABS samples and the historical ABS samples (woodstove ash and hooking/skidding) are summarized on **Table 4-8** (grouped by exposure area) and **Table 4-9** (grouped by station).

4.5.1 Woodstove Ash ABS Air

A total of seven areas were sampled and analyzed *within the OU3 Boundary* exposure area including one location during 2012 (Area 1) and six ABS areas during 2016. The pooled PCME LAA concentrations at these areas ranged from 0 to 0.34 s/cc, with an overall average concentration of 0.068s/cc (see **Table 4-8**). Four areas were sampled and analyzed *outside of the OU3 Boundary (but within in the NPL boundary)* exposure area including Flower Creek during 2012 and ABS Areas B, G and I during 2016. The pooled PCME LAA concentrations at these areas ranged from 0 to 0.018 s/cc, with an overall average concentration of 0.011 s/cc (see **Table 4-8**). Only one location was sampled and analyzed *outside of the NPL boundary* exposure area (Bear Creek during 2012). The pooled PCME LAA concentration at this location is 0.0072 s/cc (see **Table 4-8**). **Table 4-9** shows summary statistics for each individual station by exposure area (i.e., minimum and maximum of all samples by station, and the pooled mean for each station).

4.5.2 Hooking/Skidding ABS Air

A total of seven areas were sampled and analyzed *within the OU3 Boundary* exposure area including one location during 2012 (Area 1) and six locations during 2016. The pooled PCME LAA concentrations at these areas ranged from 0.00075 to 0.11 s/cc, with an overall average concentration of 0.040 s/cc (see **Table 4-8**). Two areas were sampled and analyzed *outside of the OU3 Boundary (but within in the NPL boundary)* exposure area including Areas B and G during 2016. The pooled PCME LAA concentrations at these areas ranged from 0 to 0.0030 s/cc, with an overall average concentration of 0.0015 s/cc (see **Table 4-8**). Only one location was sampled and analyzed *outside of the NPL boundary* exposure area (Area 2 during 2012). The pooled PCME LAA concentration at this location is 0.0016 s/cc (see **Table 4-8**). **Table 4-9** shows summary statistics for each individual station by exposure area (i.e., minimum and maximum of all samples by station, and the pooled mean for each station).

4.6 Wetlands Delineation

The detailed results of the 2016 wetlands evaluation are included in the Wetlands Report (MWH, 2017b). A brief summary of the results presented in the delineation report are presented below.

Assessments were performed to evaluate the acreage and functionality of each wetland observed. Wetland area assessments were performed based on vegetation, soil, and hydrology in accordance with USACE methodology (USACE, 1987; USACE, 2010). The outcome of the wetland area assessments yielded 27 wetlands totaling approximately 28.2 acres that were delineated within the evaluation areas. In addition, a functional evaluation of the wetlands was performed using the MDEQ MRWA methodology (MDEQ, 2005). Based on this functional evaluation, approximately 70% of the wetlands were ranked with a MRWA overall condition of ‘Excellent’ or ‘Good’. The remaining 30% of the wetlands were ranked with an overall condition of ‘Fair’.

In addition to the assessments performed to evaluate the acreage and functionality of wetlands in the evaluation areas, an assessment of the acreage below the OHWM was evaluated using USACE methodology (USACE, 2014). A total of 28.7 acres were found to be at or below the OHWM.

Each wetland also was qualitatively classified by both its Cowardin (Cowardin *et al.,* 1979) and HGM classifications (Brinson, 1993). The Cowardin wetland classes observed were Palustrine Emergent and Palustrine Scrub-Shrub, which were either saturated, semi-permanently or seasonally flooded, and may have been impounded. The HGM wetland classes observed were SLOPE (wetlands that are normally found where there is a discharge of groundwater to the land surface), RIVERINE (wetlands that occur in flood plains and riparian corridors in association with stream channels), or LACUSTRINE FRINGE (wetlands that are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland).

5 RISK ASSESSMENT AND OU3 BOUNDARY DETERMINATION

5.1 ABS Air Data and Calculated Hazard Quotients (HQs)

The results of the personal air samples collected during the 2016 woodstove ash ABS and 2016 hooking/skidding ABS activities are summarized on **Table 4-8** (by ABS scenario) and **Table 4-9** (by station) and presented in **Attachment C**As described in Section 4.0, ABS air data from each ABS area were grouped together for the purposes of calculating EPCs for each exposure area. In cases where air filters required the use of indirect preparation techniques prior to TEM analysis, the reported PCME LAA air concentration was adjusted (decreased) by a factor of 2.5 to avoid potentially biasing calculated EPCs high due to the effect of indirect preparation. The ABS air sample results were used to calculate HQs by area. Section 2 of the HHRA Addendum (EPA, 2018a) briefly describes the risk characterization methodology and approach used to calculate the HQs.

Table 5-1 summarizes 2016 woodstove ash ABS and presents the exposure parameter data and resulting HQs for each ABS area. The ABS areas are shown on **Figure 5-1**. As described in the HHRA Addendum (EPA, 2018a), previous woodstove ash studies (Ward et. al., 2009; EPA 2012, CDM Smith 2012; CDM Smith 2013) indicate that LAA structures can be retained in the ash after source materials (wood, duff) are burned. This may present an exposure pathway to residents collecting wood from near the Former Mine Area for burning in woodstoves. The 2016 woodstove ABS ash study was conducted to provide additional calculated HQ values associated with spatially arrayed locations to support delineation of risk-based boundaries for tree bark. Samples in each area were pooled to calculate the mean PCME LAA concentrations from which HQs were then calculated. The calculated HQ results for the 2016 woodstove ash ABS activities were all less than or equal to 0.6. An HQ greater than 0.6[7] is used as the OU3-specific threshold for identifying activities that may result in unacceptable, cumulative human-health risks.

Table 5-2 summarizes 2016 hooking/skidding ABS and also presents the exposure parameter data and resulting HQs for each ABS area. The ABS areas are shown on **Figure 5-2** along with the 0.6 HQ isopleth, which outlines a preliminary area where hooking/skidding performed by a commercial logger may contribute to overall unacceptable cumulative human-health risks at OU3 (see **Section 5.3.1** below). Previous ABS studies have been conducted to evaluate LAA concentrations in air when duff/soil are vigorously disturbed. The Site-wide HHRA (EPA, 2015b) identified those exposure scenarios where the non-cancer HQ exceed 1 (see HHRA Addendum, Section 4.1). Of those, dry mop-up and commercial logging have the highest non-cancer HQs within OU3. Commercial logging was selected as the target/surrogate for soil/duff disturbance activity. Commercial logging may present an exposure pathway to outdoor workers conducting hooking/skidding, site restoration following logging or slash pile building (and firefighters conducting dry mop-up and holding crew activities) near the Former Mine Area. The 2016 hooking/skidding ABS study was conducted to provide additional calculated HQ values associated with spatially arrayed locations to support delineation of risk-based boundaries for

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[7] An HQ of greater than1 is typically the threshold for identifying unacceptable non-cancer human health risks under CERCLA (EPA, 1991). At OU3, the threshold is conservatively set at greater than 0.6 to account for cumulative risks. In a letter from EPA to Grace dated January 25, 2018, EPA acknowledged acceptance of the threshold HQ of greater than 0.6 (EPA, 2018a) (as opposed to greater than or equal to 0.6) based on rationale provided by Grace in a former memorandum.

duff/soil. Samples in each area were pooled to calculate the mean PCME LAA concentrations from which HQs were then calculated. The calculated HQ results for the 2016 hooking/skidding ABS activities ranged from 0 at Area B to 2 at Area C and Area E. An HQ greater than 0.6 is used as the OU3-specific threshold for identifying activities that may result in unacceptable, cumulative human-health risks.

5.2 Comparison of Source Media LAA Concentrations and Calculated ABS HQs

As discussed in **Section 3.3.1**, an important objective of the 2016 woodstove ash and hooking/skidding ABS was to provide additional ABS (air and source media) data to better understand the relationship, if any, between LAA concentrations in source media (tree bark and duff) and airborne LAA concentrations (and calculated HQ values) when the source media is disturbed. As shown on **Figure 5-3** and discussed below, the results of the 2016 ABS sampling indicate no discernible relationship between mean PCME LAA concentrations in source media and the calculated ABS HQ values. This finding is consistent with EPA's 2008 asbestos framework document. However, when all OU3 ABS results are considered (including those performed prior to 2016), both source media LAA concentrations and HQs generally tend to decrease as distance from the mine increases.

Woodstove Ash ABS. Comparisons of mean PCME LAA concentrations in tree bark and mean PCME LAA concentrations in woodstove ash and the resulting calculated woodstove ash ABS HQs are shown on **Figure 5-3**. No apparent correlation between PCME LAA concentrations in woodstove ash and the calculated woodstove ash ABS HQs is evident on **Figure 5-3**.

Hooking/Skidding ABS. Comparison of PCME LAA concentrations in duff and the resulting calculated hooking/skidding ABS HQs are also shown on **Figure 5-3.** There is a lack of apparent correlation between PCME LAA concentration in duff and calculated HQs as shown on **Figure 5-3**.

5.3 Summary of the HHRA Addendum

As mentioned in **Section 1**, the HHRA Addendum (EPA, 2018a) was prepared by the EPA to present supplemental risk estimates based on the 2016 ABS data. Based on EPA's exposure assumptions and the area-specific ABS data, the HHRA Addendum concluded that:

- For risks from exposures to woodstove ash, the calculated HQs are less than 1 for all the exposure areas evaluated, and decreased with increasing distance from the mine. Exposures from the use of LAA-contaminated firewood are not likely to be of potential concern and this exposure scenario would not be expected to contribute significantly to cumulative risks.
- For risks from exposures during certain soil/duff disturbance activities (hooking/skidding, site restoration following logging, dry mop-up, and slash pile building), the calculated HQs have the potential to exceed or approach 1 throughout most of the OU3 boundary, with the highest HQ in an area located approximately one mile downwind from the mine (i.e., Area 1).
- The HHRA Addendum also stated that the results from tree bark and underlying inner wood sampling "*support the conclusion that the primary mechanism by which tree bark*

becomes contaminated with LAA is via airborne dispersion and deposition onto the outer surface of the tree bark. These results also indicate debarking of firewood prior to burning would likely reduce potential LAA exposures during woodstove ash removal activities."

Section 5 of the HHRA Addendum (EPA, 2018a) describes various sources of uncertainty that exist when evaluating area-based and cumulative risk exposures, which include inherent variability, sampling uncertainty, and collection procedures. It should be noted that risk management decision-making is based on estimated risks and exposures intended to represent members of the population with high-end, reasonable maximum exposures (RME), which is intended to be conservative and, therefore, likely to be an overestimate of actual exposure.

5.4 Delineation of the OU3 Boundary

The final FS OU3 Boundary (excluding the area within the Kootenai River, which is still being negotiated) is presented on **Figure 5-4** and represents the area where cumulative unacceptable human health risks may be present based on the results of the RI (MWH, 2015), Site-wide HHRA (EPA, 2015), and HHRA Addendum (EPA, 2018a). The boundary also delineates the area where remedial alternatives will be evaluated in the OU3 FS. The OU3 Boundary was conservatively delineated through a collaborative process with stakeholders by considering multiple lines-of-evidence as discussed below. A letter dated March 14, 2017 from EPA (EPA, 2017) titled "Libby OU3 Boundary Figure" confirms the conclusion of the development of the boundary. The resultant OU3 Boundary encompasses the spatial extent represented by each line-of-evidence. The significance of each line-of-evidence is discussed below.

5.4.1 ABS Calculated HQ Isopleth

The first line of evidence is the area that contains hooking/skidding (the surrogate for high disturbance activities) ABS areas with calculated HQ values greater than 0.6. The isopleth depicted on **Figure 5-5** outlines a preliminary area where hooking/skidding performed by a commercial logger may contribute to overall unacceptable cumulative human-health risks at OU3. The isopleth, which was drawn using a linear interpolation method between data points, provides a line-of-evidence of the spatial extent of unacceptable risks associated with hooking and skidding. It should be recognized that there are limitations to using ABS data to contour the calculated HQ values (e.g., limited data set, data variability, etc.) and the 0.6 HQ isopleth should be considered an estimate.

Based on the prevailing wind direction towards the northeast and the lack of known mining operations in Areas H and E, the elevated HQ values (1 and 2, respectively) in these areas were unexpected. One possible explanation for the elevated HQ values could be the presence of LAA-containing glacial material (unrelated to mining) in these areas as shown on **Figure 5-5**. However, in order to be conservative, the decision was made to keep these areas within the OU3 boundary area.

5.4.2 Maximum LAA Concentrations

Figure 5-6 depicts the maximum LAA concentrations detected in the OU3 RI surface water samples. **Figure 5-7** depicts the maximum LAA concentrations (PLM-VE) detected in the OU3 soil/rock/mine waste samples. These data present a line-of-evidence of the spatial extent of elevated LAA in these media.

5.4.3 Topography

The predominant ridgeline shown on **Figures 5-6** and **5-7** generally follows the circular outcrop that comprises Vermiculite Mountain and the Former Mine Area. This topographic ridge is important to historical contaminant-dispersion because the ridge is significantly higher in elevation than the stack of the former dry mill (i.e., the potential source of airborne LAA) and the ridge likely acted as an impediment to dispersion of airborne LAA when the mine was operational. In addition, this ridgeline also defines the portion of the surrounding drainage basin where storm water might come into contact with elevated LAA levels in media.

5.4.4 HQ Regression Evaluation

Figure 5-8 shows an HQ regression evaluation for the high-disturbance activities represented by the various ABS activities performed during the OU3 RI. The regression evaluation plots the calculated HQs for the various high-disturbance activities against the distance that the high-disturbance activity was performed from the center of the Former Mine Area (former mill location), and uses a best-fit power regression curve. The HQ regression evaluation predicts that the 0.6 HQ for high-disturbance activities occurs within a distance of approximately 1.5 miles downwind from the center of the Former Mine Area. This evaluation provides a line-of-evidence for the spatial extent of potentially unacceptable risks as a result of performing high-disturbance activities in OU3.

5.4.5 Air Dispersion Modeling

Figure 5-9 depicts the LAA-deposition-rate isopleths as estimated by the air-dispersion model that is included in Appendix J of the OU3 RI Report. The modeled deposition rates provide a line-of-evidence of the extent of potential historical LAA deposition during mine operation.

5.4.6 OU3 Boundary

Figure 5-10 combines each line-of-evidence described in **Sections 5.4.1** through **5.4.5** into a single figure that also includes the final-agreed upon OU3 Boundary (EPA, 2017). As described above, the boundary delineates the extent of the land area where remedial alternatives will be evaluated in the OU3 FS. The portion of the Kootenai River that is included in OU3 is currently being negotiated.

6 CONCLUSIONS

6.1 2016 Supplemental Tree Bark and Forest Duff Sampling

The 2016 supplemental tree bark and duff results provide additional confirmation that LAA levels can be highly variable due to the inherent heterogeneity of the source medium (CDM Smith, 2016c). The variability and lack of normally distributed data also limit the applicability of kriging LAA concentration data at OU3.

6.2 2016 Wetlands Delineation

The wetland area assessment identified 27 wetlands totaling approximately 28.2 acres within the evaluation area. The functional evaluation showed that approximately 70% of the wetlands were ranked with a MRWA overall condition of ‘Excellent’ or ‘Good’, while the remaining 30% of the wetlands were ranked with an overall condition of ‘Fair’. The OHWM assessment found that a total of 28.7 acres were at or below the OHWM. The Cowardin wetland classes observed were Palustrine Emergent and Palustrine Scrub-Shrub. The HGM wetland classes observed included SLOPE, RIVERINE, or LACUSTRINE FRINGE. This information will be used to support OU3 FS evaluations of remedial alternatives that may impact wetlands.

6.3 2016 Inner Wood Investigation and Woodstove Ash ABS

The results of the tree bark and inner wood sampling generally support the conclusion that the primary mechanism of LAA transport is via airborne dispersion and deposition onto the outer surface of the tree bark.

The results of the 2016 woodstove ash ABS investigations indicate that, on an ABS-area-specific basis, there is no clear relationship between LAA concentrations in tree bark or woodstove ash and the resulting air concentrations/HQ values when the woodstove ash is handled. However, data suggest that both source media LAA concentrations and HQs generally tend to decrease as distance from the mine increases. Furthermore, the results do not support the resulting threshold values that were kriged to delineate areas of interest for use in the OU3 FS. The calculated HQ results for the 2016 woodstove ash ABS activities were all below the OU3-specific threshold for unacceptable, cumulative human-health risks of HQ > 0.6.

6.4 2016 Hooking/Skidding ABS Investigation

The results of the 2016 hooking/skidding ABS investigations indicate that, on an ABS-area-specific basis, there is no clear relationship between LAA concentrations in duff and the resulting air concentrations/HQ values when the duff is disturbed by hooking/skidding activities. Furthermore, the results do not support the threshold values that were kriged to delineate areas of interest for use in the OU3 FS. However, data suggest that both source media LAA concentrations and HQs generally tend to decrease as distance from the mine increases. Also, the resulting duff LAA concentrations compared to the hooking/skidding HQ values suggest that soil may be the more important source medium contributing to airborne LAA concentrations when soil/duff disturbances occur.

The calculated HQ results for the 2016 hooking/skidding ABS activities ranged from 0 at Area B to 2 at Areas C and E. One possible explanation for elevated hooking/skidding HQs in ABS locations (i.e., Area E and Area H) could be due to the presence of glacial or other LAA-containing source rock in those areas.

6.5 HHRA Addendum

The HHRA Addendum (EPA, 2018a) concluded that:

- For risks from exposures to woodstove ash, the calculated HQs are less than 1 for all the exposure areas evaluated, and decreased with increasing distance from the mine. Exposures from the use of LAA-contaminated firewood are not likely to be of potential concern and this exposure scenario would not be expected to contribute significantly to cumulative risks; and
- For risks from exposures during certain soil/duff disturbance activities (hooking/skidding, site restoration following logging, dry mop-up, and slash pile building), the calculated HQs have the potential to exceed or approach 1 throughout most of the OU3 boundary, with the highest HQ in an area located approximately one mile downwind from the mine (i.e., Area 1).
- Results from tree bark and underlying inner wood sampling "*support the conclusion that the primary mechanism by which tree bark becomes contaminated with LAA is via airborne dispersion and deposition onto the outer surface of the tree bark. These results also indicate debarking of firewood prior to burning would likely reduce potential LAA exposures during woodstove ash removal activities*".

Section 5 of the HHRA Addendum (EPA, 2018a) describes various sources of uncertainty that exist when evaluating area-based and cumulative risk exposures, which include inherent variability, sampling uncertainty, and collection procedures. It should be noted that risk management decision-making is based on estimated risks and exposures intended to represent members of the population with high-end, reasonable maximum exposures (RME), which is intended to be conservative and, therefore, likely to be an overestimate of actual exposure.

6.6 OU3 Boundary

The OU3 Boundary presented on **Figure 5-4** and depicts the area where cumulative unacceptable human health risks may be present based on the results of the RI (MWH, 2015), Site-wide HHRA (EPA, 2015b), and HHRA Addendum (EPA, 2018a). The OU3 Boundary delineates the extent of the land area where remedial alternatives will be evaluated in the OU3 FS. The portion of the Kootenai River that will be included in OU3 is currently being negotiated.

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TABLES

Table 3-1: Summary of Samples Collected and Analyzed in 2016 for OU3

Phase	Description	Completed In Year	Total Number of Samples Analyzed[a]	ABS Air	Duff[b]	Tree Bark[b]	Inner Wood	Ash
ABS-2016	ABS Investigation	2016	198	94	32	36	9	27
BD-2016	Bark and Duff Investigation	2016	38	0	17	21	0	0
Total Asbestos Samples			236	94	49	57	9	27

NOTES:

[a] Excludes field and laboratory quality control samples/analyses

[b] It should be noted that during the BD-2016 sampling phase, 24 duff samples were collected but only 17 were analyzed and 29 tree bark samples were collected but only 21 were analyzed. The samples that were collected but not analyzed have been archived.

ABS - Activity Based Sampling

PHASE	PHASE NAME
ABS-2016	2016 Activity Based Sampling - Hooking/Skidding, Woodstove Ash
BD-2016	Bark and Duff Supplemental Sampling

Table 3-2: Remedial Investigation Station Descriptions, Sampling Phase/Event, and Analyses Performed in 2016 for OU3

Media	Station ID	Station Description	Libby Amphibole Asbestos (LAA) Sample Collection and Analysis by Phase / Event	
			ABS-2016	BD-2016
Forest Duff Material, Tree Bark, Ash and Inner Wood from Forested Areas				
Duff Material	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
	BD16-01	Duff sample location located far from the former mine area		X
	BD16-02*	Duff supplimental sample location at same location as SL45-12 (previously sampled in 2007)		X (NA)
	BD16-03	Duff sample location located intermediate from the former mine area		X
	BD16-04	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-05	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-06	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-07	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-15	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-16	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-17	Bark/Duff sample location located intermediate from the former mine area		X (NA)
	BD16-18	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-19	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-20*	Duff supplimental sample location at same location as SL195-10 (previously sampled in 2007)		X
	BD16-21	Bark/Duff sample location located intermediate from the former mine area		X (NA)
	BD16-22	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-23	Bark/Duff sample location located intermediate from the former mine area		X
Tree Bark	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
	Area I	Area located intermediate to and upwind from the former mine area	X	
	BD16-04	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-05	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-06	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-07	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-08*	Duff supplimental sample location at same location as SL315-06 (previously sampled in 2007)		X (NA)
	BD16-09	Bark sample location located near the former mine area		X
	BD16-10	Bark sample location located intermediate from the former mine area		X
	BD16-11	Bark sample location located far from the former mine area		X (NA)
	BD16-12*	Bark supplimental sample location at same location as Location#20 (previously sampled in 2012)		X
	BD16-13	Bark sample location located far from the former mine area		X
	BD16-14	Bark sample location located far from the former mine area		X
	BD16-15	Bark/Duff sample location located intermediate from the former mine area		X (NA)
	BD16-16	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-17	Bark/Duff sample location located intermediate from the former mine area		X (NA)
	BD16-18	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-19	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-21	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-22	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-23	Bark/Duff sample location located intermediate from the former mine area		X
	BD16-24	Bark sample location located intermediate from the former mine area		X
	BD16-25	Bark sample location located intermediate from the former mine area		X
	BD16-26	Bark sample location located far from the former mine area		X
	BD16-27	Bark sample location located intermediate from the former mine area		X
	BD16-28	Bark sample location located intermediate from the former mine area		X
	BD16-29	Bark sample location located intermediate from the former mine area		X
Inner Wood	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
	Area I	Area located intermediate to and upwind from the former mine area	X	
Ash	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
	Area I	Area located intermediate to and upwind from the former mine area	X	

Table 3-2: Remedial Investigation Station Descriptions, Sampling Phase/Event, and Analyses Performed in 2016 for OU3

Media	Station ID	Station Description	Libby Amphibole Asbestos (LAA) Sample Collection and Analysis by Phase / Event	
			ABS-2016	BD-2016
Activity Based Sampling (ABS) Air				
Hooking/ Skidding	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
Woodstove Ash	Area A	Area located near and downwind from the former mine area	X	
	Area C	Area located near and downwind from the former mine area	X	
	Area D	Area located near and upwind to crosswind from the former mine area	X	
	Area B	Area located intermediate to and downwind from the former mine area	X	
	Area E	Area located intermediate to and upwind from the former mine area	X	
	Area F	Area located intermediate to and crosswind from the former mine area	X	
	Area G	Area located intermediate to and crosswind from the former mine area	X	
	Area H	Area located intermediate to and upwind from the former mine area	X	
	Area I	Area located intermediate to and upwind from the former mine area	X	

NOTES:

Of the 16 stations for the Duff BD16 Samples, 13 stations were analyzed consisting of 17 analysis total (BD16-20 consisted of 5 individual samples to be composited). Location BD16-02, which was not analyzed, also consisted of 5 samples to be composited.

Of the 25 stations for the Tree Bark BD16 Samples, 21 stations were analyzed consisting of 21 analysis total. Location BD16-08, which was not analyzed, consisted of 5 samples to be composited.

LAA - Libby Amphibole Asbestos

NA - Not Analyzed

* These station identifiers are located at original locations that were sampled in 2007 and 2012 per the station description note.

PHASE	PHASE NAME
ABS-2016	2016 Activity Based Sampling - Hooking/Skidding, Woodstove Ash
BD-2016	Bark and Duff Supplemental Sampling

Table 4-1: Data Summary of 2016 Tree Bark LAA Results by Exposure Area

Location Information			PCME LAA Concentration (Ms/cm^2)					Total LAA Concentration (Ms/cm^2)[a]				
Exposure Area	Number of Stations	Number of Analyses	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	7	29	0	0.29	0.046	19	66%	0	3.0	0.35	26	90%
Outside OU3 Boundary	19	32	0	0.24	0.031	13	41%	0	1.0	0.16	25	78%
Outside NPL Boundary	4	4	0	0	0	0	0%	0	0.24	0.088	3	75%

Notes:

Data set 2016 Activty Based Sampling (Areas A through I) validated results and 2016 Supplementary (BD16- series) preliminary results for tree bark.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area A, Area B, Area E, and Area G).

[a]Includes all asbestos fibers counted regardless of length.

Ms/cm^2 = million structures per square centimeter

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

See Attachment C for all individual sample results.

Table 4-2: Data Summary of 2016 Tree Bark LAA Results by Station

Location Information			PCME LAA Concentration (Ms/cm^2)					Total LAA Concentration (Ms/cm^2)[a]				
Distance From Former Mine Site[a]	Station ID	Number of Analyses	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	Area A	6	0	0.15	0.083	5	83%	0.052	1.0	0.56	6	100%
	Area C	4	0.035	0.11	0.057	4	100%	0.037	3.0	0.98	4	100%
	Area D	4	0	0.076	0.038	3	75%	0.030	0.15	0.070	4	100%
	Area E	6	0	0.035	0.012	2	33%	0	0.25	0.094	5	83%
	Area F	4	0	0.033	0.019	3	75%	0.018	0.066	0.033	4	100%
	Area H	4	0	0.024	0.0061	1	25%	0	0.024	0.0089	2	50%
	BD16-18	1	0.29	0.29	--	1	100%	1.7	1.7	1.7	1	100%
Outside OU3 Boundary	Area B*	6	0	0	0	0	0%	0	0.29	0.109	5	83%
	Area G	6	0	0.042	0.011	2	33%	0	0.21	0.059	4	67%
	Area I	4	0	0	0	0	0%	0	0.061	0.027	2	50%
	BD16-05	1	0.057	0	--	1	100%	0.46	0.46	--	1	100%
	BD16-06	1	0	0	--	0	0%	0.23	0.23	--	1	100%
	BD16-07	1	0.12	0.12	--	1	100%	0.17	0.17	--	1	100%
	BD16-09	1	0.059	0	--	1	100%	0.059	0.059	--	1	100%
	BD16-10	1	0.059	0.059	--	1	100%	0.12	0.12	--	1	100%
	BD16-16	1	0.24	0.24	--	1	100%	1.0	1.0	--	1	100%
	BD16-19	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-21	1	0.016	0.016	--	1	100%	0.066	0.066	--	1	100%
	BD16-22	1	0.041	0	--	1	100%	0.50	0.50	--	1	100%
	BD16-23	1	0	0	--	0	0%	0.120	0.12	--	1	100%
	BD16-24	1	0.029	0.029	--	1	100%	0.20	0.20	--	1	100%
	BD16-25	1	0.11	0	--	1	100%	0.17	0.17	--	1	100%
	BD16-26	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-27	1	0	0	--	0	0%	0.24	0.24	--	1	100%
	BD16-28	1	0.044	0	--	1	100%	0.044	0.044	--	1	100%
	BD16-29	1	0.046	0.046	--	1	100%	0.32	0.32	--	1	100%
Outside NPL Boundary	BD16-04	1	0	0	--	0	0%	0.24	0.24	--	1	100%
	BD16-13	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-12**	1	0	0	--	0	0%	0.060	0.060	--	1	100%
	BD16-14	1	0	0	--	0	0%	0.054	0.054	--	1	100%

Notes:

Data set includes 2016 Activty Based Sampling (Areas A through I) validated results and 2016 Supplementary (BD16- series) preliminary results for tree bark.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area A, Area B, Area E, and Area G).

*The firewood collection location for ABS Area B was slightly outside of the NPL boundary; however, for the purposes of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping (EPA, 2018).

** BD16-12 is located near the historical station Location #20 (MWH, 2016a).

[a]Includes all asbestos fibers counted regardless of length.

Ms/cm^2 = million structures per square centimeter

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

-- = no mean calculated since less than 2 analyses

See Attachment C for all individual sample results.

Table 4-3: Data Summary of 2016 Inner Wood LAA Results by Station

Location Information			PCME LAA Concentration (Ms/g, dw)					Total LAA Concentration (Ms/g, dw)[a]				
Distance From Exposure Area	Station ID	Number of Analysis	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	Area A	1	0	0	--	0	0%	0	0	--	0	0%
	Area C	1	0	0	--	0	0%	0	0	--	0	0%
	Area D	1	0	0	--	0	0%	0.060	0.060	--	1	100%
	Area E	1	0.011	0.011	--	1	100%	0.011	0.011	--	1	100%
	Area F	1	0	0	--	0	0%	0	0	--	0	0%
	Area H	1	0	0	--	0	0%	0	0	--	0	0%
Outside OU3 Boundary	Area B*	1	0	0	--	0	0%	0	0	--	0	0%
	Area G	1	0	0	--	0	0%	0	0	--	0	0%
	Area I	1	0	0	--	0	0%	0	0	--	0	0%

Notes:

Data set includes 2016 Activty Based Sampling (Areas A through I) validated results for inner wood.

*The firewood collection location for ABS Area B was slightly outside of the NPL boundary; however, for the purposes of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping (EPA, 2018).

[a]Includes all asbestos fibers counted regardless of length.

Ms/g, dw = million structures per gram, dry weight

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

-- = no mean calculated since less than 2 analyses

See Attachment C for all individual sample results.

Table 4-4: Data Summary of 2012 and 2016 Woodstove Ash LAA Results by Exposure Area

Location Information			PCME LAA Concentration (Ms/g, dw)					Total LAA Concentration (Ms/g, dw)[a]				
Exposure Area	Number of Stations	Number of Analyses	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	7	21	0	30	4.1	11	52%	0	52	7.2	12	57%
Outside OU3 Boundary	4	12	0	9.8	0.81	1	8%	0	9.8	1.0	2	17%
Outside NPL Boundary	1	3	0	3.3	1.8	2	67%	0	3.3	1.8	2	67%

Notes:

Data set includes 2012 and 2016 Activty Based Sampling (Areas A through I) validated results for ash.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area E, Area F, and Area G).

[a]Includes all asbestos fibers counted regardless of length.

Ms/g, dw = million structures per gram, dry weight

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

See Attachment C for all individual sample results.

Table 4-5: Data Summary of 2012 and 2016 Woodstove Ash LAA Results by Station

Location Information			PCME LAA Concentration (Ms/g, dw)					Total LAA Concentration (Ms/g, dw)[a]				
Exposure Area	Station ID	Number of Samples	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	WA-Ash-1 (Area 1)	9	0	30	14	6	67%	0	52	34	6	67%
	Area A	3	0	19	9.5	2	67%	0	19	9.5	2	67%
	Area C	3	0	0	0	0	0%	0	0	0	0	0%
	Area D	3	0	8.1	2.7	1	33%	0	8.1	2.7	1	33%
	Area E	3	0	6.3	2.1	2	67%	0	13	4.2	3	100%
	Area F	3	0	0	0	0	0%	0	0	0	0	0%
	Area H	3	0	0	0	0	0%	0	0	0	0	0%
Outside OU3 Boundary	WA-Ash-2 (Flower Creek)	9	0	0	0	0	0%	0	2.1	0.68	1	11%
	Area B*	3	0	0	0	0	0%	0	0	0	0	0%
	Area G	3	0	0	0	0	0%	0	0	0	0	0%
	Area I	3	0	9.8	3.3	1	33%	0	9.8	3.3	1	33%
Outside NPL Boundary	WA-Ash-3 (Bear Creek)	9	0	3.3	1.8	2	22%	0	3.3	1.8	2	22%

Notes:

Data set includes 2012 (WA-Ash-1, -2, -3) and 2016 Activty Based Sampling (Areas A through I) validated results for ash.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area E, Area F, and Area G).

*The firewood collection location for ABS Area B was slightly outside of the NPL boundary; however, for the purposes of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping (EPA, 2018).

[a]Includes all asbestos fibers counted regardless of length.

Ms/g, dw = million structures per gram, dry weight

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

See Attachment C for all individual sample results.

Table 4-6: Data Summary of 2016 Duff LAA Results by Exposure Area

Location Information			PCME LAA Concentration (Ms/g, dw)					Total LAA Concentration (Ms/g, dw)[a]				
Exposure Area	Number of Stations	Number of Analyses	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	7	25	0	4.6	0.68	7	28%	0	9.1	1.6	13	52%
Outside OU3 Boundary	11	17	0	12	2.3	7	41%	0	27	4.3	7	41%
Outside NPL Boundary	3	3	0	10	3.4	1	33%	0	46	16	2	67%

Notes:

Data set includes 2016 Activty Based Sampling (Areas A through H) validated results and 2016 Supplementary (BD16- series) preliminary results for duff material.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area B, Area C, and Area E).

[a]Includes all asbestos fibers counted regardless of length.

Ms/g, dw = million structures per gram, dry weight

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

-- = no mean calculated since less than 2 analyses

See Attachment C for all individual sample results.

Table 4-7: Data Summary of 2016 Duff LAA Results by Station

Location Information			PCME LAA Concentration (Ms/g, dw)					Total LAA Concentration (Ms/g, dw)[a]				
Exposure Area	Station ID	Number of Samples	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections	Minimum	Maximum	Mean	Number of Detections	Frequency of Detections
Within OU3 Boundary	Area A	4	0	4.6	2.0	2	50%	1.7	6.6	3.8	4	100%
	Area C	6	0	4.6	2.0	4	67%	0	9.1	3.9	5	83%
	Area D	4	0	0	0	0	0%	0	0	0	0	0%
	Area E	6	0	1.4	0.35	1	17%	0	2.8	1.3	2	33%
	Area F	4	0	0	0	0	0%	0	0	0	0	0%
	Area H	4	0	0	0	0	0%	0	1.1	0.28	1	25%
	BD16-18	1	0	0	0	0	0%	3.6	3.6	3.6	1	100%
Outside OU3 Boundary	Area B	6	0	1.7	0.42	1	17%	0	1.7	0.42	1	17%
	Area G	4	0	0	0	0	0%	0	0	0	0	0%
	BD16-05	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-06	1	4.0	4.0	--	1	100%	4.0	4.0	--	1	100%
	BD16-07	1	0.0	0	--	0	0%	0	0	--	0	0%
	BD16-15	1	12	12	--	1	100%	23	23	--	1	100%
	BD16-16	1	4.5	4.5	--	1	100%	4.5	4.5	--	1	100%
	BD16-19	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-20*	5	0	9.5	4.0	1	20%	0	15	6.0	1	20%
	BD16-22	1	9.4	9.4	--	1	100%	9.4	9.4	--	1	100%
	BD16-23	1	4.4	4.4	--	1	100%	27	27	--	1	100%
Outside NPL Boundary	BD16-01	1	0	0	--	0	0%	0	0	--	0	0%
	BD16-03	1	10	10	--	1	100%	46	46	--	1	100%
	BD16-04	1	0	0	--	0	0%	2.4	2.4	--	1	100%

Notes:

Data set includes 2016 Activty Based Sampling (Areas A through H) validated results and 2016 Supplementary (BD16- series) preliminary results for duff material.

Values shown are based on the pooled concentrations for samples with replicate analysis (Area B, Area C, and Area E).

* BD16-20 is located at the historical station SL195-10 (MWH, 2016a).

[a]Includes all asbestos fibers counted regardless of length.

Ms/g, dw = million structures per gram, dry weight

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

-- = no mean calculated since less than 2 analyses

See Attachment C for all individual sample results.

Table 4-8: Data Summary of 2012 - 2016 ABS LAA Results by Scenario and Exposure Area

Location Information[1]			PCME LAA Concentration (s/cc)					
ABS Scenario	Exposure Area	No. of Stations	No. of Samples	No. of Detections	Min of PCME Air (s/cc)	Max of PCME Air (s/cc)	Mean of PCME Air (s/cc)[2]	Frequency of Detections
Woodstove Ash ABS	Within OU3 Boundary	7	39	20	0.0057	0.34	0.068	51%
	Outside OU3 Boundary	4	21	7	0.0	0.018	0.011	33%
	Outside NPL Boundary	1	3	1	0.0	0.0072	0.0072	33%
Hooking/Skidding ABS	Within OU3 Boundary	7	35	24	0.00075	0.11	0.040	69%
	Outside OU3 Boundary	2	10	2	0.0	0.0030	0.0015	20%
	Outside NPL Boundary	1	4	1	0.0	0.0016	0.0016	25%

Notes:

[1] Data set includes historical data for each ABS scenario and 2016 Activty Based Sampling (Areas A through I) validated results for air.

[2] PCME concentrations have NOT been adjusted for indirect preparation.

s/cc = structures per cubic centimeter

ABS = activity-based sampling

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

See Attachment C for all individual sample results.

Table 4-9: Data Summary 2012- 2016 ABS LAA Results by Station

Location Information[1]			PCME LAA Concentration (s/cc)					
ABS Scenario	Exposure Area	Station ID	No. of Samples	No. of Detections	Min of PCME Air (s/cc)	Max of PCME Air (s/cc)	Mean of PCME Air (s/cc)[3]	Frequency of Detections
Woodstove Ash ABS	Within OU3 Boundary	Area A	6	5	0.0	0.053	0.029	83%
		Area C	6	4	0.0	0.10	0.032	67%
		Area D	6	3	0.0	0.036	0.015	50%
		Area E	6	2	0.0	0.20	0.038	33%
		Area F	6	1	0.0	0.034	0.0057	17%
		Area H	6	2	0.0	0.033	0.0084	33%
		Area1	3	3	0.040	0.84	0.34	100%
	Outside OU3 Boundary	Area B[2]	6	3	0.0	0.035	0.015	50%
		Area G	6	0	0.0	0.0	0.0	0%
		Area I	6	1	0.0	0.054	0.0090	17%
		Flower	3	3	0.0057	0.044	0.018	100%
	Outside NPL Boundary	Bear	3	1	0.0	0.022	0.0072	33%
Hooking/Skidding ABS	Within OU3 Boundary	Area A	5	1	0.0	0.0038	0.00075	20%
		Area C	5	4	0.0	0.30	0.095	80%
		Area D	5	3	0.0	0.037	0.015	60%
		Area E	5	5	0.022	0.080	0.038	100%
		Area F	5	1	0.0	0.0038	0.0011	20%
		Area H	5	5	0.011	0.067	0.023	100%
		Area1	5	5	0.0044	0.40	0.11	100%
	Outside OU3 Boundary	Area B	5	0	0.0	0.0	0.0	0%
		Area G	5	2	0.0	0.0075	0.0030	40%
	Outside NPL Boundary	Area2	4	1	0.0	0.0065	0.0016	25%

Notes:

[1] Data set includes historical data for each ABS scenario and 2016 Activty Based Sampling (Areas A through I) validated results for air.

[2] The firewood collection location for ABS Area B was slightly outside of the NPL boundary; however, for the purposes of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping (EPA, 2018).

[3] PCME concentrations have NOT been adjusted for indirect preparation and therefore will not match the concentrations presented in Tables 5-1 and 5-2.

s/cc = structures per cubic centimeter

ABS = activity-based sampling

LAA = Libby amphibole asbestos

NPL = National Priorities List

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

See Attachment C for all individual sample results.

Table 5-1: Calculated 2016 Woodstove Ash ABS Hazard Quotients

Exposure Area	ABS Area	Exposure Point Concentration (PCME, s/cc)[1]	Exposure Parameters				
			ET	EF	ED	TWF	HQ
Within OU3 Boundary	Area A	0.029	0.25	48	52	0.0010	0.3
	Area C	0.032	0.25	48	52	0.0010	0.4
	Area D	0.015	0.25	48	52	0.0010	0.2
	Area E	0.038	0.25	48	52	0.0010	0.4
	Area F	0.0057	0.25	48	52	0.0010	0.06
	Area H	0.0084	0.25	48	52	0.0010	0.09
Outside OU3 Boundary	Area B[2]	0.015	0.25	48	52	0.0010	0.2
	Area G	0	0.25	48	52	0.0010	0
	Area I	0.0090	0.25	48	52	0.0010	0.1

Notes:

[1] In cases where air filters required the use of indirect preparation techniques prior to TEM analysis, the reported PCME LAA air concentration was adjusted (decreased) by a factor of 2.5 to avoid potentially biasing calculated EPCs high due to the effect of indirect preparation

[2] The firewood collection location for ABS Area B was slightly outside of the NPL boundary; however, for the purposes of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping (EPA, 2018).

s/cc = structures per cubic centimeter

ABS = Activity Based Sampling

ED = Exposure Duration, in years

EF = Exposure Frequency, in days per year

ET = Exposure Time, in hours per day

HQ = Hazard Quotient

OU3 = Operable Unit 3

PCME = phase contrast microscopy - equivalent

TWF = Time-weighting Factor, ranges from zero to one and describes the average fraction of a lifetime during which the specific exposure scenario occurs.

Exposure point concentration = LAA in air (PCME LAA s/cc)

Inputs and calculations are as described in the HHRA for this expsure scenario (EPA, 2018).

Table 5-2: Calculated 2016 Hooking/Skidding ABS Hazard Quotients

Exposure Area	ABS Area	Exposure Point Concentration (PCME, s/cc)[1]	Exposure Parameters				
			ET	EF	ED	TWF	HQ
Within OU3 Boundary	Area A	0.00075	10	24	12	0.0047	0.04
	Area C	0.044	10	24	12	0.0047	2
	Area D	0.015	10	24	12	0.0047	0.8
	Area E	0.038	10	24	12	0.0047	2
	Area F	0.0011	10	24	12	0.0047	0.06
	Area H	0.023	10	24	12	0.0047	1
Outside OU3 Boundary	Area B	0	10	24	12	0.0047	0
	Area G	0.0030	10	24	12	0.0047	0.2

Notes:

[1] In cases where air filters required the use of indirect preparation techniques prior to TEM analysis, the reported PCME LAA air concentration was adjusted (decreased) by a factor of 2.5 to avoid potentially biasing calculated EPCs high due to the effect of indirect preparation.

ABS = Activity Based Sampling

ED = Exposure Duration, in years

EF = Exposure Frequency, in days per year

ET = Exposure Time, in hours per day

HQ = Hazard Quotient

OU3 = Operable Unit 3

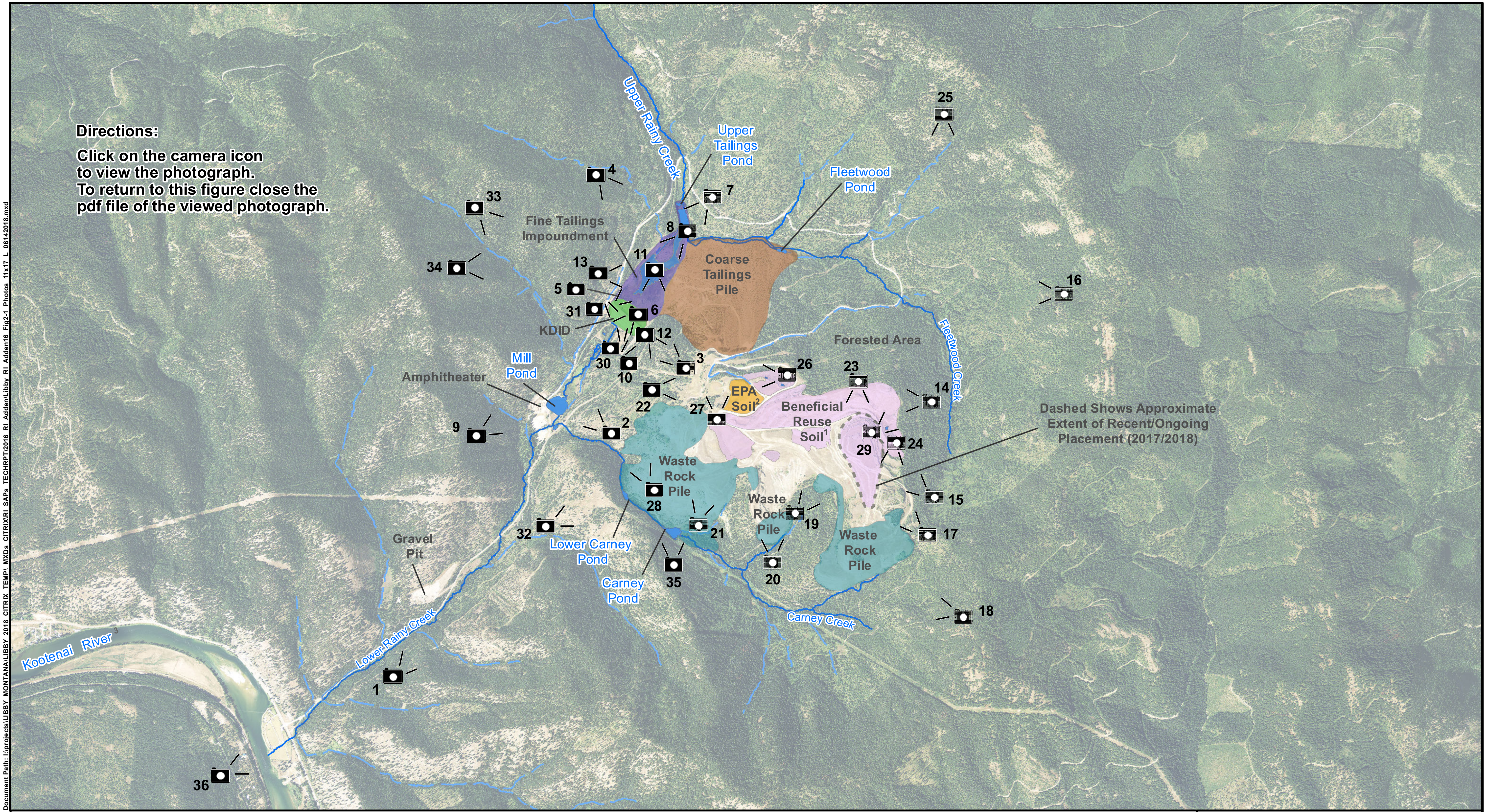
PCME = phase contrast microscopy - equivalent

TWF = Time-weighting Factor, ranges from zero to one and describes the average fraction of a lifetime during which the specific exposure scenario occurs.

Exposure point concentration = LAA in air (PCME LAA s/cc)

Inputs and calculations are as described in the HHRA Addendum for this expsure scenario (EPA, 2018).

FIGURES



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Legend

- Beneficial Reuse Soil[1]
- EPA Soil/Debris Mixture[2]
- Forested Areas
- Surface Water
- Coarse Tailings
- Fine Tailings
- KDID Embankment
- Waste Rock
- Intermittent Stream
- Perennial Stream

KDID Kootenai Development Impoundment Dam
OU Operable Unit
PPE Personal Protective Equipment

9 Approximate Photograph Location and Direction

Notes:

1 Beneficial Reuse Areas for Soil from other OUs
2 Soil Intermixed with PPE and Debris from other OUs
3 The portion of the Kootenai River that is included in OU3 is currently being negotiated

N W E S

0 0.225 0.45 Miles

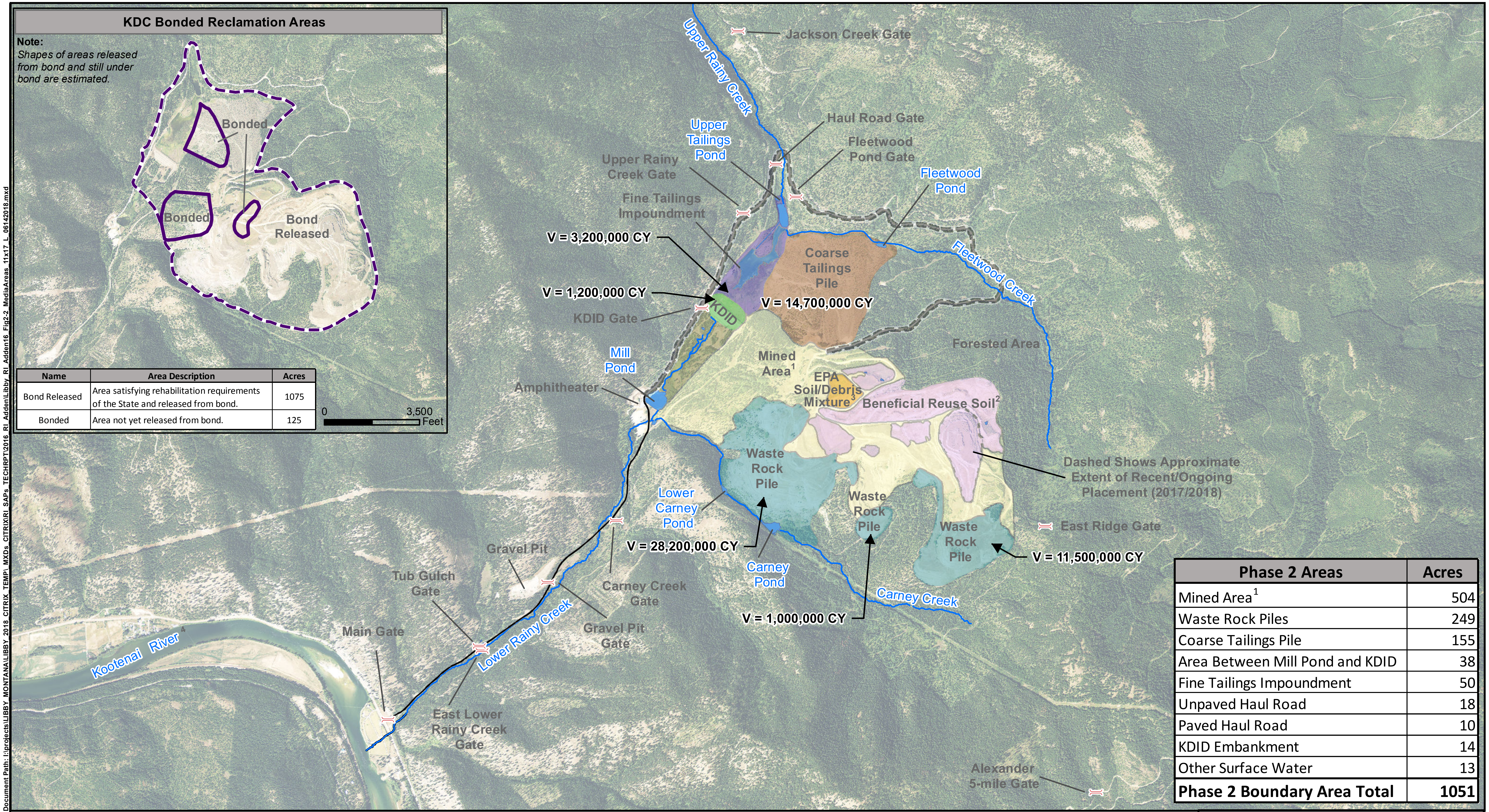
Base Image: National Agriculture Imagery Program, 2013
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 2-1

OU3 Mine Feature Photographs

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Name	Area Description	Acres
Bond Released	Area satisfying rehabilitation requirements of the State and released from bond.	1075
Bonded	Area not yet released from bond.	125

Phase 2 Areas	Acres
Mined Area[1]	504
Waste Rock Piles	249
Coarse Tailings Pile	155
Area Between Mill Pond and KDID	38
Fine Tailings Impoundment	50
Unpaved Haul Road	18
Paved Haul Road	10
KDID Embankment	14
Other Surface Water	13
Phase 2 Boundary Area Total	**1051**

Legend

- Bonded
- Bond Released
- Forested Areas
- Surface Water
- Coarse Tailings
- Waste Rock
- Fine Tailings Impoundment
- KDID Embankment
- Area Between Mill Pond and KDID
- Mined Area[1]
- Beneficial Reuse Soil[2]
- EPA Soil/Debris Mixture[3]
- Perennial Stream
- Paved Haul Road (Rainy Creek Road)
- Unpaved Haul Road
- Gate

Notes:

1 The Mined Area includes the Beneficial Reuse and EPA Soil/Debris Mixtures areas

2 Beneficial Reuse Areas for Soil from other OUs (159 acres)

3 Soil Intermixed with PPE and Debris from other OUs (13 acres)

4 The portion of the Kootenai River that is included in OU3 is currently being negotiated.

CY	cubic yards
KDC	Kootenai Development Company
KDID	Kootenai Development Impoundment Dam
LRC	Lower Rainy Creek
OU	Operable Unit
PPE	Personal Protective Equipment
V	volume

N W E S

0 0.225 0.45 Miles

Base Image: National Agriculture Imagery Program, 2013
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

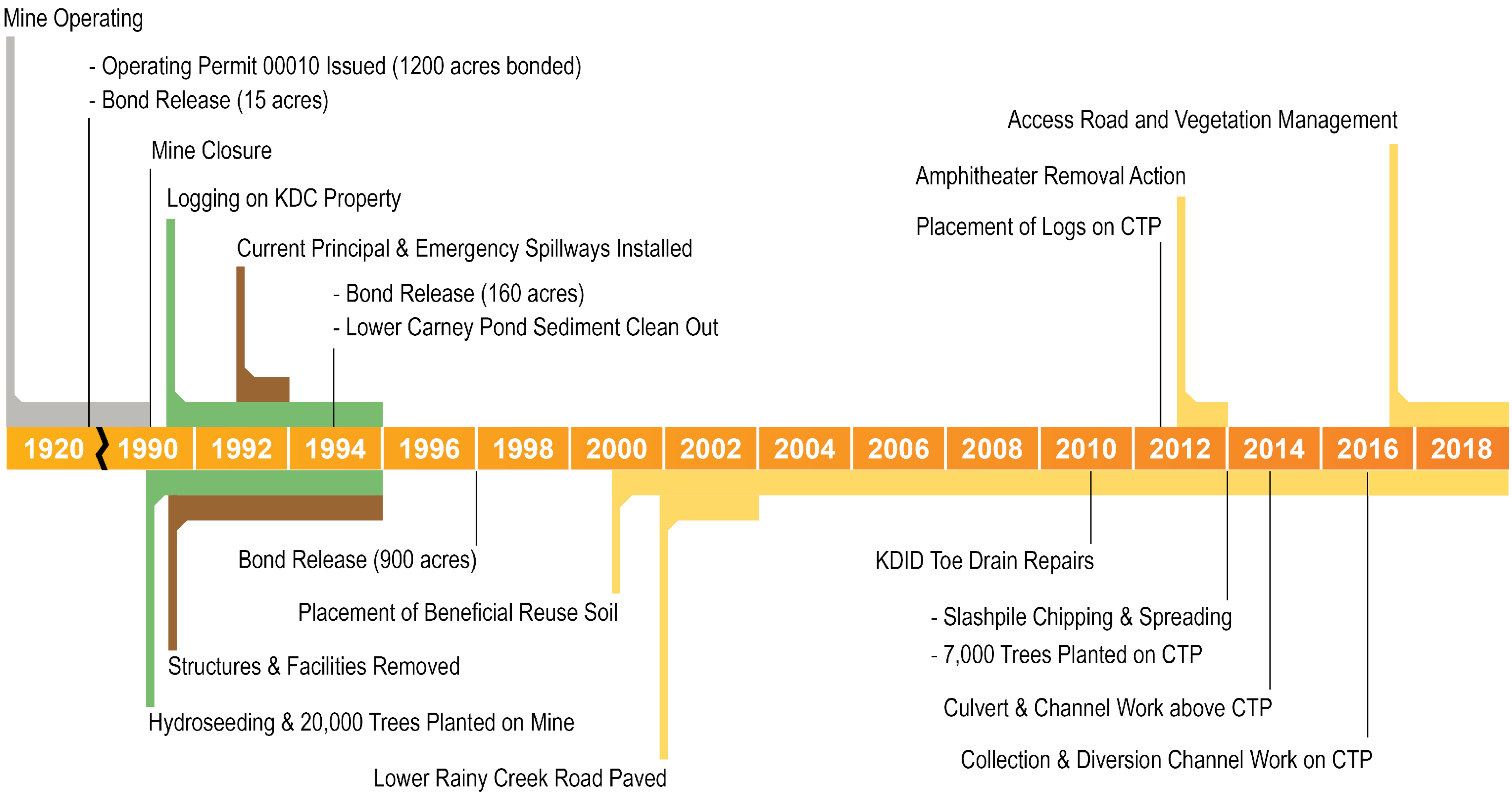
FIGURE 2-2

OU3 Phase 2 Mine Features, Areas, and Volumes

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec

Document Path: I:\projects\LIBBY_MONTANA\LIBBY_2018_CITRIX\CITRIX_TEMP_MXDs_CITRIX\RI_SAPs_TECHRPT\2016_RI_Adden\Libby_RI_Adden16_Fig2-2_MediaAreas_11x17_L_06142018.mxd



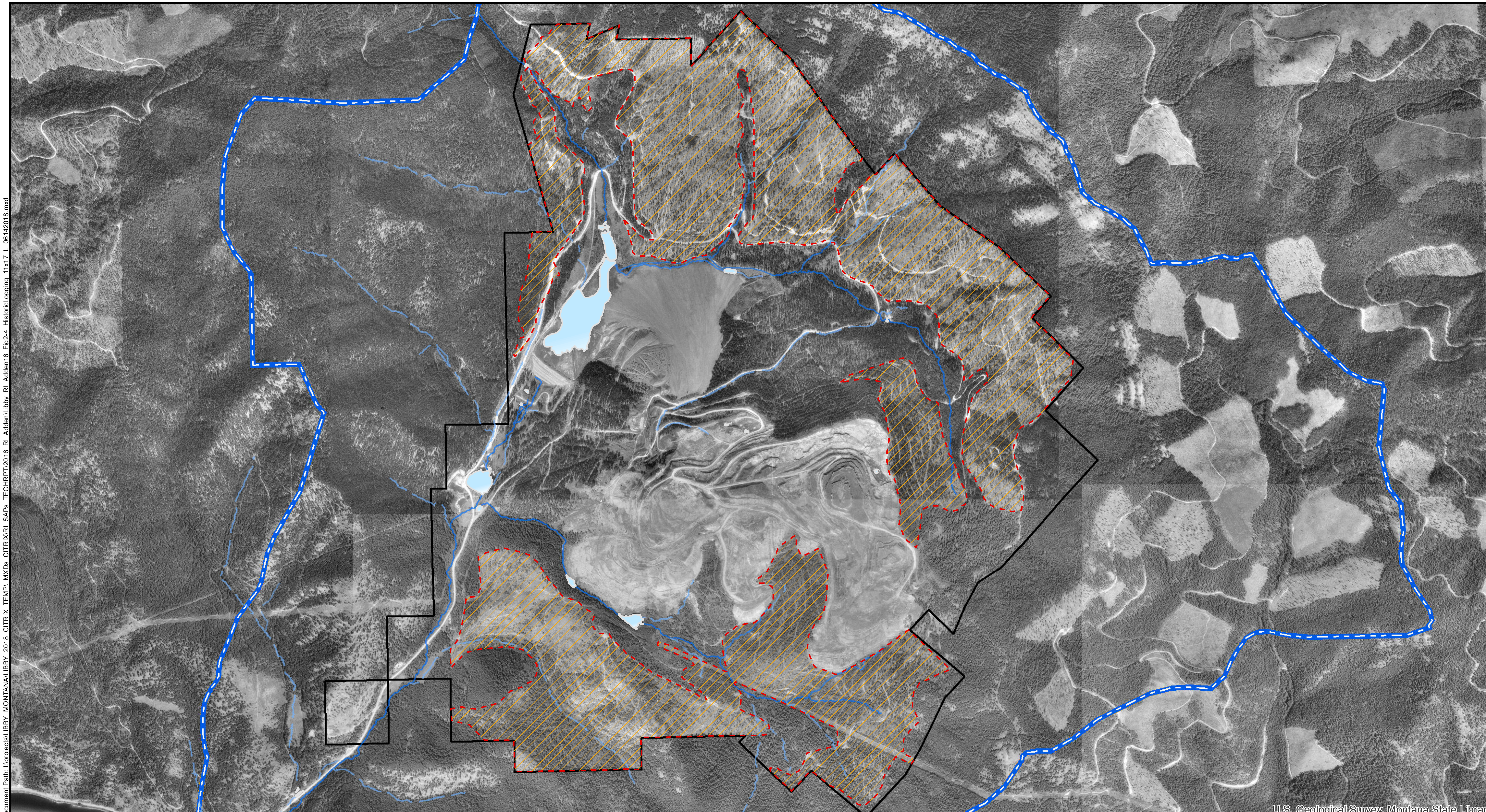
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 2-3

Activity and Reclamation Timeline for OU3 (1920-2018)

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Legend

- Pond
- Perennial Stream or River
- Intermittent Stream
- OU3 Boundary
- Mine Property Boundary ~ 3,616 Acres
- Estimated Logging Activity in Early 1990s on KDC Property ~ 1,516 Acres

Notes:

Areas with logging activity were identified based on visual interpretation of Google Earth ® Imagery from 1995.

OU = Operable Unit

N E S W

0 1,000 2,000 Feet

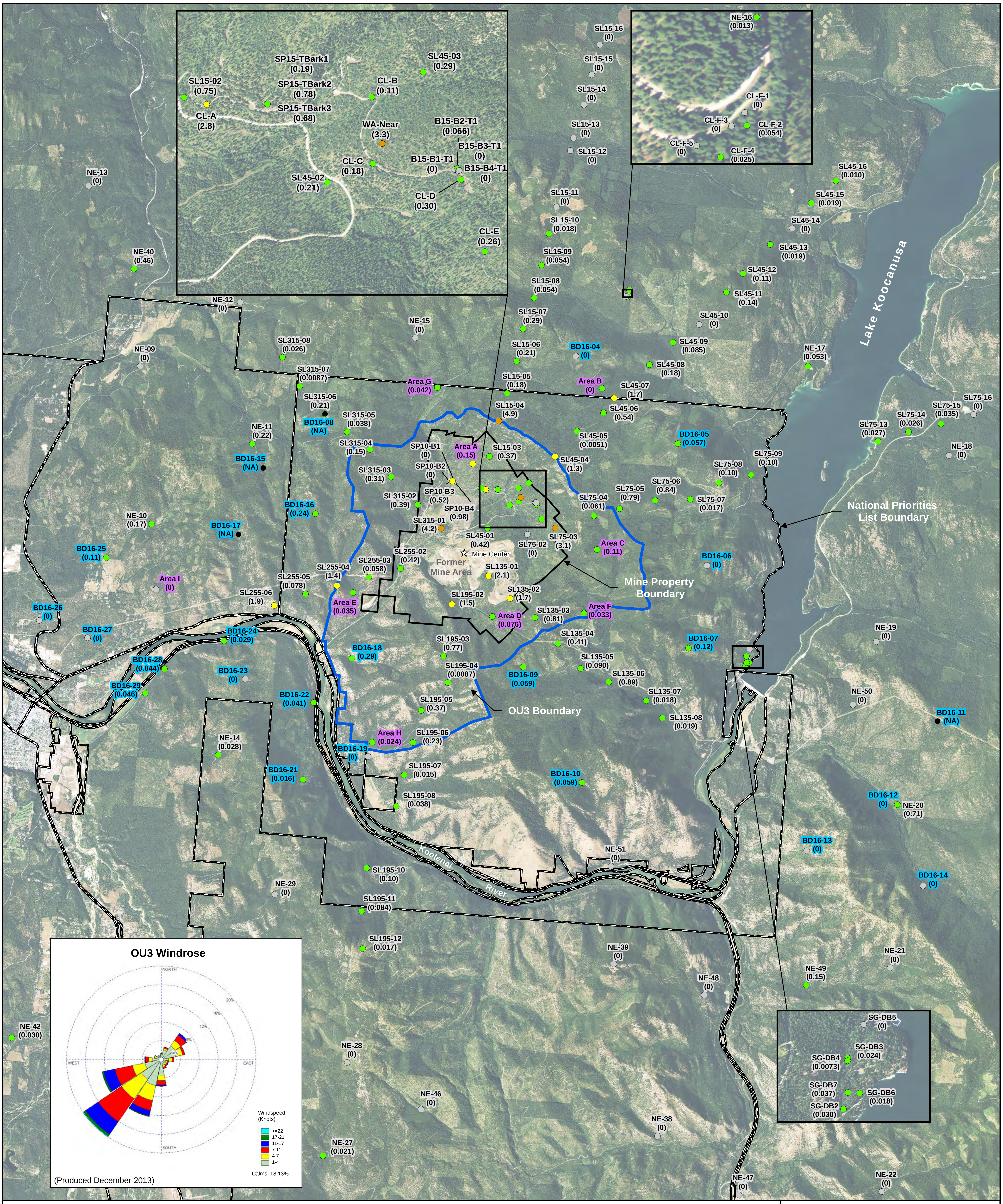
Base Image: USGS DOQQ, 1995
Coordinate System: NAD 1983 UTM Zone 11N
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 2-4

Estimated Logging Activity in Early 1990s on KDC Property

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Legend

Tree Bark PCME (Ms/cm²)

- 0
- > 0 - 0.9
- > 0.9 - 3.0
- > 3.0
- Sample Not Analyzed

2007 - 2015 RI Results

SL75-09 (0.10) — Sample Location ID; 2007 - 2015 Verified / Validated Result

2016 Samples Collected to Refine EPA Kriging Modeling

BD16-24 (0.057) — Sample Location ID; 2016 Partially Verified / Non-Validated Result

(NA) — 2016 Not Analyzed, Sample Archived

2016 Samples Collected to Support Woodstove Ash ABS

Area H (0.057) — Sample Location ID; 2016 Verified / Validated Result

National Priorities List Boundary

Mine Property Boundary

OU3 Boundary

Notes: The portion of the Kootenai River that is included in OU3 is currently being negotiated.

ABS Area B firewood collection location was slightly outside of the NPL boundary; however, for the purpose of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping.

ABS	Activity Based Sampling
EPA	Environmental Protection Agency
LAA	Libby Amphibole Asbestos
Ms/cm²	million structures per square centimeter
NE	Nature and Extent
OU3	Operable Unit 3
PCME	Phase Contrast Microscopy-Equivalent
RI	Remedial Investigation

0 2,500 5,000 10,000 Feet

0 0.5 1 Miles

Base Image: National Agriculture Imagery Program, 2013
Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

Date Revised: 6/20/2018

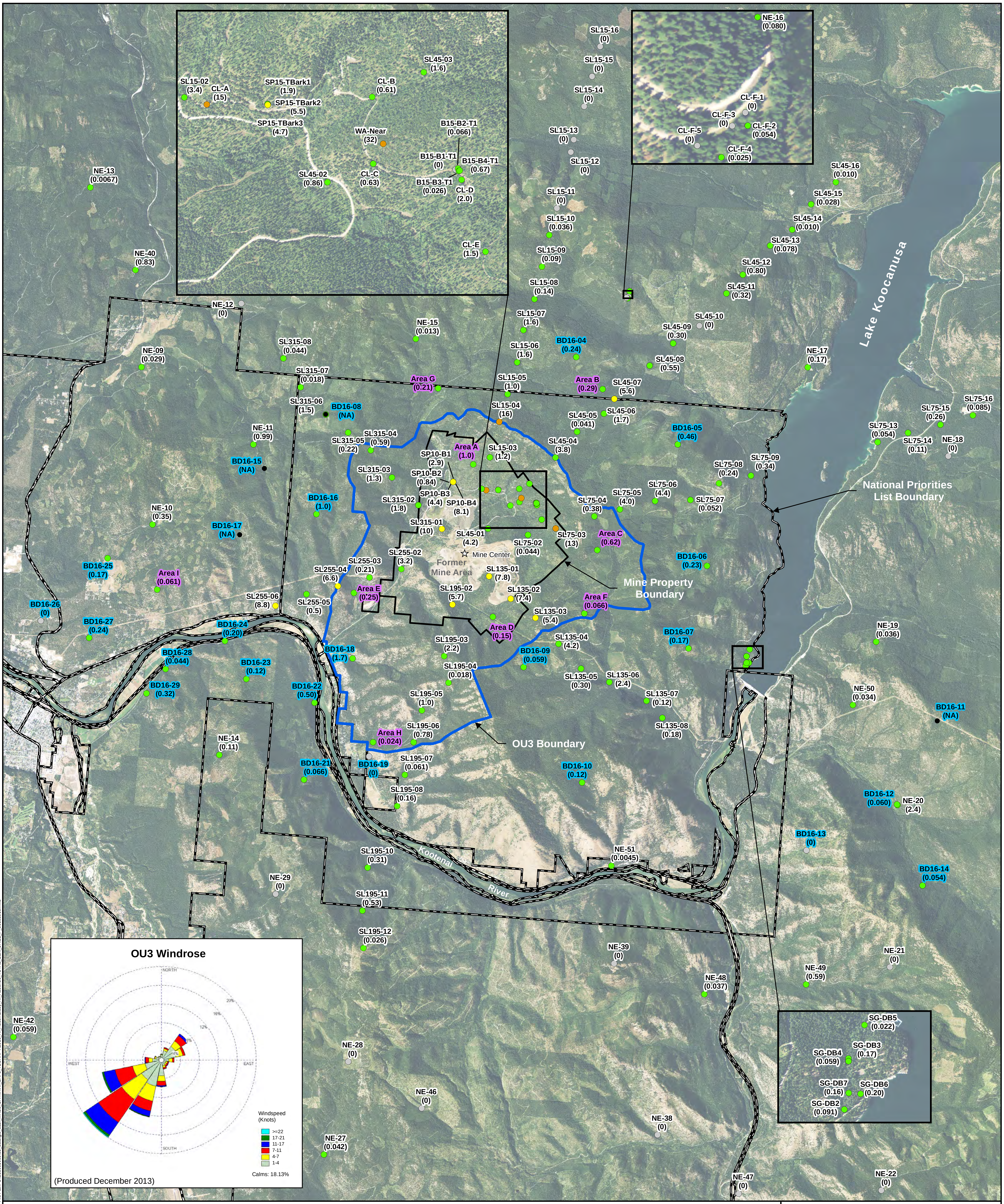
Report: OU3 2016 RI Addendum

FIGURE 3-1

Maximum LAA PCME Results for Tree Bark

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Legend

Tree Bark Total (Ms/cm²)

- 0
- > 0 - 5
- > 5 - 10
- > 10
- Sample Not Analyzed

2007 - 2015 RI Results

SL75-09 (0.10) — Sample Location ID; 2007 - 2015 Verified / Validated Result

2016 Samples Collected to Refine EPA Kriging Modeling

BD16-24 (0.057) — Sample Location ID; 2016 Partially Verfied / Non-Validated Result

(NA) — 2016 Not Analyzed, Sample Archived

2016 Samples Collected to Support Woodstove Ash ABS

Area H (0.057) — Sample Location ID; 2016 Verified / Validated Result

National Priorities List Boundary

Mine Property Boundary

OU3 Boundary

Notes: The portion of the Kootenai River that is included in OU3 is currently being negotiated.

ABS Area B firewood collection location was slightly outside of the NPL boundary; however, for the purpose of the risk estimates, this area was included in the "Outside OU3 Boundary" grouping.

ABS	Activity Based Sampling
EPA	Environmental Protection Agency
LAA	Libby Amphibole Asbestos
Ms/cm²	million structures per square centimeter
NE	Nature and Extent
OU3	Operable Unit 3
PCME	Phase Contrast Microscopy-Equivalent
RI	Remedial Investigation

N W E S

0 2,500 5,000 10,000 Feet

0 0.5 1 Miles

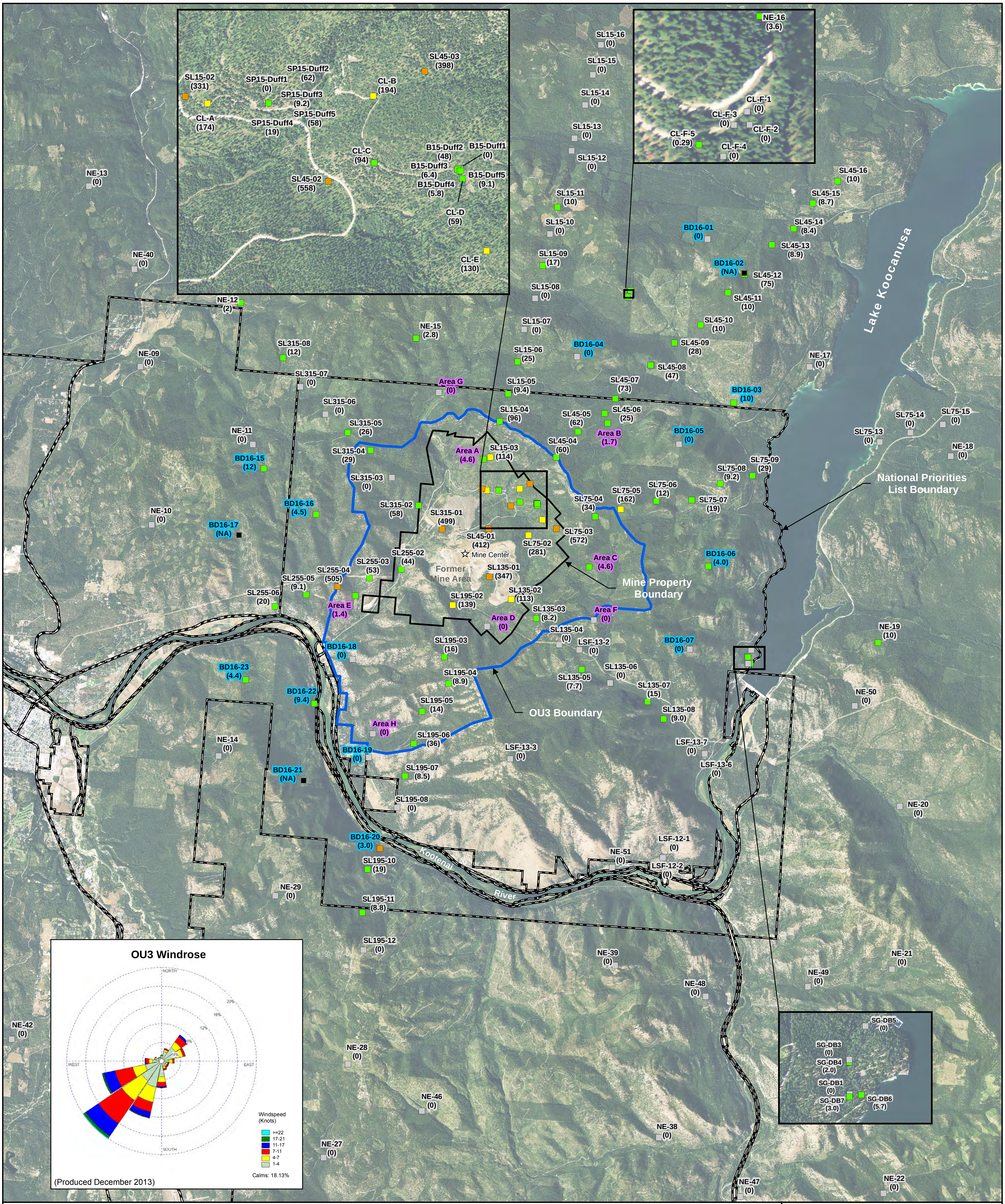
Base Image: National Agriculture Imagery Program, 2013
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/20/2018
Report: OU3 2016 RI Addendum

FIGURE 3-2

Maximum LAA Total Results for Tree Bark

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



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Legend

Duff Material (PCME (Ms/g - dw)

- 0
- > 0 - 100
- > 100 - 300
- > 300
- Sample Not Analyzed

2007 - 2015 RI Results

SL75-09 (0.10) — Sample Location ID; 2007 - 2015 Verified / Validated Result

2016 Samples Collected to Refine EPA Kriging Modeling

BD16-24 (0.057) — Sample Location ID; 2016 Partially Verfied / Non-Validated Result

(NA) — 2016 Not Analyzed, Sample Archived

2016 Samples Collected to Support Hooking/Skidding ABS

Area H (0.057) — Sample Location ID; 2016 Verified / Validated Result

- National Priorities List Boundary
- Mine Property Boundary
- OU3 Boundary

Note: The portion of the Kootenai River that is included in OU3 is currently being negotiated.

ABS	Activity Based Sampling
EPA	Environmental Protection Agency
LAA	Libby Amphibole Asbestos
Ms/g-dw	Million structures per gram – dry weight
NE	Nature and Extent
OU3	Operable Unit 3
PCME	Phase Contrast Microscopy-Equivalent
RI	Remedial Investigation

N E S W

0 2,500 5,000 10,000 Feet

0 0.5 1 Miles

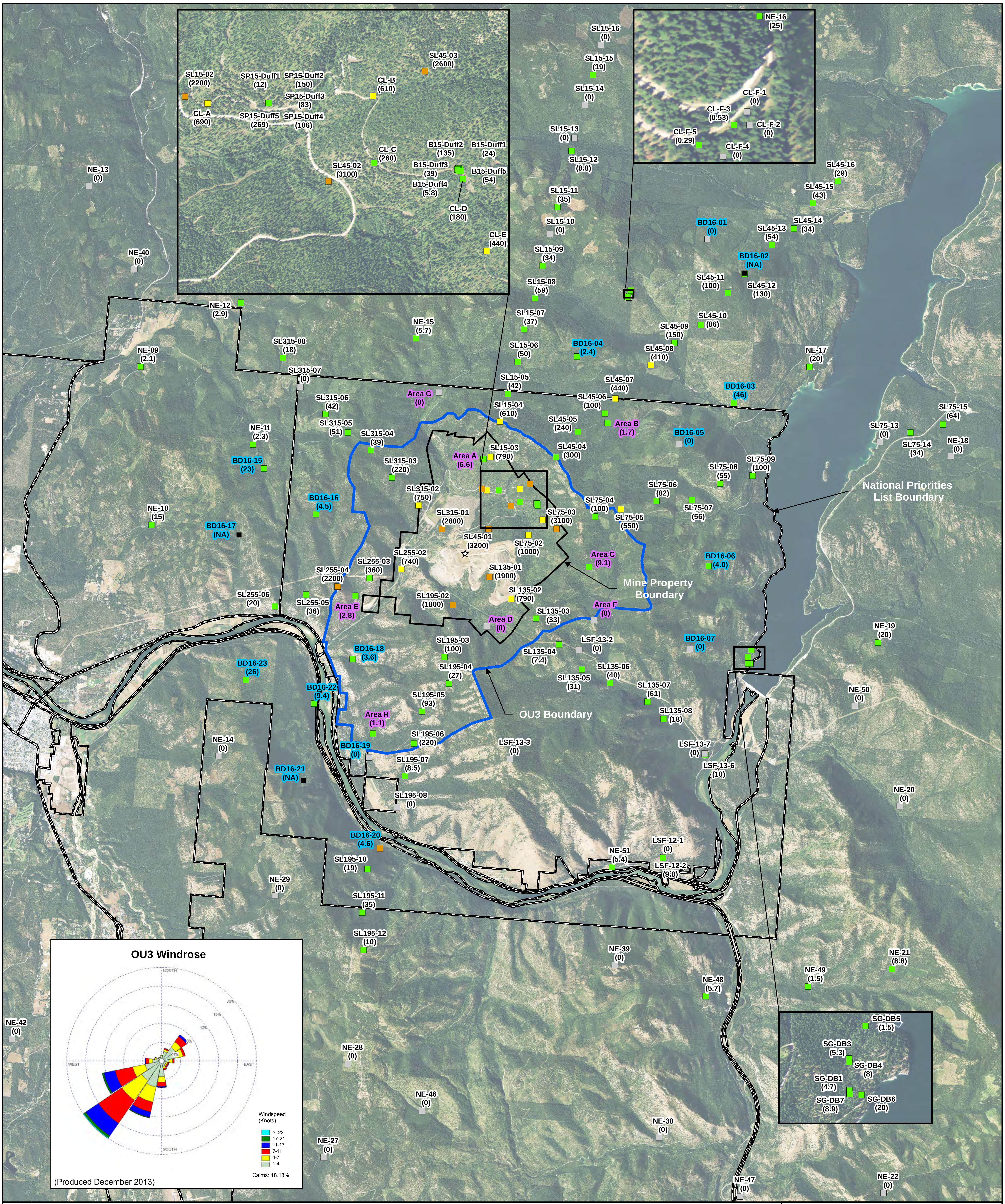
Base Image: National Agriculture Imagery Program, 2013
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/20/2018
Report: OU3 2016 RI Addendum

FIGURE 3-3

Maximum LAA PCME Results for Duff

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



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Legend

Duff Material (Total (Ms/g - dw))

- 0
- > 0 - 400
- > 400 - 1000
- > 1000
- Sample Not Analyzed

2007 - 2015 RI Results

SL75-09 (0.10) — Sample Location ID; 2007 - 2015 Verified / Validated Result

2016 Samples Collected to Refine EPA Kriging Modeling

BD16-24 (0.057) — Sample Location ID; 2016 Partially Verified / Non-Validated Result

(NA) — 2016 Not Analyzed, Sample Archived

2016 Samples Collected to Support Hooking/Skidding ABS

Area H (0.057) — Sample Location ID; 2016 Verified / Validated Result

National Priorities List Boundary

Mine Property Boundary

OU3 Boundary

Note: The portion of the Kootenai River that is included in OU3 is currently being negotiated.

ABS	Activity Based Sampling
EPA	Environmental Protection Agency
LAA	Libby Amphibole Asbestos
Ms/g-dw	Million structures per gram – dry weight
NE	Nature and Extent
OU3	Operable Unit 3
PCME	Phase Contrast Microscopy-Equivalent
RI	Remedial Investigation

N E S W

0 2,500 5,000 10,000 Feet

0 0.5 1 Miles

Base Image: National Agriculture Imagery Program, 2013
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/20/2018
Report: OU3 2016 RI Addendum

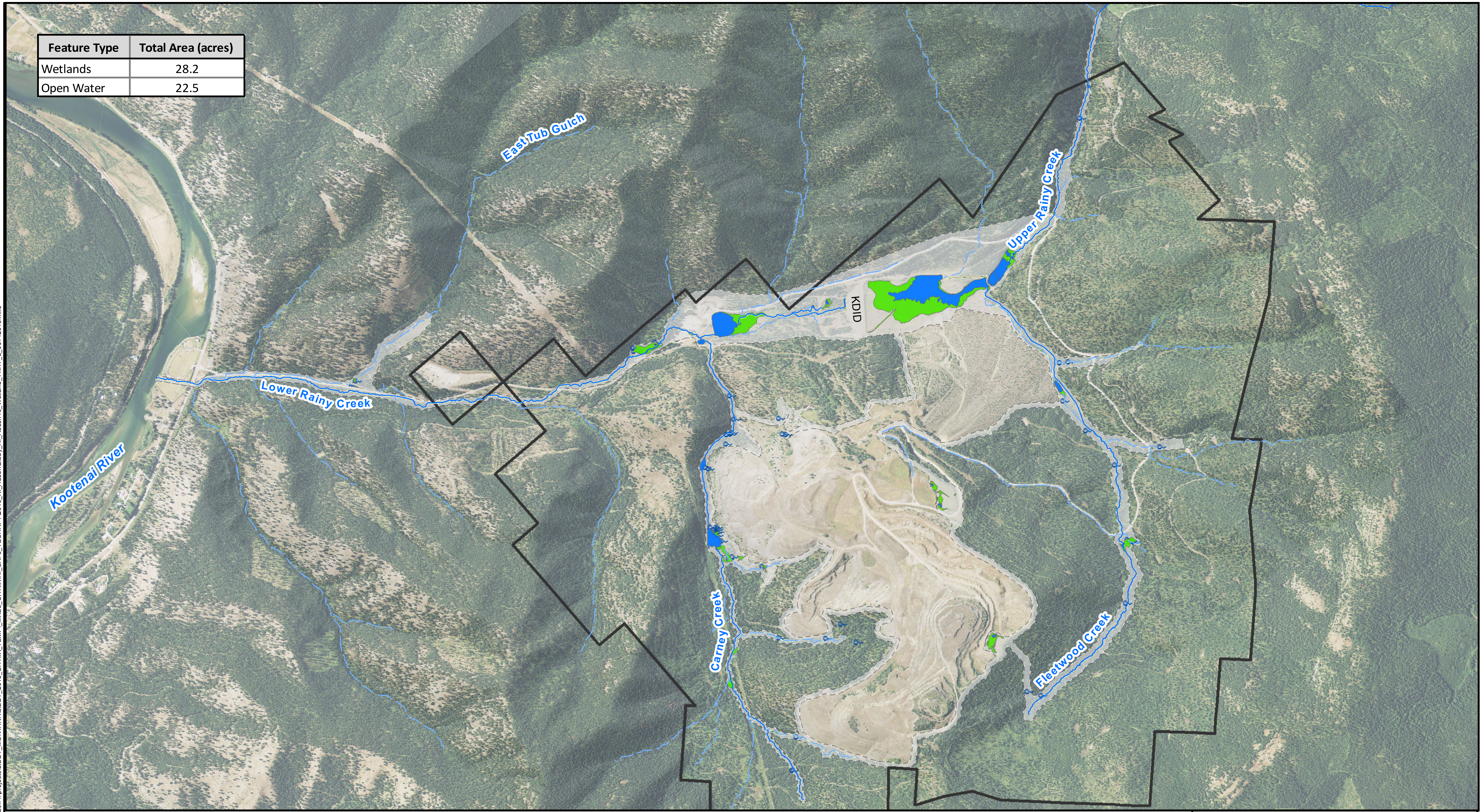
FIGURE 3-4

Maximum LAA Total Results for Duff

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec

Feature Type	Total Area (acres)
Wetlands	28.2
Open Water	22.5



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Legend

- Relatively Permanent Waterway
- Non-Relatively Permanent Waterway
- Mine Property Boundary
- Evaluation Area
- 2016 Delineated Wetland
- 2016 Delineated Pond (Open Water)

KDID Kootenai Development Impoundment Dam

W N S E

0 950 1,900 3,800 Feet

0 0.2 0.4 0.8 Miles

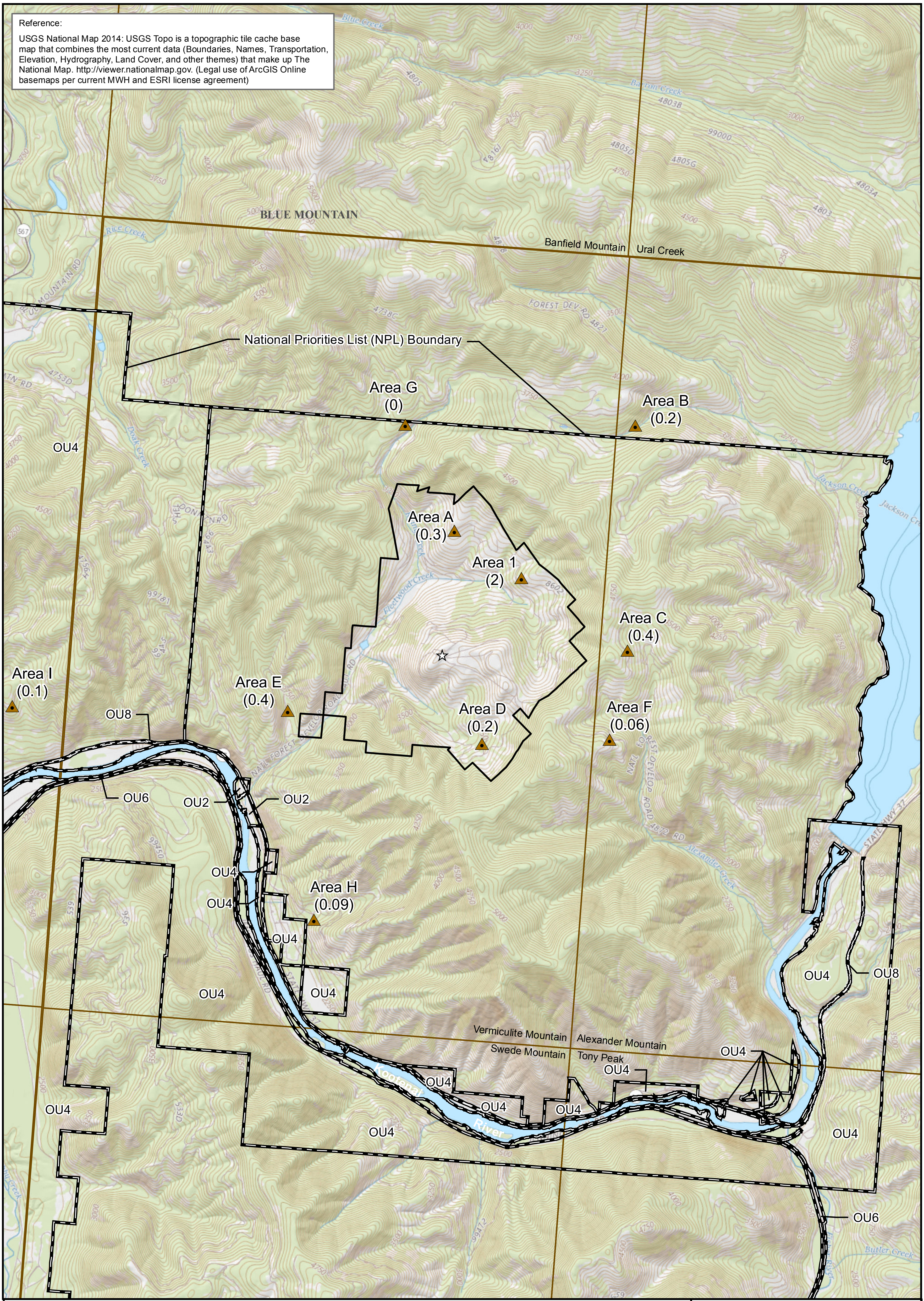
Base Image: National Agriculture Imagery Program, 2013
Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 3-5

Wetland Evaluation Areas

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



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Legend

- ☆ Mine Center
- ▲ Woodstove Tree Collection Location
- National Priorities List Boundary
- Mine Property Boundary
- USGS Quadrangle Boundary

ABS	Activity Based Sampling
Area D (0.2)	ABS Area with Calculated HQ in Parenthesis
HQ	Hazard Quotient
*	HQ values based on HHRA (EPA, 2015), HHRA Addendum (EPA, 2017), and EPA's exposure assumptions

N W E S

0 3,250 6,500 Feet

0 0.5 1 Miles

Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

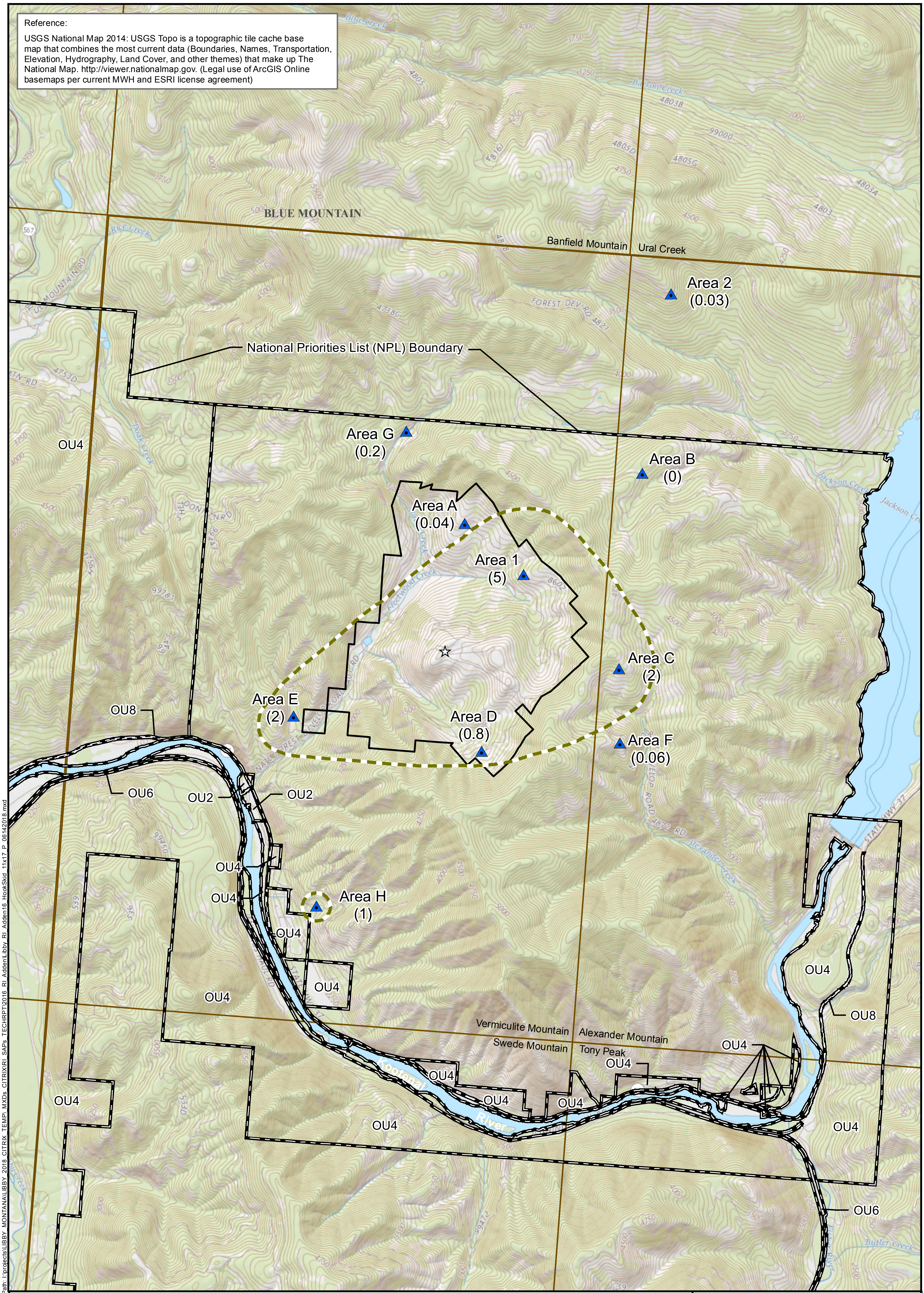
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-1

Woodstove Ash ABS Calculated Hazard Quotients

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Legend

- ☆ Mine Center
- Hooking / Skidding Location
- HQ* > 0.6 Hooking/Skidding Hand Contour
- National Priorities List Boundary
- Mine Property Boundary
- USGS Quadrangle Boundary

ABS — Activity Based Sampling

Area D (0.2) — ABS Area with Calculated HQ in Parenthesis

HQ — Hazard Quotient

* — HQ values based on HHRA (EPA, 2015), HHRA Addendum (EPA, 2017), and EPA's exposure assumptions

N / W / E / S

0 3,250 6,500 Feet

0 0.5 1 Miles

Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

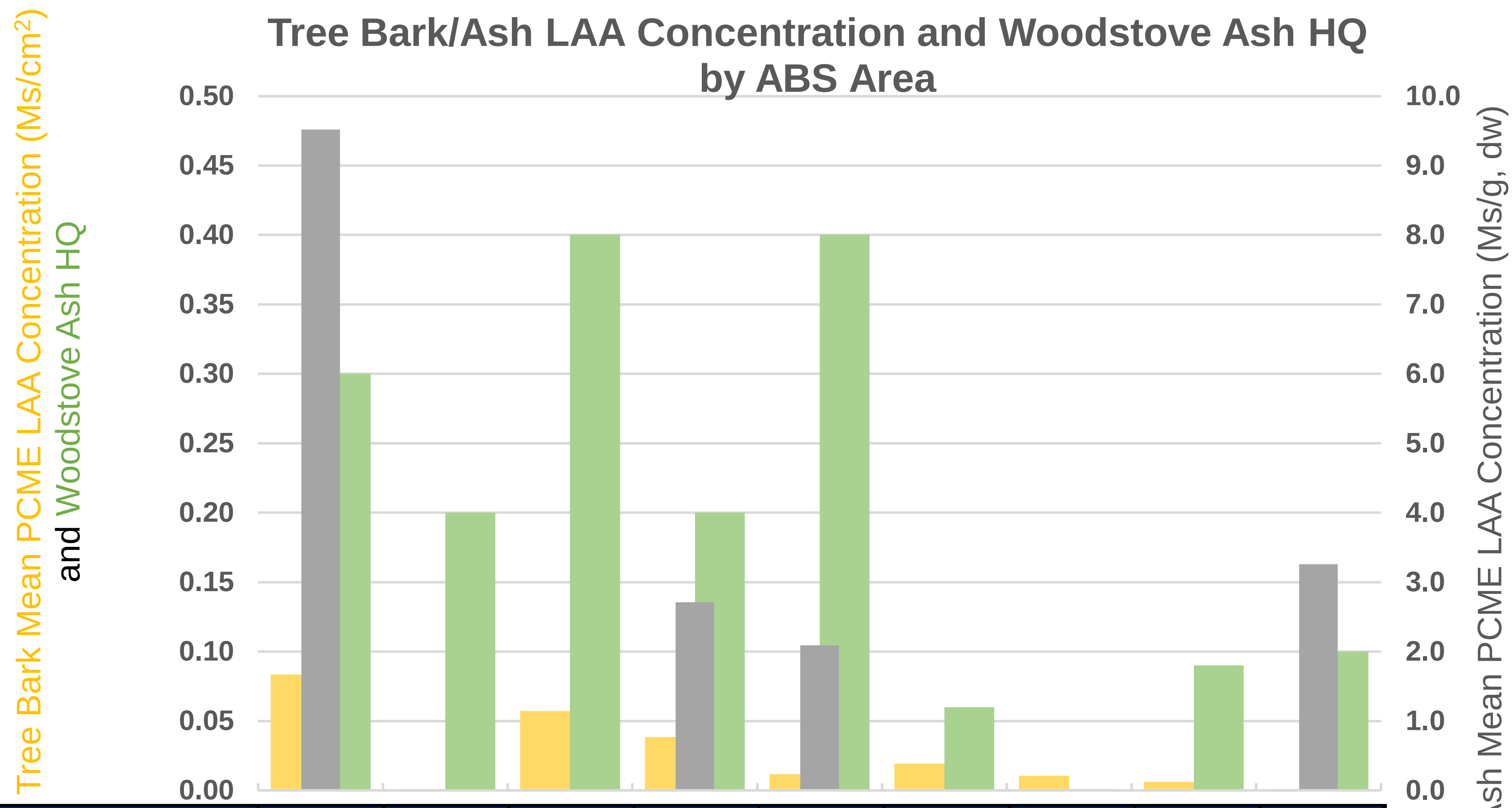
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-2

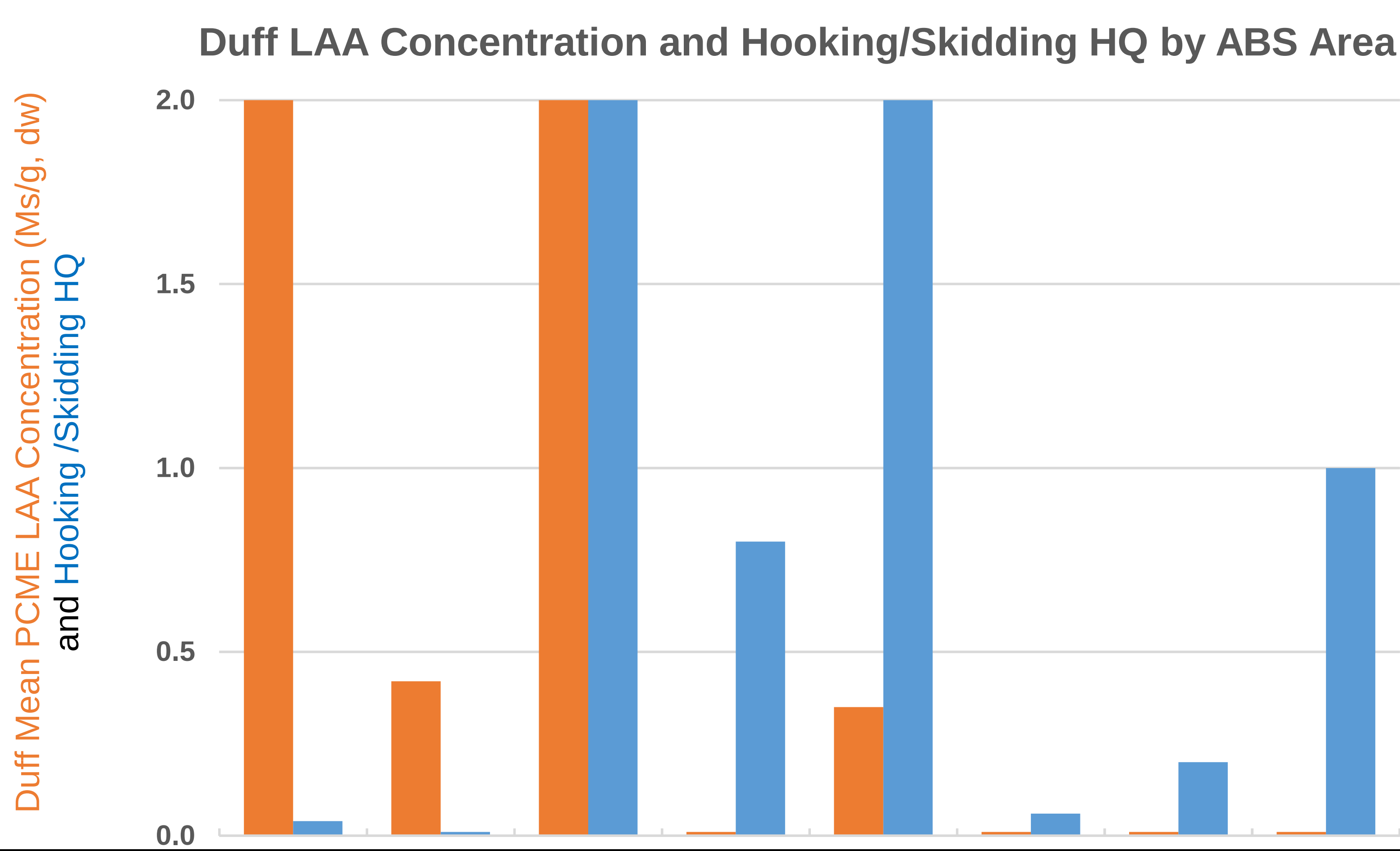
Hooking/Skidding ABS Calculated Hazard Quotients

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



ABS Area	Area A	Area B	Area C	Area D	Area E	Area F	Area G	Area H	Area I
Bark Mean PCME LAA Surface Loading (Ms/cm^2)	0.083	0.0	0.057	0.038	0.012	0.019	0.011	0.0061	0.0
Ash Mean PCME LAA Conc. (Ms/g, dw)	9.5	0.0	0.0	2.7	2.1	0.0	0.0	0.0	3.3
Woodstove Ash HQ	0.30	0.20	0.40	0.20	0.40	0.06	0.00	0.09	0.10



ABS Area	Area A	Area B	Area C	Area D	Area E	Area F	Area G	Area H
Duff Mean PCME LAA Conc. (Ms/g, dw)	2.0	0.42	2.0	0.0	0.35	0.0	0.0	0.0
Hooking/Skiding HQ	0.04	0.0	2.0	0.8	2.0	0.06	0.2	1.0

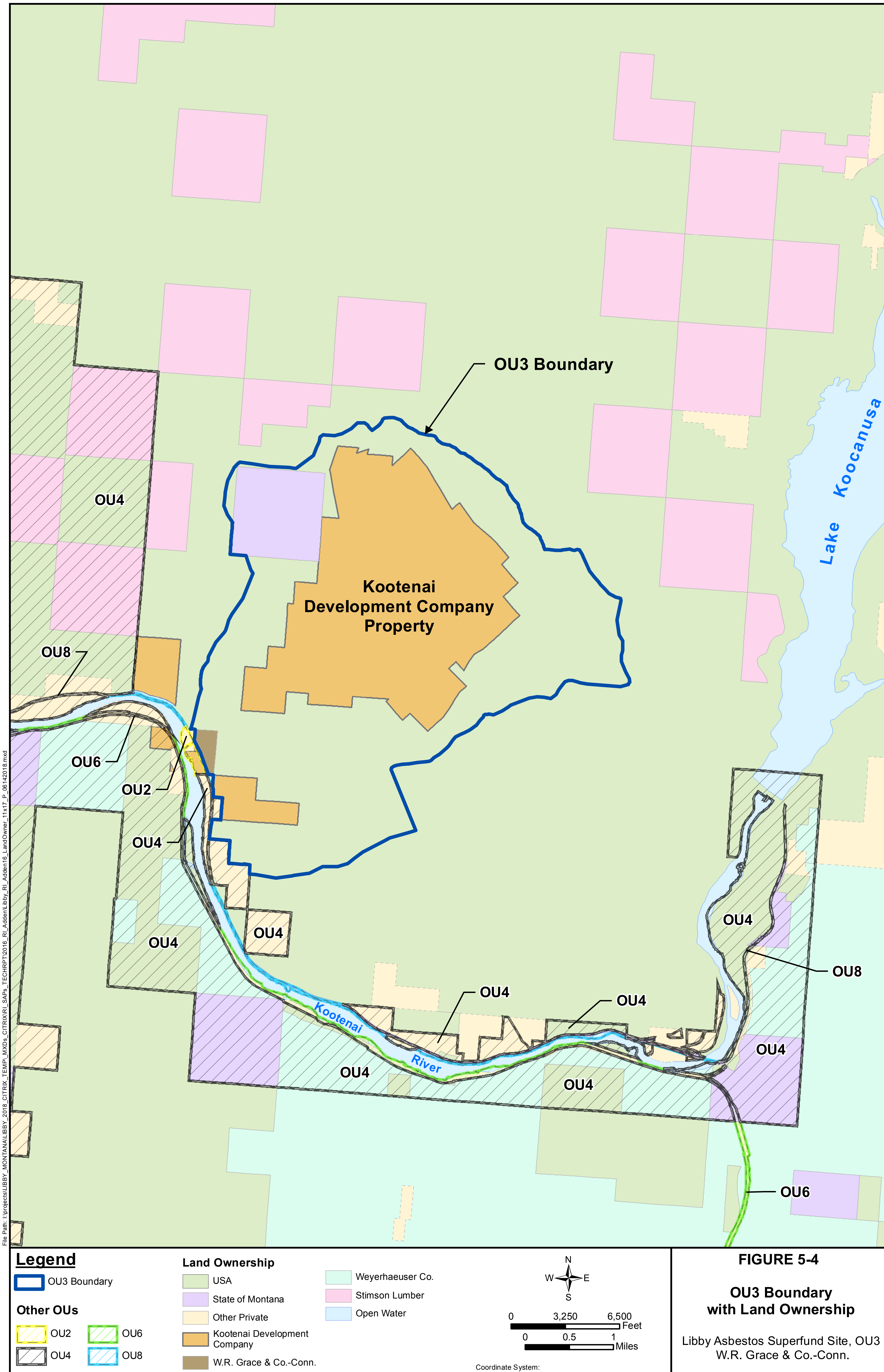
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-3

LAA Concentrations in Source Media and Corresponding Calculated Hazard Quotient

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Note: The portion of the Kootenai River that is included in OU3 is currently being negotiated.

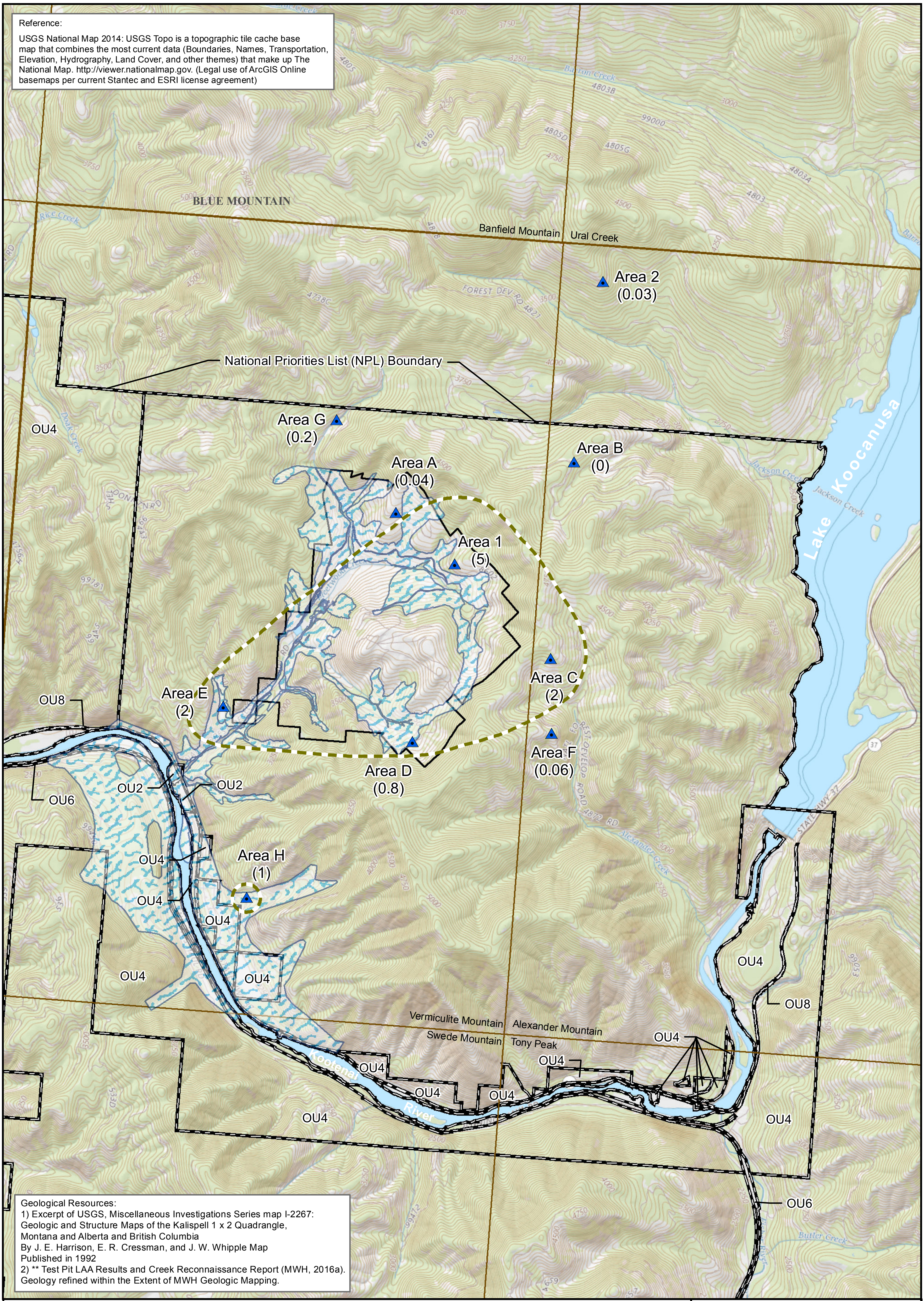
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-4

OU3 Boundary with Land Ownership

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



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Legend

- Hooking / Skidding Location
- HQ* > 0.6 Hooking/Skidding ABS Contour
- Quaternary Glacial Material
- Mine Property Boundary
- USGS Quadrangle Boundary
- National Priorities List Boundary

ABS	Activity Based Sampling
Area D (0.8)	ABS Area with Calculated HQ in Parenthesis
HQ	Hazard Quotient
*	HQ values based on HHRA (EPA, 2015), HHRA Addendum (EPA, 2017), and EPA's exposure assumptions

N W E S

0 3,250 6,500 Feet

0 0.5 1 Miles

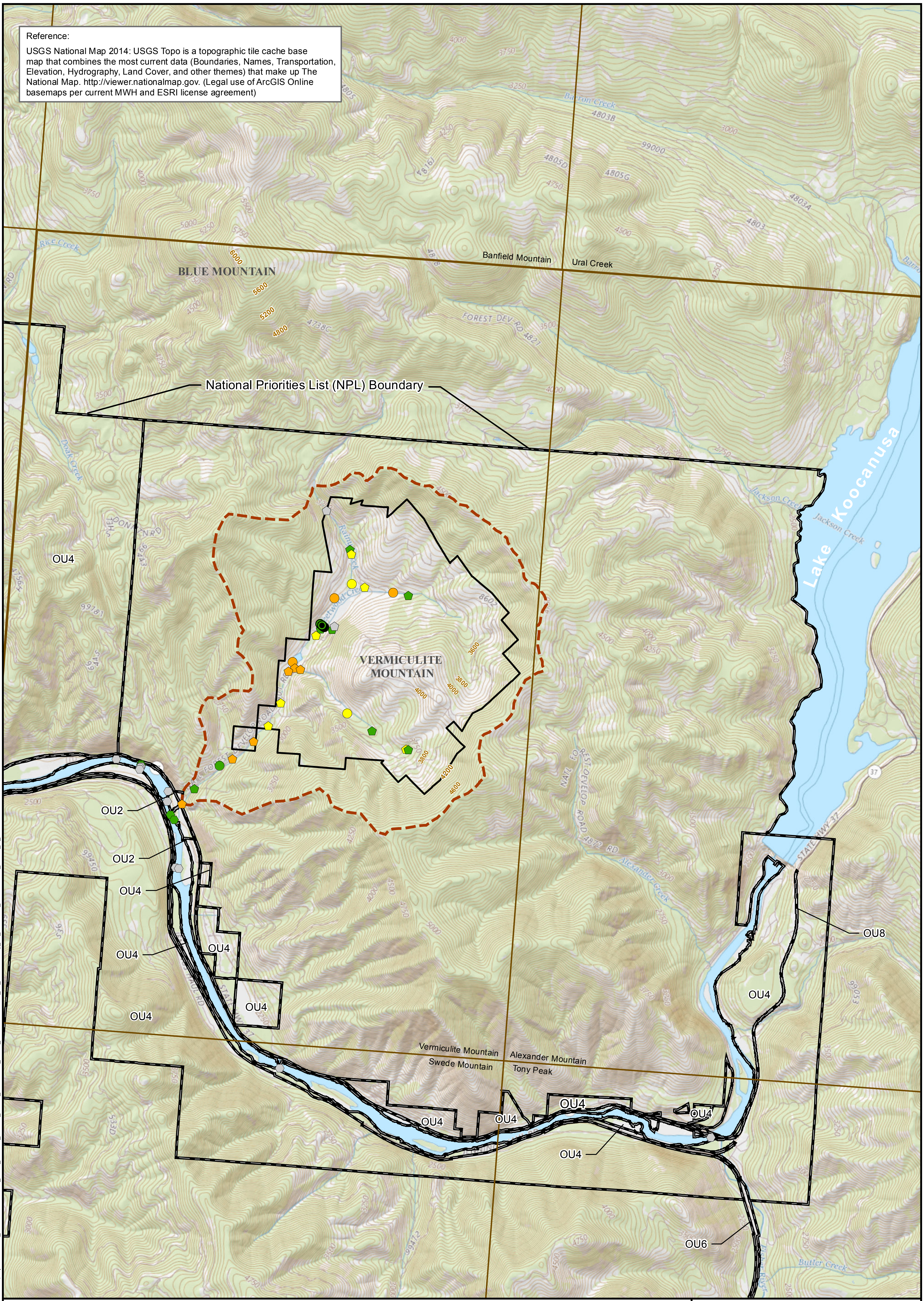
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-5

Hooking/Skidding ABS HQ Isopleth

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



Legend

Surface Water Sample Locations
- Creek
- Pond
- River
- Seep
- Toe Drain

Surface Water
(MFL LAA ≥ 10 µm in length)
- 0
- > 0 - 1
- > 1 - 7
- ≥ 7

LAA Libby Amphibole Asbestos
MFL million fibers per liter
µm micrometers

- Ground Surface Contour, Contour Interval 40 feet
- Predominant Ridgeline Surrounding Former Mine Area
- Mine Property Boundary
- National Priorities List Boundary
- USGS Quadrangle Boundary

N W E S

0 0.5 1 Miles

Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

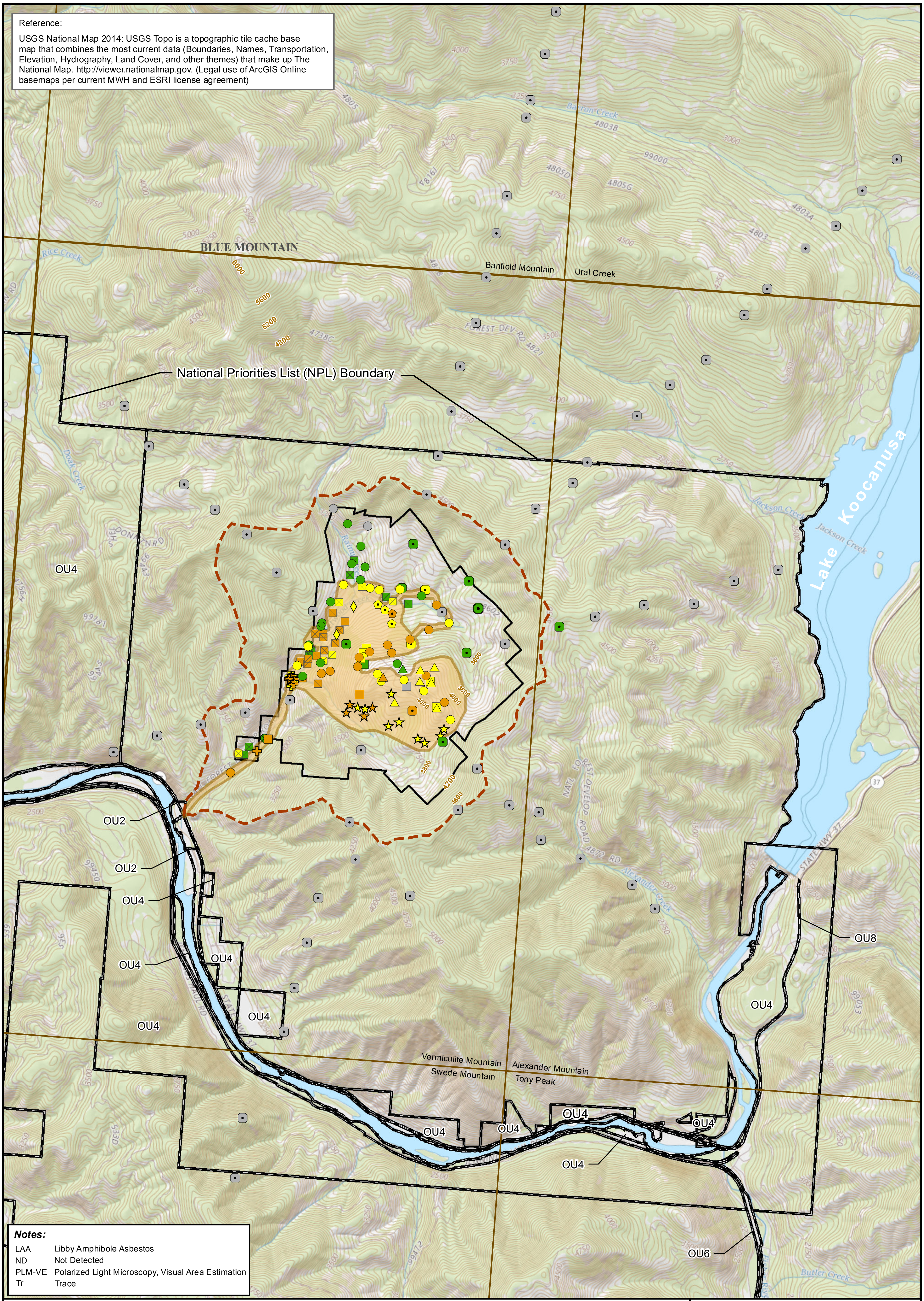
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-6
Predominant Ridgeline and Maximum LAA Results for Surface Water (Former Mine Area)

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec

File Path: I:\projects\LIBBY_MONTANA\LIBBY_2018_CITRIX_TEMP_MXDs_CITRIX\RI_SAPs_TECHRPT\2016_RI_Adden\Libby_RI_Adden16_MaxLAASW_11x17_P_06142018.mxd



Legend

Soil/Rock/Mine Waste Sample Locations

- Test Pit *
- Forest Soil **
- Coarse Tailings
- Fine Tailings
- Waste Rock
- Road Material
- Cover/Fill Material
- Alluvium/Other Material
- Glacial
- Bedrock (Outcrop)

LAA PLM-VE (% mass fraction)

- ND (Bin A)
- Tr (Bin B1; >ND<0.2%)
- <1% (Bin B2; ≥0.2%<1%)
- ≥1% (Bin C; ≥ 1%)

- LAA Soil > 0.2% Isopleth
- Predominant Ridgeline Surrounding Former Mine Area
- USGS Quadrangle Boundary
- National Priorities List Boundary
- Mine Property Boundary
- Ground Surface Contour, Contour Interval 40 feet

N W E S

0 0.5 1 Miles

Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl

Date Revised: 6/14/2018

Report: OU3 2016 RI Addendum

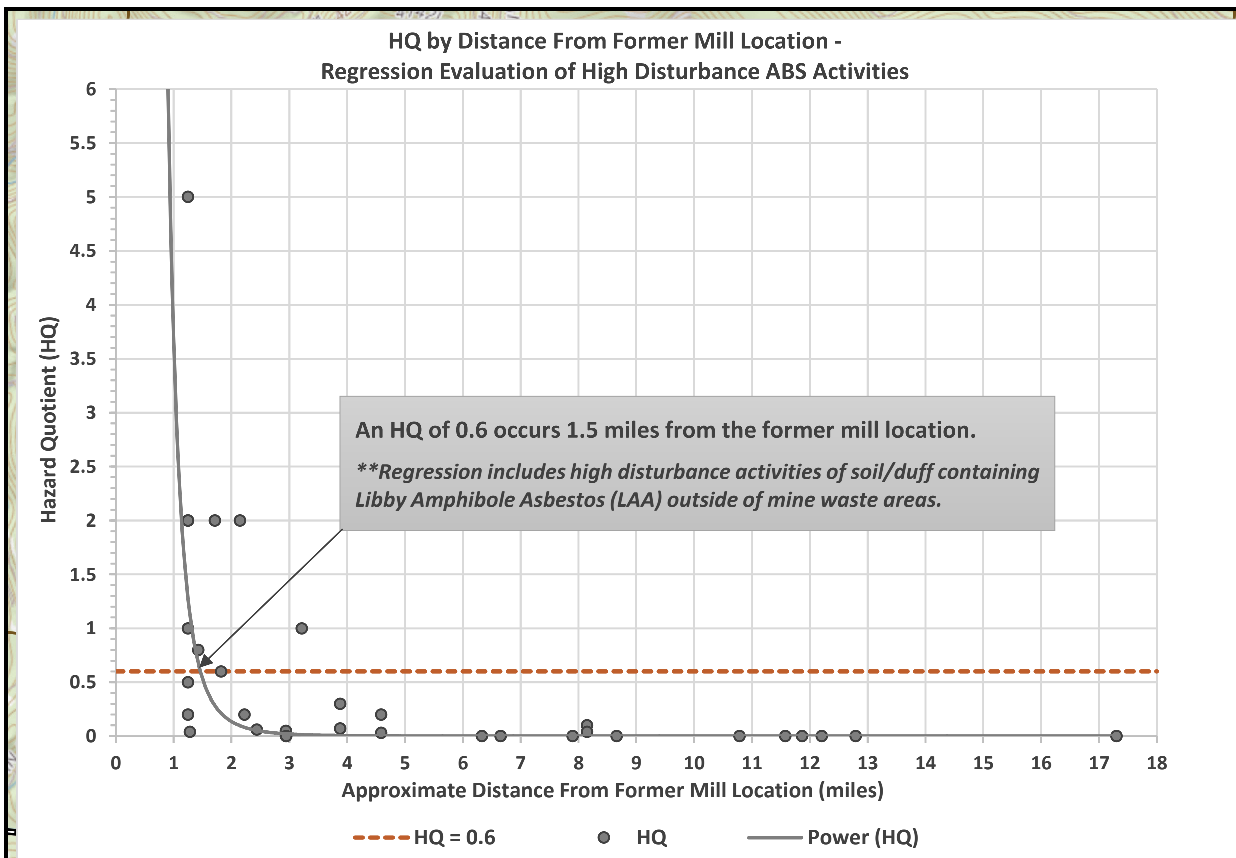
* Samples collected at various depths and include tailings, fill, alluvium, glacial, and bedrock materials
** Forest Soil location samples outside the view area of this figure are all ND (Bin A).

FIGURE 5-7

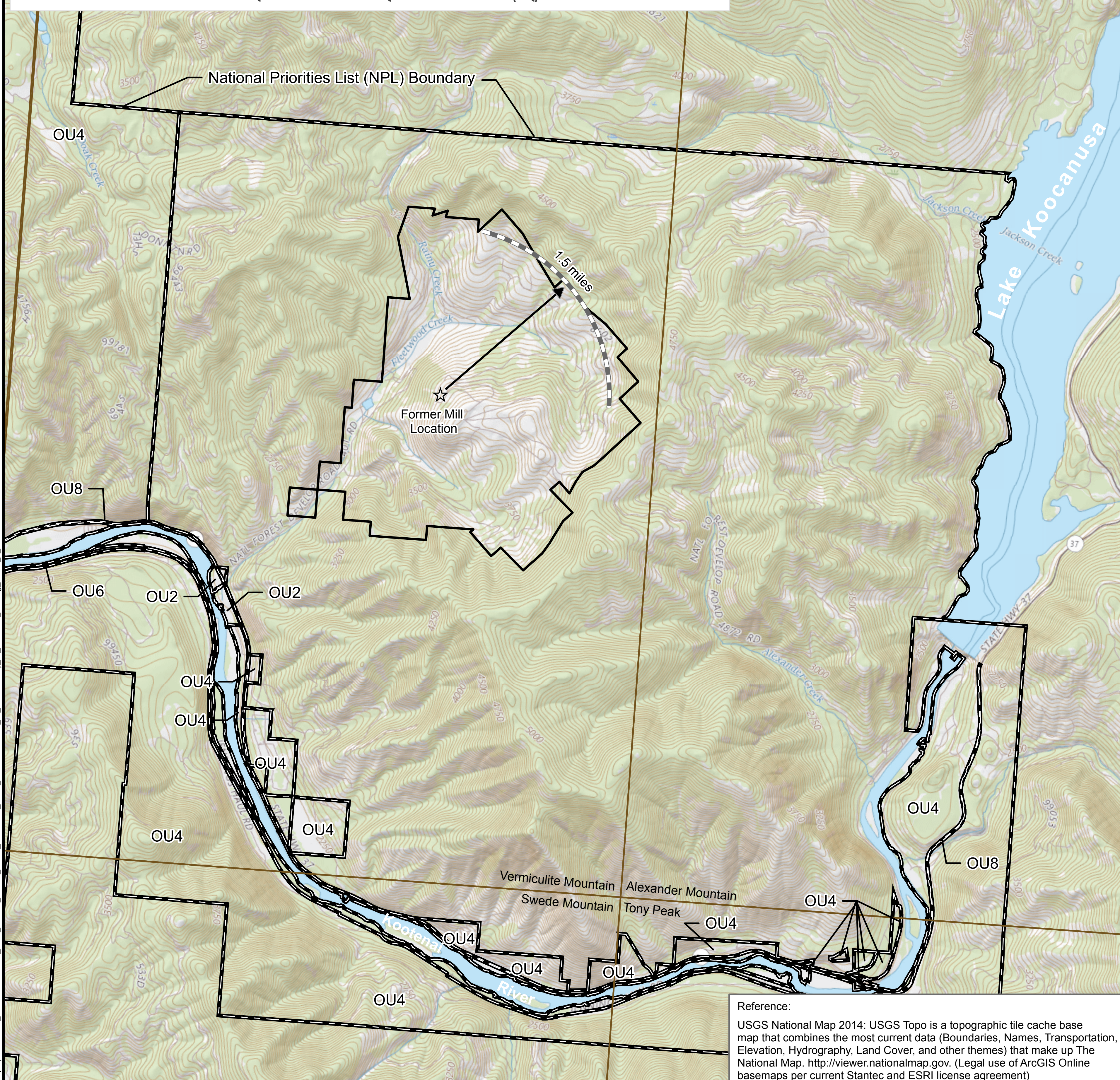
Predominant Ridgeline and Maximum LAA PLM-VE Results for Soil/Rock/Mine Waste (Former Mine Area)

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



High Disturbance ABS Activity Description
Hooking/Skidding of Timber
Site Restoration
Nature and Extent Cutting Fire Lines by Hand
3d Cutting Fire Lines by Hand
3e Cutting Fire Lines with Heavy Equipment
During Dry Mop-Up - Wildfire
During Wet Mop-Up - Wildfire
Building Slashpile - Maintenance
During Dry Mop-Up - Maintenance
During Wet Mop-Up - Maintenance
Hiking/Antler Shed Hunting Lower Rainy Creek



Reference:
USGS National Map 2014: USGS Topo is a topographic tile cache base map that combines the most current data (Boundaries, Names, Transportation, Elevation, Hydrography, Land Cover, and other themes) that make up The National Map. http://viewer.nationalmap.gov. (Legal use of ArcGIS Online basemaps per current Stantec and ESRI license agreement)

File Path: I:\projects\LIBBY_MONTANA\LIBBY_2018_CITRIX_TEMP_MXDs_CITRIX\RI_SAPs_TECHRPT\2016_RI_Adden\Libby_RI_Adden16_HQReg_11x17_L_06142018.mxd

Legend

- ☆ Former Mill Location
- Estimated Distance from the Former Mill Location where an HQ = 0.6
- Mine Property Boundary
- National Priorities List Boundary
- USGS Quadrangle Boundary

ABS Activity Based Sampling
HQ Hazard Quotient
LAA Libby Amphibole Asbestos

N W E S

0 3,250 6,500 Feet
0 0.5 1 Miles

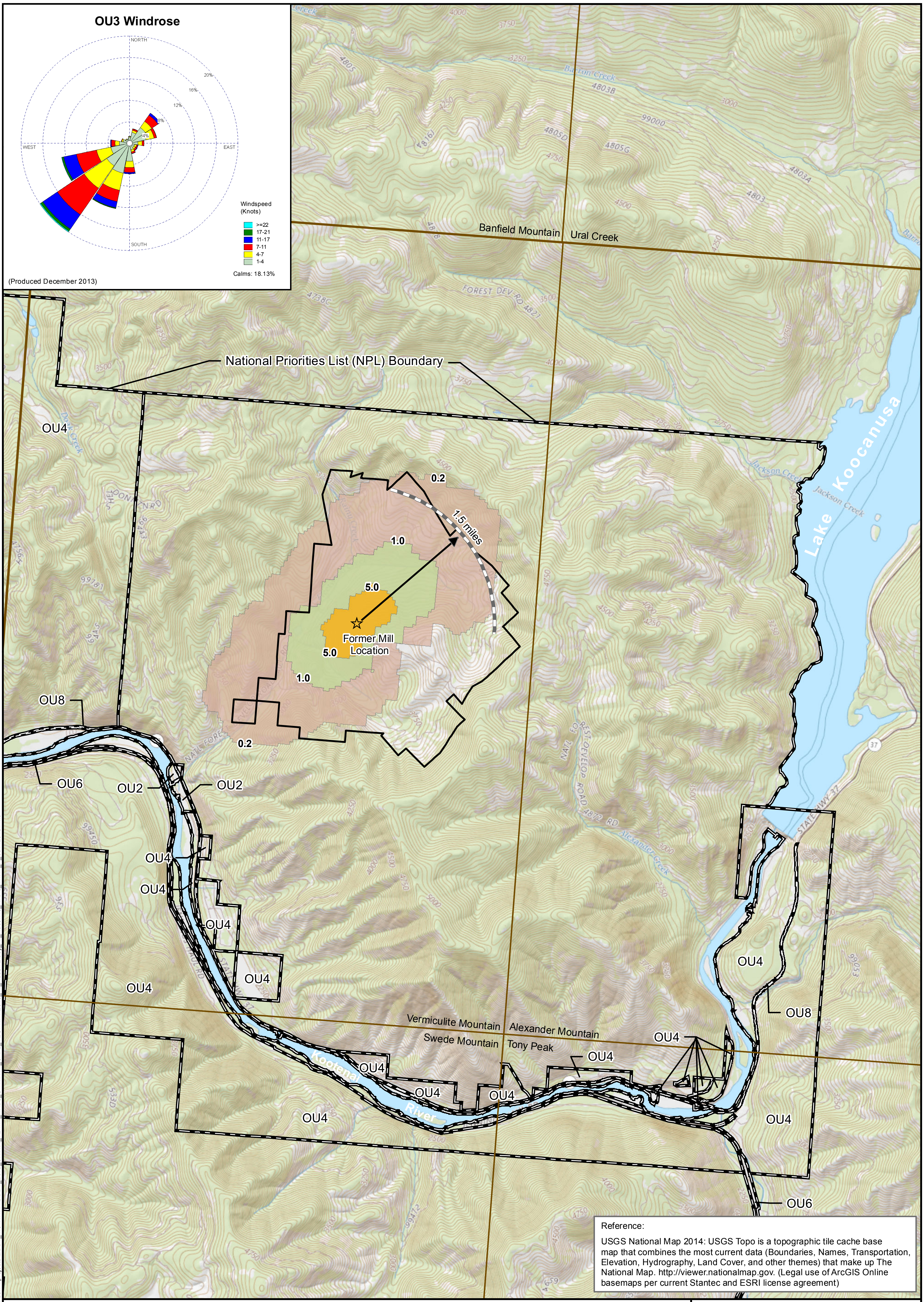
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-8

HQ Regression Evaluation of High Disturbance Activities

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



File Path: I:\projects\LIBBY_MONTANA\LIBBY_2018_CITRIX_TEMP_MXDs_CITRIX\RI_SAPs_TECHRPT\2016_RI_Addend\Libby_RI_Adden16_AirDis_11x17_P_06142018.mxd

Legend

- ☆ Former Mill Location
- Estimated Distance from the Former Mill Location where an HQ = 0.6
- Mine Property Boundary
- National Priorities List Boundary
- USGS Quadrangle Boundary

Air Model Isopleths

Estimated LAA Deposition Rates (g/m^2-yr)

- 0.2 - <1.0
- 1.0 - <5.0
- ≥ 5.0

g/m^2-yr grams per meter squared per year

LAA Libby Amphibole Asbestos

NOTES:

The lower contour threshold of 0.2 g/m^2-yr air dispersion model isopleth is the best-fit with the results of the regression evaluation shown on Figure 5.

N W E S

0 3,250 6,500 Feet

0 0.5 1 Miles

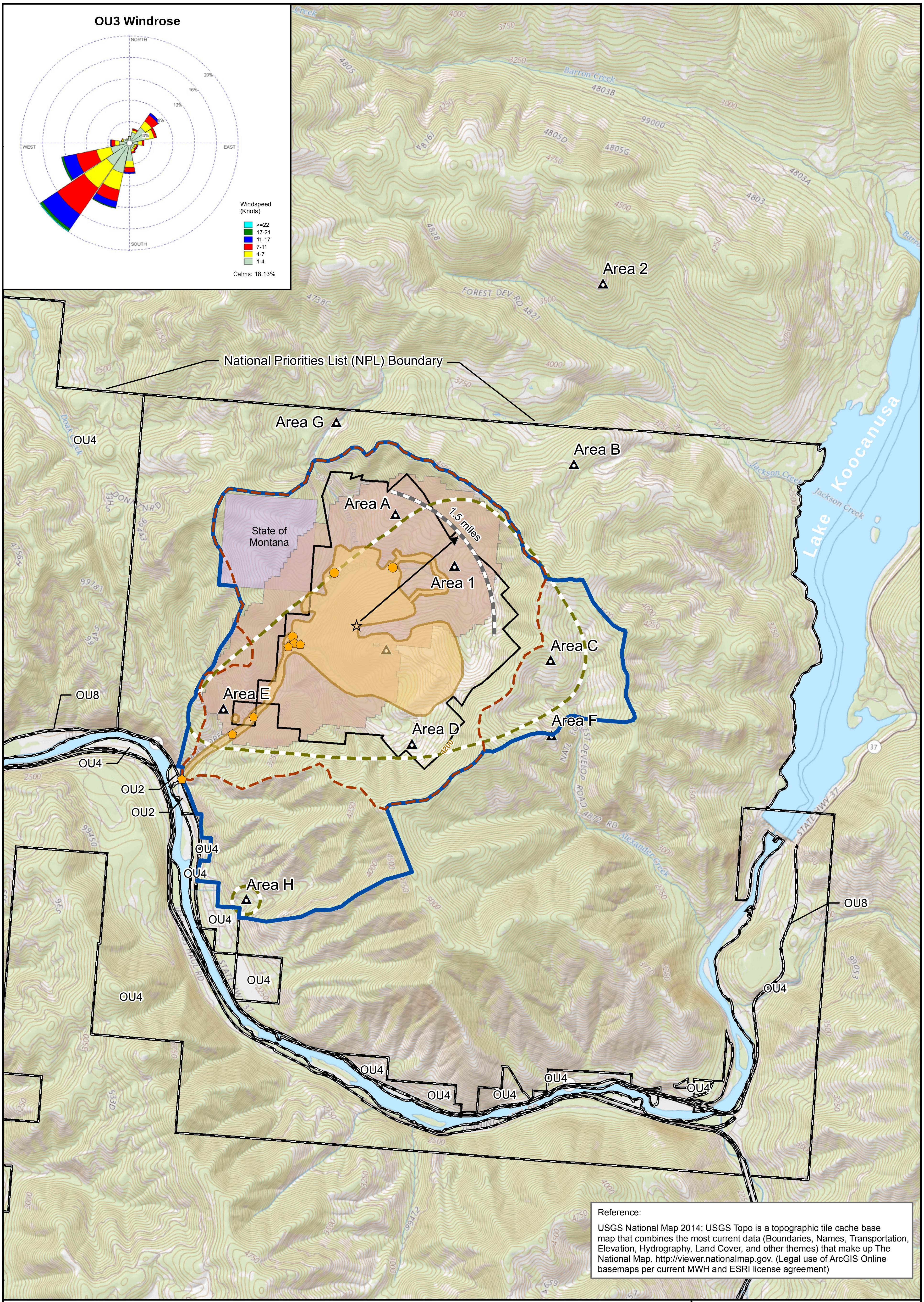
Coordinate System:
NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/14/2018
Report: OU3 2016 RI Addendum

FIGURE 5-9

Best-Fit Air Dispersion Model Isopleth

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec



File Path: U:\233001008\03_data\gis_cad_MXDs_CITRIX\RI_SAPs_TECHRPT\2016_RI_Adden\Libby_RI_Adden16_AllEvidence_11x17_P_06212018.mxd

Legend

- 2016 ABS
- Former Mill Location
- OU3 Boundary
- HQ* > 0.6 Hooking/Skidding ABS Contour
- Predominant Ridgeline Surrounding Former Mine Area
- LAA Soil > 0.2% Isopleth
- Estimated Distance from the Former Mill Location where an HQ = 0.6
- Air Model Isopleth ≥ 0.2 Estimated LAA Deposition Rates (g/m² - yr)
- Mine Property Boundary
- National Priorities List Boundary
- State of Montana
- Surface Water ≥ 7 (MFL LAA ≥ 10 µm in length)

g/m² - yr grams per square meter per year
ABS Active Based Sampling
HQ Hazard Quotient
LAA Libby Amphibole Asbestos

MFL million fibers per liter
µm micrometers

N W E S

0 0.5 1 Miles

Coordinate System: NAD 1983 HARN StatePlane Montana FIPS 2500 Feet Intl
Date Revised: 6/21/2018
Report: OU3 2016 RI Addendum

FIGURE 5-10

Multiple Lines of Evidence for Proposed OU3 Boundary Determination

Libby Asbestos Superfund Site, OU3
W.R. Grace & Co.-Conn.

Stantec

ATTACHMENTS

ATTACHMENT A
OU3 MINE FEATURE PHOTOGRAPHS INCLUDED ON FIGURE 2-1

1. Rainy Creek Road and Lower Rainy Creek drainage basin looking northwest (June 2017)

2. Mill Pond and Amphitheater looking northeast (June 2017)

3. KDID and the southwestern portion of the Fine Tailings Impoundment looking northwest (2007)

4. Coarse Tailings Pile and top of Former Mine Area looking southeast (June 2017)

5. View from the crest of the KDID looking northeast at the Fine Tailings Impoundment and edge of the Coarse Tailings Pile (2014)

6. View from the crest of the KDID looking southwest and downstream at the toe of the KDID (2014)

7. KDID, Fine Tailings Impoundment, and western edge of the Coarse Tailings Pile looking southwest (2016)

8. Fine Tailings Impoundment and Mill Pond looking southwest (June 2017)

9. Aerial of Mill Pond, Amphitheater, KDID, Fine Tailings Impoundment, and Coarse Tailings Pile looking north-northeast (2007)

10. KDID spillway looking northeast (2017)

11. Fine Tailings Impoundment and KDID spillway entrance looking south (June 2017)

12. Former Mill Area looking southeast (June 2017)


13. Fine Tailings Impoundment and Coarse Tailings Pile looking east (2016)

14. Top of Former Mine Area looking west-southwest (June 2017)

15. Top of Former Mine Area looking northwest (June 2017)

16. Top of Former Mine Area and Fleetwood Creek drainage looking west (June 2017)

17. Top of Former Mine Area and weather station looking northwest (June 2017)

18. Top of Former Mine Area and Waste Rock Piles looking west-northwest (June 2017)

19. Top of Former Mine Area looking northwest (June 2017)

20. Top of Former Mine Area looking north (June 2017)

21. Top of Former Mine Area looking northeast (June 2017)

22. Top of Former Mine Area and Former Mill Area looking east (June 2017)

23. Top of Former Mine Area looking south (June 2017)

24. Top of Former Mine Area looking south (2017)

25. Top of Former Mine Area looking south (June 2017)

26. Top of Former Mine Area looking west (2016)

27. Fill from other Operable Units placed in Beneficial Reuse Area looking north (2008)

28. Edge of West Waste Rock Pile looking northwest (2014)

29. Top of Former Mine Area looking northeast (2016)

30. KDID looking north (2017)

31. KDID looking southeast (2017)

32. West Waste Rock Pile looking northeast (2017)

33. Top of Former Mine Area and West Waste Rock Pile looking southeast (2017)

34. Fleetwood Creek Drainage and Coarse Tailings Pile looking east (2017)

35. Carney Pond and West Waste Rock Pile looking north (2017)

36. Lower Rainy Creek Confluence with Kootenai River (2017)

ATTACHMENT B
SUPPLEMENTAL REVIEW OF DISTINGUISHING CHARACTERISTICS OF LIBBY AMPHIBOLE ASBESTOS

B.1 Supplement to Remedial Investigation Report on OU3 Study Area, Appendix B-1 Review of Distinguishing Characteristics of Libby Amphibole Asbestos

B.1.1 Background

Appendix B-1 of the *Remedial Investigation Report Operable Unit 3 Study Area, Libby Asbestos Superfund Site, Libby, Montana* (OU3 RI Report; MWH, 2016a) reviewed the available literature and data on the composition of amphibole and amphibole asbestos associated with the former Zonolite mine near Libby, Montana to provide information suitable for the identification of amphibole asbestos from the Rainy Creek Complex, referred to as "Ore Body Amphibole." (See, Appendix B-1 p. 1 et seq.) Appendix B-1 summarized the work of a number of researchers demonstrating that Ore Body Amphiboles contain measureable quantities of both potassium and sodium, and analyzed the energy dispersive spectroscopy (EDS) spectra from samples of known Ore Body Amphiboles to develop confidence intervals for the range of potassium and sodium concentrations found in Ore Body Amphiboles. This supplement refines those findings by further analyzing the data presented in Appendix B-1 to better define the compositional characteristics of Ore Body Amphibole.

B.1.2 Analysis of the Meeker Data

The starting point for this effort is the Wave Dispersive Spectrometry (WDS) data set that is used as the basis for the 2003 Meeker, et al. publication referenced in Appendix B-1 at page 3.[1] This data set contained the normalized weight percent and atomic per formula unit (APFU) results for 782 microprobe measurements. While the Meeker WDS data has utility, in its current form, a data conversion is needed before it can be used to compare with other elemental-composition data collected for the OU3 RI, such as Activity Based Sampling (ABS) data, which relied on EDS methods rather than WDS. To facilitate the comparison between the Meeker data and OU3 ABS data, the following conversions were conducted on the Meeker WDS data.

For each microprobe measurement, the Meeker WDS data are used to calculate an EDS spectra using the industry-standard DTSA-II software package published by the National Institute of Standards and Technology (NIST).[2] The DTSA-II software outputs a calculated EDS spectra that the leading authorities at NIST consider to be highly accurate and suitable for use in precise elemental analysis.[3]

[1] Meeker GP, Bern AM, Brownfield IK, Lowers HA, Sutley SJ, Hoeffen TM, Vance JS. 2003. The Composition and Morphology of Amphiboles from the Rainy Creek Complex, Near Libby, Montana. American Mineralogist 88:1955-1969

[2] As background, both the WDS and EDS count x-rays, but WDS tabulates the data by the wavelength of the x-ray, while EDS tabulates data by the energy of the x-ray. To have a basis for comparison with EPA EDS data on samples collected at OU3, an EDS spectra can be calculated from the WDS data. NIST has developed the software package DTSA-II to accomplish the calculation. See additional information on the NIST website, https://www.nist.gov/programs-projects/dtsa-ii-reinvention-classic, and http://www.cstl.nist.gov/div837/837.02/epq/dtsa2/index.html

[3] See: Newbury and Ritchie, Performing elemental microanalysis with high accuracy and high precision by scanning electron microscopy/silicon drift detector energy-dispersive X-ray spectrometry. Available online at: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4555346/. See also, Newbury and Ritchie, Measurement of Trace Constituents by Electron-Excited X-Ray Microanalysis with Energy-Dispersive Spectrometry, Available online at https://www.cambridge.org/core/journals/microscopy-and-microanalysis/article/measurement-of-trace-constituents-by-electronexcited-xray-microanalysis-with-energydispersive-spectrometry/EA90613D1F0C1F4A583954C66D159E0F.

The OU3 ABS air samples collected in support of the RI were analyzed using either the light element (windowless) detector, or the non-light element (beryllium) detectors. The DTSA-II software can calculate an EDS spectra for either type of detector window, and thus the Meeker data were converted to EDS spectra for both the windowless and beryllium style detectors.[4] However factors other than the window type were considered, especially particle shape and thickness. For instance, the particle was modeled as a 0.25-micron thick cylinder, as this would best describe the general morphology of the amphiboles. Calculations for 0.1- and 5-micron thick cylinders, found this range of thickness had little to no effect on the peak heights for Al, Si, and K, while the Na and Mg peak were higher for the 0.1 micron particle, and the Ca and Fe were lower as compared to the 5 micron particle. Although other factors are harder to control, they could also be observed in the EDS spectra (e.g., if an amphibole was too close to a vermiculite particle, then there could be an anomalously high Al peak).

In the next step of the analysis, the peak heights for specific elements are measured on the EDS spectra. The ratio of the peak heights of each element to the peak height of the element silicon (Si) are calculated. The resultant ratios reflect the magnitude of the peak heights for each element and are used to normalize the peak heights for different elements to the same scale.

For the Meeker data, the elemental ratio data are plotted on two ternary plots; one using the EDS spectra for the windowless detector and the other using data for the beryllium detector. In addition, two sets of elements are plotted for each detector, the first representing the elements sodium-aluminum-potassium (Na-Al-K) and the second representing the elements magnesium-calcium-iron (Mg-Ca-Fe). Therefore, as shown in **Figure B-1**, below, there are four resultant ternary plots.

[4] The DTSA-II package can generate simulated spectra that would be expected by a windowless detector or by a beryllium window detector. For more information on how DTSA-II handles different detector types, see the NIST website: http://www.cstl.nist.gov/div837/837.02/epq/dtsa2/index.html.

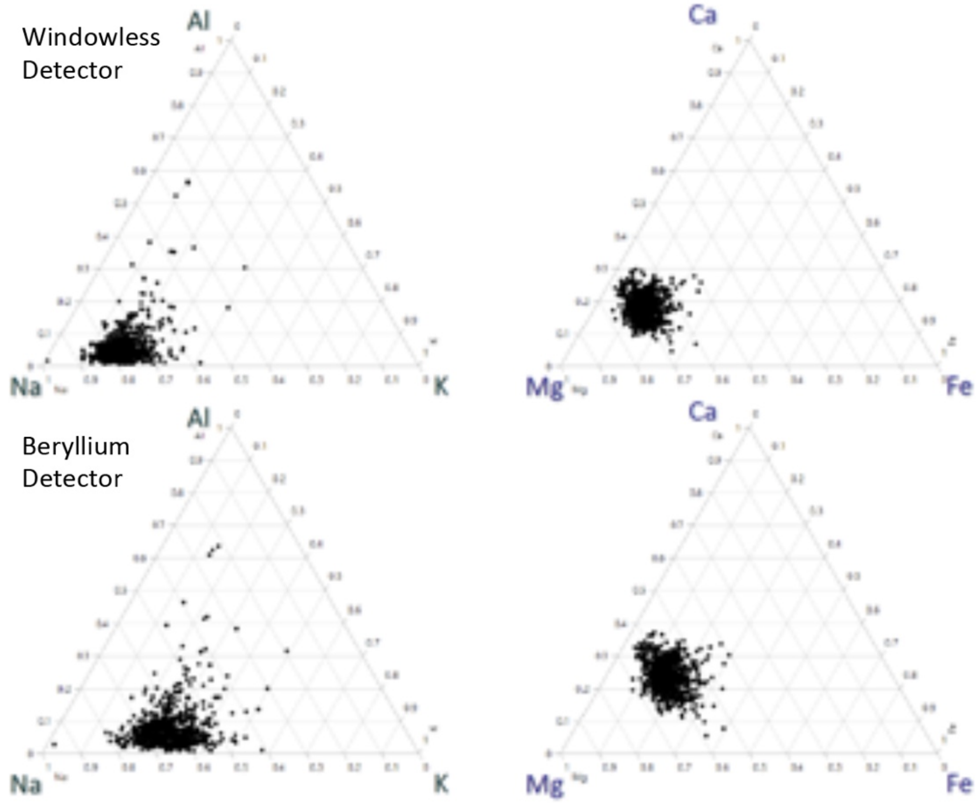


Figure B-1. Ternary plots of the Meeker data based on peak heights in calculated EDS spectra for both windowless and beryllium detectors.

In a ternary plot, data points close to a labeled apex contain relatively more of that element. For example, samples that plot near the sodium (Na) apex above have relatively more sodium and less potassium (K) or aluminum (Al).

On the ternary plots of Na-Al-K, the Meeker data shown in **Figure B-1** are clustered in an area of the ternary plots showing predominantly sodium (Na), relatively less potassium (K) and little to no aluminum (Al). Amphiboles that lack potassium designated “NaX,” would plot to the left of the Meeker data cluster, along the left side of the triangle. Amphiboles that lack sodium, designated “XK,” would plot to the right of the Meeker data cluster, along the right side of the triangle.

Although not directly relied on by previous work, the Mg-Ca-Fe ternary plots also are useful screening tools. In fact, the Meeker data cluster on the Mg-Ca-Fe plot is even more tightly defined than on the Na-Al-K plot.

B.1.3 Data from the 2016 ABS Event

In the summer of 2016, additional ABS was conducted in OU3. EDS spectra were generated from amphiboles found in the corresponding air samples. These EDS spectra for the hooking and skidding ABS air samples were analyzed in the same way as the Meeker data – measuring peak heights, calculating ratios versus silicon (Si), normalizing the data, and finally, plotting the results on ternary plots.

Figure B-2 illustrates this process for a particular ABS sample. The peak heights of Mg, Ca, and Fe (in green below) are measured. Next the peak height of Si (red below) is measured. Finally the resulting normalized data are plotted on the Mg-Ca-Fe ternary plot (blue arrow below).

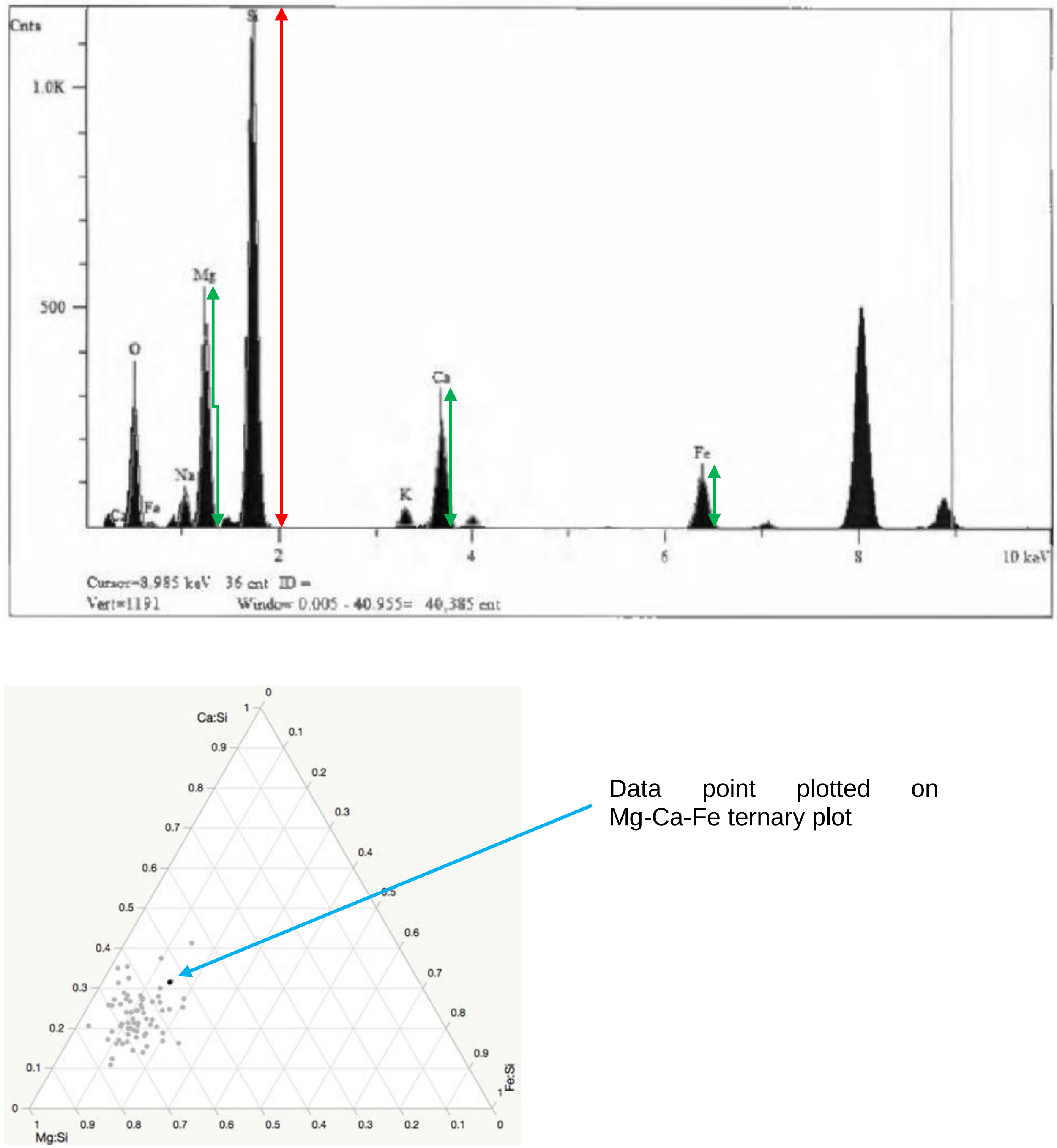


Figure B-2. Example of plotting compositional data from an EDS plot of 2016 hooking and skidding ABS data.

This process was repeated for each of the 82 EDS image files generated from the 2016 ABS hooking and skidding air samples. **Figure B-3** presents this data set, plotted on Na-Al-K and Mg-Ca-Fe ternary plots for both detector types. Note that some of the EDS spectra from the 2016 hooking and skidding ABS air samples were developed using a windowless detector while others were developed using a beryllium detector.

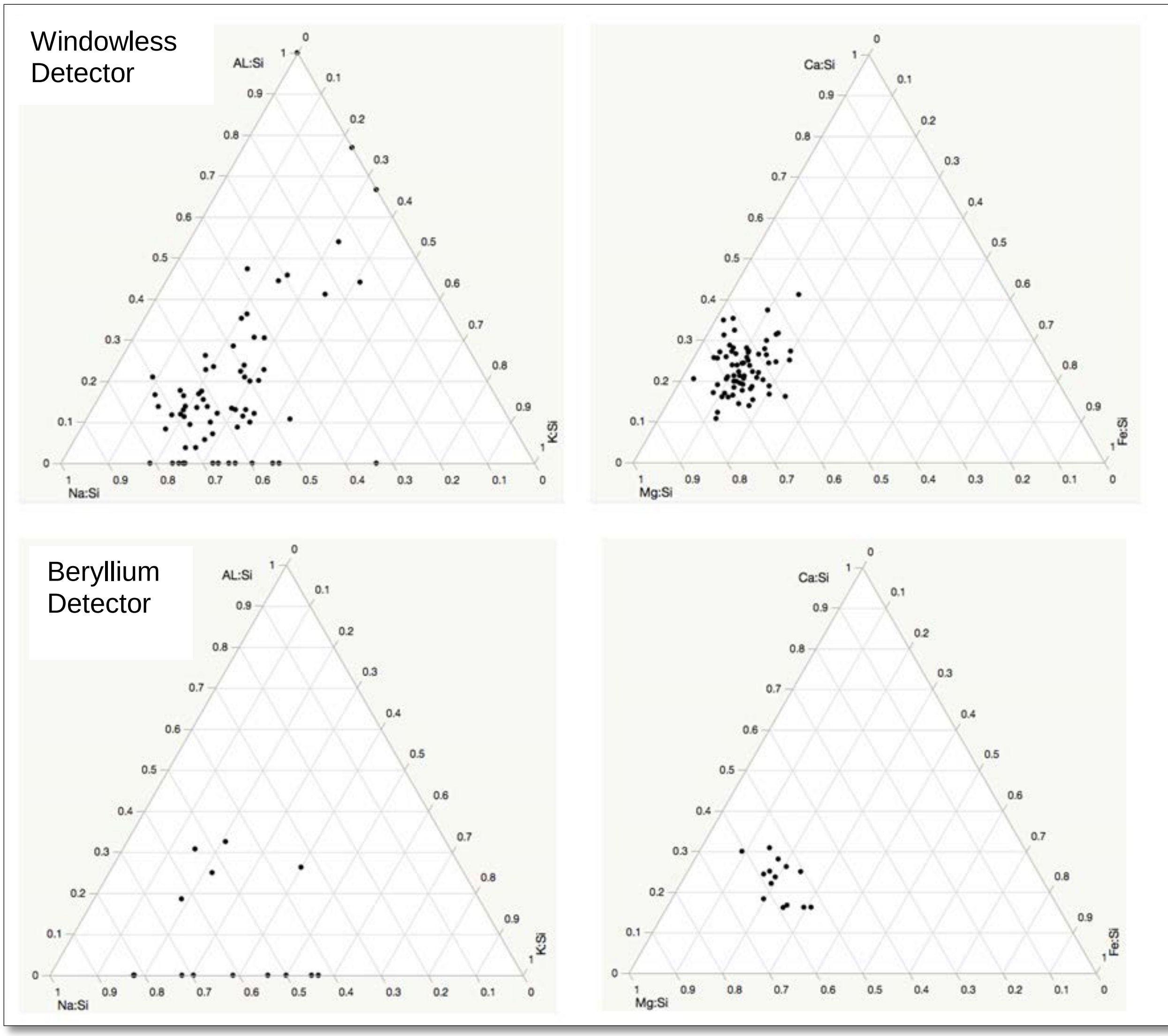


Figure B-3. Ternary plots of the 2016 hooking and skidding ABS data based on peak heights in calculated EDS spectra for both windowless and beryllium detectors.

B.1.4 Conclusions and Recommendations

Plotting the elemental ratio data for the Ore Body Amphibole samples on ternary plots indicates that LAA sourced from the Rainy Creek Complex exhibits discernable patterns. These patterns can be used as a line-of-evidence to distinguish Ore Body Amphibole from the Meeker study from non-Ore-Body Amphibole. Visual comparisons of the ternary plots generated using the Ore Body Amphibole samples and the 2016 ABS samples suggest that some of the LAA in the 2016 hooking and skidding ABS samples may be non-Ore-Body Amphibole. Additional evaluations may be prudent to better understand the apparent variability in EDS spectra in ternary plots between

Meeker and recent ABS data. Next steps could include an overlay of the Meeker and hooking and skidding ABS ternary plots for identification of potential data anomalies. The potential data anomalies may provide additional insight into the current conceptual model and a better understanding of the fate and transport of LAA.

ATTACHMENT C
LABORATORY DATA
(PROVIDED AS AN EXCEL FILE ATTACHED TO THIS PDF)

ATTACHMENT D
2016 ANNUAL LABORATORY QA/QC SUMMARY REPORT

APTIM Federal Services, LLC
QATS Program
2700 Chandler Avenue
Las Vegas, Nevada 89120

August 22, 2017

Document ID #: 1021-08222017-1

David Berry
USEPA, Region 8
1595 Wynkoop Street (8EPR-SR)
Denver, CO 80202-1129

EPA CONTRACT NUMBER EP-W-16-016
TASK ORDER NUMBER 1021
QUALITY ASSURANCE SUPPORT FOR RI/FS AT THE LIBBY ASBESTOS SITE OU3

Dear Mr. Berry:

Enclosed please find the final Annual Laboratory QA/QC Summary Report (2016). This report is a deliverable under Task 9 of Task Order 1021.

If you have any questions, please feel free to contact me.

Sincerely,

Lyndsay Gensler
Task Leader, QATS Program
E-Mail Address: lyndsay.gensler@aptim.com
Phone: (702) 895-8730
APTIM Federal Services, LLC

APTIM Federal Services, LLC
QATS Program
2700 Chandler Avenue
Las Vegas, Nevada 89120

ANNUAL QA/QC SUMMARY REPORT (2016)

FOR TASK ORDER 1021
QUALITY ASSURANCE (QA) SUPPORT FOR REMEDIAL INVESTIGATION/FEASIBILITY STUDY (RI/FS) AT SITE OU3

Prepared by:

The Data Auditing Group
Quality Assurance Technical Support Program
APTIM Federal Services, LLC
2700 Chandler Avenue
Las Vegas, Nevada 89120

June 09, 2017

QATS Contract Number: EP-W-16-016

Prepared for:

Christina Progess and David Berry

Task Order Manager
Remedial Project Manager
U.S. EPA Region 8
1595 Wynkoop Street (8EPR-SR)
Denver, CO 80202-1129

Through:

Sara Duncan

Analytical Services Branch
U.S. Environmental Protection Agency
Washington, D.C. 20460

OFFICE OF SUPERFUND REMEDIATION AND TECHNOLOGY INNOVATION
U. S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Table of Contents

Acronym List

<	Less Than
≥	Greater Than or Equal To
%	Percent
AHERA	Asbestos Hazard Emergency Response Act
ABS	Activity-based Sampling
AOC	Administrative Order on Consent
ASTM	American Society for Testing and Materials
CB	Compact Bundle
CBO	Compact Bundle Obscured
CC	Compact Cluster
CF	Compact Fiber
CFO	Compact Fiber Obscured
CH	Chrysotile
CI	Confidence Interval
COC	Chain-of-Custody
CSF	Close Support Facility
EDD	Electronic Data Deliverable
EDS	Electron Diffraction System
EPA	Environmental Protection Agency
ESAT	Environmental Services Assistance Team
f/cc	Fibers per Cubic Centimeter
f/mm^2	Fibers per Square Millimeter
FB	Field Blank
FBAS	Fluidized Bed Asbestos Segregator
FG	Finely Ground
GO	Grid Opening
IL	Inter-laboratory
ISO	International Organization for Standardization
ISSI	ISSI Consulting Group, Inc.
LA	Libby Amphibole
LB	Laboratory Blank
LC	Laboratory Coordinator
LDC	Laboratory Duplicate Cross-check
LDS	Laboratory Duplicate Self-check
MAS	Material Analytical Services, LLC
MB	Matrix Bundle
MBO	Matrix Bundle Obscured
MC	Matrix Cluster
MFL	Million Fibers per Liter
MF	Matrix Fiber
MFO	Matrix Fiber Obscured
NA	Not Applicable
NAM	Non-asbestos material
ND	Non-Detect
NIOSH	National Institute for Occupational Safety and Health
NVLAP	National Voluntary Laboratory Accreditation Program
OA	Other Amphibole
OU	Libby Operable Unit
PC	Point Count
PCM	Phase Contrast Microscopy
PCMe	PCM-Equivalent
PES	Performance Evaluation Sample
PLM	Polarized Light Microscopy
PLM-Grav	Polarized Light Microscopy Gravimetric
PLM-VE	Polarized Light Microscopy-Visual Area Estimation
QAM	Quality Assurance Manager
QAPP	Quality Assurance Project Plan
QA	Quality Assurance
QARD	Quality Assurance Reference Document
QATS	Quality Assurance Technical Support
QC	Quality Control
RD	Recount Different
RI/FS	Remedial Investigation/Feasibility Study
RP	Re-preparation
RPD	Relative Percent Difference
ROM	Record of Modification
RS	Recount Same
SAED	Selected Area Electron Diffraction
SAP	Sampling and Analysis Plan
s/cc	Structures per Cubic Centimeter
SOP	Standard Operating Procedure
SPF	Soil Preparation Facility
SRM	Solid Reference Material
TAT	Turn-around Time
TEM	Transmission Electron Microscopy
VA	Verified Analysis

1.0 Introduction

1.1 Purpose of this Report

This Annual Summary Report provides a summary of the Quality Assurance (QA) activities applied to asbestos sample data collected from Libby Superfund Site Operable Unit (OU) that occurred in 2016. The QC activities include the assessment of QC data, asbestos sample data validation, on-site laboratory audits, laboratory mentoring, and recommendations for improvements. Operable Unit 3 (OU3) is one (1) of eight (8) OUs designated by EPA for the Libby Remedial Investigation/Feasibility Study (RI/FS), which encompasses the mine property and surrounding areas impacted by releases from the mine, such as creeks, the Kootenai River, settling ponds, nearby forests, and Rainy Creek Road. The primary contaminant at OU3 is Libby Amphibole (LA) which is a form of asbestos present in the vermiculite that was mined at the site from 1919 to 1990. The Libby RI/FS at OU3 is being conducted through an Administrative Order on Consent (AOC) entered into by EPA with respondents W.R. Grace and Co. and Kootenai Development Corporation (KDC). This report was prepared for the U.S. Environmental Protection Agency (EPA) Region 8 by APTIM Federal Services, LLC's Quality Assurance Technical Support (QATS) Program under Task 9 of Task Order 1-021, *QA Support for RI/FS at Site OU3.*

1.2 Report Outline

The 2016 OU3 QA/QC assessments described in this report include:

- QC Data Evaluated
- Asbestos Data Validation
- Laboratory On-site Audits
- Laboratory Mentoring Program
- Conclusions and Recommendations

2.0 QC Data Evaluated

The QC data described in this section are from samples which were collected from the OU3 site and analyzed in 2016 by the EPA contract laboratories listed in **Table 1**, below.

Table 1 – 2016 Libby Laboratories

Abbreviation	Name, Location
EMSL03	EMSL Analytical, Inc., New York, NY
EMSL04	EMSL Analytical, Inc., Cinnaminson, NJ
EMSL32*	LA Testing/ EMSL Analytical, Inc., Pasadena, CA
ESATR8	ESAT Region 8, Golden, CO

* Formerly EMSL Analytical, Inc., Sierra Madre (EMSL45)

In 2016 EPA initiated two studies, or investigation phases, at the OU3 site. These include the Tree Bark and Duff Sampling (KG) and Woodstove Ash and Hooking/Skidding Activity-Based Sampling (WH) studies. **Table 2** presents the investigation phases with titles and the approximate dates in which they were performed at the Libby OU3 Superfund Site.

Table 2 – Libby OU3 Site Investigation Phases

Phase	SAP Phase Title	Date
Woodstove Ash & Hooking/Skidding (WH)	2016 Woodstove Ash and Hooking/Skidding Activity-Based Sampling Study Quality Assurance Project Plan, Revision 1	August – September, 2016
Tree Bark & Duff (KG)	2016 Tree Bark and Duff Sampling Study Quality Assurance Project Plan, Revision 0	September 2016

In 2016 EPA Region 8 contracted 285 field sample analyses from Libby OU3. Of these, 40 field samples were for the KG study, and 245 field samples were for the WH study. In total, including QC, 42 KG samples, 266 WH samples, and 116 blank samples were analyzed for the 2016 OU3 projects. The samples varied in media (air, ash, tree bark, duff, and wood) and were analyzed by EPA contract laboratories using the transmission electron microscopy (TEM) ISO 10312 method.

To determine and document the quality of the asbestos analyses conducted in support of these phases, EPA requires Quality Control (QC) analysis to accompany field sample analysis at frequencies and criteria goals as specified in Libby OU3 Laboratory Modifications and Sampling and Analysis Plans (SAPs). Two (2) types of QC analyses are applied to the Libby OU3 samples collected in 2016:

- Field QC Analyses
- Laboratory QC Analyses

2.1 Field QC Analyses

All of the field QC samples for OU3 in 2016 were analyzed by TEM.

Three (3) types of field QC analyses were applied to the Libby OU3 samples analyzed in 2016: field duplicates, field blanks, and lot blanks. These are defined as follows:

Field duplicates – A QC sample which is collected from the same approximate location and utilizing the same collection technique as the parent sample. As stated in both of the project QAPPs, "Because field duplicate samples are expected to have inherent variability that is random and may be either small or large, typically, there is no quantitative requirement for the agreement of field duplicates. Rather, results are used to determine the magnitude of this variability to evaluate data usability." For the 2016 OU3 projects, field duplicates were collected at a frequency of 10% (1 field duplicate for every 10 field samples) for each sample media (excluding air).

Field blanks – QC samples which are collected to evaluate potential contamination introduced during sample collection, shipping and handling, or analysis. For the 2016 OU3 WH project-only, air field blanks were collected at a frequency of one (1) field blank per day of collection.

Lot blanks – QC samples which are selected at random from each group of cassettes to be used for collection of air samples. Before air filter cassettes can be used for asbestos sampling, the lot must be asbestos-free. The selected lot blanks are analyzed for asbestos fibers by the same method used for field sample analysis. If any asbestos fibers are detected on the lot blanks, the entire batch of cassettes is rejected. Only lots of filters with acceptable lot blank results are placed in the general supply area for use by project personnel. For the 2016 OU3 WH project-only, two (2) lot blanks were randomly selected for TEM analysis.

Field QC are collected at the frequencies specified in Section B5 Quality Assurance/Quality Control of the project-specific QAPPs, and are specific to each media type as described above.

2.1.1 Field QC Results

Table 3 presents the TEM field QC sample summary for field duplicates, field blanks, and lot blanks related to the 2016 OU3 sampling events.

Table 3 – 2016 OU3 TEM Field QC Summary

Media	# of Field Samples		Field QC (frequency requirement)			
			Field Duplicates (10%)		# of Field Blanks (1/day)	# of Lot Blanks (2 total)
	Total	# of Not QC	#	%[2]		
Air	109	95			12	2
Ash[1]	36	33	3	9.1%		
Duff	61	55	6	10.9%		
Tree Bark	69	65	4	6.2%		
Wood	10	9	1	11.1%		
Totals	**285**	**257**	**14**	**8.6%[3]**	**12**	**2**

[1] Ash samples are prepared and analyzed in triplicate.
[2] Calculated using number of field samples, not including Field QC samples.
[3] Calculated excluding air samples (QAPPs do not require field duplicates for air media).

The frequency requirements for TEM field blanks and lot blanks specified by the QAPP were met for the 2016 OU3 sampling events, as indicated in **Table 3**. All 14 of the field and lot blank samples analyzed by TEM met the requirement criteria with non-detect (ND) results.

The frequency requirements for the field duplicates, as specified in both project QAPPs, Section B5.1.3, were not met, with the areas of discordance highlighted in yellow in **Table 3** above. As specified in Section B5.1.3 of the WH QAPP for duff, tree bark, and ash, and in the KG QAPP for duff and tree bark, "Field duplicate samples…will be collected at a frequency of 10% (1 per 10 field samples)," which accounts for 17 field duplicates overall (10% of 162 field samples, excluding air). Ash and tree bark sample media fell short of this requirement by one (1) and three (3) field duplicates, respectively.

The 2016 OU3 TEM field duplicate results were compared to the original analyses using the method for comparison of two Poisson rates described by Nelson (1982), based on a 90% confidence interval (CI). While 14 field duplicate samples were analyzed, for one (1) duff sample pair, the original sample (KG-00012) was not analyzed. Of the 13 field duplicate pairs analyzed for the 2016 OU3 projects, three (3) were ash, five (5) were duff, four (4) were tree bark, and one (1) was a duff sample.

Table 4 presents the statistical comparison for the original (first evaluation) and field duplicate (second evaluation) Total LA analyses and are identified by laboratory and sample number, as analyzed by the TEM-ISO method. Note that, the 90% CI requirement is not met where there is a statistical difference between Rate 1 and Rate 2, meaning that a combination of the counts and the sensitivity, must be within the 90% Poisson Ration rate.

Table 4 – 2016 OU3 TEM Field QC Statistical Comparison Using Two Poisson Rates – Total LA

Laboratory	Field Sample ID	Field Duplicate ID	Media	First Evaluation		Second Evaluation		Poisson Ratio Rate Comparison (CI=90%)
				Count	Sens [a]	Count	Sens [a]	
EMSL04	WH-00042	WH-00043	Ash	0	8.13E+06	0	9.45E+06	Both counts are 0; the rates are not different
EMSL04	WH-00069	WH-00070	Ash	1	8.13E+06	0	9.18E+06	[0-21.44] The rates are not statistically different
EMSL04	WH-00262	WH-00261	Ash	0	9.18E+06	0	9.83E+06	Both counts are 0; the rates are not different
EMSL04	KG-00012	KG-00013	Duff	NA	NA	2	4.49E+06	The parent sample was not analyzed.
EMSL04	KG-00031	KG-00033	Duff	6	4.44E+06	5	5.30E+06	[0.31-3.36] The rates are not statistically different
EMSL04	WH-00116	WH-00117	Duff	0	8.53E+05	0	1.66E+06	Both counts are 0; the rates are not different
EMSL04	WH-00149	WH-00148	Duff	0	7.80E+05	0	1.16E+06	Both counts are 0; the rates are not different
EMSL04	WH-00285	WH-00286	Duff	0	1.22E+06	0	6.61E+05	Both counts are 0; the rates are not different
EMSL04	WH-00321	WH-00320	Duff	1	1.74E+06	0	1.27E+06	[0-13.87] The rates are not statistically different
EMSL04	WH-00188	WH-00189	Tree Bark	1	1.12E+04	1	5.81E+04	[0.01-7.46] The rates are not different
EMSL04	WH-00198	WH-00199	Tree Bark	3	3.50E+04	7	5.67E+04	[0.06-0.95] Rate 1 is less than Rate 2
EMSL04	WH-00207	WH-00208	Tree Bark	3	3.46E+04	26	5.45E+04	[0.02-0.21] Rate 1 is less than Rate 2
EMSL04	WH-00216	WH-00217	Tree Bark	2	2.60E+04	45	2.64E+04	[0.01-0.14] Rate 1 is less than Rate 2
EMSL04	WH-00003	WH-00004	Wood	0	4.32E+04	0	1.02E+04	Both counts are 0; the rates are not different

Sens [a]: Ash & Tree bark $(cm)^{-2}$, Duff & Wood $(g)^{-1}$ NA = Not Applicable

As presented in **Table 4**, when considering Total LA results for the field duplicate samples, the first evaluation rate (Rate 1) was statistically different from the second evaluation rate (Rate 2) in three (3) of the 13 field duplicate pairs analyzed (highlighted in yellow).

Table 5 presents the statistical comparison for the original (first evaluation) and field duplicate (second evaluation) PCMe LA Structures analyses and are identified by laboratory and sample number, as analyzed by the TEM-ISO method.

Table 5 – 2016 OU3 TEM Field QC Statistical Comparison Using Two Poisson Rates – PCMe LA Structures

Laboratory	Field Sample ID	Field Duplicate ID	Media	First Evaluation		Second Evaluation		Poisson Ratio Rate Comparison (CI=90%)
				Count	Sens [a]	Count	Sens [a]	
EMSL04	WH-00069	WH-00070	Ash	1	8.13E+06	0	9.18E+06	[0-21.44] The rates are not different
EMSL04	KG-00031	KG-00033	Duff	1	4.44E+06	1	5.30E+06	[0.02-32.23] The rates are not different
EMSL04	WH-00198	WH-00199	Tree Bark	1	3.50E+04	0	5.67E+04	[0-30.81] The rates are not different
EMSL04	WH-00207	WH-00208	Tree Bark	1	3.46E+04	5	5.45E+04	[0.01-0.88] Rate 1 is less than Rate 2
EMSL04	WH-00216	WH-00217	Tree Bark	0	2.60E+04	7	2.64E+04	[0-0.53] Rate 1 is less than Rate 2

Sens [a]: Ash & Tree bark $(cm)^{-2}$, Duff $(g)^{-}$

As presented in **Table 5**, when considering PCMe LA structure results only, two (2) of the field duplicate sample pairs (highlighted in yellow above), of the five (5) total, resulted in first and second evaluation rates which were statistically different.

As shown in Table 4 and Table 5, ten (10) of the 13 results (76.9%) for the field duplicate sample pairs compared (were within the 90% CI) when evaluating for Total LA and three (3) of the five (5) results (60.0%) for the field duplicate sample pairs compared when evaluating for PCMe LA structures-only.

2.2 Laboratory QC Analysis

A variety of laboratory-based QC analyses are performed for Libby asbestos sample analyses, which are used to assess the quality of the associated sample data. Only TEM analyses were performed on the samples collected from the OU3 site in 2016. The results of laboratory QC applied to samples collected from the Libby OU3 Superfund site and analyzed for TEM by the contract laboratories (**Table 1**) in 2016, are described in this section.

TEM Laboratory QC

The laboratory QC requirements for TEM analyses at the Libby OU3 site are patterned after the requirements set forth by NVLAP, which include:

- TEM Laboratory Blanks (LBs)
- TEM Recount Analyses (RS, RD, and VA)
- TEM Re-preparations (RPs)
- TEM Inter-laboratory (IL) Analyses

Each of these TEM laboratory QC types have Phase-specific, program-wide frequency goal requirements as a percentage of the field samples analyzed. **Table 6** provides summaries of the number and frequency of TEM laboratory QC analyses performed for all media by laboratory in 2016.

Table 6 – 2016 OU3 TEM QC Sample Frequency

Lab	# of Field Samples	Laboratory QC (% Frequency Goal)											
		Blanks[1] (4%)		RS (1%)		RD (2.5%)		VA (1%)		RP (1%)		IL (1%)	
		#	%	#	%	#	%	#	%	#	%	#	%
EMSL03	12	2	16.7%	0	0.0%	1	8.3%	0	0.0%	0	0.0%	2	16.7%
EMSL04	205	102	49.8%	2	1.0%	6	2.9%	2	1.0%	2	1.0%	1	0.5%
EMSL32	12	2	16.7%	0	0.0%	1	8.3%	0	0.0%	0	0.0%	2	16.7%
ESATR8	56	10	17.9%	2	3.6%	3	5.4%	2	3.6%	1	1.8%	3	5.4%
Totals	**285**	**116**	**40.7%**	**4**	**1.4%**	**11**	**3.9%**	**4**	**1.4%**	**3**	**1.1%**	**8**	**2.8%**

[1] Blanks include Laboratory Blanks, Filtration Blanks, and Drying Blanks.

As summarized in **Table 6**, a total of 11 RD, four (4) RS and VA, and three (3) RP TEM analyses were performed in 2016 across the OU3 phases. Of the 116 total blank sample analyses, 47 were drying blanks, 44 were filtration blanks, and 25 were laboratory blanks. A total of eight (8) IL samples were analyzed for the 2016 OU3 phases, representing a total frequency of 2.8%, which exceeds the overall program goal of 1% IL frequency. One (1) reconciliation (RC) analysis was also performed due to an RD sample result which was not concordant with the original analysis result during the year.

As illustrated in **Table 6**, the TEM Laboratory QC sample frequency requirements for blanks, RS, RD, VA, RP, and IL QC samples were exceeded (by total) for all laboratories and phases combined. While some laboratories did not meet the percent frequency goals on an individual level, as highlighted in yellow above, the TEM QC frequency requirements for the 2016 OU3 sampling events, six (6) in total, met the OU3 QC requirements specified in Laboratory Modification LB-00029G for the program.

2.2.1 TEM Blanks

As shown in **Table 6**, a total of 116 blank samples of the 285 total field samples (40.7%) were analyzed and reported for TEM in 2016. No asbestos structures were found in any of the 2016 OU3 TEM laboratory QC blank analyses. 2016 OU3 TEM sample blanks were represented by three (3) blank types: laboratory blanks (LBs), drying blanks (DBs), and filtration blanks (FBs).

2.2.1.1 Laboratory Blanks

A LB for TEM analysis is prepared from new, unused filters and analyzed using the same procedures as applied to field samples. The purpose of a LB is to determine the presence of asbestos contamination during sample preparation and analysis in the TEM laboratory. As specified in Libby Laboratory Modification LB-000029 and the applicable SAPs (see **Section 8.0 References** of this report), LBs are to be analyzed at a frequency of 4.0%. All individual laboratories met the frequency goals for performing LBs, with 25 LBs for 285 field samples analyzed for an overall frequency of 8.8%.

2.2.1.2 Drying Blanks

A DB is used to determine if cross-contamination is occurring during the sample drying process, and consists of one (1) aliquot of asbestos-free quartz sand placed in each of the drying ovens used during the drying process. The DB samples were processed at a frequency of one (1) DB per drying oven used in the drying process, meeting the requirements for each project. The frequency goal for DBs was met, with 47 DBs analyzed for an overall frequency of 16.5%.

2.2.1.3 Filtration Blanks

An FB is a clean filter, prepared by passing filtered and deionized water through it to ensure that the filters are not contaminated in the laboratory, and that fluids used for diluting and processing samples are fiber-free. The FB samples were processed at a frequency of one (1) FB per filter used in the filtering process, meeting the requirements for each project. The frequency goal for FBs was met, with 44 FBs analyzed for an overall frequency of 15.4%.

2.2.2 TEM Recount Analyses

A recount analysis is an intra-laboratory re-examination of the original TEM grid openings (GOs) to verify the reported asbestos structure counts and characteristics. Three (3) types of recount analyses were performed by the 2016 OU3 TEM analytical laboratories:

- Recount Same (RS) – Select original GOs, usually the ten (10) with the highest number of LA structures, are re-examined by the same microscopist who performed the initial examination.
- Recount Different (RD) – Select original GOs, usually the ten (10) with the highest number of LA structures, are re-examined by a microscopist within the same laboratory who did not perform the initial examination.
- Verified Analysis (VA) – Similar to RD but with different documentation requirements, a VA must be recorded in accordance with the NIST (1994) protocol requirements.

Recount analyses were compared with the original analysis on a GO-by-GO, and structure-by-structure basis, with only those GOs that were able to be re-examined during the recount analysis included in the evaluation; in some instances grid openings may have been damaged with no alternates available. The degree of concordance between the original analysis and the recount analysis was evaluated based on the total number of countable LA structures observed for each grid opening that was re-examined. The concordance metrics, as defined in LB-000029, are summarized in **Table 7**.

Table 7 – TEM Recount Analysis Concordance Rules

Measurement Parameter	Concordance Rule
Number of LA structures within each grid opening	For grid openings with 10 or fewer structures, counts must match exactly. For grid openings with more than 10 structures, counts must be within 10 percent (%) as calculated as relative percent difference (RPD) (((maximum count – minimum count)/average count)*100%).
Asbestos class of structure (LA, OA, CH)	Must agree 100% on Chrysotile (CH) vs. amphibole. For assignment of amphiboles to LA or other amphibole (OA) bins, must agree on at least 90% of all amphibole structures.
LA Structure length	For fibers and bundles (all methods) and compact fiber (CF), compact bundle (CB), matrix fiber (MF), and matrix bundle (MB) structures (ISO), must agree within 1 micron (µm) or 10% (whichever is less stringent). For clusters and matrices (AHERA and ASTM) and compact fiber obscured (CFO), compact bundle obscured (CBO), compact cluster (CC), matrix fiber obscured (MFO), matrix bundle obscured (MBO), and matrix cluster (MC) structures (ISO), must agree within 2 µm or 20% (whichever is less stringent). The above percentages (%) are to be calculated as RPD (((1st analysis length – 2nd analysis length)/average length)*100%).
LA Structure width	For fibers and bundles (all methods) and CF, CB, CFO, CBO, MF, MB, MFO, and MBO structures (ISO), must agree within 0.5 µm or 20% (whichever is less stringent). For clusters and matrices (AHERA and ASTM) and CC and MC structures (ISO), there is no quantitative rule for concordance. The above percentage (%) is to be calculated as RPD (((1st analysis width – 2nd analysis width)/average width)*100%).
Presence of Sodium (Na) and Potassium (K)	There is no rule for concordance, but must be tabulated to identify potential trends that may indicate inconsistencies in recording practices or interpretation of spectra.

The TEM recount program-wide concordance criteria, as defined in LB-000029, are summarized in **Table 8**.

Table 8 – TEM Recount Program-wide criteria

QC Sample Type	Metric	Program-wide Criteria		
		Good	Acceptable	Poor
Lab Blanks	% with ≥1 asbestos structures	0% - 0.1%	0.2% - 0.5%	>0.5%
Recounts	Concordance on LA count*	>95%	85-95%	<85%
	Concordance on type (chrysotile vs. amphibole)	>99%	95%-99%	<95%
	Concordance on type (LA vs. other amphibole)	>99%	95%-99%	<95%
	Concordance on type (LA vs. NAM)	>99%	95%-99%	<95%
	Concordance on LA length	>90%	80%-90%	<80%
	Concordance on LA width	>90%	80%-90%	<80%
Re-preparations	Concordance on LA concentration/loading	>95%	90-95%	<90%

* Identified as Structures per GO throughout the applicable tables in this report.

Table 9 shows the TEM recount analysis results for the 11 RD, and four (4) each of RS and VA OU3 analyses performed in 2016. The recount results for all media and phase were combined, and are shown by mineral class, structure length, structure width, and matched structures per grid opening.

Table 9 – 2016 OU3 TEM Intra-laboratory Recount Analysis Results – By Media

Results for Matched LA Structures				
Media	**Attribute**	**Total**	**Pass**	**%**
Duff	LA vs. NAM	10	10	100%
	LA vs. OA	10	10	100%
	LA vs. CH	10	10	100%
	Structures per GO[1]	17	17	100%
	Structures per GO[2]	10	10	100%
	Structure Length	10	10	100%
	Structure Width	10	10	100%
	Na/K Presence	10	9	90%
Tree Bark	LA vs. NAM	72	72	100%
	LA vs. OA	72	72	100%
	LA vs. CH	72	72	100%
	Structures per GO[1]	24	19	79%
	Structures per GO[2]	23	18	78%
	Structure Length	72	72	100%
	Structure Width	72	72	100%
	Na/K Presence	73	58	79%
Ash	LA vs. NAM	1	1	100%
	LA vs. OA	1	1	100%
	LA vs. CH	1	1	100%
	Structures per GO[1]	5	5	100%
	Structures per GO[2]	1	1	100%
	Structure Length	1	1	100%
	Structure Width	1	1	100%
	Na/K Presence	1	1	100%
Air	LA vs. NAM	25	25	100%
	LA vs. OA	25	25	100%
	LA vs. CH	25	25	100%
	Structures per GO[1]	64	63	98%
	Structures per GO[2]	35	34	97%
	Structure Length	25	25	100%
	Structure Width	25	25	100%
	Na/K Presence	25	25	100%
Totals	LA vs. NAM	108	108	100%
	LA vs. OA	108	108	100%
	LA vs. CH	108	108	100%
	Structures per GO[1]	110	104	95%
	Structures per GO[2]	69	63	91%
	Structure Length	108	108	100%
	Structure Width	108	108	100%
	Na/K Presence	109	93	85%

LA – Libby Amphibole OA – Other Amphibole
CH – Chrysotile NAM – Non-asbestos Material
Structures per GO[1] – All grid openings, including those that did not contain reportable structures.
Structures per GO[2] – Grid openings that contained reportable structures.
Note: The structures determined to be ambiguous are included in the results presented in the table above.

As illustrated in **Table 9** above, the overall recount attributes for mineral class (LA vs. NAM, LA vs. OA, and LA vs. CH), concordance on LA count (structures per GO, including non-detects), structure length, and structure width were in the “Good” category, and concordance on LA count (structures per GO, excluding non-detects) was in the “Acceptable” range at 91%. By media, the only attribute which resulted in a “Poor” classification was the concordance on LA count (including and excluding NDs) for the tree bark recount sample analyses, as highlighted in yellow above. Though there is no rule for concordance for the presence of Na/K, they are tabulated to identify potential trends which may indicate inconsistencies in recording practices or interpretation of spectra.

In addition to the LB-000029 requirements, 100% (19 out of 19) TEM recount analysis results were within the applicable NISTR (NVLAP) requirements.

Unmatched structures are those structures either identified by the original (1st) analysis, but not the QC (2nd) analysis, or those identified by the QC analysis, but not the original analysis. **Table 10** below shows the unmatched structures by laboratory, unadjusted for ambiguous structures.

Table 10 – 2016 OU3 TEM Intra-laboratory Recount Analysis Structures Missed – By Laboratory

Laboratory	Structures Found		Structures Missed	
	Original	QC	#	%
EMSL03	1	1	0	0.0%
EMSL04	41	44	3	7.3%
EMSL32	5	5	0	0.0%
ESATR8	63	62	1	1.6%
TOTALS	**110**	**112**	**4**	**3.6%**

By laboratory, matched structures were identified with 100% confirmation by EMSL03 (1/1 structures) and EMSL32 (5/5 structures), 98.4% confirmation by ESATR8 (62/63 structures), and 92.7% confirmation by EMSL04 (41/44 structures. For the 2016 OU3 TEM recount analyses overall, laboratories confirmed the identification of all but four (4) structures (96.4%).

2.2.3 TEM Re-preparations

A TEM re-preparation (RP) is the re-analysis of a sample from which new grids have been prepared using a different portion of the same field sample filter used to prepare the original grids. The 2016 OU3 RP results were compared to the original analyses using the method for comparison of two Poisson rates described by Nelson (1982), based on a 90% confidence interval (CI). RPs provide information on analysis precision, as well as within-filter variability.

Table 11 presents the statistical comparison for the original and RP analyses as identified by sample number for the 2016 OU3 phases, representing the total LA. In 2016, three (3) sample RPs were prepared out of 285 TEM samples analyzed across all OU3 phases and laboratories, for a frequency of 1.1% (see **Table 6**). Of these three (3) RPs, none were found to be statistically different from the original analyses (see **Table 11**) with 100% of RP analyses results within the established criteria. When compared to the program-wide goals, the 100% acceptable RP analyses rates as “Good” (>95%). Note that, unless otherwise indicated, where the LA structure counts are different between the first and second evaluations, the 90% CI requirement is still met.

Table 11 – 2016 OU3 Re-preparation Statistical Comparison Using Two Poisson Rates – Total LA

Laboratory	Field Sample ID	Method	Media	First Evaluation Count	First Evaluation Sens [a]	Second Evaluation Count	Second Evaluation Sens [a]	Poisson Ratio Rate Comparison (CI=90%)
EMSL04	WH-00011	TEM-ISO	Ash	2	9.39E+06	1	9.39E+06	[0.16-57.99] The rates are not statistically different
EMSL04	WH-00217	TEM-ISO	Tree Bark	49	2.64E+04	41	2.66E+04	[0.82-1.72] The rates are not statistically different
ESATR8	WH-00128	TEM-ISO	Air	8	3.75E-03	12	3.88E-03	[0.27-1.49] The rates are not statistically different

Sens [a]: Ash & Tree bark $(cm)^{-2}$, Air $(CC)^{-1}$

Table 12 presents the statistical comparison for the original (first evaluation) and field duplicate (second evaluation) PCMe LA Structures analyses and are identified by laboratory and sample number, as analyzed by the TEM-ISO method.

Table 12 – 2016 OU3 Re-preparation Statistical Comparison Using Two Poisson Rates – PCMe LA Structures

Laboratory	Field Sample ID	Method	Media	First Evaluation Count	First Evaluation Sens [a]	Second Evaluation Count	Second Evaluation Sens [a]	Poisson Ratio Rate Comparison (CI=90%)
EMSL04	WH-00011	TEM-ISO	Ash	2	9.39E+06	1	9.39E+06	[0.16-57.99] The rates are not statistically different
EMSL04	WH-00217	TEM-ISO	Tree Bark	7	2.64E+04	4	2.66E+04	[0.53-6.35] The rates are not statistically different
ESATR8	WH-00128	TEM-ISO	Air	8	3.75E-03	11	3.80E-03	[0.29-1.7] The rates are not statistically different

Sens [a]: Ash & Tree bark $(cm)^{-2}$, Air $(CC)^{-1}$

As presented in **Table 12**, when considering PCMe LA structure results only, all three (3) sample pairs resulted in first and second evaluation rates which were not statistically different.

All three (3) of the results (100%) for the RP samples compared when evaluating for total LA and PCMe LA structures-only were within the 90% CI.

2.2.4 TEM Inter-laboratory Analyses

Eight (8) OU3 samples for the 2016 TEM re-preparation/inter-laboratory (RP/IL) analyses were selected in accordance with the most recent revision of Laboratory Modification LB-000029. These samples included four (4) air samples, two (2) tree bark samples, and one each of ash and duff samples. The list was provided to each of the Libby contract laboratories, who then retrieved the samples from archive storage, prepared the TEM grids, analyzed the samples, prepared the paperwork, and shipped the grids to the laboratory selected to perform the IL analyses. Upon receipt of the grid preparations at the laboratory scheduled to perform the second IL analysis, the GOs selected by the RP laboratory are reanalyzed in accordance with the same rules applied to the RP analyses. The criteria for TEM IL analyses are the same as those for the other recount analyses, described in **Section 2.2.2** above. **Table 13** provides a summary of the overall 2016 OU3 TEM IL results, across all laboratories, by media.

Table 13 – 2016 OU3 TEM Inter-laboratory Analyses – All Matching Structures

Results for Matched LA Structures				
Media	**Attribute**	**Total**	**Pass**	**%**
Duff	LA vs. NAM	2	2	100%
	LA vs. OA	2	2	100%
	LA vs. CH	2	2	100%
	Structures per GO[1]	10	9	90%
	Structures per GO[2]	3	2	67%
	Structure Length	2	2	100%
	Structure Width	2	2	100%
	Na/K Presence	2	2	100%
Tree Bark	LA vs. NAM	52	51	98%
	LA vs. OA	52	51	98%
	LA vs. CH	51	51	100%
	Structures per GO[1]	8	6	75%
	Structures per GO[2]	8	3	38%
	Structure Length	51	51	100%
	Structure Width	51	51	100%
	Na/K Presence	61	51	84%
Ash	LA vs. NAM	2	2	100%
	LA vs. OA	2	2	100%
	LA vs. CH	2	2	100%
	Structures per GO[1]	10	6	60%
	Structures per GO[2]	6	2	33%
	Structure Length	2	2	100%
	Structure Width	2	2	100%
	Na/K Presence	2	2	100%
Air	LA vs. NAM	7	7	100%
	LA vs. OA	7	7	100%
	LA vs. CH	7	7	100%
	Structures per GO[1]	40	37	93%
	Structures per GO[2]	9	8	89%
	Structure Length	7	7	100%
	Structure Width	7	7	100%
	Na/K Presence	7	6	86%
Totals	**LA vs. NAM**	**63**	**62**	**98%**
	LA vs. OA	**63**	**62**	**98%**
	LA vs. CH	**62**	**62**	**100%**
	Structures per GO[1]	**68**	**58**	**85%**
	Structures per GO[2]	**26**	**15**	**58%**
	Structure Length	**62**	**62**	**100%**
	Structure Width	**62**	**62**	**100%**
	Na/K Presence	**72**	**61**	**85%**

LA – Libby Amphibole OA – Other Amphibole
CH – Chrysotile NAM – Non-asbestos Material
Structures per GO[1] – All grid openings, including those that did not contain reportable structures.
Structures per GO[2] – Grid openings that contained reportable structures.
Note: The structures determined to be ambiguous are included in the results presented in the table above.

As presented in **Table 13**, with the exception of Structures per GO, IL analyses were all within the “Good” or “Acceptable” range of the program-wide criteria (**Table 8**) specified for Asbestos Class of Structure (LA vs. NAM, OA, or CH), Structure Length, and Structure Width. The exceptions for Structures per GO, as highlighted in yellow above in **Table 13**, include:

- Tree Bark – 38% and 75% of the GOs (excluding and including NDs, respectively) were in concordance with the structures per GO criteria, which falls into the “Poor” category (<85% concordance) described in **Table 8**.
- Duff – 67% of the GOs (excluding NDs) were in concordance with the structures per GO criteria, which falls into the “Poor” category (<85% concordance) described in **Table 8**.
- Ash – 33% and 60% of the GOs (excluding and including NDs, respectively) were in concordance with the structures per GO criteria, which falls into the “Poor” category (<85% concordance) described in **Table 8**.

- Totals – 58% of the GOs (excluding NDs) were in concordance with the structures per GO criteria, which falls into the “Poor” category (<85% concordance) described in **Table 8**.

In addition to the LB-000029 requirements, 75% (6 out of 8) RP/IL sample pair results were within the applicable NISTR (NVLAP) requirements.

The discordances presented above may be attributed to false negative results potentially caused by analyst error and/or misinterpretation, chemical variability among structures, tears in the film replicate causing the relocation of fibers, etc. Note that no program-wide criteria from **Table 7** apply to NaK.

Unmatched structures are those structures either identified by the RP laboratory, but not the IL laboratory, or those identified by the IL laboratory, but not the RP laboratory. **Table 14** below shows the unmatched structures by sample for each analysis, unadjusted for ambiguous structures.

Table 14 – 2016 OU3 TEM IL Analysis Structures Missed – By Sample

Sample Number	RP				IL			
	Laboratory	# Str	Missed Str	% Missed	Laboratory	# Str	Missed Str	% Missed
WH-00334	EMSL03	0	0	NA	EMSL04	0	0	NA
WH-00218	EMSL04	18	5	28%	EMSL32	23	0	0%
KG-00026	EMSL04	2	1	50%	ESATR8	3	0	0%
KG-00040	EMSL04	49	0	0%	EMSL03	39	10	26%
WH-00301	EMSL04	0	0	NA	EMSL32	0	0	NA
WH-00095	EMSL04	2	4	200%	ESATR8	6	0	0%
WH-00232	EMSL32	3	0	0%	ESATR8	3	0	0%
WH-00345	ESATR8	6	0	0%	EMSL03	4	2	50%
	TOTAL RP	**80**	**10**	**13%**	**TOTAL IL**	**78**	**12**	**15%**

Samples WH-00334 and WH-00301 were reported as ND in both analyses.

RP = Re-preparation IL = Inter-laboratory Str = Structures NA = Not Applicable

In total, matched structures were identified with 87% confirmation by the RP laboratory with a total of 10 structures missed and 80 structures found. Three (3) samples accounted for all of the missed structures in the RP analyses. Matched structures were identified with 85% confirmation by the IL laboratory with 12 structures missed and 78 structures found. Two (2) samples accounted for all of the missed structures in the IL analyses.

Evaluating by laboratory performance, **Table 15** below shows the unmatched structures by laboratory, unadjusted for ambiguous structures.

Table 15 – 2016 OU3 TEM IL Analysis Structures Missed – By Laboratory

Laboratory	Structures		% Missed
	Found	Missed	
EMSL03	43	12	28%
EMSL04	71	10	14%
EMSL32	26	0	0%
ESATR8	18	0	0%
TOTALS	**158**	**22**	**14%**

Matched structures were found with 100% confirmation by EMSL32 and ESATR8 (26/26 and 18/18 structures, respectively), 86% confirmation by EMSL04 (61/71 structures), and 72% confirmation by EMSL03 (31/43 structures) in the 2016 OU3 TEM IL study overall, combining for the confirmed identification of 22 of 158 total structures (86%), when considering both analyses for each sample. A total of 22 of 158 combined structures were missed (14%).

The limited number of structures found in the 2016 OU3 TEM IL samples did not warrant an assessment excluding ambiguous structures. If adequate structures are found, additional considerations for laboratory performance can be made by excluding ambiguous structures, thereby basing the analyses upon only those results considered most appropriate.

3.0 Asbestos Data Validation

The QATS Program provided data validation support for 41 selected samples from the WH project. Data validation was performed in accordance with the applicable TEM ISO 10312 method, SAP Analytical Requirements Summary (WHOU3-0816), Laboratory Modifications, and QATS Libby-specific data validation SOPs. The validation SOP applied by the QATS Program included SOP QATS-70-095 (Validation of Libby Transmission Electron Microscopy (TEM) Data Deliverables).

The validation process involves evaluating asbestos data based on the analytical requirements in the applicable method or SOP used by EPA for analysis of samples collected at Libby Superfund Site OUs. Criteria that are evaluated and reported include sample receipt, sample preparation, microscope alignment, instrument calibrations, stopping rules, structure recording and identification, blank analysis (if applicable), recount/re-preparation analysis (if applicable), and overall assessment of data.

Data are qualified if the daily or monthly calibrations associated with a sample set were not performed at the required frequency, or if the calibrations fail to meet method requirements. The equipment alignment and calibration documentation from each of the Libby support laboratories are provided separately on a quarterly basis. This calibration information is entered into laboratory-specific spreadsheets, where the data validators can access the information and verify that the calibrations were acceptable and performed at the correct frequency for the analyses being evaluated.

B-qualifiers for blank contamination are applied during the validation process for those blanks directly associated with field samples (i.e., provided with a particular deliverable selected for validation). In addition to those QC analyses reviewed during the validation of select deliverables, QC analyses are also reviewed and evaluated on a program-wide basis to ensure they are both performed at the required frequency and that they are within the applicable criteria. With the exception of QC analyses directly associated with a particular set of samples, laboratory QC analyses are performed to determine the quality of the collective data, and not the quality of any specific single set of samples.

The data validation process also includes a comparison of the information reported on the bench sheets to the entries in the associated laboratory method-specific EDDs to ensure that the reported results are complete, compliant with the specified methodology, and accurate. These comparison discrepancies are noted in a separate table of the data validation report. An EPA-approved QATS Data Review Checklist is used to document the data validation process.

Forty-one (41) of the total 424 OU3 samples (9.7%) were validated of the 2016 OU3 samples analyzed. The 41 asbestos samples validated came from five (5) Laboratory Job Numbers, analyzed by four (4) different laboratories for the 2016 Libby OU3 analytical events. The phase, laboratories, chain-of-custody (COC) numbers, Laboratory Job Numbers, method, matrix, and sample counts are presented, as follows, in **Table 16** for the asbestos data:

Table 16 – 2016 OU3 Asbestos Sample Data Validation Summary

Phase	Lab	COC Number	Laboratory Job Number	Method	Matrix	Total Sample Analyses	Field Samples (Not QC)	Total QC Samples
WH	ESATR8	160916JK06	A160559	TEM ISO	Air	8	6	2
WH	ESATR8	060916MB01	A160500	TEM ISO	Air	8	6	2
WH	EMSL32	150916JK01	321620863	TEM ISO	Air	8	6	2
WH	EMSL04	050916MB02	041625412	TEM ISO	Air	9	6	3
WH	EMSL03	150916JK04	031629111	TEM ISO	Air	8	6	2
OVERALL TOTALS						**41**	**30**	**11**

The 41 total asbestos samples validated for OU3 in 2016 consisted of 30 field samples and 11 QC samples. The QC samples included seven (7) LBs, two (2) RDs, and one (1) each of RS and RPs. No qualifiers were applied to any of the 41 2016 OU3 asbestos samples validated. The bench sheet/EDD information comparisons found that of the 41 asbestos samples validated, two (2) samples and one (1) LB contained some type of bench sheet/EDD discrepancy. All of the identified discrepancies were considered by the validators as minor (i.e., typographical errors or omissions in fields) and as having no impact on the sample results. As verified by QATS personnel, the EDDs were corrected by the applicable laboratory personnel to reflect the correct information subsequent to this validation, and so no further action is required.

4.0 Laboratory On-site Audits

No on-site audits of the Troy, MT soil preparation facility (SPF) or asbestos laboratories used by USEPA for analytical support at the OU3 Libby Superfund Site were conducted in 2016.

4.1 On-site Audit Process

As directed by EPA Region 8, no on-site audits were performed for OU3 in 2016. On-site audits are typically used by EPA to verify that samples analyzed by their contract facilities are processed in accordance with EPA requirements. Each on-site audit involves the general elements of preparation, on-site support, and report generation, which are modified as needed to fit the type of audit being performed.

Preparation for asbestos laboratory audits typically involves ensuring the on-site audit checklist to be used is updated to reflect the latest methods and modifications required for Libby sample preparation and analysis; coordination with Region 8 to receive the most recent copies of the laboratory's SOPs, Quality Assurance Manual (QAM) and other needed documentation; and coordination with the EPA representative attending the audit with regard to travel logistics. If there are any anticipated problem areas based on prior evaluation of QC/QA data or validation reports, the auditor will discuss these with the EPA member of the Audit Team prior to the audit.

The on-site audit generally starts with an entrance briefing to the laboratory regarding the areas to be evaluated and the anticipated duration of the audit. This is followed by evaluating areas throughout the laboratory to verify adherence to Libby project analysis requirements, the laboratory preparation and analysis SOPs, and adherence to the requirements in the laboratory QAM. The areas typically audited in an asbestos laboratory include: Sample Receipt, Log-in, Storage, and Chain-of-Custody (COC) procedures; Indirect and Direct Preparation of Samples; Transmission Electron Microscopy (TEM) Analysis; Polarized Light Microscopy (PLM) Analysis; Data Management; and Quality Control/Quality Assurance. As part of the QA/QC assessment, the laboratory's internal audit and air monitoring programs are evaluated. All laboratory staff involved with handling, preparing, analyzing, reporting, and performing QC on Libby samples are interviewed. Findings are identified and reported to the laboratory at the exit debriefing.

On-site audit reports detailing the findings are prepared and submitted to EPA typically within 30 days and, following EPA approval, are sent to the laboratories by EPA. Audited laboratories are required to provide corrective action responses to EPA regarding the on-site audit findings. Areas where findings were identified are evaluated during the subsequent on-site audit to determine the degree to which the laboratories have applied corrective action.

5.0 Laboratory Mentoring Program

EPA Region 8's mentoring program for laboratories supporting Libby OU3 projects include training, site-specific reference materials, technical discussions, monthly EPA/laboratory calls, electronic data audits, and the use of laboratory modification forms.

To ensure that new laboratories have properly trained staff to perform analysis of Libby site samples, EPA established training programs that allow laboratories and/or analysts who are experienced with the analysis of LA provide training and mentoring to new laboratories prior to the receipt and analysis of Libby field samples. This training program for new laboratories includes a rigorous 2-3 day period of on-site training provided by senior personnel from those laboratories who are highly experienced with the Libby project. Training includes a review of morphological, optical, chemical, and electron diffraction characteristics of LA, as well as training on the project-specific analytical methodology, documentation, and administrative procedures required for the Libby site. No new laboratories were mentored for Libby OU3 during 2016.

For those laboratories and analysts already analyzing samples from the Libby site, the following reference materials, EDD tools, SOPs, laboratory modification, and meeting participation are in place to ensure consistency and continued training:

<u>Site-specific Reference Materials</u>

- TEM - Because LA is not a common form of asbestos, USGS prepared site-specific reference materials using LA collected at the Libby mine site (EPA 2008a), which each laboratory must analyze in order to become familiar with the physical and chemical appearance of LA and establish a reference library of instrument-specific LA EDS spectra.

<u>Monthly Technical Discussions</u>

To ensure that all laboratories are aware of technical or procedural issues and requirements, teleconference calls, when scheduled, are held between EPA, their contractors, and each of the participating laboratories. These calls cover all aspects of the analytical process, including sample flow, information processing, technical issues, analytical method procedures and development, documentation issues, project-specific laboratory modifications, and pertinent asbestos publications.

Electronic Data Deliverable (EDD) Reporting

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 Libby-specific EDD was developed for each type of analytical method. Each EDD contains a variety of built-in QC functions that improve the accuracy of data entry and help maintain data integrity. As reported in the data validation section, the three (3) EDD reporting discrepancies observed in the 41 samples validated reflects a 93% EDD reporting accuracy.

Laboratory Modification Forms

When changes or revisions are needed to improve or document specifics about analytical methods or procedures used by the Libby laboratory team, these changes are documented using laboratory modification forms, which provide a standardized format for tracking procedural changes in sample analysis, allowing project managers to assess potential impacts on the quality of the data being collected. A list of current, active modifications is provided in **Section 6.0**.

6.0 Laboratory Modifications

Of the 17 permanent laboratory modifications which were current and active in 2016, eight (8) were applicable to the 2016 OU3 sampling projects as presented in **Table 17**. A summary description of laboratory modification LB-000105A which was updated in September 2016, follows the table.

Table 17 – 2016 OU3 Applicable Laboratory Modifications

Lab Mod	Effective/ Revision Date	Description
LB-000016H	03/19/2012	TEM by Method ISO 10312
LB-000020D	04/22/2015	TEM Water
LB-000029G	03/21/2016	TEM QC
LB-000066E	08/15/2013	Structure photos, spectra, and NaK codes
LB-000067C	04/01/2013	General TEM recording rules (sketch structures, ND stands for “Not Detected”, list of valid values for Structure ID, lab blanks always have LQ-00001 as sample number, Prep Date is when prep starts)
LB-000085A	05/04/2012	TEM Calibrations
LB-000091	07/16/2013	Indirect Preparation
LB-000105A	09/21/2016	EPA-Libby-2012-11 Ash-specific

LB-000029G (revised 03/21/2016) – This permanent modification was necessary to non-countable/countable counting rules to account for variations between the TEMs used at the different labs, which can sometimes rotate the Grids in such a way that what is countable at one laboratory is not countable at another. In addition, the frequency of the inter-labs has been changed from annually to quarterly to ensure potential problems are addressed in a more timely manner. This modification was necessary to both address the countable/non-countable issue encountered during the TEM inter-labs and also increase the frequency to ensure problems are addressed in a more timely manner.

LB-000105A (revised 09/21/2016) – This modification serves to standardize the ash-specific preparation and analysis procedures, as related to EPA-Libby-2012-11. This modification clarifies that for forest fire ash, asbestos concentration is reported in terms of ashed residue and for woodstove ash, it clarifies that chunks or bits of charred wood are not expected to contribute significantly to airborne dust.

7.0 Conclusions and Recommendations

QC Data Evaluated

Field QC

The field QC samples collected for the 2016 OU3 studies included field blanks, lot blanks and field duplicates for TEM. Field QC frequencies and requirements were met in all cases, with the exception of TEM field duplicates, which, overall, fell just short of the 10% frequency requirement specified in the QAPPs. A total of 17 field duplicates overall (10% of 162 field samples, excluding air) would be required, where only 14 field duplicate samples (9%) were actually collected. The QATS Program recommends that a field record of modification (ROM) be generated by the sampling contractor which describes the deficiency.

While the field QC frequencies required by the two (2) sampling projects for OU3 in 2016 were the same, because each OU3 phase typically requires different QC sample processing frequencies based upon the applicable SAP, the QATS Program recommends that field SAPs be read and acknowledged by all field personnel, and that COCs are reviewed to ensure that field QC are collected at the frequencies required by the investigation-specific SAPs.

Laboratory Analysis QC - TEM

<u>TEM QC Frequency</u>

As described in **Section 2.2**, the results reported from all four (4) laboratories combined met the OU3 program-wide TEM QC sample frequency requirements for LB, RS, RD, VA, RP, and ILs, as described in Laboratory Modification LB-0000029. TEM QC frequency requirements were also met in the previous year, which was likely attributed to procedural changes enacted to ensure an appropriate number of QC analyses were performed in 2015, specifically those with frequency requirements of 1.0%. Laboratory Modification LB-000029 was modified (following a QATS Program recommendation) to ensure that adequate QC analyses are performed when less than the number of samples necessary to trigger these analyses are reached.

One hundred sixteen (116) total blanks (including 25 TEM LBs, 44 filtration blanks, and 47 drying blanks) were analyzed by participating laboratories in 2016, with no asbestos structures observed. This suggests that asbestos contamination was not introduced during preparation or analyses of TEM samples. All individual laboratories met the OU3 program frequency requirements for blanks without exception. The overall program frequency of TEM LB analyses is 8.8%, exceeding the Laboratory Modification LB-000029 frequency requirement of 4.0%.

Laboratory TEM QC Concordance

The 2016 TEM intra-laboratory recount analyses (i.e., RS and RD) presented in **Table 9** fell into the "Good" and "Acceptable" ranges described in **Table 8** with the exception of the "Poor" categorization for LA count structures per GO (including and excluding NDs; 79% and 78%, respectively) for the tree bark recount sample analyses. Statistical analysis of the RP results detailed in **Table 11** shows that 100% of the three (3) RP analyses were within the 90% CI established for their evaluation of total and PCMe LA, falling into the "Good" rating category, as established by the program-wide goals.

Overall, the 2016 TEM inter-laboratory (IL) analyses presented in **Table 13** fell into the "Good" and "Acceptable" ranges described in **Table 8** with the exception of the "Poor" categorization for structures per GO (including and/or excluding NDs) for various media (tree bark, ash, and duff) and in total (excluding NDs; 58%).

Asbestos Data Validation

In 2016, data validation was performed on 41 Libby OU3 samples, which is 14.4% of the number analyzed. One-hundred percent (100%) of the 41 Libby OU3 asbestos results for samples validated in 2016 required no qualification. Bench sheet/EDD comparisons were also conducted on all samples validated in 2016. Of the 41 sample results validated, three (3) bench sheet/EDD discrepancies were identified. These were considered minor (i.e., typographical errors or omissions in fields), and had no impact on the sample results.

Laboratory On-site Audits

In 2016, the QATS Program was not tasked to perform any on-site audits of the Troy, MT soil preparation facility (SPF) or asbestos laboratories used by USEPA for analytical support at the OU3 Libby Superfund Site. It is recommended that the on-site audit program continue, with at least biennial full, 2-day on-site audits scheduled at the Libby asbestos support laboratories and the SPF. The QATS Program will use information gathered from the validation process, Inter-laboratory studies, and feedback from data users to further enhance the on-site audit process.

8.0 References

EPA 2016 Woodstove Ash and Hooking/Skidding Activity-Based Sampling Study Quality Assurance Project Plan, Operable Unit 3, Libby Asbestos Superfund Site (Revision 1). U.S. Environmental Protection Agency, Region 8. August 2016.

EPA 2016 Tree Bark and Duff Sampling Quality Assurance Project Plan, Operable Unit 3, Libby Asbestos Superfund Site (Revision 0), U.S. Environmental Protection Agency, Region 8. August 2016.

Nelson W, Applied Life Data Analysis, John Wiley and Sons, New York, 1982.

NIST, Airborne Asbestos Method: Standard Test Method for Verified Analysis of Asbestos by Transmission Electron Microscopy – Version 2.0. National Institute of Standards and Technology, Washington DC. NISTIR 5351, March 1994.

Stantec

ATTACHMENT E
COMPARISON OF TOTAL AND PCME LAA CONCENTRATIONS IN TREE BARK AND INNER WOOD

Attachment E. Comparison of Total and PCME LAA Concentrations in Tree Bark and Inner Wood

ABS AREA	DISTANCE CATEGORY	PCME or TOTAL LAA	Pooled Tree Bark Results (Converted to Ms/g)			Inner Wood Results			Poisson Ratio Comparison Test (90% CI) *Rate 1 = Tree Bark LAA Concentration* *Rate 2 = Inner Wood LAA Concentration*
			N STRUCTURES	POOLED LAA CONCENTRATION (Ms/g, dw)	POOLED ACHIEVED SENSITIVITY (g^{-1})	N STRUCTURES	POOLED LAA CONCENTRATION (Ms/g, dw)	POOLED ACHIEVED SENSITIVITY (g^{-1})	
Area A	Within OU3 Boundary	TOTAL	94	2.4	3E+04	0	0	3E+04	[0-0.04] Rate 1 is greater than Rate 2
Area C	Within OU3 Boundary	TOTAL	37	1.0	3E+04	0	0	4E+03	[0-0.01] Rate 1 is greater than Rate 2
Area D	Within OU3 Boundary	TOTAL	10	0.16	2E+04	2	0.060	3E+04	[0.7-17.35] The rates are not different
Area E	Within OU3 Boundary	TOTAL	25	0.44	2E+04	1	0.011	1E+04	[7.73-801.15] Rate 1 is greater than Rate 2
Area H	Within OU3 Boundary	TOTAL	2	0.023	1E+04	0	0	1E+05	[0-34.48] The rates are not different
Area B	Outside OU3 Boundary	TOTAL	12	0.47	4E+04	0	0	1E+05	[0-0.7] Rate 1 is greater than Rate 2
Area F	Outside OU3 Boundary	TOTAL	5	0.095	2E+04	0	0	4E+04	[0-1.87] The rates are not different
Area G	Outside OU3 Boundary	TOTAL	21	0.48	2E+04	0	0	3E+04	[0-0.18] Rate 1 is greater than Rate 2
Area I	Outside OU3 Boundary	TOTAL	6	0.14	2E+04	0	0.00	3E+05	[0-6.95] The rates are not different
Area A	Within OU3 Boundary	PCME	14	0.36	3E+04	0	0	3E+04	[0-0.28] Rate 1 is greater than Rate 2
Area C	Within OU3 Boundary	PCME	8	0.23	3E+04	0	0	4E+03	[0-0.07] Rate 1 is greater than Rate 2
Area D	Within OU3 Boundary	PCME	6	0.10	2E+04	0	0	3E+04	[0-1.19] The rates are not different
Area E	Within OU3 Boundary	PCME	2	0.04	2E+04	1	0.011	1E+04	[0.25-91.74] The rates are not different
Area H	Within OU3 Boundary	PCME	1	0.012	1E+04	0	0	1E+05	[0-188.68] The rates are not different
Area B	Outside OU3 Boundary	PCME	0	0	4E+04	0	0	1E+05	Both counts are 0; the rates are not different
Area F	Outside OU3 Boundary	PCME	3	0.057	2E+04	0	0	4E+04	[0-3.9] The rates are not different
Area G	Outside OU3 Boundary	PCME	4	0.092	2E+04	0	0	3E+04	[0-1.31] The rates are not different
Area I	Outside OU3 Boundary	PCME	0	0	2E+04	0	0	3E+05	Both counts are 0; the rates are not different

Notes:

g^{-1} = per gram

Ms/g, dw = million structures per gram (dry weight)

ABS = activity based sampling

CI = confidence interval

LAA = Libby amphibole asbestos

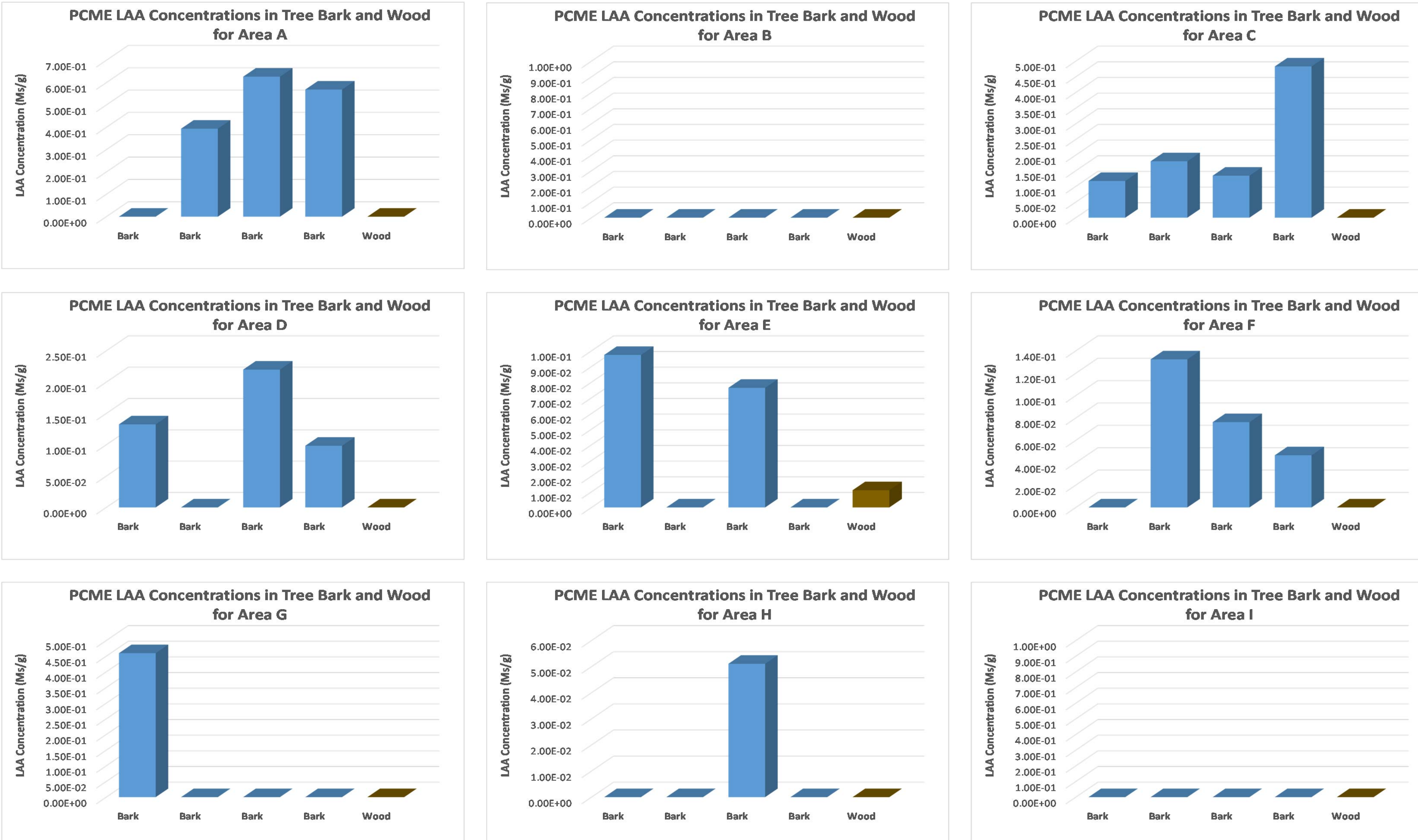
No. = number

OU3 = Operable Unit 3

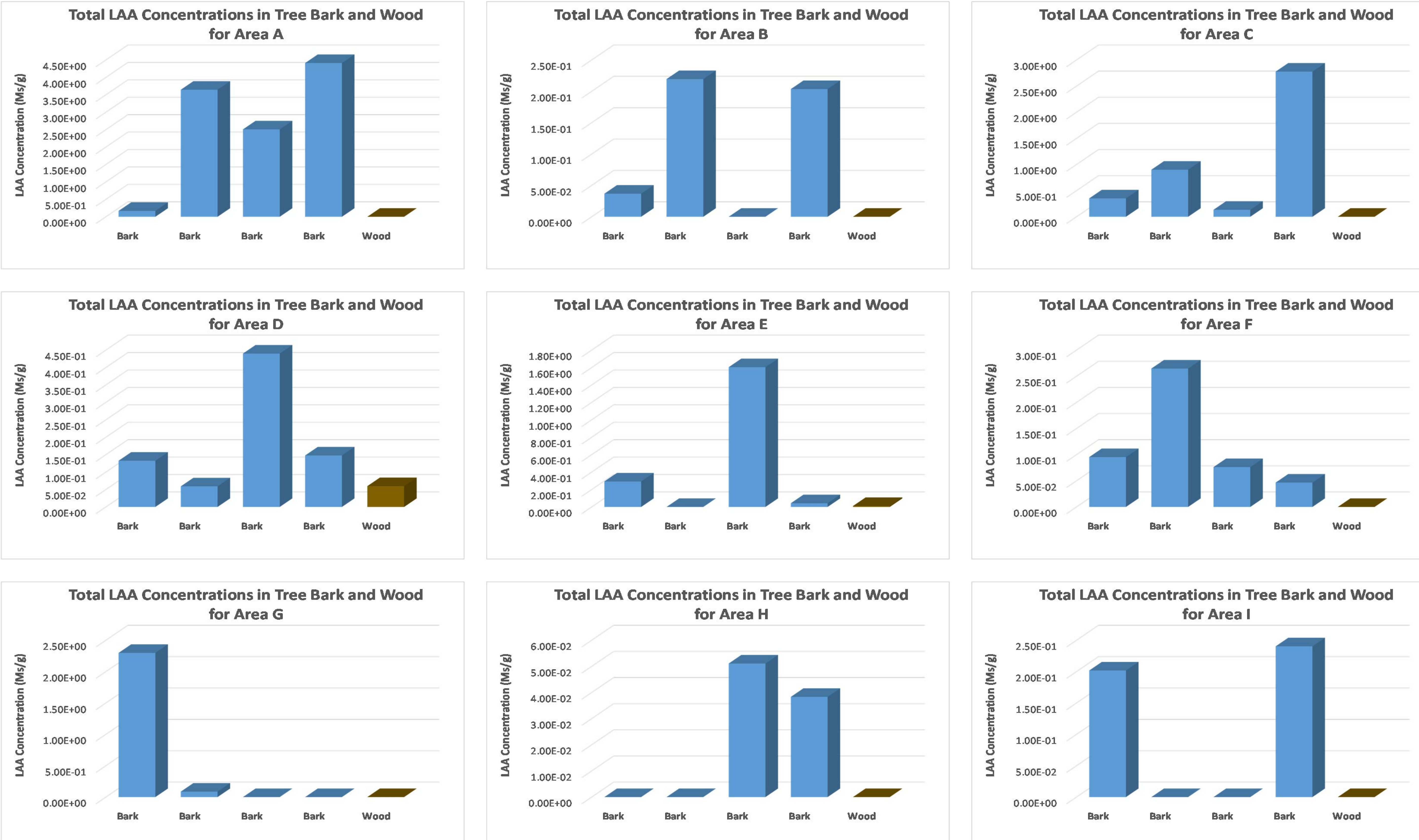
PCME = phase contrast microscopy equivalent

Total LAA: Structures with a length ≥ 0.5 micrometer (µm) and an aspect ratio ≥ 3:1

PCME LAA: Structures with a length > 5 µm, width ≥ 0.25 µm, and an aspect ratio ≥ 3:1



Attachment E-1. Tree Bark/Inner Wood PCME LAA Graphical Data Comparison by ABS Area



Attachment E-2. Tree Bark/Inner Wood Total LAA Graphical Data Comparison by ABS Area