Expert Witness Report – Barnes, Braaten and Flores vs. BNSF et al.

Submitted by Julie F. Hart, PhD, CIH
October 25, 2018

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October 21, 2018

Mr. Ethan Welder
McGarvey, Heberling, Sullivan & Lacey, P.C.
345 First Avenue East
Kalispell, MT 59901

Dear Ethan,

I have reviewed the materials provided to me pertaining to the Libby Claimants' actions against the BNSF Railway Company, with specific reference to Tracie Barnes, Rhonda Braaten and Gerrie Flores. My analysis and opinions regarding their exposure to asbestos resulting from BNSF activities in the Libby area follows. This report is authored at your request and direction to provide those opinions and a summary of the grounds therefor. Over the course of several years, I have collaborated with Dr. Terry Spear in analyzing and developing reports he has authored regarding railroad activities in the Libby area. Due to that close collaboration with Dr. Spear, along with the fact application of the pertinent facts here to generally accepted industrial hygiene and toxicology standards requires opinions like those authored by Dr. Spear, I am independently adopting many aspects of Dr. Spear's prior reports. While my opinions may be similar to those previously offered by Dr. Spear, this report represents a summary of my opinions and all of which are offered to a reasonable degree of scientific certainty, more probable than not. The opinions expressed in this report are based on my education, training, and years of experience in the field of toxicology and industrial hygiene as well as my review of literature, publications, research and other information on the subject. I expect to reference and rely upon opinions and materials referenced or discussed in the expert reports and disclosures of Dr. Barry Castleman, Dr. Arthur Frank, Dr. Carrie Redlich, Dr. Terry Spear, and Julian Marshall. I reserve the option to alter my opinion based on additional information obtained through discovery or otherwise. Recently, numerous documents have been produced by BNSF in discovery and have been produced by BNSF's contractors in response to subpoenas. I am currently in the process of reviewing those recently produced documents and may supplement this report as review progresses. Please note, the referenced Exhibits are included as hyperlinked attachments to this document, available in the associated Attachments file, and listed in the Table of Exhibits.

I. Qualifications

1. **General**: My name is Julie F. Hart. I hold a Ph.D in Toxicology and a M.S. in Industrial Hygiene. I am certified by the American Board of Industrial Hygiene in Industrial Hygiene, Comprehensive Practice (certification number 7751 CP). I have served as a faculty member in the Safety, Health and Industrial Hygiene Department at Montana Tech since 2000 and was appointed department chair in 2014. In addition, I currently serve as an officer for the Pacific Northwest Section of the American Industrial Hygiene Association. My curriculum vitae is attached as Appendix A of this report.

2. **Libby Specific:** I have experience in the field of industrial hygiene and exposure science. In 2005, after our research team discovered amphibole contamination on the surface of

tree bark in the forested area near the former vermiculite mine, we performed substantial research on the potential for human exposures related to this source. I have been successful in securing funding from external sources for this research from the United States Department of Agriculture Forest Service, National Institute for Occupational Safety and Health and The Rocky Mountain Center for Occupational and Environmental Health, University of Utah School of Medicine. I am lead author on two and co- author on five peer-reviewed publications pertaining to Libby amphibole asbestos (LA) and I am currently involved in research in the Libby area. I have presented this LA exposure work at regional and national conferences.

I have reviewed the expert reports of Dr. Julian Marshall, Dr. Carrie Redlich, Dr. Arthur Frank, and Dr. Barry Castleman and I rely, in part, on these reports in the formation of my opinions. I am familiar with the studies, reports and other materials referenced in these reports and rely upon, and may refer to them, in support of my opinions during my testimony in deposition or at trial. I have interviewed several dozen railroad workers and Libby residents regarding their knowledge of the presence of vermiculite and the production of dust in and around railroad properties in Lincoln County, Montana, among other topics. I have visited Libby on numerous occasions over a 13-year period. I have reviewed thousands of records from BNSF[1], W.R. Grace, Zonolite, governmental agencies including United States Environmental Protection Agency ("EPA") records, State of Montana agency records, records of third parties, relevant and industrial hygiene and toxicology literature, and applicable statutes, and regulations. I have reviewed numerous transcripts of testimony of BNSF employees, industrial hygienists, and expert witnesses (along with associated expert reports). I have reviewed over many years relevant industrial hygiene literature pertaining to asbestos and have conducted research into pathways of exposure to asbestos. All of these materials are the type regularly relied upon by professional industrial hygienists in the performance of their profession.

II. <u>Industrial Hygiene and Asbestos</u>

3. **IH Purpose**: Industrial hygiene (IH) is the science and art devoted to the anticipation, recognition, evaluation, and control of those workplace environmental factors that may cause sickness, impaired health and well-being, or significant discomfort and inefficiency among workers or among citizens of the community. The scope of IH activities encompasses the "cradle-to-grave" concept (research of industrial processes from initiation all the way through the final waste disposal stage). Industrial hygiene is both an aspect of preventative medicine and in particular occupational medicine, in that its goal is to prevent industrial disease, using the science of risk management, and exposure assessment.

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[1] Unless more specifically referenced, the term "BNSF" refers to the Burlington Northern Santa Fe Railway along with its predecessor railroads including but not limited to the Chicago, Burlington & Quincy Railroad Company (Burlington Railroad), the Atchison, Topeka and Santa Fe Railroad Company (Santa Fe Railroad) and the Great Northern Railroad.

Reasonable and prudent industrial hygiene practice since the early 1900s requires that workplaces be evaluated for potential employee exposure to toxic materials and that controls be implemented on any worksite where there are employees with potential exposure to toxic dust, such as asbestos. Ultimately, the central purpose of industrial hygiene is to: (1) study; (2) warn; and (3) protect.

4. **Sources of IH Literature:** Industrial hygienists commonly rely on literature published in the fields of Industrial Hygiene, Occupational Medicine, and Toxicology, as well as general medical literature. Occupational hygienists rely on literature from industry, academia, governmental agencies and independent entities. It is important to assess available data from all sources, both qualitative and quantitative, to measure potential exposures and to utilize professional judgment in the application of industrial hygiene principles.

5. **1920s First Reported Cases of Asbestosis:** While there was documentation of pulmonary disorders associated with asbestos exposure in the early 20th century, Dr. W.E. Cooke, an English pathologist, was the first to describe fibrosis of the lungs due to asbestos exposure in medical literature (Cooke, 1924 and Cooke, 1927). The subject of Cooke's papers was a 33-year-old female that worked in the spinning room of a Rochdale asbestos company. An investigation into the problem among textile factory workers was undertaken in Great Britain in 1928 and 1929. In the United States, the first official claim for compensation associated with asbestos was in 1927 in the form of a Massachusetts worker's compensation claim (Lanza, 1936).

6. **1930s Hazard:** Asbestos exposure was recognized as a deadly hazard in industrial hygiene literature by the 1930s. In 1930, Dr. E.R.A. Merewether and Dr. C.W. Price published a study proving asbestos exposure causes deadly lung disease (Merewether and Price, 1930). The same year, the Journal of the American Medical Association reported a fatal case of asbestosis in an asbestos miner (Lynch and Smith, 1930). Throughout the 1930s, dozens of articles appeared in the scientific literature confirming that asbestos exposure causes fatal disease. In the 1930s, industrial hygiene journals published studies demonstrating that x-ray reports of workers exposed to asbestos dust over long periods of time were showing pulmonary abnormalities. "That the long-continued inhalation of asbestos dust is responsible for the development of pulmonary fibrosis is now unquestioned. From many parts of the world come radiographic reports of fine fibrosis in the lungs of persons exposed by occupation to the inhalation of this substance" (Gardner,1931). It was recognized that the longer an individual was exposed to asbestos fibers, the greater degree of disease. "The lungs of workers become affected in direct proportion to the length of time they have been exposed to it, until after twenty years of work 80 percent are affected." Dhers (1931). "…in every instance where a patient had been working for more than ten years, asbestosis could be demonstrated radiologically" (Gerbils and Ucko, 1932). The American Journal of Public Health demonstrated the importance of ensuring proper working conditions for asbestos workers:

> Although the total number of workers in asbestos mills is probably far smaller than in many other lines of trade, their health is of paramount

> importance. The conditions surrounding the greater proportion of the employees constitute a distinct and serious industrial hazard, and often sufficient devices for protection have not been provided. It is doubtful if any single employee in certain departments of these mills can possibly escape some damage to his respiratory system because of the unavoidable inhalation of asbestos dust. Naturally, the longer the service of an employee, the more certain is more or less extensive pulmonary damage.
>
> Although the number of asbestos workers is much less than that in many other industries, their occupation is extremely hazardous, and they are amply justified in expecting whatever protection it is possible to give them. Furthermore, the fact that efficient protective devices in this industry, in spite of the added expense, will effect a substantial financial savings, is becoming more apparent. The workers themselves are becoming informed of the danger to health, and many civil suits for damages against factory owners are the result. (Donnelly, 1933).

Cases of asbestosis in insulation workers were reported in this country as early as 1933 (Ellman, 1933). The U.S. Public Health Service fully documented the significant risk involved in asbestos textile factories in 1938 (Dressen, 1938). The authors urged precautionary measures and the elimination of hazardous exposures.

7. **1940s Lung Cancer Link:** By the 1940s the connection between asbestos exposure and lung cancer was established within the medical and industrial hygiene communities. The link between asbestos and cancer was referenced in an article by Kenneth M. Lynch and W. Atmar Smith in a widely disseminated journal in 1935 (Lynch and Smith, 1935). In 1944, asbestos was identified as a physical or chemical agent known to or suspected of causing occupational cancer in the Journal of the American Medical Association (JAMA, 1944). Occupational cancers were defined as those "elicited by exposure to the agents in the course of regular occupations." While Lynch and Smith (1939) suggested that asbestosis was a predisposing factor in carcinoma of the lung, Homburger (1943) concluded that "statistical calculations and morphologic studies did not reliably answer the question of whether asbestosis has to be considered as an etiologic factor in pulmonary carcinoma." In 1955, a study published by Sir Richard Doll, conclusively demonstrated asbestos causes cancer (Doll 1955).

8. **Tremolite Highly Toxic 1951- LA Composition:** In 1951, Vorwald et al. published a summary of case studies conducted at the Saranac lab describing experiments conducted on animals exposed to various kinds of asbestos dust. Inhalation and intratracheal injection techniques were used on guinea pigs, rabbits, cats, dogs, rats and mice to investigate tissue reactions. Vorwald et al. concluded that the rabbit, guinea pig and rat animals, but not the mouse and dog, developed peribronchial lung fibrosis similar to human asbestosis after being exposed to chrysotile asbestos. In addition, he concluded that long fibers (20 to 50 microns) were essential in the production of this fibrosis and that as the asbestos concentration increased, the pulmonary reaction time decreased. While chrysotile asbestos was the primary mineral discussed in Vorwald's comment and

summary, it is important to note that similar peribronchial lung fibrosis observations were made with amphibole mineral species, including tremolite (Vorwald, et al., 1951 (Tables 15 and 16)). At the time of Vorwald's publication, tremolite was reported to be the primary amphibole contaminant within the Rainy Creek Complex (Pardee and Larsen, 1929; Bassett, 1959; Boettcher, 1966b).

In early publications, LA has been referred to as "tremolite." More recently, sophisticated analysis has shown that LA is 84% winchite, 11% richterite and 6% tremolite (Meeker, 2003). Winchite and richterite are close geo-chemical relatives to tremolite.

9. **1947 Asbestosis Deaths:** Drinker and Hatch, Industrial Dust is a standard authoritative industrial hygiene text. At page 39, the text notes the 1947 total of 160 deaths from asbestosis in Great Britain. At page 46, the text demonstrates a 10 times greater than normal incidence of lung cancer among those exposed to asbestos or among those with asbestos related disease (Drinker and Hatch, 1954).

10. **1960 Meso Link, 1964 Selikoff:** In 1960, Dr. J.C. Wagner published a study concluding exposure to asbestos causes mesothelioma (Wagner et al., 1960). In 1964, Dr. Irving Selikoff published a landmark study further demonstrating that exposure to asbestos causes the fatal diseases of asbestosis, lung cancer and mesothelioma (Selikoff, 1964). With this and subsequent publications (Selikoff et al., 1964; Selikoff and Hammand 1965-66) asbestos exposure and disease research extended from asbestos mining and asbestos factory workers to those that used asbestos containing materials in their occupations (Bartrip, 2003).

11. **By 1960s – Hazard:** By the 1960's, hundreds of articles and studies published in the industrial hygiene and medical literature established that asbestos exposure is harmful and can be fatal. These materials were readily available to anyone interested in and capable of learning about the dangers of asbestos. As a standard practice, industrial hygienists review industrial hygiene literature, as well as occupational medicine literature.

12. **1970s Regulation**: The Occupational Safety and Health Act was promulgated in 1970, 29 U.S.C. § 651 et seq., 84 Stat. 1590. Because of the recognition of the grave occupational health problem posed by asbestos as a toxic and physically harmful substance, asbestos was the first toxic substance regulated under this Act. The Act gives the Secretary of Labor the authority to establish standards for permissible concentrations of airborne asbestos fibers. In the 1970s, OSHA required employers to monitor the workforce for asbestos related disease and required preventative measures be taken in the airborne asbestos levels met or exceeded the Permissible Exposure Limit (PEL). 29 CFR 1910.93a (1972). Later, in the preamble to the 1986 revision to the OSHA standard, OSHA identifies pulmonary fibrosis as among the diseases associated with exposure to asbestos. OSHA further stated, in 1986, "OSHA is aware of no instance in which exposure to a toxic substance has more clearly demonstrated detrimental health effects on humans than has asbestos." 51 F.R. 22612, et seq., June 20, 1986, at p. 22615.

13. **Libby Ore - % asbestos and amount shipped**: The vermiculite that BNSF brought into and shipped out of Libby was heavily contaminated with highly toxic LA. A 1982 Environmental Protection Agency (EPA) study reported that approximately 21 to 26% of the unprocessed ore and 0.3 to 7% (by weight) of the concentrated vermiculite was asbestos (Atkinson et al., 1982).

Sample	Fibrous phases Estimated mass, %	Fibrous phases Mineral types	Nonfibrous amphiboles Estimated mass, %	Nonfibrous amphiboles Mineral types
Libby Grace				
Grade 1, 270-I	4-6	Trem-actin	1-3	Trem-actin
Grade 2, 276-I	4-7	Trem-actin	3-5	Trem-actin
Grade 3, 259-I	2-4	Trem-actin	< 1	Trem-actin
Grade 4, 282-I	0.3-1	Trem-actin	1-3	Trem-actin
Grade 5, 264-I	2-4	Trem-actin	2-5	Trem-actin
Grade 5 (1-day), 267-I	2-5	Trem-actin	4-8 < 1	Trem-actin Anthophyllite
Screen Plant Composite (288-I)	2-5	Trem-actin	1-4	Trem-actin

The lowest asbestos content of any of the composite sample results was identified with Grade 4 vermiculite at 0.3%-1%, which result was an outlier among the rest of the composite data which ranged from 2-4% asbestos to 4-7% asbestos. The mean asbestos content in the vermiculite concentrate based on this composite sample data is approximately 3.5%. Asbestos content likely significantly exceeded this level in the preceding decades when the processing methods were less refined. See also United States Department of Health and Human Services Agency for Toxic Substances and Disease Registry, Chemical-Specific Health Consultation: Tremolite Asbestos and Other Related Types of Asbestos, 2001, page 11.

14. **Fiber years**: For chrysotile asbestos, the most commonly encountered form of asbestos, it is thought that 25 fiber per cubic centimeter years (f/cc years) of exposure is sufficient to cause asbestosis, whereas, for amphiboles in general and LA in particular, the threshold exposure has been reported at 2 f/cc years or less (Rohs et. al. 2007). *See also* Sluis-Cremer et al. (1990), page 440, "Table 5 showing that even when exposed to an average fiber concentration of 2 f ml-1 or less, very significant proportions of the men have developed asbestosis." As discussed in detail in Section 29, the EPA has more recently examined the toxicity of the LA in its 2014 Toxicological Review of Libby Amphibole Asbestos and arrived at a reference concentration (RfC) of 0.00009 f/cc for non-malignant asbestos related findings and an Inhalation Unit Risk (IUR) representing the lung cancer and mesothelioma risk associated with LA exposure.

15. **Libby Amphibole Asbestos makeup**: LA is a particularly toxic form of amphibole asbestos actually consisting of a mixture of three amphibole asbestiform minerals; 84% winchite, 11% richterite, and 6% tremolite (Meeker 2003).

16. **Asbestos Fiber Fate and Transport**: Every time the ore or the vermiculite concentrate was moved or disturbed, Libby Asbestos dust was entrained into the air. Employees of BNSF who worked in Libby while BNSF was engaged in the handling of Libby vermiculite report that BNSF's activities created huge amounts of airborne vermiculite dust.

    The suspension of LA in air is measured in "half times," representing the time it takes 50% of LA particles to settle out of the air column. A particle with a thickness of 0.5 µm (0.5 micrometers) has a half time of approximately two hours, assuming the source of disturbance has been removed (CDM, 2009). Larger particles will settle faster; a particle of 1 µm has a half time of about 30 minutes. Smaller LA particles may stay suspended for significantly longer. The typical half time for a 0.15 µm particle is close to 40 hours (CDM 2009, EPA 2013). Asbestos fibers in the air are known to travel long distances from their source or point of origin. The EPA states:

    > During the time that the [asbestos] fiber remains airborne, it is able to move laterally with air currents and contaminate spaces distant from the point of release. Significant levels of contamination have been documented hundreds of meters from a point source of asbestos fibers, and fibers also move across contamination barrier systems with the passage of workers during removal of material.
    >
    > The theoretical times needed for [various sizes of respirable] fibers to settle from a 3 meter (9 ft) ceiling are 4, 20 and 80 hours in still air. Turbulence will prolong the settling and also cause re-entrainment of fallen fibers. (EPA 1978b).

    The EPA recently reported:

    > Activity-specific testing found that the half-time of LA asbestos suspended by dropping vermiculite on the ground was about 30 minutes. LA asbestos suspended from disturbing vermiculite insulation settled within approximately 24 hours (CDM Smith 2009). Once suspended, LA Asbestos moves by dispersion through air. LA asbestos concentration will be highest near the source and will decrease with increasing distance. In outdoor air, wind speed will determine direction and velocity of LA asbestos particle transport. Wind can cause the rapid dispersal of LA asbestos from the source of release (EPA 4/30/2014).

17. **Bystander & Community Exposure:** It has been known since 1930 or earlier that bystanders are at risk of significant asbestos exposure. That is, people who do not themselves work directly with asbestos materials or dust are at risk of significant exposure

caused by others who are working with or around with asbestos. For this reason, it was recommended in the 1930s that dusty processes involving asbestos be isolated from other work areas to avoid exposing people whose presence is not necessary in the dustier operations, or performing the dustier operations with asbestos at times when there is a minimum number of other workers present. See, e.g., Hoffman, 1918; Oliver, 1927; Merewether, 1930; Ellman, 1933; and Alton Documents.

More generally, the dangers of exposure to workers' families and the community from workers bringing home toxic dusts on work clothing has been recognized since the early 1900's.

The 1913 textbook by Tolman, Safety, Methods for Preventing Occupational and other Accidents and Disease, states:

> The importance of wearing suitable clothing on the premises should be strongly impressed upon workers in dangerous trades. The ordinary street clothes should be taken off and replaced by special suits to be worn during working hours. It is not sufficient for a working-suit, jacket or apron to be put on over the ordinary clothing. The working suit should be taken off before the midday meal and before leaving the factory and exchanged for the street-clothes. Working garments should be cut perfectly plain, without folds or pockets, and should be made of strong, smooth, washable materials. By removing the working-clothes before meals and before leaving the factory, the poison is not carried into lunchrooms or into the homes of the workers. (Tolman, 1913).

In 1914, W.G. Thompson emphasized the hazard which could occur from permitting a worker to wear his dirty work clothes home:

> The provision of adequate washing facilities, water closets and opportunities for removing overalls so that they do not have to be worn home when impregnated, for example, with lead dust or dyes, are other factors of much importance in influencing general health.
>
> The workman who goes home to a scanty meal, wearing clothing steeping in perspiration and fumes, dust or solutions of toxic materials in which he has been working, and who sleeps in a close, dirty apartment in which he hangs his reeking clothes, carries much of his occupational hazard with him, if it be of toxic nature. These are not all conditions which can be controlled by legislation, but are largely to be remedied through education of the workman in personal and home hygiene, and by such moral and social influences as may be brought to bear upon the situation.

(Thompson 1914). By the mid-1930's, L.D. Bristol wrote that employers had a definite responsibility to ensure that workers were safe on and off the job:

> While industrial managements cannot be expected to take over the responsibilities of individuals, private doctors, or community health and safety authorities, there most certainly is an opportunity, if not a definite responsibility for industries to be interested in not only the so-called occupational diseases and accidents, but also in the non-industrial diseases and accidents off the job. The practice of good health and safety habits on the part of employees, and the practice of good plant sanitation and safety on the part of management, should be objectives of prime importance in any and every program of industrial hygiene.

(Bristol 1935). In 1934, The International Labor Office (ILO) published its Standard Code of Industrial Hygiene. In addition to advising to avoid the escape of dust into workrooms or adjacent premises, the 1934 ILO Code also provides that, "In dusty trades, cloakrooms, washing accommodations, and eventually douche-baths, separate from the workrooms, should be provided for the workers" (ILO, 1934). The ILO Code further provided:

> Working Clothing
>
> All personnel exposed to infectious, irritating or toxic substances shall be provided with suitable overalls or working clothing and also head coverings where needed, which-
>
> (a) shall be removed before partaking of food or leaving the premises, and deposited in the places set apart for such purpose;
>
> (b) shall not be taken out of the factory by the users for any purpose; and
>
> (c) shall be maintained in good repair and shall be sterilized when necessary and washed, cleaned or changed for clean clothing at least once a week or more often if necessary. ***
>
> All personnel exposed to substances which are poisonous through ingestion shall be required to wash their faces and hands thoroughly before partaking of any food, drink or tobacco, or leaving the premises. ***
>
> Dressing Rooms
>
> (1) All industrial establishments shall have suitable and sufficient installations for accommodating the workers' clothes and drying them.
>
> (2) These installations shall be placed in rooms separate from the workrooms.

> A separate dressing room shall be made available for all employees whose working clothes are exposed to contamination with poisonous, infectious, irritating or radioactive substances and shall be provided with well separated facilities for street and working clothes.
>
> When workers are engaged in processes of such a nature that their working clothes are liable to become wet or have to be washed between shifts, suitable arrangements shall be made to ensure that dry clothes are always available to each employee on his return to work.
>
> Dressing rooms shall be provided with individual lockers of adequate size and with adequate ventilation, preferably of metal and fitted with locks, for clothing taken off during working hours (ILO,1949).

According to Kotin (1977), there are data that suggest that the risk to asbestos-related disease is not exclusively limited to the workplace:

> There are neighborhood cases of asbestos-related disease demonstrated by research and studies in the States, and research and studies in the United Kingdom. Again, these neighborhood cases reflect exposures to effluents in the days of virtual non-regulation and in the days of excessive exposure. Another group that has been identified as being at risk to asbestos-related disease at a site other than the workplace are the instances of the asbestos-related disease in family members of asbestos workers, conjugal cases. Two important things need to be said about neighborhood cases and conjugal cases. There are no data, despite the oft repeated statement… "that these represent minimal exposures." Actually, the exposures, and let us say the conjugal cases, represent maximal exposures. They are exposures that are 24 hours a day, certainly day-long exposures. They are resuspended exposures to asbestos brought home by the worker. You have a spectrum of susceptibilities."

Transcript of Remarks by Paul Kotin, M.D. Senior Vice President, Health Safety & Environment, Johns-Manville Corporation before Consumer Product Safety Commission June 9, 1977.

Incidental environmental asbestos exposures in populations living near plants where asbestos has been mined and/or processed have been well documented throughout the world since the 1960s and continue to be reported in recent literature (Wagner et al., 1960; Newhouse et al., 1965; Barbieri et al., 2012).

Exposure to asbestos by individuals outside of employment is central to this case.[2] In

[2] Portions of this section have been adopted from the report of Steve Amter from the previous Libby asbestos case of *Knadler, et al. v. The State of Montana*.

contrast to workers who are exposed directly by handling asbestos-containing materials, individuals also can be exposed to asbestos by a variety of other, more indirect, ways. As discussed below, in the community around the Libby mine and plant, this occurred by several pathways: 1) Inhalation of airborne dust emitted from vermiculite operations taking place in proximity to locations where individuals lived, worked, and recreated; 2) contact between family members and employees who worked in or around vermiculite operations and brought asbestos-contaminated dust into the home; and 2) inhalation or contact by community members with vermiculite or associated materials in and outside of Libby. These pathways by which non-workers or workers who do not directly handle toxic materials can be exposed to them are variously referred to as community, environmental, "bystander," indirect, or secondary exposures.

Descriptions of how the understanding of environmental and bystander exposures evolved over time, both for chemicals in general and for asbestos in particular, are provided in the reports and affidavits of Plaintiffs' Experts Dr. Arthur Frank and Dr. Barry Castleman as well as in a chapter in Castleman's comprehensive book on asbestos. As set forth in greater detail in the Expert Disclosure of Barry Castleman, the Affidavit of Barry Castleman, and the text Asbestos: Medical and Legal Aspects authored by Barry Castleman, a threat to life from breathing asbestos has long been recognized (from the 1930s and earlier) by the medical community, railroads, and other industries as extending not only to workers and their families, but to community members as well, including individuals only environmentally exposed to the dust.

As a general concept, the understanding of these exposure pathways for various chemicals and mineral elements goes back many decades. For example, with respect to environmental exposures in surrounding communities, the dust, fumes, and smoke from gold, silver, and copper ore processing in Butte, Montana in the late nineteenth century caused severe air pollution and health effects among the populace, leading to the political and courtroom battles known as "smoke wars." [3] Such conflicts were rife across the nation between 1880 and 1960, where communities rose up against smelters, chemical plants, and many types of industrial and manufacturing operations that polluted the air with dust, fume, and smoke containing arsenic, lead, cadmium, fluoride, sulfuric acid and sulfur dioxide, organic chemicals, and many other toxic compounds. [4]

Toxic chemicals used in various manufacturing operations were also known to pose risks to non-employees through the pathways described above. For example, in the 1930s chlorinated organic chemicals such as PCBs, which often were in powdered form, were known to cause chloracne and liver degeneration among family members exposed to dust brought home on employee work clothes. Reports of these exposures invariably contained recommendations for the standard industrial hygiene measures designed to prevent such occurrences: minimizing contact with the offending compounds, mandatory use of work

[3] D. MacMillan, *Smoke Wars: Anaconda Copper, Montana Air Pollution, and the Courts, 1890 - 1924*, Montana Historical Society, 2000.

[4] Ross and Amter, *The Polluters*, Chapters 2 and 3.

clothes that stayed at the plant, and two sets of clothes lockers separated by adequate washing, showering, and laundry facilities.[5]

This general danger of industrial toxins affecting neighbors – and the pathways of indirect or secondary exposure – was explained by Wilhelm Hueper in his widely read 1942 treatise on Occupational Cancer. In the mid-twentieth century Dr. Hueper was perhaps the most known authority on occupational cancer.[6] His text cites references from as early as 1919 which attributed bladder cancer among community members living near dye factories to environmental exposures through dust, air, and other pathways.[7] These exposure pathways into the community were schematically illustrated in a widely read 1950 publication authored by Dr. Hueper and issued by the National Cancer Institute, a Division of the National Institutes of Health, which lists asbestos as a lung carcinogen.[8]

The dangers of breathing asbestos were recognized by the U.S. government no later than 1918[9] and by the 1930s it was understood that not only workers exposed directly by handling asbestos-laden material were at risk, but workers in nearby operations and members of the surrounding community were also at risk of exposure and developing asbestos-related conditions.

The evolution of knowledge about diseases caused by asbestos, including cancer and mesothelioma, is described by Dr. Spear and Dr. Castleman. Based on an extensive review of technical and medical reports, Castleman concludes that "...it was evident by the mid-1930s that "bystanders" such as clerical workers in asbestos plants could develop asbestosis from years of relatively light exposure."[10] The medical community recognized that inhalation of asbestos by factory neighbors could potentially affect their lungs. Researchers publishing in the early 1930s found asbestos bodies "in the lungs, *post mortem*, in a man who lived close to a factory for many years but who had never been

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[5] W.B. Fulton and J.L. Mathews, *A Preliminary Report of the Dermatological and Systemic Effects of Exposure to Hexachloro-Naphthalene and Chloro-Diphenyl*, Pennsylvania Bureau of Industrial Standards Industrial Hygiene Section, March 16, 1936 reported on an infant who contracted chloracne from contact with his father's soiled work clothes; a newspaper account of this exposure reports that both the childs mother and sister also showed symptoms: J. Laventhol, Plant Closed as Mysterious Malady Hits 100, Philadelphia Record, January 22, 1936; L. Schwartz, Dermatitis from Synthetic Resins and Waxes, Amer. J. of Public Health, vol. 26, pp. 586-92, 1936 and C.K. Good and N. Pensky, Halowax Acne ("Cable Rash"), Archives of Dermatology and Syphilology, vol. 48, no. 3, 1943 both report that families of workers contracted chloracne from contact by personal and laundering clothes.

[6] Ross and Amter, *The Polluters*, Chapter 6.

[7] W.C. Hueper, *Occupational Tumors and Allied Diseases*, Charles Thomas Publisher, pp. 525-6, 1942. The chapter of this seminal treatise devoted to occupational lung cancer has a section devoted to asbestos (p. 399-405) as well as a summary of industrial hygiene measures to eliminate or reduce asbestos dust hazards to workers, including wetting to reduce dust levels, improved ventilation, and separation and closing off dust-producing operations, piping, and conveyances.

[8] W. Hueper, Environmental Cancer, National Institutes of Health, 1950.

[9] F.L. Hoffman, *Mortality* from *Respiratory Diseases in Dusty Trades*, Bureau of Labor Statistic Bull. 231, pp. 176-180, 1918.

[10] B.I. Castleman, p. 425.

inside it..."[11] Castleman cites additional evidence from the 1930s and 1940s that demonstrates that lung disease arising from indirect exposure among individuals in "non-production asbestos factory workers (machine adjuster, plant manager, departmental manager)" was recognized within the industrial and medical communities.

In 1960, medical researchers in South Africa reported an unusually large number of cases of the relatively rare cancer mesothelioma in a region known for its asbestos deposits.[12] The authors concluded that the disease resulted from both direct and indirect exposure pathways. Also in 1960, Raimo Kiviluoto reported that 499 cases of pleural calcification had been found among citizens without occupational exposure who lived in the region surrounding two asbestos mines and processing plants in Finland. Even individuals a considerable distance from the facilities showed effects.[13] Additional investigation by V. Raunio added 1300 more cases. Two air pollution surveys of the region surrounding the mines reported the unsurprising fact that the amount of asbestos dust in the air and falling on the land varied with wind direction and distance from the mines and associated areas.[14]

In 1964, Dermot Hourihane and others, following the work of several researchers studying asbestos-related disease in urban London, described the link between mesothelioma and asbestos and commented that "many of the cases gave no history of industrial exposure, and it is possible that a temporary or relatively trivial exposure may have occurred."[15] That same year, Irving Selikoff and others cited the findings in South African, London, Finland, and elsewhere and concluded:[16]

> ...pleural and peritoneal neoplasms among individuals who had chance environmental exposure to asbestos many years before raises the very important question of possible widespread carcinogenic air pollution. The possibility of environmental exposure has long been known... What is new, however, is an appreciation of the potential extent of the problem.

In a paper titled "Prevention of Industrial Cancers," Wilhelm Hueper provides a good summary of the standard industrial hygiene preventative measures that had been

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[11] M.J. Stewart, N. Tattersall, and A.C. Haddow, On the Occurrence of Clumps of Asbestosis Bodies in the Sputum of Asbestos Workers, *J of Pathology*, pp. 737-41, 1932."

[12] J.C. Wagner, C.A. Sleggs, and P. Marchand, Diffuse Pleural Mesothelioma and Asbestos Exposure in North Western Cape Province, *British Journal of Industrial Medicine*, vol. 17, pp. 260-71, 1960.

[13] R. Kiviluoto, Pleural Calcification as Roentgenologic sign of Non-Occupational Endemic Anthophyllite-Asbestosis, *Acta Radiologica*, Supplement 194, pp. 1-67, June 1960.

[14] A. Laamanen, L. Noro, and V. Raunio, Observations on Atmospheric Air Pollution Caused by Asbestos, *Annals of the New York Academy of Science*, 1965. These authors were with the Institute of Occupational Health in Helsinki, Finland.

[15] D.O. Hourihane, The Pathology of Mesotheliomata and an Analysis of Their Association with Asbestos Exposure, *Thorax*, vol. 19, pp. 268-78, 1964.

[16] I.J. Selikoff, J. Churg, and E.C. Hammond, Asbestos Exposure and Neoplasia, *Journal of the American Medical Association*, vol. 188, pp. 22-6, 1964.

developed over previous decades.[17] A section of this paper states:

> Workers exposed to carcinogenic agents should be provided with suitable protective clothing... Separate lockers and rooms should be available for work clothes and street clothes. Contaminated work clothes should not be taken home for laundering, since such a procedure might spread the cancer hazard to members of the family of exposed workers or to workers employed in public laundries or persons subsequently using the same laundering equipment in public or commercial establishments. Contaminated clothes should be cleaned in the plant under adequate conditions of safety... Workers should have adequate bathing facilities and should be required to take a bath after work and before leaving for home... All workers should be instructed as to the reasons for the precautionary regulations made and any warning symptoms of cancerous reactions.

And also:

> All available means of education and information should be used by public health agencies for spreading all available knowledge of recognized, probable and potential occupational carcinogens and cancers among all concerned with such matters, including worker organizations, for ensuring an early recognition of actual and possible occupational cancer hazards, and for making possible the institution of preventive measures before such hazards may produce any epidemic-like appearance of cancers.

18. **Libby Community Dispersion Modeling:** As explicated in the expert report of Julian Marshall, aerial asbestos emissions resulting from vermiculite transportation activities in Libby led to the widespread contamination of ambient air in the area, which in turn resulted in inhalation exposures to Lincoln County residents and visitors.

19. **Asbestos Concentrations in Libby Ambient Air**: Outdoor asbestos air concentrations were measured at locations near the downtown BNSF Railyard in 1975 at up to 1.5 f/cc, more than 16,000 times higher than the LA RfC. (Results of W.R. Grace 1975 Dust Surveys – Source Emissions).

20. **Asbestos Concentrations in Libby Ambient Air - Transportation Corridors:** Several air monitoring studies have been performed to assess ambient air quality at the Libby superfund site decades after the vermiculite mine ceased operations. In 2006, EPA initiated an ambient air monitoring campaign within the community of Libby and the former mine site (OU3). In 2010, the focus of this program was transferred to ambient air monitoring along transportation corridors (major roadways, railroad, and Railyard) in Libby (EPA, 2015, Section 5.1). Monitoring within the community of Libby showed that

[17] W.C. Hueper, Prevention of Occupational Cancer Hazards, CA Cancer J Clin, pp. 88-97, 1966.

58 of the 620 ambient air samples collected (9 percent) revealed detectable phase contrast microscopy equivalent (PCME) Libby amphibole asbestos, whereas 34 of 238 (14 percent) of the samples collected along transportation corridors and 13 of 96 (13 percent) of the samples collected at the former mine site revealed detectable PCME Libby amphibole asbestos. The mean exposure point concentration (EPC) calculated for ambient outdoor air considering the receptor population of residents within the Libby community was 4.8 x 10^-6 Libby amphibole s/cc, while the mean EPC for ambient outdoor air considering the receptor population of residents along transportation corridors was 9.8 x 10^-6 Libby amphibole s/cc and 2.0 x 10^-4 Libby amphibole s/cc at the former mine site (EPA, 2015, Table 5.4). When applied to risk estimates for Libby amphibole in ambient air, the hazard quotients associated with ambient air exposures for residents along transportation corridors are double those calculated for hazard quotients associated with ambient air exposures for residents within the Libby community (EPA, 2015, Table 5.4).

21. **Minneapolis Libby Amphibole Dispersion Modeling:** In addition to the Libby, MT community, dispersion modeling has been performed in residential areas where Libby vermiculite was transported. Community exposure modeling performed in a densely populated urban residential neighborhood near a former vermiculite processing facility in Minneapolis revealed that fiber emissions from the plant were the largest source of exposure for the majority of the cohort, even when several activity scenarios such as moving asbestos contaminated waste, using waste at home on the lawn and garden and installing/removing vermiculite insulation were considered (Adgate et al., 2011).

22. **Family Member/ Take-Home Exposure:** As early as 1949, reports of asbestos disease among housewives exposed to dust brought home on their husband's work clothes appeared in the medical literature (Wyers, 1949). The studies by Newhouse and Thompson, Wagner et al., and Dr. Selikoff in the 1960's further documented asbestos disease among family members exposed to asbestos dust carried home on clothing (Newhouse, 1965; Wagner et al., 1960; Selikoff, 1964).

    Studies investigating secondary exposures from work clothing contaminated with asbestos concluded (1) the shaking of typical work clothes that are contaminated from the use of asbestos will cause amosite fibers to be released into the breathing zone of the individual who is performing this work resulting in a significant exposure to airborne amosite fibers, and (2) also caused the surfaces in the area to become contaminated with amosite fibers (as measured by the passive dust samplers) providing another potential source of exposure through re- entrainment from such activities as sweeping, vacuuming or other cleaning projects (Hatfield and Longo, 1999).

    In another study, a laundry operation was examined because of its relevance to household exposures in cases of malignancies in families of asbestos workers. Airborne asbestos concentrations during general laundry activities showed a mean of 0.4 f/cc and a maximum of 1.2 f/cc (Sawyer, 1977).

    Exposure to indoor dust that is contaminated with asbestos is a potentially important exposure pathway for residents. This is because most people spend a large fraction of time indoors, and a wide variety of routine and indoor activities may cause the asbestos in dust to become suspended in air where it can be inhaled into the lung. One potential source of asbestos contamination in indoor dust is asbestos in outdoor soil (EPA 2007a).

23. **1960's Wagner, Selikoff, Newhouse**: A notable 1960 study showed asbestos disease in family members and neighbors to asbestos plants (Wagner, 1960). Wagner and other studies showing spread of asbestos disease to family members and community members were discussed in Selikoff, 1964. By the mid-1960's, Newhouse, et al, (1965) reported individuals with household and environmental exposures to asbestos were at an increased risk of mesothelioma. This article clearly established that individuals who laundered asbestos-contaminated clothing were at risk. The acceptance of Newhouse's findings were widespread including by the New York Academy of Sciences:

> Dr. Newhouse's work and observations, and those of Dr. Wagner bring out a striking resemblance between accumulating data on asbestos and those on beryllium. This is brought to mind by recent observations concerning mesotheliomas, made, in a sanitorium in South Africa, as reported by Wagner and his co-workers. Dr. Hardy observed berylliosis in household members of the families of beryllium workers, and subsequent studies demonstrated the release of beryllium in the laundering and handling of work clothes of beryllium workers. Similarly, Dr. Newhouse has observed mesotheliomas among the relatives in the household of asbestos workers, who had laundered their work clothes. The resemblance continues with biological effects of air pollution. Berylliosis was observed among resident nonemployees within a certain radius of beryllium manufacturing plants in Ohio and Pennsylvania, and Drs. Newhouse and Wagner have reported mesotheliomas, and Kiviluoto pleural plaques, of residents living within a certain radius of asbestos factory and mining operations.

24. **OSHA take home:** Upon enactment of OSHA's asbestos standards, the federal government reaffirmed through regulation the risks to family members of an asbestos-exposed worker. OSHA required that workers exposed in excess of its permissible exposure limit must be provided facilities to change out of their contaminated work clothing without contaminating their street clothes. Furthermore, OSHA required that warnings be provided to any individual who laundered contaminated work clothes.

25. **Asbestos use by Railroad**: Asbestos has been used in the railroad industry in a variety of ways, including insulation for railroad shops, wrapping around the boilers of locomotives, insulation in the driving cabins and carriages of locomotives, in asbestos cement ties, and for other heat-transfer protection. Asbestos was also found in brake pads, brake linings, clutches and ceiling and floor tiles of passenger cars. Railroad workers at risk of exposure to asbestos include workers engaged in repair, demolition, technical control, maintenance (including machinists), handling waste materials, and railroad construction and maintenance, locomotive engineers, electricians, joiners, painters, laborers, brakemen, station maintenance workers, pipefitters, riggers, insulators, fitters, finishers, polishers, mechanics, and other ancillary workers who work in close proximity to others directly

exposed to asbestos (Dodson and Hammer, Asbestos: Risk Assessment, Epidemiology, and Health Effects, 2011). There have been numerous report of asbestos-related diseases in railroad workers (Maltoni et al., *Ann N Y Acad Sci* 1991;643:347; Mancuso, *Am J Ind, Med* 1983;4:501; Mancuso, *Am J Ind, Med* 1983;4:501; Schenker et al., *Am Rev Resp Dis* 1986;134:461; Malker et al., *Acta Oncol* 1990;11:203).

III. Epidemiology Literature and Toxicity of Libby Amphibole

26. Epidemiology Literature – Occupational LA exposure and asbestos related disease. In 1983, the Lockey study demonstrated Libby vermiculite was capable of causing pulmonary changes focused on a worker population from a Marysville, Ohio fertilizer plant that had utilized vermiculite from the Libby mine and South Africa (Lockey et al., 1983). This cohort became the basis for the proposed RfC discussed in Section 29. Significant correlations were observed with respiratory symptoms (shortness of breath and pleuritic chest pain) and cumulative fiber exposures (Lockey et al., 1984). Studies focusing on Libby workers soon followed.

McDonald et al. (1986) included a cohort of 406 men employed at the mine for at least one year prior to 1963 and followed them until 1983. Compared with white men in the U.S., the cohort experienced excess mortality, with standard mortality ratios (SMRs) of 2.45, and 2.55 for respiratory cancer and non-malignant respiratory disease (NMRD) respectively. Standard mortality ratios are defined as the observed number of cases over expected. The proportional mortality for the four identified mesothelioma deaths was 2.4%.

Data collection for a parallel study sponsored by the National Institute for Occupational Safety and Health (NIOSH) was initiated at approximately the same time (Amandus et al. 1987; Amandus and Wheeler, 1987) and included 575 men employed at the mine for a minimum of one year prior to 1970. Similar to the McDonald et al. (1986) study, SMRs were 2.23 and 2.43 for respiratory cancer and non-malignant respiratory disease respectively (Amandus and Wheeler, 1987). These early occupational-based studies demonstrated strong exposure years/response relationships (McDonald et al., 1986; Amandus and Wheeler, 1987; Antao et al., 2012).

McDonald published additional work in 2004 in which he updated epidemiology data for his original 406 man cohort, following them until 1999 (McDonald et al., 2004). The SMRs reported in this update for lung cancer and non-malignant respiratory disease were 2.40 and 3.09, respectively. The proportional mortality for the 12 identified mesothelioma deaths was 4.21% and "is similar to that for crocidolite mines in South Africa (4.7%) and in Australia (3.9%) and over 10 times higher than that in Quebec chrysotile miners (0.4%)" (McDonald et al., 2004). An all-cause linear model implied a 14% increase in mortality for mine workers exposed occupationally to 100 f/mL/yr and approximately 3.2% increase for the general population exposed to 0.1 f/mL for 50 years (McDonald et al., 2004).

An additional NIOSH sponsored study included a cohort of 1,672 Libby miners, millers, and processors in 1982 and followed subjects through 2001 (Sullivan, 2007). Compared with U.S. white men, SMRs for asbestosis, lung cancer, and cancer of the pleura were 165.8, 11.7, and 23.3, respectively.

An update regarding vermiculite worker mortality (Larson et al., 2010), with a cohort of 1862 Libby miners, demonstrated a clear exposure response relationship between cumulative Libby amphibole fiber exposure and asbestosis, lung cancer, mesothelioma, and NMRD mortality. A limitation noted for earlier epidemiology studies evaluating lung cancer SMRs in Libby mine and mill workers was the lack of control for cigarette smoking. Bias analysis revealed that cigarette smoking had minimal impact on the exposure response relationships reported in this study (Larson et al., 2010; reviewed by Antao et al., 2012). An additional conclusion from this study was the association between Libby amphibole fiber exposure and cardiovascular mortality based on a rate ratio of 1.5 with a 95% confidence interval of 1.1 to 2.0 (Larson et al., 2010).

A follow-up to the Lockey et al. (1984) Marysville, Ohio fertilizer plant study revealed pleural changes in 28.7% of the cohort (Rohs, et al., 2007). As noted previously, this cohort was the basis for the proposed Libby amphibole RfC. Pleural changes were originally reported in 2.2% of the overall cohort and 8.4% of the highest cumulative fiber exposure group (Lockey et al., 1984). The study is significant in that the cohort was based on exfoliation plant workers outside of Libby, MT, with relatively low cumulative fiber exposure (CFE) levels compared to those described in the Libby mine and mill worker studies; the CFE level of 2.2 fiber cc-years was observed.

27. **Epidemiology Literature – Community Libby amphibole exposure and asbestos related disease.** In addition to epidemiology studies that considered Libby mine and mill workers, there have been numerous epidemiology based studies evaluating ARD mortality among Libby community members. A cross-section interview and medical testing of 7,307 persons who had lived, worked or played in Libby for at least six months prior to 1991 was conducted in 2000 and 2001 by the Agency for Toxic Substance and Disease Registry (ATSDR) investigators (Peipins et al., 2003). Of the 6,668 participants $\geq$ 18 years of age who received chest radiographs, pleural abnormalities and interstitial abnormalities were observed in 17.8% and < 1% of the participants, respectively.

A recent community study evaluated asbestos-related mortality in Libby from 1979-2011, while controlling for occupational exposure (Naik et al., 2017). Statistically significant SMRs were observed for both males and females for non-malignant respiratory diseases and asbestosis, both before and after controlling for past W. R. Grace employment. In addition, non-worker chronic obstructive pulmonary disease SMRs were also elevated for females, but not males.

In 2008, a clinical and exposure summary report for 11 individuals diagnosed with mesothelioma who were not Libby mine or mill employees was published (Whitehouse et al., 2008). All cases were non-occupationally exposed individuals. The authors concluded that exposure most likely resulted from Libby amphibole contamination in the community, the surrounding forested area, and areas in proximity to the Kootenai river and railroad tracks that were used to transport vermiculite concentrate (Whitehouse et al., 2008). The mean LA occupationally related mesothelioma latency period has been reported as 35 years (Case, 2006). The latency period reported for these non-occupational cases was 13-67 years from the first known exposure (Whitehouse et al., 2008).

In terms of both occupational and non-occupational mesothelioma cases, current mortality figures indicate one new case per year in Lincoln County, Montana (McDonald et al., 2004; Case, 2006; Whitehouse et al., 2008). Lincoln County has the third highest age-adjusted mesothelioma death rate in the nation with a rate of 56.1 per million (NIOSH, 2008). Increased risks for the development of mesothelioma have also been observed in the worker cohort at the Marysville, Ohio plant with a SMR of 10.5 (95% CI, 1.3, 13.8) reported (Dunning et al., 2012).

A community study was conducted in a densely populated urban residential neighborhood in Minneapolis, Minnesota where an expansion facility processed Libby vermiculite ore from 1938 to 1989 (Alexander et al., 2012). In addition to commercial vermiculite products such as Zonolite® insulation and Monokote® fireproofing, the facility produced a waste material reported by the Minnesota Department of Health to contain 10% amphibole asbestos (Alexander et al., 2012). The waste product was piled on the property and offered to the community for use in gardening, driveway fill materials, etc. The prevalence of pleural abnormalities obtained for the 461 participants was 10.8%. The odds ratio associated with direct contact with vermiculite ore waste or ever playing in waste piles and pleural abnormalities was 2.78 (95% CI: 1.26, 6, 10) and 2.17 (95% CI: 0.99, 4.78) when adjusted for background exposure. The results suggest that community exposure to Libby vermiculite is associated with measurable effects (Alexander et al., 2012).

In addition to pulmonary based ARD, rates of systemic autoimmune diseases (SAID) have been evaluated in the Libby community. A follow-up case-control study was conducted among the participants in the 2000/2001 ATSDR study (Peipins et al, 2003) with cases including subjects that reported one of three SAIDs in the initial screening; systemic lupus erythematosus, scleroderma, or rheumatoid arthritis, and controls including subjects in the initial screening that responded negatively to questions regarding SAIDs (Noonan et al., 2005). Odds ratios among former Libby mine and mill workers $\geq$65 years of age of 2.14 (95% CI, 0.9-5.1) for all SAIDs and 3.23 (95% CI, 1.31 7.96) for rheumatoid arthritis, suggest that LA exposure is associated with SAIDs (Noonan et al., 2006). Increasing SAIDs risk estimates were reported for participants with relative increases in reported vermiculite exposure pathways.

These epidemiologic studies demonstrate clear and significant increases in ARD, including asbestosis, lung cancer, and mesothelioma among industrial workers. In addition, ARD has been observed in area residents with no direct occupational exposures. The most common health outcome among Libby residents and others with low lifetime cumulative fiber exposure levels are pleural changes.

28. **Pleural Disease and Pulmonary Function:** While pleural disease and progressive loss of pulmonary function has been reported within occupational and non-occupational Libby populations (Whitehouse, 2004), there have been several publications evaluating the relationship between Libby amphibole related pleural changes and lung function with inconsistent results (Clark et al., 2014; Lockey et al., 2015a; Lockey et al., 2015b; Zu et al., 2016; Lockey et al., 2017; Clark et al., 2017). The most recent assessment (Miller et al., 2018) of individuals who worked at the Libby vermiculite mine for a minimum of 6 months revealed that 223 (87%) of the 256 miners had pleural thickening, and among them, 47 (21%) had associated parenchymal abnormalities. Among the 223 with pleural thickening, 68% had thin diffuse pleural thickening termed for purposes of the study as "lamellar pleural thickening," rather than the classical circumscribed pleural thickening. "Lamellar pleural thickening" was associated with low values of forced vital capacity and diffusion capacity and significantly lower values in all pulmonary function tests when associated with parenchymal abnormalities.

29. **Current Toxicological Knowledge – Libby Amphibole Asbestos:** A toxicological review of Libby amphibole asbestos was published in 2014 (EPA/IRIS, 2014). This review includes the non-cancer and cancer health effects for the inhalation route of exposure and resulted in a published reference concentration (RfC) and inhalation unit risk (IUR) for non-cancer and cancer risk, respectively. The RfC of 9×10^{-5} fibers/cc is defined as "an estimate of an exposure that is likely to be without an appreciable risk of adverse health effects over a lifetime and is expressed as a lifetime daily exposure in fibers/cc (due to measurement by phase contrast microscopy (PCM))."

    The RfC for Libby amphibole represents the first published non-cancer reference inhalation concentration for a mineral fiber. Asbestosis, pleural thickening, and other nonmalignant respiratory disease in populations exposed to Libby amphibole asbestos were considered in the development of the RfC, with localized pleural thickening selected as "the critical effect" (EPA/IRIS, 2014). Cohorts considered included two occupationally exposed groups; Libby, MT workers and Marysville, OH workers; and one non-occupational exposure group which consisted of residents near an exfoliation plant in Minneapolis, MN. Cumulative inhalation of Libby amphibole asbestos was associated with increased risk of localized pleural thickening at all sites, even at the lowest ranges of exposure for each group (Christensen et al., 2013). The Marysville cohort was selected due to the strength of the industrial hygiene data and exposure response relationships and the lack of confounding residential/community exposures to Libby amphibole asbestos. The Marysville cohort considered workers who were hired after 1972 and who participated in health evaluations in 2002-2005 (EPA/IRIS, 2014).

    The IUR represents the upper-bound estimate of cancer risk from chronic inhalation exposure to Libby amphibole at 1 fiber/cc (EPA/IRIS, 2014). The combined upper bound IUR for Libby amphibole asbestos, considering only mesothelioma and lung cancer models, is 0.169 excess cancer deaths per fiber/cc per person as measured by PCM (EPA/IRIS, 2014). Cohorts selected for Libby amphibole asbestos lung cancer and mesothelioma IUR models were workers employed at the Libby vermiculite mine and mill (EPA/IRIS, 2014).

The significance of this toxicological review is that it is specific for Libby amphibole asbestos, a unique mixture of amphibole minerals. The RfC represents the first non-cancer reference concentration for mineral fibers and it is substantially lower than historic exposure limits for asbestos.

30. A Summary of Inhalation Factors and Proposed Mechanisms of Toxicity:

Exposure to Libby amphibole asbestos is associated with nonmalignant and malignant asbestos related diseases including: asbestosis, lung cancer, mesothelioma, pleural thickening and pleural plaques (McDonald, 1986; Amandus et al., 1987; Amandus and Wheeler, 1987; McDonald et al., 2004; Case, 2006; Sullivan, 2007; Whitehouse et al., 2008; EPA/IRIS, 2014). As described above, localized pleural thickening was selected as the critical effect for the RfC. Work published prior to 2002 referenced earlier International Labour Organization guidelines for defining pathological alterations of lung parenchyma and pleura; therefore, pleural plaques reported in literature prior to 2002 describe what is currently referred to as localized pleural thickening (EPA/IRIS, 2014).

While other exposure routes and related health outcomes have been reported in literature, inhalation of asbestos fibers is the primary route of human exposure, and as a result, was the basis of the toxicological assessment described above. When characterizing the inhalation exposure risk for asbestos fibers, as with other aerosols, there are many variables to consider. These include, but are not limited to, the concentration of asbestos measured in the breathing zone and the dose inhaled, duration of exposure, frequency of exposure, physical and chemical characteristics of the fibers (shape, length, diameter and surface properties that are influenced by mineral composition and charge), nasal or oral breathing patterns (or both), respiration rate, specific anatomical and physiological features of the respiratory tract, fiber deposition and clearance mechanisms, and individual susceptibility (immune status, genetics) (Liu et al., 2013).

While epidemiologic studies have established that exposure to asbestos causes the ARDs summarized above, the pathogenic mechanisms of these diseases are not completely understood. Asbestosis is one type of pulmonary fibrosis. Pulmonary fibrosis is commonly described as excess collagen in the alveolar interstitium, which may also extend to the alveolar ducts and respiratory bronchioles (KLAseesn, 2013). Proposed mechanisms of collagen deposition involve epithelial cell injury and macrophage activation. Asbestos elicits a macrophage response to phagocytize and clear fibers, but this response may result in reactive oxygen species production, inflammasome activation and the release of cytokines and growth factors. Asbestos can also induce alveolar epithelial cell apoptosis, which in turn can result in additional growth factors and cytokines. These signaling pathways are considered important for myofibroblast differentiation, collagen deposition by myofibroblasts, and ultimately fibrosis (Liu et al., 2013). Fibrosis of the lungs impairs the ability for efficient oxygen/carbon dioxide exchange and leads to progressive stiffness.

While parenchymal interstitial fibrosis is observed with most asbestos disease cohorts, a large number of cases in the Libby cohort exhibit pleural disease with limited or no interstitial disease present (Peipens et al., 2003; Rohs et al., 2008; Alexander et al., 2012; Loewen, 2016; Frank, 2016). While it is postulated that many of the biological mechanisms described above in addition to fiber translocation also contribute to the pleural pulmonary fibrotic process, the mode or mechanism of action for pleural thickening has not been defined specifically for Libby amphibole asbestos (EPA/IRIS, 2014).

Complexity in defining the mechanisms of toxicity also exists for malignant ARDs. Proposed mechanisms for the carcinogenicity of asbestos fibers as defined by the International Agency for Research on Cancer (IARC, 2012; EPA/IRIS, 2014) include direct fiber-cell interaction with target cells and indirect interaction generated from cellular signaling pathways. The surfaces of asbestos fibers deposited in the lungs acquire iron that cycles between the reduced and oxidized forms (Shannahan, 2011). This redox cycle may result in DNA lesions which may lead to apoptosis, gene mutations, chromosomal aberrations, and cell transformation (Huang et al., 2011). Asbestos-induced reactive oxygen species (ROS) production may also result in p53 activation, and other cellular signals including cytokines, chemokines and growth factors (Liu, 2013). As was noted with the proposed mechanisms of fibrosis, mechanistic events for asbestos carcinogenicity also include macrophage interaction, inflammasome activation associated with frustrated phagocytosis, release of cytokines and growth factors, and subsequent inflammation. Asbestos is considered to be both an initiator and a promotor of the carcinogenic process (Mossman et al., 2011).

Pleural malignant mesothelioma is a rare disease. It is reported in literature that 50 to 90% (Carbone et al., 2012; Sebbag and Sugarbaker, 2001; Dodson and Hammer, 2011 pp 576; Strauchen, 2011) of individuals with pleural mesotheliomas have identifiable accounts of asbestos exposure. In an assessment of lung asbestos fiber burden and asbestos exposure history among patients diagnosed with pleural malignant mesothelioma, (Carbone et al., 2012) 11 of 18 (61%) individuals reporting a negative history of asbestos exposure had lung fiber burden concentrations > 0.5 million fibers/dry gram of tissue. Similar results were reported by (Leigh et al, 2002) revealing asbestos fibers in the lungs of 80% of Australian patients with no apparent asbestos exposure. These results suggest that exposure histories may not always accurately reflect asbestos exposure. Individuals with known occupational exposures to asbestos cannot be recast into the "idiopathic" or "unknown exposure" category. When confronted with an individual who has a demonstrated mesothelioma and an occupational exposure to asbestos, the mainstream scientific community recognizes that the cause of that mesothelioma is the asbestos exposure of the individual even if that exposure was "brief or low-level" (Welch, 2007). The consensus of the scientific community is that there is no demonstrable threshold of exposure to asbestos below which adverse health effects do not occur. Accordingly, "an occupational history of brief or low-level exposure should be considered sufficient for mesothelioma to be designated occupationally related" to asbestos exposure (Helsinki criteria, 2014). Asbestos-induced mesothelioma has a variable but typically long latency period, usually 30 or more years, and the latency increases with lower levels of exposure (Browne, 1994; Bianchi et al., 2007). Unlike carcinoma associated with asbestos exposure, mesothelioma is not associated with cigarette smoking (KLAssen, 2013).

The scientific community is in consensus that even brief and low-level exposure to asbestos can cause mesothelioma. The mainstream scientific community has long recognized and continues to recognize today that there is no "safe" level of exposure to asbestos (World Trade Organization, 2000; Helsinki criteria, 2014). As noted by NIOSH, excessive cancer risks have been demonstrated at all fiber concentrations studied to date. Evaluation of all available human data provides no evidence for a threshold or for a "safe" level of asbestos exposure (NIOSH, 1980). There is inconsistency in literature regarding linear dose response curves for asbestos exposure and malignant mesothelioma. It has been commonly reported that there is a dose-response relationship that is linear (risk increases with increased exposure) with no threshold (no safe level of exposure exists) (Lin et al., 2007; Dodson & Hammer, 2011 pp 576). Other studies, primarily focusing on environmental asbestos and erionite mineral fiber exposures, have not reported a linear dose-response relationship between asbestos exposure and malignant mesothelioma (Carbone et al., 2002; Carbone et al., 2012), suggesting that some individuals may be more susceptible to asbestos induced malignant mesothelioma than others due to factors such as genetics, exposure to cofactors (ionizing radiation, Simian virus), and mineral fiber constituencies (Carbone et al., 2012).

A recent mechanism proposed for mesothelial cell transformation is that asbestos fibers induce necrotic cell death of human mesothelial cells, which results in the release of high-mobility group protein B1 (HMGB-1) in the extracellular space (Yang et al., 2006 and 2010). Secreted HMGB-1 induces a chronic inflammatory response which includes an accumulation of macrophages and the release of inflammatory cytokines from macrophages, including TNF-α and IL-1β. "TNF-α activates the NF-β pathway, which increases the survival of human mesothelial cells after asbestos exposure, allowing cells with asbestos-induced DNA damage to divide rather than die, and if key genetic alterations accumulate, to eventually develop into malignant mesothelioma" (Carbone and Yang, 2012).

IV. <u>BNSF Operations in Libby</u>

31. BNSF carried tons of asbestos through Libby every day: Strip mining, transportation, and processing of vermiculite ore containing asbestiform minerals was conducted in the Libby area from approximately 1923-90. The vermiculite operation involved a mountain top removal method of mining. Throughout the nearly 70 years of vermiculite mining operations the top several hundred feet of Vermiculite Mountain was in fact removed. See, e.g., Mountain Top Removal diagram (19__) and images from 1948, 1968, and 1971 showing the removal of the top of Vermiculite Mountain in stages (cf. Google Earth

Image of the Mine from 1995). Hundreds of billions of pounds of vermiculite ore was excavated, processed and either dumped as waste or shipped into Libby by BNSF. The Libby mine produced approximately 80% of the world's vermiculite ore, which by 1970 amounted to over 29 billion pounds of ore (Bulletin 79, p. 147) and was estimated to exceed 35 billion pounds of ore from 1971 through 1981 alone.[18] According to W.R. Grace, the average daily production from the mine and milling operation was between 500 and 1000 tons of finished vermiculite concentrate per day between the late 1960s and 1970s and between 800 to 1000 tons per day in the 1980s.[19] Using the vermiculite asbestos percentages as measured in the 1980s and a daily average of 750 tons, BNSF carried up to 105,000 pounds of Libby Amphibole Asbestos into and out of downtown Libby per day in the late 1960s and 1970s and, based on a daily average of 900 tons per day, up to 126,000 pounds per day through the 1980s. This amounts to up to 383,000,000 pounds of asbestos carried into Libby in the 1970s and up to 460,000,000 pounds through the 1980s.

32. **Vermiculite rail car loading:** The ore was mined at Vermiculite Mountain, approximately seven miles outside of Libby, and processed first in Libby and then later at the mine site. After processing, the concentrate was trucked down to river storage and stored in large bins/silos in various grades. Beginning in 1949 (12/15/1949 Western News Article), the concentrate was released into tunnels below the river storage bins onto a conveyor belt and was moved across the Kootenai River to the River Loading Site, which is located 5 miles east of BNSF's Downtown Railyard in Libby (the "Railyard"). BNSF constructed a rail siding at this location for the exclusive use of Zonolite (later W.R. Grace), and, subject to BNSF's review and approval, allowed the company to install its vermiculite loading equipment there on BNSF property so the company could pour its vermiculite products into waiting rail cars. During the loading process a cloud of vermiculite dust would be produced coating the rail cars and loading equipment in a layer of dust. In addition, a substantial amount of vermiculite would always spill onto the surface of the cars. BNSF then brought each of the asbestos laden vermiculite shipments into the Railyard located in downtown Libby.[20] From the Railyard, BNSF joined the vermiculite filled railroad cars to eastbound or westbound trains. BNSF shipped an average of 10-16 car loads of vermiculite concentrate out of their downtown Railyard per day and across the Country to processing facilities nationwide.

33. **BNSFs presence in downtown Libby:** The Railyard was the heart of BNSF activities in Libby. It was located directly adjacent to downtown Libby and was immediately surrounded on all sides by Libby's residential neighborhoods, businesses, places of employment, public parks, sporting fields, the public swimming pool, and the community

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[18] See Grace Mine Production Report – April 1979.

[19] See W.R. Grace's response to the Second Request for Information Regarding the Libby Asbestos site, February 22, 2000, pp. 8-9.

[20] Prior to the construction of the River Loading siding in the late 1940s (9/13/1949 Letter from J.M. Budd to F.J. Gavin; 9/29/1949 Western News Article), the vermiculite ore was trucked to the Zonolite/W.R. Grace export plant located on the BNSF Railyard property in downtown Libby. During that period, the vermiculite ore was stored and loaded into BNSF boxcars at the Railyard.

garden. (See Mineral Ave Color C, downtown Libby circa 1950s with railcars in background; MDOT 4/25/1977, BNSF's Libby Railyard associated W.R. Grace Facilities and surrounding properties.) The Railyard was extensive, spanning the entire north end of downtown Libby. W.R. Grace's downtown Libby facility initially straddled, and later adjoined the BNSF Railyard property line and consisted of vermiculite storage, loading and processing facilities.

Baseball was popular in Libby and nearly everyone in the area attended games. See Baseball Field at Zonolite; Baseball Parade; Baseball Parade 2. The storage and export facilities attendant to the rail transportation of vermiculite were left open to the public and most children growing up in Libby recall playing in the area of the Railyard as well as in the large piles of vermiculite located throughout. See Baseball Field at Zonolite 2, Photo of baseball game being played in close proximity to BNSF's downtown Libby facilities (note children playing on ramp entering Railyard). In addition, local celebrations such as Logger Days and the Carnival were held at the baseball fields adjacent to the Railyard. See MDOT 7/13/1971, showing cleanup and removal of equipment from ball fields following Logger Days celebration and children practicing baseball on two of the three other ball fields; MDOT 6/14/67 showing children practicing on adjacent ballfields.

34. **Grace's Downtown Operations**: The first expanding plant was built in 1924-5 and adjoined the J. Neils Lumber company sawmill to take advantage of the rail siding and the availability of wood waste as a fuel source. 9/18/1924 Western News Article. Later, the limited expansion operations were moved immediately adjacent to the Downtown Libby Railyard where it operated until 1969. 9/25/1969 Western News Article. Its output was about 25 tons per week or half a 50 ton boxcar per week. The raw ore was expanded two to three times per month. The popped (or expanded) vermiculite was put in bags at the expanding plant and then moved to the loading area at the bagging plant.

    The bagging plant abutted the Railyard and was served by a BNSF spur track built over an easement granted to BNSF by W.R. Grace. Vermiculite concentrate was delivered to the bagging plant in covered trucks and loaded into storage silos. In the bagging plant, two workers bagged the vermiculite concentrate and loaded it into boxcars. At the peak of bagging plant production, it is estimated that they filled up to one boxcar per day, which was 50 tons or about 1,000 100 pound bags. The bagging plant operated five days per week (one shift). In the 1950s, production was less and then it was fairly constant at this level in the 1960s, 1970s and 1980s. BNSF hauled the filled box cars away and kept the bagging plant supplied with empty boxcars to fill. According to John Swing, BNSF Supervisory Agent in Libby up until 1984, the bagging plant/export facility was located partially on BNSF property and BNSF management would inspect the facility a couple times each month. See 9/13/16 Deposition of John Swing.

35. **River Loading Point**: Production and shipments of vermiculite ore increased over the 1950s, 1960s, 1970s, and 1980s. At the W.R. Grace River Loading Site, Grace employees loaded the rail cars that BNSF transported to and from the downtown Railyard. Initially, box cars were used exclusively. Eventually, larger hopper cars became the primary means

of shipping ore, although box cars were still used. Loading was performed five days per week, and sometimes more frequently, throughout the 40 plus years (1950 through early 1990s) that the River Loading Site was used. (See River Loading Photo 1, with approximately 18 cars being loaded on Zonolite siding; River Loading Photo 2, 9/7/1960, with at least 24 cars being loaded; River Loading Photo 3.) The river loading point had a loading rate of 100 tons per hour and Grace was able to load one 50 ton car every 40 minutes. (See 5/12/1962 Zonolite memorandum; 1951 Report on Mining Vermiculite.)

36. **Libby Log Job:** BNSF's transport operation between the River Loading Site and the Railyard adjacent to downtown Libby was known as the "Libby Log Job." Occasionally the Libby Log Job crew (consisting of 4-5 BNSF employees, depending upon time period) would make two trips per day to the Grace River Loading Site. In addition to the Grace loads, the Log Job crew was responsible for daily hauling of cars to and from the Libby lumber mill, as well as other smaller and less regular local jobs in the Libby/Troy area. When pushing loaded vermiculite cars into Libby from the River Loading Point, the train would typically travel between 15 and 20 m.p.h. and would not exceed a top speed of 25 m.p.h. (worker reports).

The river loading process was extremely dusty. See Video Clip of River Loading Site in operation; River Loading Site Video narrated by Butch Hurlbert. The airborne dust created during the processing and production of the vermiculite ore was sampled and found to contain approximately 40% asbestos (see Vermiculite Dust Sampling, 4/13/1962). The loaded rail cars and the entire area were constantly coated in a layer of this vermiculite dust. See River Loading Photo 4 – note the layer of vermiculite dust accumulated on the south facing roof in the forefront. Box cars were used exclusively at the River Loading Site until the 60s when BNSF also started using top loading hopper cars. See, e.g., 9/25/1961 Hopper car request letter from Zonolite to the Great Northern Railroad (GNRR). The process of loading the box cars through the open side doors was extremely dusty. See River Loading Photo 3, with visible vermiculite dust emanating from loaded box car and accumulated dust pile on loading shack roof; River Loading Photo 5, with a visible dust cloud spreading from the loading shack to the right covering the loaded box cars in vermiculite dust; River Loading Photo 6, 9/24/1959, with dust covered vermiculite loaded box cars to the right of the loading shack and cleaner empty cars to the left.

When hopper cars were loaded at the river site, the conveyor did not stop when passing from one hopper car hatch to another. Much loose vermiculite accumulated on the top of every car.[21] Railroad worker interviews consistently report that when hopper cars were picked up at the river load out, the cars would have several inches (6-8 inches) of loose vermiculite and vermiculite dust on the top due to the continuous feeder conveyor system. Thus, all the time from the 1950s to approximately 1993, BNSF employees riding in engines pushing the vermiculite cars to town described visible clouds of dust being

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[21] This was confirmed by Former BNSF Director of Industrial Hygiene James Shea in 2007. See 1/26/2007 Deposition of James Shea, p. 91.

produced. There was dust in the air the entire time while returning loaded cars from Grace to the Railyard. The dust came into the windows and vents into the engine cab. The United States Department of the Interior, Bureau of Mines performed testing of tremolite asbestos dust throughout the Grace Mine operation, including at the River Loading Point on several occasions. See, e.g., US Bureau of Mines Report 1971 (BN Grace Repository Docs. 20152342). The 1971 Report states:

> The car loader, located in a control booth alongside the railroad tracks, filled cars with concentrate. Although protected in the booth, and although the loading equipment was provided with a Pangborn dust-collecting system, the exposure appeared high … Settled dust was noted above the railroad car roof slots.

Later, in April of 1973, the Bureau of Mines returned to the River Loading Point and again noted significant airborne dust production:

> A cyclone dust collector was used during car filling operation, but the system tended to plug up easily; at this time, considerable airborne dust was generated…
>
> The car cleaner used brooms and jets of compressed air for cleaning cars prior to filling with vermiculite concentrate…
>
> At the ore loader station, the dust collector's cyclone tended to plug. The bucket elevator and screw conveyor (at the cover plate) leaked dust at these times. At the top of the structure at the belt transfer point, the exhaust appeared inadequate to collect the dust -- a poorly-fitting gate may have been involved or perhaps the cyclone was plugged when the belt transfer point was observed. The entire dust-collecting system should be reexamined and improved accordingly. [22]
>
> Compressed air jets should not be used for cleanup purposes around the ore loader station or in the railroad box cars…
>
> It is recommended that the fiber dust levels be determined in the shipping operations and appropriate action be taken.

1973 BOM Report. The airborne asbestos/dust condition at the River Loading Point remained in 1977 and, although the samples in this location were apparently taken within the "pressurized control room," airborne asbestos levels were among the highest measured

[22] As discussed below, BNSF retained control over the design and construction of the health and safety fixtures on its premises, including air pollution control devices.

across the entire vermiculite operation at up to more than 10 f/cc. See 1976-77 airborne asbestos sampling.

At the river loading point the spilled vermiculite concentrate and dust would regularly build up above the level of the tracks (worker reports) and had to be removed. In early years this was performed with a front end loader which was later replaced by a vacuum truck. Because spilled vermiculite and accumulated vermiculite dust had to be continually cleaned from the loading area, Grace created a spilled vermiculite dumping point along the access road to the River Loading Point. See MDOT 1967; 3/15/2007 Deposition of David McMillan pp. 23-24, 76. Asbestos sampling in the area has revealed extensive visible vermiculite and high concentrations of asbestos in the soil. See, e.g., EPA Libby Database mapping of River Loading Point soil samples.

The River Loading Site was owned by BNSF and leased to Zonolite and W.R. Grace. See, e.g., Affidavit of James Roberts 2/8/2007; Zonolite Siding Lease 9/12/1956. BNSF funded the construction of the Zonolite siding and oversaw all construction and improvements made at the site. BNSF and W.R. Grace employees worked in tandem at the River Loading Point to deliver, fill and transport the railcars of ore into Libby. The parties carried a series of landlord and tenant insurance policies which covered the River Loading Site, and named BNSF as the insured. See, e.g., Zonolite Siding Insurance Agreement 4/14/1977. As discussed below, BNSF retained control over the design and construction of the health and safety fixtures on its premises, including air pollution control devices.

The bagging plant had no ventilation. The building had an open entrance between the storage silos and the bagging plant where a boxcar entered. In 1975 or 1976 a new bagging machine greatly decreased the indoor dust produced. Some fiber monitoring was done by federal officials inside the bagging plant and inside a boxcar that was being loaded in the 1970s, which still demonstrated hazardous levels of airborne asbestos in these indoor locations.

37. **Downtown Libby Railyard**: Once transported to the downtown Railyard, loaded vermiculite cars usually sat for at least several hours, and usually longer, in the Libby yard before being attached to an east or west bound train. The cars first had to be inspected and often times weighed by BNSF workers at the scales near the depot in the Railyard. This involved decoupling and coupling the cars, "kicking" and bumping them each time. Workers report seeing dust fall from cars and being entrained into the air during this process of collisions during coupling, as well as by the buckling and unbuckling of air hoses between cars during their movements. Workers estimate that each car would be moved several times, each time going through the collision involved in coupling and decoupling, prior to leaving the downtown Libby Railyard. See, e.g., Rail Car Coupling Video.

While waiting to be attached to outbound freight trains, the loaded vermiculite cars would be placed on Tracks #1, #2, or #3, in close proximity to the main line (cars parked on track 1 would be within several feet of passing trains). Workers report that the hopper cars would still have loose vermiculite and vermiculite dust (1/8 to three inches) on their tops at this point, carried into town from the river loading process. Throughout the entire period when BNSF shipped vermiculite, freight trains consisting of up to 100 cars (or more in the 1980s) sped through the Libby yard at 55 mph, generating dust clouds which drifted in all directions.

Railyard workers estimate that on average 20 to 30 trains would pass through the Railyard on a given day during the 60s through the 80s.[23] The ground and track bed throughout the Railyard was covered in visible vermiculite which would be blown around and disturbed each time a train passed by. The diesel locomotives used by BNSF, and in particular the GP locomotives used locally in Libby, had various blowers used to cool various parts of the locomotive including the traction motors. Many of these blowers, including the traction motor blowers, would blow downward onto the ballast and surrounding substrate. Workers report that these blowers would entrain significant dust from these areas when the locomotives were in operation. It was commonplace that the force of air turbulence from passing freight trains would blow visible dust off the vermiculite cars sitting in the Libby Railyard. From a point west of the vermiculite bagging plant to a point east of the depot, the railroad right-of-way was between 100 and 300 feet wide. From this large area, and indeed all portions of the track on either end of and beyond the Railyard, dust containing dangerously high levels of LA was entrained into the air and cycled into the town of Libby and neighboring properties.

38. **BNSF and W.R. Grace co-mingled operations:** Over the years, Zonolite/Grace had multiple leases, easements and land use agreements with BNSF related to the operation of both downtown facilities. These entities engaged in multiple real property transfers in and around the Railyard. See, e.g., Affidavit of James Roberts 2/8/2007; List of Zonolite contracts with GNRR transferred to Grace in 1963 sale; Compilation of selected leases, easements, and property transfer documents. While the history is complex, what is clear is that BNSF and W.R. Grace operations were co-mingled and closely associated in downtown Libby.

39. **Leakage**: As indicated above, workers report that the hopper cars would still have up to several inches of loose vermiculite and vermiculite dust on their tops at this point, carried in to town from the River Loading process. At the downtown Railyard, BNSF workers all report seeing vermiculite leak from the loaded vermiculite cars. Much of this spillage accumulated in the Railyard. Workers report that the loose vermiculite and vermiculite dust on the loaded hopper cars would regularly spill off the cars during the weighing and moving process. They all report that the Railyard, the right of way leading into and out of

[23] Libby represented one of the busiest stops on the northern line during much of the period that BNSF transported vermiculite. This was due, in large part, to vermiculite and lumber shipments being made by W.R. Grace and the Libby Lumbermill, and for some time, the shipments of construction materials for use in the erection of the Libby Dam.

Libby and the Troy rail yard were all constantly covered in a layer of visible vermiculite.[24] They recall dust piles one to two feet high in the Libby yard from leaking vermiculite cars on a regular basis, and reported scattering the piles into the Libby yard with a shovel or simply kicking down smaller piles to avoid tripping over them when working at night. Many remember freight trains leaving the Libby yard with vermiculite cars, and noticing that the cars were leaking. See, e.g., 12/23/1958 letter from J.R. Huxley of the California Zonolite Co. to R.A. Bleich of Zonolite (reporting a car en route losing over 30 tons), and other selected documents referencing leakage and spillage.

It was BNSFs responsibility to inspect the rail cars to ensure they were clean and suitable for use in shipping of the vermiculite ore prior to delivery to the River Loading Site. See, e.g., BNSF_HHP_000626; 5/26/1966 letter from Grace to GNRR – dirty, uninspected hopper cars. The cars were again inspected by BNSF for suitability and leakage during the weighing and shipping process. Despite the Railroad's responsibility in this regard, the condition of the cars received by Grace for shipment of vermiculite was often times reportedly poor. See, e.g., Selected shipper's comment forms regarding condition of cars provided; 5/26/1966 letter from Grace to GNRR – dirty, uninspected hopper cars.

Track crews recall that regular maintenance and upkeep in the Libby yard was more challenging due to the prevalent vermiculite waste. BNSF workers spent several weeks each year in and around Libby performing the various cleaning, tamping, and surfacing projects and these constant activities disturbed, entrained, and most often redeposited asbestos-contaminated vermiculite on the tracks, in the BNSF right-of-way and on nearby properties.

40. **Derailments**: Several derailments involving vermiculite containing rail cars occurred over the years. These wrecks, and the subsequent cleanup efforts, generated major soil disruption around the rights-of-way. A derailment at the River Loading Point in the winter of 1966 resulted in overturned vermiculite hopper cars, significant dust exposure to BNSF cleanup workers, and additional contribution to asbestos in the Lincoln County airshed. See photo of Derailment at River Loading – Winter 1966 ; 2/3/1966 Western News Article; and 2/28/1966 Derailment loss claim. In February 18, 1979, there was another derailment at the River Loading Site, which resulted in the destruction of the River Loading facility, extensive spilled vermiculite and vermiculite dust, massive dust exposure to BNSF cleanup workers, and others in the area. 2/22/1979 Western News Article – Wreck Demolishes Loading Facility; and 2/18/1979 Derailment Packet. While the W.R. Grace River Loading Site was being reconstructed, ore loading operations took place at the Railyard in downtown Libby. *Id.* pp. 9-10. There were also derailments that occurred in the Railyard, which contributed to the amount of vermiculite in the rail bed of the Railyard and, when cleaned up by BNSF workers, contributed to the asbestos in the Libby airshed. See, e.g., 2/12/2002 Deposition of Frank E. Shockley.

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[24] The presence of visible vermiculite throughout the Railyard into the 2000s was confirmed by BNSF Manager of Industrial Hygiene, Gerald McCaskill, who remembers the Railyard sparkling with vermiculite. 1/24/2007 Deposition of Gerald McCaskill, p. 55.

41. Rail Cars: Often if a forklift entered a boxcar it could crack the floor, but the crack was not visible, or did not give out until the car was loaded with vermiculite. Railroad employees recall that the vermiculite was held into the box cars using grain doors, which were pieces of plywood that would be stacked across the door to hold the loose vermiculite in the car during loading and shipping. See, e.g., BNSF HHP 000033; 1951 Report on Mining Vermiculite. They recall that vermiculite would make its way through the space between the grain doors and through knot holes in the grain doors themselves and that the boxcar doors would not prevent this escaped material from spilling out onto the Railroad ballast.

Workers report that at the River Loading Site, very often the vermiculite dust would build up 8 to 16 inches above the rails, and there was so much dust from the loading operation generally that it was difficult to see if a rail car was leaking. This led to rail cars being filled and brought to town, leaking all the way. Workers report that it was a common occurrence to observe such leaks creating a pile of vermiculite so high it would reach the bottom of the hopper car.

BNSF employees were responsible for inspection of cars at the Railyard during weighing and shipping from the Railyard. See, e.g., BNSF HHP 000626; 2/12/2002 Deposition of Frank E. Shockley. During the inspection and weighing process, Railroad employees were responsible for ensuring that box cars were not leaking excessively and for ratcheting closed the hopper doors of the hopper cars. Railroad employees recall that even with proper inspection and the additional ratcheting efforts, the hopper door seals would still allow leakage. If cars (boxcar or hopper) were discovered to be excessively leaking in the Libby yard, then "repairs" were made by stuffing "waste" material (shredded rags) into the holes. This was a temporary fix at best but was still quite common. See, e.g., selected documents referencing leakage and spillage. Sometimes the railroad returned the boxcar out to the spur at River Loading, where Grace workers would do a more substantial fix on the boxcar. Due to the condition of the cars delivered for loading, Grace incurred significant expense in making repairs and since "close supervision of repairing the bad cars [was] necessary to prevent 'loss in transit.'" See 6/3/1952 letter from Zonolite to GN. Workers at the Libby lumber mill report that when they received otherwise empty boxcars for their own loading activities they regularly first had to sweep the cars clean from all the leftover vermiculite in the cars.

V. BNSF asbestos cleanup

42. Asbestos Remediation 1999-2013 – Operable Unit 6. The EPA began remediation efforts in Libby in 1999 and the Libby Asbestos Site was placed on the Superfund program's National Priorities List (NPL) in October 2002. In 2009, for the first time in the history of the agency, EPA declared a Public Health Emergency in Libby. The site includes eight operable units (OU), one of which (OU6) consists of 42 miles of rail line, rights-of-way, and rail yards owned and operated by BNSF. The 42 miles of rail lines and yards were included as an OU due to the Libby amphibole soil contamination associated with decades of vermiculite transport into and out of Libby (EPA, 2018). The EPA began investigating Libby amphibole contamination on BNSF properties in 2001. However, due to the extensive contamination on railroad properties, remediation efforts extended for more than a decade and involved multiple cleanup attempts. In order for the cleanup efforts to be deemed adequate, vermiculite and Libby amphibole asbestos contamination had been removed or capped in place from nearly every square foot of the downtown Libby Railyard and other BNSF properties in Lincoln County. See, e.g., Envirocon cleanup Photos.

BNSF entered into a consent agreement with the EPA under which BNSF agreed to perform the cleanup of its Lincoln County property using its own environmental contactors. In an 11/4/2001 document titled Settlement Negotiations: Administrative Order on Consent for Removal[25], the EPA reports:

> Respondent owns a railyard within the Site. Respondent recently implemented its own investigations to determine if yard activities would entrain asbestos fibers into the air; the results confirmed that such activities can entrain high levels of asbestos fibers.

In 2001, Environmental Resources Management, a contractor for BNSF, performed soil sampling in the Libby Railyard. A 100 ft. grid system was used. "Visibly obvious" vermiculite or biotite was mapped for placement on the CADD map and flagged with surveyor whiskers. However, soil samples were not collected from these flagged areas. Excluding areas with visible vermiculite, 22 composite samples were collected. Libby amphibole asbestos was detected in 5 of the composite samples (PLM NIOSH 9002 concentration < 1%). When one of the composite samples (BN-09000) was analyzed individually, four of five samples revealed Libby amphibole in concentrations at < 1%. In May of 2002, the EPA reported:

> Burlington-Northern Railroad (BNR) investigations identified amphibole asbestos contamination along the tracks in the rail yard, and in the buildings. BNR has begun to address these issues by removing the contaminated source materials from its property. ***
>
> The effects of these exposures may be aggravated by the prevailing tendency for meteorological inversions, which trap particulate contaminants in the area, resulting in Libby's historic designation as a non-attainment area for particulates (EPA 5/2/2002).

Soil sampling performed in the BNSF's Libby Railyard in 2002 demonstrated the presence of LA in 8 of 15 composite soil samples and 27 of the 32 individual samples making up those composite samples. (EPA 4/30/2014). Although it had been more than

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[25] To maintain brevity, subsequent citations to documents received from, or authored by, EPA will be provided as follows - (EPA date of document) and those received from BNSF will be designated using BNSF's bates numbers.

a decade since Grace had shut down its mining operations in Libby, mapping of visible "biotite"[26,27] on the rail beds of the Railyard demonstrated extensive visible vermiculite remaining throughout the rail beds. (BNSF_511_0034[28]). Visible vermiculite was also identified and sampled at the River Loading Facility where asbestos was detected in a majority of the soil samples taken at levels of up to 4% Libby asbestos. See BNSF_511_0005, p 8; EPA 3/1/2007 pp. 328-333, 335-336. By August of 2002, the EPA found:

> Respondent recently implemented its own investigations to determine if yard activities would entrain asbestos fibers into the air. Baseline monitoring along the tracks conducted by Respondent has found the highest concentrations measured during the sweeping ranges from 7 to 14 f/cc in air samples in three locations - Hwy. 37 crossing the railroad tracks, close to the 5th Street, and the loading/unloading station near the Bluffs. A total of twenty-two surface soil samples collected in November, 2001 by Respondent along the railroad tracks and its railyard ranged from trace to less than 1 % fibrous amphibole asbestos by weight. In addition, visible unexpanded vermiculite remained at Track #1, Track #2 and Track #3.

(EPA 8/19/2002). For comparison, the 14 f/cc of asbestos measured in the air during BNSF's 2002 Railyard activities, is more than 150,000 times greater than EPA's recently issued LA RfC and 140 times higher than OSHA's permissible exposure limit for workplace asbestos exposure.

It is critical to note that the initial soil characterizations occurred more than a decade after the vermiculite mine ceased operations. As reported by railroad worker interviews and testimony, ballast removal and replacement (using a regulator to remove the fines from ballast and then redepositing the ballast) typically occurred annually, while cleaning activities like sweeping typically occurred monthly. These activities are designed to remove extraneous material from the rail line in order to ensure adequate water drainage, etc. A substantial portion of the extraneous material removed through these processes would have been vermiculite and associated asbestos. Asbestos fibers were also entrained into surrounding areas and covered by subsequent depositions of dust and debris over the

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[26] Vermiculite and biotite are both found throughout the Rainey Creek complex near Libby, Montana. The "biotite" material was considered waste rock in Libby as, despite assistance from BNSF's Mineral Research and Development Department, no beneficial use of this mineral was developed. It is suggested that the vermiculite is a product of leaching of biotite by ground waters. Boettcher, A.L., Vermiculite, Hydrobiotite, and Biotite in the Rainy Creek Igneous Complex near Libby Montana, *Clay Minerals* (1966) 6, 283.

[27] Throughout cleanup efforts, BNSF insisted on referring to the vermiculite and associated LAA as "hydrated biotite" despite EPA requests that they replace this term throughout. See, e.g., EPA OU6 documents, 2022475 Letter transmits Response to EPA Comments, p. 5. Nowhere else in the Libby Asbestos Superfund Site has the material been referred to in this way. BNSF's deliberate avoidance of the use of the terms vermiculite and asbestos in their cleanup documents is suspect and seems to comport with their long-standing practice of minimizing and ignoring the asbestos problem in Lincoln County.

[28] Note that a large stretch of track was occupied by a parked train at the time of inspection so visible vermiculite was not reported for that stretch.

ensuing decade since active operations had ceased. Therefore, the chronology of soil sampling activities that occurred from 2001 on were most likely not representative of the soil conditions in the Railyard during the 70 plus years of vermiculite transport into and out of the town of Libby. In addition, the 2001 soil sampling activities did not include sample collection in areas with visible vermiculite, thereby under reporting the asbestos concentration in the soil. Notes and log sheets authored by BNSF employees and contractors during the Railyard activity sampling events indicate how dusty conditions at the Railyard were; "Huge Dust Plumes" created during ballast regulation exercise (BNSF_503_0017), "Big dust cloud generated during movement, plowing, and especially during brooming" … "Very dusty when sweeping, big dust cloud - dust noticeable to ball fields (couldn't see at times)" (BNSF_503_0018), "small cloud of dust/visible dust generated replacing tie and plate… Dust cloud generated during brooming" (BNSF_504_0002). See also BNSF Lincoln County Maintenance Operations 9/13/2016 #1, #2, #3. I have observed firsthand how dusty BNSF's Libby operations are even today nearly two decades after Libby cleanup efforts began (see Photo of Train kicking up dust over Champion Haul Road; Video of train kicking up dust 8/22/18) and have observed extensive visible vermiculite still present on BNSF's right of way (see Photo of vermiculite by tracks 8/2/2018; Video of vermiculite by tracks 8/2/2018). The nature of the rail facilities and attendant operations resulted in loose soil conditions that were conducive of extensive dust generation in Downtown Libby. (see Video of dust at Railyard 8/2/2018).

In August 2003, soil containing visible vermiculite was removed from the BNSF Railyard using vacuum trucks and an excavator. Post-excavation clearance soil sampling was then conducted. Despite BNSF's extensive cleanup efforts, LA was still detected in all three composite clearance soil samples with reported concentrations ranging from less than 1 percent to 3 percent. (EPA 4/30/2014 - Libby Asbestos OU6 Final Remedial Investigation Report). These samples, taken after removal of more recently accumulated surface material, are likely more representative of the conditions that were present during active vermiculite operations than the early surface sampling performed by BNSF. An initial pollution report regarding the Railyard issued shortly thereafter provided:

> Sampling shows that asbestos, a hazardous substance, is present in soil, raw ore, ore-concentrate and other soil-like materials at various locations in and around the community of Libby including the BNSF rail yard. Visible vermiculite has been found along the tracks and within the railyard and analytical results have shown asbestos levels in soil from 2-5%. ***
>
> Asbestos contaminated materials were hauled and shipped through the railyard, and spilled into the soil for decades. The soil around the tracks and under the ballast is contaminated and needs to be removed. BNSF has agreed to perform the cleanup at the Libby railyards and its tracks under an Administrative Order on Consent (AOC) to address the high levels of asbestos. The BNSF's work plan and sampling plan were approved on October 25, 2002. Cleanup began on August 13, 2003. Unfortunately, cleanup was not achieving satisfactory results, so work was stopped on

> August 21, 2003 and BNSF is reevaluating cleanup options. Work is expected to begin again in spring 2004. EPR-SR is overseeing the cleanup (EPA 9/29/2003).

Cleanup activities continued on BNSF property, but due to the extensive contamination, these efforts proved unsuccessful. After the 2004 characterization of Libby amphibole in the Railyard, BNSF hired Kennedy/Jenks consultants to "evaluate appropriate response actions for the railroad bed materials containing asbestiform fibers" (BNSF_511_0024). Kennedy/Jenks reported:

> The rail bed structure in the yard has been infiltrated with fine particulates of vermiculite from a local mining operation that loaded the vermiculite into railroad cars for transport. Vermiculite from Libby contains actinolite-tremolite in asbestiform fibers (asbestiform fibers), which is a regulated substance being cleaned up under The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)…
>
> The BNSF facilities in Libby include a transcontinental main line, a yard with four tracks (one including a scale), and several other industrial spurs. The yard is oriented roughly east to west and lies on the northern side of the main line... A former vermiculite mine operated by W.R. Grace & Company provided mined material for loading into railroad cars at a location east of Libby; the loaded cars were brought to the Libby yard for weighing and shipment to other locations. The cars were switched and organized into trains at the eastern end of the yard. As a result, Kennedy/Jenks Consultants understands the track ballast and adjacent soil at the eastern end of the yard contains asbestiform fibers. Four currently active yard tracks and remaining portions of some former industrial spurs with an aggregate length of approximately 9,000 feet are potentially affected.

In late 2004, BNSF's own remediation contractor EMR reported to the EPA:

> It was determined during excavation activities on the west end of the site that there are some pockets of material located randomly throughout the area north of the main line in which the presence of hydrated biotite [(vermiculite)] is visible to a depth of three to four feet below the reference elevation, which is the tops of the railroad ties along the main line track.
>
> Three [airborne asbestos] samples collected on September 24, 2004 contained detectable Libby Amphibole (LA)... Upon review of the data and discussions with site personnel, it was determined that the exclusion zone

> boundary was set up too close to decontamination activities.[29]
>
> Two additional personal air samples submitted for analysis had detectable structures. These air samples, BN-00318 and BN-301, were worn by personnel working on the site …
>
> Clearance soil samples are being collected at the east end of the site; as of October 1, results for samples... had been received. LA was detected at a concentration of less than one percent (<1 %) Tremo1ite/Actinolite in clearance samples…

(EPA 10/4/2004). Kennedy Jenks then developed a Response Action Work Plan which was implemented in the fall of 2004. Phase 1 of the response plan consisted of removal of 28,192 linear feet of rails and other track materials, the scale house and concrete support structure, and approximately 8,000 railroad ties. Phase 2 consisted of soil removal or capping in eight separate zones. Excavation of soil in zones 1, 2/3, 5, and 8, where active tracks were anticipated in the future, occurred to depths of detectable vermiculite. At the end of 2004, BNSF contractor Kennedy Jenks issued a Libby Railyard Response Action Completion Report which provided:

> In the zones scheduled for excavation, soil potentially containing Libby amphibole or hydrated biotite was excavated, and underlying soil was sampled concurrently to evaluate whether detectable Libby amphibole remained (clearance samples). Excavation proceeded until laboratory results indicated that Libby amphibole fibers were not detected in the soil samples (generally no more than 29 to 35 inches below the top of the adjacent ties comprising the existing BNSF main line) or to a depth of at least 4 feet. At several locations, excavation reached a depth greater than 4 feet, but clearance samples indicated detectable Libby amphibole had been removed. At one small location, excavation reached at least 6 feet, but clearance was not achieved, as described below. In the other portions of the Site, soil containing Libby amphibole or hydrated biotite was capped in place... Before the geotextile liner and clean backfill material (railroad sub-ballast) were set in place, soil within Zone 1/2/3 that was believed to contain Libby amphibole was excavated to a tan clay layer [approximately 18 inches below ground surface (bgs)], or to the depth required to remove all visible hydrated biotite [(vermiculite)]. After soil had been excavated to the prescribed depths, confirmation soil samples were collected to verify removal of Libby amphibole. One location (sample BN-71001) failed to achieve clearance, but the final excavation elevation was 6 feet below the original ground surface, which is greater than EPA's 4-foot standard for

[29] Airborne asbestos was detected at the perimeter of Railyard during these cleanup activity sampling events despite the use of wetting and other dust suppression techniques.

leaving potentially impacted soil in place.[30]

(BNSF_511_0041). One of the locations with visible vermiculite reported at greater than four feet in depth is designated by BNSF contractors as the "Former Dump Area." (EPA 4/30/2014, p. 151). The visible vermiculite throughout the Railyard is further documented in BNSF contractor field notes from the time. See, e.g., EMR Field Notes Sept.

Despite the extensive continuing cleanup efforts up to 2005, LA continued to be detected in clearance soil samples and site air monitoring. BNSF's cleanup efforts between 2003 and 2005 led to more than 18,000 tons of LA asbestos-containing soils and 5.34 miles of rail and other track material being removed from the Railyard alone. (EPA 4/30/2014, EPA 5/14/12). By the end of this process, nearly all of the ties and tracks had to be removed and nearly the entire Railyard was excavated and either filled or capped. See EPA 4/30/2014, Construction Drawings pp. 117-145; Envirocon Photos of Railyard excavation, tie removal and geotextile capping. Yet, in 2005, soil and air samples were still demonstrating significant asbestos contamination at the Railyard. In 2005, BNSF had reportedly completed cleanup efforts at the Railyard, however, while conducting a "final completion site walk with BNSF site representatives to inspect the restored rail yard areas" they found "a pile of Libby Vermiculite that was on existing railyard property" and were forced to remove an additional "approximately 15 cubic yards of contaminated material." (EPA 1/27/2005). BNSF's cleanup efforts continued to be unsuccessful and in 2011 extensive areas of vermiculite contamination were once again identified at the Railyard. (EPA 5/30/2011). By the time the cleanup of this contamination had been completed, vermiculite and asbestos contamination had been identified and removed or capped on place from practically every square foot of the Libby yard.

43. **BNSF – a recognized source of asbestos contamination:** Significantly, the EPA recognized that BNSF's 60 plus years of vermiculite related activities in Libby were the source of, and had caused, extensive contamination to other properties, including downtown Libby, which was located adjacent to the Railyard. In 2012, it reported:

> The Libby Asbestos Site has been the focus of a number of environmental investigations and response actions. Areas investigated have included property owned by BNSF and along BNSF rights-of-way. BNSF has performed a removal action at the Railyard. **EPA has reason to believe that sources of contamination are, at least in part, from properties, railroad tracks, and rights-of way owned, leased, and maintained by BNSF, as well as from various railroad operations performed at a number of locations at or near the asbestos mine facility at the Site** (EPA 2/2/2012).

A 2012 "Good Faith Offer" and Proposed Settlement Agreement from BNSF attorneys to the EPA states:

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[30] See Ballast excavation cross section demonstrating vermiculite presence down to clay layer.

> Respondent's rail line runs, in part, between Troy and Libby. It is believed that spillage and dispersion may have occurred along the rail line, rights of way, and other properties associated with rail transport in the area thus causing vermiculite concentrate and/or processed material to be deposited on and adjacent to these areas. It is these areas within the Site that comprise OU6. ***
>
> EPA has performed extensive analyses of both the amphibole asbestos content and friability of such asbestos in vermiculite. It has also reviewed similar data collected by W.R. Grace. The data reveal that vermiculite from the Zonolite Mine in Libby contains amphibole asbestos and that when that vermiculite is disturbed; it releases significantly high levels of amphibole asbestos fibers into the environment. ***
>
> The vermiculite spillage along Respondent's right-of-way is uncontrolled. Once disturbed, the vermiculite spillage exposes receptors to high levels of amphibole asbestos fibers. ***
>
> Respondent is the Owner and operator of property in OU6 at the Site and holds a right-of-way along its rail line. **During the operation of such rail line, vermiculite containing amphibole asbestos was released to the environment through spillage from the rail cars**. With the exception of spillage in the rail yard, the spillage has been left exposed to the environment and to disturbance by human activity. ***

(EPA 4/16/2012). In September of 2013, after more than 10 years of BNSF remediation activities at the site, the EPA determined that an additional removal action would be required on BNSF property. (EPA 9/23/2013).

Studies sampling tree bark in the Libby area, performed by myself and others including the EPA, have demonstrated that trees can act as receptors of airborne asbestos fibers. Samples of tree bark "collected 7 miles west of the town next to a railroad line had concentrations of 19 million fibers/g." Ward et al., Trees as reservoirs for amphibole fibers in Libby, Montana, Sci. Total Environ. 2006 Aug 15;367(1). This was a more than 100 fold exceedance of a bark sample taken from a tree in the City of Libby adjacent to the Libby Middle School Track (0.13 million fibers/g). Given the remote location of the railroad samples in relation to W.R. Grace facilities, BNSF's activities are the likeliest contributor to airborne asbestos fibers in this area and in other areas surrounding the BNSF corridor generally.

Because the Railyard was located in downtown Libby, asbestos fibers entrained by activities thereon would be dispersed and eventually onto the adjacent residential, commercial, and recreational properties of Libby. Once asbestos fibers settle out of the air they can be re-suspended into the air following soil, dust and sediment disturbances. Due to these characteristics of LA, BNSF's activities while handling and transporting massive amounts of concentrated vermiculite into downtown Libby and throughout Lincoln County resulted in the widespread (in distance and over time) casting of dust containing Libby asbestos into the air of the community. This was a health hazard not only for railroad workers and their families, but also for members of the Lincoln County community who lived, worked, shopped and played in relative proximity to the Railyard where asbestos monitoring demonstrated airborne fiber levels of up to 1.5 f/cc, more than 16,000 times higher than the LA RfC.

VI. BNSF Knowledge of Asbestos Hazards

44. **Asbestos Hazards recognized in 1930s-1950s:** As described in some detail above (see paragraphs 5-11), asbestos exposure was recognized as a deadly hazard in industrial hygiene literature at least by the 1930s. The connection between asbestos exposure and lung cancer was established in the 1940s within the medical and industrial hygiene communities. Tremolite asbestos, like other forms of asbestos, was recognized in the industrial hygiene literature as highly toxic by 1951 (Vorwald, 1951). Traditionally, Libby Amphibole Asbestos ("LA") has been referred to as "tremolite." More recently, sophisticated analysis has shown that LA is 84% winchite, 11% richterite and 6% tremolite (Meeker, 2003). Winchite and richterite are close geo-chemical relatives to tremolite.

45. **BNSF aware of asbestos hazard by 1930s**: BNSF and its predecessor railroads have been aware of the hazard presented by asbestos exposure for many decades. This knowledge is documented throughout the available literature by the 1930's.

46. **AAR Documents**: Several of BNSF's predecessor railroads were members of the AAR and had agents that were members of the Association of American Railroads ("AAR") Medical and Surgical Section. See e.g. Excerpts of AAR Annual Meeting Reports (highlighting the role and attendance of these officials throughout the AAR documents). For example, the Chicago, Burlington & Quincy Railroad Company (Burlington Railroad), the Atchison, Topeka and Santa Fe Railroad Company (Santa Fe Railroad) and the GNRR were members of the AAR. The Medical and Surgical Section held annual meetings and issued reports on the meetings. Both the Burlington and Santa Fe Railroads had members in attendance at these meetings. In 1937, Dr. D.B. Moss, medical director of Burlington Railroad, was Chairman of the AAR Medical and Surgical Section and presented on the topic of occupational disease and the current state of knowledge regarding asbestos exposure. He advised other members of the AAR that dust could be harmful to workers and that asbestos was one of the principal sources of toxic dust exposure to railroad workers. At the same time, Dr. Moss advised AAR members that asbestosis was strictly a dust disease, caused only by exposure to asbestos.

    The AAR Medical and Surgical Section reports acknowledged the hazard of asbestos exposure including asbestosis, pneumoconiosis, pulmonary fibrosis and cancer as well as the process of disease and latency periods. These reports also demonstrate an in depth understanding of how asbestos travels through the air, often to distant locations, and asbestos exposure prevention including through the use of protective equipment, wet procedures and separating non-essential workers from such activities. Documents consistently reference the specific attendance of high-ranking Board officers and medical officials of the GNRR, Santa Fe and Burlington railroads. A chronological summary of some of these reports follows:

47. AAR 1932. The Committee on Occupational Disease and Rehabilitation presented on the subject of "dust as an industrial Hazard."

> Dust pathology may occur in any occupation where dust is produced and inhaled in sufficient quantity over a long enough period of time. ***
>
> In conclusion, we wish to emphasize the facts that under certain conditions inhalation of dust cause a fibrosis of the lungs know as pneumoconiosis and that this is an industrial health hazard, that it can be prevented by proper use of water and ventilation, that after fibrosis develops secondary infection is prone to occur and tuberculosis is often engrafted on the fibrosis and the radiographic examination is the easiest and most reliable means of diagnosis.

Notably, the Chief Medical Officer of the Great Northern Railroad was present at the meeting (p. 13), the Chief Medical and Surgical Officer of the Burlington Railroad, Dr. Moss, was a member of the Committee of Occupational Diseases and Rehabilitation, and the Surgeon General of the Bureau of Public Health Service was an honorary member (p. 7).

48. AAR 1935. The Medical and Surgical Section of the AAR's Committee on Occupational Diseases and Rehabilitation reported:

> We as railroad surgeons are undoubtedly more interested in silicosis and asbestosis than in other types [of lung disease].

The Report went on to discuss the cause and symptoms of asbestosis. It then recommended medical monitoring practices for employees working in dust and disease prevention techniques including removal of dust, using wet methods, use of respirators and "frequent analysis of the dust content of the air at different times during the working hours."

49. AAR 1937. The report discusses the recently enacted Illinois Workmen's Occupational Diseases Act noting that:

> Silica, asbestos, and lead are the principal substances generating toxic dusts to which railway employees may be exposed… It is obvious that avoidance of great exposure to toxic dusts and other poisonous substances used in or generated by manufacturing processes and of unfavorable working condition, is the first essential in preventing and controlling occupational diseases. (pp. 19-21).

The report then discusses the importance of pre-employment physicals and histories, as well as periodic physical examination of employees "in occupations in which known hazards exist." (p. 21). The report discusses proper dust control measures, including the use of personal protection including respirators. It goes on to state "silicosis and asbestosis are strictly dust diseases . . . contracted only by breathing silica or asbestos dust. . . . Prevention and control, therefore, consists of protecting the employee against exposure by the means best adapted to preventing the generation and dispersion of these harmful dusts." The 1937 report demonstrates early BNSF knowledge of the deadly and disabling nature of asbestos exposure, and its prevention.

50. **AAR 1939.** An extensive discussion of pneumoconiosis was had and Dr. Lanza presented on the topic of "Medical Progress Toward Further Protection of Industrial health; Report of Medical Committee, Including Plans for 1939. This speaker stated that in his opinion instead of removing man from dust infection work that the dust should be removed from the work. He urged periodic examinations … He also referred to an international labor board which has made some investigations along these lines." (p. 38).

51. **AAR 1940.** Discussions note that much "time and study" has been devoted to "pneumoconiosis" by the "Air Hygiene Foundation of America, Inc." (name changed to Industrial Hygiene Foundation in 1941). The committee noted that Air Hygiene Foundation meetings don't directly apply to the railroads, "yet many details are brought out at their annual meetings which can be made of immense value to the railroads." (p. 29).

52. **AAR 1951-1953.** The AAR Committee on Disability and Rehabilitation "mention silicosis and asbestosis as forms of [lung] disease most interesting to railroad surgeons." (p. 34). The committee recommended medical examinations at the time of hiring to include history and chest x-ray, "particularly in those occupations where unusual quantities of silica or asbestos dust have been encountered or are contemplated as a routine occupational exposure." (p. 34).

53. **AAR 1957.** The Committee on Disability and Rehabilitation alters the language on pneumoconiosis from the 1951-53 reports, adding that periodic x-ray examinations should be done "annually" on employees exposed to dust. (p. 24).

54. **AAR 1958.** As with the other meetings, members of virtually all of the major railroads in the United States were present. Doctors reported that, "there is very good proof that asbestos is a cause of carcinoma. This is seen in individuals working with asbestos, particularly miners. It is also seen among plumbers who work with asbestos, seamfitters (sic) particularly." (p. 81). The doctor referenced a study "in which he showed there was a higher incidence of cancer among the operating staffs of the railroads than among the non-operating staffs." The study reported "that lung cancer cases were more than three times as numerous among "operating" railroad workers (engineers, firemen, brakemen, conductors, switchmen, and roundhouse personnel) than 'non-operating' workers. Yet the former group made up only about 25 percent of the work force."

In addition to these AAR reports, Railroad claims agents discussed asbestosis at meetings and in their journals beginning in the 1930s.[31]

55. Alton Railroad Documents: Clearly, the railroad industry was well aware of the hazards of toxic dusts, including asbestos, by the 1930's. A collection of documents commonly referenced as Alton Railroad Documents were created pursuant to the operation of the Railroad Engineering and Shop Committee, of which the Burlington and Santa Fe Railways were members. Notably, the Burlington railroad was jointly owned and controlled at the time of the Alton documents by the Great Northern and Northern Pacific Railways. See Moody's Manual of Investments documenting this fact. The Alton Documents demonstrate the railroad industries extensive knowledge of the hazards of asbestos as well as methods of prevention and detection of asbestos related disease by the railroad industry from the 1930's forward.

In a November 28, 1936 letter from Armstrong Chinn, Chief Engineer of the Alton Railroad Company and Chairman of the Railroad Engineering and Shop Committee, to railroad executives including J.P. Morris, Division Master Mechanic of the Santa Fe Railway and D.B. Moss, Chief Medical Officer of the Burlington Railroad, Mr. Chin recounted the first meeting of the committee. Mr. Chin reported, in part:

> [A]s [the committee's] first work, we are to give consideration to and recommend what action seems immediately advisable to protect the railroads from the following possible occupational diseases:
>
> 1. Asbestosis, from handling asbestos materials, such as boiler lagging
>
> . . .

In a January 5, 1937, letter from an attorney for the Illinois Central Railroad Company to railroad executives including D.B. Moss, Chief Medical Officer of the Burlington Railroad, the railroad demonstrated early knowledge regarding the highly toxic nature of asbestos, problems with the migration of asbestos fibers, and the principle for bystander exposure:

> A discussion was had concerning the best methods of protecting workers from Asbestosis and Silicosis. The men handling Asbestos or doing sand-blasting are not the only ones exposed to the danger of these diseases, as the dusts they make in doing their work create a danger to others that may be working in the vicinity.

[31] P. Folger, "Legal and Other Aspects of Dust Hazards," Minutes of the 45th Annual Meeting of the Association of Railway Claim Agents, held in May, 1934, pp. 27-48; O.G. Browne, "Silicosis," The Bulletin 19:281-284, April 1935; E.R. Hayhurst, "Common Occupational Diseases and Their Differential Diagnosis," Minutes of the 48th Annual Meeting of the Association of Railway Claim Agents held in May, 1937, pp. 31-41.

The letter further discussed that various railroads "have already studied the question of danger from these diseases, and have put out specific instructions to reduce the hazard."

The Alton Documents also include "Recommendations for Protection Against Occupational Diseases," which stated in relevant part:

> In submitting the revised recommendations for prevention of occupational diseases such as lead poisoning, silicosis, and asbestosis, the Committee recognized that the recommendations which are made and designed to comply with the requirements under the Health and Safety Act, and are to be considered a minimum. Some railroads may carry on more expansive operations, which expose employee to the risk of disease or injury by contact with harmful dusts, fumes or gases. Control of such hazards is imperative . . . The first consideration, and the most important, is isolation of any excessively dusty processes, to protect employees in the vicinity engaged in other work and not aware of the risk to which they are exposed. This may necessitate a considerable re-arrangement and re-location of equipment. . . .
>
> All dusts and all poisonous fumes may not be eradicated, but they can be controlled and reduced to a degree which is recognized by sanitarians and by experience to be non-hazardous, and the Committee recommends that at points where extensive operations are carried on, after available mechanical appliances for ventilation are installed, periodic examinations of its air should be carried on to determine the quantity and composition of the dust, . . . It is only by such examinations that the presence of harmful substances in the air can be ascertained and the adequacy of the ventilation systems checked.
>
> These recommendations relate to the engineering control. No less important is the medical control. . . . Supplementing a satisfactory pre-employment history, a physical examination should be made paying particular attention to signs indicating disease of the heart or lungs. The environment in which an employee may be required to work makes necessary this inquiry into the occupational history and physical condition to ascertain that there is no history of previous exposure which may cause impairment and no condition present which may be made worse by occupation. No less important is the periodic physical examination of employee engaged in occupations known to be health hazards if a correct diagnosis is to be made and the proper balance struck between diseases which are unfavorably influenced by occupation and these diseases in which occupation has no bearing. The Committee recommends that employees engaged in work which is recognized as more than a normal hazard such as exposure to silica, asbestos, or lead dusts, be examined semi-annually, or more frequently whenever there appears to be indications

for doing so, with transfer of employees who are becoming impaired, to less hazardous work. (Emphasis added).

The Alton series of documents go on to discuss the hazard asbestos exposure presents to railroad employees and those surrounding them as well as state of the art discussions of exposure prevention techniques. These documents demonstrate the early and extensive understanding by the railroad industry, including BNSF, that asbestos presents a serious health hazard, disturbance of asbestos containing materials presents a hazard even to people in the area who are not engaged in the disturbance activities, that periodic examinations of air for the presence of asbestos dust is necessary in railroad work areas, how exposures can be prevented and reduced, and that periodic physical examinations are necessary among employees engaged in work involving asbestos.

56. **Alton info shared with AAR in 1937**: The knowledge of the hazard and prevention of asbestos exposure demonstrated in the Alton documents was shared with the other Railroads that were part of the American Association of Railroads, including the GNRR, shortly after the above referenced Alton interactions, in June of 1937. At the 1937 AAR meeting, Dr. D.B. Moss, Medical Director of BNSF predecessor Burlington Railroad, active member of the Shop and Engineering Committee responsible for authoring the Alton documents, and the then current Chairman of the AAR Medical and Surgical Section, presented on the findings of the Shop and Engineering Committee regarding the topic of occupational disease advising the other members of the AAR that dust could be harmful to workers and that asbestos was one of the principal sources of toxic dust exposure to railroad workers. At the same time, Dr. Moss advised AAR members that asbestosis was strictly a dust disease, caused only by exposure to asbestos. For the 1937 AAR meeting, W.P. Kenney, President of the Great Northern Railroad, and S.T. Bledsoe, President of the Atchison, Topeka & Santa Fe Railway, were on the Board of Directors, and Dr. D.C. Webb, Chief Surgeon of the Great Northern Railway was on the Committee of Direction for the Medical and Surgical Section. Despite the documented knowledge and recommendations going back to the mid-1930s, BNSF never followed its own guidance in Libby even throughout the 1990s.

57. **National Safety Council Documents**: BNSF predecessors, including the Great Northern Railroad, the Burlington Railroad and the Santa Fe Railroad were members of the Railroad Section of the National Safety Council. See National Safety Council Railroad Section Chairman List; Discovery Request No. 68 (1987). The National Safety Council published and disseminated numerous articles documenting the hazards of asbestos exposure in the 1930s and later.

At least one railroad, the Norfolk & Western, had an asbestosis claim decades ago. The man worked in the engine shop of the railroad, frequently handling insulation materials made with asbestos. He claimed he was totally disabled with asbestosis and had suffered pleural effusion as well (Ancel Wheeler V. Norfolk & Western, U.S. Dist. Court S. Dist. Ohio, W. Div., Civ. No.2740; and Dr. Allen Barker's letter to Dr. W. R. Whitman, Chief Surgeon for N & W, Aug.18, 1951 describing the X-ray findings as "compatible with asbestosis").

58. **Misc. docs. evidencing RR knowledge of asbestos hazard**: In 1960, asbestos was listed as one of seven materials which had been "suspected as lung carcinogens" in an article by Dr. I. Kaplan of the Baltimore and Ohio Railroad ("Relationship of Noxious Gases to Carcinoma of the Lung in Railroad Workers." J.A.M.A. 171:2039-2042, Dec. 12, 1959, reprinted in The Bulletin 44:511-520, 1960); see also 11/18/1980 BNSF correspondence noting "Asbestos is one of the few materials which has been demonstrated to be capable of causing cancer in humans." It is notable that in this same time period Wagner (1960) identified mesothelioma in railroad workers when he described that two of his patients were lagging locomotives. BNSF was aware that "concerning asbestos containing products" "the hazard exists whenever dust is produced during the life cycle of the product." 3/29/1979 BNSF correspondence; see also 4/10/1979 BNSF memorandum "Discussion on Hazardous Materials – Products containing asbestos".

59. **Other sources of RR knowledge of asbestos hazard and IH standards**: BNSF had an extensive exposure to applicable industrial hygiene standards of care throughout the years that it shipped Libby vermiculite. BNSF maintained a Medical Department, an Industrial Hygiene Department, a Safety Department, and a Geology/Mineral Research Department. In addition to being a member of the National Safety Council, the Association of American Railroads, and the Shop and Engineering Committee, BNSF's industrial hygienists were members of the American Industrial Hygiene Association as well as the American Society of Safety Engineers and BNSF's medical officers were members of the American Occupational Medical Association. See Discovery Request No. 68 (1987), Swanson v. BNSF; BNSF's Response to Sixth Discovery Requests - Kleeck. BNSF maintained a vast industrial hygiene and occupational medicine library and received an extensive number of publications on the topic for the use of their Medical Department and industrial hygienists including various texts on asbestos hazards and prevention. See, e.g., List of publications received by BNSF Medical Department (1987). The Railroad had a Safety Division and regularly sent employees working therein to safety training courses. See 1/11/1982 BNSF correspondence.

60. **RR understanding of safety regulations:** The Railroad was aware of applicable safety regulations and regularly discussed their impact on their operation. See, e.g., 4/19/1974 BNSF correspondence, discussing Federal safety regulations and training "required by law"; 1/9/1984 BNSF memorandum discussing OSHA regulations for the exposure to asbestos and BNSF's responsibility to conform thereto; 3/24/1981 Letter from BNSF to OSHA requesting an additional copy of booklet entitled "Training Requirements in OSHA Standards" and a page from the publication discussing the Railroad's obligation to analyze work environments for potential exposure to toxic dust; 5/16/1975 BNSF Correspondence discussing OSHA regulations and their effect on Railroad industry; 6-6-1974 BNSF memorandum regarding Federal Respirator Regulations; 3/29/1979 BNSF correspondence discussing "the strict federal regulations controlling work practices with asbestos; 4/26/1979 BNSF correspondence; 4/10/1979 BNSF correspondence discussing stringent OSHA regulations regarding asbestos including the permissible exposure limit; BNSF

0517 regarding OSHA directives to be used during asbestos removal; BNSF 0394-0416 - BN Respiratory Protection Program setting forth "OSHA's Requirements for a Minimal Respirator Program." Despite its understanding and above referenced recognition of these safety standards, in 1992 BNSF itself noted that "The asbestos program within the Burlington Northern Railroad has been rather hit and miss." BNSF 0570-0571 - BN Asbestos Operating & Maintenance Program (3-4-1992).

In 1976, BNSF circulated a memorandum with an attached National Safety news article on Safety Program Evaluation and requesting regional management assess deficiencies in this regard. See 11-1-1976 BNSF Correspondence. The article sets forth applicable standards of care of the time including inquiry, among other things, into whether "exposure to toxic dust, fumes, vapors, and radiation has been analyzed to determine if health hazards to employees exist," "chemicals handled by employees are monitored to prevent respiratory irritations, and whether "occupational health surveys are performed by qualified industrial hygienists."

61. **RR self-imposed safety standards:** In addition to the applicable safety regulations and general industrial hygiene practices to which BNSF was subject, the Railroad set forth its own self-imposed safety responsibilities which similarly demonstrate its knowledge of these protective principles. See, e.g., BNSF Responsibilities for Safety – Content from Supervisor/Foreman seminars on safety 1975-1976 setting forth what BNSF considers to be "the fundamental requirements" and requiring inspection of "Atmospheric conditions, e.g. dusts"; 5/16/1975 BNSF memorandum discussing the BN Safety Policy which states "Safety is essential for efficient transportation and Safety is the primary concern and continuing responsibility of each supervisor and employee alike"; 9/11/1981 BNSF correspondence attaching a BNSF Respiratory Protection Program representing "the minimum which will meet all requirements" and setting forth the BNSF policy that "Burlington Northern will use substitution, engineering, and administrative controls to reduce employee exposures to toxic substances whenever feasible. When not feasible, or while being implemented, respiratory protection will be used." (Also found at BNSF 0379-0383). In developing its respiratory program, BNSF industrial hygienist Larry Liukonen set forth the "Requirements for a minimal acceptable program," which among other things included "Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained." BNSF 0379-0383 - BN Respiratory Protection Program (1981).

In sum, BNSF clearly had early knowledge of the hazard presented by asbestos, the proper means of identifying its presence, and appropriate means of preventing exposure. Thus, BNSF could and should have recognized and addressed the extreme asbestos hazard that BNSF's vermiculite related activities were producing in the Libby area. Despite the documented knowledge and recommendations going back to the mid-1930s, BNSF failed to take any action in Libby even throughout the 1990s. As set forth below, BNSF not only had early knowledge of the hazard presented by asbestos, but had early knowledge of asbestos in the Libby vermiculite.

VII. BNSF Knowledge of Libby Asbestos.

62. **RR knowledge of Libby asbestos by 1920s**: BNSF knowledge of the presence of asbestos in the vermiculite ore on Vermiculite Mountain near Libby is demonstrated in relevant literature, publications and BNSF company documents by the 1920s.

63. **Geological Publications**: Geologic studies of the material on Vermiculite Mountain beginning in the 1920's revealed the presence of tremolite asbestos in the vermiculite. See, e.g., *Pardee and Larsen* (1925, 1926, 1928, 1929); *Kreigel* (1940); *Perry* (1948); *Johns* (1959); *Bassett* (1959); *Peck* (1960); *Weeks* (1981). As discussed below, many such geological studies were financed and/or received by BNSF. Relevant excerpts include the following:

> **DEPOSITS OF VERMICULITE AND OTHER MINERALS IN THE RAINY CREEK DISTRICT, NEAR LIBBY, MONT.** Pardee JT, Larsen ES. 1929. Deposits of vermiculite and other minerals in the Rainy Creek District, near Libby, Montana: USGS Bulletin; 805: 17-28.
>
> In the Rainy Creek district in Montana the workings of the Vermiculite & Asbestos Co. expose several bodies of amphibole asbestos which are of dikelike or tabular form and of different widths. As commonly understood, the term asbestos embraces the fibrous varieties of several minerals, including anthophyllite, tremolite, actinolite, and crocidolite, which belong to the amphibole group, and chrysotile, a variety of serpentine. A large body of the vermiculite is being developed commercially by the Zonolite Co. In addition several smaller bodies are being explored by the Vermiculite & Asbestos) Co., and in some of these bodies the mineral makes up from 30 to 84 per cent of the pyroxenite country rock. Samples representing areas of several square feet at different places in the workings of the Vermiculite & Asbestos Co. contained from 30 to 84 per cent of vermiculite. Apparently there is a huge amount of such mixed material. Locally the pyroxene (diopside) of the large pyroxenite mass has been changed by hydrothermal metamorphism to an amphibole of fibrous habit, related to tremolite. The minerals known commercially as amphibole asbestos are more or less useful, their value depending on their quality and the relative location of the deposits.

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> **SUMMARY OF** OCCURRENCE**, PROPERTIES, AND USES OF VERMICULITE AT LIBBY, MONTANA.** Kriegel WW. 1940. Summary of occurrence, properties, and uses of vermiculite at Libby, Montana. Bulletin of The Amer Ceramic Soc. 19 (3): 94-97.
>
> Though many deposits of vermiculite have been found throughout the United States, including North Carolina, South Carolina, Colorado, New Mexico, California, Idaho, Wyoming, the New England States, and other

parts of Montana, the history and development of the industry are closely allied with that of the Libby deposits and companies. A second series of dikes intersecting the ore body consists of material high in amphibole asbestos with less altered pyroxenite. Where the concentration of asbestos is sufficiently high, it is mined and marketed.

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GEOLOGIC INVESTIGATIONS IN THE KOOTENAI-FLATHEAD AREA, NORTHWEST MONTANA. WESTERN LINCOLN COUNTY. Willis M. Johns. STATE OF MONTANA BUREAU OF MINES AND GEOLOGY. 1959.

The largest vermiculite mine in the United States has been developed by the Zonolite Company in the Rainy Creek district 7 miles northeast of Libby. Although the company has an expanding plant in Libby, the bulk of the concentrate is shipped as crude vermiculite to expanding plants throughout the country. The expanded vermiculite is marketed under the trade-name, Zonolite. The pyroxenite is very coarse grained and composed of vermiculite, aegerine-augite, soft fibrous amphibole asbestos (tremolite), magnetite, and locally a little biotite. Fibrous amphibole asbestos-, because its specific gravity is very near that of vermiculite, causes much trouble in milling the lower grade ores in which the asbestos is abundant. If a process could be perfected to make a clean separation of vermiculite and asbestos, both products would be marketable, and much material now mined and dumped as waste could be milled and made to yield a profit.

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THE ORIGIN OF THE VERMICULITE DEPOSIT AT LIBBY, MONTANA. THE AMERICAN MINERALOGIST, Bassett WA. 1959. The origin of the vermiculite deposit at Libby, Montana. Am. Mineral. 44: 282-299.

Four alteration minerals predominate, asbestos (tremolite-actinolite), biotite, hydrobiotite, and vermiculite. Many thin (approximately 1 inch), white asbestos veins cut through the pyroxenite. The asbestos has been identified by x-ray diffraction and optically as tremolite-actinolite.

64. **BNSF scientific analyses of Libby Ore**: By 1925, BNSF was one of the first entities to perform a geo-chemical analysis of the Libby Ore. See 11/1/1925 Zonolite Publication - GNRR chemical geological analysis of Libby Ore, p. 4; 1926 Publication summarizing early GNRR chemical/geological analysis of the Libby Ore, p. 2. Over the ensuing years, BNSF showed a continued interest in the economic potential of the Libby Ore and development of the resource. Among other things, BNSF issued reports on the

vermiculite operations prepared by its Division of Economic Research, funded geologic studies of the vermiculite and asbestos deposit, sampled/tested the ore several times, and visited the mine site on multiple occasions.

An August 30, 1963 letter from Alva J. Haley of Great Northern's "Mineral Research and Development Department" to J.A. Kelly, president of the Zonolite Company, discusses Great Northern's visit to the Zonolite headquarters and apparent intent to engage in a cooperative business endeavor involving the agricultural application of Zonolite's vermiculite ore. The letter provides:

> Dear Mr. Kelly,
>
> I very much enjoyed our talk in your office the other day and immediately upon my return to Seattle discussed the entire matter with Mr. Ralph Watson, our Geologist on the west end; we are fully prepared to pursue the matter of biotite investigation in accordance with your wishes. As soon as we have the samples and analyses, Mr. Watson will locate an agronomist for you who can and will undertake to proceed with the testing.
>
> In the event that it might be more convenient for you, Mr. Watson can arrange to be in Libby on September 18 or 19 and would be happy to discuss this matter with Mr. Bleich. The two of them could then take samples; whichever way you prefer.

See 8/30/1963 GNRR correspondence (Emphasis added). In 1976, the BNSF Geology Department visited the W.R. Grace mine. An August 20, 1976, letter from Ronald Seavoy of BNSF to Ray Kujawa of W.R. Grace provides:

> Dear Ray,
>
> Fred and I had a very delightful and informative time during your guided tour of the Zonolite Mine. Thank you very much for taking the time to show us the geology and allow us to collect specimens.
>
> I was particularly interested in vermiculite, having worked for Johns-Manville exploring for asbestos and knowing more than most geologists about industrial minerals. When I returned to the motel and washed some of the specimens I collected, I could see very clearly what you meant by the low temperature alteration solutions that produced vermiculite.
>
> The thing that clearly indicated the low temperature of formation was the way the very large crystals of pyroxene (enstatite?) were partially altered to tremolite-talc rock … (Emphasis added).

65. News Publications: By the mid-1920s two companies had been established to exploit the comingled vermiculite and asbestos resource on outside of Libby, the Zonolite Company and the Vermiculite & Asbestos Company, both of which shipped their products via the GNRR. In 1924, freight rate negotiations with BNSF (12/4/1924 Western News Article) allowed the companies to secure a low freight rate for shipment of their product by rail (12/11/1924 Western News Article). Shortly thereafter, rail cars were being loaded and shipped from BNSF's downtown Libby Railyard. 1926 GNRR Semaphore Article. By 1924, the Zonolite Co. announced plans to construct an aerial tram to the location on the BNSF railroad later known as the River Loading Point. See 8/7/1924 Western News Article; 3/4/1926 Western News Article; 12/16/1926 Western News Article. By 1929, the Zonolite Co. had yet to construct the tramway but was to accept bids on a contract to build the tramway. 7/4/1929 Western News Article.

A 1926 Western News article reports that the Zonolite Company has recently employed a noted engineer chemist; "The Zonolite Company has recently secured the service of Frank J. Buck, C. E., E. M., to superintend the installation of a new treating plant to be erected at the site of the present experimental furnace." See 1/21/1926 Western News Article. See also 1/20/1926 Western News Article – Vermiculite & Asbestos Co. will manufacture many products from Vermiculite and Asbestos; 2/10/1927 Western New Article – discussing possible applications for the vermiculite and asbestos mined in Libby; and 1/20/1926 Western News Article – Offering Stock in Vermiculite & Asbestos Co. In 1927, the Western News contained an entry offering stock in the Vermiculite & Asbestos Company and reporting that the "company has many thousands of dollars in commercial asbestos already opened up" … "to say nothing regarding the mountain of vermiculite" … "Our program for this property is an extensive development plan and the immediate erection of a mill. But we will not wait for mill to begin shipping the crude asbestos. This will start rolling to market soon as the tramway is completed." 1927 Western News Publication. See also 5/5/1927 Western News Article discussing extensive asbestos deposits in the Vermiculite & Asbestos Co.'s extensive Rainey Creek mine claim and discussing markets and uses for the asbestos product. A subsequent Western News publication discusses the Libby vermiculite and provides "this stuff belongs to the asbestos family, but is a higher insulator for heat or cold. The stuff has been shipped from Libby to our Los Angeles plants for several years and we worked out thirty-two uses for this material." 5/19/1927 Western News Article.[32] A May 1927 article titled "Work Progressing at Asbestos Mine" provides that the Vermiculite and Asbestos Co.'s "orders are beginning to pile up and only yesterday a letter was received from the largest users of asbestos on the west coast that they could use several cars weekly." 5/12/1927 Western News Article. Later that month the Western News reported that the neighboring Zonolite Co. was shipping out many orders. 5-26-1927 Western News Article. By June 30 of 1927, in a Flathead Monitor publication,[33] the Zonolite Company discussed the great publicity "the occurrence of the amphibole asbestos in the Rainy Creek mining district" had been given and announced that commercial export was not economically feasible based in part on the "freight rates on the Amphibole" which "would range from fifteen to twenty dollars per ton in car lots to Chicago and eastern markets with higher proportionate

[32] The Western News reprinted this article in 1967 as part of an anniversary edition.
[33] This article was also reprinted in the Western News in 1967.

rates to the west." By June of 1927, the Zonolite Company had obtained permission to build a tram with "bunkers and other terminal equipment for the lower end of the tram, which we expect to locate on the Great Northern right-of-way." See 6/9/1927 Western News Article.

An October 1927 Western News article entitled "Mining Journal Gives Write-up of Libby and Troy Districts" discusses the operations at Rainey Creek stating:

> A visit was made to the Zonolite Company's jeffersite or vermiculite mine some six miles north of Libby on Rainy Creek. This operation has attracted a great deal of interest. The noted geologist, J.T. Pardee, arrived in Libby while the reporter was at the property, and made his second visit to the mine the following day… An aerial tram will be run about 10,000 feet down Rainy Creek and across Kootenai River to a loading platform on the Great Northern railroad from which the material will be transported to the Zonolite company's treating plant in the eastern outskirts of Libby. ***
>
> On the opposite side of the same mountain the Vermiculite & Asbestos Company has started to develop an extension of the jeffersite deposit. In this section there appears to be more of the amphibole asbestos, to which the Zonolite people pay no attention. ***
>
> Two other concerns, the Micalite Company and the Jeffersite Company, have been formed to explore the outlying sections of the deposits but they are inactive.

See also 4/17/1928 Western News Article discussing Libby mines and noting that asbestos is found here also. Although by 1929, railroad records indicate that only small amounts of vermiculite had been moved by rail, shortly thereafter vermiculite shipping operations appear to have been well underway. By 1932, the Western News reported that the Vermiculite & Asbestos Co. was beginning construction of their new 125-Ton vermiculite processing mill that was expected to be able to produce 125 tons of vermiculite concentrate per day. See 10/27/1932 Western News Article. In 1934, the Vermiculite & Asbestos Co. became the Universal Insulation Co. In March of 1936, the Western news reported that the Vermiculite Company was expanding to include a processing plant in Minneapolis for its growing business. See Western News Article 3/26/1936. In 1939, the several different vermiculite operations were combined into the Universal Zonolite and Insulation Company, the name of which was changed to the Zonolite Company in 1948. In September of 1939, the Western News contained an article entitled "Concern Ships 63 Carloads in August" which describes in some detail the Zonolite operations taking place at the "loading docks north of the Great Northern tracks here in Libby… 63 freight carloads of vermiculite had been shipped from Libby to points all over the world. This is more ore than was ever shipped by either of the former companies together." 9/21/1939 Western News Article.

66. Sanborn Fire Insurance maps from June of 1946 show the Zonolite Co.'s Storage and Shipping Plant located on Great Northern's right of way at the Railyard and a former Vermiculite & Asbestos Co. property located immediately adjacent to the Railyard. See Sanborn Fire Insurance Maps. During this period, the ore was trucked from the mine site to the processing facility in Libby where it was loaded on the trains, but by 1949 the river conveyor was constructed and material was loaded on the Zonolite railroad siding directly across the river from Rainey Creek Road.

67. Company Records: The corporate records of the Great Northern Railway, held and maintained by the Minnesota Historical Society, contain various documents demonstrating BNSF's early knowledge of the presence of asbestos in the vermiculite mined in Lincoln County as well as a great interest in the economic development of the Libby vermiculite mine.

Correspondence beginning in early 1929 between G.R. Martin, Vice President of the Great Northern Railway and others demonstrates this interest and knowledge. Mr. Martin sought information regarding the vermiculite product being mined in the area from local railroad employees and the United States Department of the Interior Geological Survey. See 4/6/1929 Letter from A.B. Ashby to Mr. Martin, 4/29/1929 Letter from Mr. Kenney to Mr. Martin and 5/13/1929 Letter and attachments from Mr. J.T. Pardee to Mr. Martin with Great Northern Railway's President's Office Seal regarding Bulletin 805-B. When asked about railroad knowledge of the vermiculite, local railroad employee W.F. Kenney informed Mr. Martin that they "have heard of this; in fact, have rates in [effect], but only a very small quantity of it has moved." The noted geologist Mr. Pardee provided Mr. Martin with the study entitled "Deposits of Vermiculite and other Minerals in the Rainy Creek District near Libby, Montana" (Bulletin 805-B (1929)) which provides as follows:

> The deposits described are in an easily accessible area about 7 miles northeast of Libby Mont. . . . About two-thirds of the stock consists of a coarse-grained pyroxenite that ranges from nearly unmixed pyroxene to nearly unmixed biotite or its alteration product vermiculite. ***
>
> The principal minerals thus produced are white mica, aegirite and aegirite-diopside (both locally vandiferous), vermiculite, and fibrous amphiboles… A large body of the vermiculite is being developed commercially by Zonolite Co. In addition several smaller bodies are being explored by the Vermiculite & Asbestos Co., and in some of these bodies the mineral makes up from 30 to 84 per cent of the pyroxenite country rock. Vermiculite is comparatively new to commerce…
>
> On the spur north of Kearney Creek much of the pyroxene of the large pyroxenite body has been altered to amphibole of a fibrous habit that is known commercially as amphibole asbestos. ***
>
> The area under consideration is the lower part of the basin of Rainy Creek, about 7 miles northeast of Libby, Mont. (See pl. 1.) It is easily reached

> from the main automobile highway along the north bank of the Kootenai River by a short branch road up Rainy Creek. The Great Northern Railway approaches within 2 miles, but it lies on the opposite bank of the river. A few miles below Rainy Creek, however, a logging railroad crosses to the north bank. ***
>
> Locally the pyroxene (diopside) of the large pyroxenite mass has been changed by hydrothermal metamorphism to an amphibole of fibrous habit, related to tremolite.
>
> In the Rainy Creek district in Montana the workings of the Vermiculite & Asbestos Co. expose several bodies of amphibole asbestos which are of dikelike or tabular form and of different widths. The largest, as exposed by open cuts, appears to by 100 feet or more long and from a few feet to 14 feet wide. A body 4 feet or more wide exposed in the face of a tunnel at a depth of 150 feet or more may be the downward continuation of the same deposit. Several smaller bodies are exposed in other workings…
>
> As commonly understood, the term asbestos embraces the fibrous varieties of several minerals, including anthophyllite, tremolite, actinolite, and crocidolite, which belong to the amphibole group, and chrysotile, a variety of serpentine. ***
>
> For a few inches on both sides of the veins the pyroxene of the wall rock is changed to a fibrous amphibole related to actinolite and glaucophane. (Emphasis added.)

Plate 1 of the report is a geologic map of the Rainey Creek district which clearly shows the Zonolite and the Vermiculite & Asbestos Co. developments located immediately adjacent to each other, on top of vermiculite mountain, and directly over the pyroxenite deposit, referenced above as being associated with, and having been altered to, amphibole asbestos. The map also shows the Great Northern Railroad running in close proximity to the deposits.

Also attached to Mr. Pardee's letter to Mr. Martin was an April 8, 1929 report from the American Mining Congress Special Daily Information Service, Washington, D.C., which provides that "the vermiculite deposit near Libby, which is more extensive than other know similar deposits in this country, is accompanied by asbestos …"

These reports put BNSF's predecessor on notice, as of 1929, that the ore coming from the Rainey Creek area, which they were already engaged in shipping, was highly intermixed with tremolite and actinolite type amphibole asbestiforms.

68. RR interest in economic development of vermiculite operations: The railroad's interest in the economic development of this resource continued and in 1959 the railroad funded a State of Montana Bureau of Mines and Geology Report known as "Bulletin 12," further entitled "Progress Report on Geologic Investigations in the Kootenai-Flathead Area, Northwest Montana." The report was prepared under a cooperative agreement with, and funded by, BNSF.[34] Bulletin 12 provides:

> The largest vermiculite mine in the United States has been developed by the Zonolite Company in the Rainey Creek district 7 miles northeast of Libby… In 1939, the several different operations were combined into one under the Universal Zonolite and Insulation Company… A 1,000-ton mill, erected in 1948, produced 350 to 400 tons of concentrate per day, and it is presently being enlarged. Although the company has an expanding plant in Libby, the bulk of the concentrate is shipped as crude vermiculite to expanding plants throughout the country. The expanded vermiculite is marketed under the trade-name, Zonolite.
>
> The [vermiculite] deposit is an elongated stock composed of pyroxenite and syenite. The stock intrudes strata of both the Wallace and Striped Peak formations in the trough of a northwest-trending syncline. The pyroxenite is very coars-grained and composed of vermiculite, aegerine-augite, soft fibrous amphibole asbestos (tremolite), magnetite, and locally a little biotite. ***
>
> This unusual stock has many minerals of potential value. The vermiculite, of course, is being actively marketed at present. **Fibrous amphibole asbestos, because its specific gravity is very near that of vermiculite, causes much trouble in milling the lower grade ores in which the asbestos is abundant. If a process could be perfected to make a clean separation of vermiculite and asbestos**, both products would be marketable... (Emphasis added).[35]

The following year the railroad funded a second State of Montana Bureau of Mines and Geology Report entitled "Bulletin 17" providing:

> It consists primarily of augite pyroxenite altered on a large scale to biotite, hydrobiotite, and vermiculite. Veins of asbestos intrude the pyroxenite (see. pl. 2). Outcrops of this body are very few, and the only good exposures are

[34] That BNSF funded these studies based on its financial interest in the vermiculite operations is confirmed by BNSF's Director of Environmental Operations, Melvin Burda, who testified that it "was commissioned by the Marketing Department to see during a time of downturn economics for the railroad to see if there was any potential growth or any other commodities if it should ever come into commercial use, would it be a potential marketable service for that firm to basically need shipping requirements to move that commercial product… Asbestos was one of those that was identified as a potentially marketable product that may need shipping." See 1/25/2007 Deposition of Melvin Burda, p. 46-47.

[35] This description of the Libby Vermiculite Deposit appears to have been referenced by the Railroad in 1964, in drafting a Great Northern Goat article on the vermiculite facility; "Ore masses are cut by syenite rock dikes varying in width from a few inches to many feet."

> at the Zonolite Company's open pit in the vicinity of Vermiculite Mountain (east central part of sec. 22, T. 31 N., R. 30 W.).
>
> Four alteration minerals predominate: asbestos (tremolite-actinolite), biotite, hydrobiotite, and vermiculite. The name hydrobiotite is applied to the interstratified biotite-vermiculite from Libby. This mineral along with vermiculite and biotite, constitutes the commercial vermiculite ore. (Emphasis added.)

In 1970, the railroad funded a further State of Montana Bureau of Mines and Geology Report entitled "Bulletin 79" providing in relevant part:

> RAINY CREEK STOCK
>
> The Rainy Creek stock is west of the Kootenai River about 8 miles northeast of Libby. This large complex stock of pyroxenite and syenite underlies part of the valley of Rainy Creek and extends east beneath Vermiculite Mountain. ***
>
> Pyroxenite within the Zonolite pit is light gray to yellowish-green coarse-grained friable rock composed of vermiculite, aegirite, aegiritediopside, soft fibrous tremolite, apatite, magnetite, garnet, biotite, and hydrobiotite…
>
> Tremolite (amphibole asbestos) forms at the expense of pyroxenite in altered zones bordering syenite apophyses and quartz veins that cut the pyroxenite mass (Boettcher, 1963). ***
>
> Bordering the syenite apophysis and related syenite dikes in the pyroxenite are alteration halos of tremolite after pyroxenite, which are of potential economic importance as a source of brittle asbestos. ***
>
> The Rainy Creek pluton has many minerals of potential value, besides the vermiculite, which is being marketed at present. Amphibole asbestos (tremolite) … may be profitable byproducts if separation can be achieved economically and if markets can be developed for these minerals. (Emphasis added.)

Bulletin 79 also includes a figure depicting the Rainy Creek Stock, which shows the mine operations located directly over the pyroxenite deposit and the Great Northern Railroad passing by in close proximity to the mine location.

69. Asbestos Shorts: In addition to the freight rates from Libby for amphibole asbestos shipments reported in 1927 (referenced above), in 1962, the Zonolite Company, operator of the vermiculite mine near Libby, communicated with BNSF about the possibility of hauling pure asbestos from Libby to various locations throughout the United States This is memorialized by a Grace memorandum confirming communications between BNSF and

Grace and quoting rates to the Zonolite Company for prospective hauling of pure asbestos. See Asbestos Shorts Shipping Rates Memo, 4/30/1962. Zonolite also inquired with Great Northern's Montana tax agent regarding joint tax treatment for their vermiculite and proposed asbestos businesses given that the mining was to be done from the same property in Libby. See 2-21-1962 Zonolite Memorandum. Former BNSF Director of Industrial Hygiene James Shea confirmed these communications between the GNRR and W.R. Grace and that Bulletin 12 conveyed that then current milling technologies were unable to separate the asbestos from the vermiculite in admitting that the GNRR was aware there was "amphibole material in the vermiculite product." 1/26/2007 Deposition of James Shea, pp. 99-100.

> **Q** And one of the locations where Great Northern evaluated the content of ore to assess economic opportunities was Zonolite mountain?
> **A** Yes, that's correct.
> **Q** And the study revealed, did it not, that the vermiculite ore on Zonolite mountain contained amphibole asbestos?
> **A** Yes, it did.
> **Q** And the study even specifically said that current milling technologies were unable to separate the asbestos from the vermiculite, right?
> **A** I believe it described that.
> **Q** Were you aware that the Great Northern Railroad actually entered into negotiations with W. R. Grace discussing the establishment of rates for hauling asbestos from Libby, Montana?
> **A** That's my understanding.
> **Q** And that was in the early 1960's, right?
> **A** Well, I believe Grace took ownership in 1963, so I imagine they would have entered into that discussion immediately.
> **Q** The discussion actually was with the predecessor to Grace, the Zonolite Company, right?
> **A** Yes.
> **Q** And that was in the early '60's?
> **A** That would have been in, yes, the very early '60's, yes.
> **Q** So there's really no question, is there, that Great Northern was aware that there was asbestos present in material buried on Zonolite mountain, do you agree with that?
> **A** I think that's pretty clear from judging from that document that the document spoke of amphibole material in the vermiculite product. So to the extent that described it, yes.

BNSF's Director of Environmental Operations, Melvin Burda, further confirmed that a motivation of BNSF in funding Bulletin 12 was to explore the potential for shipments of the Libby asbestos to be made on its lines and admits, with reference to Bulletin 12, that he was aware of the difficulty with separating the vermiculite concentrate from the asbestos. See 1/25/2007 Deposition of Melvin Burda, p. 55.

70. Libby Vermiculite Asbestos Warnings:

A. Railcar Warnings: W.R. Grace correspondence of October 24, 1972, discusses new regulations requiring that railroad cars carrying Libby Ore carry asbestos warning labels "in the form of a placard posted on both sides of the vehicle. By at least 1977 and thereafter, railcars carrying the Libby Ore were marked with asbestos warning placards reading as follows:

CAUTION
Contains asbestos fibers.
Avoid creating dust.
Breathing asbestos dust may
cause serious bodily harm.

See, e.g., W.R. Grace correspondence of 10/24/1972, 6/21/77 ,6/28/77 and W.R. Grace's response to the Second Request for Information Regarding the Libby Asbestos site, February 22, 2000, p. 20. The Libby Historical Society also has the attached rail car vermiculite ore warning label in its archives which was also used by Grace on cars carrying Libby vermiculite ore. River Loading Point workers remember affixing these warning signs on hopper cars going to private customers (See, e.g., 6/9/1999 Deposition of River Loading Point worker Robert Wilkens), and BNSF employees remember seeing these warnings on outgoing vermiculite cars. BNSF employees also remember a meeting of BNSF employees and management with W.R. Grace manager William McCaig after BNSF employees noticed the warnings on the outgoing railcars. See, e.g., 6/28/2016 Deposition of Bruce Carrier.

B. Other Warnings: Beginning in 1972, W.R. Grace placed government required signs in the mine and processing facilities with the following warning:

ASBESTOS DUST HAZARD
Avoid Breathing Dust.
Wear Assigned Protective Equipment.
Do Not Remain In Area Unless Your Work Requires It.
Breathing Asbestos Dust May Be Hazardous To Your Health.

See, e.g., W.R. Grace's response to the Second Request for Information Regarding the Libby Asbestos site, February 22, 2000, pp. 14, 20. BNSF executives and its geology department visited the W.R Grace mine on several occasions, at which time the government required asbestos dust warning signs in the mine and the asbestos warning labels on bags of vermiculite concentrate would have further informed BNSF of the asbestos hazard associated with the ore they were hauling.

W.R. Grace shipped bagged vermiculite ore in BNSF boxcars, which beginning in March 1976 each carried a warning label reading:

CAUTION
CONTAINS ASBESTOS FIBERS

BREATHING ASBESTOS DUST MAY CAUSE
SERIOUS BODILY HARM

Due to the co-ownership of the Export Plant facility, BNSF management inspected the Export Plant a couple times each month at which time these warnings would be visibly apparent to them. See 9/13/16 Deposition of John Swing.

C. **Vermiculite MSDS:** Beginning in 1974, Grace supplied Material Safety Data Sheets to customers receiving shipments of vermiculite ore stating that it contains the "Hazardous Ingredient" tremolite asbestos and advises to avoid creating airborne dust and to use dust control techniques when handling the material. Subsequent MSDSs for vermiculite warned of "normal physical handling given to vermiculite concentrate can create an airborne fiber level in excess of OSHA standards….See 7/19/1977 MSDS; W.R. Grace's response to the Second Request for Information Regarding the Libby Asbestos site, February 22, 2000; and BNSF HPP 001271-001491 - MSDS Materials Produced by BNSF. BNSF's industrial hygiene and toxicology expert, Francis Weir, concedes that BNSF received these MSDS, giving them further notice of the asbestos content of the vermiculite concentrate they were hauling. See 7/2/2003 Deposition of Francis Weir, p. 68. BNSF's receipt of these MSDS from W.R Grace has been further confirmed by BNSF through prior discovery.

71. **Agency Reports/Publications**: In October 1968, the U.S. Department of Health, Education and Welfare reported on its atmospheric and bulk asbestos sampling at Libby. See U.S. Public Health Department Tremolite Sampling Report 10/8/1968 and 10/17/1968. By the mid-1970s the EPA was engaged in investigations of, and publications regarding, the asbestos content of the Libby vermiculite. See, e.g., EPA's Libby Vermiculite/Asbestos Timeline; EPA 1977, Asbestos Fibers in Discharges from Selected Mining and Milling Activities; EPA 1981, Asbestos-Contaminated Vermiculite; EPA 1983, "According to the submitter, the Libby Vermiculite deposit has long been known to be contaminated with tremolite, an asbestiform mineral"; EPA 1985, "W.R. Grace and Company, the largest domestic supplier and user of vermiculite, acknowledged in 1971 the presence of asbestos contamination in the ore mined at their Libby, Montana facility. Even after the ore was processed to remove impurities, some amphibole asbestos was detected in the vermiculite (EPA 1980a)."[36] These materials were freely available to BNSF.

The 1976 NIOSH Revised Recommended Asbestos Standard produced in BNSF files at "BNSF 1818-1878" provides:

> Mining and milling of asbestos in the United States is not extensive: fewer than a thousand workers are employed (148). However, amphibole minerals and, to a lesser extent, serpentines, are sometimes found as

[36] EPA 1980(a) also notes that employees in loading areas are exposed to up to 5 f/cc and notes that "a substantial portion of the general public also is potentially exposed to asbestos contaminated vermiculite".

> contaminants of other types of ore bodies, such as talc, vermiculite, crushed stone aggregates, and in ores from various metal mining operations.***
>
> ***Research Priorities**:* Although asbestosis is well characterized clinically and has been the subject of a good deal of epidemiological research, a number of research priorities remain:
>
> I. Epidemiological studies are needed to further characterize: potential asbestos risk from exposure in the railroad industry; tremolite exposure from contaminated vermiculite and talc in the users of these products; the risk (if any) among those working in the crushed stone industry; and to assess the risk of pleural abnormalities in the absence of parenchymal changes. (Emphasis added.)

72. **National Newspaper Publications**: The problems with asbestos in the Libby vermiculite ore were announced publicly nationwide in various news publications by the 1970's. See, e.g., Louisa, VA Article 9/3/76; 10-24-1979 Letter from USM to U.S. Consumer Product Safety Commission, attaching various articles and publications demonstrating the "general acknowledgement that vermiculite ore contains chrysotile and tremolite asbestos." In 1985, Ralph Nader's Public Citizen publications reported that Libby workers, in particular, were ailing. Then in 1988, a leading Montana newspaper, The Missoulian, ran a front-page Sunday-edition story about Libby's dying workers and widows filing lawsuits against the company. BNSF continued to make shipments of the vermiculite material until 1993. See 4/28/1993 Newspaper Article – Last Train Out.

In sum, the above materials clearly establish BNSF's early actual and constructive knowledge of the presence of toxic asbestos in the vermiculite ore coming from Libby.

VIII. BNSF's Deceptive Course of Conduct Regarding Asbestos

73. **Introduction**: Contrary to applicable industrial hygiene standards of care, despite the documented early and in-depth understanding of the hazard presented by asbestos, how exposure could be prevented, and the presence of asbestos in the Libby product, the available record indicates that BNSF ignored and later concealed its problems regarding asbestos. As discussed previously, the Railroad's knowledge of the asbestos hazard in general is documented going back to the early 1930's through the Alton Documents, the American Association of Railroad Conference Reports and other documents and the Railroad's knowledge of the asbestos content of the Libby product was apparently established even earlier. Yet, there is no evidence that BNSF ever engaged in any air or dust sampling or prevention in Libby or ever provided any respiratory protection/equipment to their employees in Libby. In fact, the record demonstrates that BNSF avoided regulation or inspection of their activities in regards to air quality of BNSF premises.

74. **BNSF documents re: course of conduct**: BNSF documents show that they were aware that asbestos creates a hazard whenever dust is produced during the life cycle of the product and that asbestos causes cancer (W.A. Marshall to A.M Skinner, March 26, 1979;

Abbott Skinner to W. A. Marshall, March 29, 1979). A December 12, 1983, letter to Thompson Matthews and Mears from Donald E. Engle advises that "The Regional Vice Presidents were advised regarding the health hazards relative to asbestos following the last regional staff meeting in St. Paul. It appears necessary that we take the next step and implement rules for the handling and working with asbestos which is found to be located in BN facilities." A 1984 BNSF document states: "In connection with development of policy regarding the removal and/or handling of asbestos at BN, I feel the matter has now reached the point where severe restrictions of communications are counterproductive and can soon result in loss of credibility when trying to present any favorable findings. OSHA has issued regulations for exposure to asbestos and BN, the same as any manufacturer and real estate holder, has a potential and significant problem." See 1/9/1984 BNSF Memorandum. BNSF correspondence preserved in a 12/18/1981 letter from J.J. Button to J.G. Edwards referencing an article from the "'Occupational Hazards' individual responsibility for corporate managers" entitled "Criminal penalties coming for concealing hazards," stated: "Sounds like some of us may end up penniless and behind bars. If it passes, all of our corporate officers need to be made aware."

75. **Liukonen testimony**: Larry Liukonen was the industrial hygienist for BNSF from 1979-1987 and during that time he became the Director of Industrial Hygiene for BN. Mr. Liukonen has testified that prior to 1979, he was not aware that BNSF had ever conducted any studies to determine whether its workers had been exposed to asbestos. (Liukonen depo. of 1/24/2007 at p. 39). Mr. Liukonen testified that the written program developed by the Safety and Rules Department for BNSF, prior to his employment, did not address asbestos. Mr. Liukonen testified that BNSF did have some friable asbestos-containing materials in different places where BNSF employees worked, and that BNSF never instructed its employees to wear respirators while working with or around asbestos-containing materials. Mr. Liukonen also testified that Labor Relations for BNSF undertook to tell all of the BNSF employees that they should not work with friable asbestos-containing material sometime in the early 1980's, and before 1979, the employees were working with the friable asbestos-containing materials. Finally, Mr. Liukonen testified that BNSF's program to generally educate their employees about chemicals that they might work with did not address asbestos.

Mr. Liukonen further testified that he had no knowledge regarding the operations that BNSF conducted in Libby while he was employed by the company, that he had no knowledge of whether the vermiculite BNSF hauled out of Libby, Montana contained asbestos, that he never made any attempt to evaluate the work that the workers in Libby were doing on a daily basis, and that as far as he knew, no one else did either. (Id. pp. 40-45.)

76. **BNSF conduct re: safety regulations**: Contrary to applicable industrial hygiene standards of care, BNSF documents demonstrate a long standing course of conduct of minimizing, ignoring and avoiding safety standards, rules and regulations. See, e.g., 4/19/1974 BNSF correspondence, reporting that BNSF "can no longer afford to sidestep the responsibility of training our supervisors, and our employees' supervisors in safety methods, as required by law"; 5/16/1975 BNSF Correspondence discussing the "common

weakness throughout our industry; that of training people for their positions" and discussing broadening safety training; 9/11/1981 BNSF correspondence discussing BNSF's citations for not having a Respiratory Protection Program; 5/10/1974 BNSF memorandum noting "It is not uncommon to find employees working at hazardous jobs while failing to wear protective equipment," or to "have no safety rule book" or protective equipment available to them and recognizing that it is "necessary to continually audit any operation to check for rules compliance by all employees"; 6/30/1976 BNSF memorandum discussing, among other issues, the practice of BNSF supervisors' use of "continual threat of dismissal for failure to comply with instructions even though they are contrary to safe practices"; DuPont Safety and Environmental Probe of BNSF Operations – Negative Items finding, among other things, that "Emphasis in many areas remains on production more than safety" and that "ballast watering needs to be consistent"; DuPont Safety Management Evaluation of BNSF Operations 12-92.

77. **BNSF re: OSHA**: By the 1970s OSHA promulgated regulations regarding asbestos and other chemical hazards in the workplace which included mandatory safety requirements, required employers to post OSHA signs and warnings, set forth exposure levels, required engineering controls to eliminate the hazards, set forth work practices for dealing with asbestos similar to what the railroad industry had itself recommended decades earlier, required methods of air monitoring for exposures, respiratory protection and fit testing, and medical monitoring of exposed workers. Asbestos was the first material regulated by OSHA. Throughout the years, BNSF has maintained a contentious relationship with OSHA in regards to safe practices on their premises by refusing to conform to regulations and refusing to allow the agency to enter onto Railroad property. [37] November 1978 BNSF correspondence discusses various OSHA citations being issued to railroads and provides:

> We do not have the OSHA notice posted on our property except in the State of Minnesota. We have not been cited by OSHA inspectors at points other than Minnesota, with one or two exceptions, where OSHA has inspected our property due to employee complaint. These are rather minimal fines and believe it in our best interest not to post at this time.

[37] See, e.g., 2/6/1975 BNSF correspondence discussing requirements of posting OSHA Act posters in BNSF facilities and declining to comply by recommending "no change be made in present BN policy," and that "we do not post the notice unless we get a lot of OSHA inspectors on the property. The thought here is that this poster may encourage more employees to write to OSHA on complaints. This has my concurrence." In addition 2/7/1975 BNSF correspondence confirms this course of conduct and provides that "Even though Burlington Northern has received a citation for this type of violation, our legal department still does not fell that the OSHA posters should be displayed. Later in 1975, the International Association of Machinists submitted a formal complaint and request for inspection to OSHA, almost exclusively regarded BNSF facilities, alleging "worker exposure … to excessive dusts, fumes, vapors gases and soot [which] constitute continuous and cumulative health hazards producing systemic effects including the respiratory system." See 6/30/1975 Formal OSHA complaint. In this regard, BNSF noted that "the ventilation issue could have a major impact," "our safety audits seldom have items on ventilation" and "if the OSHA inspectors were to inspect the 69 work centers, they may find other health standards which do not comply and these areas may cause a major impact." 7/9/1975 BNSF correspondence.

See also 1/28/1975 ATSF memo discussing its decision not to post OSHA notices; 2/7/1975 letter from AAR to ATSF discussing legal department decision not to conform to OSHA notice requirements; In 1980, BNSF refused to allow OSHA inspectors on their property in Montana to investigate adequacy of respiratory protection and ventilation despite authority under a Federal Inspection Warrant and the order of a U.S. Magistrate. See 12/6/1980 Billings Gazette Article.[38] Despite BNSF's well documented awareness and understanding of OSHA regulations and accepted respiratory safety practices in general, they typically refused to come into compliance, and in Libby followed this course of conduct by making no effort to classify or quantify the visibly obvious vermiculite dust present at the Libby Railyard, the River Loading Point and its rights of way throughout Lincoln County.

IX. BNSF Working Together with Grace

78. BNSF and Grace working together general: The available materials demonstrate that from a very early point in the development of the vermiculite resource, BNSF took a special interest in the Libby operations. Based on the limited sampling of documents currently available, it is apparent that throughout the ensuing 60 plus years, BNSF played a central role in the vermiculite operations that took place in Libby that far exceeded a relationship that could fairly be described as simply that between a common carrier and a shipper. While BNSF transported the entirety of the mined payload of Vermiculite Mountain, amounting to more than 80% of the world's supply of vermiculite ore[39], out of downtown Libby on behalf of these companies, BNSF sold and leased land and rail facilities to Grace for a negligible amount. See, e.g., River Loading Lease Agreement 1 – April 1950 leasing the River Loading Point to Zonolite for $10 per year; Quit Claim Deed from Great Northern to Zonolite – November 1938. Similarly, Grace leased and sold land to BNSF in furtherance of their mutually beneficial undertaking to benefit from the export of vermiculite, which was laden with asbestos.

BNSF took upon itself to perform economic analyses of the vermiculite operations; BNSF took part in developing new uses for vermiculite products and assisted in marketing the vermiculite product to various customers; BNSF funded geologic surveys of the vermiculite deposit; BNSF engaged in several of its own geo-chemical samplings/analyses

[38] See also 4-11-1978 BNSF Correspondence discussing BNSF policy in regards to OSHA inspectors; 1-8-1986 BNSF Personal and Confidential Memo setting forth BNSF policy regarding OSHA inspections ("It is Company policy to prohibit federal or state OSHA inspections without a court order, search warrant, or a bona fide employee complaint containing an allegation of a specific hazard.").

[39] By 1970, Libby had processed over 29 billion pounds of ore (Bulletin 79, p. 147) and was estimated to exceed 35 billion pounds of ore from 1971 through 1981 alone. According to W.R. Grace, the average daily production from the mine and milling operation was between 500 and 1000 tons of finished vermiculite concentrate per day between the late 1960s and 1970s and between 800 to 1000 tons per day in the 1980s. Using a daily average of 750 tons, BNSF carried up to 105,000 pounds of Libby Amphibole Asbestos into and out of downtown Libby per day in the late 1960s and 1970s and, based on a daily average of 900 tons per day, up to 126,000 pounds per day through the 1980s. This amounts to up to 383,000,000 pounds of asbestos carried into Libby in the 1970s and up to 460,000,000 pounds through the 1980s.

of the vermiculite ore and associated constituents; BNSF and Grace executives had close personal relationships, and BNSF oversaw dust control, safety, construction and modifications of the Grace shipping facilities. Parts of Grace operations were located on BNSF property and vice versa. These entities granted each other easements, leased property to each other and worked together to construct the vermiculite export facilities. Their activities involved direct insurance agreements with one another. See, e.g., Zonolite Siding Insurance Agreement 4/14/1977, Affidavit of James Roberts 2-8-2007.

79. **Early interactions**: By 1924, the Libby Vermiculite operations had secured a "low freight rate" from the Railroad for the shipment of vermiculite. See, e.g., 12/11/1924 Western News Article. The first full train car load of Libby vermiculite was shipped to Ohio for use as an insulator in 1925. See 3/25/1925 Western News Article; and Libby Legacy Project Timeline). Shortly thereafter, regular shipments of vermiculite, and apparently some shipments of Libby asbestos, were being made from the Railroad's downtown Libby Railyard. See, e.g., 1926 Great Norther Publication discussing vermiculite operations, then existing markets for Libby ore, and containing a photo of a box car being loaded at the Libby Railyard for shipment to Dayton, Ohio; Sanborne Fire Insurance Maps showing a Zonolite shipping facility located in the Railyard and a Vermiculite and Asbestos Company facility abutting the Railyard; 5/12/1927 Western News Article referencing orders for cars of asbestos; 5/26/1927 Western News Article entitled Zonolite Shipping Out Many Orders; 1928 Zonolite Co. Annual Stockholders Report.

    By 1926, the Railroad and Zonolite were engaged in a plan to locate an additional vermiculite loading facility (the River Loading Facility) on the Railroad right of way across from Rainey Creek Road, a plan that was not realized until 1949. See, e.g., 11/30/1926 Flathead Monitor Article; 6/9/1927 Western News Article.

80. **Grace Shipping/Export/Import Facilities**: Each of W.R. Grace's shipping, export, and import related facilities were closely associated with the Railroad and received special involvement of the Railroad in their operations. These facilities included Grace's River Loading Point, Downtown Export Plant, and their downtown import dock and fuel/oil facility.

81. **River Loading Point**: The Grace-BNSF co-operation was most pronounced at the River Loading Point. [40] BNSF operated the River Loading Facility "in Libby to transport vermiculite for Grace's benefit. As a condition to having access to the BNSF facility, Grace agreed to indemnify and insure BNSF for its operations in Libby." Excerpt of BNSF's Complaint for Declaratory Judgement 2-7-14. As succinctly stated in

[40] The Universal Insulation Co., formerly the Vermiculite and Asbestos Co. initially acquired the land across from the Rainey Creek screening plant in 1934 with plans to build a tram across the Kootenai River to access the GNRR's main line. This area would eventually be adjacent to the River Loading Point and provide the access thereto. Once the River Loading Point was in operation, this property also served as a dumping point for the excess vermiculite spilled during operation of the River Loading Point.

correspondence between BNSF and Grace, "These loading facilities are as much a part of your business as they are of ours." (BNSF_HHP_000035). The River Loading facility was constructed and operated throughout its existence on BNSF property for which Grace initially paid a $10.00 annual rental fee. See River Loading Lease Agreement 1 – April 1950. This amount increased minimally over the subsequent decades. See, e.g., River Loading Lease Agreement 2 – September 1956; BNSF_HHP_000226, increasing River loading lease to $25.00 per month in 1984. BNSF and W.R. Grace carried a series of "Owners Landlords and Tenants" insurance policies which covered the River Loading site, and named BN as an insured. See, e.g., River Loading insurance policy documents. The River Loading Point was excavated out of the hillside adjacent to the mainline of the railroad and consisted of the Zonolite Siding track, the W.R. Grace conveyor and loading equipment, a storage shed and a parking area. The construction of the River Loading Point siding, with the exception of clearing and grading, was approved and paid for by BNSF. See 9/13/ 1949 Letter from J.M. Budd to F.J. Gavin.

BNSF oversaw all construction of and modifications to the River Loading equipment and was responsible for inspecting and maintaining the siding track. This included reviewing and approving plans for all River Loading Point dust control equipment prior to its installation. See, e.g., Railroad Dust Control Approval 3/9/1962; 3/30/1962; 1/21/1971; and 11/10/1977. In requesting BNSF's review and approval of the 1971 additional dust control facilities, Grace informed BNSF that they were being installed to "comply with Air Pollution Control Regulations in the state of Montana."[41] After a BNSF derailment destroyed the River Loading Point loading equipment in 1979, BNSF again reviewed and approved the new River Loading Point construction plans. See BNSF HHP 000480 discussing necessity of approval of plans by BN with district engineers as well as improvements meant to minimize liability for "**possible over exposure to personnel**."

Grace and BNSF were in constant daily contact to ensure that cars were available for River Loading, in picking up the cars when full and bringing them back to the Libby Railyard, in weighing the cars before and after filling, in inspecting the cars for leaks, in securing hopper hatches, and in attaching the cars to outbound freight trains.

82. **Downtown Export Plant**: While the chain of title for Grace's downtown export and expanding plant is complex, it appears that the original Railyard loading facility straddled the line between Libby Railyard property and the adjoining properties owned by Ralph W. Smithberger and the First Holding Company. See Sanborn Fire Maps; Chain of Title – EDC Business Park; Chain Sheet – EDC Business Park. In 1937, the Zonolite Co. purchased the Leonard Tract which adjoined the Great Northern Railway. 8/12/1937 Western News Article. In November of 1938, after 13 years of active vermiculite shipments, the Zonolite Company acquired ownership of the property owned by the Railroad for one dollar (see Quit Claim Deed from Great Northern to Zonolite –

[41] That these dust control measures were made to comply with Montana air-pollution requirements was also announced publicly in a 7/16/1970 Western News Article reporting that Zonolite was "given an extension on pollution control" with particular reference to the River Loading Point dust control.

November 1938, referencing Zonolite's adverse possession of the property for more than thirty years past) as well as those properties owned by Mr. Smithberger and the First Holding Company.[42] Of the four sidings which Grace used in their downtown export activities, one was owned by Grace while the remaining three were owned by BNSF. See 1/18/1983 Letter from Grace to the Montana Department of Revenue. BNSF kept the spur tracks stocked with boxcars for vermiculite loading, a process which required daily communications between the Grace and the Railroad. Once the boxcars were loaded, BNSF was responsible for picking them up, inspecting them (BNSF_HHP_626), weighing them and attaching them to outbound freight trains.[43] BNSF management inspected the Export Plant a couple times each month. See 9/13/16 Deposition of John Swing.

83. **Vermiculite and Asbestos Co. Loading Point/Grace Loading Dock**: Initially, the Vermiculite and Asbestos Company's downtown Libby facility was located on the south side of the Railyard adjacent to the train depot. See 10/18/1928 Western News Article; Sanborn Fire Maps; Chain of Title - KootRiverHealthPark. When the Vermiculite and Asbestos Co. merged with its competitor Zonolite Insulation Co. to become the Universal Zonolite Insulation Co. in 1939, primary shipping operations were consolidated to the north export plant, however this other property appears to have been retained. This property was apparently used in conjunction with an adjacent parcel of Railroad property leased by Grace and containing its fuel/oil storage tanks, pump house and loading dock. Just as with the River Loading Point lease, the Railroad charged negligible rate for the use and occupation of such a parcel of commercial/industrial property (this lease payment was increased to $30.00 per month in 1977). See 8/24/1977 Letter from BN to Grace.

    BNSF and Grace also shared other vermiculite related properties in other states. At these properties BNSF typically owned the spur and the parties had access and service agreements for their co-operation thereof. See, e.g., Western Mineral Site Summary and Spur Track Agreement (BNSF_511_0009).

84. **Special relationship between BNSF and Grace**: By 1926, the Railroad was engaged in in-depth analyses of the potential uses and economic value of the vermiculite deposit and published an article on the subject authored by Libby Great Northern Agent E.M. Boyes, which provides:

> A large and growing market has been established for the mineral; and at present and probably in the future, the only means of transportation for this immense tonnage will be over the Great Northern Railway on the longer part of its journey to various points for fabrication. As new markets develop, greater and greater quantities will be moved, assuring the Great Northern Railway a permanent tonnage of vast proportions.

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[42] Throughout the ensuing period of Grace operations in Libby the Export facility adjoined the Railyard and had shared spur tracks which ran from the Railyard to the facility. See Export Plant Site Plan.

[43] Pursuant to these operations, BNSF and Grace granted each other various access agreements and easements onto and across their respective properties.

> This new enterprise on the Great Northern is not only of interest to the railway and the community in which the deposit occurs, but is of national importance in its economic value. As illustrating the potentialities in the investigation and development of the non-metallic mineral resources lying along the Great Northern the story of Zonolite can not be too widely advertised.

1926 GNRR Semaphore Article. See also e.g. Publication entitled "Many Uses Found for Zonolite" summarizing a 1926 GNRR chemical geological analysis of the Libby Ore. In 1954, the Railroad published an article in the Burlington Zephyr touting the beneficial uses of the Libby vermiculite, discussing the revenue BNSF had garnered through its export and explaining the "Great Northern Railroad has cooperated with this producer since the plant establishment …" 1954 Zephyr Article.

1953 correspondence between GNRR and Grace accurately describes the relationship between these companies in regards to the Libby operations; "Ever since the introduction of vermiculite as a commercial mineral, the Great Northern Railway Company and the Zonolite Company have been partners in the promotion and development of vermiculite ore as an article of commerce." 7/31/1953 Letter from A.T. Kearney to J.M. Budd. Later that year GNRR interoffice correspondence discusses whether vermiculite shipping rates "should be the lowest possible rates the GNRR could establish as their part in the partnership between the industry and the railroad in developing over the years a movement of the estimated 300,000,000 tons which Zonolite has in sight at Libby" and concluded that "in order to continue our long-established policy of working with Zonolite as closely as possible, the matter was left with the understanding both the industry and the railroad would make various tests along the lines of rate measures …" 10/20/1953 Letter from C.E. Finley to J.M. Budd. This special relationship between the companies is borne out throughout the years through various documents. For example, in 1959 the Railroad, in conjunction with Zonolite Officers, performed an economic analysis of the Zonolite vermiculite operations. 1959 GNRR economic analysis and report on Zonolite. Later that year, C.E. Finley of the GNRR makes his point that the "studies being performed by the Department of Economic Research" were inadequate and needed to be revisited and illustrated the special role the Railroad too in vermiculite production by noting:

> We have kept the Zonolite Company in competitive alignment with Perlite from California and we have met the problem of market competition on aggregate grade of vermiculite throughout the eastern part of the United States as it is presented by perlite and also by the deposits of vermiculite operated by the Zonolite Company in South Carolina which is located much closer to the eastern markets.

6/3/1959 Letter from C.E. Finley to R.W. Downing. In 1964, GNRR met with W.R. Grace to explore accessing overseas markets for their vermiculite products by performing analyses of the markets, directing them to available sea ways and foreign ships, and offering the potential use of GNRR ore docks. See 4/17/1964 Letter from V.P. Brown to

C.E. Finley and attachments. See also 2/27/1963 Letter from C.E. Finley to J.M. Budd discussing a prior meeting with W.R. Grace, their plans to export vermiculite ore to European markets, and Grace's awareness "of the service we give them and [stressing] how close our relations have been with them."

85. **BNSF promotion of vermiculite products**: BNSF's promotion of the vermiculite product and their assistance in developing further uses of the ore material continued throughout the period of active mine operations. See, e.g., 1963 chain of correspondence documenting efforts by the Railroad's geologist and Mineral Research and Development Department to develop additional uses for unused fractions of the vermiculite ore; 1961 correspondence regarding "byproduct" problem (with summary transcription) discussing the GNRR Mineral Research and Development's ideas for potential markets and uses of the vermiculite mine byproduct; GNRR Great Resources Publication discussing Zonolite's vermiculite and geologic and analytic work being done on the topic.

In addition to the close business relationship between BNSF and Grace, BNSF and Zonolite/Grace management and executives maintained close personal relationships throughout their cooperative engagement in the Libby vermiculite operations. See, e.g., 12/28/1961GN Letter to Zonolite, "Thanks a million for the gift, also the wine of joy … Please extend to your entire staff my sincere thanks for the wonderful co operation they have extended to us the past year."; 11/26/1968 letter from Grace to GN – Boyes' retirement; 3/19/1956 letter from GN to Zonolite.

X. Principles of Industrial Hygiene and Applicable Standards of Care

86. **Basic Principles of IH**: The central principles of industrial hygiene are to (a) study; (b) warn; and (c) protect. Industrial hygiene principles and standards of care are not limited to the workplace, clearly extend to the protection of neighboring communities and to family members sharing homes with workers. "Industrial hygiene offers a method of attacking general problems of public health administration. Because industrial hygiene establishes contact with a large section of our population, and keeps it under close observation, there is an opportunity to practice preventative medicine at a low cost to the community." Dallavalle and Jones (1940).

a. Study: By the time the River Loading Point was constructed and in operation in 1950, there had already been extensive literature published regarding the best methodology to fully comprehend the degree and extent of industrial hazards. The industrial hygiene literature laid out steps that should be taken to ensure the safety of employees, their families, and neighboring communities, including specifically when dealing with asbestos laden dust. This includes studying (1) the degree of the hazard in the work environment; and (2) how the hazard impacts the worker and others in affected areas.

1) "Once asbestos was recognized as a hazardous agent, a guideline for excess asbestos exposure was explored in an attempt to protect workers. The first value for the asbestos guideline for dust control arose by

analogy to silica." Brown (1950). With the understanding that asbestos exposure was hazardous, the National Conference of Governmental Industrial Hygienists (NCGIH) (later the American Conference of Governmental Industrial Hygienists (ACGIH)) developed guidelines for asbestos exposure in the workplace. These "Maximum Permissible Concentrations" set a recommendation for limits to asbestos, although they recognized the inadequacies of such an endeavor, writing "The table [of Maximum Permissible Concentrations] is not to be construed as recommended safe concentrations." NCGIH (1942). The use of these "Maximum Permissible Concentrations" is meant primarily for engineering guidelines. "… the intent in presenting these maximum allowable concentrations is to provide a handy yardstick to be used as guidance for the routine industrial control of these health hazards – not that compliance with these figures listed would guarantee protection against ill health on the part of the exposed workers, nor should the maintenance of the suggested concentrations be considered a substitute for medical control." Cook (1945). A review of the literature makes it clear that early industrial hygienists and doctors interpreted these limits and suggestions as guides, and they were not so naïve as to think that these limits represented absolute safe level of exposure to all workers in all occupations. The necessity to understand the levels of toxic dust in the workplace was the starting point to effectuating any industrial hygiene program.

Studying a hazardous work environment requires full exploration of the hazard, its causes, and its impacts. This cannot be an isolated study, but instead one that persists. "It should not be forgotten, however, that with every test we get only, as it were, a snapshot, and we do not know what happens before and after. We need therefore to have those tests repeated." Teleky (1948).

2) Once the extent of the dust hazard was evaluated by frequent testing, the workers then need to be evaluated medically. Workers with exposure to asbestos should participate in pre-employment X-ray and physical screenings, and follow up screening should be conducted every year. Lanza et al. (1935). Without medical monitoring of employees, there is no way to grasp the impact of the hazard on the workers.

b. Warn: By 1950, there had been extensive literature regarding how to best inform workers and others exposed to an industrial hazard of the risks involved. Education of the worker regarding the potential hazards is essential to the basic premise of effective warning. In order to implement an industrial hygiene program, the workers must know the dangers present, or there will be no reason for the workers to protect themselves. For example, in 1917, in Joplin Missouri, miners and their families who were exposed to silicosis causing coal dust were informed of the hazard through newspapers and through “three-moving picture shows”. Up to 2,700 people attended these informational shows. The Department of the Interior noted,

> At the start few miners gave evidence of interest in better sanitary conditions. However, as they began to acquire a knowledge of the ill effects of silicosis dust their attitude changed, and the miners as a whole became interested in the abatement of silicosis dust and the general improvement of conditions underground and on the surface. There were many instances of miners quitting their working places if they were not supplied with means of allaying the dust.” Higgins et al. (1917).

Worker training and education must encompass two elements: (1) why something should be done; and (2) how it should be done. Brandt (1943). To accomplish the first step, the worker must be informed of the hazard and why prevention to exposure is important. “A cooperative, interested, and well-trained worker can accomplish much with any control equipment, whereas the indifferent, lackadaisical, untrained worker produces the maximum amount of atmospheric contamination with any control device.” Brandt (1947). “The education of the worker for his own protection is as important as to prevent the creation of unnecessary dust…He must be told which contaminants are harmful and sold on the idea of avoiding the higher concentrations.” Brandt (1947).

To accomplish the second step, the worker must then be instructed how they he can minimize their exposure to a hazardous substance through education. This can be done through supervisors, the community, and through various educational programs.

> The most erroneous and expensive policy any employer can adopt is to minimize to his workmen the dangers of free silica dust; no true observance of dust protection can be expected from the workman unless he is fully acquainted with the dangers of his occupation…Supervisors should be told the whole story, and workmen, severally and individually, in season and out of season, week in and week out, should be educated, warned, and even cajoled into full observance of the rules.” Harrington and Davenport (1937).

The literature states that not only should the information be communicated through supervisors, but pressure can be put on the community to assist in the dissemination of information. “[Precautions can reduce or prevent disease by] forcing their adoption on the workers; of doctors in correctly diagnosing the disease, giving publicity to its prevalence, seriousness, preventative remedies, etc., and assigning death certificates dust disease as the cause if such is the case; and of merchants, newspapers, and other influences in the community in trying to prevent the disease rather than hide its existence.” Harrington and Davenport (1937). In fact, one of the principles underlying industrial hygiene is the protection of employees and the safety of the public. The unified code of ethics adopted by the ACGIH and other industrial hygiene organizations notes the importance of public health and safety, as well as the necessity to disseminate information to the public if the hazard can lead to detrimental health impacts:

> II.C. Public health and safety.
>
> 1. Follow appropriate health and safety procedures, in the course of performing professional duties, to protect clients, employers, employees and the public from conditions where injury and damage are reasonably foreseeable.

(ACGIH, 2007).

c. Protect: By the 1950s, there existed extensive published literature regarding the necessity to protect workers exposed to asbestos dust from the hazards associated with the job. By 1936, industrial hygiene journals were publishing articles regarding the dangers of asbestos dust exposure and the necessity to mitigate worker exposure.

> …asbestos dust is a serious occupational hazard, and it also is apparent that these workers must be protected against the hazard as effectively as is possible.
>
> Sufficient evidence has been produced to prove that the inhalation of asbestos dust is productive of serious impairment of health. In fact, the victim of asbestosis, as a rule, eventually becomes totally disabled from engaging in any form of labor.
>
> An industrial worker is entitled to every protection that may safeguard his health, so that he may earn a livelihood for himself and family for at least a reasonable period of years in the work in which he is most skilled. Donnelly (1936).

In order to protect workers from asbestos exposure, "The minimum requirements recommended segregation of dusty work, special ventilation, use of respirators, and periodic medical examinations." Minimum Req. for Safety, 1943. In the present case, the need to extend protections to the public were evident, given the close proximity of recreational, residential, and business locations to BNSF industrial level activities involving a substance long known by BNSF to contain asbestos. For example, from the Downtown Libby Railyard, which was covered in asbestos contaminated vermiculite even a decade after active vermiculite operations ceased, BNSF employees and management could readily observe the children playing on the immediately adjacent ball fields mere feet away from their extremely dusty operations. At all relevant times, BNSF was well aware of bystander asbestos exposure principles.

87. Asbestos in the Literature Prior to 1950: By 1950, there was extensive industrial hygiene literature available regarding known hazards associated with asbestos dust exposure and the medical issues associated with prolonged exposure. As a result, industry groups, federal agencies, and state governments began to publish information regarding methods to prevent excessive exposure to known toxic dust in the workplace. This literature demonstrates that if others besides the workers, such as family members or community members, are exposed to the hazardous dust, they should also be informed of the potential hazard and ways to protect themselves from such hazard.

The term "pulmonary asbestosis" was first used in 1927 by W.E Cooke to describe the fibrotic lung disease caused by inhalation of asbestos fibers. Work involving asbestos in the US was recognized as being "unhealthy" in the early 1900's.

> [The] conditions, necessary to establish a relationship between the inhalation of asbestos dust and the development of fibrosis, could be demonstrated. These conditions are:
>
> 1. Work involving exposure to asbestos dust.
>
> 2. The existence, demonstrable clinically and radiologically, of a definite pulmonary fibrosis.
>
> 3. The absence of previous or present infections known to cause pulmonary fibrosis-e.g., tuberculosis, influenza, or pneumonia.
>
> 4. The absence of previous or present work involving exposure to other dusts, which might cause pulmonary fibrosis.
>
> These conditions being fulfilled, a relationship between the inhalation of asbestos dust and the development of pulmonary fibrosis may be presumed. This disease, insidious in its onset, stealthily advances with but faint warnings of its progress; inexorably it cripples the essential tissues of the lungs, yet for a considerable period causes almost no inconvenience to the worker. As time goes on, however, the lungs find more and more difficulty in re-aerating the blood; and breathing is quickened on slight exertion. Merewether (1930).

In the 1930s, Industrial hygiene journals published studies demonstrating that x-ray reports of workers exposed to asbestos dust over long periods of time were showing pulmonary abnormalities. "That the long-continued inhalation of asbestos dust is responsible for the development of pulmonary fibrosis is now unquestioned. From many parts of the world come radiographic reports of fine fibrosis in the lungs of persons exposed by occupation to the inhalation of this substance." Gardner (1931).

It was recognized that the longer an individual was exposed to asbestos fibers, the greater degree of disease. "The lungs of workers become affected in direct proportion to the length of time they have been exposed to it, until after twenty years of work 80 per cent. are affected." Dhers (1931). "…in every instance where a patient had been working for more than ten years, asbestosis could be demonstrated radiologically." Gerbils and Ucko

(1932). The *American Journal of Public Health* demonstrated the importance of ensuring proper working conditions for asbestos workers:

> Although the total number of workers in asbestos mills is probably far smaller than in many other lines of trade, their health is of paramount importance. The conditions surrounding the greater proportion of the employees constitute a distinct and serious industrial hazard, and often sufficient devices for protection have not been provided. It is doubtful if any single employee in certain departments of these mills can possibly escape some damage to his respiratory system because of the unavoidable inhalation of asbestos dust. Naturally, the longer the service of an employee, the more certain is more or less extensive pulmonary damage.
>
> Although the number of asbestos workers is much less than that in many other industries, their occupation is extremely hazardous, and they are amply justified in expecting whatever protection it is possible to give them. Furthermore, the fact that efficient protective devices in this industry, in spite of the added expense, will effect a substantial financial saving, is becoming more apparent. The workers themselves are becoming informed of the danger to health, and many civil suits for damages against factory owners are the result." Donnelly (1933).

In sum, by 1950, there were extensive publications regarding the physiological impacts of asbestos exposure, including pulmonary fibrosis and death. BNSF was specifically aware of these impacts as well as the principles of bystander/community exposure to asbestos. BNSF failed to meet then applicable standards of care to protect the community surrounding its Libby operations.

88. **Government Action & Impact**: In the 1930s and 1940s, Federal agencies, in particular the Bureau of Mines, published industrial hygiene information regarding the dangers of asbestos and how to mitigate the risk. Additionally, States around the nation were ensuring that their workers compensation system was helpful in tracking issues that arose regarding occupational disease due to asbestos. In many cases, disease due to asbestos was categorized within the category of silicosis for reporting purposes.

> Evidence has appeared that the dust formed in the treatment of asbestos produces effects which are generally similar to those arising from the silica-laden dust. The fibrous formations are not precisely the same, and they appear to develop more rapidly, though adding less to the patient's susceptibility to phthisis. After careful enquiries, in fact, asbestosis has been added to silicosis as an occupational disease arising from working in dusty surroundings…" Mineral Dust in Factories (1930).

89. **Standard Practices for Dust Control and Exposure Mitigation**

a. Dust Collection and Control Systems: In any dusty environment is important to isolate people from excessive dust concentrations regardless of content. This is particularly important in situations where the dust contains toxic materials. In 1955, the Johns-Mansville Corp. constructed the largest asbestos fiber mill in the world and used some state-of-the-art practices, at the time, during its construction. The mill utilized almost 200 cyclone collectors for their dust control system. These rubber lined collectors maintained minimum pressure drop and high-efficiency in order to collect fibers of commercial value and isolate workers from high-fiber levels. Miles of large diameter sheet steel piping were installed to remove the asbestos fibers and control the dust. In addition, the dusty machines and processes were redesigned to enclose the dust and keep it from working areas. About 500,000 cfm of air was used for dust control purposes in the mill. There were hundreds of oscillating screens with dust covers to confine the dust and were fitted with exhaust connections. Conveyors were covered with tight fitting enclosures and exhaust connections were added to different points. Areas where dust might escape to the mill atmosphere, such as crushers, packers, rotating screens, and elevators were provided with exhaust air. Goldfield (1955). Given the proximity of BNSF's operations to Libby residential, recreational, and business locations, the Libby community was directly exposed to dust hazards of BNSF's workplace. As such, the long standing standard of care requiring separation of people from dusty conditions extended to the Libby community. BNSF took no meaningful dust control measures in its Libby operations.

b. Proper Housekeeping: One of the essential mechanisms of controlling dust in an industrial setting is good housekeeping, an objective of which is to prevent dust from being re-entrained into the air. BNSF took no measures in accord with this standard of care, and in fact performed activities, such as sweeping and undercutting, specifically designed to disturb and release the dirt and dust, which in this case contained high levels of vermiculite and associated asbestos.

c. Sanitation: In order to prevent secondary exposures to hazardous dust by the process of dust traveling home on the clothes of workers, a system of personal hygiene should be implemented to mitigate "take-home" exposures.

> Modern Change Houses. What could be more conductive to thoughts of safety than the approach to the place of work through the means of practical and attractive change houses. The old frame building, with row upon row of steam pipes, red with hematite and over-run by cockroaches, is now a thing of the past, and in its place we see a two-story building, of concrete and brick construction with separate rooms for street and "digging" clothes; 287 lockers that are used for clean clothes only, concrete floors, shower room, toilets and laundry, and a suspension structure with hooks operated by pulley that permits the individual's hanging of underground clothes for drying and aeration, with individual padlocks supplied to make ownership secure. Barrett and Donovan (1940).

BNSF never provided a change facility to its Lincoln County employees to keep hazardous dust from being taken home or into the general community.

d. Use of Respirators: In dusty work environments, the industrial hygiene literature demonstrated early on that the use of safety equipment, such as respirators, is an important tool to mitigate workplace exposure. "In low dust concentrations, face respirators are used. In higher dust concentrations, air-line respirators are used effectively and with comfort. A good ventilation program, like a good safety program, reflects comfort to the workman and increased efficiency to compensate for the expenditure." Barrett and Donovan (1940).

> Getting workmen to wear safety devices requires the same mental attitude on the part of the management that a good salesman must have when he goes out to capture a difficult new account. If the management is not convinced that protective devices must be employed at all times, and if they, in turn, cannot convince their shop superintendents and foremen that such devices are necessary, then they cannot but blame themselves if workmen fail to manifest a good spirit toward self-protection. For psychological as well as for protective reasons shop superintendents, as well as foremen, when approaching dusty operations should invariably wear their respirators, and even visitors to plants should not be permitted to enter dusty departments without wearing respirators. In this way workmen can finally be convinced that the management truly believes in full-time protection. For best results everyone concerned should be willing to live up to the rules of the shop, without exception. In this work any weakening on the part of the management is fatal. Harrington and Davenport (1937).

During active vermiculite operations in Libby, BNSF did not ever require the use of respirators for its employees in the area.

e. Education of the Worker and the Public: As noted above, it is essential for workers to understand why certain precautions should be taken in order for them to be an active participant in dust control. Industrial hygiene literature recommended that worker education be conducted by warnings placed throughout the workplace.

> Large bulletin boards are placed throughout the plant and smaller ones underground in lunchrooms and other places where employees gather, and in the surface industrial buildings. Most of the material used on these boards is obtained from the National Safety Council although some is clipped from various publications. Suggestions for improvement of industrial health and safety are welcome and suggestion boxes are maintained so that an employee may remain anonymous if he desires. Prizes are paid monthly for the best suggestions and they are put into effect as promptly as possible. When safety inspectors see violations, they take

> the matter up promptly and explain to the employee the hazards involved and the safe way to perform the job. These little safety talks right on the job at the time of the violation are much more effective than a series of penalties, so other action is usually unnecessary. Jones and Eisenach (1946).

Additionally, education on workplace hazards should not be limited to the workers; family members and the community should be active participants in workplace safety.

> Elements of a Personnel Program
>
> Once these policies regarding employee and community relations are operating it is advisable to organize a program for evaluating not only the employee's attitude but also his family's attitude toward them. In addition, channels of communication must be set up whereby any suggestions regarding community conditions or working conditions will receive consideration by the proper company official and his decision as well as the reason for it, made known. It is difficult to over emphasize the importance of this fourth step.
>
> Another problem of long standing is that of getting company management and supervisors to realize the importance of safety and industrial hygiene programs not only from a humanitarian and financial point of view but also from the standpoint of improved employee relations. Here again the problem is not as difficult as it was in the past because of the actual experience of many mine operators and such organizations as the National Safety Council, the U.S. Bureau of Mines, and the state industrial commissions. Some state mining associations have accumulated sufficient data to convince most operators that it is to their advantage to have a well-organized safety and industrial hygiene program.
>
> Here are a few methods of presenting information **to the public** that have been used:
>
> (1) Arrange plant tours for various business and civic organizations as well as wives of employees that will give them a clearer understanding of some of the major problems involved in the operations.
>
> (2) Mail circular letters periodically to community leaders and also to employees who will spread the information.
>
> (3) Prepare suitable press releases regarding such things as employee activities and company plans, prospects and policies.
>
> (4) Arrange for a booth at a state fair or similar local functions where information and exhibits of company activities are available.
>
> (5) Invite reporters in and see that they obtain factual information on newsworthy events.

Jones (1949; emphasis added).

In 1985, Montana passed its Employee and Community Hazardous Chemical Information Act (MCA 50-78-101 et seq.; see, e.g., BNSF_2175-2211). The Act required among other things that an employer normally having a dangerous substance in the workplace, record a list of the materials used with the county clerk and recorder, post notice of the use of the chemical in the workplace and provide effective training on the potential hazard and safe handling thereof. "For Montana employers, receipt of an MSDS with a chemical shipment indicates that the chemical manufacturer has done the evaluation required by the federal OSHA standard and determined that the chemical is hazardous." (BNSF_2194). The record indicates that BNSF received MSDS for both Libby vermiculite and therefore was required to adhere to these statutory requirements. See, e.g., BNSF Hazardous Chemical Reporting for Flathead County; Deposition of BNSF expert witness Dr. Francis Weir, 7/2/2003, p. 68, testifying that the Railroad received MSDS for Libby Vermiculite. There is no indication that BNSF ever posted notice of the presence of asbestos in the workplace, ever provided training on the potential hazard and safe handling of the material, or recorded the presence of the material with the county clerk and recorder for public review.

Moreover, BNSF did not ever conduct education campaigns for workers or the community regarding the asbestos hazard posed by their activities in Lincoln County.

f. Standard Practices for Medical Monitoring: Literature available from the 1930s forward noted the importance of monitoring employees when working in potentially toxic environments such as those with excess dust.

> The physical well-being of the workman is of primary importance in its relationship to safety. The good health of the employee and his family is given impetus by the furnishing of competent medical doctors and excellent hospital facilities sponsored by the mining industry. The best of medical care and hospitalization is furnished for this as well as humane reasons. Physical examinations are not only informative to the employer, but are beneficial to the employee as well. Barrett and Donovan (1940).

In 1933, an article titled "Protecting the Worker Against Dust Inhalation" published in *National Safety News* noted the response to the silicosis problem required two definite steps: (1) medical examinations of new employees and routine examinations of all persons exposed to dangerous dust concentrations; and (2) reduction of dust concentrations breathed by the worker to what are considered safe limits. Drinker (1933). The purpose of the examination should not solely be for the purpose of evaluating the fitness of a worker in a certain position but to inform the worker on the necessity of safety with the worker could do to curb dust dissemination. *See: Harrington and Davenport (1937).* The U.S. Bureau of Mines Bulletin published in 1937 outlines a plan for medical control of all phases of a dust hazard. This plan includes:

(1) Establishment of a medical department adequately equipped;

(2) Routine examination of all applicants for employment;
(3) Rating and placement of applicants;
(4) Periodic physical examinations; and
(5) Provisions for the disabled.

Harrington and Davenport (1937). See also Bloomfield (1952); Striegel (1952).

By 1950, numerous industrial hygiene publications including those published by governmental entities detailed the necessity for an effective medical monitoring program for workers exposed to toxic dusts. These publications recommended that radiographic screenings be conducted pre-employment and on a regular basis to monitor the health of the workers. These publications also specify that no matter how small the industry may be, it is important to have a medical monitoring program for workers and to disseminate the results of the monitoring to the employees. Many industrial facilities had adequate facilities to monitor their employees. (Bjorge, 1952).

The railroad industry has been well aware of the need for a robust medical monitoring system since at least the mid 1900's. For example, the Chairman's Address at the Thirty-Seventh Annual Meeting of the Medical and Surgical Section of the Association of American Railroads (1957) includes the following:

> Furthermore, it is our job, for most of us, to supervise the physical examinations on thousands of employees. Undoubtedly, in the different sections of our country, the different sections demand different things from our employees, and, therefore, we have to adapt our physical findings to the conditions under which these people work.
>
> The one point that I'm trying to bring out, from a personal standpoint, is this: we are spending millions in building new mechanical shops, drafting rooms and all kinds of technological advances, to take care of these new machines. How much are we doing for our manpower?
>
> There are a few of our railroads (and you know exactly where your railroad stands) where we haven't had a physical examination on some of the men since the day they started work. That may be rather far-fetched. We do know that they get the eyes and the hearing tests, but I'm talking about the physical examination of these employees, and what an important part it plays in the running of our railroads.

In summary, despite the above standards and guidance, BNSF failed to provide an effective medical monitoring program for its employees in Lincoln County. Had it met the applicable standard of care by providing an effective medical monitoring program, it more likely than not would have identified the occurrence of asbestos related findings among its employees and have been able to timely institute preventative measures.

90. **Industrial Hygiene Standards of Care**: Applicable industrial hygiene standards of care require a large corporation such as BNSF to (a) study and monitor potential workplace hazards including specifically the asbestos contaminated vermiculite dust that its workers and others were exposed to; (b) warn its workers and others potentially exposed to the hazard of the risks associated therewith; and (c) to protect workers and others from the risk. Had these practices been followed, in addition to ensuring the wellbeing of employees, many of the control strategies would have translated to the protection of the Libby community with attendant public health outcomes.

By 1950, the industrial hygiene literature stated that because toxic dust causes medical issues with potential for death, two things were necessary: (1) dust controls to protect against the exposure to toxic dust; and (2) medical monitoring of employees.

The professional literature (see generally Brandt, 1947) demonstrated the following steps were necessary to protect against exposure to toxic dust and to ensure compliance with measures put into place.

a. local exhaust systems;
b. wet processing methods;
c. proper housekeeping;
d. sanitation;
e. the use of respirators;
f. education of the workers; and
g. effective warnings and labeling.

A medical program should also be in place to monitor employee's exposure to potentially toxic hazards. *Industrial Dust* by Drinker and Hatch states:

> For the complete evaluation of the industrial dust hazard it is necessary to do more than simply determine the dust concentrations associated with various dust-producing operations. A medical study of the workers, including physical examinations, chest X-rays in certain industries, and medical histories is also necessary (Drinker and Hatch, 1936).

At no time during active vermiculite operations in Libby, including during the Plaintiffs' time in Libby, did BNSF meet the standards of care espoused by these rudimentary industrial hygiene principles.

91. **BNSF's should have sampled air in and around its Libby properties**: Applicable industrial hygiene principles going back to 1950 and earlier required that BNSF test and sample dust and general air quality at its work areas for the presence of toxic substances, including dust containing asbestos. By failing to do so in Libby, BNSF violated standards of industrial hygiene and public health of the time including OSHA standards and regulations and BNSF. The applicability of this standard of care was particularly pronounced in Libby where BNSF workers, who worked with and around the asbestos containing vermiculite, regularly reported extremely dusty conditions during vermiculite

transport and where temporary dust remediation measures were utilized (and then abandoned) due to problems with dust generation by the regular non-stop train traffic and vermiculite loading techniques utilized. (See, e.g., 6/28/2016 Deposition of Bruce Carrier, pp. 21-22, 26-28, 52-55). BNSF recognized the applicability of this standard of care in its own safety guidelines. See, e.g., BNSF Responsibilities for Safety. In fact, BNSF tested and sampled dusty working conditions at other locations where far less toxic dusts such as saw dust, coal dust and rock dust from ballast material was present. See, e.g., BNSF 0241-0245, discussing conditions at the Klamath Falls Railyard, where in 1990 BNSF sampled hazards presented by saw dust which was "blown into the air by car and engine movement and the trainmen in turn inhale and get these items in their eyes" and determined appropriate respiratory protection even though the dust was considered to be a nuisance dust. BNSF should have adhered to this same standard of care in Libby, where similar but more toxic conditions were present, but failed to do so. See also BNSF 0349-0350, BNSF 0475, 1980 BNSF correspondence regarding the proper respiratory protection for BNSF employees to use when working around coal dust. Similarly, beginning in 1982 or earlier BNSF conducted worker monitoring for silica exposure during ballast disturbance activities and found that to protect from such exposures "Ballast regulator operators, other machine operators, and their helpers, should wear respirators when elevated dust concentrations in the air are apparent." In the present case, where BNSF's industrial level activities were being performed in and on asbestos contaminated vermiculite and in close proximity to childrens' recreational facilities, the requirement to perform minimal acceptable air monitoring is obvious, particularly given the notice to BNSF of the asbestos content in the material.

92. **BNSF's should have protected workers and the neighboring public**: Pursuant to applicable industrial hygiene standards, BNSF had an obligation to protect its workers, and the community of Lincoln County, from exposure to toxic dust, and fumes, including dust containing asbestos. BNSF's failure to protect its workers resulted in the spread of LA dust throughout the neighboring areas and the exposure of the general community thereto. Had BNSF took appropriate measures to protect their employees in Lincoln County, the community would not have been exposed to the asbestos created by BNSF activities in the area. BNSF's actions in this regard violated applicable industrial hygiene and public health standards of care including OSHA standards and regulations and BNSF's own self-imposed safety regulations.

BNSF's operations failed to comply with OSHA regulations and attendant standards of care. By the early 1970s, OSHA asbestos regulations required, among other things, that wet methods be used whenever practicable when working with asbestos containing materials. They also required monitoring of air conditions in the workplace:

> "(f) Monitoring - (1) Initial Determinations. Within 6 months of the publication of this section, every employer shall cause every place of employment where asbestos fibers are released to be monitored to determine whether every employee's exposure is below the PEL."

(1974 OSHA Asbestos Regulations). This mandatory sampling was required to include both personal and environmental asbestos air sampling. The regulations also required that "Asbestos waste and scrap shall be collected and disposed of in sealed bags or other containers" and "All cleanup of asbestos dust and blowing shall be performed by vacuum cleaners. No dry sweeping shall be performed." The regulations also contain Caution Label requirements requiring that labels be affixed to all raw materials … and other products containing asbestos fibers. They also required the following: "(h) *Housekeeping* – (1) *Cleaning*. All external surfaces in any place of employment shall be maintained free of accumulations of asbestos fibers if, with their dispersion, there would be an excessive concentration." They also required employers to provide comprehensive medical examinations and follow up annual examinations to employees who have worked in an occupation exposed to airborne concentrations of asbestos fibers (no requirement that exposure exceed the PEL). BNSF performed no asbestos air monitoring of its properties in the Libby area until after the EPA required it in the 2000s. Notably they have performed OSHA mandated sampling in the area since completion of the cleanup operation on multiple occasions. There is no indication that BNSF met any of these other requirements and standards of care either. This is despite BNSF's repeated notice of the asbestos content of the vermiculite spread throughout its properties and its receipt of MSDS for vermiculite concentrate specifically providing that "normal physical handling given to vermiculite concentrate can create an airborne fiber level in excess of OSHA standards…." Moreover, given that sampling in the Railyard and River Loading Facility has demonstrated asbestos concentrations in soil ranging from 2-5% asbestos and that disturbance activities in these areas generate up to 7-14 f/cc of airborne asbestos (among the highest, if not the highest, levels measured in outdoor Libby clean-up operations), the substrate of these areas could have qualified, and should have been treated, as a regulated asbestos containing material. Rather than using appropriate "Housekeeping" and "Cleaning" techniques, utilizing vacuuming and wetting, to remove the asbestos contaminated materials and keep surfaces free of asbestos fiber accumulations, BNSF regularly utilized techniques, such as sweeping and undercutting, designed to actively disturb and entrain the material. These failures are particularly problematic given the obvious fact that they occurred within mere feet of obviously visible and highly utilized childrens' recreational facilities, residences and places of business.

93. **BNSF should have provided adequate warnings:** Although BNSF has long maintained medical, industrial hygiene and safety departments, the managers and directors of these departments have testified that to their knowledge BNSF never conducted any studies to determine whether its workers or the neighboring public were being exposed to asbestos in Libby, never instructed its employees to wear respirators while working with or around asbestos-containing materials and never made any attempt to evaluate the work that the workers in Libby were doing on a daily basis.

Under applicable industrial hygiene and public health standards of care, BNSF had an obligation to warn its workers, and the community of Libby, of the hazards associated with exposure to toxic materials, including the asbestos dust generated by its operations. By failing to warn the workers and the public of this hazard, BNSF violated applicable industrial hygiene and public health standards of care. BNSF Manager of Industrial

Hygiene, Gerald McCaskill, admitted that had BNSF been aware of the presence of asbestos in the vermiculite, it would have been unacceptable conduct not to warn its workers (1/24/2007 Deposition of Gerald McCaskill, p. 114).[44]

94. BNSF should have provided education regarding toxic hazards: In violation of applicable industrial hygiene standards of care, BNSF failed to educate its workers with respect to the hazards of asbestos exposure and exposure to other toxic materials. The BNSF workers in Lincoln County regularly worked with and around asbestos-containing vermiculite and other contaminated surfaces and substances and were exposed to asbestos-containing dust generated from their work activities. BNSF's worker education program in this regard was non-existent and inadequate and in violation of industrial hygiene standards into the 1990's. Had BNSF properly educated and protected their workers, they would have thereby also protected family members and the Libby community from the asbestos dust hazard they created.

95. BNSF's inadequate respiratory protection practices: In violation of applicable industrial hygiene standards of care, BNSF did not require its workers to wear respirators when working with and around asbestos containing materials and other toxic compounds. While BNSF had been cited for its failure to have a respiratory program and had developed a proposed respirator program by 1981, it was not put into use in Lincoln County. 9/11/1981 BNSF correspondence. In developing its respiratory program, BNSF industrial hygienist Larry Liukonen set forth the "Requirements for a minimal acceptable program," which among other things included "Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained." BNSF 0379. There is no indication that BNSF ever met this minimal standard of care in Libby by assessing the air quality conditions for their Libby employees or the neighboring community. BNSF's respirator program in Libby was inadequate and violative of industrial hygiene standards into the 1990's.

In further violation of applicable industrial hygiene standards of care, BNSF did not require or provide protective clothing or changing rooms to its employees to protect them and their families from exposure to asbestos or other toxic materials.

96. BNSF should have adapted its operations to existing knowledge: BNSF violated applicable industrial hygiene standards of care by failing to alter its work processes, in accordance with existing knowledge, to environmentally control hazards from asbestos and other toxic materials created by its operations. BNSF failed to adequately enclose or isolate its work processes involving asbestos dust. BNSF failed to control the hazardous dust generated by its operations as a result of poor housekeeping and the failure to prevent

[44] Cf. contemporaneous deposition testimony of former BNSF Director of Industrial Hygiene James Shea confirming communications between the GNRR and W.R. Grace about shipping asbestos from Libby, agreeing that Bulletin 12 conveyed to GNRR that then current milling technologies were unable to separate the asbestos from the vermiculite, and admitting that the GNRR was aware there was "amphibole material in the vermiculite product." 1/26/2007 Deposition of James Shea, pp. 99-100.

dispersion of the dust at its source by employing recognized asbestos dust suppression techniques.

97. **BNSF should have used appropriate dust control practices**: Consistent with applicable industrial hygiene standards of care, BNSF should have prevented dispersion of the asbestos dust at its source by:

(a) Segregating or confining the dust to an area near its source;
(b) Using vacuuming or washing techniques to control dust;
(c) Using local exhaust ventilation;
(d) Wetting the dust;
(e) Providing protective clothing.

By using open loading systems and failing to fence, post warnings around, enclose its facilities, or relocate its vermiculite related operations, BNSF failed to segregate its hazardous work operations from the adjacent Libby community in contravention of then existing industrial hygiene standards.

BNSF's own respiratory protection program provides:

> ENGINEERING AND ADMINISTRATIVE CONTROLS
> Built-in protection, inherent in the design of a process, is preferable to a method that depends on continual human implementation or intervention. A complete understanding of the circumstances surrounding the problem is required in choosing methods that will provide adequate control. Hazards can change with time so that health hazard control systems require continuous review and updating. ***
>
> Process Design Modifications
>
> The best time to introduce engineering controls is when the equipment or process is in the blueprint stage. If this is not done, then the equipment or process has to be changed to offer the best reduction in hazards.

BNSF 0395. BNSF should have followed this self-acknowledged standard of care, and thereby protected its employees and the Libby community, by obtaining "a complete understanding of the circumstances surrounding the problem" and then by introducing "engineering and administrative controls … in the blueprint stage" or thereafter. BNSF was given this very opportunity on the multiple occasions that BNSF reviewed and approved the dust control system at the River Loading Point, the primary source of OU6 contamination, as well as when it inspected the River Loading Facility and Export Plant.

98. **BNSF should have employed proper housekeeping techniques**: Consistent with applicable industrial hygiene standards of care, BNSF should have employed proper housekeeping in its operations. High levels of toxic dust existed on many of its Libby area work surfaces which were not properly cleaned, and as a result asbestos dust became re-

entrained into the air during normal work activities. Rather than collecting and removing toxic material from its Libby operations, BNSF disturbed and entrained the material through activities including regular sweeping and undercutting. As a result of its poor housekeeping, BNSF allowed further dispersion of asbestos dust throughout its Libby operations and beyond. Given BNSF's knowledge of asbestos in the vermiculite ore, its poor housekeeping violated applicable standards of care.

99. **BNSF should have provided a reasonably safe place to work**: Consistent with applicable industrial hygiene standards of care, BNSF had an obligation to provide its workers with a safe and healthful place to work. BNSF employee exposure to asbestos occurred as a result of BNSF's failure to control and contain the asbestos-containing materials they worked with and around in performing various activities in Lincoln County. BNSF's failure to provide a safe place to work directly led to the wide spread contamination of the areas surrounding their railyards, sidings and rights-of-way in Lincoln County.

100. **BNSF should have adhered to its own safety regulations:** In order to meet applicable industrial hygiene standards of care at the time, BNSF had to adhere to its own safety standards. See, e.g., BNSF Responsibilities for Safety**:**

> Provide safety and healthful working conditions to the maximum extent practicable for all employees. …
>
> To instruct [all] employees concerning the hazards of his job, and how to work safely to avoid injury. …
>
> Supervisors should always be alert for … lack of or inadequate guards or safety devices, poor housekeeping hazards, and hazardous atmospheric conditions. …
>
> WHAT TO INSPECT:
> 1. **Atmospheric conditions, e.g. dusts, gasses, fumes**, sprays…
> 10. Personal Protective Equipment , e.g. hard hats, safety glasses, safety shoes, respirators, etc. (Emphasis added.)

See also 9/11/1981 BNSF correspondence attaching Respiratory Protection Program; BNSF 0379 setting forth the "Requirements for a minimal acceptable program," which among other things included "Appropriate surveillance of work area conditions and degree of employee exposure or stress shall be maintained." In violation of these self-acknowledged IH standards of care, BNSF ignored these minimum acceptable standards of care as to asbestos in Lincoln County.

101. **BNSF largely ignored the basic principles of industrial hygiene**: Asbestos disease in Libby was preventable with the use of the basic industrial hygiene principles of the time. My research, including transcripts demonstrates there were a number of failures by BNSF to adhere to applicable industrial hygiene standards of care. BNSF failed to

instigate, mandate, or in some cases even recommend generally accepted standards of industrial hygiene of the time in the following respects:

a. There was not adequate housekeeping at the Railyard, Lincoln County sidings, and Railroad rights of way. Housekeeping should have kept the accumulation of dust to a minimum. The general standard was to prevent the accumulation of dust or dirt in the workplace. However, BNSF operations in Libby remained dusty and there was not a proper respiratory protection program.

b. Protection from the hazards of asbestos had been written about by Merewether and Price as early as 1930. Feasible dust control measures were utilized elsewhere. Additionally, respirators were not made available to employees and the use of respirators was not required or recommended by managers or supervisors. No respirator training or fit check program was instituted. While not an ideal method of providing warning of a hazard, the use of use of a proper respirator program in BNSF's downtown Libby operations would have provided the neighboring public an indication of the asbestos hazard present.

c. BNSF failed to perform any meaningful medical monitoring of its employees working in Lincoln County.

d. BNSF failed to sample the air in and around its Lincoln County properties, failed to control dust in its Libby operations, and failed to segregate or relocate its vermiculite operations from the recreational, residential, and business areas of Downtown Libby.

102. BNSF should have ensured effective dust control practices were observed at River Loading: BNSF contractually obtained/retained the right and responsibility to review and approve all construction, modifications and improvements made on its property at the River Loading Point. BNSF undertook oversight and pre-approval of the design and specifications of the loading facility and attendant dust control facilities at the river loading point. BNSF was explicitly aware that dust control devices were supposed to control air borne pollution at the site (1/21/1971 Dust Control letter). Later in 1979, Grace and BNSF district engineering discussed the River Loading Point rebuild (post derailment), which conversation specifically included discussion of "improvements in the design to minimize liability" for "overexposure to personnel." BNSF_HHP_000480. Pursuant to applicable industrial hygiene standards of care, this right and responsibility of oversight and approval came with the responsibility to meet the applicable standard of care by ensuring that river loading dust control facilities were sufficient to prevent the spread of LA dust. BNSF failed to meet this standard of care by approving the dust producing loading facility and the insufficient and unreliable dust control facilities that were in use throughout the period of shipping activities at the River Loading Site.

Moreover, Railroads including BNSF may establish reasonable terms for the carriage of a commodity. As has been done with the rail transport of coal and the control of coal dust, BNSF could have required Grace to take reasonable measures to control the asbestos laden vermiculite dust. (See, e.g., DEIS for Tongue River RR at 6-26, -27, April 2015.) In fact, for brief periods, BNSF required Grace to remove the asbestos-laden vermiculite from the exterior surfaces of the rail cars before the BNSF crew would push the load from River Loading into the Libby Railyard. (6/28/2016 Deposition of Bruce Carrier at p. 55.) This was confirmed by BNSF Supervisory Agent John Swing (Deposition of John Swing 9/13/16.) BNSF should have also ensured that this practice was continued throughout their years of vermiculite shipping operations. BNSF should have also required effective dust control measures were in place at the co-owned Downtown Export Plant, which BNSF management reportedly inspected on a very regular basis. See 9/13/16 Deposition of John Swing.

103. **Description of a proper medical monitoring program**: Consistent with applicable industrial hygiene standards of care, a proper medial surveillance program by the BNSF under the circumstances extant in Lincoln County required many measures insufficiently undertaken or never undertaken by BNSF, including the following:

a. Physical exams of workers by chest physicians who could integrate chest x-rays, pulmonary function tests and physical examination results and instruct the workers on how to protect their health. This was never done by BNSF. These should have been required on an annual basis.

b. Proper pulmonary function tests and chest images should have been performed on all Lincoln County BNSF employees annually.

c. Results of company chest x-rays, pulmonary function tests and physical exams (which were not performed) should have been published to local doctors, and made available to the worker.

d. BNSF did not properly solicit medical information from Grace, nor did it conduct any medical investigation into the health of workers, family members, or community members.

104. **Industrial hygiene standards of care conclusion**: Ultimately, BNSF was aware that the vermiculite ore they were handling was contaminated with asbestos, were aware that the material was widespread throughout their facilities, were aware that their industrial level activities were taking place on and around the material and in close proximity to recreational, residential, and work-place areas. BNSF was aware that, once entrained, asbestos fibers will travel by air. BNSF knew that the problem with asbestos was not isolated to railroad properties. BNSF was therefore aware that the bystander exposure to the asbestos hazard extended to the entire community. Applicable standards of care required BNSF to study, warn and protect not only its workers, but also their families

and the neighboring community. BNSF failed in recognizing and acting on existing medical and industrial hygiene information putting both its workers and the community at risk of exposure to asbestos emanating from their operations in Lincoln County.

XI. Plaintiff Exposure Pathways

105. **Exposure Pathway**: An exposure pathway is the process by which an individual is exposed to contaminants originating from a contamination source. An exposure pathway consists of the following five elements: (1) a source of contamination; (2) a media such as air or soil through which the contaminant is transported; (3) a point of exposure where people can contact the contaminant; (4) a route of exposure by which the contaminant enters or contacts the body; and (5) a receptor population. A pathway is considered complete if all five elements are present and connected.

There was substantial asbestos containing vermiculite in and around BNSF's Lincoln County properties present during active operations. These properties were located in close proximity to most residential, recreational, commercial, medical and municipal locations in Lincoln County. BNSF's operations involved extensive disturbance activities in contact with and in close proximity to the asbestos-contaminated materials, where friable asbestos was present, and where BNSF activities disturbed asbestos-containing and asbestos-contaminated materials and created the transport mechanisms to release fibers into the breathing zone of those living, working or recreating in proximity to BNSF's properties in Lincoln County.

106. **Mr. Tracie Barnes Exposure History:**[45] Mr. Tracie Barnes was born in 1955 and has resided in Libby, MT his entire life with the exception of 8 months in Missoula, MT. Several of Mr. Barnes residences were in close proximity to the railroad tracks. These include 153 Park Street where he resided from 1987 to 2001 and at Nevada Avenue and W. 3rd Street from 1983 to 1985. As a child, Mr. Barnes reported that he frequently rode his bike from his 1019 Utah Avenue home throughout the town of Libby. When he was in junior high, he frequently walked the railroad tracks to bird hunt, fish, and swim. He crossed the steel bridge over Libby Creek and threw decoys out. Mr. Barnes reported that he remembers looking down on cars from the bridge and seeing vermiculite accumulated on the top of the cars. In addition, while walking the railroad tracks, Mr. Barnes reported that he observed vermiculite along the tracks. He would kick the piles while walking and he remembers trains blasting by and moving a lot of air. Mr. Barnes also spent substantial time at the ball field. He played little league through minor and major league baseball. In addition, he coached two of his children at the same location. Mr. Barnes also spent considerable time as a child in the public swimming pool near the Legion ball field. He regularly attended Logger days in this area as well, both as a child and an adult.

[45] July 26, 2018 interview

Mr. Barnes reported that his mother did not work outside the home. His father worked for the Great Northern Railroad from 1949-1950 and 1952-1963 in the downtown Libby Railyard checking, routing and weighing railcars, including vermiculite cars. He then worked the W.R. Grace mine for one year and the St. Regis Lumbermill[46] for 21 years in the Traffic Department. This department was responsible for all shipping, including trucks and railroad.

Mr. Barnes was educated in the Libby school system and graduated in 1973. His first job out of high school was at the lumbermill in the labor pool. He worked in various locations in the mill, with the majority of time spent in the plywood plant. Mr. Barnes left the lumbermill in 1974 and spent the next four years as a dump truck operator for Remps Sand and Gravel. He reported that the majority of work was conducted in the Libby area with work on local logging roads, work near the Libby dam, and paving a highway to Kalispell. Mr. Barnes reported that on a "couple of occasions" he hauled vermiculite ore from the river loading area to the downtown Libby Railyard. Mr. Barnes began working for Wallace Colville Motor Freight in 1978 and remained there until 1984. He reported that, "UPS handled freight delivery up to 50 pounds and we took everything else." He transported tires, hardware, appliances, etc., throughout the Libby area. Mr. Barnes reported that this transport included presto logs from the lumberyard and bagged vermiculite ore to and from the downtown Libby Railyard on approximately five occasions. While working at Wallace Colville, Mr. Barnes spent one year with Robert Windom distributors. He then worked for City Services for less than one year as a gas delivery man. This route included loading in Seattle or Portland and delivering to Cutbank, MT. One of the bulk plants was in close proximity to the depot. Mr. Barnes recalls delivering to the W.R. Grace mine on one occasion with Wallace Colville and once with City Services.

The majority of Mr. Barnes's employment (1985 to Feb, 2017) was spent with Snyder's Bakeries as a Route Salesman in the Libby and Troy areas. Mr. Barnes was diagnosed with asbestos induced pleural and parenchymal fibrosis on 2/20/2013 and retired in 2017 due to his increasing inability to perform his work duties on schedule and the extreme fatigue he was experiencing at the end of his work day. Mr. Barnes and his spouse were not tobacco smokers.

107. **Mrs. Rhonda Braaten Exposure History[47]:** Mrs. Braaten was born and raised in Libby, MT. With the exception of a period from 1980 to 1983, she resided in Libby from 1960 to 2005. Mrs. Braaten lived in several residences that were in close proximity to the

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[46] The lumbermill was originally operated by J.Neils, and subsequently by St. Regis, Champion, and Stimpson Lumber.

[47] Mrs. Braaten is deceased. Plaintiff history was obtained by Mrs. Braaten's written testimony and interviews with her husband and sister, Ken Braaten and Tina Collins, on July 6, 2018 and July 13, 2018, respectively.

Railyard and/or railroad tracks. In addition, she spent considerable time as a child at her grandparents' home on Second Street near a railroad spur.

Mrs. Braaten reported that as a child she played on vermiculite piles by the railroad tracks. In addition, she played in a pile of vermiculite at her grandparents' home. Mrs. Braaten walked up and down the railroad tracks. She enjoyed watching the trains pass through Libby with her siblings. "Some of the trains would come through quite fast," "kicking up dust" as they passed by. Rhonda also enjoyed picking berries along the railroad line for extra money, as there were good patches of berries along the tracks.

Mrs. Braaten's father worked for 43 years, as a log truck driver and in the log yard. He worked as far north as Eureka and east to Kalispell. Her mother had an advertising business that she operated out of her home.

Mrs. Braaten was educated in the Libby school system. She married her first husband, a local rancher, shortly out of high school. She was married for a few years and raised a daughter and a son in Libby. Mrs. Braaten's oldest child played ball at the ball fields and she went to the fields to watch her play.

In 1993, Mrs. Braaten met her second husband, Ken Braaten, and they were married in 1995. Ken worked at the lumbermill from 1993 to 2003.

Mrs. Braaten worked several jobs while living in Libby, the majority being cooking or food preparation related. The Braatens moved from Libby to Columbia Falls in 2005 where Rhonda worked in retail environments. Mrs. Braaten smoked tobacco for 22 years, quitting in 2000 when her first grandchild was born. She was diagnosed with ovarian cancer in 2010, asbestos related fibrosis in 2012, mesothelioma in 2016, and passed away in 2016.

108. Mrs. Gerrie Flores Exposure History[48]: Mrs. Flores was born in Peoria, Illinois in 1946. She resided in California and Idaho and moved to Libby, MT in 1979 with her husband and two sons, ages 12-15. The Flores family lived in the same mobile home located in three different locations in Libby for 11 years; Orchard Vale Trailer Court (1979 to 1979) (north from Libby to Eureka), Cedar Creek (1979 to 1987) (2 miles west of Libby on Hwy 2 between Hwy 2 and the railroad tracks) and property on the Kootenai River Road (1987 to 1990). Mrs. Flores described the Cedar Creek property as "Hwy 2 in the front yard and the railroad in the back yard." As trains went by, the mobile home rumbled from the vibration. The mobile home did not have air conditioning. Mrs. Flores stated that she and her husband commonly kept the front windows shut and back windows open day and night during the summer and other warm months. Mrs. Flores thought that this approach would minimize the dust infiltrating from Hwy 2 traffic, while bringing cooler air from the river into the home. Mrs. Flores cleaned the home (vacuumed carpets,

[48]March 22, 2016, May 16, 2017 and July 27, 2018 interviews.

swept and mopped tile, and dusted). She stated that the "home seemed very dusty, even in the winter time."

Mrs. Flores reported that she frequently walked east on trails adjacent to the railroad tracks to call her sons back home or to go fishing with them. She reported walking the tracks to find them at least three times per week from June to September. Mrs. Flores reported that she did not know the train schedules and there were times when trains went by, creating lots of dust. Mrs. Flores reported that in the winter months the snow on and near the railroad tracks was frequently discolored by what she hypothesized was dust from passing trains.

In 1987 the Flores family moved their mobile home from the Cedar Creek lot to a location off of the Kootenai River Road.

Mrs. Flores reported that her sons attended junior high school and high school in Libby. Her children frequently played on the railroad tracks near their homes throwing rocks. Mrs. Flores remembers being down at the ball field for events such as Logger Days. She noted that Libby had great events for the kids and she felt very safe raising children in Libby.

Mrs. Flores and her family hunted the Cedar Creek area across the highway from their home. In addition, her husband went on many roads from their Kootenai River home. Gerrie's family burned wood the entire time they lived in Libby. The family harvested their own firewood in the forests near Libby.

Mrs. Flores worked for one year as a waitress at the Venture Inn three to four hours per day. In 1980-87, she worked at the Libby Care Center as a Nurses Aid. This facility was one block from the railroad tracks near St. John's hospital. Mrs. Flores's husband, Phil, worked as a construction laborer at the Libby Dam for a year, at ASARCO mine for a few months, and on a pipeline in eastern MT for a few months. He then worked at the post office in Libby for approximately 4-5 years. He was a carrier in Libby and he performed office maintenance. Mr. Flores then acquired a full-time position with the US Postal Service in Missoula and the family moved from Libby to Florence. Mrs. Flores worked at Kmart in Missoula for a short time and the Community Medical Hospital in Missoula for 1 – 1.5 years as a medical librarian.

In 2000 she and her husband moved to Kalispell to be near children and grandchildren when he retired from the US Postal Service. Mrs. Flores was diagnosed with pleural thickening plaquing in September of 2015 and carcinoma lung cancer shortly thereafter. Her lung cancer was successfully removed by right lower lung lobectomy later that year. Mrs. Flores was a former light smoker, having smoked as many as twelve cigarettes per day between 1961 and 1967, off and on. She did not smoke during the pregnancy of her two sons and quit for good in 1967.

109. Summary Plaintiff Exposure History.

Mr. Barnes: There is no record of air monitoring performed by BNSF that may be applied to current risk models for LA asbestos. The air modeling performed by Dr. Julian Marshall provides lifetime exposure estimates based on select BNSF activities and W.R. Grace operations. These conservative estimates of Mr. Barnes' BNSF related lifetime asbestos exposure from trains passing through the Libby Railyard and the Libby Log Job alone exceed the EPA recommended acceptable cancer risk LA concentration by more than 92 times. As applied to the background risk of asbestos related disease for non-cancer effects, Mr. Barnes' BNSF related lifetime asbestos exposure exceeds the EPA's RfC for non-cancer risk LA concentration by 604.4 times. Mr. Barnes has been diagnosed with asbestos induced pleural and parenchymal fibrosis. Considering Mr. Barnes conservative 38 year estimated average asbestos exposure from BNSF sources only, as reported by Dr. Julian Marshall, as well as conservative estimates[49] of ambient exposure duration, his non-cancer health risk as defined by the hazard quotient from inhaling Libby amphibole asbestos is estimated as well over 100, and over 200 if the exposure contributions from W.R. Grace sites are included. "While hazard index calculations exceeding a value of 1 do not indicate that an effect will definitely occur, the larger the hazard index value, the more likely that an adverse effect may occur" (USEPA, 2015). It is important to note that Dr. Marshall's model is based solely upon emissions from the through trains passing through the Downtown Libby Railyard, BNSF River Loading Site, and W.R. Grace sites. Dr. Marshall's model does not consider the myriad of other dust producing activities BNSF engaged in at the Libby Railyard. In addition, his model considers exposures up to 1994, seven years prior to any OU6 soil removal remediation activities. As a result, these values underestimate the actual increased risk of asbestos related disease Mr. Barnes incurred as a result of BNSF activities. By comparison, if the only available contemporaneous air concentrations available for downtown Libby (Results of W.R. Grace 1975 Dust Surveys – Source Emissions – using 1.5 f/cc) are considered in this same conservative lifetime cancer risk estimate, Mr. Barnes' non-cancer health risk from inhaling Libby amphibole asbestos is estimated at well over 2,000, grossly higher than the threshold of 1.

Mrs. Braaten: As noted previously in this report, pleural malignant mesothelioma is a rare disease and asbestos is considered the primary causal agent (Carbone et al., 2012; Sebbag and Sugarbaker, 2001; Dodson and Hammer, 2011 pp 576; Strauchen, 2011). All forms of asbestos cause mesothelioma (IARC, 2018). Although not at issue in a case such as this with substantial documented asbestos exposure, compared to other asbestos related diseases, malignant mesothelioma occurs at lower levels of asbestos exposure and no dose has been established below which there is no risk of malignant mesothelioma (Markowitz et al., 2015). Mesothelioma has long been recognized as occurring among individuals with no direct occupational exposures to asbestos and occurs at a much-increased rate among those environmentally exposed to significant levels of amphibole

49 (EPA, 2015) Inputs: 6.9 hours/day, 350 days/year, 38 years, mean LA exposure concentrations 0.097 and 0.139 f/ml.

asbestos. As noted in the IARC Monographs, “mesothelioma may occur among individuals living in neighborhoods of asbestos factories and crocidolite mines, and in persons living with asbestos workers.”

The rates of mesothelioma among U.S. women are extremely low (estimated at 0.000004% or .41 case per 100,000 individuals, between 2003 and 2008) (Henley et al., 2013). It is postulated that female pleural malignant mesothelioma rates are lower than male because female occupational exposures to asbestos are typically less frequent than male exposures. As a result, mesothelioma rates in females are often considered sensitive indicators to identify environmental exposures to asbestos and other mineral fibers (Baumann et al., 2015).

As noted above, there is no record of air monitoring performed by BNSF that may be applied to current risk models for LA asbestos. The air modeling performed by Dr. Julian Marshall provides lifetime exposure estimates based on select BNSF activities and W.R. Grace operations. The conservative estimates of Mrs. Braaten’s BNSF related lifetime asbestos exposure from trains passing through the Downtown Libby Railyard and the Libby log job alone, set forth in the report of Dr. Julian Marshall, is 19.32 times the EPA acceptable cancer risk LA concentration. As applied to the background risk of asbestos related disease for non-cancer effects, Mrs. Braaten’s BNSF related lifetime asbestos exposure exceeds the EPA’s RfC for non-cancer risk LA concentration by 126 times. Considering Mrs. Braaten’s conservative[50] 32 year estimated asbestos exposure from BNSF and W.R. Grace sources, as reported by Dr. Julian Marshall, as well as conservative estimates of ambient exposure duration, her cancer risk value of 1.67×10^{-3} exceeds the 1 in 10,000 excess cancer risk level. In addition, Mrs. Braaten’s non-cancer health risk as defined by the hazard quotient from inhaling Libby amphibole asbestos is estimated as over 100. “While hazard index calculations exceeding a value of 1 do not indicate that an effect will definitely occur, the larger the hazard index value, the more likely that an adverse effect may occur” (USEPA, 2015). Moreover, the Marshall Report does not consider the myriad of other dust producing activities BNSF engaged in on its Lincoln County properties, including loaded rail cars casting dust when leaving town past those of her residences that were adjacent. In addition, the model only considers exposures up to the year 1994, seven years prior to any OU6 soil removal remediation activities. As a result, these values underestimate the actual increased risk of asbestos related disease Mrs. Braaten incurred as a result of BNSF activities. By comparison, if the only available contemporaneous air concentrations available for downtown Libby (Results of W.R. Grace 1975 Dust Surveys – Source Emissions – using 1.5 f/cc) are considered in this same conservative lifetime cancer risk estimate, Mrs. Braaten’s cancer risk from inhaling Libby amphibole asbestos is 3.2×10^{-2}, or 3.2 in 100, which substantially exceeds the 1 in 10,000 threshold.

50(EPA, 2015) Inputs: 6.9 hours/day, 350 days/year, 32 years, mean LA exposure concentration 0.078 f/ml.

Mrs. Flores: Mrs. Flores has been diagnosed with lung cancer and asbestos induced pleural plaquing. Mrs. Flores does not have typical risk factors for the development of lung cancer such as a significant smoking history, family history of cancer, or genetic risk predispositions to developing cancer, greatly reducing her background risk of developing lung cancer. Mrs. Flores' exposure to LA and non-malignant asbestos related disease diagnosis places her in a heightened risk category for incurring lung cancer as a result of her asbestos exposure:

One of the most important implications of the diagnosis of nonmalignant asbestos-related disease is that there is a close correlation between the presence of nonmalignant disease and the risk of malignancy, which may arise from exposure levels required to produce nonmalignant disease or mechanisms shared with premalignant processes that lead to cancer. The major malignancies associated with asbestos are cancer of the lung (with a complex relationship to cigarette smoking) and mesothelioma (pleural or peritoneal), with excess risk also reported for other sites. There is a strong statistical association between asbestos related disease and malignancy …

(American Thoracic Society, 2003; Pairon, 2014).

Confirmation of Mrs. Flores' LA asbestos exposure is evidenced by Dr. Ronald Dodson's lung fiber burden report. A sample of lung tissue obtained during Mrs. Flores' 10/29/2015 lobectomy, and defined in the pathology report of 11/02/15 from Glacier Regional Pathology, LTD as "random lung parenchyma close to tumor" was sent to Dr. Ronald Dodson, PhD, FCCP, FAHA. Dr. Dodson performed a ferruginous body/fiber burden analysis of the lung tissue utilizing a digestion technique of the tissue sample and evaluation of the digestate with light and electron microscopy. Further demonstrating Mrs. Flores' exposure to LA, the light microscopy analysis of the digestate demonstrated the presence of classical ferruginous bodies determined to be equivalent to 119.7 ferruginous bodies per gram of deparaffinized wet weight tissue. The evaluation of the digestate at 15,000x revealed one "Libby amphibole" fiber which was determined to represent a value of 5000.6 fibers/gram of deparaffinized wet weight of tissue. An additional scan was conducted at 2,000x for the presence of ferruginous bodies and included analysis of any fibers found in the scanned area that were >3μm in length. The area scanned at 2,000x contained an additional three Libby Amphibole Asbestos fibers and one anthophyllite asbestos fiber. This equates to approximately 8,400 fibers/gram of deparaffinized wet weight of tissue. Using the generally accepted conversion rate from wet to dry tissue of 10 times, these results equate to approximately 1,200 ferruginous bodies per gram of dry tissue and between 50,000 and 84,000 amphibole asbestos fibers per gram of dry tissue. 80% (4/5) of the asbestos fibers identified were confirmed to be Libby Amphibole Asbestos and all were greater than 8 μm in length. The shortest of the Libby fibers was one of those found at 2,000x which was 8 μm in length. Thus, the fiber burden in the tissue consisted of longer fibers (>8μm). The residual population of fibers found in any lung sample at the time of sampling represents what is left after the impact over time of clearance on lung burden from time of exposure to a given dust. Mrs.

Flores' environmental exposure to Libby Amphibole Asbestos fibers began more than 39 years ago and ceased more than 25 years ago.

The very conservative estimates of Mrs. Flores' BNSF related asbestos exposure and associated additional cancer risk applying the EPA IUR for LA, set forth in the report of Dr. Julian Marshall, from trains passing through the Downtown Libby Railyard and the Libby Log Job alone exceeds what the EPA has determined to be an acceptable cancer risk concentration by 2.37 times and the EPA non-cancer risk concentration by 15.5 times. Considering Mrs. Flores' conservative[51] 12 year estimated asbestos exposure from BNSF and W.R. Grace sources, as reported by Dr. Julian Marshall, as well as conservative estimates of ambient exposure duration, her non-cancer inhalation risk based on a hazard quotient is estimated as 9. "While hazard index calculations exceeding a value of 1 do not indicate that an effect will definitely occur, the larger the hazard index value, the more likely that an adverse effect may occur" (USEPA, 2015). Considering these same conservative estimates, Mrs. Flores' cancer risk value of 1.45×10^{-4} is slightly less than the 1 in 10,000 excess cancer risk level. However, it must be noted that Dr. Marshall's model is based upon emissions from the BNSF Libby Railyard, BNSF River Loading Site, and W.R. Grace sites. Dr. Marshall's model does not consider that Mrs. Flores' suspected primary source of asbestos exposure incurred at her Cedar Creek residence abutting the railroad track from dust cast into the air from vermiculite laden rail cars passing her home multiple times per day. As she reported, she would keep the windows on the railroad side of her house open during the warmer months and had unusually high levels of dust in her home throughout the year. Her reported daily activities including cleaning, or even walking in the home, would repeatedly entrain any fibers present. The fact that passing trains created this dust is undeniable given extensive worker reports of dust emanating from vermiculite railcars and tree bark samples taken 7 miles west of Libby containing 19 million LA fibers per gram. Given the location of this home, the outgoing freight trains would likely just be reaching maximum speed or still accelerating at the point of Mrs. Flores' home two miles outside the downtown Libby Railyard. Moreover, the Marshall Report does not take into account the myriad of other dust producing activities BNSF engaged in at the Libby Railyard. As a result of the above, the additional risk of 2.37 times the EPA acceptable cancer risk concentration underestimates the actual increased risk of cancer Mrs. Flores incurred as a result of BNSF activities. By comparison, if the only available contemporaneous air concentrations available for downtown Libby (Results of W.R. Grace 1975 Dust Surveys – Source Emissions – using 1.5 f/cc) are considered in this same conservative lifetime cancer risk estimate, Mrs. Flores's cancer risk from inhaling Libby amphibole asbestos is 1.2×10^{-2}, or 1.2 in 100, which substantially exceeds the 1 in 10,000 threshold. Given her immediate proximity of her long time Libby residence to the railroad tracks leaving town, this may also underestimate the exposures she incurred during that period.

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51 (EPA, 2015) Inputs: 6.9 hours/day, 350 days/year, 12 years, mean LA exposure concentration 0.018 f/ml.

Although, by design Dr. Marshall's model significantly understates the total contribution of airborne asbestos fibers resulting from BNSF's activities in Libby, the model conservatively uses high estimates of emissions that were produced by the W.R. Grace mine and milling operations. Thus, while the model does not reflect Plaintiffs' total LA exposure from BNSF activities, it is a helpful tool in demonstrating the relative contribution of the W.R. Grace mine and milling operations in relation to just two of BNSF's activities in the area (non-stop trains through the Railyard and the Libby Log Job) and that asbestos emissions from just those two activities were a significant contributing factor in the Plaintiffs' development of asbestos related diseases. It is also worth noting that, in an effort to predict maximum Grace emissions and conservatively predict BNSF log job emissions, Dr. Marshall's model attributes emissions from the River Loading facility to W.R. Grace. This facility was owned by BNSF and operated for the benefit of W.R. Grace and the emissions therefrom are thus also attributable to BNSF.

Plaintiffs Barnes, Braaten, and Flores have each been diagnosed with multiple conditions consistent with prior asbestos exposure (Barnes – pleural and parenchymal fibrosis, pleural effusion; Braaten – mesothelioma, ovarian cancer, pleural plaquing; Flores – lung cancer, pleural plaquing) and have exposure histories commensurate with those diagnoses, making causes for each respective condition, other than their documented exposure to asbestos, less likely. In Libby, where numerous sources of environmental as well as occupational exposure pathways have been identified, it is likely that multiple pathways contributed to the cumulative fiber exposures for each plaintiff. With the exception of Mr. Barnes, none of the residents have occupational histories that are consistent with asbestos exposures. In addition to considering the source of exposure, intensity, frequency, and duration are important parameters for assessing risk. Mr. Barnes worked at the lumbermill for approximately one year and he made infrequent trips to the Grace's Railyard facility through his freight delivery employment. The frequency and duration of these potential occupational exposures is short relative to his years living in the Libby community. The potential for take-home asbestos exposures is well documented in literature (Newhouse, 1965; Wagner et al., 1960; Selikoff, 1964). Mr. Barnes' living history demonstrates that he incurred take home exposures resulting from his father's multi-year employment with the railroad and one year employment at the W.R. Grace mine, at both of which Robert Barnes incurred daily exposures to vermiculite, as well as possible take home exposure from his father's time working in the Lumbermill shipping department where he worked around residual vermiculite at the facility and associated with the rail cars and track areas. Mrs. Braaten's living history indicates possible take home exposure from her father's time working in the timber industry and her husband's time working at the Lumbermill. Mrs. Flores' living history does not indicate that she incurred significant take home exposures to asbestos. While it is apparent that multiple exposure pathways contributed to each plaintiff's cumulative asbestos exposure, based on the living/working histories of the three plaintiffs, available exposure data, community-based epidemiology studies, the conditions during transport of vermiculite into and out of Libby, other available materials, and my experience and knowledge in the field of toxicology and industrial hygiene, it is more probable than not, to a reasonable degree of scientific certainty, that their individual environmental community exposures to LA, incurred while living in the Libby area, were a substantial contributing cause of their respective asbestos related diseases. Based on this information and knowledge, it is more probable than not, to a reasonable degree of scientific certainty, that the Plaintiffs' inhalation of asbestos fibers generated from the activities of BNSF Railway and its predecessors in the Libby area substantially contributed to their overall Libby amphibole asbestos fiber exposures and associated asbestos related diseases.

XII. Necessity to Act

110. **Necessity to Act.** As described above, the health hazards related to asbestos exposure were well known by BNSF by the 1930s. Additionally, BNSF was undeniably aware of the presence of asbestos in the vermiculite concentrate mined in the Libby area which they hauled into and out of Libby. Consequently, pursuant to applicable standards of care, BNSF was obligated to protect its workers and the Lincoln County community from exposure to the asbestos on its properties, under its control, and/or generated by its activities.

The record demonstrates that the loading and transport of the vermiculite concentrate into and out of the Libby community generated copious amounts of dust. Given BNSF's knowledge of the asbestos content of the concentrate, under the applicable standard of care BNSF should reasonably have studied asbestos exposure propagating from its properties and facilities, warned of the hazards, and ensured controls were implemented to prevent exposure. Even if one were to assume that BNSF was unaware of the asbestos content of that dust it was producing, given the obvious visible presence of the dust in the BNSF workplace, under applicable standards of care BNSF should reasonably have measured and evaluated the potential dust hazard to people in and around its properties. Had BNSF met this standard of care, as imposed by general industrial hygiene and toxicology standards and its own safety rules and guidelines[52], it would have certainly learned of the asbestos content and hazardous nature of the dust, and have been able to have studied, warned, and protected its workers and the Libby community from exposure to the toxic LA.

In addition, in the Zonolite Siding Lease Agreement between W.R. Grace and BNSF covering the area of the River Loading Point, the Railroad retains oversight and approval of all construction proposed at the site. BNSF reviewed and approved the River Loading Facility design both at the time of initial construction and upon its reconstruction after the

[52] See e.g. BNSF Responsibilities for Safety – Content from Supervisor/Foreman seminars on safety 1975-1976 setting forth what BNSF considers to be "the fundamental requirements" and requiring inspection of "Atmospheric conditions, e.g. dusts"; 5/16/1975 BNSF memorandum discussing the BN Safety Policy which states "Safety is essential for efficient transportation and Safety is the primary concern and continuing responsibility of each supervisor and employee alike"; 9/11/1981 BNSF correspondence attaching a BNSF Respiratory Protection Program representing "the minimum which will meet all requirements" and setting forth the BNSF policy that "Burlington Northern will use substitution, engineering, and administrative controls to reduce employee exposures to toxic substances whenever feasible. When not feasible, or while being implemented, respiratory protection will be used."

facility was destroyed in the 1979 derailment at the site. On multiple other occasions BNSF specifically reviewed and approved the dust control appliances and improvements at the site, which historic footage, dust testing, and eye-witness testimony all demonstrate was grossly inadequate to control the massive clouds of asbestos containing dust produced during the loading process. See e.g. Railroad Dust Control Approval 3/9/1962; 3/30/1962; 1/21/1971; 11/10/1977; and Video Clip of River Loading Site. By securing the right to review and approve all improvements and modifications to the site, under the applicable standard of care, as imposed by general industrial hygiene and toxicology standards and its own safety rules and guidelines, BNSF should have required more substantial dust control mechanisms be installed and maintained, but failed to do so. Further, BNSF had this additional and specific notice of dust exposures in its work place and should have performed the necessary evaluation and instituted subsequent controls.

BNSF had a long standing awareness of the hazards associated with asbestos exposure and of the presence of asbestos in the Libby vermiculite, which is documented going back well before the Plaintiffs' exposure periods. Applicable standards of care imposed by then current principles of industrial hygiene and toxicology required that BNSF perform the necessary actions to protect the public from these hazards. There is no indication that BNSF attempted to meet this standard in Libby.

XIII. Conclusion

111. **Conclusion:** Based on the information presented in this report, my knowledge of the issues relating to Libby amphibole asbestos, and my training and experience in the field of industrial hygiene and toxicology, it is my opinion, to a reasonable degree of scientific certainty, that BNSF activities in Lincoln County significantly contributed to airborne asbestos levels in the ambient air shed and plaintiffs Barnes, Braaten, and Flores were exposed to this asbestos throughout their residencies in Lincoln County. It is more probable than not, to a reasonable degree of scientific certainty, that these community exposures significantly contributed to their associated asbestos related diseases.

Sincerely,

XIV. Appendix A: Hart CV

CURRICULUM VITAE

Julie F. Hart

Professor and Department Chair
Department of Safety, Health and Industrial Hygiene Montana Tech

Education:

University of Montana	Ph.D	Toxicology	2013
Montana Tech	M.S.	Industrial Hygiene	1991
Montana Tech	B.S.	Occupational Safety & Health	1989

Professional Registration and Licenses:

Certified Industrial Hygienist (1998) American Board of Industrial Hygiene (No. 7751)

Work Experience:

Montana Tech	Professor and Department Chair, Safety, Health and Industrial Hygiene (August, 2014-present)
Montana Tech	Professor in Safety, Health and Industrial Hygiene (August, 2013-August, 2014)
Montana Tech	Associate Professor in Safety, Health and Industrial Hygiene (August, 2010-August, 2013)
Montana Tech	Assistant Professor in Safety, Health and Industrial Hygiene (2000-2010)
Montana Power Co.	Corporate Health and Safety Auditor (1997-2000)
Thunder Basin Coal Co.	Senior Safety Advisor (1994-1997)
Thunder Basin Coal Co.	Safety Advisor (1991-1994)
Wyoming/MSHA State Grants	Part-Time Instructor (1995-1997)

Professional Affiliations:

American Board of Industrial Hygiene (1996 – present)
American Industrial Hygiene Association (1990 – present)
American Industrial Hygiene Association - Pacific Northwest Section: Montana Local Education (2000 to present)
American Industrial Hygiene Association – Pacific Northwest Section: Secretary (2017 – present)
American Conference of Governmental Industrial Hygienists (2017 – present)

Honors and Awards:

Montana Tech: Rose and Anna Busch Endowment Faculty Achievement Award in Recognition of Outstanding Teaching, Scholarship and Professional Service (2017)
Montana Tech: Merit Award: Meritorious achievement in Teaching, Scholarship and Professional Service (2016)
Montana Tech: Alumni Recognition Award (2011)
Pacific Northwest Section of the American Industrial Hygiene Association: Distinguished Industrial Hygienist Award (2009)

Funded Grants:

Hart, J.F., Combined Undergraduate and Graduate Training Program. DPHHS/CDC/NIOSH. T03OH008630. 7/1/13 – 6/30/19. Occupational Safety and Health Training Project Grant.

Spear, T.M., Hart, J.F., Evaluating the impact of weatherization activities in homes with vermiculite insulation or other asbestos containing material. Department of Energy
$100,000 (2007-2010).

Hart, J.F., An Evaluation of Potential Occupational Exposure to Asbestiform Amphiboles near a Former Vermiculite Mine. The Rocky Mountain Center for Occupational and Environmental Health (RMCOEH), Department of Family and Preventive Medicine, University of Utah School of Medicine. This Pilot/Small Projects Program was supported by the National Institute for Occupational Safety and Health (NIOSH). (2008-2009).

Principle Publications:

Hart, JF, Autenrieth, DA, Cauda, E., Chubb, LG, Spear, TM, Wock, S, Rosenthal, S. (2018 in press). A Comparison of Respirable Crystalline Silica Concentration Measurements Using a Direct-on-Filter Fourier Transform Infrared (FT-IR) Transmission Method Versus a Traditional Laboratory X-ray Diffraction Method. *Journal of Occupational & Environmental Hygiene* (in press – anticipated publication October, 2018).

Sheehy, A, Autenrieth, D, Hart, J, Risser, S (2017). Making it Sound as Good as it Tastes. Artisan Spirits - Summer Issue. http://artisanspiritmag.com/current-issue/.

Richardson, C., Capoccia, S, Hart, J (2016). Population Dynamics of the Feral Pigeon in the Central Business District of Butte, Montana. Conference Proceedings. 27th Vertebr. Pest Conf. R. M. Timm and R. A. Baldwin, Eds.) Published at Univ. of Calif., Davis. 2016. Pp. 217-220.

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Elashheb ML, Spear TM, Hart JF, Webber JS, Ward TJ (2011). Libby Amphibole Contamination in Tree Bark Surrounding Historical Vermiculite Processing Facilities. Jour of Env Prot. 2: 1062-1068.

Balasubramanian, V., Spear, T.M., Hart, J.F., Larson, J.D. (2011) Evaluation of surface lead migration in pre-1950 homes: An onsite hand-held X-ray florescence spectroscopy study. *Jour of Env Health* Vol.73, No. 10, 14-19.

Hart, J.F., Ward, T.J., Spear, T.M., Rossi, R.J., Holland, N.N., Loushin, B.G. (2011). Evaluating the effectiveness of a commercial portable air purifier in homes with wood burning stoves: A preliminary study. *Jour of Env and Public Health*. Doi:10.1155/2011/324809.

Hart, J.F., Spear, T.M., Ward, T.J., Baldwin, C.E., Salo, M.N., Elashheb, M.I. (2009). An evaluation of potential occupational exposure to asbestiform amphiboles near a former vermiculite mine. *Jour of Env and Public Health*. Doi:10.1155/2009/189509.

Ward, T.J., Hart, J.F., Spear, T.M., Meyer, B.J., Webber J.S. (2009). Fate of Libby amphibole fibers when burning contaminated firewood. *Environ. Sci. Technol*., Vol. 43, 2878-2883.

Hart, J.F., Ward, T.J., Spear, T.M., Crispen, K., and Zolnikov, T.R., (2007). Evaluation of Asbestos Exposures During Firewood Harvesting Simulations in Libby, Montana, *Annals of Occupational Hygiene*, 51, 8: 1-7.

Ward, T.J., Spear, T.M., Hart, J.F., Noonan, C., Holian, A., Getman, M., Webber, J.S., (2006). Trees as reservoirs for amphibole fibers in Libby, Montana, *Science of the Total Environment,* Vol. 367, 460 – 465.

Spear, T.M., Hart, J., Stephenson, D.J., (2006). Yellowstone Winter Use Personal Exposure Monitoring, Rocky Mountains Cooperative Ecosystem Studies Unit (RM-CESU), RM- CESU Cooperative Agreement Number: J1580050167.

Wilson, T.B., Douglass, R.J., Spear, T.M., Hart, J.F., and Norman, J.B., (2002). Evaluation of protective clothing for handling small mammals potentially

infected with aerosol- borne zoonotic agents, *Intermountain Journal of Sciences*, Vol. 8(1).

Service:

Butte Silver Bow Health Board member (2009-present) (January 2015- present)

Montana Local Education Officer, Pacific Northwest Section of the American Industrial Hygiene Association, (2000-present).

Peer Reviewer, Journal of Environmental and Public Health (2014)

Grant Peer Reviewer, National Institute for Occupational Safety and Health – Total Worker Health Programs (2016)

Grant Peer Reviewer, National Institute for Occupational Safety and Health – Total Worker Health Programs (2017)

Tenure Application Reviewer, Colorado State University, College of Veterinary Med and Bio Sciences (2017)

Application Reviewer, National Institute for Occupational Safety and Health – Pittsburgh Mining Research Division – Advancing Exposure Monitoring for Airborne Particulates (2017)

Grant Peer Reviewer, National Institute for Occupational Safety and Health – National Occupational Research Agenda (2018)

Industrial Hygiene Program Reviewer, Air Force Institute of Technology – Dayton, Ohio (2018)

Professional Development in Last Five Years:

Attended 7 professional society conferences, presented at 3.

XV. Appendix B: Contemporary Libby Asbestos IH Studies

I. General Asbestos/Government Regulation Standards

1. **Small Fibers Are Not Counted.** Another important issue pertaining to the toxicity of

asbestos is fiber morphology. For the purposes of counting asbestos fibers in air samples, regulatory agencies commonly count particles that have lengths ≥5 micrometers (μm) and length to width ratios ≥3:1 as fibers. The current occupational exposure limit for asbestos is 0.1 f/cc (8-hour time weighted average) for fibers ≥ 5 μm in length, with an aspect ratio (length:width) ≥ 3:1 (OSHA, 2001); (ACGIH, 2001).

The current standard method for determining airborne asbestos particles in the U.S. workplace is the National Institute for Occupational Safety and Health (NIOSH) Method 7400 which uses phase contrast light microscopy (PCM) (NIOSH, 1994a); (NIOSH, 1994b). Fibers are collected on a filter and counted with 400-450x magnification. The method does not accurately distinguish between asbestos and non-asbestos fibers, and cannot detect fibers thinner than about 0.25 μm.

Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) methods can detect smaller fibers than PCM and can be used to determine mineral habit in bulk materials that may become airborne. NIOSH Method 7402, Asbestos by TEM, is used to determine asbestos fibers in the optically visible range and is intended to complement PCM (NIOSH Method 7400). However, NIOSH Method 7402 still counts fibers ≥ 5 μm in length.

In addition to the occupational exposure limits specifying mineral species, counting rules for asbestos apply when comparing air concentrations to occupational exposure limits. Fibers equal to or longer than 5 μm with a length-to-width ratio (aspect ratio) (AR) of 3:1 or greater are counted (ACGIH, 2001; CDC, 2010; OSHA, 1994b). This counting rule has been questioned by epidemiologists and others in the environmental health community (Dodson et al., 2003); (Stayner et al., 2008).

Stayner et al. (2008) emphasized that the counting rule was based largely on accuracy and reproducibility limitations associated with phase contrast microscopy (PCM) counting versus a toxicological basis. Libby amphibole studies which revealed similar inflammatory potencies in respirable size fractioned and non-size fractioned LA strengthen this discussion (Duncan et al., 2010).

A common toxicological justification for the counting rule is that short fibers are cleared more readily from the lungs and that longer fibers impair the phagocytic process. (Dodson et al., 2003); (Stanton et al., 1981). Longer fibers have a greater potential than short fibers to generate an inflammatory response and stimulate a release of Il-1B from macrophages. (Kane (1992); (Donaldson et al., 2010); (Palomaki et al., 2011). However, as in any toxicological assessment, the dose and dosing frequency are critical factors to consider in the long versus short fiber toxicity discussion (Kane et al.,1992); (Castranova et al., 2000); and (Dodson et al., 2003).

In the Dodson et al. (2003) review of fiber length and pathogenicity, the conclusions drawn from Castranova et al. (2000), of "constant infusions of short fibers and a resultant eventual dust overload, can greatly compromise clearance" was cited as the main reason to underscore the short fiber clearance reasoning. A similar hypothesis regarding particle overload and the potential for short crocidolite asbestos fibers to generate substantial inflammatory responses was discussed by Kane (1992). Dodson et al. (2003) further emphasized that when appropriate techniques are used to analyze asbestos fiber tissue burden, in most tissues, a substantial majority of asbestos fibers are less than 5 μm in length. These observations may be due to increased deposition of shorter fibers and/or breaking of longer fibers over time.

Additional counting rules other than those specified by OSHA are used for ambient and indoor asbestos monitoring to provide more detailed quantification of asbestos structures. Two that have been used in studies assessing exposure to LA are the Asbestos Hazard Emergency Response Act (AHERA) and International Standards Organization 10312 methods (AHERA, 1987); (ISO, 1995). The AHERA method was derived for clearance sampling in school buildings following asbestos abatement. Under the AHERA method, an asbestos fiber is defined as a structure greater than or equivalent to 0.5 μm in length and a diameter > 0.002 μm with an AR of 5:1 or greater. Fibers are classified as 0.5 – 5 μm and > 5 μm in length (AHERA, 1987). The ISO 10312 method applies the same minimum length and diameter criteria as AHERA, however, 3:1 or 5:1 AR may be used. From an ISO 10312 analysis, several different airborne asbestos structure concentration values based on a number of fiber size classifications may be obtained (ISO, 1995).

Analytical techniques that count only fibers greater than 5 μm may substantially under-report inhalation exposures. Fiber lengths reported for LA range from less than 1 μm to greater than 20 μm with thicknesses ranging from 0.1 to 1 μm. If PCM counting rules are applied to LA, only one third of the fibers observed would be counted (Weis, 2001). Because the health effects associated with asbestos are not confined to fibers in the regulatory size fraction of greater than 5 μm, it is important to thoroughly characterize the fiber concentration and morphology and not limit this characterization to a counting rule that exists primarily because of an analytical method limitation.

2. **69% of LA fibers<5um**. Hart et al. (2007) reported that 69% of asbestos fibers collected in the Libby area were < 5 μm in length. This is consistent with ambient air sampling trends reported for Libby, using AHERA TEM analysis, of 65% of the airborne fibers collected at Libby being < 5 μm in length (ATSDR, 2003b). In addition, fiber dimension analysis of bark samples reported by Ward et al. (2006) showed the majority of the asbestos fibers detected were < 5 μm in length.

3. **Small Fibers Are Dangerous**. Consequently, the current regulatory methods of counting fibers based on fiber length and aspect ratio may not adequately describe the risk of asbestos-related health effects in that the concentration of fibers < 5 μm may contribute to health risks. Fiber size, shape and composition contribute collectively to health risks in ways that are currently being evaluated (ATSDR, 2003b). The likelihood that Libby amphibole fiber toxicity is confined strictly to fibers in this regulatory size fraction is neither toxicologically sound nor supported by the available health data from Libby (EPA, 2001). A study by Suzuki (2005) concluded that "contrary to the Stanton hypothesis, short, thin asbestos fibers appear to contribute to the causation of human malignant mesothelioma. Such fibers were the predominant fiber type detected in lung and mesothelial tissues from human mesothelioma patients.

These findings suggest that it is not prudent to take the position that short asbestos fibers convey little risk of disease." Animal and *in vitro* studies also suggest that fibers < 5 μm may also play a role in fibrosis, particularly under conditions of overload. Intense exposures may result in overload, limiting clearance of small fibers (Sullivan, 2007); (ATSDR, 2003b). Data presented by Dodson et al. (2003) argue that asbestos fibers of all lengths induce pathological responses and that caution should be exerted when an attempt is made to exclude any population of inhaled fibers, based on their length, from being contributors to the potential for development of asbestos-related diseases.

4. **Meeker and Sampling Issues**. The amphibole minerals within the Rainy Creek Complex (RCC) near Libby, MT, have been referred to under a variety of names. They were initially classified as tremolite, tremolite/actinolite, or soda-rich tremolite by early geologists (Pardee and Larsen, 1929); (Bassette, 1959); (Boettcher, 1967), with (Larsen, 1942) and (Deer et al., 1963), further characterizing the amphibole mineral as richterite. Langer et al. (1991) and Nolan et al. (1991) classified the RCC amphibole as tremolite and richterite, while Wylie and Verkouteren (2000) and Gunter et al. (2003) identified the RCC amphiboles as primarily winchite (once considered a subset of richterite). Wylie and Verkouteren (2000) further postulated that the amphibole composition may range from winchite to richterite.

   An extensive systemic evaluation of the RCC amphibole minerals was conducted by Meeker et al. (2003) which included 30 sample locations from the former mine area. Analytical techniques to characterize the composition, mineralogy, and morphology of both fibrous and non-fibrous components of RCC amphiboles included X-ray diffraction (XRD), electron probe microanalysis (EPMA) using wavelength dispersive spectroscopy (WDS), and scanning electron microscopy combined with energy dispersive X-ray analysis (SEM/EDS), respectively. Amphiboles were classified based on the Leake et al. (1997) system which is based on site assignments for each cat ion in the structure, including the oxidation state of iron. Meeker et al. (2003) approximated the respirable fraction of RCC amphiboles as winchite (84%), richterite (11%) and tremolite (6%), with possible magnesioriebecktite, edenite, and magnesio-arfvedsonite components.

   Meeker et al. (2003) further reported that the Vermiculite Mountain amphibole minerals displayed a range of morphologies from prismatic to asbestiform, with fibril diameters ranging from 0.1 to 1 μm.

   The discrepancy in the RCC amphibole mineral classification may be due to several factors. These include: (1) amphiboles were viewed as a secondary mineral by early geologists and received little attention (Bandli and Gunter, 2006); (2) there have been modifications in the International Mineralogical Association (IMA) classification systems (Wylie and Verkouteren, 2000); (3) naming of amphibole species is complex because of the variations in chemistry and the substitutions that occur in this mineral group (Gunter et al. 2003); (4) the optical properties of winchite from the RCC are very similar to tremolite (Bandli and Gunter, 2006); and (5) many techniques and methods available for analysis and classification of asbestos are not capable of adequately identifying or distinguishing these minerals according to current IMA guidelines (Meeker et al., 2003).

Environmental data for Libby collected prior to 2007 and analyzed by TEM were limited in their ability to quantify winchite and richterite, which most likely resulted in under-reporting of LA concentrations. In his 2003 paper, Meeker stated "…none of the present regulatory analytical methods (with the possible exception of well-calibrated SEM/EDS analysis using calibrated standards similar to EPMA/WDS) can accurately differentiate the amphiboles present in the asbestiform material from Vermiculite Mountain" (Meeker et al., 2003). These analytical methods were presumably not used during site characterization of the Libby Asbestos Site.

5. **EPA IRIS Toxicological Report**. In December 2014, the EPA released the toxicity assessment for Libby amphibole asbestos, setting forth a reference concentration for LA of 0.00009 fibers per cubic centimeter (fiber/cc). *IRIS Summary*, I.B.1 The reference concentration sets forth what the EPA determines to be an estimate of a daily exposure over a lifetime that is likely to not cause appreciable risk of adverse health effects. *Id.* at I.B. The assessment recognizes the abnormally toxic nature of the Libby amphibole by noting that workers exposed to LA had a 10-fold increase risk of parenchymal disease and up to a 3-fold increase of any other nonmalignant respiratory disease over the general population. *Id.* at I.B.2. Additionally, the reference concentration is considerably lower than OSHA permissible exposure limit of 1 fiber per cubic centimeter for 30 minutes or less per day and 0.1 fibers per cubic centimeter over an eight hour period per day. (29 C.F.R. 1910.1001(c))

   The reference concentration and inhalation unit risk from the toxicity assessment are unique in the sense that for the first time the risk for asbestos has been evaluated for a 24 hour period. Typically, regulatory standards have been based on occupational exposure over the course of a work day. Because of the consistent and various exposure pathways in Lincoln County, the EPA necessitated a number that reflected the unique situation. The number derived from the EPA for Libby exposure is 1,000 times lower than the OSHA standard for a 8 hour work day, or 333 times lower for a 24 hour day by converting the OSHA standard. This demonstrates the increased risk of multiple exposure pathways and chronic exposure (EPA, 2014)

6. **OSHA PELs:** OSHA has established two occupational standards for exposure of workers: an 8-hour time-weighted average (TWA) value of 0.1 f/cc, and a short-term exposure limit (STEL) of 1 f/cc. EPA found a number of personal air samples collected from residential or commercial locations (mainly those associated with active disturbance of vermiculite) exceed one or both of these standards. In relation to these findings, EPA stated:

   > "It is important to recognize that occupational exposure standards for asbestos are not generally applicable or protective for residents or workers in non-asbestos environments because occupational standards are intended

to protect individuals who a) are fully aware of the hazards of the occupational environment, b) have specific training and access to protective equipment such as respirators and/or protective clothing and, c) participate in medical monitoring (USEPA 1995). None of these conditions apply to residents or to workers at typical commercial establishments. Thus, simple compliance with the OSHA standards is not evidence that exposure levels are acceptable in a home or in a non-asbestos workplace. Indeed, risks to residents or workers occur at exposure levels substantially below the OSHA workplace standards." (EPA 2001a).

7. **NIOSH IH guidelines** regarding vermiculite recommend workers consult Occupational Safety and Health Administration (OSHA) asbestos standards for general industry and construction (29 CFR 1910.1001 and 1926.1101) when work will involve vermiculite that is known or presumed to be contaminated with asbestos. If the vermiculite is known or presumed to be contaminated with asbestos, NIOSH recommends the following general industrial hygiene guidelines for limiting asbestos exposure:

- Avoid handling or disturbing loose vermiculite
- Isolate work areas with temporary barriers or enclosures to avoid spreading fibers
- Use wet methods, if feasible, to reduce exposure
- Never use compressed air for cleaning
- Avoid dry sweeping, shoveling, or other dry clean-up methods
- Use disposable protective clothing or clothing that is left in the workplace. Do not launder work clothing with family clothing
- Use proper respiratory protection.
- Dispose of waste and debris contaminated with asbestos in leak-tight containers in accordance with OSHA and EPA standards" (DHHS (NIOSH) Publication Number 2003-141, May 2003).

II. Exposure Mechanisms: Air, Soil, & Vermiculite

15. **Fiber Travel, General**. Once asbestos fibers enter the environment from either a natural or artificial source, they tend to settle out of the air or water and deposit in soil and sediment (EPA, 1977); (EPA, 1979c). Asbestos fibers can be re-suspended into the air or water following soil and sediment disturbances. The rate at which asbestos particles settle out of the air or water depends on their size (ATSDR, 2001); (EPA,1979). Jaenicke (1979) reported that the residence time for a particle to remain

airborne is greatest for particles ranging from 0.1-1 μm in diameter. Fibers in this size range could be transported long distances in air.

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

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

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

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

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

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

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

Activity-specific testing found that the half-time of LA suspended by dropping vermiculite on the ground was about 30 minutes. LA suspended from disturbing vermiculite insulation settled within approximately 24 hours (CDM, 2009).Once suspended, LA moves by dispersion through air. LA concentration will be highest near the source and will decrease with increasing distance. In outdoor air, wind speed will determine direction and velocity of LA particle transport. Wind can cause the rapid dispersal of LA from the source of release" (EPA, 2008b).

16. **Fiber Settling Rate.** Asbestos fibers in the air are known to travel long distances from their source or point of origin and the Environmental Protection Agency (EPA) states

that,

"During the time that the [asbestos] fiber remains airborne, it is able to move laterally with air currents and contaminate spaces distant from the point of release." Significant levels of contamination have been documented hundreds of meters from a point source of asbestos fibers, and fibers also move across contamination barrier systems with the passage of workers during removal of material.

The theoretical times needed for such [respirable] fibers to settle from a 3 meter (9 ft.) ceiling are 4, 20 and 80 hours in still air. Turbulence will prolong the settling and also cause re- entrainment of fallen fibers" (EPA, 1978b).

17. **Fiber Re-entrainment**. Because of their shape and small size, asbestos fibers, particularly those of respirable dimensions, remain airborne for hours once they are introduced into the air. Once they are airborne the asbestos fibers will drift long distances from their source. Movement and air turbulence causes fibers that have settled out of the air to be reintroduced (re-entrained) into the air and to drift long distances from their source. In addition, the human traffic on a worksite can also be expected to disburse asbestos throughout the entire work area. For this reason, asbestos fibers do not respect work areas or job classifications. It has been repeatedly demonstrated that a source of asbestos emission in the air puts everyone in the general vicinity (bystander exposure) at risk. Because of the microscopic size of asbestos fibers, and their aerodynamic properties, typical housekeeping activities such as sweeping tend not to remove that asbestos from the plant. Rather, such activities have the effect of stirring up and re- entraining the asbestos that is in the location, ensuring that it is available for inhalation by workers in the vicinity.

18. **EPA (2001) Disturbed Vermiculite Study**. As part of the Phase 2 study, EPA (2001) collected data from personal and stationary air monitors in the immediate vicinity of people actively engaged in disturbing vermiculite insulation. This scenario (referred to as Scenario 3) was intended to assess exposures that might be experienced either by homeowners who engaged in activities in unfinished attic areas, or for contractors who might come into contact with vermiculite during repair or remodeling activities. The results of personal air samples [transmission electron microscopy (phase contrast microscopy –asbestos) TEM (PCME-asb)] showed a mean concentration of 0.309 f/cc with a range of 0.042 – 1.057 f/cc. The results of stationary air samples (TEM (PCME-asb) showed a mean concentration of 0.309 f/cc with a range of 0.023 – 0.789 f/cc.

19. **EPA (2003a) Disturbed Vermiculite Study.** EPA collected data from personal and stationary air monitors in the immediate vicinity of people actively engaged in disturbing vermiculite insulation. This scenario was intended to assess exposures that might be experienced either by homeowners who engaged in activities in unfinished attic areas, or for contractors who might come into contact with vermiculite during repair or remodeling activities. These data demonstrated that active disturbance of vermiculite results in very high concentrations of fibers as measured by both phase-contrast microscopy (PCM) and transmission electron microscopy (TEM) phase-

contrast microscopy equivalents (PCME). The highest airborne concentration of 3.3 total asbestos fibers per cubic centimeter (f/cc) by TEM occurred during the simulation with Zonolite Vermiculite. In Phase 2, levels of airborne asbestos fibers were detected during seven simulations conducted in an artificial containment system. Bulk analysis of the Zonolite product indicated that it contained trace amounts of asbestos fibers (PLM: <1% tremolite; TEM: <0.1% tremolite/actinolite). Airborne asbestos fibers were detected in approximately half of the total air samples collected (total from all personal and stationary air samples combined). The maximum airborne concentration of 4.3 total actinolite f/cc by TEM occurred during the first simulation with dry vermiculite (EPA, (2003a).

These findings are consistent with previous studies conducted by W.R. Grace. These “drop tests” demonstrated that fiber concentrations in air resulting from pouring vermiculite insulation onto the floor under controlled conditions can be extremely high even when bulk concentrations in the vermiculite are less than 1% (Grace, 1976).

20. **Soil Disturbance, Greatest Exposure Source.** A variety of factors can influence the extent of airborne exposures associated with asbestos fibers in soil, the most important of which appears to be a disturbance of contaminated soil or material by human activity. Even today, after years of soil remediation in Libby "outdoor activities that disturb soil appear to be the greatest source of Libby amphibole exposure" (McKean, 2011).

    Other factors that may affect the suspension of asbestos fibers into the air, and thus airborne asbestos exposures, include the environmental conditions, moisture content of the soil, concentration of asbestos in the soil, the type of the soil, and the characteristics of the asbestos present. Nearly all exposure comes from near-surface soils. These soils generate dust and are often actively disturbed. In most circumstances, contamination is also limited to near surface soils. The EPA Action Plan for Libby established a maximum depth of excavation at 12-18 inches based on the depth that typical residential activities may intrude into the soil (EPA, 2003c)

21. **Soil Disturbance/ND Can Release Fibers.** Individuals may be exposed to asbestos in outdoor soil during a variety of different activities that disturb the soil and cause release of fibers from soil into the breathing zone of the person engaged in the soil disturbance activity. When outdoor soil that contains LA is disturbed (e.g., by raking, mowing or digging), fibers are released into the breathing zone of the person who is causing the soil disturbance. The concentration of fibers that are released into the air is highly variable, based on differing types of disturbance activities, but there is a clear trend for levels in air to increase as the levels in soil (as measured by a polarized light microscopy method referred to as PLM-VE) increase. That is, the lowest average levels of LA in air are observed while disturbing soil that is non-detect (ND)(Bin A) by PLM-VE, with increasing average levels for soil that is < 0.2% (Bin B1), between 0.2% and 1% (Bin B2), or > 1% (Bin C) (EPA, 2007a). However, from studies of outdoor soil disturbance, it is evident that soils that are ND can release LA fibers into the air (Addison et al., 1988). As BNSF’s contractor EMR points out, there is “evidence

to suggest that vermiculite material with an asbestos content as low as 0.1% may generate airborne fiber concentrations ranging between 5 and 10 f/cc." (BNSF_501_0014_0008).

22. **Soil<1%Asb. Poses a Hazard When Disturbed, CO.** According to the Colorado Department of Public Health And Environment, Hazardous Materials and Waste Management Division, several studies using a variety of approaches, including the state of the science, for the release of asbestos fibers from significantly <1% asbestos in soil/debris demonstrated that all types of asbestos fibers can be released into the air or breathing zone during soil disturbing activities resulting in unacceptable risk that is significantly above acceptable cancer risk level of 1 in a million at 0.000004 ($4X10^{-6}$) f/cc (EPA IRIS), and even above the OSHA limit of 0.1 f/cc, in some cases.

23. **EPA (2004b) Spokane LA Soil Disturbance Study.** EPA Region 10 (EPA 2004b) conducted a three phase study at the Spokane vermiculite exfoliation plant to determine if asbestos fibers in the soil at the site could become airborne when the soil was disturbed. Soil samples were taken from several locations within the site boundary and analyzed using polarized light microscopy and X-ray diffraction. Analysis revealed that most of the asbestos in the soil was similar to the amphibole asbestos that occurs in vermiculite from Libby, Montana. In phase two of this study, twelve soil specimens were collected from the site and eleven were agitated inside a laboratory enclosure equipped with air monitoring equipment. Ten of the eleven soil specimens contained asbestos that became airborne when the soil was agitated. Filters used for collection of air samples were analyzed with a transmission electron microscope (TEM) and were found to contain asbestos, with concentrations of asbestos in the air ranging from 0.051 fibers per cubic centimeter (f/cc) to 10.713 f/cc.

    During phase three, air samples were collected while performing property maintenance and excavation tasks at two locations on-site. Samples analyzed using TEM showed concentrations of asbestos ranging from 0.010 f/cc to 0.045 f/cc of air. Several asbestos fibers were also detected in filters from stationary air monitors. According to EPA (2004b), this study clearly shows that asbestos in the soil at the former vermiculite exfoliation plant in Spokane can be released into the air when the soil is actively disturbed. Because there is a clear pathway for asbestos to move from contaminated soil to the air, individuals working on the site can be exposed to potentially hazardous levels of airborne asbestos fibers.

24. **Addison (1988, 1995), Soil > .001% Asbestos can generate excess of 0.1f/ml**. The best information about the levels of asbestos content in soils likely to cause a health risk comes from the Addison et al. (1988) experiments where it was recommended "that soils containing more than 0.001% asbestos are regarded as being capable of generating airborne fibre concentrations in excess of 0.1 f ml-1 (the OSHA workplace standard) and that precautions to protect the workforce by wetting the soil, providing respiratory protection etc., are taken." Addison (1995) stated:

    > It would be necessary therefore to take action specifically to control for the asbestos emissions if soils containing higher levels than 0.001%

> asbestos were to be handled without significant health risks. Asbestos, if present in vermiculite, is likely to behave in a similar fashion; with the asbestos loosely dispersed and readily available for release into the air. Even relatively gentle handling of the vermiculite would abrade the friable asbestos, splitting fiber bundles, and adding to the released fibers. Thus, even though the carcinogens legislation may impose only a 0.1% limit for packaging and labeling, the vermiculite industries would be advised to establish their own target limit of 0.001% for amphibole asbestos. Most current supplies of vermiculite could still meet this standard (Addison, 1995).

25. **Addison (1988), 200X OSHA PEL from Soil at 1% Asbestos**. Addison et al. (1988) conducted experiments to evaluate the release of dispersed asbestos fibers from soils. Addison et al. (1988) showed that the most important factor controlling airborne fiber concentrations in the experiments with dry loose aggregate mixtures was the bulk asbestos content and that, irrespective of fiber type or soil type, high airborne fiber concentrations over 200 times the current OSHA Permissible Exposure Limit (PEL) for asbestos can be generated from soil containing just 1% asbestos. Addison also showed that soil with concentrations of 0.1%, or 1/10 the EPA action level, were capable of producing airborne asbestos levels in excess of 8 times the current OSHA PEL for asbestos.

26. **Addison (1988), Reduction in % Asbestos Not Proportionate.** Addison (1988) also reported:

> There was a progressive reduction in airborne fibre concentrations at a given dust concentration with reducing amounts of asbestos in the mixtures, but this reduction was not proportionate to the reduction in asbestos content below 0.1%. With 0.1%, and often 0.01%, of asbestos in soils, the 0.5 f/ml-1 Control Limit for chrysotile and the 0.2 f/ml-1 Control Limit for crocidolite and amosite could be exceeded while respirable dust concentrations were below 5 mg/m-3, the nuisance dust OEL. Similarly, it is apparent that the clearance limit of 0.01 f/ml-1 could be exceeded with any of the 0.01% and 0.001% asbestos mixtures if respirable dust concentrations approached the nuisance dust OEL.

27. **Ward (2006) Bark Study.** In 2005, it was discovered that trees in areas surrounding the vermiculite mine and throughout Libby serve as reservoirs for LA (Ward et.al. 2006), when tree bark samples were collected in support of a proposed firewood harvesting / commercial logging exposure study in the Libby area. Bark samples were collected to simulate a probable amphibole fiber concentration gradient emanating from the mine from forests around the W.R. Grace mine. Bark samples were collected from three separate, heavily forested locations within the Superfund site, within the town of

Libby and on the railroad line seven miles west of town, and two miles northeast of the mine on United States Forest Service (USFS) road 4872 in an area that had been recently clear cut. Asbestos concentrations on bark near the mine were greater than one hundred million fibers per square centimeter of tree bark surface area. Asbestos concentrations on bark within the town of Libby showed a quarter of a million fibers per square centimeter, and the tree bark sample collected from a ponderosa pine tree located on the railroad line seven miles west of town (note that the vermiculite mine is east of town) showed 5.8 million fibers of asbestos per square centimeter of tree bark surface area. Tree bark samples collected two miles northeast of the mine on United States Forest Service (USFS) road 4872 showed asbestos concentrations ranging from non-detect to 2 million fibers per square centimeter of tree bark surface area (Ward et.al. 2006).

28. **EPA (2008c) & Ward Bark Study.** From the original samples that were collected near the abandoned W.R. Grace Mine in November 2004 (Ward, 2006), concentrations ranged from 14 million asbestos structures/cm2 bark surface area (s/cm2) to 110 million s/cm2. These original results were confirmed by our team in follow-up bark sampling programs throughout the mine site, and through a more comprehensive bark sampling program conducted by Region 8 EPA (EPA 2008c).

29. **EPA (2008c) Bark Study Results.** EPA (2008c) collected samples of bark from trees at least 30 years old were collected at a number of stations located on transects that radiate away from the mine, with special emphasis on the predominant downwind direction (northeast). The EPA bark sampling map is shown in Appendix 1. All tree bark samples were collected from the side of the tree facing toward the mine site, from a height of about 4-5 feet above ground. The tree bark samples were ashed and analyzed for LA by TEM. Results are expressed as LA fibers per cm^2 of tree bark. Although there is moderate spatial variability, there is a general tendency for the highest levels (> 2.5 million fibers per cm^2) to occur within about 2 to 3 miles of the mined area, with a tendency for values to diminish as a function of distance from the mine. Elevated values are noted not only in the downwind direction (north-northeast from the mine), but also along nearly all transects. It is suspected that the majority of the LA in tree bark is attributable to historic releases to air during the time the mine was active, although current and on-going releases may also be contributing (EPA 2008c). The EPA program measured significant amphibole contamination in tree bark near the mine (2.5 to 20 million structures/cm^2), with contamination extending out miles from the mine in all directions (Ward et al., 2012).

30. **EPA(2008c) Bark Study, Forest Soil and Duff.** Forest soil and duff samples were collected from approximately equally spaced locations around the perimeter of a circle with a radius of about 5 feet, centered on the same tree where the bark sample was collected. The grab samples were combined into one composite and analyzed for LA by PLM-VE. LA was detectable in a number of soil samples located relatively close to the mined area, but was not detectable at a distance more than about 2 miles from the

mined area. The source of the LA observed at these locations is unknown, but might include a) naturally occurring outcrops of the LA-bearing ore body, b) deposition from historic airborne releases from the mine and mill, and c) water-based erosion from past and/or present materials at the mine site (EPA 2008c).

31. **EPA (2011b) Human Receptors in OU3.** As described above, historic mining, milling, and processing of vermiculite at the Libby mine site, Operable Unit 3 (OU3), are known to have caused releases of vermiculite and LA to the environment. A range of different human receptors may be exposed to LA in OU3, including:

    - Commercial loggers in the forested area – This receptor population includes adult workers who are employed in commercial logging operations in OU3. Exposures of potential concern for asbestos include inhalation of ambient air, inhalation of airborne emissions of LA from roadways and inhalation of air that contains LA released from soil or duff as well as LA fibers released to air by cutting and stacking timber that has LA in the tree bark. Commercial loggers harvesting wood in OU3 may be exposed as a result of release of fibers from soil, duff or tree bark into breathing zone air. At present, EPA has not collected any data that are specifically intended to allow an evaluation of risks to commercial loggers. The movement of the vehicle along the road may disturb contaminated soil in or along the roadway, potentially leading to inhalation exposure of the vehicle occupants (EPA 2011b).
    - Forest service workers in the forested area – This population includes employees of the USFS who may engage in a range of forest management activities, including maintenance of roads and trails, cutting fire breaks, thinning and trimming trees, measuring trees, etc (EPA 2011b).
    - Recreational visitors in the forested area – This receptor population includes older children (assumed to be age 7 or older) and adults who engage in activities such as camping, hiking, dirt bike riding, all-terrain vehicle (ATV) riding, hunting, etc. Exposures of primary concern for asbestos include inhalation of ambient air, inhalation of air in the vicinity of contaminated soil, duff, or roadways/trails disturbed by recreational activity, and inhalation of LA released from contaminated tree bark while gathering wood for a campfire and while burning the wood in a campfire (EPA 2011b).
    - Residential wood harvester in the forested area – This receptor population includes adult area residents who engage in sawing, hauling, and stacking wood for personal use. Exposures of potential concern for asbestos in OU3 include inhalation of ambient air, inhalation of airborne emissions of LA from roadways and inhalation of air that contains LA released from soil or duff as well as LA fibers released to air by cutting and hauling timber that has LA in the tree bark (EPA 2011b).

32. **Bark Activity Based Studies Intro.** Following the initial discovery of LA

contamination in tree bark (Ward et al., 2006), multiple independent studies that have been conducted in an effort to understand the impact of these findings on the Libby community. These studies include assessing the potential for inhalation exposures to the general public that disturb LA-contaminated trees through residential home heating activities (i.e. firewood harvesting and wood stove use) (Hart et al., 2007; Ward et al., 2009), as well as studies designed to evaluate wild land firefighting and other routine occupational tasks conducted by the United States Department of Agriculture Forest Service (Forest Service) in Libby (Hart et al., 2009; Ward, 2012).

33. **Hart (2007) Firewood Harvesting Study.** Hart et.al (2007) demonstrated that amphibole fibers are released from tree reservoirs during firewood harvesting activities in asbestos-contaminated areas and that the potential for asbestos exposure exists during such activities. The firewood harvesting study consisted of three independent simulation trials conducted on Forest Service property in an area of the Kootenai Forest inside the EPA restricted zone with potential exposures primarily assessed via personal breathing zone (PBZ) sampling and surface wipe sampling of the outer layer of Tyvek™ clothing. The majority of the personal breathing zone (PBZ) samples collected during the EPA-restricted zone harvest simulations showed concentrations above analytical sensitivities for transmission electron microscopy (TEM) (21 of 24 samples).

    The mean time weighted average concentration for fibers <5 μm long was 0.15 s/ml, while the mean concentration for fibers >5 μm long was 0.07 s/ml. Even though the PBZ sample from the chainsaw operator's assistant revealed the highest mean total LA concentration (0.40 ± 0.51 s/ml), overall no significant differences were observed in PBZ concentrations between tasks.

    In addition to the airborne exposure potential associated with harvesting amphibole-contaminated trees, there is also a strong potential for clothing contamination and substantial LA concentrations were also revealed on Tyvek clothing wipe samples from each of the investigators. Wipe samples collected from the investigators' chest and thigh revealed asbestos fiber contamination above the AS in 23 of 24 samples. The mean LA concentration (n = 14) was 30,000 s/cm2, with 91% (27,000 s/cm2) composed of fibers <5 μm long.

34. **Hart (2009) USFS Employee Exposure Study.** A United States Department of Agriculture (USDA) Forest Service occupational exposure study was conducted during the summer of 2008 to assess the potential for Forest Service employee exposures while working near the abandoned vermiculite mine, but outside of the EPA restricted zone (Hart et al., 2009). Investigators simulated the following four routine activities: 1) walking through forested areas, 2) conducting tree measurement, 3) constructing a fire line, and 4) performing trail maintenance. In addition to PBZ and Tyvek clothing surface wipe sampling, pre and post vehicle wipes were collected on the rear bumper of the vehicle used to transport investigators and equipment to the research site. Wipe samples were also collected from the chainsaw used in several of the trials post activity.

For individual PBZ samples with LA >5 µm detected, 10 of 24 samples (42%) exceeded the Occupational Safety and Health Administration (OSHA) exposure limit of 0.1 f/ml (assuming an eight hour exposure duration) when analyzed by PCM. These 10 PBZ samples were all collected during the fireline construction simulation activity. When analyzed by TEM (and therefore excluding cellulose fibers from the analyses), 25% of the PBZ samples revealed concentrations greater than the analytical sensitivity (AS). These samples were collected during the fireline construction and tree measurement simulation activities. The mean (n = 4) PBZ sample weighted average concentration for fireline construction activity samples was 0.08 s/ml, while the mean PBZ sample weighted average concentration for tree measurement activity was 0.01 s/ml.

LA was detected on wipe samples collected from all of the activities evaluated. Fifty two percent of post activity wipe samples revealed concentrations greater than the detection limit, with mean concentrations (n = 10) of 941 s/cm2. The most elevated wipe concentrations were associated with the fireline construction activity, with a mean (n = 4) of 1,456 s/cm2. Similar to the PBZ samples, the tasks that generated wipe sample concentrations greater than the AS for the fireline construction activity were brush clearing, comby tool operating, and Pulaski tool operating. Other activities that generated LA (as detected by the wipes) were tree measurement activities, trail maintenance (brush clearer and chainsaw operator), and hiking activities.

In addition, the wipe samples collected from the chainsaw bar after each trial (n = 3) revealed amphibole contamination ranging from 896 to 11,825 s/cm2, with 12 of 15 fibers <5 µm long. Clothing and equipment contamination may serve as a secondary source of exposure to forest service personnel. Cross contamination of vehicle cabs, vehicle boxes, equipment storage areas, equipment maintenance areas, and offices may occur as a result of clothing and equipment contamination.

The vehicle wipes collected for one of the roads evaluated near the mine revealed concentrations below the AS, while results from another roadway (Jackson Creek) evaluated measured LA concentrations of 17,917 s/cm2.

35. **Ward (2012) USFS Controlled Burn Study.** While the Forest Service occupational exposure assessment provided some guidance into the exposure potential associated with common occupational activities, firefighting or controlled burn activities were not included in this assessment. To address this activity, a small-scale controlled burn was conducted in a (3.7 m X 3.7 m) plot in July 2009 (Ward et al., 2012). The plot location was within the same geographical area where several of the simulated Forest Service tasks were conducted in the occupational assessments described above.

The controlled burn consisted of three activities, including fire line construction, combustion, and mop-up. Sampling was performed independently for each controlled burn activity. In addition to PBZ and Tyvek clothing surface wipe sampling, high volume ambient air sampling was performed during the controlled burn activities. This sampling consisted of four sampling stations positioned 1.2 m from the perimeter of the burn, one station positioned 3.7 m above the burn plot, and one station positioned within the prevailing wind direction. Following the controlled burn, three ash samples were collected from the burn plot.

Nine of 12 (75%) of the PBZ samples revealed concentrations greater than the analytical sensitivity when analyzed by AHERA TEM, with the majority (64%) of structures detected >5µm. Tyvek clothing wipe samples collected from each investigator showed TEM total LA structure concentrations ranging from ND to 2,500 s/cm2, with the majority (62%) of LA <5 µm.

Sixty-two percent of the high volume ambient air samples revealed LA concentrations greater than the analytical sensitivity when analyzed by AHERA TEM, with LA identified in samples collected during all three activities (fireline construction, combustion, and mop-up). The mean high volume TEM air concentrations for LA <5 µm and > 5µm were 0.01 and 0.01 s/ml, respectively. In terms of fiber counts, 70% of the LA fibers identified in high volume air samples were >5 µm long. Bulk ash LA concentrations collected above mineral soil ranged from 8,294,575 to 18,736,220 s/g, with 61% of LA <5 µm.

36. **Disturbance of Contaminated Trees.** Results from the above studies suggest that there is an acute airborne exposure potential to LA associated with disturbing contaminated trees and undergrowth such as brush – both through common public and occupational activities. When analyzed by TEM, 100% of the firewood harvesting samples, 25% of the Forest Service occupational assessment samples, and 75% of the controlled burn samples revealed detectable concentrations of LA. PBZ results showed that the majority of the fibers detected were <5 µm in length, which is consistent with the size fractions seen in our bark sample results measured in the areas surrounding the abandoned vermiculite mine. LA concentrations as measured by PBZ sampling were consistently higher in the firewood harvesting simulation samples compared to samples collected during the Forest Service occupational assessment and controlled burn trials. It is unclear whether the firewood harvesting activity is more likely to contribute to inhalation and clothing contamination or whether the higher concentrations observed were due to elevated concentrations of LA in tree bark. Since two of the Forest Service occupational activities evaluated also employed the use of a chainsaw (fireline construction and trail maintenance), this supports the hypothesis that the higher PBZ and wipe concentrations are most likely associated with elevated tree bark (source) concentrations (Ward et al., 2012).

37. **EPA (2011a) Warning Re: Gathering of Wood in the Libby Valley.** Recent notices by EPA (Victor Ketellapper, 5/5/2011) and the USDA Forest Service [Informed Choices Regarding Libby Amphibole (Asbestos On the Forest)] stated the following:

> **"Gathering Of Wood In The Libby Valley**
>
> To understand the effects of vermiculite mining activity on the surrounding forest area, EPA sampled tree bark and forest ground covering around the Vermiculite Mountain mine. Asbestos fibers were

detected in both the tree bark and forestground covering as far as 8 miles away from the mine. Based on these findings, EPA suggests residents only cut and gather firewood from outside of the Libby valley. **Be aware the bark from trees in the Libby valley may contain asbestos fibers.”** (EPA 2011a)

XVI. Appendix C: Works Cited

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