HEALTH CONSULTATION

(FORMER) VERMICULITE NORTHWEST, INC.

(a/k/a ZONOLITE DIVISION OF W.R. GRACE & CO.; W.R. GRACE & Co., CONSTRUCTION PRODUCTS DIVISION; & W.R. GRACE & CO. – CONN.; NW VERMICULITE-PORTLAND)

PORTLAND, MULTNOMAH COUNTY, OREGON

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Prepared by the

Oregon Department of Human Services
Superfund Health Investigation & Education Program
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
Division of Health Assessment & Consultation
Atlanta, Georgia

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Foreword: ATSDR National Asbestos Exposure Review

Vermiculite, a mineral with many commercial and industrial uses, was mined in Libby, Montana, from the early 1920s until 1990. During those years, vermiculite from Libby was shipped to hundreds of locations throughout the United States. We now know that the vermiculite from Libby contained asbestos.

The National Asbestos Exposure Review (NAER) is a project of the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is working with other federal, state, and local environmental and public health agencies to evaluate public health impacts at sites that processed Libby vermiculite.

The evaluations focus on the processing sites and on human health effects that might be associated with possible past or current exposures. They do not consider commercial or consumer use of the products of these facilities.

The sites that processed Libby vermiculite will be evaluated by: (1) identifying ways that people could have been exposed to asbestos in the past or ways that people could be exposed now, and (2) determining whether the exposures represent a public health hazard. ATSDR will use the information gained from the site-specific investigations to recommend further public health actions as needed. Site evaluations are progressing in two phases:

Phase I: ATSDR has selected 28 sites for the first phase of reviews on the basis of the following criteria:

- The U.S. Environmental Protection Agency (EPA) mandated further action at the site based upon contamination in place, or

- The site was an exfoliation facility that processed more than 100,000 tons of vermiculite ore from Libby mine. Exfoliation, a processing method in which ore is heated and "popped," is expected to have released more asbestos than other processing methods.

The following document is one of the site-specific health consultations ATSDR and its state health partners are developing for each of the 28 Phase 1 sites. A future report will summarize findings at the Phase 1 sites and include recommendations for evaluating the more than 200 remaining sites nationwide that received Libby vermiculite.

Phase 2: ATSDR will continue to evaluate former Libby vermiculite processing sites in accordance with the findings and recommendations contained in the summary report. ATSDR will also identify further actions as necessary to protect public health.

Purpose and Health Issues

The former Vermiculite Northwest/W.R. Grace site is located at the intersections of N. Harding, N. Randolph, and N. Loring in an industrial area of northeast Portland, Oregon, near the Willamette River. Vermiculite was processed at the site from the early 1950's through 1993. From 1967 through 1991, Vermiculite Northwest/W.R. Grace received shipments of 193,112.78 tons (386,225,563 lbs) of Libby vermiculite (unpublished information from EPA's database of W.R. Grace invoices) that were exfoliated at the site.

In response to scientific studies in the 1990s that indicated higher rates of asbestos-related health conditions in Libby, Montana [1, 2], EPA investigated a number of sites throughout the country where Libby vermiculite had been reportedly processed. As part of this investigation, EPA visited the Vermiculite Northwest/W.R. Grace plant in March 2000 and collected soil, dust, and air samples inside the former plant. EPA identified Vermiculite Northwest/W.R.Grace as a site for further investigation as a result of this sampling effort. After follow-up interior cleanup was complete in 2002, the Oregon Department of Environmental Quality (ODEQ), lead agency for site cleanup, determined that no further cleanup actions were needed at the site [3]. However, there have been many advances in the understanding of vermiculite cleanups, as well as fiber toxicity, since the site's initial cleanup and the Oregon Department of Human Services (ODHS) Superfund Health Investigation and Education program (SHINE) recommended that the site be revisited by the EPA for further limited sampling. EPA, along with staff from SHINE and ODEQ and a former plant employee, recently revisited the property in August 2004 and March 2005, to begin investigating if adequate cleanup was performed in 2002. Initial samples have indicated that further cleanup is needed.

This health consultation evaluates the public health implications from potential past, present and future exposure pathways to asbestos in Libby vermiculite exfoliated at the former Vermiculite Northwest site. SHINE has prepared this consultation in cooperation with ATSDR.

Background

Site Description and History

The former Vermiculite Northwest facility (40,000 square feet) was located in a warehouse at 2302 N. Harding (latitude 45.53937 N, longitude –122.678171 W). The site is situated in an industrial area approximately two blocks south of the Fremont Bridge and two blocks northeast of the Willamette River. The site location is shown in Figure 1. The area is zoned General Industrial and is located in the Eliot Neighborhood. The property is within Portland's Interstate Corridor Urban Renewal District with Interstate Avenue situated two blocks east. Bordering former Vermiculite Northwest are warehouses and empty lots. The property to the south is an electrical substation. Directly to the east of the warehouse are railroad tracks.

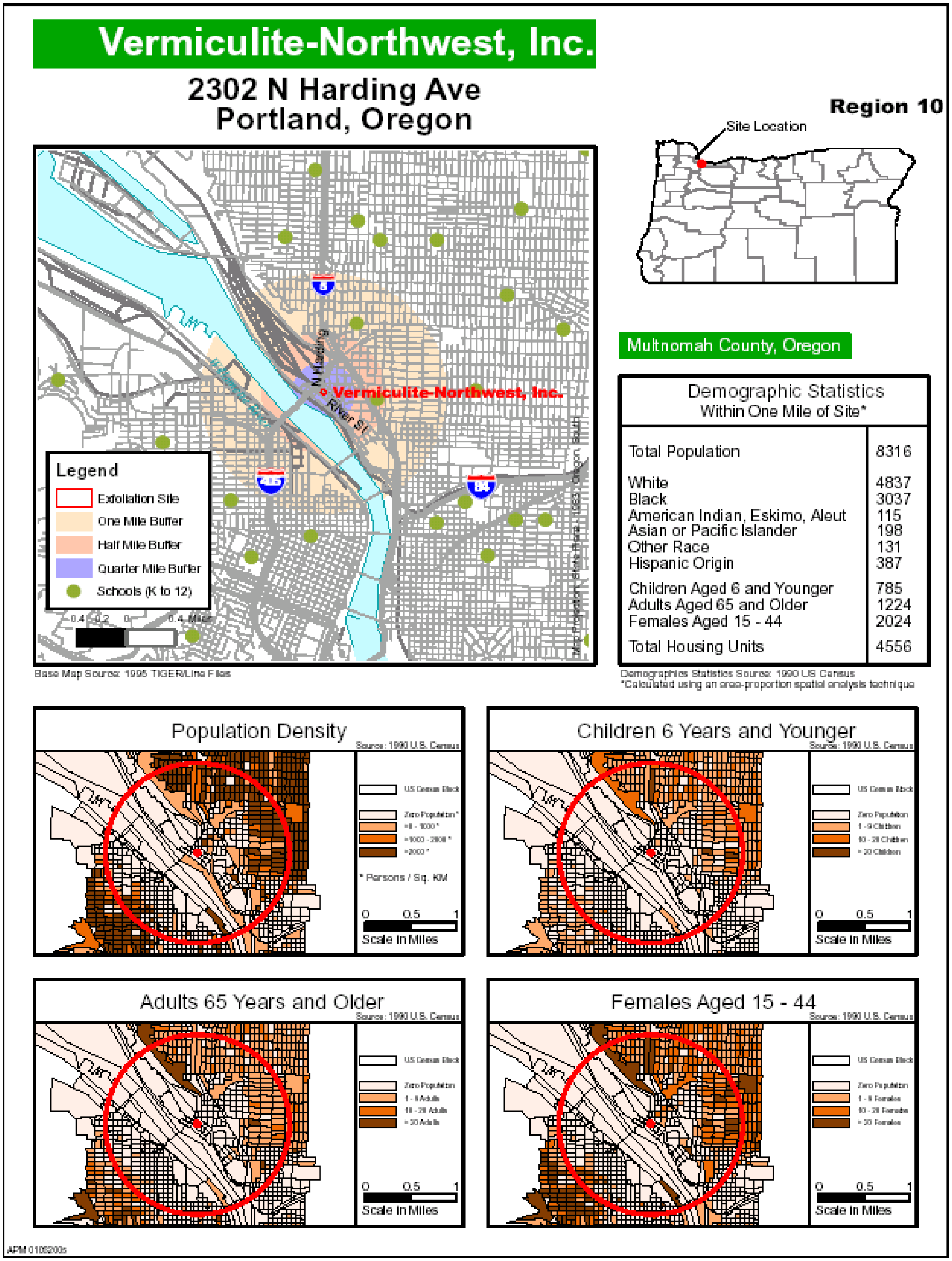
The nearest residences to former Vermiculite Northwest are walk-up apartment buildings approximately one-quarter mile northeast of the site on Mississippi Avenue and Knott Street. According to the 1990 census, there were 1078 residents who lived within 1 mile of former

Vermiculite Northwest. The two closest residential neighborhoods are approximately three-quarters of a mile north in the Overlook Neighborhood and to the east in the Eliot Neighborhood (see Figure 1). There are two elementary schools, one middle school and one high school within one mile of the property. Parks within one mile of the site include the Lillis-Albina, Dawson, Overlook, Unthank, and Denorval Parks.

Figure 1 – Former Vermiculite Northwest vicinity

The former Vermiculite Northwest facility falls within the Albina Community (a group of neighborhoods that make up inner North/Northeast Portland), designated by community leaders and two environmental organizations as an area of Portland that is disproportionately affected by environmental hazards. The Albina area has a higher percentage minority population with a lower socio-economic level than other areas of Portland. Historically, many black families moved to inner Northeast Portland after the Vanport flood destroyed that predominately black section of town in 1948 [4]. According to the 1990 census, thirty to forty percent of the population that makes up the Eliot Neighborhood has an income that is below poverty level and up to sixty percent is minority (see Figure 2). Eliot is a neighborhood in transition due to the influx of people looking to purchase a home and the change in racial/ethnic makeup over the past twenty years. Up to 60 % of housing units are renter occupied with only 34% of people having resided in the same house in 1985.

Figure 2 – Demographics



Former Vermiculite Northwest was originally incorporated as Northwest Insulations Company in 1950. It changed hands in late 1968 to become Northwest Vermiculite/W.R. Grace (Zonolite Division) and remained under W.R. Grace ownership until 1994. According to internal documents, the operations were located initially in a 10,000-foot section of the 40,000 square foot warehouse. Successive additions to plant operations resulted in extra quadrants of the plant being leased, first in 1961, then in 1976 and finally the entire building in 1980. The operations at the facility included manufacturing, packaging and storing commercial vermiculite insulation products. The facility primarily engaged in vermiculite expansion and monokote mixing operations. Vermiculite was heated at high temperatures until water inside the material expanded and the material exfoliated, or “popped.” The exfoliated material was then bagged as “Zonolite” Insulation products, and was used to insulate water heaters, as attic insulation, and packed around buried pipes. Monokote and other bagged cementious materials, that were mixed into slurry and sprayed onto substrates (steel and polyurethane foam) to fireproof them, were the other major products produced at the former Vermiculite Northwest facility, as well as limited amounts of professional soil mixtures containing expanded vermiculite for the horticultural industry.

Prior to 1982, former Vermiculite Northwest had one vermiculite-expanding furnace with the Monokote mixing station in a separate room, and two vermiculite-storage silos. At that time, the plant increased its annual vermiculite production rate from 6,000 tons to 12,000 tons with the addition of another expansion furnace. By the time the plant closed, former Vermiculite Northwest had reduced production and was receiving only about 3800 tons of vermiculite from Libby per year, and was producing over one million cubic feet of vermiculite insulation as well as 10,000 tons of Monokote product. The ore was brought to the facility by rail, and product was distributed by truck.

Former employees and visitors to the plant report poor working conditions during the years Libby vermiculite was processed at the plant. There were approximately thirteen workers employed at any one time with production weeks ranging from 16 hours/day (two shifts), six days a week to 24 hours/day (3 shifts), five days a week in a 52 week year. Jobs included vermiculite ore manager (shoveling ore into a wheelbarrow and dumping ore into a hopper that fed the furnace), expanded vermiculite bagger, Monokote mixer, Monokote bagger, fork truck driver/truck loader, hopper operator, shift leader, plant manager, and custodian. The environment inside the plant was very dusty and noisy (personal communication with former worker, internal documents). There were several points during the process where workers were exposed to dusty conditions and Grace records indicate that workers were exposed to high levels of Libby asbestos (LA) in the air at the plant (unpublished information from EPA’s database of W.R. Grace documents). This was the case even after dust suppression methods were required in response to industrial hygiene surveys citing severe and excessive dust visible in the plant. Dust control devices that were implemented in the mid and late 1970s included installation of exhaust vents on the roof and baghouses that performed a filtering function to control dust and emissions, as well as plans to manage spills of waste and product at bagging stations [5].

One visitor to the plant reported that he noticed the dust immediately after entering the plant because the bagging and hopper operations were situated near the will-call area (personal communication with vendor who regularly made deliveries to the plant). Former employees report that the conditions were unbearable, with dust compounded by heat in the summer.

Coveralls, glasses, and dust masks (3M, disposable) were available to wear, and were mandatory during times when industrial hygiene surveys found the dust measurements to be above current standards. However, repeated clogging of the masks along with discomfort made wearing them a chore. In a workman's compensation claim form from WR Grace internal records for this site, a worker states, "So I was exposed, to the tremolite in the vermiculite. I, just like every one, never wore any kind of breathing protection, except while making mono kote fire proofing. I was never told of any hazards of breathing the dust until after I had been working there for, 4 or 5, maybe 6 years. After being told of the hazards of breathing the vermiculite dust, I often wondered how safe the other materials, I had been working with, was." A former worker also recounted that the majority of workers used tobacco during work shifts, so that a mask would be a nuisance. Even when used, these masks were likely to be ineffective. At least two former employees have been diagnosed with asbestosis (EPA VNW report, unpublished data, 2000), [6].

The former Vermiculite Northwest facility annually produced up to 200 tons of waste (known as waste rock or stoner rock) from vermiculite processing. Furnaces were equipped with baghouses that performed a filtering function to control dust and emissions. After 1975, baghouse dust and waste rock were wetted down and collected in bags. According to internal memos, the bags were temporarily stored in dumpsters located inside the plant until they were returned to Libby, Montana, for disposal. Other sources indicate that the waste was disposed of at the now closed St. John's Landfill. It is unknown whether community members carried the waste rock offsite; however, a former worker reported that employees often removed the waste material (sometimes by the truckload) and applied it for personal uses. It is possible that waste rock from this facility went back to Libby, to the local landfill, or was removed by employees for personal use.

The property was sold in March of 1994 to an unrelated party. By 2000, the facility was divided into two sections and leased to two businesses (occupied by various businesses over time). Although the building had been power washed by W.R. Grace when they vacated the premises, dust from the rafters was released into the air by the vibrations caused by passing trains. The dust reportedly fell on work products and employees of the businesses. EPA was investigating a number of sites throughout the country where Libby vermiculite had been reportedly processed. As part of this investigation, EPA visited the Vermiculite Northwest/W.R. Grace plant in March 2000 and collected soil, dust, and air samples inside the former plant. Based on the sampling of dust on the exposed rafters in the building, Oregon Department of Environmental Quality (ODEQ), lead agency for site cleanup, required further cleanup. In 2002, cleanup was completed by pressure washing, removing contaminated dust, and scraping the rafters and insulation that had been sprayed on walls previously. After follow-up interior cleanup was complete, the ODEQ determined that no further cleanup actions were needed at the site [5]. However, there have been many advances in the understanding of vermiculite cleanups and fiber toxicity since the site's initial cleanup, and SHINE staff recommended that the site be revisited by the EPA for further limited sampling.

Currently, the building is leased in four sections to different businesses and groups of businesses. EPA, along with staff from SHINE and ODEQ and a former plant employee, recently revisited the property in August 2004 and March 2005, to begin investigating if adequate cleanup was performed in 2002. Initial samples have indicated that further cleanup is needed.

Libby Asbestos and Vermiculite Processing

The following section provides an overview of toxicity and health effects associated with Libby asbestos. A more detailed discussion of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques and the current regulations concerning asbestos in the environment can be found in Appendix A at the end of this document.

Vermiculite is a non-fibrous, platy weathered mica mineral type used in many commercial and consumer applications. Raw vermiculite ore is used in gypsum wallboard, cinder blocks, and many other products, and exfoliated vermiculite is used as loose fill insulation, as a fertilizer carrier, and as an aggregate for concrete. Exfoliated vermiculite is formed by heating the ore to 1000^0 -1800^0 F [7], which explosively vaporizes the water contained within the mineral structure and causes the vermiculite particles to expand from 6 to as much as 30 times their original volume.

Over time, vermiculite from Libby was found to be contaminated with several types of asbestos fibers. Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers. Asbestos minerals fall into two classes – serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Regulated amphibole minerals include crocidolite, amosite, and the fibrous forms of tremolite, actinolite, and anthophyllite [8]. Other amphibole minerals, however, including winchite, richterite, and others, can exhibit fibrous asbestiform properties. (See Appendix A for information on health effects from exposure to asbestos, analytical techniques, and regulations concerning asbestos.)

The vermiculite mined in Libby contains amphibole asbestos, with a characteristic composition that includes wichite, richterite, and tremolite as defined by Leake et al., 1997 [1],[2] [7][BA1]. In this report, the asbestiform minerals contaminating the vermiculite are referred to as “Libby asbestos” (LA). The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite (from #0, or coarse, to #5, fine) that were then shipped by rail to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products. Some studies have suggested that the different ore grades may have had varying asbestos contents, with finer-sized grades having higher contamination [8, 9]. Additional studies suggest that the tremolite content ranged from 0.3% to 7% in the various grades of ore [10, 11].

Vermiculite Processing at W.R. Grace/Vermiculite Northwest

Vermiculite was exfoliated at Vermiculite Northwest/W.R.Grace from the early 1950s until the plant closed in 1993. The Libby vermiculite that was shipped to the site was grade #0, #1, #2, #3, and #4. Products made at this site included, Monokote, Zonolite insulation, acoustical plaster,

1 Meeker G, Bern A, Brownfield I, Lowers H, Sutley S, Hoefen T, et al. The composition and morphology of amphiboles from the Rainy Creek complex, near Libby, Montana. Amer Mineral. Nov-Dec 2003;88 (11-12):1955-69.
2 Leake B, Woolley A, Arps D, Birch W, Gilbert M, Grice J, et al. Nomenclature of the amphiboles: report of the subcommittee on amphiboles of the International Mineralogical Association, Commission on New Minerals and Mineral Names. Amer Mineral. 1997;82:1019-37.

and soil amendments, including Terra-Lite, and Redi-Earth. The VNW plant had two primary manufacturing processes. The facility and manufacturing processes were described in company records below. It should be noted that this describes facility processes in 1988, and that prior to the 1970s baghouses and other dust control devices were not installed, resulting in an increased risk of exposures for workers and community members before 1975.

Vermiculite concentrate is stored in three different grades: coarse (#2), medium (#3), and fine (#4). The approximately 96 ton (net) rail hopper cars are mechanically unloaded into two 200 ton, [and] one 25 ton storage silos located in the west section of the property. From the storage silo the vermiculite concentrate is mechanically conveyed to one of two vermiculite expanding furnaces for processing.

The vermiculite expansion furnaces are fired by natural gas heat. The vermiculite concentrate is heated to a desired temperature (1000-1800 F) at which point it exfoliates (expands). The vermiculite then passed on to a shaker separator, which separates the expanded vermiculite from the waste rock present in the concentrate. The expanded vermiculite is dampened with water at specific addition rates and bagged in 4 to six cubic feet bags for sale. Occasionally the vermiculite has different raw materials added or applied to alter the vermiculite's performance for specific end uses.

Each of the vermiculite expansion furnaces is equipped with a Micro-Pul baghouse with an 845 sq. ft. filtering capacity for dust and emission control purposes.

The baghouse dust and vermiculite concentrate waste rock are wetted and placed in double lined bags. These bags are then deposited in the dumpsters for disposal at Libby, Montana, a W.R. Grace facility and point of origin.

In addition to the vermiculite expansion process, this facility also has a batch mixing process which is performed by a ribbon Blender. This mixing process manufactures both fireproofing material for the construction industry and professional soil mixes for the horticultural industry.

The blender is equipped with a Micro-Pul baghouse with a 900 sq. ft. filtering capacity for dust and emission control purposes. The baghouse dust from the mixing process is dampened and poly bagged before placement into the dumpsters.

The south central side of the facility has an enclosed masonry shredding room for polystyrene board, a product incorporated in our mix. It is shredded and transferred by blower to the mixer.

The manufacturing/warehouse building is a sprinkled wood and concrete construction building.

Warehousing of the raw materials and finished goods occurs inside the plant building. All waste dumpsters are located inside the plant building on the north/west corner of the property.

The plant operation varies from one to three shifts with between six and eight production employees on each shift.

Climate

Portland, Oregon, has a relatively mild climate with an average temperature of 66 in the summer and 38 in the winter. Portland's average annual rainfall is 37 inches per year, with nearly 90% of rainfall occurring from October through May [12]. Precipitation is predominantly rain, with an average of only five days of measurable snow per year. Winds in the Portland area are primarily from the northwest and the south.

Emissions Data

Records from the Oregon DEQ indicate that W.R. Grace was granted an expansion of the plant's emissions limitations in 1982 when a second furnace was installed which increased the plant's production capacity from 6,000 to 12,000 tons of vermiculite annually. In 1983 similar review documentation of the plant indicates that the air particulate emissions were 2.51 tons/year and were in compliance with DEQ's emissions limitations. Compliance was similarly noted in a 1990 review report.

A preliminary analysis of emissions for the time the facility was in operation, indicate that several factors contributed to the unlikelihood that fibers would move toward residences. The wind direction, a significant change in elevation and the nature of fugitive emissions acted together to concentrate emissions closer to the source along the general pathway of the river, and generally in the industrial area bordering the plant (Phil Allen, Oregon Department of Environmental Quality, personal communication, 2005, [13]) (See Appendix B for more information.).

Emissions Devices

The Oregon DEQ records indicate three emissions contaminant sources at the Harding Street plant, including two vermiculite exfoliation furnaces, each with baghouses installed after 1975. The third source was the Monokote mixer, with a baghouse installed in 1978.

Permits

Records obtained from the Oregon DEQ document permits recorded for the years 1975, 1978, 1982, 1983 and 1993. These records indicate that DEQ was monitoring the production capacity of the plant as well as emissions. There is no indication that the plant exceeded emission limitations. However, emission limitations at the time focused on visible particles of dust and particulates rather than microscopic fibers, and these same emissions today may not be considered safe.

Discussion

Vermiculite processed at former Vermiculite Northwest originated from the mine in Libby, Montana, known to be contaminated with asbestos. Studies conducted in the Libby community indicate health impacts that are associated with asbestos exposure [14, 15]. The findings at Libby provided the impetus for investigating this site, as well as other sites across the nation that received asbestos-contaminated vermiculite from the Libby mine. It is important to recognize, however, that the asbestos exposures documented in the Libby community are in many ways unique and will not collectively be present at other sites that processed or handled Libby vermiculite. The site investigation at Vermiculite Northwest is part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these other sites. This site is being investigated further because of the large volume of Libby vermiculite ore processed here and because the process used here — exfoliation — can release more asbestos fibers than other types of processing [7].

ODHS/ATSDR Site Visits

ODHS and ATDSR staff first visited the site in March 2001 after abatement had been completed. [16]. Kevin McCrann, ODEQ, conducted a walk-through of the site and identified areas formerly used for the processing and storage of vermiculite. Mr. McCrann presented details of the clean up conducted under ODEQ oversight subsequent to the collection of the dust and soil samples in 2000 (see below). In August of 2002 ODHS/ATSDR conducted a second walk-through of the former exfoliation facility and observed the areas immediately adjacent to the facility. The following observations were made:

- No vermiculite was observed in areas immediately around the site. No dust or visible contamination was observed inside the buildings.
- The buildings were occupied by a number of small businesses.
- The area immediately around the site is light industrial.
- There were no residences observed close to the site. The nearest residences observed approximately one-quarter of a mile away, appeared to be relatively new.

In August 2004, representatives of OR-OSHA, ODEQ, EPA and DHS, as well as a former worker visited the site to begin the process of drawing up a second bulk-sampling plan in response to SHINE's request for further limited sampling. Representatives heard accounts of historic work conditions at the facility and identified mica-like flakes in the soil on the property facing Loring Street, which appeared to be vermiculite remnants.

In January and March 2005, SHINE staff joined EPA staff in site visits to identify locations for passive and activity-based sampling.

Environmental Investigation

EPA staff visited the site on March 2, 2000. Staff observed vermiculite sparkles on the soil surface at the rear of the building [17]. Samples were taken of dust collected from rafters inside the southwest and northwest sections of the building that contained 1.4% asbestos (actinolite, tremolite). Since 2002, EPA has detected winchite, richterite, and tremolite, which are consistent with Libby asbestos. There was 0.6% asbestos (actinolite and tremolite) in between framing on an inside wall. Insulation in one area contained 2.1% asbestos (chrysotile, actinolite). Approximately 20 bags of Zonolite vermiculite were discovered in the crawlspace in the west side of the building. Multiple samples from bag contents and soil were negative for asbestos. However, one sample had a trace of tremolite asbestos. Abatement was recommended and completed by a W.R. Grace contractor under the oversight of ODEQ. Three additional areas were sampled during the abatement and analyzed by R.J.Lee Laboratory, which was later determined to be a long-term contract lab for W.R. Grace. Based on the samples provided by

W.R. Grace and an asbestos abatement clearance inspection in February 2001, ODEQ staff recommended no further action [3].

Exposure Assessment and Toxicological Evaluation

Evaluating the health effects of exposure to Libby asbestos requires extensive knowledge of both exposure pathways and toxicity data. The toxicological information currently available is limited, and therefore, the exact level of health concern for different sizes and types of asbestos remains controversial. Site-specific exposure pathway information is also limited or unavailable.

- There is limited information on past concentrations of Libby asbestos in air in and around the plant. Also, as described in the preceding section, significant uncertainties and conflicts in the methods used to analyze asbestos exist. This makes it hard to estimate the levels of Libby asbestos to which people were exposed.
- There is not enough information known about how people came in contact with the Libby asbestos from the plant, and how often. This information is necessary to estimate quantitative exposure doses.
- There is little information available about how some vermiculite materials, such as waste rock, were handled or disposed. This makes it difficult to identify and assess both past and present potential exposures.

Given these difficulties, the public health implications of past operations at this site are evaluated qualitatively. Current health implications are also evaluated qualitatively. The following sections describe the various types of evidence we used to evaluate exposure pathways and reach conclusions about the former Vermiculite Northwest site.

Occupational Exposure

There were several points during the process where workers were potentially exposed to dusty conditions, including unloading of the vermiculite from rail cars, use of the forklift and hopper to transfer the materials, bagging of the exfoliated product. Emissions from the vermiculite furnace, dust from processes, and weather conditions affecting air also contributed to worker exposure.

Workers were protected by the use of cotton disposable masks, but adherence to the use of protective facemasks was inconsistent. There is no data available to evaluate additional factors that influence the effectiveness of respiratory equipment, including proper selection of equipment and fit testing the mask to the individual worker. Although there is documentation that workers were trained in the proper use of respirators during later periods of operation (W.R. Grace internal documents), workers often neglected to wear protective masks when the weather was especially hot. In addition, many workers smoked while in the plant, and the masks were inconvenient for smokers. There were showers in the building but there were no changing areas with lockers available to the workers, so workers wore their work clothes home at the end of the day. OR-OSHA (Oregon Occupational Safety and Health Administration) made multiple inspections during the years that vermiculite was processed, and a number of fines were levied due to poor ventilation, high levels of dust, and excessive noise. In addition, there is evidence from industrial hygiene surveys that personal samples exceeded the dust standard of 10 mg/m^3

and 8-hour time weighted averages of air samples indicated up to 14.274 fibers per cubic centimeter (f/cc) of air (assumed to be Libby asbestos or chrysotile asbestos).

Community Exposure

It is possible that people who did not work in the plant may have been exposed to asbestos fibers. These exposures include possible inhalation of fibers brought home on workers' clothing, or if waste piles were disturbed by children or adults. Nearby neighbors were also at risk of inhalation exposure from stack emissions and fugitive dust released into the air from the plant, although initial modeling performed by the Oregon DEQ indicate that conditions likely kept fibers from traveling to neighborhoods (see Appendix B). Former workers have indicated that waste material may have been brought to homes for gardening, paving driveways, and as fill material in residential yards or driveways. This use of waste materials placed community members at risk for exposure due to inhalations of the dust associated with these materials.

Exposure Pathway Analysis

An exposure pathway describes how a person comes in contact with contaminants originating from a source. Every 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 can move; (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 (people who can come into contact with the contaminant at the point of exposure).

An exposure pathway is considered **complete** if all five elements are present and link the contaminant source to the receptor population. A pathway is considered **potentially complete** if it is currently missing one or more of the pathway elements, but the element(s) could easily be present at some point in time. A pathway is also considered potentially complete if insufficient information is available to eliminate or exclude the pathway. An **incomplete** pathway is missing one or more of the pathway elements and it is likely that the elements were never present and not likely to be present at a later point in time. An **eliminated** pathway was a potential or completed pathway in the past, but has had one or more of the pathway elements removed to prevent present and future exposures.

After reviewing information from Libby, Montana, and from facilities that processed vermiculite ore from Libby, a list of possible exposure pathways for vermiculite processing facilities was developed. All pathways have a common source (vermiculite from Libby contaminated with Libby asbestos) and a common route of exposure (inhalation). Although asbestos ingestion and dermal exposure pathways could exist, health risks from these pathways are small in comparison to those resulting from inhalation exposure to asbestos and will not be evaluated in this health consultation.

The exposure pathways considered for every site that formerly processed Libby vermiculite are listed in Table 1A. Not every pathway identified will be a significant source of exposure for a particular site. An evaluation of the pathways for the former Vermiculite Northwest site is presented in Table 1B, and the significance of the pathways are discussed in the text below the table.

Table 1A - Summary of Inhalation Pathways Considered for Vermiculite Processing Facilities Nationwide

Pathway Name	Exposure Scenario(s)	Past Pathway Status	Present Pathway Status	Future Pathway Status
Occupational	Former workers exposed to airborne Libby asbestos during handling and processing of contaminated vermiculite	*Complete*	*Not applicable*	*Not applicable*
	Current workers exposed to airborne Libby asbestos from residual contamination inside former processing buildings	*Not applicable*	*Potential*	*Potential*
Household Contact	Household contacts exposed to airborne Libby asbestos brought home on workers' clothing	*Complete*	*Potential*	*Potential*
Waste Piles	Community members (particularly children) playing in or otherwise disturbing onsite piles of contaminated vermiculite or waste rock	*Potential*	*Eliminated*	*Eliminated*
Onsite Soils	Current onsite workers, contractors, or community members disturbing contaminated onsite soils (residual contamination, buried waste)	*Potential*	*Potential*	*Potential*
Ambient Air	Community members or nearby workers exposed to airborne fibers from plant emissions during handling and processing of contaminated vermiculite	*Potential*	*Eliminated*	*Eliminated*
Residential Outdoor	Community members using contaminated vermiculite or waste material at home (for gardening, paving driveways, fill material)	*Potential*	*Potential*	*Potential*
Residential Indoor	Community members disturbing household dust containing Libby asbestos fibers from plant emissions, workers' clothing, or residential outdoor waste	*Potential*	*Potential*	*Potential*
Consumer Products	Community members, contractors, and repairmen disturbing consumer products containing contaminated vermiculite	*Potential*	*Potential*	*Potential*

Table 1B. Pathways of exposure identified and evaluated at the Vermiculite NW Site

Pathway Name	Exposure Scenario(s)	Point of exposure	Route of exposure	Exposure population	Time
Occupational	Suspension of LA fibers into air during transport, handling, or processing or vermiculite	*Onsite, nearby businesses*	*Inhalation*	*Workers*	*Past*
	Suspension of LA from residual contamination inside former processing buildings	*Onsite*	*Inhalation*	*Workers*	*Present, future*
Household Contact	Suspension of LA brought home on workers' clothing	*Worker's homes*	*Inhalation*	*Former or current workers' families*	*Past, present, future*
Waste Piles	Suspension of LA into air by playing in or disturbing onsite piles of vermiculite or waste rock	*Onsite*	*Inhalation*	*Community members/children*	*Past*
Onsite Soils	Current onsite workers, contractors disturbing contaminated onsite soils (residual contamination, buried waste)	*Onsite*	*Inhalation*	*Workers*	*Past, present, future*
Ambient Air	Stack emissions and fugitive dust from plant operations into air	*Nearby neighborhood*	*Inhalation*	*Community members, nearby workers*	*Past*
Residential Outdoor	Suspension of LA from vermiculite or waste material brought to homes for gardening, paving driveways, fill material	*Residential yards or driveways*	*Inhalation*	*Community Members*	*Past, present, future*
Residential Indoor	Suspension of household dust containing LA fibers from residential outdoor waste	*Residences*	*Inhalation*	*Community members*	*Past, present, future*

Occupational (past and present) –Limited data are available on the levels of LA in the air at the plant during the years Libby vermiculite was exfoliated at the site. From 1967 through 1991, Vermiculite Northwest/W.R. Grace received shipments of 193,112.78 tons (386,225,563 lbs) of Libby vermiculite (unpublished information from EPA's database of W.R. Grace invoices) that were exfoliated at the site. Workers were potentially exposed to LA during the various stages of vermiculite processing, including the unloading of vermiculite from rail cars, during transfer of vermiculite to the furnace, and during the bagging of exfoliated material. Pollution control equipment and dust suppression measures varied over time, being minimal until later in the history of the facility (1970s and 1980s), although they complied with the pollution control requirements at the time. Review of air monitoring data collected for industrial hygiene studies during the late 1970's, reveals that fibers were present at levels often exceeding both the current occupational exposure standard and the less restrictive occupational standard that existed at the time. Data from plant productions in 1950s and 1960s, when dust controls were likely minimal, is not available. The past occupational exposure pathway is a complete pathway and is the most significant exposure pathway at Vermiculite Northwest. This pathway is considered a *past public health hazard*.

Workers employed in businesses renting the remainder of the facility during the years W.R. Grace occupied a portion of the building may have been exposed to asbestos. Facility operations in one part of the building would likely ensure that fibers were present in other parts of the building. Not enough information is available to determine the extent of exposure for this group of workers. Exposure to contaminated dust at the site for workers in collocated businesses from 1950 to 1980 is an *indeterminate public health hazard*.

Workers employed in businesses occupying the facility subsequent to its sale by W.R. Grace may have been exposed to asbestos. EPA and ODEQ conducted an investigation in April 2000 and found asbestos to be present in soil and dust samples at the facility. These results prompted an investigation by Oregon OSHA, which determined that employees of businesses located in the building after Vermiculite Northwest vacated the premises might have been exposed to asbestos fibers remaining in the building. Although the exposure would have been much less than for the vermiculite processing workers, the actual level of exposure is unknown. Exposure to contaminated dust at the site from 1994 to present is considered an *indeterminate public health hazard* for workers.

Household contact (past, present, future) – Household contacts and family members may have been exposed to Libby asbestos brought home on the clothing and hair of those who worked at the plant. Vermiculite processing is known to be dusty, and in the 1950s, 1960s, and much of the 1970s, there was no filtering system in place. According to former workers, disposable suits were not worn, and workers did not shower or change clothes before going home. Later, industrial hygiene practices improved in the industry, and systems were added to control dust. Family or other household contacts may have come in contact with LA by direct contact with the worker, by laundering clothing, or by the re-suspension of dust during household activities. Exposures to household contacts cannot be estimated without information concerning LA levels on worker clothing and specific clothing handling and laundering practices. Past exposure to household contacts is considered a complete exposure pathway and a past public health hazard. During 2000, the former processing facility was cleaned under the supervision of ODEQ. According to the asbestos abatement clearance inspection from 2000, the cleanup was thought to reduce and potentially eliminate contaminated dust inside the building. Since then, EPA sampling has detected the presence of fibers consistent with Libby asbestos at the facility suggesting that further cleanup is warranted.

Waste piles (past and present) – Information on waste materials is limited, but materials from the baghouses may have been taken to a local landfill. W.R. Grace documents indicate the waste (stoner rock) was disposed of at the Libby mine. If any vermiculite waste has been disposed of on-site, the exposure pathway would be complete only if soil is disturbed. It is not known for sure if nearby workers or residents had access to waste piles or whether they took materials home to use as garden amendments or for use in paving driveways; however, former workers indicate that waste rock was taken off site for personal use. Past and present exposure to waste materials is a potential pathway of exposure. This pathway is considered an *indeterminate public health hazard*.

Onsite soil (past, present, future) – EPA sampling at another facility in the northwest in April 2000 found 1.2% LA contamination in the soil near the railroad unloading area and traces in three additional soil samples at the rear of the building. It has been shown that disturbing soils with even trace amounts of LA can result in levels of inhalable LA of concern [18, 19]. Generally, however exposures to LA-contaminated soil were of short duration and were much less likely to lead to health effects than long-term, high-level exposures that may have been experienced by workers during vermiculite processing at the plant. Recently EPA collected air and soil samples at Vermiculite Northwest (Portland site) and these are being analyzed for the presence of asbestos. Results of the investigation are pending and will be evaluated by SHINE in a future health consultation. Onsite soil is considered a potential exposure pathway and is an *indeterminate public health hazard*.

Ambient air (past) – Workers at neighboring industrial sites and community members could have been exposed in the past to LA fibers released into the ambient air from fugitive dusts or the furnace while the plant was processing Libby vermiculite. Little information is available, however, concerning emissions from

the plant during many of the years Libby vermiculite was exfoliated at the site, so no estimate of risk from these exposures can be made. An air dispersion model used to estimate past emissions from a vermiculite processing plant in Minnesota suggested that areas very close (within one block) to an expansion plant could have had elevated fiber levels, but the levels were predicted to drop off rapidly as distance increased [20]. Site-specific emissions characteristics and meteorological conditions could affect results greatly however. SHINE approached ODEQ about the possibility of initial site-specific modeling. ODEQ staff provided an initial study that models relative concentrations as a means to begin to evaluate patterns of dust dispersion. Available wind rose data from the Federal Building, located across the Willamette River from Vermiculite NW, shows winds predominately aligned along the river from the NW, and less frequently from the south. The pattern of modeled concentrations indicates that emissions would likely be confined to industrial areas surrounding the facility and would not extend into residential areas [13]. Workers, particularly those who worked outdoors to the northwest, northeast, and southeast of the site may, however, have been exposed to LA. Due to the lack of adequate emission data, no estimate of risks can be made for this past exposure pathway. Exposures to Libby asbestos fibers from ambient air emissions were eliminated in 1994 when the facility closed. This pathway is considered an *indeterminate public health hazard*.

Residential outdoor and indoor (past, present, future) - There is no information on past levels of contamination in ambient air. However air dispersion models indicate that it is unlikely that past ambient air emissions would have been high enough to infiltrate significantly into residential areas. Some vermiculite-processing facilities in the United States allowed or encouraged workers and the nearby community residents to take stoner (waste) rock, vermiculite, or other process materials for personal use [21]. Workers and community members hauled LA contaminated materials away from sites, for use in driveways and gardens in residential areas. If waste material and vermiculite were removed from Vermiculite NW, community members could have been exposed to LA fibers in the past when they disturbed vermiculite used as a soil amendment or drove over driveways graveled with waste rock. Similarly, exposure could continue in the present and in the future. Some workers have reported that vermiculite or waste material was used at homes of workers and within the community.

In homes of former workers, it is possible that dust could be contaminated with LA fibers brought home on clothing. Housekeeping (particularly wet cleaning methods) over the years may remove residual fibers, but no information is available to further evaluate this pathway. This pathway is an *indeterminate public health hazard*.

Consumer products – People who purchased and used company products that contain Libby vermiculite may have been exposed to asbestos fibers from using those products in and around their homes. At this time, determining the public health implication of commercial or consumer use of company products (such as home insulation or vermiculite gardening products) that contain Libby vermiculite is beyond the scope of this evaluation. However, studies have shown that disturbing or using these products can result in airborne fiber levels higher than occupational safety limits [18, 19]. Additional information concerning products that contain Libby vermiculite has been developed by EPA, ATSDR, and NIOSH and provided to the public (see www.epa.gov/asbestos/insulation.html).

Contaminated vermiculite insulation in homes and in soil could pose an inhalation hazard if it is disturbed. Exposure to asbestos in vermiculite insulation in an uninhabited attic or behind walls should be negligible. Exposure to asbestos in soil is less likely if the soil is covered by asphalt, concrete, or vegetation. Asbestos fibers do not break down in the environment, and asbestos in soil, may remain for decades [8].

Asbestos Health Effects and Toxicity

When asbestos fibers are breathed in, they may get trapped in the lungs. In general, health risks increase with longer exposure and exposure to greater amounts of asbestos. Short-term high-level or chronic low-level asbestos inhalation exposures have been associated with lung cancer, mesothelioma, and pleural disorders [8]. Breathing any type of asbestos increases the risk of the following health effects.

Malignant mesothelioma is a cancer of the membrane (pleura) that surrounds the lungs and lines the chest cavity. The great majority of mesothelioma cases are attributable to asbestos exposure [8]. An estimated 1,500 cases of mesothelioma per year occur in the United States (compared with an average of 130,000 cases of lung cancer per year). Latency periods for mesothelioma due to asbestos exposure are generally 20 to 30 years or more.

Lung cancer is a cancer of the lung tissue, also known as bronchogenic carcinoma. The exact mechanism relating asbestos exposure with lung cancer is not completely understood. The combination of tobacco smoking and asbestos exposure greatly increases the risk of developing lung cancer [8]. Latency periods are generally 10 to 30 years or more for lung cancer.

Non-cancer effects of asbestos exposure include asbestosis, scarring and reduced lung function caused by asbestos fibers lodged in the lung; pleural plaques, localized or diffuse areas of thickening of the pleura; pleural thickening, extensive thickening of the pleura which may restrict breathing; pleural calcification, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and pleural effusions, fluid buildup in the pleural space between the lungs and the chest cavity [8]. Either heavy exposure for a short time [22] or lower exposure over a longer period may result in asbestosis [8]. Latency periods for the development of asbestos-related nonmalignant respiratory effects are usually 15-40 years from the time of initial exposure to asbestos.

There is not enough evidence to conclude whether inhalation of asbestos increases the risk of cancers at sites other than the lungs, pleura, and abdominal cavity [8].

Ingestion of asbestos causes little or no risk of non-cancer effects. There is some evidence, however, that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors [8].

Skin nodules (corns) from handling asbestos-containing materials can also occur [23].

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of sites that received Libby vermiculite. Exposure scenarios that are protective of the inhalation route of exposure should be protective of dermal and oral exposures.

There is general acceptance in the scientific community that fiber length as well as fiber mineralogy influence asbestos toxicity. Fiber length may play an important role in clearance and mineralogy may affect both biopersistence and surface chemistry.

ATSDR, responding to concerns about asbestos fiber toxicity from the World Trade Center Disaster, held an expert panel meeting to review fiber size and its role in fiber toxicity in December 2002 [24]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5µm (1µm is about 1/25,000 of an inch) are essentially non-toxic when considering a role in mesothelioma or lung cancer promotion. However, fibers less than 5 µm in length may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively make this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly due to physical characteristics that allow chrysotile to be broken down and cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [25]. Some researchers believe the resulting increased duration of exposure to amphibole asbestos significantly increases the risk of mesothelioma and, to a lesser extent, asbestosis and lung cancer [25]. OSHA, however, continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [26]. EPA's Integrated Risk Information System (IRIS) assessment of asbestos also treats mineralogy (and fiber length) as equipotent [27].

Evidence suggesting that the different types of asbestos fibers vary in carcinogenic potency and site specificity is limited by the lack of information on fiber exposure by mineral type. Other data indicate that differences in fiber size distribution and other process differences can contribute at least as much to the observed variation in risk as does the fiber type itself [25].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects, as fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to preferentially deposit in the deep lung, but longer fibers might disproportionately increase the risk of mesothelioma [8,28]. Some of the unregulated amphibole minerals, such as the winchite present in Libby asbestos, can exhibit asbestiform characteristics and contribute to risk. Fiber diameters greater than 2-5 µm are considered above the upper limit of respirability (that is, too large to inhale) and do not contribute significantly to risk. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [28].

Health Effects Evaluation

Exposure to asbestos does not necessarily mean an individual will get sick. The frequency, duration, and intensity of the exposure, along with personal risk factors such as smoking, history of lung disease, and genetic susceptibility determine the actual risk for an individual. The mineralogy and size of the asbestos fibers involved in the exposure are also important in determining the likelihood and the nature of potential health impacts. Because of existing data gaps and limitations in the science related to the type of asbestos at these sites, the risk of current or future health impacts for exposed populations is difficult to quantify.

Quantifying the risk of health effects from exposure to LA is difficult for several reasons. First is the limited information on past concentrations of LA in air in and around the plant and appropriate exposure assumptions to make for activities that happened long ago. Even if this information was available, there are significant uncertainties and conflicts in the methods used to analyze asbestos, especially in the past. Finally, the exact level of health concern for different sizes and types of asbestos is controversial due to limitations in toxicological information currently available.

Health Outcome Data

Health outcome data can give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (e.g., the number of people dying from a certain disease) or morbidity information (e.g., the number of people in an area getting a certain disease or

illness). In Libby, Montana, the number of recorded deaths related to asbestos was significantly elevated (as compared with the state or the nation as a whole) especially among former workers of the vermiculite mine and their household contacts [14]. Former workers and their household contacts also showed higher rates of pleural abnormalities, indicating higher exposure and a higher risk for developing asbestos-related disease [29].

As a separate project, the ATSDR Division of Health Studies, in cooperation with state partners, is conducting an ongoing effort to gather health outcome data at selected former vermiculite facilities. The Oregon DHS Superfund Health Investigation & Education program is currently working with ATSDR to compile available mortality and morbidity information in the vicinity of the two facilities in Oregon that processed Libby vermiculite (Vermiculite Northwest and Supreme Perlite in north Portland). As the population in the immediate vicinity of the (former) Vermiculite Northwest site is small, elevated health effects from exposure to vermiculite may be statistically difficult to determine. ATSDR will release the findings of the health statistics reviews in a separate summary report.

Children's Health Considerations

ODHS and ATSDR recognize that infants and children might be more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, ODHS and ATSDR are committed to evaluating their special interests at the site. The effects of asbestos on children are thought to be similar to adults, however children could be especially vulnerable to asbestos exposures due to the following factors:

- Children are more likely to disturb fiber-laden soils or indoor dust while playing.
- Children are closer to the ground and thus more likely to breathe contaminated soils or dust.
- Children are more at risk than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease.

The most at-risk children (many who are now adults) are those who were household contacts of workers during the years when the plant was exfoliating Libby vermiculite. Baghouse dust and waste rock was reportedly not stored out of doors nor was there outside storage of vermiculite ore during the years vermiculite was processed at the site. There is no known current exposure to vermiculite that could pose a public health hazard for children.

Summary

During the DEQ investigation and cleanup of the Vermiculite Northwest site, bags of Zonolite insulation found by DEQ staff in a crawlspace during a site visit were removed. Portions of the inside of the building were pressure-washed and some rafters were scraped. The building was cleared in April of 2001. Subsequently, a second former W.R. Grace facility in Spokane, WA was investigated. After reviewing information about both the former facilities, SHINE recommended that a follow up investigation be conducted at the former Portland facility. SHINE recommended that soil samples be collected in the area along the rail line where vermiculite was unloaded, and that indoor dust samples be taken to ensure a thorough cleanup was accomplished in 2000. As a result, EPA is currently completing a second investigation at the Vermiculite NW Portland site. SHINE staff will review new data as it is released.

SHINE and ATSDR staffs are conducting a health statistics review of the area in the immediate vicinity of the Former Vermiculite Northwest site. Health statistics reviews are statistical analyses of existing health outcome data (e.g., cancer registry data and death certificate data) on populations near selected sites of concern to determine if an excess of disease(s) has occurred.

SHINE is reviewing available electronic data, which includes mortality data and cancer incidence data from 1979 through 1998.

Conclusions

Based on the data reviewed for Vermiculite Northwest and similar sites, ODHS/SHINE concludes the following:

- Workers employed at Vermiculite Northwest were exposed to hazardous levels of Libby asbestos as a result of working in and around the facility during unloading and exfoliation of Libby vermiculite. These exposures represent a *past public health hazard*.
- Household contacts of former workers were also likely to have been exposed to Libby asbestos brought home on clothing and hair of workers. These exposures represent a *past public health hazard*.
- Workers employed in businesses renting the remainder of the facility during the years W.R. Grace occupied a portion of the building may have been exposed to asbestos. Not enough information is available to determine the extent of exposure for this group of workers. Exposure to contaminated dust at the site for workers in collocated businesses from 1950 to 1980 is an *indeterminate public health hazard*.
- Workers employed in businesses occupying the facility subsequent to its sale by WR. Grace, may have been exposed to asbestos. Although the exposure would have been much less than for the vermiculite processing workers, the actual level of exposure is unknown. Current EPA sampling has detected the presence of fibers consistent with Libby asbestos at the facility suggesting that further cleanup is warranted. Exposure to contaminated dust at the site from 1994 to present is considered an *indeterminate public health hazard* for workers.
- Exposure to soil at the railroad tracks east of the building where vermiculite was unloaded cannot be evaluated until data on asbestos content in the soil is available. Potential exposure to soil in this area is considered an *indeterminate public health hazard*.
- There is not enough information to determine the extent of past exposure to Libby asbestos from air emissions from the plant. Past exposures of nearby residents and workers employed at adjacent businesses to airborne asbestos is an *indeterminate public health hazard*.
- Anecdotal information indicates that some waste rock may have been used off-site. Exposure to asbestos from waste rock is an *indeterminate public hazard* because information about potential exposures is lacking.

Recommendations

- Promote awareness of past asbestos exposures among former workers and workers of businesses that were collocated, members of their households, and local health care providers.

- Until sampling and cleanup (if indicated) are completed at the former rail spur at the rear of the building, actions such as restricting soil disturbance, covering the area, or keeping the area wet, should be taken to reduce potential exposure.
- Review additional information about this site and similar sites, if it becomes available, and utilize any new information to evaluate indeterminate exposure pathways.
- Provide educational materials and references upon request to community members who have concerns about vermiculite exposure.
- Investigate the site identified in this investigation where waste rock may have been used and may be accessible to community members.
- Work with the correct state or federal authority and the City of Portland Office of Planning and Development to explore permit restrictions to ensure adequate controls are in place to protect workers from asbestos exposure during excavation or disturbance of onsite soils. SHINE will determine if it is appropriate to work with an environmental state or federal authority to file a public notice to be attached to the records for this property.

Public Health Action Plan

The Public Health Action Plan for Vermiculite Northwest contains a description of actions that have been or will be taken by ATSDR, SHINE, and/or other government agencies at the site. The purpose of the Public Health Action Plan is to ensure that, in addition to identifying public health hazards, a plan of action is provided that is designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR to follow up on this plan to ensure its implementation.

Actions Completed

- EPA conducted collected environmental samples at the site in March 2000.
- ATSDR, EPA, DEQ, and ODHS staff conducted a site visit in March 2001. ATSDR and ODHS staff conducted a site visit in August 2002, and ODHS staff visited the site again in September 2003 and August 2004.
- ODEQ-led investigation and cleanup was completed in April 2001.
- EPA collected additional soil and dust samples in August 2004 and March 2005.
- Vermiculite attic insulation fact sheets have been developed by ATSDR, NIOSH, and EPA and are available at www.epa.gov/asbestos/insulation.html.
- SHINE created a fact sheet with site-specific information for the former Vermiculite Northwest facility. (See Appendix D).

Actions Ongoing

- ATSDR will combine the findings from this health consultation with findings from other sites nationwide that received Libby vermiculite to create a comprehensive report outlining overall conclusions and strategies for addressing public health implications.

- ATSDR staff is researching unpublished information within the EPA database of W.R. Grace documents (estimated 3 million pages of information relating to Libby, Montana, and other nationwide vermiculite processing sites).
- SHINE and ATSDR staff is conducting a health statistics review of the area in the immediate vicinity to (Former) Vermiculite Northwest site. ATSDR will publish annual reports summarizing result of health statistics reviews for the vermiculite processing sites.

Actions Planned

- SHINE staff will review additional soil and dust data from EPA's follow up investigation when the data becomes available.
- ATSDR, in cooperation with SHINE and other state partners and federal agencies, is researching and determining the feasibility of conducting worker and household contact follow-up activities.
- SHINE will work with EPA to evaluate a site identified by SHINE that may contain waste rock.
- SHINE will provide educational materials and site-specific information upon request to former workers, their families and other household members; and those who lived or worked near the former Vermiculite Northwest site who may have concerns or questions about vermiculite exposure.
- SHINE will work with the correct state or federal authority and the City of Portland Office of Planning and Development to arrange permit restrictions to ensure adequate controls are in place to protect workers from asbestos exposure.
- SHINE will determine if it is appropriate to work with an environmental state or federal authority to file a public notice to be attached to the records for this property.
- SHINE will work with EPA to develop a plan to evaluate potential exposure and sample issues at sites that may contain waste rock according to anecdotal information uncovered by SHINE.
- SHINE will publicize the findings of this health consultation within the community surrounding the site; SHINE will make the report accessible on the Internet and in the community.

Site Team

Author of Report
Amanda Guay, MPH
Karen L. Larson, PhD
Jae Douglas, PhD MSW
Janice Davin Panichello[3], MPA

3 Ms. Panichello is not longer with the Oregon Department of Human Services.

Regional Representative
Karen L. Larson, PhD
Program Representative
Office of Regional Operations, Region X, Seattle Office

Oregon Department of Human Services,
Superfund Health Investigation & Education Program
Amanda Guay, MPH
Jae Douglas, MSW, PhD
Julie Early, MS
Kathryn Toepel, MS

References

[1] Lockey JE, Brooks SM, Jarabek AM, Khoury PR, McKay RT, Carson A, Morrison JA, Wiot JF, Spitz HB. Pulmonary changes after exposure to vermiculite contaminated with fibrous tremolite. Am Rev Respir Dis 1984; 129:952-958.

[2] Amandus HE, Wheeler R. The morbidity and mortality of vermiculite miners and millers exposed to tremolite-actinolite: Part II. Mortality. Am J Ind Med 1987; 11:15-26.

[3] Oregon Department of Environmental Quality. Letter to Mr. Marriam of Remedium Group Inc, from Kevin V. McCrann, DEQ Air Quality Program, concerning site decontamination at 2335 N. Harding. DEQ letter from February 2001.

[4] Robben J. Whose neighborhood is it? McDonald's fight reveals an inner Northeast tug of war. The Portland Tribune 2002 Nov 12.

[5] W.R.Grace and Company. Department of Environmental Quality Air Contaminant Discharge Permit Application for 2303 N Harding St. property. Portland, Oregon 1978.

[6] Robinson Insulation's Sick and Deceased. The Great Falls Tribune 2004 Mar 8.

[7] US Geological Survey. Bulletin 2192. Reconnaissance study of the geology of US vermiculite deposits — Are asbestos minerals common constituents? Denver: US Department of the Interior. May 7, 2002 [cited, accessed on 2002 July 31, 2002]. Available at URL: http://geology.cr.usgs.gov/pub/bulletins/b2192/

[8] Agency for Toxic Substances and Disease Registry. Toxicological profile for asbestos (update). Atlanta: U.S. Department of Health and Human Services; September 2001.

[9] Midwest Research Institute. Collection, analysis, and characterization of vermiculite samples for fiber content and asbestos contamination. Kansas City: report prepared for the US Environmental Protection Agency Office of Pesticides and Toxic Substances; September 1982.

[10] Chemical-Specific Health Consultation: Tremolite Asbestos and Other Related Types of Asbestos, September 2001, ATSDR Division of Toxicology.

[11] Moatamed, Farhad, Lockey, J.E., and Parry, W.T., 1986, Fiber contamination of vermiculites: a potential occupational and environmental health hazard: Environmental Research, v. 41, p 207-218.

[12] National Weather Service, Portland Area, Climate of Portland, Clinton C.D. Rockey. http://www.W.R.h.noaa.gov/Portland/climate.

[13] Allen P, Aalbers S. Oregon Department of Environmental Quality. Vermiculite NW: Initial air quality screening analysis. Portland, Oregon. October 21, 2003.

[14] Agency for Toxic Substances and Disease Registry. Health consultation on mortality in Libby, Montana. Atlanta, GA: U.S. Department of Health and Human Services. August, 2002.

[15] Peipins et al. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana. Environ Health Perspect: doi:10.1289/ehp.6346. [Online 2 July 2003 at http://dx.doi.org/]

[16] ATSDR Record of Activity, Tim Walker and Karen Larson, April 30, 2002.

[17] EPA Site Visit Report notes, April 26, 2000.

[18] Weis CP. Memorandum to P. Peronard of US Environmental Protection Agency, Amphibole mineral fibers in source materials in residential and commercial areas of

Libby pose an imminent and substantial endangerment to public health. Denver: US Environmental Protection Agency Region 8; December20, 2001.
[19] US Environmental Protection Agency. Sampling and analysis of consumer garden products that contain vermiculite. Seattle: US Environmental Protection Agency, Region 10; August 2000.
[20] Pratt GC. Memorandum to J. Kelly of Minnesota Department of Health, Modeled concentrations and deposition of tremolite near the Western Mineral Products/W.R. Grace facility. Minneapolis St. Paul: Minnesota Department of Health June 12, 2001.
[21] Minnesota Department of Health, under cooperative agreement with the Agency for Toxic Substances and Disease Registry. Health consultation for Western Mineral Products site (a/k/a Western Mineral Products), City of Minneapolis, Hennepin County, Minnesota. Atlanta: US Department of Health and Human Services; May 2001.
[22] ATSDR (2003) Report on the Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers: The Influence of Fiber Length. Agency for Toxic Substances and Disease Registry, Division of Health Assessment and Consultation, Atlanta, GA (http://www.atsdr.cdc.gov/HAC/asbestospanel/index.html).
[23] Agency for Toxic Substances and Disease Registry. Asbestos Toxicity - Case Studies in Environmental Medicine. Atlanta: U.S. Department of Health and Human Services; December 1997, Revised November 2000.
[24] Churg, A. Asbestos-related disease in the workplace and the environment: controversial issues. In: Churg, A. and Katzenstein, A.A. The lung: current concepts (Monographs in pathology, no. 36). Philadelphia (PA): Lippincott, Williams, and Wilkins; 1993. p. 54-77.
[25] Occupational Safety and Health Administration. Preamble to final rules for asbestos (amended 1994). III. Summary and explanation of revised standards. Accessed at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=PREAMBLES&p_id=777 on July 16, 2002.
[26] U.S. Environmental Protection Agency. Integrated risk information system (for asbestos). Accessed on July 31, 2002 at: http://www.epa.gov/iris/subst/0371.htm.
[27] Berman DW and Crump K. Methodology for conducting risk assessments at asbestos Superfund sites. Part 2: Technical background document (interim version). Prepared for the U.S. EPA Region 9. San Francisco, CA: February 15, 1999.
[28] Environmental Protection Agency. Guidelines for conducting the AHERA TEM clearance test to determine completion of an asbestos abatement project. Washington: U.S. EPA, Office of Toxic Substances, NTIS No. PB90-171778. 1989.
[29] Peipins et al. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana. Environ Health Perspect: doi:10.1289/ehp.6346. [Online 2 July 2003 at http://dx.doi.org/]

Appendix A – Asbestos Overview

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Asbestos minerals fall into two classes, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA and EPA include five classes: fibrous tremolite, actinolite, anthophyllite, crocidolite, and amosite. However, other amphibole minerals, including winchite, richterite, and others, can exhibit fibrous asbestiform properties [1].

Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate and are resistant to heat, fire, and chemical and biological degradation.

The vermiculite mined at Libby contains amphibole asbestos, with a characteristic composition including tremolite, actinolite, richterite, and winchite; this material will be referred to in this report as Libby asbestos. The raw vermiculite ore was estimated to contain up to 26% Libby asbestos as it was mined [2]. For most of the mine's operation, Libby asbestos was considered a byproduct of little value and was not used commercially. The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite that were then shipped to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products. Samples of the various grades of unexpanded vermiculite shipped from the Libby mine contained 0.3% to 7% fibrous tremolite-actinolite (by mass) [2].

The following sections provide an overview of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques, toxicity and health effects, and the current regulations concerning asbestos in the environment. A more detailed discussion of these topics will also be provided in ATSDR's upcoming Summary Report for the national review of vermiculite sites.

Methods for Measuring Asbestos Content

There are a number of different analytical methods used to evaluate asbestos content in air, soil, and other bulk materials. Each method varies in its ability to measure fiber characteristics such as length, width, and mineral type. For air samples, fiber quantification is traditionally done through phase contrast microscopy (PCM) by counting fibers with an aspect ratio (length-to-width) greater than 3:1. This is the standard method by which regulatory limits were developed. Disadvantages of this method include the inability to detect fibers thinner than 0.2 to 0.3 µm in diameter (and shorter than 5 µm) and the inability to distinguish between asbestos and nonasbestos fibers [1].

Asbestos content in soil and bulk material samples is commonly determined using polarized light microscopy (PLM), a method which uses polarized light to compare refractive indices of minerals and can distinguish between asbestos and nonasbestos fibers and between different types of asbestos. The PLM method is also limited by resolution; fibers finer than about 1 µm in diameter cannot be identified by PLM. Detection limits for PLM methods are typically 1% asbestos by volume.

Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods and can detect smaller fibers than light microscopic techniques. One disadvantage of electron microscopic methods is that it is difficult to determine asbestos concentration in soils and other bulk materials [1].

Historically, the majority of epidemiological studies performed on asbestos exposure used phase contract microscopy (PCM) to determine fiber levels in the air (f/cc). Advances in technology (e.g., transmission electron

microscopy, or TEM) allows measurement of fibers that are many times smaller than those that would have been detected by PCM and thus typically results in counts much higher than would be seen had PCM been used. Therefore, for risk assessment purposes, TEM data needs to be converted to an equivalent PCM value: referred to as PCM equivalents (PCMe). Two ways to make this conversion are : 1) Count (or bin) fibers with sizes equal to those that would be counted with PCM (diameter >0.4µm and length > 5µm) or, 2) make simultaneous measurements of TEM counts and PCM counts and compute a conversion factor. It should be noted that even under the best of circumstances, PCMe conversions can be up to 22-53% in error (U.S.EPA, 1986).

In limited situations PCM fiber levels can be higher than TEM levels. Since PCM cannot determine fiber types, environments that may have high non-asbestos fiber loads will show higher PCM fiber counts than TEM, which distinguishes asbestos fibers from non-asbestos fibers. In general, it has been assumed that the epidemiological literature is based on fiber environments that were predominantly asbestos, in which PCM did not significantly overestimate fiber loads. However, this limitation may be important in environments that contain non-asbestos fibers and are being measured by PCM.

EPA is currently working with several contract laboratories and other organizations to develop, refine, and test a number of methods for screening bulk soil samples.

Asbestos Health Effects and Toxicity

When asbestos fibers are breathed in, they may get trapped in the lungs. In general, health risks increase with longer exposure and greater amounts of asbestos fibers in the exposures. Although short-term high-level or chronic low-level asbestos inhalation exposures have been associated with lung cancer, mesothelioma, and pleural disorders [3]. Breathing any type of asbestos increases the risk of the following health effects.

Malignant mesothelioma – Cancer of the membrane (pleura) that encases the lungs and lines the chest cavity. The great majority of mesothelioma cases are attributable to asbestos exposure [1]. An estimated 1,500 cases of mesothelioma per year occur in the United States (compared with an average of 130,000 cases of lung cancer per year). Latency periods for mesothelioma due to asbestos exposure are generally 20 to 30 years or more.

Lung cancer – Cancer of the lung tissue, also known as bronchogenic carcinoma. The exact mechanism relating asbestos exposure with lung cancer is not completely understood. The combination of tobacco smoking and asbestos exposure greatly increases the risk of developing lung cancer [1]. Latency periods are generally 10 to 30 years or more for lung cancer.

Noncancer effects – these include *asbestosis*, scarring and reduced lung function caused by asbestos fibers lodged in the lung; *pleural plaques*, localized or diffuse areas of thickening of the pleura (lining of the lung); *pleural thickening*, extensive thickening of the pleura which may restrict breathing; *pleural calcification*, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and *pleural effusions*, fluid buildup in the pleural space between the lungs and the chest cavity [1]. Either heavy exposure for a short time [32] or lower exposure over a longer period may result in asbestosis [1]. Latency periods for the development of asbestos-related nonmalignant respiratory effects are usually 15-40 years from the time of initial exposure to asbestos.

There is not enough evidence to conclude whether inhalation of asbestos increases the risk of cancers at sites other than the lungs, pleura, and abdominal cavity [1].

Ingestion of asbestos causes little or no risk of noncancer effects. There is some evidence, however, that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors [1]. Skin nodules (corns) from handling asbestos-containing materials can also occur [3].

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of sites that received Libby vermiculite. Exposure scenarios that are protective of the inhalation route of exposure should be protective of dermal and oral exposures.

There is general acceptance in the scientific community of correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Fiber length may play an important role in clearance and mineralogy may affect both biopersistence and surface chemistry.

ATSDR, responding to concerns about asbestos fiber toxicity from the World Trade Center Disaster, held an expert panel meeting to review fiber size and its role in fiber toxicity in December 2002 [4]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5µm (1µm is about 1/25,000 of an inch) are essentially non-toxic when considering a role in mesothelioma or lung cancer promotion. However, fibers less than 5 µm in length may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively make this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly due to physical characteristics that allow chrysotile to be broken down and cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [5]. Some researchers believe the resulting increased duration of exposure to amphibole asbestos significantly increases the risk of mesothelioma and, to a lesser extent, asbestosis and lung cancer [5]. OSHA, however, continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [6]. EPA's Integrated Risk Information System (IRIS) assessment of asbestos also treats mineralogy (and fiber length) as equipotent [7].

Evidence suggesting that the different types of asbestos fibers vary in carcinogenic potency and site specificity is limited by the lack of information on fiber exposure by mineral type. Other data indicate that differences in fiber size distribution and other process differences can contribute at least as much to the observed variation in risk as does the fiber type itself [5].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects, as fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to preferentially deposit in the deep lung, but longer fibers might disproportionately increase the risk of mesothelioma [1,8]. Some of the unregulated amphibole minerals, such as the winchite present in Libby asbestos, can exhibit asbestiform characteristics and contribute to risk. Fiber diameters greater than 2-5 µm are considered above the upper limit of respirability (that is, too large to inhale) and do not contribute significantly to risk. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [8].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, asbestos-containing materials are defined as any material with greater than 1% bulk concentration of asbestos, where asbestos includes only the 5 regulated asbestiform minerals (i.e., fibrous tremolite, actinolite, anthophyllite, crocidolite, and amosite) [9]. It is important to note that 1% is not a health-based level, but instead represents the practical detection limit in the 1970s when OSHA regulations were created. Studies have shown that disturbing soils containing less than 1% amphibole asbestos can suspend fibers at levels of health concern [10].

Friable asbestos (asbestos which is crumbly and can be broken down to suspendable fibers) is listed as a Hazardous Air Pollutant on EPA's Toxic Release Inventory [11]. This requires companies that release friable asbestos at concentrations greater than 0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to Know Act.

Low levels of asbestos can be detected in almost any air sample. In rural areas, for example, there are typically 10 fibers in a cubic meter (fibers/m3) of outdoor air (or 0.00001 fibers per cubic centimeter (cc). (A cubic meter is about the amount of air someone breathes in 1 hour.) Health professionals often report the number of fibers in cubic centimeters (f/cc); 10 fibers per cubic meter is the equivalent of 0.00001 f/cc. Typical levels found in cities are about 10 times higher. Close to an asbestos mine or factory, levels may reach 10,000 fibers/m3 (or 0.01 f/cc) or higher. Levels could also be above average near a building that contains asbestos products and is being torn down or renovated or near a waste site where asbestos is not properly covered up or stored to protect it from wind erosion [1].

OSHA has set a permissible exposure limit (PEL) of 0.1 f/cc for asbestos fibers longer than 5 µm and with an aspect ratio (length-to-width) greater than 3:1, as determined by PCM [12]. This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour workweek. In addition, OSHA has defined an excursion limit in which no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [12]. Historically, the OSHA PEL has steadily decreased from an initial standard of 12 f/cc established in 1971. The PEL levels prior to 1983 were determined based upon empirical worker health observations, while the levels set from 1983 forward employed some form of quantitative risk assessment. ATSDR has used the current OSHA PEL of 0.1 f/cc as a reference point for evaluating asbestos inhalation exposure for past workers. ATSDR does not, however, support using the PEL for evaluating community member exposure, as the PEL is based on an unacceptable risk level.

In response to the WTC disaster in 2001 and an immediate concern about asbestos levels in homes in the area, ATSDR formed the Environmental Assessment Workgroup. This workgroup was made up of ATSDR, US Environmental Protection Agency, National Institute of Occupational Safety and Health, CDC National Center for Environmental Health, Occupational Safety and Health

Administration, New York City Department of Health and Mental Hygiene, and the New York State Department of Health. The workgroup set a re-occupation level of 0.01 f/cc if after clean-up continued monitoring was performed to limit long-term exposure to this level [13].

The National Institute of Occupational Safety and Health (NIOSH) set a recommended exposure limit of 0.1 f/cc for asbestos fibers longer than 5 µm. This limit is a TWA for up to a 10-hour workday in a 40-hour workweek [6]. The American Conference of Government Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its threshold limit value [14].

EPA has set a maximum contaminant level (MCL) for asbestos fibers in water of 7,000,000 fibers longer than 10 µm per liter, based on an increased risk of developing benign intestinal polyps [15]. Many states use the same value as a human health water quality standard for surface water and groundwater.

Asbestos is a known human carcinogen. Historically, EPA has calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos [7]. This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma. This quantitative risk model has significant limitations. First, the unit risks were based on measurements with phase contrast microscopy and therefore cannot be applied directly to measurements made with other analytical techniques. Second, the unit risk should not be used if the air concentration exceeds 0.04 f/cc, since above this concentration the slope factor might differ from that stated [7]. Perhaps the most significant limitation is that the model does not consider mineralogy, fiber size distribution, or other physical aspects of asbestos toxicity. EPA is in the process of updating their asbestos quantitative risk methodology given the limitations of the current assessment and the knowledge gained since it was implemented in 1986.

References – Asbestos Overview

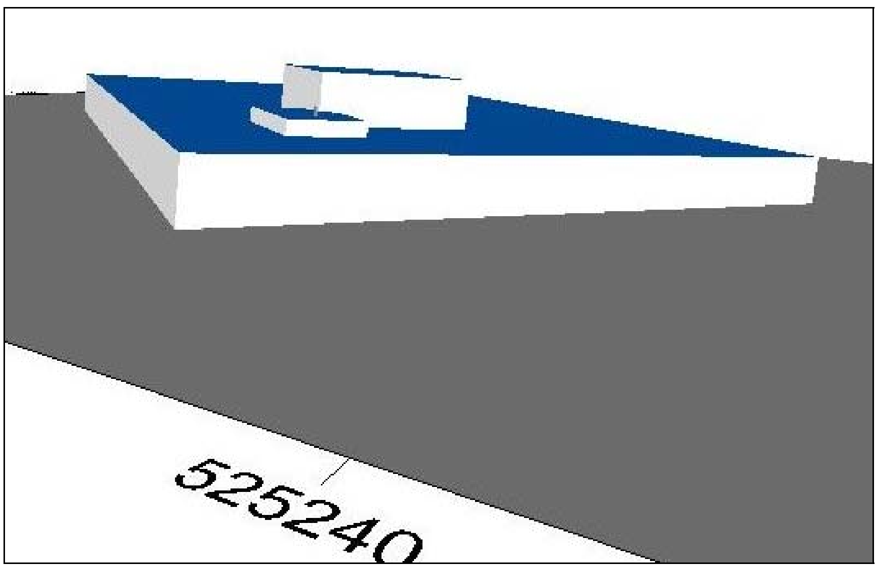
1. Agency for Toxic Substances and Disease Registry. Toxicological profile for asbestos (update). Atlanta: U.S. Department of Health and Human Services; September 2001.
2. Midwest Research Institute. Collection, analysis, and characterization of vermiculite samples for fiber content and asbestos contamination. Kansas City: report prepared for the US Environmental Protection Agency Office of Pesticides and Toxic Substances; September 1982.
3. Agency for Toxic Substances and Disease Registry. Asbestos Toxicity - Case Studies in Environmental Medicine. Atlanta: U.S. Department of Health and Human Services; December 1997, Revised November 2000.
4. ATSDR (2003) Report on the Expert Panel on Health Effects of Asbestos and Synthetic Vitreous Fibers: The Influence of Fiber Length. Agency for Toxic Substances and Disease Registry, Division of Health Assessment and Consultation, Atlanta, GA (http://www.atsdr.cdc.gov/HAC/asbestospanel/index.html).
5. Churg, A. Asbestos-related disease in the workplace and the environment: controversial issues. In: Churg, A. and Katzenstein, A.A. The lung: current concepts (Monographs in pathology, no. 36). Philadelphia (PA): Lippincott, Williams, and Wilkins; 1993. p. 54-77.
6. Occupational Safety and Health Administration. Preamble to final rules for asbestos (amended 1994). III. Summary and explanation of revised standards. Accessed at: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=PREAMBLES&p_id=777 on July 16, 2002.

7. U.S. Environmental Protection Agency. Integrated risk information system (for asbestos). Accessed on July 31, 2002 at: http://www.epa.gov/iris/subst/0371.htm.
8. Berman DW and Crump K. Methodology for conducting risk assessments at asbestos Superfund sites. Part 2: Technical background document (interim version). Prepared for the U.S. EPA Region 9. San Francisco, CA: February 15, 1999.
9. Environmental Protection Agency. Guidelines for conducting the AHERA TEM clearance test to determine completion of an asbestos abatement project. Washington: U.S. EPA, Office of Toxic Substances, NTIS No. PB90-171778. 1989.
10. Peipins et al. Radiographic abnormalities and exposure to asbestos-contaminated vermiculite in the community of Libby, Montana. Environ Health Perspect: doi:10.1289/ehp.6346. [Online 2 July 2003 at http://dx.doi.org/]
11. Environmental Protection Agency. Toxic Air Pollutants web site. Accessed on October 29, 2002 at: http://www.epa.gov/air/toxicair/newtoxics.html
12. National Institute of Occupational Safety and Health. Online NIOSH pocket guide to chemical hazards. Accessed on July 16, 2002 at: http://www.cdc.gov/niosh/npg/npgd0000.html.
13. ATSDR (2003) World Trade Center Response Activities. Close-Out Report. September 11, 2001 - April 30, 2003. May 16, 2003. U. S. Dept. of Health and Human Services.
14. American Conference of Government Industrial Hygienists. 2000 Threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati (OH); 2000.
15. U.S. Environmental Protection Agency. National primary drinking water regulations. Accessed on July 16, 2002 at: http://www.epa.gov/safewater/mcl.html.

Appendix B - Vermiculite NW: Initial air quality screening analysis performed by Oregon DEQ

1) The model used was ISCST3 with the PRIME downwash algorithm.

2) Approximate building configuration and dimensions were used for the BPIP runs. These dimensions were estimated from photographs and an onsite visual assessment. No measurements were made. Stack parameters were taken from source test results table. A stack height of 26 ft (7.92 m) was used rather than the 23 ft. There is some uncertainty as to the location of the stack. There is currently a small stack that sits atop a low structure on the roof of the main building that is adjacent to the tall penthouse (see image below). Although it is unclear if this was the stack used when Vermiculite NW was operating, it is the stack location used in this analysis.



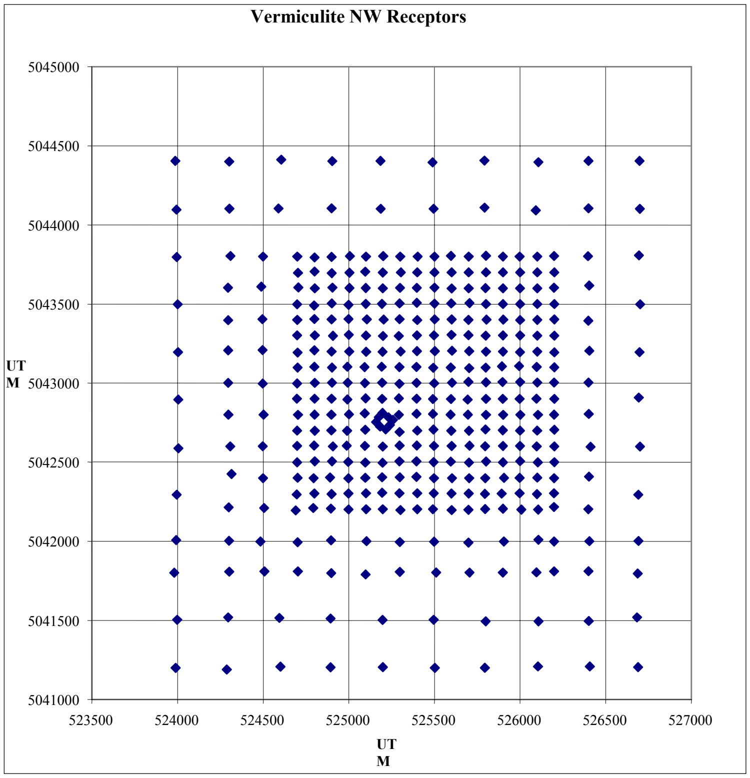
View of Vermiculite NW building from the southwest corner, as used in ISCST3 model

2) Stack parameters are as follows:

Vermiculite NW					
	Stack parameters used in initial screening analysis of PM				
	Emissions g/s	Stack Ht m	Stack Temp K	Velocity m/s	Stack Dia m
	1.0	7.92	377.5	0.0	0.61

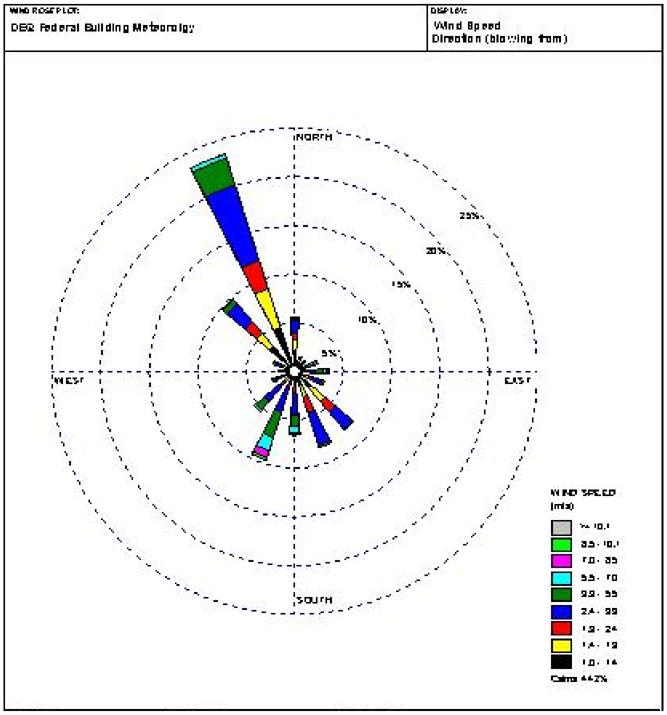
Note that the vertical velocity is zero because of an apparent rain cap on the stack.

2) Receptors locations and elevations were taken from USGS 7.5 min quad using TOPO! Grid resolution varied from approximately 50 m around plant perimeter, 100 m within about 600 m of the facility, and at larger resolution beyond 600 m. Receptor grid was intentionally kept small as significant impacts were assumed to occur close to the facility because of downwash.



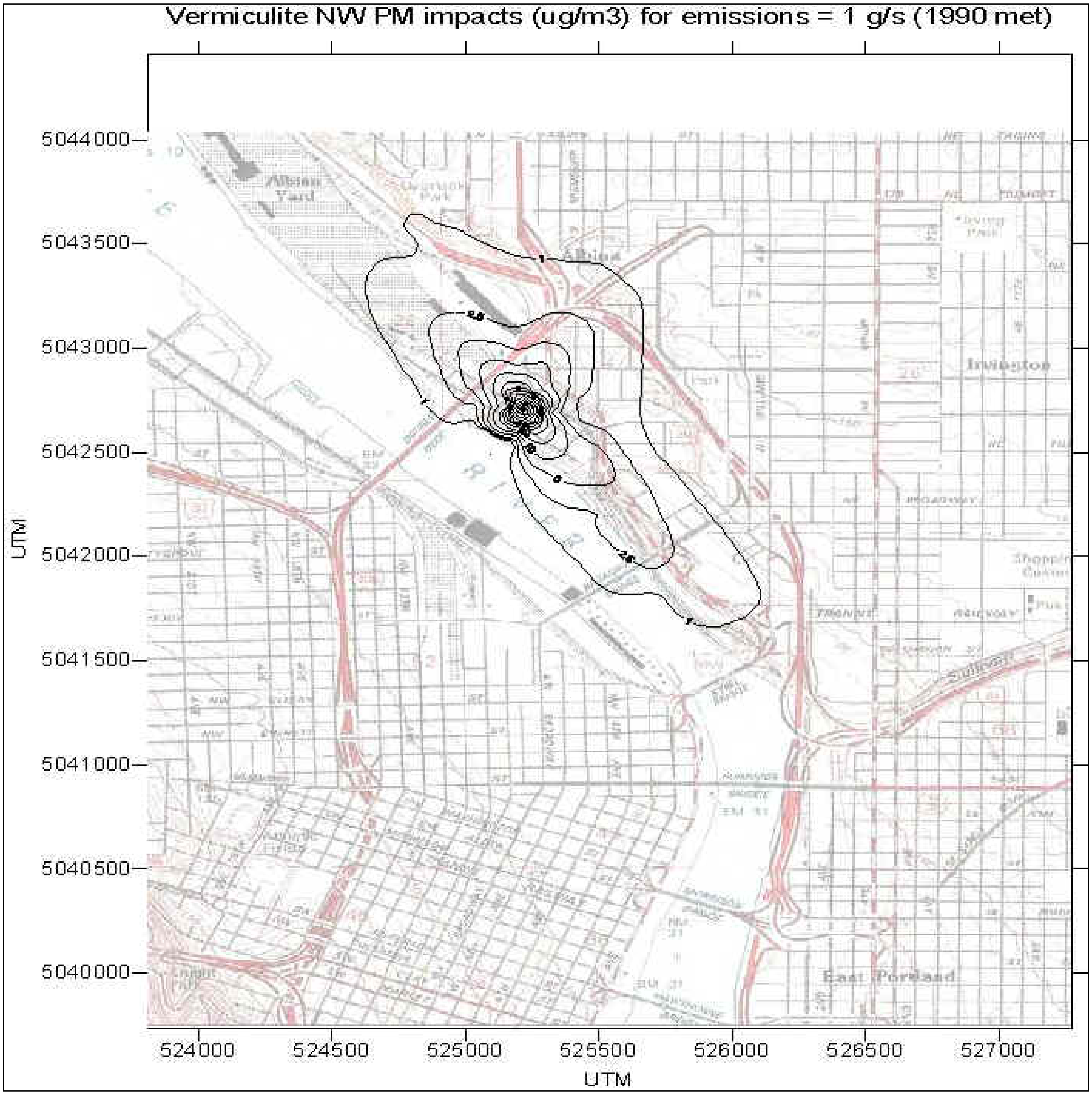
3) The unit emission rate of 1 gram/sec of particulate was used so that the modeled concentrations could be factored to reflect actual emission rates.

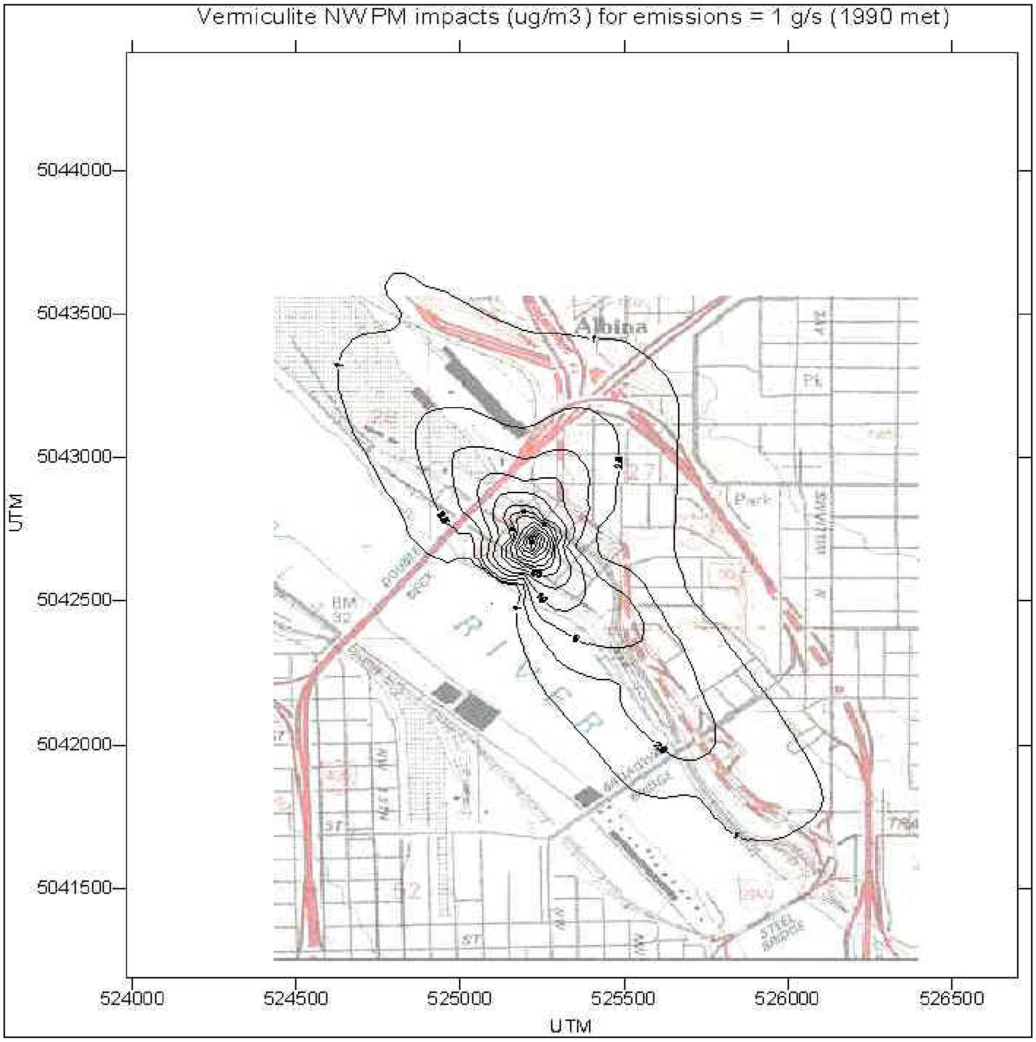
4) The met data used was from a former DEQ site on the Federal Building in NW Portland which is located across the Willamette from Vermiculite NW. A representative wind rose for 1990 from the same site shows winds predominately from the NW, along the alignment of the Willamette, with a less frequent southerly component.

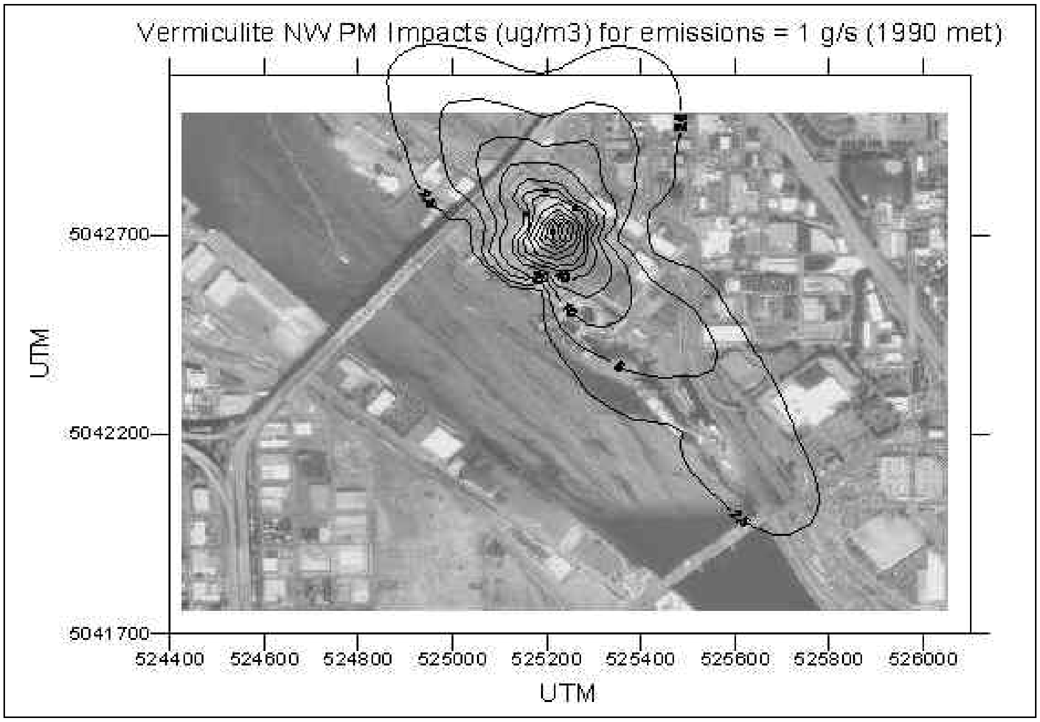


Representative windrose showing 1990 meteorology

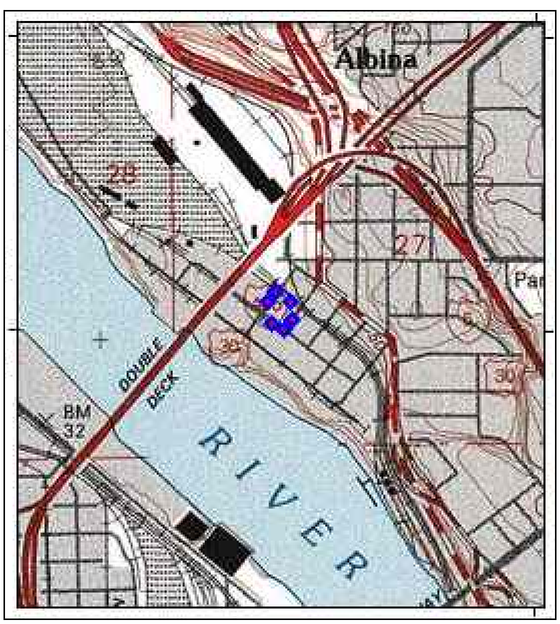
5) The two plots of annual average concentrations (one an enlargement of the other) show the highest concentrations follow the predominate wind direction. Because of the shortness of the stack relative to the so-called penthouse, near-source impacts are strongly affected by building downwash.


Vermiculite NW PM impacts (ug/m3) for emissions = 1 g/s (1990 met)
5044000
5043500
5043000
5042500
5042000
5041500
5041000
5040500
5040000
UTM
524000
524500
525000
525500
526000
526500
527000
UTM


Vermiculite NWPM impacts (ug/m3) for emissions = 1 g/s (1990 met)
5044000
5043500
5043000
5042500
5042000
5041500
UTM
524000
524500
525000
525500
526000
526500
UTM
Albina
RIVER



6) For comparison sake the six highest modeled concentrations (54-382 ug/m3 annual average) occur in the industrial area adjacent to the plant to the southwest. Note that there are no modeled impacts greater than 1.0 ug/m3 in any residential area, as shown on the isopleth plots of concentration.



7) The concentrations reported here are only useful as relative values, since we are using an arbitrary 1 g/s emission rate. For example, if we use an actual emission rate of 2.8 tpy, equivalent to 0.08 g/s, then the predicted concentrations are factored by 0.08, and the 1 ug/m3 isopleth now represents a concentration of 0.08 ug/m3. If asbestos is a fraction of total particulate emitted, say 0.1%, then the actual concentrations would be further reduced.

8) The purpose of this initial study is to show only the pattern of modeled concentrations, not actual concentrations, as a means to subjectively evaluate likely areas of high concentration.

9) The emissions are all assumed to come from the heater stack. Other sources of emissions could result from material transfer, for example from a rail car to storage in the facility, transfer from storage to the heater, etc. These so-called fugitive emissions would be "emitted" in the area of the rail car outside of the building, and from openings in the building such as doorways, windows, or from roof vents. Depending on the operation, these fugitive emissions could easily be greater than the emissions from the heater stack. However, the overall pattern of modeled concentrations would probably not be significantly different, as fugitive emissions with low buoyancy and little or no vertical velocity, will have highest impacts near the source.

Philip Allen
Steve Aalbers
Oregon DEQ
10/21/03

Appendix C - Hazard Category Definitions

Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Appendix D – Former Vermiculite Northwest Fact Sheet

Former Vermiculite Northwest
Portland, Oregon
Summary Factsheet

Health Consultation Completed

The Oregon Department of Human Services, Superfund Health Investigation and Education (SHINE) Program in cooperation with the Agency for Toxic Substances and Disease Registry (ATSDR) has evaluated the potential for health risks associated with asbestos from vermiculite ore that was received from Libby, Montana and processed at the former Vermiculite Northwest facility in Portland, Oregon.

The evaluation focused on ways that people could have been or may be exposed to asbestos from vermiculite processed at this site from the early 1950s until it closed in 1994. This factsheet outlines some of the important findings from the evaluation.

What are the conclusions of this health consultation?

Former workers and household members (people who lived with them, including children during the time they worked at Vermiculite Northwest) should learn more about asbestos and see a physician trained in asbestos-related lung disease. Workers employed at Vermiculite Northwest during 1950 until 1994 were exposed to elevated levels of Libby asbestos as a result of working in and around the facility. Household contacts of former workers were also likely to have been exposed to Libby asbestos brought home on clothing and hair of workers. Workers employed in businesses in the building after 1993, may have been exposed to asbestos, however, the actual level of exposure to these workers is unknown.

Could I be exposed to asbestos from this site now?

It is unknown whether people who live and work around this site are likely to be exposed to asbestos from the site. Despite prior building cleanup efforts, employees in businesses in the building after the processing plant closed may have been exposed to asbestos. The soil near the railroad tracks east of the facility has not been tested for asbestos, so contact with this soil may result in exposure to asbestos.

There have been reports that some waste rock may have been removed from the site for personal use. Exposure to waste products from the site is possible, although there is no evidence that there were waste piles from vermiculite processing.

Could I have been exposed to asbestos from this site in the past?

You were probably exposed to asbestos from this site if you:

- Worked at this facility when it processed vermiculite, or
- Lived with someone who worked at the facility when vermiculite was processed there, or
- Came in contact with waste rock from the site.

What are the health effects of asbestos exposure?

Exposure to asbestos does not necessarily mean that a person will become ill as a result of the exposure. Breathing in asbestos fibers that can be released from asbestos-contaminated vermiculite may increase a person's likelihood of developing lung cancer, mesothelioma (a cancer of the outer lining of the lungs and/or abdominal cavity), lung abnormalities and breathing disorders. Repeated and prolonged exposure to high levels of asbestos increases the chances of developing these diseases.

What is the history of the site?

From 1950 until 1994, the former Vermiculite Northwest facility processed vermiculite at their facility at 2303 N. Harding Street in Portland. Some of the vermiculite was from Libby, Montana, and was found to contain asbestos.

The facility exfoliated (expanded or "popped") vermiculite to manufacture attic insulation. The Vermiculite Northwest plant processed more than 193,113 tons of Libby vermiculite.

The area around the former Vermiculite Northwest facility is zoned industrial. The nearest residences are apartments located a quarter mile to the northeast and the nearest neighborhoods are three-quarters of a mile away.

EPA identified the site for further investigation after sampling found asbestos contamination in the facility. Cleanup of the contaminated building was completed in 2001. EPA has recently revisited the building for further limited sampling at the request of SHINE.

Where can I get more information?

The health consultation report is available at www.healthoregon.org/superfund. For more information, call Amanda Guay at 503-872-5357.

What is vermiculite?

Vermiculite is a naturally occuring mineral compound. It is composed of shiny stone flakes and looks like mica. In the past, much of the world's supply of vermiculite came from a mine near Libby, Montana. After years of mining, the Libby mine was found to have a natural deposit of asbestos, and the vermiculite from Libby contains asbestos.

What is "asbestos exposure"?

Breathing in asbestos fibers is called asbestos exposure. When asbestos fibers are breathed into your lungs, they may remain there for a lifetime. In some cases, these fibers might damage your lungs or the linings of your lungs and cause illness or even death.

What is asbestos?

Asbestos is the name of several fibrous minerals that occur naturally in the environment. Asbestos is composed of separable, long, and thin "needlelike" fibers. The asbestos fibers in vermiculite are too small to be seen by the naked eye.

June, 2005

Appendix E - Glossary of Environmental Health Terms

Acute Exposure Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to14 days.

Additive Effect A response to a chemical mixture, or combination of substances, that might be expected if the known effects of individual chemicals, seen at specific doses, were added together.

Adverse Health Effect A change in body function or the structures of cells that can lead to disease or health problems.

Amosite Asbestos A special form of the amphibole mineral, tremolite, that displays separable, long, thin fibers often arranged in parallel in a column or in matted masses. The fibers are generally strong enough and flexible enough to be spun and woven, are heat resistant, and are chemically inert

Amphibole A large group of silicate minerals with more than 40–50 members. The molecular structure of all amphiboles consists of two chains of SiO4 molecules that are linked together at the oxygen atoms. In the earth's crust, amphibole minerals are mostly nonasbestiform; asbestiform amphiboles are relatively rare. See definitions of asbestiform, mineral, and mineral habit.

Asbestiform A habit of crystal aggregates displaying the characteristics of asbestos: groups of separable, long, thin, strong, and flexible fibers often arranged in parallel in a column or in matted masses. See definitions of mineral and mineral habit. Mineralogists call asbestiform amphibole minerals by their mineral name followed by "asbestos." Thus, asbestiform amosite is called amosite asbestos.

Asbestos A group of highly fibrous minerals with separable, long, thin fibers often arranged in parallel in a column or in matted masses. Separated asbestos fibers are generally strong enough and flexible enough to be spun and woven, are heat resistant, and are chemically inert. See definitions of fibrous and mineral. Currently, U.S. regulatory agencies recognize six asbestos minerals: the serpentine mineral, chrysotile; and five asbestiform amphibole minerals, actinolite asbestos, tremolite asbestos, anthophyllite asbestos, amosite asbestos (also known as asbestiform cummingtonite-grunerite), and crocidolite asbestos(also known as asbestiform riebeckite).

Asbestosis Interstitial fibrosis of the pulmonary parenchymal tissue in which asbestos bodies (fibers coated with protein and iron) or uncoated fibers can be detected. Pulmonary fibrosis refers to a scar-like tissue in the lung which does not expand and contract like normal tissue. This makes breathing difficult. Blood flow to the lung can also be decreased, and this causes the heart to enlarge. People with asbestosis have shortness of breath, often accompanied by a persistent cough. Asbestosis is a slow-developing disease that can eventually lead to disability or death in people who have been exposed to high amounts of asbestos over a long period. Asbestosis is not usually of concern to people exposed to low levels of asbestos.

Aspect Ratio Length to width ratio.

ATSDR The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.

Background Level An average or expected amount of a chemical in a specific environment, or amounts of chemicals that occur naturally in a specific environment.

Cancer A group of diseases that occur when cells in the body become abnormal and grow, or multiply, out of control

Cancer Slope Factor (CSF) The slope of the dose-response curve for cancer. Multiplying the CSF by the dose gives a prediction of excess cancer risk for a contaminant.

Carcinogen Any substance shown to cause tumors or cancer in experimental studies.

Chronic Exposure A contact with a substance or chemical that happens over a long period of time. ATSDR considers exposures of more than one year to be *chronic*.

Chrysotile Asbestos A fibrous member of the serpentine group of minerals. Chrysotile asbestos fibers are flexible and have a curved morphology. It is the most common form of asbestos used commercially, also referred to as white asbestos.

Completed Exposure Pathway See **Exposure Pathway**.

Concentration How much or the amount of a substance present in a certain amount of soil, water, air, or food.

Contaminant See Environmental Contaminant.

Dermal Contact	A chemical getting onto your skin (see **Route of Exposure**).
Dose	The amount of a substance to which a person might be exposed, usually on a daily basis. Dose is often explained as "amount of substance(s) per body weight per day."
Dose / Response	The relationship between the amount of exposure (dose) and the resultant change in body function or health.
Duration	The amount of time (days, months, years) that a person is exposed to a chemical.
Environmental Contaminant	A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.
Environmental	Usually refers to the air, water, and soil in which chemicals of interest **Media** are found. Sometimes refers to the plants and animals eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
US Environmental Protection Agency (EPA)	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Exposure	Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)
Exposure Assessment	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.
Exposure Pathway	**A description of the way a chemical moves from its source (where it** began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts: 1. Source of Contamination, 2. Environmental Media and Transport Mechanism, 3. Point of Exposure, 4. Route of Exposure, and 5. Receptor Population.

When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.

Fiber Any slender, elongated mineral structure or particle. For the purposes of counting asbestos fibers in air samples, regulatory agencies commonly count particles that have lengths >5 µm and length:width ratios >3:1 as fibers. For detecting asbestos fibers in bulk building materials, particles with length:width ratios >5:1 are counted as fibers.

Fiber-year/mL A cumulative exposure measure calculated by multiplying a worker's duration of exposure (measured in years) by the average air concentration during the period of exposure (measured in number of fibers/mL of air). Epidemiologic studies of groups of asbestos-exposed workers commonly express exposure in these units.

Fibrous A mineral habit with crystals that look like fibers. A mineral with a fibrous habit is not asbestiform if the fibers are not separable and are not long, thin, strong, and flexible.

Frequency How often a person is exposed to a chemical over time; for example, every day, once a week, twice a month.

Friable ACM Friable **a**sbestos-**c**ontaining **m**aterial is any asbestos-containing material that can be crumbled, pulverized or reduced to powder by hand pressure when dry. Friable asbestos material includes any asbestos-containing material that is shattered or subjected to sanding, grinding, sawing, abrading, or has the potential to release asbestos fibers.

Hazardous Waste Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

Health Effect ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).

Ingestion Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (see **Route of Exposure**).

Inhalation Breathing. It is a way a chemical can enter your body (see **Route of Exposure**).

Interstitial A term used as an adjective relating to spaces within a tissue or organ.

	Pulmonary interstitial fibrosis refers to fibrosis (scarring) developing within lung tissue.
Mesothelioma	Cancer of the thin lining surrounding the lung (the pleura) or the abdominal cavity (the peritoneum). Mesotheliomas are rare cancers in the general population.
Mineral	Any naturally occurring, inorganic substance with a crystal structure.
NESHAP	**N**ational **E**mission **S**tandards for **H**azardous **A**ir **P**ollutants are EPA emission standards for hazardous air pollutants.
NPL	The **N**ational **P**riorities **L**ist is a list kept by EPA of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or at least looked at to see if people can be exposed to chemicals from the site.
ODEQ	**O**regon **D**epartment of **E**nvironmental **Q**uality. The state agency that develops and enforces environmental laws to protect the environment and public health.
ODHS	**O**regon **D**epartment of **H**uman **S**ervices. The state public health agency; ODHS has a cooperative agreement with ATSDR to conduct health assessments and consultations at Superfund/NPL and other hazardous waste sites in Oregon.
PLM	**P**olarized **L**ight **M**icroscopy is standard method used to quantify asbestos fibers.
Public Health Consultation (PHC) or Public Health Assessment (PHA)	A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHC or PHA also tells if possible further public health actions are needed. A PHA generally addresses situations where there is one chemical or environmental hazard of concern.
Pleura	A thin lining or membrane around the lungs or chest cavity. This lining can become thickened or calcified in asbestos-related disease.
Pleural	Having to do with or involving the pleura.
Pleural abnormalities	Abnormal or diseased changes occurring in the pleura. Pleural abnormalities associated with exposure to asbestos include pleural plaques, pleural thickening or calcifications, and pleural effusion.

Pleural calcification As a result of chronic inflammation and scarring, pleura becomes thickened and can calcify. White calcified areas can be seen on the pleura by X-ray.

Pleural cavity The cavity, defined by a thin membrane (the pleural membrane or pleura), which contains the lungs.

Pleural effusion Cells (fluid) can ooze or weep from the lung tissue into the space between the lungs and the chest cavity (pleural space) causing a pleural effusion. The effusion fluid can be clear or bloody. Pleural effusions might be an early sign of asbestos exposure or mesothelioma and should be evaluated.

Pleural plaques Localized or diffuse areas of thickening of the pleura (lining of the lungs) or chest cavity. Pleural plaques are detected by chest x-ray, and appear as opaque, shiny, and rounded lesions.

Pleural thickening Thickening or scarring of the pleura that might be associated with asbestos exposure. In severe cases, the normally thin pleura can become thickened like an orange peel and restrict breathing.

Point of Exposure The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). Some examples include the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, or the backyard area where someone might breathe contaminated air.

Pulmonary interstitial fibrosis Scar-like tissue that develops in the lung parenchymal tissue in response to inhalation of dusts of certain types of substances such as asbestos.

Route of Exposure The way a chemical can get into a person's body. The three exposure routes are:

- breathing (also called inhalation),
- eating or drinking (also called ingestion), and
- getting something on the skin (also called dermal contact).

Source (of Contamination) The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.

Superfund See **NPL.**

Toxic Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.

CERTIFICATION

The Health Consultation for the (Former) Vermiculite Northwest, Inc. was prepared by the Oregon Department of Health Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated.

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Gregory V. Ulirsch
Technical Project Officer, SPAB, DHAC
Agency for Toxic Substances and Disease Registry (ATSDR)

The Division of Health Assessment and Consultation (DHAC), ATSDR, has reviewed this Health Consultation and concurs with its findings.

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Alan Yarbrough
Team Leader, CAT, SPAB, DHAC, ATSDR