Health Consultation

FORMER ZONOLITE/W.R. GRACE & COMPANY SITE

4729 RIVER ROAD

NEW ORLEANS, JEFFERSON PARISH, LOUISIANA

SEPTEMBER 22, 2005

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Prepared by:

U.S. Department of Health and Human Services
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September 22, 2005 Addendum

The current site conditions as described in this report may have changed as a result of Hurricane Katrina and its aftermath. ATSDR recommends that the site conditions be reevaluated when public health and environmental conditions, resources, and priorities indicate it is prudent.

Foreword: ATSDR's National Asbestos Exposure Review

Vermiculite was mined and processed in Libby, Montana, from the early 1920s until 1990. We now know that this vermiculite, which was shipped to many locations in the United States for processing, 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 local, state, and federal 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, current, or future exposure to asbestos from processing operations. Determining the extent and the hazard potential of commercial or consumer use of products such as vermiculite attic insulation or vermiculite gardening products made with contaminated vermiculite is outside the scope of this project. Information for consumers of vermiculite products has been developed by the U.S. Environmental Protection Agency (EPA), ATSDR, and the National Institute for Occupational Safety and Health (NIOSH). This information is available at www.epa.gov/asbestos/insulation.html.

The sites that processed Libby vermiculite will be evaluated by (1) identifying ways people could have been exposed to asbestos in the past and 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 1: ATSDR has selected 28 sites for the first phase of reviews. These sites were chosen on the basis of the following criteria.

- EPA mandated further action at the site because of contamination in place

- or -

- The site was an exfoliation facility that processed more than 100,000 tons of vermiculite from the Libby mine. Exfoliation, a processing method in which vermiculite 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 other sites across the United States 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.

Executive Summary

The Agency for Toxic Substances and Disease Registry (ATSDR) evaluated the Zonolite/W.R. Grace & Company vermiculite site in New Orleans, Louisiana, because approximately 148,000 tons of asbestos-contaminated vermiculite were shipped to a facility on the site for processing by exfoliation. Commercial exfoliation of vermiculite is a process of heating it in a furnace to expand, or “pop” it into lightweight nuggets.

The New Orleans facility operated during 1965–1989. Other businesses have leased the facility since W.R. Grace vacated the premises. The site consists of a 16,000 square foot building situated on approximately 2 acres of land. Land use around the site is a mixture of residential, commercial, and industrial. A residential area a few hundred yards east and northeast of the site was present before the facility began processing vermiculite. Based on U.S. census data, a total of 5,047 people lived within 1 mile of the site in 1990.

While the facility was operating, processing and handling of asbestos-contaminated vermiculite and waste rock at the New Orleans facility resulted in asbestos exposures to former workers and their household contacts. Sufficient site- and process-specific information is available to consider these exposures a public health hazard. On the basis of the information available, ATSDR estimates that 70 to 90 former workers were exposed during the time the plant operated.

Some abandoned vermiculite processing equipment is still present in an unused area of the warehouse. Also, vermiculite was observed in soil near the railroad spur on the northwest side of the building. Insufficient information is available to determine whether the processing equipment or on-site soil contains residual asbestos. The processing equipment, the room where the equipment was housed, and the areas of soil near the railroad spur did not appear to be used during recent EPA and ATSDR site visits, but future redevelopment of the site or a change in site usage could result in more frequent access of these areas. Before using or disturbing these areas, they should be assessed for residual asbestos fibers.

Community members who lived or worked near the New Orleans facility in the past could have been exposed to Libby asbestos in a variety of ways. Very little information is available to verify community exposure or to quantify the magnitude, frequency, or duration of any exposure. The two potential pathways of greatest concern are (1) plant emissions of Libby asbestos that may have reached the residential area during 1969–1974 before emission control equipment was installed and (2) stockpiles of waste rock on the site that may have been accessible to community members, especially children. Children who were exposed to asbestos are a population of particular concern because asbestos-related health effects have a long latency period and children who are exposed would have more years to develop problems.

Most community members who live or work near the site now are not being exposed to asbestos from the site. The community exposure pathways that existed while the facility was operating, such as exposure from plant emissions and from contact with piles of vermiculite and waste rock on the site, have been eliminated. In the past, community members or workers may have taken waste rock off the site to use as fill material, driveway surfacing material, or as a soil amendment. Not enough information is available to determine whether some individuals may be exposed to Libby asbestos through direct contact with waste rock taken from the site.

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 nature of potential health impacts. Because of existing data gaps and scientific limitations in information about the type of asbestos at these sites, the risk for current or future health impacts on exposed populations is difficult to quantify.

At this site, where little can be done about past exposures and possible health effects relating to exposure, promoting awareness and offering health education to exposed and potentially exposed populations are important public health actions. Health messages should be structured to facilitate self-identification and to encourage exposed persons to either inform their primary care physician or consult a physician with expertise in asbestos-related lung disease. Health care provider education would facilitate surveillance and improved recognition of atypical risk factors (for example, those related to nontraditional asbestos-related occupations or nonoccupational exposure) that can contribute to asbestos-related diseases.

Background

ATSDR evaluated the Zonolite/W.R. Grace & Company (W.R. Grace) New Orleans site (New Orleans facility) because a large amount of vermiculite contaminated with amphibole asbestos was processed at the site by exfoliation. Available invoice data indicate that the facility received approximately 148,000 tons of vermiculite during1966–1988 (EPA, unpublished data, 2001). [1]

W.R. Grace leased the site and used the existing 16,000 square-foot building for exfoliation operations during 1965–1989 (EPA, unpublished data). [2] W.R. Grace sold some of their manufacturing and office equipment to the property owner when they terminated the lease (EPA, unpublished data). The facility has been leased to other businesses since 1989.

W.R. Grace reportedly cleaned the facility and collected air samples to test for asbestos after they ceased vermiculite operations in 1989. EPA Region 6 completed a site investigation in 2000, and ATSDR conducted a site visit in 2002 [1, 2]. The company on the premises during these site visits operated a clothing wholesale and printing business out of the main warehouse area. An adjoining structure on the back portion of the warehouse contained equipment that had been used to process vermiculite in the past; this area appeared to be unused and inaccessible from the inside of the main warehouse [1, 2].

In the past, the New Orleans facility produced attic insulation, masonry insulation, lightweight concrete aggregate, spray-applied fireproofing, and various horticultural soil conditioners. The Monokote brand of spray-applied fireproofing was produced at New Orleans until 1976 (EPA, unpublished data). The Monokote 3 (MK-3) product, discontinued at all W.R. Grace facilities in 1973, was formulated with 10% to 19% chrysotile as an additive (EPA, unpublished data). Subsequent formulations of Monokote, MK-4 and MK-5, were produced at the New Orleans facility without the addition of chrysotile.

Site description

The New Orleans facility is located at 4729 River Road in Jefferson Parish, about 7 miles west of the center of New Orleans, Louisiana (Figure 1). The site consists of a 16,000 square-foot building situated on approximately 2 acres of land (Figure 2) (EPA, unpublished data). Several metal storage silos are located on the north side of the building. An abandoned railroad spur, overgrown with vegetation, runs along the west side of the building. Most of the site is covered with concrete, although grass and other vegetation cover the ground surface along the north, west and south sides of the building. A chain link fence encloses a grass-covered area along the west side of the building, but most of the property outside the building is open to public access.

The site is bordered to the north and west by other commercial and industrial properties, to the east by St. George Street, and to the south by River Road. The Mississippi River is 1,000 feet south of the site. Current land use surrounding the area west of the site is a mixture of commercial and industrial properties while a residential area is northeast of the site. The closest residential properties are within a few hundred yards northeast of the site (Figures 2 and 3). This

[1] Unpublished data from an EPA database of W.R. Grace invoices for shipments of vermiculite from the Libby mine from 1964 through 1990.
[2] Unpublished data from a database of W.R. Grace documents that EPA Region 8 obtained during the Libby mine investigation. This document database contains confidential business information as well as private information that is not available to the public.

residential area is visible in aerial photographs dating back to 1969 [3]. According to 2000 census data, more than 75% of the homes in this northeast residential area were constructed before 1969 [4]. The 1990 U.S. census reported that 5,047 people lived within 1 mile of the facility when it was exfoliating vermiculite (Figure 3).

New Orleans area temperatures range from an average of 54 degrees Fahrenheit in winter (December through February) to an average of 82 degrees Fahrenheit in summer (June through August) [5]. Normal annual precipitation for New Orleans is 64 inches, with rainfall typically occurring 115 days of the year [5]. Snowfall is rare. Meteorological data from the New Orleans International Airport 7 miles northwest of the site suggest the primary wind directions are from the northeast, east and south (Figure 4). Actual conditions at the site could vary due to local topography and other factors.

Vermiculite exfoliation

The U.S. Geological Survey describes vermiculite as "… a general term applied to a group of platy minerals that form from the weathering of micas by ground water. Their distinctive characteristic is a prominent accordion-like unfolding and expansion when heated … the [expanded] vermiculite material is very lightweight and possesses fire- and sound-insulating properties. It is thus well suited for many commercial applications."[6]

The vermiculite ore mined in Libby, Montana, was concentrated and milled to produce different sizes, or grades, of vermiculite. This milled vermiculite was then shipped to the New Orleans facility and to other processing facilities throughout the country. Before milling, the raw vermiculite from the Libby mine contained up to 26% asbestos [7]. The various grades of milled vermiculite shipped from Libby contained fibrous amphibole asbestos at concentrations ranging from 0.3% to 7.0% [7].

Commercial exfoliation of vermiculite is a process that can be likened to popping popcorn. Vermiculite is heated in a furnace to temperatures of 1,500 degrees to 2,000 degrees Fahrenheit. As water molecules within the mineral structure are driven off, the vermiculite expands into lightweight, accordionlike nuggets (Figure 5) [6]. The unpopped material that remains after the vermiculite is expanded is called waste rock or stoner rock (Figure 6). Estimates of the asbestos content of the waste rock vary from 2% to 10% (EPA, unpublished data; J. Kelly, Minnesota Department of Health, personal communication, 2002).

In general, vermiculite exfoliation facilities were small-scale operations employing fewer than 50 people. Vermiculite was often delivered to the facilities in bulk by railcar. Workers at the exfoliation facilities used shovels or front-end loaders to manually unload vermiculite from the railcars and store it on the site in open stockpiles or enclosed silos. At many of the facilities, the transfer processes were later automated with screw-type augers and conveyor belts to deliver vermiculite to the storage areas and into the exfoliation furnace. Other manual tasks at these facilities included filling and sealing product bags, adding bags of vermiculite and chrysotile asbestos to the Monokote mixer, managing waste rock (filling bags or transferring bulk material), maintaining equipment, and providing housekeeping services.

Several equipment and operational changes were implemented at vermiculite exfoliation facilities in response to environmental and worker regulations promulgated throughout the 1970s. Although asbestos emissions from these exfoliation facilities were not regulated under

1970 EPA Clean Air Act amendments, W.R. Grace submitted information to EPA in May 1973 indicating that 19 of their 31 exfoliation facilities had particulate and asbestos emission control equipment that was compliant with the regulations (EPA, unpublished data). As the Occupational Safety and Health Administration (OSHA) permissible exposure level (PEL) for occupational exposure to asbestos steadily decreased from an initial standard of 12 fibers per cubic centimeter of air (f/cc) established in 1971 to the 1994 standard of 0.1 f/cc [8], W.R. Grace initiated employee monitoring and various process design changes to achieve compliance (EPA, unpublished data).

At some exfoliation facilities, respiratory protection (e.g., dust masks, various types of respirators) was periodically documented for certain job categories in industrial hygiene reports dating back to the early 1970s (EPA, unpublished data). Information is not available to evaluate the use or effectiveness of this respiratory equipment in reducing workers' exposure to asbestos. The overall effectiveness depends on a number of factors, including the protection factor of the masks, the effectiveness of the fit testing protocols, and the actual compliance of individuals required to wear the masks. In 1977, W.R. Grace initiated an internal communication program intended to enforce respirator use and provide education to workers regarding the health impacts of smoking combined with asbestos exposure (EPA, unpublished data). The increased risk of lung cancer from smoking combined with asbestos exposure is stated as the basis for an employee "no smoking" policy found in the 1982 W.R. Grace employee handbook (EPA, unpublished data).

Records indicate waste rock and fine particulates from the dust and fiber control equipment at many of the exfoliation facilities was bagged and disposed of at local landfills beginning in the late 1970s and early 1980s [9]. Before that time, very little information is available to track the handling and disposal of waste rock and fine particulates at these facilities. Anecdotal reports indicate the waste rock at some facilities was temporarily stockpiled on the site; these stockpiles were accessible to the public, and children played in them [10, 11]. At one exfoliation facility, workers and nearby community members were encouraged to take waste rock home for personal use [10].

Asbestos and asbestos-related health effects

Asbestos minerals fall into two groups, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Fibrous amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA include five classes: crocidolite, amosite, and the fibrous forms of tremolite, actinolite, and anthophyllite. Other unregulated amphibole minerals, including winchite, richterite, and others, can also exhibit fibrous asbestiform properties [6].

Vermiculite from Libby was found to contain several types of asbestos fibers, including the amphibole asbestos varieties tremolite and actinolite and the related fibrous asbestiform minerals winchite, richterite, and ferro-edenite [6]. In this report, the terms Libby asbestos and Libby amphibole will be used to refer to the characteristic composition of asbestos contaminating the Libby vermiculite.

Individual asbestos fibers are too small to be seen without a microscope or other laboratory instruments. However, asbestos can sometimes be visible when many fibers form together in "bundles" or when the minerals form in nonfibrous, blocky fragments (Figure 6). Asbestos fibers do not have a detectable odor or taste. They do not dissolve in water or evaporate in the air, although individual asbestos fibers can easily be suspended into the air. Asbestos fibers do not move through soil. They are resistant to heat, fire, and chemical and biological degradation. As such, they can remain virtually unchanged in the environment over long periods of time [12].

Appendix B provides an overview of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques and federal regulations concerning asbestos.

In terms of human exposure, ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of sites that received vermiculite from Libby. Although both ingestion and dermal exposure routes may exist, health risks from these exposures are low compared with health risks from the inhalation route [12]. Health effects associated with breathing asbestos include the following:

- *Malignant mesothelioma*—Cancer of the membrane (pleura) that encases the lungs and lines the chest cavity. This cancer can spread to tissues surrounding the lungs or other organs. The majority of mesothelioma cases are attributable to asbestos exposure [12].
- *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 for lung cancer [12].
- *Noncancer effects*—These include asbestosis (scarring of the lung, 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) [12] .

Numerous studies of occupationally exposed workers conclusively demonstrate that inhalation of asbestos can increase the risk for mesothelioma, lung cancer, and various noncancer health effects [12]. Several studies have documented health impacts consistent with asbestos-related disease in workers and others associated with the Libby mine [13-18]. Asbestos-related health impacts to workers associated with vermiculite exfoliation facilities have also been documented [19, 20].

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 [12]. The mineralogy and size of the asbestos fibers involved in the exposure are also important in determining the likelihood and nature of potential health impacts. Exposure to amphibole asbestos fibers that are long (greater than 10 micrometers) increases the risk of carcinogenic health effects such as mesothelioma and lung cancer [12, 21, 22]. Short amphibole fibers (less than 5 micrometers) are thought to be less important in inducing carcinogenic effects, but they may play a role in increasing the risk of noncancer effects such as asbestosis [23]. The fibrous forms of amphibole asbestos are potentially more toxic than other commonly encountered serpentine fibers (for example, chrysotile) [12, 22, 24].

Chronic exposure is a significant risk factor for asbestos-related disease. However, brief episodic exposures may also contribute to disease. A brief, high intensity exposure from working just two summers at a vermiculite exfoliation facility in California has been linked to a case of fatal asbestosis [20]. Very little conclusive evidence is available regarding the health effects of low-dose, intermittent exposures to asbestos. A “safe” exposure level below which health effects are unlikely has yet to be formally defined in federal regulations and policies.

Methods

Data sources

ATSDR obtained site-specific environmental and facility operational data from either EPA or W.R. Grace, the company that formerly owned the Libby mine and many of the exfoliation sites around the country. Current environmental data for the site consisted of indoor air samples collected by W.R. Grace in 1989, after they stopped exfoliating vermiculite at the site.

ATSDR acquired historical industrial hygiene data (i.e., personal air samples for workers), engineering sampling data from work areas, and various operational and technical data for the New Orleans site from a database of W.R. Grace documents. EPA Region 8 obtained this document database, comprising approximately 2.5 million electronic image files, during the Libby mine investigation.

EPA assembled and summarized W.R. Grace invoices for shipments of vermiculite from the Libby mine to many different sites across the country. These invoice records corresponded to Grace’s tenure as owner of the Libby mine. Limited information is available about production and shipping of vermiculite before 1964. ATSDR used EPA’s summary of the W.R. Grace information to obtain the vermiculite tonnage figures attributed to the New Orleans facility (EPA, unpublished data, April 2001).

Other sources of data used for evaluating the site include U.S. Census data, aerial photographs, and site visits by ATSDR and EPA.

Site evaluation methodology

The site evaluation consisted of (1) identifying and assessing complete or potential exposure pathways to Libby asbestos for the past, present, and future and (2) determining whether the exposure pathways represent a public health hazard. The latter determination is qualitative or semiquantitative at best due to a number of underlying limitations, including difficulties in quantifying asbestos exposures, assessing asbestos toxicity, and quantifying risks for carcinogenic and noncarcinogenic health endpoints. A more rigorous, quantitative approach of calculating the risk for potential health impacts was not possible given the limitations in available data.

ATSDR used knowledge gained from investigations in Libby and at a few early investigations at vermiculite exfoliation facilities to identify several likely pathways for occupational, household contact, and community exposure to asbestos at such facilities (Appendix C). As stated previously, ATSDR considered only the inhalation route of exposure.

An exposure pathway consists of five elements: a *source* of contamination, a *medium* through which the contaminant is transported, a *point of exposure* where people can come into contact with the contaminant, a *route of exposure* by which the contaminant enters or contacts the body, and a *receptor population*. A pathway is considered complete only if all five elements are present and connected. More information on exposure pathways is included in Appendix A.

To determine whether complete or potential exposure pathways pose a public health hazard, ATSDR considered available site-specific exposure data (for example, frequency, duration, and intensity of exposure). Although a few risk-based metrics are available to evaluate levels of airborne asbestos, no *health-based* comparison values are available to indicate "safe" levels of asbestos in air, soil, dust, or other bulk materials such as vermiculite and waste rock. Additionally, very little information is available about the health risks associated with low-dose, intermittent exposure to amphibole asbestos. These limitations necessitate that ATSDR use a conservative approach to public health decisionmaking for the site.

For asbestos fiber levels in air, ATSDR used the current risk-based OSHA PEL of 0.1 fibers per cubic centimeter (f/cc) of air as one metric to assess asbestos inhalation exposure for workers [8]. The 0.1 f/cc OSHA PEL, calculated as an 8-hour time-weighted average, represents the upper limit of exposure for a worker during a normal work day. It is worthwhile to note that OSHA's final rules for occupational exposure to asbestos acknowledged that "…a significant risk remains at the PEL of 0.1 f/cc" [8]. Instead of reducing the PEL even further, OSHA elected to eliminate or reduce this risk through mandated work practices, including engineering controls and respiratory protection for various classifications of asbestos-related construction activities [8].

ATSDR acknowledges two community exposure guidelines for airborne asbestos established by interagency workgroups following the World Trade Center collapse in 2001. For short-term (less than 1 year) exposures, 0.01 f/cc asbestos in indoor air was developed as an acceptable reoccupation level for occupants of residential buildings [25]. A risk-based comparison value of 0.0009 f/cc for asbestos in indoor air was established to be protective under long-term residential exposure scenarios [26]. All three exposure values (the OSHA PEL and the two World Trade Center community guidance values) are primarily applicable to airborne chrysotile asbestos fibers that have lower toxicity than Libby asbestos.

In the absence of any health- or risk-based comparison levels for asbestos in soil, dust, or bulk materials, ATSDR is evaluating these exposure pathways qualitatively, with strong consideration given to known or potential exposure scenarios at each site. For example, to determine whether asbestos in soil poses a public health hazard at a site, ATSDR is considering the concentration of asbestos in the soil, the horizontal extent of asbestos-contaminated surface areas, the presence or absence of ground cover, the frequency and type of activities that disturb soil, and accessibility. Soil containing Libby asbestos at levels greater than or equal to 1% is generally considered a health hazard requiring remediation. Depending on site-specific exposure scenarios, remediation or other measures may also be appropriate to prevent exposure to soil containing less than 1% Libby asbestos. Because federal standards regulate materials that contain more than 1% asbestos [27, 28], the 1% value has been used as an action level for soil remediation activities at a number of sites. EPA and ATSDR recognize that this 1% standard is not derived from a risk assessment or any other type of health-based analysis; therefore, it does not ensure that airborne asbestos fibers resuspended by disturbing these soils will be below levels protective of human health [29]. In fact, recent activity-based studies have shown that disturbing soil containing less than 1%

Libby asbestos can resuspend fibers and generate airborne concentrations at or near the OSHA permissible exposure limit [30, 31].

Results

A summary of the exposure pathway evaluations for the New Orleans site is presented in Table 2. The findings for each of the pathways are presented in the following paragraphs.

Table 1. Summary of pathway evaluations for the New Orleans site

Pathway	*Exposure Scenario*	*Timeframe*	*Pathway Status**	*Public Health Hazard Determination**
Occupational	Former workers inhaling Libby asbestos in and around the facility during handling and processing of contaminated vermiculite	**Past (1965–1989)**	**Complete**	**Public health hazard**
		Recent past (1989–2005)	Potential	Indeterminate
	Current on-site workers inhaling Libby asbestos from residual contamination inside former processing buildings or in on-site soil (residual contamination, buried waste)	Present/ Future	Potential	Indeterminate
Household Contact	Household contacts inhaling Libby asbestos brought home on workers' clothing, shoes, and hair	**Past (1965–1989)**	**Complete**	**Public health hazard**
		Recent past (1989–2005)	Potential	No apparent public health hazard
		Present/ Future	Potential	No apparent public health hazard
Community	Facility emissions: Community members or nearby workers inhaling asbestos fibers from plant emissions during handling and processing of contaminated vermiculite	Past	Potential	Indeterminate
		Present/ Future	Eliminated	No public health hazard
	Waste piles: Community members (particularly children) inhaling asbestos while playing in or disturbing piles of contaminated vermiculite or waste rock on the site	Past	Potential	Indeterminate
		Present/ Future	Eliminated	No public health hazard
	On-site soil: Community members inhaling Libby asbestos from contaminated on-site soil (residual contamination, buried waste)	Past	Potential	Indeterminate
		Present/ Future	Potential	No apparent public health hazard
	Residential outdoor: Community members inhaling Libby asbestos while using contaminated vermiculite or waste material at home (for gardening, driveways, fill material)	Past	Potential	Indeterminate
		Present/ Future	Potential	Indeterminate
	Residential indoor: Community members disturbing household dust containing Libby asbestos fibers from plant emissions or residential outdoor waste	Past	Potential	Indeterminate
		Present/ Future	Potential	No apparent public health hazard

*Pathway status descriptions and public health hazard category definitions are provided in Appendix A.
Bold type indicates a completed pathway that is considered a public health hazard.

Occupational pathway (past: 1965–1989 timeframe)

The occupational exposure pathway for former workers exposed to airborne Libby asbestos in and around the New Orleans facility during handling and processing of vermiculite during 1965–1989 is considered complete. On the basis of the available information concerning the intensity, frequency, and duration of past occupational exposures, this exposure pathway is considered a public health hazard.

Personal sampling results for workers at the facility indicate airborne fiber levels consistently in the range of 0.1 f/cc to 1 f/cc in the 1970s (Figure 7). These fiber levels were measured using phase contrast microscopy (PCM) analytical techniques.[3] By the mid-1980s, annual measured airborne PCM fiber concentrations from both personal and area sampling inside the facility were consistently below the current OSHA PEL of 0.1 f/cc. Personal samples, typically collected within a worker's breathing zone, were associated with specific workers. Most of the area sampling was conducted at consistent locations in the exfoliation process where fibers were likely to be released (e.g., the furnace baghouse, the furnace stoner deck where waste rock and expanded product were separated, the waste rock hopper) (EPA, unpublished data).

Air sampling data are not available from 1965 to 1974. Airborne fiber levels during this period were likely at or above the levels documented in 1975 (0.1 f/cc to 1 f/cc). Measured airborne fiber levels within the New Orleans facility decreased throughout the 1970s and 1980s as W.R. Grace responded to federal OSHA requirements[4] to protect workers from occupational asbestos exposure (EPA, unpublished data). Asbestos exposure levels for workers could have been much higher before the OSHA regulations were first introduced in 1971. Asbestos exposures would also be higher for workers in the past who manually performed some of the material handling processes, such as unloading vermiculite deliveries from railcars, transferring vermiculite into furnace hoppers, and transferring bulk quantities of waste rock.

The frequency and duration of former worker exposures varied depending on their job assignment, facility operation schedule, and period of employment. The New Orleans facility exfoliated vermiculite 24 hours a day, typically in three 8-hour shifts, for 5 days a week. The New Orleans facility reportedly employed 12 people in 1976 and 1978. The number of employees dropped to 8 by 1987. The length of employment for workers at the New Orleans facility is unknown. Workers appeared to perform the same job assignment throughout the day, such as bagging product, operating the furnace, or driving a forklift or front-end loader (EPA, unpublished data).

Industrial hygiene reports from 1986, 1987, and 1988 indicated some workers at the New Orleans facility had disposable, filtering face piece dust masks (3M 8710 model); however, reports from earlier years did not mention worker use of respiratory protection (EPA, unpublished data). Information is not available to evaluate the overall effectiveness of respiratory equipment in reducing worker exposures to asbestos at this facility. The overall effectiveness depends on several factors, including the protection factor of the masks, the effectiveness of the fit-testing protocols, and the actual compliance of individuals required to wear the masks. W.R. Grace appropriated funds to construct a shower and locker room area for employees at the New Orleans plant in 1977 (EPA, unpublished data). Information is not available to determine whether this project was completed and, if so, whether workers used the facilities.

[3] PCM analytical techniques cannot detect fibers less than 0.25 (<0.25) µm in diameter and cannot distinguish between asbestos and nonasbestos fibers. Reference Appendix B for more information about analytical techniques used for asbestos.

[4] Historically, the OSHA PEL for airborne asbestos has been lowered a number of times since it was first introduced: 12 f/cc (initial level, May 1971), 5 f/cc (December 1971), 2 f/cc (July 1976), 0.2 f/cc (June 1986), and 0.1 f/cc (August 1994).

Although most personal and area sampling data are associated with specific process operations, Libby asbestos fibers were released into the facility air throughout the workday during vermiculite processing and handling. In 1978, air samples collected in the employee lunch room and in the general warehouse area indicated 0.3 f/cc and 0.57 f/cc respectively (EPA, unpublished data).

Workers could have been exposed to Libby asbestos outside the facility as well. Fugitive emissions from loading, unloading, or transferring bulk vermiculite or waste rock resulted in outdoor airborne asbestos fiber releases. Information provided to EPA in 1978 by a company that exfoliated Libby vermiculite indicated airborne fiber levels were as high as 245 f/cc in the unloading area where unexpanded vermiculite was dumped from rail cars [32]. Stack emissions from the furnaces also contributed to outdoor fiber releases. W.R. Grace installed baghouse filters at the New Orleans facility in 1975 to control particulate emissions from the exfoliation furnace and Monokote mixer (EPA, unpublished data). The concentrations of particulates and airborne asbestos fibers in outdoor air around the facility due to fugitive and stack emissions were likely much higher before this control equipment was installed. Complaints from neighboring businesses about emissions from the New Orleans facility were documented in 1977 and 1981 (EPA, unpublished data).

Various non-W.R. Grace workers probably visited the New Orleans facility periodically to haul waste rock away from the facility, purchase products, pick up products for delivery, or provide services (e.g., construction and electrical services, equipment maintenance). These workers were probably exposed to airborne asbestos in and around the facility, but the frequency and duration of their exposures were likely very low. Data available from other facilities indicate waste haulers were exposed to asbestos as they loaded and unloaded waste rock (EPA, unpublished data). The intensity, frequency, and duration of the exposure to asbestos experienced by waste haulers may have been higher than the exposure of other non-W.R. Grace worker groups. All of these non-W.R. Grace workers were exposed much less frequently and for shorter durations than the full-time workers at the W.R. Grace facility itself.

Occupational pathway (recent past: 1989–2005 timeframe)

W.R. Grace terminated their lease to the site in 1989. Other businesses have leased the facility since that time. Most sources of Libby asbestos have been eliminated from the site; however, some abandoned vermiculite processing equipment is still housed in an unused area of the warehouse. Also, vermiculite was observed in soil near the railroad spur on the northwest side of the building. Insufficient information is available to determine whether the process equipment or soil on the site contains residual asbestos; therefore, exposure pathways involving these areas are considered an indeterminate public health hazard.

W.R. Grace reportedly cleaned the facility and collected six air samples in and around the facility in April 1989, after they stopped exfoliating vermiculite (EPA, unpublished data). Insufficient information is available to determine whether aggressive sampling was performed (aggressive methods include disturbing air and dust around the sample pump to re-suspend any residual fibers during sampling). Laboratory sample results indicated less than 0.0002 f/cc at each sample location (analytical detection limit listed as 0.004 f/cc) (EPA, unpublished data). ATSDR has no information concerning health and safety measures used for the W.R. Grace workers or contractors who cleaned the facility prior to sample collection.

Upon terminating their lease of the site, W.R. Grace sold some of the New Orleans processing equipment and office equipment to the Deckbar Company, the business that owns and leases the premises now (EPA, unpublished data). Among the items left behind or sold to the lessor were the unloading conveyor system for vermiculite, storage silos, the Monokote baghouse, the exfoliation furnace, and various material handling elevators and conveyors (EPA, unpublished data).

EPA Region 6 representatives inspected the site in February 2000, noting that the main warehouse building was clean [1]. Four empty metal storage silos and a conveyor system were documented on the north side of the building. Vermiculite processing equipment was also noted in an abandoned section of the warehouse. The EPA report stated that no waste rock was observed at the site.

ATSDR representatives returned to the site in September 2002 [2]. Site conditions were similar to those documented during EPA's site visit. The main portion of the warehouse was utilized by a clothing wholesale and printing company. The vermiculite processing equipment was still on the site in a separate but attached structure on the north end of the warehouse; this area was not being used by the current lessee. In addition to the processing equipment, the area contained several 55-gallon drums and various miscellaneous pieces of equipment and debris. However, no waste rock or vermiculite was observed in or around the processing equipment. Two empty metal silos were located north of the building. Some vermiculite was observed in the soil around the unused railroad spur, although this area was heavily vegetated. Most of the ground on the property was covered by the building and concrete parking areas. Grass and other vegetation covered the ground surface along the north, west and south sides of the building.

Insufficient data are available to evaluate whether the abandoned vermiculite processing equipment and areas of soil around the railroad spur contain residual asbestos fibers.

Occupational pathway (present/future timeframe)

Most sources of Libby asbestos seem to have been eliminated from the site. However, some abandoned vermiculite processing equipment is still housed in an unused area of the warehouse. Also, vermiculite was observed in soil near the railroad spur on the northwest side of the building. Insufficient information is available to determine whether the processing equipment or the soil on the site contain residual asbestos. These areas do not appear to be used now; the processing equipment is isolated in an unused portion of the warehouse and the railroad spur area is overgrown with vegetation. Future development of the site or a change in site usage could result in more frequent access of these areas. Exposure pathways involving these areas are considered an indeterminate public health hazard.

Household contact pathway (past: 1965–1989 timeframe)

Exposure of household contacts to airborne Libby asbestos brought home on the clothing, shoes, and hair of former workers is considered a complete exposure pathway that represents a public health hazard. Although exposure data are not available for household contacts, their exposures are inferred from documented former worker exposures and facility conditions that did not prevent contaminants being brought into the workers' homes.

Vermiculite exfoliation was reportedly a very dusty operation. W.R. Grace appropriated funds to construct a shower and locker room area for employees at the New Orleans plant in 1977 (EPA, unpublished data). Information is not available to evaluate whether this project was completed and, if so, whether workers used the showers or locker room in a way that would reduce or eliminate the amount of asbestos fiber contamination they carried home. Although W.R. Grace proposed on-site laundering facilities for all their exfoliation facilities in 1984, the proposal was not implemented due to union disputes (EPA, unpublished data).

Members of the households of former W.R. Grace workers were exposed to Libby asbestos fibers brought home on the workers' clothing, shoes, and hair if the workers did not shower or change clothes before leaving work. Family members or other household contacts could have been exposed to asbestos by direct contact with the worker or by laundering clothing. These exposures cannot be quantified without information concerning the levels of asbestos on the workers' clothing and behavior-specific factors (e.g., worker practices, household laundering practices). However, exposure to asbestos resulting in asbestos-related disease in family members of asbestos industry workers has been well-documented [33, 34]. Asbestos exposure in family members of Libby vermiculite workers has also been documented [18].

Household contact pathway (recent past: 1989–2002 timeframe)

Workers at the site may have been exposed to residual asbestos fibers associated with vermiculite processing equipment or soil on the site. The amount of asbestos contamination brought home by these workers was likely very low. Therefore, the exposure pathway for household members who had contact with the workers or their clothing is considered no apparent public health hazard.

Household contact pathway (present/future timeframe)

Current or future workers at the site may be exposed to residual asbestos fibers associated with the abandoned vermiculite processing equipment or soil on the site. The amount of asbestos contamination brought home by these workers would be very low. Therefore, the exposure pathway for household members who had contact with the workers or their clothing is considered no apparent public health hazard.

Community pathways (past timeframe)

Community members who lived or worked around the New Orleans facility from 1969 to 1989 could have been exposed to Libby asbestos from facility emissions, by disturbing or playing on on-site waste rock piles, by disturbing on-site soil, or from direct contact with waste rock brought home for personal use. Very little information is available to reconstruct the magnitude, frequency, or duration of these community exposures; therefore, they are considered an indeterminate public health hazard.

Community members and area workers could have been exposed to Libby asbestos fibers released into the ambient air from fugitive emissions or from furnace stack emissions generated while the facility was operating. The wind directions are primarily from the northeast, east, and south (Figure 4). Residential homes northeast and east of the facility were downwind some of the time. This residential area was present when the New Orleans facility began operating in 1969 [3].

Fugitive emissions from loading, unloading, or transferring bulk vermiculite or waste rock resulted in airborne asbestos fiber releases in areas outside the facility. Stack emissions from the furnaces also contributed to outdoor fiber releases. Complaints from neighboring businesses about emissions from the New Orleans facility were documented in 1977 and 1981 (EPA, unpublished data). W.R. Grace installed baghouse filters at the New Orleans facility in 1975 to control particulate emissions from the exfoliation furnace and the Monokote mixer (EPA, unpublished data). The concentrations of airborne asbestos fibers in outdoor air around the facility due to fugitive and stack emissions were likely much higher before the pollution control equipment was installed. Specific information concerning airborne fiber levels resulting from stack emissions is not available for the New Orleans site. At an exfoliation facility in Weedsport, New York in 1970, stack test data for an exfoliation furnace without particulate control equipment indicated particulate emission rates of 6 pounds per hour (EPA, unpublished data). Particulates captured by the filters in the pollution control equipment (when installed) reportedly contained 1%–3% friable Libby asbestos (EPA, unpublished data).

The exposure pathways for community members (particularly children) playing in or otherwise disturbing on-site piles of contaminated vermiculite, waste rock, or on-site soil at the facility in the past is considered a potential exposure pathway. When the facility was operating, waste rock may have been temporarily stockpiled on the site and accessible to children and other community members. Anecdotal or photographic evidence of children playing in on-site waste piles is available for several similar exfoliation facilities [10, 11, 35].

Community members use of contaminated vermiculite or waste material at home is considered a potential exposure pathway. At a former vermiculite exfoliation facility in Minneapolis, Minnesota, waste rock was advertised as “free crushed rock,” and community members took it home to use in their yards, gardens, and driveways [10]. Insufficient information is available to determine whether this happened in the community around the New Orleans facility while the facility operated. If so, people may have been exposed to airborne Libby asbestos by handling waste rock and working with it in their yards and gardens.

Libby asbestos fibers could have infiltrated homes surrounding the New Orleans facility from plant emissions or from waste rock brought home for personal use. Insufficient information is available concerning past air emissions and community use of waste rock; therefore, residential indoor exposure to Libby asbestos fibers is an indeterminate past public health hazard.

Community pathways (present/future timeframe)

Most community members who live or work near the site now are not being exposed to Libby asbestos from the site. Several community exposure pathways, such as ambient air emissions, piles of vermiculite and waste rock on the site, and asbestos-contaminated soil on the site, have been eliminated and therefore pose no public health hazard to the current community. Pathways involving exposure of individuals to waste rock brought home from the facility in the past for personal use as fill material, driveway surfacing material, or soil amendments are potentially complete. Because not enough information is available to determine whether individuals brought waste rock home for personal use, this exposure pathway is considered an indeterminate public health hazard.

During site visits in 2000 and 2002, EPA and ATSDR staff noted that no waste piles were present at the site [1, 2]. The present and future exposure pathway to on-site waste piles is considered eliminated and therefore poses no public health hazard to community members.

Present and future exposures to Libby asbestos from facility air emissions also have been eliminated because the facility is no longer in operation.

Not enough information is available to determine whether individuals brought waste rock home for personal use. Vermiculite or waste rock brought home from the facility in the past could still be a source of exposure today. If the asbestos-containing material is covered (with soil, grass, or other vegetation) and is not disturbed, the asbestos fibers will not become airborne and will not pose a public health hazard.

Facility emissions have ceased and are no longer a source of potential contamination in nearby homes. Residual Libby asbestos from potential past sources is possible, though housekeeping (particularly wet cleaning methods) over the past years would probably have removed any residual Libby asbestos in area homes. The only likely current source of Libby asbestos fibers in the home would be from waste rock brought home for residential use. Insufficient information is available to determine whether waste rock was used in the community. However, the waste rock alone would not be expected to contribute significantly to residential indoor exposure. The current and future residential indoor exposure pathway is considered no apparent public health hazard for community members.

Discussion

Exposure pathway evaluations

Processing and handling of asbestos-contaminated vermiculite at the New Orleans facility clearly resulted in asbestos exposures to former workers and their household contacts while the facility was operating. Sufficient site- and process-specific information is available to consider these exposures a public health hazard. On the basis of the available information, ATSDR estimates that 70 to 90 former workers were exposed during the time the plant operated. The frequency and duration of former worker exposure depended upon the workers' job assignments, facility operation schedules, and periods of employment. Use of respiratory protection would also influence the degree of worker exposure to airborne asbestos fibers.

Some abandoned vermiculite processing equipment is still present in an unused area of the warehouse. Also, vermiculite was observed in soil near the railroad spur on the northwest side of the building. Insufficient information is available to determine whether the processing equipment or on-site soil contain residual asbestos. The processing equipment, the room where the equipment was housed, and the areas of soil near the railroad spur did not appear to be used during recent EPA and ATSDR site visits, but future redevelopment of the site or a change in site usage could result in more frequent access of these areas.

Community members who lived or worked near the New Orleans facility in the past could have been exposed to Libby asbestos from facility emissions, by disturbing or playing on waste rock piles at the site, by disturbing on-site soil, or from direct contact with waste rock brought home for personal use. Very little information is available to verify these community exposures or to quantify their magnitude, frequency, or duration. They are therefore considered an indeterminate public health hazard. The two potential pathways of greatest concern are (1) plant emissions of Libby asbestos that may have reached downwind residential areas during 1969–1974 (before pollution control equipment was installed) and (2) on-site waste rock piles that may have been accessible to community members, especially children. Children who were exposed to asbestos are a population of particular concern because of the length of time the asbestos fibers could remain in their lungs and the long latency period of asbestos-related diseases.

Most community members who live or work near the site now are not being exposed to Libby asbestos from the site. Several community exposure pathways that existed while the facility was operating, such as plant emissions and vermiculite and waste rock piles on the site, have been eliminated. EPA did not find any evidence of asbestos-contaminated waste rock during a thorough visual inspection of residential and commercial properties adjacent to the site. However, not enough information is available to determine whether some individuals may still be exposed to Libby asbestos through direct contact with waste rock taken from the site in the past to use in the community as fill material, driveway surfacing material, or as a soil amendment.

Potential health impacts

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 nature of potential health impacts.

Given the limited or nonexistent exposure data available to characterize many of the pathways associated with Libby asbestos at the New Orleans site, the risk for future adverse health effects among exposed people cannot be quantified. ATSDR is working with state health department partners across the United States to review historical health statistics for communities around many of the facilities that processed Libby vermiculite, including the New Orleans facility. As this information is reviewed and validated, ATSDR's Division of Health Studies will release the findings of the health statistics reviews in a separate summary report.

Limitations

A number of site-specific limitations affect the exposure pathway evaluation and health risk characterization efforts at the New Orleans site. Exposure data are not available for many of the past and current exposure pathways. This information may never be available for the past exposure scenarios. Site-specific sampling results that are available do not typically describe the mineralogy and fiber size distribution of asbestos detected; this information is critical to quantitatively assess the actual toxicity and potential health impacts associated with an exposure. Historical personal and area samples collected in the New Orleans facility and analyzed by phase contrast microscopy (PCM; see Appendix B) refer to measured fiber levels. However, fibers other than asbestos may have been counted in the sample analyses. PCM techniques alone cannot distinguish between asbestos and other, nonasbestos fibers. PCM techniques also cannot detect thin fibers with a diameter less than 0.25 µm.

Limitations in the current state of science related to amphibole asbestos also influence the evaluation of Libby asbestos exposures and associated health risks. Health-based comparison values representing "safe" levels of amphibole asbestos in air have not yet been developed. Determining "safe" levels of asbestos in environmental media such as soil or dust is even more difficult because a safe level is not determined by the inherent asbestos fiber or mass concentration in the medium itself, but rather on the potential airborne fiber exposures associated with disturbing asbestos-contaminated soil or dust.

A practical model or empirical relationship to estimate the resuspension of asbestos fibers from soil or dust into air during realistic exposure scenarios does not exist. Two options are available to estimate the resuspension of asbestos fibers from soil or dust into air during realistic exposure scenarios, but they are both relatively difficult and costly to implement. One option is to conduct site-specific, activity-based field tests that directly measure airborne fiber levels during simulated exposure scenarios. The other option is to collect site-specific soil samples, analyze them in accordance with EPA 540/R/97/28[5] to obtain the number of asbestos fibers per mass unit of soil released to the air, and then use this information in an appropriate air modeling effort to simulate exposure scenarios.

An adequate toxicological model to evaluate the noncarcinogenic health risks of amphibole asbestos exposure does not exist. The current EPA model used to quantify carcinogenic health risks due to asbestos exposure has significant limitations, including the fact that it does not consider mineralogy or fiber size distribution and it combines lung cancer and mesothelioma risk into one slope factor. EPA is in the process of updating their asbestos risk methodologies. A draft model for quantifying carcinogenic health risks associated with amphibole asbestos has been developed, although it has not been formally accepted through the EPA review process [21]. This draft methodology requires detailed asbestos sample characterization beyond what was generated at these sites. Data gaps in scientific research concerning Libby asbestos have resulted in ongoing and largely unresolved discussions within the scientific community regarding the potential health risks of low-level, intermittent exposures and the relative importance of short asbestos fibers (i.e., fibers <5 micrometers in length) in noncancer health effects [22, 23].

Additional considerations and limitations associated with asbestos-related evaluations are provided in Appendix B.

Public health response

Most of the current and future exposure pathways associated with Libby asbestos at the New Orleans site have been eliminated or do not pose a public health hazard. The abandoned vermiculite processing equipment that remains at the site and the vermiculite-containing soil around the railroad spur are considered potential exposure pathways that should be addressed.

ATSDR characterized the presence of waste rock in the community as a potential exposure pathway that poses an indeterminate health hazard. Insufficient information is available to determine whether this pathway is complete or if the identified uses of this waste material in the past (at other facilities) would result in significant exposures today. Providing awareness and information to people in the neighborhood surrounding the New Orleans facility is an appropriate public health response at this time.

ATSDR characterized several historical exposure pathways as either confirmed or indeterminate public health hazards. Increased health risks due to past exposure to Libby asbestos are difficult to quantify, and actual asbestos-related health effects are difficult to treat. The latency period between asbestos exposure and disease can be 15 to 20 years or more. Asbestos-related diseases

[5] U.S. Environmental Protection Agency. Superfund method for the determination of releasable asbestos in soils and bulk materials. Washington DC: EPA Office of Solid Waste and Emergency Response; 1997.

are not curable, though some treatments are available to ease the symptoms and perhaps slow disease progression. People who have been exposed to asbestos can take steps to control their risk or susceptibility, such as preventing additional exposure to asbestos and refraining from smoking.

At this site, where little can be done about past asbestos exposure or possible resulting health effects, promoting awareness and offering health education to exposed and potentially exposed populations are important public health actions. For exposed individuals (e.g., former workers, their household contacts, and children who played in waste piles), health messages should be structured to facilitate self-identification and encourage exposed persons to either inform their primary care physician about their asbestos exposure or consult a physician with expertise in asbestos-related lung disease. Health care provider education in this community would facilitate improved surveillance and recognition of atypical risk factors (for example, those related to nontraditional asbestos-related occupations or nonoccupational exposure) that can contribute to asbestos-related diseases.

Conclusions, recommendations, and public health action plan

Former workers and their household contacts (1965–1989)

People who worked at the W.R. Grace New Orleans facility during 1965–1989 were exposed to airborne levels of Libby asbestos above current occupational standards. Chronic exposure to airborne asbestos at these elevated levels increased their risk for asbestos-related disease and therefore posed a *public health hazard* to former employees.

Members of the households of former workers may have been exposed to asbestos fibers if the workers did not shower or change clothes before leaving work. Although exposure data are not available for household contacts of former exfoliation workers, their exposures are inferred from documented worker exposure and facility conditions. This pathway therefore represents a *public health hazard* to members of the households of former workers.

Recommendations

- Promote awareness of past asbestos exposure among former workers and members of their households.
- Encourage former workers and their household contacts to inform their primary care physician about their exposure to asbestos. If former workers or their household contacts are concerned or symptomatic, they should be encouraged to see a physician who specializes in asbestos-related lung diseases.

Public health action plan

- ATSDR will develop and disseminate reliable and easily accessible information concerning asbestos-related health issues for exposed individuals and health care providers.
- ATSDR will publicize the findings of this health consultation in the community around the site; ATSDR will make the report accessible on the Internet and in the community.
- ATSDR will notify former workers for whom contact information is known and provide exposure and health information about asbestos.
- ATSDR is researching and determining the feasibility of conducting additional worker and household contact follow-up activities.

Current or future workers and their household contacts (1989 to present/future)

Available air sampling data indicate that the inside of the building has no residual Libby asbestos sources. Insufficient information is available to determine whether the abandoned processing equipment or the vermiculite-containing soil near the railroad spur contain residual asbestos. These areas do not appear to be used now; the processing equipment is isolated in an unused portion of the warehouse and the railroad spur area is overgrown with vegetation. If these conditions change, exposure pathways involving these areas represent an *indeterminate public health hazard*.

Recommendations

- Before using or moving the processing equipment, it should be assessed for residual asbestos fibers. The debris in the area surrounding the equipment should also be assessed for the presence of asbestos.
- Before using, disturbing, or developing the area of the site around the railroad spur, the soil should be assessed for residual asbestos fibers.
- If residual asbestos is detected in either of these areas, appropriate measures should be employed to eliminate or reduce exposure to asbestos.

Public health action plan

- ATSDR will inform the site owner of the findings and recommendations of this report.
- ATSDR will coordinate with EPA and state environmental and health officials to ensure awareness of the site conditions and work with the site owner to address them.

Community members who lived near the facility (1965–1989)

The people in the community around the site during the time the New Orleans facility processed Libby vermiculite could have been exposed to Libby asbestos fibers by disturbing or playing in soil or waste piles on the site, from plant emissions, from waste rock brought home for personal use, or from indoor household dust that contained Libby asbestos from one or more outside sources. Insufficient information is available to determine whether these exposures occurred, how often they may have occurred, or what concentrations of airborne Libby asbestos may have been present during potential exposure. This information may never be available. Because critical information is lacking, these past exposure pathways for community members are considered *indeterminate public health hazards*.

Recommendations

- Promote awareness of potential past asbestos exposures among community members who lived near the facility during 1965–1989. Provide these people with easily accessible materials that will assist them in identifying their own potential for exposure.
- Encourage persons who lived in the community in the past and feel they were exposed to inform their regular physician about their potential asbestos exposure.

Public health action plan

- ATSDR will develop reliable, easily accessible, and understandable information concerning asbestos-related health issues for individuals who may have been exposed and for health care providers in the area.
- ATSDR will publicize the findings of this health consultation in the community around the site. ATSDR will make the report accessible on the Internet and in the community.

Community members who live near the site now (1989 to present)

The New Orleans facility no longer processes vermiculite at the site; they stopped processing vermiculite from Libby in 1989. Many of the community exposure pathways, such as ambient emissions and disturbing or playing on on-site waste piles, have been eliminated. Areas of asbestos-contaminated soil at the site and surrounding property have been excavated and disposed of appropriately. These exposure pathways pose *no public health hazard* to the surrounding community members.

Currently, individuals in the community could be exposed to airborne Libby asbestos from waste rock brought home from the facility in the past and used as fill material, for gardening, or for paving driveways. This exposure pathway is an *indeterminate public health hazard* because insufficient information is available to determine whether waste rock was used in the community.

Recommendations

- Promote awareness of potential asbestos exposure from direct contact with waste rock brought home from the facility in the past. Provide easily accessible materials to help community members in identify their own potential for exposure.

Public health action plan

- ATSDR will develop reliable, easily accessible, and understandable information concerning asbestos-related health issues for individuals who may have been exposed and for health care providers in the area.
- ATSDR will publicize the findings of this health consultation in the community around the site. ATSDR will make the report accessible in the community and on the Internet.

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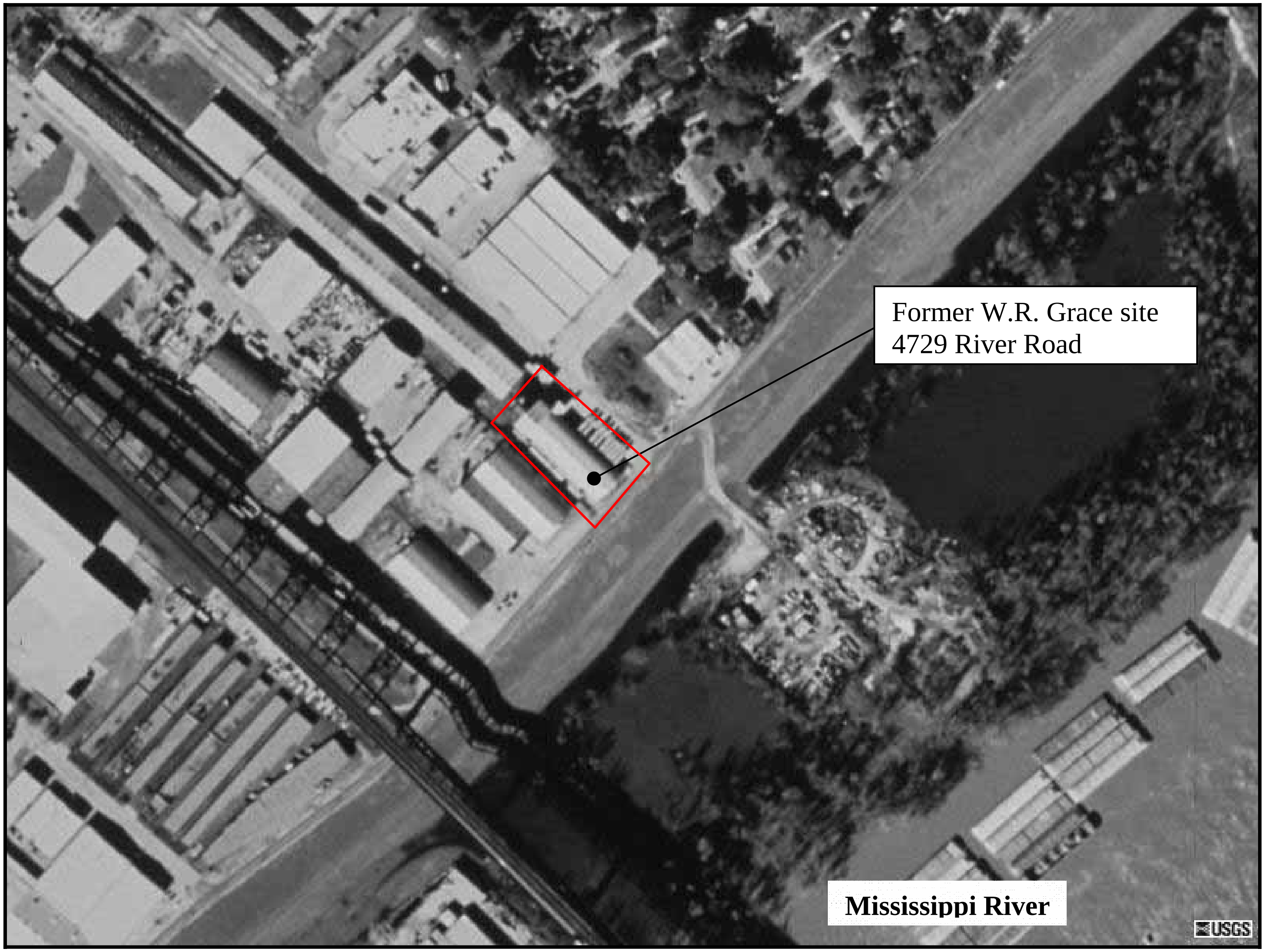
Figures

Figure 1. Site location map*

* Source: LouisianaMAP geospatial portal available at http://wwwlamap.doa.state.la.us/default.htm.

Figure 2. Aerial photograph of the site and surrounding area, 1998*



* Source: Aerial photography print service for 4729 River Road, New Orleans, Louisiana. Historical aerial photographs from US Geological Survey (1998). Milford, Connecticut: Environmental Data Resources, Inc.; 2004. Site boundaries are approximate.

Figure 3. 1990 US census data for the area surrounding the New Orleans, Louisiana, site

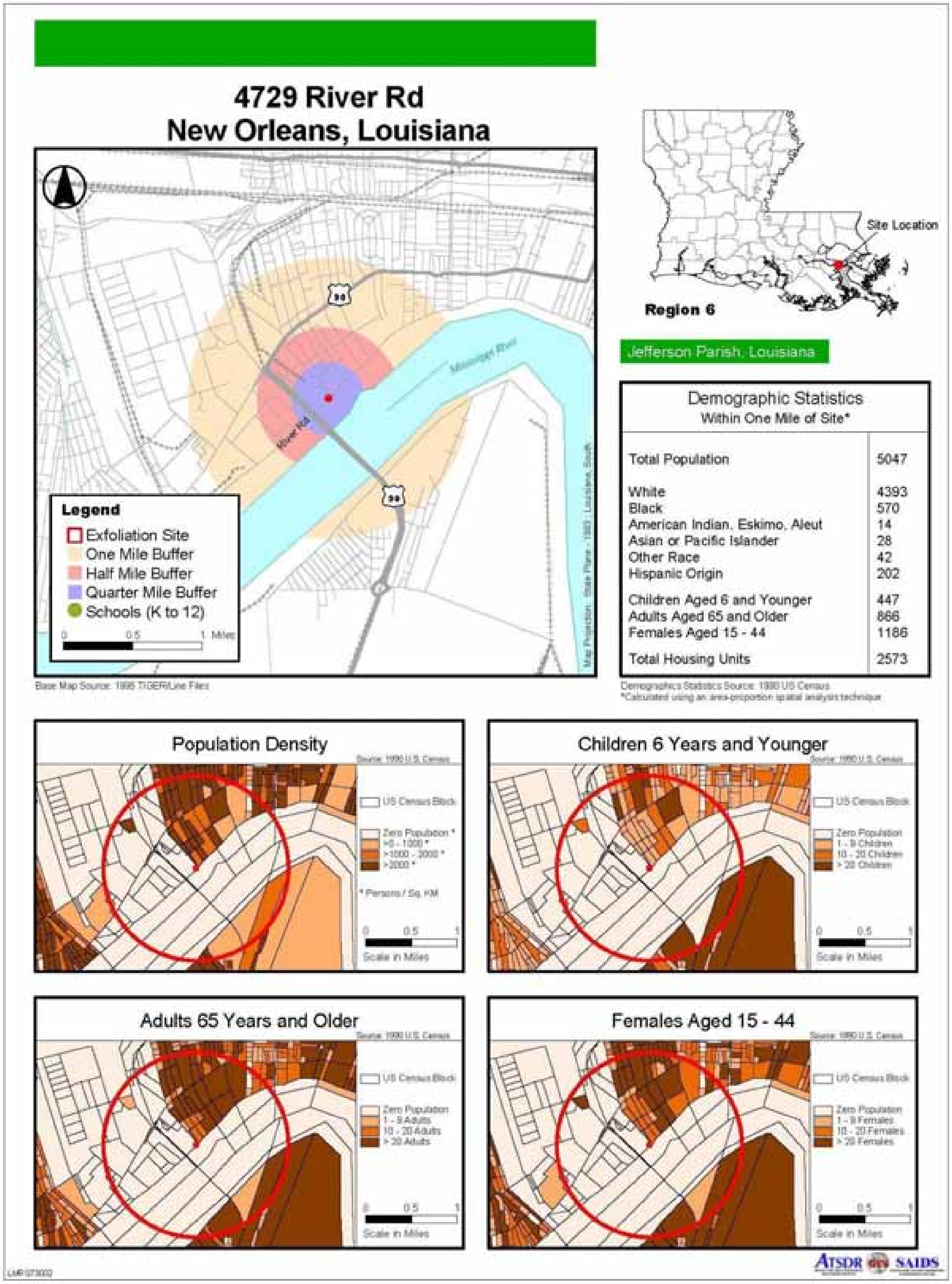


Figure 4. Meteorological data from the New Orleans International Airport

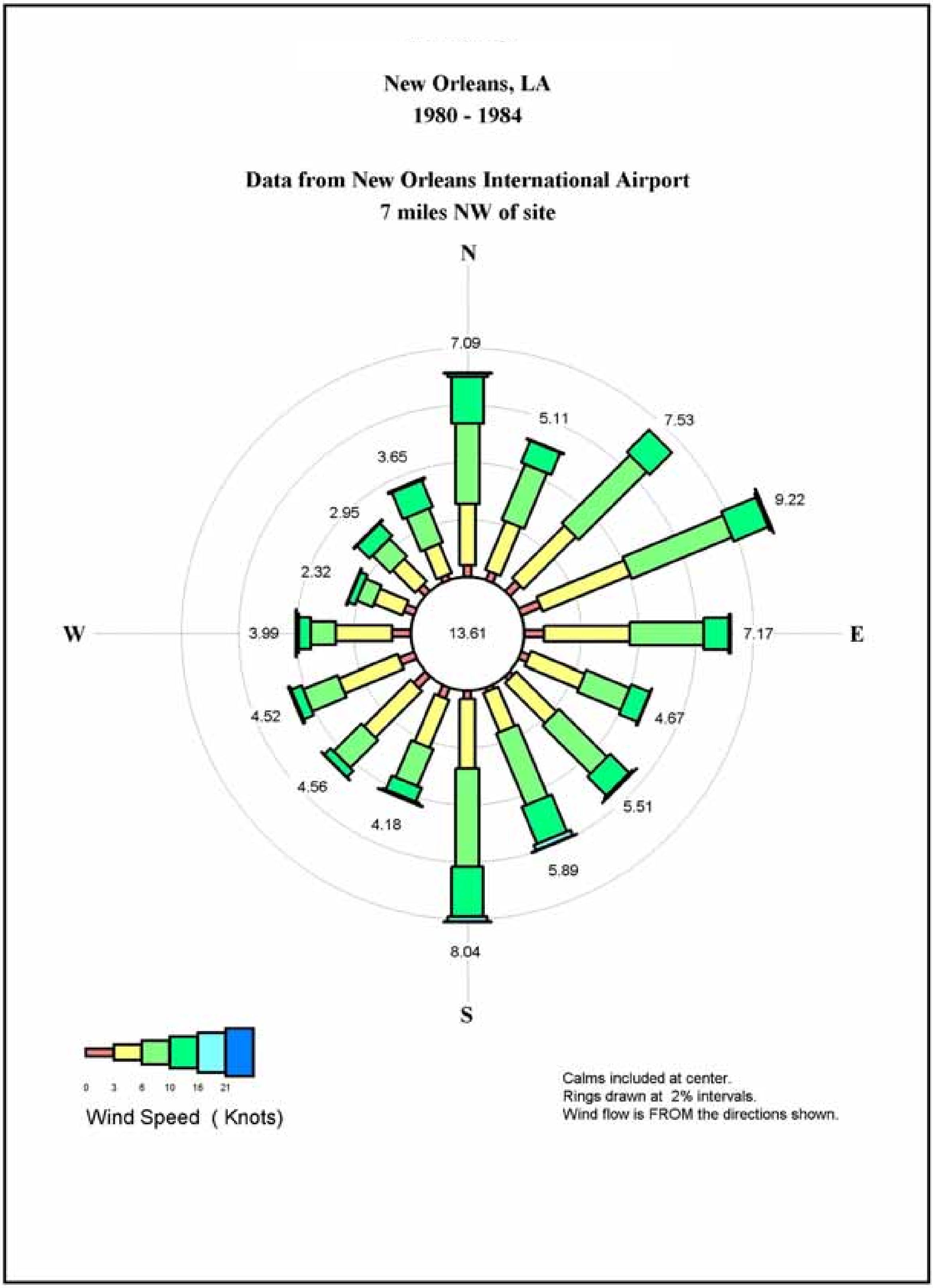
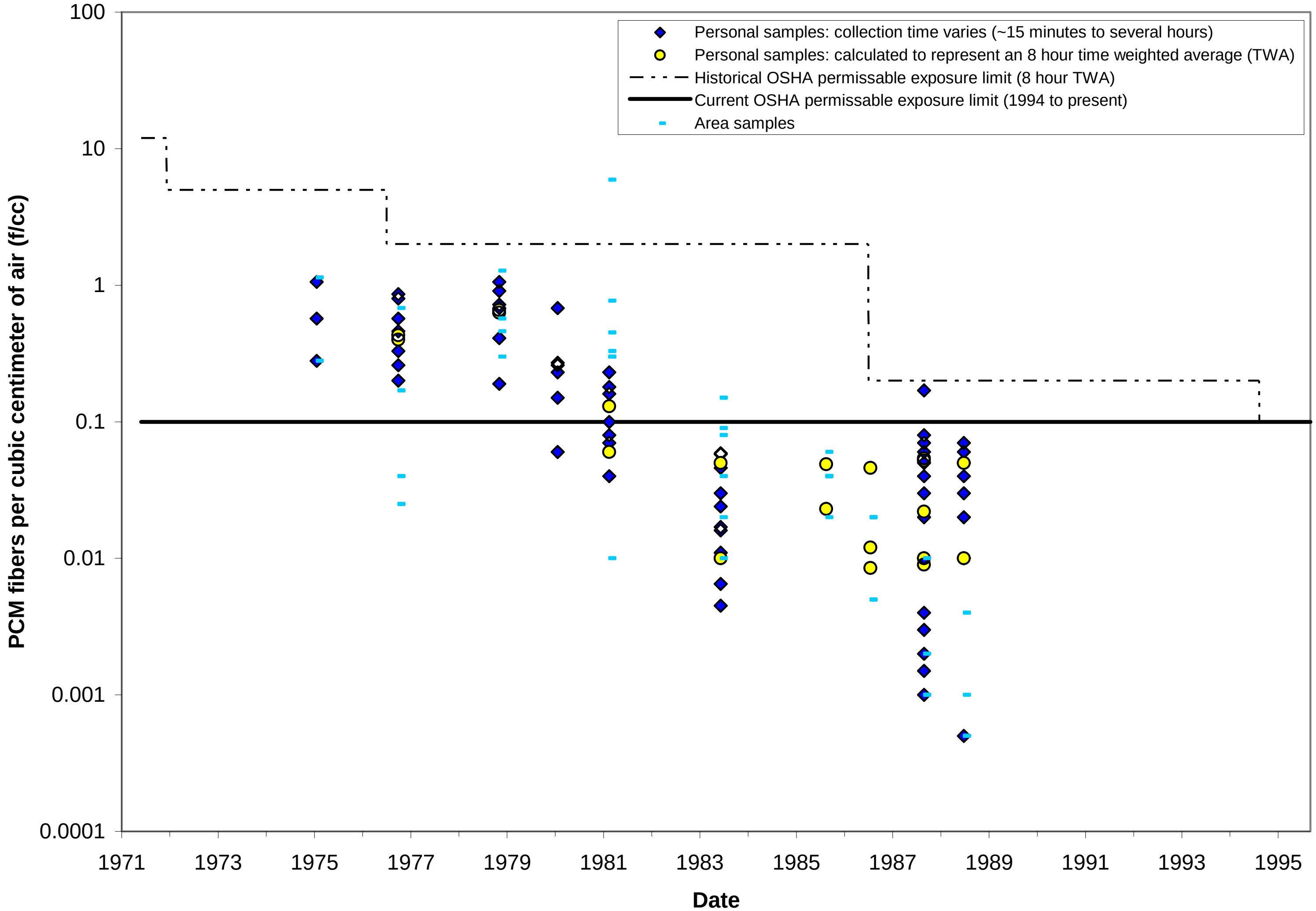


Figure 5. Vermiculite

Figure 6. Waste rock

Waste rock from vermiculite exfoliation can look like other types of rock. The only way this waste rock could be present in your yard is if someone brought it there from a vermiculite processing plant in the past. This waste rock often contains visible "bundles" or blocky fragments of asbestos that are grayish-white and about the size of a grain of rice.

Figure 7. Airborne PCM fiber concentrations over time: personal and area sample data (N=132) at the former W.R. Grace facility, New Orleans, Louisiana*



* From W.R. Grace Industrial Hygiene Surveys, 1975-1988. Personal samples were collected within a worker's breathing zone. Area samples were collected at various points around the processing equipment or other occupied spaces of the building. Fibers concentrations were determined by phase contrast microscopy (PCM) using counting rules similar to NIOSH Method 7400.

Appendix A. Definitions

Exposure pathways

An exposure pathway is the way in which an individual comes into contact with a contaminant. An exposure pathway consists of the following five elements: (1) a *source* of contamination; (2) a *medium* such as air or soil through which the contaminant is transported; (3) a *point of exposure* where people can contact the contaminant; (4) a *route of exposure* by which the contaminant enters or contacts the body; and (5) a *receptor population*. A pathway is considered **complete** if all five elements are present and connected. A p**otential** exposure pathway indicates that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future. A potential exposure exists when information about one or more of the five elements of an exposure pathway is missing or uncertain. An **incomplete** pathway is missing one or more of the pathway elements and it is likely that the elements were never present and are 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 exposure.

Public health hazard categories

ATSDR uses public health hazard categories to describe 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 defined as follows.

No public health hazard

A category used in ATSDR's assessments for sites where people have never been and will never be exposed to harmful amounts of site-related substances.

No apparent public health hazard

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

Appendix B. 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. Fibrous amphibole minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA include five classes: crocidolite, amosite, and the fibrous forms of tremolite, actinolite, and anthophyllite. Other unregulated amphibole minerals, including winchite, richterite, and others, can also exhibit fibrous asbestiform properties [1].

Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate into the air, although individual asbestos fibers can easily be suspended in the air. Asbestos fibers do not move through soil. They are resistant to heat, fire, and chemical and biological degradation. As such, they can remain virtually unchanged in the environment over long periods of time.

Vermiculite that was mined in Libby, Montana, contains amphibole asbestos, with a characteristic composition including tremolite, actinolite, richterite, and winchite; this material will be referred to 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 by-product 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%–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

A number of different analytical methods are 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 lengths greater than 5 micrometers (>5 µm) and 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 less than 0.25 (<0.25) µm in diameter 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 can detect fibers with lengths greater than approximately 1 μm (~1 μm), widths greater than ~0.25 μm, and aspect ratios (length-to-width ratios) greater than 3. Detection limits for PLM methods are typically 0.25%–1% asbestos.

Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods that can detect smaller fibers than light microscopic techniques. TEM allows the use of electron diffraction and energy-dispersive x-ray methods, which give information on crystal structure and elemental composition, respectively. This information can be used to determine the elemental composition of the visualized fibers. SEM does not allow measurement of electron diffraction patterns. One disadvantage of electron microscopic methods is that determining asbestos concentration in soil and other bulk material is difficult [1].

For risk assessment purposes, TEM measurements are sometimes multiplied by conversion factors to give PCM equivalent fiber concentrations. The correlation between PCM fiber counts and TEM mass measurements is very poor. A conversion between TEM mass and PCM fiber count of 30 micrograms per cubic meter per fiber per cubic centimeter (μg/m3)/(f/cc) was adopted as a conversion factor, but this value is highly uncertain because it represents an average of conversions ranging from 5 to 150 (μg/m3)/(f/cc) [3]. The correlation between PCM fiber counts and TEM fiber counts is also very uncertain, and no generally applicable conversion factor exists for these two measurements [3]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular air sample.

Asbestos Health Effects and Toxicity

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. This cancer can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure [1].

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].

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].

Not enough evidence is available to determine 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 non-cancer effects. However, some evidence indicates 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].

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

The scientific community generally accepts the 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 <5 µm are essentially non-toxic in terms of association with mesothelioma or lung cancer promotion. However, fibers <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 reach this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly because physical differences allow chrysotile to break down and to be 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]. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [6]. Currently, EPA's Integrated Risk Information System (IRIS) assessment of asbestos also currently treats mineralogy (and fiber length) as equipotent.

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 as fiber type to the observed variation in risk [7].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects. Fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to deposit preferentially in the deep lung, but longer fibers may disproportionately increase the risk of mesothelioma [1,7]. 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 thus 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 [7].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, asbestos-containing materials are defined as any material with >1% bulk concentration of asbestos [8]. 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 soil containing <1% amphibole asbestos, however, can suspend fibers at levels of health concern [9].

Friable asbestos (asbestos which is crumbly and can be broken down to suspendible fibers) is listed as a hazardous air pollutant on EPA's Toxic Release Inventory [10]. This classification requires companies that release friable asbestos at concentrations >0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to-Know Act.

OSHA's permissible exposure limit (PEL) is 0.1 f/cc for asbestos fibers with lengths >5 µm and with an aspect ratio (length:width) >3:1, as determined by PCM [6]. This value represents a time-weighted average (TWA) exposure level based on 8 hours per day for a 40-hour work week. In addition, OSHA has defined an "excursion limit," which stipulates that no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [6]. 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 on the basis of 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 exposure for community members, because the PEL was developed as an occupational exposure for adult workers.

In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in buildings in the area, the Department of Health and Human Services, EPA, and the Department of Labor formed the Environmental Assessment Working Group. This work group was made up of ATSDR, EPA, CDC's National Center for Environmental Health, the National Institute for Occupational Safety and Health (NIOSH), the New York City Department of Health and Mental Hygiene, the New York State Department of Health, OSHA, and other state, local, and private entities. The work group set a re-occupation level of 0.01 f/cc after cleanup. Continued monitoring was also recommended to limit long-term exposure at this level [11]. In 2002, a multiagency task force headed by EPA was formed specifically to evaluate indoor environments for the presence of contaminants that might pose long-term health risks to residents in Lower Manhattan. The task force, which included staff from ATSDR, developed a health-based benchmark of 0.0009 f/cc for indoor air. This benchmark was developed to be protective under long-term exposure scenarios, and it is based on risk-based criteria that include conservative exposure assumptions and the current EPA cancer slope factor. The 0.0009 f/cc benchmark for indoor air was formulated on the basis of chrysotile fibers and is therefore most appropriately applied to airborne chrysotile fibers [12].

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 work week [13]. The American Conference of Government Industrial Hygienists 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, on the basis of 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's IRIS model calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos [3]. 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 because the slope factor above this concentration might differ from that stated [3]. 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 IRIS model currently used and the knowledge gained since this model was implemented in 1986.

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Appendix C: Exposure pathways for vermiculite processing facilities*

Pathway	Environmental media and transport mechanisms	Point of exposure	Route of exposure	Exposed population	Time
Occupational	Suspension of Libby asbestos fibers or contaminated dust into air during materials transport and handling operations or during processing operations	On the site	Inhalation	Former workers	Past
	Suspension of Libby asbestos fibers into air from residual contamination inside former processing buildings	Inside former processing buildings	Inhalation	Current workers	Present, Future
Household Contact	Suspension of Libby asbestos fibers into household air from clothing or body of workers who did not shower or change clothes after work	Workers' homes	Inhalation	Former and/or current workers' families and other household contacts	Past, present, future
Waste Piles	Suspension of Libby asbestos fibers into air by playing in or otherwise disturbing piles of vermiculite or waste rock	Waste piles on the site	Inhalation	Community members, particularly children	Past, present, future
On-site soil	Suspension of Libby asbestos fibers into air from disturbing contaminated material remaining in on-site soils (residual soil contamination, buried waste)	At areas of remaining contamination at or around the site	Inhalation	Current on-site workers, contractors, community members	Past, Present, future
Ambient Air	Stack emissions and fugitive dust from plant operations into neighborhood air	Neighborhood around site	Inhalation	Community members, nearby workers	Past
Residential Outdoor	Suspension of Libby asbestos fibers into air by disturbing contaminated vermiculite brought off the site for personal uses (gardening, paving driveways, traction, fill)	Residential yards or driveways	Inhalation	Community members	Past, present, future
Residential Indoor	Suspension of household dust containing Libby asbestos from plant emissions or waste rock brought home for personal use	Residences	Inhalation	Community members	Past, present, future
Consumer Products	Suspension of Libby asbestos fibers into air from using or disturbing insulation or other consumer products containing Libby vermiculite.	At homes where Libby asbestos-contaminated products were/are present	Inhalation	Community members, contractors, and repairmen	Past, present, future

* The contaminant source for all pathways is asbestos-contaminated vermiculite from Libby, Montana.