

Health Consultation
W.R. Grace & Company Santa Ana Plant
2502 S. Garnsey Street
Santa Ana, Orange County, California

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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 around the U.S. 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 federal, state, and local environmental and public health agencies to evaluate public health impacts at sites that processed Libby vermiculite.

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

The sites that processed Libby vermiculite will be evaluated by (1) identifying ways 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 on the basis of the following criteria:

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

- or -

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

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

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

Site Background

In 2001, the site was evaluated by contractors for the EPA as part of a national evaluation of facilities that received ore from the mine in Libby, Montana [1]. W.R. Grace & Company's Santa Ana Plant (referred to herein as the Santa Ana Plant) was selected for review based on its high tonnage. It was one of the highest volume vermiculite processors in the nation. From 1972 until 1993, the plant received approximately 400,000 tons of vermiculite from the Libby mine (Unpublished data from EPA's database of W.R. Grace invoices). Interviews conducted by EPA as part of its assessment of this site revealed that the plant processed vermiculite until 1993 [1]. Industrial sources, such as stack emissions from exfoliation plants and industrial users of vermiculite, probably contribute the bulk of asbestos releases from vermiculite mined at Libby, Montana [2]. The Santa Ana Plant is located at 2502 South Garnsey Street in the city of Santa Ana, Orange County, California. The facility is still owned by W.R. Grace & Co. The site consists of approximately four acres. The immediate site surroundings are mainly light industrial and commercial, with an elementary school located approximately 200 yards to the north of the facility (built in 1950). Residential development occurs in all directions within one mile of the site.

Site Demographic Information

1990 US census data indicated that approximately 35,000 people lived within one mile of the site. Demographic information is included in the site introduction map, Appendix A, Figure 1. 1990 US census data also indicate that the majority of homes in the surrounding census blocks were built during or prior to the time that the plant was processing vermiculite (see Appendix A, Figures 2 and 3). According to 2000 census data, approximately 94% of the structures were built prior to 1980. In the 1990 census, approximately 93% of the structures were built prior to 1980. Also, the census data show that residents in the area during the 2000 and 1990 census were present during plant operations (see Appendix A, Figures 4 and 5). At least 48.8% of the 2000 population was residing in the area during the time when the plant was in operation.

Site Climate Information

Temperatures in Santa Ana range from an average low of 54° F to an average high of 75° F. Santa Ana receives approximately 12.27 inches of rain annually. According to the Santa Ana plant manager, prevailing winds are from the southwest. However, the wind comes from the east in a "Santa Ana" wind event [1].

Vermiculite Processing

Vermiculite is a non-fibrous, platy, weathered mica mineral type used in many commercial and consumer applications [3]. Raw vermiculite is used in gypsum wallboard, cinder blocks, and many other products, and exfoliated vermiculite is used as loose fill insulation, as a fertilizer carrier, and as an aggregate for concrete [3]. Exfoliated vermiculite is formed by heating the ore to approximately 2,000 degrees Fahrenheit (°F), which explosively vaporizes the water contained within the mineral structure and causes the vermiculite to expand by a factor of 10 to 15 [3]. The

Santa Ana Plant produced expanded vermiculite and the vermiculite-containing material Monokote[®], a fireproofing material typically sprayed on steel beams. The facility also produced other products from expanded vermiculite, such as attic insulation, masonry fill, pool cushion, soil mix, soil conditioner, stabilized concrete aggregate, and dealer stabilized concrete aggregate. W.R. Grace stopped producing Monokote[®] with vermiculite at this site in 1990. In 1993, the site ceased vermiculite expansion operations. Currently, the site produces Monokote 6[®] by using polystyrene and gypsum [1].

During a site evaluation, EPA interviewed several current workers who worked at the facility in the 1970s and 1980s. During the time that vermiculite was used at the facility, plant workers unloaded rail cars, operated furnaces, and ensured that vermiculite flowed through the production process [1]. Vermiculite arrived in as many as three covered rail cars daily, although sometimes, a week or two could pass between shipments. Conveyors were used to move vermiculite from a rail car to the silos and then to the furnaces. The furnaces expanded the vermiculite to its final form. From there, the product was separated from the waste rock (stoner rock) and bagged. Product bags were then sewn shut. According to the employees interviewed by EPA, waste rock was sent to Phoenix for encapsulation, to the Libby Mine via boxcar, or to a hazardous waste facility in Kettleman City, California [1]. Employees reported that bag houses have always been present for dust control. Bag houses were cleaned every week to every other week. According to the plant manager, air sampling was conducted on a yearly basis. Workers said they wore cotton disposable masks and that respirators and disposable suits were available [1].

Through the National Asbestos Exposure Review, ATSDR and its partners have learned other past process information that may apply to the Santa Ana Plant. For example, at many vermiculite processing sites, before ore and waste handling was automated, workers used shovels or front end loaders to handle ore. Other types of asbestos, particularly chrysotile, were reportedly used in the Monokote[®] mixing process. According to the plant manager, the Santa Ana Plant ceased making the particular type of Monokote[®] that used chrysotile in 1974 [1].

Site Environmental Data

In winter 2001, representatives of EPA collected soil, surface, and air samples at the Santa Ana Plant [1]. EPA representatives observed vermiculite in the soil along the rail spur, particularly near the conveyor. Eleven soil sample locations were selected in the unpaved portions of the site. The overall size of the site and the sizes of the unpaved portions were not specified in the EPA report; however, according to EPA drawings, only a small percentage of the site was unpaved. Seven composite and four grab samples were collected from these locations. Soil samples were processed in accordance with procedure ISSI-Libby-01 [1]. Analysis was performed by use of polarized light microscopy (PLM), per National Institute of Occupational Safety and Health method 9002. Results of soil sampling are shown in Appendix B, Table 1. These sample results found non-detect to trace levels of asbestos contamination. Sample results are reported as tremolite-actinolite to indicate the presence of Libby asbestos.

Three horizontal areas inside the production building were sampled for settled asbestos fibers. Approximately 100 square centimeters per area were sampled by use of microvacuum dust sampling. This technique sampled settled dust and fibers by drawing air through a 0.45-

micrometer pore-size, mixed cellulose esterase (MCE) filter at a flow rate of 2.0 liter per minute. Sampling was performed for two minutes at each location. Air was pulled through the cassettes by battery-powered sampling pumps. Locations sampled included dusty areas such as tops of equipment cabinets and window sills. Samples (i.e., the MCE filters) were analyzed by use of International Standards Organization (ISO) Method 10312. ISO method 10312 is a transmission electron microscopy (TEM) method that determines the type of asbestos fibers present, as well as the lengths, widths, and aspect ratios of asbestos structures. Results of the sampling effort are shown in Appendix B, Table 2. Results of the filter analysis for two of the three samples indicated that no asbestos structures were present. Results for the third sample indicated the presence of a single tremolite fiber under 5 microns in size. The detection of this single fiber on the filter sample was reported as an estimated concentration of 2,552 structures per square centimeter for the surface that was sampled (i.e., the 100 square centimeter area).

Indoor air samples were collected by drawing air through a mixed cellulose esterase filter (0.45 micrometer pore size) over an approximately 7- to 8-hour period. Samples were collected at a height 5 feet above the floor. Air was pulled through the cassettes by electric sampling pumps. Four ambient air samples were collected in the production building where vermiculite processing previously occurred. Samples were analyzed by use of ISO Method 10312. Results of air sampling are shown in Appendix B, Table 3. No airborne asbestos fibers were detected in the air samples.

W.R. Grace air sampling results for the Santa Ana Plant are summarized in Figures 6 and 7, Appendix A. Sample data are taken at various dates from 1975 through 1987 (unpublished information from EPA's database of W.R. Grace documents). Samples collected in worker breathing zones (personal samples) are shown in Figure 6. Area samples, which are samples taken as measures of dust control effectiveness, are shown in Figure 7. Samples were analyzed by phase contrast microscopy (PCM). Maximum fiber levels were 3.04 fibers per cubic centimeter (f/cc) and 79 f/cc for personal and area sampling, respectively.

Site Visit

ATSDR staff visited the community surrounding the Santa Ana Plant in August 2002. Because of scheduling difficulties, site access was not granted by the current facility operator; therefore, staff conducted a visual tour of the surrounding neighborhood and a review of documents collected from W.R. Grace & Co. by EPA.

The following observations were made:

- A cursory review of the community surrounding the plant indicated that vermiculite waste material did not appear to be present in the lawns, driveways, and gardens inspected.
- The site did not appear to be attractive for children to play near. The nearest homes were about ¼ mile away, with a canal separating the plant from the community to the west.
- Security fencing was noted around the site.

Asbestos Overview

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Asbestos minerals fall into two classes, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle, with a rod- or needle-like shape. Amphibole minerals regulated as asbestos by the Occupational Safety and Health Administration (OSHA) includes five classes: fibrous tremolite, actinolite, anthophyllite, crocidolite, and amosite. However, other amphibole minerals, including winchite, richterite, and others, can exhibit fibrous asbestiform properties [3].

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

The vermiculite mined at Libby contains amphibole asbestos, with a characteristic composition that includes tremolite, actinolite, richterite, and winchite; this characteristic 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 [4]. For most of the mine's operation, Libby asbestos was considered a byproduct of little value and was not used commercially. The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite that were then shipped to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products. Samples of the various grades of unexpanded vermiculite shipped from the Libby mine contained 0.3-7% fibrous tremolite-actinolite (by mass) [5].

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 longer than 5 μm with an aspect ratio (length:width) greater than 3:1. This is the standard method by which regulatory limits were developed. Disadvantages of this method include the inability to detect fibers thinner than 0.25 μm in diameter and the inability to distinguish between asbestos and nonasbestos fibers [3].

Asbestos content in soil and bulk material samples is commonly determined by use of polarized light microscopy (PLM), a method that uses polarized light to compare refractive indices of minerals and that distinguishes between asbestos and nonasbestos fibers and between different types of asbestos. The PLM method can detect fibers with lengths greater than $\sim 1 \mu\text{m}$, widths greater than $\sim 0.25 \mu\text{m}$, and aspect ratios (length to width ratios) of 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 that provide 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 it is difficult to determine asbestos concentration in soils and other bulk materials [3].

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, however. A conversion factor of 30 micrograms per cubic meter per fiber per cubic centimeter ($\mu\text{g}/\text{m}^3$)/(f/cc) was adopted to equate TEM mass to PCM fiber count, but this value is highly uncertain because it represents an average of conversions ranging from 5 to 150 ($\mu\text{g}/\text{m}^3$)/(f/cc) [5]. 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 [6]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular sample.

EPA is currently working with several contract laboratories and other organizations to develop, refine, and test a number of methods for screening bulk soil samples. The methods under investigation include PLM, infrared (IR), and SEM (personal communication, Jim Christiansen, US Environmental Protection Agency, November 2002).

Asbestos Health Effects and Toxicity

Breathing any type of asbestos increases the risk of the following health effects:

Malignant mesothelioma—cancer of the lining of the lung (pleura) and other internal organs. This cancer can spread to tissues surrounding the lungs or other organs. The majority of all mesothelioma cases are attributable to asbestos exposure [3].

Lung cancer—Cancer of the lung tissue, also known as bronchogenic carcinoma. The exact mechanism relating asbestos exposure to lung cancer is not completely understood. The combination of tobacco smoking and asbestos exposure greatly increases the risk of developing lung cancer [3].

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 [3].

Insufficient evidence exists to support any conclusion that inhalation of asbestos increases the risk of cancers at sites other than the lungs, pleura, and abdominal cavity [3].

Ingestion of asbestos causes little or no risk of noncancer effects. However, there is some evidence 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 [3].

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

There is general acceptance in the scientific community of correlations of asbestos toxicity with fiber length as well as with 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 [6]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5 μm are essentially non-toxic when considering a role in mesothelioma or lung cancer promotion. However, fibers less than 5 μm in length may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively make this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly as a result of physical characteristics that allow chrysotile to be broken down and cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [7]. 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 [7]. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease [8]. EPA's Integrated Risk Information System (IRIS) assessment of asbestos also 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 to the observed variation in risk as does the fiber type itself [9].

Counting fibers by use of the regulatory definitions (see below) does not adequately describe the risk of health effects, as fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to preferentially deposit in the deep lung, but longer fibers might disproportionately increase the risk of mesothelioma [3,9]. 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 penetrate to the respirable region of the lung) and do not contribute significantly to risk. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [9].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, asbestos-containing materials are defined as any material with greater than 1% bulk concentration of asbestos [10]. It is important to note that 1% is not a health-based level, but instead represents the practical detection limit in the 1970s when OSHA regulations were created. Studies have shown that disturbing soils containing less than 1% amphibole asbestos can suspend fibers at levels of health concern [11].

Friable asbestos (asbestos that is crumbly and can be broken down to suspendable fibers) is listed as a Hazardous Air Pollutant on EPA's Toxic Release Inventory [12]. EPA requires companies that release friable asbestos at concentrations greater than 0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to-Know Act.

OSHA has set a permissible exposure limit (PEL) of 0.1 f/cc for asbestos fibers longer than 5 μm and with an aspect ratio (length:width) greater than 3:1, as determined by PCM [13]. This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour work week. In addition, OSHA has defined an excursion limit in which no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [14]. Historically, the OSHA PEL has steadily decreased from an initial standard of 12 f/cc established in 1971 [14]. The PEL levels prior to 1983 were determined on the basis of empirical worker health observations, while the levels set from 1983 forward employed a 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 of past workers. ATSDR does not, however, support using the PEL for evaluating community member exposure, as the PEL is based on an unacceptable risk level.

In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in homes 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, US Environmental Protection Agency, National Institute of Occupational Safety and Health, CDC National Center for Environmental Health, Occupational Safety and Health Administration, New York City Department of Health and Mental Hygiene, the New York State Department of Health, and other state, local, and private entities. The workgroup set a re-occupation level of 0.01 f/cc after cleanup. Continued monitoring was also recommended to limit long-term exposure to this level [7].

The National Institute of Occupational Safety and Health (NIOSH) set a recommended exposure limit of 0.1 f/cc for asbestos fibers longer than 5 μm . This limit is a TWA for up to a 10-hour workday in a 40-hour work week. The American Conference of Government Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its Threshold Limit Value [15].

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

Asbestos is a known human carcinogen. Historically, EPA has calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos [5]. This value estimates additive risk of lung cancer and mesothelioma by using a relative risk model for lung cancer and an absolute risk model for mesothelioma. This quantitative risk model has significant limitations, however. First, the unit risks were based on measurements with phase contrast microscopy and therefore cannot be applied directly to measurements made with other analytical techniques. Second, the unit risk should not be used if the air concentration exceeds 0.04 f/cc, since above this concentration the slope factor might differ from that stated [5]. 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 its asbestos quantitative risk methodology, given the limitations of the current assessment and the knowledge gained since it was implemented in 1986.

Discussion

The vermiculite processed at this site originated from the mine in Libby, MT known to be contaminated with asbestos. Studies conducted in the Libby community indicate health impacts that are associated with asbestos exposure [16,17]. The findings at Libby provided the impetus for investigating this site, as well as other sites across the nation that received asbestos-contaminated vermiculite from the Libby mine. It is important to recognize, however, that the asbestos exposures documented in the Libby community are in many ways unique and will not collectively be present at other sites that processed or handled Libby vermiculite. The site investigation at the Santa Ana plant is part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these other sites.

Exposure Assessment and Toxicological Evaluation

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

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

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

conclusions about the site. Definitions for the hazard category terminology used to characterize the pathways is presented in Appendix C.

Exposure Pathway Analysis

An exposure pathway is how a person comes in contact with chemicals originating from a source of contamination. Every exposure pathway consists of the following five elements: 1) a *source* of contamination; 2) a *media* such as air or soil through which the contaminant 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 pathway is considered potential if the pathway elements are (or were) likely present, but insufficient information is available to confirm or characterize the pathway elements. A pathway may also be considered potential if it is currently missing one or more of the pathway elements, but the element(s) could easily be present at some point in time. An incomplete pathway is missing one or more of the pathway elements and it is likely that the elements were never present and not likely to be present at a later point in time. An eliminated pathway was a potential or completed pathway in the past, but has had one or more of the pathway elements removed to prevent present and future exposures.

After reviewing information from Libby, Montana and from facilities that processed vermiculite ore from Libby, the National Asbestos Exposure Review team identified likely exposure pathways for vermiculite processing facilities. All pathways have a common source—vermiculite from Libby contaminated with Libby asbestos—and a common route of exposure—*inhalation*. Although asbestos ingestion and dermal exposure pathways could exist, health risks from these pathways are minor in comparison to those resulting from inhalation exposure to asbestos and will not be evaluated.

The exposure pathways considered for each site are listed in the following table. More detail on the pathways is included in the table in Appendix D. Not every pathway identified will be a significant source of exposure for a particular site. An evaluation of the pathways for this site is presented in the following paragraphs.

Summary of Pathways Considered for the Santa Ana Plant

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

Occupational (past) —The occupational exposure pathway for people who worked at the Santa Ana plant prior to 1994 is considered complete. W.R. Grace & Co records indicate that workers were exposed to high indoor levels of Libby asbestos in the air. Employee air sample results for the years 1975 to 1987 (Unpublished information from EPA's database of W.R. Grace Documents) are shown in Appendix A, Figure 6. Personal samples collected were approximately 15 to 115 minutes in duration. These samples do not directly represent 8-hour TWAs for these employees because the sample durations are well below the duration of the work shift. However, based on field observations of two active vermiculite exfoliation facilities, employee job tasks are similar throughout the workday. Therefore, for purposes of evaluating potential exposure from these data, ATSDR took an overall average for employee exposure data per sampling event.

Individual sample results ranged from non-detect to 3.04 f/cc. Average fiber sample results from personal sampling ranged from 1.81 f/cc in 1975 to 0.04 f/cc in 1987. According to available information obtained from W.R. Grace records, efforts were underway to control fiber levels through local exhaust ventilation systems in 1976. Fiber levels appear to have substantially and continuously decreased after 1976. According to these sampling data, indoor fiber levels inside the plant were probably compliant with the present OSHA permissible exposure limit of 0.1 f/cc by 1983. Area samples collected by W.R. Grace show that concentrations (up to 79 f/cc) of fibers were generated by plant operations. These levels declined through 1987, as shown in Appendix A, Figure 7.

While no specific health data are available for this particular plant, two studies indicate that vermiculite exfoliation workers are at risk for developing lung disease related to asbestos

exposure. The first is a report of a person developing fatal asbestosis as a result of working two summers in a vermiculite exfoliation facility [18]. The second report is a study that was conducted in response to a report of 12 cases of pleural effusion within a 12-year period in an Ohio fertilizer plant that expanded and used Libby, Montana vermiculite [19]. The Ohio study of this cohort demonstrated cumulative tremolite-actinolite fiber exposure was correlated with dyspnea and pleuritic chest pain, and on chest radiographs pleural changes (thickening and/or plaques with and without calcification) [20]. Workers at this plant were exposed to airborne asbestos at levels above the current OSHA occupational standard prior to 1983. Because personal sampling results were only found for 1983 and 1987, ATSDR can not firmly conclude if workers were exposed to levels below the PEL after 1983. Inhalation of airborne asbestos above the OSHA PEL would increase the risk for asbestos-related disease and therefore would have posed a public health hazard to former employees.

Occupational (present/future) — The pathway concerning exposure of current or future workers to Libby asbestos from residual contamination inside the former processing building during or after 1994 is considered potentially complete. EPA recently collected four air samples and three composite dust samples inside the former processing buildings. All four air samples and two of the three composite dust samples indicated no detectable asbestos fibers. A single asbestos structure was detected on the sample filter of the third composite dust sample. Based on the actual filter area analyzed and the composite surface areas sampled (via microvacuum), this result was extrapolated to correspond to an estimated surface concentration of 2,552 structures per centimeter.

Libby asbestos fibers in surface dust do not directly pose a public health hazard. For health impacts to occur, the fibers must be re-suspended into the air and then inhaled. It is difficult to measure or model how many fibers will be re-suspended by various activities and how many fibers will be inhaled by people in the area, therefore it is difficult to determine health impacts. The applicable ASTM Standard Method for microvacuum sampling states that the method is not appropriate to determine if persons currently occupying a building are exposed to asbestos [20]. However, microvacuum sampling techniques employed as part of site-specific sampling strategy (e.g. randomized grid sampling, or worst-case sampling) can be used to indicate the historical presence of Libby asbestos inside these buildings. Critical information such as methods used to decontaminate the building after exfoliation operations ceased and confirmatory sampling after cleanup should also be used to evaluate the likelihood of exposure to residual Libby asbestos inside buildings used to process Libby vermiculite.

One of three dust sample results indicated residual Libby asbestos may be present at very low levels in surface dust inside the buildings used to process Libby vermiculite in the past. Air samples collected in these areas indicated no detectable airborne Libby asbestos. Therefore, current occupational exposure poses no apparent public health hazard.

Household contacts — The pathway for exposure of household members to airborne Libby asbestos brought home on the clothing of former workers (i.e., those people that worked at the plant before 1994) is considered complete. Former workers exposed household contacts to asbestos fibers if they did not shower and change clothes before leaving work. Family or other household contacts could have come in contact with Libby asbestos by direct contact with the

worker, by laundering clothing, or by the re-suspension of dusts during cleaning activities. Exposures to household contacts cannot be estimated without information concerning Libby asbestos levels on worker clothing and behavior-specific factors (e.g., worker practices, household laundering practices). Employees described that they wore respirators and disposable clothing during dusty operations such as bagging or cleaning vermiculite [1]. ATSDR does not know if wearing disposable suits was mandatory, or if on-site shower facilities were available to workers and were utilized. Still, exposure to asbestos resulting in asbestos-related disease in family members of asbestos industry workers has been well-documented [21]. Inhalation of Libby asbestos fibers by household contacts as a result of worker take-home contamination is therefore considered a past public health hazard.

The pathway for exposure of household contacts to airborne Libby asbestos brought home on the clothing of current or future workers (i.e., those people who worked in the plant during or after 1994) is considered eliminated. Based on recent air samples collected by EPA, current and future workers at this site are probably not likely to be exposed to residual Libby asbestos fibers inside the building. Workers may occasionally be exposed to Libby asbestos still present in onsite soils, however this contact is expected to be infrequent, of short duration, and at very low levels. This type of exposure would not be a concern for household members who have contact with workers or their clothing. No apparent public health hazard exists for the household contacts of current or future employees at the site.

Waste piles — Community members (particularly children) playing in or otherwise disturbing onsite piles of contaminated vermiculite or waste rock at the facility is considered a potential pathway in the past. EPA interviewed five current employees at the facility who had worked during the period when vermiculite was processed at the facility. According to these employees, the wastes from the processing operations were either land-filled or shipped off site to the Phoenix plant or back to the W.R. Grace mine in Libby. According to three plant employees, a security fence has reportedly surrounded the site for at least the past 23 years, thus eliminating community access to the site after 1980.

The onsite handling and disposal practices for the waste material is important because stoner rock (the waste rock created in the exfoliation process) contains approximately 10% asbestos by weight (Personal communication with James Kelly and Jean Small-Johnson of the Minnesota Department of Health). At the Western Minerals Plant in Minneapolis, MN, the waste rock was given to the community as free crushed rock to be used in places such as lawns, gardens and driveways [24]. According to W.R. Grace's responses to an EPA 104(e) request, records of waste shipments from Santa Ana to the following facilities/locations are available [22]:

- 1983
 - Coyote Landfill, Irvine, CA*
 - Santiago Landfill, Orange, CA*
- 1985
 - Fontana Landfill, Fontana, CA

* W.R. Grace reported that they had no information indicating whether the waste rock or baghouse fines were segregated and sent to a separate facility.

- January 1985 until July 1989
 - Chemical Waste Management Landfill, Kettleman City, CA
- September 1989 until March 1987
 - Libby, MT (disposed of in waste cells at Libby facility)
- March 1987 until April 1989
 - W.R. Grace Facility in Phoenix, AZ
- April 1989 until approximately August 1992
 - Libby, MT (disposed of in waste cells at Libby facility)
- August 1992 until cessation of use of Libby ore
 - Chemical Waste Management Landfill, Kettleman City, CA

Based on the available information, community exposure to waste piles at the site posed an indeterminate public health hazard for the time period prior to 1980. After 1980, community access to the site was restricted by a fence reportedly surrounding the site. Community exposures to onsite waste piles after 1980 posed no apparent public health hazard.

The facility no longer processes vermiculite from Libby, MT and no evidence of waste rock piles was observed on-site during the site visits by EPA. Exposure to waste rock at the site poses no public health hazard for present and future community members.

Onsite Soils — The exposure pathway concerning current onsite workers or contractors disturbing contaminated onsite soils – including residual contamination or buried waste – is considered a potentially complete pathway for the present and future. EPA sampling showed trace amounts of residual Libby asbestos-contaminated vermiculite present in the soil around the plant. This soil is currently covered with grass or railroad ballast [1]. It has been shown that disturbing soil containing even trace amounts of Libby asbestos can result in airborne levels of Libby asbestos fibers [12]. Under current conditions and assuming occasional contact with these areas from activities such as mowing, on-site exposure to Libby asbestos-contaminated soils poses no apparent public health hazard.

We do not know if a change in the condition or future use of the property would result in increased exposures. The future exposure pathway for onsite workers or contractors is therefore an indeterminate health hazard.

Ambient air — Past exposures to airborne fibers from plant emissions is considered a potentially complete pathway for the community surrounding the site as well as for nearby workers. Community members and area workers could have been exposed to Libby asbestos fibers released into the ambient air from fugitive dusts or the furnace stack while the plant was running. According to W.R. Grace documents, a community air pollution complaint was filed with the plant in 1983 regarding dust emissions; therefore the past ambient air pathway is probably complete [1]. Specific information concerning historical emissions from the plant is not available, therefore an estimate of risk from this exposure cannot be made. Even with emission data, it would be infeasible to construct past exposures. Figure 8, Appendix A, demonstrates why atmospheric modeling is infeasible at this site. In interpreting the wind rose for this site, the predominant wind direction is calm (19.30%). This makes prediction of where contamination may have blown during this time period impossible using standard Gaussian methods used in

atmospheric models. Also, an individual's exposure will be driven by factors other than wind direction, such as plant operational cycles and locations and times where people work, go to school or recreate. However, exposure of the public to airborne emissions downwind of the site would have been at much lower concentrations than that experienced by the Grace workers. Some contamination of nearby businesses may have occurred from the airborne dispersal of asbestos fibers.

Potential present and future exposures to Libby asbestos from air emissions have been eliminated because the facility no longer processes vermiculite from Libby.

Residential outdoor— The exposure pathway for past, present, or future community members using contaminated vermiculite or waste material at home is considered a potential pathway. Some vermiculite processing facilities in the United States allowed or encouraged workers and nearby community members to take stoner rock, vermiculite, or other process materials for personal use [23]. Some vermiculite sites have disposed of waste rock as fill material on site by burial [24]. EPA interviews with several current employees indicated that waste materials from the Santa Ana facility were not distributed to the community, however these testimonials may not accurately represent plant practices prior to their employment. Available documentation dating back to 1983 indicated waste from the facility was shipped to various landfills for disposal, however actual quantities of waste generated and disposed could not be verified from this information. Waste disposal records were not available for operating periods prior to 1983. Because the facility processed a high tonnage of Libby vermiculite in the past and insufficient information is available concerning historical waste disposal, the past, present, and future community exposures to waste rock brought home for personal use are considered an indeterminate public health hazard.

Residential indoor — The exposure pathway for community members disturbing household dust containing Libby asbestos fibers from plant emissions or from waste brought home for personal use is considered potentially complete. Insufficient information is available concerning past air emissions and community use of waste rock, therefore residential indoor exposure to Libby asbestos fibers that infiltrated homes is an indeterminate past public health hazard.

The Santa Ana facility does not currently process Libby vermiculite, therefore facility emissions are not currently a source for Libby asbestos contamination in nearby homes. Residual Libby asbestos from potential past sources is possible, though housekeeping (particularly wet cleaning methods) over the past 10 years would probably have removed any residual fibers. Not enough information is available to determine if waste rock was used at homes within the community. Exposure to Libby asbestos from waste rock in the community would primarily be an outdoor exposure concern; the waste rock alone would not be expected to significantly contribute to residential indoor exposures. As such, the current and future residential indoor exposure pathway is considered no apparent public health hazard for community members.

Consumer Products— People who purchased and used company products that contain Libby vermiculite may be exposed to asbestos fibers from using those products in and around their homes. At this time, determining the public health implication of commercial or consumer use of company products (such as home insulation or vermiculite gardening products) that contain

Libby vermiculite is beyond the scope of this evaluation. It has been shown that disturbing soil containing even trace amounts of Libby asbestos can result in airborne levels of Libby asbestos fibers that are of concern [12]. Additional information for consumers of vermiculite products has been developed by USEPA, ATSDR, and NIOSH and provided to the public (see www.epa.gov/asbestos/insulation.html).

Contaminated vermiculite insulation in homes and in soil could pose an inhalation hazard if it were disturbed. Exposure to asbestos in vermiculite insulation in an uninhabited attic or behind walls should be negligible. Exposure to asbestos in soil is less likely if the soil is covered by asphalt, concrete, or vegetation. Asbestos fibers do not break down in the environment, and asbestos in soil may remain for decades [4].

Health Outcome Data

As a separate project, ATSDR's Division of Health Studies has funded states to perform health statistics reviews around sites that have received vermiculite ore. The California Department of Health Services, Environmental Health Investigation Branch has performed this review of cancer incidence data for this site. Results of the health statistics review for this site are presented and discussed in Appendix E.

Summary of Removal and Remedial Actions Completed and Proposed

EPA has not required cleanup at the Santa Ana Plant (Personal communication by Bret Moxley, EPA Region IX).

Child Health Considerations

ATSDR recognizes that infants and children may be more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the site as part of the ATSDR Child Health Initiative.

The effects of asbestos on children are thought to be similar to the effects on adults. However, children could be especially vulnerable to asbestos exposures because they are more likely to disturb fiber-laden soils or indoor dust while playing. Children also breathe air that is closer to the ground and may thus be more likely to inhale airborne fibers from contaminated soils or dust.

Furthermore, children who are exposed could be more at risk of actually developing asbestos-related disease than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease.

For this site, the most at-risk children were those who were household contacts of former workers while the plant was operating.

Conclusions

Occupational Exposure Pathways

- Libby asbestos contamination posed a public health hazard to people who worked at the W.R. Grace & Company's Santa Ana Plant before 1994.
- Libby asbestos contamination currently poses no apparent public health hazard to workers at the W.R. Grace & Company's Santa Ana Plant.

Household Contacts

- Household members of former workers (i.e., those that worked at the plant before 1994) may have been exposed to asbestos fibers brought home on workers clothing. These past exposures represent a public health hazard to household contacts of former workers.
- Libby asbestos contamination currently poses no apparent public health hazard to household members of workers at the W.R. Grace & Co.'s Santa Ana Plant during or after 1994.

Waste Piles

- Community exposure to waste piles at the site prior to 1980 posed an indeterminate public health hazard. Available information indicates that the community probably did not have access to waste piles on the site after 1980 because the site was fenced around that time.
- Currently, the facility does not process vermiculite from Libby and no waste piles were observed at the site. Therefore, no public health hazard from vermiculite waste piles at the Santa Ana plant exists for current or future community members.

Onsite Soils

- Under current conditions, and assuming occasional contact with areas that may contain Libby asbestos, on-site exposure of workers and contractors to Libby asbestos-contaminated soils poses no apparent public health hazard. If site conditions or use of the property changes in the future, on-site exposures pose an indeterminate public health hazard.

Ambient Air

- Insufficient data exist to evaluate past asbestos exposure to the community from air emissions of asbestos from the plant. Therefore, the residential indoor and ambient air exposure pathways pose an indeterminate health hazard.
- Present and future community exposures to Libby asbestos from air emissions have been eliminated because the facility no longer processes vermiculite from Libby.

Residential Outdoor

- Because the facility processed a high tonnage of Libby vermiculite in the past and

insufficient information is available concerning historical waste disposal, the past, present, and future community exposures to waste rock brought home for personal use are considered an indeterminate public health hazard.

Residential Indoor

- Insufficient information is available to evaluate past indoor residential exposures, therefore this pathway poses an indeterminate public health hazard to the community.
- Current indoor residential exposures pose no apparent public health hazard to the community.

Recommendations

Occupational and Household Contacts Exposures

- Identify former workers and members of their households to investigate health effects from Libby asbestos exposure. Contact former workers and request information about waste disposal and operating practices at the facility to assist in exposure analysis and confirm that wastes were not disposed of onsite.
- To confirm that the present occupational exposure pathway is no apparent public health hazard, investigate further to determine how well the building was cleaned to remove residual asbestos fibers after vermiculite operations ceased.

Waste Piles and Residential Outdoor Exposures

- Identify and contact residents who lived in the area during the period when the plant was operating to confirm that waste material was not given to the community.

Onsite Soil Exposures

- If soil containing trace levels of asbestos are disturbed at the site, implement controls to protect onsite workers/contractors and limit fugitive dust emissions.

Public Health Action Plan

The purpose of the public health action plan is to ensure that public health hazards are not only identified, but also addressed. The public health action plan for this site describes actions that ATSDR and/or other government agencies plan to take at the site to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR will also follow up on the plan to ensure implementation of the following public health actions:

Actions Completed

- An EPA site visit was conducted in February 2001.
- ATSDR visited the surrounding community in August 2002.

- ATSDR has funded the California Department of Health Services (CDHS) to conduct health statistics reviews (HSR) of sites within CA (including the Santa Ana plant) that may have received the asbestos-contaminated Libby ore. HSRs are statistical analyses of existing health outcome data (e.g., cancer registry data [incidence] and death certificate data [mortality]) on populations near selected sites of concern to determine if an excess of disease(s) has occurred.

Actions Ongoing

- ATSDR will combine the findings from this health consultation with findings from other sites nationwide that received Libby vermiculite to create a comprehensive report outlining overall conclusions and strategies for addressing public health implications.
- ATSDR staff is researching unpublished information within the EPA database of WR Grace documents (estimated 3 million pages of information relating to Libby, Montana and other nationwide vermiculite processing sites). Specifically, ATSDR is searching for documents relating to building cleaning to remove asbestos fibers, waste disposal practices, and information that could be used for air modeling of past air emissions.
- CDHS will identify local community members who may know if waste vermiculite material was given to the local community.

Actions Planned

- ATSDR, in cooperation with state partners, is researching and determining the feasibility of conducting worker and household contact follow-up activities.
- ATSDR will review new information as it becomes available to determine appropriate site-specific public health actions.

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APPENDIX A. Figures

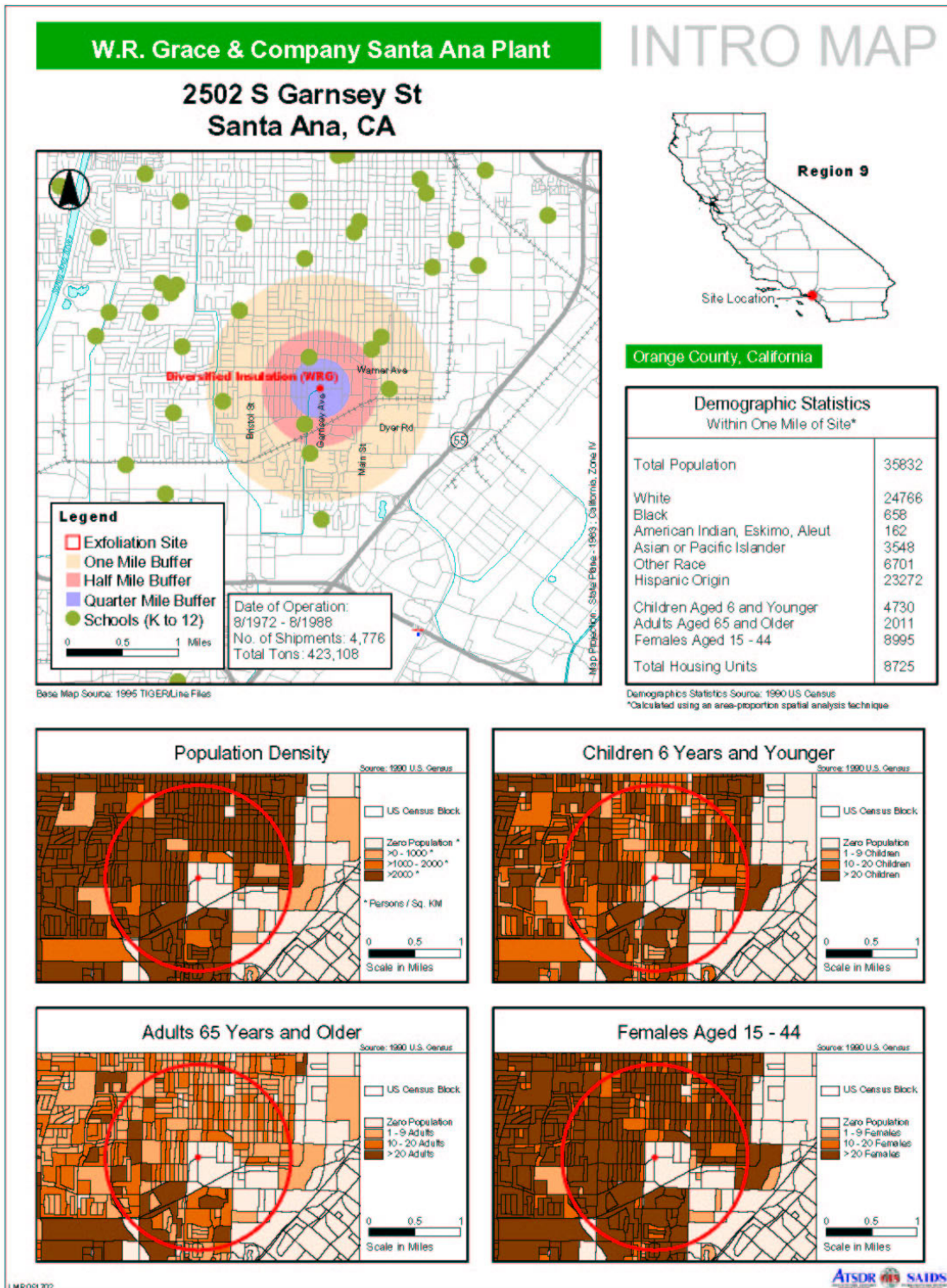


Figure 2- Age of Structures around Santa Ana Plant, 2000 Census

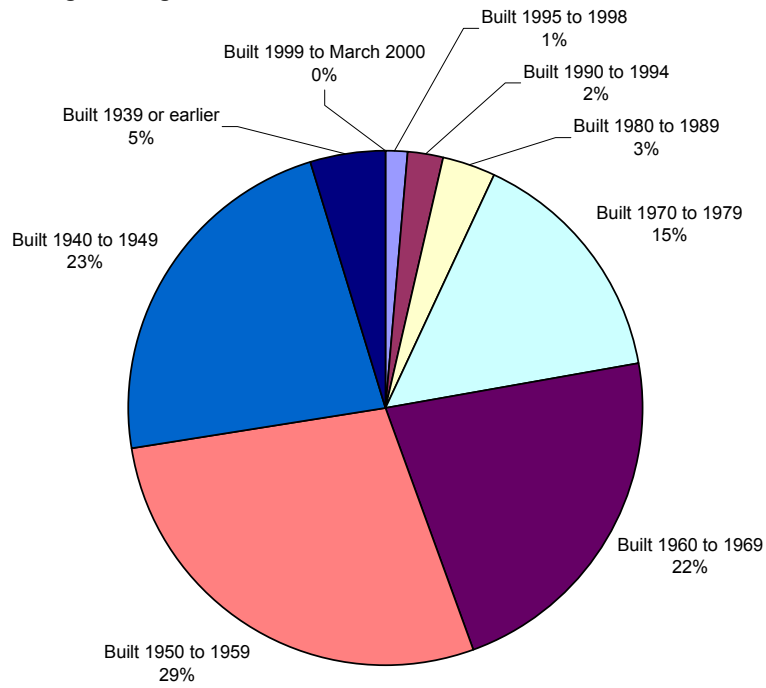


Figure 3 - Age of Structures around Santa Ana Plant, 1990 U.S. Census

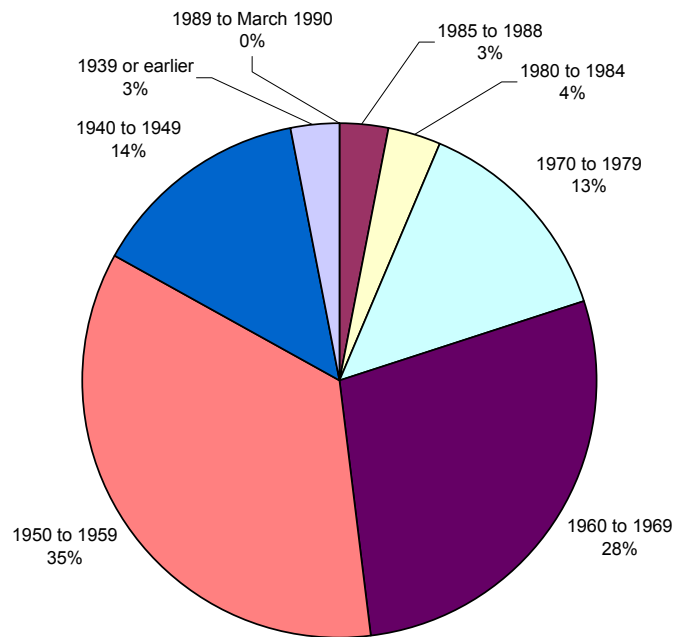


Figure 4 - Year Householder Moved Into Unit, 2000 Census Data

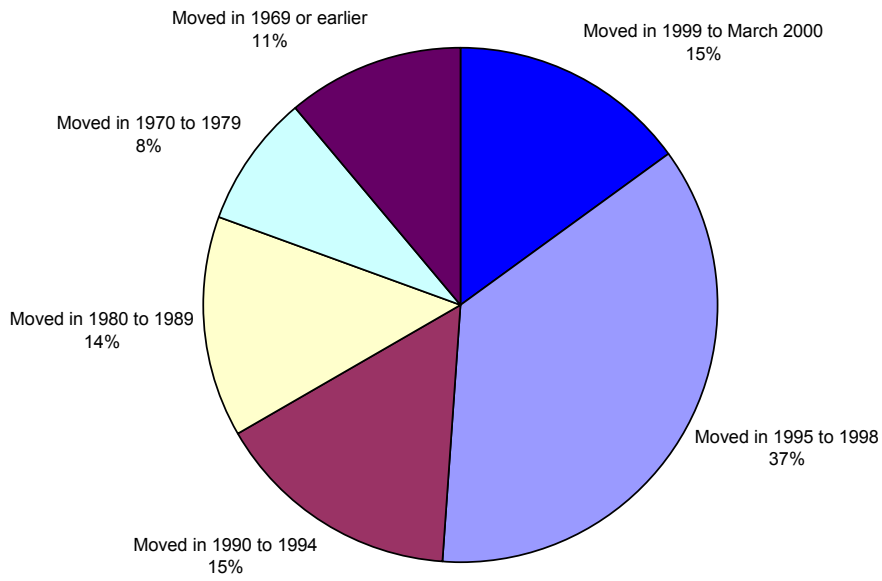


Figure 5 - Year Householder Moved Into Unit, 1990 U.S. Census Data

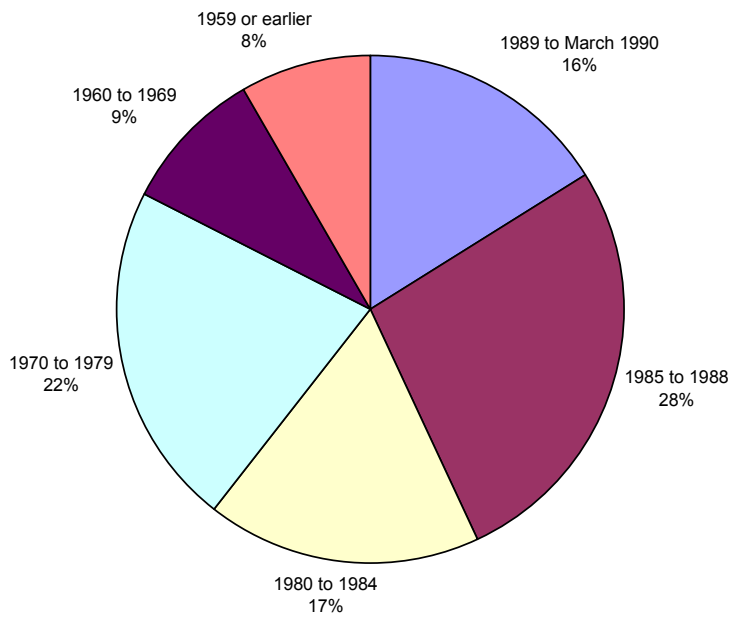


Figure 6- Asbestos Levels in Personal Samples Collected by W.R. Grace at the Santa Ana Plant

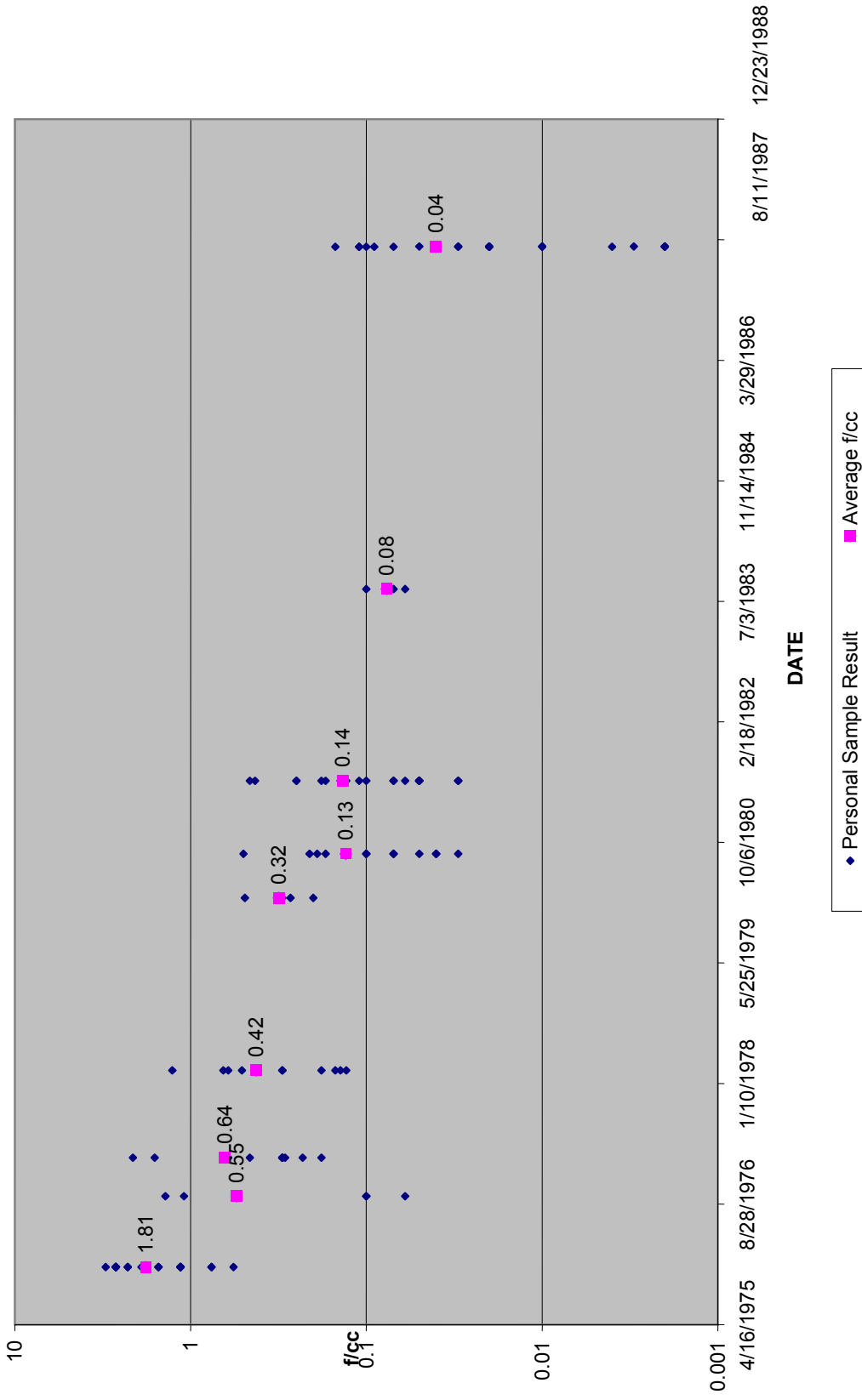
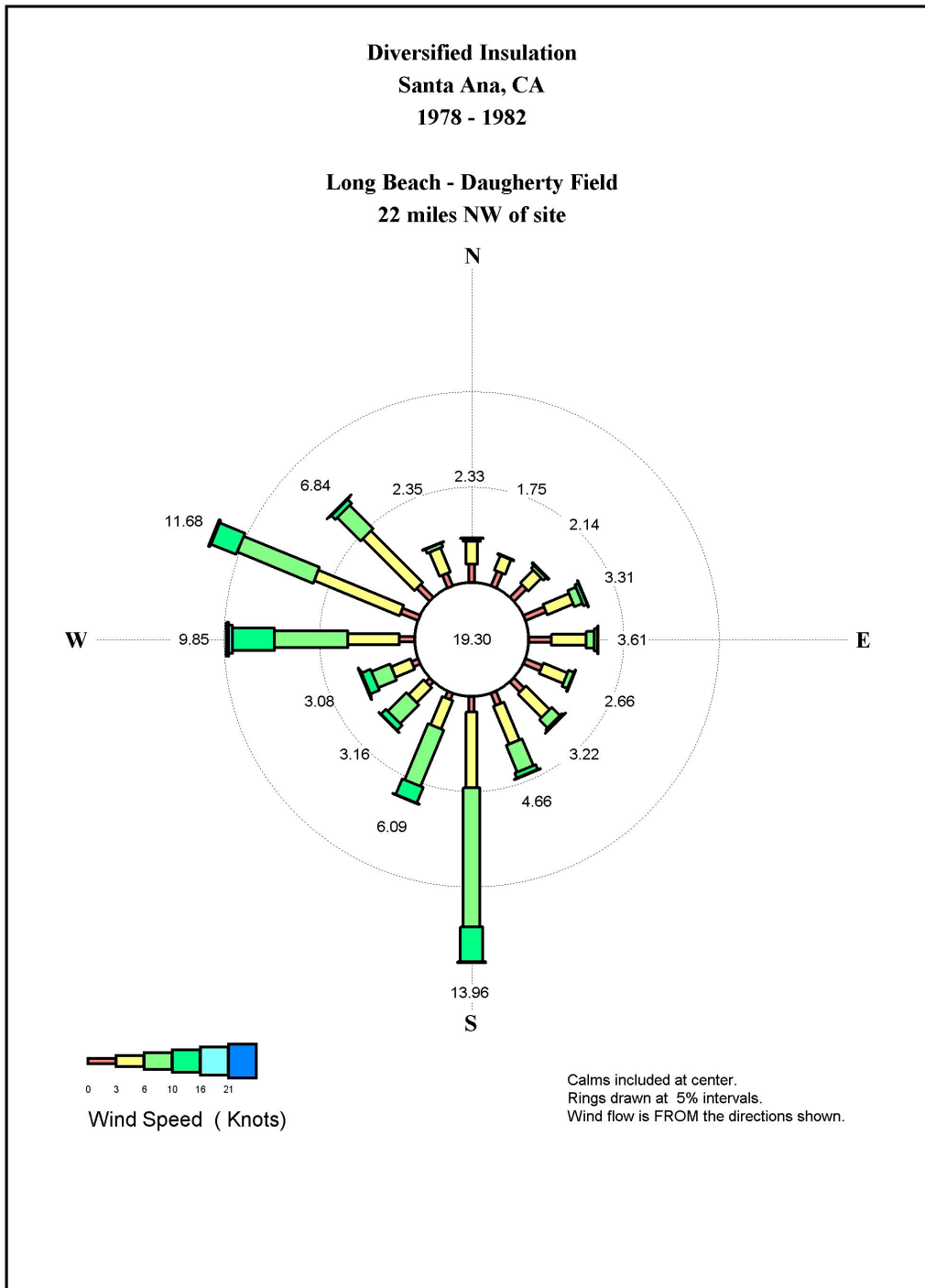


Figure 8, Wind Rose



Appendix B. EPA Sampling Results —W.R. Grace & Company Santa Ana Plant***Table 1 Results of Surface Soil Sample Analysis †**

Sample Type	Sample Location	Asbestos Concentration (% by Volume)	Type of Asbestos
Grab	SW corner of office building in planter	Trace	Tremolite-actinolite
Grab	SE corner of office building in the planter	Trace	Tremolite-actinolite
Composite	Grass area central north portion of site	Non-detect	NA
Composite	Grass area central north portion of site	Non-detect	NA
Composite	Grass area central north portion of site	Non-detect	NA
Composite	Grass area central north portion of site	Non-detect	NA
Composite	Along rail spur north end of site	Non-detect	NA
Composite	Along rail spur parallel with production building	Trace	Tremolite-actinolite, Chrysotile
Composite	Along rail spur south of production building	Trace	Tremolite-actinolite
Grab	At previous conveyor location	Trace	Tremolite-actinolite
Grab	Duplicate of grab sample taken at previous conveyor location	Trace	Tremolite-actinolite
Grab	West of rail spur at south end of the site	Trace	Tremolite-actinolite

* US Environmental Protection Agency. Focused removal assessment report for W.R. Grace & Co. Santa Ana: CDM for US Environmental Protection Agency. 2001.

† All soil samples were analyzed by Polarized Light Microscopy (PLM)

Table 2. Results of Microvacuum Surface Dust Sample Analysis*

Sample Type	Sample Location	Number of Asbestos Structures Detected (on the filter sample)	Total Asbestos Concentration (s/cm²) (estimated for the surface area sampled)
Composite	Three separate window sills in the office near the production building.	Non-detect	<32
Composite	Top of control panel and tops of two transformers in production machine area in production building.	Non-detect	<638
Composite	Flammable storage cabinet, transformer and storage cabinet in production building warehouse area	1 structure (0.5 to 5 µm)	2,552
Blank Sample	Blank Sample	Non-detect	NA
Blank Sample	Blank Sample	Non-detect	NA

* All microvacuum dust samples were analyzed by ISO Method 10312 (TEM). Results reported as “Number of Asbestos Structures Detected” correspond to the actual number of structures observed during analysis of a portion of the microvacuum filter. The “Total Asbestos Concentration” values are estimated for the surface area sampled.

Table 3. Results of Indoor Air Sample Analysis*

Sample Type	Sample Location	Asbestos Result	Type of Asbestos
Air	Production building Office copy room	Non-detect [†]	NA
Air	Production building Central warehouse area	Non-detect	NA
Air	Production building North warehouse area	Non-detect	NA
Air	Production area of production building	Non-detect	NA
Blank	Blank sample	Non-detect	NA
Blank	Blank sample	Non-detect	NA

* All air samples were analyzed by ISO Method 10312 (TEM).

[†] Analytical sensitivity for all ambient air samples is 0.0009 s/cc.

APPENDIX C – Health Hazard Category Definitions

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

No public health hazard

A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

No apparent public health hazard

A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

Indeterminate public health hazard

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

Public health hazard

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

Urgent public health hazard

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

APPENDIX D. Table 1 - EXPOSURE PATHWAYS- VERMICULITE PROCESSING FACILITIES**SOURCE FOR ALL PATHWAYS: Libby Asbestos-contaminated Vermiculite from Libby, Montana**

PATHWAY NAME	ENVIRONMENTAL MEDIA & TRANSPORT MECHANISMS	POINT OF EXPOSURE	ROUTE OF EXPOSURE	EXPOSURE POPULATION	TIME
Occupational	Suspension of Libby asbestos fibers or contaminated dust into air during materials transport and handling operations or during processing operations	Onsite	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 air from dirty clothing of workers after work	Workers' homes	Inhalation	Former and/or current workers' families and other household contacts	Past
Waste Piles	Suspension of Libby asbestos fibers into air by playing in or otherwise disturbing piles of vermiculite or waste rock	Onsite, at waste piles	Inhalation	Community members, particularly children	Past
Onsite Soils	Suspension of Libby asbestos fibers into air from disturbing contaminated material remaining in onsite soils (residual soil contamination, buried waste)	At areas of remaining contamination at or around the site	Inhalation	Current onsite workers, contractors, community members	Present, future
Ambient Air	Stack emissions and fugitive dust from plant operations into neighborhood air	Neighborhood around site	Inhalation	Community members, nearby workers	Past
	Suspension of Libby asbestos fibers into air by disturbing contaminated vermiculite brought offsite 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

APPENDIX E –Health Statistics Review for Populations in Close Proximity to the W.R. Grace and Company facility in Santa Ana, CA

Background

Through an analysis of mortality records, ATSDR and the Montana Department of Public Health and Human Services detected a statistically significant excess of asbestos-related disease (asbestosis) among residents of Libby, MT (1). Rates of asbestosis were 60 times higher than the national rates and this difference was highly unlikely due to natural fluctuations in the occurrence of this disease. This discovery led to several follow-up activities in Libby to address the health impacts on the community (2, 3). Another follow-up activity was a nation-wide effort to screen for a similar impact on the health of communities near facilities that processed or received vermiculite ore from the mine in Libby. As part of that activity, ATSDR awarded the California Department of Health Services (CDHS) funding to conduct health statistics reviews (HSR) on sites within CA that may have received the asbestos-contaminated Libby ore. HSRs are statistical analyses of existing health outcome data (e.g., cancer registry data and/or death certificate data) that help provide information on whether people living in a particular community have gotten asbestos-related diseases more often than a comparison population (i.e., people living in the rest of the country). Finding an excess of asbestos-related disease in a community through an HSR analysis would inform ATSDR and CDHS to the possibility that workers and/or community members might have been exposed to Libby asbestos from the vermiculite ore. Therefore, ATSDR has funded CDHS and other state health departments to conduct HSRs for *all* of the communities near vermiculite facilities, regardless of whether it is known if the community was exposed to Libby asbestos through the processing or handling of vermiculite ore. The methodology of the HSR used for Santa Ana and other vermiculite sites across the US was developed by ATSDR (4).

Methods

Cancer registry records were chosen by CDHS and ATSDR for this HSR because these are detailed health outcome records which are readily accessible in the state of California. ATSDR and CDHS are currently exploring the feasibility of conducting HSRs for this and other sites around the state using death certificate data. The target area consisted of people who were diagnosed with potential asbestos-related cancers while residing within any of the five census tracts surrounding the WR Grace Santa Ana site (740.03, 740.04, 740.05, 741.03 and 742.00). These census tracts were chosen as the geographic boundary for analysis because it is the smallest geographic area that is electronically coded on CA cancer registry records. The analysis period used was from 1986 to 1995. This period was used by CDHS because 1) it covers the most recent 10 years worth of cancer incidence data available in most firmly established cancer registries, 2) it corresponds to an approximate latency period in which initial exposure occurred and onset of disease would be expected, and 3) it allows for enough years worth of data for meaningful analyses. There were eight disease groupings used for this cancer incidence analysis; these can be found in ATSDR's HSR protocol (4). Of the eight groupings, the three of greatest interest to ATSDR were the cancers that have a known association with asbestos exposure. These three include malignant neoplasm of mesothelium [ICD-0-2 M-9050:9053], malignant neoplasm of peritoneum, retroperitoneum, and pleura [ICD-0-2 C480:C488, C384, excluding type M-9590:9989], and malignant neoplasm of lung and bronchus [ICD-0-2 C340:C349, excluding type M-9590:9989]. The other five disease groupings analyzed were reported in the

literature as having weaker associations with asbestos exposure or were ones that were included to evaluate reporting/coding anomalies in the target area.

Gender specific age-standardized incidence ratios (SIRs) were calculated for asbestos-related cancers. An SIR is a measure of whether the number of people who got cancer in this Santa Ana community is the same as, lower, or higher than the number of people we would expect to find if the occurrence of cancer in the Santa Ana community was the same as the occurrence of cancer in a comparison population. The comparison population used in this analysis was for the rest of the country. This comparison population was national cancer registry data received from the Surveillance, Epidemiology, and End Results (SEER) program at the National Cancer Institute (5). If the number of people getting cancer in this Santa Ana community is the same as the number we would expect to find, the SIR will equal 1. If the number of Santa Ana community members getting cancer is less than one would expect, the SIR will be between 0 and 1. If the number of Santa Ana members getting cancer is more than one would expect, the SIR will be greater than 1.

The number of people who get cancer in the United States changes from year to year (this is part of the nature of cancer as a disease). As a result, the value of the SIR for a community will also change, depending on which years are being studied: one year, the SIR may be higher than 1 (e.g., 1.2), and the next year it may be less than 1 (e.g., 0.9). Some degree of fluctuation in the SIR values from year to year is considered normal.

An important question is: when is a SIR higher or lower than what would be expected? In other words, when are more or fewer people getting cancer than we would expect, taking into account that there is a normal fluctuation in the number of people getting cancer? In order to answer this question, a measure called a 95% confidence interval (CI) is calculated for the SIR using Byar's approximation (6). The 95% CI consists of two numbers which define a range (a lower and an upper) of expected, or normal, values for the SIR for a community. If both numbers are less than 1, then we conclude that cancer is occurring less frequently in the community than it is in the rest of the country (this is called a statistically significant decrease). If both of the numbers in the confidence interval are higher than 1, then we conclude that cancer is occurring more frequently in the community than it is in the rest of the country (this is called a statistically significant excess). Lastly, if one of the numbers in confidence interval is less than 1 and the second number is higher than 1, then we conclude that cancer is occurring in the community at the same frequency as it is occurring in the rest of the country (this is called a non-statistically significant difference).

Results

Table A shows, for each cancer group studied: 1) whether past studies have shown a link between asbestos exposure and that type of cancer; 2) the number of people in the Santa Ana community who got each type of cancer; 3) the number of people we would expect to get cancer if the community had the same occurrence of cancer as the rest of the country; 4) the SIR; and 5) the 95% confidence interval for the SIR.

For the time period 1986-1995, the occurrence of these eight types of cancer in the Santa Ana community was the same as the occurrence in the rest of the country.

The results for the types of cancers that are known to result from asbestos exposure are:

- The numbers of people who developed mesothelioma and neoplasm of the peritoneum, retroperitoneum, and pleura were slightly higher than expected (the SIR is greater than 1). However, these numbers are within the normal range of what we would expect if the occurrence of cancer in this community was the same as the occurrence of cancer in the rest of the country (the lower number of the confidence interval is less than one and the upper number is greater than one).
- The number of people who developed lung or bronchus cancer was less than expected (the SIR is less than 1), however this number is within the normal, or expected, range.

Therefore, cancers caused by exposure to asbestos are not occurring more frequently in the Santa Ana community than they are in the rest of the country.

The number of people in this Santa Ana community who got cancers with weak associations with asbestos exposure is less than expected (the SIR is less than 1). However, this difference is within the normal, or expected, range. There is no difference between the occurrence of these cancers in the Santa Ana community and their occurrence in the rest of the country.

Lastly, the occurrence of cancers with no known link to asbestos exposure was either significantly less frequent than the rest of the country, or the same as the rest of the country.

Discussion and Limitations:

The main goal of conducting these HSRs is to help determine if communities near facilities that received Libby vermiculite have higher than expected occurrences of asbestos-related cancers and disease. This SIR analysis suggests that the occurrence of asbestos-related cancers in this Santa Ana population is not higher than expected compared to the rest of the country.

There are many limitations to using existing data sources to examine the relationship between environmental exposures and chronic diseases such as cancer. (A chronic disease is one that

develops over a long period of time.) Some of the major limitations in this analysis include, but are not limited to: exposure misclassification, population migration, lack of control for confounding factors (i.e., smoking status data), overstated numerators/under-estimated denominators, large study areas, small numbers of cases, and under-reporting of cancer cases to the state registry (4). Most of these limitations would make it less likely (as opposed to more likely) that this type of analysis would identify an abnormally high occurrence of asbestos-related cancers among people who lived near the WR Grace & Co. facility during its years of operation.

References

1. Dearwent S. Mortality in Libby, Montana, 1979 - 1998. Agency for Toxic Substances and Disease Registry, December 2000.
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Table A: Cancer registry data findings for selected cancer cases diagnosed in close proximity to the W.R. Grace and Company facility in Santa Ana, CA (Census Tracts 740.03, 740.04, 740.05, 741.03 and 742.00)

Cancer Group (ICD-0-2 codes)	Past studies have shown a link to asbestos exposure?	Number of people who got cancer	Expected number of cases*	SIR [†]	95% confidence interval [‡]	
					Lower	Upper
Malignant neoplasm of lung and bronchus (C340:C349, excluding M-9590:9989) [§]	Yes	79	95.41	0.83	0.66	1.03
Malignant neoplasm of peritoneum, retroperitoneum, and pleura (C480:C488, C384, excluding M-9590:9989) [§]	Yes	6	2.68	2.24	0.82	4.87
Malignant neoplasm of mesothelioma (M-9050:9053) [§]	Yes	4	1.49	2.68	0.72	6.87
Malignant neoplasm of digestive organs (C150:C218, C260:C269, excluding M-9590:9989)	Weak link	79	103.95	0.76	0.60	0.95
Malignant neoplasm of respiratory system and intrathoracic organs (C320:C399, excluding M-9590:9989)	Weak link	86	104.98	0.82	0.66	1.01
All malignant neoplasms (C000:C809)	No	595	728.70	0.82	0.75	0.88
Malignant neoplasm of female breast (C500:C509, excluding M-9590:9989)	No	101	110.23	0.92	0.75	1.11
Malignant neoplasm of prostate (C619, excluding M-9590:9989)	No	77	88.01	0.87	0.69	1.09

* Calculated using national cancer registry data received from the Surveillance, Epidemiology, and End Results (SEER) (5).

† The Standardized Incidence Ratio (SIR) equals the number of people who got the disease divided by the expected number of cases.

‡ The 95% CIs were calculated to assess statistical significance using Byar's approximation (6).

§ Have known associations with asbestos exposure. The other disease groupings analyzed were reported in the literature as having weaker associations with asbestos exposure or were ones that were included to evaluate reporting/coding anomalies in the target area.

