Health Consultation

W.R. GRACE & COMPANY
(a/k/a ZONOLITE CO. WILDERS)

112 NORTH STREET

WILDER, CAMPBELL COUNTY, KENTUCKY

EPA FACILITY ID: KYN000407413

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
Agency for Toxic Substances and Disease Registry
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Foreword

ATSDR National Asbestos Exposure Review

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

The Agency for Toxic Substances and Disease Registry (ATSDR) is working with local, state, and other federal environmental and public health agencies to evaluate sites that received vermiculite from Libby. The evaluations are focused on human health effects that might be associated with possible past or current exposure at the processing sites and in communities near the sites.

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

Phase 1 is an evaluation of 28 priority sites that ATSDR selected for review on the basis of the following criteria:

The US Environmental Protection Agency (EPA) required further action at the site on the basis of current contamination or

The site was an exfoliation facility that processed more than 100,000 tons of vermiculite mined in Libby according to EPA's database of W.R. Grace Libby invoices. (Exfoliation processing of vermiculite involves heating vermiculite at high temperatures to expand it; higher quantities of asbestos are released during exfoliation processing than in other processing methods.)

The following document is one of the site-specific health consultations that that ATSDR and state health partners are developing for each of the priority sites. In a future report, ATSDR will provide a summary of the results of the evaluations of the priority sites selected for initial review and present recommendations for evaluating the remaining sites that received vermiculite from Libby (more than 200 sites nationwide).

In Phase 2, ATSDR and state partners will utilize the findings and recommendations of the summary report to continue to evaluate sites that received Libby vermiculite and to identify appropriate public health actions.

Table of Contents

Site background

During the last century, W.R. Grace & Co supplied most of the United States with either processed or unprocessed vermiculite from the Zonolite Mine located in Libby, Montana. The Zonolite Mine processed vermiculite for roughly 60 years, and as a byproduct of mining activities, Libby amphibole asbestos was released into the environment. The former W.R. Grace & Co plant in Wilder, Kentucky, processed vermiculite from Libby, Montana. From 1952 until 1992 the plant processed approximately 220,000 tons of Libby vermiculite (USEPA database of W.R. Grace documents — unpublished data).The main products of the plant included structural fireproofing, thermal insulation for masonry construction, lightweight concrete aggregate, and other products based on vermiculite (USEPA database of W.R. Grace documents — unpublished data). The plant at one point employed an average of 16 employees (USEPA database of W.R. Grace documents — unpublished data). W.R. Grace disposed of waste materials from the processing operation on its own property and disposed of waste materials on an adjoining tract as fill material.

Site description, history and demographic information

Three buildings are on the Wilder site: a former exfoliation facility, a warehouse, and an office building. The site is located in a light industrial area of Wilder — a small community just south of Newport, Kentucky. The 5.4-acre site is bounded to the west by the CSX Railroad and Newport Steel. The rest of the site is bounded by commercial properties [1]. The nearest residences are over ¼ mile from the site.

ATSDR found the following information about the site's history in unpublished information from USEPA's database of W.R. Grace Documents:

- The facility began operations in 1952. Until 1970 the facility operated two Model A expanding furnaces. In 1970 one of these furnaces was replaced with a newer Model D-18 furnace.
- A Monokote™ mixing station was also present at the facility. Monokote ™ is a structural fireproofing that until the 1980s was made from vermiculite. Chrysotile was added to Monokote 3 ™ in the early 1970s. Other vermiculite-based products made at Wilder may have had chrysotile as an additive as well (e.g. Zono-coustic, a decorative textured finish that contained approximately 12% chrysotile asbestos, was also manufactured at Wilder).
- In addition to enclosed ore conveyance systems, by 1974 baghouses were installed at the facility to comply with state pollution control regulations.

1990 U.S. census data indicate that approximately 9,000 people lived within 1 mile of the site. Demographic information is included in the site map, Appendix A, Figure 1. 1990 U.S. census data also indicate that the majority of homes in the surrounding census tracks were built during or before the time that the plant was processing vermiculite (see Appendix A, Figures 2 and 3).

Site environmental data

In 1971 the Kentucky State Department of Health (KYDOH) monitored airborne asbestos fibers at the Monokote™ station [2]. Using phase contrast microscopy, KYDOH 's sampling showed fiber levels at the mixer of 10.1 f/cc, using phase contrast microscopy (PCM). An area sample near the Monokote™ station showed levels at 10.6 f/cc, PCM. An area sample near the D-18 showed fiber levels of 9.3 f/cc, PCM [2].

In May 2000, W.R.Grace contracted a site investigation to determine the extent of contamination relating to past disposal practices [3]. Analyses for asbestos in these soil samples were conducted using Polarized Light Microscopy (PLM). Analytical results produced by Grace contractors documented the presence of tremolite or actinolite asbestos — or both — in subsurface and surface soil samples in excess of 1% asbestos. One soil sample contained 18% asbestos.

In March 2002, the USEPA Region 4 Science Ecosystem Support Division (SESD) collected soil samples to confirm the presence of asbestos containing material (ACM) on site. Visual evidence of potential ACM in surface soil at various on-site locations was noted. The investigation confirmed the presence of tremolite asbestos in surface soil at levels up to 5% asbestos, and confirmed the presence of other non-regulated Libby-class amphiboles, as measured by Transmission Electron Microscopy (TEM). In May of 2002, USEPA/Environmental Response Team Center (ERT) collected 7 air samples inside the former exfoliation building. These samples were analyzed using ISO method 10312. No Libby amphiboles were detected, however three samples detected chrysotile asbestos at concentrations ranging up to 0.0003 s/cm^3.

In February 2004, the U.S. Environmental Protection Agency (USEPA) collected 13 wipe samples (ASTM 6480-99) and 10 microvacuum dust samples (ASTM D5755-03). Of the 13 wipe samples, 6 detected chrysotile structures and 6 detected Libby amphibole fibers. The maximum concentration was 560,000 asbestos structures per square centimeter (s/cm^2), with the majority of fibers detected being chrysotile. Of the 10 microvacuum dust samples, only 1 sample detected asbestos at a concentration equivalent to 85,000 s/cm^2 of chrysotile. Laboratory reports for these samples are included in Appendix B.

In 2004, twelve aggressive clearance samples were collected using AHERA clearance protocol [4]. Asbestos fibers were not found on any clearance sample (reported limits of detection <7.70 – 13.00 s/mm^2 using AHERA counting rules) [5].

From documents collected by USEPA under a CERCLA 104(e) information request, ATSDR has reviewed W.R. Grace industrial hygiene sampling results for this facility. ATSDR located in these documents employee and engineering air sample results for the years 1975 to 1991. Samples in this set of data were analyzed by PCM. These results are summarized on Figures 4 and 5.

ATSDR site visits

ATSDR conducted a site visit in September of 2002. During this visit grains of what appeared to be Libby amphibole asbestos were visible in the area where the vermiculite wastes were dumped. Remnants of the ore conveyor system was visible at the site. A fence protected the entrance to the area of the site where the contamination was located, although the fence did not totally enclose the contaminated area. Along the rail spur near the plant, vermiculite materials were visible.

On September 4, 2003, USEPA held the first W.R. Grace Site Public Meeting at the Wilder City Building. Representatives from USEPA, ATSDR, the Kentucky Department of Environmental Protection (KYDEP), and Campbell County Emergency Management attended this meeting. Approximately seven community members also attended the meeting. The meeting's purpose was to discuss the site history, the hazards of asbestos, and USEPA's planned remediation activities at the site.

Discussion

The vermiculite processed at this site originated from the Libby, MT mine is known to be contaminated with asbestos, and health effects associated with asbestos exposure are indicated by studies conducted in the Libby community [6,7]. The Libby findings provided the impetus for investigating this site as well as other sites across the nation that received asbestos-contaminated vermiculite from the Libby mine. Still, it is important to recognize that the asbestos exposures documented in the Libby community are in many ways unique; they will not collectively appear at other sites where Libby vermiculite had been processed or handled. The site investigation at the Wilder plant is, however, part of a national effort to identify and evaluate potential asbestos exposures that may be expected at these 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 about asbestos that is 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 at this site is also limited or unavailable.

There is limited information on past concentrations of Libby asbestos in air in and around the plant. 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 and subsequent health risks.

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 largely 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 health hazards after evaluating toxicity, pathways and exposure data are presented in Appendix C. A review of Libby amphibole asbestos toxicity and standards is present in Appendix D.

Exposure pathway analysis

An exposure pathway is the way in which an individual is exposed to contaminants originating from a contamination source. Every exposure pathway consists of the following five elements:

1. a *source* of contamination,
2. a *media* such as air or soil through which the contaminant 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. **Potential** exposure pathways indicate 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; it is likely that the elements were never present, and that they 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 to prevent present and future exposures has had one or more of the pathway elements removed.

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 which will not be evaluated.

The exposure pathways considered for each site are listed in the following table. Not every pathway identified represents a significant source of exposure for a particular site. An evaluation of the pathways for this site is presented below.

Summary of pathways considered for the Wilder plant

Pathway Name	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 (1954-1992)	Complete	Public health hazard
	Harry Grau & Sons, Inc. employees exposed to airborne asbestos from residual contamination inside former processing buildings.	Past (1999-2003)*	Potential	No apparent public health hazard
		Present/ Future	Eliminated	No public health hazard
Household Contact	Household contacts of exfoliation workers inhaling Libby asbestos brought home on workers' clothing, shoes, and hair.	Past (1954-1992)	Complete	Public health hazard
	Household contacts of workers exposed to airborne Libby asbestos from residual contamination inside former processing buildings.	Past (1999-2003)*	Potential	No apparent health hazard
		Future	Eliminated	No public health hazard
Community	Facility air emissions: Community members or nearby workers inhaling asbestos fibers from plant emissions during handling and processing of contaminated vermiculite	Past (1954-1992)	Complete	Indeterminate
		Present/ Future	Eliminated	No public health hazard
	Waste piles: Community members (particularly children) inhaling asbestos while playing in or disturbing on-site piles of contaminated vermiculite or waste rock	Past	Potential	Indeterminate
		Present	Incomplete	No public health hazard
	On-site soil: Community members inhaling Libby asbestos from contaminated on-site soils (residual contamination, buried waste)	Past	Potential	Indeterminate
		Present/ Future	Eliminated	No 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 health hazard

* USEPA began cleanup of site in 2003 and finished 2004. Employees were not present during cleanup. The site was not occupied 1994-1999

Occupational (past workers exposed to Libby asbestos)

The occupational exposure pathway is considered complete for people who worked at the Wilder plant during the period the facility exfoliated vermiculite from Libby (1952–1992). Former W.R. Grace workers were exposed to airborne levels of asbestos that posed a public health hazard.

The sources of asbestos contamination were the vermiculite shipped from the Libby mine and the chrysotile added to some vermiculite products such as Monokote 3 ™. Approximately 220,000 tons of Libby Vermiculite was shipped to this facility from 1952 until 1992. Zonolite initially developed Monokote™ 3 in 1959. W.R. Grace began phasing out the production of Monokote™

3 during 1971 – 1973. Documents ATSDR has found indicate that 100 pounds of chrysotile was added to each batch of Monokote 3 ™ produced [8]. ATSDR has not located records indicating the production rates (i.e., batches per day or week) that the Wilder plant produced, or records that specify exactly when Monokote 3 ™ production at this facility began and ended.

Because release of asbestos fibers occurred throughout the processing steps, vermiculite handling and storage processes were of special concern to W.R. Grace. An internal W.R. Grace memo asked for the installation of the D-18 furnace also requested vermiculite handling and storage facilities to reduce levels of dust generated during the vermiculite unloading process at the facility (USEPA database of W.R. Grace documents — unpublished data). Prior to 1970, ore was stored in open bins that were filled by gravity drop and a Payloader was used to empty these bins (USEPA database of W.R. Grace documents — unpublished data). According to the 1969 memo, the ore handling procedures created significant dust problems:

> Large clouds of dust are created during loading and unloading of the bins, and employees working at the furnaces are constantly exposed to this dust, as is the payload operator. The dust control problem is evident outside of the plant and has been the basis of several complaints from both municipal officials and the Kentucky Air Pollution Control Board.

In the 1970s, W.R. Grace initiated efforts to install and to optimize local exhaust ventilation to reduce asbestos fibers in the air of their expansion plants, including Wilder (USEPA database of W.R. Grace documents — unpublished data). Working at the facility is the primary point of exposure for the occupational pathway. Additional exposure could have occurred as a result of contamination of workers' clothing and subsequent re-entrainment of fibers at other locations.

ATSDR does not know how many people have worked at the W.R. Grace facility in Wilder, Kentucky during its 40-year history. The number of employees at any given time varied from 10 to 30 (USEPA database of W.R. Grace documents — unpublished data). 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 1991 (USEPA database of W.R. Grace documents — unpublished data) are shown in Appendix A, Figure 4. When a sampling time was provided, personal samples collected were approximately 12 to 120 minutes in duration. Eight-hour time weighted averages (TWA) were calculated for 25 workers sampled from 1986 until 1991. TWA results ranged from 0.0008 f/cc to 0.129 f/cc. Because most of the W.R. Grace samples had sample times below the total work shift, these samples do not directly represent 8-hour TWAs. That said, however, field observations of two active vermiculite exfoliation facilities showed that employee job tasks were similar throughout the workday. Therefore, for purposes of evaluating potential exposure concentrations from these data, ATSDR took an overall average for employee exposure data per sampling event. Area samples, which are samples taken as measures of dust control effectiveness, are shown in Appendix A, Figure 5.

Various non-W.R. Grace workers probably visited the Wilder facility periodically to haul away waste rock, to purchase products, to pick up products for delivery, or to provide services (e.g., construction, electrical, equipment maintenance). The above-mentioned on-site, non-W.R. Grace workers may have been exposed to airborne asbestos in and around the Wilder facility, but the frequency and duration of their exposures was likely very low. The intensity, frequency, and duration of the waste hauler and construction worker exposures was likely higher than the other non-W.R. Grace worker groups. All of these on-site workers were exposed much less frequently and for much shorter durations than the full-time workers at the W.R. Grace facility itself. An example of such workers is waste haulers and landfill operators who handled vermiculite waste material from the Wilder plant. Internal W.R. Grace memos indicate that the waste was shipped to various landfills as early as 1977. According to internal W.R. Grace documents, wetting of vermiculite waste was begun in 1986 to reduce the amount of fibers released from the waste vermiculite material. Internal Grace documents also indicate that in 1986, waste was wetted and double bagged and sent to Bavarian Landfill in Walton, Kentucky (USEPA database of W.R. Grace documents — unpublished data). ATSDR does not know the extent to which asbestos waste haulers who handled waste were exposed. W.R. Grace industrial hygienists did, however, monitor exposures of workers involved in hauling of waste products from four exfoliation plants: Weedsport, NY Muirkirk, MD, Easthampton MA, and New Castle PA (USEPA database of W.R. Grace documents — unpublished data). All four exfoliation plants processed Libby vermiculite. PCM Data analysis from the monitoring is provided below:

Levels of person asbestos exposure (PCM) to waste haulers and handlers

Plant Location	***Date***	***Duration (minutes)***	***Concentration (f/cc)***	***8-hour Time Weighted Average(f/cc) ****
Muirkirk, MD	4/12/1979	87	0.08	0.0145
Weedsport, NY	9/18/1980	43	0.11	0.047
		43	0.43	
Weedsport, NY	8/3/1983	69	0.26	0.037
New Castle, PA†	6/27/1984	126	<0.002	<0.002
		126	<0.002	
Easthampton, MA‡	8/9/1983	24	0.26	0.0014

*8 hour TWA = ∑(concentration x duration)/480 minutes

†Waste rock was wetted and placed in cardboard gaylords for disposal

‡ Sample was from grader operator crushing bags at landfill

According to WR Grace responses to USEPA 104(e) requests, pickup of waste at the Wilder plant occurred on an “as needed basis,” generally “once or twice a week” (USEPA database of W.R. Grace documents — unpublished data). From 1986 until 1992, waste was wetted and double bagged in 6-mil bags prior to transport to landfills (USEPA database of W.R. Grace documents — unpublished data).

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 [9]. The second is a study 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 [10]. The Ohio study of this cohort demonstrated cumulative tremolite-actinolite fiber exposure was correlated with dyspenea and pleuritic chest pain, and with pleural changes on chest radiographs (i.e., thickening or plaques with and without calcification) [10]. 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. There are some indications from employee interviews conducted at other W.R. Grace sites by USEPA and from internal W.R. Grace documents that a respiratory protection program was in place. Depending on the date the program came into effect, areas where respiratory protection was required, and the level of effectiveness of this program, the hazard to the employees could have been significantly reduced.

Occupational (Harry Grau & Sons, Inc. Employees)

Harry Grau & Sons, Inc. (Grau), a gasoline service station maintenance company, has occupied the premises since 1999. ATSDR does not have data regarding asbestos levels in indoor air from 1999 through 2003. Wipe and microvacuum samples taken inside the facility detected both chrysotile and tremolite-actinolite series fibers to a maximum concentration of 560,000 s/cm^2. These fibers could have become resuspended in the air from activities that disturb surfaces of the facility, such as an employee sweeping. These fibers would then be available for employees or other building occupants to breathe. ERT testing showed maximum chrysotile concentrations inside the former building to be up to 0.0003 s/cm^3.

Given our available data, it does not appear that current Grau workers have been exposed to a health hazard. In 2003, USEPA began cleaning the site, which included the interior of the buildings. USEPA used recognized methodologies to remove asbestos fibers. In 2004, twelve aggressive clearance samples were collected using AHERA clearance protocol [4]. Asbestos fibers were not found on any clearance sample (reported limits of detection <7.70 – 13.00 s/mm^2 using AHERA counting rules) [5]. Therefore, this pathway has been eliminated and poses no public health hazard to present occupants.

Household contacts

The pathway for exposure of household members to airborne Libby asbestos brought home on the clothing of former workers (c.f. Occupational (past W.R. Grace Employees)) 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). ATSDR screenings of Libby residents found a higher rate of pleural abnormalities associated with having been a household contact of a W.R. Grace worker [7]. Environmental exposures and other nonoccupational risk factors were also important predictors of asbestos-related radiographic abnormalities [7].

ATSDR does not know if at this plant procedures were in place to reduce the amount of fibers that workers took home. Exposure to asbestos resulting in asbestos-related disease in family members of asbestos industry workers has been well-documented [11]. Inhalation of Libby asbestos fibers by household contacts because of worker take-home contamination is therefore considered a past public health hazard.

The exposure pathway for household contacts of Grau workers — who were working at the site prior to the USEPA removal action in 2003 — is considered potentially complete. Nevertheless, given the sampling at other similar facilities and the duration that Grau occupied this building prior to cleanup, this exposure was minimal. ATSDR therefore considers this exposure of household contact of past Wilder workers as no apparent public health hazard.

Because of the completed removal action by USEPA, current and future workers at this site are not likely to be exposed to residual Libby asbestos fibers inside the building. Accordingly, no public health hazard exists for the household contacts of current or future employees at the site.

Waste piles

At the Wilder plant, stoner rock (i.e., the waste rock created in the exfoliation process) was used to fill a ravine behind the facility. Appendix A, Figures 6, 7, 8 and 9 show historical aerial photographs of the plant. Waste piling and land filling appear to be present in these photographs of the facility in 1955, in 1960, and in 1970. The 2000 aerial photograph does not show this activity. The location of the apparent waste piles and landfill are consistent with the locations USEPA remediated in 2004. We have found one document (a testimony of a W.R. Grace plant manager in a USEPA cost recovery lawsuit related to the Newport Dump) that describes the activity of placing waste stoner rock into the ravine behind the facility (USEPA database of W.R. Grace documents — unpublished data).

Community members — particularly children — playing in or otherwise disturbing on-site piles of contaminated vermiculite, waste rock, or on-site soils 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 site and accessible to children and other community members. Anecdotal or photographic evidence of children playing in on-site waste piles is available for a similar exfoliation facility [12]. That said, however, ATSDR does not know whether children played in waste piles at this site.

Disturbances of the waste material can lead to suspension of asbestos fibers into the air. This can happen from wind erosion or from human activities. We do know that on occasion, all-terrain vehicles were driven over the areas of contamination, although we are uncertain how much asbestos exposure this created [13]. Because USEPA completed removing the buried stoner rock in 2004, current community exposure has been eliminated.

On-site soils

On-site soil contamination was identified by a contractor for W.R. Grace [3]. USEPA completed removing the onsite soil contamination in 2004 [11]. Therefore, we consider the future exposure to the onsite soils eliminated.

Ambient air

Past exposures to airborne fibers from plant emissions is considered a completed pathway for the community. This exposure was an indeterminate public health hazard because the concentration of fibers that was present is unknown.

Sources of asbestos emissions from the facility included

- stack emissions from the expanding furnaces and the Monokote ™ mixer,
- fugitive emissions from ore unloading and handling procedures, and

- fugitive emissions from waste handling procedures.

Estimation of the amount of asbestos released from these sources is problematical. Air permits submitted to the state of Kentucky list only "vermiculite dust" as an emission, making difficult the estimation of asbestos fiber emissions. As discussed in the occupational pathway section, significant emissions of dust seemed to emanate from Payloaders loading and unloading vermiculite bins. We do not have data on asbestos-fiber levels during the ore-handling operations at Wilder prior to the installation of ore silos and conveyors. W.R. Grace did, however, conduct area sampling at its exfoliation facility Dearborn, Michigan in 1972, during the ore unloading and found air concentrations ranging from 5.5 f/cc to 81.8 f/cc[a] throughout the facility. After ore unloading, levels throughout the Dearborn facility dropped by about half, although a single sample collected inside of the roof monitor of the building found 166.8 f/cc (the memorandum is unclear whether unloading operations ceased during this sample). Asbestos concentration at Dearborn was measured in the ambient air at 2 f/cc (on roof, 50 feet downwind of the baghouse). In 1970, the Wilder plant installed ore silos and enclosed conveyors. Grace documents reported this type of system significantly reduced visible dust — and probably asbestos — emissions at this facility.

Figure 10, Appendix A, shows the wind rose from a meteorological station located 15 miles from the site. Predominant wind direction is towards the North, but significant terrain differences exist between the location of the meteorological station and the location of the Wilder facility. The Wilder facility is in a valley surrounding the Licking River, a tributary of the Ohio River. This valley will affect the wind direction.

A person's exposure will be driven by factors other than wind direction; factors such as plant operational cycles and locations and times where people work, attend school or recreate can all influence exposure. Community members and area workers could have been exposed to an unknown concentration of Libby asbestos fibers released into the ambient air from fugitive dusts or, while the plant was running, furnace stacks. Exposure of the public to airborne emissions downwind of the site would have been at much lower concentrations than those experienced by the Grace workers. We also note from U.S. Census data and aerial photography that most homes surrounding the site were built after the installation of emission control equipment (e.g., baghouses and enclosed conveyors), thus limiting residents' potential time of exposure (see figures 2,3,6,7,8 and 9). On the other hand, some contamination of nearby businesses may have occurred from the airborne dispersal of asbestos fibers.

Present and future exposures to Libby asbestos from air emissions are not occurring because the facility no longer processes vermiculite from Libby. Because USEPA has also removed remaining asbestos contaminated soils and wastes from the facility, fugitive emissions of asbestos from this site are not occurring.

Residential outdoor

Some vermiculite processing facilities in the United States allowed or encouraged workers and nearby community members to remove stoner rock, vermiculite, or other process materials for personal use. At Wilder, at least some vermiculite was used as on-site fill material. Available documentation dating back to 1977 indicated waste from the facility was shipped to various landfills for disposal; but actual quantities of waste generated and disposed could not be verified

[a] Method of determination is not specified.

from this information. 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 taken for personal use are considered an indeterminate public health hazard.

Residential indoor

Because insufficient information is available concerning past air emissions and community use of waste rock, residential indoor exposure to Libby asbestos fibers that infiltrated homes is an indeterminate past public health hazard.

The Wilder facility does not currently process Libby vermiculite; in nearby homes therefore, facility emissions are not currently a source for Libby asbestos contamination. Residual Libby asbestos from potential past sources is possible, although housekeeping (particularly wet cleaning methods) over the past 10 years would probably have removed most residual fibers. As discussed in the *Residential outdoor* pathway above, insufficient information is available to determine whether 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 contribute significantly to residential indoor exposures. As such, for community members the current and future residential indoor exposure pathway is considered a "no apparent public health hazard."

Consumer Products

Purchasers and users of company products containing Libby vermiculite may be exposed to asbestos fibers as a result of 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. 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 (last updated 2005 24 June, cited 2005 24 June)].

Health Outcome Data

Health outcome data can be used to give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (for example, the number of people who have died from a certain disease) or morbidity information (for example, the number of people in an area who have a certain disease or illness). A health statistics review cannot prove a causal relationship between potential exposures and health outcomes, but it may indicate whether additional studies are needed. ATSDR will release annual reports summarizing health statistics review findings for sites where data has been received and evaluated. In Libby, Montana, the number of recorded deaths associated with asbestos-related diseases was significantly elevated (as compared with the state or the nation as a whole), especially among former workers at the vermiculite mine and their household contacts [6]. Former workers and their household contacts also had higher rates than expected of pleural abnormalities, indicating higher levels of exposure and a higher risk for developing asbestos-related disease [7].

ATSDR's Division of Health Studies, in cooperation with state partners, is conducting an ongoing effort to gather health outcome data from selected former vermiculite facilities. No review of the available health statistics data for this site has been completed at this time. It should be noted that the small number of potentially affected people around the site could make it difficult to detect if there are any community-level health effects. ATSDR will release a report summarizing health statistics review findings for selected sites for which data have been received.

Summary of Removal and Remedial Actions Completed and Proposed

USEPA has overseen a removal action at this site including

- remediation of all surfaces inside buildings,
- remediation of highly contaminated soils onsite and along railroad spur, and
- removal of waste vermiculite fill material from the site.

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. Children could, however, 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 to asbestos 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.

Given the limited amount of information regarding the exposure pathways at this site, the health implications to children are difficult to determine. ATSDR's information review to date shows that the most at-risk children were those who were household contacts of former workers while the plant was expanding vermiculite. Other exposure pathways (e.g., ambient air, residential outdoor, waste piles) may also have affected children, but ATSDR does not have information at this time to determine whether these pathways were completed.

Conclusions

Occupational exposure pathways

People who worked at the W.R. Grace Wilder facility from 1952 to 1992 were exposed to asbestos. For much of this time period, airborne levels of Libby asbestos were above current occupational standards. Repeated exposure to airborne Libby asbestos at these elevated levels increased a worker's risk for asbestos-related disease and therefore posed a *public health hazard* to former employees.

Exposure to workers at the site from 1999 until 2003[b] constituted no apparent public health hazard.

---

[b] Site was apparently not occupied from 1994 until 1999.

For workers currently at this site, Libby asbestos contamination poses no public health hazard.

Household contacts

Household members of former workers (i.e., those who worked at the plant before 1992) may have been exposed to asbestos fibers brought home on workers' clothing. These past exposures were a public health hazard to household contacts of former workers.

No apparent public health hazard existed for household contacts of workers who were at this site between 1999 and commencement of remedial action in 2003.

Waste piles

Past exposure to waste piles at the site from trespassing is an indeterminate public health hazard. Insufficient information is available to determine whether other community exposures existed (e.g., children playing in waste piles).

Currently, the facility does not process vermiculite from Libby, and remaining asbestos contamination has been removed from the site. Therefore, no public health hazard from vermiculite waste piles at the Wilder plant exists for current or future community members.

On-site soils

Again, the facility does not process vermiculite from Libby, and remaining asbestos contamination has been removed from the site. Therefore, for current or future community members, no public health hazard exists from on-site soil contamination at the Wilder plant.

Ambient air

Insufficient data exist to evaluate past asbestos exposure to the community from air emissions of asbestos from the plant. Therefore, the ambient air exposure pathway poses an indeterminate health hazard.

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

Residential outdoor

Because the facility processed a high tonnage of Libby vermiculite in the past, and because insufficient information is available concerning past waste disposal, community exposures to waste rock removed from the Wilder site 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.

Because this site stopped processing vermiculite in 1993, current indoor residential exposures pose no apparent public health hazard to the community.

Recommendations

- Promote awareness of past asbestos exposures among former workers and members of their households.
- Encourage former workers and their household contacts to inform their regular physician about their asbestos exposures. If they are concerned or symptomatic, they should be encouraged to see a physician that specializes in asbestos-related lung diseases.
- Promote awareness of potential past asbestos exposures among community members that lived near the facility from1952 to 1992; provide easily accessible materials that assist community members in self-identifying their exposures.
- Encourage past community members to inform their regular physician about their potential asbestos exposures if they feel they were exposed.
- Promote awareness of potential asbestos exposures from direct contact with waste rock brought home from the facility in the past; provide easily accessible materials that assist community members in self-identifying their exposures.

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 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

- ATSDR visited the site in September 2002
- ATSDR attended an USEPA community meeting regarding the site on September of 2003.
- USEPA has completed removal of Libby asbestos-contaminated materials and has completed remedial cleanup of the interior of the site's buildings.

Actions Ongoing

- ATSDR is conducting health statistics reviews (HSR) of sites within Kentucky (including the Wilder 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.
- ATSDR will combine the findings from this health consultation with findings from other sites nationwide that received Libby vermiculite and will create a comprehensive report outlining overall conclusions and strategies for addressing public health implications.

- ATSDR staff is researching unpublished information within the USEPA database of W.R. Grace documents — an estimated 3 million pages of information relating to Libby, Montana and other nationwide vermiculite processing sites. Specifically, ATSDR is searching for documents relating to cleaning of buildings to remove asbestos fibers, documents relating to waste disposal practices, and information that could be used for air modeling of past air emissions.

Actions Planned

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

Site Team

Author

James T. Durant, MSPH, CIH

Environmental Health Scientist, Exposure Investigations Team
Exposure Investigations and Consultation Branch (EICB)
Division of Health Assessment and Consultation (DHAC)

Technical Assistance/Project Coordination

Barbara Anderson M.S., P.E.

Environmental Health Scientist, Consultation Team
EICB, DHAC, ATSDR

Regional Representative

Bob Safay

Environmental Health Specialist
Office of Regional Operations, Region 4

Reviewed by

John Wheeler, PhD, DABT

Toxicologist
EICB, DHAC, ATSDR

Susan Moore, M.S.

Chief, Consultations Team
Exposure Investigations and Consultation Branch (EICB), DHAC, ATSDR

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Appendix A – Figures

Figure 1, Site Introductory Map

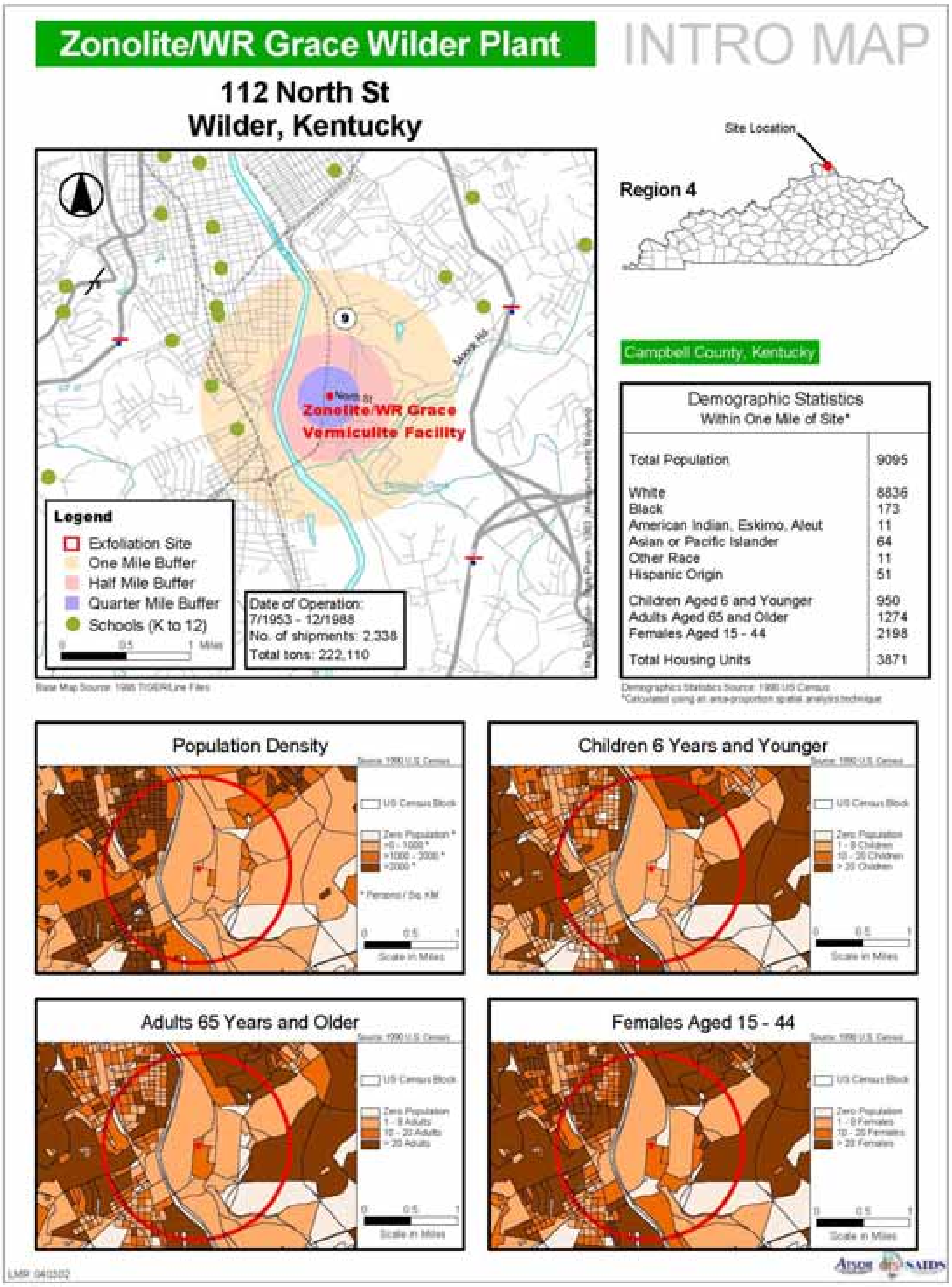


Figure 2, Year Housing Unit Structure Built by Census Tract Campbell County, Kentucky

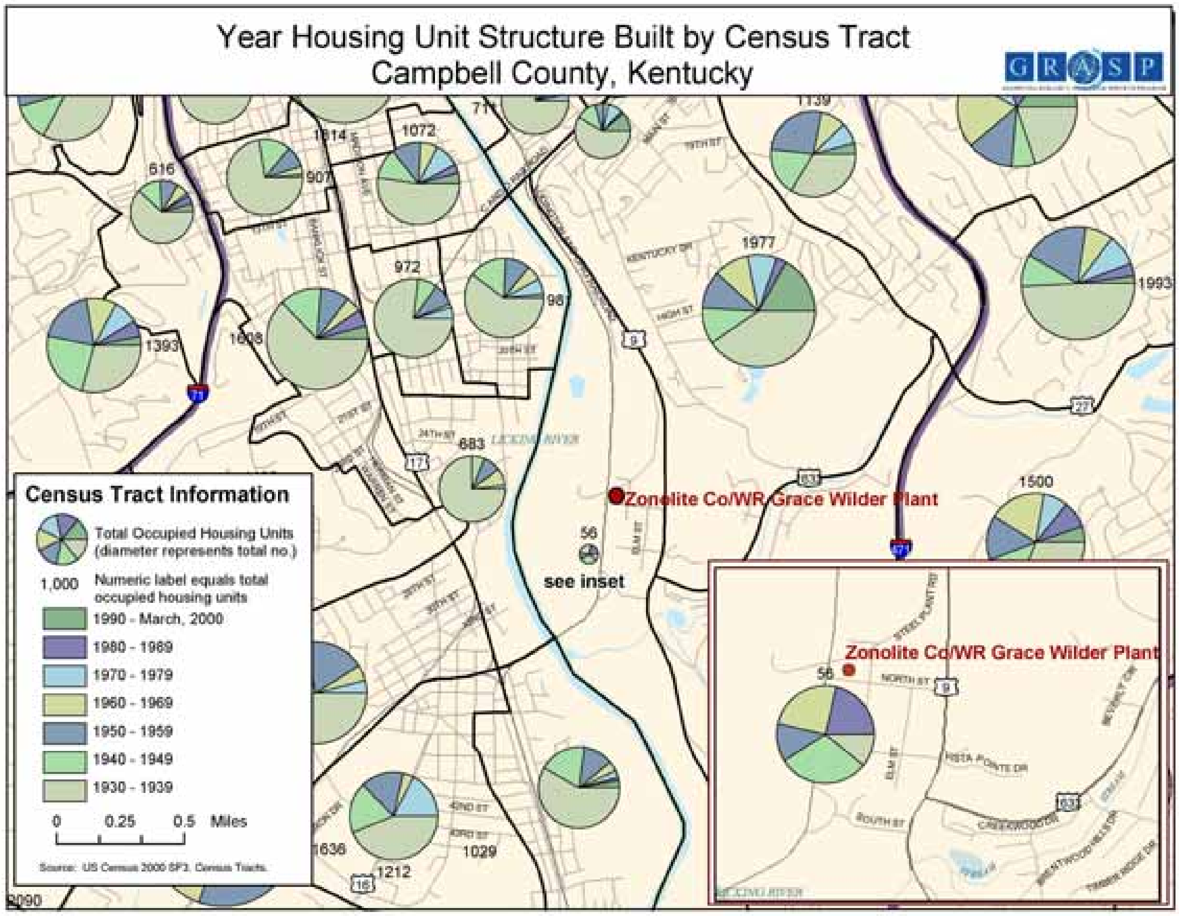


Figure 3, Year Householder Moved Into Current Housing Unit by Census Tract Campbell County, Kentucky

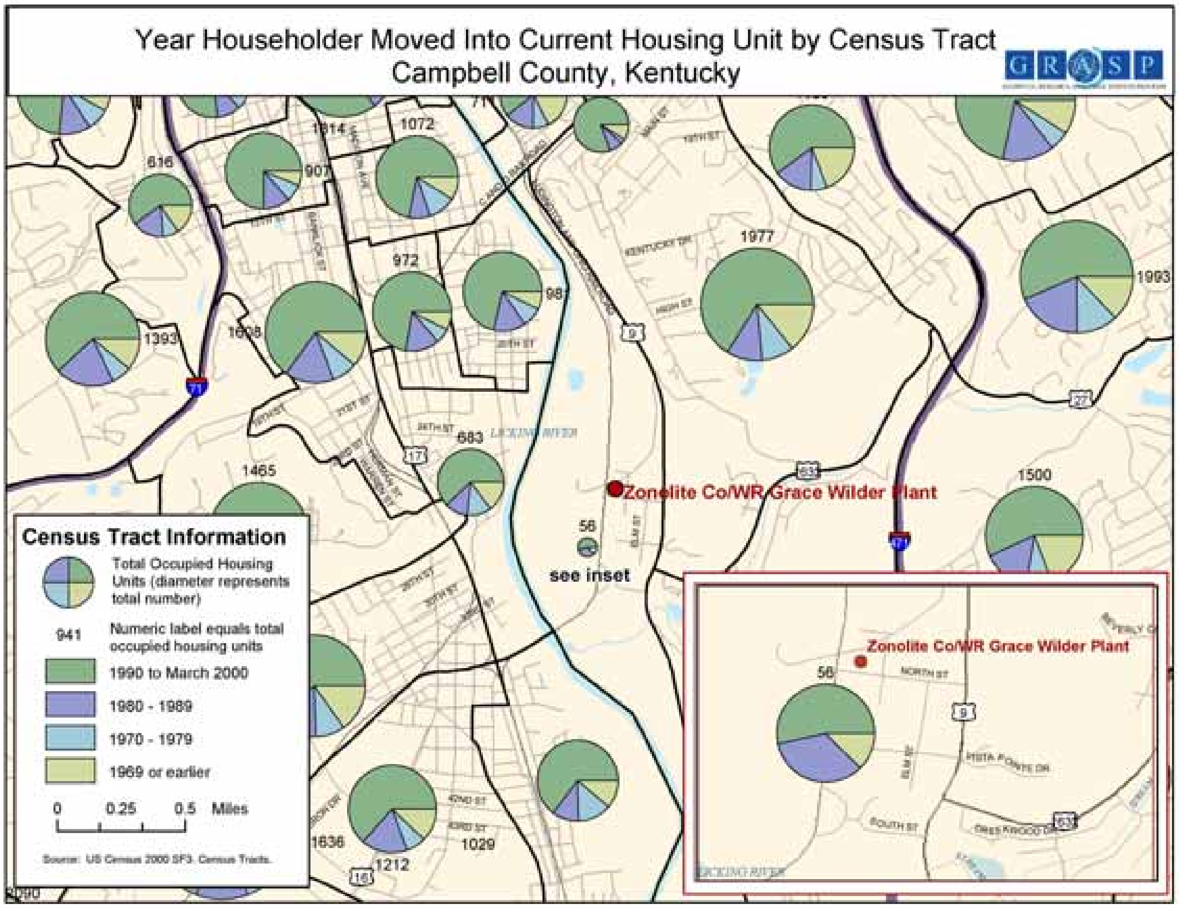


Figure 4, Asbestos Levels in Personal Samples Collected by W.R. Grace at Wilder Plant

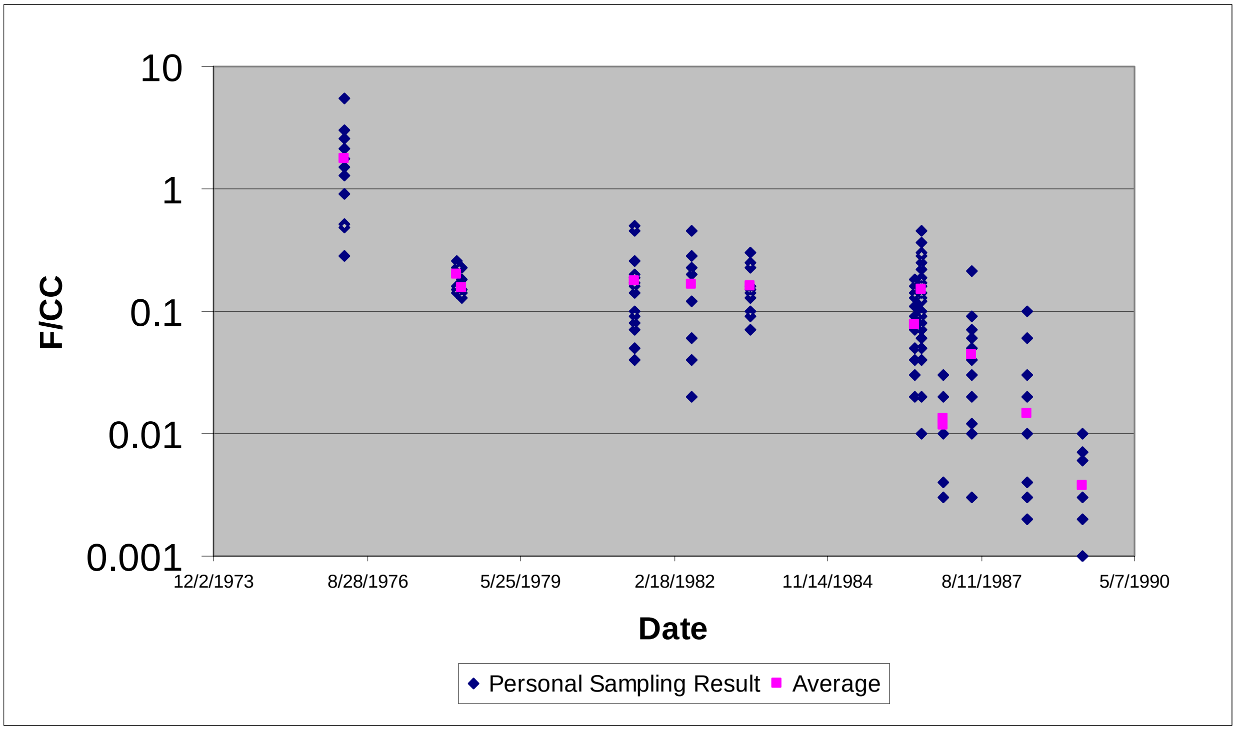


Figure 5: Asbestos Levels in Indoor (Area) Samples Inside Wilder Plant Collected by W.R. Grace

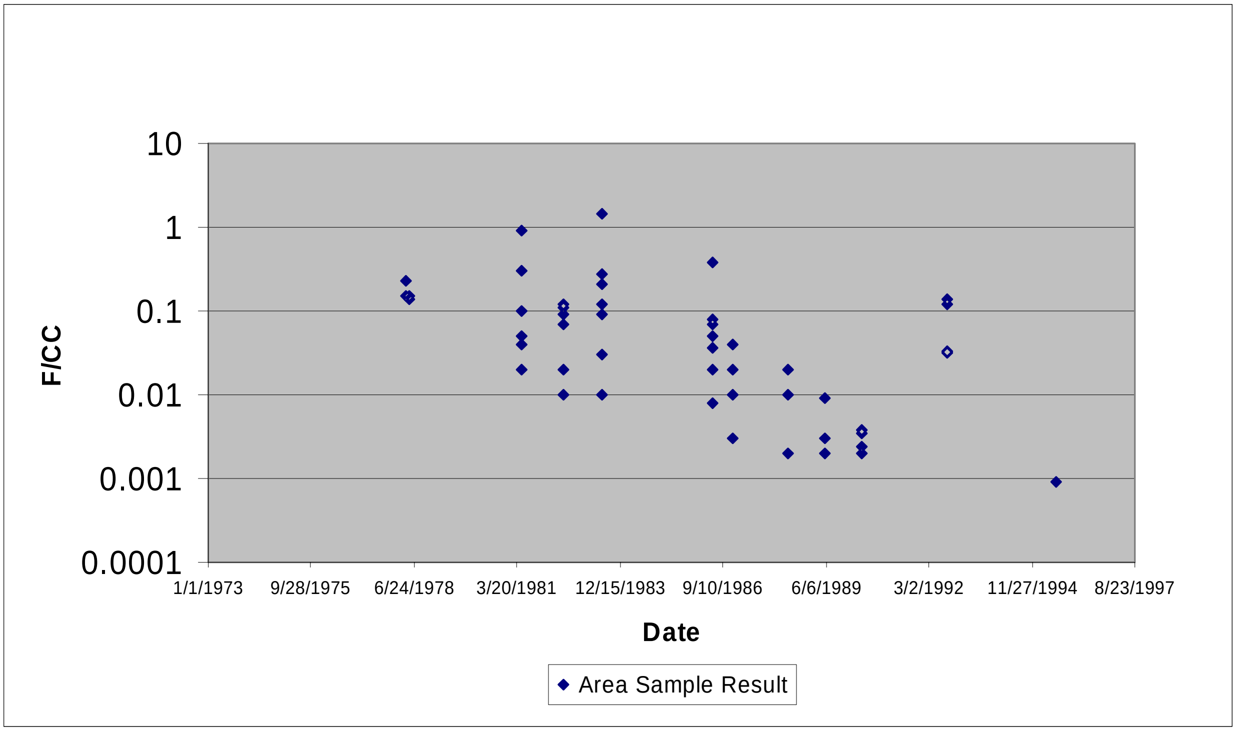


Figure 6, Aerial Photo 1955, Wilder Plant

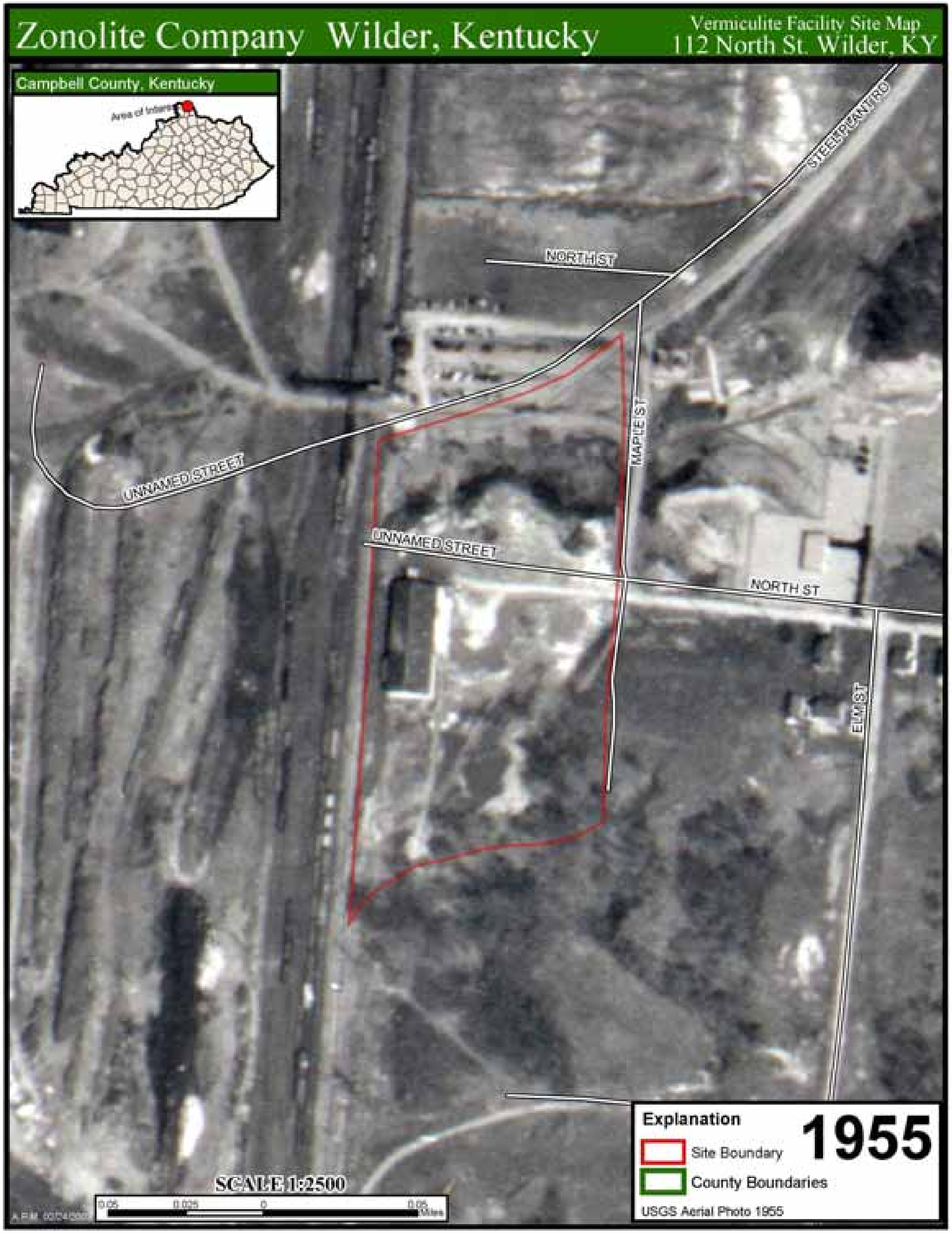


Figure 7, Aerial Photo, Wilder Plant 1960

Figure 8, Aerial Photo, 1970, Wilder Plant

Figure 9, Aerial Photo, 2000, Wilder Plant

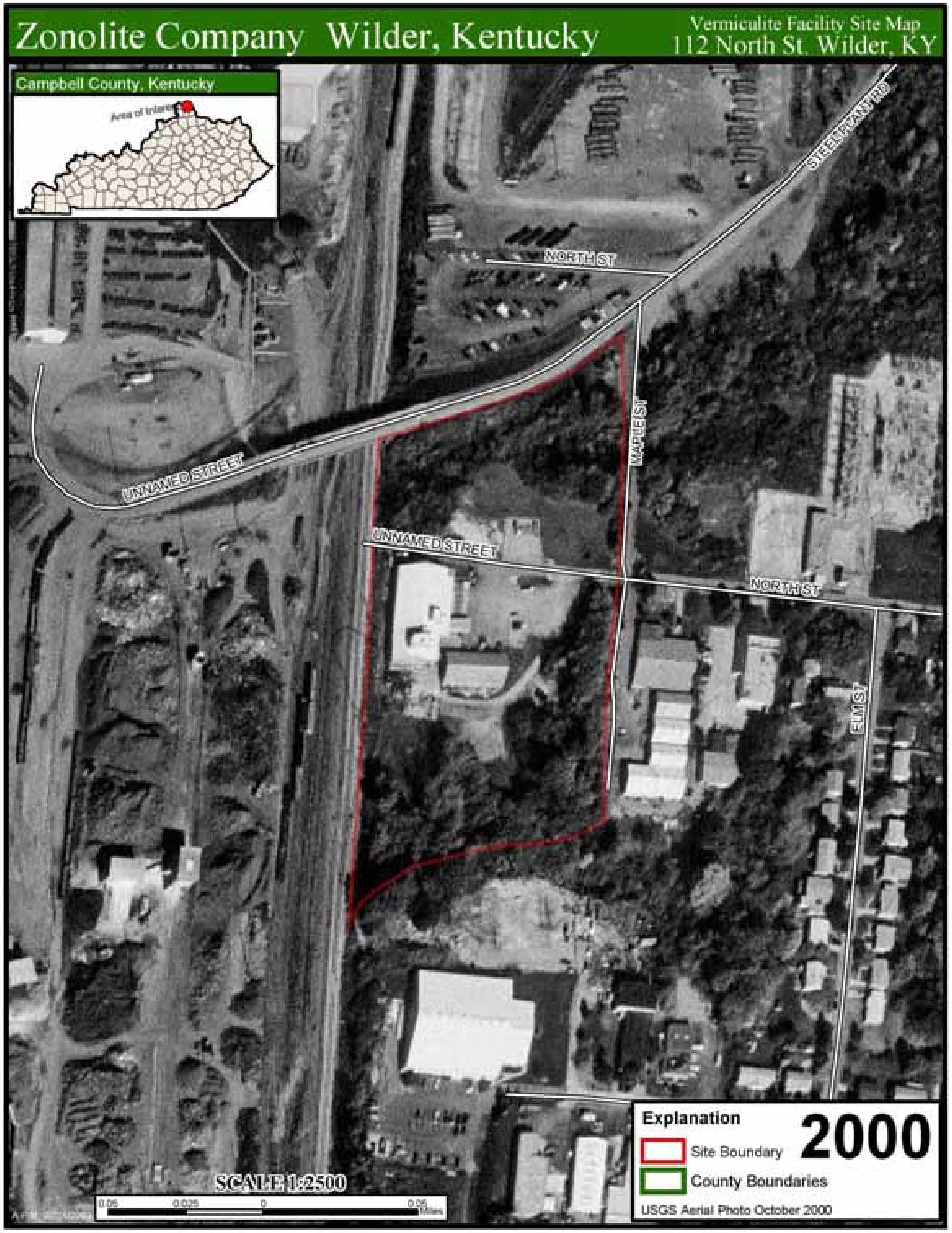
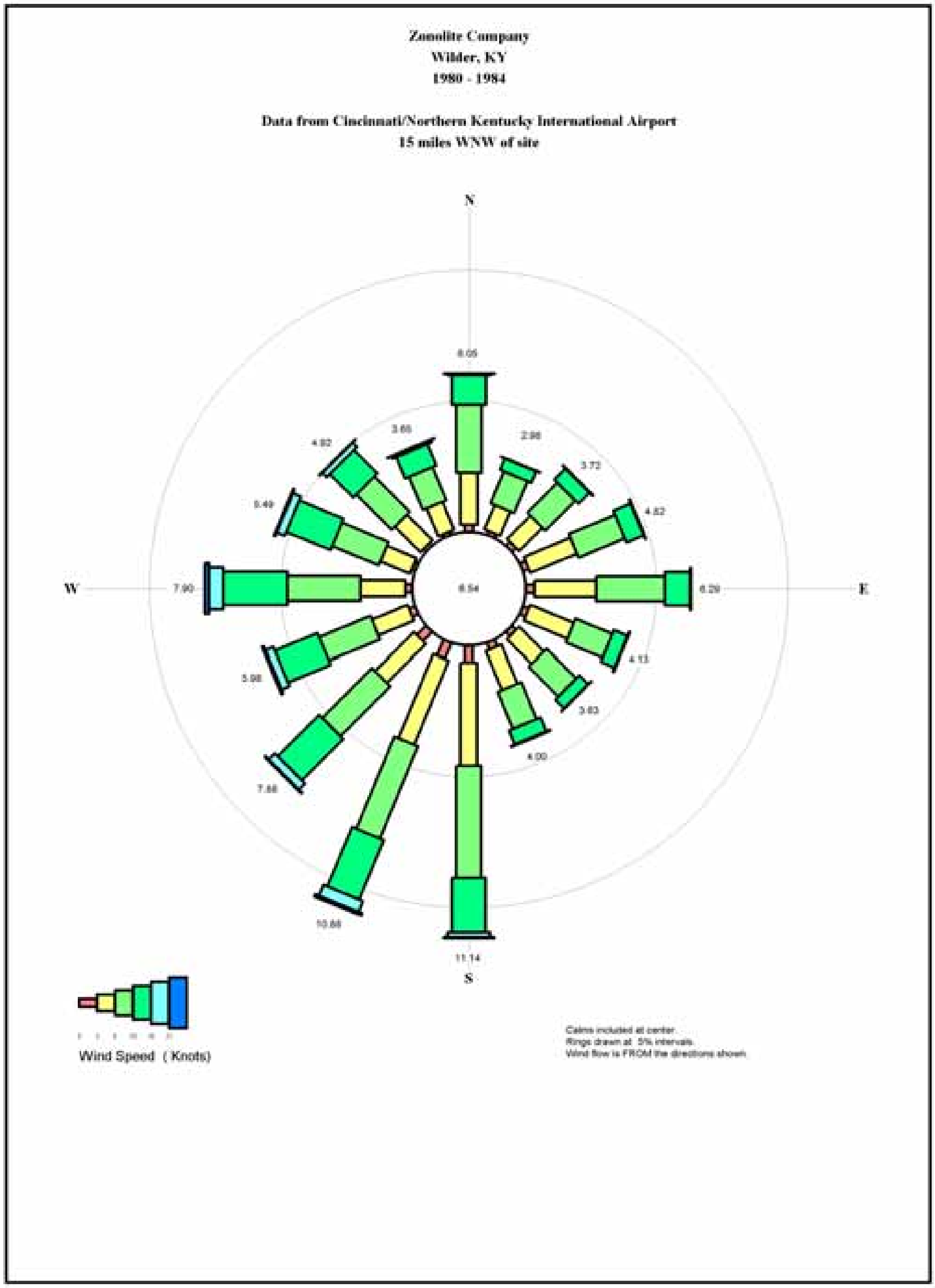


Figure 10, Wind Rose from Northern Kentucky International Airport



Appendix B – EMSL Analytical Results for Wipe and Surface Dust Samples

EMSL Analytical, Inc.
107 Haddon Ave., Westmont, NJ 08108
Phone: (856) 858-4800 Fax: (856) 858-4960 Email: ssiegel@EMSL.com

Attn: Donny Anderson, PM
CMC, Inc.
112 North Street
Wilder, KY 41071
Fax: (859) 261-6955 Phone: (859) 351-5277
Project: **W.R. GRACE SITE**

Customer ID: CMC44A
Customer PO: 2022-002
Received: 02/16/04 10:51 AM
EMSL Order: 040402479
EMSL Proj: W.R. Grace, Wilder, KY
Analysis Date: 2/18/04

Asbestos Analysis via Transmission Electron Microscopy ASTM Method D5755-03

SAMPLE ID	AREA SAMPLED (cm^2)	ASBESTOS TYPE	ASBESTOS STRUCTURES	Sensitivity (str/cm^2)	CONCENTRATION (str/cm^2)	COMMENTS
WG001MV *040402479-0001*	100	None Detected	<3	21000.000	<64000.000	
WG002MV *040402479-0002*	100	None Detected	<3	2100.000	<6400.000	
WG003MV *040402479-0003*	100	None Detected	<3	21000.000	<64000.000	
WG004MV *040402479-0004*	100	None Detected	<3	2100.000	<6400.000	
WG005MV *040402479-0005*	100	Chrysotile	<3	21000.000	<64000.000	
WG006MV *040402479-0006*	100	None Detected	<3	210000.000	<640000.000	
WG007MV *040402479-0007*	100	None Detected	<3	210000.000	<640000.000	
WG008MV *040402479-0008*	100	None Detected	<3	21000.000	<64000.000	
WG009MV *040402479-0009*	100	None Detected	<3	21000.000	<64000.000	
WG010MV *040402479-0010*	100	None Detected	<3	210000.000	<640000.000	
WG011MV *040402479-0011*	100	Chrysotile	4	21000.000	85000.000	
WG333FB *040402479-0012*		None Detected	<3			Blank

Analyst(s)

Debbie Little (12)

or other approved signatory

EMSL Analytical, Inc.
107 Haddon Ave., Westmont, NJ 08108
Phone: (856) 858-4800 Fax: (856) 858-4960 Email: ssiegel@EMSL.com

Attn: Donny Anderson, PM
CMC, Inc.
112 North Street
Wilder, KY 41071

Fax: (859) 261-6955 Phone: (859) 351-5277
Project: **W.R. GRACE SITE**

Customer ID: CMC44A
Customer PO: 2022-002
Received: 02/16/04 10:47 AM
EMSL Order: 040402480
EMSL Proj: W.R. Grace, Wilder, KY
Analysis Date: 2/18/04

Asbestos Analysis of Wipe Samples Using Method ASTM 6480-99

SAMPLE ID	AREA SAMPLED (cm^2)	ASBESTOS TYPE	ASBESTOS STRUCTURES	Sensitivity (str/cm^2)	CONCENTRATION (str/cm^2)	COMMENTS
WG007WP *040402480-0001*	100	None Detected	<2.99	11000.000	<32000.000	
WG008WP *040402480-0002*	100	None Detected	<2.99	4200.000	<13000.000	
WG009WP *040402480-0003*	100	Chrysotile L. Amphibole	13	4200.000	55000.000	
WG010WP *040402480-0004*	100	L. Amphibole	<2.99	4200.000	<13000.000	
WG011WP *040402480-0005*	100	Chrysotile L. Amphibole	15 1	11000.000	170000.000	
WG012WP *040402480-0006*	100	None Detected	<2.99	21000.000	<63000.000	
WG013WP *040402480-0007*	100	Chrysotile L. Amphibole	11 2	4200.000	55000.000	
WG014WP *040402480-0008*	100	Chrysotile L. Amphibole	51 2	11000.000	560000.000	
WG015WP *040402480-0009*	100	None Detected	<2.99	11000.000	<32000.000	
WG016WP *040402480-0010*	100	Chrysotile	3	21000.000	64000.000	
WG017WP *040402480-0011*	100	Chrysotile	<2.99	11000.000	<32000.000	
WG018WP *040402480-0012*	100	Chrysotile	<2.99	11000.000	<32000.000	

Analyst(s)
Debbie Little (15)

or other approved signatory

EMSL Analytical, Inc.
107 Haddon Ave., Westmont, NJ 08108
Phone: (856) 858-4800 Fax: (856) 858-4960 Email: ssiegel@EMSL.com

Attn:	Donny Anderson, PM CMC, Inc. 112 North Street Wilder, KY 41071			Customer ID: Customer PO: Received:	CMC44A 2022-002 02/16/04 10:47 AM
Fax: Project:	(859) 261-6955 **W.R. GRACE SITE**	Phone:	(859) 351-5277	EMSL Order: EMSL Proj: Analysis Date:	040402480 W.R. Grace, Wilder, KY 2/18/04

Asbestos Analysis of Wipe Samples Using Method ASTM 6480-99

SAMPLE ID	AREA SAMPLED (cm^2)	ASBESTOS TYPE	ASBESTOS STRUCTURES	Sensitivity (str/cm^2)	CONCENTRATION (str/cm^2)	COMMENTS
WG019WP *040402480-0013*	100	L. Amphibole	<2.99	11000.000	<32000.000	
WG334FB *040402480-0014*		None Detected	<2.99			Blank
WG335FB *040402480-0015*		None Detected	<2.99			Blank

Analyst(s)

Debbie Little (15)

or other approved signatory

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 – Libby Amphibole Asbestos Toxicology

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Asbestos minerals fall into two classes, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. 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 ($\mu g/m^3$)/(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 ($\mu g/m^{3)}$/(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 health 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; 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 cancer at sites other than the lungs, pleura, and abdominal cavity [1].

Ingestion of asbestos causes little or no risk of noncancer 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 clearing the materials from the body, 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 nontoxic in terms of association with mesothelioma or lung cancer promotion. However, fibers with lengths <5 µm 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]. 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 risk 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 µm–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 to assess the risk posed by varying types of asbestos are being developed 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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