Health Consultation

FINAL REPORT

(Former) VERMICULITE NORTHWEST
FINAL REMOVAL AND CLEAN-UP

2302 N. HARDING
PORTLAND, MULTNOMAH COUNTY, OREGON

EPA FACILITY ID: ORSFN1002216

APRIL 22, 2008

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:

Oregon Public Health Division
Office of Environmental Public Health
Environmental Health Assessment Program
Under Cooperative Agreement with the
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 National Asbestos Exposure Review (NAER) is a project of the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR is working with other federal, state, and local environmental and public health agencies to evaluate public health impacts at sites that processed Libby vermiculite.

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

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

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

- The U.S. Environmental Protection Agency (USEPA) 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.

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.

SUMMARY

This health consultation evaluates data from the final removal and clean-up actions completed by the United States Environmental Protection Agency (USEPA) at the W.R. Grace processing plant known as “Vermiculite Northwest” located in Portland, Oregon. Vermiculite Northwest, the Zonolite Division of W.R. Grace, manufactured, packaged and stored commercial vermiculite insulation products from 1950 to 1993. In 2000 the USEPA, in cooperation with the Oregon Department of Environmental Quality (ODEQ) identified asbestos fibers in dust, soil and air samples and the ODEQ issued an abatement order for the plant. The building was cleaned in April of 2001, and it was determined that no further clean-up actions were needed at the site.

In 2004, prompted by many advances in the understanding of vermiculite clean-ups since the site’s initial clean-up, as well as new information about asbestos fiber toxicity, the Environmental Health Assessment Program (EHAP) of the Oregon Public Health Division (OPHD) recommended that the site be revisited by the USEPA for further limited sampling. Air, soil and bulk samples were collected by the USEPA in August 2005, and it was determined that amphibole asbestos fibers were still detectable throughout the building. In June 2006, a removal action was completed and clearance testing was conducted. All areas of the building passed a test to determine that the removal action reduced asbestos contamination in each portion of the building to a level at or below background levels, and EHAP has determined that *no apparent public health hazard* exists for workers and visitors at the site.

PURPOSE AND HEALTH ISSUES

The former W.R. Grace processing plant known as “Vermiculite Northwest” is located at the intersections of N. Harding, N. Randolph, and N. Loring in an industrial area near the Willamette River in northeast Portland, Oregon. Vermiculite was processed at the site from the early 1950’s through 1993. From 1967 through 1991, Vermiculite Northwest received shipments of Libby vermiculite that were exfoliated at the site. Libby vermiculite is known to contain asbestos (See Appendix B) which was released into the indoor air of buildings where the material was processed.

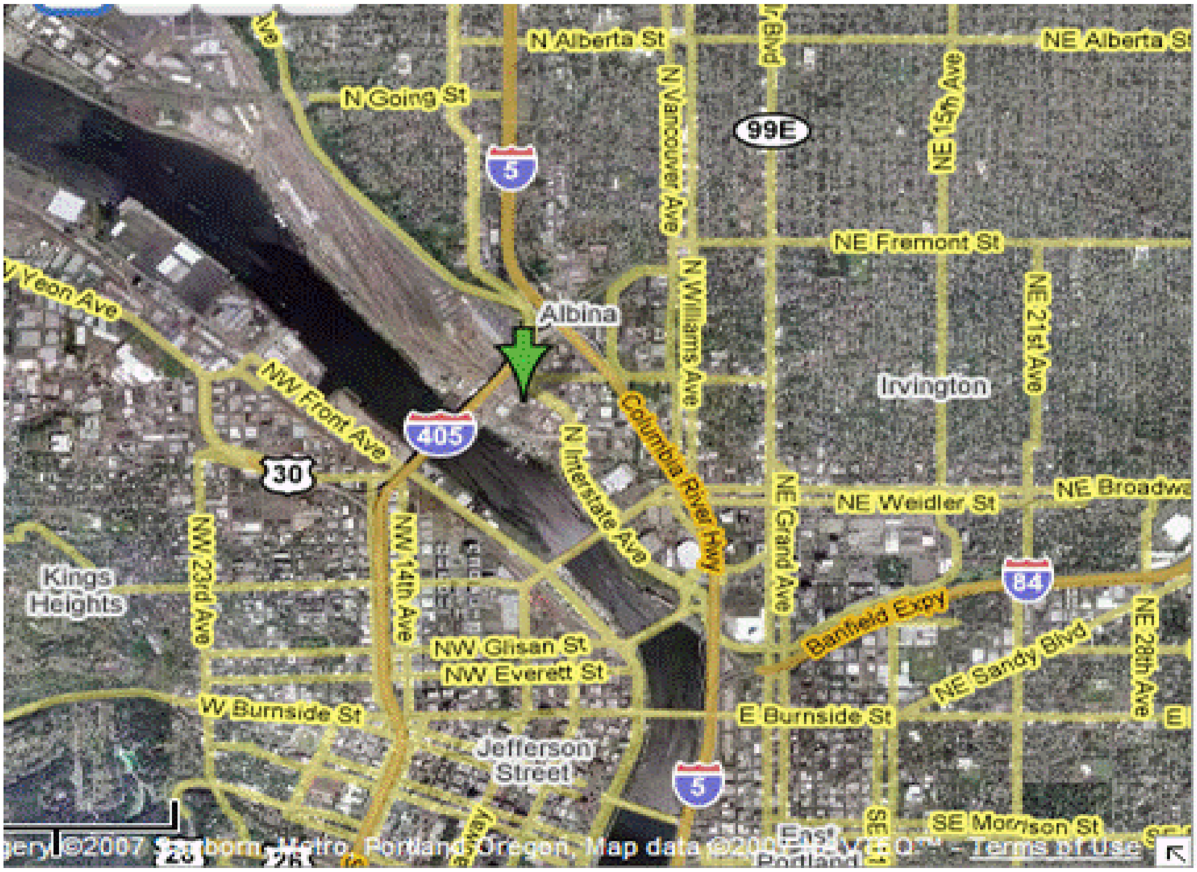
This health consultation addresses the health considerations for building tenants from exposure to asbestos fibers remaining at the site after the final clean-up actions conducted in June 2006. It evaluates the data from the final removal and clean-up actions completed by the United States Environmental Protection Agency (USEPA). The Oregon Public Health Division’s (OPHD) Environmental Health Assessment Program (EHAP) has prepared this consultation in cooperation with ATSDR.

BACKGROUND

Site Description

The building which housed the former Vermiculite Northwest facility is located at 2302 N. Harding St. in Portland, Oregon (See Figure 1). The site is situated in an industrial area approximately two blocks south of the Fremont Bridge and two blocks northeast of the Willamette River. Bordering the former Vermiculite Northwest building to the south is an electrical substation, railroad tracks are located directly to the east of the site, and warehouses and empty lots are located to the north and west. The closest residential neighborhoods are approximately three-quarters of a mile to the north.

Figure 1 – Former Vermiculite Northwest vicinity



Site History

Vermiculite Northwest (the Zonolite Division of W.R. Grace) manufactured, packaged, and stored commercial vermiculite insulation products from 1950 to 1993. Vermiculite, which was mined in Libby, Montana, is known to be contaminated with several different forms of asbestos. The plant remained under W.R. Grace's ownership until 1994.

The property was sold in March of 1994 to Walter Pelett, Sr. a local Portland businessman. In response to scientific studies in the 1990s that indicated higher rates of asbestos-related health conditions in Libby, Montana, the USEPA investigated a number of sites throughout the country where Libby vermiculite was reportedly processed. The USEPA identified Vermiculite Northwest as a site for further investigation due to the high volume of Libby vermiculite exfoliated at the site. In 2000 the USEPA, in cooperation with the Oregon Department of

Environmental Quality (ODEQ), conducted soil, dust, and air sampling inside the former plant. Asbestos fibers were found in dust, soil and air samples collected, and the ODEQ issued an abatement order for the former plant.

ODEQ supervised the asbestos abatement that was completed in February 2001. Portions of the inside of the building were pressure-washed and some rafters were scraped. The building was cleaned in April of 2001, and it was determined that no further clean-up actions were needed at the site [3].

EHAP and ATDSR staff first visited the site in March 2001, after the initial abatement was completed [1]. The team toured the site and identified areas formerly used for the processing and storage of vermiculite. An ODEQ representative presented details of the clean-up conducted under ODEQ. In August of 2002, EHAP conducted a second walk-through of the former exfoliation facility and observed the areas immediately adjacent to the facility. At that time, workers in the building reported to EHAP and ODEQ staff that large amounts of dust were released from the rafter each time a train went by on the tracks to the east of the site.

In 2004, prompted by concerns raised by existing tenants of the building combined with new information about asbestos fiber toxicity and many advances in the understanding of vermiculite clean-ups since the site's initial clean-up, EHAP recommended that the site be revisited by the USEPA for further limited sampling. As a result, USEPA completed a second investigation and clean-up at Vermiculite Northwest site, which is the subject of this health consultation. In August 2004, representatives of EHAP, USEPA, ODEQ, OR-OSHA, and a former worker visited the site to begin the process of drawing up a plan in response to EHAP's request for further limited sampling.

In 2005, EHAP released a health consultation [2] which addressed the historical health risks to former Vermiculite Northwest workers, their family members, plant visitors and community members who used the plant's by-products for home projects. That document concluded that workers employed at Vermiculite Northwest, and those who lived with them were exposed to hazardous levels of Libby asbestos as a result of working in and around the facility during unloading and exfoliation of Libby vermiculite, and asbestos fibers being brought home on clothing contaminated at the plant. The document concluded that these exposures represent a *past public health hazard*.

That health consultation also concluded that workers employed in businesses occupying the facility after vermiculite processing was discontinued may have been exposed to residual asbestos fibers in the building, but the actual levels of exposure are unknown. EHAP concluded that exposure to contaminated dust at the site from 1994 to present was considered an *indeterminate public health hazard* for workers because insufficient data were available to make a determination.

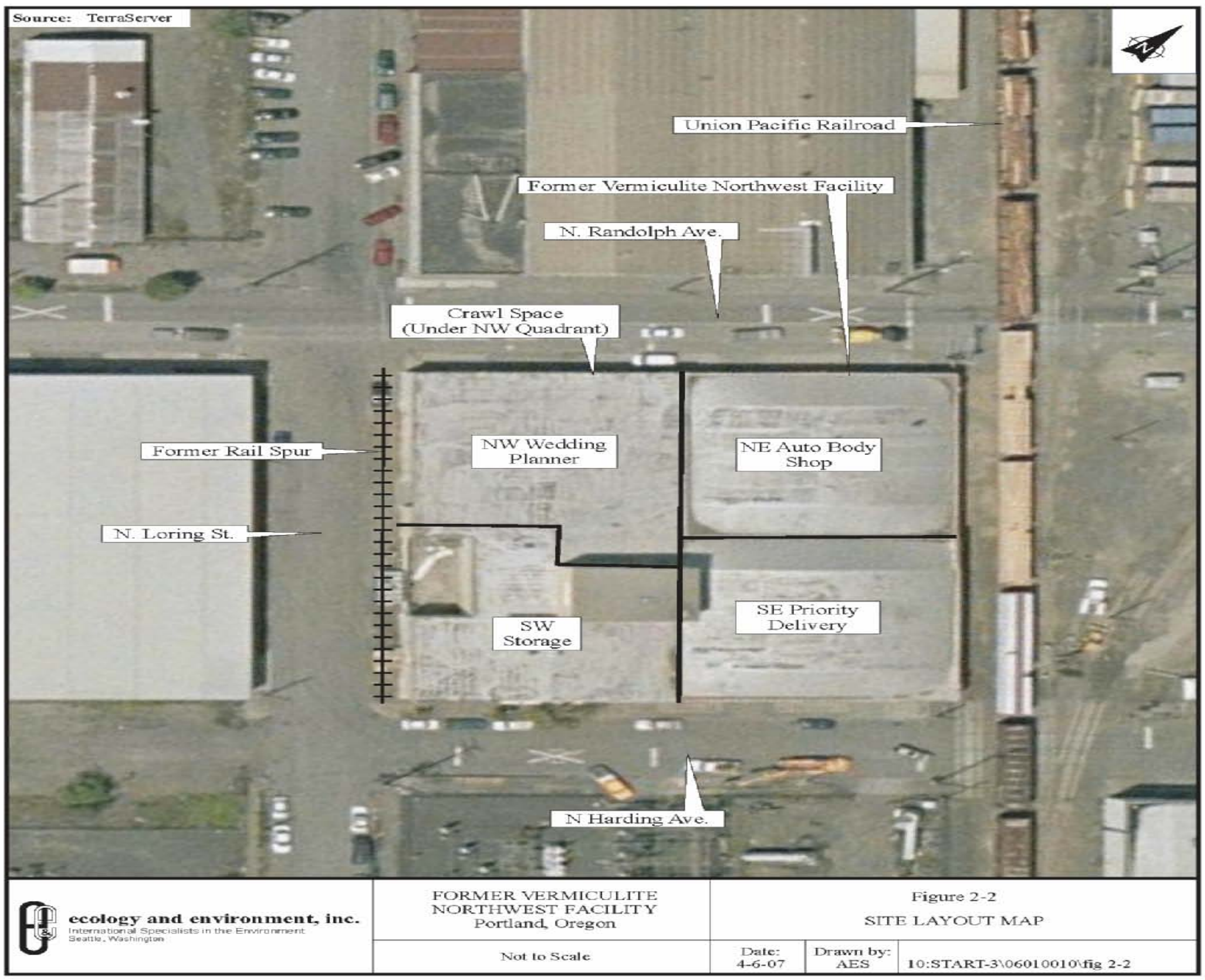
In May 2006, EHAP and USEPA staff and one of the building owners conducted a site visit, and identified areas where clean-up actions which, based on air sampling results, were deemed necessary. The carpeted area above the crawlspace in the NW quadrant (See Figure 2) was of particular concern, as was the crawlspace in the same quadrant where USEPA identified a large mound of vermiculite.

In August 2006, EHAP completed another site visit to learn what actions were being taken in the final removal and clean-up of asbestos contaminated vermiculite at the plant.

Current Use of the Building

At the time of the final clean-up, the building which housed Vermiculite Northwest was divided into four quadrants with various businesses occupying space within each section (See Figure 2).

Figure 2 – Building Overview. April 2007 [3]



At that time, the current owner of the building was running a delivery service occupying the southeast quadrant of the building. The northeast quadrant of the building was occupied by an auto-detailing business and the southwest quadrant was rented out as a storage space. The northwest quadrant is the only section of the building that had a finished interior, and it was occupied by a wedding planner and a photographer’s studio. It is also the section of the building with a crawlspace where bags of vermiculite were found in 2000 and where a mound of vermiculite was found by the USEPA in 2006. Figure 2 shows how the building space was divided and used at the time the final clean-up was completed.

DISCUSSION

Exposure Assessment and Toxicological Evaluation

Table 1 details the exposure pathways used to assess the potential health effects of asbestos exposure to current and previous workers and tenants at the former Vermiculite Northwest site. Workers employed in businesses located in the facility after vermiculite processing was discontinued may have been exposed to asbestos fibers remaining in dust and other bulk materials and released into indoor air and vermiculite remaining in outside soils.

Table 1 - Exposure Pathway Analysis After Final Clean-up

Pathway Name	Exposure Pathway Elements				Completed Exposure Pathways
	Source	**Environmental Medium**	**Route of Exposure**	**Exposure Scenario(s) Potentially Exposed Population**	
Indoor Air	Indoor Air, Dust, Vermiculite Mound	Indoor Air	Inhalation	Current workers exposed to airborne Libby asbestos from residual contamination inside former processing buildings	Past - Yes Present - No Future - No
Outdoor Air	Onsite Soils	Outdoor Air	Inhalation	Current workers disturbing contaminated onsite soils (residual contamination, buried waste)	Past - Yes Present - No Future - No

DATA

Data from the sampling event conducted by the USEPA in August 2005 indicated the presence of amphibole asbestos fibers detected throughout the building. Amphibole asbestos has been associated with increased cancer rates in residents of Libby, Montana. The USEPA has classified asbestos as a known human carcinogen and identified the cancer risk per asbestos fiber inhaled over a lifetime.

The data from the August 2005 sampling event and subsequent review of the data collected indicated that the presence of residual amphibole asbestos fibers "posed a long-term health risk to building occupants and visitors" [3], and that final cleaning and clearance testing were required to eliminate these risks. OPHD/EHAP agrees with the assessment of the potential health risks from residual fibers and the decision to conduct additional clean-up actions.

Removal Action and Final Clean-Up

Because residual vermiculite and related asbestos fibers were found during sampling, the USEPA entered into an agreement with the building owner to clean the building again and to re-sample the indoor and outdoor air after the removal and clean-up was completed. In June 2006, a removal action was performed by a certified asbestos abatement contractor, hired by the current building owner and supervised by the USEPA. Clearance testing was conducted after the removal action was completed. Each quadrant of the building, including the crawlspace and outside soils, was treated as a separate area, and the work in that area (from removal, to clean-up to clearance testing) was completed before moving on to the next area. As a result of the clean-up, the asbestos abatement contractor disposed of 135 tons of asbestos contaminated materials. A complete description of the removal action and clearance data are documented in the report *"Responsible Party Removal Action Report; Former Vermiculite Northwest Facility, Portland OR."* prepared by the USEPA's contractor, Ecology and the Environment, Inc.

Table 2 – 2007 Post Clean-Up Clearance Testing Results

Location	Structure Count	Concentration (s/cc)	Z-Test Results
Auto Shop			Pass
Base of Stairs	0	<.0003	
West Storage Shelves	5	0.0005	
Hurricane Intake	3	0.0003	
Upholstery Table	1	<.0003	
Paint Booth Areas	0	<.0003	
Delivery Service			Pass
NW corner	1	<.0003	
Near Auto Shop North	0	<.0003	
Near East Ramp	0	<.0003	
Mechanic East	0	<.0003	
Near West Ramp	0	<.0003	
Photo/Video			Pass
Inside Suite 101	2	<.0003	
Inside Suite 102	1	<.0003	
Inside Suite 103	1	<.0003	
Inside Suite 103	1	<.0003	
Inside Hall	0	<.0003	
Storage - First Round *			Fail
Basement	65	0.0065	
Above Basement	90	0.009	
Office Area	Not Analyzed - Testing Terminated		
Near New Wall	Not Analyzed - Testing Terminated		
Garage Door	Not Analyzed - Testing Terminated		
Storage - Second Round			Pass
Sheetrock Wall	10	0.001	
Above Basement	4	0.0004	
Office Area	3	0.0003	
Near New Wall	11	0.0011	
Garage Door	5	0.0005	

The Southwest quadrant of the building did not pass the initial clearance test. The area was re-cleaned, and passed the second clearance test.

Sampling was conducted throughout the removal action to determine that no asbestos fibers remained in the building after the clean-up was completed. Prior to collecting air samples, fans and leaf blowers were used to disturb the air inside the area being tested. In addition, bulk samples were taken from the crawlspace and soil samples taken from the perimeter of the building. Samples were collected by a sub-contractor for the building owner, and analyzed using the Transmission Electron Microscopy (TEM) method 10312 by QuantTEM Laboratories, LLC. As a quality check, additional samples were collected by the USEPA and were analyzed using either TEM method 10312 or 13794 by Lab/Cor of Seattle, WA, or Lab/Cor of Portland, OR. Both analytic methods are able to detect fibers to 0.0001 structures per cubic centimeter.

The Asbestos Hazard Emergency Response Act (AHERA) Z-Test method was used to compare samples taken from inside the building to samples collected at sites outside of the building, also known as background samples.[4] It is a method designed to test if an area is sufficiently cleaned, and no longer poses a health hazard. Table 3 shows the results of the clearance testing. The southwest quadrant of the building (the storage area) initially failed the Z-test comparison, so the area was re-cleaned and subsequently re-tested. This area passed the Z-test comparison the second time.

CHILDREN'S HEALTH CONSIDERATIONS

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

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

The purpose of this health consultation was to assess the health risks to on-site workers. However, levels of asbestos measured at the plant after the final removal action is protective of children who might visit the site.

CONCLUSIONS

- Final removal and clean-up actions have eliminated exposures to asbestos fibers remaining from historical operations. *No apparent current public health hazard* exists for on-site workers.
- As concluded in EHAP's previous health consultation, workers employed in businesses occupying the facility prior to the final clean-up in June 2006 may have been exposed to asbestos contaminating the indoor air of the building. These exposures represent an *indeterminate public health hazard* because insufficient data are available to make a determination.

- As concluded in EHAP's previous health consultation, soil at the railroad tracks east of the building where vermiculite was unloaded and in other areas in the perimeter of the building were determined to contain vermiculite. Workers employed in businesses occupying the facility may have been exposed to asbestos contaminating the soil in the perimeter of the building. Exposure to soil in this area is considered an *indeterminate public health hazard* due to insufficient data.

RECOMMENDATIONS/ PUBLIC HEALTH ACTION PLAN

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

Actions Completed

- USEPA collected environmental samples at the site in March 2000.
- ATSDR, USEPA, DEQ, and ODHS staff conducted a site visit in March 2001.
- ODEQ-led investigation and clean-up was completed in April 2001.
- ATSDR and EHAP staff conducted a site visit in August 2002, and EHAP staff visited the site again in September 2003 and August 2004.
- EHAP created a fact sheet with site-specific information for the former Vermiculite Northwest facility.
- USEPA collected additional soil and dust samples in August 2004 and March 2005.
- EHAP released a public health consultation assessing exposure at site.
- USEPA used data to assess health risk from asbestos exposure, and to ensure that a final removal and clean-up action was completed in 2006.

Actions Planned

- EHAP will provide educational materials and site-specific information upon request to building tenants and their workers who may have concerns or questions about vermiculite exposure.

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CERTIFICATION

The Environmental Health Assessment Program of the Oregon Department of Human Services prepared the W.R. Grace processing plant "Vermiculite Northwest", Portland, Multnomah County, Oregon Health Consultation under a cooperative agreement with the Agency for Toxic Substances and Disease Registry. This document is in accordance with approved methodology and procedures.

Alan Crawford, REHS/RS
Technical Project Officer for Oregon, CAPEB, DHAC

I have reviewed this health consultation, as the designated representative of the Agency for Toxic Substances and Disease Registry and concur with its findings.

Alan Yarbrough, M.S.
Leader, Cooperative Agreement Team, CAPEB, DHAC

APPENDIX A – ASBESTOS OVERVIEW

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

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

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

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

Methods for Measuring Asbestos Content

There are a number of different analytical methods used to evaluate asbestos content in air, soil, and other bulk materials. Each method varies in its ability to measure fiber characteristics such as length, width, and mineral type. For air samples, fiber quantification is traditionally done through phase contrast microscopy (PCM) by counting fibers with an aspect ratio (length-to-width) greater than 3:1. This is the standard method by which regulatory limits were developed. Disadvantages of this method include the inability to detect fibers thinner than 0.2 to 0.3 µm in diameter (and shorter than 5 µm) and the inability to distinguish between asbestos and non-asbestos 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 non-asbestos fibers and between different types of asbestos. The PLM method is also limited by resolution; fibers finer than about 1 µm in diameter cannot be identified by PLM. Detection limits for PLM methods are typically 1% asbestos by volume.

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

Historically, the majority of epidemiological studies performed on asbestos exposure used phase contract microscopy (PCM) to determine fiber levels in the air (f/cc). Advances in technology (e.g., transmission electron microscopy, or TEM) allows measurement of fibers that are many times smaller than those that would have been detected by PCM and thus typically results in counts much higher than would be seen had PCM been used. Therefore, for risk assessment purposes, TEM data needs to be converted to an equivalent PCM value: referred to as PCM equivalents (PCME). Two ways to make this conversion are: 1) Count (or bin) fibers with sizes equal to those that would be counted with PCM (diameter >0.4μm and length > 5μm) or, 2) make simultaneous measurements of TEM counts and PCM counts and compute a conversion factor. It should be noted that even under the best of circumstances, PCME conversions can be up to 22-53% in error (U.S.USEPA, 1986).

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

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

Asbestos Health Effects and Toxicity

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

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

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

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

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

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

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

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

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

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

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

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

Current Standards, Regulations, and Recommendations for Asbestos

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

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

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

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

In response to the WTC disaster in 2001 and an immediate concern about asbestos levels in homes in the area, ATSDR formed the Environmental Assessment Workgroup. This workgroup was made up of ATSDR, US Environmental Protection Agency, National Institute of Occupational Safety and Health, CDC National Center for Environmental Health, Occupational Safety and Health Administration, New York City Department of Health and Mental Hygiene, and the New York State Department of Health. The workgroup set a re-occupation level of 0.01 f/cc if after clean-up continued monitoring was performed to limit long-term exposure to this level [13].

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

USEPA has set a maximum contaminant level (MCL) for asbestos fibers in water of 7,000,000 fibers longer than 10 µm per liter, based on an increased risk of developing benign intestinal polyps [14]. 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, USEPA has calculated an inhalation unit risk for cancer (cancer slope factor) of 0.23 per f/cc of asbestos [7]. This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma. This quantitative risk model has significant limitations. First, the unit risks were based on measurements with phase contrast microscopy and therefore cannot be applied directly to measurements made with other analytical techniques. Second, the unit risk should not be used if the air concentration exceeds 0.04 f/cc, since above this concentration the slope factor might differ from that stated [7]. Perhaps the most significant limitation is that the model does not consider mineralogy, fiber size distribution, or other physical aspects of asbestos toxicity. USEPA is in the process of updating their asbestos quantitative risk methodology given the limitations of the current assessment and the knowledge gained since it was implemented in 1986.

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APPENDIX B - LIBBY ASBESTOS AND VERMICULITE PROCESSING

The following section provides an overview of toxicity and health effects associated with Libby asbestos. A more detailed discussion of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques and the current regulations concerning asbestos in the environment can be found at the end of this document and will also be provided in ATSDR's upcoming Summary Report for the national review of vermiculite sites.

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

Vermiculite from Libby is contaminated with several types of asbestos fibers. Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers. Asbestos minerals fall into two classes – serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Regulated amphibole minerals include amosite, tremolite actinolite, anthophyllite, and crocidolite [10]. Other amphibole minerals, however, including winchite, richterite, and others, can exhibit fibrous asbestiform properties.

Asbestos fibers found in vermiculite from Libby include the amphibole asbestos varieties tremolite and actinolite and the related fibrous asbestiform minerals winchite, richterite, and ferrodenite [11]. In this report, "Libby asbestos" (LA) is used to refer to the characteristic composition of asbestos contained in Libby vermiculite. The raw vermiculite ore was estimated to contain up to 26% Libby asbestos as it was mined [12]. The mined vermiculite ore was processed to remove unwanted materials and then sorted into various grades or sizes of vermiculite (from #0, or coarse, to #5, fine) that were then shipped to sites across the nation for expansion (exfoliation) or use as a raw material in manufactured products.) Some studies have suggested that the different ore grades may have had varying asbestos contents, with finer-sized grades having higher contamination [13, 14]. Additional studies suggest that the tremolite content ranged from 0.3% to 7% in the various grades of ore [12, 15].

Vermiculite is a non-fibrous, platy weathered mica mineral type used in many commercial and consumer applications [16]. Raw vermiculite ore is used in gypsum wallboard, cinder blocks, and many other products, and exfoliated vermiculite is used as loose fill insulation, as a fertilizer carrier, and as an aggregate for concrete. Exfoliated vermiculite is formed by heating the ore to approximately 2,000 degrees Fahrenheit (^{o}F); a process which explosively vaporizes the water contained within the mineral structure and causes the vermiculite to expand by a factor of 10 to 15.

APPENDIX C - ATSDR GLOSSARY OF ENVIRONMENTAL HEALTH TERMS

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR serves the public by using the best science to take responsive public health actions and provides trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health.

This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call ATSDR's toll-free telephone number, 1-888-42-ATSDR (1-888-422-8737).

Absorption How a chemical enters a person's blood after the chemical has been swallowed, has come into contact with the skin, or has been breathed in.

Acute Exposure Contact with a chemical that happens once or only for a limited period of time. ATSDR defines acute exposures as those that might last up to 14 days.

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

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

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

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

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

Asbestos	A group of highly fibrous minerals with separable, long, thin fibers often arranged in parallel in a column or in matted masses. Separated asbestos fibers are generally strong enough and flexible enough to be spun and woven, are heat resistant, and are chemically inert. See definitions of fibrous and mineral. Currently, U.S. regulatory agencies recognize six asbestos minerals: the serpentine mineral, chrysotile; and five asbestiform amphibole minerals, actinolite asbestos, tremolite asbestos, anthophyllite asbestos, amosite asbestos (also known as asbestiform cummingtonite-grunerite), and crocidolite asbestos(also known as asbestiform riebeckite).
Asbestosis	Interstitial fibrosis of the pulmonary parenchymal tissue in which asbestos bodies (fibers coated with protein and iron) or uncoated fibers can be detected. Pulmonary fibrosis refers to a scar-like tissue in the lung which does not expand and contract like normal tissue. This makes breathing difficult. Blood flow to the lung can also be decreased, and this causes the heart to enlarge. People with asbestosis have shortness of breath, often accompanied by a persistent cough. Asbestosis is a slow-developing disease that can eventually lead to disability or death in people who have been exposed to high amounts of asbestos over a long period. Asbestosis is not usually of concern to people exposed to low levels of asbestos.
Aspect Ratio	Length to width ratio.
ATSDR	The **A**gency for **T**oxic **S**ubstances and **D**isease **R**egistry. ATSDR is a federal health agency in Atlanta, Georgia that deals with hazardous substance and waste site issues. ATSDR gives people information about harmful chemicals in their environment and tells people how to protect themselves from coming into contact with chemicals.
Background Level	An average or expected amount of a chemical in a specific environment. Or, amounts of chemicals that occur naturally in a specific environment.
Bioavailability	See **Relative Bioavailability**.
CAP	**See Community Assistance Panel.**
Cancer	A group of diseases which occur when cells in the body become abnormal and grow, or multiply, out of control
Carcinogen	Any substance shown to cause tumors or cancer in experimental studies.
CERCLA	See **C**omprehensive **E**nvironmental **R**esponse, **C**ompensation, and **L**iability **A**ct.

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

Completed Exposure Pathway

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

Comparison Value (CVs) Concentrations of substances in air, water, food, and soil that are unlikely, upon exposure, to cause adverse health effects. Comparison values are used by health assessors to select which substances and environmental media (air, water, food and soil) need additional evaluation while health concerns or effects are investigated.

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) **CERCLA** was put into place in 1980. It is also known as **Superfund**. This act concerns releases of hazardous substances into the environment, and the clean-up of these substances and hazardous waste sites. This act created ATSDR and gave it the responsibility to look into health issues related to hazardous waste sites.

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

Contaminant See **Environmental Contaminant**.

Delayed Health Effect A disease or injury that happens as a result of exposures that may have occurred far in the past.

Dermal Contact A chemical getting onto your skin. (see **Route of Exposure**).

Dose The amount of a substance to which a person may be exposed, usually on a daily basis. Dose is often explained as “amount of substance(s) per body weight per day”.

Dose / Response The relationship between the amount of exposure (dose) and the change in body function or health that result.

Duration The amount of time (days, months, years) that a person is exposed to a chemical.

Environmental Contaminant A substance (chemical) that gets into a system (person, animal, or the environment) in amounts higher than the **Background Level**, or what would be expected.

Environmental Media U.S.	Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. **Environmental Media** is the second part of an **Exposure Pathway**.
Environmental Protection Agency (EPA)	The federal agency that develops and enforces environmental laws to protect the environment and the public's health.
Epidemiology	The study of the different factors that determine how often, in how many people, and in which people will disease occur.
Exposure	Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see **Route of Exposure**.)
Exposure Assessment	The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.
Exposure Pathway	A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having 5 parts 1. Source of Contamination, 2. Environmental Media and Transport Mechanism, 3. Point of Exposure, 4. Route of Exposure, and 5. Receptor Population. When all 5 parts of an exposure pathway are present, it is called a **Completed Exposure Pathway**. Each of these 5 terms is defined in this Glossary.
Fiber	Any slender, elongated mineral structure or particle. For the purposes of counting asbestos fibers in air samples, regulatory agencies commonly count particles that have lengths >5 µm and length: width ratios >3:1 as fibers. For detecting asbestos fibers in bulk building materials, particles with length: width ratios >5:1 are counted as fibers.
Fiber-year/mL	A cumulative exposure measure calculated by multiplying a worker's duration of exposure (measured in years) by the average air concentration during the period of exposure (measured in number of fibers/mL of air). Epidemiologic studies of groups of asbestos-exposed

	workers commonly express exposure in these units
Fibrous	A mineral habit with crystals that look like fibers. A mineral with a fibrous habit is not asbestiform if the fibers are not separable and are not long, thin, strong, and flexible.
Frequency	How often a person is exposed to a chemical over time; for example, every day, once a week, and twice a month.
Friable ACM	Friable **a**sbestos-**c**ontaining material is any asbestos-containing material that can be crumbled, pulverized or reduced to powder by hand pressure when dry. Friable asbestos material includes any asbestos-containing material that is shattered or subjected to sanding, grinding, sawing, abrading, or has the potential to release asbestos fibers.
Hazardous Waste	Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.
Health Effect	ATSDR deals only with **Adverse Health Effects** (see definition in this Glossary).
Indeterminate Public Health Hazard	The category is used in Public Health Assessment documents for sites where important information is lacking (missing or has not yet been gathered) about site-related chemical exposures.
Ingestion	Swallowing something, as in eating or drinking. It is a way a chemical can enter your body (See **Route of Exposure**).
Inhalation	Breathing. It is a way a chemical can enter your body (See **Route of Exposure**).
Interstitial	A term used as an adjective relating to spaces within a tissue or organ. Pulmonary interstitial fibrosis refers to fibrosis (scarring) developing within lung tissue
LOAEL	**L**owest **O**bserved **A**dverse **E**ffect **L**evel. The lowest dose of a chemical in a study, or group of studies, that has caused harmful health effects in people or animals.
Malignancy	See **Cancer**.

MRL	**M**inimal **R**isk **L**evel. An estimate of daily human exposure – by a specified route and length of time -- to a dose of chemical that is likely to be without a measurable risk of adverse, noncancerous effects. An MRL should not be used as a predictor of adverse health effects.
MCL	**M**aximum **C**ontaminant **L**evel - the highest permissible level of contaminant in drinking water for it to be deemed suitable for human consumption.
NPL	The **N**ational **P**riorities **L**ist. (Which is part of **Superfund**.) A list kept by the U.S. Environmental Protection Agency (EPA) of the most serious uncontrolled or abandoned hazardous waste sites in the country. An NPL site needs to be cleaned up or is being looked at to see if people can be exposed to chemicals from the site.
NOAEL	**N**o **O**bserved **A**dverse **E**ffect **L**evel. The highest dose of a chemical in a study, or group of studies, that did not cause harmful health effects in people or animals.
No Apparent Public Health Hazard	The category is used in ATSDR's Public Health Assessment documents for sites where exposure to site-related chemicals may have occurred in the past or is still occurring but the exposures are not at levels expected to cause adverse health effects.
No Public Health Hazard	The category is used in ATSDR's Public Health Assessment documents for sites where there is evidence of an absence of exposure to site-related chemicals.
PHA	**P**ublic **H**ealth **A**ssessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.
PCME	**P**hase **C**ontrast **M**icroscopy **E**quivalent structures are those that are longer than 5 μm, thicker than 0.25 μm, and exhibit an aspect (length to width) ratio greater than 3:1.
PLM	**P**olarized **L**ight **M**icroscopy is standard method used to quantify asbestos fibers.
Pleura	A thin lining or membrane around the lungs or chest cavity. This lining can become thickened or calcified in asbestos-related disease.
Pleural	Having to do with or involving the pleura.
Pleural	Abnormal or diseased changes occurring in the pleura.

Pleural abnormalities Abnormalities associated with exposure to asbestos include pleural plaques, pleural thickening or calcifications, and pleural effusion
.

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

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

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

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

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

Plume A line or column of air or water containing chemicals moving from the source to areas further away. A plume can be a column or clouds of smoke from a chimney or contaminated underground water sources or contaminated surface water (such as lakes, ponds and streams).

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

PRP **P**otentially **R**esponsible **P**arty. A company, government or person that is responsible for causing the pollution at a hazardous waste site. PRP's are expected to help pay for the clean-up of a site.

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

Public Health Assessment(s)	See **PHA**.
Public Health Hazard	The category is used in PHA's for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.
Mesothelioma	Cancer of the thin lining surrounding the lung (the pleura) or the abdominal cavity (the peritoneum). Mesothelioma is a rare cancer in the general population
Mineral	Any naturally occurring, inorganic substance with a crystal structure.
Reference Concentration (RfC)	The concentration of a chemical in air that is very unlikely to have adverse effects if inhaled continuously over a lifetime.
Reference Dose (RfD)	An estimate, with safety factors (see **safety factor**) built in, of the daily, life-time exposure of human populations to a possible hazard that is <u>not</u> likely to cause harm to the person.
Relative Bioavailability	The amount of a compound that can be absorbed from a particular medium (such as soil) compared to the amount absorbed from a reference material (such as water). Expressed in percentage form.
Route of Exposure	The way a chemical can get into a person's body. There are three exposure routes – breathing (also called inhalation), – eating or drinking (also called ingestion), and – getting something on the skin (also called dermal contact).
Safety Factor	Also called **Uncertainty Factor**. When scientists don't have enough information to decide if an exposure will cause harm to people, they use "safety factors" and formulas in place of the information that is not known. These factors and formulas can help determine the amount of a chemical that is <u>not</u> likely to cause harm to people.
SARA	The **Superfund Amendments and Reauthorization Act** in 1986 amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects resulting from chemical exposures at hazardous waste sites.
Sample Size	The number of people that are needed for a health study.

Sample	A small number of people chosen from a larger population (See Population).
Source (of Contamination)	The place where a chemical comes from, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an **Exposure Pathway**.
Special Populations	People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and older people are often considered special populations.
Statistics	A branch of the math process of collecting, looking at, and summarizing data or information.
Superfund Site	A way to collect information or data from a group of people (**population**). Surveys can be done by phone, mail, or in person. ATSDR cannot do surveys of more than nine people without approval from the U.S. Department of Health and Human Services.
Synergistic effect	A health effect from an exposure to more than one chemical, where one of the chemicals worsens the effect of another chemical. The combined effect of the chemicals acting together are greater than the effects of the chemicals acting by themselves.
TEM	Transmission Electron Microscopy - the preferred technique for air, dust, soil and water asbestos analyses.
Toxic	Harmful. Any substance or chemical can be toxic at a certain dose (amount). The dose is what determines the potential harm of a chemical and whether it would cause someone to get sick.
Toxicology	The study of the harmful effects of chemicals on humans or animals.
Tumor	Abnormal growth of tissue or cells that have formed a lump or mass.
Uncertainty Factor	See **Safety Factor**.