Health Consultation

Evaluation of Community-Wide Asbestos Exposures

EL DORADO HILLS NATURALLY OCCURRING ASBESTOS SITE
EL DORADO HILLS BOULEVARD, EL DORADO HILLS, CALIFORNIA

EPA FACILITY ID: CAN000906083

AUGUST 16, 2011

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

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners 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 or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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Table of Contents

Summary

Introduction

ATSDR's top priority is to ensure that people living in the El Dorado Hills area have the best information possible to safeguard their health. ATSDR is a public health agency that provides information and makes recommendations to reduce or prevent harmful exposures to hazardous substances in the environment.

ATSDR conducted this health consultation in response to concerns about potential community exposures to naturally occurring asbestos (NOA) deposits in local soil and rock formations. Sampling conducted by the U.S. Environmental Protection Agency (EPA) had previously shown that people performing typical outdoor recreational activities could breathe in high concentrations of NOA, compared to reference samples. Community members asked ATSDR what this finding meant to their health and what they should do to protect their health.

To answer these questions for the community as a whole, ATSDR used the EPA sampling results to estimate how much NOA an El Dorado Hills resident might breathe in throughout life. Several different risk assessment calculation methods were then compared to get a general sense of the risk of developing asbestos-related cancers from those exposures. Finally, results of additional studies on NOA in the El Dorado Hills area were examined.

Conclusions

ATSDR reached two important conclusions in the health consultation:

Conclusion 1

Breathing in naturally occurring asbestos (NOA) in the El Dorado Hills area, over a lifetime, has the potential to harm people's health.

Basis for conclusion

- Background concentrations of NOA in El Dorado Hills are higher than asbestos concentrations measured in other non-urban and most urban environments. Activities that disturb NOA could result in concentrations higher than background.
- A general sense of the increased risk of developing cancer from breathing in asbestos throughout life was obtained using several different risk assessment methods with the results of EPA's activity-based sampling in El Dorado Hills. For each method, a range of theoretical increased risks of developing cancer was estimated using different assumptions about how much and how often people breathed in NOA. Each risk method has considerable uncertainty, but the different risk methods gave similar results: the predicted increased risk of cancer ranged from too low to be of concern to a level high enough that action to prevent exposures would be warranted.
- Any one person could have markedly higher (or lower) exposures than the general estimates made in this report, depending on whether, how, and how often they encounter NOA in their daily activities.

Next steps

The following actions will reduce the likelihood for people to breathe NOA:

Increase Awareness

- El Dorado County should continue to assess the community's knowledge about the presence and associated risk of NOA and to provide information about ways to manage the risk. ATSDR can provide assistance, if requested.
- El Dorado County should implement, to the extent possible, effective ways to:
  - Maintain current records of locations known to contain NOA and
  - Notify current and prospective landowners of the possibility for NOA to exist in soil or bedrock on their property.

Limit Exposure

- State and local entities should continue to enforce applicable dust regulations throughout the community, which will reduce releases of NOA. These regulations include:
  - Prohibition of visible dust emissions outside the property line or more than 25 feet from the point of dust-disturbing activities,
  - Implementation of procedures to prevent vehicles and equipment from releasing dust or tracking soil off-site, and
  - Requirements for planning, notification, and record-keeping.
- Community members and groups should learn how to minimize their exposure to NOA while conducting their normal activities. ATSDR guidelines are included in Appendix H of this report.

Conclusion 2

Reducing exposures to NOA will protect people's health and is warranted in El Dorado County based on estimates of past exposures. State cancer registry information indicates that the community's health has not been impacted at this time. However, health impacts to individuals from past exposures are highly variable and may take years before the cancer registry detects them.

Basis for conclusion

- The association between asbestos exposure and disease is well established. Preventing inhalation of asbestos will reduce risk of disease.
- Mesothelioma incidence, tracked by the California Cancer Registry, is not higher than expected in western El Dorado County at this time. However, mesothelioma may take decades after exposure to appear.
- Although the community in general is estimated to have an increased risk of exposure and disease, individuals' risk may vary widely due to the sporadic nature of NOA occurrences and individual behaviors leading to exposure. Individual assessment by personal health care providers for those who are concerned about past exposures will be more efficient than general community screening in treating any health effects that may appear.

Next Steps

- State authorities should continue to monitor asbestos-related cancer incidence rates in the area.
- Community members should consult with their personal medical provider about their individual health concerns arising from NOA exposure.
- ATSDR encourages further research on NOA exposures and community health by governmental, academic, and other organizations. ATSDR may refine the conclusions and recommendations of this health consultation as results of ongoing asbestos research become available.

For More Information

For further information about this health consultation, please call ATSDR at 1-800-CDC-INFO and ask for information about the "El Dorado Hills Naturally Occurring Asbestos" site. If you have concerns about your health, you should contact your health care provider.

Background

El Dorado Hills is a community located on the western side of El Dorado County, about 20 miles east of Sacramento, California. The area around El Dorado Hills has been the subject of attention in recent years due to natural deposits of asbestos minerals in local soils and rock formations and concern about potential human exposure to asbestos resulting from disturbance of the deposits. The Agency for Toxic Substances and Disease Registry (ATSDR) is a public health agency that provides information and makes recommendations to reduce or prevent harmful exposures to hazardous substances in the environment. In 2006, ATSDR evaluated potential exposures to students and staff at a high school in El Dorado Hills and published a health consultation. As an outcome of that evaluation and remaining questions about risk in the community as a whole, ATSDR undertook further review of data collected by the U.S. Environmental Protection Agency (EPA) and others at other El Dorado Hills locations. This health consultation summarizes those data, describes additional data analysis that ATSDR funded to obtain more detailed results from earlier sampling, and describes the methods used to determine the likelihood of general community exposures leading to adverse health effects.

Peer Review / Public Comment

Many issues in asbestos science are currently debated among scientists. ATSDR requested a draft of this public health consultation be "peer reviewed" to ensure that the evaluation performed in the document was done using the best science given the nature of the available information. This public health consultation was reviewed by three independent asbestos science experts. Appendix A contains further information about the peer review, the questions posed to the peer reviewers, their comments (verbatim), and ATSDR's responses to the comments.

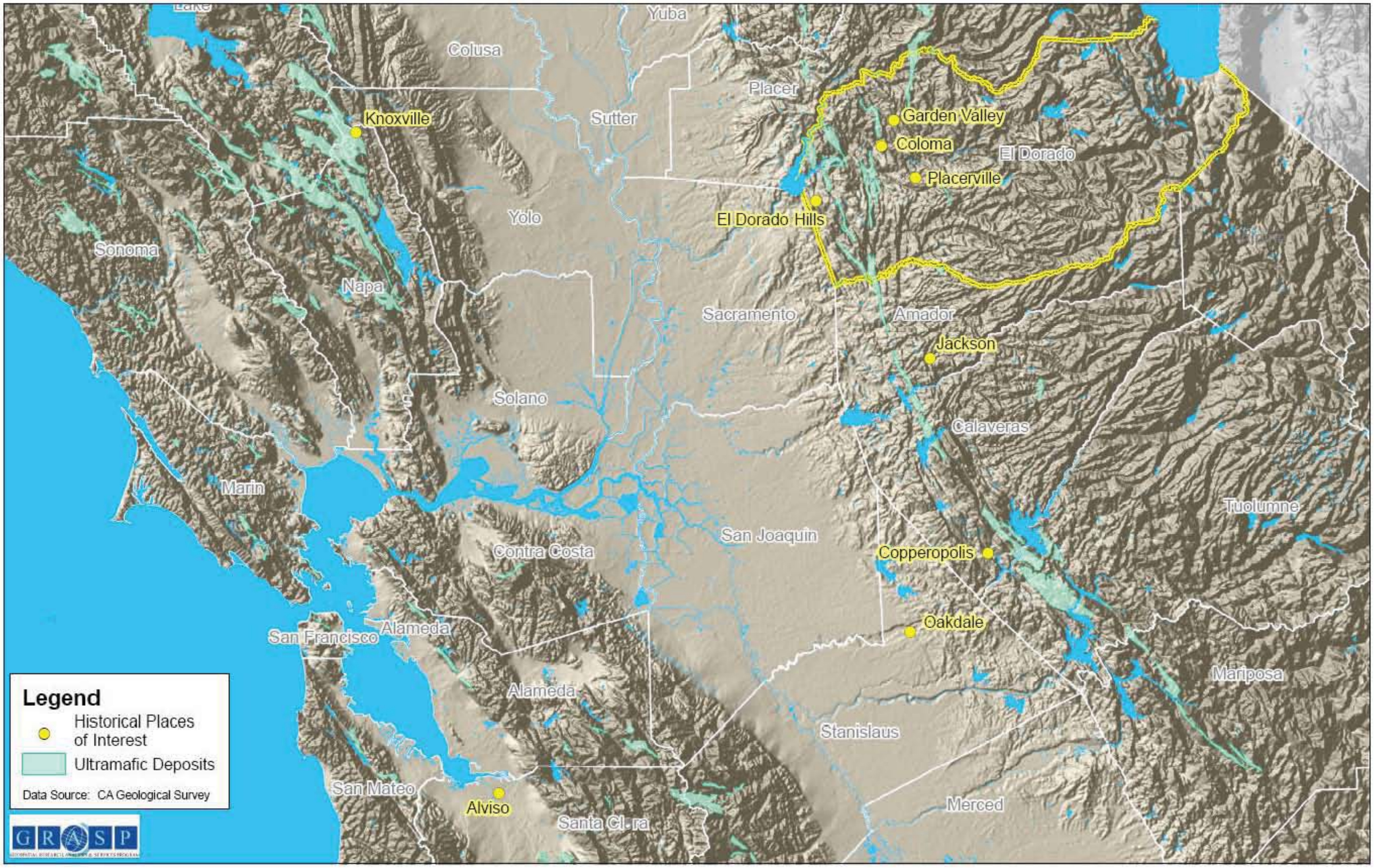
ATSDR released a draft of this health consultation (including peer review comments and responses) in March 2010 for public comment. This revised final version includes written public comments received (verbatim) and ATSDR's responses in Appendix J.

History

El Dorado County, shown in Figure 1, was designated in 1850 with the statehood of California. The name "El Dorado" refers to a city of gold imagined to exist in the New World by Spanish conquistadors and was applied to this area of California after the 1848 discovery of gold in the Coloma area. Many towns in the present-day El Dorado County, including the county seat of Placerville, grew out of gold mining camps set up in the California Gold Rush. The areas of El Dorado County not directly related to mining were typically used as agricultural land. Today, El Dorado County extends east from the Sierra Nevada foothills to the Nevada border, and north to south from the middle fork of the American River to the south fork of the Consumnes River. Much of the population growth in El Dorado County in recent years has been on the eastern and western edges of the county as a result of expansion of the Lake Tahoe and Sacramento areas, respectively.

The unincorporated community of El Dorado Hills is located along the western boundary of the county and, at approximately 20 miles east, is considered part of the Sacramento metropolitan area. The community was a master planned community envisioned in the early 1960s to be developed over the years with a series of residential "villages," a business park, golf course,

Figure 1. Location of El Dorado County (Yellow Highlight) and Historical Places of Interest



community parks, schools, and a shopping center. Initially, the population of the community grew moderately, reaching about 6,400 in 1990. In the mid-1990s, however, population growth exploded as businesses moved to the area to escape the high costs of other California locations and as a residential developer built a 3,500-acre planned community in El Dorado Hills. By 2006, the population of El Dorado Hills was estimated at over 35,000, making it the largest community in El Dorado County.

Because of its geological history, the state of California (including portions of El Dorado County and many other counties) contains areas with a high proportion of silicate rocks high in magnesium; these rocks are called ultramafic rocks. Under certain geological conditions, ultramafic rocks can be altered to serpentinite, the greenish-colored “State Rock of California.” This alteration process can also result in formation of different types of asbestos. Asbestos minerals can be formed in other types of rocks but they are more commonly formed in ultramafic rocks and near fault lines which provide necessary conditions for asbestos formation [1]. These rock types, along with geological conditions leading to formation of asbestos, have occurred not only in areas of California, but in many other places throughout the United States and the world.

For many years, geologists have been aware of the potential of serpentine rocks to contain asbestos. However, the potential for harmful exposures to the public to occur does not appear to have been realized until relatively recently. California was one of the first states to become aware of the potential for public exposure to asbestos deposits in the mid-1980s. At that time, the EPA was cleaning up a Superfund site (South Bay Asbestos) in Santa Clara County contaminated with both manufactured asbestos materials and naturally occurring asbestos from a local quarry. As part of the cleanup, EPA paved several dirt roads in the community to further reduce the chance for public exposure to asbestos [2, personal communication, Jere Johnson, EPA, November 2007]. Soon after, EPA received information that other quarries were selling asbestos-laden serpentine gravel for roads, including one in the Garden Valley area near Coloma in El Dorado County [personal communication, Arnold Den, EPA, November 2007]. EPA emergency response teams completed paving projects at Garden Valley Ranch Estates in El Dorado County and in Copper Cove Village in Calaveras County in 1986 [2-4], but it soon became clear that the number of potentially contaminated roads in California was too great to address through the Superfund emergency response process. To respond to the problem, then-California Governor Pete Wilson formed an asbestos commission which supported studies of the potential risks posed by roads. Results of testing and studies by federal and state agencies have shown the potential for asbestos exposure from serpentine gravel roads or roads cutting through natural serpentine deposits in El Dorado (Garden Valley), Calaveras (Copperopolis, Diamond XX development), Napa (Knoxville), Amador (Jackson), and Stanislaus (Oakdale) counties [5]. Approximate locations of some of the studies performed, as well as other locations mentioned in this background, are indicated in Figure 1.

Perhaps it was the information on naturally occurring asbestos from the Garden Valley publicity in combination with the sudden rapid growth in western El Dorado County in the 1990s that initiated some El Dorado Hills residents’ concerns about the potential for asbestos exposure from development activities there. Residents alerted the Sacramento newspaper, the Sacramento Bee, about their concerns and in 1998 the Bee published a series of articles describing the asbestos deposits and potential for exposure [2]. The Bee also collected air samples showing the potential for elevated exposure to asbestos, particularly the amphibole varieties tremolite and actinolite which were more prevalent in the area. As a result of the media attention on this issue, the county began screening sites for naturally occurring asbestos, tightening construction standards and requiring dust control measures on construction sites. The state banned the use of gravel containing asbestos above the detection level of 0.25%, conducted an air monitoring program to assess ambient concentrations of asbestos in the community and in other California counties, and produced a detailed geological map of rock formations in western El Dorado County more likely to contain asbestos.

The local asbestos issue continued to be fraught with controversy, however, as homeowners concerned about property values and children's health, stone processing interests concerned about increasing regulation and liability, and county officials concerned about responding to both voter and business tax bases could not agree on the degree of risk and appropriate response. In 2002, a vein of amphibole asbestos was uncovered during construction of new soccer fields at Oak Ridge High School in El Dorado Hills. Among other consequences, this event led to:

- extensive testing of the school with involvement of federal environmental and health agencies and mitigation of asbestos in and around campus by the school district and EPA,
- a health consultation by ATSDR focused on exposures at the school, described below [6],
- additional sampling in areas away from the school by EPA to assess the potential for exposure elsewhere in the community [7], and
- characterization of area soils and rocks by the U.S. Geological Survey (USGS) to identify minerals present [8].

ATSDR was asked by a community member to evaluate past exposures at Oak Ridge High School and found, based on limited sampling results, that certain groups (coaches, student athletes, and outdoor maintenance workers) may have had exposures high enough to increase the risk of asbestos related disease [6]. ATSDR committed to evaluating exposures to the general community of El Dorado Hills, in areas away from the high school. To do this, ATSDR planned to evaluate the results of sampling conducted by EPA in 2004 in community areas of El Dorado Hills [7]. The activity-based sampling used personal monitoring techniques to measure asbestos concentrations a child or adult might breathe during various activities such as playing baseball or jogging down a dirt trail. ATSDR funded additional analyses of the data to gain reliable estimates of long asbestos structure concentrations not typically enumerated by EPA, allowing a variety of standard and non-standard risk methods to be applied. Some of the specific areas with asbestos sampling and/or detection in the El Dorado Hills area are indicated in Figure 2.

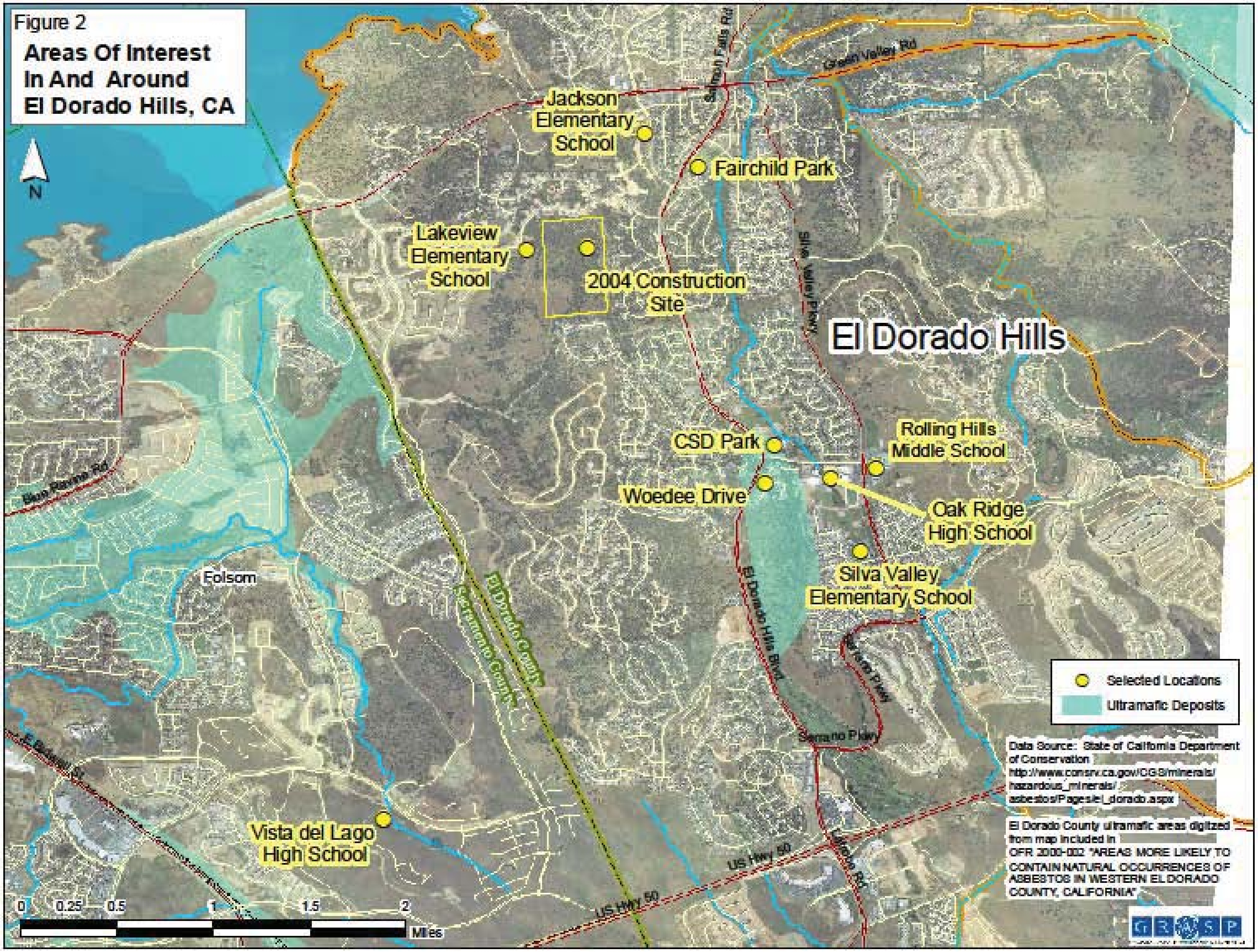


Figure 2
Areas Of Interest
In And Around
El Dorado Hills, CA
N
Jackson Elementary School
Fairchild Park
Lakeview Elementary School
2004 Construction Site
El Dorado Hills
CSD Park
Woedee Drive
Rolling Hills Middle School
Oak Ridge High School
Silva Valley Elementary School
Folsom
Vista del Lago High School
Green Valley Rd
Salmon Falls Rd
Silva Valley Pkwy
El Dorado Hills Blvd
Serrano Pkwy
US Hwy 50
El Dorado County
Sacramento County
Selected Locations
Ultramafic Deposits
Data Source: State of California Department of Conservation http://www.consrv.ca.gov/CGS/minerals/hazardous_minerals/asbestos/Pages/el_dorado.aspx
El Dorado County ultramafic areas digitized from map included in OFR 2000-002 "AREAS MORE LIKELY TO CONTAIN NATURAL OCCURRENCES OF ASBESTOS IN WESTERN EL DORADO COUNTY, CALIFORNIA"
0 0.25 0.5 1 1.5 2
Miles

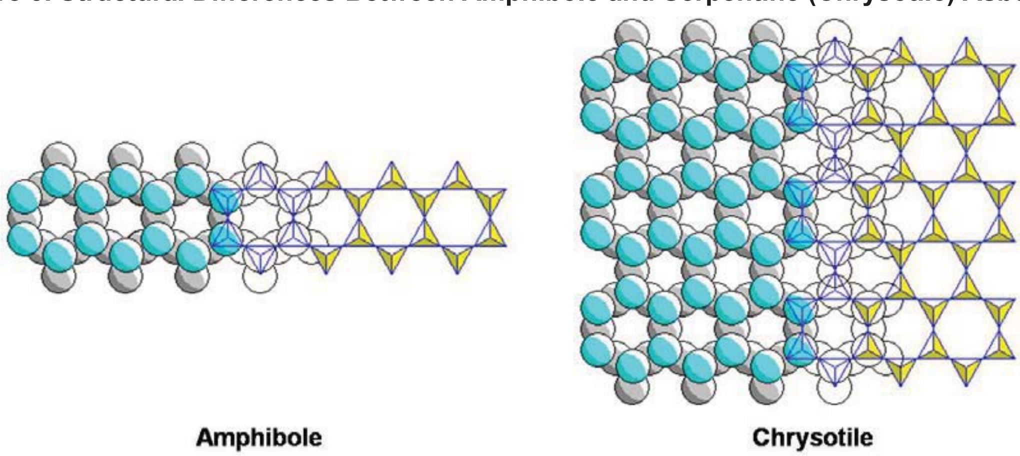
Asbestos Background

What is Asbestos? A General Term for a Group of Commercially Valuable Minerals

Asbestos refers to a special form of certain minerals that consists of long, thin, crystals (fibers) that are particularly strong, flexible, and heat resistant. They often form in bundles of very thin fibers called fibrils; their shape and flexibility means they can be woven or processed easily, but because they are silicate-based minerals, they don't react with other chemicals, conduct electricity, degrade, or burn. Asbestos minerals have been used for thousands of years. However, the scale and variety of uses, and the number of workers who mined and processed the asbestos, was small until after the industrial revolution, in the late 1800s.

Although many minerals can form into fibers with properties of asbestos, only a few varieties were plentiful enough and had the right properties to be profitably mined. The term *asbestos* came to refer only to those commercial varieties: chrysotile, amosite, crocidolite, anthophyllite, actinolite, and tremolite. Chrysotile, or "white asbestos," was (and is) the most prevalent form of asbestos used commercially. Amosite, an acronym for the Asbestos Mines of South Africa, where it was mined, and also known as "brown asbestos," had properties making it especially useful in ship and other insulation applications. Crocidolite, or "blue asbestos," was mined predominately in South Africa and Australia and used in World War II gas masks and cigarette filters, among other products. The remaining varieties (anthophyllite, actinolite, and tremolite) were mined and used in limited quantities in the past but never reached the market levels of chrysotile, amosite, and crocidolite [9]. These six types of commercial asbestos are all formed from microscopic silicate tetrahedral units and fall into two general classes as depicted in Figure 3. In *serpentine asbestos* minerals, the silicate tetrahedra form in sheets which roll to form asbestos fibers—chrysotile asbestos is the only variety of asbestos in this class. All the other commercial asbestos varieties are *amphibole asbestos* minerals, in which the silicate tetrahedra form in double chains.

Figure 3. Structural Differences Between Amphibole and Serpentine (Chrysotile) Asbestos



Both amphibole asbestos and chrysotile have a basic framework of silica tetrahedra, where a blue silicon atom is surrounded by gray oxygen atoms; oxygen atoms are shared between tetrahedra to form polymers with different structures. In amphibole asbestos, the polymer forms as a double chain (shown on the left) which can form long, thin fibrous structures. Chrysotile, in contrast, forms a sheet structure as illustrated on the right. Because of ionic charge imbalances the sheet tends to roll up in thin tubes which create the fiber. [Diagrams used with permission from Steven Dutch, Professor, University of Wisconsin – Green Bay]

In addition to identifying the chemical composition and crystal structure, commercial producers and mineralogists identify asbestos by determining if it has the desired properties for a commercial product. The following excerpt from a 2002 USGS open-file report lists the typical features of an asbestos sample:

> These fibrous minerals…are found in bundles of fibers which can be easily separated from the host matrix or cleaved into thinner fibers; the fibers exhibit high tensile strengths, they show high length:diameter (aspect) ratios, from a minimum of 20 up to greater than 1000; they are sufficiently flexible to be spun; and macroscopically, they resemble organic fibers such as cellulose [10].

To summarize, there are composition, crystal structure, and bulk properties of the mineral sample that together determine whether a particular mineral could be considered asbestos. A mineral sample of one of the six asbestos varieties would not be considered asbestos if its fibers did not meet the above description. Likewise, some minerals not included in the six varieties may form asbestos-like (asbestiform) fibers, but would not be considered commercial asbestos. This is an important distinction for understanding some of the current controversies regarding regulation and risk assessment for asbestos and other related mineral fibers. These controversies have their roots in the revelation of significant adverse health effects in men and women who worked with and around asbestos materials and products. Differing usages of the term asbestos were introduced as the number of perspectives on the varying properties of these materials increased [11].

Disease and Death Caused by Breathing Asbestos Materials

As industrial uses of asbestos grew in the late 19th century, it became evident that asbestos workers were disproportionately afflicted with lung diseases. British, French, and Italian reports highlighted the progressive nature of the fibrotic disease and its latency (the delay between exposure and the onset of symptoms of disease) around the turn of the 20th century, and the first named case of asbestosis was described in 1906 [12]. Evidence mounted, and by the 1920s, American and Canadian insurance companies refused to insure asbestos workers due to “the injurious nature of the industry”. By the mid 1900s, many studies had shown that asbestos exposure also caused elevated rates of lung cancer, pleural abnormalities, and mesothelioma among workers. By the time the U.S. Occupational Safety and Health Administration (OSHA) was established in 1972, asbestos exposure was a known workplace hazard, and its regulation was one of the first promulgated by the agency. Research studies also began to document asbestos diseases in people who lived with asbestos workers and were subjected to “take-home” exposure and people who lived near asbestos mines and processing plants [13]. Several studies have also found elevated rates of asbestos related disease in communities near asbestos deposits not commercially mined, but sometimes used locally for various purposes. (Further details of community exposures will be given in the “Naturally Occurring Asbestos” section beginning on page 12.) With increasing information on potential health effects, worker asbestos exposure limits were reduced and many countries moved to ban the use of asbestos altogether. The regulation of asbestos exposure in the workplace and elsewhere led to another perspective on the appropriate definition of asbestos, which will be described further in the “Defining “Asbestos” – Occupational Safety and Regulatory Perspectives” section below. First, though, the major asbestos-related diseases and their relation to worker and community exposures will be discussed.

Breathing in asbestos is associated with diseases related to the respiratory system, and diseases of the lung and pleural membrane surrounding the lungs have been extensively studied. Breathing asbestos is also associated with cancer of the larynx, and it has been suggested that breathing asbestos may increase the risk of autoimmune diseases, cancers of the gastrointestinal system, and other non-respiratory diseases [14]. Although these diseases are of concern, the focus of this discussion will be on lung and pleural diseases because they are the best studied and are thought to be more common and/or serious than other diseases associated with asbestos exposure.

Lung and Pleural Cancers Associated with Asbestos Exposure

Lung Cancer is a disease where the epithelial cells lining the lung grow uncontrollably. They may invade surrounding tissues or metastasize to cause cancer in other tissues in the body. For both men and women in the United States, lung cancer is the second most common form of cancer (behind prostate cancer for men and breast cancer for women). Lung cancer is the leading cause of cancer deaths [15]. Asbestos exposure has been known to cause lung cancer in asbestos workers since the early 1920s (though published studies were not available until many years later) [12]. Although asbestos exposure is a known causative agent, exposure to tobacco smoke remains the major risk factor for lung cancer. Combining asbestos exposure with tobacco smoke exposure greatly increases the risk for lung cancer over the sum of both factors. Other lung cancer risk factors include exposure to radon gas or some forms of silica or chromium and personal genetics [16].

In communities exposed to asbestos, lung cancer rates were often elevated compared to expected rates [17,18,19]. In many cases, however, smoking data from the population (which could strongly influence lung cancer rates) were not available or reported. Because of the number of different risk factors contributing to lung cancer risk, it is difficult to study the effects of community asbestos exposures on lung cancer rates.

Mesothelioma is a cancer of the mesothelium, the membrane surrounding internal organs like the lung (pleural mesothelium), digestive organs (peritoneal mesothelium), or heart (pericardial mesothelium). Asbestos exposure has been associated with mesothelioma in all these locations, but is most frequently associated with mesothelioma of the pleura and peritoneum [12,20,21]. Mesothelioma is a rare cancer, usually assumed to occur at a rate of about 1 in 100,000 in a typical industrialized country. In all but the rarest of cases, mesothelioma is associated with exposure to asbestos or another durable mineral fiber. Because the latency period from first exposure to disease presentation is so long (20-50 years) and because the disease is rapidly fatal after diagnosis (average survival is on the order of 15 months), it is difficult to obtain accurate information on potential past exposures from victims of this disease. However, some studies have described cases of mesothelioma where the only exposure to asbestos was incidental, such as working in a place where a short-term renovation disturbed asbestos-containing materials or riding a bicycle regularly in the vicinity of an asbestos plant [22,23]. Other studies have suggested that genetic factors in combination with mineral fiber exposure may increase risk of mesothelioma [24].

Mesotheliomas were reported in asbestos worker populations beginning in the middle 1900s, and it soon became evident that nonoccupationally exposed cases were present as well. Because mesothelioma may be detected in persons with lower exposures compared to asbestosis or lung cancer, and because it is almost always associated with asbestos exposure, it is often studied in environmental exposure situations. Communities exposed to asbestos or similar fibers have often been identified by elevated rates of mesothelioma, leading researchers to search for the causative agent. For example, this is how exposure of residents to asbestos or other harmful minerals from local materials was discovered in Turkey [25], New Caledonia [26], Sicily [27], Greece [28], and China [19].

Lung and Pleural Noncancerous Diseases Associated With Asbestos Exposure

Asbestosis is a noncancerous disease that has been identified in asbestos workers since the early 1900s. Asbestos fibers lodge within the lung, resulting in scar tissue formation which reduces lung elasticity and function. The disease progresses, typically slowly, and can eventually be fatal.

Asbestosis is typically thought to require very high levels of asbestos exposure over many years. However, at least one case report described a worker who developed the disease many years after a relatively brief (months) period of high-level exposure [29]. Some studies have shown increased rates of asbestosis in communities living near asbestos deposits (in Da-Yao, China, for example [19]. These communities may have had unusually direct or high-level exposures to asbestos. In general, the lower-level exposures expected in most communities suggest that asbestosis is not a likely health outcome in most community exposure situations.

Pleural changes are abnormalities observed in the pleural mesothelium, the membrane lining the chest cavity and covering the outside of the lungs. Pleural changes are considered a marker of asbestos exposure and may or may not result in a loss in lung function. Pleural changes can include areas of pleural thickening, calcification (plaques), or pleural effusions. Pleural plaques were first described in asbestos factory workers in 1931 [12]. Pleural changes resulting from asbestos exposure are typically observed bilaterally (on both sides) on the parietal pleura (the exterior membrane closest to the chest cavity). Occasionally, pleural abnormalities may also be associated with a history of chest trauma, chest surgery, or previous infections.

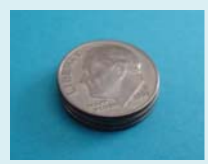
Increased rates of pleural abnormalities are often seen in asbestos-exposed communities. One would expect a rate of less than 1% in an unexposed population [30]. In contrast, the rates of pleural abnormalities in asbestos-exposed communities were, for example, 18% in Libby, Montana [31]; 38% in Anatolia, Turkey [25]; and 40% in Corsica, France [32]. Recent studies have shown that the prevalence of pleural abnormalities in some asbestos workers may increase over time, even after exposure ceases [33].

Defining "Asbestos" – Occupational Safety and Regulatory Perspectives

As was mentioned above, the need to regulate exposure to asbestos in the workplace and elsewhere led to yet another perspective of the definition for asbestos, one focused on characterizing the causative agent of the respiratory disease observed in workers. By 1972, due to the documented elevated rates of disease in workers, asbestos was a known workplace hazard. Because disease was associated with inhalation exposure, early industrial hygiene controls had focused on reducing the dust and fiber levels in workplace air. Initially, dust levels were monitored using the midget impinger, an apparatus which measures particles in air (in units of million particles per cubic foot, or mppcf). As it became clear that asbestos was more toxic than dust in general, optical microscopic methods were developed that could measure the elongated particles considered to originate from the processed asbestos materials and to pose the greatest risk. Phase contrast microscopy (PCM) was prescribed for monitoring occupational air fiber levels in U.S. occupational regulations [34]. This method followed an earlier British method which defined fibers as particles greater than 5 micrometers (μm) in length and with a length to width ratio (aspect ratio) of 3:1 or greater; results are presented in units of fibers per cubic centimeter of air (f/cc) [35]. These specifications were selected for convenience and as a result of the optical limitations of PCM. The specifications had no relationship to commercial or toxic properties of asbestos materials [personal communication, Dan Crane, OSHA, November 2007]. In addition, the PCM method, due to resolution limitations, only detects fibers with diameters greater than about 0.25 μm. Although it was recognized that PCM was unable to detect a large number of the asbestos fibers in an asbestos workplace, PCM has been and remains in use in the occupational setting as an index for monitoring and regulating harmful exposures [35]. OSHA permissible exposure limits use PCM concentrations as measured using the NIOSH 7400 standard method.

Asbestos Fiber Concentrations: How Much is a cc?

Asbestos concentration is typically recorded in number of fibers per volume of air. The cubic centimeter (cc) volume, equivalent to one milliliter, has been used for describing asbestos concentrations in the United States for many years. A cc is a small volume, less than ¼ teaspoon (see picture below). Exposure studies have shown that adults at rest breathe 500 cc of air with every breath, and, on average, 20 million cc of air every day [36]. Therefore, even small concentrations of f/cc may result in significant numbers of fibers being breathed in. For example, the OSHA worker 8-hour exposure limit of 0.1 f/cc corresponds to 50 fibers with each breath. The concentration used in EPA's World Trade Center cleanup to clear apartments for residential occupancy was 0.0009 f/cc, which corresponds to only about 1 fiber per 2 breaths, but over the course of an entire day results in 18,000 fibers breathed in.



A stack of 3 dimes has a volume of about 1 cc.

The development of transmission electron microscopy (TEM) allowed much greater resolution than optical methods (diameters as small as 0.002 μm can be visualized). In addition, the techniques of selected area electron diffraction (SAED) and x-ray energy dispersive spectroscopy (EDS), often available on a TEM, could give detailed information on particle crystal structure and elemental composition, allowing specific identification of asbestos minerals. The NIOSH 7402 method is a TEM-based method which determines percentage of asbestos and nonasbestos fibers in the PCM-sized range of an OSHA compliance sample. This percentage can be used to "correct" the PCM result and obtain the actual asbestos fiber concentration in an industrial atmosphere containing asbestos and non-asbestos fibers.

TEM is often used to determine the number of asbestos structures meeting the PCM fiber size criteria and mineralogical definition; the concentration resulting is referred to as PCM equivalent (PCMe) structures per cubic centimeter (s/cc). PCMe s/cc measurements are also often used interchangeably with PCM f/cc measurements in risk methods. However, this introduces uncertainty since the correlation between PCM and PCMe is not well defined [37].

In the early 1980s, the EPA Level II (Yamate) method was drafted in an attempt to standardize various laboratories' TEM methods for airborne asbestos. This draft method was not formally adopted by EPA; however, it came to be generally accepted as the method for TEM analysis of asbestos in air [38]. The method counts structures greater than 0.5 µm in length with a 3:1 or greater aspect ratio and documents asbestos fibers as well as bundles, clusters and matrices.

In 1986, the Asbestos Hazard Emergency Response Act (AHERA) was enacted as an amendment to the Toxic Substance Control Act (TSCA) to provide a regulatory framework for inspection and abatement of friable (easily crumbled) asbestos-containing materials (ACM) in schools. This legislation also laid out procedures for the removal of existing ACM and air testing protocols to ensure that removal did not contaminate the schools and that cleanup was complete [39]. Air testing analytical procedures specified by AHERA were similar to the Yamate method but simplified some aspects. The method uses TEM and counts structures greater than 0.5 µm in length with a 5:1 or greater aspect ratio; the resulting concentration will be referred to herein as total TEM structures per cubic centimeter (s/cc). Individual structure data is not documented in the AHERA method, but the concentration data is listed separately for structures less than and greater than 5 µm in length [40]. Air samples collected inside a containment area where removal took place and collected after using leaf blowers or fans to disturb any dust are statistically compared to air samples collected outdoors. If the indoor total structure count falls below a reference value or there is no statistical difference between indoor and outdoor air, the area passes clearance and is prepared for reoccupancy [38]. Because the AHERA method was codified into federal regulations, it has become more common than the Yamate method.

In 1995, the International Standards Organization (ISO) released the ISO 10312 method, which expanded classifications and reporting for asbestos structures compared to the Yamate and AHERA methods [41]. The ISO 10312 method is far more time-consuming and expensive than other methods, but captures data in a way that is more detailed and that allows re-evaluation for different dimensional characteristics if changes in regulatory requirements or medical evidence warrant [38]. The ISO 10312 method counts structures and fibers greater than 0.5 µm in length and greater than 0.002 µm in width. The procedure is used with a minimum aspect ratio of 5:1, but allows for using 3:1 when performing risk assessments (U.S. regulations specify 3:1 so this is why ISO allows flexibility; neither 5:1 or 3:1 aspect ratios are health-based). ISO 10312 results are reported in units of total TEM s/cc. There may not be an exact correspondence between ISO 10312 and AHERA total TEM s/cc counts due to structure definition differences; however, for the purposes of this document we will consider the concentrations equivalent and refer to each as total TEM s/cc.

In summary, the occupational safety and environmental regulatory agencies base their standards on various analytical methods which define fibers or structures to be counted in specific ways. Clearly, there are differences between regulatory, analytical, commercial, and mineralogical asbestos definitions—and little is known about how well these various definitions describe the actual agent responsible for causing respiratory disease (the medical or toxicological definition of asbestos). As more is learned about asbestos' mechanisms of action in causing disease, it may be possible to refine regulatory definitions to better reflect the toxic nature of asbestos and to determine the appropriate relationship between regulatory, analytical, commercial, and mineralogical definitions. It is doubtful that this knowledge will be available and widely accepted any time in the near future.

Naturally Occurring Asbestos (NOA)

As described above, asbestos minerals have been mined and used in products throughout the world. Despite a reduction in asbestos use, mines still operate; the largest producers include Canada, Russia, China, Kazakhstan, Brazil, and Zimbabwe [42]. While all asbestos is ultimately natural in origin, from a public health perspective, the term NOA is used to refer to asbestos and asbestos-like minerals that are not intentionally mined or used commercially, but whose disturbance could release fibers into the air, causing exposure and, possibly, asbestos-related disease. In the United States, natural occurrences of asbestos (former mines, former prospects, and reported occurrences) have been mapped by the USGS for all the states except California [43,44,45,46,47]. The California Geological Survey has published maps of rock formations more likely to host NOA at both the state level and certain county levels (including El Dorado County); these are available on the Internet [48,49]. In addition, a thorough discussion of the variety of geologic settings where asbestos may occur is included in the special California Geologic Survey publication “Guidelines for Geologic Investigations of Naturally Occurring Asbestos in California” [50]. No asbestos mining takes place today in the United States. We consider potential exposures occurring at U.S. former mines and prospects to be NOA exposures.

NOA deposits have been described in many locations throughout the world, and NOA exposure has been associated with asbestos related diseases in several locations. Some of these studies and locations are briefly described here.

> People coming from a certain region in Northern Greece or Macedonia were observed to exhibit bilateral pleural plaques (areas of pleural calcification on x-ray) consistent with asbestos exposure. Upon investigation in the late 1980s, the pleural changes were found to be associated with the use of local rocks containing asbestos for whitewashing houses. Of 818 people studied in the late 1980s, 198 had pleural plaques and 5 cases of mesothelioma were diagnosed. Follow-up of the 198 persons with pleural plaques through 2003 indicated that pleural plaques had worsened, and 4 additional cases of mesothelioma occurred. The rocks used in the past for whitewash were found to contain up to 90% asbestos (both chrysotile and tremolite), and limited exposure characterization documented fiber concentrations (using approximate PCM definitions) in the yard of an abandoned house with remnants of whitewashed walls (0.01 f/cc), in a newly whitewashed room (0.01 f/cc), and in the same room with mild scraping of a 2-square meter area of the wall (17.9 f/cc). [28,51,52].

> In the Mediterranean island of Cyprus, chrysotile and tremolite asbestos fibers were found in stucco materials in villages in the vicinity of a large chrysotile mine, in one mesothelioma victim’s lungs, and in lungs of local sheep. A 1987 study reported 12 confirmed mesothelioma cases in the area; 7 were chrysotile miners, 3 were wives of miners, and 2 were residents near the mine. Because not all the cases had a direct association with the mine, the authors concluded that environmental exposure may contribute to the risk of disease. [53,54]

> The northeast portion of the Mediterranean island of Corsica contains chrysotile and tremolite surface deposits, and roads have been paved with crushed serpentine (which can contain asbestos).

Researchers found that villages near the surface deposits had a higher rate of pleural plaques than unexposed villages. There were case reports of mesothelioma, although it is difficult to separate out possible influences from a chrysotile mine that operated in the area. Local goats were shown to contain chrysotile and a low amount of tremolite in their lungs [55,56,57,58,59,32,60,61]

In two villages on the main island of New Caledonia in the southwest Pacific, whitewash made from local deposits of tremolite asbestos was used by Melanese natives. This resulted in elevated rates of mesothelioma as well as lung cancer among exposed villagers. Investigators found tremolite fibers (using approximate PCM definition) in air samples in a whitewashed house at 0.04 f/cc, and some studies showed concentrations as high as 79 f/cc during cleaning. In addition, elevated levels of tremolite and other forms of asbestos were found in bronchoalveolar lavage fluid and lung samples collected from villagers. [62,63,26,64,65]

In Da-yao, a rural area in Yunnan Province in southwest China, “blue clay” or crocidolite in surface deposits is prevalent. The fibers are described as “short and rigid” with limited industrial application, but the material was used throughout the community for producing stoves used in every household, paving roads, and stuccoing houses. Exposures began at birth and contributed to extremely high rates of pleural changes, mesothelioma, lung cancer, and asbestosis. In a general population of about 67,000 people, 166 cases of mesothelioma (83 histologically confirmed) were recorded over the period from 1984 to 1999. Measurements of potential exposures where the stoves made using the “blue clay” were manufactured showed an average fiber concentration (using approximate PCM definition) of 6.6 f/cc with a peak concentration of 25 f/cc. [19,66,67]

Several areas of Turkey, including specific villages in Central Anatolia, Southeastern Anatolia, and Cappadocia, have been the focus of several studies of environmental mineral fiber exposure. Asbestos-containing local materials (mostly tremolite) were used in some villages for whitewash and baby powder. Elevated rates of mesothelioma were documented in these villages [25,68,69,70,71,72]. Even higher rates of mesothelioma (up to 50%) were measured in certain villages in Cappadocia which contain a fibrous zeolite, called erionite, in local stucco [73,74]. Genetic susceptibility may interact with exposure to cause the high rates of disease in these villages. [24]

In Biancaville, a small town in Eastern Sicily, an elevated mesothelioma incidence rate (about 10 times the average rate in Italy) was identified. From 1988 to 1992, 12 cases were found in a population of about 23,000. Investigation showed that quarries, building materials, and the lungs of a mesothelioma victim all contained the same long, thin fibers, ranging from 12–40 μm in length and 0.4–1 μm in diameter in the lung. The fibers were identified as fluoro-edenite, an amphibole which had not been previously recognized to occur in the fibrous form. [27,75]

In Libby, a small town in northwestern Montana, USA, vermiculite mined and processed locally was contaminated with percent levels of tremolite asbestos as well as other asbestiform amphibole minerals such as winchite and richterite. ATSDR’s definition of NOA includes Libby because the asbestos fibers were not intentionally mined for commercial purposes. Elevated rates of asbestosis and lung cancer were documented in both workers and residents of the town [17,76]. In a town with less than 3,000 people, approximately 22 cases of mesothelioma have been reported in a 30 year period [personal communication, Steve Dearwent, ATSDR, November 2010]. In the past, many of the town’s residents worked at the mine or processing facilities; contaminated waste rock was used throughout the town for driveways and fill material; and children played in contaminated waste rock piles. Pleural changes were documented in 18% of Libby residents participating in a 2000-2001 study; the changes were correlated with the number of different opportunities for exposure reported by the participants [77].

While the above cases from the literature demonstrate that asbestos-related disease can be caused by NOA, they all have important differences from the situation in El Dorado Hills which make it impossible to say similar findings would occur in El Dorado Hills. The most important differences are listed below.

- The population is different. In the studies cited above, the typical study population is a small town with a stable population. Many or most of the residents lived their entire lives in the same town, increasing exposure durations and simplifying the task of following people for epidemiologic study. In contrast, El Dorado Hills encompasses a large land area, with a diverse, transient, and growing population.
- The exposures are different. In the studies cited above, the exposures were not very well characterized, but certain observations can be made. The materials implicated contained high levels of asbestos and were sought out for specific uses; the materials were used widely in the towns; and because of this wide use, the exposures were probably consistent, relatively high and occurring for long durations. Specific occurrences of NOA in the El Dorado Hills area may be highly concentrated, but they are not very large, the NOA is not evenly distributed throughout the area, and the NOA (or material containing NOA) is not intentionally used for specific purposes.

Although these differences may be important, limited studies have suggested that exposure to NOA in California could be a problem. Pan *et al.* examined mesothelioma cases diagnosed between 1988 and 1997 (as reported in the State registry) in relation to possible occupational exposure and proximity to NOA (after controlling for occupational exposure) [78]. While the authors did find a statistical correlation between proximity to NOA and mesothelioma incidence, the study can only be considered suggestive because of the limited data available for analysis. Occupational exposure was determined using the longest occupation or industry listed for each case in the registry; this may miss important exposures that were not listed in registry data. Perhaps more importantly, for cases that had no known occupational exposure, the distance to NOA was measured using the house or street level address at diagnosis and the edge of the nearest ultramafic rock formation on geologic maps as a surrogate for NOA source rocks. The residence at diagnosis may not reflect the location where exposure occurred many years previously, and ultramafic rocks do not always or exclusively host asbestos. Finally, studies of asbestos exposure generally indicate that exposure is highly dependent on the specific area of disturbed asbestos – asbestos concentrations often cannot be measured just a few feet away from the disturbed area. For this reason, the cited distances in Pan *et al.* may not be relevant for NOA exposures ("odds of mesothelioma decreased approximately 6.3% for every 10 km farther from the nearest asbestos source").

In summary, this review of scientific literature demonstrates NOA's potential to cause asbestos-related disease and supports the concern about NOA exposure in El Dorado Hills. Because of the differences cited above between exposure in El Dorado Hills and other NOA locations worldwide, and because of the limitations of studies using local health outcome data, ATSDR focused our evaluation on using risk assessment methods to assist in determining whether the exposures occurring in this community could be of concern.

Uncertainty Related to NOA Exposure and Potential for Developing Asbestos-related Disease

Currently, we estimate the risk of disease by applying methods based on historical worker studies (discussed in the "Asbestos Risk Assessment Methods" section below) to the exposures occurring in NOA situations. There is uncertainty involved with this as will be discussed further in this section.

To evaluate risk ATSDR needs to have reasonably accurate exposure data, which requires collection of representative environmental samples, analysis of the samples to reveal the quantity of NOA in the sample, and an understanding of activities in the community that could lead to exposure. ATSDR currently recommends activity-based sampling methods using ISO 10312-type analytical methods to give the best picture of asbestos in the community combined with community-specific exposure assumptions; however, even the best exposure data are still difficult to interpret with respect to disease risk. This is because there are many differences between NOA exposures in the community and typical worker asbestos exposures that may affect the degree of risk. These include differences in the people being exposed, the types, shapes and sizes of the asbestos they are exposed to, the frequency of the exposure, and the amount of time they are exposed.

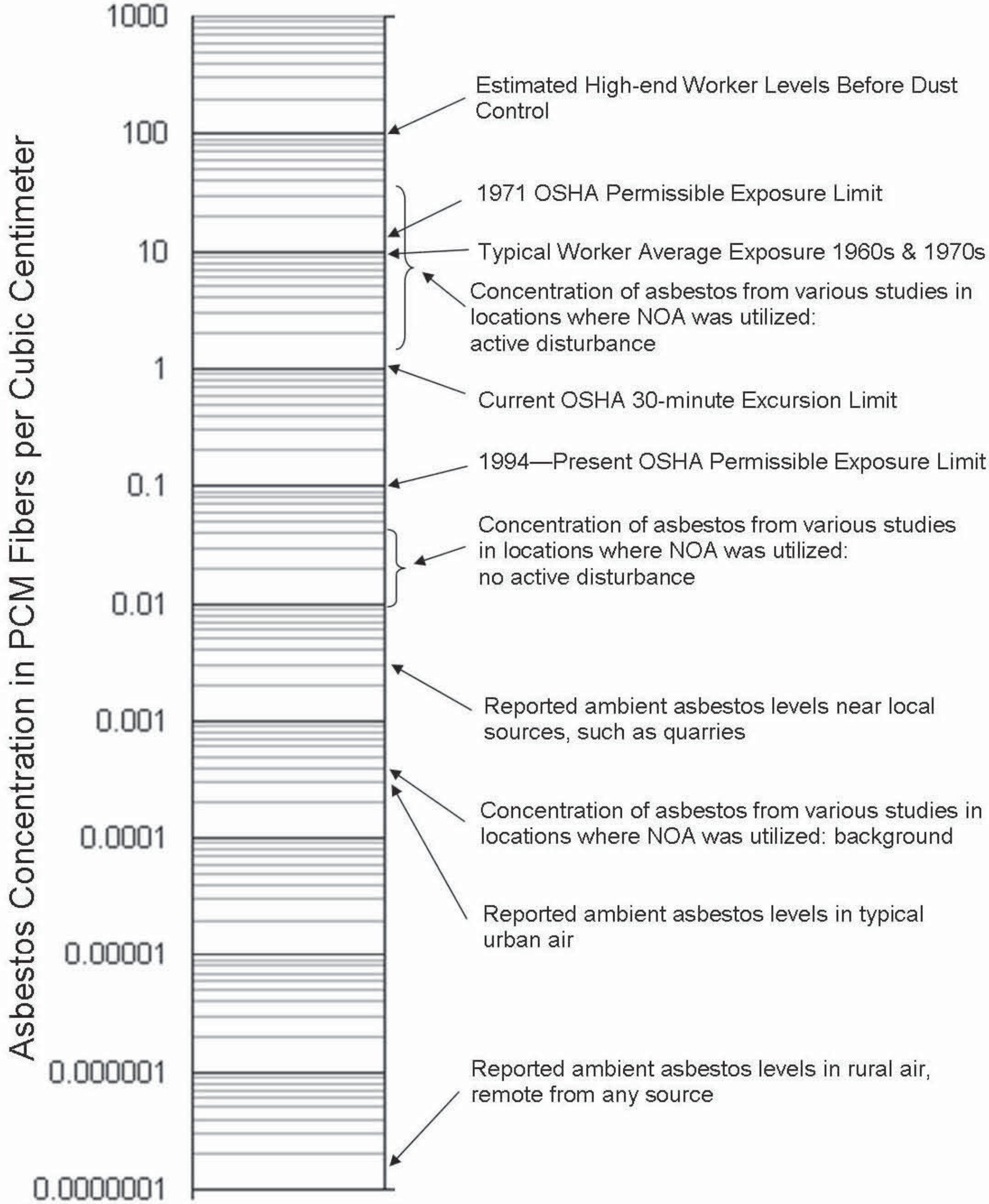
The methods used to estimate risk are based on exposure/disease studies of asbestos workers. Typically, these workers were healthy males in the prime of life, as contrasted with communities that could include children, the elderly, or people with underlying medical conditions making them more susceptible to asbestos-related health complications. The concentrations of asbestos the workers breathed were typically much higher than would be expected in a community situation. Early asbestos workers experienced asbestos concentrations hundreds or thousands of times higher than current occupational limits or asbestos concentrations expected in NOA areas. Workers' exposure to these high asbestos concentrations was more frequent, more regular, and lasted longer than occasional high-concentration exposures we would expect in a community situation. Figure 4 is a schematic illustrating general differences in asbestos concentrations reported for historical workers, environmental or community exposure situations, ambient measurements, and occupational limits. The concentrations have been standardized according to general PCM fiber definitions, but the figure is meant only as a qualitative comparison for perspective. In addition, note that the figure only illustrates concentration; exposure (and the risk of disease) depends not only on concentration, but also how often and for how long the exposure occurs.

Finally, the type, size and shape of asbestos particles breathed in by asbestos workers were relatively consistent, because they worked with relatively pure asbestos (or highly contaminated vermiculite) every day. Although the shape and size of the asbestos fibers breathed by a worker may have varied depending on the area of the plant or process he or she worked with, the exposure was likely relatively consistent with regard to the mineralogy and other characteristics of the asbestos particles. In contrast, NOA exposures occur in diverse locations and may include a wider range of asbestos fiber types, shapes and sizes. NOA exposures also typically include a large percentage of non-asbestos particles originating from soils or other materials present with NOA in the natural environment. Unfortunately, confirming these differences by comparing fiber mineralogy and size distributions between exposures of asbestos workers and people exposed to NOA is not scientifically possible at this time—the historical data on worker exposures simply does not contain such detailed information. There has been some effort to analyze archived historical air sampling filters to obtain this information, but it is a task requiring significant resources and time. Some findings have been published (see [79], for example), but it is our understanding that further work to reanalyze historical filters (by EPA and NIOSH) is still in the planning stages.

Differences between worker and NOA exposure exist. This is a source of uncertainty in applying risk methods developed from worker studies directly to NOA exposures. In addition, the risk methods themselves contain uncertainty. The use of the PCM size fraction to describe exposures in historical worker studies may or may not fully describe the exposures responsible for the observed health effects. In addition, the risk methods had to obtain many of the PCM measurements by converting obsolete exposure measurements to PCM.

All of these factors add uncertainty to the public health concern regarding NOA exposure. Scientists are currently working to eliminate some of these sources of uncertainty, but at present these risk methods represent the state of the science and provide the best possible estimate of risk to the El Dorado Hills community. As scientific and measurement techniques progress, ATSDR may re-examine the conclusions of this health consultation in light of new information.

Figure 4. General Comparison of Asbestos Concentrations – Occupational vs. Nonoccupational



NOTE: This schematic compares generalized estimates of past occupational exposures, past and present occupational limits, environmental exposures as described in the section "Naturally Occurring Asbestos", and ambient asbestos levels reported for various locations in the United States, all reported generally as Phase Contrast Microscopy (PCM) fibers per cubic centimeter concentration. The estimates are placed on a "log" scale, which allows widely different values to be seen on the graph—each heavy line is a value ten times the next lower heavy line. The overall exposure any person receives is a function both of the level as shown here and the length of time for which the exposure continues. Values are for comparison and context only. Assumptions and sources listed in Appendix B.

Risk

Risk is defined by Byrd and Cothern as "the probability of a future loss" [80]. This could include being struck by lightning, getting in an accident, losing money at the black jack table, or almost any human activity one can think of that can have a negative outcome. In this document we try to predict the risk of contracting lung cancer or mesothelioma from environmental exposures to asbestos. Risk can be viewed as being either a voluntary or involuntary process. Voluntary risks are those in which the individual partakes in the risk knowingly (for example, going skiing, gambling, scuba diving, or swimming in shark-infested waters). Involuntary risks are those that one may not know about or that one may have little control over, such as exposure to cosmic radiation or radon, or being exposed unknowingly to environmental contaminants such as chemicals spilled during industrial activities. Most people are willing to accept a higher risk when the risk is of a voluntary nature, perhaps because people feel more "in control" of voluntary risks than involuntary risks. However, people and communities can also take action to reduce the risk from involuntary sources. This document and its recommendations discuss how risk from environmental sources of asbestos can be reduced.

Risk is expressed numerically as a probability. Numerically the range of probabilities span from 0 to 1. Zero means there is absolutely no theoretical risk of a "future loss", and 1 means the theoretical risk of "future loss" is certain, 100%. For example, based on the entire population and the rates of cancer in the U.S., a person in the U.S. has a 0.4 (1 in 2.5) chance of developing some kind of cancer in his or her lifetime [81]. The same person has a 0.0002 (1 in 5,000) chance of being struck by lightning [82].

People decide whether to participate in a risky activity (voluntary risk), and regulatory agencies determine allowable levels for contaminants (involuntary risk). In both cases, they make decisions by comparing the risk resulting from the activity/contaminant to an "acceptable" level of risk. Unfortunately, determining what constitutes an acceptable risk is not straightforward. The nature of the risk (voluntary vs. involuntary), the potential benefits obtained, and the person/population involved may change what is found to be "acceptable".

EPA outlined their CERCLA (Superfund) risk management decision policy related to acceptable risk from carcinogens in the environment in a 1991 memo [83]. The memo states:

> EPA uses the general 10^{-4} (1 in 10,000) to 10^{-6} (1 in 1,000,000) risk range as a "target range" within which the Agency strives to manage risks as part of a Superfund cleanup.… A specific risk estimate around 10^{-4} may be considered acceptable if justified based on site-specific conditions, including any remaining uncertainties on the nature and extent of contamination and associated risks. Therefore, in certain cases EPA may consider risk estimates slightly greater than 1×10^{-4} to be protective.

To put this into context, if the additional theoretical cancer risk resulting from exposure to a contaminant is 1 in 10,000, that means that out of 10,000 people being exposed to that contaminant for a specified length of time, usually a lifetime, one additional cancer might develop from the exposure, above the normally expected 4,000 cancers (using the general U.S. rate of cancer (0.4) explained above).

Comparisons of Risk

Sometimes it is useful to compare risks to other well known risks to better understand the magnitude of risk. Many people in El Dorado Hills asked ATSDR to provide them with information on everyday risks people face that they could compare with risk estimates for excess cancer from asbestos exposures. This would provide them with some perspective and allow them to determine if the asbestos exposure was a risk they were willing to live with. ATSDR has reservations about making such comparisons, because they could be perceived as an attempt to minimize—or exaggerate—the actual risk posed by potential asbestos exposures in the area (see Covello *et al.* [84] for more details). Over the past several years, ATSDR has worked to maintain scientific integrity and objectivity while still responding to community concerns—for this reason, we present the following comparisons with the sole intent of giving perspective—not judgment.

Table 1 presents estimated lifetime risks that may be used for comparison. The lifetime risk for each event is the risk of occurrence at any time in an individual's life. Lifetime risk is inherently much higher than the risk of an event occurring in any particular year of a person's life, such as may be documented in annual mortality statistics (yearly death rates). In addition, the lifetime risk estimates in Table 1 are based on the numbers of people experiencing that event, the total population, and average life expectancy. Some people will have much greater risks than others. For example, the lung cancer risk presented below is based on the entire population—smoking is thought to account for as many as 90% of all lung cancer deaths, therefore the risk for smokers is much greater than the number presented here. Similarly, a person's risk of being struck by lightning will be much smaller if he or she stays inside during thunderstorms and follows other safety recommendations.

Table 1. Lifetime Risks for Selected Events

Event/Risk	Lifetime Risk of Occurring	Lifetime Risk out of 10,000	Source
Being Killed by a Venomous Animal or Plant	0.00003	0.3	National Safety Council [85]
Being Struck by Lightning	0.0002	2	National Weather Service [82]
Estimated Additional Cancer Risk from Hazardous Air Pollutants, El Dorado County (no asbestos included)	0.0003	3	Scorecard. The Pollution Information Site [86]
Drowning	0.0009	9	National Safety Council [85]
Dying in a Motor Vehicle Accident	0.01	100	National Safety Council [85]
Being Diagnosed with Cancer of the Colon or Rectum	0.05	500	National Cancer Institute [81]
Being Diagnosed with Cancer of the Lung	0.07	700	National Cancer Institute [81]
Being Diagnosed with Cancer (all causes)	0.4	4,000	National Cancer Institute [81]
Developing Arthritis in the Knee	0.4	4,000	Murphy et al. [87]

Risk Assessment Methods

General Concept

The purpose of the risk assessment method is to predict the theoretical likelihood of an adverse health effect (disease) occurring from an exposure to a hazardous substance. The way this is done is by examining studies where the relationship between exposure and the resulting adverse health effects is known and assuming a similar exposure you are interested in will result in the same adverse health effects. This process, for the case of asbestos, is summarized in the following steps:

- Experimental studies provide the basis for determining the relationship between exposure and resulting disease. These can include:
  - *toxicological studies*, animal- or cell-based experiments where biological effects from different asbestos exposures are measured in the laboratory environment, or
  - *epidemiological studies*, analyses of disease and/or death rates in cohorts (groups) of asbestos workers.

  Although both toxicological and epidemiological studies are available, the epidemiology studies have been most commonly used for asbestos risk assessment because human data are generally considered the most relevant. Asbestos studies have almost all focused on lung cancer and mesothelioma as disease endpoints since cancers are typically the most sensitive disease endpoints.

- To relate exposure with disease, a mathematical description (a "model") of disease risk as a function of exposure parameters is needed. The coefficients of this mathematical expression are known as "potency factors." Lung cancer and mesothelioma are described with two different models. Details of these models are presented in Appendix C. Worker exposure data and resulting mortality are used with the appropriate disease risk model to determine the corresponding potency factor that gives the best fit to the epidemiological data.

- Finally, the potency factors are used with the disease risk models to link exposure and risk for a new situation. This can be done to estimate risk of disease for a given exposure scenario; alternatively, it can be used to determine exposure levels that would correspond to an "acceptable" degree of risk. For this step to be valid, the measures of exposure and the potential for disease in the new situation must correspond with those in the studies used to determine the potency factors. In other words, the measure of exposure (e.g., TEM or PCM) must be the same, and also the diseases monitored (e.g., mesothelioma) must be the same.

Several asbestos risk methods have been developed over the years. Although all are broadly based on historical worker cohort studies, they use different procedures to obtain estimates of risk. Some methods use the mathematical models and potency factors to estimate risk directly for different levels and periods of exposure. Others use assumptions such as a lifetime of exposure to derive a "unit risk" from the basic mathematical models and potency factors – this unit risk can be used to estimate risk for a given exposure using a simple arithmetic equation. The more recent methods have updated worker cohort information, added additional studies, or made assumptions allowing additional data manipulations to be performed in an attempt to improve risk assessment based on evolving understanding or hypotheses about asbestos toxicity.

ATSDR heard many opinions from local community members, local stakeholders, and other stakeholders and scientists about which method should or should not be used to estimate risk in El Dorado Hills. However, there remains significant controversy surrounding the procedures and assumptions made in various risk methods, and no scientific consensus on the most appropriate method is foreseeable. Because ATSDR's goal is to make general public health recommendations, we only need a general sense of the degree of risk in the community. Therefore, as described in the "Summary – Asbestos Risk Methods" section on page 27, ATSDR decided to apply several different risk methods to the activity-based sampling data. This course of action is responsive to requests from community members and other stakeholders, will provide a range of predicted risks sufficient to make public health recommendations, and may allow comparison between risks predicted by different methods.

The following sections will give brief summaries of the most common risk methods. For brevity and simplicity, many of the details of method development have not been discussed fully. The interested reader is referred to the original citations for additional information.

EPA Airborne Asbestos Health Assessment Update, 1986

In 1986, EPA published the Airborne Asbestos Health Assessment Update, produced under contract by Nicholson [89]. This document is the basis for the current EPA integrated risk information system (IRIS) method, which will be described below [37]. Nicholson used worker cohort studies published between 1979 and 1984 which contained data on worker mortality resulting from exposure to asbestos. Fourteen studies had data on lung cancer and 4 had data on mesothelioma. Briefly, dust exposures reported in million particles per cubic foot (mppcf) were converted to PCMe by dividing them by a factor of 3. Then, a weighted linear regression technique was used to obtain the lung cancer or mesothelioma potency factor for each study; the geometric mean of all studies was used to determine the overall K_L (lung cancer potency factor) and K_M (mesothelioma potency factor). These potency factors are used with the basic mathematical models presented in Appendix C, using PCM exposure data, to estimate the excess risk of developing lung cancer or mesothelioma from a given occupational exposure.

Nicholson evaluated uncertainties in the studies included and determined that the data did not justify differentiating between chrysotile and amphibole exposures. The risk is generally estimated from the equations from Appendix C using a life table analysis technique (this type of analysis will be discussed later). However, Nicholson used these techniques to create tables showing additional risks resulting from different ages of initial exposure and durations of continuous exposure, based on life table analyses using 1977 U.S. mortality data. To produce these tables, risks associated with occupational exposure were converted to continuous exposure by multiplying by the number of hours in a week (168 hours) and dividing by the typical number of work hours (40 hours), equivalent to multiplying by the unitless conversion factor 4.2. Potency factors and risk are based on fiber concentrations measured by PCM, presented in units of fibers per cubic centimeter air (f/cc). Further details of the life table analysis applied to the EPA 1986 method are in Appendix D.

EPA Integrated Risk Information System (IRIS) Method, 1988 (last revised 1993)

The studies and theory behind IRIS risk estimates are the same as in the Nicholson assessment. The methods both represent central tendency estimates of risk. In IRIS, a different conversion between occupational and continuous exposure is applied: risks associated with occupational exposure were adjusted to continuous exposure by assuming a total breathing rate of 20 m^3 per day and 10 m^3 breathed by workers in a workday, so the conversion factor is air breathed continuously (20 cubic meters × 7 days a week) divided by air breathed by workers during a work week (10 cubic meters × 5 days a week), which equals 2.8 [37]. Using life table techniques like in Nicholson's method, IRIS calculates a unit inhalation risk, based on a lifetime of continuous exposure beginning at birth, for the combined risk of lung cancer and mesothelioma and as a composite value for males and females. The unit risk value is based on risks calculated using U.S. general population cancer rates and mortality patterns without consideration of smoking habits. Using the unit risk greatly simplifies the calculations involved in estimating risk. The inhalation unit risk, 0.23 $(f/cc)^{-1}$, is multiplied by average lifetime exposure, in units of PCM f/cc, to determine cancer risk. An example calculation using this method is presented in Appendix D.

Hodgson and Darnton Method, 2000

The Hodgson and Darnton method [90] offers a unique look at risk from asbestos exposure because it departs from the risk models used in almost all other risk assessments (these models as well as a more detailed description of the Hodgson and Darnton method can be found in Appendix C). Instead of assuming that risk is linearly dependent on exposure, this method models risk as a nonlinear function of exposure. It also includes some important studies, such as the South African crocidolite miner study, not considered in other methods. A disadvantage of this method is that it is difficult to compare results with the other studies because the estimated risk assumes exposure begins at age 30 and lasts 5 years; risk is estimated only for ages 40 – 80. Although there are limited means to correct for exposures earlier in life or longer durations of exposure, it is difficult to obtain an accurate lifetime risk that could be compared to the other available methods.

Berman and Crump Method, 2003

This method was developed by Berman and Crump under contract to the EPA in 2003 [91]. It reflects modifications of a 2001 draft method made in response to comments from subject matter experts participating in an EPA-sponsored peer consultation workshop on the draft [92]. This method was never adopted by EPA (although it serves as a basis for further risk assessment work by the agency, described below). However, it has been applied by various researchers and is put forth by some as an improved method for assessing asbestos risk. In the method, differing potencies are ascribed to amphibole and chrysotile fibers and greater potency is ascribed to longer, thinner fibers. Some of the assumptions and procedures of the method remain controversial (and the authors themselves have published papers studying alternate assumptions, as described later in the section “Recent Developments”). However, various stakeholders and community members requested us to evaluate risk using this method. Therefore, we evaluated risk with this method along with others to see if these factors could have a significant difference on the predicted risk of disease. Our inclusion of the Berman and Crump method is not intended to convey any value judgment as to its scientific validity.

The Berman and Crump method uses the same lung cancer and mesothelioma risk model equations as in the EPA 1986 method, and it also uses central tendency estimates for risk. Changes include the use of additional and updated epidemiology studies and more recent (2000) U.S. mortality data. In addition, an evaluation of animal inhalation studies was used to determine that fiber length provided the best correlation with toxicity. In order to convert exposure concentrations reported in human epidemiology studies to more toxicologically relevant fiber sizes, the authors of the method applied TEM-determined size distributions of materials from similar industries to the reported exposures (due to data limitations, the longest category for fiber length was greater than 10 μm). Two of the studies for which no fiber size data were available were dropped from consideration. In addition to fiber length considerations, amphibole and chrysotile were considered separately. For mixed exposures, the percentage of a study’s exposure concentration for each class of asbestos was estimated using plant history, air data, or professional judgment. This allowed separate potency factors (K_Ls and K_Ms) for amphibole and chrysotile to be determined. The analysis was performed on all the epidemiology studies together. The authors reanalyzed animal studies and available epidemiological data to conclude that all risk is posed by fibers greater than 10 μm long and less than 0.4 μm wide. Numerical analysis was used to find the best fit relative potency factors to minimize “spread” in the studies.

Similarly to the EPA 1986 method, the Berman and Crump method uses a factor to convert occupational to continuous exposures. The Berman Crump conversion factor, approximately 3, was derived by assuming a total breathing rate of 20 m^3 per day and 10 m^3 per workday, and 240 days of work per 365-day year, *i.e.*, 20 cubic meters a day × 365 days a year divided by 10 cubic meters × 240 work days a year, which equals 3.0). The conversion is incorporated into the potency factors so calculations can be performed directly [91]. As in EPA 1986, these potency factors are used with model equations presented in Appendix C, and life table analysis described below and in Appendix D, to determine excess lung cancer and mesothelioma risk. The amphibole- and chrysotile-specific potency factors allow the specific contribution to risk of each fiber type to be assessed. Risk is based on TEM-measured concentrations of fibers greater than 10 μm long and less than 0.4 μm wide. Further details of the life table analysis applied to the Berman Crump method are in Appendix D.

California-EPA OEHHA Method, 2003

The state of California has its own method for assessing asbestos risk. California-EPA's Office of Environmental Health Hazard Assessment (OEHHA) developed this method for air regulations and determining reporting requirements for Proposition 65 [93]. This method employs a unit inhalation risk technique similar to IRIS to simplify calculations. In contrast to IRIS's PCM fibers, the exposure index for the Cal-EPA method is specified as total TEM structures, including all asbestos structures greater than 0.5 μm long with aspect ratios of 3:1 or greater [94]. However, because the unit risk was determined from epidemiology studies reporting PCM concentration results, the TEM structure count must be converted to PCM equivalents by dividing by a Cal-EPA determined factor of 320. Another difference from IRIS is that the unit risk of 1.9×10^{-4} in units of $(100 \text{ PCM fibers per m}^3)^{-1}$ gives mesothelioma risk in female nonsmokers, as opposed to an average of males and females and smokers and nonsmokers [personal communication, Melanie Marty, Cal-EPA OEHHA, November 9, 2007]. Female nonsmokers would have the highest theoretical mesothelioma risk. Another difference in the Cal-EPA unit risk is it was determined using an approach that considered the 95% upper confidence limit in evaluating the epidemiological studies, as opposed to the EPA and Berman and Crump methods which used a central tendency approach. An example calculation using this method is presented in Appendix D.

Alternate Application of Cal-EPA Method

In some recent cases, the U.S. EPA has applied the Cal-EPA unit inhalation risk directly to the PCM-sized fraction determined from TEM measurements, avoiding the use of the 320 conversion factor. The conversion factor is known to be very uncertain, as it represents the geometric mean of several studies where the factor ranged from 10—1,000. However, most California air districts and the ARB use the risk guidance as written, and studies of the correlation between actual PCM measurements and PCM-sized fractions of TEM measurements would have to be performed to validate this alternate application [personal communication, John Budroe, Cal-EPA OEHHA, January 20, 2009]. An example calculation using this method is presented in Appendix D.

Proposed EPA OSWER Interim Risk Approach, 2008

Although there were issues with the Berman and Crump method that prevented its adoption, many in the public and scientific communities criticized EPA for continuing to use the IRIS method instead of a method that assigns greater potency to amphiboles or longer fibers. In response, around 2004 or 2005 EPA's Office of Solid Waste and Emergency Response renewed efforts to address some of the remaining uncertainties associated with the Berman and Crump method and develop an interim asbestos risk assessment method for use until the ongoing IRIS update is complete [95].

The first part of this effort, mainly performed under contract with Syracuse Research Corporation and led by Brattin, generated a document entitled "Proposed Approach for Estimation of Bin-Specific Cancer Potency Factors for Inhalation Exposure to Asbestos" [95]. The approach expanded the work of the Berman and Crump method by including a wider range of fiber size "bins" (length, width, and mineralogy classifications) to evaluate the best fit to the worker cohort studies. The document did not include calculation of bin-specific cancer potency factors (necessary for calculating risk), but merely described the approach proposed to attain them.

A meeting was held of the Asbestos Committee of EPA's Science Advisory Board to discuss the proposed approach. The meeting was held in Washington, DC on July 21 and 22, 2008 and was open to the public [96]. The final report from the committee was released in November 2008 [97]. Although the committee generally supported the need for developing risk assessment methods to account for potential differences in risk on the basis of mineral types and size characteristics of asbestos, the scientific basis laid out in the proposed document was felt to be inadequate. Of particular concern was the lack of available size distribution for estimating exposure concentrations in the epidemiological studies evaluated [97]. Public comments made at the meeting and available for viewing on the science advisory board webpage showed a range of viewpoints, from those who supported the approach as more accurately describing greater toxicity of amphiboles and longer fibers and those who felt the approach would lead to a weakening of asbestos regulations [95].

EPA Framework for Investigating Asbestos-Contaminated Superfund Sites, 2008

EPA's Asbestos Committee of the Technical Review Workgroup developed the Framework for Investigating Asbestos-Contaminated Superfund Sites (Framework) as a tool to improve flexibility and consistency in assessing asbestos-contaminated Superfund sites [98]. The Framework specifies sampling methods and decision criteria for performing site sampling and also provides a risk assessment methodology adapted from combining aspects of the EPA 1986 method and the IRIS method. The Framework fits mathematical equations to the EPA 1986 tables of unit risks (calculated using 1977 mortality data) for less-than-lifetime exposures, so that less-than-lifetime unit risks can be calculated for any duration of interest. IRIS assumptions for converting occupational to continuous exposures are used. This health consultation was prepared independently of the Framework and has a different purpose. The risk methods used in this health consultation (EPA 1986 with updated mortality data and the IRIS method) are not the same as used in the Framework.

Recent Developments

In August 2008, Berman and Crump published updates of potency factors for lung cancer and mesothelioma using cohort data updates published since the EPA 1986 method [99]. Potency factors for lung cancer and mesothelioma were calculated for each identified study using more recent data. The authors discuss applicability of dose-response models for lung cancer and mesothelioma in light of more recent data, and they compare potencies between studies. Historical discrepancies in calculated potencies for studies of similar exposures (which have been a continuing question) were still present after including more recent data.

Berman and Crump suggest that study discrepancies may be addressed by accounting for fiber diameter, length, and mineral type, and they explore this topic in a companion article [100]. In this analysis, surrogate size data and mineral type information were applied to study data to see if discrepancies in calculated potency factors between studies could be improved. Statistical tests suggested that chrysotile was much less potent in causing mesothelioma (best estimates for mesothelioma potency of chrysotile were 0—1/200th that of amphibole). For some size ranges, statistical tests suggested differences in lung cancer potency between chrysotile and amphibole as well. For diameter, the authors found that the occupational study results are in best agreement when fiber exposure data includes either "all widths" or widths less than 0.4 μm rather than only widths greater than 0.2 μm [ATSDR note: this suggests that very thin fibers not normally detected by PCM have significant potency]. For length, the authors concluded that lengths between 5 and 10 μm were not necessarily non-potent, but had significantly less potency than fibers with lengths greater than 10 μm. The authors stated that no consistent evidence was found indicating potency of fibers less than 5 μm in length in causing either lung cancer or mesothelioma. No matter what assumptions were made, the authors were not successful in resolving the discrepancies in potencies calculated for different studies. The authors suggest that the available data are not detailed enough to explain the differences.

Updated potency values similar to those from 2003 were published in the second 2008 paper [100]. ATSDR has not used the updated values in this health consultation because the 2003 Berman and Crump method was requested by various stakeholders when ATSDR began evaluating the data in 2006. The updated 2008 potency values do not differ greatly from the 2003 values and would not have a significant effect on the risks calculated or the conclusions of this health consultation.

"Life Table Analysis" - Time Considerations

Age of first exposure and duration of exposure are important considerations in risk assessment. For example, early-life asbestos exposures generally carry more overall risk because, with a longer life expectancy, the individual has a longer time to develop diseases with long latency periods, and therefore more chance of developing asbestos-related disease before dying of another cause. Many of the risk methods described above develop unit risks. The unit risks are derived using potency factors, mathematical models, and standard assumptions about exposure, such as a lifetime of continuous exposure. Their use simplifies calculations. This is useful for risk management purposes, but may not be fully informative for exposures that are discontinuous, have changing concentrations with time, or occur for periods much shorter than a lifetime. "Life table analysis" is a method for determining risk at various points in a person's life given specific exposure patterns and using general population mortality data. It can be used with most of the basic risk methods and potency factors described above. The "life table analysis" procedure used in this health consultation is consistent with the approach used by Nicholson (EPA 1986 method) and Berman and Crump [89,91]. A full description of the procedures is presented in Appendices C and D.

Because of the way life table analysis is done, and because of the long latency periods needed for asbestos-related disease (especially mesothelioma) to develop, groups who live longer end up having a higher risk of disease. For example, women have a higher life expectancy than men, and therefore their overall risk of developing mesothelioma is higher than men's. Smokers are a special case. Whether they are exposed to asbestos or not, a person who smokes tobacco has a higher risk of dying of lung cancer or other causes than nonsmokers. If a smoker is also exposed to asbestos, their risk of developing lung cancer is increased greatly. This increased lung cancer risk has the effect of decreasing the risk of mesothelioma—because the person is more likely to die from lung cancer before they would have time to develop mesothelioma. Similarly, a nonsmoker actually has a higher risk for mesothelioma because they are more likely to live long enough to develop the disease. Because of these differences, some risk assessors calculate separate asbestos risks for men and women and for smokers and nonsmokers.

Separating risks between smokers and nonsmokers is not straightforward; published mortality data do not document smoking status. The procedure involves using data on relative risk of dying for smokers vs. nonsmokers (data were collected in the 1980s) along with more recent data on prevalence of smoking in men vs. women to construct mortality tables for the separate groups of male smokers and nonsmokers and female smokers and nonsmokers [99,102,91]. Other groups have chosen to calculate risks based on only one sensitive group—*e.g.*, female nonsmokers [93].

ATSDR has chosen not to compute separate risk estimates for smokers and nonsmokers in this health consultation. This will allow straightforward use of updated mortality data without needing the (potentially outdated) relative risk data, and it does not require specific knowledge of smoking rates in this community. Further, although risks are calculated for men and women separately, we present only the range of risk for the population as a whole. We feel this is adequate and appropriate for our stated goal of obtaining a general idea of potential risk in the community.

Summary – Asbestos Risk Methods

Each risk method uses a specific fiber/structure definition of exposure to correlate with mortality data and describe risk. This exposure index is a measure of a subset of structures in a given exposure that could be used effectively in the method to describe risk associated with that exposure. However, it is likely that structures not meeting a particular index definition also contribute risk. Further research in structure size populations for different types of exposure as well as dimensional and mineralogical effects on asbestos toxicity for various disease endpoints may eventually allow refinement of exposure indices to correspond more closely with known toxic properties. Today, however, evidence is conflicting and arguments for any particular index are debated too strongly to allow a public health practitioner to select one alone.

In light of the fact that no one risk method has been accepted fully (and exclusively) in the scientific or regulatory communities, ATSDR was faced with the question of how to determine the risk posed by El Dorado Hills-area exposures. The agency decided that a practical way to address this problem would be to compare risk predictions from several different methods (using the same exposure data) to get an idea of the range of predicted risk. ATSDR chose to evaluate risk using as many of the risk methods described above as possible. The Hodgson and Darnton method was not used because a lifetime risk could not be calculated accurately given the method procedures, and the 2008 OSWER approach could not be used as it did not include potency factors required to calculate risk. Therefore, ATSDR estimated risk using the IRIS method, the Cal-EPA method, the EPA 1986 method, and the Berman and Crump method. Life table analyses with the EPA 1986 and Berman and Crump methods were performed using mortality statistics from 2003 (the most recent year available when we performed the analyses in 2008).

ATSDR recognizes that some of these methods are not accepted by EPA for regulatory purposes and may have scientific inadequacies. However, in this case we feel the use of alternate risk methods is justified because our objective is to make qualitative, practical recommendations to the community on the level of concern associated with exposure and ways to reduce potentially harmful exposures. We do not endorse using numerical results from our evaluation to take regulatory or enforcement actions. We caution that the risk estimates presented later in this report should be considered with these purposes in mind.

El Dorado Hills Activity-Based Sampling and Analysis

At the request of a community member, EPA collected activity-based samples in community areas of El Dorado Hills in Fall 2004. This type of air sampling uses personal monitoring techniques to measure asbestos concentrations a child or adult might breathe during various activities such as playing baseball or jogging down a dirt trail. Activity-based sampling is currently thought to represent the most realistic and accurate way to measure potential breathing-zone exposures. Over 300 activity-based sample filters were analyzed by Lab/Cor (Seattle, WA) in 2004-05 using a modified ISO 10312 method, which gives detailed structure information including dimensions and mineralogy. Preliminary findings from the EPA sampling were presented to the El Dorado Hills community in May 2005, and the final report was issued in January 2006 [7]. The findings indicated that activities resulted in significantly greater asbestos exposures than measured at activity-free reference stations. More details can be found in the EPA report [7].

ATSDR planned to use these results to evaluate risk associated with the exposures; however, the initial analysis of the samples did not allow meaningful application of risk methods utilizing a “long fiber” (greater than 10 µm) exposure index. Specifically, the original analytical procedure required each filter to be counted until a minimum of 50 structures equal to or longer than 5 µm in length had been identified. In many cases, this “stopping rule” was met before any structure longer than 10 µm was counted, so that the true “long” structure concentration was not known. ATSDR funded additional analysis of the filters, which had been archived by the laboratory, to count only structures greater than 10 µm long and less than or equal to 1.5 µm wide. Because there were very few of these structures, we specified that the laboratory was to count until 10 of these structures were identified or until a total of 400 grid openings had been counted, whichever came first. This was anticipated to give sufficient sensitivity to allow meaningful application of “long” structure risk methods such as the Berman and Crump Method.

To conserve limited funds, ATSDR selected about 180 of the more than 300 filters for additional analysis. Samples were selected to allow description of each exposure scenario of interest and to fully describe the reference station samples. In addition, ATSDR instructed the laboratory to perform the counting at a lower magnification (which saves analysis time). Most of the structures were not so thin as to limit visibility at the lower magnification, so this was not expected to have an impact on overall structure count.

ATSDR funded the additional analysis through a contract with Eastern Research Group (ERG, Cambridge, MA), which coordinated the analysis by Lab/Cor, the same laboratory used by EPA for the initial analysis. To facilitate turnaround time, analyses were performed concurrently, on equivalent TEM equipment, in Lab/Cor's Seattle and Portland (OR) locations. The additional analyses were performed primarily in March-July 2007, and final data reports were delivered to ATSDR in August and September 2007. A report giving further details of the objectives and describing the findings of the ATSDR additional analysis is included as Appendix E to this health consultation.

Exposure Assumptions

The activity-based sampling results give airborne asbestos structure concentrations for various activities that might take place in the community—the activities focused on outdoor activities like sports and exercise which might be expected to disturb NOA and result in exposure. In order to estimate a community member's typical exposure, ATSDR worked with stakeholders to develop assumptions for the length of time a person would spend doing each activity— "time-duration assumptions." Three scenarios were considered:

- The low activity case corresponds to a person who, throughout life, participates in very few outdoor activities. The only exposures beyond background assumed for this case are through required outdoor activities during school years.
- The moderate activity case corresponds to a moderate level of participation in outdoor activities, team sports, and outdoor exercise throughout life.
- The high activity case corresponds to those who spend lots of time outdoors, participate in many team sports, and continue high level of outdoor sports and exercise activities throughout life.

ATSDR developed draft exposure assumptions for each of these cases and provided them to a local citizens group and local, state, and federal stakeholders for comment. Appendix F includes the original spreadsheet containing draft exposure assumptions, comments made by the various groups, ATSDR responses indicating revisions made to the assumptions, if applicable, and the resulting revised exposure assumption spreadsheet. The revised time-duration assumptions are summarized in the next section and presented in Table 2 following that summary.

In addition to time-duration assumptions, ATSDR proposed a method of selecting and combining the air sampling results to correspond with various activities. For example, physical education activities at school were assumed to be represented by a 50/50 contribution of results for child participants in "grassy fields" scenarios (soccer, baseball) and results for child participants in "asphalt courts" scenarios (basketball, 4-square court). These "structure concentration assumptions" were also provided to stakeholders, and comments, changes, and responses are included with the time-duration assumptions in Appendix F. The revised structure concentration assumptions are summarized beginning on page 32 and presented in Table 3 following that summary.

It is important to note that the assumptions made cannot perfectly describe any individual's exposure to asbestos-related materials in the El Dorado Hills area. The goal of this exercise is to obtain a range of potential exposures which can inform the public whether the community, as a whole, is at risk for elevated exposure and disease. However, both individual differences in activities (type, location, duration, intensity) and time or spatial variations in community areas (weather patterns, maintenance activities, level of asbestos-related materials) could all cause any one person's exposure to diverge, possibly significantly, from the estimates made herein.

Notes on Revised Time-Duration Assumptions

The total time of potential exposure is assumed to be 50 weeks per year, assuming a 2-week vacation to a location without potential for asbestos exposure. Of this, 13 weeks are assumed to constitute a "rainy" period when outdoor activities are curtailed and background exposures are lower. (Online data as well as local data collected by state and private entities form the basis for this assumption [103–105].) Assuming a 45-week school year running from mid-August until early June, ATSDR determined that the non-rainy school year (for estimating exposures during physical education, etc.) would be 32 weeks. A "digging" scenario describes young children participating in garden activities at school and older children participating in soil experiments through science classes. In addition to required school activities, children in the moderate and high activity scenarios are assumed to participate in extracurricular outdoor activities, split evenly between "grassy fields," "asphalt courts," and the New York Creek Trail, during a total of 36 weeks per year (some activities take place during the summer break).

For the 12-18 year-olds' high activity scenario, 10 hours per week was assumed for extracurricular activities (8 hours for practice and games during the school week and 2 hours on the weekend). For the moderate scenario, 5 hours per week was assumed (half of the "high" activity level and similar to recommendations made by the U.S. Surgeon General's Office that children older than 8 and adolescents engage in "at least 60 minutes of moderate intensity, continuous activity on most days, preferably daily." [106]) Total hours for extracurricular activities for 5-11 year olds was the same as for 12-18 year olds, but the proportion of time spent on grassy fields or asphalt courts was increased and time on New York Creek Trail reduced, since younger children are assumed to be more likely to engage in supervised sports activities than independent exercise. Time-duration assumptions are presented in Table 2, and more details can be found in Appendix F.

Table 2. Time Duration Assumptions Used for Activities in El Dorado Hills, California

Age	Activity*	Case: Low Activity – Hours per Week	Weeks per Year	ratio†	Hrs per Year	Case: Moderate Activity – Hours per Week	Weeks per Year	ratio†	Hrs per Year	Case: High Activity – Hours per Week	Weeks per Year	ratio†	Hrs per Year
Age: 0-4 yrs	Child - Dry Background		37		**6216.0**		37		**5994.0**		37		**5772.0**
	Child - Wet Background		13		**2184.0**		13		**2184.0**		13		**2184.0**
	Child - Tot Lot					3	37		**111.0**	6	37		**222.0**
	Child - Bicycling (alone or on parent's bike)					3	37		**111.0**	6	37		**222.0**
Age: 5-11 yrs	Child - Dry Background		37		**5984.0**		37		**5740.0**		37		**5544.0**
	Child - Wet Background		13		**2184.0**		13		**2184.0**		13		**2184.0**
	Child - Walking on NY Trail to & from school					2	32		**64.0**	2.5	32		**80.0**
	Child - Recess	2.5	32		**80.0**	2.5	32		**80.0**	2.5	32		**80.0**
	Child - "Digging"	1	32		**32.0**	1	32		**32.0**	1	32		**32.0**
	Child - Physical Education	3.75	32		**120.0**	3.75	32		**120.0**	3.75	32		**120.0**
	Child - Asphalt Courts Play					6	12		**72.0**	12	12		**144.0**
	Child - Grassy Fields Play					6	12		**72.0**	12	12		**144.0**
	Child - New York Trail Biking/jogging					3	12		**36.0**	6	12		**72.0**
Age: 12-18 yrs	Child - Dry Background		37		**6146.6**		37		**5902.6**		37		**5706.6**
	Child - Wet Background		13		**2184.0**		13		**2184.0**		13		**2184.0**
	Child - Walking on NY Trail to & from school					2	32		**64.0**	2.5	32		**80.0**
	Child - "Digging"	0.5	3	0.57	**0.9**	0.5	3	0.57	**0.9**	0.5	3	0.57	**0.9**
	Child - Physical Education	3.75	32	0.57	**68.6**	3.75	32	0.57	**68.6**	3.75	32	0.57	**68.6**
	Child - Asphalt Courts Play					5	12		**60.0**	10	12		**120.0**
	Child - Grassy Fields Play					5	12		**60.0**	10	12		**120.0**
	Child - New York Trail Biking/jogging					5	12		**60.0**	10	12		**120.0**
Age: 19-30 yrs	Adult - Dry Background		37		**6216.0**		37		**6120.0**		37		**6024.0**
	Adult - Wet Background		13		**2184.0**		13		**2184.0**		13		**2184.0**
	Adult - Asphalt Courts Play					2	6		**12.0**	4	6		**24.0**
	Adult - Grassy Fields Play					2	6		**12.0**	4	6		**24.0**
	Adult - New York Trail Biking/jogging					3	24		**72.0**	6	24		**144.0**
Age: 31-120 yrs‡	Adult - Dry Background		37		**6216.0**		37		**6150.0**		37		**6048.0**
	Adult - Wet Background		13		**2184.0**		13		**2184.0**		13		**2184.0**
	Adult - Asphalt Courts Play					1	6		**6.0**	2	6		**12.0**
	Adult - Grassy Fields Play					1	6		**6.0**	2	6		**12.0**
	Adult - New York Trail Biking/jogging					2.25	24		**54.0**	6	24		**144.0**

* Time for activities subtracted from time for dry background.

† Used to correct for 4 out of 7 years that PE and soil experiments are required.

‡ Adult exposures are assumed to continue throughout life to a maximum of 120 years; however, the exposure only applies to the population remaining alive, so the contribution to risk in high-age years is very small.

Notes on Structure Concentration Assumptions

Each activity is assumed to be described by a combination of activity-based sampling results. Table 3 shows the activity-based samples included in the calculation for each activity's structure concentration. Each sample's result will depend on how the structure of interest is defined: for example, in the same sample, the numerical concentration of PCMe-sized fibers is different from that of total TEM structures. Later in this document, ATSDR will evaluate risk using different methods, many of which use different definitions for structures of interest.

Of note in the structure concentration assumptions, the grassy field scenario is assumed to be described by the scenarios taking place on baseball and soccer fields (including grassy field composite samples). The asphalt court scenario, similarly, includes results from basketball and the Jackson playground (4-square) scenarios. Most activities used personal air monitoring results (participants in the activity-based sampling) to describe exposures. However, some scenarios (walking to school on New York Trail or recess activities, for example) were considered to be less intense than the corresponding activity-based sampling (biking/jogging on New York Trail or sport activities, respectively). In these scenarios, stationary monitoring results (corresponding to observers in activity-based sampling) were used to describe exposure.

Reference station samples were assumed to represent background under "dry" conditions, because the activity-based sampling occurred during the dry season. For the wet season, ATSDR assumed the background concentration would be one-tenth of the dry season value. This assumption is supported by El Dorado Hills specific sampling data and is discussed in greater detail later in this document and in Appendix F (see sections beginning on pages 42 and 102).

As shown in Table 3, structure concentrations are determined for each scenario by combining identified activity-based sampling results. For several of the exposure measurement definitions calculated (for example, structures longer than 10 μm and thinner than 0.4 μm), the structures of interest were detected very rarely, even with the additional analysis in which up to 400 grid openings per sample were counted. For these cases, a "nondetect" value was assumed to truly represent the absence of that size structure in the sample, and a value of zero was assigned. The average value of all the samples contributing to the scenario is expected to adequately represent exposures to the majority of individuals in that scenario and is used herein to calculate a "mid-range" estimate of the annual exposure concentration. However, as an indication of "spread" in the data and to obtain a conservative estimate of the possible exposure, a "high-end" value for each scenario was also selected: the highest value detected in any of the activity-based samples contributing to that scenario. With the use of high-end values for each exposure scenario considered, the estimated yearly structure concentration represents a more conservative estimate of the average annual exposure. (The high end estimate does not represent an upper bound because the maximum detection in each scenario is averaged with the other scenarios and weighted according to the estimated time spent in each scenario over the year.)

Appendix G tabulates intermediate and final results of calculations performed in this consultation. Table G1 shows yearly structure concentrations calculated using the mid-range and high-end values for each scenario, for each structure definition of interest. These concentrations are inserted into life table analysis for each risk method evaluated.

Table 3. Assumptions Used for Calculating Structure Concentrations for Activities

Activity	Values to Include in Concentration Average
Child - Dry Background	All reference stations
Child - Wet Background	All reference stations (divided by factor of 10)
Child - Tot Lot	Personal monitors at tot lot, also observer (hi-vol)* samples at playground
Child - Bicycling (alone or on parent's bike)	Child participant personal monitors for biking scenario
Child - Walking on NY Trail to & from school	Observer (hi-vol) samples for biking and jogging scenarios on New York Trail
Child - Recess	All grassy field and asphalt court observer (hi-vol) samples
Child - "Digging"	Jackson Elementary Gardening (note only one observer (hi-vol) sample available)
Child - Physical Education	Child participant personal monitors for grassy fields, asphalt courts (including composites)
Child - Asphalt Courts Play	Child participant personal monitors for asphalt courts
Child - Grassy Fields Play	Child participant personal monitors for grassy fields (including composites from grassy fields)
Child - New York Trail Biking/jogging	Child participant personal monitors for biking scenario
Adult - Dry Background	All reference stations
Adult - Wet Background	All reference stations (divided by factor of 10)
Adult - Asphalt Courts Play	Child & nonactive adult participant personal monitors for asphalt court scenarios (no adult participant samples were collected)
Adult - Grassy Fields Play	Adult participants & nonactive participant personal monitors for grassy fields
Adult - New York Trail Biking/jogging	Adult participant personal monitors for jogging scenario

* Observer (hi-vol) samples refer to stationary monitors set up nearby activities to represent observers of the activity.

Risk Estimation

Estimated lifetime risk of combined excess lung cancer and mesothelioma was calculated using several different risk methods as described previously. The methods used were:

- EPA 1986 life table analysis, using a PCM equivalent (PCMe) structure definition of combined amphibole and chrysotile structures with length greater than 5 µm, width greater than or equal to 0.25 µm and less than or equal to 3 µm, and aspect ratio greater than or equal to 3:1 [89]. These dimensions are consistent with PCM fibers as specified in the EPA 1986 method; however, it should be noted that there may be differences between PCMe (measured with a transmission electron microscope) and PCM (measured a with phase contrast optical microscope) counts. The exposure durations were as described above in Table 2, and estimation of total lifetime risk was performed by summing risks each year for all surviving population members using 2003 NCHS mortality data [107,108]. (As noted in Table 2, only the population remaining alive contributes to each year's risk, so the risk contributed by later ages is small. However, all ages with survivors [up to age 120 for the 2003 data] must be considered to estimate true lifetime risk.)

- IRIS procedure, using the same PCMe structure definition as above. Yearly exposure estimates used for life table analysis were averaged to obtain an average lifetime estimate of exposure for this method. The average lifetime exposure was then multiplied by the IRIS inhalation unit risk, 0.23 $(f/cc)^{-1}$ [37].
- Berman and Crump method life table analysis, using a structure definition separating amphibole and chrysotile structures greater than 10 µm long and less than 0.4 µm wide [91]. Life table analysis was performed as for the EPA 1986 method above.
- Cal-EPA procedure, using a structure definition of combined amphibole and chrysotile structures of length greater than or equal to 0.5 µm and aspect ratio greater than or equal to 3:1 [93,94]. As part of the procedure, total number of structures was converted to PCM equivalent structures by dividing by 320, a conversion factor determined by Cal-EPA. Yearly exposure estimates used for life table analysis were averaged to obtain an average lifetime exposure for this method. It should be noted that risk calculated using this method is only for mesothelioma risk in female nonsmokers (considered the most sensitive group) and does not include excess lung cancer risk.
- In addition to the official Cal-EPA method, we also examined the impact of using the Cal-EPA unit inhalation risk directly with PCMe data (bypassing the conversion step) as has been proposed by U.S. EPA.

Limitations

Each risk method relies on exposure data from historical epidemiological studies which have a great degree of uncertainty associated with them, especially in characterizing worker exposures. We do not know with certainty whether the size of particles selected in each method to describe exposures (e.g., PCM, TEM) fully or accurately captures those particles contributing to risk of disease. For each risk method, there is uncertainty in the numbers chosen as coefficients in the exposure-disease model used. For the methods that separated risk based on fiber mineralogy, there is uncertainty in the adequacy of the data to describe exposures by mineralogy. Additional uncertainty comes from the exposure assumptions we developed to use in the various risk methods. EPA's sampling data were collected during a short timeframe at a few locations and may not fully reflect the temporal and spatial average exposures occurring in the community. Also, the activity simulations performed may not adequately represent the type, number, and frequency of activities performed throughout a lifetime or the variability of those activities between individuals.

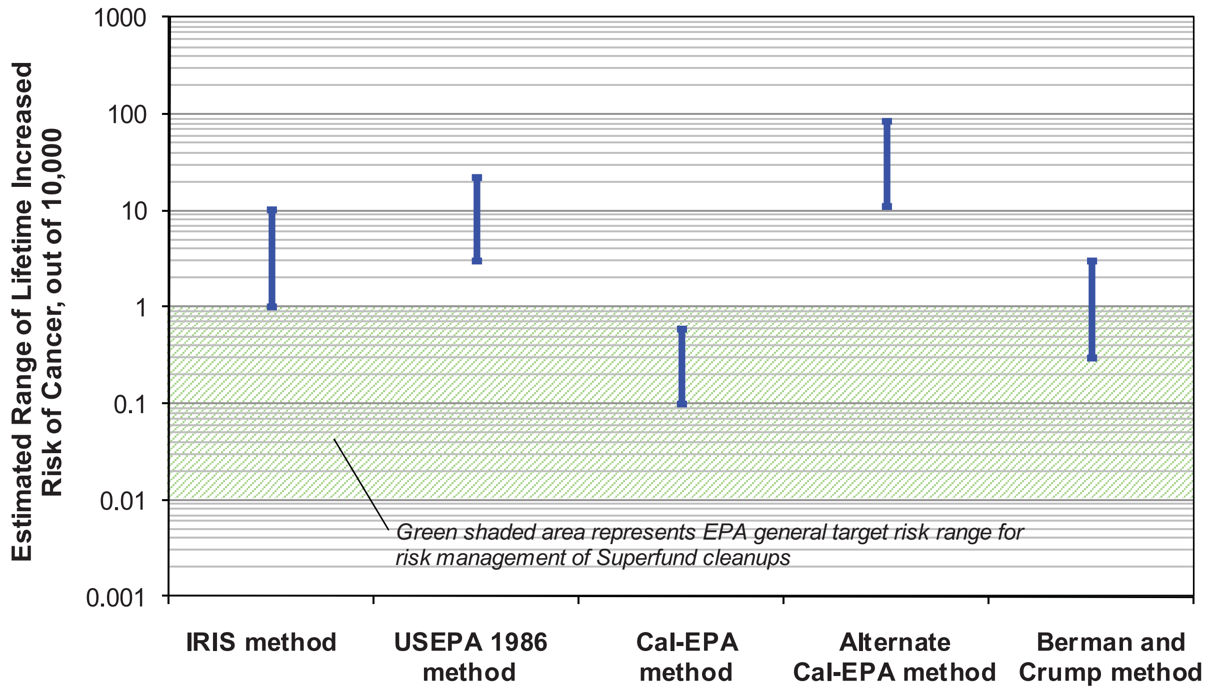
Our goal was to get a general idea of the potential increased risk of developing disease from community exposures, not to predict a specific numerical risk. Therefore, although we recognize the inherent uncertainties, we used the available risk methods and data to obtain estimates of risk.

These estimates are presented as the lowest and highest lifetime risks predicted by each method, using the exposure scenarios and mid-range and high-end concentration estimates described in the "Exposure Assumptions" section above. The ranges presented do not include any estimate of confidence around the individual predicted risks. We did not analyze the sensitivity of the results on uncertainty in any one variable. We are only showing the range of estimated increased risk calculated based on the four methods evaluated and specified exposure assumptions.

Risk Results

Estimated risk of lung cancer and mesothelioma combined was calculated for each method (except the Cal-EPA methods which only consider mesothelioma risk). Calculations used asbestos structure concentrations for low, medium, and high activity patterns, for men and women, and for mid-range and high-end values used in calculating exposure scenario concentrations. This allowed a range of potential lifetime risk to be generated. The results are shown in Figure 5 below.

Figure 5. Ranges of Estimated Lifetime Increased Risk of Cancer from NOA Exposure



Another presentation of the data is in Table 4. In this table, to get an indication of the relative contribution of activities and background exposures, the risk calculations were repeated with background concentrations for all ages set to zero. This gives the risk contributed by activities as shown in the second results column in Table 4.

Table 4. Ranges of Predicted Lifetime Cancer Risk from NOA Exposure using Different Risk Methods

Risk Method	Structure Definition	Range of Estimated Risk out of 10,000*		Analysis Procedure
		Lifetime Estimated Risk	Risk Contributed by Activities†	
IRIS	PCMe Structures, combined amphibole / chrysotile	1 to 10	0.02 to 3	averaged over lifetime
EPA 1986	PCMe Structures, combined amphibole / chrysotile	3 to 22	0.1 to 8	life table analysis
Cal-EPA	Total Structures, ≥0.5 μm long and ≥3:1 aspect ratio, combined amphibole / chrysotile	0.1 to 0.6	0.004 to 0.3	averaged over lifetime (meso only)
Alternate Cal-EPA	PCMe Structures, combined amphibole / chrysotile	11 to 85	0.2 to 23	averaged over lifetime (meso only)
Berman and Crump	Structures >10 μm long and ≤0.4 μm wide, separate amphibole / chrysotile	0.3 to 3	0.03 to 3	life table analysis

* Note that ranges do not indicate confidence intervals, merely the range of risks predicted for each model for various activity level, gender, and exposure concentration assumptions. See "Limitations" section in text.

† Lifetime risk with background concentrations set to zero.

Discussion of Risk Results

The range of estimated risk for each risk method represents the variation in risk for different exposure scenarios (low to high activity throughout life), gender, and the use of mid-range to high-end exposure concentration estimates for each activity. It is important to note that the high end of this risk range is not an overly conservative estimate. Even when high-end exposure concentrations were used, these were averaged over various scenarios and time and still reflect an average value; additionally, the activity level (low, medium, or high) had a relatively small effect on the predicted risk. Finally, the activity-based sampling was conducted in public areas of El Dorado Hills that may not represent the highest NOA exposures that could be possible. The USGS studied mineralogy in the area and found that while the areas sampled in the activity-based sampling contained particles meeting regulatory definitions for asbestos, the most highly asbestiform particles came from other public locations [8,109]. Therefore, a specific individual could have significantly higher or lower exposure, depending on the particular areas he or she accessed during life.

The EPA 1986 method and the alternate application of the Cal-EPA method generally resulted in the highest predicted risk ranges, followed by the IRIS method and the Berman and Crump method. The Cal-EPA method predicted the lowest range of risk. This could be a result of the conversion factor used to convert total TEM concentrations to PCM being too high. Using actual PCMe measurements (as in the alternate application of the Cal-EPA method) gives estimated risk two orders of magnitude larger than the "official" method and even higher than the risk predicted using the EPA 1986 life table method. This makes sense since the Cal-EPA unit risk was calculated more conservatively than the EPA unit risk.

Estimated lifetime risks, including both background and activities, ranged from 1 in 100,000 (1×10^{-5}) to greater than 8 in 1,000 (8×10^{-3}). (As stated throughout this document, these risk estimates are highly uncertain and are only calculated to obtain a general idea of the degree of risk in the population.) For risk contributed by activities alone (not including background), the predicted risks ranged from 4 in 10,000,000 (4×10^{-7}) to 2 in 1,000 (2×10^{-3}).

These results do not allow us to predict with certainty the risk of developing asbestos-related cancers. The estimated ranges include risks from levels that would not be of concern to those that would be considered elevated above EPA's range of acceptable risk for Superfund. This holds true for both background exposures and those resulting from outdoor activities.

ATSDR generally recommends that public health action be taken if exposures indicate the potential for an increased risk of cancer. While our findings have limitations, we believe it is prudent to inform the public about the potential risk and recommend public health actions to reduce potential exposures. Figure 6 presents suggested actions to minimize the potential for exposure to NOA. Taking these public health actions will reduce the potential for harmful exposures to NOA and thus minimize the risk of disease occurring in the community.

For perspective on where the estimated NOA concentrations for specific scenarios and annual averages fall compared to other occupational and nonoccupational asbestos concentrations shown earlier in Figure 4, we have superimposed the estimated concentration ranges and show the result in Figure 7.

Figure 6. Suggestions for Minimizing Community Exposure to NOA

Minimize Current Exposure to NOA:

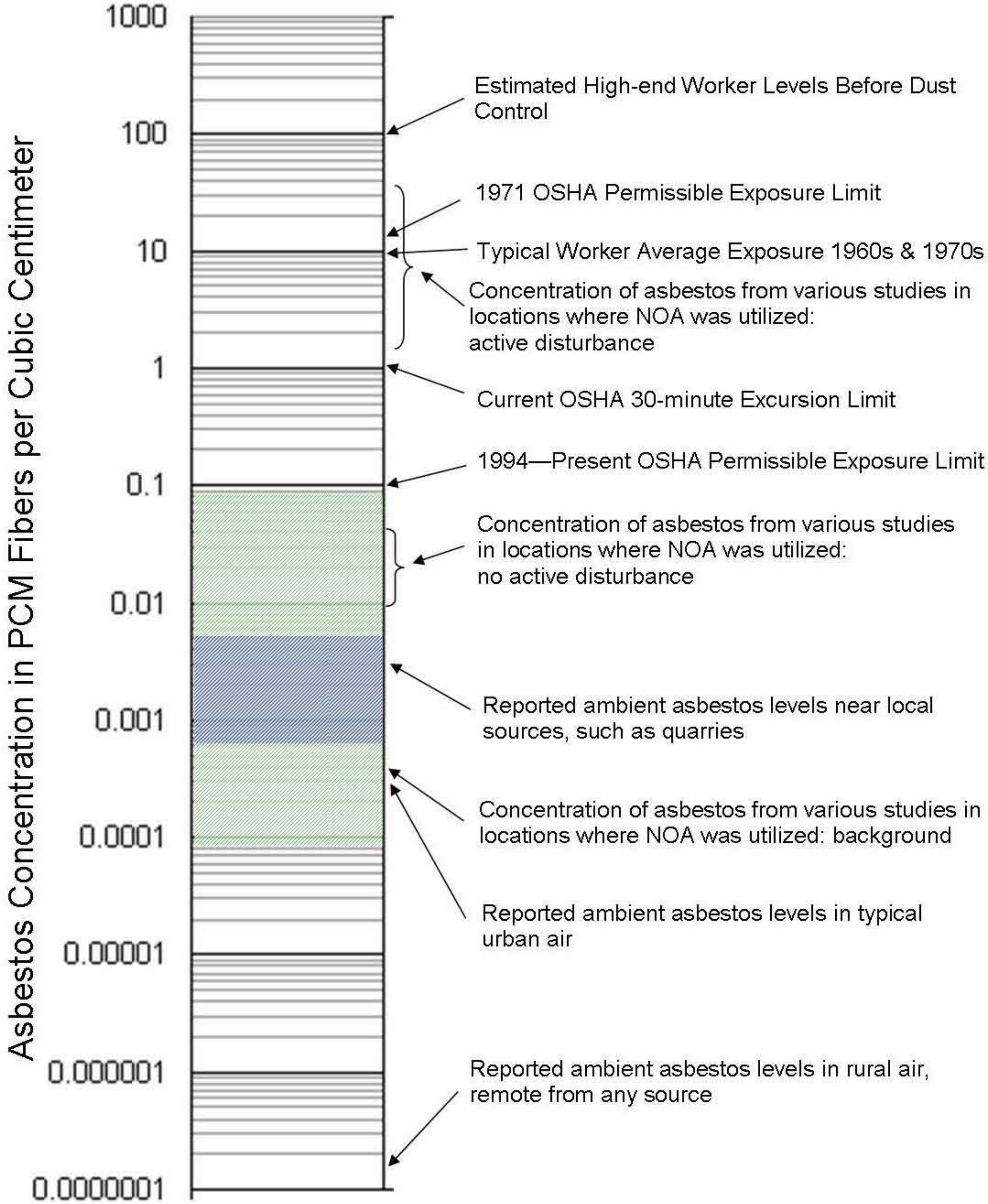
- Wet areas with water prior to use to avoid stirring up dust that may contain NOA.
- Avoid the use of leaf blowers or compressed air.
- Drive slowly over unpaved roads, with windows and vents closed.
- Pave over or cover NOA-containing rock or soil, or cover with asbestos-free soil or landscape covering.
- Lower the amount of soil tracked into homes: use doormats, remove shoes, and clean pets' fur and feet.
- Keep buildings' and homes' windows and doors closed on windy days and during nearby construction.
- Use a wet rag instead of a dry rag or duster to dust; use a wet mop on non-carpeted floors.
- Use washable area rugs on floors and wash rugs regularly.
- Vacuum carpet often using a vacuum with a high efficiency particulate air (HEPA) filter, or steam clean.

Minimize Future Releases of NOA to Community Background:

- Document areas of known NOA
- Avoid uncontrolled disturbance of areas known or suspected to contain NOA
- Enforce state and local air regulations

For specific additional information targeted to workers and residents, see Appendix H.

Figure 7. Comparison of El Dorado Hills Results (Shaded Areas) with Occupational and Nonoccupational Asbestos Concentrations (Refer to Figure 4).



Refer to Figure 4.
Green shaded area is the range of maximum asbestos levels associated with specific scenarios in El Dorado Hills.
Blue shaded area shows the estimated range of annual average exposure levels in El Dorado Hills.
Assumptions and sources are given in Appendix B. All concentration estimates reported as Phase Contrast Microscopy (PCM) fibers per cubic centimeter.

"Background" Considerations

ATSDR evaluated risk including a value for background exposure in addition to activity-specific exposures. This was done to account for exposures occurring in places where the activity-based sampling was not performed, but where it is possible to be exposed to NOA disturbed through natural weathering or other activities not simulated in the sampling.

ATSDR's approach is consistent with EPA guidance stating that background should be considered in performing risk assessments [110,98]. Although background is a consideration, EPA risk assessments do not always include background in calculating risk from exposures—exposure may only occur intermittently at the site, or risk managers may decide to base cleanup decisions only on site-related exposure above background [111,112]. The inclusion of background concentrations contributed to estimated risk in our analysis. As indicated in Table 4, omitting background exposures reduced the low end of the risk range significantly; the high end of the risk range was reduced by a smaller amount.

Since background does contribute to overall predicted risk, we examined how the estimated background concentrations in El Dorado Hills compare with other locations in the United States. Knowledge about background asbestos concentrations in other locations is limited. ATSDR's toxicological profile summarizes various findings for ambient concentrations of asbestos in air. The profile cites studies finding that ambient outdoor air, remote from any special sources, contains 0.00000003 to 0.000003 PCM f/cc; urban areas typically contained 0.000003 to 0.0003 PCM f/cc, but could reach up to 0.003 PCM f/cc near local sources [14]. For comparison, this consultation used reference station data to estimate background concentrations. For "mid-range" assumptions, the average of 0.0008 PCM f/cc during dry periods and 0.00008 PCM f/cc during wet periods was used, and for "high end" assumptions, the highest concentration of 0.004 PCM f/cc for dry periods (0.0004 PCM f/cc for wet periods was used). The values for background in El Dorado Hills may reach values similar to high end typical urban environments or near local sources.

ATSDR does not know what every source is that contributes to the background concentrations in El Dorado Hills. We also do not know how much each of those sources contributes. Therefore, we believe it would be prudent to limit activities that could lead to increased background concentrations in the area.

Feasibility and Need for Further Investigation

Epidemiologic health studies are undertaken by ATSDR when the relationship between exposure to an environmental contaminant and resulting disease is not well understood. In El Dorado Hills the issue is exposure to naturally occurring asbestos. There is no question that exposure to asbestos increases the risk of asbestos-related disease. Therefore actions to reduce exposures in El Dorado Hills are needed.

Having known individual exposure information (especially regarding past exposures which would contribute to disease risk today) is essential for conducting these types of studies. ATSDR is unable to reliably estimate individual exposures in El Dorado Hills. Individuals have no way of knowing when or to what extent they were exposed to NOA. Available biomarker methods do not allow reproducible measurement of past exposures [113]. Therefore it is impossible to develop individual cumulative exposure estimates necessary to establish a correlation with current health conditions.

To explore whether exposure to NOA might have caused an increase in the numbers of mesothelioma cases in areas of NOA in El Dorado County, we asked the California Cancer Registry (CCR) to examine and update the rates of mesothelioma for specific census tracts in western El Dorado County. The results are described in ATSDR's health consultation for Oak Ridge High School in El Dorado Hills; rates from 1988- 2001 were not higher than expected. The current evaluation included cases through 2008. Census tracts included in the current evaluation are shown in Figure 8. The age-adjusted rates for the all race/ethnic and sex group in the selected census tract were compared with California all race/ethnic and sex group, age-adjusted incidence rates for mesothelioma. The updated analysis shows that in the selected census tracts from 1988-2008, 31.65 cases of mesothelioma would be expected, and 37 cases were observed. The standardized incidence ratio (SIR, the ratio of observed to expected cases) was 1.17 (99% Poisson confidence interval 0.73—1.76). Because the confidence interval of the SIR includes 1, the difference between the observed and expected rates is not statistically significant.

The CCR also examined the geographical distribution of the 37 cases observed over the 21 years from 1988 to 2008. This information may help understand the distribution of cases, but we caution that examining the number of cases per census tract can be misleading if population is not considered. None of the census tracts had significantly elevated SIRs. Of the 26 census tracts evaluated, 4 census tracts had no cases, 12 census tracts had only one case; 7 census tracts had 2 cases, and 2 census tracts had 3 cases. One census tract, 309.02 near Placerville, had 5 cases diagnosed over the 21-year study period. While the SIR for this census tract was higher than others, the excess of mesothelioma cases was not statistically higher than what would be expected based on state rates (SIR 4.35 with 99% CI of 0.94-12.31). The CCR provided the following information about this finding:

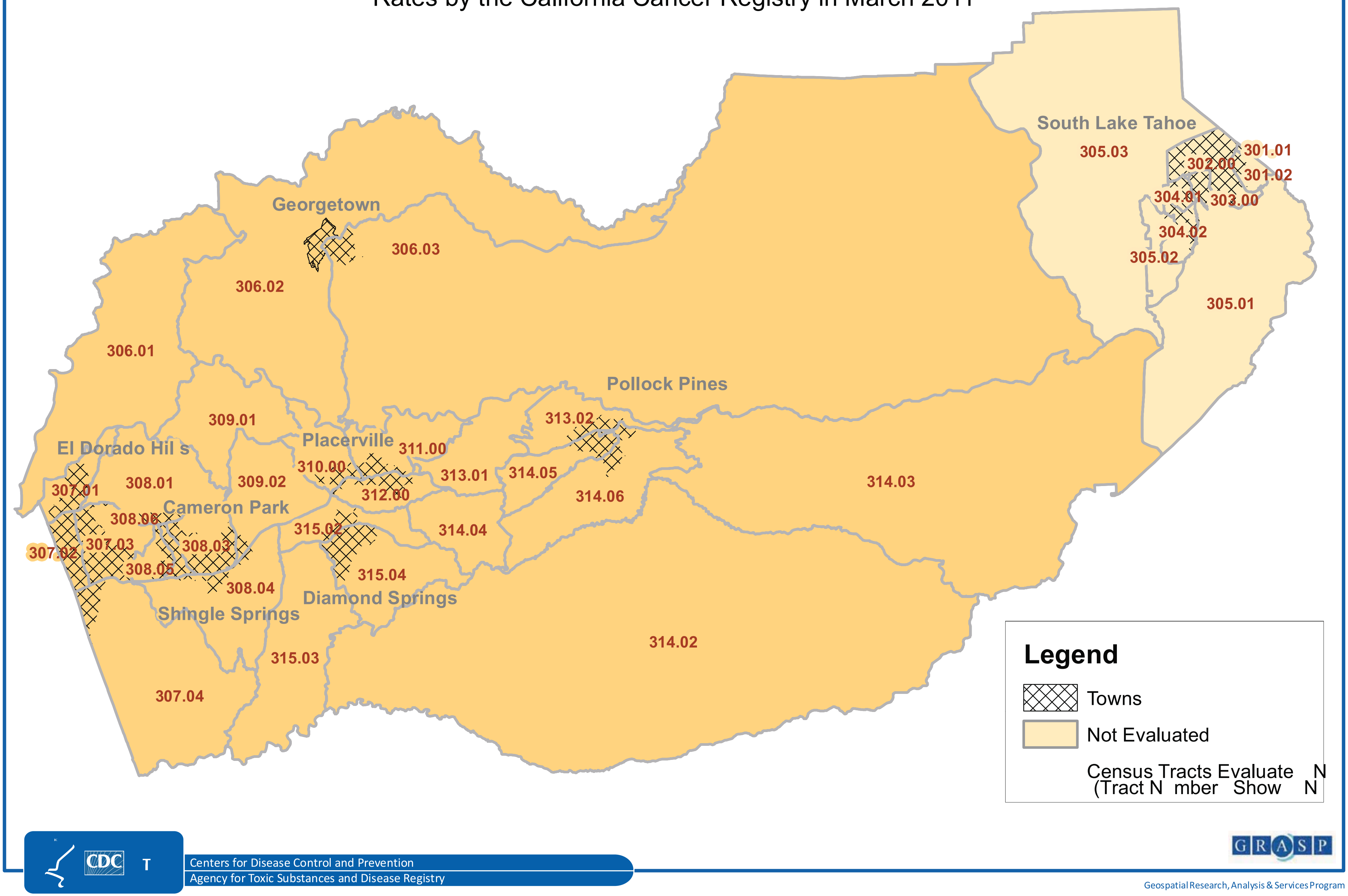
> All 5 cases of mesothelioma in census tract 309.02 were among non-Hispanic white males, ranging in age from 50-85 years old at diagnosis. We unfortunately have no information on the residential or work history of these men or other possible risk factors that may have contributed to the development of mesothelioma.

More details of this analysis can be found in the CCR report, included as Appendix J.

Community screening for asbestos related disease has been undertaken at other NOA sites (Libby, Montana, and some villages in Turkey, for example). These screening efforts were initiated in response to an indication that unusual rates of disease were present in the community. Based on the current state cancer registry information, general community screening is not warranted in El Dorado Hills. However, individuals may have highly variable past exposures and health outcomes. Community members should consult with their medical providers about health concerns related to NOA exposure.

Figure 8.

El Dorado County Census Tract N mbers Evaluated for Mesothelioma Rates by the California Cancer Registry in March 2011



Additional Information on NOA in the El Dorado Hills Area

The site-specific activity-based sampling data gave us the best information possible on actual exposures people in the community might experience, and applying risk methods gave us the best estimate of resulting excess cancer risk possible given the state of the science. However, as described earlier in the "Uncertainties" section, measuring exposures and estimating risk for NOA-exposed communities involves uncertainty. We heard concerns from community members and from stakeholders that the activity-based sampling may not have been representative of all possible exposures, that the various risk methods do not fully account for risk, and that other data from the local area may not agree with the activity-based sampling data. Therefore, we looked at other studies that have been done in the area to provide additional information and support to our conclusions from using activity-based sampling data to estimate risk. The following section describes these additional studies and discusses how their findings relate to the activity-based sampling results on which our risk estimates are based.

- The California Air Resources Board (CARB) conducted ambient monitoring for NOA at several locations, including several in El Dorado County, during the years 1998-2003. Results are available online [105]. Little information is given on the rationale for choosing locations for ambient monitoring, but it is likely that sampling was targeted to areas of concern or with a higher likelihood for having NOA. Documentation of the exact sampling conditions, including whether dust control measures were being used, was not available. Table 5 summarizes findings for various locations in El Dorado County; ATSDR calculated statistics on results downloaded from the CARB website. Although average values are generally relatively low (nondetect values were counted as zero), concentrations detected varied widely both within a particular sample area and between various areas. This indicates a potential for locally high asbestos concentrations under some conditions. It should also be noted that CARB conducted ambient monitoring in other California areas; the statistics performed on those results (not shown) are similar to those presented in Table 5 for El Dorado County.

Table 5. Summary of California Air Resources Board Ambient Air Monitoring for NOA in El Dorado County *

Area Description (All Areas in El Dorado County)	Sampling Dates	# Detects / # Samples	Average ± Standard Deviation (total TEM s/cc)	95th Percentile (s/cc)	Maximum (s/cc)
El Dorado County, Various Sites	Apr-Oct 1998	57 / 252	0.001 ± 0.004	0.006	0.04
El Dorado County, Residences Near Quarry	Oct 1998	64 / 86	0.008 ± 0.02	0.03	0.1
El Dorado County, Quarry Entrance	Oct 1998	23 / 24	0.05 ± 0.05	0.1	0.2
Silva Valley, Various Sites	Apr 1999	5 / 35	0.0002 ± 0.0005	0.001	0.002
Garden Valley, Various Sites	Aug 1999	32 / 38	0.004 ± 0.004	0.008	0.02
Woedee Drive	Jan 2000	0 / 22	N/A†	N/A	N/A
Woedee Drive, Dirt Pile Removal	Feb 2000	0 / 8	N/A‡	N/A	N/A
Oak Ridge High School: Upper Soccer Field during mitigation	Jun-Jul 2003	62 / 85	0.0009 ± 0.0009	0.003	0.004
Oak Ridge High School: Lower Soccer Field during mitigation	Jun-Jul 2003	52 / 81	0.0006 ± 0.0006	0.002	0.002
Oak Ridge High School: Receptor Sites during mitigation	Jun-Jul 2003	26 / 58	0.0004 ± 0.0005	0.001	0.003

* Units are total TEM structures per cubic centimeter (s/cc) measured using AHERA definitions. Statistics were performed on all reported results for categories defined by CARB, applying a value of zero to nondetect results.

† Average minimum detection limit 0.0009 s/cc

‡ Average minimum detection limit 0.0008 s/cc

- In 1998, the Sacramento Bee newspaper reported findings of an industrial hygienist the newspaper had hired to study potential asbestos exposures in the El Dorado County area [2]. Various tests were performed in September 1997 at 3 houses: on Woedee Drive in El Dorado Hills (indoor dust and front yard air); on Wild Turkey Drive in Shingle Springs south of El Dorado Hills (indoor dust, front and back yard air, and along unpaved road); and on Cothrin Ranch Road in Shingle Springs (indoor dust). Although not explicitly stated, other information in the article implies that these analyses were performed according to AHERA-type procedures and thus include all structures greater than 0.5 µm in length – the values cannot be compared with standards based on PCM f/cc units. According to the newspaper report, the stationary air monitors showed no detectable asbestos or barely detectable levels of chrysotile asbestos. The monitor set up along the unpaved road while a vehicle passed by to simulate traffic showed an actinolite concentration of 0.22 fibrous structures per cc. Indoor dust samples collected with a microvacuum from areas not regularly cleaned showed actinolite asbestos ranging from about 4,000—500,000 structures per square centimeter (s/cm^2); each home had at least one sample above 10,000 s/cm^2 [2]. For comparison, experts in this type of sampling have indicated that values below 1,000 s/cm^2 are generally not different from background, levels around 10,000 s/cm^2 may show an elevation above background, and levels around 100,000 s/cm^2 show a significant elevation, such as from a release of asbestos containing material [114]. Also for comparison, in the World Trade Center test and clean program following the 9/11 tragedy, cleanup was performed if asbestos in dust exceeded 5,000 s/cm^2 for accessible areas or 50,000 s/cm^2 for infrequently accessed areas (like behind appliances) [115].

- Cal-EPA's Department of Toxic Substances Control (DTSC) performed a series of studies of potential exposure associated with unpaved roads in California. In El Dorado County, a study was performed in 2004 at Slodusty Road in the Garden Valley area near Coloma [5]. Air measurements were collected before and after resurfacing of a serpentine-covered road, and risks were estimated using the Cal-EPA method. Prior to resurfacing of the unpaved road, typical traffic patterns resulted in total asbestos structure concentrations ranging from 0.009–9.5 s/cc, depending on number of vehicles per hour, speed of the vehicles, and distance of the sample from the roadway. Resurfacing of the roadway significantly reduced asbestos release, reducing the maximum values by two orders of magnitude. The primary type of asbestos detected in this study was chrysotile.

- Oak Ridge High School in El Dorado County was one of the locations where CARB conducted ambient air monitoring (in 1998 and during mitigation of asbestos in 2003). Several additional sampling events took place at the school following the discovery of amphibole asbestos during construction of new soccer fields in 2002. Soil testing and active and passive air monitoring were conducted at various indoor and outdoor campus locations; sampling was primarily conducted by contractors of the school district and by EPA. These studies, summarized in ATSDR's previous health consultation on Oak Ridge High School, indicated the potential for elevated exposure to asbestos, especially during outdoor athletic and maintenance activities [6]. At this time, most areas of the campus have had NOA mitigated.

- Academic researchers working with local citizens performed experiments in which lungs from four deceased dogs and one deceased cat from El Dorado County were analyzed for asbestos. The lung tissue contained considerable numbers of amphibole asbestos fibers . A cat from an area without NOA had no fibers detected [116]. In response to previous reports of this work, ATSDR held an expert panel in May 2006 in which the possibility of using lung fiber measurements in sentinel animals to measure community exposure was discussed [113]. The panel generally felt that these results are interesting and suggest that exposures could be occurring in the community. However, there are many differences between animal and human physiology and behaviors that make it impossible to quantify human exposures or predict the possibility of disease from animal data [113].

- As part of the Air Toxics Control Measures, developers of construction sites containing NOA are required to conduct dust suppression and may be required to perform air monitoring. The El Dorado County Air Management District provided ATSDR with approximately one year of sampling data for a large construction site in the county [104]. ATSDR summarized the data as shown in Figures 9 (total TEM s/cc) and 10 (PCM f/cc).

These data were used as partial support for our assumption of a 13-week "wet" period in which lower asbestos concentrations were detected, as indicated on each figure by the period where concentrations were an order of magnitude smaller.

- In Fall 2005, the El Dorado Hills Community Services District conducted air sampling at several locations in the Community Service District parks and recreational areas. The sampling was a modified activity-based method in which raking was performed around a high-volume stationary monitor. Of 15 samples analyzed with TEM, the average total structure concentration was 0.007 s/cc and the maximum 0.02 s/cc [117]. These values are similar to those reported by the local developer shown in Figure 9, and they are also similar to the "average" values for total TEM s/cc in the activity scenarios evaluated in this consultation.

- Rescue Union School District conducted NOA sampling at the site of the Promontory Point Elementary School in 2005 [118]. "Upwind" and "downwind" stationary air monitoring results were similar, with average total structure concentrations of around 0.003 s/cc and a maximum of 0.03 s/cc. These values are also similar to the construction data, community services district data, and estimates used in this health consultation.

Figure 9. Transmission Electron Microscopy Asbestos Results at a Construction Site

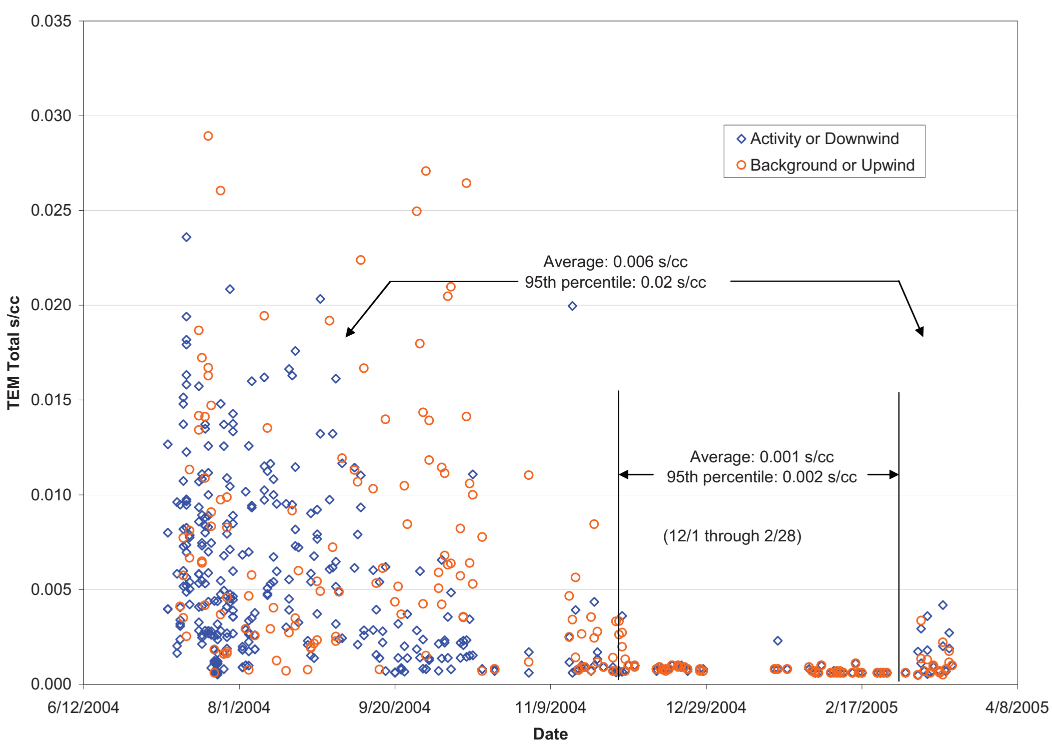
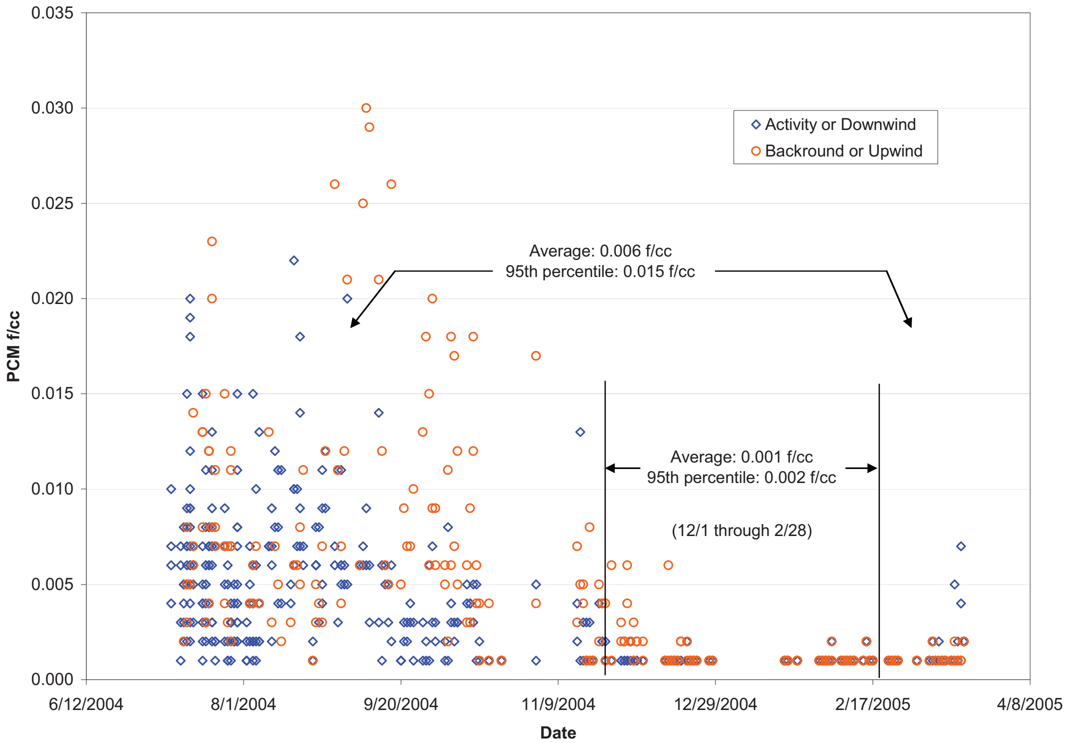


Figure 10. Phase Contrast Microscopy Asbestos Results at a Construction Site



- In response to criticisms by an interested party that there should be no concern because the particles measured in EPA's sampling do not fit the definition of commercial asbestos, the EPA requested the USGS to characterize the mineralogical nature of NOA materials present around the El Dorado Hills area. USGS characterized mineralogy and morphology of asbestos-related structures in soil samples collected by USGS in the area in Spring 2006, and compared the findings with results from analysis of activity-based sampling filters collected by the EPA in Fall 2005 [8]. Soil samples showed actinolite, magnesio-hornblende, and tremolite amphibole particles, with morphologies ranging from prismatic and acicular to asbestiform. An additional report described highly asbestiform material found in another specific El Dorado County location [109]. Regarding the particles measured by EPA during the activity-based sampling, the USGS reported that "many of the amphibole particles examined in this study meet the counting rule criteria used by USEPA from both chemical and morphological requirements. However, most of these particles do not meet the morphological definitions of commercial-grade asbestos". In other words, the EPA correctly counted asbestos particles according to accepted analytical procedures, even though the particles would not be considered asbestos per commercial definitions. The USGS cautioned, "Based on the current level of understanding in the asbestos community, it is not clear that toxicity strictly correlates with only the commercial or regulated forms of asbestos" [8]. As stated in the "Discussion of Risk Results" section on page 36, the USGS found that the particles that were the most asbestiform came from public locations where activity-based sampling was not conducted. From this, we infer that the activity-based sampling does not necessarily reflect the highest exposures possible in the community.

Taken in sum, these additional studies illustrate the potential for NOA to exist in several locations throughout the El Dorado Hills area. They also suggest that the concentrations measured in EPA's Fall 2004 activity-based sampling were typical of those that might be measured elsewhere in the local area.

Is the Situation in El Dorado County Unique?

ATSDR heard, many times, concerns from local stakeholders that they felt El Dorado Hills and El Dorado County were being "singled out" and subjected to an unfair level of scrutiny, given that NOA is present in many other areas of California and the country. They asked ATSDR to put the NOA issue in El Dorado Hills in perspective by discussing other NOA sites and the actions taken at those sites. While every site is unique in the sense that particular exposure situations and the recommended public health actions may differ, we agree that western El Dorado County is not the only place where disturbance of NOA has arisen as a public health issue. We agreed to provide information on other NOA sites to illustrate the breadth of sites and areas that have had to deal with NOA issues and give examples of how the issues were addressed.

Actions taken will be different depending on the particular sites' characteristics and the local environment. We emphasize that the conclusions for the El Dorado Hills area are based on the site-specific exposure data collected, risk estimates made from those data, and other site-specific NOA studies (used qualitatively). The following information on other sites is provided for perspective only.

- Other counties in California and elsewhere are known to have NOA deposits. Several are like El Dorado County in that they have recognized a potential problem and instituted local ordinances or community outreach efforts to prevent exposures. These include Fairfax County in northern Virginia, and Lake and Placer counties in California [119–121]. CARB conducted air monitoring in Lake and Placer Counties; results were similar to those found by CARB in El Dorado County [105]. ATSDR is not aware of other air sampling or activity-based sampling efforts in these locations that could be compared with El Dorado County.

- ATSDR is aware of other communities potentially exposed to NOA materials where activity-based sampling was performed to assess exposure.
  - In Ambler, Alaska, ATSDR measured asbestos concentrations as high as 0.05 PCMe s/cc during ATV riding on NOA-contaminated gravel roads. The road material was brought into town from a local gravel pit which was contaminated with naturally occurring chrysotile asbestos. ATSDR determined that a health hazard was presented by road dust for both asbestos and particulate exposure. ATSDR recommended immediate cessation of use of the gravel for road cover, closure of the pit, development of short-term and long-term solutions to road-generated dust, mitigation of areas where children could contact contaminated soils, and community education [122].
  - Activity-based sampling was performed by EPA at Swift Creek, Washington. The contamination washed down a creek from a remote slow landslide of chrysotile-contaminated rock; contaminated material had been periodically dredged and

stored on banks of the creek. EPA performed activity-based sampling in August 2006 during handling dredged material with heavy equipment, raking/shoveling, and recreational scenarios. Results showed that the highest PCMe concentrations were associated with handling dredged material and ranged from 0.03–0.2 s/cc. The raking and recreation scenario results ranged from nondetect–0.09 s/cc [123]. Further work to characterize the extent of the NOA contamination downstream is ongoing.

- EPA conducted activity-based sampling at Clear Creek Management Area in California This recreational area includes the largest natural deposit of chrysotile asbestos in the U.S. Results of sampling showed that intense activities like ATV riding resulted in PCMe asbestos structure concentrations as high as 2 s/cc [111]. At this time, the Bureau of Land Management (BLM) has temporarily closed the area to all public use due to the exposure potential. The closure will remain in effect while the BLM completes a resource management plan to determine if and how visitor use can occur without the associated excess health risk [124].
- Activity-based sampling has been conducted by EPA in Libby, Montana, a town contaminated with amphibole asbestos from local mining and processing operations. Limited sampling conducted in 2001 showed that outdoor activities like rototilling and indoor activities like cleaning could result in elevated concentrations of asbestos [125]. These samples were reanalyzed to achieve greater sensitivity, and additional samples were collected in 2005. Indoor cleaning activities were found to result in asbestos detections ranging from 0.0007-0.2 PCMe s/cc; indoor routine activity detections ranged from 0.00007-0.007 PCMe s/cc; and a limited number of outdoor activity samples had detections ranging from 0.03-0.2 PCMe s/cc [126]. More extensive activity-based sampling in was conducted in 2007 and 2008. The most recent findings showed indoor activities corresponded to asbestos levels ranging from nondetect to about 0.01 PCMe s/cc; outdoor activities showed a wide range of results and ranged from nondetect to more than 20 PCME s/cc [127].
- EPA conducted activity-based sampling at Sapphire Valley Gem Mine, a private mine in western North Carolina that contains amphibole (anthophyllite) asbestos along with gemstones in its rock formation. The sampling was conducted to assess the risk from asbestos exposure for occasional recreational visitors and gem collectors. Results of the sampling showed that the most intense activities, chipping at the rocks to release stones, resulted in PCMe asbestos structure concentrations as high as 0.29 s/cc. Risks were above acceptable ranges only if a person engaged in such activities regularly for many years. At the request of state health authorities, access to the mine has been restricted and limited by private actions [128].
- ATSDR and EPA conducted activity-based sampling at Illinois Beach State Park north of Chicago, Illinois, to assess risk to recreational beach users from asbestos-containing materials washing up on the shore and possibly contaminating beach sand, with possible contribution from NOA. Asbestos concentrations were below detection in most samples and very low in others. ATSDR concluded that potential asbestos exposures at the park are not expected to harm people's health [129].

Conclusions

ATSDR reached two important conclusions in this health consultation:

Conclusion 1

Breathing in naturally occurring asbestos (NOA) in the El Dorado Hills area, over a lifetime, has the potential to harm people's health.

Basis for conclusion

- Background concentrations of NOA in El Dorado Hills are higher than asbestos concentrations measured in other non-urban and most urban environments. Activities that disturb NOA could result in concentrations higher than background.
- A general sense of the increased risk of developing cancer from breathing in asbestos throughout life was obtained using several different risk assessment methods with the results of EPA's activity-based sampling in El Dorado Hills. For each method, a range of theoretical increased risks of developing cancer was estimated using different assumptions about how much and how often people breathed in NOA. Each risk method has considerable uncertainty, but the different risk methods gave similar results: the predicted increased risk of cancer ranged from too low to be of concern to a level high enough that action to prevent exposures would be warranted.
- Any one person could have markedly higher (or lower) exposures than the general estimates made in this report, depending on whether, how, and how often they encounter NOA in their daily activities.

Next steps

The following actions will reduce the likelihood for people to breathe NOA:

Increase Awareness

- El Dorado County should continue to assess the community's knowledge about the presence and associated risk of NOA and to provide information about ways to manage the risk. ATSDR can provide assistance, if requested.
- El Dorado County should implement, to the extent possible, effective ways to:
  - Maintain current records of locations known to contain NOA and
  - Notify current and prospective landowners of the possibility for NOA to exist in soil or bedrock on their property.

Limit Exposure

- State and local entities should continue to enforce applicable dust regulations throughout the community, which will reduce releases of NOA. These regulations include:
  - Prohibition of visible dust emissions outside the property line or more than 25 feet from the point of dust-disturbing activities,
  - Implementation of procedures to prevent vehicles and equipment from releasing dust or tracking soil off-site, and
  - Requirements for planning, notification, and record-keeping.
- Community members and groups should learn how to minimize their exposure to NOA while conducting their normal activities. ATSDR guidelines are included in Appendix H of this report.

Conclusion 2

Reducing exposures to NOA will protect people's health and is warranted in El Dorado County based on estimates of past exposures. State cancer registry information indicates that the community's health has not been impacted at this time. However, health impacts from past exposures may be highly variable in different individuals and may not have been seen to date.

Basis for conclusion

- The association between asbestos exposure and disease is well established. Preventing inhalation of asbestos will reduce risk of disease.
- Mesothelioma incidence, tracked by the California Cancer Registry, is not higher than expected in western El Dorado County at this time. However, mesothelioma may take decades after exposure to appear.
- Although the community in general is estimated to have an increased risk of exposure and disease, individuals' risk may vary widely due to the sporadic nature of NOA occurrences and individual behaviors leading to exposure. Individual assessment by personal health care providers for those who are concerned about past exposures will be more efficient than general community screening in treating any health effects that may appear.

Next Steps

- State authorities should continue to monitor asbestos-related cancer incidence rates in the area.
- Community members should consult with their personal medical provider about their individual health concerns arising from NOA exposure.
- ATSDR encourages further research on NOA exposures and community health by governmental, academic, and other organizations. ATSDR may refine the conclusions and recommendations of this health consultation as results of ongoing asbestos research become available.

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Glossary

Important Note: *As we have tried to convey in the text of this report, the scientific community has not reached consensus on many terms related to asbestos. We provide the following suggested definitions and information as guidelines and illustration of what we mean in this report. We anticipate that many scientists and non-scientists will not agree fully with all of our definitions – and we would caution others against using these definitions unquestioningly. However, they do illustrate ATSDR's best effort to explain technical terms in ways that are helpful to the public.*

Acicular – A description of particle shape or *morphology*, literally "needle-like." This term is used most often to describe particles that are long and thin, but may not show the flexibility typically associated with a more fibrous shape.

Actinolite – A type of asbestos in the amphibole class. Actinolite was mined and used commercially in relatively limited quantities.

Amosite – A type of asbestos in the amphibole class. Amosite, also known as "brown asbestos," is named for the **A**sbestos **M**ines **O**f **S**outh Africa which contained many of the commercial mines.

Amphibole – Amphiboles are a group of widely distributed rock-forming magnesium-iron-silicate minerals. Certain amphiboles exist in a highly fibrous form and include 5 commercial varieties of asbestos: actinolite asbestos, amosite, anthophyllite asbestos, crocidolite, and tremolite asbestos.

Anthophyllite – A type of asbestos in the amphibole class. Anthophyllite was mined and used commercially in relatively limited quantities

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Asbestiform – A description of particle shape and characteristics, referring to fibrous particles that also show characteristics such as durability/nonreactivity, high aspect ratios, high tensile strength, nonconductivity, etc. See *morphology*.

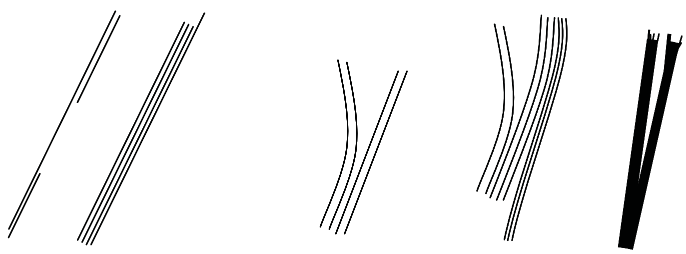
Asbestos – Asbestiform varieties of six specific minerals, historically mined for commercial use: actinolite, anthophyllite, amosite, chrysotile, crocidolite, and tremolite. It should be noted that different types of asbestos and even different samples of the same type may have notable differences in properties such as strength, flexibility, or average aspect ratio.

Asbestosis – A noncancerous disease caused by breathing in large amounts of asbestos. Asbestos fibers lodge within the lung, resulting in scar tissue formation which reduces lung elasticity and function. The disease progresses, typically slowly, and can eventually be fatal.

Asbestos-related disease – A disease that may be caused by breathing asbestos or another durable mineral particle that behaves like asbestos. Asbestos-related diseases include asbestosis, lung cancer, pleural disease, and mesothelioma.

Aspect ratio – A number describing the shape of a particle obtained by dividing the length by the width. Asbestos counting rules typically dictate a minimum aspect ratio of 3:1 or 5:1 to define a fiber; commercial asbestos has been reported to consist mostly of fibers with aspect ratios greater than or equal to 20:1.

Bundle – A type of asbestos structure counted by certain microscopic methods. The International Standards Organization defines a bundle as "a grouping composed of apparently attached parallel fibers." The aspect ratio of the bundle may have any value, as long as the individual fibers making it up have aspect ratios equal to or greater than 3:1 or 5:1, as defined by the particular method used.

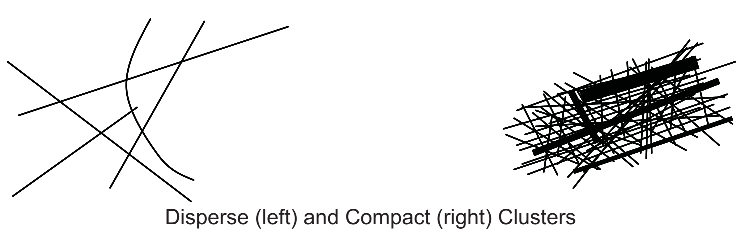


Bundles

Chrysotile – A type of asbestos, the only type in the serpentine class. Chrysotile, also known as "white asbestos," was and remains the major type of asbestos used commercially.

Cleavage fragment – A piece of mineral broken off of a larger chunk, usually along a line of weaker bonds known as a "cleavage plane". A cleavage fragment may have the same *elemental composition* as an asbestos fiber but has a different *crystal structure*. A group of cleavage fragments are generally shorter and thicker than a group of asbestos fibers, but identifying any single structure as fiber or cleavage fragment can be difficult because some cleavage fragments meet size and shape definitions for fibers.

Cluster – A type of asbestos structure counted by certain microscopic methods. The International Standards Organization defines a cluster as "an aggregate of two or more randomly oriented fibers, with or without bundles." Clusters can be disperse, such that individual fibers or bundles can be identified and measured, or compact, where dimensions of individual fibers and bundles cannot be unambiguously determined.



Disperse (left) and Compact (right) Clusters

Crocidolite – A type of asbestos in the amphibole class. Crocidolite, also known as "blue asbestos" was commercially mined and used in many products including gas masks and cigarette filters.

Crystal – A homogeneous, three-dimensional solid formed by specific repeating atoms or molecules, with smooth external faces.

Crystal structure – The particular pattern of distances and angles between constituent units in a crystal, which can uniquely identify the crystal.

Cubic Centimeter (cc) – a unit of volume represented by a cube 1 centimeter long on each side, equivalent to a milliliter. The cc has been used for describing asbestos concentrations in the United States for many years. A cc is a small volume, less than ¼ teaspoon (see picture below). A stack of 3 dimes has a volume of about 1 cc, and a normal bottle of wine contains 750 ccs.

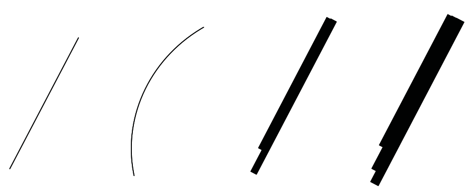
A stack of three dimes has a volume of about 1 cc.

Electron microscopy – A way to visualize very small things by examining interaction of the item with an electron beam. Allows very high magnifications – to the atomic scale.

Elemental composition – Identification of a mineral's chemical makeup, as opposed to its physical characteristics [see *morphology*].

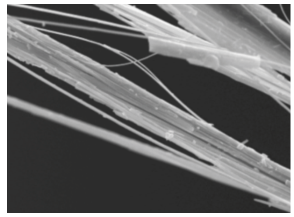
Fiber per cubic centimeter (f/cc) – Measurement of asbestos fiber concentration in air. The f/cc units are typically reported for phase contrast microscopy results, and include all particles that meet dimensional criteria for fibers as defined by the method. [see also *s/cc*]

Fiber – In general, fiber refers to any long, thin, and thread-like particle. Asbestos includes many fibers. In microscopic methods for measuring asbestos, fiber refers to a particle meeting dimensional criteria set by the method for counting fibers. The criteria typically include parallel or stepped sides, a minimum *aspect ratio* (3:1 or 5:1) and, in some cases, specific length and/or width requirements.



Fibers

Fibril – A very thin fiber which often can make up a larger fiber, like individual nylon threads that make up a rope.



Electron micrograph showing fibrils of asbestos making up larger fiber/bundle.

Fibrotic disease – Refers to respiratory disease resulting from buildup of fibers in the lungs, which can lead to scarring and other lung problems.

Fibrous – A description of particle shape, referring to long, thin, thread-like shapes. See *morphology*.

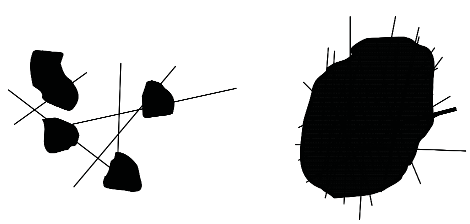
Latency – The time lag between a disease-inducing event and the development of the disease itself. Asbestos diseases have long latency – symptoms of disease may not appear until many years after the exposure.

Lung cancer – A disease where the epithelial cells lining the lung grow out of control. They may invade surrounding tissues or move (metastasize) to cause cancer in other tissues in the body. Breathing in asbestos is one of many potential causes of lung cancer.

Macroscopic – Able to be seen with the naked eye.

Massive – Refers to minerals that have the same crystal structure and physical properties in all directions, that is, they don't have a platy, fibrous, or other structure that varies directionally.

Matrix – A type of asbestos structure counted by certain microscopic methods. The International Standards Organization defines a matrix as a structure in which one or more fibers or fiber bundles are attached to, or partially concealed by, a single particle or group of overlapping nonfibrous particles. Special rules apply for counting matrices and depend on whether the matrix is disperse (where at least one individual fiber can be discerned and measured) or compact (where individual fibers cannot be measured).



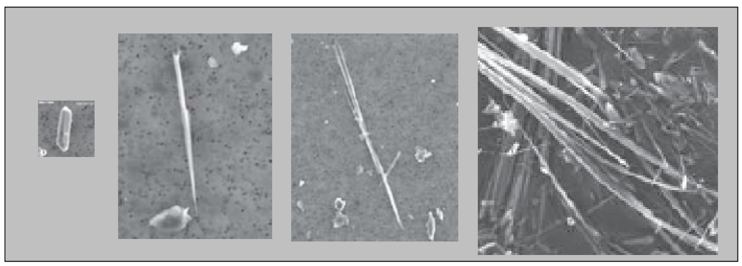
Disperse (left) and Compact (right) Matrices

Mesothelioma – A cancer of the mesothelium, the membrane surrounding internal organs like the lung (pleural mesothelium), digestive organs (peritoneal mesothelium), or heart (cardial mesothelium). Mesothelioma is a very rare cancer, but in almost all cases is associated with exposure to asbestos or a similar durable mineral fiber.

Micrometer (or micron, µm) – A unit of length measuring one one-millionth of a meter, or about the size of a bacteria. The smallest line a human eye can see is about 30 µm – ¼ to ½ the width of a typical human hair.

Microscopic – Too small to be seen with the naked eye. Requiring a microscope to see.

Morphology – In contrast to *elemental composition*, identification of a mineral by its size, shape, and *crystal structure* (e.g., physical characteristics).



Electron Micrographs from the US Geological Survey illustrating particle morphologies, from left to right, prismatic, acicular, fibrous, and asbestiform. The images were manipulated to put them on the same scale.

Million particles per cubic foot (mppcf) – A measure of particle concentration in air. Early dust measurements in the asbestos industry were collected using an apparatus called a midget impinger, whose results were in units of mppcf.

Nonfibrous – Referring to particles that do not exhibit the long, thin, thread-like shape associated with fibrous particles; can include *acicular* and *prismatic* particles.

Optical microscopy – A way to visualize very small things using light with magnifying lenses. Limited in resolution to about 0.25 µm.

Pleural changes –Abnormalities observed in the pleural mesothelium, the membrane lining the chest cavity and covering the outside of the lungs. Pleural changes can include areas of pleural thickening, calcification (plaques), or pleural effusions (accumulation of liquid in the pleural space). Pleural changes resulting from asbestos exposure are typically observed bilaterally (on both sides of the chest) and may or may not result in a loss of lung function.

Polymer – A substance made up of smaller, repeating molecules.

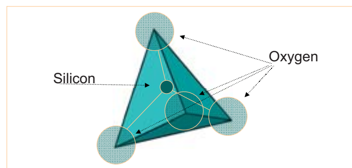
Prismatic – A description of particle shape and characteristics, referring to blocky particles with relatively low aspect ratios, similar to crystal forms which have faces parallel to the vertical axis. See *morphology*.

Progressive disease – A disease that gradually gets worse over time.

Structures per cubic centimeter (s/cc) - Measurement of asbestos concentration, referring to number of asbestos structures per cubic centimeter of air. This measurement is typically used for electron microscopic methods and includes the count of asbestos *fibers* as well as asbestos *bundles*, *clusters*, and *matrices* as defined by the method. [see also *f/cc*]

Serpentine – A type of rock originally formed from high-magnesium source rocks [see *ultramafic*]. Serpentine can exist in a highly fibrous form, chrysotile asbestos.

Silica tetrahedron – The molecular “backbone” of asbestos, consisting of the elements silicon and oxygen bonded in the shape of a tetrahedron (a pyramid-like structure formed by 4 triangles).



Silica tetrahedron

Silicate – A mineral containing a silicate molecule, containing the elements silicon and oxygen, as its major “backbone” material. Silicates form the largest class of rock-forming minerals. Examples of silicate minerals include talc, quartz, emerald, and asbestos.

Structure – A microscopic term including asbestos *fibers* and associated particles such as *bundles*, *clusters*, and *matrices* as defined by the analytical method used.

Tremolite asbestos – A type of asbestos in the amphibole class. Tremolite asbestos was rarely mined commercially, but is often a contaminant in chrysotile asbestos, vermiculite, or other mined products.

Ultramafic – A type of igneous rock (formed by cooling of lava) containing high levels of magnesium and iron. Under certain conditions, ultramafic rocks can be changed (metamorphized) into rocks that may host asbestos. This process takes millions of years.

Appendix A. Peer Review Comments and Responses

Many issues in asbestos science today are debated among scientists. ATSDR requested a draft of this public health consultation be "peer reviewed" to ensure that the evaluation performed in the document was done using the best science given the nature of the available information. The public health consultation was peer reviewed by three asbestos science experts who have no affiliation with ATSDR and are listed below. This appendix contains the questions posed to the peer reviewers, their comments (verbatim), and ATSDR's responses to the comments. The comments from peer reviewers are labeled #1, #2, and #3 but these numbers do not necessarily correspond to the order the reviewers are listed below.

Peer reviewers:

Robert (Bob) French
Professional Engineer
EHS-Alaska

Paul J. Lioy
Professor of Environmental and Community Medicine
Rutgers University, Robert Wood Johnson Medical School

Morton Lippmann
Professor of Environmental Medicine
New York University School of Medicine

1. Does the health consultation provide adequate background information for the lay public to understand the potential for concern about community exposures to naturally occurring asbestos in the El Dorado Hills area?

[Comments from Reviewer #1]:

Yes.

[Comments from Reviewer #2]:

Yes, the outline and the format of the evaluation provide a good background for the issue at hand. The summary of the various risk assessment tools used are confusing and do not provide enough information to help convey the meaning of the results to the community.

I think you need to break down the issue into what does a 1/10,000 or 1/1000 risk mean to a community of the size of El Dorado Hills with a population of 35,000 that cuts across a wide range of ages and time spent living in the community. There also should be a statement that none of these methods are without uncertainties and the results are used for guidance and not the prediction of actual number of cases of Asbestos related disease.

[Comments from Reviewer #3]:

I feel that some terms and background information should have additional explanations. For example, on Pg 7, there could be a discussion of what disease latency is, and typical latency periods for various asbestos related diseases, as latency is brought up on Pg 8 without an explanation of what it means.

Many lay persons do not have an intuitive feel for the tiny sizes involved in microscopic particles, and metric units, therefore on Pg 9, a discussion of micrometers, cc's, structures versus fibers, fiber morphology etc. would be helpful. On page 11, technical terms such as "cleavage fragments", "acicular", "massive" (perhaps blocky is a better term), "asbestiform", "nonfibrous", could use additional descriptions, perhaps examples could be illustrated with the TEM photographs from the USGS report OF06-1362.

A discussion of how past worker exposures (that are the basis of epidemiological data) may be at least an order of magnitude higher than the potential community exposures, and the difficulties and uncertainties of extrapolating past exposure data would also be useful. See related comments in item 2 below. While the consultation does qualitatively discuss this ("much less", "well below"), examples of actual exposure data would help the public understand the relative exposures, and give a perspective on the relative risks.

Q#1 – Response from ATSDR: *ATSDR has responded to the peer reviewers' concerns by making the following additions to the health consultation:*

- *Figure 4 was added to illustrate typical asbestos exposure concentrations, workplace standards and background concentrations in a visual, semi-quantitative form. This figure is later re-introduced and modified as Figure 7, showing where the asbestos concentrations estimated for El Dorado Hills fall.*
- *The addition of a glossary (on page 66, following the references) to give further explanation for technical terms and measurements used in the document.*
- *Addition of section describing general concepts of risk on page 18, before the introduction of asbestos risk assessment methods. The comparisons of risk previously found at the end of the text has been revamped and moved forward into this section as well.*

We hope these additions improve the readability and clarity of the technical information we want to convey to the public.

2. Does the health consultation clearly describe the purpose for applying various risk assessment methods to estimated community exposures? Does the text maintain objectivity when describing differences between current and proposed risk assessment methods?

[Comments from Reviewer #1]:

Yes.

[Comments from Reviewer #2]:

This is a rather confusing statement. I assumed you were completing risk calculations based upon the same exposure information. Again this leads to my above concern that there is a need for more clarity in presentation of the risk assessments for the community. The largest uncertainties were associated with the form and the size of the fibers being used as the basis for the inherent toxicity of the particles

The text is objective in its view of the methods, but leaves the reader without an anchor to begin understanding the reasons for using all these methods.

[Comments from Reviewer #3]:

The text seems to treat the various methods objectively, but I feel that there could be more discussion in the background section regarding why there are so many models being used, and some of the complexities, and current work being done to try to clarify the "holes" in the existing data. For example, Pg 24 states that the historical epidemiological studies "have a great deal of uncertainty associated with them", but the reasons for those uncertainties are barely discussed. While the fact that exposure to asbestos causes disease is well known to the public, the discussions on how different size and shape fibers may contribute to diseases is not well known, and can be quite confusing. A brief discussion at the beginning of the "Defining 'Asbestos'" portion on Pg 9 would be useful to help clarify the data that follows. That could include the different ways that different analysis methods count "fibers", "structures" or "particles" and how refinements of both sampling and analysis techniques have influenced the evolving information about how potency may be related to fiber size and shape. How both sampling and analysis techniques as well as latency affects interpretations of exposure data and potential health effects could use additional discussion. Discussions of the limitations and differences between impinger data, PCM, TEM, and ISO and uncertainties about older worker exposure data versus epidemiological data and how new analysis techniques are being used to re-analyze older archived filters in an attempt to correlate past exposures, fiber size distributions and mortality could help the public understand why all of these different models are being examined. While the data about differences between analysis methods is presented, short summary statements (such as "TEM analysis can distinguish much smaller fibers and counts fibers about 1/10th the size of what are counted by PCM", or "the ISO 10312 method tries to bridge the limits of other analysis methods and provides multiple results related to fiber size, length and slenderness ratios"), can help to clarify why there are controversies regarding fiber-size specific risks.

Discussion of fiber morphology differences and past exposure data and epidemiological data from mining versus other asbestos trades, and a comparison with the fiber morphology from the NOA at El Dorado could help the public understand how their potential exposures compare to that of "classic" asbestos exposures, as well as NOA exposures in different locations around the world.

Perhaps the "Summary – Asbestos Risk Methods" on page 18 could be moved to the beginning of the section, as a kind of preamble.

Q#2 – Response from ATSDR: *The peer reviewers' comments made clear to us that we needed to expand the basic explanation of risk and what it means. We added an expanded and simplified discussion of general concepts of risk on page 18, before the introduction of risk assessment methods.*

We have also added additional explanation of why ATSDR applied different risk assessment methods to the same exposure data on pages 21 and 27. All asbestos risk methods have been questioned and criticized, and we wanted to see the range of risks that were predicted with various methods, each of which have their strengths and weaknesses. Each risk method may have different dimensional definitions for a fiber that counts towards exposure and that is why different numerical concentrations can come from the same exposure data.

Some suggestions by the reviewers, such as comparing fiber morphology differences between different types of exposure, are impossible. There are simply not enough data available to describe the fiber morphology and size distributions of historical worker exposures, epidemiological studies, and environmental exposures in other locations around the world. We have discussed this limitation in the document on page 16.

3. Does the health consultation clearly and adequately describe the uncertainties associated with estimating community exposures and applying any type of risk assessment method to determine risk of disease?

[Comments from Reviewer #1]:

Yes.

[Comments from Reviewer #2]:

Marginally. The Limitations are not stated in clear language, and should be for the community. One major point is that that all the risk calculations only provide estimates of the lifetime population risk. Further, I do not see where the values obtained from the risk calculations are much different from method to method. Considering the overall uncertainty of each risk assessment method used by the ATSDR, the coherence in the results needs further discussion and emphasis.

[Comments from Reviewer #3]:

In general I feel that the uncertainties involved in estimating community exposures were well explained. A statement such as "just as not every smoker develops lung cancer, not everyone who is exposed to asbestos will have the same likelihood of developing an asbestos related disease" could help the public understand that there are also uncertainties in individual responses to exposure to NOA.

I felt that the section on Risk could have used a brief discussion of the basics about risk statistics, such as what a risk of 0.004 out of 10,000 means, and how to convert that data to whole numbers. Also, the Death Rates per 100,000 in Table 5 *[Data revised and table renamed Table 1 in revised report]* are not directly comparable to the risks in Table 3 *[Table 4 in revised report]*.

I feel it would be useful to include mortality rates for smoking (1 pack, 3 packs) a day in Table 5 *[Data revised and table renamed Table 1 in revised report]*.

Q#3 – Response from ATSDR: *We discuss uncertainties of the various risk methods beginning on page 34. In agreement with reviewer #2, we were also surprised to find that the predicted risks were not vastly different between risk methods using such different assumptions. We* *hypothesize that this result might reflect the large uncertainties present in the historical epidemiological data upon which all the risk methods are ultimately based.*

To improve our explanation of risk, we added an expanded and simplified discussion of the purpose and meaning of risk assessment immediately before the introduction of risk assessment methods.

The mortality data used to create the former Table 5 did not contain deaths due to smoking, but merely reported the immediate cause of death (e.g., lung cancer, vehicular accident, etc.) Smoking is known to be a cause or contributing factor in many different diseases, including several types of cancer, heart disease, aneurysms, bronchitis, emphysema, and stroke. While we have seen unreferenced statements that smoking may be associated with a lifetime risk of dying of a smoking-related disease of 1 in 2, or 0.5, finding the original data and references and confirming these statements are beyond the scope of this health consultation.

Because the annual mortality rates in the original Table 5 were difficult to compare with risk estimates, we changed the focus of the table to lifetime risks for various occurrences and used different data sources. We moved the table up to the general risk section added in response to reviewer comments and it became Table 1.

4. In addition to the evaluation of EPA activity-based sampling data, the health consultation presents a discussion of additional investigations/findings related to asbestos in the El Dorado Hills area. Does this discussion improve confidence in conclusions that would otherwise be based solely on theoretical risk assessment?

[Comments from Reviewer #1]:

Yes.

[Comments from Reviewer #2]:

From the point of view of a community member. No. The language is very unclear. I understand because of my background and training. Further, does the community really need to know the details of the aspect ratios and other assumptions used by each method? These would be better presented in an appendix.

The data from other locations seems irrelevant in light of the fact that you have collected all the local data. It is unfortunate that you have spent more time on this aspect of the analysis rather than dealing effectively with other activity scenarios, and providing estimates of uncertainty caused by not completing other sampling scenarios outlined by the community.

[Comments from Reviewer #3]:

Inclusion of data from other sources and investigations does improve confidence, as otherwise the public may feel that other data is being suppressed or ignored. The variability of the range of potential exposures may provide a good opportunity to emphasize that simple precautions to keep down dust generation, such as wetting, may allow a hundred or thousand fold reduction in airborne concentrations. This may encourage citizens to take such precautions, and encourages awareness that their personal actions do have a large effect on their potential exposure to asbestos.

Q#4 – Response from ATSDR: *Thank you for your comments. We had heard that some felt the activity-based sampling may not be completely representative of exposures throughout El Dorado Hills, so we felt that including findings from all the studies done in and around El Dorado Hills would build confidence, especially since the findings were generally consistent. We have added additional language explaining the purpose of including this data on page 42.*

Yes, we feel the community member does really need to know at least some of the details of aspect ratios and assumptions of the various risk methods, if they want to critically judge some of the statements that have been made in the community. For example, although the Berman and Crump risk method assigns a much greater potency to amphibole fibers than the IRIS method, only a tiny fraction of the fibers counted by the IRIS method are long and thin enough to count in the Berman and Crump method—so that, in this case, the predicted risk is not very different.

5. Does the discussion of other naturally occurring asbestos sites/areas in the United States provide an adequate basis for comparing public health responses in similar situations?

[Comments from Reviewer #1]:

No. It helps, but only partially. Public health responses are so dependent on fiber type, fiber length, and variations in exposure based on lifestyle activities and air exchange rates that extrapolations to other sites/areas would be highly uncertain.

[Comments from Reviewer #2]:

No, it just provides more information. Each situation is different, what should be paramount is a presentation that focuses critically on the situation at hand.

What is surprising is the lack of a question on the exposure assessment. In contrast to many previous studies of this type there were actual activity based sampling and analyses. This is an important set of data, and has far more relevance than comparisons with other locations. What disappoints me is that the idea had to come at the request of the community member, kudos to Him or Her; and not from the ATSDR. The data are an excellent example of what should be done at all waste site health investigations, and should be a more prominent part of the conclusions as to why a health study is not necessary.

Further, there are some legitimate concerns about some of the scenarios. The most obvious is the limited amount of time toddlers and children less than 5 years of age spend in dirt. So children just play in the dirt and dig. The “activities” concerns of the community should be revisited once more by the ATSDR before the report is issued.

This study is actually a model of the types of exposure data that should be routinely collected in health consultations. It would reduce uncertainties and give more strength to conclusion.

[Comments from Reviewer #3]:

The 2/3 of a page of discussion on Pg 33 about what the actual public health responses have been in other communities could have been expanded, as there were little details provided. The range of potential exposures found during activity based sampling have a similar range to those found in El Dorado County, but the responses are varied. Further discussion could help explain why there were different responses or no responses given for some sites.

Q#5 – Response from ATSDR: *Thank you for your comments. We have added additional discussion of why we added this section on other NOA sites on page 48. This was done to respond to several community concerns that El Dorado Hills was being "singled out"; various community members and stakeholders requested ATSDR to compare what happened at El Dorado Hills with other NOA sites in California and the U.S. We agree that the responses taken at NOA sites will always be site-specific, but learning about experiences and actions taken at other sites helps provide context for the community.*

6. Are the conclusions and recommendations appropriate in view of the potential community asbestos exposures as described in the health consultation?

[Comments from Reviewer #1]:

Yes. The many uncertainties resulting from the quite sparse databases that are relied upon are appropriately caveated, and the conclusions drawn, and the recommendations made are very reasonable for public health guidance.

[Comments from Reviewer #2]:

Yes the conclusions appear appropriate, but not adequately summarized in light of the extensive exposure data. For example if some manager just read the conclusion about the lack of a need for a health study, he or she: 1. would have no idea that the risk assessment is based upon actual exposure sampling data (using activity based sampling), and 2. The number of projected people that may contract asbestos related disease based upon a population of 35,000 (across a wide age range) using range of risk (from all estimation procedures) calculated for the local situation. All of the information is vaguely presented, and considering the good ideas provided to improve the exposure assessment the community be provided a more quantitative summary supporting the ultimate conclusions. I would still agree with the conclusions.

[Comments from Reviewer #3]:

Yes, based on the range of exposures found, the relatively new age of the community, population mobility, and the lack of epidemiological data showing otherwise, the conclusions and recommendations appear to be appropriate. The indications that air monitoring and epidemiological studies will continue, as well as proposed informational campaigns, is important, and should provide further opportunities for community outreach and lessening of potential exposures.

Q#6 – Response from ATSDR: *Thank you for your comments. We have included additional text in the conclusions summary to emphasize that the risk calculations used site specific, activity-based sampling from El Dorado Hills. However, our risk results do not support any prediction of the actual number of people who might become sick from exposure in this community because of* *the wide range of predicted risks and the uncertainties associated with the risk methods used. We hope that the additional discussion of risk that was added in response to prior comments will help clarify that our intention in calculating theoretical risk was only to gain a general idea of potential risk ranges to direct us towards reasonable public health responses.*

7. Are there any other comments about the health consultation that you would like to make?

[Comments from Reviewer #1]:

I commend the authors for the preparation of this quite thorough and informative review, and for coming up with very reasonable conclusions and recommendations. I also want to commend ATSDR for going well beyond normal health agency practice in commissioning the additional TEM analyses of the EPA personal sampling filters. This added a new dimension to the validity of the risk assessment.

[Comments from Reviewer #2]:

None

[Comments from Reviewer #3]:

Hopefully, taking appropriate dust control measures will be incorporated into various municipal policies, but probably equally important will be having the public turn those same dust control measures into nearly unconscious habits. Greater emphasis could be placed on opportunities for education about the fact that the differences between a high exposure to asbestos and a low or negligible exposure will not be perceptible, and that it is through individual personal habit changes that people can influence their own future health. There is a balance that needs to be found, so that the public sees this kind of information as empowering themselves to make healthy changes, rather than being seen as “the Government” attempting to shift responsibility, and saying people’s health is entirely influenced by their own choices.

Q#7 – Response from ATSDR: *Thank you for your comments. These points will be important for environmental and health agencies to consider as they respond to an increasing number of concerns about NOA issues.*

ADDITIONAL QUESTIONS:

A1. Are there any comments on ATSDR's peer review process?

[Comments from Reviewer #1]:

It is well considered and appropriate.

[Comments from Reviewer #2]:

None

[Comments from Reviewer #3]:

I appreciate the opportunity to contribute to this important discussion and process.

Q#A1 – Response from ATSDR: *Thank you for your comments.*

A2. Are there any other comments?

[Comments from Reviewer #1]:
No.

[Comments from Reviewer #2]:
None

[Comments from Reviewer #3]:
I would suggest not using scientific notation where possible. It was mostly well done in the main body of the consultation, but less so in the Appendices. For example, the fiber concentration data given in Tables F1, and F2 in Appendix F could easily be changed to decimal notation, and be more consistent with other parts of the consultation.

The lists of "What can you do to reduce your exposure to asbestos" found in the Fact Sheets in Appendix G, are important, and should be repeated in the consultation. Those lists could also be augmented, as there are slight differences between the ATSDR fact sheet for Workers, vs. Residents, and between those fact sheets and the Washington State Department of Health fact sheet for the Sumas River. I'd suggest including discussions about not using leaf blowers, bathing pets, keeping car windows closed, keeping dirt and dust out of cars, and potentially installing HEPA filtration in air conditioning units in these recommendations.

Q#A2 – Response from ATSDR: *Thank you for your comments. We have changed the Table notation to decimal notation (note that Table and Figure numbers have changed from the peer review draft to the final draft). In addition, we have summarized recommendations for minimizing exposures to NOA in the body of the consultation in Figure 6.*

Appendix B. Assumptions and Sources for Asbestos Exposure Estimates in Figures 4 and 7

Note: All units are in PCM f/cc unless otherwise noted.

Estimated Worker Exposure Concentrations

- High Concentrations Before Dust Control — Value: 100 f/cc
- Typical Exposure 1960s and early 1970s — Value: 10 f/cc

Sources/ Assumptions:

- Armstrong *et al.*[1] reported that at the Wittenoom mine in Australia, particle measurements collected from 1948-1958 "frequently exceeded" 1,000 particles per cubic centimeter, and that the mill was often shut down prior to testing, which would presumably lower the measured concentrations. [ATSDR used factors of 1 ppcc per 0.028 mppcf and 1 mppcf per 3 f/cc to convert 1,000 ppcc to approximately 84 f/cc.] Armstrong *et al.*[1] also reported results from a 1966 study of a new mill at Wittenoom in which the highest area (the bagging area) exhibited 100 fibers longer than 5 µm per cc.
- Dement *et al*[2]. reported industrial hygiene data collected between 1930-1940 in a South Carolina textile mill using mainly chrysotile asbestos. Averages ranged from around 10-78 f/cc with upper confidence intervals as high as 117 f/cc. High values were reduced down to about 20 as process controls were instituted in the late 1960s and 1970s.
- The National Asbestos Exposure Review Summary Report[3] presented aggregated personal and area sampling data for 17 exfoliation sites during 1972–1992. Measured PCM fiber concentrations inside the exfoliation facilities ranged from below detection levels to 139 f/cc. Before 1980, measured PCM fiber concentrations were typically in the range of 1 f/cc to 10 f/cc.

Occupational Limits[4]

- 1971 OSHA Permissible Exposure Limit — Value: 12 f/cc
- Present OSHA 30-Minute Excursion Limit — Value: 1 f/cc
- 1994-present OSHA Permissible Exposure Limit — Value: 0.1 f/cc

"Environmental" Exposure Concentrations

- During disturbance of locally used asbestos-containing substances — Range: 1.8-25 f/cc
- Inside house whitewashed with asbestos material — Range: 0.01-0.04 f/cc
- Background in village containing asbestos-covered houses — Value: 0.0004 f/cc

[1] Armstrong BK, De Klerk NH, Musk AW, Hobbs MST. Mortality in miners and millers of crocidolite in Western Australia. Br J Ind Med 1988; 45:5-13.
[2] Dement JM, Harris RL, Symons MJ, Shy CM. Exposures and mortality among chrysotile asbestos workers. Part I: exposure estimates. Am J Ind Med 1983;4:399-419.
[3] ATSDR. Summary report, exposure to asbestos-containing vermiculite from Libby, Montana at 28 processing sites in the United States. Atlanta: Department of Health and Human Services. October 2008.
[4] OSHA (Occupational Safety and Health Administration). 1994. Introduction to 29 CFR Parts 1910, 1915, 1926, occupational exposure to asbestos. Federal Register 1994 August 10;59:40964-41162.

Sources/ Assumptions:

- Luce *et al.*[5,6] measured asbestos concentrations in air for various scenarios in New Caledonian villages where local asbestos deposits were historically used for whitewash. The authors reported concentrations of fibers greater than 5 μm long as geometric mean values. During cleaning activities, separate studies measured 1.8 f/cc up to 78 f/cc. In an undisturbed whitewashed house, the concentration was 0.04 f/cc. Background in the village was reported as 0.0004 f/cc.
- Sichlitidis et al.[7] reported asbestos concentrations in a room painted with asbestos containing whitewash and in the yard of an abandoned whitewashed house of 0.01 f/cc. After mild scraping of a whitewashed wall, they measured an asbestos concentration of 17.9 f/cc.
- Luo et al.[8] reported asbestos concentrations in a "crusher" room where stoves containing crocidolite "blue clay" asbestos were made. Average concentration was 6.6 f/cc and peak concentrations were 25 f/cc.

"Background" Concentrations[9]

- Near local sources — Value: 0.003 f/cc
- Typical urban air — Value: 0.00015 f/cc*
- Ambient outdoor air, remote from source — Value: 0.000000167 f/cc**

*Midpoint of range reported, from 0.000003 to 0.0003 f/cc
**Midpoint of range reported, from 0.00000003 to 0.0000003 f/cc

El Dorado Hills Concentrations[10]

- Maximum concentrations for specific scenarios — Range: 0.00008 to 0.08 f/cc
- Estimates of annual average exposure — Range: 0.0006 to 0.0055 f/cc

[5] Luce D, Billon-Galland MA, Bugel I, Goldberg P, Salomon C., Fevotte J, Goldberg M. Assessment of environmental and domestic exposure to tremolite in New Caledonia. Arch Env Health 2004; 59(2):91-100.
[6] Luce D,Brochard P, Quenel P, Salomon-Nekiriai C, Goldberg P, Billon-Galland MA, Goldberg M. Malignant pleural mesothelioma associated with exposure to tremolite. The Lancet 1994; 344:1777.
[7] Sichletidis L, Daskalopoulou E, Chloros D, Vlachogiannis E, Vamvalis C. Pleural plaques in a rural population in central Macedonia, Greece. Med Lav 1992; 83(3):259-265.
[8] LuoS, Liu X, Mu S, Tsai SP, Wen CP. Asbestos related diseases from environmental exposure to crocidolite in Da-yao, China. I. Review of exposure and epidemiological data. Occup Environ Med 2003; 60:35-42.
[9] Agency for Toxic Substances and Disease Registry. Toxicological profile for asbestos (update). Atlanta: U.S. Department of Health and Human Services; September 2001.
[10] Tables G1 and G2 of Appendix G of this document.

Appendix C. Models of Exposure and Life Table Analysis

Mathematical Models of Exposure Response

Methods Based on EPA 1986

The following equations are used in the EPA 1986 and Berman and Crump method. Also, they serve as the base equations for estimating unit inhalation risks such as used in the IRIS method and the Cal-EPA methods.

For lung cancer (LC), which is a relatively common cancer with multiple causes, it is assumed that there is a baseline risk in the absence of asbestos exposure. The risk of developing lung cancer upon exposure to asbestos is assumed to be proportional to the cumulative asbestos exposure (intensity of exposure times duration) and the underlying baseline risk. To account for the observed latency period, the exposures are assumed to have no effect on risk until a lag period of ten years has passed. Mathematically, this is expressed as:

$$\text{LC risk with asbestos exposure} = \text{LC baseline risk with no exposure} \times [1 + K_L \times CE10],$$

$$\text{Excess LC risk with asbestos exposure} = \text{LC baseline risk with no exposure} \times [K_L \times CE10],$$

Where K_L is the lung cancer potency factor and CE10 is the cumulative exposure (expressed in units of concentration-years) lagged by 10 years.

For mesothelioma, it is assumed that the incidence is zero in the absence of asbestos exposure. In the presence of asbestos exposure, risk increases as a nonlinear function of the exposure concentration, the duration of exposure, and the time since first exposure, as follows:

$$\text{Mesothelioma risk} = 3 \times K_M \times \int_0^{t-10} E(u) \times (t - u - 10)^2 \, du,$$

Where K_M is the mesothelioma potency factor, E(u) is the exposure as a function of time, t is the time from onset of exposure, and u represents incremental time units over the duration of exposure (the coefficient 3 is included to simplify the integrated equation). When E(u) is constant (E_c) over an exposure duration d, this integral can be solved to obtain the following:

Mesothelioma risk	$= 0$	$0 < t < 10$
	$= K_M \times E_c \times (t - 10)^3$	$10 < t < 10 + d$
	$= K_M \times E_c \times (t - 10)^3 - (t - 10 - d)^3$	$t > d + 10$

In this consultation, changing exposures throughout life were addressed with the above equation by calculating risk separately for each year's average, continuous exposure and summing the total risk.

Hodgson and Darnton Method, 2000

The Hodgson and Darnton model is based upon an examination of 17 asbestos exposed cohorts for which exposure data exist. Three of the cohorts have been split into 2 sub-cohorts as the original study showed differing exposures or outcomes based upon fiber type or sex. The study focus on developing risk models for the three most prevalent asbestos minerals in commercial use, chrysotile, amosite, and crocidolite. For mesothelioma risk estimates of the various minerals, crocidolite, amosite, and chrysotile were shown to vary on the order of 0.5, 0.1 and 0.001 (% per fiber/ml-year). The results for lung cancer were complicated by the large differences seen in the Quebec and Carolina cohorts and ranged from 0.03 to 6.7 (% per fiber/ml-year). The amphibole data are more consistent with mean risk for all amphibole cohorts of 4.8% per f/ml-yr.

The Hodgson and Darnton method deviates significantly from the other methods presented here in that the other methods use the cautious default assumption that risk is proportional to dose. Hodgson and Darnton suggest that the present data support a non-linear exposure response. However, they conclude that only peritoneal mesothelioma can be statistically shown to be non-linear, and a linear relationship remains arguable for pleural and lung tumors.

Hodgson and Darnton suggest the following model best predicts the non-linear relationship of asbestos exposures to combined pleural and peritoneal mesothelioma,

$$P_M = A_{pl}X^r + A_{pr}X^t$$

where P_M is the percent excess mortality, r and t are the pleural and peritoneal slopes of the exposure response on a log–log scale, A_{pl} and A_{pr} are constants of proportionality for the pleural and peritoneal elements of the risk respectively, and X is cumulative exposure in f/ml-yr.

Using the best estimates for the model parameters P_M can be calculated for the various minerals using the following table.

Slope/Fibre	*Apl*	95% Confidence Interval	*Apr*	95% CI
Best estimate slope (r=0.75, t=2.1)				
Crocidolite	**0.94a**	(0.71,1.2)	0.0022	(0.0011,0.0039)
Amosite	**0.13b**	(0.060,0.25)	0.0006	(0.00025,0.0012)
Chrysotile	**0.0047a**	(0.0030,0.0069)		

The model for non-linear lung cancer is;

$$P_L = A_L X^r$$

Best estimates of lung cancer model parameters yield the following,

Fiber/model	AL	95% CI
Amphibole		
Best (r=1.3)	1.6	(1.2, 1.9)
Chrysotile		
Best (r=1.3)	0.028	

The Hodgson and Darnton method offers a unique look at risk from asbestos exposure because it departs from the risk models used in almost all other risk assessment methods [89,37,91,93,94]. It also includes some important studies (South Africa) not used in other methods. However, it should be pointed out that the calculated P_M assumes exposure begins at age 30 for a duration of 5 years and absolute mortality is calculated for ages 40 – 80 (10 year latency). The method currently does not address early life exposures (although a correction can be made for exposure starting as low as 20 years of age), nor does it address very long exposures. Consecutive 5 year periods can be added together to get a total risk but due to life-table differences this total risk is not completely accurate. In addition, as in all the methods presented in this document, the predictions for community exposure in El Dorado Hills are made for exposure concentrations well below the range of those observed in the occupational studies evaluated in the method.

Life Table Analysis

Many of the risk calculations performed in this health consultation were based on "life table analysis," a method to account for discontinuous exposures and age in estimating risk of developing asbestos-related disease. Specifically, the additional risk of lung cancer (LC) and the risk of mesothelioma (meso) are addressed with this analysis. Life table analysis applies the basic mathematical equations described in the section "Methods Based on EPA 1986" on a year-by-year basis with changing exposure and mortality information, to obtain a realistic estimate of increased risk associated with asbestos exposures. The "life table analysis" procedure used in this health consultation was developed in accord with the methods and techniques reported by Nicholson and Berman and Crump [89,91]. Simplified "unit risk" methods use life table analysis indirectly, since standard assumptions about exposure are combined with general life table analysis to calculate the unit inhalation risk.

The following evaluation focuses on the difference in risks for "exposed" and "unexposed" groups. For the purposes of this consultation, we specify that we are only considering the specific exposure measured in El Dorado Hills activity-based and reference sampling. That is, "exposed" refers to groups who experience the exposure scenarios modeled in this consultation throughout life in this community. "Unexposed" refers to the general population who does not experience this additional exposure. It is understood that the "unexposed" population may be exposed to asbestos in other ways, such as from asbestos-containing materials in residences or workplaces, occupational exposure, etc. However, the number of cases of cancer due to these other sources of asbestos exposure is expected to be a small fraction of the total cases, so no adjustment is made in this assessment.

Lung Cancer Excess Risk Equations

Given survival of a person up to any year *i*, the excess risk (ER) of dying from LC from asbestos exposure in year *i* equals the total risk of dying from LC during year *i* under a particular asbestos exposure minus the baseline risk of dying of LC in year *i* without that asbestos exposure:

$$ER_{LC,i} = R_{LC,exp,i} - R_{LC,unexp,i} \qquad (C1)$$

Risk of Lung Cancer Mortality in the Unexposed (Baseline) Population

We first consider the baseline risk term, $R_{LC,unexp,i}$. In any year *i* this term equals the probability of surviving up to year *i* multiplied by the probability of dying from LC during year *i*. The probability of dying of LC during year *i* is the ratio of LC to all-cause death rates (DR) for year *i* multiplied by the probability of dying during year *i* (expressed here as 1 minus the probability of surviving year *i*):

$$R_{LC,unexp,i} = P_{unexp}(\text{entering year } i \text{ alive}) \times P_{unexp}(\text{dying of LC during year } i)$$

$$= P_{unexp}(\text{entering year } i \text{ alive}) \times \frac{DR_{LC,unexp,i}}{DR_{all-cause,unexp,i}} \times (1 - P_{unexp}(\text{surviving year } i)) \qquad \text{(C2)}$$

Assuming the death rate in a population is approximately constant over a short time interval such as one year, survival probabilities are described by an exponential function [130]. The number of people surviving to the end of the year (N_{i+1}) is computed from the number of people alive at the start of the year (N_i) as follows:

$$N_{i+1} = N_i \times exp(-DR_i)$$

Thus, given survival up to the start of year i, the probability of surviving year i alive (N_{i+1} / N_i) is given by:

$$P_{unexp}(\text{surviving year } i) = exp(-\, DR_{all\text{-}cause,unexp,i}) \qquad \text{(C3)}$$

The probability of entering year *i* alive is the product of surviving each of the preceding years:

$$= \prod_{j=1}^{i-1} P_{unexp}(\text{surviving year } j),$$

$$= \prod_{j=1}^{i-1} exp(-\, DR_{all\text{-}cause,unexp,j}) \qquad \text{(C4)}$$

Substituting, the equation for unexposed lung cancer risk of dying in year *i* can be written:

$$R_{LC,unexp,i} = \frac{DR_{LC,unexp,i}}{DR_{all-cause,unexp,i}} \times (1 - exp(-\, DR_{all\text{-}cause,unexp,i})) \times \prod_{j=1}^{i-1} exp(-\, DR_{all\text{-}cause,unexp,j}) \qquad \text{(C5)}$$

Lung cancer death rates for the general population (assumed to be mostly unexposed) are available for years up to 2003 from the National Center for Health Statistics (NCHS) [107]. The information is given in 5-year age blocks in units of deaths per 100,000. Thus, the death rates must be divided by 100,000 to put them in fractional form before use in the exponent term above. The NCHS also provides life tables from which all-cause death rates can be calculated using equation C3 above [108].

Risk of Lung Cancer in the Population Exposed to Asbestos
A parallel procedure is used to determine the total exposed risk term, $R_{LC,\exp,i}$.

$$R_{LC,\exp,i} = \frac{DR_{LC,\exp,i}}{DR_{all-cause,\exp,i}} \times P_{\exp}(\text{entering year } i \text{ alive}) \times (1 - P_{\exp}(\text{surviving year } i)) \qquad (C6)$$

The death rate from lung cancer in the exposed population in year *i* is calculated as described in Appendix C, as follows:

$$DR_{LC,\exp,i} = DR_{LC,\text{unexp},i} \times (1+CE10_i \times K_L), \qquad (C7)$$

where $CE10_i$ is the cumulative exposure lagged by 10 years and K_L is the lung cancer potency factor.

The all-cause death rate in the exposed population in year *i* is computed as:

$$DR_{all\text{-}cause,\exp,i} = DR_{all\text{-}cause,\text{unexp},i} - DR_{LC,\text{unexp},i} + DR_{LC,\exp,i} + DR_{meso,\exp,i}$$

$$= DR_{all\text{-}cause,\text{unexp},i} + (DR_{LC,\text{unexp},i} \times CE10_i \times K_L) + m_i, \qquad (C8)$$

where m_i is the incidence of mesothelioma in the exposed population in year *i*, calculated as described in the "Mathematical Models of Exposure Response" section of this Appendix.

The probability terms are similar to the unexposed cases except they use the exposed death rate terms.

$$P_{\exp}(\text{surviving year } i) = exp(- DR_{all\text{-}cause,\exp,i}) \qquad (C9)$$

$$P_{\exp}(\text{entering year } i \text{ alive}) = \prod_{j=1}^{i-1} exp(- DR_{all\text{-}cause,\exp,j}) \qquad (C10)$$

Therefore, the equation for the risk of dying from lung cancer in year *i* in the asbestos-exposed population can be written:

$$R_{LC,\exp,i} =$$

$$\frac{DR_{LC,\text{unexp},i} \times (1 + CE10_i \times K_L)}{DR_{all-cause,\text{unexp},i} + (DR_{LC,\text{unexp},i} \times CE10_i \times K_L) + m_i} \times$$

$$\{1 - exp[-(DR_{all\text{-}cause,\text{unexp},i} + (DR_{LC,\text{unexp},i} \times CE10_i \times K_L) + m_i)]\} \times$$

$$\prod_{j=1}^{i-1} \{ exp[-(DR_{all\text{-}cause,\text{unexp},j} + (DR_{LC,\text{unexp},j} \times CE10_i \times K_L) + m_j)]\} \qquad (C11)$$

Mesothelioma Risk Equations

The death rate from mesothelioma in people who are not exposed to asbestos is very low and is generally assumed to be zero. Under asbestos exposure, the risk of dying of mesothelioma in year *i* is given by a similar equation as for the LC case:

$$R_{meso,exp,i} = P_{exp}(\text{entering year } i \text{ alive}) \times P_{exp}(\text{dying of meso during year } i)$$

$$= P_{exp}(\text{entering year } i \text{ alive}) \times \frac{DR_{meso,\exp,i}}{DR_{all-cause,\exp,i}} \times (1 - P_{exp}(\text{surviving year } i))$$

Substituting in from equation D8 to D10 yields:

$$R_{meso,exp,i} = \prod_{j=1}^{i-1} exp(- DR_{all\text{-}cause,\exp,j}) \times \frac{m(i)}{DR_{all-cause,\text{unexp},i} + (DR_{LC,\text{unexp},i} \times CE10_i \times K_L) + m_i}$$

$$\times \{1 - exp(-[DR_{all\text{-}cause,\text{unexp},i} + (DR_{LC,\text{unexp},i} \times CE10_i \times K_L) + m_i])\}, \qquad (C12)$$

where m_i is the mesothelioma risk expression from the "Mathematical Models of Exposure Response" section of this Appendix, which for constant periods of exposure E_c of duration d evaluated at time t from onset of exposure is given by:

$$m_i = \begin{cases} 0 & 0 < t < 10 \\ K_M \times E_c \times (t - 10)^3 & 10 < t < 10 + d \\ K_M \times E_c \times (t - 10)^3 - (t - 10 - d)^3 & t > d + 10 \end{cases}$$

Estimates of Risk from Life Table Analysis

ATSDR developed an Excel spreadsheet to estimate risks from lung cancer and mesothelioma using the equations described above, for the exposure assumptions developed for El Dorado Hills. The exposure assumptions included a lifetime of exposure, starting at birth, to asbestos at concentrations estimated from activity-based sampling in the community, as described in the body of the document. Mortality tables were obtained for 2003 from the National Center for Health Statistics [107,108]. Lifetime risk was estimated by summing yearly risks until no survivors remained, age 120 for the 2003 data. Because risk is dependent on the number of people surviving, later years contributed only a small amount to lifetime risk. The steps followed in the life table analysis are:

- First, the exposure assumptions are chosen. ATSDR worked with local, state and federal stakeholders to develop appropriate exposure assumptions for El Dorado Hills, spanning low to high activity levels in age-specific categories of exposure over a resident's lifetime.

- Next, a risk method is chosen. This selection sets the structure size and mineralogy definitions to use to determine exposure concentrations from activity-based sampling; it also sets the appropriate potency factors developed for that structure definition.

- For each year of life, the average exposure concentration (in the appropriate units corresponding to the structure definition of interest) is calculated, then combined with mortality data and appropriate risk method potencies to calculate risks of lung cancer and mesothelioma, as well as survival functions for use in future years' calculations. The risks for all years are summed to obtain the total risk.

For mesothelioma, calculations for changing exposure concentrations were simplified by performing separate calculations for each constant-concentration period; risks were then summed to obtain the total mesothelioma risk for all exposures.

(Note: For lung cancer and mesothelioma, risk for males and females was calculated separately because mortality data were gender specific. The risk ranges reported include gender-specific risks comprising both excess lung cancer and mesothelioma risks.)

Appendix D. Example Calculations and Further Explanation of Life Table Analysis

All of the risk methods used in this health consultation (IRIS, EPA 1986, Cal-EPA, and Berman and Crump) are based fundamentally on the mathematical models presented the "Mathematical Models of Exposure Response" section of Appendix C. The EPA 1986 method and the Berman and Crump method use a life table analysis to account for discontinuous exposures and age in estimating risk of developing asbestos-related disease. The "Life Table Analysis" section of Appendix C gives the equations needed to use life table analysis. This Appendix illustrates how site specific data are used to calculate risks using the different risk methods employed in the consultation.

The structure concentrations used to calculate risk must match the size fraction (structure definition) specified for the particular method. The yearly and lifetime average exposures for the different size fractions and various exposure assumptions used are given in Table G2 on p. 104. To illustrate what the calculations for each risk method used, let us assume a moderate activity level and high-end estimates of structure level per activity.

From Table G2, the relevant yearly and lifetime average structure concentrations are:

Table D1
Annual Average Structure Concentration

Age	PCMe f/cc (length > 5 μm, 0.25 μm ≤ width ≤ 3 μm, length:width ≥ 3:1)	Total TEM s/cc (length > 0.5 μm, length:width ≥ 3:1)	Amphibole s/cc (length > 10 μm, width ≤ 0.4 μm)	Chrysotile s/cc (length > 10 μm, width ≤ 0.4 μm)
0-4 years	0.0045	0.01	0.00011	0.00006
5-11 years	0.0044	0.026	0.00013	0.00015
12-18 years	0.0044	0.018	0.00012	0.00012
19-30 years	0.0039	0.006	0.00012	0.00006
31-120 years	0.0037	0.006	0.00011	0.00006
Lifetime Average	0.0039	0.008	Not used	Not used

IRIS

The lifetime average exposure (in PCMe f/cc) is multiplied by the asbestos inhalation unit risk (0.23 $(f/cc)^{-1}$) to obtain the lifetime risk.

$$\text{Risk} = 0.0039 \text{ f/cc} * 0.23 \text{ (f/cc)}^{-1} = 9 \times 10^{-4} \text{ or 9 in 10,000 risk.}$$

Cal-EPA

The lifetime average exposure (in total TEM s/cc) is divided by a conversion factor of 320 to obtain PCM f/cc, and the result multiplied by the unit risk. The unit risk is 0.00019 per 100 PCM fibers/cubic meter, so this result must be multiplied by conversion factors as shown below to obtain the unitless lifetime risk.

$$\text{Risk} = 0.008\,\frac{s}{cc} \times \frac{1\,PCM\,\frac{f}{cc}}{320\,\frac{s}{cc}} \times 0.00019\,\frac{1}{(100\,PCM\frac{f}{m^3})} \times \frac{(100\,PCM\,f)}{100\,(PCM\,f)} \times \frac{1{,}000{,}000\,cc}{m^3}$$

= 5×10^{-5} or 5 in 100,000 risk.

Alternate Cal-EPA

The lifetime average exposure (in PCMe f/cc) is multiplied by the unit risk and conversion factors to obtain the lifetime risk.

$$\text{Risk} = 0.0039\,PCM\,\frac{f}{cc} \times 0.00019\,\frac{1}{(100\,PCM\frac{f}{m^3})} \times \frac{(100\,PCM\,f)}{100\,(PCM\,f)} \times \frac{1{,}000{,}000\,cc}{m^3}$$

= 7×10^{-3} or 7 in 1,000 risk

Life Table Analysis: Used for EPA 1986 and Berman and Crump

For life table analysis, risk must be summed over a lifetime using exposure functions (describing cumulative exposure to the method-specific structure concentration of interest over time) and incorporating method-specific K-values (potency factors), all-cause death rates, and lung cancer death rates as described in the "Life Table Analysis" section of Appendix C – the risks are then summed to obtain the lifetime risk. The all-cause and lung cancer death rates used in the life table analyses are given in Tables G3 and G4 on pages 105 and 106.

ATSDR created a spreadsheet to do the complicated calculations involved in life table analysis. The two major steps of the analysis are: 1) calculating the exposure functions and 2) calculating risk.

Calculating the exposure functions

For lung cancer, the exposure contributing risk for any one year is the cumulative exposure for that year plus all previous years; however the exposures are lagged by 10 years to account for latency. That is, the exposure contributing at age 40 to lung cancer risk is the cumulative exposure up to age 30 because you subtract 10 years of exposures. This is done for each year of life.

For mesothelioma, exposures also contribute to cumulative risk, but the mathematical function used to change exposure concentrations year by year is complicated. To simplify the calculations, we calculated the exposures separately for periods of constant annual average exposure (e.g., ages 0-4 have the same annual average exposure concentration). This allowed us to calculate the exposure contributing to mesothelioma risk using the simplified equations given in Appendix C; all the periods of constant exposure evaluated were then summed to obtain the overall exposure contributing to risk. (These equations also assume a 10-year lag time before any risk appears).

Calculating Risk

Once the exposure functions are obtained for each year of life, the risk for each year is calculated. The risks for lung cancer are calculated using equation C11 (from Appendix C).For mesothelioma, Equation C12 is used. The death rates are obtained from the mortality statistics listed in Tables G3 and G4. (Note that each of these equations uses exposure functions and risk of dying from both lung cancer and mesothelioma. Each year's calculation is influenced by the results of the previous years. This is why the equations are so difficult to illustrate here.)

For each year of life, the average exposure concentration, along with cumulative exposure from previous years, is combined with mortality data from Table G3 and G4 and method-specific potency values for lung cancer (K_L) and mesothelioma (K_M) to calculate risk of dying from lung cancer and mesothelioma using equations C11 and C12. Each equation uses the probability of living up to the given year given mortality statistics and previous years' risks. The lifetime risk is obtained by summing lung cancer and mesothelioma risks for all years from birth to the year in which no survivors remain, 120 years for the data used in this health consultation. Risks for males and females are calculated separately because the mortality statistics are different.

EPA 1986 vs. Berman and Crump Life Table Analysis

For EPA 1986, exposure functions are based on PCMe concentrations as shown in the Table D1 on the previous page. K_L is 1×10^{-2}; and K_M is 1×10^{-8}. The risks for lung cancer and mesothelioma are calculated separately and then added together.

In the Berman and Crump method, exposure functions are calculated using structure concentrations based on structures longer than 10 µm and diameters equal or less than 0.4 µm, for amphibole and chrysotile separately (see Table D1). Berman and Crump defined potencies specific to the type of asbestos: K_L for amphibole is 3×10^{-2}; K_L for chrysotile is 6×10^{-3}; K_M for amphibole is 3×10^{-7}; and K_M for chrysotile is 4×10^{-10}. Separate risk calculations are performed for each type of asbestos and then added together.

Appendix E. ATSDR Additional Analysis of El Dorado Hills Data

Background

The U.S. Environmental Protection Agency (EPA) collected activity-based samples in El Dorado Hills, California, locations in Fall 2004 as part of its multimedia exposure assessment. This occurred at about the same time the Agency for Toxic Substances and Disease Registry (ATSDR) was evaluating naturally occurring asbestos (NOA) exposures at Oak Ridge High School in El Dorado Hills. ATSDR released its health consultation on Oak Ridge High School for public comment at the same time EPA released results of the activity-based sampling, in May 2005. In the final version of the Oak Ridge High School health consultation, released in January 2006, ATSDR committed to evaluating the EPA activity-based sampling data in an effort to make a determination of the public health impact of NOA exposures in the general community.

Goals and Findings of EPA Analysis of Activity-Based Samples

EPA described the objectives and analysis procedures of the activity-based sampling in its Quality Assurance Project Plan finalized in September 2004 [E1]. EPA's analysis of the samples was intended to give data of sufficient quality to determine if activities were associated with elevated asbestos exposures compared to reference stations where no activities were performed [E1]. The comparison would be done using Z-test statistical methods similar to those specified in the Asbestos Hazard and Emergency Response Act (AHERA) method for comparing indoor and outdoor air measurements to assess asbestos cleanups in school buildings. Analysis of the activity-based sampling air filters was done by transmission electron microscopy. The laboratory was directed to use International Standard Organization (ISO) counting methods to reach the specified analytical sensitivity based on total asbestos structures (all regulated asbestos structures, irrespective of length, with aspect ratio greater than or equal to 3:1). Analytical sensitivity was specified as 0.001 total asbestos structures per cubic centimeter (s/cc) for samples collected using less than 4,000 liters of air and 0.0003 s/cc for samples collected using greater than 4,000 liters of air. The laboratory was further directed to stop counting before reaching the required analytical sensitivity if 50 primary structures were counted (completing counting on the grid containing the 50^{th} primary structure), provided the resulting concentration would exceed 0.1 s/cc [E1].

The results of the original analysis allowed comparison between activities and reference stations and showed that activities could result in significantly increased levels of exposure. EPA finalized the Preliminary Assessment and Site Inspection (PA/SI) report in January 2006 [E2]. EPA focused its presentation of results on PCM-equivalent structures (structures greater than or equal to 5 μm long, between 0.25 and 3 μm wide, and with aspect ratios greater than or equal to 3:1) and on total asbestos structures ("AHERA-like" total structures, structures with aspect ratios greater than or equal to 3:1, irrespective of length). PCM-equivalent structures are the size of structures specified for use in EPA's Integrated Risk Information System (IRIS) risk assessment method, typically used by the Superfund program for risk assessment, and AHERA structures are those specified for characterizing school cleanups in the AHERA program. In Table 6.1 of the final report, EPA showed that most activities were associated with statistically significant elevations of exposure compared to reference stations, for either PCM-equivalent or AHERA structures [E2].

ATSDR's Need For Additional Information

ATSDR planned to examine the activity-based sampling results and make recommendations as to the degree of public health risk from such exposures in the community. This could have been done using EPA's Integrated Risk Information System (IRIS) risk method, which can use PCM-equivalent data. However, at the time ATSDR started looking at the data, events were occurring that suggested that relying solely on the IRIS method might not be the best science for determining public health risk.

- Some stakeholders raised an issue that most of the structures detected in the EPA sampling were not "true" asbestos fibers, but were instead so-called "cleavage fragments" or nonasbestiform particles; use of the IRIS method would overestimate risk [E3]. The assertion was made largely on the basis that many of the structures detected were shorter or thicker than commercial asbestos fibers. (ATSDR did not necessarily agree, since there is no strong evidence indicating cleavage fragments are non-toxic and NIOSH recommends counting them. Also, no accepted method exists for differentiating between asbestiform particles and cleavage fragments of similar dimensions.)
- Local community members and activists asserted that using the IRIS method, based mainly on epidemiological studies of chrysotile asbestos workers, would not be protective. (Most of the structures detected in El Dorado Hills were amphibole, and many reports in the scientific literature have concluded that amphibole asbestos is significantly more potent in causing some types of cancer than chrysotile [E4].)
- El Dorado County sought advice from D.W. Berman, a consultant and co-author of the Berman and Crump method for assessing asbestos risk. Dr. Berman's letters to the county indicated that use of his approach would make it unnecessary to differentiate between fibers and cleavage fragments and would be more scientifically appropriate because it counted the length of fibers found to be toxic [E5,E6].

At the time (2005-2006), the Berman and Crump risk method was considered as improving on the IRIS method for assessing asbestos inhalation risk. The Berman and Crump method was drafted in 2001 and revised in 2003 in response to a generally favorable peer consultation panel discussion [E7,E8]. It assigns different potencies to amphibole and chrysotile asbestos and considers only long, thin structures, which the authors believed to be the greatest contributors to biological activity. However, the 2003 revised method did not address some of the recommendations of the peer consultation panel, and there were lingering questions as to some of the method's assumptions – the method has never been used or adopted by EPA. ATSDR was aware of the scientific questions surrounding the Berman and Crump method. But we felt that including this method in our evaluation would generate information that would help address the issues listed in the bullets above.

At about the same time, EPA initiated further work to expand and improve the Berman and Crump method to address some of the outstanding issues. This work, led by the Office of Solid Waste and Emergency Response (OSWER), was undertaken in hopes of developing an interim risk assessment method for the Superfund program. The method was to be used until another group within EPA completed their ongoing update of the IRIS method. ATSDR reviewed preliminary drafts of this work which indicated that risk was most associated with long (greater than 10 µm) amphibole structures with diameters up to 1.5 µm. Although ATSDR had reservations about the utility of this method similar to our reservations about the Berman and Crump method, we planned to include it as a comparison to the Berman and Crump method.

To use either the Berman and Crump method or the proposed OSWER method, we needed information on the long (greater than 10 µm long) structure concentrations in the El Dorado Hills sampling. EPA provided ATSDR with a Microsoft Access database containing the raw data from the PA/SI, including structure dimensions [0]. ATSDR examined the greater than 10 µm long subset of structure data from the database to determine whether it could be used for the type of risk assessment we proposed. ATSDR found that the analytical sensitivity for long fibers was not low enough for us to use the long structure data.

Analytical sensitivity is a function of the amount of air drawn through the filter when collecting an air sample and the area of the filter examined later under the electron microscope (that is determined by the "number of grid openings" examined by the lab). For both PCM-equivalent and AHERA-like structures, most samples had enough structures present on the filters that reliable counts could be made and the samples could be compared with one another. In contrast, relatively few long structures were present on the filters. In many cases the lab reached the stopping rule based on total structures before it had counted any long structures, so many of the samples were "nondetect" for long structures and the concentration was reported at the detection limit, a function of the analytical sensitivity. The low number of structures counted in samples that did detect long structures resulted in large confidence intervals (uncertainty that the number of fibers counted accurately represented the number of fibers present). These two factors made it impossible to compare long structure results between samples. In addition, the reported detection limits were too high for meaningful application of the long-structure risk methods described above. (Preliminary calculations showed that concentrations of long structures lower than these detection limits, but not zero, could contribute to unacceptable risk).

The analytical sensitivity and corresponding detection limits could be improved by counting a greater number of grid openings (greater filter area) on each filter. The resulting long structure data would be more useful in evaluating risk using long-structure risk methods. To obtain this information, ATSDR's Division of Regional Operations provided funding to allow additional analysis of filters that had been retained from EPA's original analysis.

Additional Analysis and Results

To conserve limited funds, ATSDR selected 182 of the original 316 samples for additional analysis. The analysis used direct ISO methods to count structures greater than or equal to 10 µm long and less than or equal to 1.5 µm in diameter. Because few of these structures were present, we specified that the laboratory was to count until 10 of these structures were identified or until a total of 400 grid openings on the filter had been counted, whichever came first. This was anticipated to give sufficient sensitivity to allow meaningful application of "long" structure risk methods described above. In addition, ATSDR instructed the laboratory to perform the counting at a lower magnification (which saves analysis time). Most of the structures were not so thin as to limit visibility at the lower magnification, so this was not expected to have an impact on overall structure count. The additional analysis was performed by the same laboratory that had performed the original analysis (LabCor, Seattle, WA).

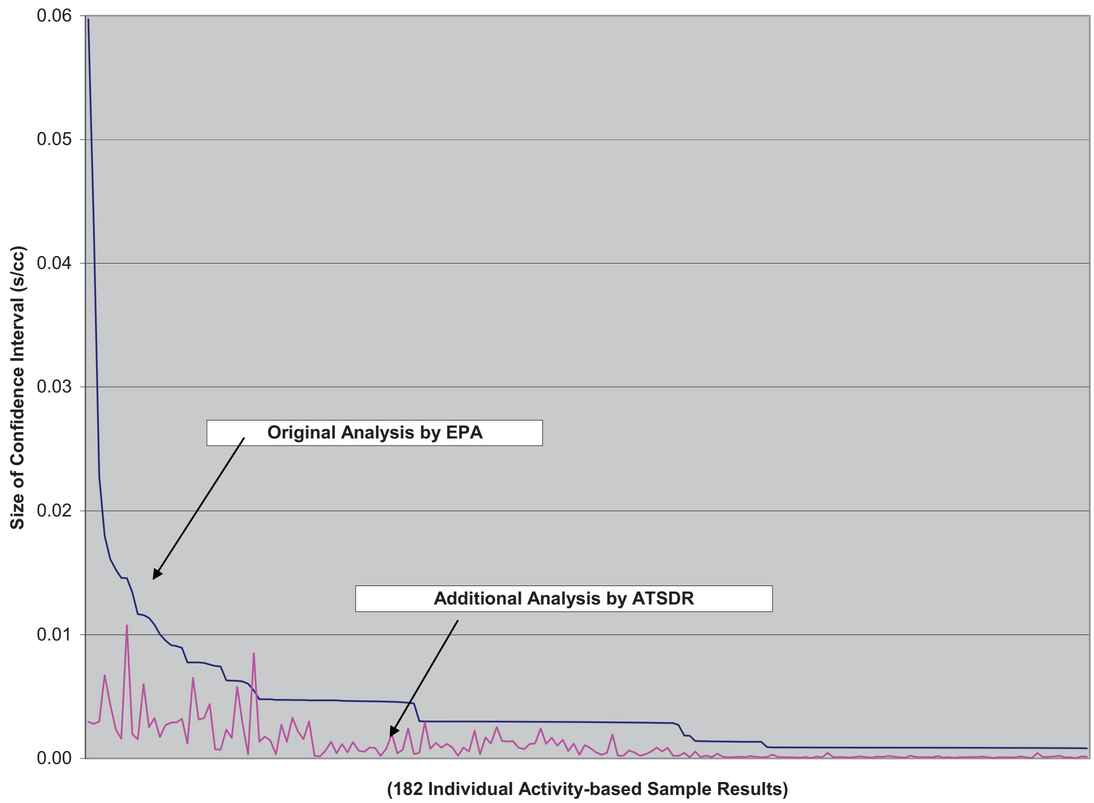
Raw data and data summaries were provided to ATSDR in September 2007 [E10]. Table E1 summarizes the improvement in structure detection that was attained with the additional analysis. The additional analysis improved the sensitivity so that long structure concentrations could be assigned to over 80% of the samples originally reported as nondetect.

Table E1. Summary of Long Structure Data*

Analysis	Total Number of Samples Analyzed	Number of Samples With Nondetect Result	Range of Detection Limits for Nondetects
EPA Original Analysis	182	113	0.0008—0.04
ATSDR Additional Analysis	182	21	0.00004—0.01
*Long structures defined as regulated asbestos structures greater than or equal to 10 μm long and less than 1.5 μm wide.			

The confidence in the detected values was also improved with the additional analysis. Figure E1 shows that the size of the confidence interval (based on Poisson distributions of structures on the air filter, per ISO method specifications) was decreased significantly for almost all the samples analyzed. This indicates a greater confidence in the laboratory results for structure concentration on the filters. (Note: Although the results in Figure E1 indicate greater confidence in the laboratory findings was achieved with the additional analysis, there are still a great many uncertainties with other aspects of the activity-based sampling and risk estimation, as described in the accompanying health consultation. We have not attempted to estimate confidence intervals for any exposure or risk estimates listed in the consultation.)

Figure E1. Improvement in Confidence in Analysis Results



Additional analysis reduced the size of the Poisson 95% confidence interval around the laboratory-reported structure concentration for structures greater than 10 μm long and less than 1.5 μm wide. The plot shows difference between upper and lower confidence limits (in structures per cubic centimeter, calculated according to ISO conventions) for each sample for the original EPA analysis of long fibers (in blue) and for the ATSDR re-analysis (in pink). The additional analysis resulted in an average 75% reduction in the size of the confidence interval, indicating greater confidence in the ATSDR long structure results. (To ease viewing, the data were sorted from the highest to lowest EPA confidence interval size. The same samples are paired in the plot; thus the ATSDR additional analysis is not sorted from high to low.)

Timing and New Developments

ATSDR identified the need for further analysis in spring/summer 2006, and over the next several months worked to obtain funding, develop appropriate counting and stopping rules with the laboratory, and identify the appropriate subset of samples to analyze. The laboratory started analyzing samples in early 2007, and ATSDR received the final report in September 2007 (because of the large number of grid openings counted to obtain high analytical sensitivity, each sample took about a day to analyze).

Meanwhile, EPA continued developing the OSWER proposed interim method. ATSDR provided informal comments on a Fall 2006 draft through its participation on the Technical Review Workgroup Asbestos Committee, and ATSDR provided official comments on a later draft in Winter 2008. The later draft was reduced in scope from the earlier draft and mainly described an approach for determining potency factors for use in assessing risk [E11]. Because the potency factors were not published, it was impossible to use the Winter 2008 proposed approach for risk estimation. EPA convened the Asbestos committee of the Science Advisory Board panel in July 2008 to provide technical advice on the Winter 2008 proposed OSWER approach [E11]. The Committee found that while the objective of determining influence of mineral type and dimensions on cancer potencies estimated from epidemiological studies was a worthy one, the quality of the available exposure data was generally insufficient to support the proposed approach [E12]. At this time, EPA has decided not to pursue this activity further [E13].

Because the Berman and Crump method uses similar data to the proposed OSWER approach, some feel that it is scientifically inadequate for use in assessing risk. However, others continue to assert that, despite its shortcomings, it represents an improvement over currently used risk methods. The authors have continued to publish articles on this topic in the peer-reviewed literature [E14,E15]. Finally, although there are numerous subtleties and clarifications needed for accuracy, the belief that "amphibole asbestos is more toxic" has embedded itself into the awareness of general population through media stories and discussion with local activists. El Dorado Hills community members understandably want ATSDR to consider a method that accounts for amphibole toxicity. Therefore, ATSDR proceeded to consider the 2003 Berman and Crump method, with appropriate caveats, in the health consultation.

Conclusion
The additional analysis gave results that improved ATSDR's evaluation of the sampling data by allowing application of a risk method that accounts for the effects of mineral type and dimensions on toxicity. ATSDR recognizes the scientific uncertainty and limits of this method compared to traditional risk assessment methods, especially in light of EPA's SAB review. We do, however, think this method has merit when used in comparison with results of other risk assessment methods and in conjunction with other evidence about the nature of asbestos exposures at the site.

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Appendix F. Comments Received on El Dorado Exposure Assumptions

ATSDR worked with EPA and Cal-EPA's OEHHA in the development of proposed exposure assumptions for estimating risk in El Dorado County. To obtain input from the community, ATSDR provided a draft spreadsheet describing these exposure assumptions to representatives of three groups in El Dorado County: the El Dorado County Office of Education, El Dorado County Board of Supervisors, and a Community Advisory Group made up of local private citizens. The draft spreadsheet, provided in Fall 2006 and included as Figures E2-E5 at the end of this Appendix, included sheets summarizing exposure time and duration assumptions, fiber concentration estimation assumptions, and explanatory text. The Agency received suggestions and comments on the spreadsheet from private citizens and the El Dorado County Office of Education. ATSDR categorized the comments into various subject areas and prepared responses or made changes to the exposure assumptions. Verbatim comments and ATSDR responses/description of changes made are listed below.

Comments on Time-Duration Assumptions

***Request for additional exposure scenario:* "Please conduct risk assessment for children, ages 5 through 11, playing and digging in soil on the northwest area of Silva Valley Elementary School property, immediately adjacent and northwest of portable buildings, along property boundary. The school has or had a garden area there where children conducted planting and gardening activities similar to Jackson School's activities. Children's faces were relatively close to soil during work, within a foot or two."** –private citizen

ATSDR Response. To account for potential exposures in digging scenarios, ATSDR added 1 hour per week, 32 weeks per year of a "digging scenario" for 5-11 year olds in low, medium, and high exposure categories [assumed 2 half-hour periods of gardening activity per week for non-rainy school weeks]. In addition to the described scenario, high school science students were reported to perform soil science experiments with soil collected from school grounds. ATSDR therefore added 0.5 hour per week, 3 weeks per year, of a "digging" scenario for 12-18 year olds in all exposure categories who might collect soil and perform short-term experiments in science class. The resulting time is multiplied by the fraction 4/7 to reduce the exposure, based on professional judgment that students would be unlikely to be enrolled in a science class performing the same soil experiments every year. (4 out of 7 years chosen as reasonably conservative; 3 weeks of half-hour daily experiments also chosen as a conservative assumption.) No data are available showing exposures from gardening activities at Silva Valley Elementary. One direct result for a "digging scenario" collected at Jackson Elementary was used to estimate fiber concentrations for all digging scenarios.

***Request to reduce time assumptions for certain categories:* "The chart assumes that a "high activity" 12-18 year old athlete will engage in athletics six hours a day/seven days a week in addition to P.E. This seems excessive. The highest activity athletes are generally those engaged in high school sports. A typical member of a high school soccer team, for example, will play games on Monday and Wednesday, which last approximately two hours each, including warm up. Fifty percent of the games are played away. Practice on Tuesday, Thursday and Friday is typically two hours a day. Although it is possible, we know of no**

students who continue to practice on their own for an additional four hours after the game or after practice. On weekends the dedicated athlete will continue to train, but we don't know of any athletes that train for six hours on Saturday and six hours on Sunday. Similarly, we wonder whether the "moderate activity" assumptions of 3 hours day/ seven days a week in addition to P.E. is appropriate for someone who is just moderately active. This assumes someone engaging in sports as soon as school lets out at 3:00 p.m. until 6:00 p.m. every school day plus weekends. We wonder if this will be considered as more than just moderate activity." –El Dorado County Office of Education

ATSDR Response: ATSDR believes the draft's explanation of assumed times and durations was unclear and may have led to this commenter's misinterpreting the assumptions. The high activity 12-18 year old was assumed to spend, in addition to 34 weeks of P.E. at 3.75 hours per week, time performing activities on asphalt courts, grassy fields, or the New York Creek trail jogging or biking. The hours per week for each of these scenarios was assumed to be 14 hours, but it was assumed that not all activities would take place each week; instead each specific activity (asphalt courts, grassy fields, trail activities) was assumed to take place during a "season" of 12 weeks per year, with the three seasons corresponding roughly to the 34 weeks of fair weather activity assumed for P.E. Similar comments could be made for the moderate activity scenario, except that longer "seasons" were assumed. The overall assumptions made originally come out to an assumption of about 14 hours of additional activity per week in addition to P.E. for the high activity scenario, and about 10-12 hours of additional activity per week in addition to P.E. for the moderate activity scenario (if corrected to account for the longer "seasons" assumed).

ATSDR obtained additional information which allowed a refinement of the weeks per year assumed in various activities. On-line weather information and data collected locally by state agencies and private corporations indicated that the rainiest months include November, December, January, February, and March, and that lower concentrations of asbestos in air were measured during a "rainy" season of about 13 weeks [103–105]. Assuming a 45-week school year (including breaks) running from mid-August until early June, ATSDR therefore determined that the non-rainy school year (for estimating exposures during P.E., etc.) would be 32 weeks. Allowing for summer activities, each "season" for grassy field, asphalt court, and trail activities was set at 12 weeks, for a total of 36 non-rainy weeks of activity.

In response to the information provided on soccer schedules, and in an attempt to simplify the assumptions, ATSDR has modified the "seasons" of weeks per year and the assumed hours of additional activities per week for both the moderate and high activity scenarios. Both scenarios were assumed to include 12 weeks per year of activities on grassy fields, asphalt courts, and New York Creek Trail. For the 12-18 year-olds' high activity scenario, 10 hours per week was assumed for grassy fields, asphalt courts, and trail activities. This allows for 8 hours as described by the commenter plus an additional 2 hours on the weekend. ATSDR feels this change is responsive while remaining conservative. For moderate activities, in addition to changing the assumed number of weeks per year to 12 for each activity (grassy field, asphalt court, New York Creek Trail), the hours per week assumed for each of these activities has been changed to 5, half of the "high" activity level. This value is similar to recommendations made by the U.S. Surgeon General's Office that children older than 8 and adolescents engage in "at least 60 minutes of moderate intensity, continuous activity on most days, preferably daily." [106] Total hours for extracurricular activities for 5-11 year olds was the same as for 12-18 year olds, but the proportion of time spent on grassy fields or asphalt courts was increased and time on New York Creek Trail reduced, since younger children are assumed to be more likely to engage in supervised sports activities than independent exercise.

Request to remove walking to school on New York Creek Trail: **"We also note that the moderate and high activity scenarios all involve students walking to and from school along New York Creek Trail. Most students do not use this trail to go to school. We believe one scenario should be included that would be relevant for students and other members of the community who do not use New York Creek Trail."** –El Dorado County Office of Education

ATSDR Response: Although most students may not perform this activity, it is important to include it since students who do walk may not have another option for getting to school. (The low activity scenario is one which does not include walking to school.)

Comments on Fiber Concentration Assumptions

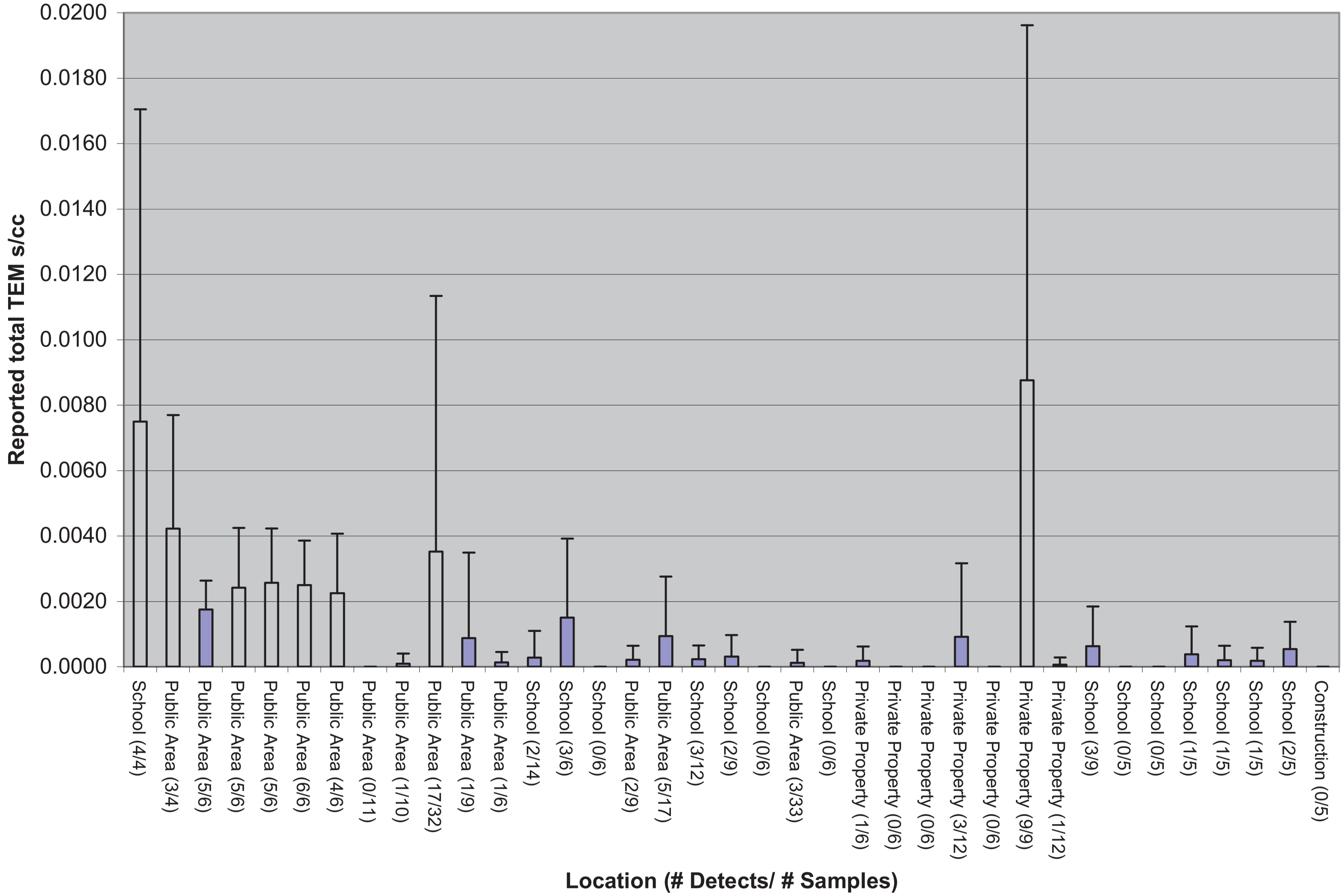
Comments on use of background levels: **"The spreadsheet indicates that ATSDR intends to incorporate background levels in the analysis. We question whether the reference samples collected by the EPA in the study were intended to establish background levels for El Dorado Hills. We specifically asked in our response to the QAPP that the EPA include several additional sites for the stationary monitors in El Dorado Hills to provide more valid background data. DTSC also made this request. Unfortunately our requests were rejected. The number of samples and locations are not indicative of the El Dorado Hills area, do not reflect the differences in the seasons and do not reflect a 24 hour period. As you know, CARB has conducted a number of tests in the El Dorado Hills area. It may be appropriate to include their data in making assumptions of background levels."** –El Dorado County Office of Education

ATSDR Response: The EPA reference stations are the only data available which contain detailed size distribution data and therefore can be used in multiple risk models. Although CARB data was not detailed enough to use in the health consultation, ATSDR evaluated the CARB ambient monitoring to see how it might compare to the EPA reference station results. ATSDR used CARB data available on its web site [105]. The data contained a text description of each sampling location, but no details as to how the sampling was performed or exact location were available. Samples appeared to be 24-hour averages. Text descriptions stated that analysis was by transmission electron microscopy (TEM) following the AHERA method (40 CFR Part 763, Subpart E) with ARB modifications, but specific information on structure definitions, counting criteria, or changes to the standard method were not given. ATSDR assumed that the data presented on CARB's web site (both structure per cubic centimeter and fiber per cubic centimeter) represented AHERA structures greater than 0.5 μm long and with an aspect ratio greater than or equal to 5:1. For each location, ATSDR determined the average and standard deviation of all daily samples collected, counting non-detect results as zero. Figure F1 shows a summary of the results (number of detections is shown below each column) for locations in El Dorado County. The data do not include locations that were denoted as near a potential asbestos source (which were much higher), nor do they include one series of locations taken during the winter rainy season (no asbestos detected). Figure F1 indicates that other ambient monitoring locations, which included samples collected at various times from April through October, had averages ranging from non-detect to relatively high concentrations. The 24-hour asbestos concentration is quite variable, both between locations and at different sampling periods of the same location (as indicated by error bars representing standard deviation).

The mean (± standard deviation) of all CARB ambient samples in Figure F1 is 0.001±0.004 AHERA 5:1 aspect ratio s/cc. To compare, the mean of EPA activity-based sampling results for all reference stations was 0.002±0.001 AHERA 3:1 aspect ratio s/cc. (The CARB value is smaller, as would be expected since 5:1 aspect ratio structures are a subset of 3:1 aspect ratio structures, but the large standard deviations show that the difference between the means is not statistically different.) *Therefore, ATSDR has determined that the EPA reference station data adequately represent background for areas away from potential sources during non-rainy periods.*

As further support, asbestos monitoring data for a local construction area were also available and are presented in the body of the document as Figures 9 and 10 [104]. This data showed concentrations during non-rainy periods generally similar to the CARB data, but it also included sample data from rainy periods of time. In general, the asbestos concentrations during the season corresponding to rainy periods (November-March) were an order of magnitude smaller than during drier periods. *Therefore, to address the fact that these data indicate significantly lower asbestos concentrations during rainy seasons, ATSDR will assume that "background" asbestos concentrations are one-tenth of the EPA reference station concentrations during a 13-week rainy period.*

Figure F1. CARB Ambient Asbestos Monitoring Summary



*NOTE: Data obtained from CARB website at http://www.arb.ca.gov/toxics/asbestos/airmon.htm in Fall 2006; further analysis performed by ATSDR in April 2008. Bars represent average structure concentration and error bars represent standard deviation.

More comments on use of background levels: **"In addition, the use of background levels as an "additional exposure" in other risk assessment models should be discussed. If other risk models assume no exposure from background levels, even though background levels may have been present, this should be discussed. While we realize ATSDR takes a protective approach in its Consultation, we believe the value of the report will be greatly enhanced if realistic assumptions are used and any deviation from the data or methods used in generating accepted models is fully explained."** –El Dorado County Office of Education

ATSDR Response: Risk models developed from worker cohort data typically neglect background exposure. This is because the high levels of occupational exposure far outweigh any background exposures. However, it is known that lower-level exposures, such as experienced by family members living in the house of a worker or people living in the neighborhood of a processing plant, have resulted in disease. Background exposures are important to include in a place like El Dorado Hills where these "background" exposures are comparable to (and over the course of a lifetime potentially greater than) any direct activity-related exposure.

We have added discussion of this issue in the body of the document beginning on page 40. We have emphasized that the risk estimates presented in the health consultation should not be compared with results of EPA risk assessments for other sites or EPA risk ranges for Superfund cleanup.

More comments on use of background levels: **"On the issue of using background levels in the study, we understand detectable levels of asbestos two and one-half (2.5) times higher than the background samples taken by CARB at ORHS have been measured thirteen miles out in the Pacific Ocean. www.asbestos.org/HealthEffect/Non-Occupational.html. According to tests completed by CARB during the period between 1998 and 2003, daily background levels in Santa Clara County were seventeen (17) times higher than the readings at ORHS even before the EPA completed their work at ORHS. Readings in Monterey County were three and one-half (3.5) times higher than the readings at ORHS. Recent readings in the Clear Creek Management Area indicate that the levels are over 100 times the readings at ORHS. We have previously provided you with this information and it is available on the CARB website. www.arb.ca.gov/toxics/asbestos/orhs.htm?PF=Y. Since there are background levels in many areas in California and the United States, the exposures in El Dorado Hills should be put in context of other areas with naturally occurring asbestos."** –El Dorado County Office of Education

ATSDR Response: ATSDR was asked to assess the risk from naturally occurring asbestos in the area around El Dorado Hills. Site specific data have been collected in El Dorado County, and the EPA activity-based data is the only data for which detailed size distribution data were available. While other areas in California and elsewhere might also have naturally occurring asbestos, and therefore some potential risk, this does not affect the risk for El Dorado Hills. We have added discussion of how background contributed to risk in the document beginning on page 40, and have indicated how background in El Dorado Hills area compares to ambient concentrations reported in general U.S. urban environments. We also included a section describing some findings at other U.S. naturally occurring asbestos areas beginning on page 48.

***Comment that activity-based sampling scenarios may not represent true exposures:* "The Asphalt Court Scenarios will use data that included the use of brooms to stir up the dust while 4-square and basketball were played. We requested the EPA include at least one test that did not use brooms during the game, but they rejected our request and all of the games included the use of brooms. If there is any data to indicate that the broom exposure scenario approximates the exposure without the use of brooms, it should be included in the report. If not, the applicability of the data to games that do not involve the use of brooms should be discussed."** –El Dorado County Office of Education

ATSDR Response: Details of the specific actions followed during each of the activity scenarios are given in EPA's final Preliminary Assessment/ Site Inspection (PA/SI) report [7]. Brooms were used on the Rolling Hills Middle School basketball court during the first 10 minutes of a 2-hour scenario, to represent cleaning of the court that might occur before a game. The basketball and paved kindergarten playground (4-square) scenarios at Jackson Elementary School did not include any use of brooms prior to activities. It is impossible to construct an activity scenario that exactly represents actual activity patterns. ATSDR has determined that the use of data including broom use is justified since pre-game cleaning could occur or because wind, leaf blowers, or traffic might raise up dust during court activities.

***Request to fully describe activity-based sampling scenarios and their relation to true exposures:* "It would be helpful if a section were devoted to explain the methods used to generate the data and how this data may differ from the actual exposure to the individual. The usefulness of the report will be greatly enhanced with a comprehensive discussion of the protocol used for the generation of the data. In addition to the use of brooms during the basketball games, issues such as the use of leaf blowers in the playground tent should be explained, especially if this data is averaged in with the other data. The height of the stationary and personal monitors, many of which were set at approx 3-4 feet, should also be included in the discussion. The fact that the baseball fields were not wetted down before the tests, even though we believe it is common practice of the fields where the tests were conducted, should be discussed. The Districts were also requested to alter their normal irrigation schedule for the tests. In the Jackson School garden area, the test participants were observed aggressively throwing dirt in the direction of the filters. As much discussion as possible about the test methods would be helpful to the reader."** –El Dorado County Office of Education

ATSDR Response: Details of the specific actions followed during each of the activity scenarios are given in EPA's final Preliminary Assessment/ Site Inspection (PA/SI) report [7]. It is impossible to construct an activity scenario that exactly represents actual activity patterns. Because the concern for exposures is greatest during times when dust control measures might not occur, when windy conditions might raise up dust, or when children might throw dirt at each other, it is protective to estimate potential exposures under these conditions. Moisture content of soil at each activity scenario was measured and reported; moistures varied due to prior wetting of fields, minor rain events, and site characteristics. In the children's playground area, typical activities were conducted with no suspension of dust. For the "aggressive play" scenario, the same activities were conducted, but a leaf blower was used outside of the playground prior to activities, with fans used throughout activities to blow suspended dust towards the activities. In addition to simulating potential for exposure to dust suspended elsewhere, this is a reasonable way to attempt to simulate potentially higher exposures during aggressive play, when individuals participating in the activity scenario might not be as consistent in their actions. However, the aggressive play scenario was not used in ATSDR's exposure estimations performed in this health consultation. All child activity scenarios were performed with the sampler set at approximately 3 feet (adult scenarios were at 5 feet). Obviously, this may not perfectly represent the breathing zone for shorter or taller children.

***Request to discuss use of indirect vs. direct test method results:* "Finally, this section should also discuss whether any of the test results involved filters subject to the indirect test method. If so, the issues associated with this data should be discussed."** –El Dorado County Office of Education

ATSDR Response: Some of the sample collected by EPA were heavily loaded with solids, necessitating an "indirect" method of analysis. However, ATSDR's calculations and ATSDR-funded additional analyses were performed only on filters that were analyzed using the direct method.

***Request to clarify cleavage fragment issue:* "The excel spreadsheet uses the term "fiber level" in making the exposure assumptions. Since the ISO test method used in the 2005 Ladd study states in the abstract description that it is not capable of differentiating between fibers and cleavage fragments, our geologist informs us that it is appropriate to clarify that structures with aspect ratios greater than 3:1 were identified and therefore classified as fibers. We note this to acknowledge the current discussion in the scientific and health communities regarding the importance of distinguishing between cleavage fragments and fibers. In fact, it would be informative for the health consultation to provide an overview discussion on the current levels of uncertainties regarding health risks from cleavage fragments versus fibers, the probable pervasiveness of cleavage fragment dust in the environment, and the subjective nature of laboratory analyst structure identification considering fiber / fragment terminations, parallel sides, etc."** –El Dorado County Office of Education

ATSDR Response: For clarity of discussion, ATSDR has changed its general terminology throughout the document to refer to "structures" instead of "fibers." ATSDR considers mineral particles of interest purely on dimensional characteristic and mineral composition; we neither attempt nor accomplish any distinction between structures arising from crystal growth (fibers) versus cleavage ("cleavage fragments"). Although ATSDR supports further research into these untested mineral forms, we believe prudent public health practice does not allow so-called "cleavage fragments" to be neglected from risk calculations at this time.

It is well beyond the scope of this consultation to verify and/or address each of the above statements. The following points, however, are applicable to the El Dorado Hills situation. 1) All accepted counting methods use dimensional criteria to define which structures are to be counted; for the method used in the EPA study a modified ISO method documented all structures greater than 0.5 µm long and with an aspect ratio (length:width) of greater than or equal to 3:1. Structures fitting more restrictive dimensional criteria can later be selected from the structures counted. ATSDR's reanalysis of a subset of the EPA samples documented only structures longer than 10 µm with aspect ratios of 3:1 or greater. With such dimensional criteria, there is no need (nor is there any scientifically agreed-upon method) to differentiate between fibers and cleavage fragments of similar dimension. 2) It is generally recognized that dimensional characteristics play an important role in determining a structure's toxicity. ATSDR has not seen convincing proof that the nature of formation of a structure is a more important determinant than dimension. 3) In response to the report criticizing EPA's data as misidentifying so-called "cleavage fragments" as fibers, the EPA asked the U.S. Geological Survey to study the amphibole materials in El Dorado Hills. The USGS released a report in December 2006 and concluded that, while most of the amphibole particles examined do not meet the morphological definitions of commercial-grade asbestos, most met the counting rule criteria used by EPA from both chemical and morphological requirements. In addition, the report found "the El Dorado Hills amphiboles clearly do not fit a population of cleavage fragments…" [8]

ATSDR is currently working with other federal agencies to encourage basic research in to the toxicity of prismatic, acicular, and fibrous particles such as those present at El Dorado Hills. This research is being planned and will be conducted by the National Toxicology Program.

Suggestions for Assumptions/ Data Analysis: **"We appreciate the explanation of the assumptions used in the spreadsheet and believe it would be very helpful if this explanation were also included in the Consultation. For example, the assumptions on winter break and the winter rainy season should be explained in the front of the report. This section could also discuss issues such as whether the Grassy Field Scenario averages in the exposure from sliding into home plate or from dragging the field. We question whether averaging the data is really appropriate, since the exposure from sliding into home plate or dragging the field will occur much less frequently than the exposure from other activities during practice and it will only happen in the game of baseball."** –El Dorado County Office of Education

ATSDR Response: ATSDR will include a full explanation of the assumptions used in the text of the report and a full description of exact data used to estimate and average fiber concentrations. Each activity scenario had several participants, and because personal air samplers ran continuously throughout the scenario (typically 2 hours), each sample result represents an average exposure concentration over the two-hour period. Activities such as dragging the field took place for only a short period during the entire scenario, and the team member who slid into home base did not wear a personal sampler and performed activities for only 30 minutes of the entire scenario. Thus the results indicate the exposure that might be experienced by a general member of the team, not the actual exposure that was experienced just by the person sliding into home plate or dragging the field. Because players in soccer and other field sports slide and fall down in the course of a game, it is appropriate to apply the baseball results to all grassy field sports.

Comments on General Report Format, Analysis

Request for Additional Discussion of NOA Prevalence: **"Thank you for the opportunity to comment on the exposure assumptions that ATSDR intends to utilize in its upcoming Health Consultation Report for El Dorado Hills. Our comments are submitted in the spirit**

of improving the Consultation and the usefulness of the report for our community. We believe that a number of the comments from the El Dorado Union High School District on the Health Consultation for Oak Ridge High School should be incorporated into this Report. For example, the suggestion that ATSDR provide background information about the prevalence of NOA in California and the emergence of general population exposure to NOA as a potential public health issue is still extremely relevant and would be very helpful." –El Dorado County Office of Education

ATSDR Response: ATSDR has included discussion of the prevalence of natural deposits of asbestos (in California and elsewhere in the United States) and the recent recognition of the potential public health hazard associated with exposure to these deposits beginning on page 12 of the consultation.

Request for Additional Discussion of Cancer Potency Slope for Asbestos: **"We also continue to believe it would be very helpful to include a concise, readable summary of the process of generating a cancer potency slope for asbestos. This discussion would be very helpful in light of the issues associated with applying existing cancer slope factors that were generated from data collected in occupational settings with high levels of asbestos to non-occupational settings with only trace levels. The discussion should describe the process of generating a cancer potency slope, the underlying cancer data utilized for the extrapolation and a very plain language explanation of the applicability of the cancer risk estimates in describing cancer risks at much lower exposure levels. We believe this is particularly important since the EPA is undertaking a major effort to update the IRIS asbestos cancer slope factor. A discussion of the underlying data utilized for the cancer potency slope factor ATSDR intends to use in this study is particularly important if the model is based upon high-level exposure to industrial grade asbestos, since those conditions are not likely to be present in El Dorado Hills.**

"The basis for the cancer potency slope and its use should be prominently presented early in the report. The early information would make interpreting the estimation of risk much easier for the lay reader. It would also be of benefit to include the formula for calculating risk based on average lifetime fiber concentration. We think it is extremely important that the report present the underlying philosophy of cancer potency slope generation and their use. We believe too many people do not understand their derivation (in general terms) and interpret risk estimates as actual risk. For example does ATSDR consider this slope factor to truly calculate the risk for low-level exposure of asbestos? The concepts we find in the 2002 ATSDR Toxicology Profile (i.e., "large degree of uncertainly in extrapolating from the available data to levels of exposure that may be several orders of magnitude lower than the current U.S. occupational exposure limit of 0.1 f/mL.") is extremely valuable. Similarly Page 18 of the Toxicology Profile states there is "considerable uncertainty in using a linear, no-threshold model for calculating health risks." We think these are important concepts that should be explained in the report." –El Dorado County Office of Education

ATSDR Response: ATSDR chose to evaluate risk using more than one asbestos risk model in this consultation. There are advantages and disadvantages to the use of any model. For each model applied, a general description of the assumptions and derivation of the model are given in the text. The uncertainty cited by the commenter is a general uncertainty in any cancer risk assessment, and its inclusion is beyond the scope of this health consultation. Further information on cancer risk assessment can be found in EPA documents [131].

Request to Discuss Berman Risk Protocol: **"As you know, the Final Draft of the Technical Support Document for a Protocol to Assess Asbestos-Related Risk prepared for the EPA by authors Dr. Wayne Berman and Kenny S. Crump examines the existing epidemiology studies to determine the relationship between asbestos exposure and response in humans, and concludes on page 1.4 that "the optimal exposure index that best reconciles the published literature assigns equal potency to fibers longer than 10 um and thinner than 0.4 um and no potency to fibers of other dimensions." If possible, we would appreciate a discussion of this finding and the applicability of the finding to data."** –El Dorado County Office of Education

ATSDR Response: In February 2003, EPA sponsored a peer consultation workshop to obtain feedback from subject matter experts on the scientific merit of the first draft (2001) of the Technical Support Document. The meeting was held in San Francisco, CA, was open to the public, and a report of the workshop is available [92]. Although the panel members were in general agreement that the proposed methodology offered the potential for substantial improvement over the existing (IRIS) methodology, they did made a number of recommendations for improving the methodology, including considering fibers with diameters up to 1.5 µm and performing further analysis to refine fiber size categories. Not all these recommendations were addressed in the final draft protocol cited by the commenter.

ATSDR agrees that dimensional and mineralogical characteristics may have an impact on toxicity of a particular structure and supports further research to elucidate chemical, physical, and toxicological relationships. However, eagerness to supply hard and fast rules of toxicity should be tempered with caution, as there are significant limitations in every existing and proposed model to date. The models are essentially derived by different types of numerical fitting of mortality/morbidity data with reconstructed historical exposures of occupational cohorts. Historical exposure data must be considered uncertain, since inaccuracies can be introduced in worker exposure concentration assignation; conversion of historical particle measurements to more recent fiber measurement techniques; the application of "surrogate" fiber size distribution data to describe historical worker exposures in particular industries; and selective reporting of mineral characteristics by the industries and companies involved. Mortality and morbidity data can also be uncertain due to differences in disease reporting and classification.

Complicated gradations of toxicity with changing dimensional characteristics are far more likely than the simple length/width "bins" of toxicity that have been proposed. With further research (better exposure data and more knowledge of toxicity mechanisms), the goal of finding dimensional "bins" that sufficiently describe toxicity may eventually be discovered. However, at this point it would not be protective of public health to completely dismiss potential toxicity of any elongated mineral particle that could remain in the lung for extended periods.

The Berman and Crump risk method was one of the methods evaluated in this health consultation. In order to evaluate this method, ATSDR funded additional analysis of the data to obtain greater confidence in the long structure concentrations specified for exposure measurement in the method.

Request to Describe Fiber Averaging Assumptions: **"We also believe it would be extremely helpful in the discussion to compare the assumptions used in developing the slope factor and the assumptions that will be used in the Health Consultation. For example, if you are in fact going to assume an "average" length for fibers, the issues associated with this assumption should be explained in some detail. Will you use a log-normal transformation, a median value of some non-parametric technique? Will you use different assumptions, i.e., eliminate all fibers shorter than 10 microns or wider than 0.4 microns from the count, and thus adjust the exposure estimate at the same time? The difference in the assumptions from accepted risk models should also be discussed."** –El Dorado County Office of Education

ATSDR Response: ATSDR chose to evaluate more than one asbestos risk method in this consultation. The exposure measurement definition used (i.e., the size of asbestos-related structures making up the assumed exposure) depends on the size definitions specified in the particular risk method of interest. For example, the IRIS method includes all structures meeting phase contrast microscopy dimensional criteria of greater than 5 microns long, between 0.25 and 3 microns in diameter (inclusive), and with aspect ratios (length:width) of greater than or equal to 3:1 in calculating exposure. ATSDR has included complete information on the specific size characteristics used in each method in explanatory text in the document.

"We also believe it is appropriate to consider the comments from Dr. Berman in his June 30, 2006 report to the NSSGA. A copy of his report is attached for your convenience. The conclusions on page 2 and 3 are significant. Will you use the IRIS risk factor when Dr. Berman has concluded that it will not provide reliable estimates of risk in El Dorado County if the data from the 2005 Ladd study is the basis for the assessment? Do you intend to rely upon this data before the quality control issues are resolved? It would be helpful if the issues raised by Dr. Berman were also addressed in the report." –El Dorado County Office of Education

ATSDR Response: As stated above, ATSDR chose to evaluate the data using more than one asbestos risk method in this consultation. The original data were of sufficient quality to apply most of these methods. ATSDR funded additional analysis of the sample filters to obtain more confidence in long-structure concentrations needed to apply certain of the methods, including the Berman and Crump method.

Figure F2: Original Draft Exposure Assumption Spreadsheet, Tab "Explanatory Text" **[SUPERCEDED]**

ORIGINAL DRAFT FALL 2006 - Explanatory Notes for This Workbook

This workbook contains proposed assumptions for estimating a range of potential exposures to asbestos.

The "Time-Duration" sheet contains proposed estimates of length of time spent in various activities for different age ranges.
The "Fiber Level" sheet contains the proposed methods for estimating fiber level present during each activity using results of EPA air sampling from 2004.

Duration of exposure in various activities will be combined with fiber level for each activity to obtain exposure estimates.
Exposure estimates will be uncertain due to the limited area and quantity of sampling performed.

Notes on Time-Duration Assumptions:

-Three cases are considered: Low, Medium, and High Activity
-The low activity case corresponds to a person who, throughout life, participates in very few outdoor activities. The only exposures beyond background assumed for this case are to required outdoor activities during school years.
-The medium activity case corresponds to a moderate level of participation in outdoor activities, team sports, and outdoor exercise throughout life.
-The high activity case corresponds to those who spend lots of time outdoors, participate in many team sports, and continue high level of outdoor sports and exercise activities throughout life.
-School activities are assumed to be curtailed due to summer break and the winter rainy season.
-Assumed 2 weeks of vacation to an area with no potential for exposure.
-Multiplied 12-18 year old's physical education duration by 4/7 since PE is required only 4 out of the 7 years covered in this age range.
-Background exposure duration calculated as total hours in 50 weeks minus hours of other activities.

Notes on Fiber Level Assumptions:

-We are proposing to use averages of measured fiber levels to estimate exposures.
-We will examine uncertainty/variance to determine if averages are an adequate expression of exposure.
-The values of concentration to use in calculating averages will vary depending on the fiber definition used in the model of interest.
-Asphalt Court Scenarios include all Basketball Scenarios and the Jackson Playground (4-Square) Scenario.
-Grassy Field Scenarios include all Baseball and Soccer Scenarios.
-Activities deemed to be similar to observers use stationary monitors; participants use personal monitors.

NOTE: This version is for review purposes only. We are asking for input from stakeholders to improve the accuracy of assumptions made. All values and assumptions are subject to change!

Figure F3: Original Draft Exposure Assumption Spreadsheet, Tab "Time-Duration" **[SUPERCEDED]**

ORIGINAL DRAFT FALL 2006 - Exposure Assumptions - El Dorado Hills NOA

******See Explanatory Text for Notes******

Case: Low Activity

Age	Activity	Hours per Week	Weeks per Year	fraction	=Hours per Year
Age: 0-4 yrs	Background		50		**8400.0**
Age: 5-11 yrs	Background		50		**8187.5**
	Recess	2.5	34		**85.0**
	PE (half asphalt, half grass)	3.75	34		**127.5**
Age: 12-18 yrs	Background		50		**8327.1**
	PE (half asphalt, half grass)	3.75	34	0.57143	**72.9**
Age: 19-30 yrs	Background		50		**8400.0**
Age: 31-70 yrs	Background		50		**8400.0**

Case: Moderate Activity

Age	Activity	Hours per Week	Weeks per Year	fraction	=Hours per Year
Age: 0-4 yrs	Background		50		**8196.0**
	Tot Lot	3	34		**102.0**
	Bicycling (alone or on parent's bike)	3	34		**102.0**
Age: 5-11 yrs	Background		50		**7777.5**
	Walking on NY Trail to & from school	2	34		**68.0**
	Recess	2.5	34		**85.0**
	PE (half asphalt, half grass)	3.75	34		**127.5**
	Asphalt courts Play	6	20		**120.0**
	Grassy Fields play	6	20		**120.0**
	New York Trail Biking/jogging	3	34		**102.0**
Age: 12-18 yrs	Background		50		**7803.1**
	Walking on NY Trail to & from school	2	34		**68.0**
	PE (half asphalt, half grass)	3.75	34	0.57143	**72.9**
	Asphalt courts Play	8	20		**160.0**
	Grassy Fields play	8	20		**160.0**
	New York Trail Biking/jogging	4	34		**136.0**
Age: 19-30 yrs	Background		50		**8200.0**
	Asphalt courts Play	2	20		**40.0**
	Grassy Fields play	2	20		**40.0**
	New York Trail Biking/jogging	3	40		**120.0**
Age: 31-70 yrs	Background		50		**8270.0**
	Asphalt courts Play	1	20		**20.0**
	Grassy Fields play	1	20		**20.0**
	New York Trail Biking/jogging	2.25	40		**90.0**

Case: High Activity

Age	Activity	Hours per Week	Weeks per Year	fraction	=Hours per Year
Age: 0-4 yrs	Background		50		**7992.0**
	Tot Lot	6	34		**204.0**
	Bicycling (alone or on parent's bike)	6	34		**204.0**
Age: 5-11 yrs	Background		50		**7262.5**
	Walking on NY Trail to & from school	2.5	34		**85.0**
	Recess	2.5	34		**85.0**
	PE (half asphalt, half grass)	3.75	34		**127.5**
	Asphalt courts Play	7	40		**280.0**
	Grassy Fields play	7	40		**280.0**
	New York Trail Biking/jogging	7	40		**280.0**
Age: 12-18 yrs	Background		50		**7738.1**
	Walking on NY Trail to & from school	2.5	34		**85.0**
	PE (half asphalt, half grass)	3.75	34	0.57143	**72.9**
	Asphalt courts Play	14	12		**168.0**
	Grassy Fields play	14	12		**168.0**
	New York Trail Biking/jogging	14	12		**168.0**
Age: 19-30 yrs	Background		50		**8000.0**
	Asphalt courts Play	4	20		**80.0**
	Grassy Fields play	4	20		**80.0**
	New York Trail Biking/jogging	6	40		**240.0**
Age: 31-70 yrs	Background		50		**7920.0**
	Asphalt courts Play	6	20		**120.0**
	Grassy Fields play	6	20		**120.0**
	New York Trail Biking/jogging	6	40		**240.0**

Figure F4: Original Draft Exposure Assumption Spreadsheet, Tab "Fiber Level" **[SUPERCEDED]**

ORIGINAL DRAFT FALL 2006 - Proposed Method to Estimate Fiber Level for Various Activities and Ages

******See Explanatory Text for Notes******

Child Activities (Up to 18 Years Old)

Activity	Proposed Scenario to Describe Exposure During Activity	Proposed Estimate of Fiber Level During Activity
Background	Reference Stations	Average of all reference stations
Tot Lot	Typical Activity Scenario at Tot Lot	Average of personal monitors for child participant in this scenario
Bicycling (alone or on parent's bike)	Biking Scenario on NY Trail (assume similar for other activities on trail)	Average of personal monitors for child participant in this scenario
Walking on NY Trail to & from school	Biking and Jogging Scenarios on NY Trail (assume similar to observer exposure)	Average of stationary monitor samples for these scenarios
Recess	Grassy Field and Asphalt Court Scenarios (assume similar to observer exposure)	Average of all stationary monitor samples for these scenarios
Physical Education	Grassy Field and Asphalt Court Scenarios (assume equal contribution)	Average of personal monitors for child participant in these scenarios
Asphalt Courts Play	Asphalt Court Scenarios	Average of personal monitors for child participant in these scenarios
Grassy Fields Play	Grassy Field Scenarios	Average of personal monitors for child participant in these scenarios
New York Trail Biking/jogging	Biking Scenario on NY Trail (assume similar for other activities on trail)	Average of personal monitors for child participant in this scenario

Adult Activities (Ages 19-70 Years Old)

Activity	Proposed Scenario to Describe Exposure During Activity	Proposed Estimate of Fiber Level During Activity
Background	Reference Stations	Average of all reference stations
Asphalt Courts Play	Asphalt Court Scenarios	Average of personal monitors for child participants and adult nonparticipants (no data on adult participants)
Grassy Fields Play	Grassy Field Scenarios	Average of personal monitors for adult participants in these scenarios
New York Trail Biking/jogging	Jogging Scenario on NY Trail (assume similar for other activities on trail)	Average of personal monitors for adult participants in this scenario

Figure F5: Revised Exposure Assumption Spreadsheet, Tab "Explanatory Notes"
(Note: Tabs "Time-Duration" and "Fiber Concentration" are summarized in the body of the text as Tables 1 and 2.)

REVISED Explanatory Notes for This Workbook

This workbook contains assumptions for estimating a range of potential exposures to asbestos.
The "Time-Duration" sheet contains estimates of length of time spent in various activities for different age ranges.
The "Fiber Level" sheet contains the methods used to estimate fiber level present during each activity using results of EPA air sampling from 2004.
Duration of exposure in various activities is combined with fiber level for each activity to obtain exposure estimates.
Exposure estimates will be uncertain due to the limited area and quantity of sampling performed.

Notes on Time-Duration Assumptions:

-Three cases are considered: Low, Medium, and High Activity
-The low activity case corresponds to a person who, throughout life, participates in very few outdoor activities. The only exposures beyond background assumed for this case are to required outdoor activities during school years.
-The moderate activity case corresponds to a moderate level of participation in outdoor activities, team sports, and outdoor exercise throughout life.
-The high activity case corresponds to those who spend lots of time outdoors, participate in many team sports, and continue high level of outdoor sports and exercise activities throughout life.
-Assumed 2 weeks of vacation to an area with no potential for exposure for a total year of 50 weeks.
-Subtracted 13 week "wet" period (see explanation in school time-duration section below) from 50-week year to obtain "dry" exposure duration assumption of 37 weeks.

School Time-Duration Assumptions:

-School year consists of 180 days (CA law) and runs from mid-August to early June. Assumed 45 weeks of school year. (School breaks included.)
-"Wet" period assumed to have lower background levels of asbestos =13 weeks (based on local construction data, NOAA and weather.com reports).
-Subtracted 13 weeks from 45-week school year to obtain "dry" school year of 32 weeks (for physical education, etc.).
-Assumed 1 hour per week of "digging" for 5-11 year-old's gardening activities at school, only during "dry" times.
-Multiplied 12-18 year old's physical education duration by 4/7 since PE is required only 4 out of the 7 years covered in this age
-Assumed 3 weeks of "digging" for 12-18 year-old's soil science experiments; multiplied by 4/7 since science assumed to be taken 4 out of the 7 years covered in this age range.
-"Dry" background exposure duration calculated as total hours in 50 weeks minus "wet" periods minus hours of other activities.
-Assumed time spent in extracurricular activities split between grassy fields, asphalt courts, and NY Creek Trail ("seasons" or average indicated by weeks per year, total adds up to 36-weeks to include the "dry" school year plus 4 weeks during the summer.) 5-11 year olds have greater proportion of activities on fields & courts.
-For children and adolescents, hours of extracurricular activity averages just under 1 hour per school day for the "moderate" scenario and slightly less than 2 hours per school day for the "high" scenario. The Surgeon General recommends a minimum of 1 hour of physical activity on most days for children and adolescents.

Notes on Fiber Level Assumptions:

-Assume reference stations describe "dry" background levels.
-Assume "wet" periods are described by a value one-tenth that of the "dry" reference station levels. (Supporting info=local construction data, CARB data - see text.)
-Annual average exposure concentrations used scenario averages in mid-range estimates and scenario maximums for high-end estimates. In all calculations, non-detects were counted as zero.
-The values of concentration to use in determining averages/ maximums varies depending on the fiber definition used in the method of interest.
-Asphalt Court Scenarios include all Basketball Scenarios and the Jackson Playground (4-Square) Scenario.
-Grassy Field Scenarios include all Baseball and Soccer Scenarios.
-Activities deemed to be similar to observers use stationary monitors; participants use personal monitors.
-Use of direct measurement data only.

Appendix G. Tabulated Selected Detailed Data and Results

Table G1. Average and Maximum Asbestos Structure Concentrations for Each Activity Scenario.

Activity	AHERA 3:1 - All samples analyzed by EPA (s/cc)		PCMe - All samples analyzed by EPA (f/cc)		AHERA 3:1 - Only Those Samples Selected for Additional Analysis (s/cc)		PCMe - Only Those Samples Selected for Additional Analysis (f/cc)		Chrysotile Structures >10μm Long and 0.4 μm in Diameter - From Additional Analysis (s/cc)		Amphibole Structures >10μm Long and 0.4 μm in Diameter - From Additional Analysis (s/cc)	
row index # -->	2	3	4	5	6	7	8	9	10	11	12	13
	average	maximum	average	maximum	average	maximum	average	maximum	average	maximum	average	maximum
Adult - Asphalt Courts Play	0.005	0.01	0.002	0.005	0.007	0.01	0.003	0.005	0	0	0	0
Adult - Dry Background	0.002	0.006	0.0008	0.004	0.002	0.006	0.0008	0.004	0.000003	0.00008	0.00002	0.0001
Adult - Grassy Fields Play	0.02	0.1	0.004	0.02	0.03	0.1	0.008	0.02	0	0	0.0001	0.001
Adult - New York Trail Biking/jogging	0.04	0.1	0.02	0.06	0.05	0.1	0.03	0.06	0	0	0.0003	0.002
Adult - Wet Background	0.0002	0.0006	0.0001	0.0004	0.0002	0.0006	0.0001	0.0004	0.0000003	0.000008	0.000002	0.00001
Child - "Digging"	0.002	0.003	0.0003	0.001	0.003	0.003	0.001	0.001	0	0	0	0
Child - Asphalt Courts Play	0.006	0.01	0.002	0.005	0.007	0.01	0.003	0.005	0	0	0	0
Child - Bicycling (alone or on parent's bike)	0.06	0.1	0.03	0.08	0.09	0.1	0.05	0.08	0	0	0	0
Child - Dry Background	0.002	0.006	0.0008	0.004	0.002	0.006	0.0008	0.004	0.000003	0.00008	0.00002	0.0001
Child - Grassy Fields Play	0.07	0.8	0.007	0.03	0.1	0.8	0.009	0.03	0.0002	0.004	0.0003	0.001
Child - New York Trail Biking/jogging	0.06	0.1	0.03	0.08	0.09	0.1	0.05	0.08	0	0	0	0
Child - Physical Education	0.05	0.8	0.005	0.03	0.08	0.8	0.008	0.03	0.0001	0.004	0.0002	0.001
Child - Recess	0.02	0.3	0.002	0.02	0.02	0.2	0.004	0.02	0.00003	0.0006	0.0001	0.0006
Child - Tot Lot	0.02	0.3	0.003	0.01	0.04	0.3	0.005	0.01	0.00004	0.0003	0.0001	0.001
Child - Walking on NY Trail to & from school	0.006	0.04	0.003	0.02	0.010	0.04	0.006	0.02	0	0	0.00004	0.0004
Child - Wet Background	0.0002	0.0006	0.00008	0.0004	0.0002	0.0006	0.0001	0.0004	0.0000003	0.000008	0.000002	0.00001

NOTES

Average concentration value for each scenario used to estimate "mid-range" annual average exposure concentration.

Maximum value for each scenario used to estimate "high-end" annual average exposure concentration.

Table G2. Mid-range and High-end Estimated Annual Average Structure Concentrations

	Annual Averages Including All Samples Analyzed by EPA						Annual Averages Including Only Those Samples Selected for Additional Analysis by ATSDR					
	PCMe f/cc (All)						PCMe f/cc (Selected)					
	Mid-range estimate			High-end estimate			Mid-range estimate			High-end estimate		
	Activity Level			Activity Level			Activity Level			Activity Level		
Age	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
0-4 yrs	0.0006	0.0011	0.0015	0.0034	0.0045	0.0055	0.0006	0.0013	0.0020	0.0034	0.0045	0.0055
5-11 yrs	0.0007	0.0009	0.0011	0.0038	0.0044	0.0050	0.0007	0.0011	0.0014	0.0038	0.0044	0.0050
12-18 yrs	0.0006	0.0010	0.0012	0.0035	0.0044	0.0051	0.0007	0.0011	0.0016	0.0035	0.0044	0.0051
19-30 yrs	0.0006	0.0008	0.0010	0.0033	0.0039	0.0044	0.0006	0.0009	0.0011	0.0033	0.0039	0.0044
31-120 yrs	0.0006	0.0007	0.0010	0.0033	0.0037	0.0043	0.0006	0.0008	0.0011	0.0033	0.0037	0.0043
lifetime average	0.0006	0.0008	0.0010	0.0033	0.0039	0.0045	0.0006	0.0009	0.0012	0.0033	0.0039	0.0045

	Annual Averages Including All Samples Analyzed by EPA						Annual Averages Including Only Those Samples Selected for Additional Analysis by ATSDR					
	Total TEM s/cc (3:1 Aspect Ratio, All)						Total TEM s/cc (3:1 Aspect Ratio, Selected))					
	Mid-range estimate			High-end estimate			Mid-range estimate			High-end estimate		
	Activity Level			Activity Level			Activity Level			Activity Level		
Age	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
0-4 yrs	0.002	0.003	0.004	0.005	0.010	0.015	0.002	0.003	0.005	0.005	0.010	0.015
5-11 yrs	0.002	0.003	0.004	0.019	0.026	0.033	0.003	0.004	0.005	0.018	0.025	0.032
12-18 yrs	0.002	0.003	0.004	0.011	0.018	0.024	0.002	0.004	0.005	0.011	0.018	0.024
19-30 yrs	0.002	0.002	0.002	0.005	0.006	0.007	0.002	0.002	0.003	0.005	0.006	0.007
31-120 yrs	0.002	0.002	0.002	0.005	0.006	0.007	0.002	0.002	0.003	0.005	0.006	0.007
lifetime average	0.002	0.002	0.003	0.006	0.008	0.010	0.002	0.002	0.003	0.006	0.008	0.010

	Annual Averages for Structures Used in Berman Crump Method Determined from Samples Selected for Additional Analysis by ATSDR											
	Amphibole Fibers >10 μm Long, ?0.4 μm in Diameter						Chrysotile Fibers >10 μm Long, ?0.4 μm in Diameter					
	Mid-range estimate			High-end estimate			Mid-range estimate			High-end estimate		
	Activity Level			Activity Level			Activity Level			Activity Level		
Age	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High	Low	Moderate	High
0-4 yrs	0.000017	0.000018	0.000019	0.00010	0.00011	0.00012	0.000002	0.000003	0.000003	0.00006	0.00006	0.00006
5-11 yrs	0.000020	0.000022	0.000024	0.00012	0.00013	0.00014	0.000005	0.000006	0.000008	0.00012	0.00015	0.00018
12-18 yrs	0.000019	0.000020	0.000022	0.00011	0.00012	0.00012	0.000003	0.000005	0.000006	0.00009	0.00012	0.00014
19-30 yrs	0.000016	0.000020	0.000022	0.00010	0.00012	0.00013	0.000002	0.000002	0.000002	0.00006	0.00006	0.00006
31-120 yrs	0.000016	0.000019	0.000022	0.00010	0.00011	0.00013	0.000002	0.000002	0.000002	0.00006	0.00006	0.00006

NOTES

Mid-range estimate uses average concentration value for each scenario in calculating annual average across all scenarios.

High-end estimate uses highest concentration value for each scenario in calculating annual average across all scenarios.

Table G3. 2003 All-Cause Death Rates Used in Life Table Analysis (Source: [108]).

	Males		Females	
Age	Probability of Dying Between Year x and x+1 (from Table 2. Life Table for Males, United States, 2003)	Unexposed Death Rate (from solving Equation D3, equals -ln(1-probability of dying))	Probability of Dying Between Year x and x+1 (from Table 3. Life Table for Females, United States, 2003)	Unexposed Death Rate (from solving Equation D3, equals -ln(1-probability of dying))
0-1	0.007611	0.00764	0.006083	0.00610
1-2	0.000518	0.00052	0.00041	0.00041
2-3	0.000365	0.00037	0.000296	0.00030
3-4	0.000293	0.00029	0.000223	0.00022
4-5	0.00022	0.00022	0.000175	0.00018
5-6	0.000192	0.00019	0.000143	0.00014
6-7	0.000173	0.00017	0.000127	0.00013
7-8	0.000152	0.00015	0.000132	0.00013
8-9	0.000157	0.00016	0.000121	0.00012
9-10	0.000138	0.00014	0.000129	0.00013
10-11	0.000186	0.00019	0.000143	0.00014
11-12	0.000162	0.00016	0.000132	0.00013
12-13	0.000217	0.00022	0.000133	0.00013
13-14	0.000255	0.00026	0.000164	0.00016
14-15	0.000334	0.00033	0.000176	0.00018
15-16	0.00043	0.00043	0.000243	0.00024
16-17	0.000706	0.00071	0.000353	0.00035
17-18	0.000908	0.00091	0.000399	0.00040
18-19	0.001212	0.00121	0.000494	0.00049
19-20	0.001356	0.00136	0.000465	0.00047
20-21	0.001395	0.00140	0.000486	0.00049
21-22	0.001412	0.00141	0.000489	0.00049
22-23	0.001444	0.00145	0.000505	0.00051
23-24	0.001388	0.00139	0.000495	0.00050
24-25	0.001373	0.00137	0.000514	0.00051
25-26	0.001326	0.00133	0.000494	0.00049
26-27	0.00136	0.00136	0.000547	0.00055
27-28	0.001317	0.00132	0.000566	0.00057
28-29	0.001301	0.00130	0.000549	0.00055
29-30	0.001367	0.00137	0.000618	0.00062
30-31	0.001393	0.00139	0.000626	0.00063
31-32	0.001416	0.00142	0.000669	0.00067
32-33	0.001521	0.00152	0.000693	0.00069
33-34	0.001505	0.00151	0.000799	0.00080
34-35	0.001596	0.00160	0.000852	0.00085
35-36	0.001732	0.00173	0.000977	0.00098
36-37	0.001876	0.00188	0.00104	0.00104
37-38	0.002008	0.00201	0.001141	0.00114
38-39	0.002126	0.00213	0.001216	0.00122
39-40	0.002341	0.00234	0.001356	0.00136
40-41	0.002535	0.00254	0.001521	0.00152
41-42	0.0028	0.00280	0.001635	0.00164
42-43	0.00304	0.00304	0.001795	0.00180
43-44	0.003231	0.00324	0.001876	0.00188
44-45	0.003582	0.00359	0.002125	0.00213
45-46	0.003777	0.00378	0.002261	0.00226
46-47	0.004278	0.00429	0.002486	0.00249
47-48	0.004598	0.00461	0.002613	0.00262
48-49	0.004926	0.00494	0.00278	0.00278
49-50	0.005356	0.00537	0.00304	0.00304
50-51	0.005773	0.00579	0.003264	0.00327
51-52	0.006153	0.00617	0.003508	0.00351
52-53	0.006633	0.00666	0.003829	0.00384
53-54	0.006813	0.00684	0.003978	0.00399
54-55	0.007688	0.00772	0.004502	0.00451
55-56	0.007986	0.00802	0.004759	0.00477
56-57	0.009095	0.00914	0.005466	0.00548
57-58	0.008825	0.00886	0.005474	0.00549
58-59	0.010289	0.01034	0.006512	0.00653
59-60	0.011298	0.01136	0.007104	0.00713
60-61	0.012631	0.01271	0.007979	0.00801
61-62	0.013049	0.01313	0.00815	0.00818
62-63	0.014841	0.01495	0.009356	0.00940
63-64	0.015666	0.01579	0.010029	0.01008
64-65	0.017184	0.01733	0.11201	0.11879
65-66	0.018456	0.01863	0.011923	0.01199
66-67	0.020034	0.02024	0.012895	0.01298
67-68	0.021998	0.02224	0.0144225	0.01453
68-69	0.023697	0.02398	0.015455	0.01558
69-70	0.026257	0.02661	0.016688	0.01683
70-71	0.028427	0.02884	0.01889	0.01907
71-72	0.030325	0.03079	0.020078	0.02028
72-73	0.033933	0.03452	0.022156	0.02241
73-74	0.036781	0.03747	0.024088	0.02438
74-75	0.039863	0.04068	0.026516	0.02687
75-76	0.04446	0.04548	0.02915	0.02958
76-77	0.048518	0.04973	0.032215	0.03275
77-78	0.052622	0.05406	0.035695	0.03635
78-79	0.057085	0.05878	0.038807	0.03958
79-80	0.062847	0.06491	0.043098	0.04405
80-81	0.069652	0.07220	0.048423	0.04963
81-82	0.075675	0.07869	0.053033	0.05449
82-83	0.081382	0.08488	0.05839	0.06016
83-84	0.094027	0.09875	0.067373	0.06975
84-85	0.095172	0.10001	0.069965	0.07253
85-86	0.103762	0.10955	0.077121	0.08026
86-87	0.113017	0.11993	0.084936	0.08876
87-88	0.122971	0.13122	0.093453	0.09811
88-89	0.133651	0.14347	0.102719	0.10839
89-90	0.145087	0.15676	0.112778	0.11966
90-91	0.157299	0.17114	0.123671	0.13201
91-92	0.170307	0.18670	0.135439	0.14553
92-93	0.184124	0.20349	0.148116	0.16030
93-94	0.198755	0.22159	0.161733	0.17642
94-95	0.214201	0.24105	0.176314	0.19397
95-96	0.230452	0.26195	0.191874	0.21304
96-97	0.247491	0.28434	0.208419	0.23372
97-98	0.265289	0.30828	0.225945	0.25611
98-99	0.283809	0.33381	0.244433	0.28029
99-100	0.303003	0.36097	0.263854	0.30633
100+	1	*extend above death rate out to age 120	1	*extend above death rate out to age 120

Table G4. 2003 Lung Cancer Death Rates Used in Life Table Analysis (Source: [107]).

	Males		Females			Males		Females	
Age	Lung Cancer Death Rate per 100,000 (from Worktable 210R, 2003	Lung Cancer Death Rate	Lung Cancer Death Rate per 100,000 (from Worktable 210R, 2003	Lung Cancer Death Rate	Age	Lung Cancer Death Rate per 100,000 (from Worktable 210R, 2003	Lung Cancer Death Rate	Lung Cancer Death Rate per 100,000 (from Worktable 210R, 2003	Lung Cancer Death Rate
0-1	0	0	0	0	43-44	9.5	0.00010	7.5	0.000075
1-2	0	0	0	0	44-45	9.5	0.00010	7.5	0.00008
2-3	0	0	0	0	45-46	24.8	0.00025	17.8	0.00018
3-4	0	0	0	0	46-47	24.8	0.00025	17.8	0.00018
4-5	0	0	0	0	47-48	24.8	0.00025	17.8	0.00018
5-6	0	0	0	0	48-49	24.8	0.00025	17.8	0.00018
6-7	0	0	0	0	49-50	24.8	0.00025	17.8	0.00018
7-8	0	0	0	0	50-51	50.0	0.00050	31.9	0.00032
8-9	0	0	0	0	51-52	50.0	0.00050	31.9	0.00032
9-10	0	0	0	0	52-53	50.0	0.00050	31.9	0.00032
10-11	0	0	0	0	53-54	50.0	0.00050	31.9	0.00032
11-12	0	0	0	0	54-55	50.0	0.00050	31.9	0.00032
12-13	0	0	0	0	55-56	101.3	0.0010	63.5	0.00064
13-14	0	0	0	0	56-57	101.3	0.0010	63.5	0.00064
14-15	0	0	0	0	57-58	101.3	0.0010	63.5	0.00064
15-16	0	0	0	0	58-59	101.3	0.0010	63.5	0.00064
16-17	0	0	0	0	59-60	101.3	0.0010	63.5	0.00064
17-18	0	0	0	0	60-61	183.7	0.0018	117.4	0.0012
18-19	0	0	0	0	61-62	183.7	0.0018	117.4	0.0012
19-20	0	0	0	0	62-63	183.7	0.0018	117.4	0.0012
20-21	0	0	0	0	63-64	183.7	0.0018	117.4	0.0012
21-22	0	0	0	0	64-65	183.7	0.0018	117.4	0.0012
22-23	0	0	0	0	65-66	292.1	0.0029	176.2	0.0018
23-24	0	0	0	0	66-67	292.1	0.0029	176.2	0.0018
24-25	0	0	0	0	67-68	292.1	0.0029	176.2	0.0018
25-26	0	0	0.2	0.000002	68-69	292.1	0.0029	176.2	0.0018
26-27	0	0	0.2	0.000002	69-70	292.1	0.0029	176.2	0.0018
27-28	0	0	0.2	0.000002	70-71	411.0	0.0041	236.1	0.0024
28-29	0	0	0.2	0.000002	71-72	411.0	0.0041	236.1	0.0024
29-30	0	0	0.2	0.000002	72-73	411.0	0.0041	236.1	0.0024
30-31	0.7	0.000007	0.5	0.000005	73-74	411.0	0.0041	236.1	0.0024
31-32	0.7	0.000007	0.5	0.000005	74-75	411.0	0.0041	236.1	0.0024
32-33	0.7	0.000007	0.5	0.000005	75-76	514.2	0.0051	277.9	0.0028
33-34	0.7	0.000007	0.5	0.000005	76-77	514.2	0.0051	277.9	0.0028
34-35	0.7	0.000007	0.5	0.000005	77-78	514.2	0.0051	277.9	0.0028
35-36	2.4	0.000024	2.5	0.000025	78-79	514.2	0.0051	277.9	0.0028
36-37	2.4	0.000024	2.5	0.000025	79-80	514.2	0.0051	277.9	0.0028
37-38	2.4	0.000024	2.5	0.000025	80-81	541.5	0.0054	281.4	0.0028
38-39	2.4	0.000024	2.5	0.000025	81-82	541.5	0.0054	281.4	0.0028
39-40	2.4	0.000024	2.5	0.000025	82-83	541.5	0.0054	281.4	0.0028
40-41	9.5	0.000095	7.5	0.000075	83-84	541.5	0.0054	281.4	0.0028
41-42	9.5	0.000095	7.5	0.000075	84-85	541.5	0.0054	281.4	0.0028
42-43	9.5	0.000095	7.5	0.000075	85+	475.1	0.0048	221.0	0.0022

Appendix H. ATSDR Fact Sheets

Note: the following two fact sheets were included with earlier versions of this health consultation. They may contain outdated information. Please check ATSDR's El Dorado Hills website (www.atsdr.cdc.gov/sites/eldoradohills) for current contact information and updated fact sheets.

"Limiting Environmental Exposure to Asbestos in Areas With Naturally Occurring Asbestos";
"Asbestos For Workers Involved in Activities That Disturb Soil or Generate Dust in Areas With Naturally Occurring Asbestos"

This fact sheet was written by the **Agency for Toxic Substances and Disease Registry** (ATSDR), a federal public health agency. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposure and disease related to toxic substances.

Asbestos

Limiting Environmental Exposure to Asbestos in Areas with Naturally Occurring Asbestos

Who should read this fact sheet

Read this fact sheet if you or someone you know currently lives, works, attends school, or plays in areas with asbestos in the soils, or has done so in the past.

Purpose of this fact sheet

This fact sheet answers the following questions:

- What is asbestos?
- How could asbestos exposure make you sick?
- What can you do to reduce your exposure to asbestos?
- Where can you get more information?

05-0278

What is asbestos?

Asbestos defined

Asbestos is the name given to a group of six different fibrous minerals that occur naturally in the environment. Asbestos fibers are too small to be seen by the naked eye. They do not dissolve in water or evaporate. They are resistant to heat, fire, and chemical or biological degradation.

Naturally occurring asbestos refers to those fibrous minerals that are found in the rocks or soil in an area and released into the air by:

- routine human activities or
- weathering processes.

If naturally occurring asbestos is not disturbed and fibers are not released into the air, then it is not a health risk. Asbestos is used in many commercial products, including insulation, brake linings, and roofing shingles.

Classes of asbestos

The two general classes of asbestos are amphibole and chrysotile (fibrous serpentine). Chrysotile asbestos has long, flexible fibers. This type of asbestos is most commonly used in commercial products. Amphibole fibers are brittle, have a rod or needle shape, and are less common in commercial products. Although exposure to both types of asbestos increases the likelihood of developing asbestos-related illness, amphibole fibers tend to stay in the lungs longer. They also are thought to increase the likelihood of illness, especially mesothelioma, to a greater extent than chrysotile asbestos.

Where asbestos is found in your environment

Asbestos is commonly found in ultramafic rock, including serpentine rock, and near fault zones. The amount of asbestos that is typically present in these rocks ranges from less than 1% up to about 25%, and sometimes more. Asbestos can be released from ultramafic and serpentine rock if the rock is broken or crushed.

In California, ultramafic rock, including serpentine rock, is found in the Sierra foothills, the Klamath Mountains, and the Coast Ranges. This type of rock is present in at least 44 of California's 58 counties. Not all ultramafic rock contains asbestos, it only has the potential to contain asbestos. Environmental testing can determine if a rock contains asbestos.

How you might be exposed to asbestos

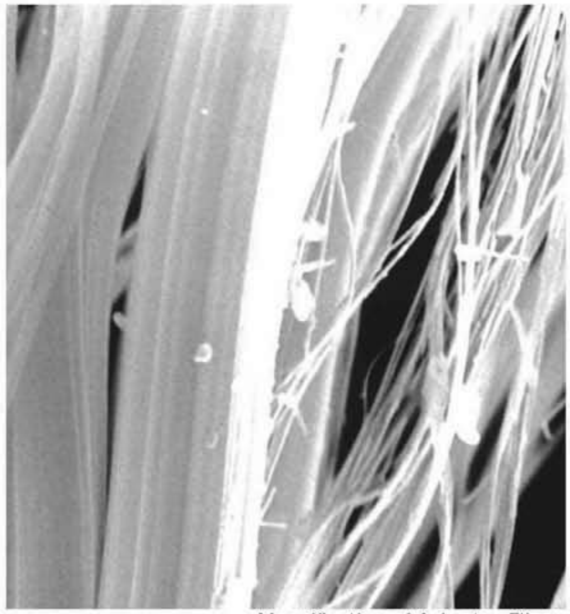
You might be exposed to asbestos through routine activities that crush asbestos-containing rock or stir up dust in soils that contain asbestos fibers. The following are some examples of these activities:

- Working in your yard or garden
- Digging or shoveling dirt
- Riding bicycles on unpaved surfaces
- Riding off-road vehicles such as four wheelers and dirt bikes
- Running and hiking on unpaved surfaces
- Driving over unpaved surfaces

How could asbestos exposure make you sick?

Important!

Being exposed to asbestos does not mean you will develop health problems. Many things need to be considered when evaluating whether you are at risk for health problems from asbestos exposure. A doctor can help you find out whether you are at risk for health problems from asbestos exposure.



Magnification of Asbestos Fibers

Asbestos exposure and health

Asbestos is made up of fibers that are so small that you cannot see them. If asbestos fibers are in the air you breathe, you might get asbestos fibers in your lungs. Breathing in the fibers is the primary way that people are exposed to asbestos.

Asbestos fibers may remain in the lungs for a lifetime. In some cases, the fibers might damage the lungs or the membranes that cover the lungs, leading to illness and even death. Most people don't show any signs or symptoms of asbestos-related disease until 10 to 20 years or more after they were exposed.

For more information about asbestos-related disease, refer to ATSDR's fact sheet entitled:
"Asbestos and Health: Frequently Asked Questions"

What can you do to reduce your exposure to asbestos?

Take steps right now

Limit exposure by taking the following steps if you live in an area where naturally occurring asbestos has been disturbed and is likely to become airborne:

- Walk, run, hike, and bike only on paved trails.
- Play only in outdoor areas with a ground covering such as wood chips, mulch, sand, pea gravel, grass, asphalt, shredded rubber, or rubber mats.
- Pave over unpaved walkways, driveways, or roadways that may have asbestos-containing rock or soil.
- Cover asbestos-containing rock or soil in gardens and yards with asbestos-free soil or landscape covering.
- Pre-wet garden areas before digging or shoveling soil.
- Keep pets from carrying dust or dirt on their fur or feet into the home.
- Remove shoes before entering your home to prevent tracking in dirt.
- Use doormats to lower the amount of soil that is tracked into the home.
- Keep windows and doors closed on windy days and during nearby construction.
- Drive slowly over unpaved roads.
- Use a wet rag instead of a dry rag or duster to dust.
- Use a wet mop on non-carpeted floors.
- Use washable area rugs on your floors and wash rugs regularly.
- Vacuum your carpet often using a vacuum with a high efficiency HEPA filter.

Where can you get more information?

Stay informed

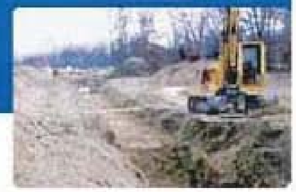
If you want more information about how to limit environmental exposure to asbestos, or if you have specific questions, contact ATSDR:

Toll free call:
1-888-42-ATSDR (1-888-422-8737)

Online:
http://www.atsdr.cdc.gov/contactus.html

Some of the information in this fact sheet comes from the brochure Asbestos-Containing Rock and Soil—What California Homeowners and Renters Need to Know, California Air Resources Board, 2002. Accessed online at http://www.arb.ca.gov/cap/pamphlets/asbestosbrochure.pdf on April 26, 2005.

This fact sheet was prepared by the Agency for Toxic Substances and Disease Registry (ATSDR). ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances.



Asbestos

For workers involved in activities that disturb soil or generate dust in areas with naturally occurring asbestos.

Who should read this fact sheet?

This fact sheet is for people in El Dorado County, California who work or have worked outdoors in areas where asbestos has been found in the soil. Some of this information may apply to other locations where naturally occurring asbestos is present.

Purpose of this fact sheet

This fact sheet addresses common asbestos-related concerns, such as:

- How do you find out if asbestos is a problem in your work area?
- Who do you contact if you suspect a problem with asbestos at work?
- How can you be exposed to asbestos at work?
- How can you protect yourself from asbestos at work?

Limiting Asbestos Exposure While Working in Areas with Naturally Occurring Asbestos

What is asbestos?

Asbestos defined

Asbestos is a group of fibrous minerals that occur naturally in rock formations. Asbestos fibers are too small to be seen by the naked eye. They do not dissolve in water or evaporate. They resist heat, fire, and chemical or biological degradation. Because of these properties, asbestos has been mined and used in many commercial products including insulation, fireproofing and acoustic materials, wallboard, plaster, cement, floor tiles, brake linings, and roofing shingles.

Naturally occurring asbestos

Naturally occurring asbestos refers to those fibrous minerals that are found in the rocks or soil in some areas and released into the air by routine human activities or weathering processes. ***If naturally occurring asbestos is not disturbed and fibers are not released into the air, then it is not a health risk.***

Where asbestos is found in your environment

Asbestos is commonly found in ultramafic rock, including serpentine rock, and near fault zones. The typical amount of asbestos in these rocks ranges from less than 1% to 25%. Asbestos can be released into the air or soil if the rock is broken or crushed.

Asbestos *Limiting Asbestos Exposure While Working in Areas with Naturally Occurring Asbestos*

In California, ultramafic rock, including serpentine rock, is found in the Sierra foothills, the Klamath Mountains, and the Coast Ranges. This type of rock is present in at least 44 of California's 58 counties. Not all ultramafic rock contains asbestos. Environmental testing can determine if a rock contains asbestos.

How can you find out if a problem exists in your work area?

Who to contact to find out if a problem exists

To learn if you work in an area that might have naturally occurring asbestos, consult the following agencies:

1. California Geological Survey provides information on the geology of asbestos occurrences in California. http://www.consrv.ca.gov/cgs/minerals/hazardous_minerals/asbestos/index.htm

2. El Dorado County Environmental Management Department http://www.co.el-dorado.ca.us/emd/apcd/asbestos.html.

These agencies can assist with understanding the current conditions in your area. **If asbestos is present in an area, but it is not disturbed by human activity or construction, then it is not a health risk.**

How to find out if asbestos is present in a work area

If you work in an area with naturally occurring asbestos, the only way to know if asbestos is present where you work is to test your work area. The Occupational Safety and Health Administration's (OSHA) asbestos standards need to be followed when working with asbestos. More information is posted on the OSHA Internet page at:

http://www.osha.gov/SLTC/asbestos/index.html

Material that contains asbestos is not a health risk if it is undisturbed or covered. It can be a hazard if it becomes friable (crumbly) and airborne.

How can you be exposed to asbestos?

How you might be exposed to asbestos

Limit activities that create dusty conditions near asbestos containing soil. You might be exposed to asbestos through activities that crush asbestos-containing rock or stir up dust in soils that contain asbestos in your work area. The following are some examples of activities that might result in exposure if they create dusty conditions:

- Working in a garden
- Digging or shoveling dirt
- Landscaping
- Sweeping or leaf blowing
- Plowing or planting
- Excavating or using a backhoe
- Rock drilling or using a jackhammer
- Driving over unpaved surfaces
- Walking or running on gravel roads
- Running underground cable or pipe
- Disturbing dirt on unpaved surfaces
- Felling trees because it disturbs dirt
- Blasting, chipping, hammering, drilling, crushing, loading, hauling, and dumping rock
- Working near a helicopter that is creating dusty conditions
- Working in railroad construction or maintenance
- Working in highway construction or maintenance
- Operating heavy equipment where the soil contains asbestos fibers
- Engaging in any activity that disturbs the soil or crushes rocks that contain asbestos

Types of workers who may be exposed to naturally occurring asbestos

Any activity that creates dust or disturbs soil in an area where asbestos is present can cause exposure to asbestos. Construction workers and excavators have jobs that could expose them to asbestos. These include backhoe, crane, tractor, and other heavy equipment operators. Miners, rock drillers or jackhammer operators, demolition workers, bricklayers, stone workers, and cement workers also have jobs that could expose them to asbestos. Other people who might be exposed to asbestos on-the-job include utility workers, lumberjacks, foundry workers, and gravel pit operators.

Highway and railroad construction or maintenance workers also may be at risk. The list also includes outdoor sports instructors and playground workers, outdoor maintenance workers, farmers and nursery workers, landscapers, and others.

What can you do to reduce potential asbestos exposure?

Take steps to avoid dusty conditions and reduce exposure

Workers should take steps to limit the generation and inhalation of dust known or thought to be contaminated by asbestos. As with any dust workers should avoid prolonged high-level exposures. If you work in areas that contain naturally occurring asbestos that can become airborne and creates dusty conditions, limit your exposure by taking some of the following steps:

- Use wet methods to reduce airborne exposure. Wet the soil before gardening or planting. Wet down dusty areas when operating a jackhammer or when cleaning up construction sites.
- Avoid handling or disturbing loose material that contains asbestos.
- Never use compressed air for cleaning. Also avoid using leaf blowers.
- Avoid dry sweeping, shoveling, or other dry clean-up methods.
- When drilling rock, apply water through the drill stem to reduce airborne dust, or use a drill with a dust collection system.
- Follow OSHA and EPA standards for disposing of waste and debris that contains asbestos. Use appropriate leak-proof containers.
- Do not eat, drink, or smoke in dusty work areas where asbestos fibers may be airborne. Move away from the work area for breaks. Also wash your hands and face before eating, drinking, or smoking.
- Limit bystander exposure. Prevent visitors and coworkers from standing in work areas where asbestos fibers may be airborne.
- Use disposable protective clothing or clothing that is left in the workplace.
- Shower (if possible), wash your hair, and change out of work clothes before leaving the worksite. This helps prevent contamination of car, home, and other work areas.
- Do not wash work clothing at home. The people you live with could develop asbestos-related diseases from the fibers brought home on work clothes and boots.
- Drive slowly over unpaved roads, with windows and vents closed.
- Keep vehicles dust-free to prevent continuing exposure. Wash equipment and vehicles when the job is finished.

Personal Protective Equipment (PPE)

When working with material that may contain asbestos, use proper breathing protection. When you need to reduce asbestos exposure below OSHA standards, wear respirators that use high-efficiency filters (e.g., N100). Supplied air respirators also are effective.

Which type of respirator to use depends upon the amount of airborne asbestos or conditions of use. Medical clearance and respirator training are also required. Disposable respirators or dust masks do not prevent asbestos exposure. If personal protective equipment (PPE) is required at your worksite for asbestos work, then use proper respiratory protection. OSHA guidelines for PPE are posted at:

http://www.osha.gov/SLTC/respiratoryprotection/index.html or http://www.cdc.gov/niosh/npptl/topics/respirators/

How can asbestos make you sick?

Asbestos exposure and health

If asbestos fibers are in the air you breathe, the fibers may lodge in your lungs. The tiny fibers can scar your lungs and make it difficult to breath. That condition is called asbestosis. The fibers also can cause lung cancer and mesothelioma. Mesothelioma is a cancer of the membrane that covers the lungs and chest cavity (pleura). It is also a cancer of the membrane that lines the abdominal cavity (peritoneum). The symptoms of these diseases do not usually appear until about 15 to 40 years after the first exposure to asbestos. However, being exposed to asbestos does not mean you will definitely develop health problems. Many factors influence a person's chances of developing disease. They include how much, how often, and how long a person is exposed to asbestos. They also include the type of asbestos the person is exposed to, and that person's smoking history.

Workers who have significant past or ongoing exposure to asbestos should get a medical exam from a physician who knows about diseases caused by asbestos. The OSHA asbestos standard (http://www.osha.gov/SLTC/asbestos/compliance.html) describes medical tests used to assess workers exposed to asbestos.

For more information about asbestos-related disease, refer to ATSDR's "Asbestos and Health: Frequently Asked Questions" fact sheet. You can find it online at: http://www.atsdr.cdc.gov/NOA/Asbestos-and%20Health.pdf

Smoking and asbestos exposure

Smokers exposed to asbestos are much more likely to develop asbestos-related lung cancer than are most nonsmokers. Smoking also causes asbestosis to progress more quickly. Workers should quit smoking and avoid the cigarette smoke of others. Employers can help workers by offering smoking cessation programs.

Where can you get more information?

Stay informed

Contact ATSDR or the National Institute for Occupational Safety and Health (NIOSH) for more information about how to limit exposure to asbestos in the workplace and for answers to specific questions.

Toll free call:

1-888-42-ATSDR (1-888-422-8737) ATSDR:
http://www.atsdr.cdc.gov/asbestos/

or

1-800-35-NIOSH (1-800-356-4674) NIOSH:
http://www.cdc.gov/niosh/topics/asbestos/

Online Resources:

Protect Your Family: Reduce Contamination at Home
DHHS (NIOSH) Publication No. 97-125 (1997)
http://www.cdc.gov/niosh/thttext.html

Occupational Respiratory Disease Surveillance (ORDS)
NIOSH Topic Page about occupational respiratory disease medical screening and monitoring
http://www.cdc.gov/niosh/topics/surveillance/ORDS/

Work Related Lung Disease Surveillance Report 2002
DHHS (NIOSH) Publication No. 2003-111 (2002)
http://www.cdc.gov/niosh/docs/2003-111/2003-111.html

Environmental Protection Agency:

Naturally Occurring Asbestos in California:
http://www.epa.gov/region09/toxic/noa/index.html

General Information about Asbestos:
http://www.epa.gov/oppt/asbestos/help.html

Some of the information in this fact sheet comes from the brochure NIOSH Recommendations for Limiting Potential Exposures of Workers to Asbestos Associated with Vermiculite from Libby, Montana 2002. Access online at http://www.cdc.gov/niosh/docs/2003-141/ or call 1-800-35-NIOSH to request a copy.

05-0605-Asbestos

Appendix I. Public Comments Received and ATSDR Responses

This health consultation was available for public review and comment at the El Dorado County Main Library in Placerville, California; the El Dorado Hills Community Services District offices in El Dorado Hills, California; and the El Dorado Hills Branch Library in El Dorado Hills, California. The public comment period was open from March 29, 1010 through June 30, 2010. The document was also available for viewing or downloading from the ATSDR web site.

The public comment period was announced to local media outlets. ATSDR presented and discussed the findings of the health consultation with community members at informal open houses on May 21 and 22, 2010, at the El Dorado Hills Fire Station 85 in El Dorado Hills, California. Copies of the health consultation and fact sheets summarizing the findings were also provided to the community during these open houses.

ATSDR also shared the findings of the health consultation with local, state, and federal partner agencies shortly before the public release. However, we requested all comments be submitted through the public comment process, so that comments could be part of the official record and to improve the transparency of the changes to be made to the document.

ATSDR received written comments from private citizens, academic researchers active in the field, a previous peer reviewer of the draft health consultation, and local and federal agencies. The comments received are listed in their entirety below (with personal identifiers for private citizens removed). ATSDR responses are inserted as italicized text. Notes and removed text are indicated in a different font. Page and figure numbers in comments refer to the public comment version of the health consultation, whereas those cited in ATSDR responses refer to this final version.

Many changes have been made to the health consultation based on the public comments received. The responses below indicate changes made, but the major changes are summarized here:

- We have rewritten Conclusion 2 to emphasize that actions to reduce harmful exposures are needed.
- We have expanded the discussion of other NOA sites throughout the world where asbestos disease was found to include a discussion of the exposures occurring and any exposure data collected. This discussion is in the section “Naturally Occurring Asbestos” beginning on page 12.
- We have included a new section entitled “Feasibility and Need for Further Investigation”, beginning on page 40, which addresses questions related to health studies and reports updated statistics on mesothelioma rates in the area.

Comments from a private citizen (PC1):

PC1-1: Thank you for your health consultation document. It provides a very appropriate analytical perspective, and in doing so it will be a good resource for discussion of this issue in our community. My specific comments follow below as individual bullet items.

ATSDR Response: Thank you for your comment.

PC1-2: Historic population of El Dorado Hills (EDH): The Census-based population reports undercount the historic population of EDH:

Between the time of the Gold Rush and the start of development as El Dorado Hills in 1962 this area was known as Clarksville. At its peak in the 19th Century Clarksville reached a population of about 17,000 before beginning a gradual decline. I'm not aware of any indication of an unusual incidence of lung-related illness or mortality in that period.

The Census population listed as about 6,400 in 1990 is for an area smaller than the actual EDH Community Region. In fact, [personal information removed] in 1990 the sign on US 50 listed the EDH population as more than 14,000. The Census Designated Place was unchanged for the 2000 Census, when it reported 18,016. A better indication of EDH population is the set of statistics published in each Annual Report of the El Dorado Hills County Water District ("Fire Department"). That report for 2009 showed a current population between 42,000 and 43,000.

ATSDR Response: ATSDR cited U.S. Census data, which is validated and of high quality. Because El Dorado Hills is not incorporated, it is very possible that population counts vary depending on how boundaries are defined. The idea that population in El Dorado Hills has grown rapidly in recent years is the same, regardless of the actual population count used.

PC1-3: The 2010 Census will have a realistically defined Census Designated Place for El Dorado Hills. [personal information about position in community] In many respects EDH is defined more by the topology of our road network than by conventional geography.

ATSDR Response: Thank you for this comment. No response is necessary.

PC1-4: Incidence of mesothelioma:

At one point in time when NOA was active as a public issue I checked statistics for the national average rate of occurrence of mesothelioma in the general population, then used the ratio of El Dorado County population to national population to project the expected number of active cases in El Dorado County. This projection produced an expectation of 1.8 cases. I then checked the number of actual cases in the County at that time, which proved to be 2. This was consistent with a conjecture that El Dorado County as a whole did not have an exceptional rate of mesothelioma. That quantization would tend to support a further conjecture that whatever risk may exist locally from NOA is small enough to be unmeasurable by that particular metric.

ATSDR Response: ATSDR requested the California Cancer Registry update the mesothelioma statistics on western El Dorado County as discussed in the section beginning on page 40. The results confirm this observation - mesothelioma rates are not significantly elevated.

PC1-5: EPA sampling for NOA:

In addition to hearing a report of EPA's techniques for activity-based sampling, a friend personally observed the EPA sampling at the El Dorado Hills Community Services District, on a softball field. His description emphasized that the EPA's technique was far in excess of ground disturbance that would occur naturally during a softball game. Based on his description I'd expect the EPA's results to be generally as least one order of magnitude (factor of 10) higher than normal, probably closer to two orders of magnitude (factor of 100), and possibly as much as 3 orders of magnitude (factor of 1,000). This limits my confidence in relevance of the EPA measurements.

ATSDR Response: It is impossible to construct an activity scenario that exactly represents actual activity patterns. Because the concern for exposures is greatest during times when dust control measures do not occur, when windy conditions result in airborne dust, or when children throw dirt at each other, it is protective to estimate potential exposures under these conditions.

PC1-6: An anecdotal case: [anecdote of relative who worked in offices of a plant where asbestos-insulated tile was produced; relative never had asbestos related health problems and died of natural causes at age 89.] One case forms the smallest possible sample set in statistics, but this at least appears to provide an existence proof that low-level exposure to asbestos does not guarantee to produce serious health problems.

ATSDR Response: Thank you for sharing this information. This kind of personal variability is what makes determining effects of exposure so difficult.

PC1-7: There is a possibility that a set of El Dorado Hills residents have asserted NOA risk for political purposes, arguing against certain specific new development, especially for new housing planned for construction on Oak Ridge. Historically, most of the EDH population has wanted to remain a small community with a rural interface, while El Dorado County government has sought to build El Dorado Hills into a robust but unincorporated city.

ATSDR Response: Thank you for this comment. No response is necessary.

PC1-8: Considering all factors, I think your basic conclusion is reasonable, that any actual NOA impacts in El Dorado Hills probably are not significant enough to measure. However, somewhat at variance with part of your conclusions, I think that the EDH population has in fact been large enough for a sufficient number of decades to afford observation of any substantial incidence of NOA-related health problems.

ATSDR Response: Thank you for this comment. In response to numerous comments we received regarding the draft conclusions, we have reworded conclusion 2 and it no longer refers to a health study. We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area..

Comments from a private citizen (PC2):

PC2-1: The document is meaningless since risk assessment formulas, calculations and explanatory material were not completely provided to the public in the report-- what is the basis for conclusions? How does ATSDR expect the lay public to understand the basis for risk estimates? Please provide calculations/formulas and explanatory material and re-circulate to the public so meaningful review and comment of risk assessment can take place.

ATSDR Response: We have added example calculations and further explanation of the life table procedures in Appendix D.

PC2-2: All risk assessments provided in consult presumably used an assumed respiratory volume of 20 cubic meters of air inhaled during every 24 hour period of time. The estimate of 20 cubic meters of air is derived from an average adult sitting at rest. Peer-reviewed research of the past shows subjects' respiratory rates and volumes exponentially increase when moderate to heavy workload are introduced. Please refer to ISO respiratory rates. As volumes exceed 20 cu m/24 hrs, fibers per cc remains the same but inhalation exposure increases (inhalation volume greater than 0.83 cubic meters of air per hour, or greater than 14 liters of air inhaled per minute). Did ATSDR calculate any of its risk assessments using higher respiratory volumes than the outdated 20 cu m/24 hrs rest rate? Did ATSDR calculate risk during exercise, with higher inhalation volumes, and used in conjunction with data collected from activity-based sampling that was conducted (e.g.--riding bicycle, running, playing, etc)? If not, please provide calculations using increments above 20 cu m/24 hours (e.g.- 25, 30).

ATSDR Response: The average volume of air breathed per day is based on average activity patterns, including both high- and low-respiration activities. While the average value is by definition lower than the highest respiration rates that could take place, this will not have a greater effect on risk than the significant uncertainty already present. For example, asbestos risk methods are only sensitive enough to estimate risk for average exposures (over a year or more) because mortality data used to in the "life table analysis" is published on an annual basis; this means concentrations, breathing rates, etc. are all essentially averaged out over the entire time period.

PC2-3: ATSDR states there are limited exposure studies of NOA in communities, which includes all asbestos types, including the abundant chrysotile fiber, the world's most dominant asbestos type. Remarkably, the studies cited in the consult where communities had a marked increase in disease (e.g.-mesothelioma) all dealt with amphibole asbestos, not chrysotile---the same fiber type evaluated in the consult. This supports the citizenry's claim that more time is warranted for proper review and evaluation of this amphibole fiber, so that true exposure and risk and can be better understood (e.g.-cause and effect).

ATSDR Response: Current research indicates exposure to either chrysotile or amphibole asbestos can cause mesothelioma. We have expanded discussion of health effects seen in other NOA communities around the world, in the section beginning on page 12 entitled "Naturally Occurring Asbestos" – both chrysotile and amphibole forms of asbestos were present in some communities. ATSDR agrees that additional work should be done to clarify the role played by exposure to amphibole and chrysotile fibers in developing asbestos related disease.

PC2-4: The public, school staff, students/parents and others had volunteered to wear a continuous high-flow air monitors so exposures could be determined/understood at breathing zone levels for various groups of individuals. Federal agencies, EPA and ATSDR, rejected that proposal, calling it unethical. Now ATSDR reports that there is no reliable way to measure a particular person's exposure. I believe readings from those monitors would have been useful and results would have benefited this consult greatly--would have provided ATSDR with a snapshot of normal exposures through every day activities.

ATSDR Response: ATSDR has clarified in the section beginning on page 40 that individual exposures, especially those in the past that would contribute to disease risk today, cannot be measured. Measurement of monitors today would only give a snapshot in time, not the detailed cumulative exposure over years needed for scientifically rigorous studies.

PC2-5: The consult and its conclusions are unclear and does not adequately address exposures. Even investigative reporters for the Sacramento Bee and Mountain Democrat concluded in articles for their respective newspapers that risk to NOA exposure was minimal, after reviewing consult. If those conclusions are untrue, ATSDR needs to clarify its position. Conversely, if accurate, ATSDR needs to provide more information to support its claim.

ATSDR Response: We have reworded conclusion 2 to emphasize that actions to reduce harmful exposures are needed.

PC2-6: California law known as Prop 65 was created using risk calculations of CalEPA's OEHHA. Prop 65 requires warning/notification/disclosure to be issued whenever 100 pcm asbestos fibers are likely to be inhaled within a 24 hour period of time. 100 f/d equals an expected cancer rate of 1/100,000, according to OEHHA's epidemiologists. The number of fibers collected by EPA, school district, CARB etc at various times and days over a number of years exceeded the 100 f/d threshold by a minimum of one order of magnitude, to more than a two orders of magnitude (10X to >100X). Why does consult not list these projected cancer rates?

ATSDR Response: We have added text about Proposition 65 in the discussion of the Cal-EPA risk method. We did not cite this risk because we assessed the risk directly using the site specific data and the Cal-EPA unit risk. California's Proposition 65 specifies that warnings must be issued if the risk of exposure exceeds 1 in 100,000. The Cal-EPA method evaluated as part of this health consultation is the same method used to evaluate risk when determining if a Proposition 65 warning were warranted.

PC2-7: Worker risk studies are referenced. ATSDR needs to reveal the number of orders of magnitude of risk to young children that are exposed, when compared with an adult worker. Please include age of one year and older.

ATSDR Response: Life table analysis was used to account for exposure beginning at birth and continuing through life. The risk for exposures at birth and early in life are generally greater than the risk for the same exposures occurring to an adult, but the difference is not huge - generally less than a factor of 3.

PC2-8: ATSDR refers to air monitoring data collected as "potential exposures." ATSDR should remove the word "potential" throughout its consult. The basis for this should be clear.

ATSDR Response: The data evaluated by ATSDR indicate exposures to NOA are likely to be occurring in the community; however, the data do not provide sufficient information to develop specific exposure rates; therefore we believe the use of the word "potential" throughout the document is appropriate.

PC2-9: ATSDR claims it is very unlikely that a health study would provide additional information not already known. Based on findings from health consult for amphibole exposure in another state, I completely disagree. Here, several citizens have shared personal information concerning poor health, respiratory issues (e.g.-persistent coughing), pleural abnormalities, etc.. By not developing a meaningful evaluation program, or health study, ATSDR will not learn the facts as they stand today, whatever they may be.

ATSDR Response: We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area. Anecdotal reports of health problems cannot be used in an epidemiologic health study. Individuals with concerns need to be treated by their personal medical provider.

PC2-10: It is disturbing to read ATSDR risk assessors citing an example of involuntary risk as "being hit in the head by a meteor when walking down the side walk." Since most of El Dorado Hills residents are primarily exposed to involuntary risk, I find this example offensive. I do not know of a single incident in the history of this planet where it is documented that someone was struck in the head by a meteor while walking down a side walk. If I am wrong, please provide citation.

ATSDR should be able to think of many more examples of involuntary risk where the public is/was unknowingly routinely exposed to harmful situations or constituents. Libby Montana should be a reminder to ATSDR, as well as situations in other communities in which the public is unknowingly exposed to harmful constituents (air, water, food etc).

ATSDR Response: This statement has been removed.

Comments from a private citizen (PC3):

PC3-1: Page 11 includes a discussion on published documents showing the locations of where NOA might be found. In California Geological Survey Special Publication 124, there is also a discussion on many types of rock in addition to ultramafic rock where NOA may be found. Some of the proposed definitions of asbestos are broad enough that NOA may be identified anywhere that amphibole minerals are present.

ATSDR Response: Page 22 of the California Geologic Survey publication gives a good description of the geologic settings where NOA may be found. We have added the reference.

PC3-2: The inclusion of comparative charts for asbestos concentrations, such as page 13, is very helpful.

ATSDR Response: Thank you for your comment. No response is necessary.

PC3-3: Page 15 discusses risk. People are likely to use this health consultation to make risk management decisions. The environmental risks from NOA as discussed are closely tied to an area or region, although this may not always be the case. Other areas with or without NOA can have different kinds of environmental risks. An example would be a risk for children breathing air from living near a busy freeway intersection. The consultation should acknowledge that it may be used as a risk management tool for people making a decision on whether to live in the El Dorado Hills area or in some other community.

ATSDR Response: Thank you for this comment. ATSDR intends for this consultation to provide information to enable people to make their own risk management decisions related to NOA.

PC3-4: Page 32 discusses NOA background consideration. We know that NOA is present in many areas of the United States (i.e. Virginia and Georgia). Background concentrations in the air in some of these other areas should be measured and discussed for reference. This might be a part of an addendum document that covers background air concentrations in multiple areas.

ATSDR Response: We agree that this would help clarify the extent of NOA issues elsewhere. ATSDR does not conduct this type of research; however upon request we can provide technical review of sampling plans developed by other organizations.

PC3-5: The discussion on the uniqueness (or lack thereof) on pages 40 and 41 is helpful to show that the NOA issue is widespread. Geological conditions likely to contain NOA under the current definition are more widespread by several orders of magnitude than what was believed just a few years ago.

ATSDR Response: Thank you for your comment. No response is necessary.

PC3-6: **General Comments**
We deeply appreciate the opportunity to provide comment on the public comment version of the health consultation for the evaluation of community-wide asbestos exposures for El Dorado Hills. We are currently using the document to help existing and potentially new residents to make decisions about living in the community. While, to us, the consultation is presented in a clear and concise form that is easy to use; we are finding that this not always the case for most of the public. We have seen highly skilled physicians struggle with understanding the document. The answer to this problem is that the document should be used in conjunction with other documents that describe the occurrence of NOA. Specifically in El Dorado Hills, users of the document need to be even more aware of many other documents, including the existing rules and regulations regarding NOA.

ATSDR Response: ATSDR worked with El Dorado County and has provided them with several informational brochures to help provide information to the public. ATSDR is working to include these materials on its El Dorado Hills webpage, www.atsdr.cdc.gov/sites/eldoradohills.

Comments from private citizen (PC4):

PC4-1: Please accept the below indirect comments, addressed to [an independent environmental consultant], as my Comments for the Health Consultation requested by ATSDR on March 29, 2010 for El Dorado County California. EPA Facility ID: CAN00906083. I realize that this is highly unusual. I simply can not bring myself to directly respond to people I have no respect for, have no faith in their competence, hold no belief that the comments obtained are anything other than fodder for the circular file. I might add that these past 14 years have been the most disgusting and lowest experience I have ever had the opportunity to experience. All due to EPA and ATSDR interaction with our community. I am quite proud to know that I do not have friends in that low of places

ATSDR Response: We accepted all public comments received on this health consultation. We respect the opinions of all stakeholders at this site.

PC4-2: Dear [independent environmental consultant],
I have just read the pertinent sections for El Dorado County and Dr. Schenker's investigation in California of [consultant's testimony to a Senate Committee.] I have reduced and attached those comments below.
On June 30, 2010 + or -, the ATSDR will adopt a Health Consultation (attached hereto) for El Dorado County. Unfortunately, there are very few if any, of your "what is needed" comments incorporated into this document. In fact, the "what is needed" part of this document does not even rise to the somewhat rigorous but naive, regulations that have been in place in California State Codes since 1970. I presume, since the authors of this paper, specifically Jill Dyken, but others too, have been involved in Libby Montana, and since I additionally suspect their involvement in Jefferson Parish Louisiana, that this Health Consultation will be the applied regulatory "environmental tactic" used henceforward throughout the US. In essence the idea is this "there will be preventable deaths...get over it and get used to it...don't let it bother you"

ATSDR Response: ATSDR is concerned about the health and well being of the people of El Dorado Hills as evidenced through our efforts to provide information to better characterize the risk posed by NOA.

PC4-3: Important for any casual reader of this Health Consultation and even those who wish to analyze it.....is that EPA did not nor did any other public agency ever measure on top of or even within relative exposure distance to one of the actual Tremolite deposits. Nobody has any clue as to what the largest exposure level in El Dorado County is, although we have measured 10 times higher levels than what EPA has done (actionable levels that EPA ignores and stays completely geographically away from in their investigation). I suspect based upon evidence, that the highest exposure that actually occurs to "some" residents exceeds even this by another order or two of magnitude. This is vastly different than what you refer to in your testimony. Unfortunately, your comments in testimony regarding EPA's measurements, create yet another thread of erroneous and poorly researched science. One of hundreds of erroneous threads that exist. Please do not misunderstand, I do not blame you for this....science is not supposed to create faulty information for others to rely upon, as you are well aware.

ATSDR Response: The intent of this consult was to get an idea of the general impact of typical exposures in El Dorado County on the public's health. The consult recognizes that the activity-based sampling may not describe the highest exposures possible and that individual exposures, and resulting risk, could be even higher. Although the sampling was not intended to describe the worst case exposures that may occur at outcroppings or quarries, the general conclusions based on the sampling are still valid.

PC4-4: This Health Consultation represents a forgone conclusion from 1998, that has taken EPA, ATSDR, Local Politicians and California State agencies, the past 12 years to simply filigree the details for public consumption. I have attached another document "EPA-HQ....." for your perusal that begins to explain indirectly why in 1998 this Health Consultation was a forgone conclusion. Emphasis on "begins". The entirety of the details are much broader in scope. However, an understanding of this document and its details is important in understanding the complete situation in environmental exposure scenarios to various fiber types, from Erionite to Chrysotile. It also helps a person transition to the entirely different, yet predictable from environmental studies, occupational scenarios. I often lament that it is too bad that we had to re discover in modern times, induced "asbestos" diseases in the occupational setting. We would have been so much farther ahead had we first studied and understood environmental exposures and deaths, then applied that knowledge to occupational scenarios.
I would only suggest this to you for your future reference. To rely on EPA and ATSDR data or conclusions in the field of asbestos study for any purpose whatsoever, is a foolish thing to do. Down this road only lies more and more erroneous information. Information tailored for public consumption, not for reliance in actual science. The larger picture is thus obscured and from my point of view, is unattainable without substantial input from private scientists as unrelated to EPA, ATSDR etc as is possible. In addition the heavy reliance of the media upon government sources, adds exponentially to the problem of a real understanding. The environmental aspects of asbestos disease is somewhat complicated but there is no hope to unravel what is actually occurring if a reliance on government reporting and data is made.

ATSDR Response: ATSDR does not agree with the premise that government data and reports can't be relied on, nor with the implication that our conclusions were predetermined.

PC4-5: [Commenter attached Memo Dated December 10, 2004 Addressed to EPA Headquarters, RE: Test Alternative Method to Remove Asbestos, Docket ID No. EPA-HQ-ORD-2005-0028, Informal Comments, describing personal experiments on tremolite asbestos and surfactants]

ATSDR Response: ATSDR is unable to evaluate the validity and applicability of these experiments to the situation in El Dorado Hills; such is outside the scope on this health consultation.

Comments from private citizen (PC5):

PC5-1: Thank you for the opportunity to comment on this Health Consultation. And thank you for the tremendous amount of work your team has put into this rather thankless task but nevertheless important task.

ATSDR Response: Thank you for your comment. No response is necessary.

PC5-2: It is unfortunate that probably few members of the public understand epidemiological studies, risk, and basic statistics well enough fully to appreciate the difficulties inherent in studies of this kind, especially in the charged atmosphere associated with the considerable and very real economic factors present in this case. This may perhaps be illustrated by the cries of "Where are all the bodies? The County has been dug up everywhere since the Gold Rush." These cries ignored a very transitory population of miners, disease development several decades long, much more common mortality due to diseases like typhoid and cholera, absence of development pressure until just recently, and failure to recognize asbestos as a cause of disease until much later.

ATSDR Response: These hypotheses are plausible. ATSDR is not aware of any data that would allow us to address them.

ATSDR worked with El Dorado County and has provided them with several informational brochures to help provide information to the public. ATSDR is working to include these materials on its El Dorado Hills webpage, www.atsdr.cdc.gov/sites/eldoradohills.

PC5-3: It is also unfortunate that the media has contributed to misunderstanding by misrepresenting the conclusions:

"Scare no more" was the headline on an editorial in the *Mountain Democrat* that ended, "This final 'Health Consultation' means there remains nothing to be scared of anymore." This statement seems to disregard the Consultation's first Conclusion:

> Breathing in naturally occurring asbestos (NOA) in the El Dorado Hills area, over a lifetime, has the potential to harm people's health.
>
> - Background levels of NOA in El Dorado Hills are higher than asbestos levels measured in other non-urban and most urban environments. Activities that disturb NOA could result in levels higher than background.
> - A general sense of the increased risk of developing cancer from breathing in asbestos throughout life was obtained using several different risk assessment methods with the results of EPA's activity based sampling in El Dorado Hills. For each method, a range of theoretical increased risks of developing cancer was estimated using different assumptions about how much and how often people breathed in NOA. Each risk method has considerable uncertainty, but the different risk methods gave similar results: the predicted increased risk of cancer ranged from too low to be of concern to a level high enough that action to prevent exposures would be warranted.

• Any one person could have markedly higher (or lower) exposures than the general estimates made in this report, depending on whether, how, and how often they encounter NOA in their daily activities.

(Emphasis added.)

The *Sacramento Bee's* article had a subhead reading, "Big Health Study Not Needed, U.S. Says", though the article itself was a little more nuanced (Headlines aren't generally written by the reporters.) But such a statement mischaracterizes your second Conclusion:

> A health study of the community of El Dorado Hills would not provide helpful information at this time.

"Not needed" is not the same as "would not provide helpful information at this time". This conclusion was explained in the Health Consultation's "Basis for conclusion".

Perhaps the most important part of the Health Consultation is the "Next steps" portion of your first Conclusion:

Increase Awareness

• El Dorado County should continue to assess the community's knowledge about the presence and associated risk of NOA and to provide information about ways to manage the risk. ATSDR can provide assistance, if requested.

• El Dorado County should implement, to the extent possible, effective ways to: o Maintain current records of locations known to contain NOA and o Notify current and prospective landowners of the possibility for NOA to exist in soil or bedrock on their property.

Limit Exposure

• State and local entities should continue to enforce applicable dust regulations throughout the community, which will reduce releases of NOA. For sites subject to asbestos hazard mitigation requirements, these regulations involve:

- Prohibition of visible dust emissions outside the property line or more than 25 feet from the point of dust-disturbing activities,
- Implementation of procedures to prevent vehicles and equipment from releasing dust or tracking soil off-site, and
- Requirements for planning, notification, and record-keeping.

• Community members and groups should learn how to minimize their exposure to NOA while conducting their normal activities. ATSDR guidelines are included in Appendix H of this report.

None of this was mentioned until the 6 paragraph of the Bee's article. I am unaware of any scheduling of public meetings by the county to discuss your report, as mentioned in the article's 16th paragraph.

ATSDR Response: ATSDR provided a press release with our conclusions. In this final release, we have reworded conclusion 2 to emphasize that actions to reduce harmful exposures are needed.

PC5-4: You could have been assured at the outset that you might please few readers of the final Health Consultation. For instance, broad assumptions as to exposure were necessary and were, therefore, sure to result in nitpicking comments. The old cleavage-fragment controversy has never been laid to rest despite input from the Open-File report of the U.S. Geological Survey.

I think it might have been helpful if early in the Consultation you were more clear about the difference between chrysotile and amphibole asbestos, the relation of both to “serpentine”, the role of the various kinds in commerce, that commercial uses are the basis of regulation and most knowledge, and the potency for causing disease of the various kinds. Expanded treatment of these issues in the Consultation could then be referenced for more in depth reading. Amphibole asbestos is known from areas not considered “serpentine’ or even ultramafic.

ATSDR Response: These subjects were covered in detail in the “Asbestos Background” section on pages 6-17 of the health consultation. Several changes and clarifications have been made in response to specific comments we received.

PC5-5: Another approach that I think would help to make results meaningful to an average citizen is to expand the meaning in practice of such trivial-sounding data as, e.g., 0.01 fiber per cubic centimeter. A non-scientifically trained person might have little comprehension of how small a cc is. Relating such a figure to fibers per typical breath volume would help, along with providing a range of typical breath volumes for males vs. females, children vs. adults, and “at rest” vs. strenuous activity.

ATSDR Response: Asbestos concentration is typically recorded in number of fibers per volume of air. The cubic centimeter (cc) volume, equivalent to one milliliter, has been used for describing asbestos concentrations in the United States for many years. A cc is a small volume, less than ¼ teaspoon (see picture below). Exposure studies have shown that adults at rest breathe 500 cc of air with every breath, and, on average, 20 million cc of air every day. Therefore, even small concentrations of f/cc may result in significant numbers of fibers being breathed in. For example, the OSHA worker 8-hour exposure limit of 0.1 f/cc corresponds to 50 fibers with each breath. The concentration used in EPA’s World Trade Center cleanup to clear apartments for residential occupancy was 0.0009 f/cc, which corresponds to only about 1 fiber per 2 breaths, but over the course of an entire day results in 18,000 fibers breathed in.

A stack of three dimes has a volume of about 1 cc.

We have added this discussion as a text box on page 10 in the "Background" section of the health consultation, However, changing all of the units within the report would not be appropriate and would be unlikely to lead to greater comprehension by the general public.

PC5-6: Because of the economic downturn, there has been little recent activity toward further development of areas suspected of harboring NOA. Thus the whole issue of NOA has been absent from the news for some time. Development interests no doubt would prefer that it continue to be absent.

The fundamental question is the degree to which precautionary measures will continue to be practiced or enforced by residents, school authorities, and El Dorado County's Environmental Management Department. Are real estate disclosure forms being used?

It was encouraging to see the County's new Public Health Officer in attendance at one of the recent public meetings as an indication that she at least takes the issue seriously. But unthoughtful readers might well have conclude that precautionary measures are not needed.

Again, thank you for this opportunity to comment.

ATSDR Response: ATSDR agrees there is reason for concern. People in the community need to be aware that they live in an area where NOA is present. ATSDR worked with El Dorado County and has provided them with several informational brochures to help provide information to the public. ATSDR is working to include these materials on its El Dorado Hills webpage, www.atsdr.cdc.gov/sites/eldoradohills.

Comments from a private citizen (PC6):

PC6-1: ATSDR correctly notes that "a lifetime of breathing in naturally occurring asbestos in the El Dorado Hills area could increase the risk of disease and recommended actions by local authorities and residents to reduce exposure".

ATSDR Response: Thank you for your comment.

PC6-2: ATSDR correctly and commendably uses multiple models for risk, not a single model, and provides background for each. ATSDR correctly and commendably consulted Andrew Darnton of HSE (UK) and Wayne Berman regarding such modeling, lacking sufficient in-house expertise themselves; Darnton and Berman are co-authors of the the most up-to-date risk assessment models for asbestos exposure and disease (Hodgson and Darnton 2000; Berman and Crump 2008a; Berman and Crump 2008b; Darnton 2010). Because of disagreement and uncertainty over the relative benefits of models, and because some models may be better for some sites than others, this should be emulated in future by other agencies, in particular EPA and ATSDR itself.

ATSDR Response: Thank you for your comment.

PC6-3: ATSDR correctly notes that the naturally occurring asbestos risk (in) "western El Dorado County is not the only place where disturbance of NOA has arisen as a public health issue". The wording of this conclusion however confuses "issues" with actual risk, and the examples given do not fully cover world-wide instances of NOA exposure and concomitant disease risk. A full discussion of the extensive risks present elsewhere is beyond the scope of this discussion; suffice it to say that in Figure 6 on page 34 there is a clear overlap of the values found with other situations in which mesothelioma, in particular, has been increased in other parts of the world outside the United States.

ATSDR Response: We have expanded the discussion of other NOA sites throughout the world where asbestos disease was found to include a discussion of the exposures occurring and any exposure data collected. This discussion is in the section "Naturally Occurring Asbestos" beginning on page 12.

PC6-4: ATSDR correctly notes, based in part on USGS analyses, that "…the particles that were the most asbestiform came from public locations where activity-based sampling was not conducted. From this, we infer that the activity-based sampling (done by EPA in the Fall of 2004 in one area of the County and forming the principal basis of the conclusions offered in this document) does not necessarily reflect the highest exposures possible in the community". They note further, on pages 30=31, that

> It is important to note that the high end of this risk range is not an overly conservative estimate. Even when high-end exposure concentrations were used, these were averaged over various scenarios and time and still reflect an average value; additionally, the activity level (low, medium, or high) had a relatively small effect on the predicted risk. Finally, the activity-based sampling was conducted in public areas of El Dorado Hills that may not represent the highest NOA exposures that could be possible. The USGS studied mineralogy in the area and found that while the areas sampled in the activity based sampling contained particles meeting regulatory definitions for asbestos, the most highly asbestiform particles came from other public locations (Meeker, Lowers et al. 2006) [ATSDR reference 8]. Therefore, a specific individual could have significantly higher or lower exposure, depending on the particular areas he or she accessed during life (emphasis added).

Despite the clear admissions outlined in (4), above, ATSDR does not take these deficiencies to their logical conclusion, which in fact invalidates the entire exercise. The fact is that, contrary to the statement above and in contradiction to USGS and other findings, virtually all of the conclusions of this exercise flow from the flawed Fall 2004 EPA activity-based sampling site referred to throughout the document.

ATSDR Response: The intent of this consult was to get an idea of the general impact of typical exposures in El Dorado County on the public's health. The consult recognizes that the activity-based sampling may not describe the highest exposures possible and that individual exposures, and resulting risk, could be even higher. Although the sampling was not intended to describe the worst case exposures that may occur at outcroppings or quarries, the general conclusions based on the sampling are still valid. In fact, the EPA activity-based sampling, as performed, gave us a state-of-the-art estimate of community exposures, allowing the best available estimate of the impact those exposures have on public health.

PC6-5: To be fair, ATSDR apparently recognizes the lack of value of this site in terms of both representativeness of exposure to citizens and applicability to risk assessment, in that

a. They attempt to add data to the EPA data as regards long, thin amphibole fibers per "Table E1. Summary of Long Structure Data" (page 82). While this improved the detection of at least one "long" (length > 10 um) fiber to 88.5% of the 182 selected samples from 316 available compared with 37.9% in the original EPA counts, improvement in detection does not change the distribution of what is detected. In other words, the area selected by EPA for activity based sampling was, in retrospect, poorly chosen in that areas in the County, as clearly evidenced in (4), above and admitted by ATSDR, have more "highly asbestiform" (and therefore also "longer") fiber concentrations present and present greater risk.

b. They implicitly admit the deficiency of the original EPA activity-based sampling of Fall 2004 by adding very sporadic (and incomplete, see below) data including some (from USGS) which is in direct contradiction to the EPA data (pages 36-39).

c. They overtly admit the deficiency of the original EPA activity-based data set on page 88 in response to a previous comment: "The EPA reference stations are the only data available which contain detailed size distribution data and therefore can be used in multiple risk models". Because poor data is the "the only data available" is not an adequate excuse for basing a Public Health Consultation on poor data.

d. The concluding statement on page 39 that "They (the data mentioned in (b), above) also suggest that the levels measured in EPA's Fall 2004 activity-based sampling were typical of those that might be measured elsewhere in the local area" is overtly false. This phrase should be removed as it constitutes false reassurance. Lack of adequate data is not data; the fact that the EPA data-set is larger and usable does not make it better for risk assessment than properly collected data in areas of the county where risk of exposure to fibers having greater disease risk is higher. There may be practical problems which make this difficult or even impossible, but this does not excuse use of the EPA data as if it were representative of areas of higher risk (Parenthetically it should be noted that this writer does not believe that EPA's choice of sampling area, although it proved ultimately ill-advised, could necessarily have been recognized as such a poor choice a priori, especially given the community desire to have this specific area sampled).

ATSDR Response: The intent of this consult was to get an idea of the general impact of typical exposures in El Dorado County on the public's health. In contrast with the commenter's statements, ATSDR recognizes that the activity-based sampling performed by EPA was of excellent quality and design for our purposes. The sampling was not intended to describe the worst case exposures that may occur at outcroppings or quarries. Instead, it gave us a state-of-the-art estimate of community exposures, allowing the best available estimate of the impact those exposures have on public health. The consult recognizes that the activity-based sampling may not describe the highest exposures possible and that individual exposures, and resulting risk, could be even higher. The conclusions and recommendations of the health consultation take into *account the potentially higher exposures and risk of individuals based on their individual activity patterns.*

PC6-6: ATSDR notes that the interest in the problems in this area came to light through a particular exposure situation in 1998 (Bowman, C; various articles in The Sacramento Bee; ATSDR document reference [1]). They note in particular that the situation "on Wild Turkey Drive in Shingle Springs south of El Dorado Hills (indoor dust, front and back yard air, and along unpaved road)… The monitor set up along the unpaved road while a vehicle passed by to simulate traffic showed an actinolite concentration of 0.22 fibrous structures per cc". ATSDR do not mention, and are apparently unaware of, two publications relating to this specific area; one a USGS technical report sampling the unpaved road area and finding for two samples analysed by scanning electron microscopy (TEM) with identification of fiber type by energy dispersive spectrometry (EDS) "The morphology of amphibole from each sample is asbestiform…The compositions of amphibole fibers…fall completely within the tremolite and actinolite fields, respectively…X-ray diffraction analysis confirms the materials analyzed by SEM/EDS are amphibole, most likely belonging to the tremolite-actinolite series" (Lowers and Meeker 2007). In addition Case and Abraham (Case and Abraham 2009) have studied dog lungs from canines resident for many years in this unpaved road area, finding very high concentrations of long-fiber tremolite-actinolite (0.5 million to ten million fibers per gram dry lung in two different laboratories using different methods, fibers longer than 5 um; laboratories found up to two million fibers longer than 5 um; other county area pet values were lower but non-zero; true control animals from Quebec were below the limit of detection). These findings confirm the heterogeneity of exposure in Western El Dorado county and confirm as well that the area sampled by EPA is not representative of the areas of highest potential exposure.

ATSDR Response: We have added the USGS technical report reference to discussion on pages 36 and 48. The findings of this report substantiate our discussion that the most asbestiform materials were not necessarily captured in the activity-based sampling. We have also added discussion of the animal lung research cited (summarized in a 2009 peer-reviewed conference summary) to the section of the health consultation beginning on page 42 entitled "Additional Information on NOA in the El Dorado Hills Area."

PC6-7: ATSDR give a laudable number of potential measures that could be taken to minimize exposure, particularly in Figure 5 on page 32. However, the long list of common-sense measures to be taken by individuals would, if taken seriously, take up so much time as to be virtually incompatible with normal living. More important are the first two recommendations regarding "Minimiz(ing) Future Releases of NOA to Community Background". These are to "Document areas of known NOA" and to "Avoid uncontrolled disturbance of areas known or suspected to contain NOA". Regrettably, ATSDR gives very little guidance as to how this is to be accomplished, other than to enforce "state and local air regulations" which are highly unlikely to do so. At a minimum, any local business, organization, or individual that produces, though any activity, dust in an area of heterogeneously distributed long-fiber amphibole asbestos such as this has a moral and ethical obligation to do adequate testing to accomplish such documentation and to avoid such disturbance (and the exposures it would cause). This includes, but is not limited to, real-estate developers, the construction businesses and others which serve them, road-builders, etc. A similar obligation should be incumbent upon any individual selling any property sited upon any deposit of such material, whether the existence of the material at that site is presently known or not. Clearly this is an arduous and difficult responsibility for all concerned, and support should be given by federal, state and local agencies including ATSDR and EPA.

ATSDR Response: We recommended that local agencies document NOA locations and enforce dust regulations. Individual residents can take simple actions to minimize their chances for exposure to NOA. ATSDR is an advisory agency and cannot require agencies or individuals to follow its recommendations.

Comments from a private citizen (PC7):

PC6-8: This is just to second [private citizen PC8's] request, as co-author of publications. I wish we could be there to use them to help all concerned, but the timeline was unrealistic (I understand from your previous reply to [private citizen] that you did your best with what you had but it sounds like you were yourself not given enough time).

Another small piece (but important) of the puzzle is provided by the short report by Lowers and Meeker, also attached. For the record (and as part of the record), the area studied in this USGS report is similar to that of the "range" of two dogs with the highest values of tremolite detected in both laboratories [private citizens' laboratories and affiliations listed]. Not in the publications is the fact that our studies here of Quebec dogs have shown zero tremolite of any type, so there are controls.

ATSDR Response: We have added the USGS technical report reference to discussion on pages 36 and 48. The findings of this report substantiate our discussion that the most asbestiform materials were not necessarily captured in the activity-based sampling. We have also added discussion of the animal lung research cited (summarized in a 2009 peer-reviewed conference summary) to the section of the health consultation beginning on page 42 entitled "Additional Information on NOA in the El Dorado Hills Area."

Comments from a private citizen (PC8):

PC8-1: I respectfully request this email and the attachments be part of the official record on this issue. The notice for this meeting is certainly quite (unrealistically) short, so I request you read my note as a commentary at the meeting in my absence. This can be accessed at: www.upstate.edu/pathenvi/studies/case6.htm

My message is short: I want to bring to the attention again our presentation of data which the EPA did NOT allow to be presented at the meeting on this issue a few years ago. The presentation should be SHOWN at this meeting. Also, the paper by [private citizen PC7] and myself should be made available and put on the record for this meeting. I am attaching this and my current CV for your records. Thank you. Please confirm receipt of this and your response that it will be presented as requested, or some valid reason why it will not be presented.

[commenter attached presentation found at the above web link and the publication: Case BW, Abraham JL. Heterogeneity of exposure and attribution of mesothelioma: trends and strategies in two American counties. J Physics: Conf Series 151, 2009. Inhaled Particles X, 23-25 September 2008, Manchester]

ATSDR Response: ATSDR has added discussion of this research (summarized in a 2009 peer-reviewed conference summary) to the section of the health consultation entitled "Additional Information on NOA in the El Dorado Hills Area." The meeting referred to by the commenter was ATSDR's series of informal open houses. ATSDR contacted the commenter and explained that the format of the meetings precluded us from presenting others' research; however we agreed to include the email as a public comment.

Comments from a private citizen (PC9)

PC9-1: My name is [name removed], and I was asked to be one of the peer reviewers on the Health Consultation in 2009. Since that time I have had the occasion to find out more specific information about the conditions at El Dorado County, and thus have several comments about the findings and conclusions of the Consultation.

ATSDR Response: We accepted all public comments received on this health consultation. For the reader's information, ATSDR did not receive questions or requests for more information from any of the three peer reviewers during the peer review process or after the release of the public comment draft health consultation. Although changes in wording were made in response to peer review and Agency review comments, the conclusions and recommendations of the health consultation were the same for both peer review and public comment drafts. (The second conclusion has been completely reworded in this final draft in response to comments received.)

PC9-2: Of primary importance to any health consultation that is based on a particular dose of a carcinogen is to determine what the range of potential doses are. Of concern here is the use of previous air monitoring data that may not correlate to the highest exposures that may exist in El Dorado County, and also that the air monitoring should be parsed with regard to the type and "quality" of asbestos present at the air monitoring sites. While the assertion that "Any one person could have markedly higher (or lower) exposures than the general estimates made in this report" is certainly true, in my opinion, it is critical to determine just how representative the air monitoring data that was used as the basis of this consultation is to actual potential exposures.

ATSDR Response: The intent of this consult was to get an idea of the general impact of typical exposures in El Dorado County on the public's health. Knowing the full range of potential exposures, or detailed mineralogy and morphology from every specific potential exposure location, is not necessary for such a general evaluation. ATSDR considers our evaluation to sufficiently represent community exposures for the following reasons:

- *The types of activities and durations of activities performed during the activity-based sampling and included in this health consultation's assumptions were determined in consultation with the community and local, state, and federal agencies,*
- *The areas sampled were high community use areas,*
- *The USGS study of mineralogy in the area (discussed beginning on page 48) showed that the activity-based sampling captured asbestos-defined particles that contribute to risk,*

- *The conclusions and recommendations of the health consultation take into account potentially higher exposures (or exposure to "more toxic" mineralogical forms) and resulting risk to individuals based on their individual activity patterns.*

PC9-3: Much of the basis of the IRIS and EPA methodology was flawed by the idea that "all asbestos exposures are equal". There is clear medical evidence that different forms of asbestos, and fiber morphology, as well as the bio-persistence of the fibers are critical in disease causation, and that amphiboles are of much higher "potency" than chrysotile. Also of particular concern is the highly variable morphology of tremolite/actinolite, ranging from blocky cleavage fragments that may be both less "potent" and less likely to travel distances than the longer, skinnier, more classically "asbestiform" varieties of tremolite/actinolite. Airborne concentrations at one site with 15% "asbestiform" tremolite in the soils can be completely different from airborne concentrations at a different site, even though there may be the same "percentage of asbestos" in the soils.

ATSDR Response: We recognize that some believe the IRIS method to have drawbacks and that is why we chose to used several different risk methods and compare the findings. We did not rely on results from any one method to reach our conclusions.

PC9-4: I don't believe that "Conclusion 2" (that a health study of El Dorado Hills is not necessary or would not provide helpful information) is supported by the data. The primary reason for my opinion is that the consultations' assertion that "potential exposures are orders of magnitude lower than those experienced by former asbestos workers" is not proven. Indeed the graph on page 13 of the consultation is misleading because of the lack of distinction between amphibole and chrysotile exposures, and the lack of evidence for some of the concentrations shown, for example, "Reported ambient asbestos levels near local sources, such as quarries." There are quarries and worksites where different forms of asbestos are being disturbed, why not get actual data instead of postulating on the basis of old data from totally unrelated sites? Starting a data base of residents, their jobs and activities, their smoking activities, their home's location versus location of known asbestos areas, etc., as well as the length of residency will clearly be valuable to provide correlating data if/when those former residents eventually come down with asbestos related diseases. We should be looking to get the best data available on the actual effects of living near or on different types of asbestos deposits, not saying "Therefore, we anticipate there would be very few cases of disease, if any, and the findings may not be generalizable to the community as a whole". What if your anticipation is incorrect?

ATSDR Response: We have reworded conclusion 2 and it no longer refers to a health study or potential exposure levels. We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area. An epidemiological health study is not needed here because the relationship between asbestos exposure and disease is already well established. In addition, there is no way to obtain quantitative, individual estimates of past NOA exposures, information that is essential for conducting a scientifically rigorous epidemiological health study. While collecting detailed data such as suggested by the commenter may be interesting in the academic sense, taking action to reduce exposure now is the appropriate public health response.

PC9-5: The "activity based sampling" data was highly limited, and is missing several exposure scenarios that can easily be orders of magnitude higher than what was found here. Of concern:

1. Data taken at the El Dorado High School was apparently taken after the fields and track had been covered with "clean" backfill.
2. Data is primarily from sports activities, and misses mechanized activities. Exposures for the second or third ATV or car going down a dirt road that has asbestos-containing gravel with the windows down will certainly be far higher than people jogging or riding bikes.
3. Exposure data for homes and people who live adjacent to Quarries or dirt roads is missing.
4. Exposure scenarios, such as Post Office workers, rangers, police or delivery personnel who spend hours each day driving dirt roads are completely missing.
5. Data is missing from the interior of personal homes. A home built on a long-fiber tremolite deposit may cause significantly higher dosages than the background data assumed here, especially when settled dusts are re-entrained into the air by vacuuming or other activities. Indoor concentrations during the "rainy season" may actually be higher than other times, because of re-entrainment of dusts from dried mud, and closing of window and doors.
6. The air monitoring data is not correlated to proximity or relationship to localized asbestos deposits, including asbestos type and morphology. Exposures near a short fiber chrysotile site are much less likely to cause mesothelioma than exposures near a long-fiber tremolite site.
7. Exposure data was taken from a concentrated geographical area, and there is no evidence that that particular area had the potential for either the highest exposures, or that it was somehow more "representative" than other areas in the community. It just happened to be where EPA had previously conducted their sampling.

ATSDR Response: No data from Oak Ridge High School were used in this health consultation. Our previous health consultation on the school did conclude that mitigation activities there had minimized potential exposures. Regarding the other points, ATSDR discussed uncertainties related to the sampling and evaluation in detail throughout the health consultation. For the reasons described above in response to PC9-2, we believe the data are sufficient for our goal to obtain a general sense of the impact from community exposures.

PC9-6: The health consultation is clearly suffering from a lack of data. The activity scenarios shown in Table G1 clearly do not cover the broad range of possible exposures, as discussed above. While the exposure data may not be as rigorous as the "activity based sampling" conducted by EPA, requiring quarry owners, "dirt-work" contractors, federal employees, etc. to pay for independent exposure monitoring on their personnel, and their job sites, and to turn over the filters to the EPA and/or independent contractors for analysis. That data would provide the breadth and quantity of data that will provide meaningful and statistically valid information about the range of "risks" that may actually be present in El Dorado Hills, as well as similar sites throughout the country.

ATSDR Response: The intent of this consult was to get an idea of the general impact of typical exposures in El Dorado County on the public's health. The consult recognizes that the activity-based sampling may not describe the highest exposures possible and that individual exposures, and resulting risk, could be even higher. Determining whether additional exposure monitoring *for local workers is needed is beyond the scope of this health consultation, and outside ATSDR's authority as an advisory agency examining community exposures and public health.*

PC9-7: As discussed in the health consultation, there clearly is a lack of correlating data in the existing epidemiological studies that form the basis for all of the risk models, regarding past exposures, fiber types, fiber morphology and other contributing factors, such as smoking and exposure to 2nd hand smoke. It is high time that sound, peer reviewed science be conducted on the archived historical air sampling filters, as well as continuing incorporation of data from other countries and other current investigations to establish a firm foundation for the risk models. EPA/ATSDR's continued reliance on faulty data that forms the foundation of their IRIS and other methods is simply not acceptable. The IRIS method is based primarily on epidemiological studies of chrysotile workers, and as such, is clearly outdated and not applicable to amphibole exposures.

ATSDR Response: We recognize that some believe the IRIS method to have drawbacks and that is why we chose to evaluate several different risk methods and compare the findings. We considered results from all the risk methods evaluated, as well as other local data and information, in reaching our conclusions. However, we do point out that other risk methods rely on historical exposure data similar to IRIS. We agree that further analysis of archived historical filters may improve understanding of morphology, but uncertainty would remain as to reliability of sampling methods and whether the archived filters adequately represented worker exposures.

PC9-8: The health consultation would benefit from including actual data that was the basis of the report. In particular, data on the asbestos type and morphology is important, so that the specifics of the findings can be evaluated, rather than discussed in generalities. The data presented in Appendix E is particularly striking. Apparently the more accurate re-analysis of 182 samples using direct ISO methods discovered that the original analysis missed identifying asbestos in 92 of those samples. To have over half of the original samples be reported as a "false negative" raises serious questions about the validity of the original sample data. It also shows the possible benefits of re-analyzing the archived historical air sampling filters to more accurately determine what those workers were actually exposed to.

ATSDR Response: The original sample analysis performed by EPA was valid, and EPA did not miss identifying asbestos in 92 samples. The non-detect values discussed in Appendix E refer to non-detect for the particular size range of interest – longer than 10 μm and thinner than 0.4 μm – the same samples did detect asbestos in other size ranges, such as PCMe. The long thin structures are rare, and "stopping rules" were based on more prevalent sizes counted in standard EPA methodology. ATSDR funded additional analysis because of the community's desire to have ATSDR include the Berman-Crump risk method in our evaluation; further analysis was required to get more accurate data on the number of structures longer than 10 μm and thinner than 0.4 μm - structures that are not specifically counted using standard EPA methodology. A full description of the reasons for, goals of, and outcome of the additional analysis is presented in Appendix E.

The raw data sheets from the laboratory include mineralogy and morphology details of the additional analysis. They are too voluminous to include as an attachment to the health *consultation.*

PC9-9: Finally, while the "Next Steps" recommendations to reduce exposures to NOA are valid, there needs to be actual laws "with teeth" for these recommendations to be protective of human health and the environment. It will take actual enforcement of existing CARB, EPA, and OSHA laws, not to mention enactment of future laws, to actually "ensure that people living in the El Dorado Hills area have the best information possible to safeguard their health".

ATSDR Response: ATSDR is not a regulatory or enforcement agency. However, we can, upon request, provide technical assistance and expertise to agencies who are interested in developing additional regulations.

Comments from the El Dorado County Office of Education (PC10)

PC10-1: Thank you for this opportunity to comment on the above Health Consultation and this response is being sent on behalf of the school districts that have been involved, including the Buckeye Union Elementary School District, the Rescue Union Elementary School District, the El Dorado Union High School District, as well as the El Dorado Hills Community Service District and the El Dorado County Office of Education. The Local Agency Working Group has been following this issue since 2002. We were pleased to see that ATSDR included many of the comments we asked to be considered in the Health Consultation.

We appreciate, for example, the discussion about the "great deal of uncertainty" surrounding the use of the various risk models that were developed from historical worker studies in a non-industrial setting such as El Dorado Hills. We also appreciate that ATSDR's calculations discarded results from filters that used the indirect test method and that you considered most of our comments regarding the different test methods. We would also commend you for including information on other risk scenarios that help put this issue into a contextual perspective.

ATSDR Response: Thank you for your comments. We try to be responsive to stakeholder requests.

PC10-2: There is one area that we would continue to suggest be added in the report. We believe the report would have been enhanced, for example, if a paragraph was added to explain the various scenarios that were used by the EPA to gather the data used in the report. Knowing that brooms were used to disturb dust during the outdoor basketball game and that air monitors were set at three feet above the ground would enable the reader to put the data for the asphalt courts scenario in its true context. The digging scenario involved throwing dirt at the air filters to imitate children throwing dirt at each other. Each scenario involved aggressive dust disturbance methods that often failed to mimic the actual activities. While we understand the importance of taking a protective approach and studying a worst case scenario, we believe a discussion concerning these methods should have been included in the report.

ATSDR Response: Details of the specific actions followed during each of the activity scenarios are given in EPA's final Preliminary Assessment/ Site Inspection (PA/SI) report [7]. For *readability purposes, ATSDR cannot include details of every report we used. Interested parties can consult the original references.*

PC10-3: Thank you again for addressing our comments in the Health Consultation and for the professional manner that your staff have conducted the process, including the communication with stakeholder groups in El Dorado County.

ATSDR Response: Thank you for your comment.

Comments from EPA Region 9 (PC11):

PC11-1: Thank you for the opportunity to review and comment on the draft Health Consultation for the El Dorado Hills Naturally Occurring Asbestos Site. Using exposure data gathered by Region 9 in 2004, and its own additional analysis of the EPA filters, ATSDR performed a risk assessment addressing exposures to naturally-occurring asbestos (NOA) in the El Dorado Hills community. This risk assessment supports the Health Consultation, which reaches two important conclusions:

> Conclusion 1: Breathing in NOA in the EI Dorado Hills area, over a lifetime, has the potential to harm people's health.
>
> Conclusion 2: A health study of the community of EI Dorado Hills would not provide helpful information at this time.

We agree with Conclusion 1, but feel the text of the draft Health Consultation should be revised to more fully support and communicate the potential health risks. We are not in full agreement with Conclusion 2 and are concerned about how it is presented in the draft Health Consultation. This concern arises because, as it is stated and discussed, Conclusion 2 has already been interpreted by the community, the media and others to mean that Conclusion 1 is not valid.

ATSDR Response: The text describes thoroughly the health risks associated with asbestos exposure. The evaluation performed in this consultation was not specific or detailed enough to be able to predict an individual's risk of disease, or to predict the actual rate of disease that might be found in the community. We have reworded conclusion 2 to emphasize that actions to reduce harmful exposures are needed. The relationship between asbestos exposure and disease is already well established and the analysis shows that a risk warranting reduction in exposures exists.

PC11-2: An additional concern is that much of the language in the draft Consultation appears to question the U.S. EPA risk assessment process. Our specific comments are detailed in the attachment, but our overall concerns fall into several categories:

<u>The discussion of uncertainties in the draft Consultation is slanted towards concluding that the risks are *over*estimated by the risk assessment:</u> Beginning with the language of Conclusion 2 ("Although theoretical risk was increased ... we anticipate there would be very few cases of disease, if any ... ") text in the draft Consultation undercuts Conclusion 1 and downplays the

risks of NOA exposures. The discussion includes copious information on the uncertainties related to asbestos toxicity but does not highlight important facts such as asbestos is a Known Human Carcinogen that has been responsible for significant morbidity and mortality in communities around the world. In addition, the draft Consultation pays little attention to studies documenting the risks of NOA exposure in California and elsewhere.

ATSDR Response: We have reworded conclusion 2 and added significant additional material on NOA health risks both in El Dorado Hills and elsewhere in the world to address this and similar comments. We do not agree that discussions of uncertainty in the draft document implied that risks were lower than shown in our analysis. In fact, the discussion of uncertainty stated repeatedly that individual exposures and risk in the community could be higher than estimated in the report. This evaluation could only give a very general idea of the degree of risk in the community and we found that the risk was enough that actions and recommendations to reduce exposure were warranted. The same actions and recommendations would have been warranted had a higher risk been found.

PC11-3: The lack of a non-cancer risk assessment may mean that NOA risks are actually *under*estimated in the draft Consultation: The draft Consultation glosses over and does not estimate the risks of developing non-cancer disease from the EI Dorado exposures, even though the report states that non-cancer health effects "are often seen in asbestos-exposed communities". This is especially important because data have shown that non-cancer health effects may be more prominent than asbestos-related cancers in NOA-exposed populations. Recent ATSDR publications also show that non-cancer health effects may develop more quickly than asbestos-related cancer.

ATSDR Response: The available exposure data do not suggest any concern for El Dorado residents developing asbestosis - very high concentrations and durations of exposure are necessary. There is currently no accepted method to estimate other noncancer risks. We have expanded discussion of health effects seen in other NOA communities around the world, in the section beginning on page 12 entitled "Naturally Occurring Asbestos".

PC11-4: The draft Consultation overemphasizes the uncertainty inherent in the risk assessment process: The draft Consultation significantly understates the level of confidence that EPA has in our risk - assessment approach for asbestos and uses subjective language to imply reservations regarding the strength of the risk assessment and/or the risk process (i.e. "...theoretical risk...", "...considerable uncertainty...,"...a general sense of the increased risk...", "...great deal of 'uncertainty..."). These statements challenge not only this risk assessment for El Dorado Hills NOA exposures, but also the fundamental principles of the EPA risk assessment process. If ATSDR feels this risk assessment is significantly less certain than most risk assessments, especially those for asbestos, this conclusion should be stated explicitly along with supporting details.

ATSDR Response: While we have removed some modifiers to make these statements more objective, we do not agree that recognizing uncertainty takes away from our conclusion. All risk assessments involve uncertainty. ATSDR's conclusions are based not only on the risk assessment but results of numerous other studies in the area and a professional consideration of the *potential for exposures. All this evidence supports the conclusion that an increased risk is present. We do not believe that ignoring real uncertainties in the assumptions and theory behind risk assessment methods would improve the credibility of this work.*

PC11-5: <u>Risk comparison language in the draft Consultation appears to trivialize the risk:</u> The draft Consultation attempts to put the NOA risks in EI Dorado Hills into context for the community, but in doing so, it trivializes the subject, especially the comparison to " ...being hit in the head by a meteor when walking down the side walk…," as an example of an involuntary risk. A better comparison would be the risks from exposure to radon gas, another naturally-occurring substance, and risks in other ATSDR Health Consultations. The radon example would be especially germane and informative because EPA and other public health agencies have radon awareness and assessment programs in place to educate the public to reduce the high risks posed by this naturally-occurring substance.

ATSDR Response: The comparison to a meteor has been removed. Radon is a good comparison and has been added as an example in the text on page 18. We did not include details of radon awareness and assessment programs. While such details would be informative, they are outside the scope of this health consultation.

Attached please find detailed comments prepared by Region 9 staff.

PC11-6: The draft Health Consultation addresses health risks arising from exposure to naturally-occurring asbestos (NOA) in the community of El Dorado Hills, CA, which is in the foothills of the Sierra Nevada Mountains. This Health Consultation is based primarily on data on personal exposures to NOA during various recreational activities at public schools and parks in the community. These activity-based exposure data, along with concurrent data on ambient air NOA concentrations, were collected by U.S. EPA Region 9 during 11 days of simulated recreational activities in the fall of 2004. ATSDR used these personal exposure and ambient background data to construct scenarios estimating 24 hour/day NOA exposures for El Dorado Hills residents engaging in low, medium and high levels of recreational activities. These exposures were then incorporated into a series of asbestos risk assessment models to generate a range of excess lifetime cancer risk estimates accruing to residents as a result of their NOA exposures in the community; use of one of the models required that ATSDR perform additional analytical work on a subset of the original U.S. EPA field samples. This extensive risk assessment analysis is presented as the primary focus of the draft Health Consultation and forms the basis for ATSDR's conclusions regarding risk and the advisability of conducting a Health Study in the community.

ATSDR Response: Thank you for these observations. No response is needed.

PC11-7: ATSDR has produced a thorough, detailed assessment of NOA-related cancer risks which provides important health risk information to this community and, by extension, to other foothill communities where NOA is present. It is clear that ATSDR performed a more rigorous, comprehensive cancer risk assessment than usual to support this draft Health Consultation. In addition to utilizing extensive personal monitoring data collected by U.S. EPA on the specific exposures addressed in the risk assessment, ATSDR commissioned additional analytical work and employed a number of different models for assessing asbestos-related cancer risks arising from those activities, as well as background exposures.

ATSDR Response: Thank you for this comment. This was our intent in performing this work.

PC11-8: CONCLUSION 1 GETS LOST
The report, as written in its current draft, does not convey to the reader a complete understanding of the magnitude of health risks, both cancer and non-cancer, from naturally occurring asbestos (NOA) that are facing the El Dorado Hills community (and by extension other foothill communities similarly exposed to NOA). The risk message, although well supported by the quantitative results of the technical assessment, is weakened by a discussion of uncertainties that over-emphasizes the possibility that actual cancer risks from NOA are significantly lower than shown by the analysis. Furthermore, the draft report also excludes, or down-plays, information from other sources that support the conclusion of significant health risks in the community due to NOA exposure.

ATSDR Response: We have reworded conclusion 2 and added significant additional material on NOA health risks both in El Dorado Hills and elsewhere in the world to address this and similar comments. We do not agree that discussions of uncertainty in the draft document implied that risks were lower than shown in our analysis. In fact, the discussion of uncertainty stated repeatedly that individual exposures and risk in the community could be higher than estimated in the report. This evaluation could only give a very general idea of the degree of risk in the community and we found that the risk was enough that actions and recommendations to reduce exposure were warranted. The same actions and recommendations would have been warranted had a higher risk been found.

PC11-9: A revised discussion of uncertainty and consideration of other pertinent risk information are crucial because they affect the take-away message of the report. In its current form, with the discussion of uncertainty so strongly one-sided and with supporting information from other sources incompletely presented, an important conclusion of the draft Health Consultation gets lost. Namely, Conclusion 1 that "**Breathing in naturally occurring asbestos (NOA) in the El Dorado Hills area, over a lifetime, has the potential to harm people's health**" gets overshadowed, especially by the many comments on uncertainty which give the impression the results of this cancer risk assessment are not to be believed.

ATSDR Response: We have reworded conclusion 2 and added significant additional material on NOA health risks both in El Dorado Hills and elsewhere in the world to address this and similar comments. We do not agree that recognizing uncertainty takes away from the conclusion. All risk assessments involve uncertainty. ATSDR's conclusions are based not only on the risk assessment but results of numerous other studies in the area and a professional consideration of the potential for exposures. All this evidence supports the conclusion that an increased risk is present. We do not believe that ignoring real uncertainties in the assumptions and theory behind risk assessment methods would improve the credibility of this work.

PC11-10: The community and the media have already interpreted this draft Health Consultation to mean there is no concern for potential health threats from NOA in this and other communities (including the Clear Creek Management Area). Three aspects of the draft report reinforce this interpretation for interested parties: (1) Conclusion 2 that performing a Health Study would not provide helpful information, especially the statement that "… we do not expect observable increases in disease", (2) lack of detail on and only limited discussion about epidemiological studies around the world showing disease from environmental, non-occupational asbestos exposures, and (3) the one-sided discussion and many statements emphasizing the potential for risk assessment to overestimate risk. Although the quantitative cancer risk assessment shows potentially significant cancer risks from NOA exposure in the community, this message is lost in the overall benign tone of the draft report.

ATSDR Response: We have reworded conclusion 2 to emphasize that actions to reduce harmful exposures are needed. We have added detailed discussion of exposures at other worldwide NOA locations in the section "Naturally Occurring Asbestos" beginning on page 12. We do not agree that discussions of uncertainty in the draft document implied that risks were lower than shown in our analysis. In fact, the discussion of uncertainty stated repeatedly that individual exposures and risk in the community could be higher than estimated in the report. This evaluation could only give a very general idea of the degree of risk in the community and we found that the risk was enough that actions and recommendations to reduce exposure were warranted. The same actions and recommendations would have been warranted had a higher risk been found.

PC11-11: 1. Present A More Balanced Discussion of Risk Assessment Uncertainties:

The report needs to present a more balanced view of the uncertainty in the risk assessment. The discussion of uncertainty is disproportionately slanted towards concluding that cancer risks are <u>over</u>estimated by the assessment (i.e., that the true risks of asbestos-related cancer are significantly <u>lower</u> than indicted by the risk assessment). Thus, much of the discussion appears to down-play cancer risks from NOA exposures and/or call into question the strength of the risk assessment and or risk assessment process. For example:

- "…theoretical risk…" (pp. v, vi)
- "…considerable uncertainty…" (p. v)
- "…a general sense of the increased risk…" (p. v)
- "… great deal of uncertainty…" (p. 12)

ATSDR Response: We do not agree that discussions of uncertainty in the draft document implied that risks were lower than shown in our analysis. In fact, the discussion of uncertainty stated repeatedly that individual exposures and risk in the community could be higher than estimated in the report. In addition, while we have removed some modifiers to make uncertainty statements more objective, we do not agree that recognizing uncertainty in risk assessments takes away from our conclusion. All risk assessments involve uncertainty. ATSDR's conclusions are based not only on the risk assessment but results of numerous other studies in the area and a professional consideration of the potential for exposures. All this evidence supports the conclusion that an increased risk is present. We do not believe that ignoring real uncertainties in the assumptions and theory behind risk assessment methods would improve the credibility of this work.

PC11-12: If ATSDR feels the results of this cancer risk assessment contain significantly less certainty than most risk assessments or than other asbestos exposure risk assessments, this conclusion should be stated explicitly and supporting details for this position should be presented and referenced.

ATSDR Response: All risk assessments involve uncertainty. We do not believe that ignoring real uncertainties in the assumptions and theory behind risk assessment methods would improve the credibility of this work.

PC11-13: Based on our experience, we conclude this is a much stronger, more robust cancer risk assessment than implied by the many comments on uncertainty in the manuscript. We also believe there are reasons that asbestos-related health risks actually may be <u>under</u>estimated by the draft report. These conclusions are supported by a number of factors:

ATSDR Response: We agree that the use of multiple risk methods, along with a high quality exposure data set has added to confidence in the assessment. It is likely that exposure scenarios and asbestos levels in the El Dorado Hills community exist that could lead to increased risk; there are, likewise, scenarios that could lead to less risk. ATSDR's goal was to get a general sense of the impact of NOA on the community, not characterize every possible exposure. To that end we think that the assumptions in this assessment provide a reasonable estimate of the risk in El Dorado Hills.

- PC11-14: Reliable exposure concentration data. The cancer risks calculated for recreational activities are based on personal exposure monitoring data (measurements of asbestos concentrations in the breathing zone) collected during the exact activities and at the exact same locations that are the focus of the cancer risk assessment. This is in contrast to many risk assessments which rely on exposure concentrations mathematically modeled from contaminant concentrations in environmental media (e.g., inhalation exposure to soil contamination is often based on models of fugitive dust generation or results from stationary air monitors). Thus, the exposure assessment underlying this risk assessment is based on measurements of actual breathing zone concentrations during the specific activities included in the assessment – this is a more rigorous quantification of exposure than appears in most risk assessments.

  This observation is supported by comments from Peer Reviewer #2 who expressed the opinion that "[t]his study is actually a model of the types of exposure data that should be routinely collected in health consultations." U.S. EPA's Science Advisory Board has also made a number of observations acknowledging the advantages of basing exposure estimates on breathing zone monitoring data.

ATSDR Response: Thank you for these observations. We agree that the high quality exposure data added to confidence in the assessment. The exposure data were of higher quality than available in many situations. ATSDR thanks EPA for providing such high quality data to work with.

- PC11-15: Reliable exposure frequency & duration assumptions. The recreational exposure scenarios in this cancer risk assessment are based on realistic exposure frequency and duration assumptions. The validity of these frequency and duration assumptions were confirmed through a review by the very same community that is the focus of the assessment. In addition, these frequency and duration assumptions are consistent with statistical data on children's recreational activities as presented in the Child-Specific Exposure Factors Handbook (EPA/600/R-06/096F, September, 2008). This is in contrast to many risk assessments which rely on generic or national default assumptions about exposure frequency and duration.

ATSDR Response: Thank you for this observation. ATSDR worked with many stakeholders in the community to develop realistic exposure frequency and exposure assumptions.

- PC11-16: Concurrence of risk model results. A somewhat unique feature of this risk assessment is the application of a number of different cancer risk assessment models to the same exposure scenarios. The fact that cancer risk estimates developed using these different models were all within a fairly tight (for risk assessment) range gives additional credibility to the results.

  Risk assessors generally feel that when similar results are obtained using different models this strengthens confidence in the risk assessment conclusions. Given how different the various models used in this risk assessment were, the fact they all predicted cancer risks within a fairly narrow range provides additional support to the conclusion that risks from NOA in the community are significant.

  With respect to this issue, Region 9 notes that even Peer Reviewer #2, whose comments generally emphasized the uncertainty in risk assessment, commented that "…the coherence in results [from the various risk assessment methods] needs further discussion and emphasis."

ATSDR Response: Thank you for these observations. ATSDR agrees that the similar findings of various risk methods adds confidence in the results. We have added Figure 5 to the final health consultation to illustrate this finding graphically.

- PC11-17: Lack of non-cancer risk estimates. While the cancer risk assessment in this Health Consultation is robust, non-cancer risks are not estimated at all in the risk assessment. Nor is there much discussion of non-cancer risks to the community. This is an important deficit because non-cancer health effects (e.g., pleural abnormalities, asbestosis) have been observed in a number of situations involving low-level exposures to asbestos. In fact, the high incidence of pleural abnormalities in Libby MT and elsewhere suggest that non-cancer health effects from asbestos exposure may be more prominent (i.e., create higher risk) than asbestos-related cancers in NOA-exposed populations. In addition, follow-up studies of workers at the O.M. Scott, Marysville plant are also showing pleural abnormalities occurring from relatively low level exposures (Rohs AM, Lockey JE, et al., Low-Level Fiber-Induced Radiographic Changes Caused by Libby Vermiculite, A 25-Year Follow-up Study. Am J Respir Crit Care Med 177:630-637, 2008).

The draft Health Consultation does make the observation that asbestos-related non-cancer health effects (e.g., pleural abnormalities) "are often seen in asbestos-exposed communities". This is an important observation for the residents of El Dorado Hills and should be more fully discussed.

We recognize that there are currently no well-accepted, peer-reviewed toxicity values for quantifying non-cancer risks from asbestos exposures, but feel there is sufficient information in the published literature for a detailed discussion of potential non-cancer risks. It is our opinion that the lack of a non-cancer risk estimate makes it likely that actual risks are underestimated, rather than overestimated, by this risk assessment.

ATSDR Response: We have expanded discussion of health effects seen in other NOA communities around the world, in the section beginning on page 12 entitled "Naturally Occurring Asbestos." As discussed in this section, ATSDR does not agree that exposures to community members in El Dorado Hills are comparable to those experienced by Libby, Montana residents or workers at Marysville. There is currently no accepted method to estimate noncancer risks such as pleural abnormalities. The risk assessment in this consultation only considered cancer risk.

PC11-18: With respect to the level of uncertainty in asbestos health risk assessment, it is noteworthy to us that ATSDR produced an earlier Health Consultation addressing NOA exposures in the El Dorado community that did not contain similar discussions of uncertainties and did not appear to question the cancer risk assessment results supporting that Health Consultation. In fact, the Uncertainties section of the January 2006 Health Consultation for "Asbestos Exposures at Oak Ridge High School" concludes that the EPA 1986 risk model, which is used in both Health Consultations, may underestimate actual cancer risk.

ATSDR Response: We do not agree that recognizing uncertainty takes away from our conclusion. ATSDR's conclusions are based not only on results from multiple risk methods but results of numerous other studies in the area and a professional consideration of the potential for exposures. All this evidence supports the conclusion that an increased risk is present. The commenter points out that ATSDR's earlier health consultation concluded that EPA's IRIS unit risk may underestimate risk from exposure to amphibole. This is precisely why ATSDR used several different risk methods in this health consultation.

PC11-19: 2. More Thorough Consideration of Data From Other Sources:

There are published studies, and other information, not cited in the draft Health Consultation which support the conclusion that communities exposed to NOA in California, and elsewhere, are at significantly elevated risk for asbestos-related diseases. We feel that both the quality of the Health Consultation and the message for the El Dorado Hills community would benefit from a more thorough discussion of this information, including:

ATSDR Response: ATSDR has added discussion of the Pan et al. study ("Schenker Study") to the section entitled "Naturally Occurring Asbestos"; and discussion of updated California Cancer Registry analysis of mesothelioma in El Dorado County to the section "Feasibility and Need for Further Investigation".

- PC11-20: Schenker study. The "Schenker study" is a publication by epidemiologists at the University of California Davis showing an association between residential exposure to sources of environmental asbestos in California and incidence of mesothelioma (Pan X, Day HW, Wang W, Beckett LA, Schenker MB. Residential proximity to naturally occurring asbestos and mesothelioma risk in California. Am J Respir Crit Care Med, 172(8):1019-1025, 2005). This study is referenced in the draft Health Consultation but only a passing reference is made to it and there is no discussion of its findings. It concluded that residential proximity to NOA is significantly associated with increased risk of mesothelioma, as borne out by actual cancers reported to the California Cancer Registry. This is an important study which is directly germane to the question of whether asbestos-related cancer risks are elevated in areas such as El Dorado Hills; it therefore deserves a thorough presentation and discussion in the Health Consultation.

ATSDR Response: ATSDR has added a more detailed discussion of the Pan et al. study ("Schenker Study") to the section entitled "Naturally Occurring Asbestos". The health consultation already contains much technical information and detailed discussion of all relevant studies and references is not possible. The Pan et al. study shows that residential proximity at diagnosis to ultramafic rocks (the most common type of rock that may host NOA) is associated with location of cases of mesothelioma. However, there are too many limitations in this study to make the conclusions as strongly stated as the commenter suggests. For example, proximity at diagnosis may not be relevant to a disease which may have a 20-50 year latency period, and no information about the length of residence or past residences was available. In addition, proximity to rocks that could contain NOA does not necessarily relate in any way to NOA exposure because not all ultramafic rocks contain NOA and if the NOA is not disturbed, no exposure can occur. Finally, no information about domestic exposure and only limited information on occupational exposure was available (only the longest or most recent occupation, typically), which may obscure actual contribution of occupational or other domestic exposures known to contribute to risk of mesothelioma.

- PC11-21: California Cancer Registry Data. The general tone of the report downplays the possibility that exposures to NOA are causing health effects in affected communities. In this context it is interesting to note that 4 of the 5 California counties noted in the report as having "the potential for asbestos exposures from serpentine gravel roads or roads cutting through natural serpentine" (p. 3) are within the upper quartile of California counties with the highest rates for invasive cancer of the pleura (the California Cancer Registry classifies pleural mesothelioma as a "pleural invasive cancer" for their website). These 4 counties are El Dorado, Calaveras, Napa and Amador. According to the California Cancer Registry website, Napa has the highest invasive pleural cancer rate in California, with Alpine-Amador-Calaveras (grouped) the 6th highest and El Dorado the 8th highest (cancer rate data for years 1988-2007). Lake County, another county identified by the California Air Resources Board (CARB) and the draft report (p. 40) as having a high potential for NOA exposures, has the 3rd highest rate of invasive pleural cancer in California. Placer County, where CARB air sampling indicated ambient asbestos exposures similar to those in El Dorado (P. 40), is also in the upper quartile for invasive pleural cancer rates and ranks 10th highest of the California counties. Information on these associations has been published (Case BW, Abraham JL. Heterogeneity of exposure and attribution of mesothelioma: Trends and strategies in two American counties. J Physics: Conf Series 151, 2009).

ATSDR Response: ATSDR has added discussion of updated California Cancer Registry analysis of mesothelioma in El Dorado County to the section "Feasibility and Need for Further Investigation" beginning on page 40 of the final document. In Fall 2010, ATSDR asked CCR to update the mesothelioma rates for western El Dorado County. Data are available from 1988 to 2008. The results show that the census tracts in El Dorado County where NOA is more likely to occur do not have greater than the expected number of cases of mesothelioma based on State rates. We have also included the entire report from CCR as Appendix J.

Although information on other counties helps give perspective, our focus in this health consultation is specifically on the El Dorado Hills area.

PC11-22: 3. Provide Additional Supporting Details:

Many important issues or observations in the report are incompletely discussed or referenced. The report should provide additional details and/or specific references when discussing some of the more important assumptions, calculations, interpretations and conclusions of the risk assessment.

ATSDR Response: This health consultation is for the public and already contains much technical detail; interested parties can consult the original references.

- PC11-23: Background ambient air concentration. The text on pages 32-33 states the "background concentration" of 4x10-3 PCME f/cc for dry periods based on U.S. EPA's reference station data (which was collected during a dry period). The average of U.S. EPA's reference station data was 0.0008 PCME f/cc – no details are given as to how the assumed background exposure concentration was derived from this value.

ATSDR Response: Thank you for pointing this out. We have modified the text to clarify that the average values were used to calculate "mid-range" exposures and the maximum values were used for calculating "high-end" exposures.

- PC11-24: Child exposure concentrations. Table 3 notes that stationary monitor data ("observer hi-vol") were used as the exposure point concentrations for the child-recess, child-digging and child-physical education scenarios. In contrast, data from personal monitors were used for the exposure point concentrations for the other child-activity scenarios (e.g., bicycling, asphalt courts). The text should explain why personal exposure data were not used for all child-activity scenarios.

ATSDR Response: We used professional judgment as was explained in the health consultation on page 32, "Notes on Structure Concentration Assumptions." "Some activities...were considered to be less intense than the corresponding activity-based sampling.... In these scenarios, stationary monitoring results (corresponding to observers in activity-based sampling) were used to describe exposure."

- PC11-25: Comparison to exposures causing disease. The discussion under Conclusion 2 states that NOA exposures in El Dorado Hills are lower than those responsible for causing disease in other communities where NOA is present. However, no data are presented - nor is there a detailed discussion - to support this statement. Ambient air community monitoring data from Libby MT, where a large percentage of the non-worker population exhibits signs of asbestos-related pleural changes, suggests that similar low-level exposures may indeed cause observable health effects. The situation in Libby also conflicts with the implication of the statement under Conclusion 2 about worker and community exposures ("Although theoretical risk was increased, potential exposures are generally orders of magnitude lower than those experienced by former asbestos workers").

ATSDR Response: We have added further discussion about the exposures to NOA that led to disease in the section entitled "Naturally Occurring Asbestos" beginning on page 12. We do not believe that the exposures in El Dorado Hills are directly comparable to the exposures in Libby, MT that led to elevated rates of disease there. Little to no air monitoring on historical asbestos concentrations in Libby exist. While current ambient monitoring shows very low asbestos concentrations in the community, it is likely exposures were much higher in the past. A large percentage of the townspeople worked in the mine or processing plant, the processing plant and transport operations were in the town itself, and asbestos-containing stoner rock was stored and used throughout the community for many purposes. In contrast, the exposures in El Dorado Hills are incidental, and NOA-containing substances are not used for any specific purpose in the community.

- PC11-26: Alternate application of Cal/EPA risk method. The results of the alternate application of the Cal/EPA risk method, in which the Cal/EPA inhalation unit risk is applied to measured PCME data rather than PCME concentrations calculated using the 320 conversion factor, should be presented in Table 4 along-side the results of the other risk assessments methods.

ATSDR Response: We have included a graphical format (Figure 5) and updated Table 4 to specifically include results from the alternate application of the Cal-EPA method.

PC11-27: 4. "Asbestos" Terminology & Characterization:

The terminology surrounding asbestos exposures and related health effects is complicated, controversial and is used by some stakeholders to obfuscate potential health issues (for example by implying that only asbestiform habits of the 6 regulated fibers are toxic). For this reason extreme care should be taken to only use scientifically appropriate terminology. The definitions/terms differ depending upon whether you are a geologist, laboratory analyst, health professional or a regulator. More often than not these differences are significant and remain contentious, even more so when it involves NOA. For example some might define asbestos as limited to the 6 asbestiform types listed under OSHA or EPA regulations whereas the geologists' definition might expand the amphibole definition to 60 or 70 types. The health professional is not limited to the 6 regulatory types but is concerned about any amphibole (whether asbestiform, non asbestiform or transitional structures) that might cause adverse health effects. For this reason extreme care should be taken to only use appropriate terms and avoid terms such as one which is used in the report, "true asbestos".

ATSDR Response: We agree with these points and have extensive discussion regarding the controversy and difficulty in setting terminology. We have replaced "true asbestos" in the "Asbestos Background" section beginning on page 6 with "asbestos". In Appendix E, "true" is placed in quotations with asbestos as a description of the points raised by critics of the activity-based sampling results.

PC11-28: ATSDR could look to the U.S. Geologic Service report on amphiboles in El Dorado Hills (Meeker GP, Lowers HA, Swayze GA, Van Gosen BS, Sutley SJ, Brownfield IK. Mineralogy and morphology of amphiboles observed in soils and rocks in El Dorado Hills, California. U.S. Geological Survey Open-File Report 2006-1362. December 2006) for guidance on appropriate terminology. The USGS report highlights the scientific complexity when dealing with naturally occurring amphiboles particularly the difference between the occupational situations that involved usually 3 types of asbestos (chrysotile, amosite and crocidolite) and the NOA exposure to many more forms of amphibole. A more expansive discussion of NOA as described in the USGS report is recommended as the report seems to concentrate on occupational exposures rather than the situation in El Dorado Hills with NOA amphiboles. It would also help the reader to know that there is also mortality and disease from exposure to non occupational asbestos (see various articles from the Mediterranean area, Cappadocia, Wittenoom and even Libby).

ATSDR Response: The USGS report is referenced several times in the document and the findings are discussed on page 48 in the section entitled "Additional Information on NOA in the El Dorado Hills Area." USGS has detailed mineralogical terminology regarding asbestos and asbestos-like minerals, but as discussed in the "Background" section, this terminology may not fully describe properties related to the mineral's disease-producing potency. Expanded information on mortality and disease associated with NOA is included in the section "Naturally Occurring Asbestos."

PC11-29: 5. Conclusion 2:

We feel that a well designed study of disease rates in the community could potentially yield valuable information on the risks of NOA exposure, not only for El Dorado Hills but also for other foothill communities throughout California where similar exposures are occurring or may occur in the future. It is true, as noted in the draft Health Consultation, that many current El Dorado Hills residents may be too new to the community to have developed asbestos-related diseases at present (due to the very long latency characteristic of these diseases). However, a study focused on the many long-term residents of El Dorado County may indeed find significantly elevated incidences of asbestos-related diseases. Such a result is already suggested by the Schenker study (see details above) and would be an important public health finding both for newer El Dorado residents and for those of other foothill communities undergoing similar rapid population growth.

ATSDR Response: We have reworded conclusion 2 and it no longer refers to a health study. We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area. An epidemiological health study is not needed here because the relationship between asbestos exposure and disease is already well established. In addition, there is no way to obtain quantitative, individual estimates of past NOA exposures, information that is essential for conducting a scientifically rigorous epidemiological health study.

- PC11-30: Health study. One supporting statement to Conclusion 2 is that a "health study would not conclusively state that NOA caused a specific person's health condition" (p. vi); this statement deserves comment. First, this is true of any health study. It is rare that a health study is able to make an unequivocal cause-effect link between a measured environmental exposure and specific cases of disease; usually the best that can be done is to observe if there is an association between increased disease rates and elevated exposures. Second, asbestos exposure is well recognized as almost the only cause of at least two specific health conditions (mesothelioma and pleural plaques); therefore finding either condition in El Dorado residents who have not worked with asbestos would be a very strong indication that NOA exposures are causing disease in the community. In this regard, a health study of exposure to asbestos has perhaps the greatest chance of any health study to attribute causation; more so than for most hazardous chemical exposure situations.

ATSDR Response: We have reworded conclusion 2 and the statement referenced in the comment no longer appears. We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area.

- PC11-31: Health study. Another supporting statement to Conclusion 2 is that "[e]ven if exposure were high enough to cause disease, it takes decades for symptoms to appear. Therefore health conditions may not be detected at this time." This observation assumes that exposures began recently and ignores the many people who have lived in El Dorado for decades. It is true that the population has increased significantly over the last 10-15 years, but there are significant numbers of people who have lived there for decades.

ATSDR Response: We have reworded conclusion 2 and the statement referenced in the comment no longer appears. We have included a new section entitled "Feasibility and Need for Further Investigation", beginning on page 40, which addresses questions related to health studies and mesothelioma rates in the area. There is no way to obtain quantitative, individual estimates of past NOA exposures, information that is essential for conducting a scientifically rigorous epidemiological health study.

PC11-32: 6. Presentation of Risk Comparisons:

Some of the risk comparisons seem inappropriately intended to trivialize risk estimation (e.g., "risk of being hit by a meteor while walking on the sidewalk") or not germane to a Health Consultation for an environmental exposure. It would be useful, and informative for the community, to include some comparisons to risk estimates generated for other Health Consultations and/or at Superfund sites. It would be especially useful if these comparisons indicated whether the risks at these other sites were judged sufficiently high to warrant a health study by ATSDR and/or a remedial (clean up) action by EPA.

ATSDR Response: The comparison to a meteor has been removed. The risk comparisons were included at the request of community stakeholders to give perspective on how the risk estimates compare to other risks they face in daily life. In order to include risks that are comparable to predicted risk estimates, this necessitated including some rare events. We included caveats regarding making these comparisons because we do not believe risks are truly comparable. For example, an involuntary risk that is preventable (NOA exposure) may warrant action to be taken at a relatively low risk level, whereas if the risk is voluntary or cannot be prevented it may not warrant specific action. We do not believe that comparing our risk estimates to other health consultations or EPA risk assessments is appropriate - ATSDR bases conclusions and recommendations on many site specific considerations, not only on numerical risk estimates.

PC11-33: Another good comparison would be to cancer risks from indoor exposures to naturally-occurring radon gas. This risk seems especially germane because, similar to NOA cancer risk, it arises from exposure to a naturally-occurring agent (radon), the level of exposure and distribution of which varies depending on local geology (as is the case with NOA). If the radon example is used it would be informative to note that U.S. EPA and other public health agencies have radon awareness and assessment programs in place because of the high risks posed by this naturally-occurring chemical threat.

ATSDR Response: Thank you for this observation. Radon is a good comparison and has been added as an example in the text on page 18. We did not include details of radon awareness and assessment programs. While such details would be informative, they are outside the scope of this health consultation.

MISCELLANEOUS / EDITORIAL COMMENTS

PC11-34: Exposure point concentrations. The term "structure level" appears to be used to mean the concentration of asbestos which the risk assessment assumes is breathed during the various activities that form the exposure scenarios. This term is confusing and is not customarily used in risk assessment. A more typical term would be "exposure point concentration", or the term used in ATSDR's Health Consultation for Oak Ridge High School, "asbestos fiber concentration".

ATSDR Response: Because ATSDR used multiple risk assessment methods which utilize different structure definitions we prefer to use more generic terminology than we did in the Oak Ridge High School health consultation. To prevent unnecessary confusion, we have standardized our terminology in this document to "structure concentration".

PC11-35: Distribution of NOA exposures in El Dorado Hills. Various comments in the report imply that NOA exposures may be very limited in the community. It is important for the community to understand that U.S. EPA's ABS activities, which showed significant exposures, did not take place directly on NOA deposits or veins. Rather, as documented in the USGS report, the amphibole exposures monitored by the ABS personal exposure samplers resulted from weathering and dispersion of NOA in the community (USGS Open-File Report 2006-1362).

ATSDR Response: The health consultation emphasized that the activity based sampling may not represent the highest exposures possible. We considered the sampling adequate for obtaining a general sense of community risk, for the reasons stated previously in the response to public comment PC9-2:

- *The types of activities and durations of activities performed during the activity-based sampling and included in this health consultation's assumptions were determined in consultation with the community and local, state, and federal agencies,*
- *The areas sampled were high community use areas,*
- *The USGS study of mineralogy in the area (discussed beginning on page 48) showed that the activity-based sampling captured asbestos-defined particles that contribute to risk,*
- *The conclusions and recommendations of the health consultation take into account potentially higher exposures (or exposure to "more toxic" mineralogical forms) and resulting risk to individuals based on their individual activity patterns.*

Although we recognize that exposures could be higher based on individual exposure patterns, we also note that asbestos is not uniformly distributed in El Dorado County, or even in rocks more likely to host asbestos. Instead, asbestos occurs in concentrated veins. Therefore, it is reasonable to assume that the much higher exposures anticipated from disturbing veins and outcrops do not occur in many locations or to much of the population of the County. This reasoning supports our determination that activity based sampling in a general community area would be adequate for representing typical exposures to community members.

PC11-36: Community versus worker exposures. The discussion of community versus worker exposures on page 12 is misleading in downplaying the frequency and duration of community exposures. There are 2 statements alleging that community exposures are shorter and more infrequent than worker exposures. Given that PCME amphiboles were observed in every ambient air sample collected by U.S. EPA in the El Dorado Hills community, this statement is not supported by the data. For a stay-at-home resident, the data show that exposure could be 24 hours per day, assuming that asbestos is not somehow filtered as ambient air becomes indoor air. And, although there are many newer residents in the community, some El Dorado residents have lived there for decades – census data show that the largest percentage population increase in El Dorado County occurred in the 1970s (www.census.gov/population/cencounts/ca190090.txt). These observations appear to contradict the statement that "… workers' exposure was more frequent, more regular, and lasted longer than we would expect in the community situation."

ATSDR Response: ATSDR has reworded part of this paragraph, which appears on page 15 of the final document. We recognize that community exposures to background concentrations are *essentially continuous and we accounted for this in our exposure and risk calculations. However, exposures to high levels such as early asbestos workers experienced are likely to be shorter and more infrequent, if they occur at all. The reworded sentence reads: "Workers' exposure to these high concentrations was more frequent, more regular, and lasted longer than occasional high-concentration exposures we would expect in a community situation."*

PC11-37: There appears to be a direct contradiction between 2 sentences in the discussion of fiber types, shapes and sizes on page 12. An unsupported and unreferenced statement is made that workplace exposures are more uniform than NOA because "… NOA exposures typically include a much wider range of asbestos fiber types, shapes and sizes as well as a large percentage of non-asbestos particles and/or accessory minerals." This statement is directly followed by "Unfortunately, comparing fiber mineralogy and size distributions between exposures of asbestos workers and people exposed to NOA is impossible at this time—the historical data on worker exposures simply does not contain such detailed information."

ATSDR Response: ATSDR has reworded the referenced paragraph, found on page 15 of the final document, to clarify our intended meaning that intuitive differences exist between worker and NOA exposures that cannot be confirmed because the historical worker data are not detailed enough. The revised paragraph now reads:

> *Finally, it seems intuitive that the type, size and shape of asbestos particles breathed in by asbestos workers were relatively consistent, because they worked with relatively pure asbestos (or highly contaminated vermiculite) every day. Although the shape and size of the asbestos fibers breathed by a worker may have varied depending on the area of the plant or process he or she worked with, the exposure was likely relatively consistent with regard to the mineralogy and other characteristics of the asbestos particles. In contrast, NOA exposures occur in diverse locations and may include a wider range of asbestos fiber types, shapes and sizes. NOA exposures also typically include a large percentage of non-asbestos particles originating from soils or other materials present with NOA in the natural environment. Unfortunately, confirming these differences by comparing fiber mineralogy and size distributions between exposures of asbestos workers and people exposed to NOA is impossible at this time—the historical data on worker exposures simply does not contain such detailed information. There has been some effort to analyze archived historical air sampling filters to obtain this information, but it is a task requiring significant resources and time. Some findings have been published (see [79], for example), but it is our understanding that further work to reanalyze historical filters (by EPA and NIOSH) is still in the planning stages.*

PC11-38: "Wet" background exposure assumption: Additional data or information should be presented to support the assumption that background asbestos exposures during "wet" times are 1/10 of the exposures during dry periods. The current text refers to construction monitoring data in Figure 7 as "partial support" for the assumption that during the "wet" period "concentrations were an order of magnitude smaller but does not provide a detailed discussion of how these data were used to make the 1/10 assumption. It has been U.S. EPA Region 9's experience that exposure concentrations from soil disturbance activities during wet periods are similar to those during dry periods. Activity-based sampling at the Clear Creek Management Area off-road recreational area exhibited similar personal exposure monitoring concentrations during both dry and rainy seasons.

ATSDR Response: We have clarified in the text on page 32 that the observation that the "wet" period average asbestos level was approximately one-tenth of the "dry" period average asbestos concentration was how we made this determination. CARB monitoring also supported the assumption that wet periods had significantly lower asbestos concentrations than dry periods, since sampling conducted during wet periods showed no detected asbestos. We do not have activity based sampling during wet periods (in fact, activity based sampling procedures generally call for sampling under relatively dry conditions), but in practice this does not matter much since during wet periods, outdoor activities will also be curtailed. We considered only data from the El Dorado Hills area in this health consultation. It is doubtful that comparisons to a different site, with different uses, geology, and asbestos type, will be relevant to this site.

PC11-39: Toxicity profile citations. Many of the statements presented in the discussion are cited to the ATSDR Toxicity Profile on Asbestos, which contains a review of various experimental and observational studies on asbestos exposures and health effects. However, it would be more helpful to the reader if statements about the observations or conclusions from individual studies were referenced to the original publications themselves, not to a review publication.

ATSDR Response: ATSDR believes use of the Toxicological Profiles is appropriate for a document geared towards the general public. ATSDR Toxicological Profiles are a respected source cited by researchers all over the world, especially for general information on substances. When discussing specific studies, the health consultation references the specific literature study.

PC11-40: Acceptable risk discussion (p. 14): Although stated in the quote, the discussion of acceptable risk from carcinogens should note that is an EPA policy applying to CERCLA (Superfund) risk management decisions.

ATSDR Response: The text has been reworded as follows: "EPA outlined their CERCLA (Superfund) risk management decision policy related to acceptable risk from carcinogens in the environment in a 1991 memo [52]. The memo states:…"

PC11-41: The next paragraph says that these risks relate to "people being exposed for a specified length of time, usually a lifetime…". Actually, most Superfund risk assessments are based on a 30 year exposure duration using an RME (Reasonable Maximum Exposure) scenario [and occasionally a 9 year Central Tendency exposure scenario].

ATSDR Response: This document is a health consultation, not an EPA risk assessment, and although it uses general risk assessment methods, does not mirror EPA Superfund risk assessment procedures. ATSDR often calculates risks with the more protective assumption that people are exposed continuously for a 70-year lifetime, which is the duration assumed for unit risks.

PC11-42: Inclusion of background exposures. Regarding the discussion on p. 32 of including background exposures into the consultation's risk assessment, Region 9 believes it is appropriate to include background exposures. In this community the background exposure is created by the same source as the activity-specific exposures, namely the presence of NOA in the community.

Background exposures may be treated differently by U.S. EPA at CERCLA sites when those exposures are due to a different source than the contamination at the site.

ATSDR Response: Thank you for your comment and support of our including background exposures.

Comments from EPA Technical Review Workgroup Asbestos Committee (PC12)

(Note: The ATSDR El Dorado Hills team members who sit on the TRW Asbestos Committee did not participate in the subcommittee that prepared comments on this document and were not party to discussions relating to the Committee comments.)

PC12-1: The document is clearly written and the level of detail is appropriate for the intended audience. The committee identified several technical issues listed below that should be addressed. If you need additional assistance, please feel free to contact us.

ATSDR Response: Thank you for this comment. No response is necessary.

PC12-2: General Comments

The health consultation generally follows the outline of their previous health consultations. The document presents background information and information about disease incidence relating to asbestos exposure. Some areas of information are highly detailed and others are almost glossed over. The document could benefit from some editing to even out the treatment of various topics.

ATSDR Response: We have expanded several sections to respond to public comments received. The document is for the general public, and we recognize that our efforts to balance technical detail with readability may be imperfect.

PC12-3: The goal of the document is to present an understanding of potential adverse health outcomes associated with exposure to asbestos and how that might relate to NOA exposures in El Dorado Hills. The study should detail various ways persons might come in contact with NOA and should evaluate how likely it is that human health effects might occur for current/future receptors because of the NOA in their neighborhood. The consultation should be a tool to help identify existing and potential adverse health outcomes due to the presence of NOA. The consultation is also a tool to assist ATSDR in protecting the public health in El Dorado Hills. The health consultation is not an investigation of current health conditions or a medical examination. Moreover, the health consultation is not a study that will tell the community directly whether any existing health outcome or future outcomes can be directly related to the existence of NOA in the community.

ATSDR Response: Thank you for this comment. No response is necessary.

PC12-4: Some governmental agency should establish a long term program for the residents of El Dorado Hills to monitor for adverse health effects known to be associated with exposure to amphibole asbestos. The program should include both El Dorado County and Sacramento

County since most of the residents in El Dorado Hills would seek medial consultation and treatment in Sacramento.

ATSDR Response: We concluded that exposures have the potential to cause harmful effects. The best, most efficient public health action to take is to prevent and reduce exposures now. Reducing exposures is the surest way to protect the public from potential future health effects. We also recommend the California Cancer Registry continue monitoring cancer incidence in the area to identify any unexpected increases in rates.

Specific Comments

PC12-5: Page iv, Summary, Introduction, 2nd paragraph: Were only recreational activities sampled?

ATSDR Response: Yes.

PC12-6: Page iv, Summary, Introduction, 3rd paragraph, 2nd line: Is "general sense" the right term or would "range" be more appropriate for what was intended?

ATSDR Response: The suggested change has not been made. ATSDR feels the data and our purposes only allowed us to get a "general sense" of the risk to the community.

PC12-7: Page v, Basis for Conclusion, 2nd bullet: suggest change “risk assessment methods” to “exposure and toxicity assessment methods.” The general risk assessment approach is the same regardless of the model used.

ATSDR Response: This suggested change has not been made. We have been using this terminology in our discussions with the community for several years, so making this change would be likely to result in confusion among community members.

PC12-8: Page v, explain or provide examples for the public to understand what are: “sites subject to asbestos hazard mitigation requirements.”

ATSDR Response: We have reworded the statement to say "State and local entities should continue to enforce applicable dust regulations throughout the community, which will reduce releases of NOA. These regulations include:…"

PC12-9: Page v, include some examples from Appendix H of how community members can reduce the likelihood of inhaling asbestos fibers (using grassy areas for recreational activities, pre-wetting garden areas before digging, preventing dirt from being tracked in homes and cleaning methods that reduce dust).

ATSDR Response: The reader is clearly directed to Appendix H for examples.

PC12-10: Page vi, Conclusion 2: What would a “health study” consist of? It is reasonable to suggest that a health study of disease incidence may not provide valuable information. However, it might be appropriate to recommend additional steps be taken to either mitigate or monitor exposures.

ATSDR Response: We have rewritten conclusion 2 and the discussion of potential further investigation because the discussion in the public comment draft seemed to cause confusion, based on the number of comments received on the topic. The discussion of potential further investigation begins on page 40 and includes discussion of mesothelioma rates in western El Dorado County, which we requested the California Cancer Registry to re-examine in Fall 2010.

PC12-11: Page vi, first open bullet: Can more information be presented to describe the actual exposures (or potential) at the other NOA communities? If so, it would be good to present it, if not how do we know the exposures are lower? This is also discussed on pp. 11 and 33.

ATSDR Response: We have rewritten conclusion 2 and the comparative statement referred to by the commenter is no longer present. We have expanded the discussion of other NOA sites throughout the world where asbestos disease was found to include a discussion of the exposures occurring and any exposure data collected. This is in section "Naturally Occurring Asbestos" beginning on page 12.

PC12-12: Page vi, third open bullet: How long have people lived in the area? This information would help explain why disease is not yet expected to be observed in the community.

ATSDR Response: We have reworded Conclusion 2. While some people may have lived in the area for decades, it is mainly the inability to quantify their exposures that makes conducting study of long-term residents infeasible.

PC12-13: Page 1, History, last full sentence on page: Who or what is Serrano?

ATSDR Response: We have clarified the text as follows: "...and as the developer Serrano built a 3,500 acre planned community…."

PC12-14: Page 4, "ATSDR funded additional analyses…variety of risk methods to be applied." Could this be reworded to "... funded additional analyses to improve statistical comparisons of fibers of different dimensions.."? As is, it sort of sounds like EPA didn't collect reliable data.

ATSDR Response: The sentence has been reworded to state, "ATSDR funded additional analyses of the data to gain reliable estimates of long asbestos structure concentrations not typically enumerated by EPA, allowing a variety of standard and non-standard risk methods to be applied."

PC12-15: Page 6, Figure 3: are these the most illustrative images for what you're trying to demonstrate as the differences between amphibole and chrysotile fiber structural differences?

ATSDR Response: We feel these images are appropriate.

PC12-16: Page 7, top of page: Why introduce a new term "true asbestos"? Wouldn't "asbestos" be adequate?

ATSDR Response: We have replaced "true asbestos" in the section beginning on page 6 with "asbestos". In Appendix E, "true" is placed in quotations with asbestos as a description of the points raised by critics of the activity-based sampling results.

PC12-17: Page 7, Disease and Death: the phrase inside the parenthesis to describe latency should be reworked. It's a bit clumsy and confusing as written.

ATSDR Response: The parenthetical phrase has been simplified.

PC12-18: Page 8, The non-cancer adverse health outcomes of amphibole asbestos are significant and striking. The amphiboles from Libby, Montana [which include tremolite, 6%] appear to cause significant pleural abnormalities in workers including pleural calcification, pleural thickening, interstitial and parenchymal thickening, and fibrosis. The major adverse health outcome identified in Libby is pleural disease. References that support the non-cancer outcome include: Amandus et al., 1987, MacDonald et al., 1986, Peipins et al., 2003, Sullivan, 2007, Whitehouse et al., 2004, and Rohs, et al., 2008.

ATSDR Response: As described in the expanded section "Naturally Occurring Asbestos" beginning on page 12, the exposure pathways and levels, frequency, and duration of exposure at Libby, Montana and El Dorado Hills are likely quite different, so a direct comparison of the two would be inappropriate.

PC12-19: Page 8, Somewhere in the text, a discussion of non-cancer endpoints [i.e., a hazard quotient or index] should be mentioned. On-going experiments are being conducted by EPA to further assess the toxicity of amphibole asbestos. The toxicity factor is not available at this time and it may not be applicable to the amphiboles identified at El Dorado Hills. Not being able to assess the potential for non-cancer endpoints at the El Dorado Hills site is a significant data gap in the consult.

ATSDR Response: We do not agree. While it is true that non-cancer endpoints cannot be assessed at this time, ATSDR found that the estimated cancer risk was great enough that actions and recommendations to reduce exposure are warranted. Reducing exposures will reduce the risk of both cancer and non-cancer adverse health effects.

PC12-20: Page 9, "OSHA specifications were selected for convenience"–weren't they also based on the limits of detection at the time?

ATSDR Response: As is stated on page 10, "These specifications were selected for convenience and as a result of the optical limitations of PCM*."*

PC12-21: Page 9, last sentence in Defining Asbestos paragraph: Suggest rewording to say "OSHA permissible exposure limits use PCM concentrations..."

ATSDR Response: The suggested change has been made.

PC12-22: Page 9, the authors should update the description of pleural changes known to result from amphibole exposure. See Rohs, et al., 2008 for a recent review. Pleural effusions and fibrosis can lead to death.

ATSDR Response: We added a reference to this study in the text on page 9. The cited paper (Rohs et al. 2008) updates previous findings of pleural abnormalities in Marysville, OH workers exposed to Libby asbestos-contaminated vermiculite. The follow-up showed a greater prevalence of pleural thickening and interstitial changes than in previous studies, even though exposure had ceased. The paper does not describe any deaths related to the pleural changes. The paper does cite another study (Sullivan 2007) that found excess mortality in Libby workers for nonmalignant respiratory disease (which includes asbestosis, chronic obstructive pulmonary disease, and a minor category described as "other respiratory diseases.")

PC12-23: Page 10, end of first paragraph: If we don't typically perform the NIOSH correction for PCM-sized range particles, why include the discussion here?

ATSDR Response: This correction is more commonly used in occupational settings. We include it here for completeness and for the asbestos professional who may want to know where it fits in.

PC12-24: Page 10, last complete sentence on page: The text states that 3:1 aspect ratios are not health-based, but PCM measurements (which form the basis for the current potency factor in IRIS) used a 3:1 aspect ratio.

ATSDR Response: The 3:1 ratio used in PCM and that forms the basis for IRIS is not health based.

PC12-25: Page 11, last sentence above "NOA" section: Consider rewriting as: "available and widely accepted."

ATSDR Response: The suggested change has been made.

PC12-26: Page 11 (and elsewhere), the uncertainty discussion should be expanded to include uncertainties associated with the ABS sampling [sample variance] and with some of the data that has been collected. The ambient air data and ABS data are largely short-term sampling data. There are other data gaps that could be addressed as well. It is interesting to note that with all of the uncertainty in how we estimate excess cancer risks, the 4 models used in this analysis all generally yielded similar results.

ATSDR Response: This discussion has not been added. The "Limitations" section already includes a statement on uncertainties related to the activity-based sampling. This statement is adequate to describe uncertainty related to sampling recognized as the state-of-the-art technique for describing community exposures.

PC12-27: Page 11, the authors would greatly benefit from additional discussion of the USGS report when discussing NOA.

ATSDR Response: The USGS study is described on page 48 in the section entitled "Additional Information on NOA in the El Dorado Hills Area."

PC12-28: Page 12, when discussing the worker exposure relative to NOA exposure, the authors should include some pertinent references providing relative levels of exposure [e.g., up to 130 s/cc for some industrial exposures and up to 0.08 s/cc for the ABS at El Dorado Hills]. You have this in Appendix B but it would help your discussion in the text on page 12.

ATSDR Response: We have added a specific reference on page 15 to Figure 4, which was created for that very purpose in response to a suggestion from the external peer reviewers.

PC12-29: Page 12, end of 3rd full paragraph: Question--who is analyzing archived filters and what filters are available?

ATSDR Response: ATSDR does not have this level of detailed information. It is our understanding that EPA and NIOSH are involved in this effort. Please contact them for more information.

PC12-30: Page 12, end of 4th full paragraph: Didn't some of the epidemiology studies rely on PCM measurements? Don't refer to PCM as obsolete.

ATSDR Response: We have reworded the statements as follows: "In addition, the risk methods themselves contain uncertainty. The use of the PCM size fraction to describe exposures in historical worker studies may or may not fully describe the exposures responsible for the observed health effects. In addition, the risk methods had to obtain many of the PCM measurements by converting obsolete midget impinger exposure measurements to PCM."

PC12-31: Page 13, Figure 4 and Figure 6 (pg 34), and Appendix B: Do the various indicators on this figure refer to the same fiber types (e.g., dimensions?) If not, this comparison is not valid. These figures present concentrations as "fibers of size defined by occupational standards". Is this equivalent to PCM or PCMe? If so, this should be stated more clearly. In addition, Appendix B should be modified to clearly present the basis of the reported concentrations (i.e., total TEM, PCM, PCMe). Throughout document: The definition of PCMe includes an upper bound on width of 3 µm. Although this is consistent with the Asbestos Framework, this is not a structure dimension criteria associated with PCM (NIOSH 7400).

ATSDR Response: The axis titles have been changed to refer to PCM f/cc. A note was also added to Appendix B, Sources/Assumptions to describe the fiber dimension. The referenced figures were included as a general comparison of fiber levels, to give perspective on how levels compare between occupational and nonoccupational settings and what was measured in El Dorado Hills. The concentrations depicted in the figures are all reported as or converted into PCM units, allowing general comparability. The values depicted should not be construed as exact numbers, only estimates.

PC12-32: Page 14, as mentioned above in the general comments, the discussion of risk should not include items that tend to trivialize potential health risks.

ATSDR Response: The comparison to a meteor has been removed. The risk comparisons were included at the request of community stakeholders to give perspective on how the risk estimates compare to other risks they face in daily life. In order to include risks that are comparable to predicted risk estimates, this necessitated including some rare events. We included caveats regarding making these comparisons because we do not believe risks are truly comparable. For example, an involuntary risk that is preventable (NOA exposure) may warrant action to be taken at a relatively low risk level, whereas if the risk is voluntary or cannot be prevented it may not warrant specific action.

PC12-33: Page 14, end of 2nd paragraph: Editorial, sentence has an extra period before the [51].

ATSDR Response: This correction has been made.

PC12-34: Page 14, fifth paragraph: Suggest rewording--For environmental contaminants, "EPA outlined its policy on acceptable risk from exposure to carcinogens..."

ATSDR Response: The text has been reworded as follows: "EPA outlined their CERCLA (Superfund) risk management decision policy related to acceptable risk from carcinogens in the environment in a 1991 memo [52]. The memo states:…"

PC12-35: Page 15, Table 1. Are other risks perceived by the public to be as dreaded as dying from asbestos related disease? These comparisons may not be appropriate. The cancer risk numbers might provide some perspective by showing how the "excess" risk from the NOA compares.

ATSDR Response: The risk comparisons were included at the request of community stakeholders to give perspective on how the risk estimates compare to other risks they face in daily life. In order to include risks that are comparable to predicted risk estimates, this necessitated including some rare events. We included caveats regarding making these comparisons because we do not believe risks are truly comparable.

PC12-36: Page 16, Table 1: Some of the items in this table represent risk of dying, while others represent risk of contracting a disease. As these are not comparable, suggest presenting in different table.

ATSDR Response: The risk comparisons were included at the request of community stakeholders to give perspective on how the risk estimates compare to other risks they face in daily life. We included caveats regarding making these comparisons because we agree that the risks are not truly comparable.

PC12-37: Page 16, suggest changing title of section to “Asbestos Health Effects Assessment Methods” or “Asbestos Toxicity Assessment Methods” to avoid confusion with the later section on risk assessment in which the toxicity and exposures are combined to characterize the site risk.

ATSDR Response: This suggested change has not been made. We have been using this terminology in our discussions with the community for several years, so making this change would be likely to result in confusion among community members.

PC12-38: Page 16, some suggested changes for clarity under “General Concept”: replace the first 2 sentences: The purpose of the health effects (or toxicity) assessment method is to evaluate health effects (disease) that might occur as a result of exposure to a hazardous substance. The evaluation considers how people might be exposed and the levels at which health effects might occur.

ATSDR Response: The text on page 20 of the final document has been modified to state: "The purpose of the risk assessment method is to predict the likelihood of an adverse health effect (disease) occurring from an exposure to a hazardous substance. The way this is done is by examining studies where the relationship between exposure and the resulting adverse health effects is known and assuming the exposure you are interested in will result in the same adverse health effects."

PC12-39: Page 17, discussion of risk assessment methods. Have both the state and EPA conducted risk assessments?

ATSDR Response: To our knowledge, neither EPA nor the state of California has completed a risk assessment in the El Dorado Hills area.

PC-11-40: It may add clarity for the community to convey which approaches are used by EPA and the state and clarify that these and additional methods were used. The OSWER 2008 Interim Risk Approach was never developed into a risk assessment approach, so perhaps should be mentioned in the text but not highlighted as a method?

ATSDR Response: The text for each method describes which agencies developed and use each method and the status of the methods. The OSWER risk approach is included because it was being developed at the same time as this health consultation. Stakeholders may have been aware of its existence and would question why it was left out.

PC12-41: Is the life table analysis the same as that in the Framework? Suggest listing all the methods in the intro and very briefly stating why some are used and others not.

ATSDR Response: Discussion of which methods were and were not used, and why, is in the section "Summary - Asbestos Risk Methods". We have added a section describing EPA's Framework for Investigating Asbestos-Contaminated Superfund Sites (2008) on p. 25 of the final health consultation. The theory of the life table analysis is similar to that used in the Framework. The Framework fits mathematical equations to Nicholson's (1986) tables of unit risks (calculated using 1977 mortality data) for less-than-lifetime exposures, so that less-than-lifetime unit risks *can be calculated for any duration of interest. This health consultation used the potency factors given by Nicholson (1986) with 2003 mortality data and site-specific exposure assumptions to estimate risk using life table analysis. This health consultation was prepared independently of the Framework document and has a different purpose.*

PC12-42: Page 17, EPA Airborne Asbestos Health Assessment Update, 1986: Editorial, IRIS is the Integrated Risk Information (not assessment) System.

ATSDR Response: This correction has been made.

PC12-43: Page 18, when discussing the EPA 1988 model, the author needs to add the fact that the slope factor is a central tendency value; not a 95th percentile value.

ATSDR Response: ATSDR could not find any official definition of "central tendency" so we have assumed that the term is used loosely to differentiate between using averages versus using high-end estimates such as 95^{th} percentiles or upper confidence limits of values in the approach. The EPA 1986 method used averages of individual epidemiological study results to estimate potency values. Therefore, the approach is considered a central tendency approach, and resulting slope factors used to calculate inhalation unit risks such as in the IRIS ("EPA 1988") method would by extension be considered central tendency values. The Berman and Crump method used a maximum likelihood approach, also considered a central tendency approach. These points were in the public comment version of the health consultation, in the discussion of the Cal-EPA method which uses a 95% upper confidence approach. We have added similar statements to the discussions of the other methods.

PC12-44: Page 19, "similar" should be "surrogate". Surrogate was the term used by Berman and Crump, 2003 report (page 5.3). Also, ATSDR undertook a significant effort to recount ABS filters to attain a lower detection limit to quantify Berman & Crump fibers ≥10 µm long and ≤1.5 µm in diameter. This allowed ATSDR to estimate risk for lung cancer using the Berman & Crump model. The committee does not know if there is literature that adequately supports the conclusion that long, thin fibers are more toxic than the shorter, larger diameter fibers in amphiboles. Recall that the Berman & Crump (2003) paper has not been peer reviewed.

ATSDR Response: "Similar" was used as a more comprehensible term and adequately describes to the lay reader what was done. There is extensive discussion of uncertainties as to asbestos toxicity and the various risk methods employed throughout the health consultation.

PC12-45: Page 20, the three paragraphs discussing the OSWER 2008 Interim Risk Approach should be revised to change "mid-2000's" to "around 2004 to 2005." Also, add "Bill" before "Brattin" in the second paragraph in this section.

ATSDR Response: We modified the dates in the text as suggested. For consistency, no first names were included when discussing risk methods.

PC12-46: Page 20, first full paragraph: Appears an internal note "[?how do you say that?]" needs to be removed.

ATSDR Response: Thank you for your comment. This error was caught and corrected shortly after the initial version was posted to the website.

PC12-47: Page 20, when discussing the risk models, we recommend including the EPA Framework [2008].

ATSDR Response: We have added a section describing the Framework on page 25 of the final health consultation.

PC12-48: Page 21, second paragraph: Even though Berman and Crump (2008) note that the best fitting potency factors for lung cancer and mesothelioma should be considered interim, the values based on no width restrictions are clearly superior to the potency values derived from Berman and Crump (2003) which was a draft document that was prepared for the EPA, but never endorsed as final policy. The potency factors derived in the 2008 report should be used over the 2003 report.

ATSDR Response: No changes have been made. The 2003 values were used because that was the method requested by various stakeholders when ATSDR began evaluating the data in 2006. The potency values published in Berman 2008 [$K_{LA} = 7.7\times10^{-2}$; $K_{LC}=0.49\times10^{-2}$; $K_{MA}=30.8\times10^{-8}$; $K_{MC}=0$] do not differ greatly from the 2003 values [$K_{LA} = 3\times10^{-2}$; $K_{LC}=0.6\times10^{-2}$; $K_{MA}=30\times10^{-8}$; $K_{MC}=0.04\times10^{-8}$] and would not have a significant effect on the risks calculated or the conclusions of this health consultation.

PC12-49: Page 22, the initial discussion of risk and the presentation of comparative risks such as being hit by a meteor or being struck by lightning are not appropriate for a document such as this. Risk communication is a delicate, personal matter and should not be trivialized. The authors should eliminate any and all mention of comparative risk events that trivialize potential adverse health outcomes.

ATSDR Response: The comparison to a meteor has been removed. Other risk comparisons have not been removed. The risk comparisons were included at the request of community stakeholders to give perspective on how the risk estimates compare to other risks they face in daily life. In order to include risks that are comparable to predicted risk estimates, this necessitated including some rare events. We included caveats regarding making these comparisons because we do not believe risks are truly comparable.

PC12-50: Page 22, first sentence of 1st paragraph: the committee disagrees that “many” risk assessors calculate separate risks for men and women, smokers and nonsmokers. This is not standard EPA practice.

ATSDR Response: While this procedure would not be typically used by a risk assessor using IRIS or the Framework, it appears relatively common for assessing asbestos risk through life table analysis. The reason is the strong effect of these factors on mortality, which affects the risk. Nicholson, Berman & Crump, and OEHHA all separate risk into males and females and smokers/nonsmokers. We have reworded the statement to say "some" risk assessors calculate....

PC12-51: Page 22, middle of 1st paragraph: Editorial, data "were" collected.

ATSDR Response: This correction has been made.

PC12-52: Page 22, first Summary paragraph: Why is a new term introduced "elongated mineral structures"? Can we stick with fiber/structure?

ATSDR Response: The text has been modified to refer to "structures" instead of "elongated mineral structures).

PC12-53: Page 22, EPA does have a method that it uses for regulatory decisions. It may not be fully accepted by the entire scientific community, but it is routinely used by the regulatory community.

ATSDR Response: The discussion in the document was not focused on EPA, but on asbestos risk assessment in general. In particular, not all regulatory agencies use the same practices as EPA. We feel that our statement is accurate.

PC12-54: Page 22, in the summary of risk method, did the ATSDR ask EPA about using the various methodologies to communicate risk to the El Dorado Hills Community? Given the number of activists and the relatively high profile of this site, it would seem that the risk assessment should have been more coordinated.

ATSDR Response: ATSDR communicated plans and progress with EPA regional and national staff throughout the process. We value the informal input we received. However, ATSDR is an independent advisory agency with slightly different purposes and constraints than EPA; in this case, both agencies decided an independent evaluation of risks in the El Dorado Hills was best.

PC12-55: Also, the discussion of the various risk models used to evaluate the increases in excess cancer risk should include some more details on the data that went into the development of the toxicity factor[s] used in each model. The IRIS IUR is a value based on a central tendency slope for lung cancer and an absolute determination for mesothelioma. Most cancer slope factors are a 95th upper bound value rather than a central tendency. The Berman and Crump model only generated a slope factor for lung cancer as there were insufficient data to derive a value for mesothelioma.

ATSDR Response: Thank you for the comment. This health consultation already contains much technical detail, and adding more details about risk model development would not add to the health consultation's stated goal of getting a general sense of the degree of risk in the community. Interested parties can consult the original references if they want more details. As described elsewhere, the approaches used in EPA 1986, IRIS, and Berman and Crump to evaluate epidemiological studies are central tendency approaches. The IRIS inhalation unit risk is based on a relative risk model for lung cancer and an absolute risk model for mesothelioma, but the approach for both is considered central tendency. No slope factors or unit risks were derived in the Berman and Crump 2003 method.

PC12-56: Page 22, the goal of the risk calculations is to estimate excess cancer risks using the 4 different models. The exposure assumptions provide a basis for bounding the risks from low exposures to medium, to high relative exposures.

ATSDR Response: Thank you for this comment. No response is necessary.

PC12-57: Page 24, the exposure parameters developed for the various age groups are probably appropriate for the situation. In most cases, the exposure times are overestimates of actual long-term use to the various exposure units. The exposure units constitute a small use area of the El Dorado Hills area as a whole. Given the economy and the transient nature of the residents in El Dorado Hills, residence time may be overestimated.

ATSDR Response: Thank you for these comments. We recognize that the conclusions are based on assumptions with many uncertainties.

PC12-58: Page 27, the term "Structure Level" is confusing. Why is this used rather than "exposure level"?

ATSDR Response: We have modified the text to refer to "structure concentration" throughout the document.

PC12-59: Page 27, second paragraph: At Swift Creek walking resulted in the release of detected concentrations of asbestos similar to other activities in 4 out of 6 samples. It may not be appropriate to use stationary samplers to represent a walking activity.

ATSDR Response: Thank you for this comment. We feel the uncertainties and assumptions used in our analysis were discussed in enough depth in the document.

PC12-60: Page 27, third paragraph: Clarify what is meant by an “upper bound”. The text seems to imply that it means continuous exposure to the highest concentrations measured anywhere. Are ATSDR, EPA, and the state using the same definitions of upper bound risks?

ATSDR Response: We use the term “upper bound” in the sense stated by the commenter. We use the term loosely and only to inform the reader that our use of "high end" exposure estimates does not result in an unrealistically high exposure such as some might think is represented by an upper bound.

PC12-61: Page 28, Table 3: If an ABS sample is not available for a child digging (Jackson Elementary Gardening Scenario), consider using a different ABS sample to represent this exposure rather than a stationary sample.

ATSDR Response: Thank you for this comment. We feel the uncertainties and assumptions used in our analysis were discussed in enough depth in the document. A change such as suggested would have no significant difference on the estimated risk, conclusions, or recommendations of this health consultation.

PC12-62: Page 28, Bullet on EPA 1986 method should refer to Table 2 for exposure durations, not Table 1.

ATSDR Response: This correction has been made.

PC12-63: Page 29, the risk approach referred to as "EPA 1986" might be better referred to as "Updated IRIS", assuming that it is using the EPA (1986) potency factors combined with 2003 mortality statistics. Note that the calculation should use a factor of 2.8 to extrapolate from workers to residences, as discussed in EPA (1988).

ATSDR Response: No change was made. EPA 1986 refers to Nicholson (1986) potency values updated with 2003 mortality data and the conversion factor specified by Nicholson, 4.2. The IRIS approach used the current IRIS procedures (which use Nicholson 1986 potency values and a different conversion, 2.8).

PC12-64: Page 29, first paragraph in Limitations: Editorial, EPA's sampling data "were" collected...

ATSDR Response: This correction has been made.

PC12-65: Page 30, the discussion of the USGS study should be expanded, and it would be helpful to indicate that the source areas are relatively small in area relative to the rest of the community. The discussion on pages 30 and 31 needs to be better grounded to areas of exposure.

ATSDR Response: No changes have been made. The USGS study is described on page 48 in the section entitled "Additional Information on NOA in the El Dorado Hills Area." We have much discussion of the uncertainties and general nature of this evaluation throughout the document. Because the activity based sampling took place in areas not especially considered to be source areas, but possibly near them, the activity based sampling is appropriate for making such general conclusions, not more.

PC12-66: Page 30, the USGS report should be used much more extensively to describe the nature of the contaminant [NOA] and to dispel the misinformation provided by the RJ Lee Group concerning the El Dorado Hills amphiboles. The USGS report clearly states that the materials found in soil and air at El Dorado Hills are amphibole asbestos. The document would also benefit from an expanded explanation of the chemistry and mineralogy of the fibers and particles detected by the EPA and the USGS.

ATSDR Response: No changes have been made. The evaluation performed in this health consultation was very general. The many sources of information available, including the USGS report, support our general findings. We feel this comment may overstate the findings of the USGS. The document already contains details of the USGS findings on page 48 in the section entitled "Additional Information on NOA in the El Dorado Hills Area." Interested readers are referred to the original citation for further information.

PC12-67: Page 30 (and elsewhere) wherever you are discussing excess cancer risk as it relates to model estimations, it would be best to use the term probability of excess cancer risk.

ATSDR Response: We do not feel additional qualifiers are necessary for this document. We discuss in detail the uncertainties of cancer risk assessment and refer to theoretical cancer risk to indicate that the risk assessment methods are not quantitative or predictive.

PC12-68: Page 30, Table 4 is a summary of estimated excess cancer risks for the 4 models. It is difficult to understand the background contribution to risk the way it is presented. The table and text need to be edited to make it clear that risk due to ambient background is a significant contributor to total excess cancer risk in this investigation. It would help the lay reader if the table/text could refer to an Appendix section where a sample risk calculation is provided.

ATSDR Response: We chose not to highlight the background contribution to risk in the tables, as suggested by the commenter, because the ABS was focused on measuring exposures associated with activities, not to get a true background level in the community. We did an analysis and found that the reference samples were relatively compatible with what CARB sampling had found and they would provide a reasonable estimate for background for the purposes of our general health consultation; however highlighting the background risk in the table may give the data more weight than they deserve. A comprehensive background study might help give more confidence in the findings.

PC12-69: Page 31 states that "results do not allow us to predict with certainty the risk of developing..." This statement should be removed. Risk assessments are not quantitative predictive tools. The risk calculations can only provide probabilities of excess cancer risks.

ATSDR Response: We have not removed this statement. It was, in fact, inserted to emphasize the fact that cancer risk assessments are not quantitative predictive tools for disease.

PC12-70: Page 32, concerning ambient background should make it clear that the major source of background risk is ambient air. As with metropolitan areas, ambient sources might include building materials, dust containing asbestos fibers from brake pads, disturbance of soils containing asbestos fibers, and other unknown sources. As pointed out on page 33, it is prudent to not disturb soils that are known to contain asbestos fibers.

ATSDR Response: We have not made changes. Based on our discussions with local stakeholders, we feel that it is understood that background exposures are from ambient air.

PC12-71: Page 32, Figure 5: Editorial, HEPA stands for "high efficiency particulate air."

ATSDR Response: The full acronym has been spelled out.

PC12-72: Page 32, practical suggestions are made for reducing exposure to fibers indoors. There is no mention of risks indoors which may result in the underestimation of risk. Is there any information on NOA found indoors?

ATSDR Response: Page 44 describes the Sacramento Bee testing which included some indoor sampling. Our risk estimation assumed continuous exposure to asbestos at the measured "background" level; this would occur indoors or outdoors and is considered sufficient for the very general evaluation as performed in this health consultation.

PC12-73: Page 32, should the report present and discuss background in the area (background exposure in the absence of a disturbance event) as well as national background?

ATSDR Response: The report did include background in the area as part of its assessment of risk. This is discussed in the referenced section.

PC12-74: Page 33, future health studies in El Dorado Hills might not be a bad idea. Our current understanding of adverse health effects from asbestos exposure is based on relatively high dose, occupational exposures. Science has not addressed low level, environmental exposures with regard to potential adverse health outcomes.

ATSDR Response: Because the relationship between asbestos exposure and disease is already well-established, ATSDR does not need further study to make recommendations to protect public health. We agree that investigating low level exposures would add to the science. If requested, we would be glad to provide technical comments on design of health studies by private researchers or other governmental agencies.

PC12-75: Page 33, third bullet: Editorial, delete double word "California Cancer Surveillance..."

ATSDR Response: This correction has been made.

PC12-76: Page 34, Figure 6: While the occupational scenarios provide for a good point of reference, they are not protective of children's exposures and children are at increased risk due to latency issues associated with asbestos.

ATSDR Response: Figure 6 (Figure 7 in the final consult) was provided for perspective and a frame of reference only. We conducted life table analysis to account for early life exposures.

PC12-77: Pages 35-39, "Additional Information on NOA in the El Dorado Hills Area": Much of the air concentration data presented in this section are reported as total TEM structures (not PCME), so it is difficult to make comparisons to previous sections which presented concentrations as PCM or PCME.

ATSDR Response: ATSDR regrets that we are unable to convert the reported values because the methods used do not define and count the same sizes and types of fibers.

PC12-78: Page 36, Table 4 should be labeled Table 5.

ATSDR Response: This correction has been made.

PC12-79: Page 37, 3rd line: Double citation [8282], end of this paragraph: cite should be [83] rather than [82].

ATSDR Response: This correction has been made.

PC12-80: Page 38, Figures 7 and 8, the authors use the origin of the Y axis as 0.000. It is not 0. It is below the level of detection but above 0. This should be clarified in the figures and in the text explaining the data. The detection limit is a function of the amount of air passed through the filter, the size of the filter, and the number of grid openings that are counted by the analyst.

ATSDR Response: The origin of the y axis is correctly zero. Asbestos concentrations are calculated from fiber counts, which are either zero or positive - therefore, concentrations are accurately listed as zero. As can be observed on Figures 9 and 10 in the final consult, nondetects were placed at the reported sensitivity of the method, not at zero, and those values were used in calculating the reported statistics. This will tend to bias the concentrations high.

PC12-81: Page 39, the last paragraph implies the NOA is everywhere in El Dorado Hills and potentially uniform in distribution. The USGS report does not state or imply that. The USGS only sampled in areas where there was a high probability of detecting amphiboles in the soil or rocks. The work by Churchill and Clinkenbeard of the California Geologic Hazards Unit of the California Resources Agency provide a more detailed description of the aerial extent of NOA in the El Dorado Hills area.

ATSDR Response: No changes have been made. The statement "these additional studies illustrate the potential for NOA to exist in several locations throughout the El Dorado Hills area" does not imply a uniform distribution. The following statement, that the activity based sampling results "were typical of those that might be measured elsewhere in the local area," is also supported by the information provided on the preceding 4 pages. We also note that if background asbestos levels are elevated, they would not be only associated with NOA source areas.

PC12-82: Page 39, 1st bullet: Reference [82] doesn't sound right. Please verify.

ATSDR Response: Thank you for pointing this out. The correct reference has been inserted.

PC12-83: Pages 40-41, as noted on PC12-: Page 40 (second paragraph, last sentence), this section is intended to summarize "other site-specific NOA studies". Yet this summary includes findings from Libby, Montana and Sapphire Valley Gem Mine in North Carolina, both of which are not NOA sites per the NOA definition presented in this report (see pg 11 "Naturally Occurring Asbestos (NOA)", 1st paragraph, 2nd sentence).

ATSDR Response: No changes have been made. Both locations are consistent with the definition that NOA is not intentionally mined or used but disturbance could cause exposure and disease. The asbestos at Libby, Montana was a contaminant of the vermiculite mined and processed there and its disturbance led to exposure and disease in workers and the community. The asbestos at

Sapphire Valley Gem Mine in North Carolina was not mined either, but people may have disturbed and been exposed to asbestos while collecting gems at the mine.

PC12-84: Page 40, last open bullet: Editorial, consider rewriting last sentence: "…the highest PCMe concentrations were associated with handling dredged material…"

ATSDR Response: The suggested change has been made.

PC12-85: Page 41, first line: Change the "0.009 – 0.09" to "non detect – 0.09."

ATSDR Response: The suggested change has been made.

PC12-86: Page 41, second open bullet: EPA does not characterize Libby as NOA exposure (which bullet is this sub-bullet under)? Also, change "collected" to "conducted" in the second sentence.

ATSDR Response: ATSDR considers the exposures in Libby to be NOA. We have added text describing our rationale. We recognize that EPA may not categorize the site similarly. The suggested editorial change has been made.

PC12-87: Page 41, third open bullet: Consider changing "the mine" to "rock formations" in the first sentence. In the third sentence, consider changing "Risk was" to "Risks were."

ATSDR Response: The suggested changes have been made.

PC12-88: Page 41, last bullet: Was NOA assessed as part of the Illinois Beach State Park report?

ATSDR Response: Yes.

PC12-89: Page 42, Basis for Conclusion: Again, consider changing "risk assessment" to "exposure and toxicity assessment" in the first sentence. Also, the document should be revised to reflect the fact that certain areas of El Dorado Hills have the potential for exposed rock and soil containing both chrysotile and amphibole asbestos. The risks posed to residents in the community are elevated to a level that the EPA would classify as unacceptable if the residents spent their lifetime in these limited areas. The risk management decisions that have to be made at this site have to consider that response actions to mitigate the risks are not practicable given the location of the source areas and the presence of naturally occurring asbestos. Some of the risk management actions that are prudent are listed in the conclusions.

ATSDR Response: This suggested change has not been made. We have been using this terminology in our discussions with the community for several years, so making this change would be likely to result in confusion among community members.

We feel that our health consultation already conveys the point that NOA exists in various locations in the community and that community members may have an increased risk of exposure and disease. ATSDR's focus is on reducing harmful exposures; there are many ways to *accomplish this, including but not limited to mitigation actions. Risks from natural phenomena (e.g. cosmic radiation), mankind's activities (e.g. automobile exhaust), and lifestyle behaviors (e.g. smoking tobacco) also result in risks that EPA would consider unacceptable by Superfund standards. We have tried to supply practical public health recommendations for reducing exposures to NOA which will reduce the resulting risk.*

PC12-90: Page 42, ATSDR should clearly state in the conclusion that they are NOT a regulatory agency and that the risks they have estimated are not intended to nor able to force EPA or a State regulatory agency to take any removal or remedial action.

ATSDR Response: We have added statements describing ATSDR's advisory role in the Executive "Summary" and "Background" sections of the health consultation.

PC12-91: Page 42, the authors should try to use a more positive tone in the concluding portions of the consult.

ATSDR Response: ATSDR has rewritten the second conclusion.

PC12-92: Page 42, NOA exposure to residents of El Dorado Hills appears to exceed an acceptable cancer risk. It is not clear that increasing awareness of the problem and suggesting techniques for limiting exposure will be sufficient to protect public health.

ATSDR Response: The estimated risks were uncertain and, depending on various assumptions used, ranged from risks that would not be a concern to those that would. We feel that the recommendations are appropriate given the current evaluation and the current state of the science on NOA. If new information becomes available that changes this, we may revise our conclusions and recommendations.

PC12-93: Page 43, Conclusion 2: Define what the "health study" would consist of (e.g., screening, questionnaires, evaluations).

ATSDR Response: We have rewritten conclusion 2 and the discussion of potential further investigation because the discussion in the public comment draft seemed to cause confusion, based on the number of comments received on the topic.

PC12-94: Page 43, Basis for Conclusion, first open bullet: Comparisons of measured levels to former asbestos worker exposure levels may be of interest, but may not be protective of exposures that begin early in life. Consider adding discussion around this issue.

ATSDR Response: We have rewritten conclusion 2 and this comparison no longer appears there, although similar comparisons (discussion and Figure 7) are found elsewhere in the document. Those comparisons were put in as suggested by peer reviewers to give perspective to the levels. We agree that it is helpful to know how the estimated exposures compare to other exposures. The discussion in the text and Figure 7 in the final consult were provided for perspective and a frame of reference only. We conducted life table analysis to account for early life exposures.

PC12-95: Page 64, ATSDR response to Q#3: The reason that the different risk models resulted in similar risks is likely that all of the risk models are generally derived from the same group of epidemiology studies, but use different fiber populations of interest. Given that any subgroup of fibers is just a surrogate for total exposure, these results are not surprising.

ATSDR Response: Thank you for this comment. No response is necessary.

PC12-96: Page 72, Appendix C, the authors should provide an example calculation of risk. If the community wanted the details of each of the models presented in the health consult as presented in Appendix C, it might be helpful to include an example of how the equations are solved to yield excess cancer risks. It is unlikely that many of the community members could solve any of the equations provided in the appendix to yield risk estimates.

ATSDR Response: We have added Appendix I which gives example calculations and further explanation of the life table procedures.

PC12-97: Page 77, in the derivation of the mesothelioma risk, the substitution should be D8 to D10 yields: instead of C8 and C10.

ATSDR Response: This correction has been made.

PC12-98: Page 79, the statistical method described in AHERA for making comparisons of two datasets has a number of limitations - 1) it assumes the sample datasets are lognormal, 2) assumes both distributions have a GSD of 2.2, 3) doesn't account for Poisson counting variation, and 4) uses 1/2 the detection limit for non-detects. Therefore, the validity of statements regarding differences between these datasets should be reviewed in light of these limitations.

ATSDR Response: All statistical methods have limitations. EPA, not ATSDR, made the decision to use the AHERA Z-test for comparing reference sampling to ABS sampling. ATSDR believes this was an appropriate test to determine these differences and concurs with Region 9 that exposures during ABS activities were elevated above non-activity exposures.

PC12-99: Page 80, the authors make reference to amphibole being more toxic than chrysotile. Please include references.

ATSDR Response: ATSDR's toxicological profile for asbestos, particularly the addendum "Chemical-Specific Health Consultation: Tremolite Asbestos and Other Related Types of Asbestos, Sept. 2001" contains many original references describing the proposed greater toxicity of amphibole asbestos. This reference is appropriate for the general audience this health consultation is targeted to and has been added to the text.

PC12-100: Page 81, first full paragraph, last sentence: Revise to "...analytical sensitivity was too high..."

ATSDR Response: This correction has been made.

PC12-101: Page 81, first partial paragraph on page: Editorial, the population of fibers of interest (greater than 10 microns long and less than 1.5 microns wide) is described in an awkward way. Consider editing.

ATSDR Response: We rewrote the sentence to state, "ATSDR reviewed preliminary drafts of this work which indicated that risk was most associated with long (greater than 10 µm) amphibole structures with diameters up to 1.5 µm."

PC12-102: Page 81, second full paragraph on page: Is the reason that low counts resulted in large confidence intervals due to the Poisson distributions around the small counts? Note that resolution of this issue is currently being discussed by the asbestos TRW. The report significantly understates the level of confidence the EPA has in its risk assessment approach for asbestos. While it is true that there is considerable uncertainty associated our dose-response assessment models for asbestos, we have sufficient confidence that these models can be used to determine when there in an unacceptable risk and to justify taking action to mitigate those risks.

ATSDR Response: The large confidence intervals were in part due to using Poisson statistics to report confidence intervals for nondetect counts, but the main issue was the nondetect values for long fibers, which resulted from EPA stopping rules based on shorter fibers. By counting a larger area of the filter (and more long fibers), ATSDR was able to reduce confidence intervals. At the October 2010 TRW Asbestos Committee meeting, there was discussion that asbestos fibers often do not fit a Poisson distribution. The findings of this health consultation do not depend on this issue or its resolution.

ATSDR did not comment on EPA's level of confidence in its own risk assessment methods. The El Dorado Community expressed concern about relying solely on EPA's methods given that other approaches are available in the scientific literature. Therefore ATSDR considered, discussed uncertainties, and presented results from several different approaches.

PC12-103: Page 81, second paragraph, 1st sentence: Revise to "... (that is determined by the "number of grid openings" examined by the lab)."

ATSDR Response: This correction has been made.

PC12-104: Page 81, third paragraph, 1st sentence: Revise to "... counting a greater number of grid openings..."

ATSDR Response: This correction has been made.

PC12-105: Page 81, last paragraph on page: The text states that most of the structures were not so thin as to limit visibility at lower magnification. How was this known if higher magnifications were not used?

ATSDR Response: We had information on structure dimensions measured during the initial analysis done by EPA and further work done by USGS. The initial EPA analysis and the further *characterization work done by USGS had shown that the structures detected in El Dorado Hills were thick enough to be seen at lower magnification.*

PC12-106: Page 89, first full paragraph: An additional bit of information which may be useful in comparing CARB ambient samples to EPA ABS samples is the percentage of non-detects in each data set. It may also be useful to know the analytical sensitivities achieved in each data set. If the standard deviations are large, then it may be that both data sets are poor or that data are distributed widely, rather than actually meaning the results are similar.

ATSDR Response: CARB's El Dorado County data reported had 94 detects out of 325 samples (30%). The EPA reference station data had 69 detects out of 73 samples (95%). The analytical sensitivity of the EPA data was in general slightly lower (more sensitive) than the CARB data. Although uncertainties remain, we consider the reference results to adequately represent background for the general purposes of this health consultation.

PC12-107: Page 89 and Figure F-1 on page 90, indicate that the ordinate of the y axis is 0.000. It is not. It is non-detect and should be assigned some value such as the MDL for the ISO 10312 TEM filter analysis. It is technically incorrect to assign a value of zero.

ATSDR Response: It is technically correct to assign a value of zero to nondetected asbestos counts, because concentrations are calculated from actual fiber counts. Although ISO recommends a multiplier for low counts to correct for Poisson distribution uncertainties, we do not feel this is always appropriate. At the October 2010 TRW Asbestos Committee meeting, there was discussion that asbestos fibers often do not fit a Poisson distribution due to the large number of nondetects (zero counts) often obtained. The findings of this health consultation do not depend on this issue or its resolution. In the cited Figure, assigning the MDL for nondetects would have made it impossible to differentiate the detected values from the nondetects – an important aspect of this presentation of data.

PC12-108: Page 91, second paragraph: Please provide justification for the following comment: "background exposures are comparable to (and over the course of a lifetime potentially greater than) any direct activity-related exposure."

ATSDR Response: Because activities take up a small fraction of time in any one day compared to the background assumed for all other times, the contribution to risk from background exposures was comparable or greater than the contribution from activities. This was an observation from the calculations performed in the health consultation.

PC12-109: Page 91, fourth paragraph: Regarding the asbestos levels detected 13 miles out in the ocean, what is the source of fibers there? What analytical sensitivities were achieved in the background studies conducted by CARB in 1998 and 2003?

ATSDR Response: These facts were stated by other organizations commenting on our draft assumptions. We refer the commenter to the cited web sites for this information.

PC12-110: Page 93, second full paragraph: What percent of the samples were analyzed indirectly?

ATSDR Response: Because ATSDR did not use the indirect sample results, we do not have access to the exact percentage of the samples that were analyzed indirectly.

PC12-111: Page 93, Comment re: indirect analysis. Why weren't results of indirect analysis used? How did these results compare to direct analysis and how many samples were analyzed via indirect analysis?

ATSDR Response: We did not consider the indirect sample results because an adequate number of direct sample results were available and because several stakeholders had expressed concern that indirect sample analysis may not be truly comparable with direct sample results. We did not do any comparison of the indirect and direct results obtained by EPA.

PC12-112: Page 94, third full paragraph: Was the baseball infield grass? If so, then we agree that these results would be applicable to other grassy sports areas, but if the infield is dirt or if the running path around the bases is dirt, then these results may not be directly applicable to grassy field sports.

ATSDR Response: Thank you for this comment. Although one might argue in the label applied, we feel that the baseball and soccer scenarios are similar enough for our general purposes that they can be considered together. We agree that the greatest sources of exposure are likely from unvegetated areas in both scenarios.

PC12-113: Page 97, last paragraph: You may want to note that Dr. Berman is not the sole expert on asbestos sampling, analysis, toxicology and risk assessment issues. While he has vast experience in the field, there are many others that do not agree with his approaches and take a critical view of his work. The fact that his binning approach was not adopted by EPA speaks to the remaining questions and uncertainties associated with the approach he advocates.

ATSDR Response: It was and is not our intent to cast judgment on any approach. We were specifically requested by the community to consider Dr. Berman's work and we feel we were responsive to that request. The "Acknowledgments" section on page 52 illustrates that we value input from a wide variety of experts on asbestos issues.

PC12-114: Throughout document, but especially prevalent in Appendix E: The terms "detection limit" and "sensitivity" are being used interchangeably, but these have different interpretations and meanings. Also, throughout the document the author uses "done" when the verb "performed" would be more appropriate.

ATSDR Response: The text has been modified to distinguish "analytical sensitivity" from "detection limit". We note that the idea is the same for either use in the text, as both analytical sensitivity and the reported detection limits were too high for long fibers to allow ATSDR to use the original data. For readability purposes, we feel the word "done" conveys our meaning adequately.

PC12-115: Page 99, Figure F3: Why are there so many blanks in these tables. Shouldn't each activity have hours per week associated with it?

ATSDR Response: The blanks come up because for the "low activity" scenario, people are assumed to not participate in that activity, so there is no associated time. This would be equivalent to putting 0.0 hours of activity for that activity.

PC12-116: Page 104, Table G2, how were "highest concentration values" used in calculating the "annual average?" Is the annual average truly an average or a biased high estimate?

ATSDR Response: The annual average is an estimate of the average exposure over the year, but incorporates averages of asbestos levels for different scenarios and average time assumed in various scenarios. As discussed in the section "Notes on Structure Concentration Assumptions" on page 32, the high-end asbestos levels for each scenario are used to obtain a more conservative estimate of the annual exposure level. It is noted: "The high end estimate does not represent an upper bound because the maximum detection in each scenario is averaged with the other scenarios and weighted according to the estimated time spent in each scenario over the year".

PC12-117: Page 104, Appendix G, the term "protocol structures" is not defined.

ATSDR Response: The document has been modified to remove references to protocol structures.

Appendix J. Update of Western El Dorado County Mesothelioma Statistics by the California Cancer Registry

Searching for Causes & Cures

CCR **CALIFORNIA CANCER REGISTRY**

CALIFORNIA DEPARTMENT OF PUBLIC HEALTH

March 25, 2011

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Dr. Dyken,

This letter summarizes work done at the request of ASTDR to revisit the occurrence of mesothelioma among residents of western El Dorado County, California, specifically in census tracts 306.01-306.03, 307.01-307.04, 308.01-308.06, 309.01-309.01, 310, 311, 312, 313.02, 314.01-314.02,314.05 and 315.01-315.04. These census tracts cover the entirety of El Dorado County with the exception of the City of South Lake Tahoe (census tracts 301.0, 301.02, 302, 303, 304.01, 304.02, 305.01-305.03).

The policy of the California Cancer Registry (CCR) is to conduct a statistical comparison of the observed and expected number of cases by estimating a 99-percent confidence interval (CI) around the standardized incidence ratio (SIR), based on the Poisson distribution. In the original analysis conducted by the Sacramento regional office (Region 3) of the CCR in 2004, we observed 24 cases of mesothelioma among residents diagnosed 1988-2001. The average annual number of cases for that period was 1.71. The expected number of cases was calculated at 1.98; the was SIR of 0.864 (CI: 0.005-7.430). These results, as were reported, indicated that there was not a statistically significant excess in cases of mesothelioma over what would be expected in the Sacramento region given the age, sex, race/ethnic distribution of the population in the selected census tracts.[i]

Since 2004, there have been several changes to the CCR's methodology for evaluating suspected cancer clusters. All analyses are now preformed in the central office of the CCR, whereas in the past these analyses were preformed in regional offices. The methodology used for these analyses is now standardized, utilizing the State of California age-specific invasive cancer incidence rates (ASR) to calculate expected case numbers. Previously, although the general methodology used at regional office was generally the same, there could have been some variation in methodology at the discretion of the regional office and expected case numbers were calculated based on the ASR of the region.

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March 25, 2011
Page 2

Table 1, Standardize Incidence Ratios (SIR) with 99% Confidence Intervals (CI) for Selected Census tracts in El Dorado County, California, 1988-2008.
The California Cancer Registry, March 15, 2011

El Dorado County, 2000 U.S. Census Tracts	Years	Observed cases	Expected cases*	99% CI for expected cases		SIR	99% CI for SIR	
				LL	UL		LL	UL
306.01-306.03, 307.01-307.04, 308.01-308.06, 309.01-309.02, 310, 311, 312, 313.02, 314.01-314.02, 314.05, and 315.01-315.04	1988-2001	26	19.94	14.74	42.25	1.30	0.74	2.12
	1988-2001	26	21.07**	14.14	42.25	1.23	0.70	2.01
	2002-2008	11	11.71	4.32	22.78	0.94	0.37	1.96
	1988-2008	37	31.65	23.21	55.75	1.17	0.73	1.76
309.02	1988-2008	5	1.15	1.08	14.15	4.35	0.94	12.31

* Expected case counts based on California all race/ethnic and sex group, age-specific incidence rates for mesothelioma, 1988-2001
** Expected case counts based on CCR, Region 3, all race/ethnic and sex group, age-specific incidence rates for mesothelioma, 1988-2001

LL=lower limit; UL= upper limit

The results for this series of analyses are shown in table 1. We initially duplicated the original 2004 analysis using CCR's current methodology. We now observed 26 cases of mesothelioma diagnosed among residents, 1988-2001. This was a gain of 2 cases since 2004. The CCR is a dynamic surveillance system due to continuous case gathering and ongoing quality assessments, it is therefore not usual that cases are added over time. In this analysis we calculated an expected number of cases at 19.9. The SIR was 1.3 (CI: 0.74-2.12). These results indicated there was not a statistically significant excess in mesothelioma cases over what would be expected in California. We then repeated this analysis calculating the expected number of cases using Region 3 cancer rates and found very little difference in the actual numbers and no difference in the conclusion. The SIR was 1.23 (CI: 0.70-2.01), indicating there was not a statistically significant excess in mesothelioma cases over what would be expected in the region.

To update the original analysis, we examined cases diagnosed from 2002-2008 in the selected census tracts. We observed 11 cases of mesothelioma among residents. The expected number of cases was calculated at 11.71. The SIR was 0.94 (CI: 0.37-1.94). We, again, did not find a statistically significant excess in cases of mesothelioma over what would be expected in the State.

Jill J. Dyken, Ph.D., P.E.
March 25, 2011
Page 2

The last analysis of this series was to examine all cases of mesothelioma diagnosed from 1988-2008 among residents of the selected census tracts. There were a total of 37 cases observed. The SIR was calculated at 1.17 (CI: 0.73-1.76). We did not find a statistically significant excess of mesothelioma cases over what would be expected in the state.

When we examined the distribution of the 37 cases of mesothelioma, we found that 4 census tracts had no cases; 12 had only one case of mesothelioma (46.2%) diagnosed among residents over the study period; 7 (26.9%) census tracts had 2 cases; and 2 (7.7%) census tracts had 3 cases. Census tract 309.02 was exceptional with 5 cases diagnosed over the study period. The SIR for this census tract was 4.35 (CI: 0.94-12.31). We did not find a statistically significant excess of mesothelioma cases over what would be expected in the state.

All 5 cases of mesothelioma in census tract 309.02 were among non-Hispanic white males, ranging in age from 50-85 years old at diagnosis. We unfortunately have no information on the residential or work history of these men or other possible risk factors that may have contributed to the development of mesothelioma.

I hope this information is useful. Please do not hesitate to contact me or the CCR if you require further assistance.

Thank you,

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cc: Janet Bates, MD, MPH, Chief, Cancer Surveillance Section, California Department of Public Health

[i] We are unable to provide any additional details from the original 2004 analysis, because those documents have been destroyed.