Health Consultation

Public Comment Release

ASBESTOS EXPOSURES AT OAK RIDGE HIGH SCHOOL
1120 HARVARD WAY
EL DORADO HILLS, CALIFORNIA

EPA FACILITY ID: CAN000906055

MAY 6, 2005

Comment Period End Date: June 20, 2005

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

Health Consultation: A Note of Explanation

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

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

Comments must be made in writing and sent to ATSDR by **June 20, 2005.** Please send written comments to:

ATSDR
ATTN: Division of Health Assessment and Consultation
Records Center
1600 Clifton Road, NE, Mail Stop E-60
Atlanta, Georgia 30333

Please indicate that your comments refer to the health consultation on Oak Ridge High School in El Dorado Hills, California. Comments received during the public comment period will be recorded as part of the administrative record for the health consultation. ATSDR will address comments in an appendix of the final health consultation. Names of persons who have submitted comments will not be included in the final health consultation; however, their names will be subject to release, if requested, under the provisions of the Freedom of Information Act.

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Background

Oak Ridge High School is located at 1120 Harvard Way in El Dorado Hills, California, about 30 miles northeast of Sacramento, in El Dorado County. Naturally occurring asbestos has been identified in rocks and soils on and around school property, and a vein of asbestos was disturbed during construction of a soccer field in 2002. A community member asked the Agency for Toxic Substances and Disease Registry (ATSDR) to evaluate the public health implications of current and past asbestos exposures of students and staff at the high school. In this public health consultation, ATSDR reviews available environmental data and potential exposure pathways to determine whether adverse health effects are possible from past or present asbestos exposure at Oak Ridge High School and recommends actions to prevent, reduce, or further identify the possibility for adverse health effects. ATSDR has also received numerous reports of health-related concerns about the area surrounding the high school and other areas with naturally occurring asbestos. The US Environmental Protection Agency (EPA) is currently collecting and analyzing data on asbestos levels in other areas of El Dorado County, and ATSDR will address those pathways in a subsequent health consultation.

Peer Review

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. The public health consultation was reviewed by three asbestos science experts who have no affiliation with ATSDR. 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.

History

Oak Ridge High School was constructed in 1980. According to state reports, the presence of naturally occurring asbestos in the general area was previously known and documented [1]. Because of community concerns about asbestos, the California Air Resources Board (CARB) performing ambient air sampling at the school in 1998 and 1999 (no asbestos was detected). In 2002, the El Dorado Union School District began construction of two soccer fields at the school. During construction, a vein of white fibrous material was uncovered and found to contain 90% asbestos (of the amphibole variety). Construction was delayed, and questions arose as to release of asbestos fibers from the construction site, erosion of contaminated soils downhill towards the school building, and levels of asbestos in soil in other parts of the campus. EPA performed soil testing that showed that amphibole asbestos fibers were present in school soils. Classrooms were cleaned, and testing was performed by the school district to ensure that the classrooms were safe for occupancy by students. In addition, activities were initiated to mitigate the risk of exposure to potential asbestos-containing soils at athletic fields and in other areas of the campus. Campus mitigation activities were completed in November 2004 [2].

Asbestos Background

Asbestos is a general name applied to a group of fibrous silicate minerals including chrysotile, the main type used commercially, and fibrous amphibole-type minerals (including actinolite, anthophyllite, crocidolite, tremolite and amosite) [3]. Whereas chrysotile has relatively long and flexible crystalline fibers, amphibole minerals are brittle and have a rod- or needle-like shape [3]. Breathing either type of asbestos into the lungs increases a person's risk of developing a rare cancer of the lung or abdominal lining called mesothelioma, lung cancer, or certain types of nonmalignant respiratory disease. Many scientists believe that the amphibole varieties of asbestos are more potent in causing disease than is the chrysotile variety, because the amphibole fibers remain in the lungs longer [3].

In general, asbestos is formed geologically in rocks of the ultramafic variety (iron-magnesium silicate minerals). Two of the more common rock types that can contain asbestos are serpentinite and talc. Both chrysotile and amphibole varieties of asbestos can be found associated with these rock types.

For many years, asbestos (mainly chrysotile) was mined and used in many commercial products, including insulation, brake linings, building materials, and flooring. The term "naturally occurring asbestos" has come into use to refer to asbestos as a natural mineralogical component of soils or rocks as opposed to asbestos released from commercial products or mining and processing operations. Suspension of naturally occurring asbestos fibers into air occurs incidentally with natural processes, such as erosion, or human activities unrelated to the asbestos, such as construction, soil tilling, or automobile or foot traffic. **For a given size, shape, and mineralogy of fiber, naturally occurring asbestos is indistinguishable from and carries the same health risk as asbestos from a commercial material.** Therefore, in this consultation ATSDR refers to asbestos fibers in general, without reference to the source. The type of asbestos (chrysotile or amphibole) may be specified if it is known. Information available about sampling at and around Oak Ridge High School indicates that most of the asbestos fibers detected have been of the amphibole type, specifically the closely related amphiboles tremolite and actinolite.

Asbestos Health Effects

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

Malignant mesothelioma—Cancer of the membrane lining the chest cavity and covering the lungs (pleura) or lining the abdominal cavity (peritoneum). This cancer can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure [3]. Many scientists believe that amphibole asbestos fibers have a potency for causing mesothelioma that is as much as 100 times greater than that of chrysotile fibers, mainly because of increased persistence of amphiboles in the lungs.

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

> *Noncancer effects*—These include *asbestosis*, a restrictive lung disease caused by asbestos fibers scarring the lung; *pleural plaques*, localized areas of thickening of the pleura; *diffuse pleural thickening*, generalized thickening of the pleura; *pleural calcification*, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and *pleural effusions*, fluid buildup in the pleural space between the lungs and the chest cavity [3]. Loss of lung function or other clinical signs may or may not be associated with these noncancer effects.

Weak evidence exists that inhalation of asbestos may increase the risk of cancer in the gastrointestinal tract (because of swallowing of fibers removed from the lung by mucociliary transport). However, the studies are conflicting and show a much weaker effect than the proven correlation of asbestos inhalation with cancers of the lungs, pleura, or peritoneum [3].

Ingestion of asbestos causes little or no risk for noncancer effects. However, some evidence exists that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors [3]. Dermal exposure to asbestos is associated with the formation of small warts or corns, particularly on the hands.

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of Oak Ridge High School. Actions taken to limit inhalation exposures will minimize risk from dermal and oral exposures as well.

The risk of health effects from breathing in asbestos increases with the concentration of fibers inhaled, how often and how long the fibers are inhaled, and the length of time since the first exposure occurred. Asbestos-related lung disease has been identified in several communities around the world with naturally occurring asbestos, including areas of Greece, Turkey, Corsica, Italy, Sicily, Cyprus, China, and New Caledonia [3–16]. Similarly, disease associated with environmental-level exposures has been identified in people living near mines or processing operations for asbestos or asbestos-containing minerals, such as in Libby, Montana, or in Wittenoom, western Australia [17,18]. However, little information exists on the exact levels of asbestos exposure experienced by these communities, and exposure characteristics might differ significantly from those of other areas where environmental exposures are possible. It is not possible to extrapolate these findings to other areas in an attempt to predict the likelihood of disease.

Various authorities have set standards, created regulations, and made recommendations regarding asbestos to protect public health and the environment. For inhalation exposure, occupational regulatory and advisory agencies recommend that workers' exposure be limited to 0.1 fibers per cubic centimeter (f/cc), averaged over a typical work week and usually based on 25 years of exposure [19,20]. Although useful as a point of reference, ATSDR does not support using worker asbestos limits for evaluating community member exposures, because the worker limits are based on risk levels that would be considered unacceptable in nonworker populations. In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in buildings in the area, the Environmental Assessment Working Group (made up of federal, state, local, and private entities) set a reoccupation level of 0.01 f/cc after initial cleanup, with continued monitoring recommended to limit long-term exposure at a clearance level of

0.0009 f/cc [21,22]. The 0.0009 f/cc level is based on EPA's current asbestos cancer slope factor for combined lung cancer and mesothelioma, with a 1 in 10,000 increased risk over a 35-year occupancy. This slope factor was derived without consideration for the probable increased toxicity of amphibole fibers for causing mesothelioma [23].

More details about asbestos can be found in Appendix B of this document.

Purpose of This Report

In this public health consultation, ATSDR will evaluate the environmental data collected at Oak Ridge High School to see whether it is possible to estimate potential exposures to asbestos, both past and present. ATSDR will discuss public health implications of potential exposures to students and staff and make recommendations, if necessary, for minimizing the health impact of potential exposures.

Environmental Data Evaluated

Although ATSDR attempts to summarize all asbestos data collected at the school, this report is not necessarily comprehensive, and raw data are not included (original reports should be requested from the agency responsible for collecting the data). In addition, not all data types reviewed were appropriate to use for estimating exposures. Those data would not have been used directly in calculations, although the results may have been used qualitatively.

The following sections summarize the data evaluated by ATSDR for this public health consultation. The data fall into several categories, described below:

Indoor Air Sampling

- In 1998, 2002, and 2003, the school district sampled indoor air in selected classrooms and other indoor areas of the school [24,25,26].
- In 2003, the California Department of Occupational Safety and Health performed limited air sampling in some classrooms [27].
- In 2003 and 2004, the school district sampled air in classrooms and other indoor areas of the school after the areas had been cleaned [28]. The data obtained were assumed to represent potential exposures to students and staff in classrooms at present.
- In 2003, the school district sampled indoor air to determine whether one classroom was affected by dust blown in by a leaf blower operating nearby [29].

Outdoor Air Sampling

- In 1998 and 1999, CARB collected ambient air samples in outdoor locations at the school to assess ambient asbestos levels [30]. No construction or disturbance of soil was occurring during this sampling. These data were assumed to represent exposure of the general public in the absence of soil disturbance.
- In 2002 and 2003, the school district and/or CARB collected several sets of air data outdoors during excavation and mitigation activities that were expected to disturb naturally occurring asbestos in soil [1,31,32,33,34]. Soil wetting and dust suppression requirements of the El Dorado County Airborne Toxic Control Measure (ATCM) were

followed during these activities. Area samples were collected at various places (within the work area, on the perimeter, and at locations outside the work area), and personal samples were collected from monitors worn by equipment operators or other personnel. These data were assumed to represent potential outdoor exposures of students, staff, and workers to asbestos during mitigation activities.

- In 2003, the school district collected air samples to assess potential exposures at athletic fields on campus [35]. Activities such as dragging the track were performed during the sampling so that the sampling would better reflect asbestos concentrations that might be present while athletic fields were being used. Dust suppression and soil wetting were not performed during this testing. Both area samples and personal samples were collected. These data were assumed to represent potential exposures of students, staff, and spectators during sporting practices and events.

In most cases, air samples were analyzed using transmission electron microscopy (TEM) with a modified Asbestos Hazard Emergency Response Act (AHERA) method (counting structures longer than 0.5 μm and with aspect ratios greater than 3:1; structures refers to asbestos fibers, bundles, clusters, and matrices). Some personal monitors were also analyzed using phase contrast microscopy (PCM, counting fibers longer than 5 μm and with aspect ratios greater than 3:1), as required for occupational safety compliance. For the purposes of the exposure estimates and analysis in this consultation, ATSDR treated equivalently the two units of measure, structures per cubic centimeter (s/cc) and f/cc.

In general, fiber counts determined using PCM are not directly interchangeable with structure counts determined using AHERA counting rules with TEM. However, for the qualitative analysis performed in this health consultation, a reasonable approximation is obtained using total s/cc counts (the result reported on summary sheets) interchangeably with f/cc counts. After examining the TEM raw data sheets for the activity-based sampling, ATSDR noted that structures greater than 5 μm in length contributed 50% or more to the total structure count. Therefore, estimates of exposure using the total structure count and those using only structures greater than 5 μm in length will differ by only a factor of two. In addition, the raw data sheets identified the mineralogy and characteristics of reported structures. All structures contributing to the total structure count were asbestos fibers. Therefore, using s/cc and f/cc interchangeably is acceptable in this instance.

Soil/Dust Sampling

The following materials were sampled and tested to determine asbestos content:

- soils from athletic fields and the former dirt parking lot [36,37,38],
- materials from veins of mineral uncovered during the soccer field excavation [38],
- soil and fill materials associated with baseball and softball fields [39,40,41,42],
- soil samples from athletic fields and bare areas throughout the campus [43], and
- dust collected from the classroom potentially affected by a leaf blower [44].

Although important to show the presence or absence of asbestos, **soil and dust data are of limited use in predicting potential exposures**. This is because little is currently known about the correlation between soil or dust concentration and resulting air concentration of suspended fibers. Trace levels of asbestos in soil are defined as levels less than 1%—the level used by

OSHA to define "asbestos-containing materials" and the "action level" in soil historically used by EPA for risk management purposes. However, studies have shown that air concentrations of suspended asbestos fibers can reach levels of concern when the soil contains trace levels of asbestos [45]. Conversely, soils containing more than 1% asbestos may not release fibers to air to an appreciable extent if the soils are not disturbed or if soil characteristics keep fibers attached strongly to the soil particles.

Current Status of Site

Many of the environmental sampling data were collected before mitigation activities that have since been completed:

- Mitigation of soccer fields, including grading and covering native soils with geotextile fabric, 24 inches of clean topsoil, and sod, was completed in 2003. Cut banks were also sprayed with materials to reduce erosion or other release of asbestos fibers.
- Mitigation of the baseball and softball fields, which included replacement of fill materials with clean fill, was completed in 2004.
- The track around the football field was paved in 2003.
- Paths and bare areas were paved or landscaped in the spring and summer of 2004.
- Mitigation of remaining areas (bare soil under bleachers, piles of removed soil) was completed in the summer of 2004.

The current status of the site was considered in evaluating exposures that might be taking place at present and in the recent past. Because all identified bare soil has been removed or covered with geotextile fabric and clean soil or landscape materials, **current exposures to asbestos have been minimized**, that is, the potential for exposure to asbestos from activities in the school or on school grounds is considered to be very low. Proper maintenance of ground cover and fields and proper cleaning and monitoring of classrooms is necessary to ensure that future exposures remain minimized. The school district has developed an operations and maintenance plan to formalize procedures for ensuring minimal exposures at the school; this plan was reviewed by agencies including ATSDR, EPA and the schools program of the California Department of Toxic Substance Control (DTSC) [46].

Exposure Pathway Analysis

An exposure pathway is the way in which an individual is exposed to contaminants originating from a contamination source. Every exposure pathway consists of the following five elements: (1) a *source* of contamination; (2) *media* such as air or soil through which the contaminant is transported; (3) a *point of exposure* where people can come in contact with the contaminant; (4) a *route of exposure* by which the contaminant enters or comes in contact with the body; and (5) a *receptor population*. A pathway is considered **complete** if all five elements are present and connected. A pathway is considered **potentially complete** if it is currently missing one or more of the pathway elements, but the elements(s) could easily be present at some point in time. An **incomplete** pathway is missing one or more of the pathway elements and it is likely that the elements were never present and are not likely to be present in the future. An **eliminated** pathway was a potential or completed pathway in the past, but one or more of the pathway elements have been removed to prevent exposures in the present and the future.

After reviewing information from community members and school officials, ATSDR identified possible exposure pathways for Oak Ridge High School. All pathways have a common source—asbestos fibers that are present in soil—and a common route of exposure—inhalation. Although asbestos ingestion and dermal exposure pathways could exist, health risks from these pathways are minor compared with the risks resulting from inhalation exposure to asbestos and will not be evaluated. The pathways evaluated in this public health consultation are listed below:

- *Classrooms*—exposure of students, teachers, and custodial staff to asbestos fibers suspended from contaminated dust inside classrooms
- *Sports Fields*—exposure of student athletes, coaches, spectators, and outdoor maintenance staff to asbestos fibers suspended from soil or fill materials at the soccer fields, baseball fields, softball fields, tennis courts, basketball courts, football field, or running track
- *Dirt Parking Lot*—exposure of students, staff, and visitors to asbestos fibers suspended from soil in the parking lot
- *Paths and Other Bare Areas on Campus*—exposure of students, staff, and visitors to asbestos fibers suspended from soil around classroom buildings and other areas of the campus

It should be noted that the exposure pathway analysis discussed is only for Oak Ridge High School. Additional pathways could be present in other community areas, on private roads, in residences, or in other areas where asbestos fibers could be suspended in the air and inhaled. These pathways are outside the scope of this health consultation; however, ATSDR will address them in a subsequent health consultation.

Discussion

Exposure Assessment and Toxicological Evaluation

This section evaluates current and past exposures to asbestos at the high school and potential health effects of those exposures. Evaluating the health effects of exposure to asbestos requires extensive knowledge of both exposure pathways and toxicity data. Limited information exists about past levels of asbestos present in air around the school and school classrooms. The fact that information is limited makes it hard to estimate the quantity of asbestos to which people may have been exposed. In addition, limited knowledge of the type of asbestos fibers present and their size distribution makes determining potential toxicity difficult. Public health implications of past exposures at the school can therefore only be evaluated qualitatively.

Current Exposures

Classrooms

Indoor air sampling of classrooms in the summer and fall of 2003 indicated that the average level of asbestos in three air samples from most rooms was lower than 0.0009 f/cc. One room had a higher average level (0.0015 f/cc), but after a second cleaning, it was retested and the average level was found to be below 0.0009 f/cc. Classrooms tested in the summer of 2004 all had asbestos air levels below 0.0009 f/cc, with one exception. This classroom, a science classroom, was found to be contaminated with chrysotile asbestos from transite countertops used for lab counters [personal communication, Gerry Hiatt of the U.S. Environmental Protection Agency, Region 9, November 2004]. After the countertops were removed and the classroom was cleaned, the classroom was tested to be below 0.0009 f/cc. The 0.0009 f/cc level is considered safe for classroom occupancy. On the basis of the available data, no adverse health effects are expected from exposure to asbestos at current classroom levels. Ongoing sampling of classrooms is essential to confirm the safety of the classrooms over time, prove efficacy of the cleaning program, and confirm that recontamination is not taking place.

Sports fields

Soccer fields—Asbestos at the soccer fields has been addressed by covering the exposed earth with a geofabric covering and placing 24 inches of clean fill on top of the fabric. Fresh sod and an irrigation system were also installed on/in the clean fill. The cut banks of the soccer field were sealed to prevent erosion. With effective operations and maintenance, these activities will prevent further release of asbestos fibers into air. No exposures to asbestos fibers or resulting adverse health effects are expected from current use of the soccer fields.

Baseball and softball fields—Fill materials on baseball and softball fields have been replaced with asbestos-free material. Therefore, no exposures to asbestos fibers or resulting adverse health effects are expected from current use of the baseball and softball fields.

Tennis or basketball courts—Because campus mitigation activities have covered or otherwise prevented NOA from being suspended or eroding from soil, asbestos fibers are not expected to be present on the tennis or basketball courts currently. Therefore, no exposures to asbestos fibers or resulting adverse health effects are expected from current use of tennis or basketball courts.

Football field and running track—The running track around the football field has been paved. Therefore, no exposures to asbestos fibers or resulting adverse health effects are expected from current use of the football field or running track.

Dirt parking lots

The dirt parking lots around the campus have been paved or otherwise mitigated to prevent release of asbestos-containing dust. Therefore, no exposures to asbestos fibers or resulting adverse health effects are expected from current use of parking lots.

Paths and other bare areas on campus

Bare areas around the campus have been paved or landscaped to prevent release of asbestos-containing dust. Therefore, no exposures to asbestos fibers or resulting adverse health effects are expected from current activities around bare areas on the campus.

Summary

All areas on the campus have been mitigated to prevent release of naturally occurring asbestos fibers into the air. Assuming that the operations and maintenance procedures are followed and subject to the results of ongoing testing to be performed through the operations and maintenance plan, *current exposures are not expected to result in adverse health effects in students or staff at Oak Ridge High School*.

Past Exposures

Classrooms

Although the limited indoor air sampling prior to cleaning of classrooms detected no asbestos fibers, this sampling was performed using a low-sensitivity counting method that might have missed low levels of fibers (the detection limit was 0.005 f/cc compared with 0.0005 f/cc for later sampling). In addition, sampling prior to cleaning was performed with little or no agitation of dust in the classrooms, compared with the post-cleaning samples which used leaf blowers to suspend as many fibers as possible. Some asbestos fibers were detected in classrooms after an initial cleaning (concentrations ranging from <0.00048 to 0.00246 f/cc). Therefore, a reasonable assumption is that at least some asbestos fibers were present in classrooms before the cleaning and that exposure to asbestos fibers could have occurred there.

Sports fields

Soccer fields —An initial assessment of the area where soccer fields were to be constructed did not identify any asbestos [38]. After construction began in 2002, a vein of amphibole asbestos was uncovered. On the basis of the fact that no asbestos was identified initially and the fact that the areas where the soccer fields were constructed were not being used for regular organized activities, it is unlikely that potential exposures in this area before 2002 were great enough to result in adverse health effects. Activities at the soccer fields were halted from 2002 until mitigation activities took place in 2003. After mitigation began, soil wetting and other dust control measures were reportedly taken. Air monitoring performed during mitigation activities in the area showed a maximum of 0.0039 structures/cc (s/cc) and an average of 0.0008 s/cc.

Baseball and softball fields —In the past, exposure to asbestos fibers probably occurred at the ball fields. The baseball field soil contained trace levels of actinolite and chrysotile asbestos, and several softball field soil samples contained greater than 1% asbestos (actinolite and chrysotile). Activity-based sampling at the baseball field was conducted while the field was being raked and dragged to simulate game activities. Area monitors near the field detected levels of actinolite asbestos as high as 0.00143 s/cc, and personal monitors worn by the workers performing the raking and dragging detected levels of actinolite asbestos as high as 0.1023 s/cc.

Tennis or basketball courts—In the past, exposure to asbestos fibers could have occurred at the tennis and basketball courts. Activity-based sampling at the tennis and basketball courts was conducted while the courts were being swept to simulate game activities. Area monitors near the courts detected levels of actinolite asbestos as high as 0.0097 s/cc, and personal monitors worn by the workers performing the sweeping detected levels of actinolite asbestos as high as 0.045 s/cc.

Football field and running track—In the past, exposure to asbestos fibers probably occurred on the football field, on the running track, and in the spectator stands. Activity-based sampling at the running track around the football field was conducted while the track was being raked and dragged to simulate use of the track and football game activities. Area monitors on and near the football field detected levels of actinolite asbestos as high as 0.00345 s/cc, and personal monitors worn by the workers performing the raking and dragging detected levels of actinolite asbestos as high as 0.0614 s/cc.

Dirt parking lots
In the past, vehicular and pedestrian traffic on the dirt parking lots probably caused exposure to asbestos fibers. Soil collected from the parking lot contained trace levels of tremolite and chrysotile asbestos [36,37,38]. No information is available concerning the level of asbestos fibers suspended from the parking lot in dust; however, it has been shown that disturbing soils that contain trace levels of asbestos can result in suspended fibers at levels of concern [45].

Paths and other bare areas on campus
In the past, pedestrian traffic in bare areas on the campus probably caused exposure to asbestos fibers. Several soil samples from bare areas on the campus contained greater than 1% asbestos (samples contained actinolite, anthophyllite, and chrysotile forms of asbestos). No information is available concerning the level of asbestos fibers suspended from bare areas in dust; however, it has been shown that disturbing soils containing even trace levels (less than 1%) of asbestos can result in suspended fibers at levels of concern [45].

Estimation of Potential Past Exposures

The past data available are limited and insufficient to allow adequate estimation of past exposures. However, to answer questions posed by the public about the implications of potential past exposures, ATSDR used professional judgment and the limited past data available to obtain very rough estimates of potential past exposures and the resulting risk. The estimates described in the following sections are uncertain because of the limited data and the many unknowns involved.

ATSDR evaluated a number of exposure scenarios for Oak Ridge High School. Table 1 presents for each exposure scenario the population of interest, the assumed exposure duration in years, and the fraction of time that exposure was assumed to occur through the identified exposure pathways.

Table 1. Exposure Duration Assumptions for the Exposure Scenarios Evaluated

Exposure Scenario/Population of Interest	Exposure Duration in Years	Exposure Pathway				
		Sports Activities	Classrooms	Dirt Parking Lot	Paths & Bare Areas	Sports Spectator Stands
Coaches	15	6 hr/day 7 days/wk	3 hr/day 5 days/wk	½ hr/day 7 days/wk	½ hr/day 5 days/wk	-
Outdoor Maintenance Staff	15	7 hr/day 5 days/wk	-	½ hr/day 5 days/wk	½ hr/day 5 days/wk	3 hr/day 2 days/wk
Student Athletes	4	3 hr/day 7 days/wk	6 hr/day 5 days/wk	½ hr/day 7 days/wk	½ hr/day 5 days/wk	-
Teachers (no coaching)	15	-	9 hr/day 5 days/wk	½ hr/day 5 days/wk	½ hr/day 5 days/wk	3 hr/day 2 days/wk
Indoor Cleaning Staff	15	-	7 hr/day 5 days/wk	½ hr/day 5 days/wk	½ hr/day 5 days/wk	3 hr/day 2 days/wk
Students (not athletes)	4	1 hr/day 5 days/wk	6 hr/day 5 days/wk	½ hr/day 5 days/wk	½ hr/day 5 days/wk	3 hr/day 2 days/wk
Parents of Athletes	4	2 hr/day 1 day/wk	-	½ hr/day 1 day/wk	-	3 hr/day 2 days/wk
Loyal Sports Spectators	15	-	-	-	-	3 hr/day 2 days/wk

Next, for each exposure pathway, ATSDR determined an "assumed asbestos fiber concentration," defined as the concentration of amphibole asbestos that might be inhaled during the assumed time of exposure. The assumed fiber concentrations and the rationale for choosing them are listed in Table 2. It should be noted that although ATSDR in general selected the highest appropriate concentration as a protective "worst case" estimate, the limited nature of the available data leave open the possibility that concentrations present in actual exposures could have been significantly higher (or lower).

Table 2. Assumed Asbestos Fiber Concentration for Each Exposure Pathway Evaluated

Exposure Pathway	Assumed Fiber Concentration, f/cc	Rationale
Sports Activities	**0.1023**	Highest value measured in athletic field activity-based monitoring [35]. (Other values measured were similar to this value.)
Classrooms	**0.005**	Detection limit of only precleaning testing of classrooms available (which showed no detection of asbestos) [24]. It is assumed that some fibers were present prior to cleaning, but only at concentrations below the high detection limit (0.005 f/cc) used.
Dirt Parking Lot	**0.1**	Assumed to be similar to values measured in athletic field activity-based monitoring [35].
Paths and Bare Areas	**0.01**	Assumed to be similar to values measured in area monitors around athletic fields in activity-based monitoring [35].
Sports Spectators	**0.0097**	Highest value measured in area monitors around athletic field activity-based monitoring [35].

Next, for each exposure scenario, ATSDR estimated the cumulative average fiber concentration for all the exposure pathways using the exposure assumptions listed in Table 1. The fiber concentration was averaged over a 70-year lifetime to allow estimation of cancer risks based on a lifetime of exposure. The formula used to calculate the average fiber concentration over a lifetime is as follows:

$$Avg\ \ fiber\ conc, \left({}^{f}\!/\!_{cc} \right) = \sum_i \left(fiber\ conc\ \ for\ \ pathway\ i \times \frac{hr/day}{24\,hr/day} \times \frac{days/wk}{7\,days/wk} \times \frac{yr\ duration}{70 - yr\ lifetime} \right)$$

Using this formula, ATSDR calculated lifetime average fiber concentrations for exposures for the various scenarios evaluated. These concentrations, which only include the estimated exposures that would have taken place at the Oak Ridge High School campus, are presented in Table 3.

Table 3. Estimated Average Fiber Concentration Over a 70-Year Lifetime

Exposure Scenario	Average Lifetime Fiber Concentration From All Pathways, f/cc
Coaches	0.006
Outdoor Maintenance Staff	0.005
Student Athletes	0.0009
Teachers (no coaching)	0.0007
Indoor Cleaning Staff	0.0007
Students (not athletes)	0.0003
Parents of Athletes	0.0001
Loyal Sports Spectators	0.00007

Estimation of Risk from Potential Past Exposures

ATSDR used EPA's asbestos risk model, developed in 1986, to estimate risks posed by past exposures at Oak Ridge High School. The 1986 EPA risk model uses a single slope factor which, when multiplied by the lifetime average asbestos fiber exposure, predicts the increased risk of developing cancer (lung cancer and mesothelioma). EPA generally uses an acceptable risk range of 1 additional cancer out of 1,000,000 to 1 out of 10,000 in its risk assessments. Table 4 qualitatively compares the cancer risk estimated using the EPA 1986 risk model with the highest acceptable risk in this range, 1 in 10,000.

Table 4. Estimated Additional Lifetime Cancer Risk for Exposure Scenarios Evaluated

Exposure Scenario (Based on assumptions and estimates listed in Tables 1–3)	**Additional Lifetime Cancer Risk**
Coaches	Greater than 1 in 10,000
Outdoor Maintenance Staff	Greater than 1 in 10,000
Student Athletes	Greater than 1 in 10,000
Teachers (no coaching)	About 1 in 10,000
Indoor Cleaning Staff	About 1 in 10,000
Students (not athletes)	About 1 in 10,000
Parents of Athletes	Much less than 1 in 10,000
Loyal Sports Spectators	Much less than 1 in 10,000

ATSDR presents the results qualitatively because a number of disadvantages exist to using the 1986 asbestos risk model for this situation. The model assumes equal toxicity of amphibole and chrysotile asbestos and does not account for the greater risk posed by longer fibers. The use of this model likely **underestimates** risk because the fibrous amphibole asbestos found at the school poses an increased risk for disease, especially for mesothelioma. As an alternative to the 1986 asbestos risk model, Berman and Crump developed a model that accounts for both the greater toxicity of amphibole fibers and the greater potency of longer fibers [47,48,49]. However, information about the size distribution of detected fibers at Oak Ridge High School was inadequate, and the Berman and Crump model results are highly dependent on the size distribution. For these reasons, the Berman and Crump model could not be used to predict increased risk of cancer from estimated past exposures at Oak Ridge High School. Although the EPA 1986 model is very limited in this situation, it gives a qualitative indication that risk from potential past exposures could be of concern.

Uncertainties

ATSDR used the available data to reach general conclusions about likely exposures and to obtain a general sense of the risk of health effects that could result from exposures. The conclusions reached are uncertain, however, because of several factors discussed in the following section:

- **Lack of Representative Data—**Data representing actual past conditions at the school were very limited, and assumptions made about applicability of the available data may be inaccurate. Actual asbestos levels at the school in the past may have been either higher or lower than levels detected in the sampling.

- **Analysis Method—**Various analytical methods were used, and the dimensions of fibers either detected or counted may not correspond to those thought to be toxicologically relevant. In some cases, the minimum detection limit or minimum reporting limit was too high to allow accurate measurement of low levels of asbestos. The detection limits are in some cases higher than levels of concern.
- **Use of EPA 1986 Risk Model—**The 1986 EPA risk model fails to account for the greater potency of amphibole asbestos and does not consider longer fibers to be more potent, but both of these points are generally accepted today. ATSDR's use of the EPA model was necessitated by limited data that prevented application of more appropriate models.
- **Exposure Scenario Assumptions—**Intensity and duration of exposure may have varied from the assumptions made in this evaluation.
- **Off-Campus Exposures—**Amphibole asbestos occurs throughout the area of California where Oak Ridge High School is located. CARB has performed ambient air monitoring in several locations in El Dorado County and detected low levels of amphibole asbestos fibers. Because activities generally result in exposure to levels of asbestos higher than those detected in static monitoring, activities that take place in other areas could contribute to the overall exposure that students and staff may have experienced.

Health Outcome Data

ATSDR was asked to evaluate health outcome data (specifically, mesothelioma incidence rates) for the area around Oak Ridge High School. In some instances, health outcome data can be used to give a more thorough evaluation of the public health implications of a given exposure. In this case, health outcome data cannot be effectively used to evaluate the high school because: (1) the potentially exposed population at the school is small in relation to census-tract-level data in the regional health outcome database, making a meaningful comparison of disease rates difficult; (2) most of the exposures have occurred recently in relation to the latency of disease progression; and (3) potentially exposed students or staff who may have moved away would not be included in the database.

Because the community requested information on mesothelioma incidence rates in the area, though, ATSDR requested mesothelioma data for western El Dorado County from the California Cancer Surveillance Program. A summary of the information that the California Cancer Surveillance Program provided is included in Appendix C of this health consultation. No difference was found between observed and expected rates of mesothelioma incidence.

Child Health Considerations

ATSDR recognizes that infants and children might be more vulnerable than adults to exposure in communities faced with environmental contamination. Because children depend on adults for risk identification and management decisions, ATSDR is committed to evaluating their special interests at the site. The effects of asbestos on children are thought to be similar to the effects on adults. However, children could be especially vulnerable to asbestos exposures because they are more likely to disturb fiber-laden soil or indoor dust while playing, and they are closer to the ground and thus more likely to inhale contaminated soil or dust. In addition, children have a higher risk of developing disease after asbestos exposure because they have a longer life expectancy and thus more time to develop asbestos-related respiratory diseases, which have long latency periods between exposure and onset of disease.

Teenagers who attended Oak Ridge High School and regularly participated in on-campus sports activities are the most likely students to have been exposed to elevated levels of asbestos. Smaller children who might have accompanied their siblings to practice, for example, could also have been exposed if they played in contaminated soil.

Hazard Category

The data are insufficient to predict exact levels of exposure and the associated risk of disease. However, a qualitative evaluation indicates that potential exposures to amphibole asbestos in the past were high enough to increase the risk of adverse health effects for highly exposed groups. For this reason, ATSDR classifies the school as a **past public health hazard**. This classification does not mean that people exposed in the past will develop asbestos-related disease. It means that potential exposures were high enough to increase risk and that mitigation activities to prevent further exposures were justified and necessary.

At present, EPA and the school district have completed mitigation activities at the school campus. Classrooms have been cleaned, and all bare areas and soils containing asbestos have been either covered with clean fill or landscaped to prevent the release of asbestos fibers. Because exposures have been minimized, ATSDR classifies the school as currently posing **no apparent public health hazard**.

Conclusions

- Current exposures to asbestos at Oak Ridge High School have been minimized by cleaning classrooms and covering or landscaping bare areas of soil throughout the campus.
- Exposures to amphibole asbestos probably occurred in the past. The greatest exposures were likely experienced by coaches who spent lots of time on athletic fields and tracks, outdoor maintenance staff, and student athletes.
- Past exposure to amphibole asbestos increases the risk of developing mesothelioma and other lung diseases. Not enough information exists to accurately calculate this risk. Groups who had the highest exposures would have more risk of developing asbestos-related disease. The increased level of risk does not necessarily mean that disease will result.
- Studies on the prevalence and magnitude of amphibole asbestos exposures outside of Oak Ridge High School will provide information essential for determining the risk of developing asbestos-related disease in community members as a whole.

Recommendations

- The school district should carry out the operations and maintenance plan to ensure that cleaned classrooms and campus areas remain free of asbestos over time.
- Because some increased risk of developing asbestos-related disease is possible, people in the most highly exposed groups (coaches, outdoor maintenance staff, and student athletes) should inform their physician about their potential asbestos exposure so that their physician can offer appropriate preventive care and watch for early signs of disease. If the time since first exposure is greater than 10 years (the minimum latency for asbestos-related lung changes), or symptoms of respiratory disease are present, the physician may recommend persons in these groups consult with a specialist who has expertise in asbestos-related disease. ATSDR physicians are available to provide advice to individuals' private physicians, if requested, and are developing outreach programs to educate local health care providers about asbestos-related disease.
- The state should continue to monitor health outcome data for asbestos-related disease.
- ATSDR should investigate the potential for amphibole asbestos exposure in the community as a whole and use this information to study the link between low level environmental exposures and resulting health effects in communities.
- The El Dorado County Air Quality Management District should ensure full enforcement of state and county air toxics regulations to minimize potential asbestos exposures in the community.
- Homeowners should follow local and state recommendations for minimizing asbestos exposure around the home.

Public Health Action Plan

The public health action plan for Oak Ridge High School contains a description of actions that will be taken by ATSDR and/or other government agencies at the site. The purpose of the public health action plan is to ensure not only that public health hazards are identified but that a plan of action is designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. ATSDR is committed to following up on the plan to ensure its implementation. The following is a list of public health actions to be implemented.

- ATSDR will evaluate EPA data being collected and use it with the Berman and Crump asbestos risk model to assess risks of amphibole exposure at Oak Ridge High School and other nearby areas with naturally occurring asbestos.
- ATSDR will use this information to evaluate the necessity and feasibility of conducting appropriate health studies for Oak Ridge High School and the community.
- ATSDR will also evaluate the necessity and feasibility of maintaining a registry to track potentially exposed people in the area.
- ATSDR will provide information and recommendations to the community and health care providers on asbestos-related disease.
- ATSDR will collect and analyze community-level data (i.e., individual concerns, questions, and news media content) and provide community education as indicated.

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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.

Peer reviewers:

Morton Lippmann, PhD
Professor
Department of Environmental Medicine
School of Medicine
New York University

Philip Harber, MD, MPH
Professor of Family Medicine
Vice Chair-Academic Affairs
Chief, Division of Occupational and Environmental Medicine
University of California, Los Angeles

John (Jack) Parker, MD, FCCP, FACP
Section Chief
Pulmonary & Critical Care Medicine Section
Department of Medicine
West Virginia University

1. Does the public health consultation adequately describe potential past and present pathways of human exposure to asbestos at Oak Ridge High School?

[Comments from Dr. Lippmann]:
Yes.

[Comments from Dr. Harber]:
Yes.

[Comments from Dr. Parker]:
Yes. Elegant exposure estimates.

2. Are the available data adequate and is the data evaluation appropriate for the estimation of potential past exposures and determination of potential health hazard(s)?

[Comments from Dr. Lippmann]:

The data are relatively rich for such an evaluation of public health risks of community level asbestos exposures, but the analyses were flawed by the nature of some of the assumptions made that led to serious overestimation of the health risks. Specifically, these assumptions were:

1) that fiber counts in f/cc and s/cc can be used interchangeably. TEM analyses following AHERA procedures count all fibers longer than 0.5 µm, and the fiber counts between these two limits almost always greatly exceed the longer ones. Table 2 mislabels s/cc levels as f/cc levels.

   Response from ATSDR: *Using the count of total structures instead of the count of structures greater than 5 µm in length will overestimate risk, but this overestimation is not significant, especially in light of the uncertainties with the sampling. The raw data sheets for the activity-based sampling reported structures less than and greater than 5 µm in length. In general, structures greater than 5 µm in length contributed 50% or more to the total structure count. Therefore, estimating exposure using the total structure count would give estimates within the same order of magnitude as estimates made using the longer structures. In addition, the raw data sheets identified the mineralogy and characteristics of reported structures. All structures contributing to the total structure count were asbestos fibers. Therefore, for the qualitative analysis performed in the health consultation, it is a reasonable approximation to use reported s/cc counts interchangeably with f/cc counts. Table 2 lists the fiber concentrations assumed in the exposure estimates, so the concentrations are listed as f/cc although the assumed values were based on reported s/cc measurements.*

   ATSDR has added clarifying information on this subject to the text of the health consultation, beginning on page 5.

2) That fiber counts collected under "aggressive sampling" protocols, i.e., with a leaf blower agitating surfaces can realistically represent people's exposures in situations where the exposure of interest for risk estimation is long-term average exposure.

   Response from ATSDR: *Samples collected using a leaf blower were not used in any of the exposure estimates. For classrooms, it was assumed that fibers were present at the detection limit of past sampling, 0.005 f/cc. Asbestos exposure in classrooms was not a major contributor to estimated exposures of the highly exposed groups. For all other areas of campus, the assumed fiber concentrations used to estimate exposures were based on results of activity-based samples collected during representative activities that are typically performed in those areas.*

3) That it is appropriate to use the highest measured value (e.g., 0.1023 s/cc for Sports Activities in Table 2) as a f/cc value, and especially as one used as a long-term exposure value in the risk assessment.

   Response from ATSDR: *The activity-based sampling was performed in a few locations over a limited time period. It is not certain whether the results truly represent levels of asbestos to which students and staff might actually have been exposed over the course of their activities at the school. Actual exposures could have been higher or lower. The use of the highest measured value was considered to be appropriately conservative. This value was not, however, used as a long-term exposure value. The value was corrected in such a way as to make it analogous to a time-weighted average. Although the assumed linearity of response is not appropriate for mesothelioma, ATSDR was unable to use the most appropriate models because of limitations in the data. The linear extrapolation does provide a reasonable qualitative estimate of risk. As described the health consultation, for each scenario evaluated, ATSDR combined the assumed fiber value for each activity (Table 2) with the assumed duration and frequency of activities (Table 1) to estimate an average long-term exposure. For all other times outside the described activities, a zero exposure was assumed—an assumption that could be untrue given the presence of natural asbestos deposits in the area.*

A more even-handed interpretation of the relatively rich air concentration database would provide a much more realistic health assessment, and one that could ease the public health concerns of the community.

Response from ATSDR: *The findings, while qualitative, are realistic and balanced. Although the exposure estimates may be relatively conservative, the uncertainty in the available data set warrants a conservative approach. Using the EPA 1986 risk model may well underestimate the risk of past exposure to the amphibole fibers seen at Oak Ridge High School. Community public health concerns would best be addressed by taking appropriate measures to reduce the chance of further exposures, such as has been done with mitigation activities.*

[Comments from Dr. Harber]:

The risk assessment approach is generally reasonable, particularly in view of the inherent uncertainties. The experts may wish to consider the following comments:

Since mesothelioma is the primary concern, considering the two classes of asbestos as equivalent may underestimate the risk in view of the high amphibole %.

Response from ATSDR: *ATSDR agrees that the risk model used may significantly underestimate risk posed by amphibole asbestos for mesothelioma.*

The impact of exposures early in life may be greater than exposures later in life for several reasons: First, early life exposures have a longer time to take an effect (appropriately discussed in the document). Second, the "slope factor" for early life exposures may be different from that later in life (either because airway geometry increases the deposition fraction or more fundamental biologic reasons). Third, the "force of mortality" (likelihood of death from another cause) is considerably lower for school age children than for older adults, potentially magnifying the impact of school related exposures.

Response from ATSDR: *ATSDR agrees that children's exposures to asbestos may pose a greater risk than adults' exposures and that our approach of extrapolating exposure to an average lifetime exposure may slightly underestimate risk for mesothelioma when exposure occurs in early lifestages. This effect is magnified for the very young. However, Oak Ridge High School's students are aged 14 to 18 years old, and physiological differences (increased breathing rate, etc.) are not as great for this age group compared with very young children. Also, the "force of mortality" reflected in the life tables for 14- to 18-year-olds is closer to that of adults than to that of very young children. Given the qualitative nature of the evaluation, averaging the exposure over a lifetime does not introduce undue uncertainty. Part of the reason ATSDR has used a conservative estimate of exposure is the uncertainty introduced by early life exposures. New methods are available that better estimate the risk from short-term and early life exposures, but the air sampling and fiber analysis must be performed in a manner that was unavailable when the data in this data set were obtained.*

The risk calculation model includes several multiplier terms that decrease the exposure risk according to the percentage of time of exposure in comparison to the reference full life exposure (ie., hours/ day, weeks/ year, years/lifetime). For short exposures such as those encountered here, this proportional decreasing of the risk is a very significant factor. One must assure that the reference lifetime studies lowered doses in the same way (i.e., that it did not assume 24 hrs daily exposure). Further, use of lifetime cumulative exposure risk as the reference reduces the impact of more recent exposures; that is not true for early life exposures (i.e., 4 fiber years accumulated over 40 years includes one fiber year in the most recent 10 years, unlikely to be significant due to the minimum latency. Conversely, 4 fiber years accumulated very early and evaluated later in life has no discounting effect for recent exposures).

Response from ATSDR: *The inability to predict risks from occasional short term exposures is an inherent problem of the risk models in use today. The mesothelioma model is of particular concern because it is more dependent upon time since first exposure than upon exposure duration at later times. Averaging exposure over a lifetime does discount the last 10 years of exposure because both the lung cancer and mesothelioma models are lagged by 10 years to account for disease latency. However, although averaging an acute early life exposure over a lifetime underestimates the risk, such a method still accounts for more than 85% (60 out of 70 years) of the exposure. In light of the other uncertainties detailed in the health consultation, the conservative risk assumptions, and the qualitative nature of the risk assessment, the calculated risk is reasonable.*

[Comments from Dr. Parker]:

Yes.

3. Does the public health consultation adequately describe uncertainties associated with the evaluation of health risks from estimated potential past exposures?

[Comments from Dr. Lippmann]:

All of the uncertainties are well described. Thus it was disturbing that worst case interpretations of them, rather than more balanced interpretations, were used in estimating risks.

> **Response from ATSDR:** *ATSDR generally uses conservative assumptions when many uncertainties exist in order to be protective of public health. ATSDR recognizes Dr. Lippmann's concerns about the conservative nature of the exposure assumptions; however, ATSDR also recognizes the nonconservative approaches of current asbestos risk models, especially when those models are used to evaluate the risk posed by amphibole fibers. This consultation's findings indicate that groups that were highly exposed to asbestos at the school might have an increased risk of developing disease and that minimizing chances for further exposures is warranted. The findings of this consultation do not mean that all (or any) members of exposed groups will develop asbestos-related disease.*

[Comments from Dr. Harber]:

Yes.

[Comments from Dr. Parker]:

Yes.

4. Does the public health consultation adequately describe what is known about the relationship between asbestos exposure levels and potential health effects?

[Comments from Dr. Lippmann]:

The answer would be yes, if the word "levels" was omitted, or "levels" referred to actual levels rather than those used in the risk assessment part of the document..

> **Response from ATSDR:** *ATSDR considers the levels of asbestos measured during activity-based sampling to be representative of actual levels of exposure during those activities. As stated earlier, ATSDR used a time-weighted approach to correct activity-based sampling results to average levels for computing lifetime risks.*

[Comments from Dr. Harber]:

- The section dealing with fiber sampling techniques is well written and communicates the difficulty interchanging results from the several methods. The discussion of work or exposures in terms of "structures" may, however, be misunderstood in the context of workers' exposure (i.e., worker exposure is still commonly considered using optical methods because of the current OSHA standards). Workers interpreting exposures expressed in "structures" might misunderstand. Perhaps the Agency may wish to consider adding a very explicit statement that structures cannot be directly interchanged into the fibers per cc as used in OSHA standards.

Response from ATSDR: *In general, fiber counts as determined using PCM (counting fibers longer than 5 μm and with aspect ratios greater than 3:1) are not directly interchangeable with counts of structures determined using AHERA counting rules with TEM (structures greater than 0.5 μm in length and with aspect ratios greater than 3:1). However, as described previously in response to Dr. Lippmann's comment, for the qualitative analysis performed in this health consultation, it is a reasonable approximation to use reported s/cc counts interchangeably with f/cc counts. The TEM raw data sheets for the activity-based sampling reported structures less than and greater than 5 μm in length. In general, structures greater than 5 μm in length contributed 50% or more to the total structure count. Therefore, estimating exposure using the total structure count would give estimates within the same order of magnitude as using the longer structures. In addition, the raw data sheets identified the mineralogy and characteristics of reported structures. All structures contributing to the total structure count were asbestos fibers (as opposed to clusters, bundles, or cleavage fragments). Therefore, it was a reasonable approximation to use s/cc and f/cc interchangeably in this instance.*

ATSDR has added clarifying information on this subject to the text of the health consultation, beginning on page 5.

- The Asbestos Background section suggests that fiber types are interchangeable. The assumption that "natural" asbestos is equivalent to "commercial" asbestos may lead to overestimating the risk- some studies have shown that miners have lower unit risk than those who work with the commercial products, probably because the preparation of the commercial products splits asbestos into higher aspect ratio fibers. Conversely, as suggested below, risk may be underestimated here because of the high proportion of amphibole asbestos.

  Response from ATSDR: *What ATSDR meant is that a fiber of a specific size, shape, and mineralogy, after it is suspended in air, has the same risk regardless of whether it was suspended from natural deposits in soil or from a commercially manufactured product. The size, shape, and mineralogy of a fiber are important determinants of risk, which is why ATSDR would prefer to use risk models that account for these factors. ATSDR has rewritten the statement on page 2 to clarify this point.*

- In the Asbestos Health Effects section, there may be two small typographical errors. The "pleural thickening" might better be termed "diffuse pleural thickening" to differentiate more clearly from localized plaque. Later, it discusses "symptoms such as loss of lung function"; technically, a symptom is something reported by a patient/person, whereas loss of lung function is a "sign" not something that the person reports.

  Response from ATSDR: *The suggested changes were made.*

[Comments from Dr. Parker]:

Yes.

5. Does the public health assessment accurately and clearly communicate the health hazard(s) posed by asbestos at Oak Ridge High School?

[Comments from Dr. Lippmann]:

Not accurately, for the reasons stated above. The wording is clear.

[Comments from Dr. Harber]:

Yes!

- The Agency should decide if it wishes to strengthen the section about community based exposures. Although the focus is on the particular school, presumably community members may face similar risks if they significantly disturb the soil in their homes. Inclusion of such a cautionary statement in this document may help public health education in the community and may represent an opportunity for improving dissemination of objective, rational, scientifically valid information for the community

  Response from ATSDR: *Other asbestos exposures in the community could be adding to the risk from exposures at Oak Ridge High School. To provide a more timely response to the petitioner, ATSDR elected to evaluate Oak Ridge High School independently of other exposures. ATSDR will evaluate community exposures in another health consultation to be released later this year. It would be prudent for people who live in the community to take steps to minimize their potential exposure to asbestos.*

- In view of the high proportion of Spanish speaking persons in CA, the Agency may wish to consider translation into Spanish. (Even if not necessary for the school students and current employees, doing this may serve the needs of those who will refer to the document in the future. Indeed, persons at greatest risk of the effects of soil exposure by virtue of working with construction, landscaping, etc. may be particularly likely to benefit from a translated version)

  Response from ATSDR: *ATSDR will translate fact sheets developed summarizing the findings of this health consultation into Spanish. ATSDR will work with the community to determine effective ways of communicating the findings to the general public.*

[Comments from Dr. Parker]:

Yes.

6. Are the conclusions and recommendations appropriate in view of the potential past and present exposures as described in the public health consultation?

[Comments from Dr. Lippmann]:

The conclusions are appropriate, and well stated.
Recommendations 1, 3, 4, and 5 are appropriate. However recommendation #2 should be restated. Based on the objective evidence presented, the risks of cumulative past exposures are so low that clinically detectable evidence of measurable effects is extremely small. It is

therefore not clear what benefits would derive from encouraging residents to seek physician consultations.

Response from ATSDR: *The original recommendation was worded to indicate that people in highly exposed groups who are concerned about their exposure or who exhibit signs of respiratory disease should consult with a specialist. ATSDR clarified this recommendation to indicate that persons in the highly exposed groups should inform their physician about their potential asbestos exposure. The physician might recommend consulting with a specialist if more than 10 years have passed since the first exposure or if respiratory symptoms are present. Although the exact levels of past exposure cannot be known with certainty, ATSDR concluded that highly exposed groups could have an increased risk of disease. A person's physician should know about any history of potential asbestos exposure so that he or she can offer appropriate preventive care and watch for early signs of disease.*

[Comments from Dr. Harber]:
These are clear and reasonable.

- Please consider strengthening the recommendations regarding the need for ongoing efforts to prevent recurrence of construction or other activities disturbing the soil. (eg, perhaps a more explicit discussion of the requirement for the school board to take direct responsibility for assuring that those responsible for maintenance and facilities always understand the implications of the asbestos in the soil).

Response from ATSDR: *ATSDR was asked to review and comment on the school board's operations and maintenance plan. ATSDR considers the plan to be protective of public health. It was ATSDR's intent to refer to that plan and not restate it in this document.*

- The document might include recommendation for posting signs, issuing notices to the community/ advisory committees on a regular ongoing basis, etc. (Over time, institutions and communities tend to forget matters that had been highly visible in the past) Including such recommendations can help assure the community that "this will not happen again" .

Response from ATSDR: *Because the potential for asbestos exposures at the school has been mitigated, warning signs and notices are not necessary there. ATSDR will consider this recommendation when evaluating asbestos exposures at other areas in the community, not all of which may be mitigated.*

- Previously exposed individuals are referred to their personal physicians. There is limited specific guidance provided, however; unfortunately, many primary care physicians may not have adequate understanding to differentiate low-level from high level exposure and might mislead patients.

Response from ATSDR: *ATSDR recommends that people who were in the most highly exposed groups inform their personal physician about their potential asbestos exposure.*

ATSDR is developing outreach programs and educational materials targeted to local health care providers that will give more specific guidance on diagnosing and treating asbestos-related disease.

- Statements about future risk are valid only if there are no repeats of the construction related exposures. (As discussed elsewhere, this is an assumption, not a definite reality)

Response from ATSDR: *This is true; however, no further construction related exposures should occur at Oak Ridge High School if the operations and maintenance plan is followed properly.*

[Comments from Dr. Parker]:
Yes. Outstanding report/consultation. This is first rate/ state-of-the-art science.

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

[Comments from Dr. Lippmann]:
On page 4, paragraph 4, line 8, "Wittenoom" is misspelled.

Response from ATSDR: *The spelling of Wittenoom has been corrected.*

[Comments from Dr. Harber]:
The document discusses a complex topic in a clear, understandable fashion. It also is effective in including reference to other support documents.

[Comments from Dr. Parker]:
No. Solid work, well supported.

8. Are there any comments on NCEH/ATSDR's peer review process?

[Comments from Dr. Harber]:
The process seems to be appropriate.

9. Are there any other comments?

[Comments from Dr. Harber]:
The above comments are purely suggestions for consideration. The document was clearly prepared with a great deal of thought and insight by many experts. Furthermore, the Agency staff have undoubtedly interacted with the affected community and is in a better position to assess appropriate communication styles than I am looking only at a paper document. Thank you for the opportunity to participate in this process.

Response from ATSDR: *ATSDR appreciates the comments and insights of all the peer reviewers.*

Appendix B. Asbestos Overview

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in a parallel arrangement. Asbestos minerals fall into two groups, serpentine and amphibole. Serpentine asbestos has relatively long and flexible crystalline fibers; this class includes chrysotile, the predominant type of asbestos used commercially. Amphibole asbestos minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA include five classes: fibrous tremolite, actinolite, anthophyllite, crocidolite, and amosite. However, other amphibole minerals, including winchite, richterite, and others, can exhibit fibrous asbestiform properties [3]. Some soils in the area around the school contain amphibole asbestos. Soil samples collected from the school property contained up to 6% fibrous amphibole asbestos, mostly actinolite. Chrysotile and tremolite asbestos were also detected in some samples.

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

The following sections provide an overview of several concepts relevant to the evaluation of asbestos exposure, including analytical techniques, toxicity and health effects, and current regulations concerning asbestos in the environment.

Methods for Measuring Asbestos Content

A number of different analytical methods are used to evaluate asbestos content in air, soil, and other bulk materials. Each method varies in its ability to measure fiber characteristics such as length, width, and mineral type. For air samples, fiber quantification is traditionally done through phase contrast microscopy (PCM) by counting fibers that are longer than 5 μm and that have an aspect ratio (length:width) greater than 3:1. This is the standard method by which regulatory limits were developed. Disadvantages of this method include the inability to detect fibers thinner than 0.25 μm in diameter and the inability to distinguish between asbestos and non-asbestos fibers [3].

Asbestos content in soil and bulk material samples is commonly determined using polarized light microscopy (PLM), a method that uses polarized light to compare refractive indices of minerals and that can distinguish between asbestos and non-asbestos fibers and between different types of asbestos. The PLM method can detect fibers with lengths greater than ~1 μm, widths greater than ~0.25 μm, and aspect ratios (length to width ratios) of greater than 3. Detection limits for PLM methods are typically 0.25–1% asbestos.

Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods that can detect smaller fibers than light microscopic techniques. TEM allows the use of electron diffraction and energy-dispersive x-ray methods, which give information on crystal structure and elemental composition, respectively. This information can be used to determine the elemental composition of the visualized fibers. SEM does not allow measurement of electron diffraction patterns. One disadvantage of electron microscopic methods is that determining asbestos concentration in soils and other bulk materials is difficult [3].

For risk assessment purposes, TEM measurements are sometimes multiplied by conversion factors to give PCM equivalent fiber concentrations. The correlation between PCM fiber counts and TEM mass measurements is very poor. A conversion between TEM mass and PCM fiber count of 30 micrograms per cubic meter per fiber per cubic centimeter [($\mu g/m^3$)/(f/cc)] was adopted as a conversion factor, but this value is highly uncertain because it represents an average of conversions ranging from 5 to 150 ($\mu g/m^3$)/(f/cc) [23]. The correlation between PCM fiber counts and TEM fiber counts is also very uncertain, and no generally applicable conversion factor exists for these two measurements [23]. Generally, a combination of PCM and TEM is used to describe the fiber population in a particular air sample.

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

Asbestos Health Effects and Toxicity

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

Malignant mesothelioma—Cancer of the membrane lining the chest cavity and covering the lungs (pleura) or lining the abdominal cavity (peritoneum). This cancer can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure [3]. Many scientists believe that amphibole asbestos fibers have as much as 100 times the potency for causing mesothelioma as chrysotile fibers, mainly because of increased persistence of amphiboles in the lungs.

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

Noncancer effects—These include *asbestosis*, a restrictive lung disease caused by asbestos fibers scarring the lung; *pleural plaques*, localized areas of thickening of the pleura; *diffuse pleural thickening*, generalized thickening of the pleura; *pleural calcification*, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and *pleural effusions*, fluid buildup in the pleural space between the lungs and the chest cavity [3].

Weak evidence exists that inhalation of asbestos may increase the risk of cancer in the gastrointestinal tract (because of swallowing of fibers removed from the lung by mucociliary transport). However, the studies are conflicting and show a much weaker effect than that proven for cancers of the lungs, pleura, or peritoneum [3].

Ingestion of asbestos causes little or no risk of noncancer effects. However, some evidence exists that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors [3]. Dermal exposure to asbestos is associated with the formation of small warts or corns, particularly on the hands.

ATSDR considers the inhalation route of exposure to be the most significant in the current evaluation of Oak Ridge High School. Actions taken to limit inhalation exposures will minimize risk from dermal and oral exposures as well.

The risk of health effects from breathing in asbestos increases with the concentration of fibers inhaled, with how often and how long the fibers are inhaled, and with the length of time since the first exposure occurred. Asbestos-related lung disease has been identified in several communities around the world that have naturally occurring asbestos, including areas of Greece, Turkey, Corsica, Italy, Sicily, Cyprus, China, and New Caledonia [3–16]. Similarly, disease associated with environmental-level exposures has been identified in people living near mines or processing operations for asbestos or asbestos-containing minerals, such as in Libby, Montana, or in Wittenoom, western Australia [17,18]. However, little information exists on the exact levels of asbestos exposure experienced by these communities, and exposure characteristics might differ significantly from other areas where environmental exposures are possible. It is not possible to extrapolate these findings to other areas in an attempt to predict the likelihood of disease.

The scientific community generally accepts the correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Fiber length may play an important role in clearance, and mineralogy may affect both biopersistence and surface chemistry.

ATSDR, responding to concerns about asbestos fiber toxicity from the World Trade Center disaster, held an expert panel meeting in December 2002 to review issues regarding fiber size and its role in fiber toxicity [53]. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths less than 5 μm are essentially nontoxic in terms of association with mesothelioma or lung cancer promotion. However, fibers less than 5 μm in length may play a role in asbestosis when exposure duration is long and fiber concentrations are high. More information is needed to definitively reach this conclusion.

In accordance with these concepts, it has been suggested that amphibole asbestos is more toxic than chrysotile asbestos, mainly because physical differences allow chrysotile to break down and to be cleared from the lung, whereas amphibole is not removed and builds up to high levels in lung tissue [54]. Some researchers believe the resulting increased duration of exposure to amphibole asbestos significantly increases the risk of mesothelioma and, to a lesser extent, asbestosis and lung cancer [54]. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, because both types increase the risk of disease [55]. EPA's Integrated Risk Information System (IRIS) assessment of asbestos also treats mineralogy (and fiber length) as equipotent [23].

Evidence suggesting that the different types of asbestos fibers vary in carcinogenic potency and site specificity is limited by the lack of information on fiber exposure by mineral type. Other data indicate that differences in fiber size distribution and other process differences can contribute at least as much to the observed variation in risk [47].

Counting fibers using the regulatory definitions (see below) does not adequately describe risk of health effects. Fiber size, shape, and composition contribute collectively to risks in ways that are still being elucidated. For example, shorter fibers appear to deposit preferentially in the deep lung, but longer fibers may disproportionately increase the risk of mesothelioma [3,47]. Some of the unregulated amphibole minerals can exhibit asbestiform characteristics and contribute to risk. Fiber diameters greater than 2–5 μm are considered above the upper limit of respirability (that is, too large to inhale) and thus do not contribute significantly to risk [3,47]. Methods are being developed to assess the risks posed by varying types of asbestos and are currently awaiting peer review [47].

Current Standards, Regulations, and Recommendations for Asbestos

In industrial applications, an asbestos-containing material is defined as any material with greater than 1% bulk concentration of asbestos [56]. It is important to note that 1% is not a health-based level but instead represents the practical detection limit in the 1970s when OSHA regulations were created. Studies have shown that disturbing soils containing less than 1% amphibole asbestos can suspend fibers at levels of health concern [45].

Friable asbestos (asbestos that is crumbly and that can be broken down to suspendable fibers) is listed as a hazardous air pollutant on EPA's Toxics Release Inventory [57]. This classification requires companies that release friable asbestos at concentrations greater than 0.1% to report the release under Section 313 of the Emergency Planning and Community Right-to-Know Act.

OSHA's permissible exposure limit (PEL) is 0.1 f/cc for asbestos fibers with lengths greater than 5 μm and with an aspect ratio (length:width) greater than 3:1, as determined by PCM [18]. This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour work week. In addition, OSHA has defined an "excursion limit," which stipulates that no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes [18]. Historically, the OSHA PEL has steadily decreased from an initial standard of 12 f/cc established in 1971. The PEL levels prior to 1983 were determined on the basis of empirical worker health observations, while the levels set from 1983 forward employed some form of quantitative risk assessment. ATSDR has used the current OSHA PEL of 0.1 f/cc as a reference point for evaluating asbestos inhalation exposure for past workers. ATSDR does not, however, support using the PEL for evaluating exposure of community members, because the PEL is based on a risk level that would be considered unacceptable in nonworker populations.

In response to the World Trade Center disaster in 2001 and an immediate concern about asbestos levels in buildings in the area, the Department of Health and Human Services, EPA, and the Department of Labor formed the Environmental Assessment Working Group. This working group was made up of staff from ATSDR, EPA, CDC's National Center for Environmental Health and National Institute of Occupational Safety and Health (NIOSH), the New York City Department of Health and Mental Hygiene, the New York State Department of Health, OSHA, and other state, local, and private entities. The working group set a reoccupation level of

0.01 f/cc after cleanup. Continued monitoring was also recommended to limit long-term exposure at this level [21].

NIOSH set a recommended exposure limit of 0.1 f/cc for asbestos fibers longer than 5 µm. This limit is a TWA for up to a 10-hour workday in a 40-hour work week [19]. The American Conference of Governmental Industrial Hygienists (ACGIH) has also adopted a TWA of 0.1 f/cc as its threshold limit value [20].

EPA has set a maximum contaminant level (MCL) for asbestos fibers in water of 7,000,000 fibers longer than 10 µm per liter, on the basis of an increased risk of developing benign intestinal polyps [58]. Many states use the same value as a human health water quality standard for surface water and groundwater.

The Asbestos Hazard Emergency Response Act (AHERA), as codified by EPA, contains reference values for clearing schools after asbestos abatement (CFR 763 subpart E). This method allows for the clearance of schools when the indoor air levels of asbestos are not statistically different from outdoor levels or when “as analyzed by the TEM method…for the five air samples does not exceed the filter background level…of 70 structures per square millimeter (70 s/mm^2).”

It has been a common practice to “back calculate” the level in air that would be associated with 70 s/mm^2 and consider that air level as a “safe” air level because it does not exceed the AHERA school standard. It is incorrect to do so. In the past, filters were contaminated with asbestos fibers at an average of 70 s/mm^2, so a sample that did not yield more than 70 s/mm^2 could not be distinguished from background contamination. Today filter contamination rates are near zero. On today’s filters, 70 s/mm^2 would correspond to an unacceptable asbestos air concentration (i.e., would result in adverse health effects) under many conditions. Because of this, AHERA clearance levels should not be used for assessing health effects.

Asbestos is a known human carcinogen. Historically, EPA has calculated an inhalation unit risk for cancer (**cancer slope factor**) of 0.23 per f/cc of asbestos [23]. This value estimates additive risk of lung cancer and mesothelioma using a relative risk model for lung cancer and an absolute risk model for mesothelioma.

This quantitative risk model has significant limitations. First, the unit risks were based on measurements made with PCM and therefore cannot be applied directly to measurements made with other analytical techniques. Second, the unit risk should not be used if the air concentration exceeds 0.04 f/cc, because above this concentration the slope factor might differ from that stated [23]. Perhaps the most significant limitation is that the model does not consider mineralogy, fiber size distribution, or other physical aspects of asbestos toxicity. EPA is in the process of updating its asbestos quantitative risk methodology given the limitations of the current assessment and the knowledge gained since the risk methodology was implemented in 1986.

Appendix C. Mesothelioma Incidence in Western El Dorado County

Health outcome data can be used to give a more thorough evaluation of the public health implications of a given exposure. Health outcome data can include mortality information (for example, the number of people who have died from a certain disease) or morbidity information (for example, the number of people in an area who have a certain disease or illness). The state of California's Cancer Surveillance Program collects information about cancer diagnosed among residents of the state. Cancer cases are reported to the registry by hospitals, doctors, and other facilities.

In 1999, the California Cancer Surveillance Program conducted an evaluation of mesothelioma incidence in western El Dorado County; program staff updated this evaluation in 2004 [50–52]. The census tracts evaluated included the towns of Placerville, Diamond Springs, Pollock Pines, Shingle Springs, Cameron Park, El Dorado Hills, Georgetown, Cool, and Diamond Valley. Between the years of 1988 and 2001, 24 cases of mesothelioma were reported in the census tracts evaluated. The observed number of cases per year (1.714, statistical confidence interval 0.005–7.430) was not significantly different from the expected number of cases per year (1.984 for the Sacramento region). The people who contracted mesothelioma were mostly male, between the ages of 50 to 85 (median age 73), and lived in various locations around the county. The occupation of most of the affected individuals was not identified.

In general, asbestos-related illness takes many decades to develop after significant exposure. This characteristic is called latency. Detection of asbestos-related illness caused by environmental exposure would take many decades. El Dorado County is growing rapidly. The population in the area around Oak Ridge High School has doubled about every 10 years since the school was built. Therefore, detecting an increase, if any, in asbestos-related illness in the state cancer registry from relatively recent increases in asbestos exposure would be very difficult. Although the state cancer registry does not currently report an apparent increase in mesothelioma rates in the area, the future mesothelioma rates cannot be predicted on the basis of the available environmental data collected.