Health Consultation

SAPPHIRE VALLEY GEM MINE NATURALLY OCURRING ASBESTOS SITE

JACKSON COUNTY, NORTH CAROLINA

Prepared by the
North Carolina Health and Human Services

SEPTEMBER 18, 2009

Prepared under a Cooperative Agreement with the
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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Acronyms

ABS	Activity-based Sampling
AEGL	Acute Exposure Guideline Level
AT	Averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
CF	Conversion factor
cm	Centimeter
CREG	ATSDR Cancer Risk Evaluation Guide
CR	Contact rate
CV	Comparison Value
ED	Exposure duration
EF	Exposure frequency
EMEG	ATSDR Environmental Media Evaluation Guide
EPA	U.S. Environmental Protection Agency
f/cc	fibers per cubic centimeter
f/mL	fibers per milliliter
IRi	Inhalation rate
IUR	Inhalation Unit Risk factor
Kg	Kilogram
LOAEL	Lowest Observed Adverse Effect Level
M	Meter
mg	milligram
mg/m^3	milligram per cubic meter
N.C. DENR	North Carolina Dept of Environment and Natural Resources
DPH	Division of Public health
PCME	Phase Contract Microscopy Equivalent
µg/dL	micro-gram per deci-liter
µg/L	micro-gram per liter
$\mu g/m^3$	micro-gram per cubic meter
µg	microgram
µm	micrometer
ng	nano-gram
NA	Not applicable
N.C. DHHS	North Carolina Dept. of Health and Human Services
NIOSH	National Institute for Occupational Safety and Health
NOAEL	No Observed Adverse Effect Level
ppm	Parts per million
ppb	Parts per billion
RfC	Reference Concentration
RfD	Reference Dose
s/mL	structures per milliliter
TEM	Transmission Electron Microscopy

*** These acronyms may or may not be used in this report**

SUMMARY

INTRODUCTION

The N.C. Division of Public Health (DPH) understands the concerns with the potential for breathing naturally occurring asbestos (NOA) at the former Sapphire Valley Gem Mine. DPH's top priority is to make sure the community and other persons that may have access to the site have the best science information available to safeguard their health.

The Sapphire Valley Gem Mine site has been identified as a location where naturally occurring asbestos exists in the rocks and soils. The mine was operated as a commercial sapphire mine in the early 1900s. Asbestos was commercially mined at the site for approximately one year in the 1960s. The site was promoted as a recreational gem mine for approximately 20 years, ending in 2006. The U.S. Environmental Protection Agency (EPA) identified the Sapphire Valley Gem Mine site as an area of high concern for breathing naturally occurring asbestos during recreational gem mining activities and initiated a site investigation to identify potential health hazards. Breathing asbestos has been linked to the development of certain types of lung disease and cancers. The EPA collected soil and airborne asbestos samples during simulated recreational gem mining activities. The EPA requested the N.C. Department of Health and Human Services, Division of Public Health (DHHS/DPH) to evaluate the potential human health risks associated with breathing naturally occurring asbestos on the site. This Health Consultation presents DPH's findings.

CONCLUSION

The N.C. DPH concludes that the potential to breathe airborne asbestos at the Sapphire Valley Gem Mine site is not expected to harm people's health while they participate in the activities anticipated to be typical for this site. This conclusion is dependent on preventing persons from further recreational gem mining activities that may release high levels of asbestos into the air, such as hammering or chiseling rock, or sifting soils that contain high levels of naturally occurring asbestos. Participation in these types of activities over many years may result in harm to people's health.

BASIS FOR CONCLUSION

Increased cancer risk was indicated only for persons that in the past or future frequently (multiple days a year over multiple years) hammer or chisel asbestos-containing rock or vigorously disrupt asbestos-containing soil on the site. Participating in these activities at a young age increases the possibility of harm to one's health. These activities result in the release of asbestos fibers into the air where they may be inhaled.

No health risks are indicated for infrequent visitors to the Sapphire

Valley Gem Mine participating in other recreational activities that result in minimal disturbance of the soil or rock, such as hiking through the area.

NEXT STEPS

The DPH makes the following recommendations to the owners of the Sapphire Valley Gem Mine property:

- Prevent further use of the Sapphire Valley Gem Mine site as a "recreational gem mine" and limit the potential for persons to disrupt the asbestos-containing materials (soil and rock) on the site.
- Maintain "no trespassing" signs at the access points to the former Sapphire Valley Gem Mine location from the parking lot off US Highway 64 and Holly Road.
- Maintain the soil berm blocking off the former Sapphire Valley Gem Mine parking lot off US Highway 64.
- Eliminate any marketing materials referencing "recreational gem mining" activities at the Sapphire Valley Gem Mine.
- Identify to Resort visitors inquiring about gem mining that the Sapphire Valley Gem Mine is closed to future recreational gem mining and do not provide them with gem mining equipment.
- Inform Resort visitors asking about recreational gem mining at the Sapphire Valley Gem Mine about the presence of naturally occurring asbestos and the potential health hazards. DPH will provide a Naturally Occurring Asbestos fact sheet that may be given to residents and guests. The fact sheet will also include references to additional information sources and will also be made available through the DPH web site
- Prevent development of any residential lots immediately adjacent to the Sapphire Valley Gem Mine location to reduce the potential for exposure to naturally occurring asbestos.

DPH also recommends that Jackson County Health Department, with assistance from DPH:
Make efforts to educate the community about naturally occurring asbestos, its potential health risks, and how to reduce or eliminate their exposure to naturally occurring asbestos. DPH will provide a naturally occurring asbestos fact sheet to facilitate this process.
DPH will:

- Work with the N.C. DENR to make available to the public and County officials a way to identify areas where NOA deposits in Western North Carolina exist, such as with a public-accessible website and materials provided to County health officials.
- Make the NOA fact sheet available to Counties and the public.

- Make the Health Consultation available to the County and the public and provide an opportunity for public feedback and questions.

DPH makes the following recommendations for persons that may visit the Sapphire Valley Gem Mine:

- Do not participate in activities that may result in the release of high concentrations of asbestos into the air. This includes activities such as hammering or chiseling rock, or sifting soils, in the area adjacent to the Sapphire Valley Gem Mine.

In addition to the recommendations listed above specific to the Sapphire Valley Gem Mine site, DPH recommends:

- A study be undertaken to evaluate the potential health risks associated with exposure to naturally occurring asbestos under common exposure scenarios as may exist in Western North Carolina. These include residential exposures associated with activities such as lawn mowing, leaf blowing, digging soil, gardening, and driving on un-paved roads in areas where soils contain naturally occurring asbestos. It is likely that these types of exposure present a more probable naturally occurring asbestos exposure scenario to a significant number of persons in the Western areas of North Carolina where naturally occurring asbestos is known to exist.
- DPH will evaluate the potential for adverse health effects associated with any new activity-based sampling data that becomes available.

FOR MORE INFORMATION

If you have concerns about your health, as it relates to breathing naturally occurring asbestos, you should contact your health care provider. You can call the N.C. Division of Public Health at (919) 707-5900, or send an e-mail to nchace@ncmail.net, and ask for information on the Sapphire Valley Gem Mine Naturally Occurring Asbestos Public Health Consultation.

PURPOSE AND HEALTH ISSUES

The U.S. Environmental Protection Agency (EPA) requested a health consultation for the Sapphire Valley Gem Mine site after the mine was identified as a "past producer" of anthophyllite asbestos in a 2005 United States Geologic Survey (USGS), a survey of known asbestos mines and areas of naturally occurring asbestos (NOA) in the eastern U.S.

At the time of the USGS report, the Sapphire Valley Gem Mine was actively promoted as a recreational gem-mining destination by the Sapphire Valley Resort (the "Resort") property management. Active promotion of the recreational gem mining activity by the Resort management ended in October 2006 at the recommendation of the N.C. Department of the Environment and Natural Resources (DENR). While active promotion of recreational gem mining by the Resort has ceased, the site is known to the local community and persons involved in recreational gemstone collection. The Sapphire Valley Gem Mine is located in a heavily wooded area adjacent to a residential community that has relatively easy access to the mine location. Because of these circumstances, the EPA and DENR identified the Sapphire Valley Mine as a priority site for evaluating exposures to NOA. The EPA, with input from DENR and the N.C. Department of Health and Human Services (DHHS) Division of Public Health (DPH), Health Hazards Control Unit (HHCU), developed a site-specific sampling plan to estimate exposures to NOA generated during the type of recreational activities that might be expected on the site, such as hunting for semi-precious rocks or hiking through the area. The concern was for persons that had access to the site to breathe airborne asbestos fibers released from the soils or rock materials during recreational activities.

In addition to performing their own risk assessment, EPA requested the North Carolina Department of Health and Human Services Division of Public Health (N.C. DHHS DPH) to evaluate the potential human health hazards associated with the site. The data generated during EPA's sampling efforts were used by DPH to estimate potential human health hazards caused by NOA at the Sapphire Valley Gem Mine. The DPH's health risk evaluation was performed by the Health Assessment, Consultation and Education Program (HACE). The HACE program is supported through a co-operative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR), a Federal agency under the Centers for Disease Control and Prevention (CDC). The HACE program performed a Health Consultation (HC) following ATSDR guidance for assessment of the potential for harmful human health impacts related to inhalation (breathing) of asbestos fibers that may be released during recreational activities at the site.

BACKGROUND

Site Description and History

The Sapphire Valley Gem Mine site has been identified as a potential source of exposure to naturally occurring asbestos (NOA). The Sapphire Valley Gem Mine is located on the property of the former Fairfield Sapphire Valley Resort, now Sapphire Valley Resort, in Jackson County, near Cashiers, N.C (geographic coordinates: 35.11814N and -83.00503W, Appendix A, Figure 1). The site is within the boundary of the Resort property and immediately adjacent to a large residential development, Fairfield Sapphire Valley. The site lies within a residential section of the resort known as Holly Forest. The mine is located off the south side of U.S. Highway 64, approximately 0.5 miles west of the Jackson-Transylvania County line. In the early 1900s, Tiffany and Company mined the site for sapphires. Asbestos was commercially mined at the site for approximately one year in the 1960s. There have been no known commercial mining operations on the site since that time.

The site has historically been accessed as a recreational gem collecting and "rock hounding" area for semi-precious rock and mineral specimens. The site was promoted as a recreational gem mine by the Sapphire Valley Resort for approximately 20 years, ending in 2006. During that time, the Resort provided rock hammers and sieves at the recreation center for guests to use in their gem hunting pursuits. Recreational gem mining activities on the site included walking in the area, hammering and scraping of rock specimens, and digging and sieving of soil. A parking area provided for the recreational "miners" was located directly off the south side of U.S. Highway 64.

The Sapphire Valley Gem Mine was identified in a 2005 U.S. Geological Survey (USGS) of known asbestos mines and naturally occurring asbestos (NOA) formations in the eastern U.S. The USGS report documented 46 historic asbestos mines, a potential mine, and naturally exposed rock formations in North Carolina. The survey identified the Sapphire Valley Gem Mine as a "past producer" of anthophyllite asbestos. The needle-like anthophyllite asbestos is a form of asbestos less commonly used for industrial applications.

In response to the 2005 USGS report, the U.S. Environmental Protection Agency (EPA) requested DENR/DWM to assess all 46 sites to determine whether NOA-containing materials were present, if they were accessible, and if the NOA could present a health hazard.

In November 2005, the DENR DWM conducted a screening study of the USGS-identified sites and added four additional sites to the North Carolina list. Irregular layers and isolated blocks of asbestos deposits are present in ultramafic rock formations that run through western North Carolina from Georgia to Virginia (Appendix A, Figure 2). Ultramafic rocks make-up the Earth's mantle and may be exposed in mountainous areas of the Earth's surface. They are composed of dark-colored minerals low in silica. Asbestos-bearing ultramafic rock bodies occur as discrete masses that contrast with the surrounding host rock. The ultramafic bodies identified in North Carolina vary in size from less than one acre, up to 300 acres, with most covering only a few acres of surface exposure. Asbestos may be present within the ultramafic rocks at quantities sufficient to be of concern when the rock or soil is physically disturbed. Of the 50 former asbestos mines, prospects and occurrences identified by the DWM in North Carolina all contain asbestiform anthophyllite asbestos.

In addition to its screening of sites identified in the USGS report, DWM contacted 35 gemstone "mines" catering to tourists that at one time had operated in the Western NC mountains from the Franklin-Highlands area to Spruce Pine. Most of these businesses provide buckets of locally obtained soil or sediment to which the owners have added gemstone-rich material imported from Brazil. The material is then washed in a flume by the tourists, using gold pans. The purpose of DWM inquiries to these businesses was to confirm that none of the material used was native North

Carolina gem-bearing soil or gravel, since asbestos is common in many the rock types that contain gemstones such the rare rubies and sapphires that do in fact occur in Western North Carolina.

During a site visit to the Sapphire Valley Gem Mine in 2005, the DWM noted small areas of bare soil along the trail leading from the parking lot to the mine. Along the trail and in the mine area they noted anthophyllite-rich rock fragments. The DWM observed possible chisel marks on the boulders at the site. Large broken fragments of anthophyllite-rich rock were observed scattered around the site. A new home under construction was observed a few hundred feet west of the parking area. The mine area includes a large exposed rock ("outcropping", Appendix A, Figure 3) and several large boulders below the ground surface. After consultation with DPH, DWM recommended that EPA make the Sapphire Gem Mine a priority candidate for investigation because of the recreational activities promoted for the mine and the near-by residential and resort areas. Subsequent EPA discussions with a mineralogist familiar with the site indicated that stones remaining at the gem mine location are low-grade corundum of limited commercial value.

On October 10, 2006, DENR sent a certified letter to the President of the Fairfield Sapphire Valley Master Association and the Board of Directors of the Holly Forest Homeowners' Association. The letter was jointly signed by the Chief of the DENR DWM Superfund Section and the N.C. DHHS DPH Chief Epidemiologist. The letter identified the Agencies' concerns with the potential for breathing naturally occurring asbestos fibers generated during recreational gem mining activities at the Sapphire Valley Gem Mine. The letter provided a list of recommendations to be implemented as a precautionary public health measure:

- immediately stop recreational gem mining activities at the Sapphire Valley Gem Mine until a health-effects study could be completed,
- post "caution" signs,
- remove electronic and conventional recreational gem mining advertisements from Resort materials, and
- restrict parking near the gem mine

A letter dated October 23, 2006, from the Director of the Sapphire Valley Resort confirmed that the above recommendations had been implemented. Access to the parking lot was restricted by construction of a soil berm and it was noted that the area was "posted". The Resort also no longer supplied gem-mining tools to its visitors.

During a site visit in June 2009, DPH staff observed two "No Trespassing" signs. One sign was attached to a 4x4 inch wood post cemented into the ground at the old parking lot (Appendix A, Figure 4). A second "No Trespassing" sign was attached to a tree off Holly Road, in the residential area on the opposite side of the property (Appendix A, Figure 5). The gem-mining site may be accessed by walking several hundred yards northwest through undeveloped, heavily wooded terrain from the Holly Road side of the property (Appendix A, Figures 6 and 7). The site can also be accessed by walking southeast, following a ravine down gradient from the old parking lot off U.S. Highway 64 (Appendix A, Figures 8 and 9). Rock fragments containing what appeared to be NOA were observed near the gem mine location along the trail from the parking lot, as well as in the large rock outcropping itself (as identified by DWM geologist on site at the time) (Appendix A, Figure 10).

As part of EPA's prioritization of the site, they developed a study using site-specific activity-based sampling (ABS) procedures. ABS procedures are designed to mimic activities expected on a site that may lead to exposures to potentially harmful substances. The objective of the study designed for the Sapphire Valley Gem Mine site was to simulate recreational gem-mining activities, quantify the concentration of airborne asbestos fibers that could be released and ultimately inhaled during these activities, and to determine the potential for harmful human health impacts related to inhaling (breathing) any released fibers.

In March and July 2007, EPA collected soil and airborne asbestos samples using the ABS procedures designed for the Sapphire Valley Gem Mine site. The simulated gem-mining activities included shoveling and sieving of surface soil, and chiseling and hammering of rocks. Raking of soil was also included to simulate wandering through the area and disturbing the soil. Samples were collected and analyzed using EPA sampling and analytical methods.

DEMOGRAPHICS

Based on Census 2000 demographic data, there are approximately 154 individuals living in the Sapphire Valley Mine area (Appendix B). The population density of the area is 35 persons per square mile. There are approximately 71 households and 214 housing units in the area. Ninety-seven (97%) percent of the population is White and 3% is of Hispanic origin. The age distribution of the population in the area is 19% under 17 years of age compared to the state (25%) and the nation (26%). Twenty percent (20%) of the population is over 65 years of age compared to the state and the nation (12%). Thirty-nine percent (39%) of the population has earned a bachelor's degree or higher compared to 21% of the state and 24% of the nation. Only 5% of the population has less than a 9th grade education.

COMMUNITY HEALTH CONCERNS

Based on discussions with the Jackson County Health Director the issue of naturally occurring asbestos (NOA) does not seem to be a major health concern to the local community. This may be due to a lack of awareness of the occurrence of NOA in this area of North Carolina and/or a lack of knowledge of the potential health risks.

DISCUSSION

Exposure Pathway Analysis

Chemical and physical contaminants in the environment can harm people's health, but only if people have contact with those contaminants at a high enough concentration and long enough time to cause a health effect. Knowing or estimating the frequency with which people have contact with hazardous substances is essential to assessing the public health importance of these contaminants. The human exposure pathway is evaluated to determine if people can come into contact with site contaminants.

According to the ATSDR, a completed exposure pathway is one that contains the following elements:

- a source of contamination, such as a hazardous waste site or contaminated industrial site,
- travel of the contaminant through a medium such as air, water, or soil,
- a point where people come in contact with a contaminated medium, such as drinking water, soil in a garden, or in the air,
- an exposure route, such as drinking contaminated well water, eating contaminated soil on homegrown vegetables, or inhaling contaminated air, and
- a population that can come into contact with the contaminants (be exposed)

A completed pathways is one in which all five pathway components exist and exposure to a contaminant has occurred, is occurring, or will occur. If one of the five elements is not present, but could be at some point, the exposure is considered a potential pathway. An exposure pathway is eliminated from further assessment if one of the five parts is missing and will not occur in the future. The length and frequency of the exposure period, the concentration of the contaminants at the time of exposure, and the route of exposure (skin contact, ingestion, and inhalation) are all critical elements considered in defining a particular exposure event.

A. Completed Exposure Pathway

The population of concern for the Sapphire Valley Gem Mine is persons that inhale asbestos fibers released into the air during recreational activities from the asbestos-containing soils or rock material on the site. No historical data is available to evaluate whether persons participating in recreational activities at the gem mine caused the release of airborne asbestos fibers of the size range that can result in inhalation deep into the lung, and eventually lead to harmful health effects. Assumptions can only be made regarding past, present, and future exposures based on the data gathered during EPA's activity-based sampling (ABS) efforts and the health risk estimates developed using exposure parameters developed by the EPA and the DPH.

Table 1. (following) describes the completed exposure pathway identified for the Sapphire Valley Gem Mine.

Table 1. Completed exposure pathway for the Sapphire Valley Gem Mine site.

Source	Medium	Exposure Point	Route of Exposure	Exposed Population
Asbestos-containing soil and rock located at the gem mine site	Asbestos fibers released to the air from soil or rock during recreational activities	Asbestos fibers suspended in the air	Inhalation (breathing in) suspended asbestos fibers	Persons in the past and present with access to the site that participated in activities that disturbed the asbestos-containing soil or rock

The ATSDR Health Effects Evaluation Process

Inhalation of asbestos fibers is the primary health concern related to asbestos exposures. Health studies indicate that the physical dimensions of the asbestos fibers are an important indicator of the potential for harmful health effects. Fiber length affects the body's ability to clear asbestos fibers from the lung, with longer fibers more difficult to clear. Historically, health data associated with asbestos exposure has used PCM data, which shows a relationship between disease and exposure to fibers greater than 5 microns (>5 µm) long. Current risk methods continue to use PCM-equivalent (PCME) data to estimate health associated with the inhalation of airborne asbestos.

Following is a brief discussion of the health effects evaluation process used for suspected or known cancer-causing substances, as was used for the asbestos data in this health consultation. A detailed discussion of the ATSDR health effects evaluation process is provided in Appendix D.

Concentrations of substances observed on a site are compared to concentrations "comparison values" (CVs) derived by ATSDR. ATSDR comparison values are set at levels that are highly health protective, well below levels known or anticipated to result in adverse health effects. When chemicals are found on a site at concentrations greater than the screening values (CVs) it does not mean that adverse health effects would be expected. CVs are set at levels well below concentrations of known health effects to serve as a highly health protective initial screen of human exposure to chemicals. Contaminant concentrations at or below the CV may reasonably be considered safe. Those chemicals that are greater than the CV undergo further evaluation.

Increased numbers of cancers over the number that would be expected in a population are estimated for chemicals suspected or known to cause cancer. Cancer risk is estimated as the risk of getting cancer if exposed to a substance every day for 24 hours per day, for 70 years (a "lifetime exposure"). The cancer risk may be modified for a particular site and exposure (contact) situation to more appropriately represent site-specific conditions that may not result in "lifetime" exposures. Estimates of increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the calculated site-specific exposure dose and a cancer slope factor (CSF, for ingestion/eating exposures) or an Inhalation Unit Risk (IUR, for inhalation/breathing exposures) provided in ATSDR health guideline documents. This calculation is based on the assumption there is no safe level of contact with a chemical that causes cancer. However, the theoretical calculated increased cancer risk is not exact and tends to overestimate the actual risk, if any, associated with conditions of the site-specific exposure that may have occurred. The cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates a theoretical increase in cancer risk expressed as the proportion of a population that may be affected by a carcinogen during the selected exposure conditions. The cancer risk is expressed as the number of additional cancers over the number of cancers that occur in a population without these exposures. For example, an estimated cancer risk of 1×10^{-4} predicts the probability of one additional cancer over the expected number of cancers in a population of 10,000 persons. (The N.C. Central Cancer Registry estimates that <u>one</u> out of every <u>two</u> men and <u>one</u> out of every <u>three</u> women will develop a cancer of some type during his or her lifetime. So, for a population of 10,000 persons, approximately 3,300 to 5,000 would be expected to develop some type of cancer.) A qualitative assessment of the predicted numbers of cancers is also used in ATSDR documents and represents risk terms suggested by ATSDR and DPH (see Appendix D).

For the Sapphire Valley Gem Mine Naturally Occurring Asbestos Health Consultation DPH used EPA's "extrapolated unit risk values" for less-than-lifetime exposures (EPA 2008). The extrapolated unit risk values provide cancer risk values adjusted for the age a person first breathes airborne asbestos and the total number of years a person is breathing asbestos over their lifetime. EPA's extrapolated unit risk values for asbestos are listed in Appendix C, Table 2. The extrapolated unit risk values were multiplied by the airborne asbestos sample concentrations to give the estimated cancer risk value.

What is Asbestos?

Asbestos is the name given to a group of six different silicate chrystalline minerals that occur naturally in the environment, as long, thin, strong flexible fibers that are heat-resistant. There is strong evidence that breathing asbestos fibers that become trapped in the lung, at high enough concentrations, for a long period, may develop into non-cancerous and cancerous adverse (harmful) health effects. The adverse health effects may not be evident until many years, even decades, after inhaling the fibers. The adverse health effects associated with breathing asbestos fibers include the build-up of scar-like tissue in the lung and the membrane surrounding the lungs. The development of scar tissue may lead to difficulty in breathing (a disease called asbestosis). Inhalation of asbestos fibers may also lead to the development of cancer of the lung tissue or mesothelioma (a cancer of the thin membrane that surrounds the lung and other internal organs). There is also some evidence that breathing asbestos can lead to cancer of the stomach, intestines, esophagus, pancreas and kidneys.

Asbestos Sample Collection at Sapphire Valley Gem Mine

The EPA designed an activity-based sampling (ABS) plan for the Sapphire Valley Gem Mine site. The ABS protocols were designed to collect air samples that mimic the expected breathing contact for persons involved in recreational gem mining and "rock hound" activities on the site. The sampling activities included "shoveling" and "sieving" of soil, and "chiseling" (hammering) on stones or rock formations. The shoveling and sieving activities were designed to mimic digging small excavations as might be done to produce material for screening to look for gemstones. Since sapphires may be associated with intact rock formations, the chiseling activity was used to mimic this behavior by having samplers hammer or chisel on stones, boulders or rock formations. Hammers and chisels had been provided to resort visitors during operations of the recreational gem mine and evidence of this activity was visible on the rock face. A "raking" of soil sampling protocol was also included to mimic the disturbance of surface soils as persons walk across the site.

EPA developed site-specific exposure situations for each activity that included an estimate of the number of hours per day, the number of days per year, and the number of years a person would participate in each activity. An age when a person began participation in each activity was also predicted since the age of initial exposure to airborne asbestos affects the potential for development of harmful health effects. The younger the age a person first inhales asbestos, the greater the chance to develop harmful effects. EPA developed exposure parameters for 3 situations, the "rock hound", the "regional rock collector", and the 1-time recreational visitor".

The DPH Health Hazards Control Unit (HHCU) also requested two additional exposure situations, the "child vacationer" and the "adult vacationer". The HHCU added these exposure situations to identify potential hazards to persons that may make a once-a-year visit to the Sapphire Valley Gem Mine over a limited number of years. Appendix C, Table 2 lists the exposure parameters developed by EPA and DPH HHCU.

Multiple samples for each activity were collected during 3 days in March 2007, and 4 days in July 2007. The two sampling dates were intended to represent a period when wetter (March) and drier (July) soil conditions would be expected. The moisture content of the soil can potentially affect the ease with which asbestos fibers are released from soil and become suspended in the air. A higher proportion of asbestos fiber release to the air would be expected when the soil is drier (as is typical in July as compared to March). Activity-based samples were collected over 220 minutes for each sampling event. Air samples were collected while sampling personnel were performing the prescribed activity. Sample collectors were dressed in personal protective equipment (PPE) and equipped with two sampling pumps and filter cassettes (holders) to capture airborne asbestos fibers. The sample collection filters were oriented downward and located in the sampler's "breathing zone" (within approximately 6 to 9 inches from their face) to simulate inhalation (breathing) intake of airborne asbestos fibers (see Appendix A, Figure 11). The two sampling pumps worn by a sampler were calibrated to collect two distinct volumes of air, one a "low" volume (3 liters per minute, L/min), and the other a "high" volume (10 L/min). This was intended to increase the likelihood of obtaining a sample that contained a number of fibers on the sample collection filter that was greater than the method sensitivity level (the minimum detectable number of asbestos fibers that could be counted) and a sample that did not "overload" the filter with fibers, preventing an accurate identification and counting of fibers. The on-site air sampling followed EPA method *ERT SOP #2015, Asbestos Sampling*.

One upwind and two downwind air samples ("perimeter" samples) were collected in the immediate vicinity of each ABS event. Downwind samples provided an indication of the potential for airborne asbestos fibers generated during the sampling activity to travel beyond the breathing zone of the sample collection personnel, and beyond the immediate vicinity of the simulated recreational activity. The upwind samples provided an indication of background levels of airborne asbestos fibers in the immediate vicinity of the sampling activity. Figure 12 (Appendix A) illustrates the proximity of the perimeter sample collection to the ABS event.

The ABS sampling was conducted in two areas of the site. The "lower area" is at the gem mine location, a large exposed asbestos-containing rock "outcropping" (Appendix A, Figure 3). The lower area is located approximately 50 yards east through the woods from the old parking lot, then traveling approximately 25 yards north (upstream) along a small creek (Appendix A, Figures 6 and 7). All four activity-based sampling methods were completed in the lower area (chiselling, shoveling, sieving, and raking). The "upper area" was located approximately 50 yards from the lower area up a steep trail at an opening to flat ground (Appendix A, Figures 8 and 9). Three activity-based sampling methods were conducted in the upper area (shoveling, sieving and raking). The chiselling/hammering activity was not conducted in the upper area of the site because there was not a large rock outcropping in this area, such as existed in the lower area. "Natural growth" dense vegetation was noted in both the upper and lower areas of the site. Figure 13 (Appendix A) notes the locations of the lower and upper sampling areas.

Two or three “daily background” air samples were collected simultaneously on each day of the ABS events. The collection area was located upwind to the southwest, off-site of the gem mine location. The daily background samples indicate if airborne asbestos fibers traveled downwind to the Sapphire Valley Mine site and may have biased the concentrations of asbestos fibers collected during the ABS events on site. The daily background samples were collected for approximately 9 to 10 hours, except for day three of the July 2007 sampling event. The collection period for the July 2007-day 3 background sample was shortened to approximately 5 hours due to severe weather. The location of the background air sample collection area relative to the ABS collection areas is noted in Figure 13 (Appendix A). A total of 16 daily background air samples were analyzed for the March and July 2007 sampling events. High volume airflows were used to optimize the asbestos fiber detection sensitivity for the background air samples.

A brief description of each of the ABS methods used by EPA to collect samples at the Sapphire Valley Gem Mine NOA site follows. Each ABS air-sampling activity was conducted multiple times over the two sampling periods. Replicate samples were collected for quality control purposes for some ABS activities by simultaneously collecting a second set of breathing zone samples with a second pump and sample collection filter apparatus.

Shoveling: Three shoveling ABS events were conducted at both the upper and lower areas of the site. Samplers dug a hole of at least 2 cubic feet with a standard sized shovel (Appendix A, Figure 12). The digging occurred in areas that included vegetation and soil or rocks and gravel. The excavated soil was placed next to the hole and in 5-gallon buckets. The holes were then re-filled with the removed soil. Persons collecting the samples rotated 90 degrees every 15 minutes to prevent the simulated inhalation samples from being biased by the prevailing wind direction. Each shoveling ABS event was continued for 220 minutes. A portion of the removed soil generated during the shoveling activity was mixed and used for the “sieving” ABS events.

Sieving: Using hand-held sieves the samplers re-filled the hole dug during the “shoveling” activity with the well-mixed soil (Appendix A, Figure 11). Samplers rotated 90 degrees every 15 minutes during a 220-minute sampling period.

Chiseling: Sample collectors used rock hammers, geologist picks, or chisels to break or chip stones, boulders, and rock formations found within a small area in the lower area of the site near the face of the asbestos-containing rock outcropping. Samples were also collected while samplers chiseled the face of the rock outcropping (Appendix A, Figure 14). The broken material was then hand separated from the solid rock. Samplers rotated 90 degrees every 15 minutes during a 220-minute sampling period.

Raking: Using a 20 to 28 inch metal leaf rake samplers disturbed the top ½ inch of weed or grass-covered soil to remove debris such as rocks, leaves or weeds. Samplers raked the soil toward themselves, with an aggressive left to right motion. Samplers rotated 90 degrees every 15 minutes during the 220-minute sampling period, disturbing a fresh area with each rotation.

Asbestos in Soil: The EPA also collected 18 soil samples for asbestos analysis in the lower and upper areas while on site for the ABS. Fifteen of the soil samples were collected as four-part combinations of soils collected over a small area (4-part composite samples) and three were soils from a single area (discrete grab samples). The depth of soil collection ranged from 0 to 24 inches below ground surface. Samples were analyzed for percent asbestos.

Asbestos Sample Analytical Methods

The EPA submitted the air and soil samples to a contract laboratory for analysis. Samples were analyzed by Transmission Electron Microscopy (TEM) using the *International Organization for Standardization (ISO), International Standard, ISO 10312 (1995(E)), Ambient Air – Determination of Asbestos Fibers – Direct Transfer TEM Methodology*. The TEM method is the most sensitive analytical method for characterization of asbestos fibers. All asbestos in air values included in this Health Consultation and used for the risk calculations, were generated by a "direct sample preparation technique" and reported as Phase Contrast Microscopy Equivalent (PCME) values. PCME structures are greater than 5 microns in length (>5 µm), greater than 0.25 microns in width (>0.25 µm), and have an aspect ratio (length to width) greater than 3 to 1 (> 3:1). The PCME subset of TEM fibers represents the asbestos fibers that historical epidemiological studies used to correlated exposure with development of lung cancer and mesothelioma. The PCME fiber subset is used in current risk assessment methods and for setting regulatory levels (ATSDR 2003).

The air samples were collected on 0.8-micron (µm), 25-millimeter (mm) mixed cellulose ester (MCE) membrane filters connected by tubing to a personal sampling pump. The filters were housed in filter cassettes with the filter oriented downward and directly exposed to the air (cassette top cover removed, for "open-faced" sample collection). Sampling pumps were calibrated to collect air at a rate of 10 liters per minute (L/min) and 3 L/min for the high and low sample volumes over the 220 minute sample collection period. The sensitivity of the air sample analytical method was reported as 0.001 structures per milliliter (s/mL) for the activity-based air samples and 0.0001 s/mL for the off-site background air samples.

The "direct" technique for sample filter preparation does not disrupt the position of the structures and fibers collected on the filter. (An "indirect" method of filter preparation may be used when the sample collection filter is over-loaded with asbestos fibers, dust, or other types of particles in the air. The structures captured on the filter may be lost or altered during preparation for counting in the indirect method, potentially biasing the final quantitation of asbestos fibers.) During ABS, high and low volume air samples were collected simultaneously. This was done to provide a second direct method sample for analysis in case the high volume sample overloaded the capacity of the membrane filters to be read by the direct preparation method.

Soil samples were analyzed for percent asbestos by the California Air Resources Board (CARB) modified method 435 using Polarized Light Microscopy (PLM). Soils were also tested for percent moisture and particle size, using methods ASTM D6565-00(2005) *Standard Test Method for Determination of Water (Moisture) Content of the Soil by the Time-Domain Reflectometry (TDR) Method*, and the American Society of Testing and Materials (ASTM) D422-63(2002), *Standard Test Method for Particle-Size Analysis of Soils*. The sensitivity limit for the soil analytical method is 0.25% asbestos (the percent number of asbestos fibers in the total sample particles).

Asbestos Sample Analytical Results

Off-site Background Air: Three background airborne asbestos samples were collected on each of the 3 days on site in March 2007, and on the second day in July 2007. Two samples were collected each of the other two days in July 2007. All background airborne asbestos samples were reported as "not detected". The analytical method sensitivity limit was 0.0001 structures per milliliter (s/mL).

The ABS "breathing zone" airborne asbestos data is summarized in Appendix C, Table 4. Only asbestos data generated using the direct method of sample preparation is listed. Mean values of duplicate analyses are listed in the table. The data for the "perimeter" airborne asbestos samples collected in the immediate vicinity during the ABS events is listed in Appendix C, Table 5.

Shoveling ABS: Airborne asbestos fibers exceeding the method sensitivity limit (0.001 s/mL) were collected on the breathing zone filters for all 3 of the samples from both the upper and lower areas of the site during the "shoveling" activity-based sampling. Detected fiber concentrations ranged from 0.0065 to 0.036 s/mL (mean = 0.016 s/mL) in the upper area, and from 0.008 to 0.037 s/mL (mean = 0.022 s/mL) in the lower area. Asbestos fibers were detected in the upwind perimeter air samples at the method sensitivity level (0.001 s/mL) in 2 of 3 upper area samples, and 1 of 3 lower area samples. Asbestos fibers were detected in several of the downwind perimeter air samples at higher concentrations than detected in the upwind samples. Asbestos fibers were detected at 0.004 s/mL in 1 of 6 downwind perimeter samples in the upper area. Asbestos fibers were detected in 4 of 6 downwind perimeter samples in the lower area, ranging from 0.001 to 0.0025 s/mL (mean = 0.002 s/mL).

Sieving ABS: Asbestos fibers were detected in the single valid breathing zone sample collected in the upper area during the sieving ABS at 0.022 s/mL. Asbestos was detected in all 3 lower area ABS samples, ranging from 0.037 to 0.14 s/mL (mean = 0.075 s/mL). Airborne asbestos was detected at the method sensitivity level (0.001 s/mL) in both upwind perimeter samples collected in the upper area. Airborne asbestos fibers were detected at higher concentrations in 2 of 4 downwind perimeter samples collected in the upper area. There was no perimeter sample data reported for the lower area for the sieving ABS event.

Raking ABS: Airborne asbestos fibers were detected in 3 of 3 breathing zone samples collected in the upper area during the raking ABS event. Detected asbestos concentrations ranged from 0.0035 to 0.015 s/mL (mean = 0.009 s/mL) for the upper area. Asbestos fibers were detected in 1 of 2 breathing zone samples collected in the lower area raking ABS, at 0.038 s/mL. Airborne asbestos was detected at the method sensitivity level (0.001 s/mL) in 1 of 3 upwind perimeter samples in the upper area. Airborne asbestos fibers were not detected in either of the 2 upwind perimeter samples collected in the lower area. Airborne asbestos fibers were detected in 4 of 5 downwind perimeter samples in the upper area, at concentrations ranging from 0.001 to 0.002 s/mL (mean = 0.002 s/mL). Airborne asbestos fibers were detected in 1 of 3 downwind perimeter samples in the lower area, at the method sensitivity level (0.001 s/mL).

Chiseling ABS: Airborne asbestos fibers were collected in the breathing zone samples collected in all 3 chiseling ABS events in the lower area. Asbestos concentrations ranged from 0.066 to 0.29 s/mL (mean = 0.21 s/mL). Airborne asbestos fibers were detected in 2 of 3 upwind perimeter samples at 0.001 and 0.082 s/mL (mean = 0.042 s/mL). Airborne asbestos fibers were detected in 9 of 11 downwind perimeter samples at concentrations ranging from 0.0005 to 0.02 s/mL (mean = 0.005 s/mL).

Soil Data: Asbestos above the 0.25% analytical method sensitivity limit was found in 14 of the 15 soil sample locations. Soil asbestos ranged from 1.8 to 15%, with an average of 6.3%. There was good agreement between duplicate samples.

PUBLIC HEALTH IMPLICATIONS

This section discusses the health effects that could possibly result from breathing airborne asbestos on the Sapphire Valley Gem Mine site. For a public health hazard to exist, people must contact hazardous materials at levels high enough and for a long enough time to harm their health. Evaluation of potential public health hazards are based on ATSDR assessment procedures.

ATSDR prefers to use site-specific conditions whenever possible to evaluate whether people are being exposed to substances at concentrations that may be of health concern. There is no data available to evaluate the concentration of asbestos fibers, if any, people in the past participating in recreational gem mining at the Sapphire Valley Gem Mine may have been inhaled. To provide a realistic estimate of the concentrations of airborne asbestos fibers that people could inhale while participating in gem mining activities at the site, the EPA developed a suite of site-specific "activity-based" sampling methods for the Sapphire Valley gem mine investigation. EPA used these methods to collected air samples during the simulated gem mining activities. The air samples were used to quantify the concentration of airborne asbestos fibers that some one could breathe while gem mining on the site. The EPA and N.C. DPH/HHCU developed exposure parameters that included how often and how long people may participate in each of the recreational gem mining activities. The age that a person began participation in these activities was also specified. The values selected for these exposure parameters were chosen to be highly health protective. The DPH Health Assessment, Consultation and Education (HACE) program then used the airborne asbestos fiber sample concentrations and anticipated site-specific recreational exposure patterns to estimate the potential for harmful health effects resulting from breathing the asbestos fibers while participating in recreational gem mining at the Sapphire Valley Gem Mine.

Health Effects Related to Asbestos Exposure

Asbestos is the general name for 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). Chrysotile-type asbestos has relatively long and flexible crystalline fibers, while amphibole minerals are brittle and have a rod- or needle-like shape. 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, laryngeal cancer, or certain types of nonmalignant respiratory diseases. Many scientists believe that the amphibole varieties of asbestos are more potent in causing mesothelioma, and possibly other asbestos-related disease, than is the chrysotile variety. The possible increased potency of amphibole-type asbestos may be related to the amphibole fibers tendency to remain in the lungs longer (ATSDR 2001b).

For many years, asbestos (mainly chrysotile, amosite, and crocidolite) was mined and used in many commercial products, including insulation, brake linings, building materials, and flooring. The term “naturally occurring asbestos” (NOA) is used 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 NOA 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. Health effects related to exposures to NOA or commercial asbestos material are indistinguishable.

Mesothelioma is cancer of the membrane lining the chest cavity and covering the lungs (pleura) or lining the abdominal cavity (peritoneum). The malignancy can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure. Lung cancer, also known as bronchogenic carcinoma, is cancer of the lung tissue. The combination of tobacco smoking and asbestos exposure greatly increases the risk of developing lung cancer. Laryngeal cancer is cancer of the epiglottis and vocal cords. Laryngeal cancer arises from the surface epithelium that lines the upper airways, which are in direct contact with inhaled asbestos fibers (ATSDR 2001b).

Non-cancer effects of asbestos exposure 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 (ATSDR 2001b).

The risk of harmful health effects resulting from the inhalation (breathing) of asbestos fibers increases as the concentration of inhaled fibers increases, as the frequency and length of time over which fibers are inhaled increases, and as the age of first exposure (inhalation) decreases. These effects have been observed mainly in individuals who have breathed a significant amount of airborne asbestos, either in the workplace or in specific types of environmental exposures. Ingestion of asbestos causes little or no risk for non-cancer effects. However, there is some evidence from animal studies that ingestion of high amounts of asbestos fibers in a single event or several events over a short time period may lead to the development of lesions, and eventually colon cancer. While studies of populations that have ingested asbestos fibers in drinking water have not conclusively shown an association with increased cancer risk, some studies have indicated an increased risk for cancer of the stomach, kidney, and pancreas (ATSDR 2001b).

The influence of fiber length and health effects: Studies indicate that the physical dimensions of asbestos fibers are an important indicator of the potential to develop harmful health effects following inhalation. An expert panel coordinated by ATSDR concluded that fiber length plays an important role in toxicity. The role of fiber length appears to be related to the diminished efficiency in clearance of longer fibers by the lung. ATSDR concluded that fibers greater than 5 microns (>5 µm) in length are of a concern for cancer risk, but that fibers with lengths less than 5 microns (<5 μm) are unlikely to cause cancer in humans (ATSDR 2003). PCME fibers are used as the criteria for risk-based evaluations since they are the fiber definitions that were used to characterize asbestos air concentrations in studies of asbestos-related disease from occupational exposures.

While the tendency for asbestos exposure to result in disease generally increases with fiber length, asbestos fibers of all lengths may result in a negative health effect at some level of exposure. The physical and chemical characteristics of asbestos also have an impact on potential health effects and disease development. Based on studies reviewed by ATSDR, amphibole asbestos appears to be significantly more potent compared to chrysotile in causing mesothelioma and pleural effects, and possibly in causing lung cancer. The differences in the toxicity of the different types of asbestos fibers may be related to several factors, including the higher degree of bio-persistence of amphiboles, which is related to their chemical and physical make-up and the reduced ability to clear amphiboles fibers from the lungs, as compared to other fiber types (ATSDR 2001b).

Health-Effects Evaluation of the Activity-Based Sampling Asbestos Data

ATSDR does not list a non-cancer comparison value (CV) for inhalation (breathing) of airborne asbestos. ATSDR identifies asbestos as a "known human carcinogen" and recommends using the EPA value of 0.0004 f/mL (EPA IRIS) as a cancer-effect CV. ATSDR lists an EPA inhalation unit risk (IUR) value of 0.23 $(f/mL)^{-1}$ for calculation of cancer risks associated with lifetime (70 years, 24-hours per day) inhalation exposures to asbestos (ATSDR 2008 HG). Health values in units of asbestos fibers/mL were used for direct comparison to air data reported in asbestos structures/mL. The exposure parameters developed for the recreational gem mining activity-based sampling (ABS) situations (Appendix C, Table 3) were used in calculations to develop site-specific exposure estimates for inhalation of airborne asbestos fibers released during the identified recreational activities. Estimates of the increased number of cancer cases were determined using the EPA's extrapolated unit risk values for less-than-lifetime exposures (Appendix C, Table 2) (EPA 2008). Average and maximum airborne asbestos concentrations observed during the EPA's activity-based sampling events were compared to the ATSDR cancer CV. Both the maximum and average asbestos concentrations from the chiseling activities in the lower area were greater than the CV. The maximum airborne asbestos concentration observed during the sieving activity in the lower area was also greater than the CV. Generally, only substance concentrations exceeding their comparison values are selected for further evaluation. For this investigation, because of the potential for breathing asbestos to result in cancer, DPH evaluated the cancer risk associated with each of the simulated recreational gem mining activities and contact simulations developed for the site by EPA and DPH.

Table 3 (following) is a summary of the findings of the potential health hazards investigation completed by N.C. DPH associated with recreational gem mining activities at the Sapphire Valley Gem Mine, using the air samples collected by EPA in 2007. The findings are discussed in detail below.

Only the "rock hound" and "regional rock collector" activities indicated the potential for increased numbers of cancers for some of the site-specific exposure parameters (Appendix C, Table 7). All "rock hound" simulated recreational activities resulted in estimates of increased numbers of cancer cases greater than ATSDR's and N.C. DPH's most highly health protective level (1 increased cancer in a population of 1 million exposed people, "1 in a million"). The "chiseling" activity resulted in the highest estimates of increased cancers, followed by "sieving" soil in the lower area of the site. Both activities resulted in "moderate" numbers of increased cancers at both the average and maximum airborne asbestos concentrations detected during the ABS. Estimates of increased cancers for the "rock hound/chiseling" activity were 300 and 410 per 1 million persons. Estimates of 110 and 200 increased cancers were calculated for the "rock hound/sieving" activity in the lower area. All other rock hound activities resulted in "low" estimates of increased cancers.

The increased cancer estimates represent the number of additional cancers that might be expected due to breathing asbestos during recreational gem mining activities at the Sapphire Valley Gem Mine site. These "increased" cancers are those that would occur in addition to the number of cancers expected in the general population not participating in recreational gem mining (estimated at <u>one</u> out of every <u>two</u> men and <u>one</u> out of every <u>three</u> women during his or her lifetime).

The "rock hound" exposure situation outlined by the EPA is a highly health protective (conservative) exposure situation, predicting that a person, starting at age 6, spends 4 hours per day twice a month, over 30 years, in the specified site-specific recreational activity. The exposure estimates that lead to the elevated increased cancer risk estimates involve chiseling asbestos-containing rock or sieving asbestos-containing soil over anticipated time periods that may not be representative of typical recreational activities for this site. The result of the conservative values used to predict exposure estimates and cancer health-effects is likely to be an over-estimation of the number of increased cancers that would be expected.

The "regional rock collector" exposure situation resulted in "no apparent" increased cancer risk estimates for the average and maximum "chiseling" activity (2 and 3 cancers per 1,000,000 exposed persons, respectively) and for the maximum asbestos concentration in the "sieving" activity in the lower area of the site (1 cancer per 1,000,000 asbestos-exposed persons, or "1/1,000,000"). All other "regional rock collector" exposure scenarios resulted in "no increased cancers" (less than 1/1,000,000, or "<1/1,000,000").

All other exposure situations ("1-time recreational visitor", "child vacationer" and "adult vacationer") resulted in "no increased cancers" (<1/1,000,000) for all of the site-specific recreational exposure situations.

The exposure situations and parameters developed by EPA were meant to provide highly conservative (highly health protective) exposure situations for the selected activities with the intent to simulate the higher levels of exposure that might be expected for the selected activities. Alterations in the exposure parameters used for the cancer estimates, such as starting at an older age, or participating for fewer hours per day, fewer days per year, or for fewer years, would result in fewer numbers of increased cancer cases, and thus reduced health hazards, predicted for a particular activity. The specification of young children, starting at age 6, participating in any of the simulated activities for 4 hours per day may not be realistic. For example, reducing the exposure for the rock hound/chiseling scenario from 4 hours per day to 1 hour results in a reduction of cancer case estimates in the "low" to "moderate" range, using the mean and maximum asbestos concentrations (76/1,000,000 and 100/1,000,000). Changing the starting age for the rock hound/chiseling scenario from 6 years to 12 years does not substantially change the number of estimated increased cancers, with estimates remaining in the "moderate" range (230/1,000,000 and 320/1,000,000 for mean and maximum concentrations). To evaluate potential exposure situation of infrequent visitors to the site, DPH/HHCU requested the child and adult "vacationer" scenarios. These scenarios reflected reduced exposure parameters represented as 1 hour per day, 1 day per year for 3 years, starting at age 7 or age 25 years (Appendix C, Table 4). As discussed above, neither "vacation" scenario resulted in estimates of increased cancer risks greater than 1/1,000,000 (">1/1,000,000") exposed persons for any of the simulated recreational activities.

The HACE program also evaluated additional exposure situations using the downwind airborne asbestos perimeter concentrations to simulate exposures to persons walking through the area while others at the gem mine location participated in the simulated recreational activities outlined by EPA. The HACE exposure scenarios are identified as a "child hiker" and an "adult hiker". The exposure parameters used for the evaluation of the two "hiker" scenarios are listed in Appendix C, Table 8. The airborne asbestos concentrations used were the highest downwind perimeter sample value generated during the ABS events, observed during the "chiseling" activity (0.02 s/mL), and the highest value from a simulated activity other than chiseling activity, which was from the "sieving" activity (0.005 s/mL). "No apparent" increase in cancer cases were estimated for the "hiker/chiseling" scenarios (4/1,000,000 for the "child hiker" and 3/1,000,000 for the "adult hiker"). Increased cancer estimates for the "hiker/sieving" scenario indicated "no increased" cancer risk (both <1/1,000,000) (Appendix C, Table 9). The cancer estimates developed for the hiker scenarios likely represent much higher estimates of potential health hazards than would realistically be expected for persons hiking through the area. The downwind perimeter samples were collected in the immediate vicinity of the ABS events (within a few yards). Risks associated with persons hiking through the area while others participated in the recreational gem mining and disturbing asbestos-containing soils and rocks would decrease substantially as the distance between the "hiker" and the ABS activities increased. Reductions in other exposure parameters specified at highly health protective levels for the "hiker" scenario, such as the number of hours per day near the gem mining activity (1 hour per event), or the number of days per year (24 days), would result in reduction of anticipated health hazards.

Table 3. Summary of adverse health effect risk estimates for persons participating in recreational gem mining at the Sapphire Valley Gem Mine, Jackson Co., NC. Health risk estimates are based on N.C. DPH health effect evaluations using data generated by the U.S. EPA in March and July 2007.

Recreational gem mining exposure situation	Recreational gem mining activity	Cancer risk estimate
Rock hound	Upper area	
	Sieving	Low
	Shoveling	Low
	Raking	Low
	Lower area	
	Chiseling	Moderate
	Sieving	Moderate
	Shoveling	Low
	Raking	Low
Regional rock collector	Upper area	
	Sieving	No
	Shoveling	No
	Raking	No
	Lower area	
	Chiseling	No apparent
	Sieving	No apparent
	Shoveling	No
	Raking	No
1-Time recreational visitor	All activities	No
Child vacationer	All activities	No
Adult vacationer	All activities	No

Notes:
See Appendix C, Table 3 for exposure situation conditions.
See Appendix D for explanation of qualitative cancer risk terminology.
Upper area = approximately 50 yards west of the lower area, traveling towards the former Gem mine parking lot off U.S. Highway 64
Lower area = at the gem mine location, next to exposed large rock outcropping

CHILD HEALTH CONSIDERATIONS

The ATSDR and the N.C. DPH recognize there are unique exposure hazards to children that do not apply to adults. Children engage in increased outdoor activities and hand to mouth actions. Children have lower body weights and higher intake rates than adults, which result in a greater dose of hazardous substance per unit of body weight. Other variables that can affect a child's exposure response include genetic makeup, age, health, nutritional status, and exposure to other environmental substances. If exposure levels to hazardous substances are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Because adults are in charge of the housing, medical care, and risk identification of children, adults should have as much information as possible about environmental contaminants in order to make informed decisions, which can affect a child's health.

The simulated site recreational activities, and the exposure parameters selected to represent those activities, were selected to include children. The adjusted inhalation unit risk (IUR) factors developed by the EPA and used to estimates the number of increased cancer cases for this site include factors for the age of initial exposure from birth through a 70-year lifetime. The suite of site-specific recreational exposure situations included those with an initial exposure age of 6, 7, and 12 years of age, and thus potential increased risks to children from exposure to airborne asbestos at the Sapphire Valley Gem Mine site have been addressed in this health consultation.

CONCLUSIONS

The N.C. DPH has reached the following conclusion regarding potential breathing of asbestos on the Sapphire Valley Gem Mine site:

- DPH concludes that the potential to breathe airborne asbestos on the Sapphire Valley Gem Mine site is not expected to harm people's health while they participate in the activities anticipated to be typical for this site. This is because the levels of asbestos released into the air and measured during the relatively short exposure time periods associated with simulated recreational activities were too low to harm the health of children or adults. The conclusion of no expectations of a health hazard requires that persons be prevented from participating in recreational gem mining activities over multiple years on the Sapphire Valley Gem Mine site that disturb the asbestos-containing soil and rock material.

RECOMMENDATIONS

Based on N.C. DPH's review of the airborne asbestos concentrations observed by the U.S. EPA during simulated recreational gem-mining activities on the Sapphire Valley Gem Mine site, the following recommendations are provided to protect the health of persons that may access the gem mine site:

- Limit the potential for persons to disrupt the asbestos-containing soil and rock materials on the site. This may be done by maintaining the "no trespassing" signs at the access points to the gem mine location from the parking lot off US Highway 64 and Holly Road. Also, maintain the soil berm blocking off the former parking lot off US Highway 64.

- Do not advertize the Sapphire Valley Gem Mine as a “recreational gem-mining” destination and do not provide the tools for “recreational miners” to scrape or hammer rocks or disturb the soil on the site.
- Make Resort visitors asking about recreational gem mining at the Sapphire Valley Gem Mine aware of the presence of naturally occurring asbestos (NOA) and the potential health hazards associated with coming into contact with NOA. Identify the limited value of remaining stones and that the gem mine site is closed to future recreational gem mining.
- Prevent development of residential lots immediately adjacent to the Sapphire Valley Gem Mine to reduce the potential for long-term contact with asbestos-containing soil and rock materials.
- Make available to the public and County officials a way to identify areas where NOA deposits in Western North Carolina exist, such as a public-accessible website.
- Undertake efforts to educate communities in areas of Western North Carolina where deposits of NOA have been identified. Educational efforts should include information on the potential health hazards of NOA, how to identify NOA, and how to avoid or reduce their exposure.
- Develop factsheets explaining the potential health risks of NOA and make them readily available to Western North Carolina communities and visitors. Make the factsheet readily available through County and State health agencies, including providing it through Internet access.

In addition to the recommendations listed above specific to the Sapphire Valley Gem Mine site, the N.C. DPH recommends a study be done of the potential health risks associated with exposure to NOA under common exposure scenarios as may exist in Western NC communities. These include residential exposures associated with activities such as lawn mowing, leaf blowing, digging soil, gardening, and driving on un-paved roads in areas of NOA, or where asbestos-mining materials may have been discarded. It is likely that these types of exposures present a more prevalent, and probable, NOA exposure scenario to a significant number of persons in the Western areas of North Carolina where NOA is known to exist.. DPH will evaluate the potential for adverse health effects associated with any new activity-based sampling data that becomes available.

PUBLIC HEALTH ACTION PLAN

The purpose of the Public Health Action Plan (PHAP) is to ensure that this health assessment provides a plan of action designed to mitigate or prevent potential harmful health effects.

Public Health Actions Completed

At the recommendation of the N.C. DENR and the N.C. DPH, the Sapphire Valley Resort property managers have:

- Eliminated access to the parking lot off U.S. Highway 64 previously used by recreational gem-miners visiting the Sapphire Valley Gem Mine.
- Placed “No Trespassing” sign at the trailhead at the former Sapphire Valley Gem Mine parking lot off U.S. Highway 64.
- Placed a “No Trespassing” sign off Holly Road at an access point on the backside of the resort property, near a trail that runs along the creek that runs adjacent to the gem mine rock outcropping.
- Removed all references to the Sapphire Valley Gem Mine recreational gem mining activities from the Sapphire Valley Resort’s electronic and printed materials.

Public Health Actions Planned

- The N.C. DENR/DWM conducted a review of the known asbestos mines in North Carolina. The list of sites is being prepared for distribution to county health agencies and the public. The information will also be available from the DENR or DHHS web site.
- The N.C. DPH is developing a naturally occurring asbestos factsheet to be provided to the public and county health agencies. The factsheet will be included with the N.C. NOA sites information. It will also be available from the DPH web site.
- The results of the DPH Health Consultation (HC) will be disseminated to citizens of Jackson County, as well as county officials. Access will be provided through the HACE web site and print copies will be made available at locations within Jackson County. The public and the County will have the opportunity to provide feedback and pose questions to the DPH about the HC.
- The DPH will provide the opportunity for a public availability meeting in Jackson County to discuss the results of the HC and our recommendations. A meeting opportunity will be provided if county officials or the public express the desire for a meeting, or if DPH feels a meeting is appropriate based on feedback from the public or county officials to the HC.
- DPH/HACE e-mail and postal service addresses will be provided for input from the community regarding the HC.

Author:

Sandy Mort, MS, Industrial Hygiene Consultant
(Public Health Assessor)
North Carolina Department of Health and Human Services
Division of Public Health
Occupational and Environmental Epidemiology Branch
Health Assessment, Consultation and Education Program

Reviewers:

Mina Shehee, PhD, NC DHHS / DPH / OEEB
Rick Langley, MD, NC DHHS / DPH / OEEB
Mercedes Hernández-Pelletier, MPH, CHES, NC DHHS / DPH / OEEB / HACE
Mary Giguere, CIH, NC DHHS / DPH / OEEB / HHCU
Jeff Dellinger, NC DHHS / DPH / OEEB / HHCU
Jill Dyken, PhD, PE, Agency for Toxic Substances and Disease Registry (ATSDR)

Technical project officer:

Jennifer A. Freed, MPH
Technical Project Officer
Division of Health Assessment and Consultation (DHAC)
Agency for Toxic Substances and Disease Registry (ATSDR)

CERTIFICATION

This Public Health Consultation for the Sapphire Valley Gem Mine Naturally Occurring Asbestos Site was prepared by the North Carolina Division of Public Health (NC DHHS) under a cooperative agreement with the Federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was initiated. Editorial review was completed by the cooperative agreement partner.

Jennifer A Freed

Jennifer A. Freed
Technical Project Officer
Division of Health Assessment and Consultation (DHAC)
ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment, and concurs with its findings.

Gregg V. Ulrich for AY

Alan Yarbrough
Team Leader,
CAT, CAPEB, DHAC, ATSDR

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Appendix A

Figures

Figure 1. Location of Sapphire Valley Gem Mine, Sapphire, NC.

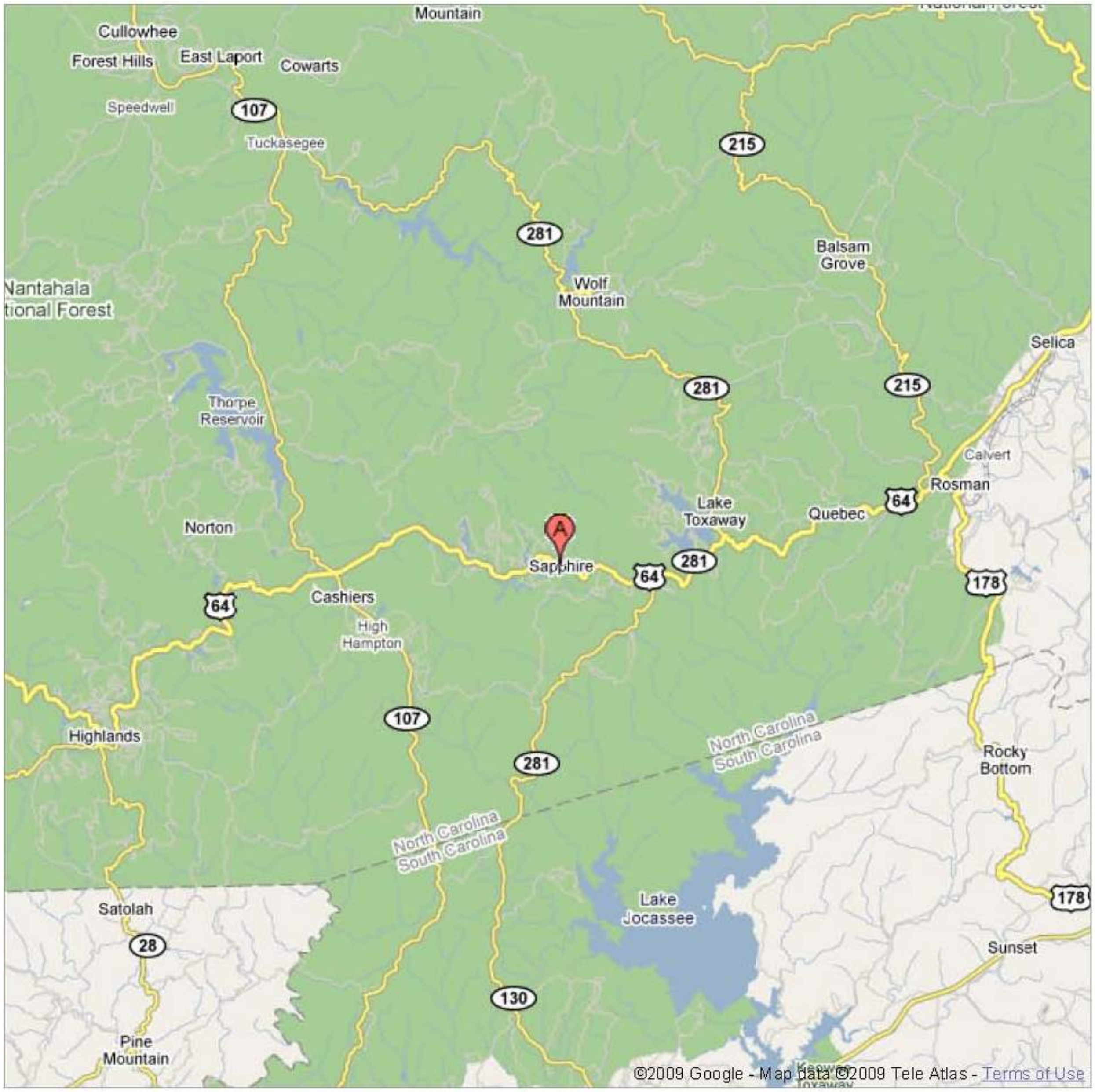


Figure 2. Geographic distribution of asbestos-bearing ultramafic rock in Western North Carolina.

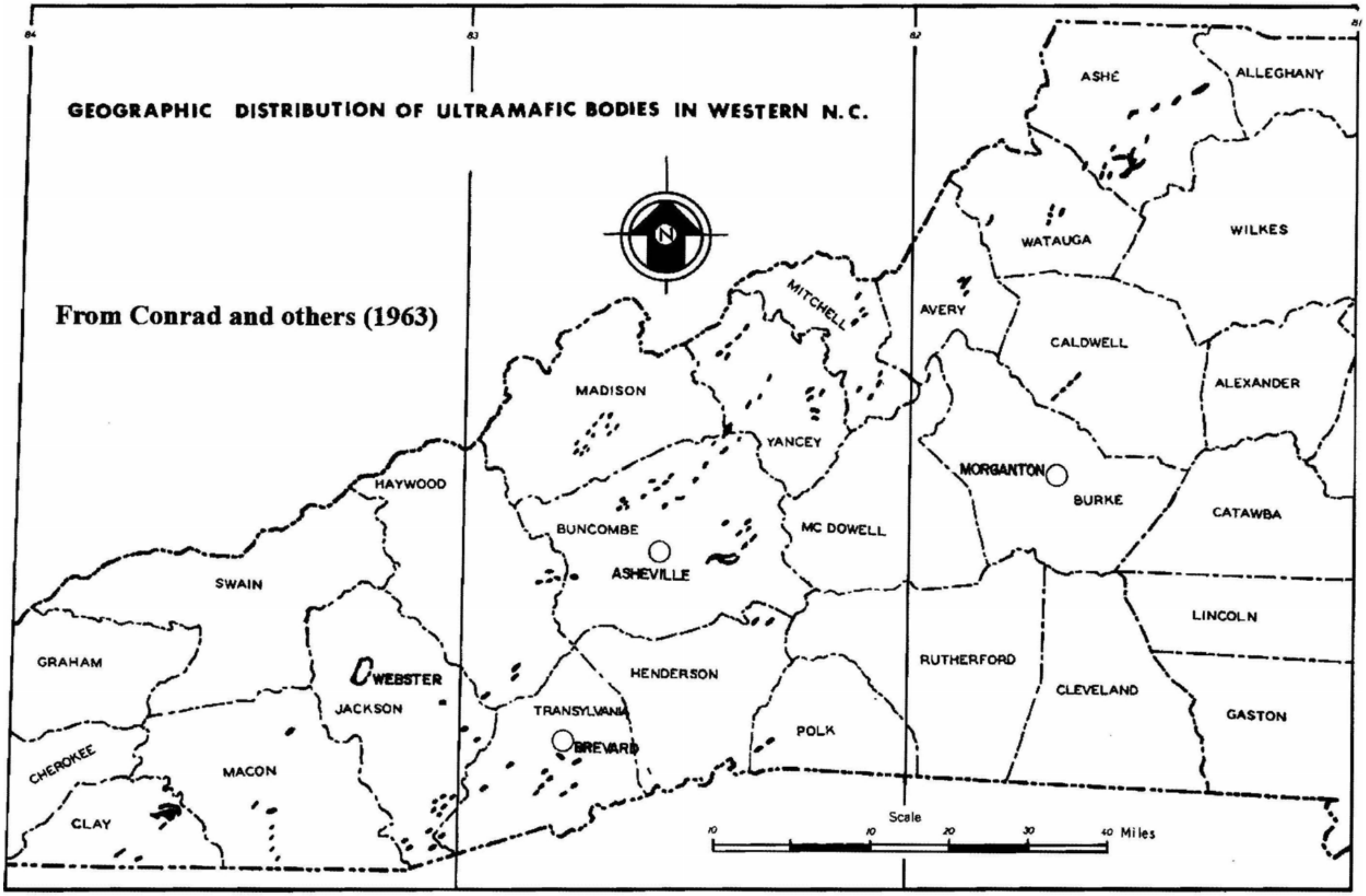


Figure 3. Sapphire Valley Gem Mine site, 2007. Lower sampling area. Large outcropping of asbestos-bearing ultramafic rock.

Figure 4. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. View from US Highway 64 facing north toward bermed former recreational gem mine parking lot.

Figure 5. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. No trespassing sign off Holly Road access area, facing north.

Figure 6. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. Access to gem mine location from south side off Holly Road, through undeveloped property.

Figure 7. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. Access to gem mine location from south side off Holly Road, continuing through undeveloped property.

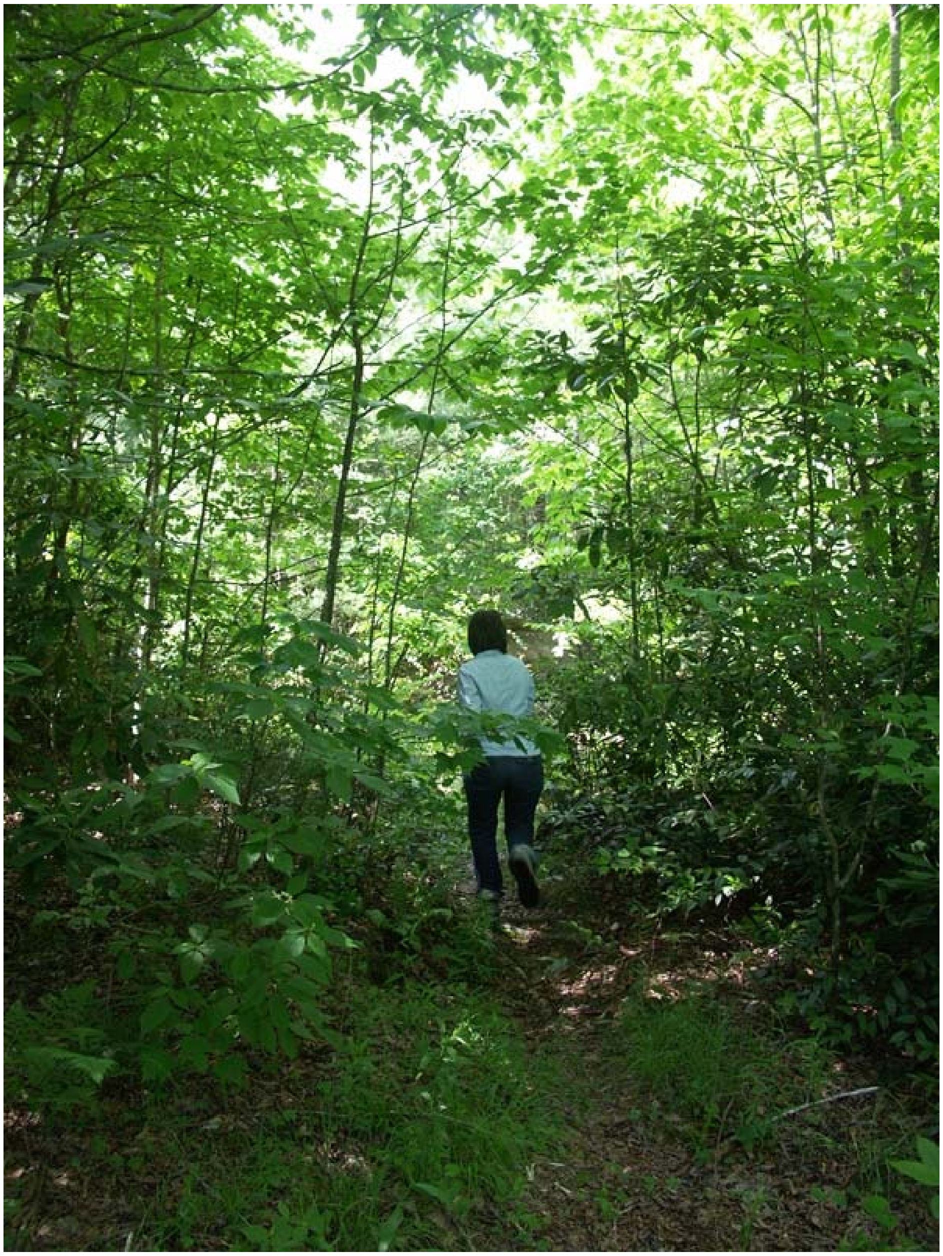


Figure 8. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. Access to gem mine location from north side off former gem mine parking lot on US Highway 64.

Figure 9. Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009. Access to gem mine location from north side off f former gem mine parking lot on US Highway 64.

Figure 10. Naturally occurring asbestos (NOA) observed at Sapphire Valley Gem Mine site, Jackson Co., NC, June 2009.

Figure 11. Sapphire Valley Gem Mine site. U.S. EPA activity-based sampling (ABS) event, 2007. Soil sieving activity. Sampling personnel in personal protective equipment (PPE) with air sampling pumps and two breathing zone airborne-fiber sample collection cassettes.

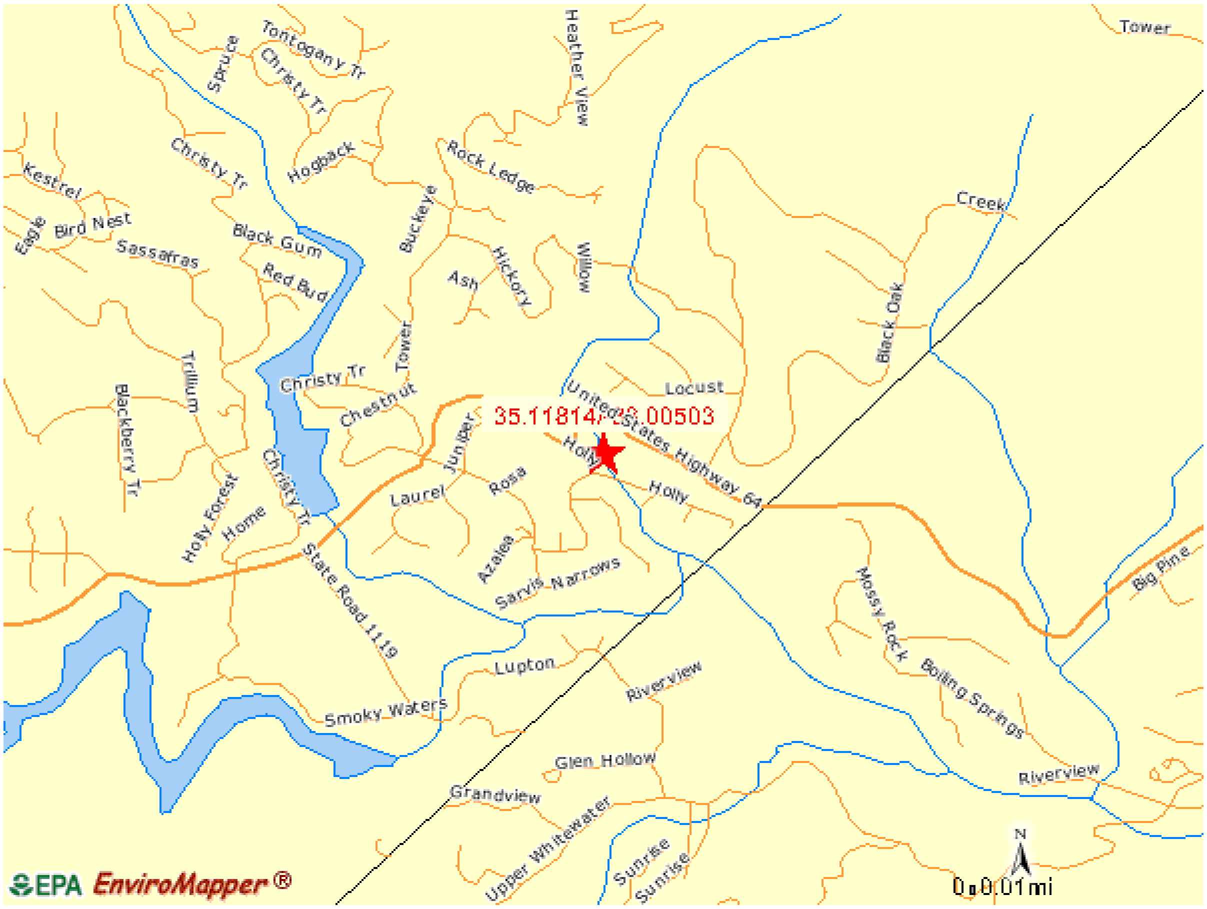
Figure 12. Sapphire Valley Gem Mine site. U.S. EPA activity-based sampling (ABS) event, 2007. Soil shoveling activity. Sampling personnel with breathing zone collection apparatus and upwind and downwind perimeter sample collection apparatus.

Figure 13. Sapphire Valley Gem Mine naturally occurring asbestos (NOA) background and activity-based sampling (ABS) sample collection locations. 2007.

Figure 14. Sapphire Valley Gem Mine NOA site. U.S. EPA activity-based sampling (ABS) event, 2007. Chiseling activity.

Appendix B

Demographics



Overview					
Total Persons:	154	Land Area:	98.9%	Households in Area:	71
Population Density:	34.98 /sq mi	Water Area:	1.1%	Housing Units in Area:	214
Percent Minority:	3.6%	Persons Below Poverty Level:	10 (6.5%)	Households on Public Assistance:	1
Percent Urban:	0%	Housing Units Built <1970:	16%	Housing Units Built <1950:	6%

Race and Age*			
(* Columns that add up to 100% are highlighted)			
Race Breakdown	**Persons (%)**	**Age Breakdown**	**Persons(%)**
White:	149 (96.8%)	Child 5 years or less:	11 (6.9%)
African-American:	0 (0.0%)	Minors 17 years and younger:	29 (19.1%)
Hispanic-Origin:	5 (3.2%)	Adults 18 years and older:	125 (80.9%)
Asian/Pacific Islander:	0 (0.1%)	Seniors 65 years and older:	30 (19.5%)
American Indian:	0 (0.1%)	*This space intentionally left blank*	
Other Race:	4 (2.7%)		
Multiracial:	0 (0.2%)		

Gender	
Gender Breakdown	**Persons (%)**
Males:	77 (50.3%)
Females:	77 (49.7%)

Education	
Education Level (Persons 25 & older)	**Persons (%)**
Less than 9th grade:	6 (5.0%)
9th -12th grade:	10 (8.7%)
High School Diploma:	22 (19.9%)
Some College/2 yr:	30 (27.2%)
B.S./B.A. or more:	43 (39.2%)

Jackson County, NC Population Estimates 2008

	Jackson County (yr. 2008)	North Carolina	U.S. (2000)
Total population	36,739	9,222,414	281,421,906
Percent Minority			
Ethnicity (yr 2007)			
White	86%	74%	75%
African-American	2%	22%	12%
Hispanics	2%	7%	13%
Asians	0.7%	2%	4%
American Indians	10%	1%	0.9%
Individuals Below Poverty Level (yr. 2000)	15%	12%	12%
High school diploma or higher (yr. 2000)	79%	78%	80%
Less than 9th grade			

Transylvania County, NC Population Estimates 2000

	Transylvania County (yr. 2000)	North Carolina	U.S. (2000)
Total population	29,334	9,222,414	281,421,906
Percent Minority			
Ethnicity			
White	94%	74%	75%
African-American	4%	22%	12%
Hispanics	1%	7%	13%
Asians	0.4%	2%	4%
American Indians	0.3%	1%	0.9%
Individuals Below Poverty Level (yr. 2000)	10%	12%	12%
High school diploma or higher (yr. 2000)	83%	78%	80%
Less than 9th grade			

Reference:

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Appendix C

Tables

Table 2. U.S. EPA's extrapolated unit risk values for continuous and lifetime exposures to airborne asbestos (PCM f/mL)$^{-1}$. From (EPA 2008).

Age at Onset	Exposure Duration (years)																		
	1	2	3	4	5	6	8	10	12	14	16	20	24	25	30	40	50	60	LT
0	1.0E-02	2.0E-02	3.0E-02	3.9E-02	4.7E-02	5.5E-02	7.1E-02	8.5E-02	9.8E-02	1.1E-01	1.2E-01	1.4E-01	1.5E-01	1.6E-01	1.7E-01	1.9E-01	2.1E-01	2.2E-01	2.3E-01
1	9.9E-03	1.9E-02	2.8E-02	3.7E-02	4.5E-02	5.3E-02	6.8E-02	8.1E-02	9.4E-02	1.0E-01	1.2E-01	1.3E-01	1.5E-01	1.5E-01	1.7E-01	1.9E-01	2.0E-01	2.1E-01	2.2E-01
2	9.6E-03	1.9E-02	2.7E-02	3.6E-02	4.4E-02	5.1E-02	6.5E-02	7.8E-02	9.0E-02	1.0E-01	1.1E-01	1.3E-01	1.4E-01	1.5E-01	1.6E-01	1.8E-01	1.9E-01	2.0E-01	2.1E-01
3	9.2E-03	1.8E-02	2.6E-02	3.4E-02	4.2E-02	4.9E-02	6.3E-02	7.5E-02	8.7E-02	9.7E-02	1.1E-01	1.2E-01	1.4E-01	1.4E-01	1.5E-01	1.7E-01	1.8E-01	1.9E-01	2.0E-01
4	8.8E-03	1.7E-02	2.5E-02	3.3E-02	4.0E-02	4.7E-02	6.0E-02	7.2E-02	8.3E-02	9.3E-02	1.0E-01	1.2E-01	1.3E-01	1.3E-01	1.5E-01	1.6E-01	1.8E-01	1.8E-01	1.9E-01
5	8.5E-03	1.7E-02	2.4E-02	3.2E-02	3.9E-02	4.6E-02	5.8E-02	7.0E-02	8.0E-02	8.9E-02	9.8E-02	1.1E-01	1.3E-01	1.3E-01	1.4E-01	1.6E-01	1.7E-01	1.7E-01	1.9E-01
6	8.2E-03	1.6E-02	2.3E-02	3.1E-02	3.7E-02	4.4E-02	5.6E-02	6.7E-02	7.7E-02	8.6E-02	9.4E-02	1.1E-01	1.2E-01	1.2E-01	1.3E-01	1.5E-01	1.6E-01	1.7E-01	1.8E-01
7	7.9E-03	1.5E-02	2.3E-02	2.9E-02	3.6E-02	4.2E-02	5.4E-02	6.4E-02	7.4E-02	8.3E-02	9.1E-02	1.0E-01	1.2E-01	1.2E-01	1.3E-01	1.4E-01	1.5E-01	1.6E-01	1.7E-01
8	7.6E-03	1.5E-02	2.2E-02	2.8E-02	3.5E-02	4.1E-02	5.2E-02	6.2E-02	7.1E-02	7.9E-02	8.7E-02	1.0E-01	1.1E-01	1.1E-01	1.2E-01	1.4E-01	1.5E-01	1.5E-01	1.6E-01
9	7.3E-03	1.4E-02	2.1E-02	2.7E-02	3.3E-02	3.9E-02	5.0E-02	5.9E-02	6.8E-02	7.6E-02	8.4E-02	9.6E-02	1.1E-01	1.1E-01	1.2E-01	1.3E-01	1.4E-01	1.5E-01	1.6E-01
10	7.0E-03	1.4E-02	2.0E-02	2.6E-02	3.2E-02	3.8E-02	4.8E-02	5.7E-02	6.6E-02	7.3E-02	8.0E-02	9.2E-02	1.0E-01	1.0E-01	1.1E-01	1.3E-01	1.4E-01	1.4E-01	1.5E-01
11	6.8E-03	1.3E-02	1.9E-02	2.5E-02	3.1E-02	3.6E-02	4.6E-02	5.5E-02	6.3E-02	7.1E-02	7.7E-02	8.9E-02	9.8E-02	1.0E-01	1.1E-01	1.2E-01	1.3E-01	1.3E-01	1.4E-01
12	6.5E-03	1.3E-02	1.9E-02	2.4E-02	3.0E-02	3.5E-02	4.4E-02	5.3E-02	6.1E-02	6.8E-02	7.4E-02	8.5E-02	9.4E-02	9.6E-02	1.0E-01	1.2E-01	1.2E-01	1.3E-01	1.4E-01
13	6.3E-03	1.2E-02	1.8E-02	2.3E-02	2.9E-02	3.4E-02	4.3E-02	5.1E-02	5.8E-02	6.5E-02	7.1E-02	8.2E-02	9.1E-02	9.2E-02	1.0E-01	1.1E-01	1.2E-01	1.2E-01	1.3E-01
14	6.1E-03	1.2E-02	1.7E-02	2.3E-02	2.8E-02	3.2E-02	4.1E-02	4.9E-02	5.6E-02	6.3E-02	6.8E-02	7.9E-02	8.7E-02	8.9E-02	9.7E-02	1.1E-01	1.1E-01	1.2E-01	1.2E-01
15	5.9E-03	1.1E-02	1.7E-02	2.2E-02	2.7E-02	3.1E-02	3.9E-02	4.7E-02	5.4E-02	6.0E-02	6.6E-02	7.5E-02	8.3E-02	8.5E-02	9.3E-02	1.0E-01	1.1E-01	1.1E-01	1.2E-01
16	5.6E-03	1.1E-02	1.6E-02	2.1E-02	2.6E-02	3.0E-02	3.8E-02	4.5E-02	5.2E-02	5.8E-02	6.3E-02	7.2E-02	8.0E-02	8.2E-02	8.9E-02	9.8E-02	1.0E-01	1.1E-01	1.1E-01
17	5.4E-03	1.1E-02	1.6E-02	2.0E-02	2.5E-02	2.9E-02	3.7E-02	4.4E-02	5.0E-02	5.6E-02	6.1E-02	7.0E-02	7.7E-02	7.8E-02	8.5E-02	9.4E-02	1.0E-01	1.0E-01	1.1E-01
18	5.2E-03	1.0E-02	1.5E-02	1.9E-02	2.4E-02	2.8E-02	3.5E-02	4.2E-02	4.8E-02	5.3E-02	5.8E-02	6.7E-02	7.4E-02	7.5E-02	8.1E-02	9.0E-02	9.5E-02	9.8E-02	1.0E-01
19	5.1E-03	9.9E-03	1.4E-02	1.9E-02	2.3E-02	2.7E-02	3.4E-02	4.0E-02	4.6E-02	5.1E-02	5.6E-02	6.4E-02	7.1E-02	7.2E-02	7.8E-02	8.6E-02	9.1E-02	9.4E-02	9.8E-02
20	4.9E-03	9.5E-03	1.4E-02	1.8E-02	2.2E-02	2.6E-02	3.3E-02	3.9E-02	4.4E-02	4.9E-02	5.4E-02	6.2E-02	6.8E-02	6.9E-02	7.5E-02	8.3E-02	8.7E-02	9.0E-02	9.3E-02
21	4.7E-03	9.2E-03	1.3E-02	1.7E-02	2.1E-02	2.5E-02	3.1E-02	3.7E-02	4.3E-02	4.7E-02	5.2E-02	5.9E-02	6.5E-02	6.6E-02	7.2E-02	7.9E-02	8.3E-02	8.6E-02	8.9E-02
22	4.5E-03	8.8E-03	1.3E-02	1.7E-02	2.0E-02	2.4E-02	3.0E-02	3.6E-02	4.1E-02	4.6E-02	5.0E-02	5.7E-02	6.2E-02	6.3E-02	6.9E-02	7.6E-02	8.0E-02	8.2E-02	8.5E-02
23	4.4E-03	8.5E-03	1.2E-02	1.6E-02	2.0E-02	2.3E-02	2.9E-02	3.5E-02	3.9E-02	4.4E-02	4.8E-02	5.4E-02	6.0E-02	6.1E-02	6.6E-02	7.2E-02	7.6E-02	7.8E-02	8.1E-02
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25	4.1E-03	7.9E-03	1.2E-02	1.5E-02	1.8E-02	2.1E-02	2.7E-02	3.2E-02	3.6E-02	4.0E-02	4.4E-02	5.0E-02	5.5E-02	5.6E-02	6.0E-02	6.6E-02	6.9E-02	7.1E-02	7.3E-02
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29	3.5E-03	6.9E-03	1.0E-02	1.3E-02	1.6E-02	1.8E-02	2.3E-02	2.7E-02	3.1E-02	3.4E-02	3.7E-02	4.2E-02	4.6E-02	4.7E-02	5.0E-02	5.5E-02	5.7E-02	5.8E-02	6.0E-02
30	3.4E-03	6.6E-03	9.7E-03	1.2E-02	1.5E-02	1.8E-02	2.2E-02	2.6E-02	3.0E-02	3.3E-02	3.6E-02	4.0E-02	4.4E-02	4.5E-02	4.8E-02	5.2E-02	5.4E-02	5.5E-02	5.7E-02
31	3.3E-03	6.4E-03	9.3E-03	1.2E-02	1.5E-02	1.7E-02	2.1E-02	2.5E-02	2.9E-02	3.2E-02	3.4E-02	3.9E-02	4.2E-02	4.3E-02	4.6E-02	4.9E-02	5.1E-02	5.3E-02	5.4E-02
32	3.2E-03	6.2E-03	9.0E-03	1.2E-02	1.4E-02	1.6E-02	2.1E-02	2.4E-02	2.7E-02	3.0E-02	3.3E-02	3.7E-02	4.0E-02	4.1E-02	4.4E-02	4.7E-02	4.9E-02	5.0E-02	5.1E-02
33	3.1E-03	6.0E-03	8.7E-03	1.1E-02	1.4E-02	1.6E-02	2.0E-02	2.3E-02	2.6E-02	2.9E-02	3.1E-02	3.5E-02	3.8E-02	3.9E-02	4.2E-02	4.5E-02	4.6E-02	4.7E-02	4.8E-02
34	3.0E-03	5.7E-03	8.3E-03	1.1E-02	1.3E-02	1.5E-02	1.9E-02	2.2E-02	2.5E-02	2.8E-02	3.0E-02	3.4E-02	3.7E-02	3.7E-02	4.0E-02	4.2E-02	4.4E-02	4.5E-02	4.6E-02
35	2.9E-03	5.5E-03	8.0E-03	1.0E-02	1.3E-02	1.5E-02	1.8E-02	2.1E-02	2.4E-02	2.7E-02	2.9E-02	3.2E-02	3.5E-02	3.5E-02	3.8E-02	4.0E-02	4.2E-02	4.2E-02	4.3E-02
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37	2.7E-03	5.1E-03	7.5E-03	9.6E-03	1.2E-02	1.3E-02	1.7E-02	2.0E-02	2.2E-02	2.4E-02	2.6E-02	2.9E-02	3.2E-02	3.2E-02	3.4E-02	3.6E-02	3.7E-02	3.8E-02	3.8E-02
38	2.6E-03	5.0E-03	7.2E-03	9.2E-03	1.1E-02	1.3E-02	1.6E-02	1.9E-02	2.1E-02	2.3E-02	2.5E-02	2.8E-02	3.0E-02	3.0E-02	3.2E-02	3.4E-02	3.5E-02	3.6E-02	3.6E-02
39	2.5E-03	4.8E-03	6.9E-03	8.9E-03	1.1E-02	1.2E-02	1.5E-02	1.8E-02	2.0E-02	2.2E-02	2.4E-02	2.7E-02	2.8E-02	2.9E-02	3.0E-02	3.2E-02	3.3E-02	3.4E-02	3.4E-02
40	2.4E-03	4.6E-03	6.6E-03	8.5E-03	1.0E-02	1.2E-02	1.5E-02	1.7E-02	1.9E-02	2.1E-02	2.3E-02	2.5E-02	2.7E-02	2.7E-02	2.9E-02	3.1E-02	3.1E-02	3.2E-02	3.2E-02
45	1.9E-03	3.7E-03	5.4E-03	6.9E-03	8.2E-03	9.5E-03	1.2E-02	1.3E-02	1.5E-02	1.6E-02	1.7E-02	1.9E-02	2.0E-02	2.0E-02	2.1E-02	2.2E-02	2.3E-02	2.3E-02	2.3E-02
50	1.5E-03	2.9E-03	4.1E-03	5.3E-03	6.3E-03	7.2E-03	8.7E-03	1.0E-02	1.1E-02	1.2E-02	1.3E-02	1.4E-02	1.4E-02	1.4E-02	1.5E-02	1.5E-02	1.5E-02	1.5E-02	1.6E-02

Table 4. Exposure parameters developed for activity-based sampling (ABS) events performed at the Sapphire Valley Gem Mine site, Jackson Co, NC.

Activity-based Sampling Scenario	**Exposure parameters**			
	Hours/day	**Days/year**	**Duration (yrs)**	**Age at start**
Rock hound	4	24	30	6
Regional Rock Collector	4	1	5	21
One Time Visitor	4	1	1	12
Vacation (child)	1	1	3	7
Vacation (young adult)	1	1	3	25

Table 5. Summary of EPA activity-based sampling (ABS) airborne asbestos fiber concentrations generated on the Sapphire Valley Gem Mine site in March and July 2007. The ATSDR recommends using the EPA IRIS value of 0.0004 f/mL as the comparison value for cancer health effects.

ABS scenario	**Frequency of detection**	**Range of detections, as PCME s/mL**	**Number of detections greater than the CV[1]**	**Mean detected concentration, as PCME s/mL**
Shoveling, upper area	3/3	0.006 to 0.036	3	0.016
Shoveling, lower area	3/3	0.008 to 0.037	3	0.022
Sieving, upper area	1/1	0.022	1	NA
Sieving, lower area	3/3	0.037 to 0.14	3	0.075
Raking, upper area	3/3	0.0035 to 0.015	3	0.009
Raking, lower area	1/2	0.038	1	NA
Chiseling, lower area	3/3	0.066 to 0.29	3	0.21

Notes: [1] CV shown is for a continuous 70-year exposure. Health effect evaluations for this site incorporated site-specific exposure time periods and extrapolated risk values that reduce the potential for adverse health effects.
ABS = activity-based sampling
CV = ATSDR inhalation comparison value
CREG = Cancer Risk Evaluation Guide
PCME = phase-contrast microscopy-equivalent
Conversion factor: 1 mg/m^3 = 33 PCM s/mL (ATSDR 2001)
f/mL = fibers per milliliter
s/mL = structures per milliliter
$\mu g/m^3$ = micrograms per cubic meter
mg/m^3 = milligrams per cubic meter
NA = not applicable

Table 6. Summary of EPA perimeter airborne asbestos fiber concentrations generated on the Sapphire Valley Gem Mine site in March and July 2007. The ATSDR recommends using the EPA IRIS value of 0.0004 f/mL as the comparison value for cancer health effects.

ABS scenario	Perimeter air sample location	Frequency of detection	Range of detections, as PCME s/mL	Number of detections greater than the CV[1]	Mean detected concentration, as PCME s/mL
Shoveling, upper area	Upwind	2/3	0.001	2	0.001
	Downwind	1/6	0.004	1	NA
Shoveling, lower area	Upwind	1/3	0.001	1	NA
	Downwind	4/6	0.001 to 0.003	4	0.002
Sieving, upper area	Upwind	2/2	0.001	2	0.001
	Downwind	2/4	0.003 to 0.005	2	0.004
Sieving, lower area	Upwind	0/0	NA	NA	NA
	Downwind	0/0	NA	NA	NA
Raking, upper area	Upwind	1/3	0.001	1	NA
	Downwind	4/5	0.001 to 0.002	4	0.002
Raking, lower area	Upwind	0/2	NA	NA	NA
	Downwind	1/3	0.001	1	NA
Chiseling, lower area	Upwind	2/3	0.001 to 0.082	2	0.042
	Downwind	9/11	0.001 to 0.020	9	0.005

Notes: [1] CV shown is for a continuous 70-year exposure. Health effect evaluations for this site incorporated site-specific exposure time periods and extrapolated risk values that reduce the potential for adverse health effects.

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Table 7. Estimates of theoretical increased number of cancer cases (over background levels) for the simulated recreational gem-mining activities and exposure parameters designed for the Sapphire Valley Gem Mine site, Jackson Co., NC. Estimates calculated for the average and maximum airborne asbestos concentrations. Estimates presented as the number of additional cancers in a population of 1 million exposed persons.

ABS exposure scenario	**Activity**	**No. of CAs per 1,000,000 at average concentration[1]**	**No. of CAs per 1,000,000 at maximum concentration[2]**
Rock hound	Shoveling, upper area	23	51
	Shoveling, lower area	31	24
	Sieving, upper area	NA	31
	Sieving, lower area	110	200
	Raking, upper area	13	21
	Raking, lower area	NA	54
	Chiseling, lower area	300	410
Regional rock collector	Shoveling, upper area	<1	<1
	Shoveling, lower area	<1	<1
	Sieving, upper area	<1	<1
	Sieving, lower area	<1	1
	Raking, upper area	<1	<1
	Raking, lower area	<1	<1
	Chiseling, lower area	2	3
1-Time recreational visitor	All activities	<1	<1
Child vacationer	All activities	<1	<1
Adult vacationer	All activities	<1	<1

[1] The number of increased cancer cases estimated in a population of 1,000,000 persons exposed at the average asbestos concentration detected for the activity.
[2] The number of increased cancer cases estimated in a population of 1,000,000 persons exposed at the maximum asbestos concentration for the activity.
CA = cancer
NA = not applicable

Table 8. Additional exposure parameters developed by the N.C. DPH HACE program to evaluate infrequent recreational user access scenarios on the Sapphire Valley Gem Mine site.

Recreational Exposure Scenario	Exposure parameters			
	Hours/day	Days/year	Duration (yrs)	Age at start
Child Hiker	1	24	10	6
Adult Hiker	1	24	30	25

Table 9. Estimates of theoretical increased number of cancer cases (over background levels) for the "hiker" simulated recreational activities added by HACE for the Sapphire Valley Gem Mine site. Estimates presented as the number of additional cancers in a population of 1 million exposed persons.

ABS exposure scenario	Exposure Situation	Airborne Asbestos Concentration, as PCME s/mL	No. of CAs per 1,000,000
Child Hiker	Downwind of sieving	0.005	<1
	Downwind of chiseling	0.02	4
Adult Hiker	Downwind of sieving	0.005	<1
	Downwind of chiseling	0.02	3

Appendix D

ATSDR Health Effects Evaluation Process

Comparison Values and the Screening Process
In evaluating data, ATSDR uses comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific medium (soil or water) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water and soil that someone may inhale or ingest each day.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on validated toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the media concentrations at which there could be a one additional cancer in a one million-person population (one in a million excess cancer risk for an adult) eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and non-cancer CVs exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

CVs used to select contaminants for further evaluation:

Environmental Media Evaluation Guides (EMEGs) represent concentrations of substances in water, soil, and air to which humans may be exposed over specified time periods without experiencing non-cancer adverse health effects. The EMEG is derived from the Agency for Toxic Substances and Disease Registry's (ATSDR) minimal risk level (MRL).

Reference Dose Media Evaluation Guides (RMEGs) represent concentrations of substances in water and soil to which humans may be exposed over specified time periods without experiencing non-cancer adverse health effects. The RMEG is derived from the Environmental Protection Agency's (EPA's) oral reference dose (RfD).

Cancer Risk Evaluation Guides (CREGs) are estimated media-specific contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs) or inhalation unit risk (IUR) values.

Risk-Based Concentrations (RBCs) are the estimated contaminant concentrations in media where non-carcinogenic health effects are unlikely. The RBCs used in this PHA were derived by EPA's Region 3 toxicologists.

EPA Soil Screening Levels (SSLs) are estimated contaminant concentrations in soil at which additional evaluation is needed to determine if action is required to eliminate or reduce exposure.

The ATSDR Health Effects Evaluation Process
The ATSDR health effects evaluation process consists of two steps: a screening analysis, and at some sites, based on the results of the screening analysis and community health concerns, a more

in-depth analysis to determine possible public health implications of site-specific exposure estimates.

In evaluating data, ATSDR uses comparison values (CVs) to determine which chemicals to examine more closely. CVs are the contaminant concentrations found in a specific medium (soil, water, or air) and are used to select contaminants for further evaluation. CVs incorporate assumptions of daily exposure to the chemical and a standard amount of air, water and soil that someone may inhale or ingest each day.

The two step screening analysis process provides a consistent means to identify site contaminants that need to be evaluated more closely through the use of "comparison values" (CVs). The first step of the screening analysis is the "environmental guideline comparison" which involves comparing site contaminant concentrations to medium-specific comparison values derived by ATSDR from standard exposure default values. The second step is the "health guideline comparison" and involves looking more closely at site-specific exposure conditions, estimating exposure doses, and comparing them to dose-based health-effect comparison values.

As health-based thresholds, CVs are set at a concentration below which no known or anticipated adverse human health effects are expected to occur. CVs are not thresholds of toxicity and do not predict adverse health effects. CVs serve only as guidelines to provide an initial screen of human exposure to substances. Contaminant concentrations at or below the relevant CV may reasonably be considered safe, but it does not automatically follow that any environmental concentration that exceeds a CV would be expected to produce adverse health effects. Different CVs are developed for cancer and non-cancer health effects. Non-cancer levels are based on validated toxicological studies for a chemical, with appropriate safety factors included, and the assumption that small children (22 pounds) and adults are exposed every day. Cancer levels are the media concentrations at which there could be a one additional cancer in a one million-person population (one in a million excess cancer risk for an adult) eating contaminated soil or drinking contaminated water every day for 70 years. For chemicals for which both cancer and non-cancer CVs exist, the lower level is used to be protective. Exceeding a CV does not mean that health effects will occur, just that more evaluation is needed.

After completing a screening analysis, site contaminants are divided into two categories. Those not exceeding CVs usually require no further analysis, and those exceeding CVs are selected for a more in-depth analysis to evaluate the likelihood of possible harmful effects.

The North Carolina Department of Public Health (N.C. DPH) uses the following screening values for public health assessments:

1. **Environmental Media Evaluation Guide (EMEG):** EMEGs are estimated contaminant concentrations in water, soil or air to which humans may be exposed over specified time periods and are not expected to result in adverse non-cancer health effects. EMEGs are based on ATSDR "minimum risk levels" (MRLs) and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.

2. **Reference Dose Media Evaluation Guides (RMEGs):** RMEGs represent concentrations of substances in water and soil to which humans may be exposed over specified time periods

without experiencing non-cancer adverse health effects. The RMEG is derived from the U.S. Environmental Protection Agency's (EPA's) oral reference dose (RfD).

3. **Cancer Risk Evaluation Guide (CREG)**: CREGs are estimated media-specific contaminant concentrations that would be expected to cause no more than one additional excess cancer in one million persons exposed over a 70-year lifetime. CREGs are calculated from EPA's cancer slope factors (CSFs) or inhalation unit risk (IUR) values.

4. **Maximum Contaminant Levels (MCL):** A Federal Maximum Contaminant Level (MCL) is the regulatory limit set by EPA that establishes the maximum permissible level of a contaminant in water that is deliverable to the user of a public water system. MCLs are based on health data, also taking into account economic and technical feasibility to achieve that level. (ATSDR 2005a)

5. **EPA Regional Screening Levels (RSL):** "Regional Screening Levels for Chemical Contaminants at Superfund Sites" are tables of risk-based screening levels, calculated using the latest toxicity values, default exposure assumptions and physical and chemical properties. The Regional Screening table was developed with input from EPA Regions III, VI, and IX in an effort to improve consistency and incorporate updated guidance. (http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm)

Contaminant concentrations exceeding the appropriate CVs are further evaluated against ATSDR health guidelines. N.C. DPH also retains for further assessment contaminants that are known or suspected to be cancer-causing agents. To determine exposure dose, N.C. DHHS uses standard assumptions about body weight, ingestion or inhalation rates, and duration of exposure. Important factors in determining the potential for adverse health effects also include the concentration of the chemical, the duration of exposure, the route of exposure, and the health status of those exposed. Site contaminant concentrations and site-specific exposure conditions are used to make conservative estimates of site-specific exposure doses for children and adults that are compared to ATSDR health guidelines (HGs), generally expressed as Minimal Risk Levels (MRLs). An exposure dose (generally expressed as milligrams of chemical per kilogram of body weight per day or "mg/kg/day") is an estimate of how much of a substance a person may come into contact based on their actions and habits. Exposure dose calculations are based on the following assumptions as outlined by the ATSDR (ATSDR 2005a):

- Children between the ages of 1 and 6 ingest an average of 1 liter of water per day
- Children weigh an average of 15 kilograms
- Infants weigh an average of 10 kilograms
- Adults ingest an average of 2 liters of water per day
- Adults weigh an average of 70 kilograms

Ingestion of contaminants present in drinking water
Exposure doses for ingestion of contaminants present in groundwater are calculated using the maximum and average detected concentrations of contaminants in milligrams per liter (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated groundwater:

$$ED_w = \frac{C \times IR \times AF \times EF}{BW}$$

Where:

ED_w = exposure dose water (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated medium (liters/day)
AF = bioavailability factor (unitless)
EF = exposure factor
BW = body weight (kilograms)

Ingestion of contaminants present in soil

Exposure doses for ingestion of contaminants present in soil are calculated using the maximum and average detected concentrations of contaminants in milligrams per kilogram (mg/kg [mg/kg = ppm]). The following equation is used to estimate the exposure doses resulting from ingestion of contaminated soil:

$$ED_s = \frac{C \times IR \times AF \times EF}{BW}$$

Where:

ED_s = exposure dose soil (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated medium (kilograms/day)
EF = exposure factor (unitless)
BW = body weight (kilograms)

The exposure factor is an expression of how often and how long a person may contact a substance in the environment. The exposure factor is calculated with the following general equation:

$$EF = \frac{F \times ED}{AT}$$

Where:

F = frequency of exposure (days/year)
ED = exposure duration (years)
AT = averaging time (ED x 365 days/year)

Inhalation (breathing) of contaminants present in air

Inhalation is an important pathway for human exposure to contaminants that exist as atmospheric gases or are adsorbed to airborne particles or fibers. Exposure doses for breathing contaminants in air were calculated using the maximum or average detected concentrations in milligrams per cubic meter (mg/m^3) or parts per billion by volume (ppbv). The following equation is used to estimate the exposure doses resulting from inhalation of contaminated air.

$$D = (C \times IR \times EF) / BW$$

Where:

D	=	exposure dose (mg/kg/day)
C	=	contaminant concentration (mg/m^3)
IR	=	intake rate (m^3/day)
EF	=	exposure factor (unitless)
BW	=	body weight (kg)

Health guidelines represent daily human exposure to a substance that is likely to be without appreciable risk of adverse health effects during the specified exposure duration. The potential for adverse health effects exists under the representative exposure conditions if the estimated site-specific exposure doses exceed the health guidelines and they are retained for further evaluation. A MRL is an estimate of daily human exposure to a substance (in milligrams per kilogram per day [mg/kg/day] for oral exposures) that is likely to be without non-cancer health effects during a specified duration of exposure. Exposures are based on the assumption a person is exposed to the maximum concentration of the contaminant with a daily occurrence.

Generally, site-specific exposure doses that do not exceed screening values are dropped from further assessment. Exposure doses that exceed MRLs, or are known or suspected cancer-causing agents, are carried through to the health-effects evaluation. The health-effects evaluation includes an in-depth analysis examining and interpreting reliable substance-specific health effects data (toxicological, epidemiologic, medical, and health outcome data) related to dose-response relationships for the substance and pathways of interest. The magnitude of the public health issue may be estimated by comparing the estimated exposures to “no observed” (NOAELs) and “lowest observed” (LOAELs) adverse effect levels in animals and in humans, when available.

ATSDR’s toxicological profiles serve as the primary source of the health-effects data. Other sources of toxicological data include EPA’s Integrated Risk Information System (IRIS) database, International Agency for Research on Cancer (IARC) Monographs, and the National Toxicology Program (NTP). Standard toxicology textbooks and peer-reviewed scientific journals of environmental toxicology or environmental health can also be consulted.

Cancer Health Effect Evaluations

Theoretical increased numbers of cancers are calculated for known or suspected cancer-causing contaminants using the estimated site-specific exposure dose and cancer slope factor (CSF) provided in ATSDR health guideline documents. This calculation is based on the assumption that there is no safe level of exposure to a chemical that causes cancer, a highly health protective approach. However, the theoretical calculated risk is not exact and tends to overestimate the actual risk associated with exposures that may have occurred. This theoretical increased cancer risk estimate does not equal the increased number of cancer cases that will actually occur in the exposed population, but estimates a theoretical excess cancer risk expressed as the proportion of a population that may be affected by a carcinogen during a lifetime or other selected period of exposure. For example, an estimated cancer risk of 1×10^{-6} predicts the probability of one additional cancer over the background number of cancers in a population of 1,000,000.

Qualitative assessment of the predicted increased numbers of cancers is also used and represents terminology suggested by ATSDR and N.C. DPH.

The N.C. Central Cancer Registry states:

"*Although much has been learned about cancer over the past couple of decades, there is still much that is not known about the causes of cancer. What we do know is that cancer is not one disease, but a group of diseases that behave similarly. We know that different types of cancers are caused by different things. For example, cigarette smoking has been implicated in causing lung cancer, some chemical exposures are associated with leukemia, and prolonged exposure to sunlight causes some types of skin cancer. Genetic research has shown that defects in certain genes result in a much higher likelihood that a person will get cancer. What is not known is how genetic factors and exposures to cancer causing agents interact.*

Many people do not realize how common cancers are. It is estimated that one out of every two men and one out of every three women will develop a cancer of some type during his or her lifetime. As a result, it is common to find what appear to be cancer cases clustering in neighborhoods over a period of years. This will occur in any neighborhood. As people age, their chance of getting cancer increases, and so as we look at a community, it is common to see increasing numbers of cancer cases as the people in the community age.

Cancers are diseases that develop over many years. As a result, it is difficult to know when any specific cancer began to develop, and consequently, what the specific factor was which caused the cancer. Because people in our society move several times during their lives, the evaluation of clusters of cancer cases is quite challenging. One can never be certain that a specific cancer was caused by something in the community in which the person currently resides. When we investigate clusters of cancer cases, we look for several things that are clues to likely associations with exposures in the community. These are:

1. *Groups of cases of all the same type of cancer (such as brain cancer or leukemia). Because different types of cancer are caused by different things, cases of many different types of cancer do not constitute a cluster of cases.*
2. *Groups of cases among children, or ones with an unusual age distribution.*
3. *Cases diagnosed during a relatively short time interval. Cases diagnosed over a span of years do not constitute a cluster of cases unless there is consistency in the type of cancer.*
4. *Clusters of rare cancers. Because lung, breast, colon, and prostate cancers are so common, it is very difficult to find any association between them and exposures in a community."*

Theoretical Increased Number of Cancers Qualitative Assessment Categories Utilized by the N.C. DPH

Per population of	No Increased Risk	No Apparent Increased Risk	"Low"	"Moderate"	"High"	"Very High"
10,000	---	---	<1	1 to 9	10 to 100	>100
100,000	---	<1	1 to 9	10 to 99	100 to 1,000	>1,000
1,000,000	<1	1 to <10	10 to 99	101 to 999	1,000 to 10,000	>10,000

Notes: "Low" theoretical increased number of cancers = 0.01%, and "Very High" = 1% increase over expected number of cancer cases in a typical population (approximately 33%)

Limitations of the Health Evaluation Process

Uncertainties are inherent in the public health assessment process. These uncertainties fall into the following categories: 1) the imprecision of the risk assessment process, 2) the incompleteness of the information collected and used in the assessment, and 3) the differences in opinion as to the implications of the information. These uncertainties are addressed in public health assessments by using worst-case assumptions when estimating or interpreting health risks. The health assessment calculations and screening values also incorporate safety margins. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

Assessment of Chemical Interactions

To evaluate the risk for noncancerous effects in a mixture, ATSDR's guidance manual (*Guidance Manual for the Assessment of Joint Toxic Action of Chemical Mixtures*, 2004) prescribes the calculation of a hazard quotient (HQ) for each chemical. The HQ is calculated using the following formula:

$$HQ = \text{estimated dose} \div \text{applicable health guideline}$$

Generally, whenever the HQ for a chemical exceeds 1, concern for the potential hazard of the chemical increases. Individual chemicals that have HQs less than 0.1 are considered unlikely to pose a health hazard from interactions and are eliminated from further evaluation. If all of the chemicals have HQs less than 0.1, harmful health effects are unlikely, and no further assessment of the mixture is necessary. If two or more chemicals have HQs greater than 0.1, then these chemicals are to be evaluated further as outlined below.

Since the HQ is greater than 1 for both adults and children the hazard index (HI) will be calculated. The HQ for each chemical then is used to determine the (HI) for the mixture of chemicals. An HI is the sum of the HQs and is calculated as follows:

$$HI = HQ_1 + HQ_2 + HQ_3 + \ldots HQ_n$$

The HI is used as a screening tool to indicate whether further evaluation is needed. If the HI is less than 1.0, significant additive or toxic interactions are highly unlikely, so no further evaluation is necessary. If the HI is greater than 1.0, then further evaluation is necessary, as described below.

For chemical mixtures with an HI greater than 1.0, the estimated doses of the individual chemicals are compared with their NOAELs or comparable values. IF the dose of one or more of the individual chemicals is within one order of magnitude of its respective NOAEL (0.1 x NOAEL), then potential exists for additive or interactive effects. Under such circumstances, an in-depth mixtures evaluation should proceed as described in ATSDR's *Guidance Manual for the Assessment of Joint Action of Chemical Mixtures*.

If the estimated doses of the individual chemicals are less than 1/10 of their respective NOAELs, then significant additive or interactive effects are unlikely, and no further evaluation is necessary.

Health Effect Evaluations for Inhalation of Asbestos Fibers

The following calculations were used to estimate the risk of increased numbers of cancers resulting from the inhalation exposure to airborne asbestos fibers generated during expected activities associated with recreational gem mining at the Sapphire Valley Gem Mine site. The airborne asbestos fiber concentrations used for the calculations were those determined during the activity-based sampling performed by the EPA in 2007. The inhalation cancer unit risk values for the different exposure scenarios developed for the Sapphire Valley Gem Mine site were taken from EPA's extrapolated cancer unit risk value tables that provide an adjusted cancer risk value based on the age of initial exposure and the number of ensuing years of exposure.

Cancer risks are developed as an estimated number of increased cancer cases over the background number of cancer cases that would be anticipated in a population.

Lifetime Cancer Risk = (fiber concentration) x (Unit Risk) x (TWF)

Where:

Lifetime Cancer Risk	= estimated increased number of cancers of the lung and mesothelioma
Fiber concentration	= concentration of PCME asbestos fibers in air, in f/mL
PCME	= phase contrast microscopy-equivalent asbestos fibers, defined as asbestos particles (fibers) with a length to width (aspect ratio) ≥3:1, >5µm in length, and >0.25 µm in width
Unit Risk	= Inhalation Unit Risk (IUR), in $(f/mL)^{-1}$ (extrapolated values taken from EPA 2008)
TWF	= Time Weighted Factor, adjusted exposure duration, in years

TWF = (exposure hrs/day)/24-hrs x (exposure days/yr)/365 days

Inhalation Unit Risk (IUR) is a dose-response measure that is expressed as the lifetime cancer risk per concentration unit. It is developed from life-time tables for assessment of asbestos cancer risk (lung cancer and mesothelioma) using EPA methods. For less than lifetime exposures DPH uses EPA's extrapolated unit risk values provided in *Framework for*

Investigating Asbestos-Contaminated Superfund Sites (EPA 2008). The extrapolated unit risk values provide cancer risk values adjusted for the age a person is first exposed to airborne asbestos and the number of years a person is exposed over their lifetime.

Uncertainties in the Health Effects Evaluation Process
Uncertainties are inherent in the public health assessment process. These uncertainties fall into the following categories:

- the imprecision of the risk assessment process,
- the incompleteness of the information collected and used in the assessment, and
- the differences in opinion as to the implications of the information.

These uncertainties are addressed in public health assessments by using worst-case assumptions when estimating or interpreting health risks. The health assessment calculations and screening values also incorporate safety margins. The assumptions, interpretations, and recommendations made throughout this public health assessment err in the direction of protecting public health.

Reference:
(Andelman 1990). *Total Exposure of Volatile Organic Compounds in Potable Water*. In: Significance and Treatment of Volatile Organic Compounds in Water Supplies, Chapter 20. Lewis Publishers, Chelsea, MI.

Appendix E

ATSDR Public Health Statement for Asbestos

PUBLIC HEALTH STATEMENT
ASBESTOS
CAS#: 1332-21-4

Division of Toxicology **September 2001**

This Public Health Statement is the summary chapter from the Toxicological Profile for Asbestos. It is one in a series of Public Health Statements about hazardous substances and their health effects. A shorter version, the ToxFAQs™ is also available. This information is important because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present. For more information, call the ATSDR Information Center at 1-888-422-8737.

This public health statement tells you about asbestos and the effects of exposure. The Environmental Protection Agency (EPA) identifies the most serious hazardous waste sites in the nation. These sites make up the National Priorities List (NPL) and are the sites targeted for long-term federal cleanup activities. Asbestos has been found in at least 83 of the 1,585 current or former NPL sites. However, the total number of NPL sites evaluated for this substance is not known. As more sites are evaluated, the sites at which asbestos is found may increase. This information is important because exposure to this substance may harm you and because these sites may be sources of exposure.

When a substance is released from a large area, such as an industrial plant, or from a container, such as a drum or bottle, it enters the environment. This release does not always lead to exposure. You are exposed to a substance only when you come in contact with it. You may be exposed by breathing, eating, or drinking the substance, or by skin contact.

If you are exposed to asbestos, many factors determine whether you'll be harmed. These factors include the dose (how much), the duration (how long), the fiber type (mineral form and size distribution), and how you come in contact with it. You must also consider the other chemicals you're exposed to and your age, sex, diet, family traits, lifestyle (including whether you smoke tobacco), and state of health.

1.1 WHAT IS ASBESTOS?

Asbestos is the name given to a group of six different fibrous minerals (amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite, and anthophyllite) that occur naturally in the environment. One of these, namely chrysotile, belongs to the serpentine family of minerals, while all of the others belong to the amphibole family. All forms of asbestos are hazardous, and all can cause cancer, but amphibole forms of asbestos are considered to be somewhat more hazardous to health than chrysotile. Asbestos minerals consist of thin, separable fibers that have a parallel arrangement. Nonfibrous forms of tremolite, actinolite, and anthophyllite also are found naturally. However, because they are not fibrous, they are not classified as asbestos minerals. Amphibole asbestos fibers are generally brittle and often have a rod- or needle-like shape, whereas chrysotile asbestos fibers are flexible and curved. Chrysotile, also known as white asbestos, is the predominant commercial form of asbestos; amphiboles are of minor commercial importance. Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate and are resistant to heat, fire, chemical and biological degradation. Because of these properties, asbestos has been mined for use in a wide range of manufactured products, mostly in building materials, friction products, and heat-resistant

DEPARTMENT of HEALTH AND HUMAN SERVICES, Public Health Service
Agency for Toxic Substances and Disease Registry

www.atsdr.cdc.gov/ **Telephone: 1-888-422-8737** **Fax: 770-488-4178** **E-Mail: atsdric@cdc.gov**

fabrics. Since asbestos fibers may cause harmful health effects in people who are exposed, all new uses of asbestos have been banned in the United States by the EPA. Please see the toxicological profile for more information on the properties and uses of asbestos.

1.2 WHAT HAPPENS TO ASBESTOS WHEN IT ENTERS THE ENVIRONMENT?

Asbestos fibers do not evaporate into air or dissolve in water. However, pieces of fibers can enter the air and water from the weathering of natural deposits and the wearing down of manufactured asbestos products. Small diameter fibers and fiber-containing particles may remain suspended in the air for a long time and be carried long distances by wind or water currents before settling. Larger diameter fibers and particles tend to settle more quickly. Asbestos fibers are not able to move through soil. They are generally not broken down to other compounds in the environment and will remain virtually unchanged over long periods. However, the most common form of asbestos, chrysotile, may have some minor mineral loss in acidic environments. Asbestos fibers may break into shorter pieces or separate into a larger number of individual fibers as a result of physical processes. When asbestos fibers are breathed in, they may get trapped in the lungs. Levels of fibers in lung tissue build up over time, but some fibers, particularly chrysotile fibers, can be removed from or degraded in the lung with time. Please see the toxicological profile for more information on the behavior of asbestos in the environment.

1.3 HOW MIGHT I BE EXPOSED TO ASBESTOS?

Asbestos minerals are widespread in the environment. They may occur in large natural deposits, or as contaminants in other minerals. For example, tremolite asbestos may occur in deposits of chrysotile, vermiculite, and talc. Asbestos may be found in soil that is formed from the erosion of asbestos-bearing rock. You are most likely to be exposed to asbestos by breathing in asbestos fibers that are suspended in air. These fibers can come from naturally occurring sources of asbestos or from the wearing down or disturbance of manufactured products including insulation, automotive brakes and clutches, ceiling and floor tiles, dry wall, roof shingles, and cement. However, these products do not always contain asbestos. Low levels of asbestos that present little, if any, risk to your health can be detected in almost any air sample. For example, 10 fibers are typically present in a cubic meter (fibers/m^3) of outdoor air in rural areas. (A cubic meter is about the amount of air that you breathe in 1 hour.) Health professionals often report the number of fibers in a milliliter (mL) (equivalent to a cubic centimeter [cm^3]) of air rather than in a cubic meter of air. Since there are one million cm^3 (or one million mL) in a cubic meter, there typically would be 0.00001 fibers/mL of asbestos in air in rural areas. Typical levels found in cities are about 10-fold higher.

Close to an asbestos mine or factory, levels may reach 10,000 fibers/m^3 (0.01 fibers/mL) or higher. Levels could also be above average near a building that contains asbestos products and that is being torn down or renovated or near a waste site where asbestos is not properly covered up or stored to protect it from wind erosion.

In indoor air, the concentration of asbestos depends on whether asbestos was used for insulation, ceiling or floor tiles, or other purposes, and whether these asbestos-containing materials are in good condition or are deteriorated and easily crumbled. Concentrations measured in homes, schools, and other buildings that contain asbestos range from about 30 to 6,000 fibers/m³ (0.00003–0.006 fibers/mL). People who work with asbestos or asbestos-containing products (for example, miners, insulation workers, asbestos abatement workers, and automobile brake mechanics) without proper protection are likely to be exposed to much higher levels of asbestos fibers in air. In addition, custodial and maintenance workers who are making repairs or installations in buildings with asbestos-containing materials may be exposed to higher levels of asbestos. Since vermiculite and talc may contain asbestos, occupational workers and the general population may be exposed to asbestos when using these products.

You can also be exposed to asbestos by drinking asbestos fibers that are present in water. Even though asbestos does not dissolve in water, fibers can enter water by being eroded from natural deposits or piles of waste asbestos, from asbestos-containing cement pipes used to carry drinking water, or from filtering through asbestos-containing filters. Most drinking water supplies in the United States have concentrations of less than 1 million fibers per liter (MFL), even in areas with asbestos deposits or with asbestos-cement water supply pipes. However, in some locations, water samples may contain 10–300 million fibers per liter or even higher. The average person drinks about 2 liters of water per day. Please see the toxicological profile for more information on how you could be exposed to asbestos.

1.4 HOW CAN ASBESTOS ENTER AND LEAVE MY BODY?

If you breathe asbestos fibers into your lungs, some of the fibers will be deposited in the air passages and on the cells that make up your lungs. Most fibers are removed from your lungs by being carried away or coughed up in a layer of mucus to the throat, where they are swallowed into the stomach. This usually takes place within a few hours. Fibers that are deposited in the deepest parts of the lung are removed more slowly. In fact, some fibers may move through your lungs and can remain in place for many years and may never be removed from your body. Amphibole asbestos fibers are retained in the lung longer than chrysotile asbestos fibers.

If you swallow asbestos fibers (either those present in water or those that are moved to your throat from your lungs), nearly all of the fibers pass along your intestines within a few days and are excreted in the feces. A small number of fibers may penetrate into cells that line your stomach or intestines, and a few penetrate all the way through and get into your blood. Some of these become trapped in other tissues, and some are removed in your urine.

If you get asbestos fibers on your skin, very few of these fibers, if any, pass through the skin into your body. Please see the toxicological profile for more information on how asbestos enters and leaves your body.

1.5 HOW CAN ASBESTOS AFFECT MY HEALTH?

To protect the public from the harmful effects of toxic chemicals and to find ways to treat people who have been harmed, scientists use many tests.

One way to see if a chemical will hurt people is to learn how the chemical is absorbed, used, and released by the body; for some chemicals, animal testing may be necessary. Animal testing may also be used to identify health effects such as cancer or birth defects. Without laboratory animals, scientists would lose a basic method to get information needed to make wise decisions to protect public health. Scientists have the responsibility to treat research animals with care and compassion. Laws today protect the welfare of research animals, and scientists must comply with strict animal care guidelines.

Information on the health effects of asbestos in people comes mostly from studies of people who were exposed in the past to levels of asbestos fibers (greater than or equal to 5 µm in length) in workplace air that were as high as 5 million fibers/m^3 (5 fibers/mL). Workers who repeatedly breathe in asbestos fibers with lengths greater than or equal to 5 µm may develop a slow buildup of scar-like tissue in the lungs and in the membrane that surrounds the lungs. This scar-like tissue does not expand and contract like normal lung tissue and so breathing becomes difficult. Blood flow to the lung may also be decreased, and this causes the heart to enlarge. This disease is called asbestosis. People with asbestosis have shortness of breath, often accompanied by a cough. This is a serious disease and can eventually lead to disability or death in people exposed to high amounts of asbestos over a long period. However, asbestosis is not usually of concern to people exposed to low levels of asbestos. Changes in the membrane surrounding the lung, called pleural plaques, are quite common in people occupationally exposed to asbestos and are sometimes found in people living in areas with high environmental levels of asbestos.
Effects on breathing from pleural plaques alone are usually not serious. There is conflicting evidence as to whether their presence in a person accurately predicts more serious disease development in the future.

Asbestos workers have increased chances of getting two principal types of cancer: cancer of the lung tissue itself and mesothelioma, a cancer of the thin membrane that surrounds the lung and other internal organs. These diseases do not develop immediately following exposure to asbestos, but appear only after a number of years. There is also some evidence from studies of workers that breathing asbestos can increase the chances of getting cancer in other locations (for example, the stomach, intestines, esophagus, pancreas, and kidneys), but this is less certain. Members of the public who are exposed to lower levels of asbestos may also have increased chances of getting cancer, but the risks are usually small and are difficult to measure directly. Lung cancer is usually fatal, while mesothelioma is almost always fatal, often within a few months of diagnosis. Some scientists believe that early identification and intervention of mesothelioma may increase survival.

The levels of asbestos in air that lead to lung disease depend on several factors. The most important of these are (1) how long you were exposed, (2) how long it has been since your exposure started, and (3) whether you smoked cigarettes. Cigarette smoking and asbestos exposure increase your chances of getting lung cancer. Also, there is a scientific debate concerning the differences in the extent of disease caused by different fiber types and sizes. Some of these differences may be due to the physical and chemical properties of the different fiber types. For example, several studies suggest that amphibole asbestos types (tremolite, amosite, and especially crocidolite) may be more harmful than chrysotile, particularly for mesothelioma. Other data indicate that fiber size dimensions (length and diameter) are important factors for cancer-causing potential. Some data indicate that fibers with lengths greater than 5.0 µm are more likely to cause injury than fibers with lengths less than 2.5 µm. (1 µm is about 1/25,000 of an inch.) Additional data indicate that short fibers can contribute to injury. This appears to be true for mesothelioma, lung cancer, and asbestosis. However, fibers thicker than 3.0 µm are of lesser concern, because they have little chance of penetrating to the lower regions of the lung.

The health effects from swallowing asbestos are unclear. Some groups of people who have been exposed to asbestos fibers in their drinking water have higher-than-average death rates from cancer of the esophagus, stomach, and intestines. However, it is very difficult to tell whether this is caused by asbestos or by something else. Animals that were given very high doses of asbestos in food did not get more fatal cancers than usual, although some extra nonfatal tumors did occur in the intestines of rats in one study.

Several government offices and regulatory agencies have considered all of the evidence regarding the carcinogenicity of asbestos. The Department of Health and Human Services (DHHS) has determined that asbestos is known to be a human carcinogen. The EPA has determined that asbestos is a human carcinogen. The International Agency for Research on Cancer (IARC) has determined that asbestos is carcinogenic to humans. Please see the toxicological profile for more information on how asbestos can affect your health.

1.6 HOW CAN ASBESTOS AFFECT CHILDREN?

This section discusses potential health effects from exposures during the period from conception to maturity at 18 years of age in humans.

Asbestos exposure in both children and adults may occur while breathing air in or near buildings (public or private) containing asbestos building materials or near asbestos-related industrial operations. Children breathe differently and have different lung structures than adults. It is not known if these differences may cause a greater amount of asbestos fibers to stay in the lungs of a child when they are breathed in than in the lungs of an adult. Children drink more fluids per kilogram of body weight than adults and can also be exposed through asbestos-contaminated drinking water. Eating asbestos-contaminated soil and dust is another source of exposure for children. Certain children intentionally eat soil, and all young children eat more soil than adults through hand-to-mouth activities. Historically, family members have also been exposed to asbestos that was carried home on the clothing of other family members who worked in asbestos mines or mills. Breathing of asbestos fibers may result in difficulty in breathing, lung cancer, or mesothelioma (another form of cancer associated with asbestos exposure). These diseases usually appear many years following the first exposure to asbestos and are therefore not likely to be seen in children. But since it may take up to 40 or more years for the effects of exposure to be seen, people who have been exposed to asbestos at a young age may be more likely to contract these diseases than those who are first exposed later in life. In the small number of studies that have specifically looked at asbestos exposure in children, there is no indication that younger people might develop asbestos-related diseases more quickly than older people. Developing fetuses and infants are not likely to be exposed to asbestos through the placenta or breast milk of the mother. Results of animal studies do not indicate that exposure to asbestos is likely to result in birth defects.

1.7 HOW CAN FAMILIES REDUCE THE RISK OF EXPOSURE TO ASBESTOS?

If your doctor finds that you have been exposed to significant amounts of asbestos, ask whether your children might also be exposed. Your doctor might need to ask your state health department to investigate.

The most important way that families can lower their exposures to asbestos is to be aware of the sources of asbestos in their homes and avoid exposure to these sources. The most important source of asbestos in a home is from damaged or deteriorating asbestos-containing insulation, ceiling, or floor tiles. Should you suspect that your house may contain asbestos, contact your state or local health department or the regional offices of EPA to find out how to test your home for asbestos and how to locate a company that is trained to remove or contain the fibers. Federal law requires schools to identify asbestos-containing material in school buildings and take appropriate action to control release of asbestos fibers.

If you live close to where asbestos and certain other ores are mined or processed, where a building that contains asbestos products is being torn down or renovated, or a waste site where asbestos is not properly covered, then the levels of asbestos in dust and wind-blown soil may be higher. Pets can also bring asbestos into the home by carrying dust or dirt on their fur or feet if they spend time in places that have high levels of asbestos in the soil. Swallowing of asbestos in house dust or soil is a potential exposure pathway for children. This problem can be reduced in many ways. Regular hand and face washing to remove asbestos-containing dusts and soil, especially before meals, can lower the possibility of asbestos fibers on the skin being accidentally swallowed while eating. Families can lower exposures to asbestos by regularly cleaning the home of dust and tracked in soil. Door mats can help lower the amount of soil that is tracked into the home; removing your shoes before entering will also help. Planting grass and shrubs over bare soil areas in the yard can lower the contact that children and pets may have with soil and reduce the tracking of soil into the home.

You can bring asbestos home in the dust on your hands or clothes if you work in the mining or processing of minerals that contain asbestos, in asbestos removal, or in buildings with damaged or deteriorating asbestos. Federal law regulates work practices to limit the possibility of asbestos being brought home in this way. Your occupational health and safety officer at work can and should tell you whether chemicals you work with are dangerous and likely to be carried home on your clothes, body, or tools, and whether you should be showering and changing clothes before you leave work, storing your street clothes in a separate area of the workplace, or laundering your work clothes at home separately from other clothes. Your employer should have Material Safety Data Sheets (MSDSs) for many of the chemicals used at your place of work, as required by the Occupational Safety and Health Administration (OSHA). Information on these sheets should include chemical names and hazardous ingredients, important properties (such as fire and explosion data), potential health effects, how you get the chemical(s) in your body, how to handle the materials properly, and what to do in an emergency. Your employer is legally responsible for providing a safe workplace and should freely answer your questions about hazardous chemicals. Either OSHA or your OSHA-approved state occupational safety and health program can answer any further questions and help your employer identify and correct problems with hazardous substances. OSHA and/or your OSHA-approved state occupational safety and health program will listen to your formal complaints about workplace health hazards and inspect your workplace when necessary. Employees have a right to seek safety and health on the job without fear of punishment.

1.8 IS THERE A MEDICAL TEST TO DETERMINE WHETHER I HAVE BEEN EXPOSED TO ASBESTOS?

The most common test used to determine if you have received sustained exposure to asbestos is a chest x-ray. A chest x-ray is recommended for detecting exposure to asbestos only in persons who have sustained relatively heavy exposure. A chest x-ray is of no value for detecting evidence of asbestos exposure in a person whose exposure to asbestos has been only brief or transient. The x-ray cannot detect the asbestos fibers themselves, but it can detect early signs of lung disease caused by asbestos. While other substances besides asbestos can sometimes produce similar changes in the lungs, this test is usually reliable for detecting asbestos-related effects produced by long-term exposures at relatively high concentrations of asbestos fibers. Other tests, such as gallium-67 lung scanning and high-resolution computed tomography, are also useful in detecting changes in the lungs. However, there are currently no means of detecting exposure-related effects from commonly encountered environmental exposures.

The most reliable test to determine if you have been exposed to asbestos is the detection of microscopic asbestos fibers in pieces of lung tissue removed by surgery, but this is a very invasive test. A test can also be run to determine the presence of asbestos fibers in material rinsed out of the lung. However, this test can cause some discomfort. Asbestos fibers can also be detected in mucus (sputum), urine, or feces, but these tests are not reliable for determining how much asbestos may be in your lungs. Low levels of asbestos fibers are found in these materials for nearly all people. Higher-than-average levels can show that you have been exposed to asbestos, but it is not yet possible to use the results of this test to estimate how much asbestos you have been exposed to, or to predict whether you are likely to suffer any health effects. Please see the toxicological profile for more information about how asbestos can be measured in people and in the environment.

1.9 WHAT RECOMMENDATIONS HAS THE FEDERAL GOVERNMENT MADE TO PROTECT HUMAN HEALTH?

The federal government develops regulations and recommendations to protect public health. Regulations can be enforced by law. Federal agencies that develop regulations for toxic substances include the Environmental Protection Agency (EPA), the Occupational Safety and Health Administration (OSHA), and the Food and Drug Administration (FDA). Recommendations provide valuable guidelines to protect public health but cannot be enforced by law. Federal organizations that develop recommendations for toxic substances include the Agency for Toxic Substances and Disease Registry (ATSDR) and the National Institute for Occupational Safety and Health (NIOSH).

Regulations and recommendations can be expressed in not-to-exceed levels in air, water, soil, or food that are usually based on levels that affect animals; then they are adjusted to help protect people. Sometimes these not-to-exceed levels differ among federal organizations because of different exposure times (an 8-hour workday or a 24-hour day), the use of different animal studies, or other factors.

Recommendations and regulations are also periodically updated as more information becomes available. For the most current information, check with the federal agency or organization that provides it. Some regulations and recommendations for asbestos include the following:

The federal government has taken a number of steps to protect citizens from exposure to asbestos. First, on July 12, 1989, EPA established a ban on new uses of asbestos. Uses established before this date are still allowable. Second, EPA has established regulations that require school systems to inspect for asbestos and, if damaged asbestos is found, to eliminate or reduce the exposure, either by removing the asbestos or by covering it up so it cannot get into the air. In addition, EPA provides guidance and support for reducing asbestos exposure in other public buildings. Third, EPA regulates the release of asbestos from factories and during building demolition or renovation to prevent asbestos from getting into the environment. EPA also regulates the disposal of waste asbestos materials or products, requiring these to be placed only in approved locations. Fourth, EPA has proposed a limit of 7 million fibers per liter on the concentration of long fibers (length greater than or equal to 5 μm) that may be present in drinking water. Fifth, FDA regulates the use of asbestos in the preparation of drugs and restricts the use of asbestos in food-packaging materials. NIOSH has recommended that inhalation exposures not exceed 100,000 fibers with lengths greater than or equal to 5 μm per m^3 of air (0.1 fibers/mL). OSHA has established an enforceable limit on the average 8-hour daily concentration of asbestos allowed in air in the workplace to be 100,000 fibers with lengths greater than or equal to 5 μm per m^3 of air (0.1 fibers/mL). Additional sources of information about asbestos are the 10 regional offices of the EPA. Most EPA regional offices have an asbestos coordinator.

Please see the toxicological profile for more information about regulations and guidelines to protect people from exposure to asbestos.

1.10 WHERE CAN I GET MORE INFORMATION?

If you have any more questions or concerns, please contact your community or state health or environmental quality department or:

Agency for Toxic Substances and Disease Registry
Division of Toxicology
1600 Clifton Road NE, Mailstop F-32
Atlanta, GA 30333

Information line and technical assistance:

Phone: 888-422-8737
FAX: (770)-488-4178

ATSDR can also tell you the location of occupational and environmental health clinics. These clinics specialize in recognizing, evaluating, and treating illnesses resulting from exposure to hazardous substances.

To order toxicological profiles, contact:

National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Phone: 800-553-6847 or 703-605-6000

Reference

Agency for Toxic Substances and Disease Registry (ATSDR). 2001. Toxicological Profile for Asbestos. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Appendix F

General and Health Effects Information for Asbestos

Asbestos General Information

Asbestos is a general name applied to a group of silicate minerals consisting of thin, separable fibers in substantially parallel sides. 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. Fibrous amphibole minerals are brittle and have a rod- or needle-like shape. Amphibole minerals regulated as asbestos by OSHA include five classes: crocidolite, amosite, and the fibrous forms of tremolite, actinolite, and anthophyllite. Other unregulated amphibole minerals, including winchite, richterite, and others, can also exhibit fibrous asbestiform properties.

Asbestos fibers do not have any detectable odor or taste. They do not dissolve in water or evaporate into the air, although individual asbestos fibers can easily be suspended in the air. Asbestos fibers do not move through soil. They are resistant to heat, fire, and chemical and biological degradation. As such, they can remain virtually unchanged in the environment over long periods of time.

Asbestos Health Effects and Toxicity

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

Malignant mesothelioma: Cancer of the membrane (pleura) that encases the lungs in addition, lines the chest cavity. This cancer can spread to tissues surrounding the lungs or other organs. The great majority of mesothelioma cases are attributable to asbestos exposure.

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.

Laryngeal cancer: Cancer of the larynx has recently been associated with breathing asbestos.

Non-cancer effects: These include asbestosis, scarring, and reduced lung function caused by asbestos fibers lodged in the lung; pleural plaques, localized or diffuse areas of thickening of the pleura (lining of the lung); pleural thickening, extensive thickening of the pleura, which may restrict breathing; pleural calcification, calcium deposition on pleural areas thickened from chronic inflammation and scarring; and pleural effusions, fluid buildup in the pleural space between the lungs and the chest cavity.

Not enough evidence is available to determine whether inhalation of asbestos increases the risk of cancers at sites other than the lungs, pleura, and abdominal cavity.

Ingestion of asbestos causes little or no risk of non-cancer effects. However, some evidence indicates that acute oral exposure might induce precursor lesions of colon cancer and that chronic oral exposure might lead to an increased risk of gastrointestinal tumors.

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

The scientific community generally accepts the correlations of asbestos toxicity with fiber length as well as fiber mineralogy. Fiber length may play an important role in clearance and mineralogy may affect both biopersistence and surface chemistry. ATSDR, responding to concerns about asbestos fiber toxicity from the World Trade Center disaster, held an expert panel meeting to review fiber size and its role in fiber toxicity in December 2002. The panel concluded that fiber length plays an important role in toxicity. Fibers with lengths <5 µm are essentially non-toxic in terms of association with mesothelioma or lung cancer promotion. However, fibers <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. 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. However, OSHA continues to regulate chrysotile and amphibole asbestos as one substance, as both types increase the risk of disease. Currently, EPA's Integrated Risk Information System (IRIS) assessment of asbestos also currently treats mineralogy (and fiber length) as equipotent.

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

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. Some of the unregulated amphibole minerals, such as the winchite (from Libby, MT), can exhibit asbestiform characteristics and contribute to risk. Fiber diameters greater than 2–5 µm are considered above the upper limit of respirability and thus do not contribute significantly to risk.

Methods for Measuring Asbestos Content

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

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 can distinguish between asbestos and non-asbestos fibers and between different types of asbestos. The PLM method can detect fibers with lengths greater than approximately 1 µm (~1 µm), widths greater than ~0.25 µm, and aspect ratios (length-to-width ratios) greater than 3. Detection limits for PLM methods are typically 0.25% to 1% asbestos.

Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods that can detect smaller fibers than light microscopic techniques. TEM allows the use of electron diffraction and energy dispersive x-ray methods, which give information on crystal structure and elemental composition, respectively. This information can be used to determine the elemental composition of the visualized fibers. SEM does not allow measurement of electron diffraction patterns. One disadvantage of electron microscopic methods is that determining asbestos concentration in soil and other bulk material is difficult.
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 (µg/m3)/(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 (µg/m3)/(f/cc). 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 (12). Generally, a combination of PCM and TEM is used to describe the fiber population in a particular air sample.

References:

Exposure Investigation – Final Report, Ambler Gravel Pit, Ambler, Alaska. ATSDR. June 2007.

Health Consultation – Evaluation of Asbestos Exposures at Illinois Beach State Park, Zion, Lake County, Illinois. ATSDR. March 2009.

Appendix G

ATSDR Glossary

ATSDR Glossary

Absorption
The process of taking in. For a person or animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Additive effect
A biologic response to exposure to multiple substances that equals the sum of responses of all the individual substances added together [compare with antagonistic effect and synergistic effect].

Adverse health effect
A change in body functions or cell structure that might lead to disease or health problems.

Aerobic
Requiring oxygen [compare with anaerobic].

Ambient
Surrounding (for example, *ambient* air).

Anaerobic
Requiring the absence of oxygen [compare with aerobic].

Analyte
A substance measured in the laboratory. A chemical for which a sample (such as water, air, or blood) is tested in a laboratory. For example, if the analyte is mercury, the laboratory test will determine the amount of mercury in the sample.

Analytic epidemiologic study
A study that evaluates the association between exposure to hazardous substances and disease by testing scientific hypotheses.

Antagonistic effect
A biologic response to exposure to multiple substances that is less than would be expected if the known effects of the individual substances were added together [compare with additive effect and synergistic effect].

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Biodegradation
Decomposition or breakdown of a substance through the action of microorganisms (such as bacteria or fungi) or other natural physical processes (such as sunlight).

Biologic indicators of exposure study
A study that uses (a) biomedical testing or (b) the measurement of a substance [an analyte], its metabolite, or another marker of exposure in human body fluids or tissues to confirm human exposure to a hazardous substance [also see exposure investigation].

Biologic monitoring
Measuring hazardous substances in biologic materials (such as blood, hair, urine, or breath) to determine whether exposure has occurred. A blood test for lead is an example of biologic monitoring.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biomedical testing
Testing of persons to find out whether a change in a body function might have occurred because of exposure to a hazardous substance.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

CAP See Community Assistance Panel.

Cancer
Any one of a group of diseases that occurs when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk of for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Case study
A medical or epidemiologic evaluation of one person or a small group of people to gather information about specific health conditions and past exposures.

Case-control study
A study that compares exposures of people who have a disease or condition (cases) with people who do not have the disease or condition (controls). Exposures that are more common among the cases may be considered as possible risk factors for the disease.

CAS registry number
A unique number assigned to a substance or mixture by the American Chemical Society Abstracts Service.

Central nervous system
The part of the nervous system that consists of the brain and the spinal cord.

CERCLA [see Comprehensive Environmental Response, Compensation, and Liability Act of 1980]

Chronic
Occurring over a long time (more than 1 year) [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].

Cluster investigation
A review of an unusual number, real or perceived, of health events (for example, reports of cancer) grouped together in time and location. Cluster investigations are designed to confirm case reports; determine whether they represent an unusual disease occurrence; and, if possible, explore possible causes and contributing environmental factors.

Community Assistance Panel (CAP)
A group of people, from a community and from health and environmental agencies, who work with ATSDR to resolve issues and problems related to hazardous substances in the community. CAP members work with ATSDR to gather and review community health concerns, provide information on how people might have been or might now be exposed to hazardous substances, and inform ATSDR on ways to involve the community in its activities.

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Comprehensive Environmental Response,
Compensation, and Liability Act of 1980 (CERCLA) CERCLA, also known as Superfund, is the federal law that concerns the removal or cleanup of hazardous substances in the environment and at hazardous waste sites. ATSDR, which was created by CERCLA, is responsible for assessing health issues and supporting public health activities related to hazardous waste sites or other environmental releases of hazardous substances.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Delayed health effect
A disease or injury that happens as a result of exposures that might have occurred in the past.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Descriptive epidemiology
The study of the amount and distribution of a disease in a specified population by person, place, and time.

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Disease prevention
Measures used to prevent a disease or reduce its severity.

Disease registry
A system of ongoing registration of all cases of a particular disease or health condition in a defined population.

DOD
United States Department of Defense.

DOE
United States Department of Energy.

Dose (for chemicals that are not radioactive)
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose (for radioactive chemicals)
The radiation dose is the amount of energy from radiation that is actually absorbed by the body. This is not the same as measurements of the amount of radiation in the environment.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur.

Epidemiologic surveillance
The ongoing, systematic collection, analysis, and interpretation of health data. This activity also involves timely dissemination of the data and use for public health programs.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure-dose reconstruction
A method of estimating the amount of people's past exposure to hazardous substances. Computer and approximation methods are used when past information is limited, not available, or missing.

Exposure investigation
The collection and analysis of site-specific information and biologic tests (when appropriate) to determine whether people have been exposed to hazardous substances.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or are exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through ground water); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Exposure registry
A system of ongoing follow-up of people who have had documented environmental exposures.

Feasibility study
A study by EPA to determine the best way to clean up environmental contamination. A number of factors are considered, including health risk, costs, and what methods will work well.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Grand rounds
Training sessions for physicians and other health care providers about health topics.

Ground water
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Half-life ($t_{½}$)
The time it takes for half the original amount of a substance to disappear. In the environment, the half-life is the time it takes for half the original amount of a substance to disappear when it is changed to another chemical by bacteria, fungi, sunlight, or other chemical processes. In the human body, the half-life is the time it takes for half the original amount of the substance to disappear, either by being changed to another

substance or by leaving the body. In the case of radioactive material, the half-life is the amount of time necessary for one-half the initial number of radioactive atoms to change or transform into another atom (that is normally not radioactive). After two half lives, 25% of the original number of radioactive atoms remain.

Hazard
A source of potential harm from past, current, or future exposures.

Hazardous Substance Release and Health Effects Database (HazDat)
The scientific and administrative database system developed by ATSDR to manage data collection, retrieval, and analysis of site-specific information on hazardous substances, community health concerns, and public health activities.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Health education
Programs designed with a community to help it know about health risks and how to reduce these risks.

Health investigation
The collection and evaluation of information about the health of community residents. This information is used to describe or count the occurrence of a disease, symptom, or clinical measure and to estimate the possible association between the occurrence and exposure to hazardous substances.

Health promotion
The process of enabling people to increase control over, and to improve, their health.

Health statistics review
The analysis of existing health information (i.e., from death certificates, birth defects registries, and cancer registries) to determine if there is excess disease in a specific population, geographic area, and time period. A health statistics review is a descriptive epidemiologic study.

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

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Maximum Contaminant Level (MCL)
The highest level of a contaminant that EPA allows in drinking water. MCLs ensure that drinking water does not pose either a short-term or long-term health risk. EPA sets MCLs at levels that are economically and technologically feasible. Some states set MCLs that are more strict than EPA's.

Medical monitoring
A set of medical tests and physical exams specifically designed to evaluate whether an individual's exposure could negatively affect that person's health.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

mg/cm^2
Milligram per square centimeter (of a surface).

mg/m^3
Milligram per cubic meter; a measure of the concentration of a chemical in a known volume (a cubic meter) of air, soil, or water.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for

a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

Morbidity
State of being ill or diseased. Morbidity is the occurrence of a disease or condition that alters health and quality of life.

Mortality
Death. Usually the cause (a specific disease, condition, or injury) is stated.

Mutagen
A substance that causes mutations (genetic damage).

Mutation
A change (damage) to the DNA, genes, or chromosomes of living organisms.

National Priorities List for Uncontrolled Hazardous Waste Sites (National Priorities List or NPL)
EPA's list of the most serious uncontrolled or abandoned hazardous waste sites in the United States. The NPL is updated on a regular basis.

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

NPL [see National Priorities List for Uncontrolled Hazardous Waste Sites]

Physiologically based pharmacokinetic model (PBPK model)
A computer model that describes what happens to a chemical in the body. This model describes how the chemical gets into the body, where it goes in the body, how it is changed by the body, and how it leaves the body.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Plume
A volume of a substance that moves from its source to places farther away from the source. Plumes can be described by the volume of air or water they occupy and the direction they move. For example, a plume can be a column of smoke from a chimney or a substance moving with ground water.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Potentially responsible party (PRP)
A company, government, or person legally responsible for cleaning up the pollution at a hazardous waste site under Superfund. There may be more than one PRP for a particular site.

ppb
Parts per billion.

ppm
Parts per million.

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevalence survey
The measure of the current level of disease(s) or symptoms and exposures through a questionnaire that collects self-reported information from a defined population.

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public comment period
An opportunity for the public to comment on agency findings or proposed activities contained in draft reports or documents. The public comment period is a limited time period during which comments will be accepted.

Public availability session
An informal, drop-by meeting at which community members can meet one-on-one with ATSDR staff members to discuss health and site-related concerns.

Public health action
A list of steps to protect public health.

Public health advisory
A statement made by ATSDR to EPA or a state regulatory agency that a release of hazardous substances poses an immediate threat to human health. The advisory includes recommended measures to reduce exposure and reduce the threat to human health.

Public health assessment (PHA)
An ATSDR document that examines hazardous substances, health outcomes, and community concerns at a hazardous waste site to determine whether people could be harmed from coming into contact with those substances. The PHA also lists actions that need to be taken to protect public health [compare with health consultation].

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

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

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Radioisotope
An unstable or radioactive isotope (form) of an element that can change into another element by giving off radiation.

Radionuclide
Any radioactive isotope (form) of any element.

RCRA [See Resource Conservation and Recovery Act (1976, 1984)]

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Registry
A systematic collection of information on persons exposed to a specific substance or having specific diseases [see exposure registry and disease registry].

Remedial Investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Resource Conservation and Recovery Act (1976, 1984) (RCRA)
This Act regulates management and disposal of hazardous wastes currently generated, treated, stored, disposed of, or distributed.
RFA
RCRA Facility Assessment. An assessment required by RCRA to identify potential and actual releases of hazardous chemicals.

RfD
See reference dose

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Safety factor [see uncertainty factor]

SARA [see Superfund Amendments and Reauthorization Act]

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or environment.

Solvent
A liquid capable of dissolving or dispersing another substance (for example, acetone or mineral spirits).

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Stakeholder
A person, group, or community who has an interest in activities at a hazardous waste site.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Substance-specific applied research
A program of research designed to fill important data needs for specific hazardous substances identified in ATSDR's toxicological profiles. Filling these data needs would allow more accurate assessment of

human risks from specific substances contaminating the environment. This research might include human studies or laboratory experiments to determine health effects resulting from exposure to a given hazardous substance.

Superfund Amendments and Reauthorization Act (SARA)
In 1986, SARA amended CERCLA and expanded the health-related responsibilities of ATSDR. CERCLA and SARA direct ATSDR to look into the health effects from substance exposures at hazardous waste sites and to perform activities including health education, health studies, surveillance, health consultations, and toxicological profiles.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with ground water].

Surveillance [see epidemiologic surveillance]

Survey
A systematic collection of information or data. A survey can be conducted to collect information from a group of people or from the environment. Surveys of a group of people can be conducted by telephone, by mail, or in person. Some surveys are done by interviewing a group of people [see prevalence survey].

Synergistic effect
A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].

Teratogen
A substance that causes defects in development between conception and birth. A teratogen is a substance that causes a structural or functional birth defect.

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents which, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Tumor
An abnormal mass of tissue that results from excessive cell division that is uncontrolled and progressive. Tumors perform no useful body function. Tumors can be either benign (not cancer) or malignant (cancer).

Ultramafic (or **ultrabasic**) rocks are dark-colored igneous and meta-igneous rocks that are rich in minerals containing magnesium and iron ("mafic" minerals) and have a relatively low content of silica. The Earth's mantle is thought to be composed of ultramafic rocks. Most of the exposed ultramafic rocks have been found in orogenic (mountain-forming) belts. Ultramafic rocks are generally composed of more than 90 percent mafic minerals (they have a high content of magnesium oxide (more than 18% MgO) and iron oxide (FeO)). Their silica content is less than 45%, and their potassium content is low.

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people [also sometimes called a safety factor].

USEPA
United States Environmental Protection Agency.

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

Volatile organic compounds (VOCs)
Organic compounds that evaporate readily into the air. VOCs include substances such as benzene, toluene, methylene chloride, and methyl chloroform.