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Health Consultation

Epidemiological Investigation Of Human Exposure To A Contaminated Vermiculite Ore Processing Site In Utah

VERMICULITE INTERMOUNTAIN AND INTERMOUNTAIN PRODUCTS, INC.
SALT LAKE CITY, SALT LAKE COUNTY, UTAH

EPA FACILITY IDs: UTN000802119 AND UT0010165126

MARCH 1, 2007

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

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Prepared By:

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Office of Epidemiology
Environmental Epidemiology Program

For the

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

EXECUTIVE SUMMARY

Vermiculite ore from Libby, Montana mine contained high levels of amphibole asbestos, and asbestiform fibers and has been associated with asbestos related disease among Libby residents. Human exposure to the contaminated vermiculite has possibly occurred in communities throughout the United States located near facilities that received vermiculite ore from the Libby mine. A major source of exposure to asbestos is from exfoliation of the ore at exfoliation facilities. The U.S. Environmental Protection Agency (EPA) has identified two former exfoliation facilities in Salt Lake City, Utah: Vermiculite Intermountain located at 333 West 100 South and Intermountain Products Inc., located at 733 West 800 South, which operated from 1941-1986 and 1985-1987, respectively.

Portions of the former Vermiculite Intermountain site currently consist of a Utah Power & Light (UPL) substation, a commercial parking lot and small businesses. The surrounding neighborhood is primarily commercial and recreational. The Intermountain Products Inc. facility no longer processes vermiculite at the site. EPA completed cleanup of the Intermountain Products site in December 2004. The majority of the Vermiculite Intermountain site has been remediated, which included two buildings adjacent to the former exfoliation plant. There are some contaminated soils beneath an asphalt parking lot. EPA has reached an agreement with the property owner to remediate the property by the end of 2006.

No public health hazard exists for current or future workers at the facility. Under current conditions, on-site exposure of workers poses no public health hazard. The pathways for current or future community exposure to airborne Libby asbestos from facility emissions and to onsite waste piles have been eliminated and pose no public health hazard. The occupational exposure pathway for former workers exposed to airborne Libby asbestos in and around these facilities during handling and processing of vermiculite is considered a completed exposure pathway and was a public health hazard. A potential exposure pathway existed for the community around the sites. Because critical information is lacking, past community exposures are an indeterminate public health hazard.

During operation of the exfoliation facilities in Salt Lake City, over 14,000 children under the age of 15 years lived within two miles of the site, with a total population of approximately 70,404 in the two-mile area. There was the potential for exposure to children and adults during the operation of the facilities located in Salt Lake City, although the number of people potentially exposed and the level of exposure is unknown.

The Utah Department of Health, Environmental Epidemiology Program investigated the incidence of asbestos-related cancers and asbestos related mortality in a two-mile radius around these sites during a 28-year time period from 1973 through 2000. Cancer data were obtained from the Utah Cancer Registry for the state of Utah, the analysis area comprised of census tracts 1001, 1002, 1005–1012, 1017-1030. Mortality data were obtained from the Office of Vital Records and Statistics for the same population groups. Data was analyzed for the following time periods: 1973-79, 1980-85, 1986-90, 1991-95 and 1996-2000.

Cancer incidence and mortality rates in the two-mile radius analysis area for all asbestos-related cancers combined, cancer of the respiratory system and intrathoracic organs, and cancer of the lung and bronchus were significantly elevated during the time periods analyzed. It is unclear if the elevations in respiratory cancers in the two-mile radius analysis area may be due in part to environmental asbestos exposure or other exposures such as tobacco smoke.

Rates for mesothelioma and asbestosis, diseases directly related to asbestos exposure, were not elevated in the analysis area compared to the state of Utah. This suggests that exposure from the vermiculite processing facilities located in Salt Lake City was not likely to be a significant contributing factor to the increased rates observed in other asbestos related cancers and diseases in the two-mile radius analysis area. However, asbestosis-related mortality is almost always found in workers with very high long-term exposure. It is unlikely that findings of excess environmental non-occupational asbestosis mortality would be observed in the two-mile radius analysis area. Mesothelioma is the most specific health endpoint of asbestos-related mortality. However, issues of latency and population migration limit this investigation with respect to mesothelioma mortality and incidence.

Factors that must be considered in the development and etiology of cancers, but that could not be evaluated in this investigation, include latency period, population migration, personal habits, diet, occupational exposures, and familial history of cancer. These issues limit the conclusions that can be drawn from this investigation. The absence of elevated asbestosis and mesothelioma cases does not invalidate the potential influence of asbestos exposure on the observed elevation of respiratory cancers in the two-mile radius analysis area.

PURPOSE

The purpose of this health consultation is to evaluate the incidence of asbestos-related cancers and asbestos-related mortality during a 28-year time period (1973 - 2000) in a two-mile radius around two former vermiculite exfoliation facilities in Salt Lake City, Utah. These facilities processed asbestos-contaminated vermiculite ore from Libby, Montana. The occupational exposure pathway for former workers exposed to airborne Libby asbestos in and around these facilities during handling and processing of vermiculite is considered a completed exposure pathway and was a public health hazard. A potential exposure pathway existed for the community around the sites. Because critical information is lacking, past community exposures are an indeterminate public health hazard.

BACKGROUND

Vermiculite ore from the Libby, Montana mine contained high levels of amphibole asbestos and asbestiform fibers and has been associated with asbestos-related disease among Libby residents [1]. Human exposure to the contaminated vermiculite has possibly occurred in communities throughout the United States located near facilities that received vermiculite ore from the Libby mine. A major source of exposure to asbestos is from exfoliation of the ore at exfoliation facilities. Exfoliation is the process of heating the vermiculite ore to drive off excess

water to produce small, lightweight, low-density pieces. Ninety-percent of the asbestos released is expelled in the exfoliation steps [2]. The primary exposure to asbestos-contaminated vermiculite occurs by inhalation. This exposure can either occur as occupational exposure, by non-occupational exposure to contaminated ambient air, or exposure to household contacts by contaminated clothing of workers employed at vermiculite processing facilities [2].

The U.S. Environmental Protection Agency (EPA) identified two former exfoliation facilities in Salt Lake City, Utah - Vermiculite Intermountain and Intermountain Products Inc. The original facility, Vermiculite Intermountain, located at 333 West 100 South, operated from 1941-1986. Vermiculite Intermountain manufactured and distributed insulation under the trade name Zonolite [3]. Other materials manufactured and distributed included Monokote structural steel fireproofing, Terralite vermiculite soil conditioners, masonry fill and concrete and plaster aggregate. EPA records show that the plant received at least 25,000 tons of vermiculite concentrate from the Libby Mine [4].

During operation of the exfoliation facilities, over 14,000 children under the age of 15 years lived within two miles of the site, with a total population of approximately 70,404 in the two-mile area [5]. There was the potential for exposure to children and adults in Utah during the operation of the facilities located in Salt Lake City, although the number of people potentially exposed and level of exposure is indeterminate.

Portions of the former Vermiculite Intermountain site currently consist of a Utah Power & Light (UPL) substation, a commercial parking lot, and small businesses. The surrounding neighborhood is primarily commercial and recreational. The original property boundaries of the Vermiculite Intermountain facility are now indistinct. However, a former employee stated that the majority of the exfoliation building was on the parcel now used by UPL as an electrical substation. Gravel fill has been placed around the substation and across the adjacent parking and service areas. The substation is secured at all times by a chain-link fence with locked gates [4].

Vermiculite Intermountain merged with a second facility, Intermountain Products Inc. in 1984. Production at the 333 West 100 South site ended in 1986. Intermountain Products Inc. was located at 733 West 800 South and operated from 1985-1987 with approximately ten employees. There was no information on the number of workers employed at the Vermiculite Intermountain facility. The Intermountain Products Inc. facility had two storage silos, a furnace, and bag house. The primary product manufactured was a spray-on fire protection, which contained vermiculite, cellulose, fiberglass, and other ingredients. Intermountain Products Inc., received vermiculite ore primarily from Libby, Montana, as well as South Carolina and South Africa. The property was purchased in 1991 and is now being leased by an auto body shop. Information on the number and demographics of employees at either facility was not available.

A representative from EPA visited the Intermountain Products Inc. site (733 West 800 South) in September 2000, and took 5 shallow composite soil samples in locations where she could see vermiculite on the ground. Analysis by the polarized light microscopy (PLM) method showed all 5 samples to have “trace” levels of tremolite-actinolite, meaning asbestos was present but in amounts less that 1 percent. The PLM method is a common method used to analyze bulk-building materials for asbestos content.

In 2002, EPA conducted a walkthrough inspection of the UPL site and observed what appeared to be vermiculite on the ground surface in several locations. In October 2002, EPA sampled portions of the substation property. Geoprobe core samples were collected and suspected vermiculite/asbestos waste material (stoner rock) was noted in the core samples. Analysis of surface and subsurface soils indicated percent-levels of tremolite asbestos in some surface locations and at some subsurface horizons [4]. Subsequently, in December 2002, UPL removed loose vermiculite from the scarified ground surface using a high-efficiency vacuum in order to address immediate exposure concerns for their employees. Percent levels of tremolite asbestos remain in the subsurface at the UPL substation and may also be present on the ground surface within and around the substation [4].

EPA completed cleanup of the Intermountain Products site in December 2004. The majority of the Vermiculite Intermountain site has been remediated, which included two buildings adjacent to the former exfoliation plant. There are some contaminated soils beneath an adjacent asphalt parking lot. EPA has reached an agreement with the property owner to remediate the property by the end of 2006 [13,14,15].

METHODS

Analysis Area

The analysis area for this investigation was an approximate two-mile radius of the Vermiculite Intermountain facility located at 333 West 100 South, Salt Lake City, Utah that included census tracts 1001, 1002, 1005–1012, 1017-1030. Map showing the location of the two-mile radius analysis area (census tracts 1001, 1002, 1005–1012, 1017-1030) within Salt Lake County is presented in Appendix A. The analysis area around the Vermiculite Intermountain facility was selected since it operated for the longest period of time, from 1941 to 1986, while the Intermountain Products Inc., only operated from 1984 to 1987. In addition, the two facilities are approximately one mile apart, and by selecting a two-mile radius, the analysis area included an area within one mile of the Intermountain Products Inc., facility.

Historical evidence tells us that take home exposures by workers employed at these facilities were common, however, the contribution to overall disease burden was low due to the low number of workers employed at the facility. While the number of workers at the Vermiculite Intermountain facility is unknown, there were only 10 employees at the Intermountain Products Inc. facility.

Mortality Data

Mortality data for this investigation were obtained from the Office of Vital Records and Statistics. Asbestos-related pulmonary diseases include: malignant neoplasm of respiratory system and intrathoracic organs (ICD-9 codes 161-165); malignant neoplasm of lung and bronchus (ICD-9 codes 162.2 – 162.9); malignant neoplasm of peritoneum, retroperitoneum, and pleura (ICD-9 codes 158 and 163); and asbestosis (ICD-9 code 501). An asbestos-related death

was defined as any individual expiring with an asbestos-related pulmonary "underlying cause of death," as specified by definition of the International Classification of Disease, Injury, and Causes of Death codes, Revision 9 [6], during January 1, 1973 through December 31, 2000, and who resided in the analysis area prior to time of death. All cases of possible asbestos-related deaths identified in Salt Lake County were geo-coded using Arc View 3.2.

Cancer Incidence Data

Cancer incidence data for this investigation were obtained from the Utah Cancer Registry. The Utah Cancer Registry receives reports on each newly diagnosed case of cancer in Utah from hospitals, radiation therapy facilities, pathology laboratories, nursing homes, and physicians. In addition, death certificate data are reviewed for cases that may not have been reported to the registry. Each newly diagnosed case is assigned to the census tract of residence at the time of diagnosis. Data obtained from the Utah Cancer Registry included incident cancer cases for the following asbestos-related pulmonary cancers: malignant neoplasm of respiratory system and intrathoracic organs (ICD-0-2 codes C320:C399, excluding M-9590: 9989); malignant neoplasm of lung and bronchus (ICD-0-2 codes C340:C349 excluding M-9590: 9989); malignant neoplasm of peritoneum, retroperitoneum, and pleura (ICD-0-2 codes C480:C4888, C384, excluding M-9590: 9989); and mesothelioma (ICD-0-2 codes M-9050: 9053). Due to the low number of cases, time periods consisting of at least five years were used to increase the statistical power of the analysis. Since the quality of the data in the Utah Cancer Registry was considered less reliable prior to 1986, larger time periods were used for the cases diagnosed prior to 1986. The number of cases was obtained for the following time periods: 1973-1979 (seven years); 1980-1985 (six years); 1986-1990 (five years); 1991-1995 (five years), and 1996-2000 (five years). These cancer cases were received according to primary site/type, sex, age group, race, and time period of diagnosis for residents living within the analysis area and the state of Utah.

Census Data

Population for the analysis area (census tracts: 1001, 1002, 1005–1012, 1017-1030) and the state of Utah were obtained from the U.S. Census Bureau for 1970, 1980, 1990, and 2000. The intercensal populations were estimated using linear regression based on the 1970, 1980, 1990, and 2000 populations. Population estimates were based on the assumption of a constant rate of growth in the analysis area and State of Utah. Cases listed with an unknown census tract in the cancer data were included based on address or zip code location. A table of population estimates used in this report is presented in Appendix B.

Comparison Population

A control population is necessary to use as a comparison to the study population in order to evaluate whether the outcome observed in the study population differs from that which would be expected if the members had not been at any special risk. The state of Utah (minus the analysis area) was used as the comparison population for this investigation.

Socioeconomic Data

Socioeconomic data were obtained from the U.S. Census Bureau for 1990 for the analysis area and the state of Utah. These variables included age, gender, race, education level, household income, housing value, and age of housing.

Statistical Analysis

Age-adjusted cancer and mortality rates were calculated for each time period using the direct method of standardization. An age-adjusted rate is defined as the rate that has been adjusted to reduce the effects of differences in the age distributions of the population being compared [7].

Standardized incidence and mortality ratios were calculated using indirect age-adjusted rates [7]. The indirect method uses the age distribution of each population group and the age-specific rates for the standard population (State of Utah) to calculate the expected number of incidences (or deaths) if the rates of disease were constant as in the standard population. The observed number of incidences (or deaths) is then compared with the expected number of deaths (or incidences) in the study population, referred to as the Standardized Incidence Ratio (SIR) or the Standardized Mortality Ratio (SMR). This statistical ratio compares the observed counts to the expected counts to determine if there is a greater risk or a lower risk of acquiring a disease or condition compared to a control population (e.g., state of Utah). A SIR or SMR of one (1.0) indicates rates are equal and there is no increased risk. A SIR or SMR of greater than one (1.0) indicates an increased risk for the numerator population or study group, while a SIR or SMR less than one (1.0) indicates a decreased risk for the numerator population or study group.

The confidence interval for the SIR or SMR is the range of values for a calculated SIR or SMR with a specified probability (95%) of including the true SIR or SMR value. The specified probability is called the *confidence level*, and the endpoints of the confidence interval are called the *confidence limits*. In this case, the specified probability is ninety-five percent. Therefore, a ninety-five percent probability exists that the true value of the parameter of interest (SIR/SMR) will fall between the two endpoints of the confidence limits. By assessing the confidence interval, information about the variability of the data and the statistical significance of the SIR/SMR is obtained. The confidence interval was used as a surrogate test of statistical significance (p-value). Both the p-value function and the spread of the function can be determined from the confidence interval [8]. The difference between the observed versus the expected is considered significant if the confidence interval does not include one (1.0) and if the SIR/SMR is greater than one (1.0) The statistical methods used are discussed in more detail in Appendix C.

RESULTS

Several of the cancers and deaths in the analysis area were found to be significantly elevated during various time-year periods when compared to the state of Utah. A summary of the results is presented in Appendix D.

Cancer Incidence

All Asbestos-Related Cancers Combined

The rate of all asbestos-related malignant neoplasms in the two-mile radius analysis area and the state of Utah were fairly stable during the study period. Cancer rates in the two-mile analysis area were significantly elevated for all five time periods (1973-79, 1980-85, 1986-90, 1991-95, 1996-2000), with SIRs ranging from 1.15 to 1.56.

Malignant neoplasm of respiratory system and intrathoracic organs

Cancer rates in the two-mile radius analysis area for malignant neoplasm of respiratory system and intrathoracic organs were significantly elevated compared to state rates for the time periods 1980-85, 1986-90, 1996-2000, with SIRs ranging from 1.72 to 2.28.

Malignant neoplasm of lung and bronchus

Cancer rates for malignant neoplasm of the lung and bronchus in the two-mile radius analysis area were significantly elevated in all five time periods, (1973-79, 1980-85, 1986-90, 1991-95, 1996-2000), with SIRs ranging from 1.16 to 1.55.

Malignant neoplasm of peritoneum and retroperitoneum

Cancer rates for malignant neoplasm of the peritoneum and retroperitoneum were not significantly elevated in any of the analysis area and time periods analyzed. SIRs ranged from 0.40 to 0.98 in the two-mile radius analysis area.

Mesothelioma

Mesothelioma rates were not significantly elevated in the two-mile radius analysis area during any of the time periods evaluated. SIRs ranged from 0.34 to 2.26. All lower confidence intervals were less than one.

Malignant neoplasm of pleura

Statistical analysis of cancer of the pleura was not performed because of the small number of observed cases reported. Only two cases were observed in the two-mile radius analysis area and eleven cases in the state of Utah over the twenty-eight year period analyzed.

Mortality

All asbestos-related diseases

Mortality rates of asbestos related malignant neoplasms were significantly elevated in the two-mile radius analysis area during the first two time periods analyzed, 1973-79 and 1980-85, with SMRs of 1.18 and 1.44, respectively.

Malignant neoplasm of respiratory system and intrathoracic organs

Two periods exhibited significantly elevated mortality rates of malignant neoplasm of respiratory system and intrathoracic organs in the two-mile radius analysis area, 1980-85 and 1991-95, with SMRs of 2.97 and 2.48, respectively.

Malignant neoplasm of lung and bronchus

Mortality rates were significantly elevated in the two-mile radius analysis area during the first two time periods, 1973-79 and 1980-85, with SMRs of 1.20 and 1.38, respectively.

Malignant neoplasm of peritoneum and retroperitoneum

Only two deaths were observed in the two-mile radius analysis area and sixty-three in the state of Utah, therefore no statistical analysis was conducted for malignant neoplasm of peritoneum and retroperitoneum.

Malignant neoplasm of pleura

Only two deaths were observed in the two-mile radius analysis area and thirty-eight in the state of Utah; therefore, no statistical analysis was performed for malignant neoplasm of pleura.

Asbestosis

Only two deaths were observed in the two-mile radius analysis area and twenty-five in the state of Utah, therefore no statistical analysis was conducted for deaths due to asbestosis.

DISCUSSION

This investigation demonstrated elevated asbestos-related cancer incidence and deaths in the two-mile radius area of the Vermiculite Intermountain site during the time periods evaluated from 1973 through 2000. Cancers found to be significantly elevated in the two-mile radius analysis area include: respiratory system and intrathoracic organs (1980-85, 1986-90, and 1996-2000); lung and bronchial (1973-79, 1980-85, 1986-90, 1991-95, and 1996-2000); and all asbestos-related cancers combined (1973-79, 1980-85, 1986-90, 1991-95, and 1996-2000). Significantly elevated mortality rates of asbestos-related cancers combined include: respiratory system and intrathoracic organs (1980-85, and 1991-95); lung and bronchial (1973-79 and 1980-85); and all asbestos-related deaths combined (1976-79 and 1980-85).

Adjustments for possible confounding socioeconomic and demographic variables of race, ethnicity, household income, and age of housing could not be made because detailed case information was not available in the cancer registry data. Variables that were similar in the analysis area and in the state population are gender and housing value. In the analysis area, 50.5% of the population was male and 49.5% female in the two-mile area compared to 49.6% male and 50.4% female in the state of Utah. In the state of Utah, 31.1% had some college (no

degree) compared to 24.5% in the two-mile analysis area. The median housing value in the analysis area was equivalent to the state; $68,700 in the state of Utah and $68,004 in the two-mile analysis area.

There was a higher minority population and lower median household income in the analysis area compared to the state. The racial breakdown of the two-mile analysis area population is 70.3% White, 1.9% Black, 2.2% American Indian, Eskimo, or Aleut, 19.1% Asian or Pacific Islander and 6.5% other race. The racial breakdown for the state was 93.9% White, 0.6% Black, 1.4% American Indian, Eskimo, or Aleut, 1.9% Asian or Pacific Islander, and 2.2% other race. Hispanic population in the analysis area was 17% compared to 4.8% in the state of Utah. The two-mile analysis area had a lower median household income of $20,259 and a median age of housing of 1952 than the state of Utah with a median household income of $29,470 and a median age of housing of 1971.

There are multiple risk factors for most cancer types, which complicates the evaluation of asbestos-disease linkage because the degree to which other important risk factors occur in the study population is unknown. Factors considered in the development and etiology of most cancers that could not be evaluated in this investigation included latency period, population migration, and personal habits such as smoking. The latency or induction period for most adult cancers range from ten to 30 years after initial exposure. Therefore, ascertaining the place and time of carcinogenic exposure is difficult. Migration into and out of the analysis area also presents a problematic issue relative to exposure and latency. Information on lifestyle factors such as smoking was not available and could not be examined. The primary risk factor for lung cancer is tobacco smoking, accounting for more than 85% of all lung cancer cases [9]. Other risk factors for lung cancer include exposure to radon, environmental tobacco smoke, occupational exposure to radioactive ores, arsenic, fuels, and diesel exhaust [10].

For some cancer cases, the street address of their home at time of diagnosis is unknown. If only a post office box or zip code was provided for the home address of the case, the census tract in which the case was assigned was based on the center of the zip code of the mailing address that was available for the case at time of diagnosis. Therefore, there may be cases that were living within the analysis area that were coded as living outside the analysis area, or it is possible that cases were living outside the analysis area but were coded as living within the analysis area. However, this selection bias was considered to be small and would not likely affect the overall conclusion.

Asbestos-Related Health Effects

Asbestos is the name given to a group of six different fibrous minerals (amosite, chrysotile, crocidolite, and the fibrous varieties of tremolite, actinolite, and anthophylite) that occur naturally in the environment. Vermiculite from Libby was found to contain several types of asbestos fibers including the amphibole asbestos varieties tremolite and actinolite [11, 12].

Asbestos is primarily a health hazard through the inhalation of asbestos fibers in air. The Department of Health and Human Services (DHHS), the World Health Organization (WHO) and the EPA have determined that asbestos is a human carcinogen. Long-term exposure to asbestos

fibers through inhalation is associated with a buildup of scar-like tissue in the lungs known as asbestosis, and with lung cancer and a cancer of the lining of the lung (or pleura) and other internal organs known as mesothelioma. Mesothelioma is a cancer of the lining surrounding the lung (pleural membrane) or abdominal cavity (the peritoneum). Asbestosis is characterized by a gradual decline in respiratory function, coughing, and breathlessness. The time period between exposure to asbestos and the occurrence of lung disease or cancer is long. Latency periods for the development of asbestos-related nonmalignant respiratory effects are usually 15-40 years from the time of initial exposure to asbestos, generally 20 years or more for lung cancer and 30 years or more for mesothelioma due to asbestos exposure. Cigarette smoke and asbestos together significantly increase the chances of getting lung cancer [11,12].

Limitations

There are limitations to using population level data to examine the relationship between environmental exposures and chronic diseases including exposure misclassification and the inability to assess past personal exposure levels. Measurement of the actual personal exposure to the contamination as well as other relevant risk factors over time is critical information needed to assure a meaningful evaluation of the data. Because personal exposure information is not available, residential proximity to the vermiculite processing facilities was used as a surrogate for exposure. However, it is unlikely that all of the residents in the analysis area were exposed to the contamination.

This study also could not control for population migration in and out of the analysis area. The length of residence of each case is unknown, thereby potentially adding to exposure misclassification. No information is available on the length of time an individual may have lived at their address before diagnosis. It is possible that some cases are new, short-term residents with little or no exposure to the site. Furthermore, former residents who moved out of the analysis area just prior to diagnosis are not available for analysis. This study assumes that in and out migration of cases will offset each other.

Other limitations include lack of control for confounding factors (i.e., smoking status data), small number of cases, and under-reporting of cancer cases to the state registry. In addition, cancer is a chronic disease that takes many years after exposure to manifest as clinical disease. The information supplied by the Utah Cancer Registry provides only an address at time of diagnosis for each case.

CONCLUSIONS

Former workers at the Intermountain Insulation facility were likely exposed to airborne asbestos at levels of concern, although the level of exposures is unknown. The occupational exposure pathway for former workers exposed to airborne Libby asbestos in and around these facilities during handling and processing of vermiculite is considered a completed exposure pathway and was a public health hazard. In addition, workers may have exposed household members to asbestos fibers if they did not shower or change clothes before leaving work. Inhalation of airborne asbestos at elevated levels would increase the risk for asbestos-related disease. Because critical exposure information is lacking, past exposure to former employees and household

contacts is an indeterminate public health hazard. No public health hazard exists for current or future workers at the site. Under current conditions, on-site exposure to workers poses no public health hazard.

A potential exposure pathway existed for the community around the sites during the time the facilities processed Libby vermiculite (estimated from 1941 to 1987) could have been exposed to Libby asbestos fibers from plant emissions. Insufficient information is available to determine if these exposures occurred, how often they may have occurred, or what concentrations of airborne Libby asbestos may have been present during potential exposures. This information may never be available. Because critical information is lacking, these past community exposures are an indeterminate public health hazard. The Intermountain Insulation facility no longer processes vermiculite at the site and no evidence of onsite waste piles were observed during a site visit. The pathways for current or future community exposure to airborne Libby asbestos from facility emissions and to onsite waste piles have been eliminated and pose no public health hazard.

Cancer incidence and mortality rates in the two-mile radius analysis area for all asbestos-related cancers combined, cancer of the respiratory system and intrathoracic organs, and cancer of the lung and bronchus were significantly elevated during the time periods analyzed. It is unclear if the elevations in respiratory cancers in the two-mile radius analysis area may be due in part to environmental asbestos exposure or other exposures such as tobacco smoke.

Rates for mesothelioma and asbestosis, diseases directly related to asbestos exposure, were not elevated in the analysis area compared to the state of Utah. This suggests that exposure from the vermiculite processing facilities located in Salt Lake City likely was not a significant contributing factor to the increased rates observed in other asbestos-related cancers and diseases in the two-mile radius analysis area. However, asbestosis-related mortality is almost always found in workers with very high long-term exposure. It is unlikely that findings of excess environmental non-occupational asbestosis mortality would be observed in the two-mile radius analysis area. Mesothelioma is the most specific health endpoint of asbestos-related mortality. However, issues of latency and population migration limit this investigation with respect to mesothelioma mortality and incidence.

Factors that must be considered in the development and etiology of cancers, but that could not be evaluated in this investigation, include latency period, population migration, personal habits, diet, occupational exposures, and familial history of cancer. These issues limit the conclusions that can be drawn from this investigation.

RECOMMENDATIONS

The Utah Department of Health will reanalyze the data when an additional five years of cancer and mortality data become available. The Utah Department of Health will also review mesothelioma case records (e.g., death certificates and cancer registry records) to determine if occupation is recorded for these cases.

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15. United States Environmental Protection Agency, PacifiCorp Property Libby Amphibole Asbestos Cleanup Final Report, Utah Power 3rd West Substation, 147 South 400 West, Salt Lake City, Utah. September 14, 2005.

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CERTIFICATION

This health consultation, **Epidemiological Investigation of Human Exposure To a Contaminated Vermiculite Ore processing Site in Utah,** was prepared by the Utah Department of Health, Environmental Epidemiology Program under a cooperative agreement with the 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 begun. Editorial review was completed by the cooperative agreement partner.

Jennifer Freed
Technical Project Officer, DHAC, ATSDR

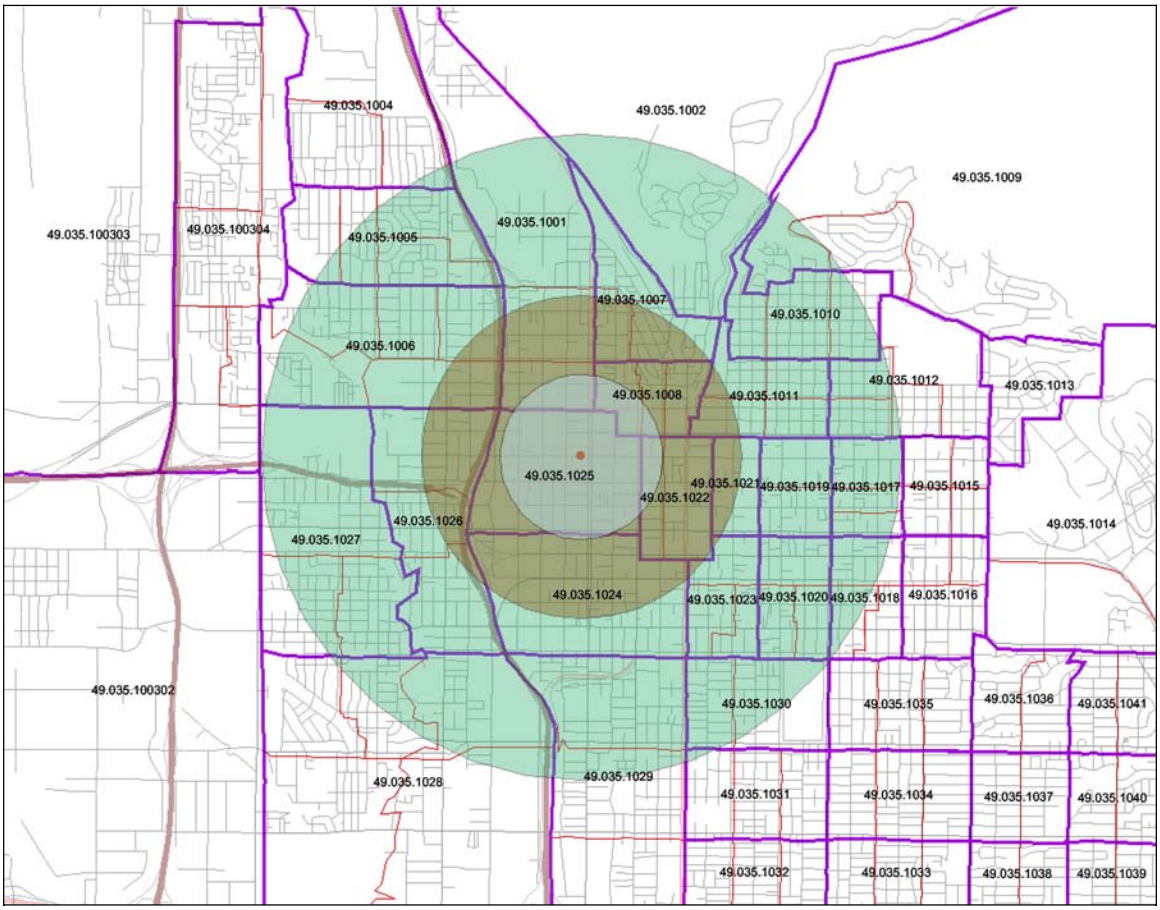
The Division of Health Assessment and Consultation, ATSDR, has reviewed this health consultation and concurs with its findings.

Alan Yarbrough
Cooperative Agreement Team Leader, DHAC, ATSDR

APPENDIX A

Map of Analysis Area Census Tracts

Map 1. Map of the two-mile radius analysis area, showing census tracts.



Map 2. Map of Utah, showing Davis, Salt Lake, and Utah Counties.

APPENDIX B

Population Estimates

The intercensal population estimates for the two-mile radius analysis area for the years 1970 through 2000. Based on linear regression with 1970, 1980, 1990, and 2000 U.S. Census data for Census Tracts 1001, 1002, 1005–1012, 1017-1030.

	Total	**Male**	**Female**
1970	3230	1453	1777
1971	3360	1526	1834
1972	3490	1599	1891
1973	3621	1673	1948
1974	3751	1746	2005
1975	3881	1819	2062
1976	4011	1892	2119
1977	4141	1965	2176
1978	4272	2039	2233
1979	4402	2112	2290
1980	4532	2185	2347
1981	4662	2258	2404
1982	4792	2331	2461
1983	4923	2405	2518
1984	5053	2478	2575
1985	5183	2551	2632
1986	5313	2624	2689
1987	5443	2697	2746
1988	5574	2771	2803
1989	5704	2844	2860
1990	5834	2917	2917
1991	5964	2990	2974
1992	6094	3063	3031
1993	6225	3137	3088
1994	6355	3210	3145
1995	6485	3283	3202
1996	6615	3356	3259
1997	6745	3429	3316
1998	6876	3503	3373
1999	7006	3576	3430
2000	7136	3649	3487

APPENDIX C

Statistical Methods

Standardized incidence and mortality ratios were calculated using indirect age-adjusted rates. The indirect method uses the age distribution of each population group and the age-specific rates for the standard population (State of Utah) to calculate the expected number of incidences (or deaths) if the rates of disease were constant as in the standard population. The observed number of incidences (or deaths) is then compared with the expected number of deaths (or incidences) in the study population, referred to as the Standardized Incidence Ratio (SIR) or the Standardized Mortality Ratio (SMR). The formula for this ratio = $\sum p_{ia}n_{ia}/\sum p_{is}n_{ia}$

Where: a=area chosen as the analysis area (two-mile radius)
s=area chosen as a reference standard (state of Utah)
n_{ia}=number of individuals in ith class of the analysis area
n_{is}=number of individuals in ith class of standard area (state of Utah)
x_{ia}=number of cases or deaths in ith age class of area a (similarly for s)
$p_{ia}=x_{ia}/n_{ia}$=incidence or death rate in ith age class of area a (similarly for s)

Harold A. Kahn and Christopher T. Sempos, "Statistical Methods in Epidemiology", Oxford University Press, 1989, pp 85-136.

The confidence interval for the SIR or SMR is the range of values for a calculated SIR or SMR with a specified probability (95%) of including the true SIR or SMR value:

$$\frac{\left[\sqrt{n} \pm (1.96 \text{ X } 0.5)\right]^2}{x}$$

Where *n* is the Number of Observed.
x is the Number of Expected.

Frumkin, H., Kantrowitz, W. (1987) Cancer Clusters in the Workplace: An Approach to Investigation. *Journal of Occupational Medicine,* Vol. 29 (No. 12):949-952.

The confidence interval is used as a surrogate test of statistical significance (p-value). Both the p-value function and the spread of the function can be determined from the confidence interval. The difference between the observed versus the expected is considered significant if the confidence interval does not include one (1.0) and if the SIR is greater than one (1.0).

Rothman, K.J. and Greenland, S. (1998) Modern Epidemiology, 2nd Edition, Lippincott-Raven Publishers, Philadelphia, PA.

Direct Age-Adjusted Rates

Direct age-adjusted rates for the analysis area and the State of Utah were calculated and compared. By using age-adjusted rates, any difference between the rates would not be due to difference in age distribution in the analysis area and the State of Utah.

Age adjusting was conducted using the 2000 US Standard Population. The age-adjusted rate was calculated by multiplying the age-specific crude rates for the analysis area and the State of Utah by the corresponding age group 2000 US Standard Population proportion. The 2000 US Standard Population is presented below:

Age Group	2000 US Standard Population	Proportion of Standard Million
0-4	69135	0.069135
5,9	72532	0.072532
10,14	73033	0.073033
15-19	72168	0.072168
20-24	66478	0.066478
25-34	135573	0.135573
35-44	162613	0.162613
45-54	134834	0.134834
55-64	87247	0.087247
65-74	66037	0.066037
75+	60350	0.06035
	1000000	1

CDC, Centers for Disease Control (1998). Age Standardization of Death Rates: Implementation of the Year 2000 Standard. *National Vital Statistics Reports*, Vol. 47 (No. 3):1-16.

APPENDIX D

Tables

All Asbestos-Related Cancers Combined

Table 1. Age-adjusted Incidence Rates (per 100,000 person years) and Standardized Incidence Ratios for all asbestos-related cancers combined in the **two-mile radius** compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
2-mile radius rates	49	54.5	51.8	53.1	54.5
State of Utah rates	33.6	35.3	35.7	36.4	23.9
Observed Cases in Analysis Area	274	235	178	186	184
Expected Number of Cases	188.2	155.5	126.9	127.1	118.0
Standardized Incidence Ratio (SIR)	1.46	1.51	1.40	1.46	1.56
SIR 95% Confidence Interval	1.29-1.64	1.33-1.71	1.21-1.62	1.26-1.69	1.35-1.80

Cancer of the Peritoneum and Retroperitoneum

Table 2. Age-Adjusted Incidence Rates (Per 100,000 person years) and Standardized Incidence Ratios for cancer of the peritoneum and retroperitoneum in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Incidence Rates	1.1	0.2	0.7	0.3	0.6
State of Utah Incidence Rates	1.3	0.3	0.6	0.7	0.9
Observed Cases in Analysis Area	5	1	2	1	2
Expected Number of Cases	8.00	1.6	2.0	2.5	3.3
Standardized Incidence Ratio (SIR)	0.63	0.63	0.98	0.40	0.61
SIR 95% Confidence Interval	0.24-1.37	0.06-2.91	0.20-3.21	0.04-1.86	0.12-1.94

Cancer of the Respiratory System and Intrathoracic Organs

Table 3. Age-Adjusted Incidence Rates (Per 100,000 person years) and Standardized Incidence Ratios for cancer of the respiratory system and intrathoracic organs in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Incidence Rates	4.5	5.1	6.9	4.7	4.8
State of Utah Incidence Rates	3.6	3	3.3	2.8	2.2
Observed Cases In Analysis Area	24	22	20	15	17
Expected Number of Cases	20.4	12.8	11.5	9.6	7.5
Standardized Incidence Ratio (SIR)	1.18	1.72	1.74	1.56	2.28
SIR 95% Confidence Interval	0.77-1.72	1.11-2.56	1.10-2.63	0.91-2.51	1.37-3.55

Cancer of the Lung and Bronchus

Table 4. Age-Adjusted Incidence Rates (Per 100,000 person years) and Standardized Incidence Ratios for cancer of the lung and bronchus in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Incidence Rates	42.4	48.7	43.9	47.1	47.7
State of Utah Incidence Rates	28.2	31.1	31	32	20.8
Observed Cases in Analysis Area	239	210	155	166	160
Expected Number of Cases	157.0	137.6	110.5	111.7	103.1
Standardized Incidence Ratio (SIR)	1.52	1.53	1.42	1.49	1.55
SIR 95% Confidence Interval	1.34-1.73	1.33-1.74	1.20-1.64	1.27-1.73	1.33-1.81

Mesothelioma

Table 5. Age-Adjusted Incidence Rates (Per 100,000 person years) and Standardized Incidence Ratios for mesothelioma in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Incidence Rates	1	0.4	0.3	0.8	1.2
State of Utah Incidence Rates	0.5	0.8	0.8	0.9	1.1
Observed Cases in Analysis Area	6	2	1	3	4
Expected Number of Cases	2.7	3.3	2.9	3.2	4.0
Standardized Incidence Ratio (SIR)	2.26	0.60	0.34	0.94	1.01
SIR 95% Confidence Interval	0.92-4.58	0.12-1.94	0.03-1.61	0.26-2.50	0.33-2.38

Mortality of All Asbestos-related Diseases

Table 6. Age-adjusted mortality rates and Standardized Mortality Ratios of all asbestos-related deaths in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Mortality Rates	35.3	36.5	31.5	29	32.4
State of Utah Mortality Rates	22.4	24.7	26.9	27.9	26.9
Observed Cases in Analysis Area	182	160	112	103	111
Expected Number of Cases	118.0	110.9	96.9	98.6	92.9
Standardized Mortality Ratio (SMR)	1.54	1.44	1.56	1.05	1.19
SIR 95% Confidence Interval	1.33-1.78	1.23-1.68	0.96-1.39	0.86-1.26	0.99-1.43

Mortality of Malignant Neoplasm of Respiratory System and Intrathoracic Organs

Table 7. Age-adjusted mortality rates (Per 100,000 Person Years) and Standardized Mortality Ratios for malignant neoplasm of respiratory system and intrathoracic organs in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Mortality Rates	1.5	3.1	0.6	2	1.5
State of Utah Mortality Rates	1.2	1	1	0.8	0.7
Observed Cases in Analysis Area	8	13	2	7	5
Expected Number of Cases	6.0	4.4	3.4	2.8	2.3
Standardized Mortality Ratio (SMR)	1.33	2.97	0.60	2.48	2.22
SIR 95% Confidence Interval	0.63-2.52	1.65-4.91	0.12-1.89	1.11-4.91	0.83-4.77

Mortality of Malignant Neoplasm of Lung and Bronchus

Table 8. Age-adjusted mortality rates (Per 100,000 Person Years) and Standardized Mortality Ratios for malignant neoplasm of lung and bronchus in the **two-mile radius** analysis area compared to the state of Utah, 1973-2000.

Time Periods	**1973-79**	**1980-85**	**1986-90**	**1991-95**	**1996-2000**
Two-Mile Radius Mortality Rates	33.5	33.1	30.4	26.7	31
State of Utah Mortality Rates	20.8	23.5	25.5	26.6	25.7
Observed Cases In Analysis Area	172	146	108	95	106
Expected Number of Cases	109.9	105.7	92.2	93.9	88.9
Standardized Mortality Ratio (SMR)	1.57	1.38	1.17	1.01	1.19
SIR 95% Confidence Interval	1.34-1.81	1.17-1.62	0.97-1.41	0.82-1.23	0.98-1.44