# Health Consultation

NATIONAL GYPSUM FACILITY

1850 PIER B STREET
LONG BEACH, LOS ANGELES COUNTY, CALIFORNIA

EPA FACILITY ID: CAD981456957

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

**Health Consultation: A Note of Explanation**

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

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

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Prepared by:

Department of Health Services
Under Cooperative Agreement with the
The Agency for Toxic Substances and Disease Registry

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## Foreword

Vermiculite was mined and processed in Libby, Montana, from the early 1920s until 1990. We now know that this vermiculite, which was shipped to many locations around the U.S. for processing, contained asbestos. Because human exposure to asbestos has possibly occurred in communities near these facilities, ATSDR's Division of Health Studies initiated the Vermiculite Health Statistics Review, a project designed to screen for similar impacts on the health of populations living near all facilities that received shipments of Libby vermiculite from the WR Grace mine and Company. As part of that effort, the Environmental Health Investigation Branch (EHIB) of the California Department of Health Services (CDHS) received funding to conduct health statistics reviews on communities located near facilities that received Libby vermiculite.

CDHS also has a cooperative agreement with ATSDR to conduct public health assessments and consultations (exposure assessments) around sites where hazardous chemicals are used or hazardous waste is present. In this health consultation, CDHS presents the findings of the Health Statistics Review and an evaluation of the environmental data, exposure pathways, and toxicological information. The objectives of the health consultation are to:

1. determine the possible pathways of past, current, and future exposure to workers and the community from Libby asbestos used at the National Gypsum site using available environmental data and researching the wallboard production process;
2. review the toxicological implications for those exposure pathways where exposure is or has occurred and for which there is environmental data that can be used to evaluate the health implications;
3. identify the residential area at highest risk of exposure to hazardous levels of asbestos from the use of Libby vermiculite at National Gypsum;
4. determine whether the population living in this area had higher incidence rates of asbestos-related cancers than the U.S. population; and
5. determine whether the population residing in this area had higher mortality rates from asbestos-related disease than the U.S. population.

**Asbestos and Asbestos-Related Disease**

Asbestos is the name of a group of minerals that occur naturally in the environment. Asbestos minerals have long, thin, and separable fibers. Asbestos fibers do not evaporate into air or dissolve in water, and they are resistant to heat, fire, and chemical and biological degradation (1). Small diameter fibers and fiber-containing particles may remain in the air for a long time and may be carried long distances by wind or water currents before settling to the ground (1).

Asbestos fibers can enter the body when inhaled (breathed in) or ingested (eaten or drunk). When asbestos fibers are inhaled, some of the fibers can become lodged in the lungs. Because asbestos fibers are very durable, they remain in lung tissue throughout life. Asbestos fibers can accumulate in lung tissue and cause scarring and inflammation. Repeated scarring and inflammation can affect breathing and lead to disease such as respiratory disease and cancer. Asbestos exposure may also cause gastrointestinal cancers.

Exposure to asbestos does not cause disease immediately; instead, disease develops many years later. The time period between when someone is first exposed to asbestos and when they develop disease is called the latency period.

## Background

In 1881, miners searching for gold unearthed a mica-like material from an area 7 miles northeast of the town of Libby, Montana. It was not until 1919 that a local businessman discovered the unique properties of this mineral: while he was walking through an abandoned mine, his torch contacted the surface of the mine, resulting in an expansion or "popping" of the vermiculite. The newly formed Zonolite Company opened a mine at this location during the following year. Since then, vermiculite has been marketed for many uses, such as loose-fill insulation, fireproofing, a fertilizer carrier, a soil conditioner, and an aggregate in many construction products.

WR Grace and Company purchased the vermiculite mine from the Zonolite Company in 1963 and expanded operations. Between the 1960s and 1980s, as much as 80% of the vermiculite used worldwide came from the WR Grace and Company mine near Libby (2). (Vermiculite from the WR Grace and Company mine near Libby will be referred to as Libby vermiculite in this document.) Much of the vermiculite from the WR Grace and Company mine in Libby was used to produce attic insulation products, often sold under the brand name Zonolite. Vermiculite was commonly sold in gardening and hardware stores. It was used as a soil amendment (a conditioner to improve soil quality), fertilizer carrier, and was an ingredient in many potting soil mixes. Vermiculite was also used in fireproofing materials, gypsum wallboard, and as a lightweight aggregate in construction materials (3). WR Grace and Company mining operations in Libby, MT, closed in 1990, and the last shipments of Libby vermiculite occurred in 1992 (4).

During the time the mine was operating, Libby vermiculite was shipped to over 200 locations in 30 states in this country for processing or packaging. Twenty of these facilities were located in California, including the National Gypsum Company in Long Beach, California. (This facility will be referred to as National Gypsum in this document.) About 516 tons of Libby vermiculite were shipped to National Gypsum between July 1970 and August 1977 (5). National Gypsum used the Libby vermiculite to produce fire-resistant wallboard (6).

All vermiculite contains a range of other minerals that were formed along with the vermiculite in the rock. The vermiculite found near Libby contains 21 to 26% asbestos (7), a mineral that is toxic to humans when it is inhaled (breathed in). There are different kinds of asbestos. The kind of asbestos in Libby vermiculite is a combination of tremolite, actinolite, richerite, and winchite asbestos. National Gypsum received grade 4 Libby vermiculite, which means it contained 0.3 to 1% fibrous tremolite-actinolite (by mass) (8). (The asbestos contained in Libby vermiculite will be referred to as Libby asbestos in this document.)

In 1999, a series of *Seattle Post-Intelligencer* articles about high rates of asbestos-related disease brought national attention to the WR Grace and Company vermiculite mine in Libby, Montana. The Agency for Toxic Substances and Disease Registry (ATSDR), in cooperation with the Montana Department of Public Health and Human Services, analyzed mortality statistics (information on causes of death obtained from death certificates) for the Libby community for a 20-year period (1979–1998). This review found that death due to asbestosis was 40 times more common in the Libby population than in the rest of the state of Montana, and 80 times more common than in the rest of the U.S. population. Death due to lung cancer was 20 to 30% (1.2 to 1.3 times) higher than expected. Although rates of mesothelioma were elevated, it was not

possible to quantify by how much. Still, these elevations were high enough that they were considered unlikely to have been due to natural fluctuations in the occurrence of these diseases (9). Findings from the review of mortality statistics led to several follow-up activities to address the health impacts to those who lived and worked in Libby (10, 11), one of which is the Vermiculite Health Statistics Review.

Health statistics reviews are statistical analyses of information from cancer registry and death certificate records that investigate whether people in a particular community have developed cancer or have died from a particular disease more often than another comparison population. The health statistics reviews are being conducted in communities located near facilities that received Libby vermiculite, regardless of whether that community was in fact exposed to hazardous levels of asbestos from the vermiculite. (Usually, reviews of health information are conducted only when exposure to a harmful chemical is known to have occurred.) Communities are being screened because, given the experience in the Libby community, it is not unrealistic to think that exposure to levels of asbestos high enough to have caused disease might have occurred.

Finding an excess of asbestos-related cancers or disease in a community would alert ATSDR and CDHS to the possibility that workers or community members might have been exposed to hazardous levels of asbestos as a result of the facility's handling or processing of Libby vermiculite. If, however, the health statistics review does not find an excess of asbestos-related disease, this does not prove that the community was not exposed to Libby asbestos.

**National Gypsum Operations and Worker and Community Exposure to Asbestos**

According to invoices from the Libby, Montana mine, 516 tons of Libby vermiculite were shipped to National Gypsum at 1850 Pier B Street site in Long Beach between July 1970 and August 1977 (5). The National Gypsum site is located on approximately 4 acres of land. The facility that currently occupies this location is owned by New National Gypsum Company (6). The site was formerly owned and occupied by a different company who used the same business name, National Gypsum Company. New National Gypsum acquired the site in March 1993 following the bankruptcy declaration of National Gypsum in October 1990. Prior to the development of the National Gypsum facility, the site has been reported to be swampland. From December 1964 until October 1990, National Gypsum conducted their operations on the site. New National Gypsum currently has a lease extending to November 30, 2024, from the Long Beach Port Authority for their present operations.

National Gypsum manufactured gypsum wallboard, a building product. Most gypsum wallboard does not contain vermiculite. Vermiculite is added to stucco to create a gypsum board that is considered fire resistant. Approximately 28% of wallboard manufacturing is fire resistant (12). In certain situations, building codes require the use of fire resistant wallboard. Adding vermiculite to gypsum keeps the wallboard from collapsing during a fire. In a fire, the gypsum in the wallboard becomes dehydrated (removal of water). Dehydrated gypsum is not rigid. In the heat of a fire, the vermiculite added to the gypsum will expand, and thus help to create stability in the wallboard while the gypsum is becoming dehydrated and collapsing.

## Discussion

Asbestos fibers were released to the workplace air during the handling and use of vermiculite in the production of fire resistant gypsum wallboard at National Gypsum. People who worked at National Gypsum between July 1970 and late 1977 could have been exposed to hazardous levels of asbestos. People who lived with former workers might also have been exposed to hazardous levels of asbestos from fibers carried home on workers' hair and clothing. It is also possible that people who lived near the National Gypsum facility between July 1970 and late 1977 were exposed to hazardous levels of asbestos from Libby vermiculite.

The National Gypsum facility no longer handles or uses vermiculite. However, people who currently work at the facility could be exposed to hazardous levels of asbestos if the areas of asbestos-contaminated soil outside the facility are disturbed through excavation or other development activities. Current operations at the National Gypsum facility are not causing community exposure to asbestos from Libby vermiculite. There is a lack of information to thoroughly investigate the historical exposures. In order to investigate these exposures, CDHS researched the handling and use of vermiculite in gypsum wallboard production at National Gypsum and reviewed air sampling conducted at a gypsum wall production facility and recent sampling data gathered from the National Gypsum site.

### Vermiculite Use and Handling in Wallboard Manufacture

In May 2004, personnel from ATSDR, CDHS, and the CDHS Occupational Health Branch (OHB), toured a gypsum wallboard facility (note: a different facility than the National Gypsum facility in Long Beach) (13). The purpose of the tour was to assess the wallboard manufacturing process for the potential to release Libby asbestos into the neighboring communities. Staff from the three agencies observed the entire wallboard manufacturing process, including the mixing of the dry ingredients, the production of the wallboard, cutting the wallboard, and storage and shipping procedures. It should be noted that the process viewed by investigators may differ significantly from the process in use when Libby vermiculite was handled. However, interviews were conducted with employees who were present during the 1970s and/or 1980s to obtain information about how vermiculite was handled during that time at the particular facility visited by investigators. It is possible that the two gypsum wallboard facilities (i.e., the one where observations were recently made versus the National Gypsum facility in Long Beach) differed in terms of process, for example, how vermiculite was delivered to or handled within the facility, or how ventilation controls may or may not have been used.

Gypsum wallboard is manufactured in the following steps:

1. gypsum rock is crushed to form small pieces, dried to evaporate surface moisture, and ground;
2. the dried gypsum is "calcined" or heated to remove excess water that is chemically bonded to the gypsum, forming what is called "stucco;"
3. dry additives (e.g., vermiculite, perlite, starch, fiberglass, sugar) are mixed into the stucco depending on the properties needed in the specific product;
4. water is added to produce a slurry;

5. the slurry is mechanically spread over a paper backing;
6. a top layer of paper backing is applied to form a "sandwich" with the slurry in the middle;
7. the long, continuous sheet of wallboard moves on conveyor belts while the slurry hardens, and the sheets are cut into specified lengths;
8. the cut boards are flipped and sent into a multi-stage kiln to dry and become hard; and
9. the hardened wallboards are trimmed to an exact length, end-taped, stacked, and placed onto skids, ready to be shipped.

Dust from the vermiculite may become airborne within the facility at several stages in the manufacturing process, including: 1) when the raw material first arrives at the facility, depending on the way it is packaged and handled; 2) when vermiculite is introduced into a batch; 3) when any spilled or released vermiculite or mixture of dry ingredients is cleaned up; and 4) during maintenance of the ventilation system, dust collector, or other equipment in the facility where dry material is present. In addition, airborne dust may escape from the facility itself through openings to the outdoor air.

At the wallboard plant visited by investigators, employees stated that Libby vermiculite was delivered in 50-pound (lb) paper bags that were lifted manually, slit open, and dumped into a hopper (13). The worker whose primary responsibility was to fill the hopper with the vermiculate will be referred to as the "hopper filler." When the hopper filler dumped the dry vermiculite into the hopper, there was the potential for a significant amount of dust to be generated. This is particularly true if local exhaust ventilation was not present or was inadequate. Investigators could not determine if local exhaust ventilation on the hopper had been present in the past at the site visited, although it is in place currently and is connected into a dust capture device (baghouse). Workers present during the 1970s at the site reported that, whether or not local exhaust ventilation was present, they remember seeing a visible cloud of dust whenever the vermiculite bag was dumped. During their site visit in 2004, investigators still observed substantial dry material (much of it gypsum but presumably with some percentage of additives as well) near the mixing hoppers and mixing tank. The observed cutting and shipping areas were similarly covered in beige-colored dust, although to a lesser degree than the mixing area and blending areas. Investigators noted visible dust in the air when outdoor sunlight shined in through the factory windows, suggesting that exposure to airborne dust could continue during the shift, even when vermiculite was not being handled directly.

Exposure to dust that contained vermiculite (and asbestos) could occur when any clean-up tasks or tasks involving maintenance of equipment in dusty areas were conducted. Although clean-up and equipment maintenance processes were not observed, dry clean-up methods such as sweeping were reportedly used in the past (13). Dry sweeping would be expected to generate significant levels of dust into the air.

In addition to exposure to dust occurring within the plant, there is the potential for community exposure due to escape of dry ingredients from a wallboard manufacturing facility, through open doors or windows, or from railcars if that was the method of vermiculite product delivery. At the facility visited by investigators, it was reported that there had been several community complaints over the years regarding the amount of dust present in the neighborhood (13).

**Laboratory Methods for Detecting Asbestos**

The detection and analysis of asbestos in samples involves both fiber quantification and mineral identification. A fiber is defined as any particle with a length greater than 5 micrometers (μm) and a length: width ratio greater than 3:1 in air or greater than 5:1 in soil or dust (1). A number of different analytical methods are used to characterize the presence of asbestos and each method has its advantages and disadvantages. For air, sample fiber quantification is traditionally done through phase contrast microscopy (PCM). PCM does not accurately distinguish between asbestos and non-asbestos fibers, and cannot detect fibers thinner than about 0.25 μm. PCM measurements are reported in fibers per milliliter (f/ml). Polarized light microscopy (PLM) uses polarized light to compare refractive indices of minerals to distinguish the asbestos fibers from other minerals. PLM can detect fibers with lengths greater than 1 μm with detection limits around 0.25-1% asbestos. PLM is often used to determine asbestos content in bulk samples. PLM results are reported as percent asbestos (%). Scanning electron microscopy (SEM) and, more commonly, transmission electron microscopy (TEM) are more sensitive methods that can detect smaller fibers than PLM. However, one disadvantage of electron microscopy is that it is not easily used to measure fibers in soil. TEM and SEM results are expressed as structures per square centimeter for dust ($s/cm^2$) and structures per centimeter cubed ($s/cm^3$) or structures per cubic centimeter (s/cc) for air. Electron diffraction and energy-dispersive x-ray methods can determine crystal structure and elemental composition and are used to identify the mineral group to which a fiber or particle belongs. For risk assessment purposes, the correlation between these different analytical methods is poor and conversion factors between the different measurements have not been fully accepted by the U.S. Environmental Protection Agency (USEPA).

However, the gypsum material itself is very dusty, and the extent to which Libby asbestos may have been contained in the released dust is unknown.

It is highly likely that family members of workers at wallboard plants using Libby vermiculite were exposed to asbestos carried home from the workplace on the clothing, shoes, or bodies of workers. At the plant visited, workers reported it was commonplace in the 1970s and 1980s for workers to wear dusty clothing home (13).

**Sampling for Worker Exposure at a Gypsum Wallboard Facility**

No sampling of the air when Libby vermiculite was used at the National Gypsum facility was available for review. However, at another gypsum facility, the gypsum manufacturer conducted short-term (15- minute) air sampling in the area of the dry ingredient mixing when an employee was dumping Libby vermiculite into the hopper (14). The air samples were collected in 1965. The air samples showed 50 to 70 fibers per cubic centimeter (f/cc). No further air sampling data was available. It is not clear if the air sampling conducted at the other gypsum facility would be directly applicable to National Gypsum; however, at the facility visited, the process involved an employee physically lifting a 50-pound bag and emptying it into the hopper.

**Sampling on the National Gypsum Property**

In order to determine if any clean-up of Libby asbestos was needed at the National Gypsum site, the U.S. Environmental Protection Agency (USEPA) directed their contractor to sample the facility (15). In 2000, sampling activities were conducted to assess whether site soil,

dust, and ambient air at the National Gypsum site contained traces of tremolite/actinolite asbestos which could have come from Libby. There is no test specific for Libby asbestos.

Soil and dust contaminated with asbestos has been shown to re-suspend asbestos when the soil or dust is disturbed. Once suspended in the air, the dust may travel with local wind currents where workers and residents in nearby communities may be exposed by breathing the air. Asbestos fibers can enter the body through inhalation (breathing) or ingestion (eating or drinking).

### *Soil Sampling*

Sixteen soil samples (including one duplicate) were collected from the site along the rail track that enters the warehouse portion of the production building (15). The samples were analyzed by Polarized Light Microscopy (PLM). A trace amount (less than 1 percent by visual estimate) of tremolite/actionlite asbestos was detected in one sample and trace levels of chrysotile asbestos were detected in two of the soil samples. These trace level samples were taken from soil along the railroad track inside the production building.

### *Microvacuum Dust Sampling*

Five composite microvacuum dust samples were collected from surfaces within the production building. Samples were analyzed using transmission electron microscopy (TEM) (15). Chrysotile asbestos structures were identified in three of the five samples. These samples were collected within the warehouse on the mezzanine level, near the mixer area, and at the wallboard area. Concentrations ranged from 56,600 structures per square centimeter (s/cm$^2$) up to 113,000 s/cm$^2$. No actinolite/tremolite asbestos structures were detected in any of the microvacuum dust samples. Two samples, which had no asbestos at an analytical sensitivity of 56,600 s/cm$^2$, were re-analyzed using Scanning Microscopy and Energy Dispersive X-ray Spectroscopy (SEM), as a means to achieve lower analytical sensitivities. SEM detected no asbestos at analytical sensitivities of 5,964 s/cm$^2$and 29,822 s/cm$^2$, respectively.

### *Ambient Air Sampling*

Five ambient air samples were collected from the interior of the production building. Samples were analyzed using TEM (15). No asbestos structures were detected in any of the ambient air samples. Analytical sensitivity ranged from 0.0016 structures per cubic centimeter (s/cm$^3$) to 0.0425 s/cm$^3$. These results indicate that no asbestos is currently airborne in the site buildings.

## Exposure Pathway and Health Implications

An exposure pathway is how a person comes in contact with chemicals originating from a source of contamination. Every exposure pathway consists of the following five elements: 1) a source of contamination; 2) a media such as air or soil through which the contaminant is transported; 3) a point of exposure where people can contact the contaminant; 4) a route of exposure by which the contaminant enters or contacts the people; and 5) a receptor population. A pathway is considered complete if all five elements are present and connected (see Appendix A for definitions). A pathway is considered potential if the pathway elements are (or were) likely present, but

insufficient information is available to confirm or characterize the pathway elements. A pathway may also be considered potential if it is currently missing one or more of the pathway elements, but the element(s) could easily be present at some point in time. A pathway may be considered eliminated if one or more of the pathway elements are missing and it is likely that the elements were never present and not likely to be present at a later point in time.

CDHS identified several exposure pathways for gypsum manufacturing facilities. All pathways have a common source (vermiculite from Libby contaminated with Libby asbestos) and a common route of exposure, inhalation. Although asbestos ingestion and dermal exposure could exist, health risks from these pathways are minor in comparison to those resulting from inhalation exposure to asbestos and will not be evaluated.

The exposure pathways considered for this site are listed in the following table. An evaluation of the pathways for this site is presented in the following paragraphs.

**Summary of Pathways Considered for the National Gypsum Plant**

| Pathway Name | Exposure Scenario(s) | Past (July 1970 to Late 1977) Pathway Status | From Late 1977 to Present Pathway Status | Future Pathway Status |
|---|---|---|---|---|
| Occupational | Workers exposed to airborne asbestos during handling and use of Libby vermiculite (mid-1970s to late 1977) | Complete | Not applicable | Not applicable |
| | Workers exposed to airborne asbestos from residual Libby vermiculite inside the National Gypsum facility (after 1977) | Not applicable | Eliminated for Libby asbestos<br><br>Potential for another kind of asbestos (chrysotile) | Eliminated for Libby asbestos<br><br>Potential for another kind of asbestos (chrysotile) |
| Onsite Soils | Onsite workers or contractors disturbing contaminated onsite soils containing residual Libby vermiculite | Potential | Potential | Potential |
| Household Contact | Household contacts exposed to airborne asbestos brought home on workers clothing after they worked with Libby vermiculite | Potential | Eliminated | Eliminated |
| Ambient Air | Community members or nearby workers exposed to airborne asbestos from plant emissions during handling and use of Libby vermiculite | Potential | Eliminated | Eliminated |
| Wallboard | Community members, contractors, and repairman disturbing wallboard containing Libby vermiculite | Potential | Potential | Potential |

***Occupational (Past National Gypsum Employees)***

Occupational exposure for people who worked at the National Gypsum facility when Libby vermiculite was used at the plant (July 1970 to late 1977) is considered a completed pathway. In particular, the employees whose job it was to unload the Libby vermiculite from the railroad car into bags and who dumped the bags of Libby vermiculite into the hopper would be exposed to

the greatest amount. Data from another gypsum facility showed that the asbestos levels in the air during the filling of the hopper were 5 to 7 times (50 to 70 f/cc) the Occupational Safety and Health Administration (OSHA) ceiling limit (10 f/cc) that was adopted in 1971 (14). This exposure was measured at the filling events, thus the total exposure for a particular shift depends on how often the employee fills the hopper per shift, how long it takes them to fill the hopper, how long the fibers stay in the air after the filling event, and how long the employee stays in the area where the Libby vermiculite is airborne.

Occupational exposure is regulated by the federal OSHA. OSHA's current permissible exposure limit (PEL) is 0.1 f/cc when determined using PCM (16). This value represents a time-weighted average (TWA) exposure level based on 8 hours a day for a 40-hour work week. In addition, OSHA has defined an excursion limit in which no worker should be exposed in excess of 1 f/cc as averaged over a sampling period of 30 minutes (17). Historically, the OSHA PEL has decreased from an initial standard of 12 f/cc established in 1971 (18). The PELs prior to 1983 were determined on the basis of empirical worker health observations, while the levels set from 1983 forward employed a form of quantitative risk assessment. ATSDR has used the current PEL of 0.1 f/cc as a reference point for evaluating asbestos inhalation exposure of past workers (18).

In order to compare the concentration of air measured in that 15-minute period when the vermiculite was being dumped into the hopper (14) to the current PEL, it is necessary to convert to the concentration to a time weighted average for an 8-hour day and 40-hour work week. In order to make this conversion, it is necessary to make use of some known information and to make some assumptions. According to interviews with workers at the gypsum facility inspected by CDHS and ATSDR staff (13), a worker (hopper filler) might fill the hopper one time per shift when the facility was producing fire-resistant wallboard. Assuming it takes 15 minutes to fill the hopper, after which the hopper filler leaves the dry ingredient area, ending any significant exposure to asbestos. This means that the exposure in the 15-minute period would then be averaged over 8 hours. This results in a time-weighted concentration for the hopper filler of 1.56 to 2.19 f/cc. This amount of asbestos exceeds the current PEL though it did not exceed the PEL at the time the air sample was taken.

CDHS evaluated the two main concerns for the hopper filler exposed to asbestos, cancer, and non-cancerous respiratory problems:

***Non-Cancerous Respiratory Problems***

Deposition of asbestos fibers in the lung can lead to substantial non-cancerous, fibrotic injury and may even cause death. This disease, called asbestosis, results from a prolonged inflammatory response stimulated by the presence of the fibers in the lung. Signs of fibrosis and increased mortality associated with asbestosis or non-cancerous disease have been observed in groups of workers with chronic cumulative exposures as low as 15-70 fibers-year/milliliter (f-year/ml) for signs of lungs fibrosis and 32-1,271 f-year/ml for asbestosis-associated mortality (1). In order to evaluate a long-term exposure to the Libby asbestos at the National Gypsum site, the exposure level for the hopper filler was averaged over the 40-hour work week based on an assumption that 28% of the production time at the plant on a weekly basis was devoted to producing fire-resistant

wallboard (12). Assuming the air samples taken in 1977 at the gypsum facility that the investigators visited were similar to the conditions in the National Gypsum facility when Libby vermiculite was used from April 1970 through 1977 (14), a hopper filler would have received 170 to 239 f-yr/ml cumulative dose. Thus, the hopper filler may have experienced non-cancerous respiratory effects, such as asbestosis, from the Libby vermiculite used at the National Gypsum facility.

***Cancer***

There is no doubt that inhalation of asbestos can lead to increased risk of lung cancer and mesothelioma (1). Asbestos exposure is also suspected of increasing the risk of cancer in the gastrointestinal tract, though the evidence is less consistent than for lung cancer or mesothelioma (1).

For lung cancer, the magnitude of the risk appears to be a complex function of a number of parameters, the most important of which are: 1) the level and the duration of the exposure; 2) the time since the exposure occurred; 3) the age at which exposure occurred; 4) the tobacco-smoking history of the exposed person; and 5) the type and size distribution of the asbestos fibers (1). The last parameter is of special practical importance, since the variability in potency in fibers means that cancer risk from asbestos exposure may vary widely from location to location. Because of the large number of variables, it is difficult to make reliable predictions of the magnitude of the cancer risk for the hopper filler exposed to Libby asbestos from mid-1970 through 1977. Qualitatively, the risk would range from medium to high[1].

Exposure to Libby asbestos probably occurred to other workers in the gypsum facility but to a lesser extent than the hopper filler or the worker who emptied the railroad car. It is not known how asbestos measured in the air near the hopper gets distributed to other parts of the facility. Nor is it known how much Libby asbestos dust would have been generated at other points in the gypsum board manufacturing process. Without additional information about the concentrations of Libby asbestos in other parts of the facility, it is not possible to predict what risks there may have been to other workers in the gypsum facility when Libby vermiculite was used.

***Occupational (Past (Before July 1970 and After Late 1977), Current, and Future National Gypsum Employees)***

Exposure to asbestos for people, who worked at National Gypsum, after National Gypsum stopped receiving Libby vermiculite (1977), is considered a potentially completed pathway. Invoice records from WR Grace show that 516 tons of Libby vermiculite was shipped to National Gypsum from mid-1970 to mid-1977. It is possible that Libby vermiculite was delivered to National Gypsum before mid-1970 or after mid-1977 until the last shipments from

[1] Risk calculations derived from the air sampling at the gypsum facility ranged from 3.4 to 4.8 premature cancer deaths per million hopper fillers, assuming the hopper filler was exposed for 7.75 years, 40 hours/week, 50 weeks per year. These risk ranges were based on EPA risk modeling of workers exposed to chrysotile asbestos. It is thought that the kind of asbestos in Libby vermiculite (tremolite and actinolite) is more toxic than chrysotile.

Libby occurred in 1992, and there are no invoice records to show these other shipments. It is also possible that residual contamination from the Libby vermiculite was present in the National Gypsum facility several months to years after the last shipment. Sampling conducted in the National Gypsum facility in 2000, showed that Libby vermiculite type asbestos (tremolite/actinolite) was no longer detected in dust or air samples.

However, another kind of asbestos was found in the dust at the National Gypsum site. Three of five dust samples collected in the facility contained chrysotile asbestos (56,600 s/cm$^2$ to 113,000 s/cm$^2$) (15). Since Libby vermiculite does not contain chrysotile, the residual contamination arises from other sources such as vermiculite from other mines, insulation material used in the facility, or other gypsum board ingredients.

Asbestos fibers in dust are not inherently hazardous to humans if left undisturbed. For health impacts to occur, the asbestos fibers must be resuspended and then inhaled. Air samples collected within the facility did not detect any asbestos, indicating that at the time of the sampling there was not sufficient disturbance of the residual chrysotile contamination to result in detectable airborne asbestos. However, most dust is subject to disturbance, either now or in the future, by many different types of activities common in a work environment, thus there is a potential for workers to be exposed to chrysotile asbestos in the future.

***On-Site Soils***

Exposure to current on-site workers or contractors disturbing contaminated on-site soils (including residual contamination or buried waste) is considered a potentially complete pathway for the past (since July 1970), present, and future. USEPA sampling showed trace amounts of Libby asbestos and trace amounts of non-Libby asbestos (chrysotile asbestos) present in two of the 16 surface soil samples taken around the facility (15). This soil is currently covered with grass or railroad ballast. It has been shown that disturbing soil containing even trace amounts of Libby asbestos can result in airborne levels of Libby asbestos fibers (19, 20). Under current conditions and assuming occasional contact with the areas of the site, trace levels of asbestos in the soil pose no apparent public health hazard.

***Household Contacts***

Exposure of household members, including the worker, to airborne Libby asbestos brought home on the clothing of former workers (i.e., those who worked at the facility from July 1970 to late 1977) is considered potentially complete. National Gypsum workers exposed to Libby asbestos fibers and who did not shower and change clothes before leaving work could have resulted in the spread of the asbestos to their household contacts. Family or other household contacts could have come in contact with Libby asbestos by direct contact with the worker, by laundering clothing, or the re-suspension of dusts during cleaning activities. Exposures to household contacts cannot be estimated without information concerning Libby asbestos levels on worker clothing and behavior-specific factors (e.g., worker practices, household laundering practices). CDHS does not know if National Gypsum employees wore disposable clothing or clothing that was left at the facility for laundering. CDHS does not know if on-site showers were available at National Gypsum and whether employees used them. When CDHS and ATSDR staff visited a different

gypsum site in 2004, the workers wore reusable jumpsuits (13). However, the workers reported it was commonplace in the 1970s and 1980s for workers to wear dusty clothing home. If the same practices took place at National Gypsum, then it is highly likely that family members of National Gypsum workers were exposed to asbestos carried home from the workplace on the clothing, shoes, or bodies of workers. It is not possible to determine how much exposure occurred to the household members. Inhalation of Libby asbestos fibers by household contacts as a result of worker take-home contamination from July 1970 to late 1977 is therefore considered an indeterminate public health hazard.

Exposure of household contacts to airborne Libby asbestos brought home on the clothing of National Gypsum workers who worked after 1977, currently, and in the future is considered eliminated. Based on recent air and dust sampling collected by USEPA, these workers are probably not likely to be exposed to residual Libby asbestos fibers inside the facility. Workers may occasionally be exposed to Libby asbestos still present in on-site soils, however this contact is expected to be infrequent, of short duration, and at very low levels. This type of exposure would not be a concern for household members who have contact with workers or their clothing. No apparent public health hazard exists for the household contacts of current, future, or past (except for July 1970 to mid-1977) employees at the National Gypsum facility.

***Ambient Air***

Past exposures (July 1970 to mid-1977) to airborne Libby asbestos fibers from plant emissions is considered a potentially complete pathway for the community surrounding the site as well as for nearby workers. Community members and area workers could have been exposed to Libby asbestos fibers released into the air from fugitive dust and vent emissions when the plant was using Libby vermiculite. Specific information concerning historical emissions from the plant is not available; therefore, an estimate of risk from this exposure cannot be made. An individual's exposure will be determined by wind direction, plant operational cycles, and where the individual lives, works, or goes to school in relation to the facility. In Long Beach, approximately 20% of the wind comes from the west, 10% comes from the south, 50% of the time it is fairly evenly distributed from all directions, and the rest of the time it is calm. The site is located to the south of the residential neighborhood. Exposure of the public to airborne emissions downwind of the site would have been at much lower concentrations than that experienced by the National Gypsum workers. Some contamination of nearby businesses may have occurred from the airborne dispersal of asbestos fibers. The site is located to the east, west and north of the nearby businesses.

Air emissions of Libby asbestos before July 1970 and after 1977, and in the future, have been eliminated from further discussion because the facility did not use Libby asbestos except for the 7-year period in the early 1970s.

***Consumer Products***

People who purchased and used company products that contain Libby vermiculite may be exposed to asbestos fibers from using those products in and around their homes (19-23). However, determining the public health implication of commercial or consumer use of company

products, such as gypsum wallboard, that contain Libby vermiculite is beyond the scope of this evaluation. Additional information for consumers of vermiculite products has been developed by USEPA, ATSDR, and NIOSH, and has been provided to the public (see appendices for fact sheets about consumer product concerns).

## Toxicology of Asbestos

### *Asbestos and Cancer*

Asbestos has been classified by U.S. and international health agencies as a substance that is known to cause cancer in humans. Numerous studies of occupational exposure to asbestos (exposure to asbestos during work) have shown that exposure to asbestos can cause two types of cancer: mesothelioma and lung cancer. Other studies have suggested that asbestos exposure might also increase the risk of some gastrointestinal and digestive cancers.

- Mesothelioma is the uncontrolled growth of abnormal cells of the membrane that encases the lungs and lines the abdominal cavity. Mesothelioma is relatively rare in the general population (approximately two out of one million people will get mesothelioma), but does occur more frequently in populations of workers in industries that use asbestos. About 5% of people who are exposed to asbestos develop mesothelioma (24). Mesothelioma has a latency period of 30 to 40 years (25).

- Lung cancer is the uncontrolled growth of abnormal cells in one or both of the lungs. While normal lung tissue cells reproduce and develop into healthy lung tissue, these abnormal cells reproduce rapidly and never grow into normal lung tissue. Lumps of cancer cells (tumors) then form and disrupt lung function (26). Studies have shown that people who were exposed to asbestos at work are 5 times more likely to develop lung cancer than workers who are not exposed to asbestos. In addition, people exposed to asbestos at work who also smoke are 50 to 90 times more likely to develop lung cancer than workers who do not smoke and who were not exposed to asbestos. The latency period for asbestos-caused lung cancer is 20 to 30 years (25).

- Gastrointestinal (digestive organ) cancers. A number of studies suggest that asbestos exposure may increase the risk of some digestive organ cancers. Some studies have observed slightly higher rates of death from gastrointestinal cancer among workers exposed to asbestos. This is presumed to be due to the transfer of inhaled fibers from the lung to the gastrointestinal tract. However, these studies were not able to determine whether the excess death from gastrointestinal cancer was due to asbestos or to other factors (e.g., exposure to other chemicals, misdiagnosis, dietary factors, alcohol intake) (1). Currently, there is no conclusive evidence that exposure to asbestos does or doesn’t cause gastrointestinal cancer.

### *Asbestos and Respiratory Illness*

Exposure to asbestos can also lead to several noncancer respiratory illnesses, including asbestosis and abnormalities in the pleura (the lining of the lungs). Asbestosis is a serious, chronic respiratory illness that occurs when asbestos fibers lodged in lung tissue cause scarring. Scarred lung tissue does not expand and contract like normal lung tissue and so breathing

becomes difficult. Oxygen and carbon dioxide do not pass through the lungs as easily and blood flow to the lungs may also be decreased, which can cause the heart to enlarge (1). Asbestosis can lead to heart failure. The latency period for asbestosis is typically 10 to 20 years (27).

Pleural abnormalities are abnormal changes in the membranes that cover the lungs and line the chest cavity (called the pleura). The most common change is the formation of thick, fibrous areas called plaques. Other effects of asbestos exposure include diffuse (widespread) thickening of the pleura, fibrosis (the formation of fibrous, scar-like tissue), and areas of pleural effusions (an abnormal collection of fluid between the pleura and the wall of the chest cavity). Small areas of pleural plaques are not thought to be of significant health concern. However, diffuse thickening of the pleura and large areas of pleural plaques or pleural effusions can impair respiratory function (1). Pleural abnormalities are not likely to be identified as a cause of death.

**Health Outcome Data Analysis**

As described in the previous sections, workers at the National Gypsum facility were exposed to asbestos from the use of Libby vermiculite at the National Gypsum facility from mid-1970 to late 1977. This exposure results in a medium to high increased cancer risk for the workers that worked as the hopper fillers. At this time, neither CDHS nor ATSDR is planning on tracking these workers to further assess their health impact.

It is possible that asbestos fibers were released as fugitive dust from the National Gypsum facility when Libby vermiculite was used. Because of significant data gaps, it is not possible to quantify the exposure. In order to assess the possibility that these releases may have impacted the health of the nearby community, CDHS reviewed available cancer registry information and mortality data for the community living near the National Gypsum facility. The analysis of incidence rates of asbestos-related cancers will be referred to as the "cancer statistics review" and the analysis of mortality rates of asbestos-related disease will be referred to as the "mortality statistics review."

A **cancer registry** is a center that collects, organizes, and analyzes information on cancer cases that have been diagnosed or treated in a geographic area (for example, California).

A **death certificate** is an official legal record of a death. It includes information on the cause of death (determined by a physician) and demographic characteristics of the deceased.

**Incidence rate** is a measure of the occurrence of disease in a population. It is the number of people in a population who get a disease in a specific time period, divided by the number of people in that population during the time period. For example, the incidence rate of lung cancer in California for the year 1997 was 60.1 per 100,000 people (28).

**Mortality rate** is a measure of the occurrence of death from a disease in a population. It is the number of people in a population who die from a disease in a specific time period, divided by the number of people in that population during the time period. For example, the mortality rate for lung cancer in California for the year 1997 was 41.8 per 100,000 people (29).

**Diseases Evaluated in the Health Statistics Review**

The ATSDR Division of Health Studies selected a variety of diseases for evaluation in order to 1) assess the full burden of disease and death that exposure to asbestos could have had on a population, and 2) confirm that the information obtained from cancer registries and vital statistics records for this review was consistent and therefore comparable.

Exposure to asbestos is known to cause lung cancer, mesothelioma, and asbestosis. Some studies suggest that exposure to asbestos might also increase the risk of certain digestive organ cancers. It is also possible that exposure to asbestos might worsen and cause premature death from certain diseases of the pulmonary and circulatory system.

One factor complicating the study of asbestos-related diseases is that physicians often misdiagnose these diseases, particularly when establishing a cause of death. This review also evaluated the number of people getting or dying from certain diseases (discussed below) because these people might have actually had an asbestos-related disease that was misdiagnosed.

Incidence rates of eight types of cancers or cancer groups were evaluated in the cancer statistics review (see list at right). Lung and bronchus cancer, mesothelioma, and digestive organ cancers were evaluated because of their known or suspected association with asbestos exposure. Cancer of the peritoneum, retroperitoneum, and pleura, as well as cancer of the respiratory system and intrathoracic organs was evaluated because people with these diagnoses might actually have had an asbestos-related cancer instead.

Lastly, all types of cancer, female breast cancer, and prostate cancer were evaluated to determine whether cancer was underreported to the cancer registries that provided information for this review.

Mortality rates from 13 types of diseases or disease groups were evaluated as part of the mortality statistics review (see list at right). Lung and bronchus cancer,

*The cancer statistics review evaluated the following types of cancer*:

- Lung and bronchus
- Mesothelioma
- Digestive organs
- Peritoneum, retroperitoneum, and pleura
- Respiratory system and intrathoracic organs
- All types of cancer
- Female breast
- Prostate

*The mortality statistics review evaluated death from the following diseases:*

- Lung and bronchus cancer
- Cancer of the peritoneum, retroperitoneum, and pleura including mesothelioma
- Asbestosis
- Digestive organ cancers
- Respiratory system and intrathoriacic organ cancers
- Cancer (no specification of site)
- Pneumoconioses
- Chronic obstructive pulmonary disease
- Diseases of pulmonary circulation
- Other diseases of respiratory system
- All types of cancer
- Female breast cancer
- Prostate cancer

cancer of the peritoneum, retroperitoneum, and pleura (including mesothelioma), asbestosis, and digestive organ cancers were evaluated because of their known or suspected association with asbestos exposure.

Respiratory system and intrathoriacic organ cancers, cancer (no specification of site), pneumoconioses, and chronic obstructive pulmonary disease were evaluated because these deaths might actually have included people with misdiagnosed asbestos-related diseases. Chronic obstructive pulmonary disease, disease of the pulmonary circulation, and other diseases of the respiratory system were evaluated because asbestos-exposure might have worsened these conditions and led to premature death. Lastly, all types of cancer, female breast cancer, and prostate cancer were evaluated to determine whether causes of death were underreported to the registries that provided information for the mortality statistics review.

### *Evaluating Mesothelioma*

During the years that were evaluated in this review, cancer and causes of death were coded in cancer registries and on death certificates according to two classification systems: the International Classification of Diseases, Oncology Codes, Revision 2 (ICD-O-2) (used by cancer registries), and the International Classification of Diseases, Injury, and Causes of Death Codes, Revision 9 (ICD-9) (used for death certificates).

The ICD-O-2 system has a specific code for mesothelioma, which makes it possible to evaluate the incidence rate of this cancer in the Long Beach community. In contrast, the ICD-9 system does not have a specific code for mesothelioma. Therefore, it is not possible to analyze mortality rates for mesothelioma alone; only a larger group of diseases (cancer of the peritoneum, retroperitoneum, and pleura (including mesothelioma) can be evaluated. Nearly all of the deaths in this cancer group are, in fact, deaths from mesothelioma (W. Kaye, ATSDR, personal communication, 2004). So, evaluating mortality from this group of cancers reflects, with relative accuracy, the occurrence of death from mesothelioma.

## Populations Evaluated

As mentioned above, whether people who lived near National Gypsum between mid-1970 and 1977 were exposed to hazardous levels of asbestos from Libby vermiculite, and if so, which areas of Long Beach experienced such exposure, is currently unknown (30).

Therefore, the first step of the health statistics review was to determine which area near National Gypsum was most likely to have experienced an increased burden of asbestos-related disease (assuming that National Gypsum did pollute the surrounding air with hazardous levels of asbestos). CDHS concluded that the population living within ¼ mile of National Gypsum could have been exposed to asbestos coming from the National Gypsum plant when it was using Libby vermiculite. It is not known if the concentrations were high enough to cause a detectable excess burden of asbestos-related disease. The distance (¼ mile) was selected based on information from health studies of lung cancer and mesothelioma rates in communities near asbestos industries (31-34).

Figure 1 shows the location of the Long Beach Plant and the area of Long Beach that is located within ¼–mile of the facility. The health statistics review would ideally evaluate the incidence and mortality rates of asbestos-related disease in the population residing in this area. But the smallest geographic area on which cancer statistics are publicly available is the census tract (providing information on a smaller geographic area could make it possible to identify a cancer patient, and thus would violate their right to privacy). For similar reasons pertaining to privacy, the smallest geographic area on which mortality statistics are publicly available is the ZIP Code.

Therefore, for the cancer statistics review, CDHS evaluated the population living in census tract 5755. For the mortality statistics review, CDHS evaluated the population residing in ZIP Code 90813. Figure 2 shows the location of National Gypsum, the area that CDHS determined was most likely to experience an excess of asbestos-related disease, and census tract 5755. Figure 3 shows the location of National Gypsum, the area that CDHS determined was most likely to experience an excess of asbestos-related disease, and ZIP Code 90813.

**Census tracts** are small geographic areas defined by the U.S. Census Bureau. Census tracts usually have 2,500 to 8,000 residents with similar population characteristics, economic status, and living conditions.

**Figure 1. Area of Long Beach, California, most likely to have been exposed to levels of asbestos high enough to cause a detectable excess burden of asbestos-related disease, assuming that National Gypsum polluted the outside air with hazardous levels of asbestos.**

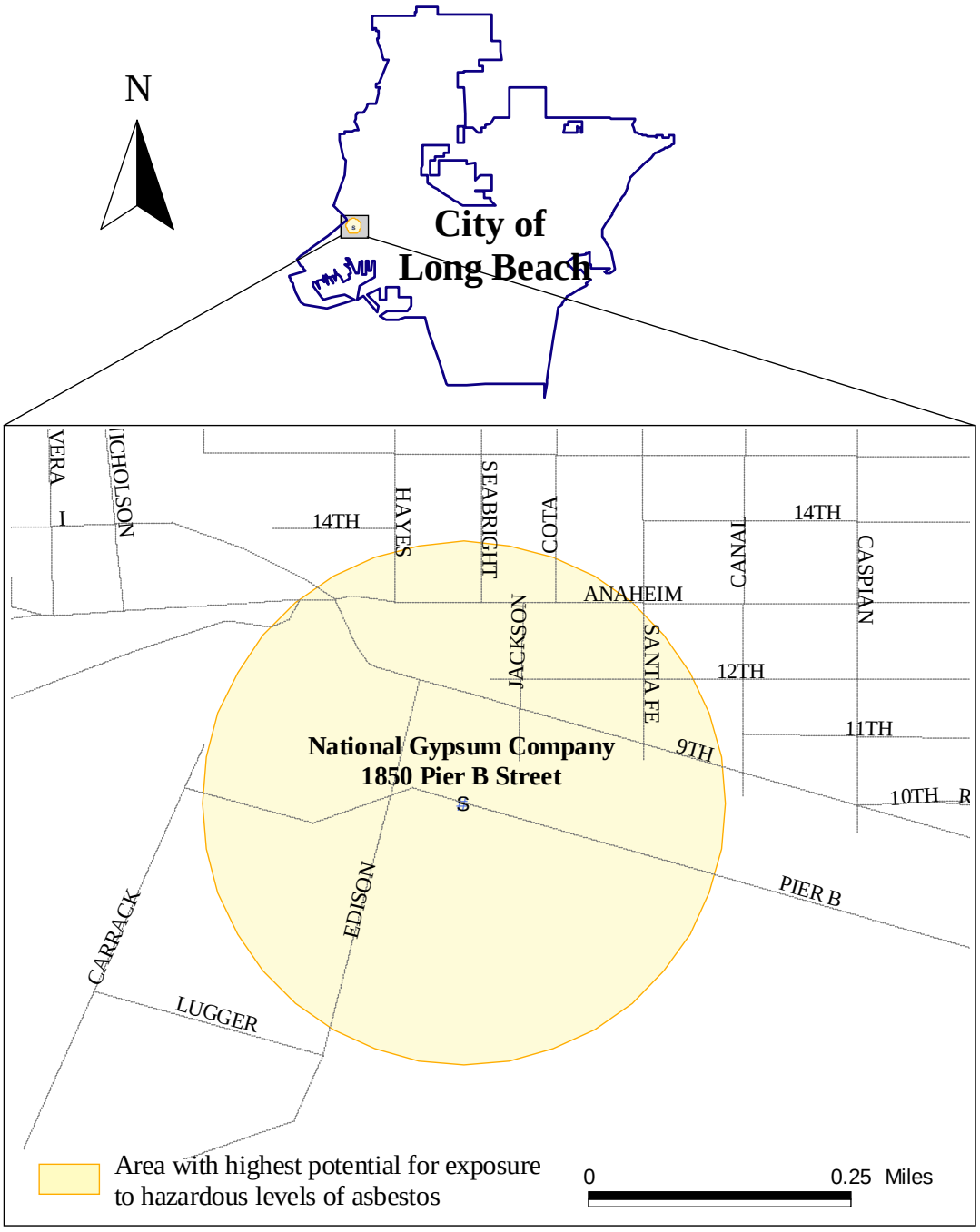


**Figure 2. Map of census tract 5755 in relationship to the area located within ¼ mile of National Gypsum, Long Beach, California.**

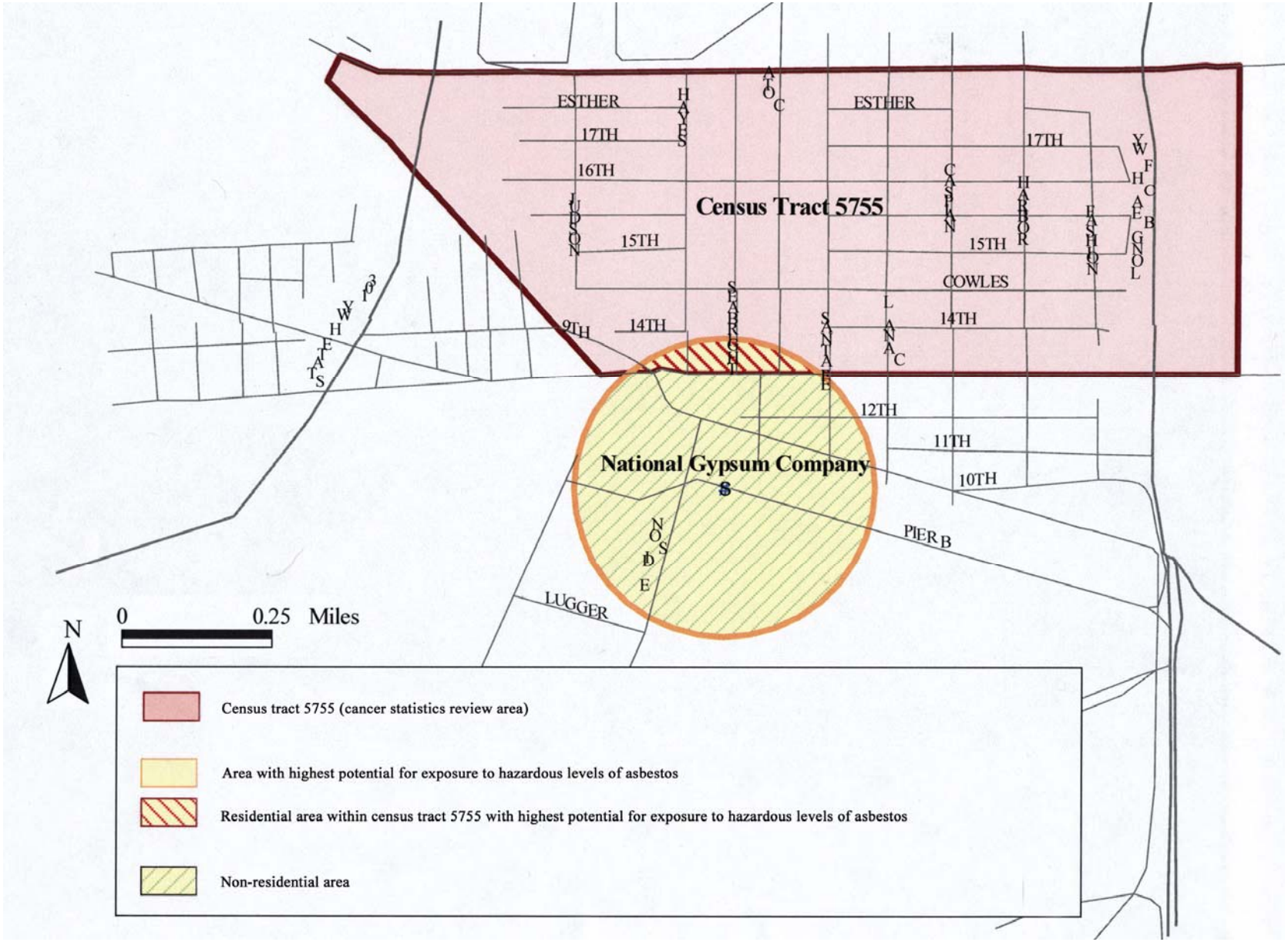
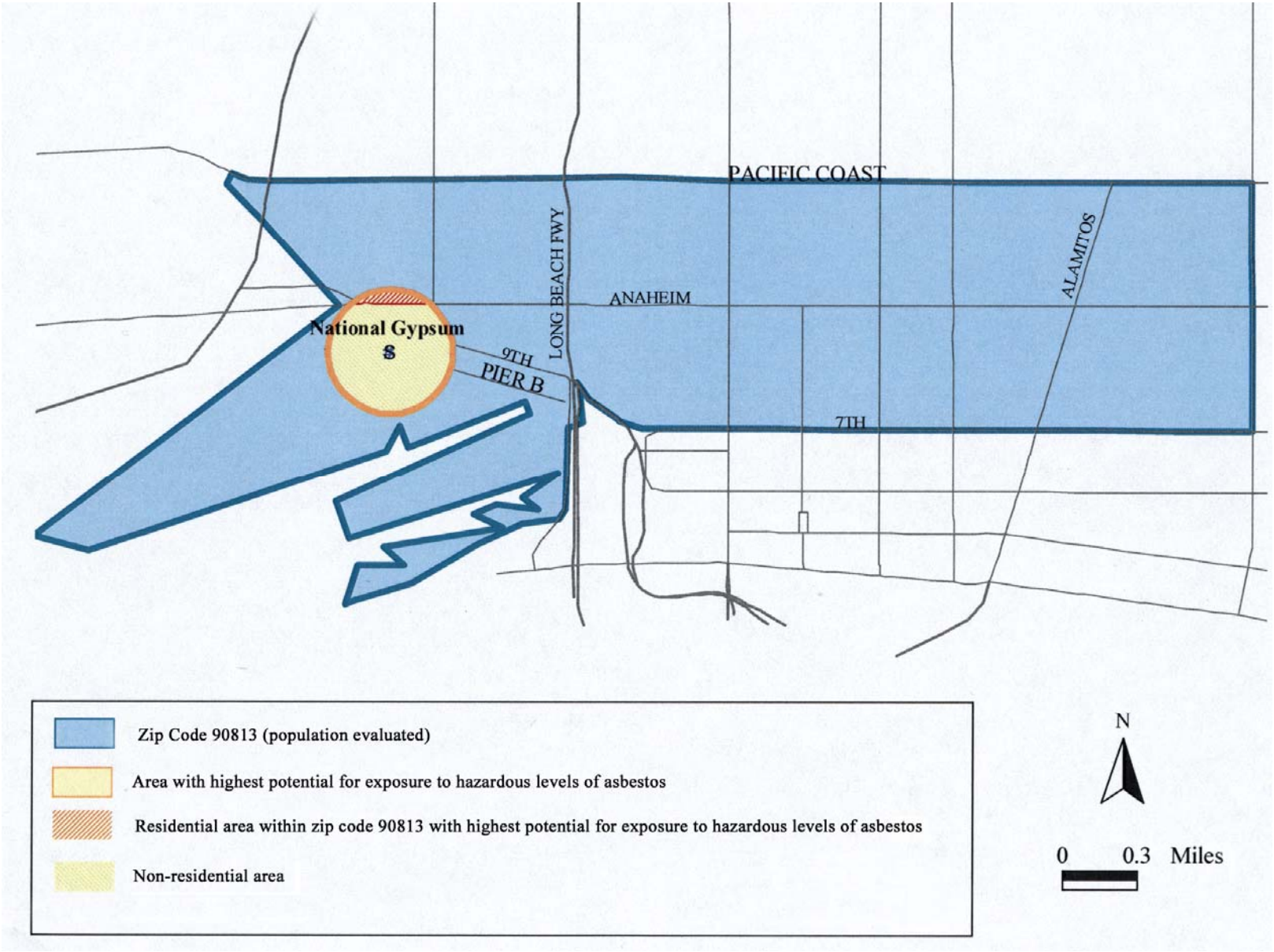


**Figure 3. Map of ZIP Code 90813 in relationship to the area located within ¼ mile of National Gypsum, Long Beach, California.**



### Time Periods of the Health Statistics Review

The cancer statistics reviewed the period from January 1, 1986, through December 31, 1995, and the mortality statistics reviewed the period January 1, 1989, through December 31, 1998. ATSDR selected these periods for two reasons: 1) they come closest to corresponding to the time of exposure and the latency period of asbestos-related disease; and 2) a 10-year period provides the minimum amount of data required for informative statistical analysis (35).

### Demographic Information of the Populations Evaluated

In 1990, there were 508 people residing in census tract 5755 and 58,022 people residing in ZIP Code 90813 (see Table 1). The census tract 5755 population had fewer males (44%) and the ZIP Code 90813 population had more males (52%) than the U.S. population (49%). Both populations evaluated were primarily Hispanic (white and "other" race) and Asian/Pacific Islander. Compared with the U.S. population, the populations evaluated had fewer people age 65 and older and had a lower socioeconomic status, as measured by educational attainment, the percentage of people in the labor force, employment status, and poverty status.

### Statistical Analysis

CDHS followed a health statistics review protocol developed by the ATSDR Division of Health Studies (35). The statistical analysis was designed to screen for an excess of asbestos-related disease in communities with facilities that received Libby vermiculite. Specifically, the following questions are explored:

**Table 1. Demographic Characteristics of the Populations Living in Census Tract 5755, ZIP Code 90813, and in the U.S. (36).**

| | Census Tract 5755 | ZIP Code 90813 | U.S. |
|---|---|---|---|
| **Total population** | 508 | 58,022 | |
| **Sex** | | | |
| Males | 44% | 52% | 49% |
| Females | 56% | 48% | 51% |
| **Race/Ethnicity** | | | |
| *Non-Hispanic* | | | |
| White | 9% | 11% | 76% |
| Black | 0% | 16% | 12% |
| Asian/Pacific Islander | 22% | 22% | 3% |
| Other Race | 0% | 0% | 0% |
| *Hispanic* | | | |
| White | 48% | 13% | 5% |
| Black | 0% | 1% | 0% |
| Asian/Pacific Islander | 1% | 1% | 0% |
| Other race | 19% | 35% | 4% |
| **Age** | | | |
| Under 18 years old | 42% | 39% | 26% |
| 18-64 years old | 49% | 56% | 62% |
| 65 and over | 9% | 5% | 12% |
| **Education** | | | |
| Less than 9$^{th}$ grade | 37% | 34% | 9% |
| Some high school | 23% | 26% | 15% |
| High school graduate | 21% | 17% | 30% |
| Some college or higher | 20% | 24% | 45% |
| **Employment** | | | |
| In labor force | 51% | 58% | 65% |
| Not in labor force | | | 35% |
| Employed | 90% | 86% | 94% |
| Unemployed | 10% | 14% | 6% |
| **Poverty** | | | |
| Income below poverty level | 57% | 36% | 13% |

1. Is the number of people who were diagnosed with an asbestos-related cancer while residing in census tract 5755 from 1986 to 1995 higher than what we would expect if the incidence rates of these cancers in census tract 5755 population were the same as the rates in the U.S. population?

2. Are the incidence rates of asbestos-related cancers in census tract 5755 population from 1986 to 1995 higher than the rates in the U.S. population?

3. Is the number of people who died from asbestos-related disease while residing in ZIP Code 90813 from 1989 to 1998 higher than what we would expect if mortality rates in the ZIP Code 90813 population were the same as the mortality rates in the U.S. population?

4. Are the mortality rates for asbestos-related disease in the ZIP Code 90813 population from 1989 to 1998 higher than the mortality rates in the U.S. population?

These four questions are similar in that they all compare the incidence and mortality rates in the Long Beach community with the incidence and mortality rates in the U.S. population. They differ, however, in how the comparison is made.

***Statistical Measures of Comparison***

The first question is explored by calculating a statistical measure called the standardized incidence ratio (SIR). The SIR is a numerical expression that compares how many people in the census tract 5755 population were diagnosed with cancer and how many diagnoses would be expected (hypothetically) if the incidence rate of cancer in the census tract 5755 population was the same as the incidence rate of cancer in the U.S. population. Details on how the SIR is calculated are provided in Appendix B. If the number of people who were diagnosed with an asbestos-related cancer while residing in census tract 5755 is the same as the expected number, the SIR will equal 1. If the number of people in the census tract 5755 population who were diagnosed with an asbestos-related cancer is less than the expected number, the SIR will be less than 1. If the number of people in the census tract 5755 population who were diagnosed with an asbestos-related cancer is more than one would expect, the SIR will be greater than 1.

The second question is explored by calculating a statistical measure called the standardized rate ratio (SRR). The SRR is a numerical expression that compares how many people in the U.S. were diagnosed with cancer and how many would be expected (hypothetically) if the U.S. population had the same incidence rates of cancer as the census tract 5755 population. Details on how the SRR is calculated are provided in Appendix C. If the incidence rate of cancer in the U.S. population is the same as that in the census tract 5755 population, the SRR will equal 1. If the incidence rate of cancer in the U.S. population is lower than the incidence rate in the census tract 5755 population, then the SRR will be less than 1. And, if the incidence rate of cancer in the U.S. population is higher than that in the census tract 5755 population, the SRR will be greater than 1.

The third question is explored by calculating a statistical measure called the standardized mortality ratio (SMR). The SMR is essentially the same measure as the SIR except that it evaluates the number of people who died from a disease rather than the number of people who

were diagnosed with a disease. Thus the SMR is a numerical expression that compares how many people in ZIP Code 90813 died of an asbestos-related disease and how many would be expected to die (hypothetically) if the mortality rates of asbestos-related disease in the ZIP Code 90813 population were the same as the mortality rates in the U.S. population. Details on how the SMR is calculated are provided in Appendix D. If the number of people who died from an asbestos-related disease while residing in ZIP Code 90813 is the same as the expected number, the SMR will equal 1. If the number of ZIP Code 90813 residents who died from an asbestos-related disease is less than the expected number, the SMR will be less than 1. If the number of people in ZIP Code 90813 who died from an asbestos-related disease is more than one would expect, the SMR will be greater than 1.

Lastly, the fourth question is also answered by calculating a standardized rate ratio (SRR), but for mortality rates instead of cancer incidence rates. So the SRR in this case is a numerical expression that compares the number of people in the U.S. who died from an asbestos-related disease and the number of people in the U.S. who would be expected (hypothetically) to die, if the U.S. population had the same mortality rates as the ZIP Code 90813 population.

### *Interpreting the Expected Number of People to Develop or to Die from a Disease*

The SIR, SMR, and SRR all compare the actual number of people to develop or to die from a disease with an expected number. This expected number of people is a calculated and theoretical number that is often not a whole number. For example, the expected number might be 2.6 people. Because it is not possible for a fraction of a person to develop or to die from a disease, the expected number can be thought of as an approximation. In this example, the expected number 2.6 people can be interpreted to mean that either 2 or 3 people are expected to develop or to die from a disease.

### *Accounting for Differences between the Populations*

In this review, the incidence and mortality rates of disease in the Long Beach and U.S. populations are compared because it is thought that the Long Beach population might have higher rates of disease, due to past exposure to harmful levels of asbestos from the National Gypsum site. But other characteristics can also increase the risk for developing many of the diseases linked to asbestos. If the populations evaluated differ from the U.S. population in terms of how common these characteristics are, then these differences can bias (i.e., create a faulty appearance in) the results of the comparison, unless they are accounted for in the analysis. For example, smoking can increase the risk of developing lung cancer. If smoking rates in the Long Beach populations are lower than the smoking rates in the U.S. population, but the analysis does not adjust for this difference, then the populations evaluated might appear to have lower rates of lung cancer in comparison with the U.S. population than they in fact do. The Long Beach population evaluated may have had more exposure to asbestos from ship building or working as a longshoreman than the rest of the U.S. population. These biases can hide a true excess of disease or it can create the appearance of an excess when none really exists.

This analysis did account for differences in age and sex, but did not account for other risk factors for asbestos-related disease (e.g., smoking, race/ethnicity, socioeconomic status, amount of work exposure to asbestos).

### *Statistical Tests*

The number of people who get or die from cancer or other diseases in a given geographic area changes from year to year; this fluctuating pattern is characteristic of the occurrence of disease and is expected. Because of this, the values of SIR, SMR, and SRR will also change, depending on which time period is under evaluated. If the number of cases occurring in one time period under review is higher than average, then SIR, SMR, or SRR will be higher than 1 (e.g., 1.2). If a different time period was under review when the number of cases was lower than average, SIR, SMR, and SRR will be less than 1 (e.g., 0.9). Some degree of fluctuation in the SIR, SMR, and SRR values from one time period to another is normal and expected.

An important question is when is SIR, SMR, or SRR higher or lower than what would be expected, given that the number of people getting disease in a given geographic area normally varies over time? In other words, is the incidence rate or mortality rate in the Long Beach population the same as that in the U.S. population, or is disease or death occurring less or more frequently in the Long Beach population than in the U.S. population?

To answer this question, a statistical test measure called a confidence interval (CI) was calculated for the SIRs, SMRs, and SRRs using Byar's approximation method (37). A confidence interval is a range of possible values for the SIRs, SMRs, or SRRs that are consistent with the normal variation in disease over time in a geographic area. If the CI range includes the value one, then there is no "statistically significant" difference between the incidence or mortality rates in the Long Beach and U.S. populations, as represented by the SIRs, SMRs, or SRRs. In other words, the incidence or mortality rate in the Long Beach population is the same as the incidence or mortality rate in the U.S. population. If the CI range is less than one or greater than one, then there is a "statistically significant" difference between the incidence or mortality rates in the two populations: the incidence rate or mortality rate in the Long Beach population is not the same as the incidence rate or mortality rate in the U.S. population.

Part of the process of calculating a confidence interval includes selecting a level of certainty for this statistical test. CDHS used a 95% level of certainty, which is the standard value selected for these types of analyses.

## Sources of Information on Incidence and Mortality Rates

Information on the number of people who developed cancer while residing in census tract 5755 was obtained from the California Cancer Registry (CCR). Information on cancer rates in the U.S. population was obtained from the Surveillance, Epidemiology, and End Results program of the National Cancer Institute (SEER) (38).

Information on the number of people who died while residing in ZIP Code 90813 was obtained from CDHS, Center for Health Statistics, Office of Vital Records (CDHS-OVR). Information on mortality rates in the U.S. population was obtained from the National Center for Health Statistics (NCHS) (39).

**Results of the Cancer Statistics Review**

The standardized incidence ratios (SIRs) and standardized rate ratios (SRRs) for the census tract 5755 population are presented in Table 2. Details regarding the SRRs are presented in Appendix E. Table 2 shows:

For each cancer group evaluated
- the reason for evaluating that type of cancer.

For the SIR analysis
- the number of people who were diagnosed with the type of cancer while residing in census tract 5755;
- the number of people expected to be diagnosed (if the census tract 5755 population had the same incidence rate as the U.S. population); and
- the SIR and 95% CI for the SIR.

For the SRR analysis
- the SRR and the 95% CI for the SRR.

**Table 2. Standardized Incidence Ratio (SIR), Standardized Rate Ratio (SRR), and 95% Confidence Intervals (CI) of Selected Cancers in the Census Tract 5755 Population, 1986–1995.**

| Cancer Group (ICD-O-2 Code) | Reason* | Census Tract 5755 | | | Standardized to U.S. Population |
|---|---|---|---|---|---|
| | | Number of diagnoses | Number expected | SIR (95% CI) | SRR (95% CI) |
| Lung and bronchus (C340:C349†) | 1 | 2 | 1.5 | 1.30 (0.15-4.70) | 0.70 (0.07-7.48) |
| Mesothelioma (M-9050:9053) | 1 | 0 | 0.02 | (0, 161.0)‡ | 0§ |
| Digestive organs (C150: C218, C260:C269†) | 2 | 4 | 1.5 | 2.65 (0.71-6.78) | 1.90 (0.78-4.81) |
| Respiratory system and intrathoracic organs (C320:C399†) | 3 | 2 | 1.7 | 1.18 (0.13-4.26) | 0.70 (0.06-6.84) |
| Peritoneum, retroperitoneum, and pleura (C480:C488, C384†) | 3 | 0 | 0.0 | 0 (0, 85.0)‡ | 0§ |
| All cancers (C000:C809†) | 4 | 17 | 11.3 | 1.51 (0.88-2.41) | 1.70 (0.97-3.01) |
| Female breast (C500:C509†) | 4 | 1 | 1.6 | 0.61 (0.01-3.41) | 0.40 (0.06-2.96) |
| Prostate (C619†) | 4 | 1 | 1.4 | 0.71 (0.01-3.94) | 0.40 (0.06-3.15) |

* Reason for evaluating the cancer grouping:

1. Exposure to asbestos is known to cause a type of cancer in this cancer group.
2. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
3. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
4. This cancer or cancer group was evaluated to confirm that information on cancer diagnoses is reported to CCR and SEER in a consistent manner.

† Excluding M-9590:9989. ‡Exact confidence interval based on Poisson distribution. §Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004).

ICD-O-2= International Classification of Diseases for Oncology, Second Edition

Between 1986 and 1995, the incidence rates of asbestos-related cancers in the census tract 5755 population were not statistically significantly different from the incidence rates in the U.S. population. Two people were diagnosed with lung or bronchial cancer, when 1.5 diagnoses would be expected if the census tract 5755 population had the same incidence rate as the U.S. population (SIR=1.30). The 95% CI (0.15-4.70) indicates that there is no statistically significant difference between the incidence rates of lung and bronchus cancer in the census tract 5755 population and the U.S. populations, as measured by the SIR. The SRR analysis also did not produce evidence that the census tract 5755 and U.S. populations had different incidence rates of lung and bronchus cancer. Similarly, the incidence rates of mesothelioma in the census tract 5755 population were not found to differ from the rates in the U.S. population by either analysis.

Between 1986 and 1995, the incidence rate of digestive organ cancers in the census tract 5755 population was not statistically significantly different from the incidence rate in the U.S. population, as measured by the SIR and SRR analyses.

The incidence rate of cancer of the respiratory system and intrathoracic organs in the census tract 5755 population was not statistically significantly different from the incidence rate in the U.S. population, as evaluated by the SIR and the SRR analyses. Neither was the incidence rate of cancer of the peritoneum, retroperitoneum, and pleura in the census tract 5755 population statistically significantly different from that in the U.S. population.

Lastly, according to both the SIR and SRR analysis, the incidence rates of all types of cancer, female breast cancer, and prostate cancer in the census tract 5755 population were not statistically significantly different from the incidence rates in the U.S. population.

**Results of the Mortality Statistics Review**

Standardized mortality ratios (SMRs) and standardized rate ratios (SRRs) for the ZIP Code 90813 population are presented in Table 3. Details regarding the SRRs are presented in Appendix E. Table 3 shows:

<u>For each disease group evaluated</u>
- the reason for evaluating the disease.

<u>For the SMR analysis</u>
- the number of people who died from the disease while residing in ZIP Code 90813;
- the number of people expected to die (if this population had the same disease mortality rate as the U.S. population); and
- the SMR and 95% CI for the SMR.

<u>For the SRR analysis</u>
- the SRR and the 95% CI for the SRR.

**Table 3. Standardized Mortality Ratio (SMR), Standardized Rate Ratio (SRR), and 95% Confidence Intervals (CI) of Selected Causes of Death Occurring in ZIP Code 90813, 1989–1998.**

| Cause of Death (ICD-9 Code) | Reason* | ZIP Code 90813 | | | Standardized to U.S. Population |
|---|---|---|---|---|---|
| | | Number deaths | Number expected | SMR (95% CI) | SRR (95% CI) |
| Cancer of the lung and bronchus (162.2-162.9) | 1 | 140 | 140.0 | 1.00 (0.84-1.18) | 1.03 (0.94-1.11) |
| Cancer of the peritoneum, retroperitoneum and pleura (including mesothelioma) (158, 163) | 1 | 1 | 1.1 | 0.95 (0.01-5.28) | 1.14 (0.16-7.91) |
| Asbestosis (501) | 1 | 0 | 0.3 | 0 (0-12.3)† | 0‡ |
| Cancer of the digestive organs (150-154, 159) | 2 | 88 | 79.2 | 1.11 (0.89-1.37) | 1.12 (1.01-1.24) |
| Cancer of the respiratory system and intrathoracic organs (161-165) | 3 | 149 | 144.7 | 1.03 (0.87-1.21) | 1.05 (0.97-1.14) |
| Cancer (no site specified) (199) | 3 | 33 | 31.8 | 1.04 (0.71-1.46) | 1.03 (0.87-1.22) |
| Pneumoconiosis (500-505) | 3 | 0 | 1.0 | 0 (0-3.69)† | 0‡ |
| Chronic obstructive pulmonary disease (490-496) | 3, 4 | 118 | 91.7 | 1.29 (1.07-1.54) | 1.29 (1.18-1.42) |
| Other diseases of the respiratory system (510-519) | 4 | 15 | 18.0 | 0.83 (0.47-1.38) | 0.73 (0.56-0.95) |
| Diseases of pulmonary circulation (415-417) | 4 | 7 | 13.1 | 0.53 (0.21-1.10) | 0.52 (0.36-0.77) |
| All cancers (140-208) | 5 | 478 | 517.9 | 0.92 (0.84-1.01) | 0.91 (0.87-0.95) |
| Female breast cancer (174) | 5 | 36 | 44.3 | 0.81 (0.57-1.13) | 0.87 (0.73-1.02) |
| Prostate cancer (185) | 5 | 26 | 29.1 | 0.89 (0.58-1.31) | 0.91 (0.75-1.10) |

***** Reason for evaluating the disease:

1. Exposure to asbestos is known to cause a type of cancer in this cancer group or this disease.
2. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
3. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
4. Exposure to asbestos might have exacerbated the condition of people with these diseases and thereby led to premature or increased chance of death.
5. This cancer or cancer group was evaluated to confirm that information is reported to California Department of Health Services, Center for Health Statistics, Office of Vital Records and the National Center for Health Statistics, in a consistent manner.

† Exact confidence interval based on Poisson distribution. ‡ Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004). ICD-9= International Classification of Disease, Ninth Edition

The mortality statistics review found no evidence that the mortality rate for asbestos-related disease (cancer of the lung and bronchus, cancer of the peritoneum, retroperitoneum, and pleura-including mesothelioma, and asbestosis) in the ZIP Code 90813 population was statistically significantly different from the rate in the U.S. population during the years 1989–1998 (Table 3).

The mortality statistics review found inconsistent evidence that the ZIP Code 90813 population experienced statistically significantly higher rates of death from digestive organ cancers, which have been inconclusively linked to asbestos exposure in previous epidemiologic studies. Between 1989 and 1999, the rate of death from digestive organ cancers in the ZIP Code 90813 population was not statistically significantly different from the rate in the U.S. population, as measured by the SMR analysis (SMR=1.11; 95% CI 0.89-1.37). In contrast, the SRR analysis did indicate that the mortality rate for digestive organ cancers in the ZIP Code 90813 population was statistically significantly higher than the rate in the U.S. population (SRR=1.12; 95% CI 1.01-1.24).

The ZIP Code 90813 population did have statistically significantly higher mortality rates for chronic obstructive pulmonary disease than the U.S. population: the SMR=1.29 and 95% CI 1.07-1.54, and the SRR=1.29 and 95% CI 1.18-1.42. However, the mortality rates for cancer of the respiratory system and intrathoracic organs, cancer (no site specified), and pneumoconiosis in the ZIP Code 90813 population were not statistically significantly different from the mortality rates in the U.S. population.

Although the SMR analysis did not produce evidence that the ZIP Code 90813 and U.S. populations had statistically significantly different mortality rates for other diseases of the respiratory system and diseases of the pulmonary circulation, the SRR analysis did. The ZIP Code 90813 population had 27% lower rates of death from other diseases of the respiratory system than the U.S. population (SRR=0.73 and 95% CI 0.56-0.95), and 48% lower rates of death from diseases of the pulmonary circulation (SRR=0.52 and 95% CI 0.36-0.77).

The rate of death from all cancers in the ZIP Code 90813 population was statistically significantly lower than the rate of death in the U.S. population according to the SRR analysis but not according to the SMR analysis. Neither the SMR nor the SRR analyses produced evidence that the ZIP Code 90813 and U.S. populations had different rates of death from female breast cancer and prostate cancer.

**Limitations of the Health Statistics Review**

Five limitations of the Health Statistics Review are worth discussion and exploration because they might 1) affect the accuracy of the results, 2) limit the ability of the analyses to observe an excess of asbestos-related disease attributable to vermiculite processing at National Gypsum, if one exists, or 3) limit the degree to which this analysis can serve as an indicator of community exposure to Libby asbestos.

1. *The SIR, SMR, and SRR results might be biased if the analyses do not account for the ways that the Long Beach and U.S. population differ with respect to other risk factors for asbestos-related diseases (e.g., race/ethnicity, socioeconomic status, smoking).*

As discussed previously, this analysis does not account for all the ways that the Long Beach population differs from the U.S. population with respect to risk factors for diseases that can be caused by exposure to asbestos (e.g., smoking, race/ethnicity, socioeconomic status). As a result, this analysis might not accurately identify an excess or lack of excess of disease attributable to asbestos exposure.

To assess whether the Long Beach and U.S. populations differ with respect to other risk factors for asbestos-related disease, CDHS gathered information from the U.S. Census. Table 1 shows that the population in census tract 5755 differs substantially from the U.S. population in terms of race/ethnicity and socioeconomic status (measured by education level and poverty status). So, too, does the ZIP Code 90813 population differ substantially from the U.S. population in terms of these characteristics. No information on smoking rates in the populations evaluated are available. That said, however, smoking has historically been less common in California (40), and, since the late 1980s, smoking rates in California have been declining more rapidly than the rest of the country (41). Smoking rates also tend to be higher among people of low socioeconomic status (42) and tend to differ by race and ethnicity (43-45). Using these statewide trends, it is likely that the smoking rates in the Long Beach population evaluated in this health statistics review are different from those in the U.S. population.

It is not possible to predict whether or how the combined racial, ethnic, and socioeconomic differences between the Long Beach population evaluated in this health statistics review and U.S. populations could bias the analysis (in other words, whether they could be masking a true elevation in rates of asbestos-related disease). However, any conclusions drawn from this health statistics review could be made more definitively if these differences were accounted for in the SIR, SMR, and SRR analyses.

2. *The results of the analyses might be inaccurate if the populations evaluated are larger or smaller than they are assumed to be.*

Information on the size of the populations evaluated during the periods evaluated (1986–1995 for the cancer statistics review and 1989–1998 for the mortality statistics review) is needed to calculate the SIR, SMR, and SRRs as well as the 95% CIs. Information on the size of the populations in census tracts and ZIP Codes is collected by the U.S. census once every decade, but not during the intervening years. Therefore, to calculate the statistical measures of comparison, ATSDR made the customary assumption that the size of the populations counted in 1990 (as determined by the U.S. Census) represents the average size of the populations during the periods evaluated.

If this assumption does not hold true, then the results of the SIR, SMR, and SRR analyses will be biased (inaccurate). Specifically, if the census-based estimated size of the populations evaluated in 1990 is smaller than the actual size of the populations evaluated during the periods evaluated, then the SIR, SMR, and SRR will be inaccurately high numbers, and the statistical tests might falsely indicate a statistically significant excess of disease. And, if the size of the populations evaluated according to the 1990 census is larger than the actual size of the populations evaluated

during the periods evaluated in this health statistics review, then the SIR, SMR, and SRR will be inaccurately low numbers, and the statistical tests might falsely indicate a lack of disease excess.

Without knowing the true size of the Long Beach population evaluated in this health statistics review during the periods evaluated, it is not possible to predict whether or in what way these statistical measures might be biased. Still, it is possible to obtain some sense of whether any bias is occurring by referring to information on the size of these populations during U.S. Census years.

According to U.S. Census data, the census tract 5755 population shrunk by 20% between 1980 and 1990 and by 50% between 1990 and 2000 (46). If these trends represent the growth of the census tract population between 1986 and 1995, then the assumed size of the population evaluated in the cancer statistics review is larger than the true size. This difference will bias the values of the SIR, SRR, and 95% CIs in a way that makes them lower than they actually are.

The ZIP Code 90813 population grew by 8% between the years 1990 and 2000 (46). If this trend represents the growth of this population during the years 1989 and 1998, then the assumed size of the population evaluated in the mortality statistics review is smaller than the true size. This difference will bias the values of the SMR, SRR, and 95% CIs in a way that makes them higher than they actually are.

In summary, if more accurate information on population size was used in the analysis, then the values of the SIRs, SMRs, and SRRs would be lower than they were in these results: the incidence and mortality rates in the Long Beach populations evaluated might be even lower, in comparison to the rates in the U.S. population, than this analysis indicates.

3. *The analysis might fail to observe a true excess of asbestos-related cancers and disease if the populations evaluated in this health statistics review include people who could not have been exposed to asbestos from the processing of vermiculite at National Gypsum.*

This health statistics review would ideally evaluate the health status of only those people who were exposed to asbestos from the processing of Libby vermiculite at National Gypsum, assuming that off-site contamination and exposure did occur. The effect of including people who were not exposed to asbestos in the population evaluated (such as persons who moved to the area after exposure ceased) is to lessen the ability to see an excess of asbestos-related disease in the population. This happens because the people who were never exposed to asbestos can make the population appear healthier than it would otherwise appear if they were not included in the analysis. Due to several reasons (e.g., lack of information on whether asbestos pollution from National Gypsum occurred, lack of information on how far the asbestos pollution would have traveled in the air, and restrictions on the geographic area for which cancer and mortality statistics are available), it is likely that this health statistics review evaluated the occurrence of asbestos-related cancers and death in a population that includes people who were never exposed to asbestos. Therefore, the SIRs, SMRs, SRRs and 95% CIs are likely to be smaller numbers than they would otherwise be if unexposed people were not included in the population being evaluated. The incidence and mortality rates in the Long Beach population might be higher, in

comparison to the rates in the U.S. population, if the populations evaluated only included people who were exposed to Libby asbestos from the processing of Libby vermiculite at National Gypsum.

4. *The analysis might fail to observe a true excess of asbestos-related cancers and disease, attributable to vermiculite processing at National Gypsum, if the periods evaluated do not correspond to the years that this excess of disease would be expected to occur.*

The diseases caused by exposure to asbestos take many years to develop. Current knowledge is that lung cancer will develop 20 to 30 years after exposure to asbestos, mesothelioma will develop 30 to 40 years after exposure, and asbestosis will develop 10 to 20 years after exposure. National Gypsum received shipments of Libby vermiculite between the years 1970 and 1977. Therefore, we would expect that any lung cancer caused by exposure to Libby asbestos would occur between 1990 and 2007, any mesothelioma caused by exposure to Libby asbestos would occur between 2000 and 2017, and any asbestosis caused by exposure to Libby asbestos would occur between 1987 and 2010.

This health statistics review evaluated the incidence rates and mortality rates from asbestos-related diseases in the years 1985–1996 and 1989–1998, respectively. The periods evaluated do not correspond entirely to the years that disease caused by exposure to Libby asbestos is most likely to occur (see Table 4). Therefore, it is possible that this analysis did not find an excess of asbestos-related disease in the Long Beach community because this excess of disease has not yet occurred. This particularly applies to the evaluation of mesothelioma.

**Table 4. Years that Disease Due to Exposure to Libby Asbestos from Vermiculite Processing at National Gypsum Would be Expected to Occur (Assuming that Hazardous Exposure Occurred), and Number of Period Years During Which Exposure-Related Disease is Expected to Occur.**

| **Disease** | **Years During Which Asbestos-Related Disease is Most Likely to Occur (Based on Latency Period)** | **Number of Years of Overlap Between the Period Evaluated and the Years that Asbestos-Related Disease is Most Likely to Occur** | |
|---|---|---|---|
| | | ***Cancer Statistics Review (1986–1995)*** | ***Mortality Statistics Review (1989–1998)*** |
| Cancer of the lung and bronchus | 1990–2007 | 6 | 9 |
| Mesothelioma | 2000–2017 | 0 | 0 |
| Asbestosis | 1987–2010 | — | 10 |

5. *The results of the health statistics review can serve as an indicator of community exposure to Libby asbestos only if the Long Beach population evaluated in this health statistics review include the people who were living near National Gypsum at the time that Libby vermiculite was processed.*

According to the protocol for this health statistics review, finding a statistically significant elevation in asbestos-related disease in a community would alert CDHS and ATSDR to the possibility that community members might have been exposed to asbestos as a result of the facility's handling or processing of vermiculite from Libby. This interpretation is based on an assumption that the population evaluated consists of people who were exposed to Libby asbestos. Therefore, this interpretation is appropriate only if the populations evaluated include the people who were living near National Gypsum during the time that Libby vermiculite was processed.

Cancer registry and vital statistics records do not collect information on residential history. Therefore, it is not possible to determine whether the people in the populations evaluated lived near National Gypsum during the years that Libby vermiculite was processed. However, information on population mobility from the U.S. Census can provide some insight into the likelihood that the populations evaluated include the people who were living near National Gypsum during the years that Libby vermiculite was processed (1970–1977).

According to the 2000 U.S. Census, an estimated 80% of heads of household living in census tract 5755 moved into their homes in 1980 or after (47). Therefore, many of the people in the populations evaluated are unlikely to have had the potential to be exposed to Libby asbestos, since they moved into their homes after National Gypsum stopped using Libby vermiculite.

**Child Health Considerations**

CDHS and ATSDR recognize that infants and children may be more vulnerable to exposures than adults in communities faced with environmental contamination. Because children depend completely on adults for risk identification and management decisions, CDHS and ATSDR are committed to evaluating their special interest at the National Gypsum site.

Children could be especially vulnerable to asbestos exposure because they are more likely to disturb fiber-laden soils or indoor dust while playing. Children also breathe air that is closer to the ground and may thus be more likely to inhale airborne fibers from contaminated soils or dust.

The effects of asbestos on children are thought to be similar to the effects on adults (1). However, children who are exposed could be more at risk of actually developing asbestos-related disease than people exposed later in life because of the long latency period between exposure and onset of asbestos-related respiratory disease. Whether the latency period for asbestos-related disease is different for people exposed during childhood is also unknown.

For the National Gypsum site, the most at-risk children were those who lived in the residence of a worker who worked at the plant while it used Libby vermiculite.

This review of health statistics screened people of all ages, including the people who were infants or children during the years that Libby vermiculite was shipped to the National Gypsum facility. This group of people who were 18 years old or younger during the years of potential exposure to Libby asbestos (1970–1977) would be between the ages of 9 and 43 during the years that the cancer statistics review evaluates (1986–1995), and between 12 and 46 during the years that the mortality statistics review evaluates (1989–1998).

## Conclusions

Asbestos fibers were released to the workplace air during the handling and use of vermiculite in the production of fire resistant gypsum wallboard at National Gypsum. People who worked at National Gypsum between July 1970 and late 1977 could have been exposed to hazardous levels of asbestos. The worker who had the job of dumping the vermiculite into the hopper may have developed non-cancer effects like asbestosis from the exposure. They also have a medium to high increased cancer risk as a result of the exposure. The cancers associated with asbestos exposure are lung cancer and mesothelioma. Other workers in the facility were probably exposed to a lesser extent, but it is not possible to quantify their risk.

The former workers and the people who lived with former workers might also have been exposed to hazardous levels of asbestos from fibers carried home on workers' hair and clothing. It is also possible that people who lived near the National Gypsum facility between July 1970 and late 1977 were exposed to hazardous levels of asbestos from Libby vermiculite.

The National Gypsum facility no longer handles or uses vermiculite. However, people who currently work at the facility could be exposed to hazardous levels of asbestos if the areas of asbestos-contaminated soil outside the facility are disturbed through excavation or other development activities. Current operations at the National Gypsum facility are not causing community exposure to asbestos from Libby vermiculite. There is a lack of information to thoroughly investigate the historical exposures to the community.

It is possible that asbestos fibers were released as fugitive dust from the National Gypsum facility when Libby vermiculite was used. Because of significant data gaps, it is not possible to quantify the exposure. In order to assess the possibility that these releases may have impacted the health of the nearby community, CDHS conducted a cancer statistics review and a mortality statistics review for the community living near the National Gypsum facility.

The cancer statistics review did not find any evidence that the census tract 5755 population experienced statistically significantly higher incidence rates of asbestos-caused cancers (lung cancer and mesothelioma) than the U.S. population during the years 1986–1995. The SIR and SRR results for the reference cancers evaluated in this review indicate that an excess of asbestos-related cancers in this Long Beach population is not being obscured by physician misdiagnosis or discrepancies between the way that cancer diagnoses are reported to the CCR and SEER.

The mortality statistics review found no evidence that the ZIP Code 90813 population experienced higher mortality rates from clearly asbestos-related diseases than the U.S. population during the years 1989–1998. Digestive organ cancers have been inconclusively linked to asbestos exposure in previous studies. This analysis found that the ZIP Code 90813 population had higher rates of death from digestive organ cancers than the U.S. population, as measured by the SMR and the SRR. However, statistically speaking, only the SRR analysis found the difference between the rates in the ZIP Code and U.S. populations to be unusual, given normal variation in the occurrence of these cancers.

The mortality rate for chronic obstructive pulmonary disease was also higher than expected, as measured by the SMR and SRR. The results of the mortality statistics review do not suggest that asbestos exposure led to premature or increased rates of death from other diseases of the respiratory system or diseases of the pulmonary circulation. There is also no evidence that the results are biased due to differences in the way that information on mortality is reported to CDHS, Center for Health Statistics, Office of Vital Records (CDHS-OVR) and the National Center for Health Statistics.

A very similar protocol to the one used in this health statistics review identified a statistically significant excess of asbestos-related disease in the Libby, Montana, community. If the Long Beach populations evaluated in this health statistics review were similar to the Libby community in terms of level of exposure to Libby asbestos, population mobility, and other characteristics, then this type of analysis would be expected to also be able to detect a statistically significant excess of asbestos-related disease in the Long Beach community.

The Long Beach populations evaluated differ from the Libby community in ways that increase the limitations of this type of analysis. Therefore, although the results of this health statistics review could be correctly reflecting that the health of the Long Beach community was not impacted by exposure to Libby asbestos, the lack of consistent evidence of disease excess could be due to any or all of the following reasons:

1. this analysis did not account for the ways in which the Long Beach and U.S. populations differ with respect to other risk factors for asbestos-related disease;

2. the assumptions about the size of the Long Beach populations evaluated made the incidence and mortality rates in the Long Beach populations evaluated appear more similar to the rates in the U.S. population than they actually are;

3. the populations evaluated include people who were never exposed to Libby asbestos from National Gypsum, which also made the incidence and mortality rates in the Long Beach populations evaluated appear more similar to the rates in the U.S. population than they actually are; and

4. given the years that exposure to Libby asbestos would have occurred, combined with the amount of time that asbestos-related disease takes to develop, this analysis might be failing to observe an excess of disease or death, because the time period it evaluates precedes the time period that most of the disease attributable to Libby asbestos would occur.

However, these findings do not rule out the possibility that community members might have been exposed to hazardous levels of asbestos as a result of the facility's handling or processing of Libby vermiculite.

## Recommendations

1. CDHS recommends efforts to identify and notify workers who worked at National Gypsum between mid-1970 and 1977 of their potential exposure to asbestos and of ways to reduce risk of asbestos-related disease (e.g., smoking cessation).

2. CDHS recommends that the current owner of the National Gypsum facility follow-up the findings of chrysotile (not-Libby related asbestos) fibers in the dust. Specifically, it might be useful to try to identify the source of the asbestos and developing an operation and maintenance plan if necessary (see http://www.epa.gov/asbestos/pubs/buildings.html).

3. CDHS recommends efforts to expand public awareness of the potential for and ways to avoid or reduce exposure to asbestos in consumer products made with WR Grace-Libby vermiculite.

## Public Health Action Plan

The Public Health Action Plan is a collection of activities intended to ensure that this health statistics review also provides a plan of action to mitigate and to prevent adverse effects on human health resulting from exposure to asbestos from Libby vermiculite. Some activities have already been taken by CDHS or ATSDR. Others activities are either ongoing or planned for the future.

### Actions Completed

1. In 2002, CDHS conducted a needs assessment with the City of Long Beach and the Los Angeles County Health Officers and Environmental Health Departments, the goals of which were to educate the departments about the vermiculite health statistics review project, to obtain information about the extent and level of stakeholder concerns, to develop an information dissemination plan, and to identify ways CDHS can support local efforts or activities pertaining to National Gypsum.

2. In May 2004, CDHS Environmental Health Investigations Branch (EHIB) and Occupational Health Branch (of CDHS) staff toured a gypsum manufacturing facility in the San Francisco Bay Area.

3. Information on the potential for and ways to reduce exposure to asbestos in vermiculite consumer products was included in this health consultation and provided to the City of Long Beach and the Los Angeles Health Officers and Environmental Health Directors.

### Ongoing Actions

1. CDHS will continue to provide technical assistance to the City of Long Beach and Los Angeles County Health Officers and Environmental Health Departments about the vermiculite health statistics review.

2. ATSDR has funded health statistics reviews in 25 states with facilities that received Libby vermiculite. Once all of the results from participating states have been received, ATSDR will compare the SRRs for all the sites examined in order to identify trends that might not be apparent when each facility is evaluated individually. The results of the health statistics reviews will also be evaluated in combination with all information on environmental exposures to asbestos produced by research by the National Asbestos Exposure Review project of ATSDR. ATSDR will distribute the results of these analyses to contributing state health departments and other interested parties.

3. Using the results of ATSDR's review of health statistics for all vermiculite facilities nation wide, CDHS will conduct follow-up activities with the City of Long Beach, and Los Angeles County Health Officers and Environmental Health Departments. The specifics of these activities will depend on what is learned from the nation-wide review.

4. ATSDR/CDHS will release a fact sheet describing the health consultation findings to the community living near the National Gypsum facility.

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## Preparers of Report

### Research Scientists

Jackie Schwartz
Epidemiologist
Impact Assessment, Contractor to
Environmental Health Investigations Branch
Department of Health Services

Marilyn Underwood, Ph.D.
Acting Chief, Site Assessment Section
Environmental Health Investigation Branch
Department of Health Services

### Community Relations Coordinator

Tivo Rojas, M.P.H.
Impact Assessment, Contractor to
Environmental Health Investigations Branch
Department of Health Services

### ATSDR Regional Representatives, Region IX

Gwen Eng
Libby Levy
Susan Musa
Regional Representatives

### ATSDR Technical Project Officer

Tammie McRae, M.S.
Environmental Health Scientist
Division of Public Health Assessment and Consultation

## Certification

The National Gypsum Facility, 1850 Pier B Street, Long Beach, Los Angeles County, California, public health consultation was prepared by the Department of Health Services 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 public health consultation was prepared. Editorial review was completed by the Cooperative Agreement partner.

Tammie McRae, M.S.
Technical Project Officer, Cooperative Agreement Team
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

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

Alan Yarbrough
Cooperative Agreement Team Leader
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry

## Appendix A—Glossary

ATSDR
The Agency for Toxic Substances and Disease Registry. ATSDR is a federal health agency based in Atlanta, Georgia, that deals with hazardous substance and waste site issues. ATSDR provides information to the public on harmful chemicals in the environment and on how to be safe from contact with chemicals.

Cancer Risk
The potential for exposure to a contaminant to cause cancer in an individual or population is evaluated by estimating the probability of an individual developing cancer over a lifetime as the result of the exposure. This approach is based on the assumption that there are no absolutely "safe" toxicity values for carcinogens. USEPA has developed cancer slope factors for many carcinogens. A slope factor is an estimate of a chemical's carcinogenic potency, or potential, for causing cancer.

If adequate information about the level of exposure, frequency of exposure, and length of exposure to a particular carcinogen is available, an estimate of excess cancer risk associated with the exposure can be calculated using the slope factor for that carcinogen. Specifically, to obtain risk estimates, the estimated chronic exposure dose (which is averaged over a lifetime or 70 years) is multiplied by the slope factor for that carcinogen.

Cancer risk is the likelihood, or chance, of getting cancer. We say "excess cancer risk" because we have a "background risk" of about one in four chances of getting cancer. In other words, in a million people, it is expected that 250,000 individuals would get cancer from a variety of causes. If we say that there is a "one in a million" excess cancer risk from a given exposure to a contaminant, we mean that if one million people are exposed to a carcinogen at a certain concentration over their lifetime, then one cancer above the background chance, or the 250,000$^{th}$ cancer, may appear in those million persons from that particular exposure. In order to take into account the uncertainties in the science, the risk numbers used are plausible upper limits of the actual risk based on conservative assumptions. In actuality, the risk is probably somewhat lower than calculated, and in fact may be zero.

Concern
A belief or worry that chemicals in the environment might cause harm to people.

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

Contaminant
See Environmental Contaminant.

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

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

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

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

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

Environmental Media
Usually refers to the air, water, and soil in which chemicals of interest are found. Sometimes refers to the plants and animals that are eaten by humans. Environmental Media is the second part of an Exposure Pathway.

Environmental Media Evaluation Guide (EMEG)
EMEGs are media-specific values developed by ATSDR to serve as an aid in selecting environmental contaminants that need to be further evaluated for potential health impacts. EMEGs are based on non-carcinogenic endpoints and do not consider carcinogenic effects. EMEGs are based on the MRLs.

Exposure
Coming into contact with a chemical substance. (For the three ways people can come in contact with substances, see Route of Exposure.)

Exposure Assessment
The process of finding the ways people come in contact with chemicals, how often and how long they come in contact with chemicals, and the amounts of chemicals with which they come in contact.

Exposure Pathway
A description of the way that a chemical moves from its source (where it began) to where and how people can come into contact with (or get exposed to) the chemical. ATSDR defines an exposure pathway as having five parts:
1. Source of Contamination
2. Environmental Media and Transport Mechanism
3. Point of Exposure
4. Route of Exposure
5. Receptor Population

When all five parts of an exposure pathway are present, it is called a Completed Exposure Pathway.

Hazardous Waste
Substances that have been released or thrown away into the environment and, under certain conditions, could be harmful to people who come into contact with them.

PHA
Public Health Assessment. A report or document that looks at chemicals at a hazardous waste site and tells if people could be harmed from coming into contact with those chemicals. The PHA also tells if possible further public health actions are needed.

Point of Exposure
The place where someone can come into contact with a contaminated environmental medium (air, water, food, or soil). Examples: the area of a playground that has contaminated dirt, a contaminated spring used for drinking water, the location where fruits or vegetables are grown in contaminated soil, or the backyard area where someone might breathe contaminated air.

Population
A group of people living in a certain area or the number of people in a certain area.

PRP
Potentially Responsible Party. A company, government, or person that is responsible for causing the pollution at a hazardous waste site. PRPs are expected to help pay for the clean up of a site.

Public Health Assessment(s)
See PHA.

Public Health Hazard
The category is used in PHAs for sites that have certain physical features or evidence of chronic, site-related chemical exposure that could result in adverse health effects.

Public Health Hazard Criteria
PHA categories given to a site which tell whether people could be harmed by conditions present at the site. The categories are:
1. Urgent Public Health Hazard
2. Public Health Hazard
3. Indeterminate Public Health Hazard
4. No Apparent Public Health Hazard
5. No Public Health Hazard

Route of Exposure
The way a chemical can get into a person's body. There are three exposure routes:
1. Breathing (also called inhalation)
2. Eating or drinking (also called ingestion)
3. Getting something on the skin (also called dermal contact)

Source (of Contamination)
The place from which a chemical comes, such as a landfill, pond, creek, incinerator, tank, or drum. Contaminant source is the first part of an Exposure Pathway.

Special Populations
People who may be more sensitive to chemical exposures because of certain factors such as age, a disease they already have, occupation, sex, or certain behaviors (like cigarette smoking). Children, pregnant women, and the elderly are often considered special populations.

Toxic
Harmful. Any substance or chemical can be toxic at a certain dose (amount).

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

## Appendix B—Standardized Incidence Ratio

The standardized incidence ratio (SIR) is a measure that compares the incidence rate of disease in two populations. In this health statistics review the SIR compares, for the time period 1986 through 1995, the number of people who were diagnosed with a type of cancer while residing in census tract 5755 and the number of people expected to be diagnosed with cancer if the incidence rate of cancer in the census tract 5755 population was the same as the incidence rate in the U.S. population. The SIR was calculated to account for ways in which census tract 5755 and U.S. populations differ in terms of age and sex.

The SIR is calculated in two steps.

*Step 1*

The expected number is calculated by 1) multiplying the incidence rate in various age and sex groups in the U.S. population by the number of people in those age and sex groups in the census tract 5755 population; then 2) summing the products to obtain the total number of expected cases in the census tract 5755 population.

*Step 2*

The SIR is calculated by dividing the actual number of people who were diagnosed with cancer by the expected number.

| | U.S. Annual Incidence Rate, All Types of Cancer 1986–1995 | | Number of People in Census Tract 5755 1986–1995 | | Number Expected of Cases in Census Tract 5755 |
|---|---|---|---|---|---|
| **STEP 1** | | | | | |
| ***Female age groups*** | | | | | |
| 0 to 4 | 0.000188 | X | 31 | = | 0.06 |
| 5 to 9 | 0.000097 | X | 29 | = | 0.03 |
| 10 to 14 | 0.000116 | X | 25 | = | 0.03 |
| 15 to 19 | 0.000205 | X | 23 | = | 0.05 |
| 20 to 24 | 0.000351 | X | 16 | = | 0.06 |
| 25 to 29 | 0.000605 | X | 20 | = | 0.12 |
| 30 to 34 | 0.000948 | X | 19 | = | 0.18 |
| 35 to 39 | 0.001601 | X | 13 | = | 0.21 |
| 40 to 44 | 0.002631 | X | 14 | = | 0.37 |
| 45 to 49 | 0.004182 | X | 10 | = | 0.42 |
| 50 to 54 | 0.005868 | X | 6 | = | 0.35 |
| 55 to 59 | 0.008014 | X | 2 | = | 0.16 |
| 60 to 64 | 0.010734 | X | 5 | = | 0.54 |
| 65 to 69 | 0.013577 | X | 6 | = | 0.81 |
| 70 to 74 | 0.016334 | X | 6 | = | 0.98 |
| 75 to 79 | 0.018378 | X | 1 | = | 0.18 |
| 80 to 84 | 0.019683 | X | 1 | = | 0.20 |
| 85 & up | 0.019640 | X | 0 | = | 0.00 |
| ***Male age groups*** | | | | | |
| 0 to 4 | 0.000216 | X | 26 | = | 0.06 |
| 5 to 9 | 0.000123 | X | 29 | = | 0.04 |
| 10 to 14 | 0.000124 | X | 19 | = | 0.02 |
| 15 to 19 | 0.000210 | X | 29 | = | 0.06 |
| 20 to 24 | 0.000333 | X | 35 | = | 0.12 |
| 25 to 29 | 0.000573 | X | 47 | = | 0.27 |
| 30 to 34 | 0.000871 | X | 22 | = | 0.19 |
| 35 to 39 | 0.001191 | X | 24 | = | 0.29 |
| 40 to 44 | 0.001630 | X | 19 | = | 0.31 |
| 45 to 49 | 0.002697 | X | 10 | = | 0.27 |
| 50 to 54 | 0.004991 | X | 7 | = | 0.35 |
| 55 to 59 | 0.008856 | X | 10 | = | 0.89 |
| 60 to 64 | 0.014763 | X | 3 | = | 0.44 |
| 65 to 69 | 0.022620 | X | 4 | = | 0.90 |
| 70 to 74 | 0.030244 | X | 5 | = | 1.51 |
| 75 to 79 | 0.035267 | X | 3 | = | 1.06 |
| 80 to 84 | 0.038441 | X | 0 | = | 0.00 |
| 85 & up | 0.037822 | X | 0 | = | 0.00 |
| ***Total number of expected cases in census tract:*** | | | | | ***11*** |
| **STEP 2** | | | | | |
| **SIR =** $\frac{\mathbf{17}}{\mathbf{11}}$ **= 1.5** | | | | | |

## Appendix C—Standardized Rate Ratio

The standardized rate ratio (SRR) is a measure that compares the incidence rate or the mortality rate for a disease in two populations. For the cancer statistics review, the SRR compares the number of people in the U.S. who were diagnosed with a type of cancer, and the number of people expected to be diagnosed if the incidence rate in the U.S. population was the same as the incidence rate in the census tract 5755 population. For the mortality statistics review, the SRR compares the number of people in the U.S. who died from a disease and the number of people expected to die if the mortality rate in the U.S. population was the same as the mortality rate in the ZIP Code 90813 population.

The SRR is calculated in a manner that accounts for ways in which the populations evaluated and the U.S. population differs in terms of age and sex. The SRR is calculated in two steps.

*Step 1*

The expected number of cases or deaths in the U.S. population is calculated by 1) multiplying the incidence or mortality rate in various age and sex groups in the population evaluated by the number of people in those age and sex groups in the U.S. population; then 2) summing the products to obtain the total number of expected cases or deaths in the U.S. population.

*Step 2*

The SRR is calculated by dividing the expected number of cases or deaths (calculated in step 1) by the actual number of cases or deaths that occurred.

These steps are demonstrated at right for the mortality rate of all types of cancer.

| | **ZIP Code 90813 Annual Mortality Rate, All Types of Cancer 1989–1998** | | **Number of People in the U.S. 1989–1998** | | **Number of Expected Deaths in the U.S. 1989–1998** |
|---|---|---|---|---|---|
| **STEP 1** | | | | | |
| ***Female age groups*** | | | | | |
| 0 to 4 | 0.00003 | X | 93,966,244 | = | 2,489.83 |
| 5 to 9 | 0.00011 | X | 91,867,322 | = | 9,835.90 |
| 10 to 14 | 0.00000 | X | 89,304,231 | = | 0.00 |
| 15 to 19 | 0.00005 | X | 87,811,833 | = | 4,213.62 |
| 20 to 24 | 0.00004 | X | 90,427,466 | = | 3,405.93 |
| 25 to 29 | 0.00004 | X | 98,755,306 | = | 3,585.89 |
| 30 to 34 | 0.00026 | X | 108,681,120 | = | 27,724.78 |
| 35 to 39 | 0.00010 | X | 107,902,167 | = | 10,715.21 |
| 40 to 44 | 0.00034 | X | 98,780,341 | = | 33,175.60 |
| 45 to 49 | 0.00059 | X | 82,737,629 | = | 49,015.18 |
| 50 to 54 | 0.00141 | X | 67,120,643 | = | 94,937.26 |
| 55 to 59 | 0.00280 | X | 57,368,622 | = | 160,471.67 |
| 60 to 64 | 0.00325 | X | 54,716,238 | = | 177,732.56 |
| 65 to 69 | 0.00527 | X | 54,396,949 | = | 286,820.28 |
| 70 to 74 | 0.00617 | X | 48,337,651 | = | 298.035,61 |
| 75 to 79 | 0.01003 | X | 39,220,867 | = | 393,438.16 |
| 80 to 84 | 0.00978 | X | 27,563,804 | = | 269,645.91 |
| 85 & up | 0.01311 | X | 24,880,271 | = | 326,100.94 |
| ***Male age groups*** | | | | | |
| 0 to 4 | 0.00005 | X | 98,444,382 | = | 5,154.16 |
| 5 to 9 | 0.00003 | X | 96,375,416 | = | 2,765.44 |
| 10 to 14 | 0.00004 | X | 93,779,769 | = | 3,484.94 |
| 15 to 19 | 0.00004 | X | 92,727,275 | = | 3,271.96 |
| 20 to 24 | 0.00006 | X | 93,916,511 | = | 5,232.12 |
| 25 to 29 | 0.00006 | X | 99,300,884 | = | 5,795.21 |
| 30 to 34 | 0.00018 | X | 107,836,073 | = | 19,194.74 |
| 35 to 39 | 0.00037 | X | 106,638,555 | = | 39,605.78 |
| 40 to 44 | 0.00034 | X | 96,528,396 | = | 33,239.81 |
| 45 to 49 | 0.00116 | X | 79,706,353 | = | 92,433.77 |
| 50 to 54 | 0.00408 | X | 63,474,519 | = | 259,079.67 |
| 55 to 59 | 0.00469 | X | 52,786,640 | = | 247,824.60 |
| 60 to 64 | 0.00623 | X | 48,333,937 | = | 300,911.67 |
| 65 to 69 | 0.01193 | X | 44,815,676 | = | 534,603.24 |
| 70 to 74 | 0.01042 | X | 36,773,021 | = | 388,052.30 |
| 75 to 79 | 0.01232 | X | 26,482,551 | = | 326,139.79 |
| 80 to 84 | 0.01606 | X | 15,345,068 | = | 246,417.15 |
| 85 & up | 0.01429 | X | 9,774,311 | = | 139,633.01 |
| ***Total number of expected deaths in U.S.: 4,799,183.4*** | | | | | |
| **STEP 2** | | | | | |
| **SRR = $\frac{\text{4,799,183}}{\text{5,259,810}}$ = 0.81** | | | | | |

## Appendix D—Standardized Mortality Ratio

The standardized mortality ratio (SMR) is a measure that compares the mortality rate for a disease in two populations. In this health statistics review, the SMR compares, for the time period 1989 through 1998, the number of people who died from a disease while residing in ZIP Code 90813 to the number of people expected to die, if the mortality rate for the disease in the ZIP Code 90813 population was the same as the mortality rate for the disease in the U.S. population. The SMR was calculated in a manner that accounts for ways in which the ZIP Code 90813 and U.S. populations differ in terms of age and sex.

The SMR is calculated in two steps.

*Step 1*

The expected number of deaths is calculated by 1) multiplying the mortality rate in various age and sex groups in the U.S. population by the number of people in those age and sex groups in the ZIP Code 90813 population; then 2) summing the products to obtain the total number of expected deaths in the ZIP Code 90813 population.

*Step 2*

The SMR is calculated by dividing the actual number of deaths that occurred by the expected number (calculated in step 1).
These steps are demonstrated at left for death from all types of cancer.

| | U.S. Annual Mortality Rate, All Types of Cancer 1989–1998 | | Number of People in ZIP Code 90813 1989–1998 | | Number of Expected Deaths in ZIP Code 90813 |
|---|---|---|---|---|---|
| **STEP 1** | | | | | |
| ***Female age groups*** | | | | | |
| 0 to 4 | 0.000027 | X | 3774 | = | 1.02 |
| 5 to 9 | 0.000026 | X | 3736 | = | 0.97 |
| 10 to 14 | 0.000024 | X | 2340 | = | 0.56 |
| 15 to 19 | 0.000033 | X | 2084 | = | 0.69 |
| 20 to 24 | 0.000045 | X | 2655 | = | 1.19 |
| 25 to 29 | 0.000082 | X | 2754 | = | 2.26 |
| 30 to 34 | 0.000162 | X | 2744 | = | 4.45 |
| 35 to 39 | 0.000319 | X | 2014 | = | 6.42 |
| 40 to 44 | 0.000591 | X | 1191 | = | 7.04 |
| 45 to 49 | 0.001075 | X | 844 | = | 9.07 |
| 50 to 54 | 0.001851 | X | 707 | = | 13.09 |
| 55 to 59 | 0.002916 | X | 715 | = | 20.85 |
| 60 to 64 | 0.004336 | X | 431 | = | 18.69 |
| 65 to 69 | 0.005933 | X | 550 | = | 32.63 |
| 70 to 74 | 0.007832 | X | 519 | = | 40.65 |
| 75 to 79 | 0.009567 | X | 319 | = | 30.52 |
| 80 to 84 | 0.011546 | X | 276 | = | 31.87 |
| 85 & up | 0.014049 | X | 206 | = | 28.94 |
| ***Male age groups*** | | | | | |
| 0 to 4 | 0.000031 | X | 3820 | = | 1.18 |
| 5 to 9 | 0.000032 | X | 3485 | = | 1.12 |
| 10 to 14 | 0.000032 | X | 2691 | = | 0.86 |
| 15 to 19 | 0.000047 | X | 2834 | = | 1.33 |
| 20 to 24 | 0.000064 | X | 3590 | = | 2.30 |
| 25 to 29 | 0.000090 | X | 3427 | = | 3.08 |
| 30 to 34 | 0.000145 | X | 2809 | = | 4.07 |
| 35 to 39 | 0.000252 | X | 2154 | = | 5.43 |
| 40 to 44 | 0.000498 | X | 1452 | = | 7.23 |
| 45 to 49 | 0.001033 | X | 1121 | = | 11.58 |
| 50 to 54 | 0.002057 | X | 686 | = | 14.11 |
| 55 to 59 | 0.003744 | X | 426 | = | 15.95 |
| 60 to 64 | 0.006262 | X | 514 | = | 32.19 |
| 65 to 69 | 0.009319 | X | 394 | = | 36.72 |
| 70 to 74 | 0.012953 | X | 336 | = | 43.52 |
| 75 to 79 | 0.016628 | X | 203 | = | 33.75 |
| 80 to 84 | 0.021582 | X | 137 | = | 29.57 |
| 85 & up | 0.027371 | X | 84 | = | 22.99 |
| ***Total number of expected deaths:*** | | | | | ***517.9*** |
| **STEP 2** | | | | | |
| **SMR = $\frac{478}{517.9}$ = 0.92** | | | | | |

## Appendix E—Standardized Rate Ratios

**Table E1. Standardized Rate Ratio (SRR) and 95% Confidence Intervals (CI) of Incidence of Selected Cancers in the Census Tract 5755 Population, 1986–1995, Standardized to U.S. Population Age and Sex Distribution.**

| Cancer Group (ICD-O-2 Code) | Reason* | Using U.S. Population Age and Sex Distribution | | |
|---|---|---|---|---|
| | | Number of Diagnoses in U.S. | Number Expected, Based on Rates in Census Tract 5755 | SRR (95% CI) |
| Lung and bronchus (C340:C349†) | 1 | 148,246 | 105,635.5 | 0.70 (0.07-7.48) |
| Mesothelioma (M-9050:9053) | 1 | 2,360 | 0.0 | 0§ |
| Digestive organs (C150: C218, C260:C269†) | 2 | 163,384 | 316,666.5 | 1.90 (0.78-4.81) |
| Respiratory system and intrathoriacic organs (C320:C399†) | 3 | 162,067 | 105,635.5 | 0.70 (0.06-6.84) |
| Peritoneum, retroperitoneum, and pleura (C480:C488, C384†) | 3 | 3,814 | 0.0 | 0§ |
| All cancers (C000:C809†) | 4 | 1,045,968 | 1,787,486.7 | 1.70 (0.97-3.01) |
| Female breast (C500:C509†) | 4 | 154,568 | 64,455.3 | 0.40 (0.06-2.96) |
| Prostate (C619†) | 4 | 153,845 | 68,246.9 | 0.40 (0.06-3.15) |

* Reason for evaluating the cancer grouping:

1. Exposure to asbestos is known to cause a type of cancer in this cancer group.
2. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
3. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
4. This cancer or cancer group was evaluated to confirm that information on cancer diagnoses is reported to CCR and SEER in a consistent manner.

† Excluding M-9590:9989

‡Exact confidence interval based on Poisson distribution

§Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004)

ICD-O-2= International Classification of Diseases for Oncology, Second Edition.

**Table E2. Standardized Rate Ratio (SRR) and 95% Confidence Intervals (CI) of Selected Causes of Death Occurring in ZIP Code 90813, 1989–1998, Standardized to U.S. Population Age and Sex Distribution.**

| Cause of Death (ICD-9 Code) | Reason* | Using U.S. Population Age and Sex Distribution | | |
|---|---|---|---|---|
| | | Number Deaths in U.S. | Number Expected, based on rates in zip code 90813 | SRR (95% CI) |
| Cancer of the lung and bronchus (162.2-162.9) | 1 | 1,476,326 | 1,513,847.7 | 1.03 (0.94-1.11) |
| Cancer of the peritoneum, retroperitoneum and pleura (including mesothelioma) (158, 163) | 1 | 10,615 | 12,077.8 | 1.14 (0.16-7.91) |
| Asbestosis (501) | 1 | 3,367 | 0.0 | 0‡ |
| Cancer of the digestive organs (150-154, 159) | 2 | 832,523 | 932,510.8 | 1.12 (1.01-1.24) |
| Cancer of the respiratory system and intrathoracic organs (161-165) | 3 | 1,524,872 | 1,602,301.4 | 1.05 (0.97-1.14) |
| Cancer (no site specified) (199) | 3 | 327,646 | 338,618.8 | 1.03 (0.87-1.22) |
| Pneumoconiosis (500-505) | 3 | 11,617 | 0.0 | 0‡ |
| Chronic obstructive pulmonary disease (490-496) | 3, 4 | 986,772 | 1,276,814.9 | 1.29 (1.18-1.42) |
| Other diseases of the respiratory system (510-519) | 4 | 172,155 | 126,059.8 | 0.73 (0.56-0.95) |
| Diseases of pulmonary circulation (415-417) | 4 | 119,554 | 62,523.3 | 0.52 (0.36-0.77) |
| All cancers (140-208) | 5 | 5,259,810 | 4,799,183.4 | 0.91 (0.87-0.95) |
| Female breast cancer (174) | 5 | 430,680 | 373,565.5 | 0.87 (0.73-1.02) |
| Prostate cancer (185) | 5 | 334,151 | 303,165.2 | 0.91 (0.75-1.10) |

***** Reason for evaluating the disease:

6. Exposure to asbestos is known to cause a type of cancer in this cancer group or this disease.
7. There is some, but inconclusive, evidence that exposure to asbestos might be associated with some digestive organ cancers.
8. This cancer group might include people with an asbestos-related cancer that was misdiagnosed.
9. Exposure to asbestos might have exacerbated the condition of people with these diseases and thereby led to premature or increased chance of death.
10. This cancer or cancer group was evaluated to confirm that information is reported to California Department of Health Services, Center for Health Statistics, Office of Vital Records and the National Center for Health Statistics, in a consistent manner.

† Exact confidence interval based on Poisson distribution. ‡ Confidence interval not calculated since expected number of deaths was 0 (W. Kaye, ATSDR, personal communication, 2004). ICD-9= International Classification of Disease, Ninth Edition.