Health Consultation

Western Mineral Products Site
(a/k/a Western Mineral Products)

City of Minneapolis, Hennepin County, Minnesota

EPA Facility ID: MNN000508056

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Prepared by:

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

FOREWORD

This document summarizes public health concerns at a hazardous waste site in Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). A number of steps are necessary to do such an evaluation:

- Evaluating exposure: MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it's found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. We rely on information provided by the Minnesota Pollution Control Agency (MPCA), U.S. Environmental Protection Agency (EPA), and other government agencies, businesses, and the general public.

- Evaluating health effects: If there is evidence that people are being exposed - or could be exposed - to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. The report focuses on public health - the health impact on the community as a whole - and is based on existing scientific information.

- Developing recommendations: In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site, and offers recommendations for reducing or eliminating human exposure to contaminants. The role of MDH in dealing with hazardous waste sites is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies - including EPA and MPCA. However, if there is an immediate health threat, MDH will issue a public health advisory warning people of the danger, and will work to resolve the problem.

- Soliciting community input: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the organizations responsible for cleaning up the site, and the community surrounding the site. Any conclusions about the site are shared with the groups and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us*.

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I. Summary of Background and History

The Western Mineral Products site is located on several parcels of land at 1719 and 1720 Madison Street NE, and 1801 and 1815 Jefferson Street NE in the city of Minneapolis, Minnesota. The site is located in a neighborhood of mixed land use, consisting of residential, commercial, and light industrial properties. The original site consists of a large brick building dating back to the early part of the 20^{th} century, two storage silos, and a gravel parking lot. Several additions to the original brick building were added in the 1940s and 1950s. The location of the site is shown in Figure 1, and a site map is presented in Figure 2.

According to city of Minneapolis directories and other available records, the Western Mineral Products Company leased the site beginning in 1936, and owned the site outright from 1954 until 1963 (URS 2001). Western Mineral Products Company operated an insulation products manufacturing plant at the site. The plant processed vermiculite ore shipped primarily from a mine operated by the Zonolite Company, and located in Libby, Montana. In 1963, the Zonolite Company was acquired by W.R. Grace & Company (W.R. Grace), who in turn acquired the Western Mineral Products Company (and the site) in 1966. The plant was operated by W.R. Grace until 1989, when W.R. Grace closed the mine in Libby, Montana, and ceased processing vermiculite at the site. Vermiculite processing operations therefore occurred at the site from 1936 until 1989.

Vermiculite is generally used for insulation, as a lightweight aggregate in construction materials, and as a soil additive for gardening uses. Vermiculite also has many other industrial uses as a fireproofing material, absorbent, and filter medium (Vermiculite Association 2000). Over time, it became known that the vermiculite ore from the mine in Libby, Montana, from which the finished vermiculite was produced contained large amounts of naturally occurring asbestos. The general mineral type of asbestos in the ore is known as amphibole, which is different from the mineral type of asbestos (known as chrysotile) typically used in common commercial applications such as pipe insulation, siding, and brake linings. In April 2000, the U.S. Environmental Protection Agency (EPA) and the Minnesota Pollution Control Agency (MPCA), as part of a national evaluation of facilities that received ore from the mine in Libby, Montana, collected surface soil samples at the site. Through microscopic examination of the surface soil samples, it was found that amphibole asbestos was present at levels as high as 20% by volume at the former Western Mineral Products Company site (Ecology and Environment 2000). The EPA and MPCA requested that the Minnesota Department of Health (MDH) review the available information about the site, and develop conclusions and recommendations regarding potential public health implications of the asbestos contamination.

Geology/Hydrogeology

The site is located approximately one mile from the Mississippi River in Northeast Minneapolis. Due to the long use of the site for industrial purposes, it is likely that surface soils consist primarily of fill materials. Beneath the surface soils are glacial deposits, consisting of sand, gravelly sand, and loamy sand overlain by thin deposits of silt, loam, or organic sediment. Beneath these glacial deposits (at a depth of 50 feet or more) is bedrock consisting of the Platteville and Glenwood Formations overlying the St. Peter Sandstone (URS 2000).

Shallow groundwater at the site (if present) is expected to flow west-southwest toward the Mississippi River. Groundwater in the regional aquifers below this is also expected to flow toward the Mississippi River.

Vermiculite Processing

Vermiculite is a non-fibrous silicate mineral used for many commercial and consumer applications. Its primary usefulness comes from its ability to expand (or 'exfoliate') up to 20 times its original size at high temperatures (EPA 1991). In addition to the properties described above, vermiculite also has a high cation-exchange capacity, making it useful for absorbing liquids or chemicals. The density of raw vermiculite ore is approximately 55 pounds per cubic foot, while the density of finished vermiculite is in the range of six to eight pounds per cubic foot (URS 2000a). The Western Mineral Products facility also produced a similar industrial product known as perlite, which is derived from a quartz-based mineral that is not known to contain asbestos.

The raw vermiculite ore mined in Libby, Montana, is estimated to have contained up to approximately 25% fibrous amphibole asbestos of the tremolite-actinolite-richterite-winchite solid solution series (hereafter referred to as "tremolite asbestos"). The raw ore was mined via open-pit mining methods, and then transferred to a milling (also known as a "beneficiation") operation to remove waste rock. The beneficiated ore (or "concentrate") was then screened into several size ranges (from #0, or coarse, to #5, fine) for processing into finished vermiculite in Libby or shipment, usually via rail, to a number of processing or "exfoliation" plants across the United States and Canada. Some studies have suggested that the different ore grades may have had varying asbestos contents, with smaller grades being more contaminated (EPA 1991). Other data suggest that the tremolite content was typically 2% - 6% in the various grades of ore (EPA 2000). Western Mineral Products was one of several known vermiculite exfoliation plants in Minnesota. Other businesses in the state are thought to have received vermiculite ore concentrate for various small industrial uses.

The Western Mineral Products facility received vermiculite ore concentrate via rail from the mining operation in Libby, Montana starting in 1937 (URS 2001). The concentrate was transported typically in open hopper cars (with an approximate capacity of 96 tons per car), and unloaded and conveyed into one of the two 45-foot high storage silos (URS 2000a). Boxcars were also reportedly used to transport the concentrate, and had to be unloaded by hand (MDH 2000). The quantity of vermiculite ore concentrate received from the mine in Libby ranged from over 8,500 tons in 1959 to less than 1,000 tons in 1988 according to W.R. Grace records (HRO 2000a). The quantities of ore shipped to the site from the mine in Libby, Montana for the time period of 1958 to 1988 are shown in Table 1. The quantity of ore shipped per year declined steadily from the early 1960s until the plant closed in 1989. In the 1970s, the Western Mineral

Products plant operated 24 hours per day, 5 days per week (approximately 250 days per year), and typically employed between 11 and 20 people, according to information submitted by W.R. Grace to the EPA (HRO 2000b).

The vermiculite ore concentrate was gravity fed into one of two expanding furnaces at a rate of up to 2,400 pounds (1.2 tons) per hour (HRO 2000c). The furnaces were located in the metal addition constructed in 1946 on the north side of the original brick building; prior to this one furnace was located on the second floor of the brick building (URS 2001). The furnaces heated the ore concentrate to a temperature of 2,000 degrees Fahrenheit, thus boiling the water trapped within the mineral and causing it to expand. The expanded vermiculite was then moved by augers or conveyors and passed through a device known as a “stoner,” where the expanded vermiculite was separated from the unexpandable minerals, known as “stoner rock.” The finished vermiculite was then cooled, dampened, and bagged in three, four, and six cubic foot paper or plastic bags for commercial or consumer use, or further screened into several size ranges for specific applications. Some of the processed vermiculite was mixed with other ingredients, including raw (likely chrysotile) asbestos to form various construction products. A schematic prepared by W.R. Grace of the plant process and material handling equipment as it existed in 1980 is shown in Figure 3 (HRO 2000c). Separate buildings located to the north and east of the expansion plant were used as a roof tile manufacturing plant and a product testing laboratory, respectively by Western Mineral Products.

The process of exfoliating vermiculite ore concentrate into finished vermiculite was reportedly a dusty one. Past employees have stated that dust was often visible in the air inside of the building, and that the windows were often closed (MDH 2000). A vent system was installed at the plant and consisted of a main vent header, branch headers, primary cyclone, fabric filter or bag house, and fan (URS 2000a). The vent system is shown in Figure 3. This system was installed in 1971; prior to that a vent system apparently existed, but its design, and whether or not any filters were present, is unknown. Mention is made of the use of furnace cyclone fines (particulate matter) in a product formulation from 1964, so these devices may have been in use prior to 1971. The bag house filters were installed in 1972. Several complaints were made to local government officials and the news media in the late 1960s and early 1970s alleging that dust from a roof vent was settling on area lawns, cars, and the inside of homes (URS 2000a). Excerpts from citizen complaints received by the City of Minneapolis over the years are presented in Appendix 1.

The 1970s vent system was designed to transport air at velocities of 3,000 to 4,000 feet per minute, and discharged to the outside air through two 24-inch diameter, 50-foot high stacks at a velocity of 1,600 feet per minute and a temperature of 230 degrees Fahrenheit (HRO 2000d). Particulate emissions were reported in 1977 to be up to 0.12 tons (240 pounds) per year for each furnace stack. Based on aerial photographs, the two stacks were located on or near the roof of the four-story metal addition on the north side of the original three-story brick building. A third, smaller stack vented dust from the product mixing operation. The 48-inch diameter low velocity cyclone was said to remove approximately 85% of the particulate matter from the collected air, while the bag house filter system was designed to remove 99% of the particulate matter from the collected air. The estimated dust loading into the bag house filter was approximately 20 pounds per hour (URS 2000a).

As of 1986, the vermiculite processing operation generated several types of solid wastes, including the following (HRO 2000c):

- Stoner rock;
- Furnace bag house fines;
- Exfoliated vermiculite fine screenings;
- Mixer bag house fines; and
- Miscellaneous paper, pallets, and other trash.

According to mineral analyses conducted by W.R. Grace, the stoner rock contained between 2% and 10% friable (or easily crumbled) tremolite asbestos (assumed to be by weight). The furnace bag house fines were found to contain between 1% and 3% friable tremolite asbestos, while vermiculite fine screenings contained less than 0.5% friable tremolite asbestos (HRO 2000c). Until the 1970s, these waste materials were considered non-hazardous. The stoner rock, in particular, was placed in one or several piles outside the west end of the building and labeled “Free Crushed Rock.” Local residents were encouraged to take the stoner rock to use on their properties, usually for fill, and neighborhood children were known to play on the piles. A 1978 photograph of the stoner rock pile published in the March 19, 2000, edition of the Minneapolis Star Tribune is attached as Figure 4. The disposition of other waste products for much of the facility’s operational life is unknown. At some point during the late 1970s, the waste materials listed above from the facility reportedly began to be trucked to one or more landfills around the Twin City metro area for disposal (URS 2000a). The final vermiculite product may also have contained a small amount of residual tremolite asbestos (0.5% to 3%) according to a recent EPA study (EPA 2000a).

In 1989, W.R. Grace closed the plant and hired a contractor to remove the machinery and equipment from the site. All remaining vermiculite ore concentrate in the storage silos was reportedly removed at that time as well. The railroad spurs serving the site were removed in 1980 and 1989. The site was sold to the current owner, Madison Complex, Inc., in October of 1989, and is now the location of several small businesses and art studios. The majority of the site buildings are occupied by a single business manufacturing steel prison furniture.

<u>Western Mineral Products Site Soil Contamination</u>

In February and April of 2000, representatives of the EPA collected soil samples at the site for analysis for tremolite asbestos. In February of 2000, two soil samples were collected near the storage silos. Laboratory microscopic analysis of the samples showed they contained less than 1% tremolite asbestos by volume (see below for a discussion of analytical methods). In April of 2000, EPA staff again collected two soil samples from the site, one from the west side (OS-7) and one from the north side (OS-8) of the main plant building. Laboratory microscopic analysis of the soil samples showed tremolite asbestos was present at levels of 8% by volume in sample

OS-8 and 20% by volume in sample OS-7 (Ecology & Environment 2000). Other samples collected by MPCA staff showed similar results, indicating that the surface soils at the site are contaminated with tremolite asbestos. Tremolite asbestos is visible in many areas as small, whitish to grayish grains or bundles with a visible fibrous component. A close-up photograph of the surface soils at the site showing the visible grains of tremolite asbestos is attached as Figure 5.

EPA collected an additional 20 surface soil samples at the site in June 2000 to further characterize the tremolite asbestos contamination. Tremolite asbestos was found in all but two of the samples, at levels ranging from trace amounts to 12% by volume. Asbestos concentrations seemed to be highest in samples collected closest to the expansion plant building, especially where the stoner rock pile was located. The locations of the surface soil samples collected by EPA and the concentration of tremolite asbestos found are shown in Figure 6.

In October and December of 2000, Phase I and Phase II Investigations were conducted at the site by URS Corporation on behalf of W.R. Grace and the current property owners. The Phase I investigation consisted of a historical record search and property inspection. The Phase II investigation consisted of the collection of soil samples from 48 soil borings and ten test trenches for analysis for tremolite asbestos (URS 2001). Additional soil samples were collected from around the former storage silos by a sub-contractor for URS Corporation. Sediment samples from three of eight stormwater catch basins on the site were also collected; the remainder lacked sediment. The URS Corporation soil boring, test trench, and sediment sample locations are shown in Figure 7.

A total of 203 soil samples from the 48 soil borings were analyzed for asbestos content. Laboratory microscopic analysis of the samples identified asbestos in 95 of the 203 soil samples, at levels of up to 21.3%. The samples were collected at various depths, and asbestos was detected at depths of up to 4.5 feet below ground in some areas. The test trenches were typically two to four feet wide, ten feet long, and five to eight feet deep. Layers of vermiculite wastes and tremolite asbestos were easily visible in some of the trenches. Samples of these materials showed tremolite asbestos contents of up to 11%. Surface soil samples collected around the storage silos also showed asbestos contamination at levels up to 3.7%. Data from the analysis of soil samples from the soil borings and test trenches is presented in Table 2.

Tremolite asbestos was detected at a concentration of 1.4% in a sediment sample from catch basin CB-2, located on the western edge of the site. Stormwater and sediments from this catch basin ultimately discharge to the Mississippi River southwest of the site (URS 2001).

<u>Soil Contamination at Neighboring Properties</u>

In June of 2000, EPA began inspecting and collecting soil samples at residential properties in the neighborhood of the site. These properties were suspected of having tremolite asbestos contamination from use of the stoner rock or vermiculite waste from the site as fill materials, garden additives, or landscaping materials. This effort continued through the fall of 2000, and focused on an area within an approximately one-quarter mile radius of the former Western Mineral Products site. All properties within this area, both public and private, were reportedly inspected. Selected properties outside this area were also inspected. The EPA also set up a hot line for residents of this or other areas who are concerned that their properties may be contaminated with vermiculite wastes. Residents can call this number to request an inspection.

As of November 2000, EPA staff (or other federal, state and local staff working on behalf of EPA) had inspected over 300 properties in the vicinity of the plant (EPA 2000b). Tremolite asbestos contamination is suspected or has been confirmed at a total of 49 of these properties, while an additional 98 properties are awaiting inspection or the results of laboratory microscopic analysis of soil samples. The majority of the properties where asbestos contamination was found are within a few blocks of the site. The locations of the impacted properties in relation to the site itself are shown in Figure 8. The presence of tremolite asbestos is usually confirmed via laboratory microscopic examination; the visual observation of tremolite asbestos fragments as shown in Figure 5 is considered adequate for determining if a property is contaminated.

Concentrations of tremolite asbestos in soils at the various residential properties ranged from non-detect in a few samples to 10% by volume, with the majority of samples in the 2% - 6% range (Weston 2001a). Laboratory microscopic analysis of the tremolite asbestos fragments themselves (as shown in Figure 5) repeatedly showed asbestos concentrations of up to 95%. Tremolite asbestos was also found in soil samples collected in several alleys behind impacted residential properties, indicating that the asbestos had been washed from driveways or gardens into the alleys.

<u>Outdoor Air Samples</u>

Contractors for the EPA have conducted ambient air sampling in selected areas around the site, as well as personal and work area air sampling during cleanups at the above-mentioned residential properties (Weston 2001b, 2001c). These samples were collected using high-volume air pumps equipped with filter cartridges capable of trapping asbestos fibers. Both the ambient air and work zone air samples were collected with the filters positioned at a height approximating the breathing zone of an adult. Notations of wind speed and direction were made during each sampling event. Air samples were analyzed using an electron microscopy method that is capable of very low detection limits (a brief discussion of asbestos analytical methods is presented later in this document). Airborne dust levels were also monitored during excavation activities using a real-time dust monitor.

The majority of the work zone air monitoring sample results were below the average laboratory detection limit of 0.0009 asbestos fiber structures per cubic centimeter of air (f/cc). Work zone monitoring was conducted during excavation activities at residential properties, as well as during vacuuming sediment from alleyways between residences (see below). The maximum level of airborne tremolite asbestos detected during work zone monitoring was 0.0096 f/cc. This level is just below the state of Minnesota standard for indoor air (applied after asbestos has been removed from the interior of a building) of 0.01 f/cc, and approximately one-tenth the current workplace standard 0.1 f/cc. In general, airborne fibers were more often detected during excavation activities than during vacuuming of alleys. Possible explanations for the detections of tremolite fibers in air samples included unseasonably dry weather, above average temperatures and wind conditions, and potential mechanical disturbance of the asbestos materials as it was being excavated or vacuumed (Weston 2001b). Some of the sample results were marked as "overloaded;" this was the result of dust captured on the filter cartridge preventing an accurate fiber count. Real time dust measurements using the direct reading instrument were generally low.

Very low levels of asbestos fibers (identified as actinolite/tremolite) were found in 10 of 25 ambient or background air samples collected in the neighborhood surrounding the site (Weston 2001c). Samples were collected from 11 different locations around the site, as shown in Figure 9. Samples were collected on multiple days from four of the sampling locations. The highest asbestos concentration detected in ambient air was 0.0052 f/cc. While the samples are described as ambient or background, cleanup of residential properties may have been occurring near the various sampling sites and could have affected the results. Overall, there was no clear trend in the sampling results. The results of the ambient air samples are presented in Table 3.

Indoor Air and Dust/Debris Samples

In October of 2000, URS Corporation, on behalf of W.R. Grace, collected 35 ambient air samples both inside and outside the former Western Mineral Products building, and 13 personal air samples from employees of businesses inside the site buildings (URS 2000c). Laboratory microscopic analysis of the samples showed no asbestos levels in excess of the Minnesota indoor air standard of 0.01 f/cc. Very low numbers of asbestos fibers were found in 3 of the 48 air samples collected.

Forty-five (45) samples of debris and dust inside the former Western Mineral Products buildings were collected as a part of the Phase II Investigation conducted by URS in December of 2000 (URS 2001). The samples were collected in areas where work activities occurred, in areas most likely to be disturbed by work activities, or in areas where increased airflow or vibration could create airborne dusts. Low levels (below 0.3% by weight) of asbestos were found in seven of the 45 samples analyzed using polarized light laboratory microscopic analysis. Only one sample had an asbestos content greater than 1%, which is the regulatory level used to define an asbestos-containing material. This sample was collected from the top of a beam in a little used area of the site building, and had an asbestos content of 1.3%. Confirmation analysis using more sensitive electron microscopic methods detected tremolite asbestos in 25 of the 45 samples; the maximum concentration detected was 0.3% by weight.

Asbestos has been detected in several building products within the site buildings, such as floor tile, pipe insulation, textured plaster, and paint (URS 2000a). The asbestos found in these products was of the commercial (chrysotile) type. Dust samples collected by MDH during the demolition and removal of the vermiculite expansion equipment in 1989 detected low levels of asbestos. Trace amounts of tremolite asbestos have also been detected in samples of vermiculite used as insulation in ceilings in the office portion of the building (Ecology & Environment 2000), and in soil and debris inside the storage silos and associated concrete storage vaults (URS 2001).

Site Visit

MDH staff conducted numerous visits to the Western Mineral Products site and surrounding neighborhoods during the summer and fall of 2000. The following observations have been made:

- The majority of the grounds of the former Western Mineral Products site have been covered by plastic sheeting at the direction of the MPCA, and temporary fencing has been erected along Jefferson Street NE. Soil piles on the east side of the Electramatic, Inc., property have also been covered. The gravel drive on the south side of the building has not been covered, however, and is still in use for site access and parking.
- Under the plastic sheeting, tremolite asbestos grains are visible, as in Figure 5. Other waste materials, such as stoner rock and vermiculite, are also visible in some areas.
- Very little of the original equipment used in the vermiculite exfoliating operation, other than the storage silos, is visible from the exterior of the buildings. The name "Western Mineral Products Company" is still visible on the south wall of the original three-story brick building, and signs reading "W.R. Grace, Construction Products Division" are visible in at least one other location.
- The area surrounding the site consists of a mixture of single-family and multi-family residential properties, commercial, and light industrial properties. Railroad tracks border the site on the east side. A number of schools, including Edison High School, are located within a few blocks of the site.
- MDH staff accompanied MPCA staff on a number of residential property inspections in the neighborhood of the site. Many of the property owners who requested inspections do not have readily identifiable asbestos waste on their properties, or have no knowledge of wastes from the site being hauled to their properties by previous owners. Stoner rock, vermiculite wastes, and tremolite asbestos were observed, however, in the garden of one property visited by MDH staff. The asbestos waste materials were readily observable at the ground surface.

II. Discussion

Asbestos Toxicology

Asbestos is primarily a human health hazard through the inhalation of asbestos fibers in air. Long-term human and animal exposure to asbestos fibers through inhalation is associated with a buildup of scar-like tissue in the lungs known as asbestosis, and with lung cancer and a cancer of the lining of the lung (or pleura) and other internal organs known as mesothelioma. Asbestosis is characterized by a gradual decline in respiratory function, coughing, and breathlessness. Both lung cancer and mesothelioma may be relatively symptomless until they reach an advanced stage. All three of the above conditions are typically diagnosed through chest X-rays and lung function tests. Evidence of asbestos exposure, in the form of pleural changes (such as a thickening of pleural tissue, or the formation of pleural "plaques") can often be seen on chest X-rays even in the absence of disease. The time period between exposure to asbestos and the occurrence of lung disease or cancer is long, usually between ten and 40 years (ATSDR 1999).

The action by which asbestos fibers cause disease is believed to be through a combination of mechanisms including the generation of reactive oxygen species on fiber surfaces, the production of growth factors by the body in response to injury caused by asbestos fibers, or direct injury to cells in the respiratory tract (Brody 1993; Voytek et al. 1990, ATSDR 1999). Exposure to asbestos fibers in drinking water (or other routes of ingestion) may be associated with an increased risk of cancer in the gastrointestinal tract, although the statistical evidence for this association is weak (ATSDR 1999). Skin contact with asbestos fibers is not believed to pose a health risk, but may result in a localized reaction. The human epidemiological studies that have established the link between asbestos exposure and lung disease and cancer are occupational in nature. Environmental exposure to tremolite asbestos, however, has also been found to be associated with higher rates of mesothelioma, and in some cases lung cancer in several areas of the world where tremolite asbestos is naturally exposed at the ground surface (ATSDR 1999, Luce et al. 2000).

Once inhaled, some asbestos fibers reach deep into the lungs, while the majority are exhaled or become trapped in the mucous lining the airways and lungs and are subsequently coughed up and swallowed (ATSDR 1999). The size of an asbestos fiber is important in determining if it will reach deep into the lung, with the width of the fiber being more important than the length or the ratio of the two, known as the aspect ratio (Berman and Crump 1999). Once in the deep lung, asbestos deposition is heaviest at places where the air ducts branch. This is also the location where the body's response mechanisms are focused, and disease most often occurs. The fiber size also affects how rapidly asbestos fibers pass through the lung tissue and into the surrounding pleural tissue. Chemical, physical, and biological processes that result in the breakdown and removal of the asbestos fibers by the body also play a role in asbestos toxicity.

Animal studies have demonstrated that no single fiber characteristic (such as length, width, and mineral type) is predictive of toxicity, but that asbestos fiber toxicity is a function of a number of characteristics considered together (Berman et al. 1995). Many studies, however, indicate that fibers longer than 5.0 micrometers (µm), or 1/5,000 of an inch are more likely to cause injury to body tissues than shorter fibers (ATSDR 1999). Specifically, fibers in excess of 5 µm seem to be most strongly associated with lung cancer and mesothelioma, with toxicity increasing with increasing length such that fibers longer than 40 µm are estimated to be some 500 times more potent than fibers less than 40 µm in length (Berman et al. 1995). Fibers shorter than 5 µm in length may have a minimal contribution to the potential risk of disease.

Fiber width is also an important consideration relevant to potential effects, with smaller fiber widths more strongly associated with mesothelioma, and larger widths with lung cancer (ATSDR 1999). Larger, more complex asbestos structures may also be more strongly associated with lung cancer risk as opposed to mesothelioma risk, as they are more likely to be retained in the lung, as opposed to passing through lung tissue into the pleura.

The various mineral types (such as chrysotile, amphibole, etc.) are also important in the toxicity of asbestos, especially with regards to the induction of mesothelioma. Amphibole asbestos (the mineral type which includes tremolite) is thought to be more potent than chrysotile for the induction of mesothelioma. There appears to be less of a difference in relative potencies between asbestos mineral types for the induction of lung cancer (Berman et al. 1995). This may be related to the fact that chrysotile asbestos is more easily broken down into shorter fiber lengths than amphibole and removed by the body due, in part, to its chemical composition. Some studies have even suggested that over long periods of exposure to chrysotile asbestos, a "steady state" may be reached where removal mechanisms balance out the deposition of new asbestos fibers in the lung. This is not the case for amphibole asbestos, however, where studies indicate that due to its increased resistance to the body's breakdown processes, the total amount of amphibole asbestos in the lung increases continually with exposure, and no such "steady state" is reached (Berman and Crump 1999).

Cancer occurs in the body when particular cells undergo genetic alteration and then are stimulated to grow and divide. If the affected cells are chronically stimulated, enough genetic mutations may occur that the cell line eventually reaches a state where uncontrolled growth occurs, and tumors develop. It is important to note that either process may occur in the absence of the other, and they are not always linked. Agents that can produce genetic alterations are referred to as "cancer initiators," while agents that are capable of stimulating cell division are known as "cancer promoters." Berman and Crump in 1999 summarized several studies that showed asbestos is believed to be a promoter of lung cancer, and both a promoter and initiator of mesothelioma due to the fact that mesothelial cells have been shown to be more susceptible to genetic damage by asbestos. Cancer promotion by asbestos is caused by the death of cells through direct cell damage, which stimulates cell division to replace the dying cells. Initiation may be the indirect result of genetic damage from the production of reactive oxygen species on the surface of the asbestos fibers as the body attempts to break them down. Asbestos is therefore considered an epigenetic carcinogen, capable of indirectly initiating and directly promoting the development and growth of cancerous cells (Williams and Weisburger 1991).

Exposure to asbestos and cigarette smoking together have been shown to result in a substantially greater risk of lung disease, particularly asbestosis and lung cancer (ATSDR 1999). The risk of dying of lung cancer in smokers exposed to asbestos may be as much as ten times higher than the risk to non-smokers exposed to asbestos, and fifty times that of people who have not been exposed to asbestos and have never smoked. Several mechanisms may contribute to this seemingly multiplicative increase in risk, including a reduction in fiber removal efficiency in smokers, and the adsorption by asbestos fibers of cancer-causing chemicals found in cigarette smoke (ASTDR 1999).

Analytical Methods

Various types of microscopic analysis methods are used to detect asbestos in air, water, and bulk materials such as building products and soil. The most common method used to measure asbestos in air, most often in an occupational setting, is by the use of phase-contrast microscopy (PCM). This method uses phase-contrast illumination to highlight fibrous structures collected on a filter through which a known volume of air has been passed. This method is relatively fast and inexpensive, but cannot distinguish between asbestos fibers and other fibrous materials. In addition, it is limited to fibers with a length greater than 5 μm and a thickness greater than 0.25 μm (ATSDR 1999). The PCM method (specifically National Institute of Occupational Safety and Health [NIOSH] Method 7400) is the method required by the federal Occupational Safety and Health Administration (OSHA) for determining compliance with workplace air standards. The current OSHA workplace Permissable Exposure Limit (PEL) is 0.1 f/cc, based on an 8-hour time-weighted average (OSHA 2000). Airborne asbestos fiber concentrations, as determined by the PCM method, were often used to assess asbestos exposure in the majority of the epidemiological studies conducted on asbestos workers.

Transmission electron microscopy (TEM) uses a high-energy electron beam to form an image of the sample material, and is often used in conjunction with PCM to confirm results. Much higher magnifications are possible than with PCM, and TEM can distinguish fibers less than 0.01 μm in diameter (Berman and Crump 1999). In addition, individual fibers can usually be analyzed via energy dispersive X-ray analysis (EDXA) to determine their mineral type. TEM analysis is slower and more expensive than PCM, but does yield valuable information on fiber types and sizes. There are several different methods used to prepare and count fibers; however, and results from different laboratories using different methods may not be directly comparable.

Both PCM and TEM methods are also typically used for the examination of water samples for asbestos. A different type of light microscopy, known as polarized light microscopy (PLM) is usually used for determining the asbestos content of bulk material samples such as pipe insulation. This method has some of the same limitations as PCM in terms of fiber identification and resolution limits. Methods for determining the asbestos content in soil samples include PLM and TEM, although there are limitations to these methods in terms of matrix interference and sample preparation. These methods typically produce a weight or volume percent estimate of asbestos in the soil sample, which is difficult to directly relate to a human health risk. A relatively new method, the Superfund Method for Determination of Releasable Asbestos in Soils and Bulk Materials involves the preliminary mechanical separation of respirable asbestos fibers from the soil or bulk material with subsequent analysis via TEM using specific fiber-counting methods (EPA 1997). The goal of this method is to produce a measurement of asbestos fibers in air from the disturbance of the soil that are in the size ranges that recent studies have shown may be the most toxicologically active.

Exposure Pathways

There are a number of potential exposure pathways, both past and present, through which people may have been exposed to asbestos-containing products and waste materials from the Western Mineral Products site. The pathway of greatest concern is the exposure by former workers at the site to dusts generated during the production and handling of vermiculite. Former workers at the site have reported that the operation was dusty and the ventilation poor. A city of Minneapolis public health official expressed concerns about the effects of exposure to vermiculite dust by workers at the site in the early 1960s (MDH 2000). A 1977 internal W.R. Grace memorandum estimates that 28% of workers with over 10 years service exposed to ore concentrate from Libby, Montana, had contracted asbestosis (MDH 2000). Cases of asbestos related disease among former workers at the site have also been reported in the media (Gordon 2000). MDH staff are currently compiling a list of former workers at the site for possible follow-up.

Air samples collected at the plant in 1978 and analyzed using PCM methods show airborne asbestos fiber levels in excess of 5 f/cc in several areas of the plant, including near one of the vermiculite expanding furnaces and at the final product bagging station (HRO 2000e). Levels in the lunchroom, located 60 feet from the bagging operation, exceeded 3 f/cc. These levels were well in excess of the current occupational standard of 0.1 f/cc. The airborne asbestos levels near the Western Mineral Products vermiculite bagging station match closely the levels measured in the 1960s and 1970s at a similar bagging operation at the W.R. Grace vermiculite mine and processing facilities in Libby, Montana (Amandus et al. 1987).

Reference is also made in the same internal W.R. Grace memorandum to even higher asbestos fiber levels of 13.5 f/cc in the area where the stoner rock was collected in wheelbarrows for disposal. Equipment problems that contributed to a dust problem in the plant, such as the poor condition of one of the expanding furnaces and a leaking stoner vent hood, are also described. These problems were apparently corrected sometime in the late 1970s, as workplace air monitoring data from the 1980s generally shows asbestos levels at or below the current occupational standard. Prior to the early 1970s, workplace air monitoring for asbestos was not required. Consequently, there is no information available on the workers' potential exposure to airborne asbestos before that time.

The families of past workers may also have been exposed to asbestos-containing dusts from the plant carried home on the hair and clothing of workers. Several studies have associated this "paraoccupational" exposure with the development of asbestos-related respiratory diseases in the families of workers exposed to asbestos on the job (ATSDR 1999). The wife of one worker at the plant recalled in a legal deposition that her husband's clothes were often dusty when he came home from work (MDH 2000).

Although the facility was reportedly cleaned when the plant shut down in 1989, there still are small amounts of residual vermiculite wastes present. While the results of air monitoring in the facility show very low levels of asbestos in indoor air, handling or disturbance of residual wastes could present an exposure hazard. The results of dust samples collected at the site in December 2000 showed that the locations with the highest level of tremolite asbestos dust were found in areas of the former plant that are now not frequently occupied.

There are other past and present exposure pathways of concern for residents in the community surrounding the site. A conceptual model of these potential exposure pathways, adapted from the model proposed by EPA for use in Libby, Montana, is presented in Figure 10 (EPA 2000c). The pathways, listed in approximate order of concern include:

1. Past inhalation of tremolite asbestos fibers from having played in piles of waste stoner rock or vermiculite at the site, or having handled or removed these waste materials from the site.
2. Past inhalation of tremolite asbestos fibers in particulate emissions from the furnace stacks in ambient air in the area of the site, and from fugitive dusts released while the plant was running.
3. Inhalation of tremolite asbestos fibers released from the disturbance of stoner rock or vermiculite wastes remaining at the site after the plant ceased operating, or in wastes hauled from the site in the past, and still present at residential properties.
4. Past and present infiltration of asbestos-containing airborne dusts or particulates into homes or businesses.
5. Ingestion of asbestos from contaminated soil or indoor dust that has been disturbed, or from soil adhering to vegetables grown in contaminated areas.

Children playing in the piles of asbestos-contaminated stoner rock, or people removing, handling, or using the stoner rock or waste vermiculite for fill or other uses, were also exposed to tremolite asbestos. The stoner rock was estimated to contain between 2% and 10% friable tremolite asbestos (HRO 2000c). It was reported that air monitoring was conducted in the area of the plant where the stoner rock was loaded into wheelbarrows for disposal. The results showed fiber levels of 13.5 f/cc (HRO 2000e). This may indicate that handling of the stoner rock had the potential to release a significant amount of asbestos into the air in the immediate vicinity. Information from the investigation underway in Libby, Montana, where similar exposures occurred, may help to better qualitatively assess the health risk of such activities. A past study of asbestos related disease from exposure to tremolite asbestos cited a case of asbestosis and lung cancer in a man who lived near a vermiculite processing plant for the first 20 years of his life, and reportedly sometimes played in the piles of vermiculite tailings (Srebro and Roggli 1994). Tremolite asbestos fibers found in the lungs of this patient were long, and many exceeded 100 µm in length.

Based on information provided by W.R. Grace, including air emission reports submitted to the MPCA in the 1970s (HRO 2000d), it is apparent that tremolite asbestos fibers were present in the particulate emissions from the two exfoliating furnaces. Friable tremolite asbestos was present in the fine particulate matter from the process vent system at concentrations ranging from 1% to 3%. Given an estimated annual particulate emission rate of 480 pounds per year from the two furnace stacks for the time period after 1972 (based on data in a 1977 report), this equates to a potential emission rate of between 4.8 and 14.4 pounds of friable tremolite asbestos per year. Prior to1972, the average annual vermiculite processing rate was much higher, and the weighted average percentage of tremolite asbestos in the ore was higher (see Table 1). The emission rates were potentially higher in terms of quantity (due to the lack of baghouse filters) and tremolite concentration. To determine an asbestos concentration at the top of the stack, the following were used: standard conversion ratios; the stack emission data described above; and a plant operating schedule of 16 hours per day, 5 days per week, and 52 weeks per year (HRO 2000d). The result is a tremolite asbestos concentration of between 30.7 micrograms per cubic meter ($\mu g/m^3$) and

92.1 μg/m^3 in the emissions from the top of the stack while the expanding furnaces were in full operation. Assuming an asbestos fiber density of 3.3 x 10^7 fibers per milligram (EPA 1986), this would correspond to an approximate asbestos fiber concentration of between 1 f/cc and 3 f/cc. Other references indicate a lower average fiber density for tremolite asbestos in raw and beneficiated ore from Libby, Montana, in the range of 2.34 x 10^4 to 1.42 x 10^5 fibers per milligram (EPA 2000a). This would result in a much lower fiber concentration.

Additional asbestos emissions may have occurred from the smaller stack that vented the product mixing operation, where finished vermiculite was added to various products for construction applications. Fugitive dusts from the rail car unloading area, the waste stoner rock piles, or other outdoor product or waste handling operations also likely contributed to the overall tremolite asbestos emissions from the site. An EPA report on vermiculite estimated levels of asbestos of 0.0005 μg/m^3 in ambient air near exfoliation plants (EPA 1991).

The areal extent to which particulate emissions (including friable tremolite asbestos fibers) from the site may have spread into the surrounding community is not currently known. There are anecdotal reports and complaints of dust from the facility settling on cars and homes in the neighborhood as described in Appendix 1. Air dispersion models, such as the Industrial Source Complex (ISC3) model developed by EPA, may be useful in estimating or reconstructing tremolite asbestos fiber concentrations in the area surrounding the site while the plant was operating. Fugitive dust emissions can also be modeled, as can long-term deposition of asbestos fibers on the ground. It appears that adequate information on the stack emissions and product and waste handling practices is available for the development of such an air dispersion model.

Some exposure to tremolite asbestos has likely occurred from stoner rock or waste vermiculite remaining at the Western Mineral Products site after it closed in 1989, or removed from the site for use as driveway fill, landscape material, or in gardening. While the majority of the waste materials removed from the site were likely used at properties near the site, reports have been received of it being hauled as far away as Wisconsin. Asbestos fibers present in surface soils may be released into the air through the action of wind, or more likely by disturbing the asbestos in some way such as digging, raking, or driving vehicles over it. These exposures will be quite variable based on such factors as wind direction, moisture content of the soil, amount of disturbance, or type and frequency of vehicle traffic. Winter conditions would presumably greatly reduce the potential for exposure. Low levels of asbestos fibers were detected in air samples collected around cleanup work zones and in ambient air in the vicinity of the site. Analysis of soil samples using the Superfund Method for Determination of Releasable Asbestos in Soils and Bulk Materials could perhaps provide useful information about the amount of asbestos in soil that can be released to the air. There are also models available for estimating dust emissions from roadways or other surfaces disturbed by wind or mechanical action. The models can be adapted for use in estimating asbestos fiber emissions where asbestos-contaminated fill has been used (Berman 2000).

As anecdotal reports suggest, tremolite asbestos in particulate emissions from the plant, both during and after it was operating, may have infiltrated structures near the facility through open windows, doors, or other routes of entry. This may have resulted in exposure to asbestos in indoor air. Dust containing asbestos may also settle out of the air, and subsequently be re-suspended in the indoor air through such activities as sweeping or vacuuming. Asbestos-containing dusts may also be tracked into homes or businesses from areas where waste stoner rock or vermiculite was used as fill. Household dust may thus serve as a continuing source of asbestos contamination in indoor air. The degree of such exposure will be extremely variable, depending on many individual factors.

Ingestion of tremolite asbestos from fruits, herbs or vegetables grown in soils contaminated with waste materials from the site is likely to be minimal, especially if the produce is washed. Some asbestos that is inhaled ultimately is swallowed as a result of the body's clearance mechanisms. The relationship between ingested asbestos and disease in humans is not well established.

EPA is in the process of conducting a series of exposure studies in Libby, Montana, that would be of use in assessing short-term exposure to asbestos at other vermiculite processing facilities such as the Western Mineral Products site (EPA 2000d).

Asbestos Risk Assessment

Human health risk from asbestos is primarily due to inhalation of asbestos fibers in the air. Currently, asbestos risk assessment is based on a risk from exposure to all types and sizes of asbestos fibers, and combines lung cancer and mesothelioma risk. The current cancer unit risk (that is, the cancer risk per asbestos fiber per cc of air inhaled over a lifetime) found on the EPA's Integrated Risk Information System (IRIS) is 0.23. If this unit risk is used to calculate a level of asbestos in air that could be considered "safe" using current risk assessment procedures, the calculated level would be 0.00004 f/cc, based on excess lifetime cancer risk of 1 in 100,000 (IRIS 2000). This level is far below the detection limit of 0.01 f/cc using the current PCM method (NIOSH method 7400) that is used to determine compliance with workplace standards for asbestos in air. The excess lifetime incremental cancer risk of 1 in 100,000 is the default level used in Minnesota.

The risk estimates listed in IRIS are based on PCM measurements, since historical exposure measurements in human epidemiological studies are based on estimates of either total particle counts or asbestos fiber counts as determined by PCM methods. As stated above, PCM methods do not distinguish between asbestos and non-asbestos fibers, and cannot determine asbestos mineral types. PCM methods, using light microscopy, also have a limited magnification range and therefore may miss small asbestos fibers. This could under-estimate actual asbestos exposures. However, this limitation may not be critical if fibers smaller than the effective detection limit have a minimal contribution to toxicity as previously described.

More recent scientific studies have suggested that fiber length and width may be critical factors in the causation of disease by asbestos. Evidence also suggests that mineral type also may play an important role, and that the risk for lung cancer and mesothelioma may not be the same. Using the established methods of assessing risk may therefore not accurately reflect the actual risk from exposure to asbestos.

In an attempt to develop a risk assessment methodology that would make up for the shortcomings of the PCM-based risk criteria, EPA Region 9 engaged a contractor in the mid-1990s to conduct a thorough literature review and analysis, and develop an updated asbestos risk assessment protocol. The result was the "Methodology for Conducting Risk Assessments at Asbestos Superfund Sites" (Berman and Crump 1999a). This methodology is based on epidemiology data available up to 1989, as well as a limited number of documents up to 1994. The development of the protocol involved re-examining the exposure information (often collected using PCM methods) used in the existing epidemiological studies and attempting to correlate it with TEM methods. In some cases TEM analyses were conducted on the original samples collected for the epidemiological studies to attempt to come up with TEM exposure data that can be linked to the epidemiological data. It incorporates both animal and human potency estimates, with a resulting risk estimated based on fiber length, width, and mineral type. Lung cancer and mesothelioma risks are also estimated separately. The resulting risk assessment protocol provides both empirical and model-based approaches to asbestos risk assessment (Berman and Crump 1999b). EPA has proposed this protocol for use in evaluating human health risks from asbestos exposure in Libby, Montana (EPA 2000c). The protocol relies on the analysis of samples using TEM methods so that the mineral type and fiber sizes can be accurately determined, and fibers within asbestos structures (i.e. fiber bundles and clumps) can be appropriately counted.

There are a number of issues to be considered with regards to the use of the proposed EPA protocol. It has not yet undergone peer review, as required by the EPA Office of Research and Development. In addition, the methodology does not incorporate the results from research and epidemiological studies conducted after 1994. The use of past epidemiological studies where exposure information may be lacking, or was collected using PCM or even older methods, make the direct use of this data (and comparisons to TEM data) in the development of the protocol uncertain. Nevertheless, the proposed EPA asbestos risk assessment protocol represents the most comprehensive attempt to establish a systematic method for evaluating human health risk from asbestos exposure conducted to date. An update of the protocol is currently underway prior to a planned scientific peer review.

Response Actions at and Around the Site

A formal investigation of the former Western Mineral Products site is underway, focusing on soil contamination around the site buildings and residual dusts inside of the buildings. The investigation is being conducted on behalf of W.R. Grace by URS Corporation, and is being conducted under the oversight of the MPCA Voluntary Investigation and Cleanup (VIC) Program. The results of the investigation will be useful for assessing the potential risk from residual tremolite asbestos contamination at the site, and will be used to develop a response action, or cleanup plan, if cleanup of the site proves necessary (URS 2000b).

The EPA, through the Emergency Response Branch of the Superfund program, has focused on investigation and removal of asbestos-contaminated wastes at residential properties around the site. These activities are focused on mitigating the potential threat to human health from exposure to the asbestos, and are not based on a detailed analysis of potential risk from that exposure. The removal activities include (EPA 2000e):

- Development of a site safety plan;
- Determining the horizontal extent of asbestos contamination at the impacted residential properties;
- Excavation and removal of asbestos-contaminated soils to a maximum depth of 18 inches;
- Installation of a synthetic liner at the base of each excavation;
- Removal and disposal of asbestos from the surface of paved alleys and driveways;
- Disposal of asbestos-contaminated soils at an approved off-site disposal facility;
- Personal and ambient air sampling during the removal activities;
- Engineering measures to control dust during cleanup;
- Analysis of soil samples using PLM and TEM methods; and
- Backfilling of excavated areas with clean fill and restoration of properties to original condition.

Asbestos contamination was determined based on visual observation, or confirmed via laboratory microscopic examination at a total of 49 properties around the site to date (Figure 7). Of these 49 properties, cleanup has been completed at 23. The nominal criterion used for cleanup is an asbestos contamination level of 1% or greater. Based on post-cleanup sampling, tremolite asbestos concentrations in excess of 1% appear to have been left in place at four of the properties (Weston 2001). No information was provided as to the locations or the depths of these samples. Asbestos contamination removal in paved alleys and driveways was accomplished using a large vacuum truck equipped with a High-Efficiency Particulate (HEPA) air filter, while traditional hand and mechanical excavation methods were used for soil removal. Cleanup of each property was estimated to take about 1.5 days. At this time, excavation of asbestos-contaminated soil below 18 inches in depth, or beneath paved surfaces or buildings, is not proposed. Soil contaminated with tremolite asbestos containing wastes may therefore still be present at some of these properties, and could be disturbed in the future.

<u>Agency for Toxic Substance and Disease Registry (ATSDR) Child Health Initiative</u>

ATSDR's Child Health Initiative recognizes that the unique vulnerabilities of infants and children make them of special concern to communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances at waste disposal sites. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are smaller than most adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children also weigh less, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

Children who lived in the community around the site were exposed to tremolite asbestos containing wastes while the plant was operating. Children were known to play on the piles of stoner rock or waste vermiculite, as Figure 4 vividly shows, and were reportedly allowed to even play inside the plant at times (Gordon 2000). Children may also have been exposed to asbestos in particulate emissions from the plant, or in dust carried into homes from air emissions or from use of the vermiculite wastes as fill at residential properties. Children could have been exposed from dust carried home on the clothing of a parent who worked at the plant. Ongoing exposure could be occurring in locations where vermiculite wastes were used as fill, and remain exposed at the ground surface. The extent of these exposures, and the potential health effects, are difficult to determine at this time. The long latency period (between 10 and 40 years) of asbestos-related diseases also places children at greater risk of developing disease earlier in life.

III. Conclusions

The Western Mineral Products plant located at 1720 Madison Street in Minneapolis processed vermiculite ore concentrate from the mine in Libby, Montana, into finished vermiculite products. Workers at the plant were exposed to levels of asbestos in excess of current occupational standards for much of the time period the plant was in operation, and cases of asbestos related disease have been reported in former workers. Particulate emissions from the two furnace stacks, as well as fugitive dusts from other outdoor operations, contained up to 3% or more friable tremolite asbestos. Waste materials from the vermiculite processing operation that contained up to 10% friable tremolite asbestos were placed in piles outside the building for use by local residents, and neighborhood children were known to play on these piles.

Approximately 50 properties around the former plant have been identified to date as contaminated with asbestos-containing wastes from the site. The U.S. EPA is in the process of removing asbestos-contaminated soil from these properties and adjoining alleys. These properties, as well as soils around the former plant itself, may have served as a continuous source of asbestos exposure since the plant ceased operations in 1989. Low levels of asbestos have been detected in some ambient air samples collected around the site. The extent of past and current exposures to tremolite asbestos from the site is difficult to estimate at this time based on available information.

Exposure to tremolite asbestos, particularly in workplace settings, has been associated with lung diseases including asbestosis, lung cancer, and mesothelioma. A contractor for the EPA has developed a promising new methodology for conducting risk assessments at Superfund sites that evaluates lung cancer and mesothelioma risk based on asbestos fiber sizes and mineral type. The methodology is in the process of being updated and peer reviewed by EPA for use in Libby, Montana where the contaminated ore was mined and elevated rates of death due to asbestos-related disease has been identified. Information on environmental exposures to asbestos that will be of use in evaluating exposure at the Western Mineral Products site is also being collected in Libby, Montana.

Based on available information, past exposure to tremolite asbestos by workers in the plant, children who played on the piles of waste materials or vermiculite, and residents who lived near the site represents a public health hazard. Current exposure by residents in the area of the site to residual waste materials represents an indeterminate public health hazard.

IV. Recommendations

1. Activities currently underway by the MPCA and EPA to investigate, and if necessary clean up the contamination at the site and at residential properties around the site should continue. Interim measures, such as the covering of soils at the site with plastic and educating residents not to disturb suspected asbestos-contaminated soils should also be continued. Air monitoring during cleanup, and proper dust control measures should continue to be followed.
2. Cleanup of residential properties should be conducted so that asbestos concentrations in exposed soil are as close to background as possible, and at a minimum are below 1%.
3. If complete cleanup of all asbestos-contaminated soil or wastes is not conducted, deed notices, restrictions, or other institutional controls should be considered for any property where residual asbestos contamination is documented to remain in soil, or beneath driveways or other structures.
4. Samples from exposed soil at properties located near the site should be collected to determine if past air emissions from the plant have resulted in residual asbestos soil contamination. Dust samples should also be collected inside selected homes near the site to determine if residual contamination exists.
5. A search should be conducted for any additional historical information on the operation of the plant, or similar operations that may help assess exposures by workers or the public.
6. An air modeling study should be conducted to estimate the areal extent of asbestos-containing particulate emissions and deposition of fibers from the site while it was operating.
7. A more quantitative estimate should be attempted of potential asbestos fiber emissions and exposures from the use of asbestos-contaminated wastes from the plant as fill material.
8. A health study and/or screening of former workers at the site focusing on asbestos-related lung disease should be considered.
9. An exposure investigation of the community surrounding the site should be conducted, and pending the outcome, a health study should be considered.
10. Past and present residents of the area surrounding the site who are concerned about their potential exposure to asbestos-containing vermiculite wastes should be evaluated by their physicians, and if necessary be examined for the presence of asbestos-related lung disease. Educational materials and training should be developed and provided to local physicians and other medical personnel to assist them in this evaluation.
11. Former workers, local residents, and others interested in the site should be updated by the local, state, and federal government entities involved on a regular basis.
12. A Public Health Assessment should be prepared when additional exposure assessment

activities at the site and in Libby, Montana, have been completed, and the proposed EPA methodology for assessing asbestos-related risks has been revised and peer reviewed.

13. Information regarding other vermiculite exfoliation plants should be collected and reviewed to determine if similar exposures could have occurred in and around those facilities.

V. Public Health Action Plan

MDH's Public Health Action Plan for the site consists of continued consultation with state and federal agencies involved with the investigation and cleanup of the site and surrounding community, such as EPA and MPCA, and participation in public outreach activities. MDH also proposes to implement an exposure investigation of current and former residents of the area around the site, and develop a program for educating physicians and other medical personnel on the recognition of asbestos-related lung disease. Furthermore, MDH will prepare a public health assessment incorporating updated information from the investigation in Libby, Montana, and further investigation and exposure assessment activities at the Western Mineral Products site as discussed above. Further information on asbestos exposure may also be found on the MDH World Wide Web page at http://www.health.state.mn.us/divs/dpc/han/asbestos.htm .

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CERTIFICATION

This Western Mineral Products Site Health Consultation was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun.

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

Richard Gillig
Chief, State Programs Section, SSAB, DHAC, ATSDR

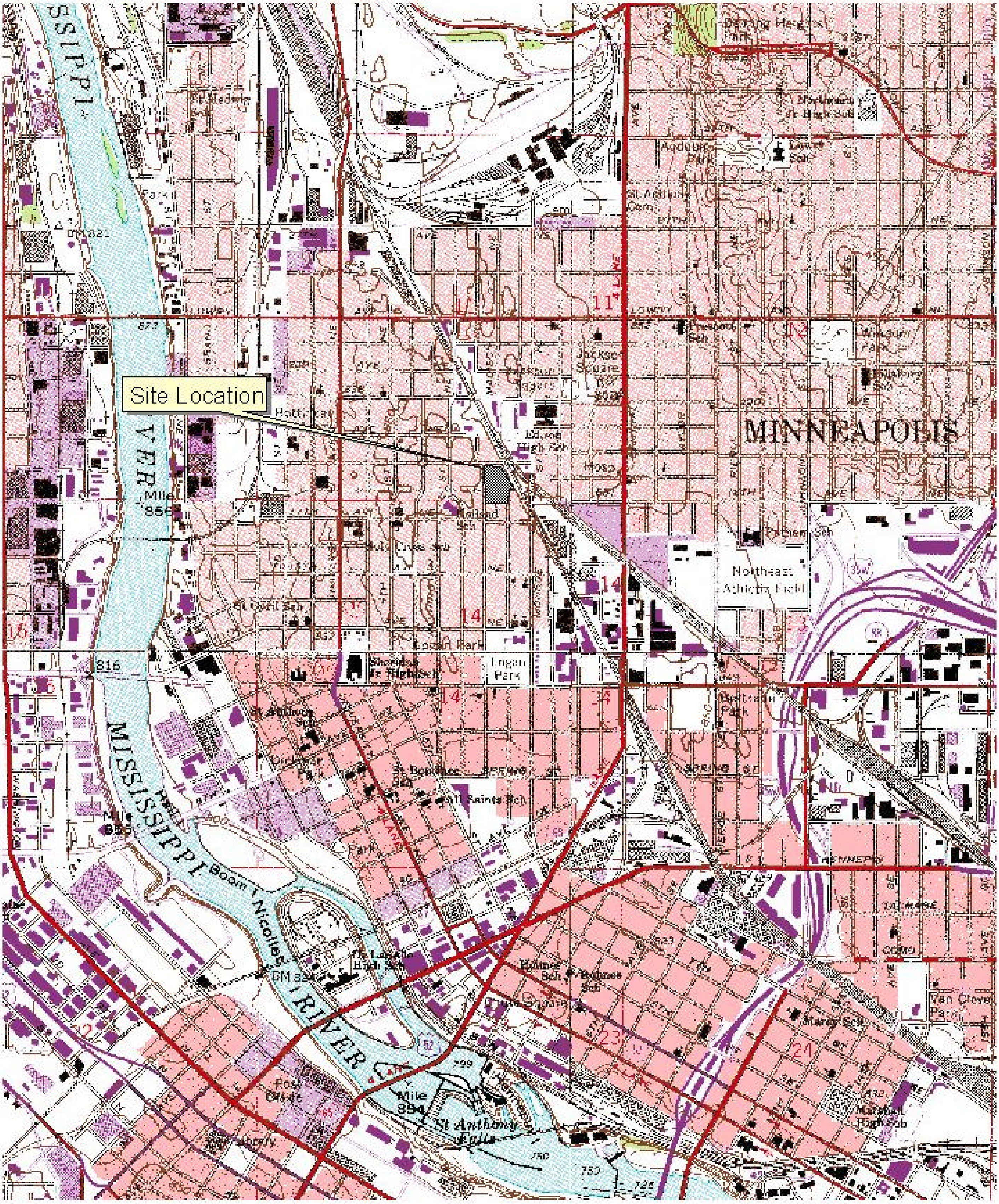
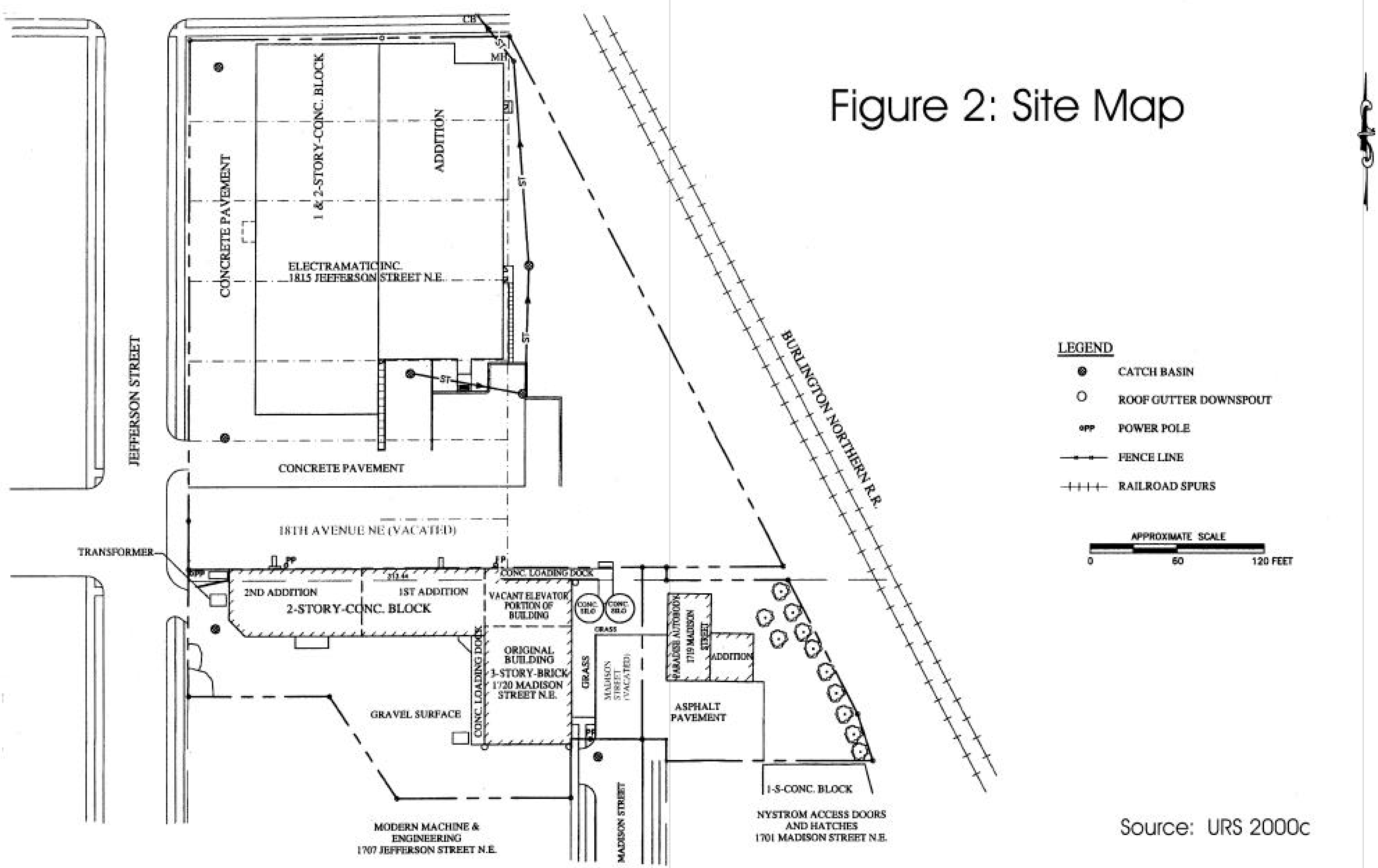


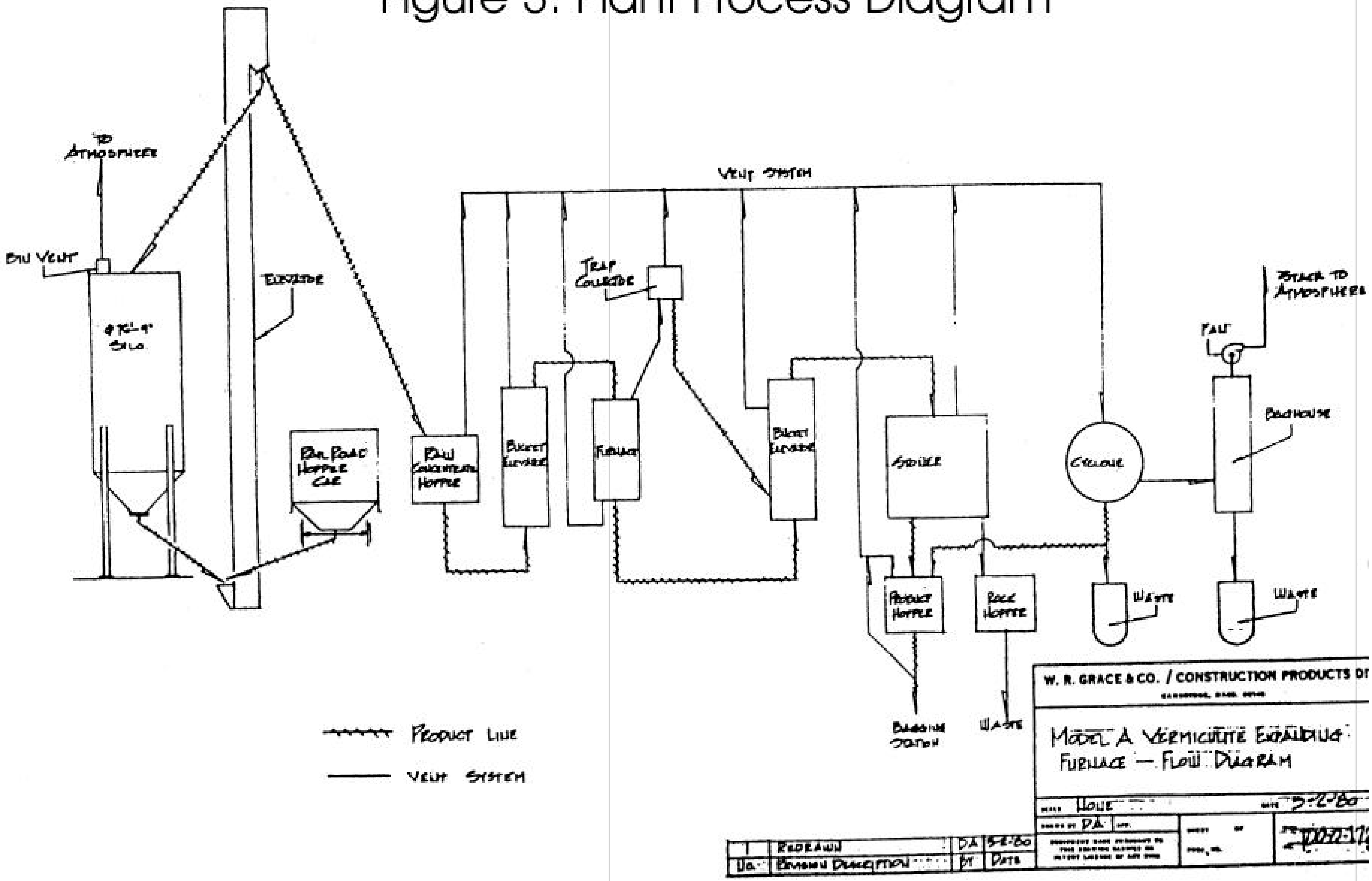
Figure 1: Western Mineral Products Site Location
1720 Madison Street NE, Minneapolis

Figure 2: Site Map



Source: URS 2000c

Figure 3: Plant Process Diagram

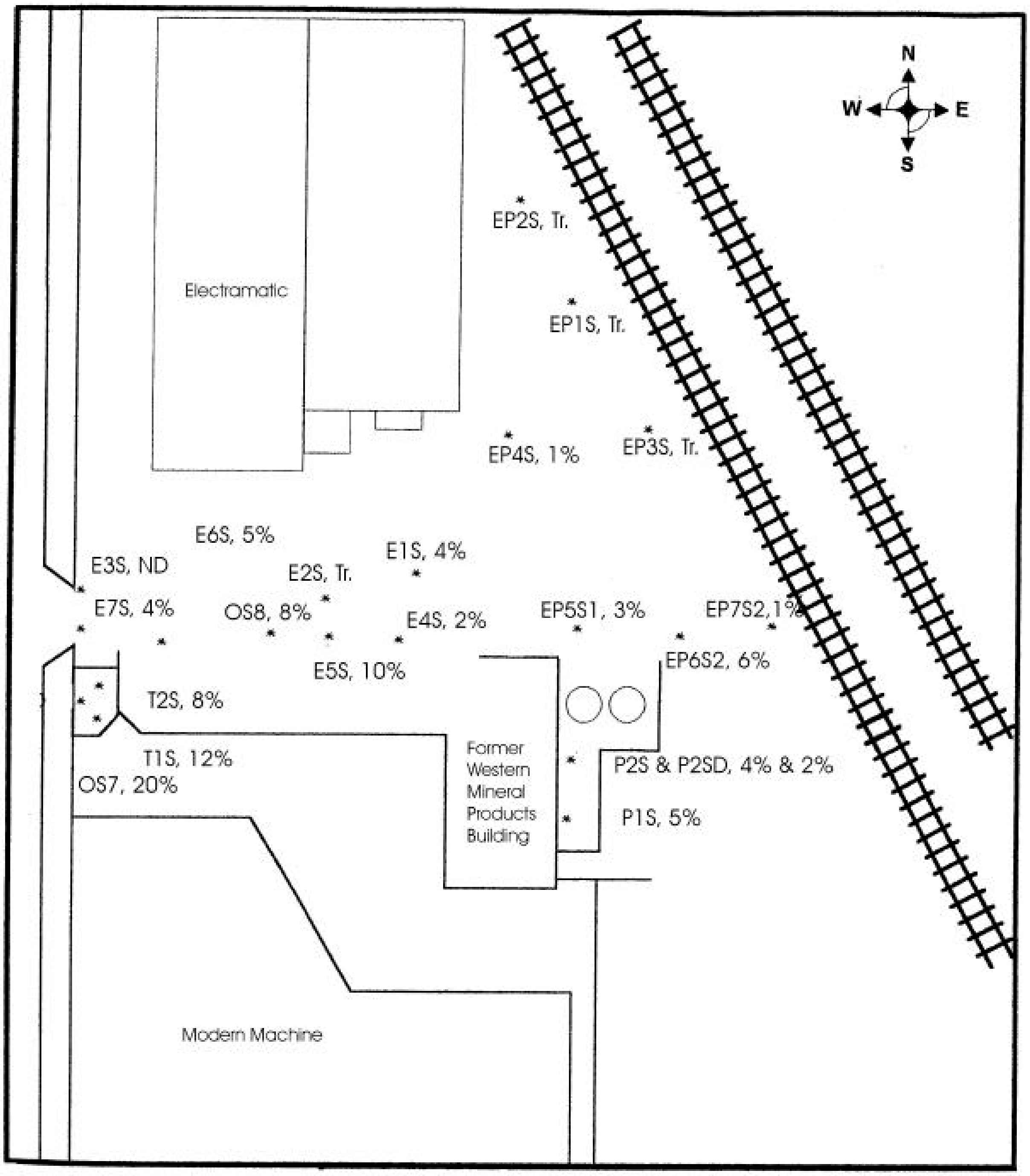


Source: HRO 2000c

Figure 4: Stoner Rock Pile

Photo Courtesy of the Minneapolis Star-Tribune and the Jorgensen family.

Figure 5: Tremolite Asbestos Grains



Source: Ecology & Environment 2000

* = Surface Soil Sample Location (Sample #, % Asbestos)

Tr. = Trace amount

ND = Non-Detect

Figure 6: Soil Sample Results

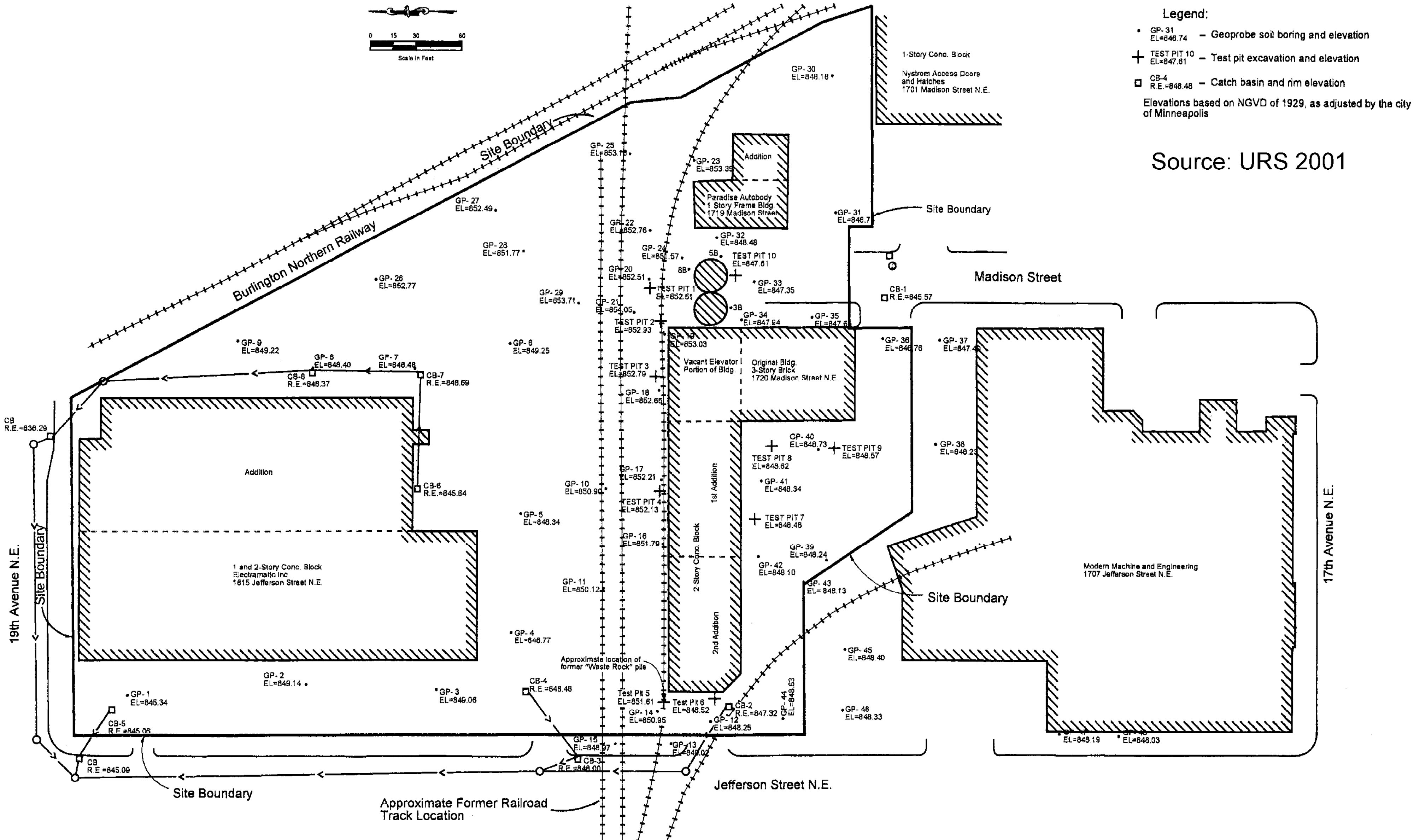


Figure 7: URS Soil Borings / Test Trenches

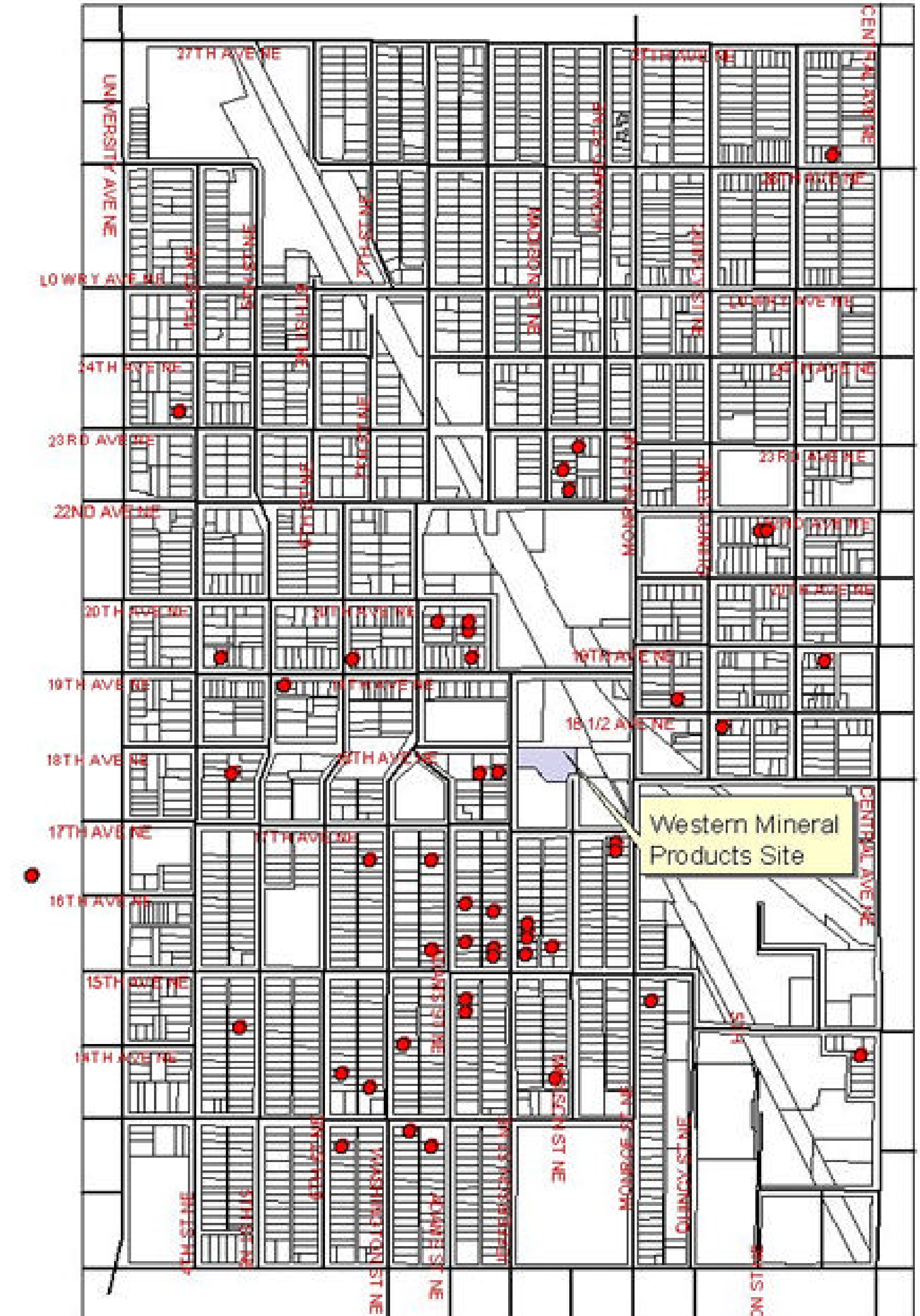


Figure 8: Impacted Properties (2000)

● = Location of Property where Vermiculite Wastes were Found

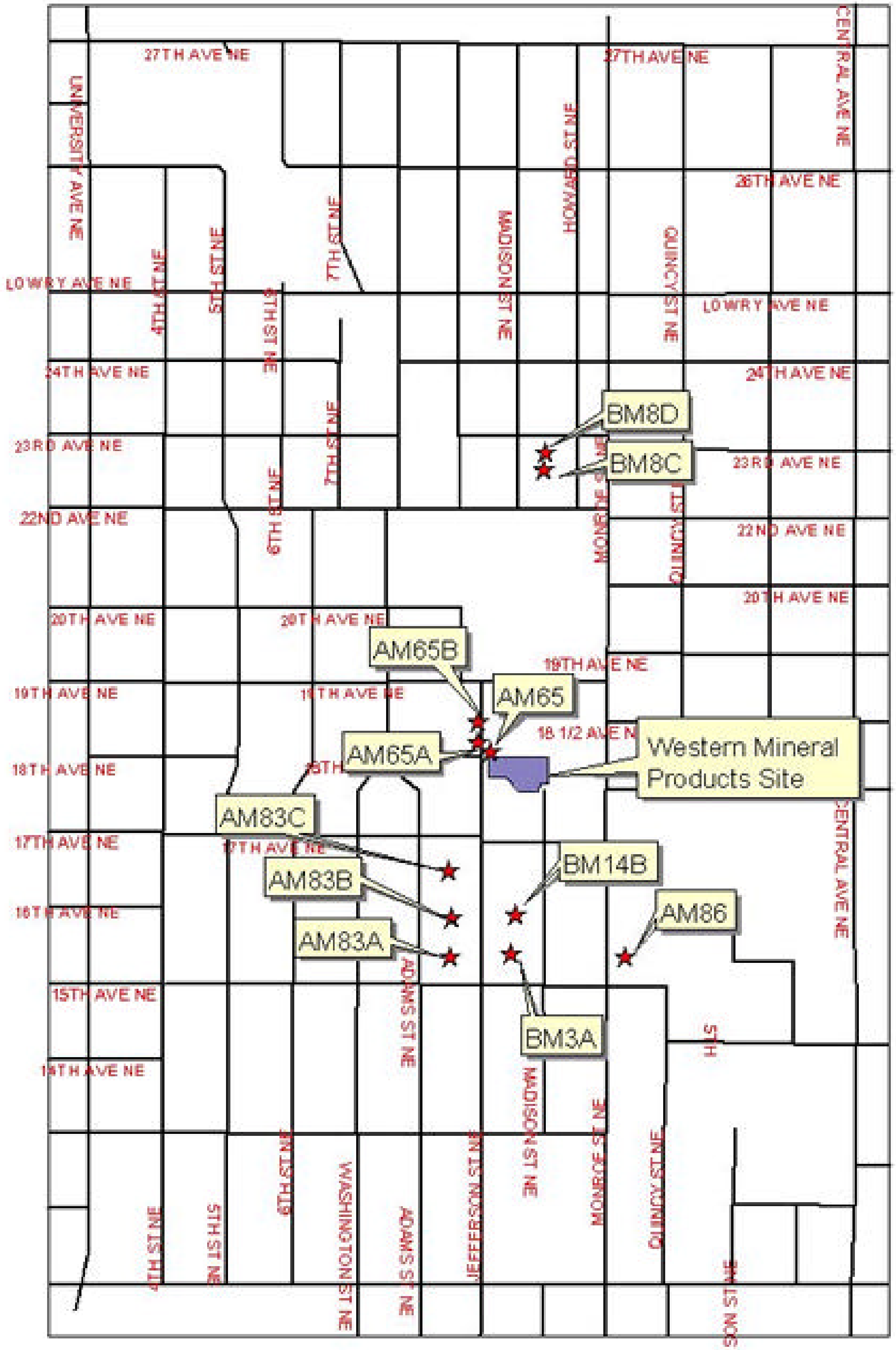
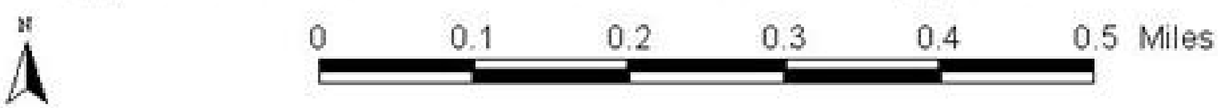


Figure 9: Ambient Air Monitoring Locations



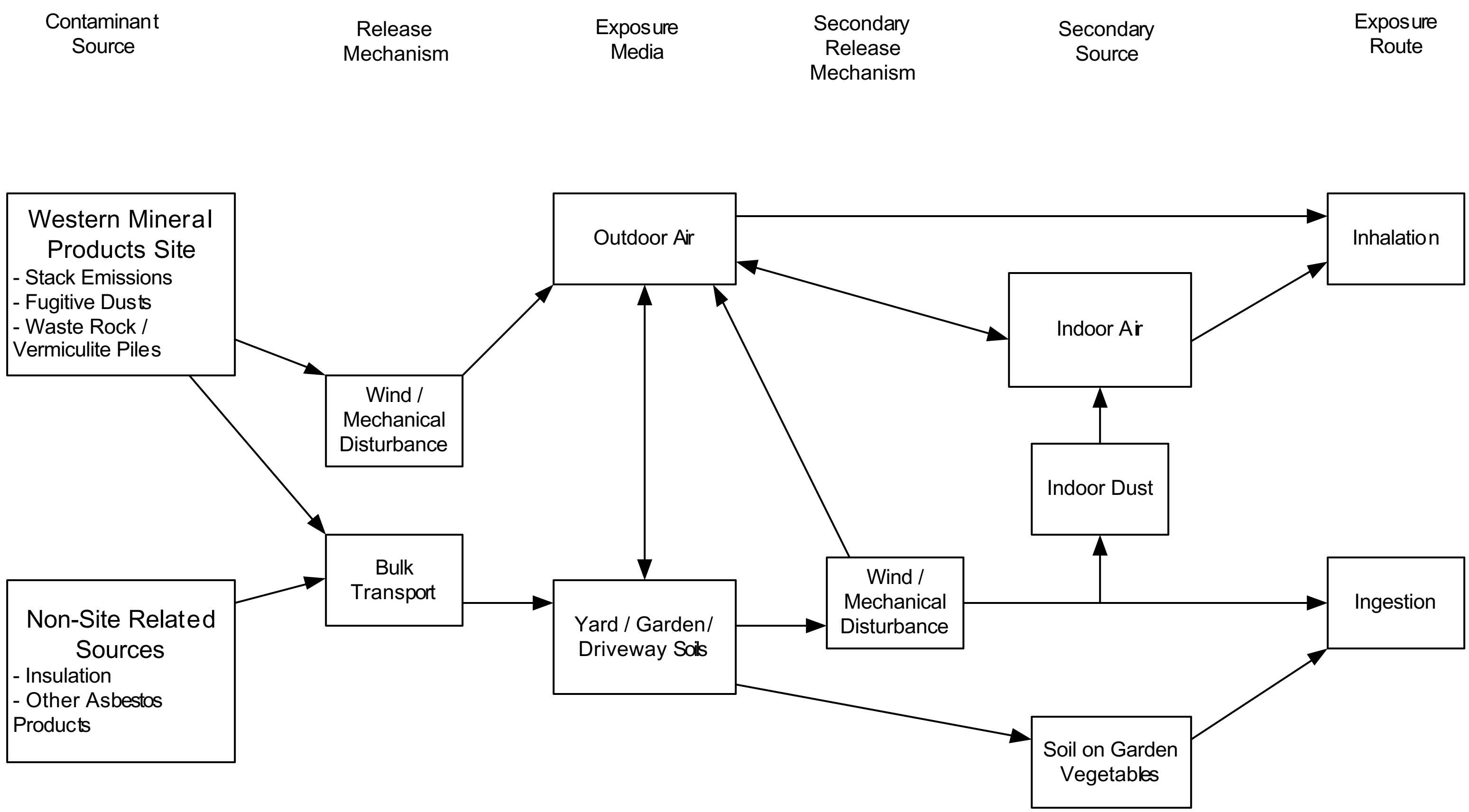


Figure 10: Conceptual Model of Exposure Pathways

Table 1

Beneficiated Ore Shipments from Libby, Montana to Minneapolis, MN
Tons per Year by Grade

Year	#0	#1	#2	#3	#4	#5	Total
1958	926	5,503	0	1,359	23		7,811
1959	942	5,743	160	1,861	32		8,738
1960	569	4,902	389	1,726	27		7,613
1961	924	4,042	204	1,482	49		6,701
1962	668	3,663	361	2,085	78		6,856
1963	411	2,958	2,152	1,700	39		6,556
1964	404	1,904	1,735	1,617	0		5,660
1965	324	1,582	1,427	1,509	183		5,025
1966	261	995	1,893	2,020	63		5,232
1967	161	892	1,705	2,301	0		5,059
1968	192	759	1,419	2,652	0		5,022
1969	456	1,061	1,252	1,776	163		4,708
1970	262	1,776	166	3,488	221		5,913
1971		1,621	195	2,445	34		4,295
1972		1,529	226	2,093	0		3,848
1973		2,096	161	2,691	0		4,948
1974		1,784	375	1,308	654		4,121
1975		1,256	343	1,064	1,076		3,739
1976		1,219	190	1,217	1,510		4,136
1977		2,137	254	627	1,816		4,834
1978		191	598	1,910	441		3,140
1979			1,424	2,464			3,888
1980			948	2,186			3,134
1981			759	2,188			2,947
1982			665	2,002			2,667
1983			1,046	2,195			3,241
1984			156	1,550			1,706
1985			162	2,156			2,318
1986			290	1,546			1,836
1987			259	1,581			1,840
1988			225	450			675
Totals:	6,500	47,613	21,139	57,249	6,409		138,207
Est. % Tremolite	(unk)	4-6	4-7	2-4	0.3-1	2-4	

(EPA 2000, data originally from Midwest Research Institute report, 1982.
EPA Report Number EPA 0717)

Average Tons per Year, 1958-1971: 6,085
Weighted Percentage of Tremolite in Ore: **4.38**

Average Tons per Year, 1972-1988: 3,119
Weighted Percentage of Tremolite in Ore: **3.52**

Source: HRO 2000a

Table 2

Soil Boring and Test Trench Analytical Results

Boring / Test Trench	Date Collected	Depth (feet)	Sample Interval, Inches	Asbestos Content, %	Vermiculite Content, %
GP-1	12/4/2000	0-2	0-1.5	0	0
GP-1	12/4/2000	0-2	4.5-5	0	0
GP-1	12/4/2000	0-2	9.5-11	0	0
GP-1	12/4/2000	2-4	45-48	0	0
GP-2	12/4/2000	0.5-2	0-1.75	0	0
GP-2	12/4/2000	0.5-2	5.25-7	0	0
GP-2	12/4/2000	0.5-2	12.25-14	0	0
GP-2	12/4/2000	2-4	33-36	0	0
GP-3	12/4/2000	0-2	0-2	0	0
GP-3	12/4/2000	0-2	6.25-8.5	**0.1**	1
GP-3	12/4/2000	0-2	15-17	0	0
GP-3	12/4/2000	2-4	33-36	0	0
GP-4	12/4/2000	0-2	0-2	**0.1**	1
GP-4	12/4/2000	0-2	6-8	0	0
GP-4	12/4/2000	0-2	14-16	**0.001**	<1
GP-4	12/4/2000	2-4	33-36	0	0
GP-5	12/4/2000	0-2	0-2.25	**4.2**	1
GP-5	12/4/2000	0-2	6.75-9	**0.04**	<1
GP-5	12/4/2000	0-2	15.75-18.25	0	0
GP-5	12/4/2000	2-4	29.5-32.5	0	<1
GP-6	12/4/2000	0-2	0-2.25	**0.2**	<1
GP-6	12/4/2000	0-2	7.5-9.75	**0.04**	<1
GP-6	12/4/2000	0-2	17-19.5	**0.6**	<1
GP-6	12/4/2000	2-4	33-36	**0.72**	1
GP-7	12/4/2000	0-2	0-2.25	0	0
GP-7	12/4/2000	0-2	6.25-8.5	0	0
GP-7	12/4/2000	0-2	15-17	0	0
GP-7	12/4/2000	2-4	45-48	0	0
GP-8	12/4/2000	0-2	0.0.75	**0.008**	<1
GP-8	12/4/2000	0-2	2.5-3.5	**0.002**	0
GP-8	12/4/2000	0-2	6.5-7.5	**1.42**	<1
GP-8	12/4/2000	2-4	45-48	0	0
GP-9	12/4/2000	0-2	0-1.75	0	0
GP-9	12/4/2000	0-2	4.5-6	0	0
GP-9	12/4/2000	0-2	10.5-12	0	0
GP-9	12/4/2000	2-4	33-36	0	0
GP-10	12/4/2000	0-2	0-2.3	**0.2**	2
GP-10	12/4/2000	0-2	7.25-9.5	**1.1**	10
GP-10	12/4/2000	0-2	16.75-19	**0.003**	<1
GP-10	12/4/2000	2-4	33-36	0	0
GP-11	12/4/2000	0-2	0-1.5	**0.18**	<1
GP-11	12/4/2000	0-2	4.5-6	**0.335**	<1
GP-11	12/4/2000	0-2	10.5-12	**0.181**	<1
GP-11	12/4/2000	2-4	33-36	**0.0157**	1-3
GP-11	12/4/2000	4-6		0	<1
GP-12	12/5/2000	0-2	0-2.5	**0.01**	<1
GP-12	12/5/2000	0-2	7.75-10.5	**0.3**	2
GP-12	12/5/2000	0-2	17.75-20.5	**0.5**	1
GP-12	12/5/2000	2-4	29-32	**0.0145**	<1

Table 2

Soil Boring and Test Trench Analytical Results

Boring / Test Trench	Date Collected	Depth (feet)	Sample Interval, Inches	Asbestos Content, %	Vermiculite Content, %
GP-12	12/5/2000	4-6		0	<1
GP-13	12/5/2000	0-2	0-2	**0.033**	1
GP-13	12/5/2000	0-2	6-8	**0.003**	0
GP-13	12/5/2000	0-2	14-16	**0.0095**	<1
GP-13	12/5/2000	2-4	33-36	0	0
GP-14	12/5/2000	0-2	0-2.25	**0.7**	1
GP-14	12/5/2000	0-2	7.25-9.75	**0.6**	5
GP-14	12/5/2000	0-2	17-19.25	**0.8**	2
GP-14	12/5/2000	2-4	33-36	**4.2**	95.8
GP-14	12/5/2000	4-6		0	0
GP-15	12/5/2000	0-2	0-2	**1.09**	3
GP-15	12/5/2000	0-2	6.25-8.25	**0.46**	20
GP-15	12/5/2000	0-2	14.38-16.25	0	0
GP-15	12/5/2000	2-4	33-36	0	0
GP-16	12/5/2000	0-2	0-1.9	**2.3**	55
GP-16	12/5/2000	0-2	5.5-7.5	**1.31**	42
GP-16	12/5/2000	0-2	13-15	**0.1**	30
GP-16	12/5/2000	2-4	33-36	**0.03**	5
GP-16	12/5/2000	4-6		0	0
GP-17	12/5/2000	0-2	0-1.9	**3.4**	10
GP-17	12/5/2000	0-2	5.5-7.4	**4.7**	10
GP-17	12/5/2000	0-2	12.5-14.5	0	0
GP-17	12/5/2000	2-4	24-27	0	20
GP-18	12/5/2000	0-2	0-2	0	0
GP-18	12/5/2000	0-2	5.75-7.75	0	0
GP-18	12/5/2000	0-2	13.75-15.75	0	0
GP-18	12/5/2000	2-4	33-36	0	0
GP-19	12/5/2000	0-2	0-1.75	0	0
GP-19	12/5/2000	0-2	5.25-7	**4.02**	96
GP-19	12/5/2000	0-2	12-14	0	2-3
GP-19	12/5/2000	2-4	33-36	0	10
GP-20	12/5/2000	0-4	0-2.25	**0.1**	5
GP-20	12/5/2000	0-4	7-9.25	0	0
GP-20	12/5/2000	0-4	16.13-18.5	0	0
GP-21	12/5/2000	0-2	0-2.25	**0.4**	<1
GP-21	12/5/2000	0-2	7.25-9.25	**0.08**	<1
GP-21	12/5/2000	0-2	14.8-18.25	**0.2**	<1
GP-21	12/5/2000	2-4	33-36	**0.5**	99.5
GP-21	12/5/2000	4-6		0	0
GP-22	12/5/2000	0-2	0-1.75	**0.2**	<1
GP-22	12/5/2000	0-2	4.9-6.5	0	0
GP-22	12/5/2000	0-2	11.25-13	0	0
GP-22	12/5/2000	2-4	33-36	**0.003**	90
GP-22	12/5/2000	4-8		0	<1
GP-23	12/5/2000	0-2	0-1.75	0	10
GP-23	12/5/2000	0-2	4.9-6.5	0	<1
GP-23	12/5/2000	0-2	11.25-13	0	0
GP-23	12/5/2000	2-4	24-27	0	<1

Table 2

Soil Boring and Test Trench Analytical Results

Boring / Test Trench	Date Collected	Depth (feet)	Sample Interval, Inches	Asbestos Content, %	Vermiculite Content, %
GP-24	12/5/2000	0-2	0-2	**0.8**	10
GP-24	12/5/2000	0-2	5.75-7.75	**21.3**	64
GP-24	12/5/2000	0-2	13.5-15.5	**1.2**	10
GP-24	12/5/2000	2-4	33-36	**5.4**	35
GP-24	12/5/2000	4-6		**0.139**	30
GP-24	12/5/2000	6-8		0	0
GP-25	12/5/2000	0-2	0-1.5	**0.04**	1
GP-25	12/5/2000	0-2	4.75-6.4	**0.0998**	<1
GP-25	12/5/2000	0-2	11-12.5	0	0
GP-25	12/5/2000	2-4	33-36	0	0
GP-26	12/6/2000	0-2	0-2.9	**0.04**	<1
GP-26	12/6/00	0-2	6.75-9	0	0
GP-26	12/6/2000	0-2	15.9-18	0	0
GP-26	12/6/2000	2-4	33-36	0	<1
GP-27	12/6/2000	0-2	0-1.9	0	0
GP-27	12/6/00	0-2	5.75-7.5	0	0
GP-27	12/6/2000	0-2	13.1-15.25	0	0
GP-27	12/6/2000	2-4	33-36	0	<1
GP-28	12/6/2000	0-2	0-2.25	**0.4**	<1
GP-28	12/6/2000	0-2	7-9.25	0	0
GP-28	12/6/2000	0-2	16.1-18.5	0	0
GP-28	12/6/00	2-4	33-36	**0.378**	<1
GP-28	12/6/2000	4-6		0	0
GP-29	12/6/2000	0-2	0-2.5	**1.508**	1-2
GP-29	12/6/00	0-2	7.5-9.75	**0.603**	0
GP-29	12/6/2000	0-2	17.75-19.75	**0.176**	0
GP-29	12/6/2000	2-4	33-36	**0.101**	<1
GP-29	12/6/2000	4-6		0	0
GP-30	12/6/2000	0-2	0-2.5	**0.002**	1
GP-30	12/6/2000	0-2	7.5-10	**0.02**	<1
GP-30	12/6/2000	0-2	17.5-20	0	<1
GP-30	12/6/2000	2-4	33-36	0	0
GP-31	12/6/00	0-2	0-2.125	0	<1
GP-31	12/6/2000	0-2	6.75-9	0	2
GP-31	12/6/2000	0-2	15.9-18	0	0
GP-31	12/6/2000	2-4	33-36	0	0
GP-32	12/6/2000	0-2	0-1.9	**1.4**	10
GP-32	12/6/2000	0-2	6-8	**1**	15
GP-32	12/6/2000	0-2	14-16	**1.7**	3
GP-32	12/6/2000	2-4	33-36	0	0
GP-33	12/6/2000	0-2	0-2.5	**0.02**	0
GP-33	12/6/2000	0-2	7-9.4	0	0
GP-33	12/6/00	0-2	16.25-18.75	0	0
GP-33	12/6/2000	2-4	33-36	0	0
GP-34	12/6/2000	0-4	0-1.9	**0.5**	20
GP-34	12/6/2000	0-4	5.75-7.5	**0.02**	<1
GP-34	12/6/2000	0-4	13-15	**0.03**	<1

Table 2
Soil Boring and Test Trench Analytical Results

Boring / Test Trench	Date Collected	Depth (feet)	Sample Interval, Inches	Asbestos Content, %	Vermiculite Content, %
GP-35	12/6/2000	0-2	0-1.9	**0.6**	10
GP-35	12/6/2000	0-2	4.25-6	**0.06**	2
GP-35	12/6/2000	0-2	12.13-14	**0.03**	1
GP-35	12/6/2000	2-4	33-36	0	0
GP-36	12/6/2000	0-2	0-2.13	0	0
GP-36	12/6/2000	0-2	6.75-9.125	0	0
GP-36	12/6/2000	0-2	15.88-18.25	0	0
GP-36	12/6/00	2-4	36-39	0	<1
GP-37	12/6/2000	0-2	0-1.9	0	0
GP-37	12/6/2000	0-2	5.25-6.88	0	<1
GP-37	12/6/2000	0-2	12.13-13.75	0	0
GP-37	12/6/2000	2-4	33-36	0	0
GP-38	12/6/2000	0-2	0-2.5	0	0
GP-38	12/6/2000	0-2	7.5-9.75	0	<1
GP-38	12/6/2000	0-2	17.75-19.75	0	0
GP-38	12/6/2000	2-4	33-36	0	0
GP-39	12/6/2000	0-2	0-2.13	**5.2**	1
GP-39	12/6/00	0-2	6.75-9	**0.5**	<1
GP-39	12/6/2000	0-2	15.875	**0.1**	<1
GP-39	12/6/2000	2-4	33-36	**0.003**	0
GP-39	12/6/2000	4-6		0	0
GP-40	12/7/2000	0-2	0-2.13	0	0
GP-40	12/7/2000	0-2	6.75-9	0	0
GP-40	12/7/2000	0-2	15.88-18	0	0
GP-40	12/7/2000	2-4	33-36	**0.051**	2-3
GP-40	12/7/2000	4-8		0	0
GP-41	12/7/2000	0-2	0-2.25	0	0
GP-41	12/7/2000	0-2	6.88-9.13	**0.05**	<1
GP-41	12/7/2000	0-2	15.88-18.25	0	0
GP-41	12/7/2000	2-4	37-40	**0.92**	1
GP-41	12/7/2000	4-8		**0.3**	0
GP-42	12/7/2000	0-2	0-2.25	**0.001**	<1
GP-42	12/7/2000	0-2	6.88-9.13	**0.027**	1
GP-42	12/7/2000	0-2	15.88-18.25	0	0
GP-42	12/7/2000	2-4	33-36	0	0
GP-43	12/7/2000	0-2	0-2.38	0	0
GP-43	12/7/2000	0-2	7.13-9.5	**3.9**	10
GP-43	12/7/2000	0-2	16.75-19	**0.2**	<1
GP-43	12/7/2000	2-4	24-27	**0.038**	3-5
GP-43	12/7/2000	4-7		0	0
GP-44	12/7/2000	0-2	0-2.13	0	0
GP-44	12/7/2000	0-2	6.25-8.5	**1.4**	10
GP-44	12/7/2000	0-2	15-17	**1.2**	10
GP-44	12/7/2000	2-4	33-36	0	0
GP-45	12/7/2000	0-4	0-1.88	**0.8**	10
GP-45	12/7/2000	0-4	5.25-7	0	0
GP-45	12/7/2000	0-4	14.13-15.13	0	0
GP-46	12/7/2000	0-2	0-1.88	0	0
GP-46	12/7/2000	0-2	5.75-7.5	**1.5**	2

Table 2

Soil Boring and Test Trench Analytical Results

Boring / Test Trench	Date Collected	Depth (feet)	Sample Interval, Inches	Asbestos Content, %	Vermiculite Content, %
GP-46	12/7/2000	0-2	13-15	**0.06**	<1
GP-46	12/7/2000	2-4	24-27	0	1
GP-47	12/7/2000	0-2	0-1.75	**0.1**	<1
GP-47	12/7/2000	0-2	5-6.5	**0.7**	1
GP-47	12/7/2000	0-2	11.25-13.25	**1.1**	4
GP-47	12/7/2000	2-4	33-36	0	0
GP-48	12/7/2000	0-4	0-2.75	**0.07**	<1
GP-48	12/7/2000	0-4	7.88-10.5	**0.02**	<1
GP-48	12/7/2000	0-4	18.25-20.75	0	<1
TP 1-1	12/7/2000	0-2		**2.3**	
TP 1-2	12/7/2000	5-6		0	
TP 2-1	12/7/2000	2.5-3		**0.5**	
TP 2-2	12/7/2000	0-2		**1.4**	
TP 3-1	12/7/2000	0-1		**5.6**	
TP 3-2	12/7/2000	2-3.5		**0.4**	
TP 4-1	12/7/2000	0-1.5		**11**	
TP 4-2	12/7/2000	2-2.5		**1.1**	
TP 5-1	12/7/2000	2.5-4.5		**5.5**	
TP 5-2	12/7/2000	4.5		**2.6**	
TP 6-1	12/8/2000	0-0.5		**3**	
TP 6-2	12/8/2000	0-0.5		**3.7**	
TP 7-1	12/8/2000	1		**0.77**	
TP 7-2	12/8/2000	3-4		**3.7**	
TP 8-1	12/8/2000	2		**0.05**	
TP 8-2	12/8/2000	3		**5.6**	
TP 9-1	12/8/2000	0.5-1		**4.4**	
TP 9-2	12/8/2000	0.7		**0.03**	
TP 10-1	12/8/2000	2		**0.2**	
TP 10-2	12/8/2000	2		**0.2**	

Samples analyzed using Polarized Light Microscopy (PLM), Method EPA/600/R-93/116

Source: URS 2001

Table 3

Ambient Air Sampling Results

Sample Location	Sample Date	Analytical Results (f/cc)	Total Asbestos Structures
BM3A	10/22/2000	**0.0018**	2
BM8C	10/22/2000	<0.0009	0
BM8D	10/22/2000	<0.0009	0
BM14B	10/22/2000	<0.0009	0
AM65A	10/31/2000	**0.001**	1
AM65B	10/31/2000	**0.0009**	1
AM65	10/31/2000	**0.001**	1
AM83A	10/19/2000	**0.0019**	2
	10/20/2000	**0.0052**	5
	10/21/2000	**0.0019**	2
	10/29/2000	**0.001**	1
	10/31/2000	<0.001	0
AM83B	10/19/2000	<0.0009	0
	10/20/2000	<0.001	0
	10/21/2000	<0.0009	0
	10/29/2000	<0.001	0
	10/31/2000	<0.0009	0
AM83C	10/19/2000	<0.0009	0
	10/20/2000	<0.001	0
	10/21/2000	**0.0009**	1
	10/29/2000	<0.001	0
	10/31/2000	<0.001	0
AM86	10/21/2000	**0.0019**	2
	10/29/2000	<0.001	0
	10/31/2000	<0.0009	0

Bold indicates concentration above laboratory detection limit
Samples analyzed using TEM method, AHERA Protocol

Source: Weston 2001c

Appendix 1

City of Minneapolis Complaint Excerpts

August 1960:
"Dust is terrible – settles on everything. Considerable dust had settled on sidewalk and collected in curb in street. Visible dust up to two blocks down wind of plant."

May 1969:
"Last few years has been getting worse. They blow this stuff out at night. Brought in a sample of grass with white material mixed in it. Coats screens and windows. Even gets in thru windows and gets on pillows, etc. skin sensitive to it."

June 1969:
"Company has expanded over the years, that is why the dust problem has increased. The material comes out of their exhaust pipes and is from the process of making the insulation and also from the bagging operation. They do most of the bagging at night. Believes it to be a health hazard as it contains mica. Stings eyes and won't dissolve in the lungs. It is a waste product of their operation and they need dust collectors……When this dust gets on windows and it rains, it makes the windows look like they have dirty mud on them. Seeps into the house and neighbors said it even covers their bed on occasion."

"Almost everyday of the week a white substance blows out of their roof vent creating a lot of dust particles in the air. Some days so thick looks like snow drifts on cars and ground. At lunch time if you are outside it blows in hair, eyes, and lungs. Gets in thru car vents. Just unbearable."

July 1969:
"Like a small snowstorm up there today, coming out of stack, ruining finish on his car, also others complain about the same thing."

September 1969:
"Zonolite is putting out as much dust as ever …..Also can see this white dust seven blocks from home…"

July 1970:
"Noticed emissions from Zonolite, comes out so thick it looks like snow, comes into the house and makes the furniture white, is very gritty, permeates everything."

March 1971:
"Waves of dust coming out of Zonolite's stack. Hasn't been bad for a long time… but is overcast today and that is when the dust shows up the most."

April 1971:
"XYZ called, has a brand new camper truck, green – which is now all white because of Zonolites emissions…. There are dozens more who are getting this stuff all over their cars. It is like snow in the area. XYZ said they "wait" until it is cloudy before they blow the stuff out so people won't see it as much."

August 1971:
"Zonolite is driving them crazy – have to close windows, can't hang out sheets, sandy stuff flying all over, eyes burn, throat irritated, been especially bad the last 3 days. Materials gets on clean clothes, claims they run at night and it is very bad then too."

August 1971:
“Zonolite is blowing stuff out all the time, their eyes get full of it and burn, chests get clogged up, noses stuffed, grass gets full of the particles and when they mow the lawn, the air is choking with this stuff. So bad over the week-end, they could sit on their porch, couldn’t even see the hi-rise 3 blocks away very good.”

January 1974:
“Light dust coming from Zonolite, settling on cars.”

August 1979:
“They burn something in the bldg as there is thick blue smoke coming out of the back part of the bldg. Haven’t changed a bit over there, the ground surrounding the bldg are very messy, this flakes of stuff all over. Should be made to clean up their yard.”