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FINAL REPORT

AMBIENT ASBESTOS CONCENTRATIONS IN CALIFORNIA.

350 Volume I

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4.0 SITE SPECIFIC RESULTS

4.1 King City (Union Carbide Mill)

4.1.1 Site Location and Meteorology

The Union Carbide mill is an asbestos processing facility located approximately one mile south of King City in west-central California, 120 miles south of San Francisco and 34 miles east of the coast. The mill both refines and packages chrysotile asbestos ore. The ore is transported during the dry season by truck from mines at Coalinga and piled in an open air field next to the processing plant. The potential source of airborne asbestos consists of two points: one is the ore pile adjacent to the processing plant, and the other is the tailings pile approximately 1/8-mile east of the plant.

The Union Carbide mill is located in an area of low rolling hills with a normally predictable wind cycle. The typical "summer" pattern consists of calm winds in the early morning and high humidity due to the reverse flow of marine air; these conditions shift in the afternoon to northwest winds of generally 10 to 30 mph. Weather data for the sampling day (9/21/81) are shown in Figure 4.1-1. A light fog from the overnight flow of marine air dissipated around 10:00 a.m. The wind direction was consistently from the northwest and the wind increased gradually throughout the day, reaching 25 mph by 4:00 p.m. These winds were insufficient to cause visible resuspension of dust from the soil or from the ore and tailings piles. The relative humidity ranged from >90% in the early morning before sampling to a low of 32% in the afternoon when the wind velocities approached 25 mph and the temperature was approximately 30°C. After the fog dissipated in the early morning, the skies stayed clear for the rest of the day, with visibilities of 10 to 20 miles.

4.1.2 Asbestos Filter Sampling

Upwind and downwind samplers were located to measure any dust being resuspended from the ore and tailings piles. One pair of upwind-downwind

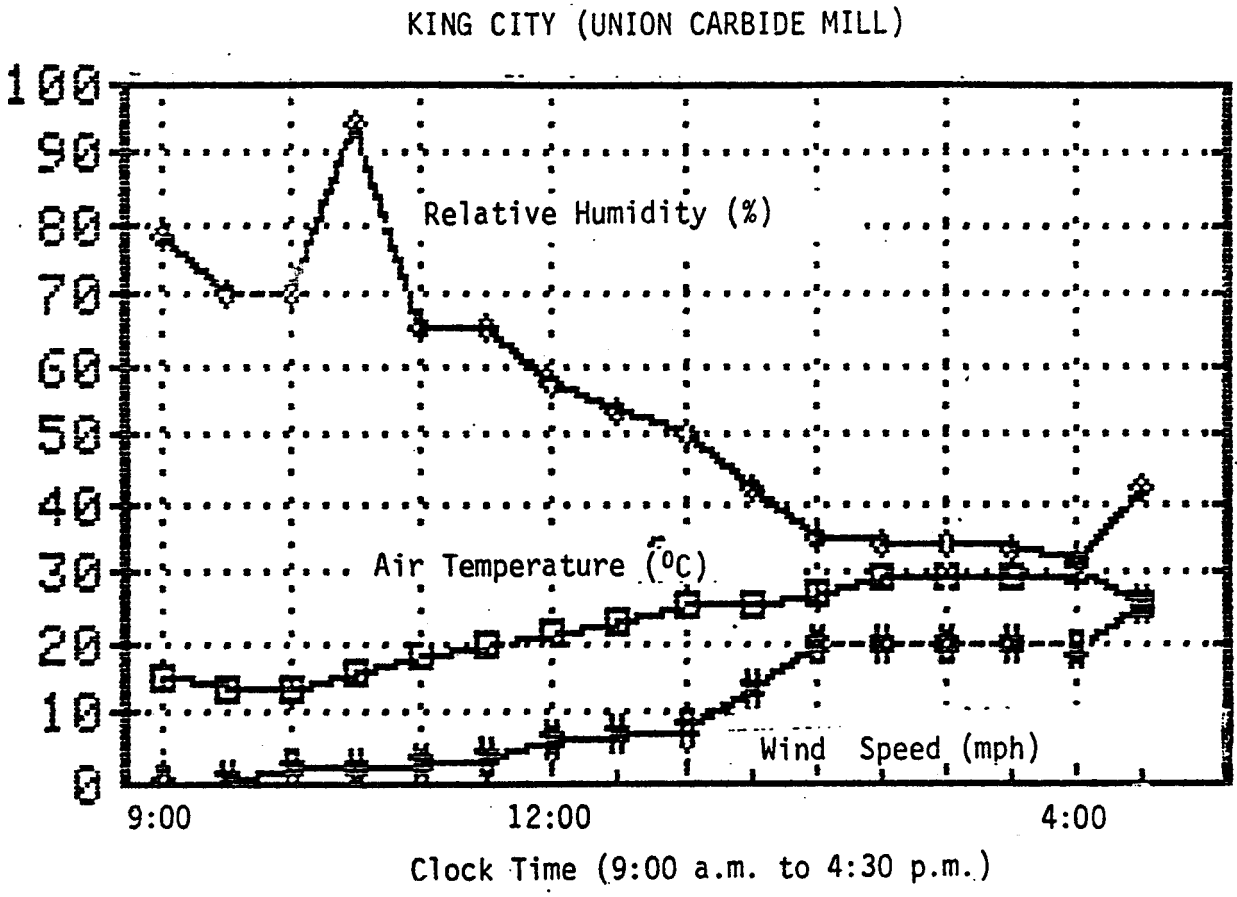


Figure 4.1-1. Meteorological Data Summary for King City. Based on one-half hour sampling intervals at the sampling location downwind from the Union Carbide mill site.

samples was taken in the morning in calm weather, and another pair was taken during the warmer, relatively windy afternoon. The analysis results from each filter sample collected are presented in Table 4.1-1.

The upwind site was located across U.S. Highway 101 on the north side of a farm house overlooking garlic fields. The sampling train was located near the edge of the cliff and placed six ft above the ground in order to minimize the effect of resuspended soil from immediately around the sampler. The upwind sample site is pictured in the top photo in Figure 4.1-2. The bottom photo is the view from the south side of the farm house looking across Highway 101 to the asbestos facility, showing the downwind sampler location relative to the ore pile. This site was located 0.25 miles directly downwind from the ore pile at the far boundary of the plant.

During the sampling period, activities potentially resuspending asbestos-laden material into the air included: the moderately high afternoon winds; the skip-loaders at the ore pile transferring ore into the plant; and tailings being transported to the waste pile east of the plant. The vehicular activity on the site and the transfer of raw asbestos material were likely to be the most important of these. However, since vehicular activity was minimal during sampling, 'worst case' conditions for asbestos emission were possibly missed.

4.1.3 Suspended Particle Monitoring

Figure 4.1-3 shows how upwind and downwind particulate mass concentrations varied throughout the sampling day at King City. These values were estimated by applying the regression equation of Royco® particle counts vs RAM® mass data determined for the Sonora site (Figure 3.4-4). Mass concentrations at the upwind location ranged from 42 $\mu g/m^3$ in the morning to approximately 14 $\mu g/m^3$ in the afternoon; the downwind levels ranged from 16 $\mu g/m^3$ to 20 $\mu g/m^3$. Differences between the early morning and afternoon mass concentrations at the upwind location are partially due to the noted presence of an

Table 4.1-1. Summary of Sampling Parameters and Analysis Results for King City (Union Carbide Mill Site).

Sample	Sampling Date	Site	Sampling Midpoint Time	Sampling Time (Minutes)	Sampling Vol. (liters)	Air Temp. (°C)	Rel. Hum. (%)	Wind Direction (°true)	Wind Speed (mph)	10^3 Particles/cu.ft. (>0.3μm <0.7μm)	Chrysotile Fibers/m^3	Amphibo Fibers/
A-13	9/21/81	Upwind	9:46	238.9	3703	13	~70	360	0 - .5	70 ± 4	1.4×10^5	<DL
A-14	9/21/81	Downwind	11:07	240.0	3720	18	65	290	3.0	70 ± 4	9.4×10^3	<DL
A-15	9/21/81	Upwind	14:03	240.0	3720	27	35	340	8.0	260 ± 22	4.7×10^3	<DL
A-16	9/21/81	Downwind	15:45	239.0	3704.5	30	~32	340	19.0	65 ± 2	2.4×10^3 (DL)	<DL

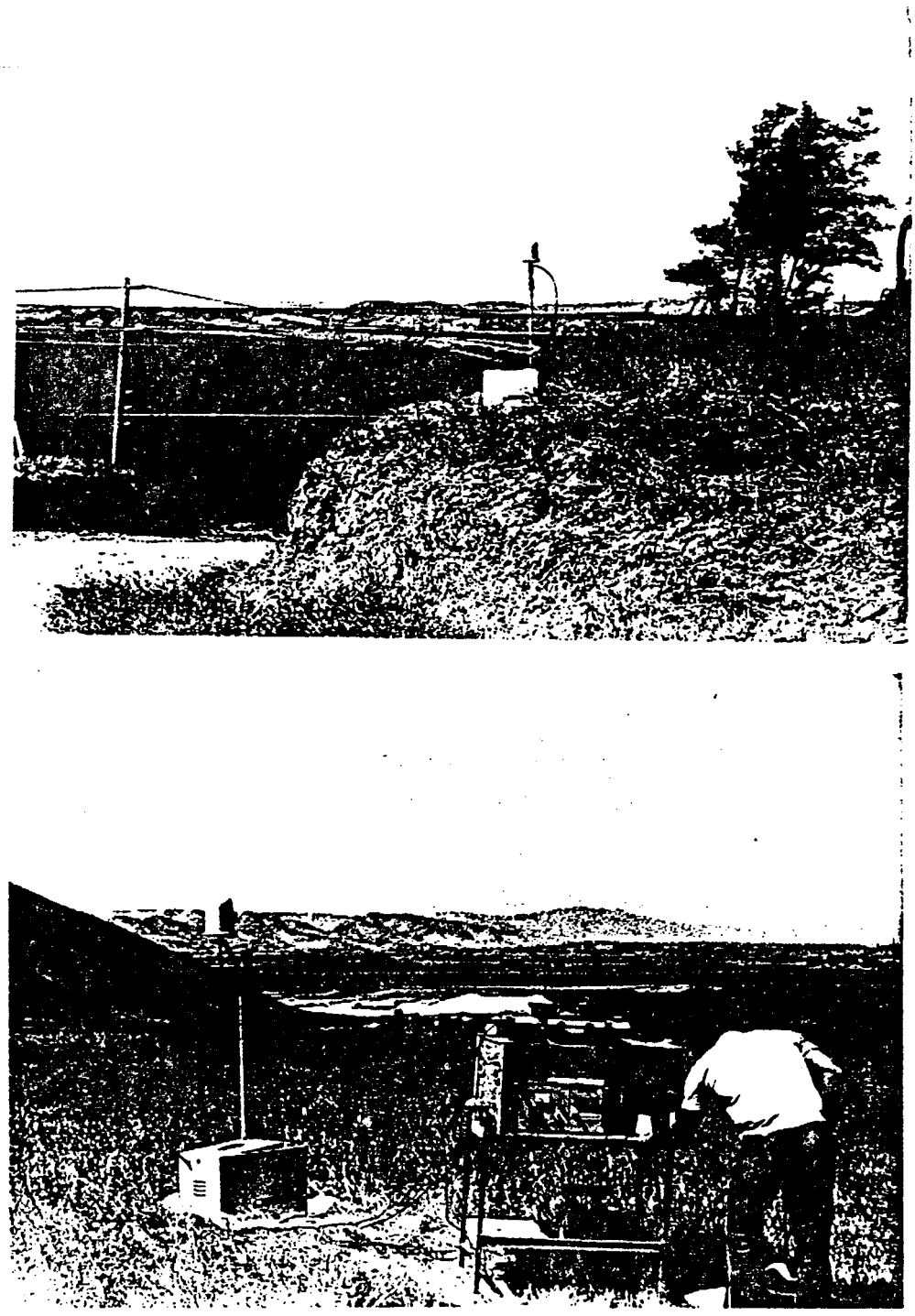


Figure 4.1-2. King City (Union Carbide Mill) Site Description.

Top Photo: The upwind sampler location; view is north. The predominant afternoon wind blows from left to right in the photo.

Bottom Photo: The downwind sampler location at the southern property boundary, directly downwind from the ore pile.

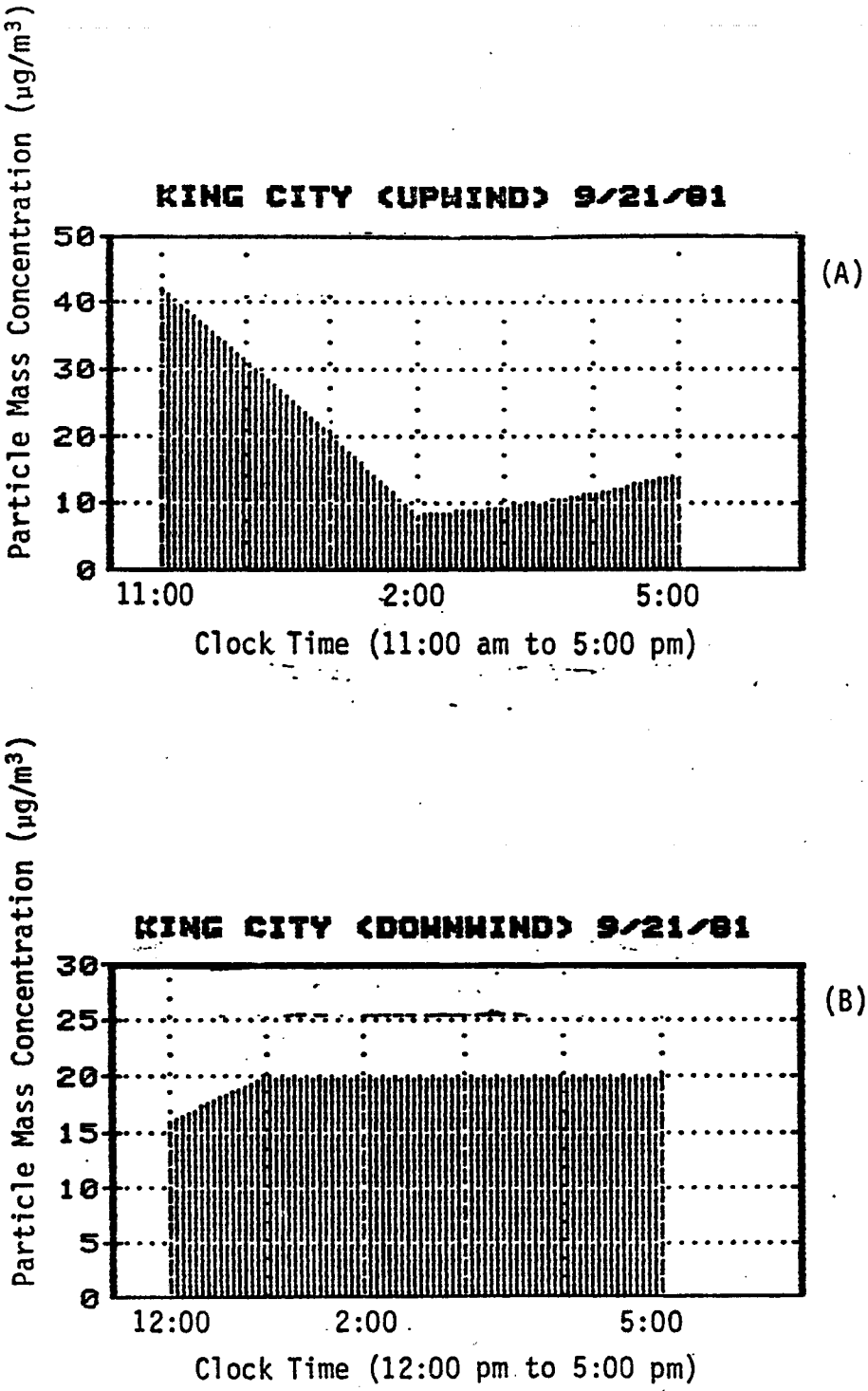


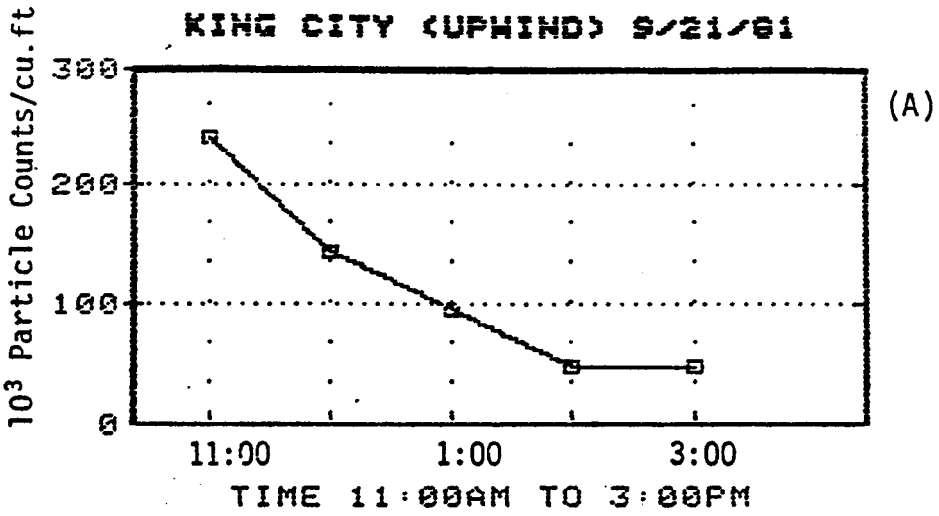
Figure 4.1-3. Optically-Derived Particle Mass Concentration Trends with Time at the King City Sites UPWIND (A) and DOWNWIND (B) from the Union Carbide Mill. Data were collected at one-hour intervals using the Royco ® Particle Counter and Mass was derived based on the Sonora Regression Analysis.

early morning fog, which produced water droplets that contributed to both mass and particle detectability. Mass concentrations at the downwind location were less variable due to a later starting time which missed much of the fog's effects. However, comparisons of the upwind and downwind data show definite differences in the mass concentrations from 2:00 a.m. to 5:00 p.m. Most likely, the difference between 20 ug/m^3 at the downwind site and the approximately 10 $\mu g/m^3$ at the upwind site was due to the placement of the downwind sampler on a dry dirt field full of dead weeds. Forming an uneven carpet approximately one ft thick, the dirt field served as a significant potential source of airborne particulate matter under any physical disturbance.

Concentrations of particles in the <0.7-μm aerodynamic diameter range for the upwind and downwind sites are graphed in Figure 4.1-4. The trends in particle counts followed the same pattern as the mass concentrations. The afternoon levels were approximately 50,000 particles/cu. ft for the upwind site and 70,000 particles/cu. ft for the downwind site. Increasing wind changed the size distribution of particles at both sites. Figure 4.1-5 depicts the upwind and downwind particle size distributions in the morning and afternoon. The key change in particle distribution was a greater proportion of large size particles due to higher afternoon winds. This shift in size distribution, coupled with a decrease in particle counts in the <0.7-μm aerodynamic diameter range in the afternoon, indicates that the local winds, at a velocity of 20 mph, were not resuspending particles, but were purging the area of any locally produced particles (including asbestos).

4.1.4 Asbestos Levels

The results of the transmission electron microscopic (TEM) analyses are presented in detail in Volume II, and the summarized results, along with sampling and meteorological information, are in Table 4.1-1. Unexpectedly, the highest value measured occurred at the upwind site in the morning. The levels of chrysotile were 10 to 100 times higher at the upwind site (140,000



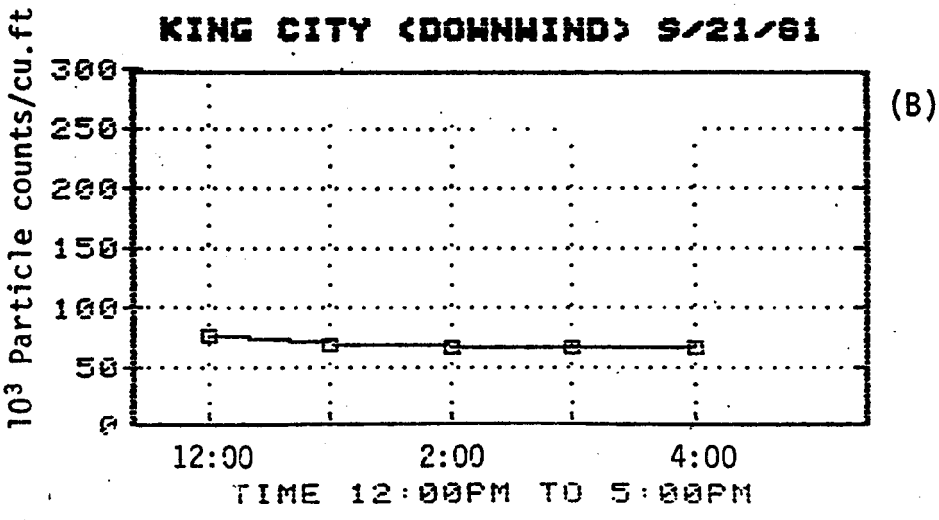
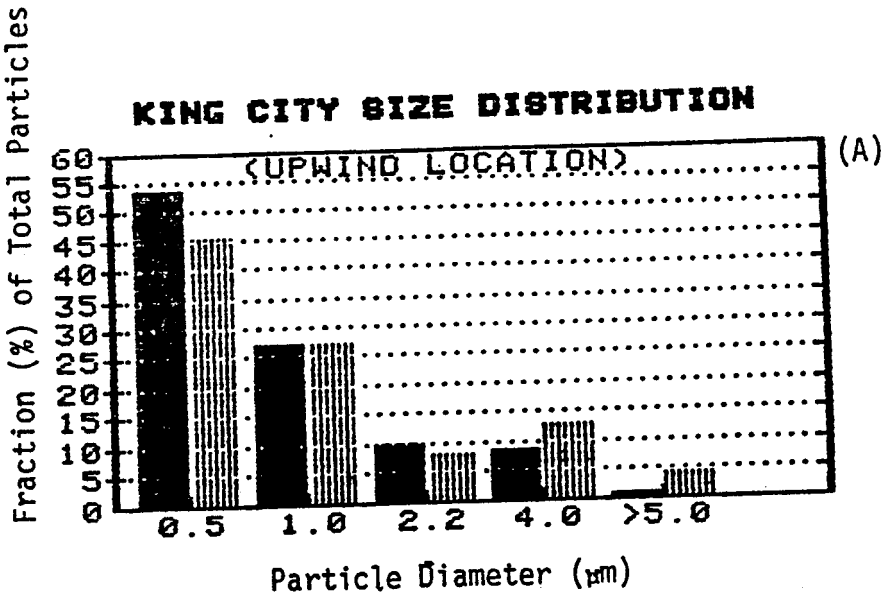


Figure 4.1-4. Optically-Derived Particle Count Trends with Time at the King City Sites UPWIND (A) and DOWNWIND (B) from the Union Carbide Mill. Data were collected at one-hour intervals using the Royco ® Optical Particle Counter for aerodynamic diameters <0.7 μm.



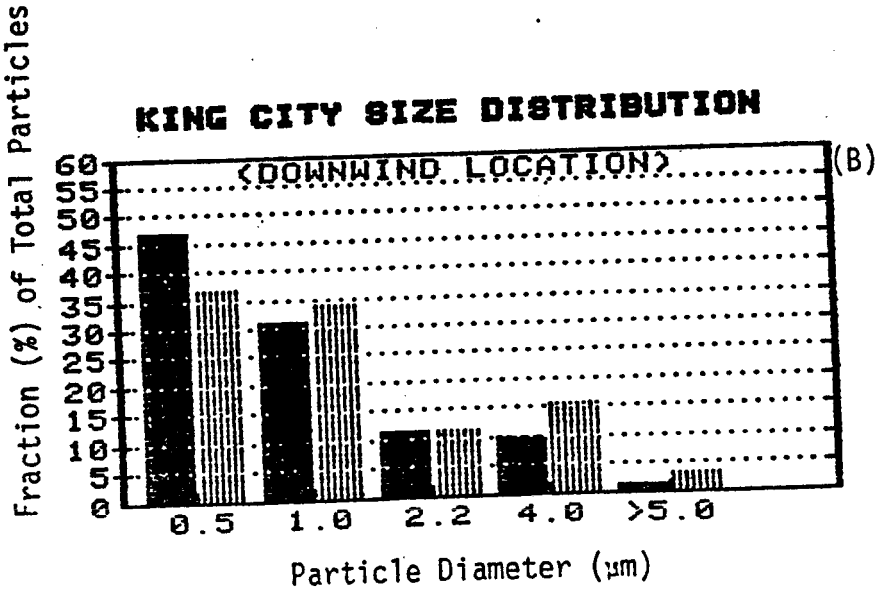


Figure 4.1-5. Particle Size Distributions at the King City UPWIND (A) and DOWNWIND (B) Sampling Sites.

fibers/m^3) than they were at the highest morning level (9,400 fibers/m^3) at the downwind site. No fibers longer than 5.0 μm were detected.

In addition to measuring ambient atmospheric asbestos, we considered the possibility that asbestos settles onto the soil in the vicinity of the plant. Accordingly, a soil sample was taken from both the upwind and downwind sites adjacent to each cyclone sampler. Since there is no formal procedure for analyzing asbestos in soil, we used a modified procedure based on standard sedimentological methods. The main impetus for measuring asbestos in soil is its potential as a source of airborne particulate matter as a result of aerodynamic entrainment under nominal wind conditions. Crushing or grinding the soil would not provide an accurate picture of potential resuspension of asbestos fibers and was therefore not used in determining asbestos concentrations. The samples were first shaken for five minutes by hand through a 120-mesh sieve (125-μm diameter pores), and each fraction weighed. The <125-μm size fraction was analyzed, since the >125-μm size fraction was assumed to be too large to undergo resuspension.

The <125-μm size fraction was placed in a plastic, round bottom 15-ml test tube with 10 ml of deionized 0.2-μm pore-size filtered water. The sample was shaken for two minutes by hand and transferred to a 2-m Emery column to separate out the larger particles. (An Emery settling column is a 2-m high, 25-mm diameter glass pipette used for routine separation of sand and silt sand size particles.) The settling rate of a particle is a direct function of its aerodynamic diameter, the viscosity of the settling medium and the difference between the particle density and the density of the settling medium which, in this case, was water. The Stokes settling equation is based on spherical particles and is given as:

$$V = \frac{2\ ar^2\ (d1-d2)}{9n}$$

V = settling velocity cm/sec

a = acceleration due to gravity

r = radius of sphere (cm)
d1 = density of sphere (g/cc)
d2 = density of settling medium (g/cc)
n = viscosity of settling medium (cp)

Since most particles (especially fibers) are not spherical, settling is also a function of individual sphericity, defined as:

$$Sp = \sqrt[3]{\frac{S^2}{\ell I}}$$

Sp = sphericity
ℓ = length
I = intermediate dimension
S = short dimension

A particle with a sphericity of 0.5 settles half as fast as one of an equivalent diameter. By definition, a fiber must have a length-to-width aspect ratio of 3:1, meaning that the shortest fibers will have a sphericity no greater than 0.69. The typical length-to-width aspect ratio for asbestos in ambient air is approximately 10:1 (Campbell, 1978), the effective sphericity for fibers in this range being approximately 0.45. The corrected settling rate for fibers is, therefore, the sphericity times the Stokes settling velocity:

Cv = Sp x V = corrected velocity
S_p = sphericity
V = velocity (cm/sec)

After the sample had settled for 100 minutes, the coarse fraction was drained through the Emery column stop-cock and discarded. The remaining 800 ml of solution were drained into a clean 1-L bottle for sample preparation. The settling time corresponds to the Wentworth size scale cutoff between 'very fine sand' and 'silt' (62-μm particle diameter). A more refined analysis might require the separation at the 20-μm diameter point, necessitating 16

might require the separation at the 20-μm diameter point, necessitating 16 hours of settling in an Emery column. Although sample preparation time would be dramatically increased, so would the asbestos detection limit in the soil sample.

The one liter collection bottle with sample was shaken for approximately one minute, and a 1-ml aliquot was transferred with 10 ml of 0.1-μm filtered water to a 25-mm diameter filter funnel having a 0.2-μm pore size Nuclepore collection filter and a 0.4-μm pore size Millipore backing filter. The filtering dilution at this point was 0.0012. After filtering, the sample was weighed then prepared for electron microscopy as described for airborne particles. Details of the results appear in Volume II; in summary, for chrysotile asbestos:

Sediment Analysis

Sample	Fibers/g (total)	Fibers/g (>5.0 μm)	Mean Length
Upwind	9,600,000	310,000	1.7 μm
Downwind	29,000,000	2,900,000	2.4 μm

As we expected, the downwind concentrations of total asbestos (29,000,000 fibers/g) were higher than the upwind levels (9,600,000 fibers/g). This should be the case because the downwind samplers were located within the confines of the asbestos mill property lines and transportation routes for transportation of asbestos ore. The mean fiber length was also slightly higher. The magnitude of the sediment levels at the upwind location was unexpectedly, only three times lower than the downwind location. Because upwind sediment samples taken at the air sampler were located one-half mile upwind from the plant facility, high asbestos levels in the soil indicate that there is a potential for asbestos transport to the upwind side of the plant under certain meteorological conditions.

4.1.5 Analysis Summary

Data for the King City site reflect complex interactions occurring between local meteorology and the asbestos mill operational parameters. On a typical day, the afternoon winds suspend fibers from the Union Carbide mill, however airborne concentrations remain relatively low as wind flow carries away and rapidly dilutes asbestos fibers to below detectable concentration limits. Factors which can alter this situation include unusual on-site vehicle activity and unusually high wind conditions. These conditions were not observed during our visit to the mill.

Higher levels of suspended particles in the upwind and downwind morning samples result from high humidity combined with very calm air. The absence of wind late at night and early in the morning prevented airborne fibers from being carried away from the plant area, setting the stage for particulate matter to form condensation nuclei in the morning fog. The early morning asbestos level of 140,000 fibers/m^3 (Table 4.1-1) was representative of a 'best case' situation. Although we did not monitor under conditions of visible dust resuspension, it is expected that in such a case asbestos levels would definitely exceed those observed in this study. It could be concluded that asbestos levels above 1,500,000 fibers/m^3 could be found in the vicinity of either the upwind or downwind locations. This would be expected to occur under the combined conditions of high dust resuspension from mechanical activity and low wind speeds.

Given these observations, the downwind area of San Lucas is likely to have elevated levels of asbestos predominantly in the afternoon and evening, and King City is likely to have elevated asbestos levels at late night and early in the morning.