Department of Toxic Substances Control (DTSC) Slodusty Road Study: Airborne Asbestos Quantitative Cancer Risk Assessment

September 2004

California Environmental Protection Agency
Office of Environmental Health Hazard Assessment
Air Toxicology and Epidemiology Section

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Summary

The Department of Toxic Substances Control (DTSC) performed a focused roadside air monitoring study within California's Garden Valley community in El Dorado County in 2002-2003. The study was designed to address DTSC's concern regarding potential exposure of communities to airborne asbestos fibers resulting from vehicular traffic along unpaved roadways known to contain asbestos. Within Garden Valley, the study site was Slodusty Road. Slodusty Rd. is an unpaved, north-south trending road, which primarily services a small residential population (35-50 people). At the start of the study, the roadway was surfaced with asbestos-containing serpentine.

The assessment sampled a volume of air that contained particulate matter, including asbestos fibers. The samples were collected from approximately 4.9 feet above ground level at distances ranging from 5 to 190 feet away from the edge of the road, on both sides of the road. Two traffic scenarios were utilized: 1) 30 vehicles/hour (vph) driven at a speed of 25 miles per hour (mph); 2) 10 vph at 10 mph. Each scenario was repeated, so that two test runs were conducted for each scenario.

The airborne asbestos concentration data obtained from the Slodusty Road study indicated that asbestos air concentrations decreased with increasing distance from the roadside, and in the upwind direction as compared with the downwind direction. However, airborne asbestos was still detectable by the air monitor farthest from the road in both the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios (190 and 130 feet, respectively; measured asbestos concentrations were 2.5×10^{2} - 3.0×10^{4} fibers/m^3 and 2.9×10^{1} - 3.1×10^{3} fibers/m^3, respectively), and estimates of the time-adjusted airborne asbestos cancer risks for lifetime exposure using those two scenarios ranged from 2.7×10^{-4} to 3.2×10^{-2} and 3.1×10^{-5} to 3.3×10^{-3}, respectively. These data suggest that the airborne asbestos cancer risks for the two vehicle frequency and speed scenarios probably bound the high-end estimated cancer risks to Slodusty Road residents. Corresponding population cancer risks assuming a 30 year exposure were 1.1×10^{-4} to 1.4×10^{-2} and 1.3×10^{-5} to 1.4×10^{-3} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 3.4×10^{-5} to 4.1×10^{-3} and 4.0×10^{-6} to 4.2×10^{-4} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively.

Airborne asbestos concentrations were resampled after the road was resurfaced to remove serpentine aggregate as a potential asbestos source. The presurfacing sampling methodology was used for the postsurfacing sampling, with the exception that sampling stations were located at 5, 30, 80, 160, 190 and 300 feet from the road. Time-adjusted airborne asbestos cancer risks using the 10 vph, 10 mph scenario ranged from 5.3×10^{-6} to 1.5×10^{-4}. Time-adjusted airborne asbestos cancer risks using the 30 vph, 25 mph scenario on ranged from 1.3×10^{-5} to 2.9×10^{-4}. The time-adjusted cancer risks associated with the post-resurfacing 10 vph, 10 mph scenario were approximately 1-2 orders of magnitude less than those of the corresponding pre-resurfacing

10 vph, 10 mph scenario, depending on wind direction and sampling distance from the road. The time-adjusted cancer risks associated with the post-resurfacing 30 vph, 25 mph scenario were approximately 1-3 orders of magnitude less than those of the corresponding pre-resurfacing 30 vph, 25 mph scenario, depending on wind direction and sampling distance from the road. Corresponding population cancer risks assuming a 30 year exposure were 2.3×10^{-6} to 6.4×10^{-5} and 3.1×10^{-6} to 1.3×10^{-4} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 6.8×10^{-7} to 1.9×10^{-5} and 9.4×10^{-7} to 3.8×10^{-5} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively. It should be noted that these risk estimates likely have substantial uncertainty associated with exposure estimates.

Introduction

The Department of Toxic Substances Control (DTSC) performed a focused roadside air monitoring study within California's Garden Valley community in El Dorado County in 2002-2003. The study was designed to address DTSC's concern regarding potential exposure of communities to airborne asbestos fibers resulting from vehicular traffic along unpaved roadways known to contain asbestos. The field and data gathering effort was conducted by personnel from the U.S. Department of Transportation's (USDOT) John A. Volpe National Transportation Systems Center (Volpe Center) under an Interagency Agreement (IAG) with some field assistance and equipment provided by DTSC staff.

The study involved monitoring of air-entrained asbestos dust associated with vehicular traffic along a representative unpaved serpentine-surfaced roadway known to contain asbestos within the road base. The study was designed to provide information regarding:

1. The ambient airborne asbestos concentration resulting from vehicular traffic along an unpaved asbestos-containing roadway;
2. How the ambient airborne asbestos concentration varies as a function of vehicle speed, vehicular traffic volume, and distance from the road.
3. How measured airborne asbestos concentrations near unpaved serpentine roadways under various traffic conditions compare to background regional concentrations of airborne asbestos.

Sampling Methodology

Test Area

Within Garden Valley, the study site was Slodusty Road. Slodusty Rd. is an unpaved, north-south trending road, which primarily services a small residential population (35-50 people). At the start of the study, the roadway was surfaced with asbestos-containing serpentine material. The test site was an approximately 250 ft. stretch of straight road.

The assessment sampled a volume of air that contained particulate matter, including asbestos fibers. The samples were collected from approximately 4.9 feet above ground level at distances of 5, 10, 30, 50, 80, 100, 130, 160, and 190 feet away from the edge of the road, on both sides of the road. Sampling was performed along a transect perpendicular to the centerline of the road and intersecting the road at the midpoint of a 220 foot segment.

Two meteorological stations were located on each side of Slodusty Road at distances of 30 and 130 feet away from the road, and each meteorological station produced one dataset per traffic simulation run.

After completion of the traffic simulations, a preliminary analysis of the airborne asbestos concentrations and the resulting potential cancer risk associated with the simulated traffic activity caused DTSC to resurface Slodusty Road in order to mitigate any potential cancer hazard. This resurfacing process involved: 1) compacting the existing serpentine gravel road; 2) covering the existing roadbed with four inches of compacted class 2 limestone aggregate base (AB); 3) spraying an asphalt tack coat on the AB; 4) spreading a layer of limestone pea gravel over the tack coat layer followed by compaction.

After resurfacing, the traffic simulation study was repeated. The presurfacing sampling methodology was used for the postsurfacing sampling, with the exception that sampling stations were located at 5, 30, 80, 160, 190 and 300 feet from the road.

Traffic Simulations

For the purposes of eventual model development, this assessment effort focused on controlling and repeating similar traffic conditions rather than measuring airborne asbestos from a multitude of traffic conditions without repeats or from uncontrolled traffic on the test segment of road. Two traffic scenarios were utilized: 1) 30 vehicles/hour (vph) driven at a speed of 25 miles per hour (mph); 2) 10 vph at 10 mph. Each scenario was repeated, so that two test runs were conducted for each scenario.

During these traffic simulation runs (from this point on, referred to as “runs”), vehicular speed and frequency was controlled by a traffic coordinator via two-way radio communication with the vehicle drivers. Air sampling took place throughout the entire two-hour duration of the run. Two vehicles were utilized as test vehicles: a pick-up truck and a mid-size sedan. Each vehicle was alternately driven along the test road segment at regular intervals depending on the traffic scenario and maintained the test speed for a distance of at least 110 feet on either side of the sampling transect (resulting in a total distance of 220 feet that test speed was maintained).

Ambient Air Sampling

Ambient air samples were collected by drawing a measured volume of air through a 25 mm diameter mixed cellulose ester (MCE) membrane filter of pore size 0.45 µm by means of a battery-powered pump. Samplers at Slodusty Road collected air throughout the two hour runs during which a controlled traffic simulation took place. Several personal samplers were also located on field personnel on each sampling day. “Ambient background” airborne asbestos concentration data from a regional location not near an area of serpentine-surfaced road traffic were not included in the study. Air samples were analyzed using a direct preparation transmission electron microscopy (TEM) method.

Asbestos Air Concentrations

Table 1 lists a subset of the air sampling data collected on Slodusty Road on July 17th and 18th, 2002. Data parameters include sample ID, vehicle frequency (vph), vehicle speed (mph), side of road collected (east or west), distance from road (ft), sampled air volume (l), filter area counted (mm^2), and asbestos air concentrations (structures/cubic centimeter, abbreviated as s/cc). Sample groups P2 and P3 were obtained on July 17th and 18th, respectively. Sample IDs P2-00001 and P3-00001 were filter blanks. Sample IDs P2-0002 through P2-0004 and P3-0002 through P3-0004 were obtained from personal samplers worn by field personnel. Not included in Table 1 are air concentrations from sample IDs P2-00030, P2-00032, P2-00034, P2-00042, P2-00043 and P2-00045. These samples were apparently sent to an analysis laboratory other than the primary laboratory as a quality check. Also, sample ID P3-00007 produced artifactual results due to equipment problems, and was therefore not included in Table 1.

Table 2 lists a subset of the air sampling data collected on Slodusty Road on August 18th – 20th, 2003 after road resurfacing was complete. Data parameters include sample ID, date of sample collection, vehicle frequency (vph), vehicle speed (mph), side of road collected (east or west), distance from road (ft) and asbestos air concentrations (s/cc). Sample group F1 was obtained on August 18th, and consisted of ambient air samples collected in the absence of a traffic simulation run. Sample F1-00020 was obtained from an ambient air monitor in the Garden Valley neighborhood approximately two miles from Slodusty Road. Sample groups F2 and F3 were collected during traffic simulation runs and were collected on August 19th and 20th, respectively. Four samples had asbestos concentrations below the limit of analytical detection (LOD). Those samples were assigned an asbestos concentration of one-half the LOD for that sample, and are noted in Table 2.

Asbestos Cancer Risk Assessment

OEHHA was requested to estimate cancer risk using the data obtained from the Slodusty Road sampling. Generally, cancer risk can be estimated by multiplying cancer unit risk factors by concentrations in air to which people are exposed chronically. In order to estimate cancer risk from the Slodusty Road data, we needed to make assumptions about how frequently residents would be exposed to the measured concentrations. Thus we applied exposure assumptions that we think were relatively conservative to estimate chronic exposures from traffic on Slodusty Road at various distances from the roadway. OEHHA has provided risk assessment guidance for the Air Toxics program in California to use to estimate cancer risk from stationary sources where we have measured or modeled annualized average concentration data. We did not think it was warranted to use more complex risk assessment methodologies, for example the Air Toxics Hot Spots Risk Assessment Guidelines, with the Slodusty Road data because of the relatively crude assumptions about chronic exposure that we made from the short-term scenario-specific airborne asbestos measurements.

Table 1: Slodusty Road Air Monitoring Results: Pre-resurfacing

Sample I.D.	Date Collected	Vehicle Frequency (vph)	Vehicle Speed (mph)	Side of Road Collected (E,W)	Distance From Road (ft)	Concentrations (s/cc)
P2-00001	7/17/02	NA	NA	NA	NA	BLANK (0)
P2-00002	7/17/02	NA	NA	NA	NA	0.4700
P2-00003	7/17/02	NA	NA	NA	NA	0.0610
P2-00004	7/17/02	NA	NA	NA	NA	0.5500
P2-00029	7/17/02	30	25	E	5	9.5000
P2-00031	7/17/02	30	25	E	10	3.6000
P2-00033	7/17/02	30	25	E	30	2.0000
P2-00035	7/17/02	30	25	E	50	1.6000
P2-00036	7/17/02	30	25	E	80	1.2000
P2-00037	7/17/02	30	25	E	100	0.7600
P2-00038	7/17/02	30	25	E	130	0.9300
P2-00039	7/17/02	30	25	E	160	0.5300
P2-00040	7/17/02	30	25	E	190	0.2800
P2-00041	7/17/02	30	25	W	5	8.7000
P2-00044	7/17/02	30	25	W	10	2.2000
P2-00046	7/17/02	30	25	W	30	2.3000
P2-00047	7/17/02	30	25	W	50	0.2200
P2-00048	7/17/02	30	25	W	80	0.2200
P2-00049	7/17/02	30	25	W	100	0.0930
P2-00050	7/17/02	30	25	W	130	0.0800
P2-00051	7/17/02	30	25	W	160	0.1700
P2-00052	7/17/02	30	25	W	190	0.0940
P3-00001	7/18/02	NA	NA	NA	NA	BLANK (0)
P3-00002	7/18/02	NA	NA	NA	NA	0.4100
P3-00003	7/18/02	NA	NA	NA	NA	4.5000
P3-00004	7/18/02	NA	NA	NA	NA	0.1100
P3-00005	7/18/02	10	10	E	5	0.5300
P3-00006	7/18/02	10	10	E	10	0.2600
P3-00008	7/18/02	10	10	E	80	0.0530
P3-00009	7/18/02	10	10	E	130	0.0093
P3-00010	7/18/02	10	10	W	5	0.9800
P3-00011	7/18/02	10	10	W	10	0.1900
P3-00012	7/18/02	10	10	W	30	0.3300
P3-00013	7/18/02	10	10	W	80	0.3700
P3-00014	7/18/02	10	10	W	130	0.0860

Sample Type: roadside sampler personal sampler filter blank NA: not available

Table 2: Slodusty Road Air Monitoring Results: Post-resurfacing

Index ID	Date collected	Vehicle frequency (vph)	Vehicle Speed (mph)	East (E) or West (W) of Road	Distance from Road Edge (ft)	Asbestos (s/cc)	Analytical Sensitivity (S/cc)
F1-00020	08/18/03	NA	NA	NA	NA	0.0047	0.0023
F1-00001	08/18/03	NA	NA	E	5	0.0990	0.0043
F1-00003	08/18/03	NA	NA	E	30	0.0088	0.0044
F1-00005	08/18/03	NA	NA	E	80	0.0022	0.0043
F1-00010	08/18/03	NA	NA	W	5	0.0180	0.0045
F1-00012	08/18/03	NA	NA	W	30	0.0049	0.0049
F1-00014	08/18/03	NA	NA	W	80	0.0046	0.0046
F1-00019	08/18/03	NA	NA	W	300	0.0091	0.0030
F2-00001	08/19/03	10	10	E	5	0.0088	0.0044
F2-00003	08/19/03	10	10	E	30	0.0016	0.0031
F2-00005	08/19/03	10	10	E	80	0.0031	0.0031
F2-00010	08/19/03	10	10	W	5	0.0110	0.0037
F2-00012	08/19/03	10	10	W	30	0.0190	0.0037
F2-00014	08/19/03	10	10	W	80	0.0250	0.0031
F2-00040	08/19/03	10	10	W	300	0.0360	0.0052
F3-00004	08/20/03	10	10	E	5	0.0240	0.0047
F3-00006	08/20/03	10	10	E	30	0.0290	0.0049
F3-00008	08/20/03	10	10	E	80	0.0450	0.0045
F3-00013	08/20/03	10	10	W	5	0.0180	0.0045
F3-00015	08/20/03	10	10	W	30	0.0044	0.0044
F3-00017	08/20/03	10	10	W	80	0.0270	0.0044
F2-00022	08/19/03	30	25	E	5	0.0550	0.0069
F2-00024	08/19/03	30	25	E	30	0.0350	0.0038
F2-00026	08/19/03	30	25	E	80	0.0060	0.0030
F2-00031	08/19/03	30	25	W	5	0.0885	0.0071
F2-00033	08/19/03	30	25	W	30	0.0073	0.0036
F2-00036	08/19/03	30	25	W	100	0.0130	0.0044
F2-00039	08/19/03	30	25	W	190	0.0090	0.0045
F2-00041	08/19/03	30	25	W	300	0.0022	0.0043
F3-00023	08/20/03	30	25	E	5	0.0510	0.0072
F3-00025	08/20/03	30	25	E	30	0.0320	0.0046
F3-00027	08/20/03	30	25	E	80	0.0092	0.0046
F3-00032	08/20/03	30	25	W	5	0.0670	0.0074
F3-00034	08/20/03	30	25	W	30	0.0130	0.0044
F3-00036	08/20/03	30	25	W	80	0.0130	0.0044
F3-00039	08/20/03	30	25	W	160	0.0023	0.0046

No traffic simulation scenario. Adjacent neighborhood ambient air sample.
Sample was assigned an asbestos concentration value of one-half the limit of analytical sensitivity (LOD).

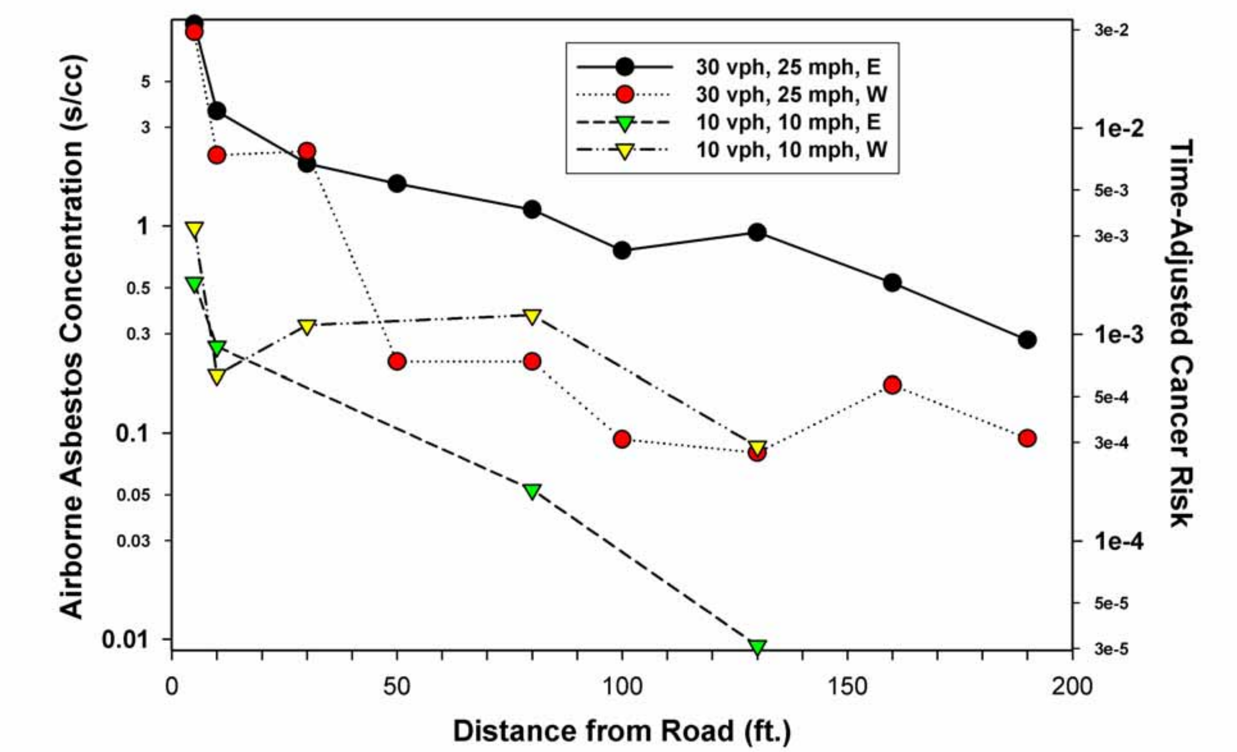
Pre-resurfacing asbestos air concentrations obtained by the roadside samplers were plotted against sampler distance from the road. These data are illustrated in Figure 1. The 30 vph, 25 mph data were obtained on July 17th; the prevailing wind this day blew towards the east side of the road. The 10 vph, 10 mph data were obtained on July 18th; the prevailing winds this day were mixed, but predominantly blew towards the west side of the road. Both distance from roadside and wind direction affected asbestos air concentrations. Asbestos air concentrations decreased with increasing distance from the roadside. However, airborne asbestos was still detectable at 190 feet regardless of wind direction in the 30 vph, 25 mph group. Asbestos concentrations were similar regardless of wind direction from 5 to 30 feet from roadside in the 30 vph, 25 mph group samples, but decreased substantially in the upwind direction compared to downwind at distances of 50 feet or greater. A similar relationship was noted for the 10 vph, 10 mph scenario, with similar concentrations regardless of wind direction from 5 to 10 feet from roadside, but decreasing substantially in the upwind direction compared to downwind at distances of 30 feet or greater.

Table 3 lists crude and time-adjusted cancer risks associated with exposure to pre-resurfacing airborne asbestos concentrations observed in the Slodusty Road study. Crude cancer risks were calculated using the following relationship: crude cancer risk = ((concentration (s/cc) × CF)/320) × UR/100)), where CF = 10^6 (conversion from cc to m^3), 320 is the Toxic Air Contaminant (TAC) program conversion factor for converting from TEM fiber counts to PCM (phase contrast microscopy) fiber counts, and UR is the asbestos unit risk ($[1.9 \times 10^{-4}$ (100 PCM fibers/$m^3)]^{-1}$). The asbestos unit risk was divided by 100 since the unit risk is stated in units of (100 PCM fibers/$m^3)^{-1}$, and the calculated airborne concentrations are in units of PCM fibers/m^3. Time-adjusted cancer risks were calculated using the following relationship: time-adjusted cancer risk = CCR × (16/24) × (365-59/365), where CCR is the crude cancer risk, (16/24) is the adjustment factor which accounts for the number of hours/day where traffic is expected to generate airborne asbestos (approximately 5 AM – 9 PM), and (365-59/365) accounts for the 59 average rain days in the Sacramento area (US National Weather Service, 2000). It would be expected that entrainment of asbestos to the air would be minimal on rain days. This assumes that the entrained dust and fibers are present at the measured concentrations continuously for 16 hours/day and that the residents are also present 16 hours/day.

Time-adjusted airborne asbestos cancer risks using the 30 vph, 25 mph scenario ranged from 2.7×10^{-4} to 3.2×10^{-2}. Time-adjusted airborne asbestos cancer risks using the 10 vph, 10 mph scenario ranged from 3.1×10^{-5} to 3.3×10^{-3}. For comparison purposes, the time-adjusted airborne asbestos cancer risks calculated from the personal samplers ranged from 2.0×10^{-4} to 1.5×10^{-2}, which substantially overlaps the range of risks for the 30 vph, 25 mph scenario.

These data suggest that road workers and drivers using this road prior to resurfacing could have been exposed to appreciable airborne asbestos concentrations. Since risk is proportional to asbestos concentration, the data described in Figure 1 and Table 3 suggest that risk decreases in the upwind direction from the road relative to the downwind direction, and also decreases as the distance from the road increases. However, the asbestos concentrations did not drop to below detection levels at the farthest distances monitored in the pre-resurfacing portion of this study (190 feet and 130 feet for the 30 vph, 25 mph and the 10 vph, 10 mph scenarios, respectively). These data suggest that the airborne asbestos cancer risks for the two vehicle frequency and

Figure 1: Pre-resurfacing airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated cancer risk.



speed scenarios probably bound the high-end estimates of pre-resurfacing cancer risks to Slodusty Road residents. Anecdotal evidence provided by the residents suggests that the average speed on this road is close to 10 mph. OEHHA made several assumptions to use the short-term scenario-specific data for estimating long-term exposure and cancer risk. Thus the cancer risk estimates have uncertainty associated with relatively crude exposure assumptions. If the actual traffic frequency and average speeds on Slodusty Road were either less than or greater than the traffic frequencies and speeds used in the study, the high-end estimates of cancer risks could be either overestimated or underestimated, respectively. Uncertainty in this respect could potentially be reduced by traffic survey data. Additionally, the time-adjusted airborne asbestos cancer risks calculated from the Slodusty Road data assume the same number of rain days occurring there as in Sacramento. Any divergence in precipitation patterns could potentially bias the airborne asbestos cancer risk calculations. It should be noted that the cancer risk estimates described above are population risk estimates, based on a 70-year lifetime exposure for 16 hours/day. The excess cancer risk to populations exposed to the airborne asbestos concentrations observed in the study for less than 70 years or 16 hours/day may be less than the risks described above. Corresponding population cancer risks assuming a 30 year exposure were 1.1×10^{-4} to 1.4×10^{-2} and 1.3×10^{-5} to 1.4×10^{-3} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 3.4×10^{-5} to 4.1×10^{-3} and 4.0×10^{-6} to 4.2×10^{-4} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively.

Table 3: Crude and Time-adjusted Slodusty Road Pre-resurfacing Airborne Asbestos Cancer Risks

Sample I.D.	Vehicle Frequency (vph)	Vehicle Speed (mph)	Side of Road Collected (E,W)	Distance From Road (ft)	Asbestos Concentrations (s/cc)	Crude Cancer Risk	Time-adjusted Cancer Risk
P2-00002	NA	NA	NA	NA	4.70E-01	2.8E-03	1.6E-03
P2-00003	NA	NA	NA	NA	6.1E-02	3.6E-04	2.0E-04
P2-00004	NA	NA	NA	NA	5.5E-01	3.3E-03	1.8E-03
P2-00029	30	25	E	5	9.5E+00	5.6E-02	3.2E-02
P2-00031	30	25	E	10	3.6E+00	2.1E-02	1.2E-02
P2-00033	30	25	E	30	2.0E+00	1.2E-02	6.6E-03
P2-00035	30	25	E	50	1.6E+00	9.5E-03	5.3E-03
P2-00036	30	25	E	80	1.2E+00	7.1E-03	4.0E-03
P2-00037	30	25	E	100	7.6E-01	4.5E-03	2.5E-03
P2-00038	30	25	E	130	9.3E-01	5.5E-03	3.1E-03
P2-00039	30	25	E	160	5.3E-01	3.1E-03	1.8E-03
P2-00040	30	25	E	190	2.8E-01	1.7E-03	9.3E-04
P2-00041	30	25	W	5	8.70E+00	5.2E-02	2.9E-02
P2-00044	30	25	W	10	2.2E+00	1.3E-02	7.3E-03
P2-00046	30	25	W	30	2.3E+00	1.4E-02	7.6E-03
P2-00047	30	25	W	50	2.2E-01	1.3E-03	7.3E-04
P2-00048	30	25	W	80	2.2E-01	1.3E-03	7.3E-04
P2-00049	30	25	W	100	9.30E-02	5.5E-04	3.1E-04
P2-00050	30	25	W	130	8.00E-02	4.8E-04	2.7E-04
P2-00051	30	25	W	160	1.70E-01	1.0E-03	5.6E-04
P2-00052	30	25	W	190	9.40E-02	5.6E-04	3.1E-04
P3-00002	NA	NA	NA	NA	4.1E-01	2.4E-03	1.4E-03
P3-00003	NA	NA	NA	NA	4.5E+00	2.7E-02	1.5E-02
P3-00004	NA	NA	NA	NA	1.1E-01	6.5E-04	3.7E-04
P3-00005	10	10	E	5	5.3E-01	3.1E-03	1.8E-03
P3-00006	10	10	E	10	2.6E-01	1.5E-03	8.6E-04
P3-00008	10	10	E	80	5.3E-02	3.1E-04	1.8E-04
P3-00009	10	10	E	130	9.3E-03	5.5E-05	3.1E-05
P3-00010	10	10	W	5	9.8E-01	5.8E-03	3.3E-03
P3-00011	10	10	W	10	1.9E-01	1.1E-03	6.3E-04
P3-00012	10	10	W	30	3.3E-01	2.0E-03	1.1E-03
P3-00013	10	10	W	80	3.7E-01	2.2E-03	1.2E-03
P3-00014	10	10	W	130	8.6E-02	5.1E-04	2.9E-04

Personal sampler data NA: not available.

Additionally, the highest airborne asbestos concentrations were observed 5 feet from the roadside. It is unlikely that residents would spend substantial amounts of time at this distance from Slodusty Road or any other road. Airborne asbestos concentrations decreased substantially as distance from the road increased. The data from both test scenarios indicated that in the upwind direction, airborne asbestos concentrations were almost two orders of magnitude less at 50 feet from the road compared to the concentrations 5 feet from the road (Figure 1).

These data also suggest that any potential cancer risks from airborne asbestos generated by road traffic over Slodusty Road (or similar unpaved roads surfaced with crushed rock containing asbestos) may have been lower in the past (for example, in the 1960s-1970s). Airborne asbestos concentrations increased as vehicle frequency and speed increased (Figure 1). Vehicle frequency is probably proportional to area population, which has increased over time. It is also possible that improved vehicle capabilities (for example, improved tires and suspensions) may have resulted in increases in average speeds on unpaved roads over time.

"Ambient background" airborne asbestos concentration data from a regional location not near an area of serpentine-surfaced road traffic were not included in the study. Therefore, it was not possible to adjust the high-end estimates of cancer risks from pre-resurfacing road exposure to take into consideration regional background levels of airborne asbestos.

Table 4 lists crude and time-adjusted cancer risks associated with exposure to post-resurfacing airborne asbestos concentrations observed in the Slodusty Road study. The same methodology and assumptions used to calculate cancer risks from the pre-resurfacing airborne asbestos concentrations were used to evaluate the post-resurfacing data. However, time-adjusted cancer risks were not calculated from either the Garden Valley neighborhood or no traffic simulation scenario airborne asbestos concentration data. The time-adjusted cancer risk calculations include an adjustment for hours of expected traffic-generated asbestos emissions. Inclusion of that adjustment would not be appropriate for those data sets, since the asbestos concentrations under those conditions would be applicable 24 hours/day. Airborne asbestos concentrations during the no traffic simulation scenario ranged from 2.2×10^{-3} to 9.9×10^{-2} s/cc. Airborne asbestos concentrations during the 10 vph, 10 mph scenarios on August 19th and August 20th ranged from 1.6×10^{-3} to 4.5×10^{-2} s/cc. Airborne asbestos concentrations during the 30 vph, 25 mph scenarios on August 19th and August 20th ranged from 2.2×10^{-3} to 8.9×10^{-2} s/cc. These data indicate that the range of airborne asbestos concentrations and the corresponding crude cancer risks generated by the traffic simulation scenarios generally fell within the range of the airborne asbestos concentrations measured on Slodusty Road when no traffic simulation was being conducted, along with the corresponding crude cancer risks.

Time-adjusted airborne asbestos cancer risks using the 10 vph, 10 mph scenario on August 19th and August 20th ranged from 5.3×10^{-6} to 1.5×10^{-4}. Time-adjusted airborne asbestos cancer risks using the 30 vph, 25 mph scenario on August 19th and August 20th ranged from 1.3×10^{-5} to 2.9×10^{-4}. Figures 2 and 3 compare pre-resurfacing and post-resurfacing (August 19th and 20th, respectively) 10 vph/10 mph traffic simulation scenario airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated time-adjusted cancer risks. Figures 4 and 5 compare pre-resurfacing and post-resurfacing (August 19th and 20th, respectively) 30 vph/25 mph traffic simulation scenario airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated time-adjusted cancer risks.

The time-adjusted cancer risks associated with the post-resurfacing August 19th and 20th 10 vph, 10 mph scenario were approximately 1-2 orders of magnitude less than those of the corresponding pre-resurfacing 10 vph, 10 mph scenario, depending on wind direction

Table 4: Crude and Time-adjusted Slodusty Road Post-resurfacing Airborne Asbestos Cancer Risks

Index ID	Date Collected	Vehicle frequency (vph)	Vehicle Speed (mph)	East (E) or West (W) of Road	Distance from Road Edge (ft)	Asbestos (s/cc)	Crude Cancer Risk	Time-adjusted Cancer Risk
F1-00020	08/18/03	NA	NA	NA	NA	0.0047	2.8E-05	
F1-00001	08/18/03	NA	NA	E	5	0.0990	5.9E-04	
F1-00003	08/18/03	NA	NA	E	30	0.0088	5.2E-05	
F1-00005	08/18/03	NA	NA	E	80	0.0022	1.3E-05	
F1-00010	08/18/03	NA	NA	W	5	0.0180	1.1E-04	
F1-00012	08/18/03	NA	NA	W	30	0.0049	2.9E-05	
F1-00014	08/18/03	NA	NA	W	80	0.0046	2.7E-05	
F1-00019	08/18/03	NA	NA	W	300	0.0091	5.4E-05	
F2-00001	08/19/03	10	10	E	5	0.0088	5.2E-05	2.9E-05
F2-00003	08/19/03	10	10	E	30	0.0016	9.5E-06	5.3E-06
F2-00005	08/19/03	10	10	E	80	0.0031	1.8E-05	1.0E-05
F2-00010	08/19/03	10	10	W	5	0.0110	6.5E-05	3.7E-05
F2-00012	08/19/03	10	10	W	30	0.0190	1.1E-04	6.3E-05
F2-00014	08/19/03	10	10	W	80	0.0250	1.5E-04	8.3E-05
F2-00040	08/19/03	10	10	W	300	0.0360	2.1E-04	1.2E-04
F3-00004	08/20/03	10	10	E	5	0.0240	1.4E-04	8.0E-05
F3-00006	08/20/03	10	10	E	30	0.0290	1.7E-04	9.6E-05
F3-00008	08/20/03	10	10	E	80	0.0450	2.7E-04	1.5E-04
F3-00013	08/20/03	10	10	W	5	0.0180	1.1E-04	6.0E-05
F3-00015	08/20/03	10	10	W	30	0.0044	2.6E-05	1.5E-05
F3-00017	08/20/03	10	10	W	80	0.0270	1.6E-04	9.0E-05
F2-00022	08/19/03	30	25	E	5	0.0550	3.3E-04	1.8E-04
F2-00024	08/19/03	30	25	E	30	0.0350	2.1E-04	1.2E-04
F2-00026	08/19/03	30	25	E	80	0.0060	3.6E-05	2.0E-05
F2-00031	08/19/03	30	25	W	5	0.0885	5.3E-04	2.9E-04
F2-00033	08/19/03	30	25	W	30	0.0073	4.3E-05	2.4E-05
F2-00036	08/19/03	30	25	W	100	0.0130	7.7E-05	4.3E-05
F2-00039	08/19/03	30	25	W	190	0.0090	5.3E-05	3.0E-05
F2-00041	08/19/03	30	25	W	300	0.0022	1.3E-05	7.3E-06
F3-00023	08/20/03	30	25	E	5	0.0510	3.0E-04	1.7E-04
F3-00025	08/20/03	30	25	E	30	0.0320	1.9E-04	1.1E-04
F3-00027	08/20/03	30	25	E	80	0.0092	5.5E-05	3.1E-05
F3-00032	08/20/03	30	25	W	5	0.0670	4.0E-04	2.2E-04
F3-00034	08/20/03	30	25	W	30	0.0130	7.7E-05	4.3E-05
F3-00036	08/20/03	30	25	W	80	0.0130	7.7E-05	4.3E-05
F3-00039	08/20/03	30	25	W	160	0.0023	1.4E-05	7.6E-06

No traffic simulation scenario. Adjacent neighborhood ambient air sample.
Sample was assigned an asbestos concentration value of one-half the limit of analytical sensitivity (LOD).

Figure 2: Pre-resurfacing and post-resurfacing (August 19th) airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated cancer risk: 10 vph/10 mph vehicle scenario.

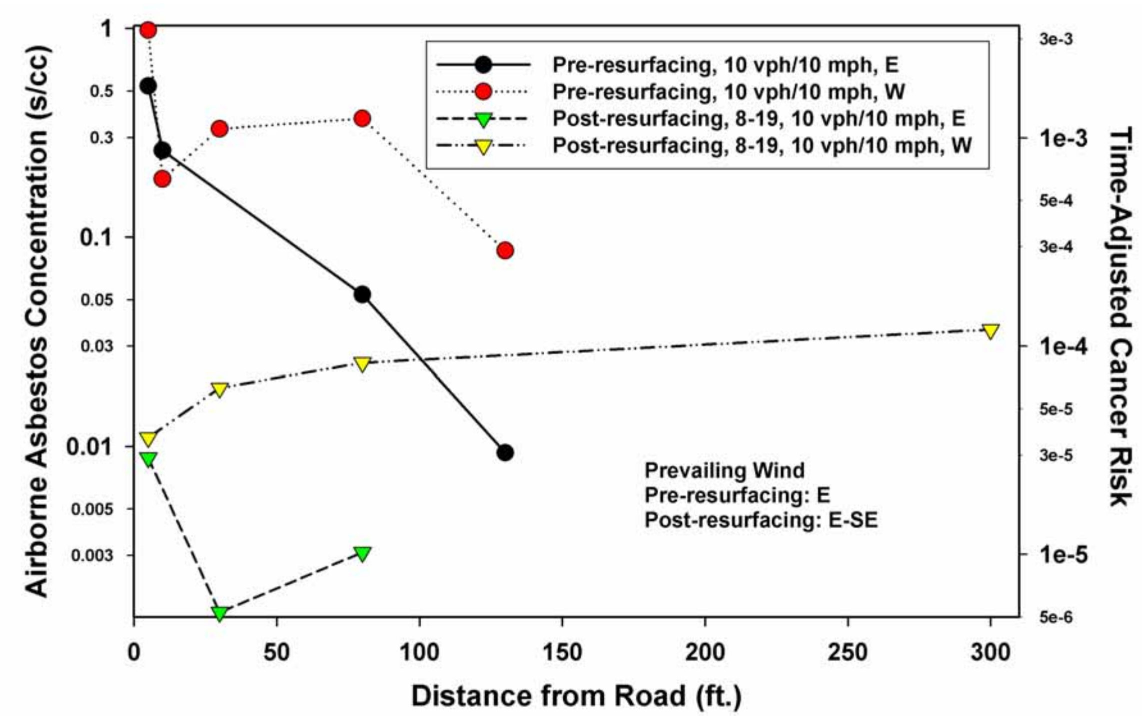


Figure 3: Pre-resurfacing and post-resurfacing (August 20th) airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated cancer risk: 10 vph/10 mph vehicle scenario.

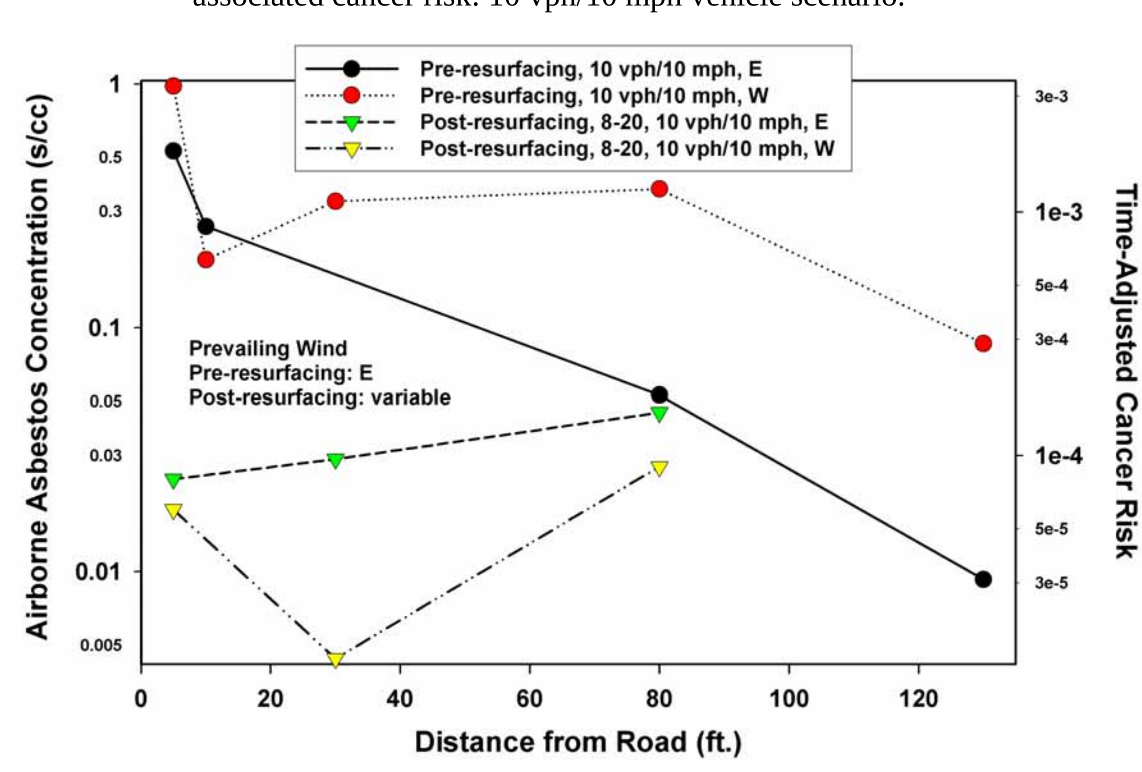


Figure 4: Pre-resurfacing and post-resurfacing (August 19th) airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated cancer risk: 30 vph/25 mph vehicle scenario.

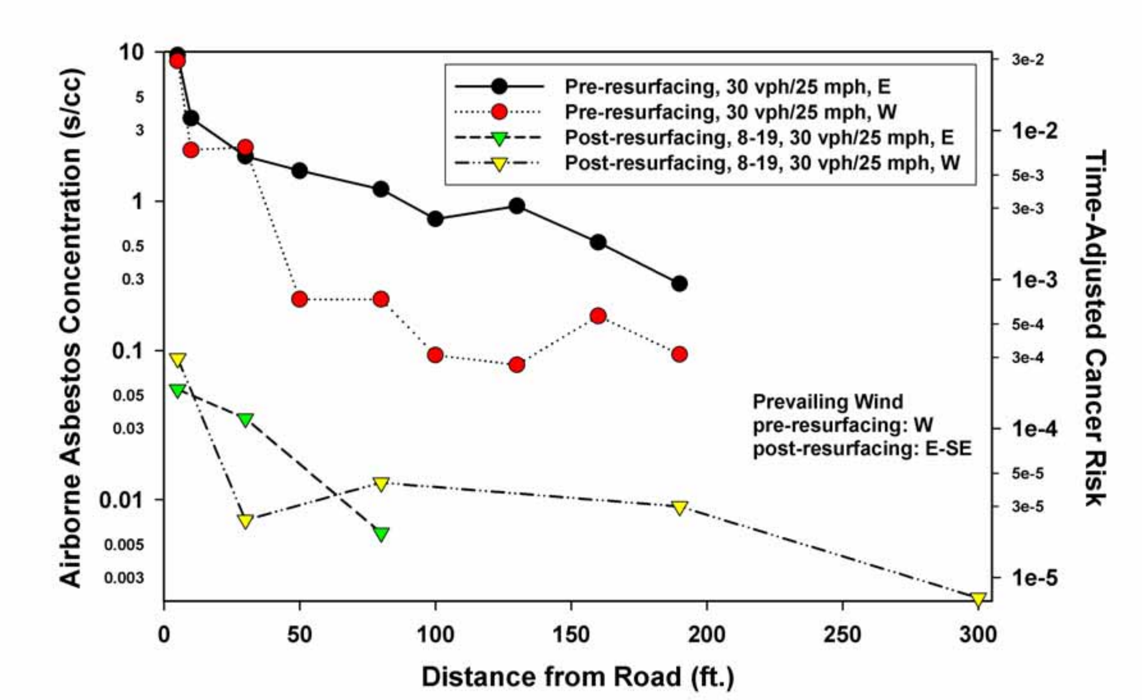
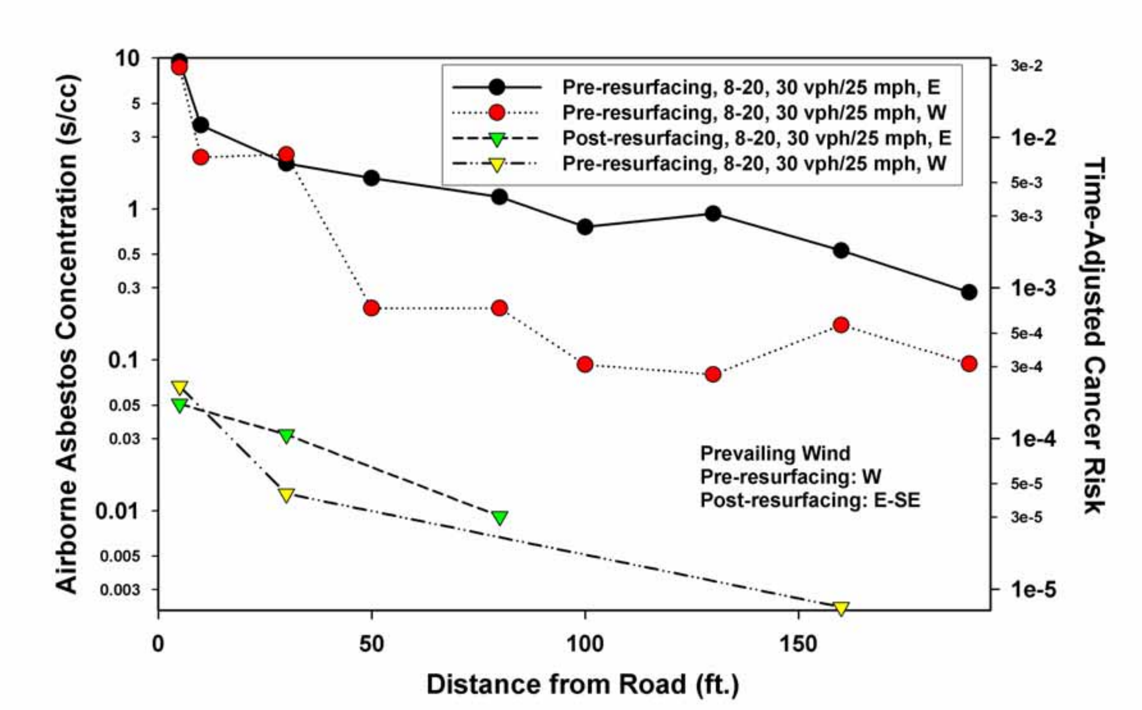


Figure 5: Pre-resurfacing and post-resurfacing (August 20th) airborne asbestos concentrations versus sampling distance from Slodusty Road and the associated cancer risk: 30 vph/25 mph vehicle scenario.



and sampling distance from the road. The time-adjusted cancer risks associated with the post-resurfacing August 19th and 20th 30 vph, 25 mph scenario were approximately 1-3 orders of magnitude less than those of the corresponding pre-resurfacing 30 vph, 25 mph scenario, depending on wind direction and sampling distance from the road.

As with the pre-resurfacing asbestos airborne concentrations and corresponding cancer risks, it should be noted that the cancer risk estimates described above are population risk estimates, based on a 70-year lifetime exposure for 16 hours/day. The excess cancer risk to populations exposed to the airborne asbestos concentrations observed in the study for less than 70 years or 16 hours/day may be less than the risks described above. Corresponding population cancer risks assuming a 30 year exposure were 2.3×10^{-6} to 6.4×10^{-5} and 3.1×10^{-6} to 1.3×10^{-4} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 6.8×10^{-7} to 1.9×10^{-5} and 9.4×10^{-7} to 3.8×10^{-5} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively.

Conclusions

The airborne asbestos concentration data obtained from the Slodusty Road study indicated that asbestos air concentrations decreased with increasing distance from the roadside, and in the upwind direction as compared with the downwind direction. However, airborne asbestos was still detectable by the air monitor farthest from the road in both the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios (190 and 130 feet, respectively; measured concentrations were 2.5×10^{2} - 3.0×10^{4} fibers/m^3 and 2.9×10^{1} - 3.1×10^{3} fibers/m^3, respectively), and time-adjusted airborne asbestos cancer risks using those two scenarios and assuming resident exposures occur 16 hours/day to the measured concentrations ranged from 2.7×10^{-4} to 3.2×10^{-2} and 3.1×10^{-5} to 3.3×10^{-3}, respectively. Corresponding population cancer risks assuming a 30 year exposure were 1.1×10^{-4} to 1.4×10^{-2} and 1.3×10^{-5} to 1.4×10^{-3} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 3.4×10^{-5} to 4.1×10^{-3} and 4.0×10^{-6} to 4.2×10^{-4} for the 30 vph, 25 mph and the 10 vph, 10 mph test scenarios, respectively.

Airborne asbestos concentrations were resampled after the road was resurfaced to remove serpentine aggregate as a potential asbestos source. Time-adjusted airborne asbestos cancer risks using the 10 vph, 10 mph scenario on August 19th and August 20th ranged from 5.3×10^{-6} to 1.5×10^{-4}. Time-adjusted airborne asbestos cancer risks using the 30 vph, 25 mph scenario on August 19th and August 20th ranged from 1.3×10^{-5} to 2.9×10^{-4}. The time-adjusted cancer risks associated with the post-resurfacing August 19th and 20th 10 vph, 10 mph scenario were approximately 1-2 orders of magnitude less than those of the corresponding pre-resurfacing 10 vph, 10 mph scenario, depending on wind direction and sampling distance from the road. The time-adjusted cancer risks associated with the post-resurfacing August 19th and 20th 30 vph, 25 mph scenario were approximately 1-3 orders of magnitude less than those of the corresponding pre-resurfacing 30 vph, 25 mph scenario, depending on wind direction and sampling distance from the road. Corresponding population cancer risks assuming a 30 year exposure were 2.3×10^{-6} to 6.4×10^{-5} and 3.1×10^{-6} to 1.3×10^{-4} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively. Corresponding population cancer risks assuming a 9 year exposure were 6.8×10^{-7} to 1.9×10^{-5} and 9.4×10^{-7} to 3.8×10^{-5} for the 10 vph, 10 mph and the 30 vph, 25 mph test scenarios, respectively. As noted above, these risk estimates likely have substantial uncertainty associated with exposure estimates.

References

U.S. National Weather Service (2000). Climate of Sacramento, California. Internet version.