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Project Summary

Airborne Asbestos Concentrations Three Years After Abatement in Seventeen Schools

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From 1988 through 1991, the U.S. Environmental Protection Agency's (EPA) Risk Reduction Engineering Laboratory (RREL) and the New Jersey Department of Health's (NJDOH) Environmental Health Service (EHS) conducted air monitoring in 17 schools in New Jersey to determine the effectiveness of their asbestos control programs. In 1988, a study was conducted to document Asbestos Hazard Emergency Response Act final clearance concentrations of asbestos at these 17 schools. The findings of this study prompted a followup study in 1990 to determine the airborne asbestos concentrations 2 yr after the abatement efforts in these schools. Although the data from the 1990 study provided information regarding airborne asbestos levels during simulated occupancy conditions 2 yr after abatement, whether these data were representative of levels during actual occupancy was equivocal. Another followup study was conducted in May 1991 to determine the airborne asbestos concentrations in these 17 schools during actual occupied conditions. Eight of the sites showed airborne asbestos levels above the AHERA criteria of 70 s/mm^2. Reentrainment of residual asbestos-containing debris from the 1988 abatement or operations and maintenance (O&M) activities may have contributed to the elevated airborne asbestos concentrations measured during the May 1991 study.

This Project Summary was developed by EPA's Risk Reduction Engineering Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project report ordering information at back).

Introduction

The ultimate goal of every asbestos abatement project is to eliminate or reduce, to the extent possible, the actual or potential hazard presented by airborne asbestos structures. From 1988 through 1991, the EPA's RREL and NJDOH's EHS conducted a series of studies to determine the effectiveness of asbestos control programs in 17 schools in New Jersey.

The 1988 study documented Asbestos Hazard Emergency Response Act (AHERA) clearance air-sampling practices and final clearance concentrations of airborne asbestos at 20 abatement projects in 17 New Jersey schools. The results of the study prompted a followup study in 1990 (Phase II) to determine the airborne asbestos concentrations in these 17 schools 2 yr after abatement. Although the data from the 1990 study provided information regarding airborne asbestos levels under simulated occupancy conditions, whether the data were representative of conditions during actual occupancy remained equivocal.

Therefore, an additional followup study was conducted in May 1991 (Phase III) to determine the airborne asbestos levels during actual occupied conditions 3 yr after abatement in these same schools. The 17 schools were not a statistical random sample; their selection was based largely on availability. Furthermore, because the

17 schools were likely to differ in their abatement history and status with respect to the presence of asbestos-containing material, a site-by-site evaluation was performed. No consideration was given to combining data across all sites to reach a general conclusion.

Objectives

The objectives of the Phase III study were: (1) to determine the airborne asbestos levels measured under occupied conditions in 17 schools that underwent abatement in 1988, (2) to determine whether the airborne asbestos levels measured under occupied conditions in 1991 were significantly different from those measured outdoors, (3) to determine whether the airborne asbestos concentrations measured in 1991 were significantly different from the AHERA clearance concentrations measured in 1988, and (4) to determine whether the airborne asbestos concentrations measured under occupied conditions in 1991 were significantly different from those measured under simulated occupancy conditions in 1990.

Study Sites

The study summarized here was conducted at the same 17 schools involved in the 1988 EPA-RREL/NJDOH-EHS study, which documented AHERA air monitoring practices and final clearance concentrations of airborne asbestos, and in the 1990 EPA-RREL/NJDOH-EHS study, which measured airborne asbestos concentrations 2 yr after abatement.

The 17 schools involved 20 abatement sites. Access to each school was coordinated directly by NJDOH-EHS. Area airborne asbestos concentrations were measured at each site in the same three areas as in the previous studies: (1) the previously abated area, (2) the perimeter area (outside the abated area but inside the building), and (3) outdoors. The actual abatement and perimeter areas could not be separated because the containment barriers present during the 1988 abatement had been removed. Also recognized was the fact that, in the interim since 1988, other sources (e.g., routine maintenance of asbestos-containing resilient floor tile or other O&M activities) may have contributed to the current concentrations of airborne asbestos.

Air Sampling Strategy

Phase III - May 1991

At each site, five area air samples and three quality assurance samples (one closed and two open field blanks) were collected at approximately the same locations as those collected during the 1988 and 1990 studies. The samples were collected during school hours, 8:00 am to 3:00 pm. Because certain sampling situations (e.g., inside a classroom) could not tolerate noise from an electrically powered sampling pump, the pumps were placed in special acoustical cases designed to attenuate the noise of the sampling pump to a sound pressure level of <40 dB (RE 20 N/m^2) at a distance of 3 ft. A noise level of 40 dB is rated as "quiet" for private offices and conference rooms.

Phase III Followup - Summer 1991

Followup air sampling in the previously abated work area and in the perimeter area was conducted during unoccupied conditions in accordance with a modified aggressive sampling protocol designed to simulate normal building activity. The protocol involved sweeping only the floors with the exhaust of a 1-hp leaf blower at a rate of 5 min/1,000 ft^2 of floor space. One stationary fan (18-in. diameter, axial flow) per 10,000 ft^3 was positioned with the air directed toward the ceiling to maintain air movement during sampling.

Phase IIIa - Early August 1991

Followup air monitoring was conducted in August 1991 at 10 of the 20 sites (Sites B, D-H, K, M ,N, and Q). Sites B, D-G, K, and M were selected because the average airborne asbestos concentration in the previously abated area and/or perimeter area exceeded 0.02 asbestos structure per cubic centimeter (s/cm^3). Sites N and Q were also monitored because these sites were in the same schools as sites K and B, respectively, which had levels exceeding 0.02 s/cm^3. Site H was monitored because replicate analyses of selected samples at this site showed average asbestos levels above 0.02 s/cm^3. This value (0.02 s/cm^3) is derived from the AHERA 40 CFR 763 initial screening criteria of 70 s/mm^2. At each of the 10 sites, 5 area air samples and 3 quality assurance samples were collected in the same three areas as the samples collected during occupied conditions in May 1991.

Phase IIIb - Late August 1991

Based on the results of the Phase IIIa monitoring, four schools (Sites F, G, H, and M) were required to conduct response actions (i.e., cleaning) in the previously abated area and/or perimeter area to reduce residual airborne asbestos contamination. After these response actions, additional area air samples were collected. At each of the four schools, five area air samples and three quality assurance samples were collected in the same areas as were the Phase III and Phase IIIa samples (no outdoor samples were collected at Site M).

Phase IIIc - September 1991

Airborne asbestos concentrations at Site M were still elevated after the Phase IIIb monitoring. Therefore, the previously abated area and the perimeter area response actions were again conducted, and five additional samples and one closed and two open field blanks were collected in these areas.

Site Documentation

For each of the 17 schools monitored in May 1991, the NJDOH-EHS documented the history of the abatement activities between 1988 and 1991 and the O&M activities on any remaining asbestos-containing building material (ACBM) in the previously abated area and perimeter area. This information was obtained from abatement notices required under the New Jersey Administrative Codes (N.J.A.C. 8:60-7 and N.J.A.C. 12:120-7), AHERA Asbestos Management Plans, and information provided by the designated person and/or school officials who were interviewed.

NJDOH Visual Inspection

After conducting the followup air monitoring at the eight schools, which involved 10 sites, in August 1991 (Phase IIIa), a certified AHERA building inspector from NJDOH-EHS visually inspected each of these schools. Before conducting the inspection, the inspector reviewed each school's Asbestos Management Plan. The review included (1) recording the material category (e.g., thermal system insulation), amount of material (e.g., linear feet), and condition of material (e.g., damaged thermal system insulation) for the ACBM remaining in the previously abated area and perimeter area; (2) recording completed response actions (including O&M); and (3) recording any renovations that had occurred.

Sampling Methods

Fixed-Station Area Air Samples

Air samples were collected on open-face, 25-mm-diameter, 0.45-µm-pore-size, mixed cellulose ester (MCE) membrane filters with a 5-µm-pore-size, MCE, backup diffusing filter and cellulose support pad contained in a three-piece cassette. The filter cassettes were positioned approximately 5 ft above the floor on tripods, with the filter face at approximately a 45-degree angle toward the floor. The filter assembly was attached to a 1/6-hp electrically powered vacuum pump operating at

a flow rate of approximately 9 L/min. Air volumes ranged from 943 to 2536 L. At the end of the sampling period, the filters were turned upright before being disconnected from the vacuum pump; they were then stored in this position. The sampling pumps were calibrated with a calibrated precision rotameter both immediately before and after sampling.

Bulk Samples

Bulk samples of suspect ACBM (e.g., thermal system insulation, fireproofing, and resilient floor tile) or debris were collected by the NJDOH inspector for laboratory analysis to determine the asbestos content. The samples were collected by either a standard coring tool or the collection of debris. Both types of samples were placed in labeled containers.

Analytical Methods

Air Samples

The MCE filters were prepared and analyzed in accordance with the nonmandatory transmission electron microscopy (TEM) method, as described in the AHERA final rule (40 CFR 763). A sufficient number of grid openings were analyzed for each sample to ensure a sensitivity (the concentration represented by a single structure) of no greater than 0.005 s/cm^3 of air sampled. In addition to the requirements of the nonmandatory TEM method, the specific length and width of each structure were measured and recorded. The samples were prepared and analyzed by EPA's TEM laboratory in Cincinnati, OH.

Bulk Samples

The type and percentage of asbestos in the bulk samples were determined by polarized light microscopy and X-ray diffraction. The samples were prepared and analyzed in accordance with the "Interim Method for Determination of Asbestos in Bulk Insulation Samples" (EPA 600/M4-82-020). The samples were prepared and analyzed by the NJDOH's Public Health and Environmental Laboratories in Trenton, NJ.

Statistical Methods

Airborne asbestos concentrations measured in each of the three sampling locations were characterized by the use of descriptive statistics. Because the 20 sites were likely to differ in their abatement history and status with respect to the presence of asbestos-containing material, each site was considered separately. The descriptive statistics included the arithmetic mean, minimum and maximum concentrations, and sample size.

A single-factor analysis of variance (ANOVA) was used to examine differences between concentrations measured in the previously abated work area, perimeter area, and outdoors for each site. A single-factor ANOVA analysis was also used to compare airborne asbestos concentrations measured in 1988, 1990, and 1991 for each sampling location. All statistical comparisons were performed at the 0.05 level of significance.

Quality Assurance

Specific quality assurance procedures outlined in the AHERA rule were used to ensure the precision of the collection and analysis of air samples, including filter lot blanks, open and closed field blanks, and repeated sample analyses.

Site Descriptions

Post-1988 abatement occurred at 1 of the 20 sites (Site O) in the previously abated area and at 4 of the 20 sites (Sites A, D, L, and N) in the perimeter area. At 15 sites, ACBM is still present in the previously abated areas; at all of the sites, ACBM is still present in the perimeter areas.

Airborne Asbestos Levels During Occupied Conditions In May 1991

Table 1 presents the mean, minimum, and maximum airborne asbestos concentrations measured at each of the 20 sites in the 17 schools. Figure 1 illustrates the average airborne asbestos concentrations in the previously abated and perimeter areas. Eight of the 20 sites showed levels above the AHERA initial screening criterion of 70 s/mm^2 (40 CFR 763) and above 0.02 s/cm^3 (NJDOH clearance criterion).

Comparison of Previously Abated Area With Outdoors

At 6 of the 20 sites (Sites B, E, F, G, K, and Q), mean airborne asbestos concentrations in the previously abated area were significantly higher than were those outdoors. Mean concentrations in the previously abated area were at least one order of magnitude (i.e., 10 times) greater than were the mean concentrations outdoors. At all of the other 14 sites, the difference between mean levels in the previously abated areas and outdoors was not statistically significant.

Comparison of Perimeter Area With Outdoors

At 4 of the 20 sites (Sites B, F, N, and Q), mean airborne asbestos concentrations in the perimeter area were significantly higher (at least one order of magnitude) than were those outdoors. At the remaining 16 sites, the difference between mean levels in the perimeter areas and the outdoors was not statistically significant.

Comparison of Previously Abated Area With the Perimeter Area

At 3 of the 20 sites (Sites E, G, and K), mean airborne asbestos concentrations in the previously abated area were significantly greater than were those in the perimeter area. Mean concentrations in the previously abated area were approximately 4 times greater than were those in the perimeter area at Site E, approximately 5 times greater at Site G, and approximately 14 times greater at Site K. At all of the other 17 sites, the difference between mean concentrations in the previously abated area and the perimeter areas was not statistically significant.

Overall Structure Morphology and Length Distributions

The TEM analysis of 100 samples collected during occupied conditions in the previously abated area, 94 samples collected in the perimeter area, and 85 samples collected outdoors yielded a total of 601 asbestos structures, 99.7% of which were chrysotile asbestos and 0.3% were amphibole. Overall, the asbestos structures were primarily fibers (66%), and to a lesser extent, matrices, bundles, and clusters.

Overall, 1.5% of the measured asbestos structures were greater than 5 μm in length; most of the structures (92%) were less than 2 μm in length.

Phase III Follow-up Air Monitoring–August 1991

Followup air monitoring was conducted by EPA-RREL/NJDOH-EHS in August 1991 at 10 of the 20 sites (B, D-H, K, M, N, and Q). These sampling results indicate that four sites (F, G, H, and M) showed average levels exceeding 0.02 s/cm^3 in both the previously abated area and the perimeter areas. Based on the results at these four sites, NJDOH-EHS required response action at each of the four schools. Three of the four schools employed licensed asbestos-abatement contractors and one used in-house, trained staff to conduct response actions to reduce the levels of airborne asbestos.

After the response actions at these four schools, EPA-RREL/NJDOH-EHS conducted followup air monitoring to determine the residual levels of airborne asbestos. Based on these sampling results, NJDOH-EHS determined that further ac-

Table 1. *Airborne Asbestos Concentrations* Measured During Periods of Occupancy at Seventeen Schools in May 1991*

	Previously abated area			Perimeter area			Outdoors		
Site	Mean	Minimum	Maximum	Mean	Minimum	Maximum	Mean	Minimum	Maximum
A	0.001	0	0.003	0.003	0	0.008	0.003	0	0.005
B	0.027	0.01	0.055	0.012	0 004	0.024	0.001	0	0.004
C	0.005	0	0.012	0.001	0	0.003	0.003	0	0.007
D	0.020	0.003	0.059	0.004	0	0.009	0.004	0	0.012
E	0.037	0.011	0.069	0.010	0	0.029	0.003	0	0.007
F	0.043	0.032	0.066	0.036	0.010	0.058	0.001	0	0.002
G	0.027	0.011	0.037	0.005	0	0.011	0.001	0	0.004
H	0.004	0	0.014	0.005	0	0.011	0.003	0	0.006
I	0.004	0	0.007	0.005	0	0.011	0.005	0	0.020
J	0.003	0	0.011	0	0	0	0.001	0	0.004
K	0.041	0.014	0.097	0.003	0	0.007	0	0	0
L	0.006	0	0.016	0.003	0	0.006	0	0	0
M†	0.023	0	0.056	0.004	0	0.007	0.003	0	0.007
N‡	0.004	0.003	0.009	0.015§	0	0.046	0	0	0
O	0.005	0	0.022	0	0	0	0.001	0	0.003
P	0.004	0	o.011	0.001	0	0.004	0	0	0
Q¨	0.009	C	0.018	0.012	0.004	0.024	0.001	0	0.004
R	0.005	0	0.010	0.001	0	0.004	0.004	0	0.012
S	0.001	0	0.004	0.003	0	0.011	0.001	0	0.004
T	0.001	0	0.007	0.001	0	0.004	0	0	0

* *Asbestos concentration, s/cm³ (N=5)*
† *Outdoor samples are the same as those collected at Site C (i.e., Site M was the second abatement project at this site).*
‡ *Outdoor samples are the same as those collected at Site K (i.e., Site M was the second abatement project at this site).*
§ *N=4.*
¨ *Perimeter and outdoor samples are the same as those collected at Site B (i.e., Site Q was the second abatement project at this school).*

tion was required at Site M. Further response actions were performed at this school, and NJDOH-EHS collected additional samples. The final results showed an average concentration of 0.005 s/cm³ in the previously abated area and 0 s/cm³ in the perimeter area; therefore, no further action was required at this school.

NJDOH Visual Inspections

Asbestos-containing debris (including fireproofing, thermal system insulation, ceiling tile, and plaster dust) was present at all of the 10 sites. The sources of the debris were the 1988 abatement, abatements that occurred after 1988, and/or O&M activities.

Six sites (B, E, F, K, H, and Q) contained at least one ACBM not identified in the original AHERA inspection; i.e., the original AHERA inspection did not record the presence of this material in the Management Plan for the school. The previously unidentified materials included ventilation duct insulation and TSI. (These data were provided to the school officials, and the schools have reportedly corrected their Management Plans accordingly.)

At one site (Site F), the Management Plan was in error regarding the identification and location of asbestos-containing material (ACM). The Management Plan indicated the presence of spray-on materials. No spray-on materials were present; however, TSI was found. (These data were provided to the school officials, and the school has reportedly corrected its Management Plan accordingly.)

Post-Abatement (1988) versus Simulated Occupancy (1990)

Previously Abated Area

On average, concentrations measured during simulated occupancy (1990) in the previously abated area were significantly less than were the post-abatement concentrations (1988) at 11 of the 20 sites (Sites C, D, F, H, J-N, Q, and T). At the remaining nine sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured during simulated occupancy (1990) in the perimeter area were significantly less than were the post-abatement concentrations (1988) at 5 of the 20 sites (Sites D, H, L, P, and T). At only one of the sites was the mean concentration significantly greater during simulated occupancy than during post abatement (Site R). At the remaining 14 sites, no significant differences were noted.

Outdoors

On average, concentrations measured outdoors in 1990 were significantly less than were concentrations measured in 1988 at 2 of the 20 sites (Sites D and N). At only one site was the mean outdoor concentration greater in 1990 than in 1988 (Site R). At the remaining 17 sites, no significant differences were noted.

Post-Abatement (1988) versus Occupied Conditions (1991)

Previously Abated Area

On average, concentrations measured in the previously abated area during occupied conditions (1991) were significantly less than were the post-abatement concentrations (1988) at 8 of the 20 sites (Sites C, D, H, L-N, Q, and T). At two sites (Sites E and G), mean concentrations of airborne asbestos were significantly higher in the previously abated area during occupied conditions in 1991 than they were post-abatement in 1988. At the remaining 10 sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured in the perimeter area during occupied conditions (1991) were significantly less than were the post-abatement concentrations (1988) at 5 of the 20 sites (Sites D, H, L, P, and T). At only one of the sites (Site F) was the mean concentration significantly greater during occupied conditions than they were post abatement in 1988. At the remaining 14 sites, no significant differences were noted.

Outdoors

On average, concentrations measured outdoors in 1991 were significantly less than were concentrations measured in 1988 at 2 of the 20 sites (Sites D and N). The mean outdoor concentration was greater in 1991 than in 1988 at two sites (Sites A and E). At the remaining 16 sites, no significant differences were noted.

Simulated Occupancy (1990) versus Occupied Conditions (1991)

Previously Abated Area

On average, concentrations measured in the previously abated area during occupied conditions (1991) were significantly greater than were those measured during simulated occupancy (1990) at 7 of the 20 sites (Sites D-G, K, M, and R). At the remaining 13 sites, no significant differences were noted.

Perimeter Area

On average, concentrations measured during occupied conditions (1991) were significantly greater than were those measured in the perimeter area during simulated occupancy (1990) at only 1 of the 20 sites (Site F). Conversely, on average, Site R showed significantly greater concentrations during simulated occupancy than during actual occupied conditions. At the remaining 12 sites, no significant differences were noted.

Outdoors

Mean outdoor concentrations of airborne asbestos measured in 1991 were significantly greater than were concentrations measured in 1990 at 2 of the 20 sites (Sites A and E). At the remaining 16 sites, no significant differences were noted.

Conclusions

Seven of the 20 sites (5 of the 17 schools) sampled under occupied conditions in 1991 showed significantly higher airborne asbestos concentrations in the previously abated area and/or the perimeter area than did those existing outdoors. Differences in mean concentrations between those measured inside the schools and those existing outdoors were not statistically significant at the other 13 sites.

Eight of the 20 sites showed average airborne asbestos concentrations above the AHERA initial screening criterion of 70 s/mm^2. Visual inspections conducted by the NJDOH indicated that reentrainment of residual asbestos-containing debris from the 1988 abatement or from O&M activities may have contributed to the elevated asbestos concentrations measured in these schools.

At the 10 sites where followup air monitoring was conducted in 1991, visual inspections conducted by the NJDOH-EHS showed that 6 sites had at least one ACM that was not identified in the Asbestos Management Plan. At one of these six sites, the Asbestos Management Plan was in error regarding the identification, location, and condition of ACM.

Three of the 20 sites showed significantly higher airborne asbestos concentrations in the previously abated area and/or the perimeter area in 1991 than did those measured in 1988. Conversely, 9 of the 20 sites showed significantly lower airborne asbestos concentrations in the previously abated area and/or perimeter areas in 1991 than those measured in 1988. Differences between mean concentrations measured in 1988 and 1991 at the other eight sites were not statistically significant.

The mean airborne asbestos concentrations measured in the previously abated area and/or the perimeter area at 7 of the 20 sites during occupied conditions in 1991 were significantly greater than were those measured under simulated occupancy conditions in 1990. Conversely, one site showed significantly lower concentrations during occupied conditions than during simulated occupancy. Differences in mean concentrations measured in 1990 and 1991 at the other 12 sites were not statistically significant.

Recommendations

Followup air monitoring should be conducted at these schools to determine if elevated post-abatement airborne concentrations of asbestos is continuing. The followup air monitoring should be coupled with detailed visual inspections to determine the sources of the asbestos and to identify appropriate remedial measures. The results of the followup study will provide information regarding the long-term effectiveness of asbestos control programs. This information may assist EPA in evaluating the need for issuance of guidance on asbestos management practices.

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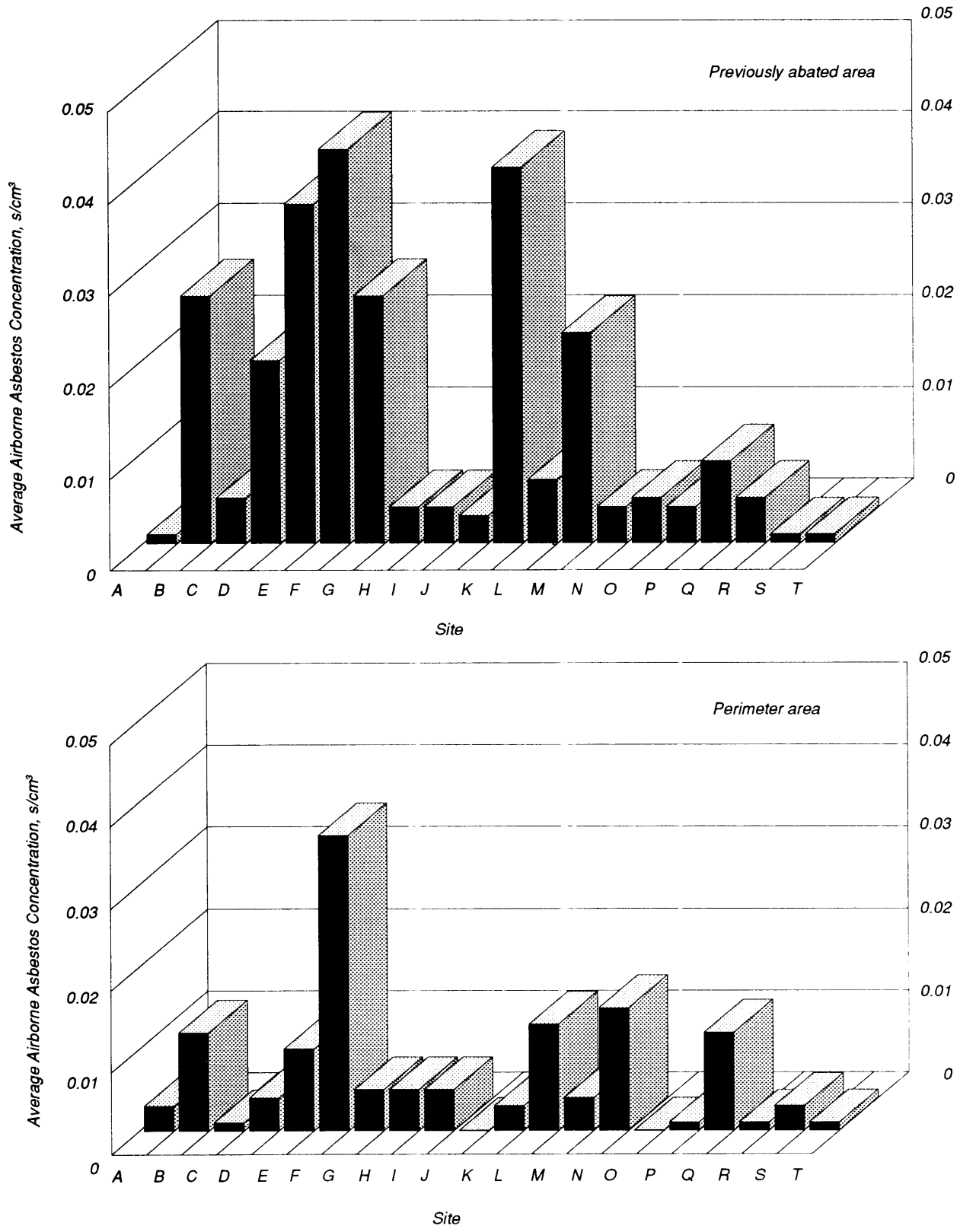

Figure 1. *Average airborne asbestos concentrations (s/cm3) in the previously abated area (top) and perimeter area (bottom) measured during occupied conditions in May 1991.*

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The complete report, entitled "Airborne Asbestos Concentrations Three Years After Abatement in Seventeen Schools," (Order No. PB93-218501AS; Cost: $27.00, subject to change) will be available only from:

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