CALIFORNIA PORTABLE CLASSROOMS STUDY
PROJECT EXECUTIVE SUMMARY

FINAL REPORT, VOLUME III
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PREPARED BY:

RTI International
3040 Cornwallis Road
Research Triangle Park, NC 27709

California Air Resources Board
Research Division
1001 I Street
Sacramento, CA 95814

and

California Department of Health Services
Environmental Health Laboratory
Indoor Air Quality Section
2151 Berkeley Way
Berkeley, CA 94704

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Background

The California Portable Classrooms Study (PCS) was conducted to address concerns raised regarding environmental conditions in California's portable classrooms. The objective of the study was to examine environmental health conditions, especially those related to indoor air quality and health risks, in K-12 portable classrooms in California. These environmental conditions included levels of airborne chemicals; the presence of potential pollutant sources; the performance of heating, ventilating, and air-conditioning systems; factors such as light, noise, temperature, and relative humidity; the presence of mold and other biological contaminants; and pollutant and allergen levels in floor dust.

Concerns over indoor environmental quality in California's schools have been raised by scientists, government agencies, school administrators, and environmental health groups, as the demand for classrooms resulted in increased reliance on portable classrooms. Population growth, class-size reduction programs, and fiscal limitations have driven this increase. Schools have primarily met the increased demand for classrooms by using portable classrooms because, relative to traditional classrooms, they are more economical and can be obtained more quickly. Additionally, until 1998 new schools were required to be designed to include 30% portable classrooms.

A mail survey to all school districts conducted by DHS in Fall, 2000, indicated that 85 percent of K-12 public schools had at least one portable classroom at that time, and that about 80,000 portable classrooms were in use statewide, totaling about one-third of all California classrooms. These portable classrooms ranged in age from less than one year old to over 40 years old.

Problems previously reported in portable classrooms included elevated levels of formaldehyde and some other VOCs, microbial growth, odors, uncomfortable temperatures, excessive noise, and excessive use of pesticides. Such problems were attributed to the use of pollutant-emitting materials, products, or equipment in or near buildings; inadequate or deferred maintenance; and poorly designed and noisy HVAC systems. Outdoor factors such as improper water drainage under the units and proximity to busy roadways used by diesel-fueled vehicles also were of concern.

Some of the contaminants and conditions found in classrooms are known to trigger allergy symptoms and asthma attacks in sensitive individuals; irritate mucous membranes in the eyes, nose and throat; cause respiratory infections or headaches; and contribute to the development of cancer. Some contaminants identified in problem classrooms have been listed as Toxic Air Contaminants by the ARB, or are known or suspected carcinogens or reproductive toxicants.

In light of the concerns raised, the California Air Resources Board (ARB) and Department of Health Services (DHS) requested funding in the 2000-2001 State budget to jointly conduct a comprehensive study of the environmental health conditions in portable classrooms. The State Legislature approved the request, and specified milestones and requirements in Assembly Bill 2872, Shelley (California Health and Safety Code [HSC] Section 39619.6). The Legislature also required that ARB and DHS develop recommendations regarding ways to "…remedy and prevent unhealthful conditions found in portable classrooms…" (AB 2872). The study was endorsed by the Superintendent of Public Instruction, Ms. Delaine Eastin.

The PCS consists of two major phases, conducted in sequence. Phase I was a mailed survey in which questionnaires and passive formaldehyde monitors were sent to a randomly selected sample of all public schools with at least one portable classroom in the spring of 2001. Phase II was a field study with a wide array of environmental measurements obtained in 201 classrooms at 67 schools statewide, from October 2001 through February 2002. Both portable and traditional classrooms were studied in both phases.

Results from this study will be used by ARB, DHS, and other stakeholders to assess the potential for adverse health impacts from environmental conditions and toxic pollutants that may be present in portable classrooms, as well as conditions considered to be outside the normal limits of comfort. They will be used to help identify sources and factors that may lead to unacceptable conditions, and provide direction for actions that can be taken to remedy or prevent any unhealthful conditions found.

This project summary provides a brief overview of the methods, results, conclusions, and recommendations documented in the two separate reports for Phase I and Phase II of the California Portable Classrooms Study.

Methods

The sampling approach for this study was designed to provide approximately equal probabilities of selection for all public schools in California with at least one portable classroom in spring 2001. The sample was drawn using the California Public School Directory 2000, which was published by the California Department of Education Press. DHS staff sorted this frame by county/district/school code and selected a 1-in-7 systematic sample from the sorted frame. The result was a sample of 1,216 schools that was stratified by county and district. DHS then conducted a preliminary survey of the resulting school districts and eliminated 177 schools that did not have any portable classrooms. These schools were deleted from further consideration for the PCS, leaving 1,039 eligible schools for inclusion in Phase I.

Two questionnaires, a Facilities Questionnaire (FQ) and a Teacher Questionnaire (TQ), were collaboratively created by ARB and DHS. These questionnaires included questions based in part on input from public, industry, and government agencies obtained during public workshops held across the state. The questionnaires were used during both phases of the study to obtain information from facility managers and teachers about the environmental quality conditions and complaints at the sampled schools. The FQ provided school-level and classrooms-level information on the physical conditions, operation, and maintenance of building facilities. The TQ provided classroom-level information, including information on the presence of potential pollutant sources.

The Phase I study was conducted in the spring of 2001 with data receipt continuing to a limited extent through the summer of 2001. Facility managers provided school-level data (n = 384) and classroom-level data (n=1,133), via the FQ. A total of 1,181 teachers provided additional classroom level data via the TQ. The classroom data were collected for three classrooms—usually two portable classrooms and one traditional classroom—at each school. Additionally, for a sub-sample of the classrooms, passive formaldehyde samplers (small glass tubes) were mailed along with the survey materials for deployment in the classrooms. They were placed in the classrooms, generally for 7-10 days to collect indoor air samples that were analyzed to determine formaldehyde concentrations. Valid indoor air formaldehyde concentration data were obtained for 911 classrooms (644 portable and 267 traditional) from 320 schools. Prior to mailing the samplers, ARB conducted tests to confirm the utility of the samplers for this study. Working with the manufacturer, ARB developed approaches that improved the sensitivity and precision of the samplers, which had been used in previous mail surveys by DHS (Sexton et al., 1989; Liu et al., 1991). Analysis of the laboratory blanks resulted in an estimated detection limit of 6 parts per billion (ppb) for the Phase I study. Analysis of the duplicate samples verified that precision was good (10% to 15% median RSD).

Phase II was a monitoring field study of environmental conditions in a smaller probability sample selected from all schools with at least one portable classroom both in the spring of 2001 and in the 2001-02 school year. Of 81 eligible schools in the Phase II sample, both questionnaire and environmental monitoring data were obtained for 67 schools and 201 classrooms. Of the 67 schools, fourteen schools were specially selected into the Phase II sample based on their Phase I results (high complaints of environmental problems or high formaldehyde levels), to help determine whether classrooms with apparent or reported problems actually had serious environmental problems. The Phase II study was conducted from October 2001 through February 2002. It utilized a probability-based sample of California public schools (and random selection of classrooms within the schools) having one or more portable classrooms. The sample of schools selected for the Phase II survey is statistically representative of all California public schools that had portable classrooms in both the spring and fall of 2001.

In the Phase II study, both school-level and classroom-level data were obtained. Consistent with the Phase I approach, classroom data were collected for three classrooms per school, usually two portable classrooms and one traditional classroom. Field technicians inspected the HVAC system and building interiors and exteriors. Various types of data were collected at each participating school including:

- Questionnaire and checklist data: (1) Facilities Questionnaire II, (2) Consultation with Facilities and HVAC Managers (Part 2); (3) Teacher Questionnaire II; (4) Classroom Form; (5) Consultation with Facilities and HVAC Managers (Part 1); and (6) an HVAC Assessment Checklist and School Characteristics data form.

- Environmental and biological measurements**:** Sampling in occupied classrooms was conducted during one school day at each school, with samplers set up in the morning prior to arrival of students, and removed at the end of the day. HVAC testing, noise measurements, and sampling for culturable airborne organisms were conducted during lunch breaks (see

Table PES-1). Environmental samples were stored on ice and shipped weekly by overnight delivery.

- Field QC samples: Field QC checks were performed before and after sampling. Field blanks and controls were each collected at a 5% rate. Field duplicates were collected for indoor air pollen and spores, aldehydes, VOCs, and dust. Precision (measured as % RSD--relative standard deviation) averaged 10% or less across the sample types.

Table PES-1. Summary of Phase II Environmental and Biological Samples

Sample	Classroom Air	Outdoor Air	Floor Dust	Comments
Airborne				
Carbonyls	X	X		13 Aldehydes, including formaldehyde
VOCs*	X	X		9 VOCs, including benzene, toluene, xylenes, chlorinated hydrocarbons
Pollens & Spores	X	X		22 pollen and fungi species possible
Culturable microorganisms	X	X		Specially selected schools only
Particle counts	X	X		2 cut points: <2.5 and <10 :m
Floor Dust				
Pesticides			X	20 studied
Metals			X	18 including Lead
PAHs			X	16 studied
Allergens			X	5 (cat, dog, 2 dust mite, cockroach)
Environmental				
CO_2	X	X		continuous
Temperature Rel. Humidity	X	X		continuous
Noise	X	X		Unoccupied classroom measurements
Light	X			3 locations in room
Moisture	X			Walls, floor, and ceiling

*Half the schools were selected for VOC monitoring.

Results

The estimated number of K-12 public classrooms in California in the 2000-2001 school year was about 268,000, and about one-third of those (80,000) were portable classrooms based on the DHS preliminary survey. The target population of K-12 public schools with one or more portable classroom was estimated to consist of 230,000 classrooms, 37% of which are estimated to be portable classrooms.

To fulfill the objectives of the study, questionnaire responses, observations, and measurements of indoor pollutant levels, ventilation conditions, noise and lighting levels were characterized, and comparisons to environmental standards and guidelines, and comparisons between portable and traditional classrooms were made. Also, associations between indoor environmental conditions and building factors such as age, building material types and ventilation factors were explored.

Response Rates

Phase I

There were 1,181 completed Teacher Questionnaires from the 2856 mailed, and 384 completed Facilities Questionnaires from the 952 sampled schools. Valid indoor air formaldehyde concentration data were obtained for 911 classrooms. Response rates between 40 and 45% (for questionnaires and formaldehyde monitoring) were obtained for school-level responses. However, for schools that responded, response rates of about 95% were obtained at the classroom level for the teacher questionnaires and for school deployment of the formaldehyde samplers, suggesting a strong interest by the participating schools. The overall response rates of 40-45% are considered good for mail surveys.

Phase II

Questionnaire data and environmental monitoring data were successfully collected in 67 of 81 sample schools, resulting in an overall weighted school-level response rate of 83%. Such a response rate for school-level participation in Phase II of this study is quite good and limits the possibility for nonresponse bias to seriously affect the results. The Phase II response was successful because of additional steps taken to achieve good participation: recruitment began early in the school year, permission was obtained from superintendents before contacting principals, and three experienced staff members made repeated recruitment calls to superintendents and principals.

Phase I Results

School Characteristics and Maintenance Practices

The sample consisted largely of elementary schools (59% of the total), schools in suburban areas (74%), and schools more than 30 years old (64%). About half of the schools had 55% or more of their students on Federal meal assistance (Bell, 2001), and about half spent at least the state-wide median of $5500 per student each year (Edwards, 2001).

In the past year, facility managers received major complaints about environmental problems in classrooms--such as air quality, water leaks, and noise--in about half of the schools (52%). About one third (35%) of the facility managers were aware of the U.S. EPA's program for managing indoor air quality in schools (Tools for Schools), but only 11% of the facility managers used the program. About two-thirds of the facility managers (67%) reported keeping maintenance logs for the HVAC system, although all schools are required to keep such logs. About 5% of the facility managers reported never inspecting major components of the HVAC system, such as the outdoor air damper setting, condensate drain pan, and coils. About half of the schools (57%) swept, vacuumed, and dusted the classrooms five days a week.

Classroom Characteristics and Results

In Phase I, significant differences in the reported building characteristics, environmental complaints, and teacher symptoms were found between portable classrooms and traditional classrooms. Portable classrooms were most often used at elementary schools, and typically for general instruction rather than laboratory, art, or other special classes. They were typically 600-1100 square feet in size (69% of the total). About 55% of the portables were 10 years old or newer.

As indicated in Table PES-2**,** portable classrooms were reported more frequently than traditionals ($p \leq 0.10$) to have carpeted floors, vinyl tackable wallboard, pressed wood bookcases, suspended ceilings, and metal roofs. Traditional classrooms were located more often at high schools and middle schools, were used more often for special classes, had a larger floor area, and were older (only 19% were 10 years old or less).

Table PES-2. Percent of Classrooms with Characteristics Noted, Phase I

Characteristic	Portables	Traditionals	All
Carpeted floors	70.7	34.3	47.8
Vinyl tackable wallboard	78.6	28.4	47.0
Pressed wood bookcases	55.3	47.8	50.6
Suspended ceilings	86.5	62.4	71.6
Metal Roofs	54.2	15.0	29.5

The HVAC systems in portable classrooms were typically packaged wall units (81%) with thermostat control by teachers in the room (45%). Teachers reported opening the windows or exterior doors at least occasionally in about half the portable classrooms (58% and 42%, respectively). A high percentage (60%) of the teachers in portables turned off the HVAC system due to noise. About half the teachers (52%) reported disruptive noises in classrooms, and about two thirds (64%) reported disruptive noises outside the portable classrooms. The above HVAC, window, and noise characteristics were reported less often ($p \leq 0.05$) for traditional classrooms.

In Phase I, teachers reported on various factors that contribute to indoor environmental quality. As shown in Table PES-3, the most common pollutant source category reported for portable classrooms was paints and marker pens (97% of all portables), followed by glues and correction fluids, and laboratory chemicals and cleaning products. Less commonly reported pollutant sources included office equipment, pesticide ever used by the teacher, and construction in the classroom that year. Air fresheners, which may also indicate poor classroom air quality, were used in about 40% of the portable classrooms and about 30% of the traditional classrooms.

Table PES-3. Selected Pollutant Source Categories Reported by Teachers (% yes), Phase I

Classroom Type	Paints, Marker Pens	Glues, Correction Fluids	Laboratory Chemicals, Cleaning Fluids	Pesticide Use[a]	Construction in Classroom[b]	Air Fresheners
Portable	97[c]	67	44	21	16	39[c]
Traditional	91	66	52[d]	24	14	31

a. Similar proportions of facility managers reported that they had sprayed these rooms in the past year.
b. During the school year the questionnaire was administered.
c. Significantly greater ($p \leq 0.05$).
d. Significantly greater ($p \leq 0.10$).

Traditional classrooms differed significantly from portable classrooms in some of these categories. Air fresheners, and paints and marker pens, were reported slightly less often in traditional classrooms ($p \leq 0.05$). On the other hand, traditional classrooms had slightly more reports of the presence of laboratory chemicals ($p \leq 0.10$).

With regard to moisture and mold indicators, over two-thirds (69%) of teachers in portable classrooms reported that they noticed musty odors at times. Less than half (43%) of these teachers reported current or previous leaks or floods in the room, the majority of the leaks coming from the roof (27% of all portables). Visible mold, either currently or previously, was reported by 11% of portable classroom teachers. For traditional classrooms, teachers reported the presence of musty odor less often (58%, $p < 0.01$), but they reported previous flooding significantly more often (47%, $p \leq 0.05$).

Teachers in portable classrooms were asked to characterize the general environment of their classroom. Nearly one-fourth of these teachers reported the temperature to be too hot (13%) or too cold (9%). Over one third of these teachers described the room air as too stuffy (38%). About one-third of the teachers in portable classrooms reported the lighting to be too dim (21%) or too bright (7%). Over one-seventh (13%) of these teachers rated the overall environmental quality of their classroom as poor. About one-third of the teachers (30%) in portables preferred working in portable classrooms, and another third (35%) preferred traditional classrooms.

Compared to teachers in portable classrooms, the teachers in traditional classrooms reported fewer of the above problems with room air quality (especially stuffiness) and with lighting (especially dim conditions) ($p \leq 0.01$). Temperature problems, especially excessive heat, were reported more frequently in traditional classrooms ($p < 0.05$). Teachers in traditionals less frequently rated their class room environmental quality as poor ($p \leq 0.10$). A much higher percentage of these teachers (84%) preferred working in traditional classrooms ($p < 0.05$).

In portable classrooms, the frequencies of most types of odors–for example, new carpet or furniture, fresh paint, pesticide odors, vehicle exhaust, and trash/dumpster odors–reported by teachers ranged from about 5 to 15% of the classrooms. However, cleaning product odors were reported more frequently (31% of portables). In comparison to portable classrooms, teachers in traditional classrooms reported odors from new carpet and furniture significantly less often (9%). However, odors from cleaning products and fresh paint were reported significantly more often (41% and 15%, respectively).

Measurement Results

In Phase I, valid indoor-air formaldehyde concentration data were obtained from 911 classrooms (320 schools), and the large majority of samples were over 7-10 days. The mean formaldehyde levels were 32 ppb in portables, 24 ppb in traditional classrooms, and 27 ppb across all classrooms. Only about 3% of the classrooms had non-detectable concentrations, i.e., less than 6 ppb. Thus, nearly all of the classrooms had indoor, 7-10 day average formaldehyde levels greater than the typical outdoor levels in California (3 ppb). Most of the classroom levels were also greater than the level equivalent to a ten-in-a-million excess risk of cancer (1.3 ppb), and the California Chronic Reference Exposure Level (REL) of 2 ppb for long-term exposure (ARB, 2001; OEHHA, 2002; OEHHA, 2001). The latter level is based on protecting sensitive individuals from nasal and eye irritation and nasal/upper airway injury resulting from long-term exposures.

The cancer risk estimate above is based on conservative assumptions that the indoor formaldehyde levels do not decline over time (they generally do as building materials age), and that the same level of exposure continues over a person's lifetime (it usually does not). Therefore, cancer risk estimates based on these classroom measurements across two seasons would overestimate the child's actual risk, but on the other hand, formaldehyde levels are often elevated in other indoor environments where people spend their lives, such as homes and workplaces. Thus, formaldehyde levels should be reduces in all indoor environments where they are elevated.

The short-term health-based guidelines for formaldehyde in California are 27 ppb (Draft 8-hour Indoor REL) and 76 ppb (1-hour Acute REL) (Broadwin, 2000; OEHHA, 1999). These guidelines are designed to protect sensitive individuals against eye irritation and effects on the respiratory and immune systems resulting from acute, short-term exposures. The 7-10 day average levels of formaldehyde are designed as screening estimates, and do not directly compare to standards and guidelines based on shorter time periods. However, because they are longerterm averages, they are likely conservative estimates of 1- and 8-hour levels of formaldehyde reached in classrooms.

As can be seen in Table PES-4, the formaldehyde concentrations were significantly higher for portable classrooms than for traditional classrooms. For example, 50% of the portables had concentrations above 27 ppb, whereas only 29% of the traditional classrooms were higher than 27 ppb. Also, 4% of the portables had concentrations above 76 ppb, whereas only 0.4% of the traditional classrooms were higher than 76 ppb. When adjusted for classroom age, the difference between the two classroom types was only significant in the newer classrooms.

Table PES-4. Phase I Formaldehyde Concentrations Compared to Health Guidelines

	All Rooms	Portable Classrooms	Traditional Classrooms
% of Rooms > 27 ppb	36.9	50.3	29.0
% of Rooms > 76 ppb	1.8	4.0	0.4
Mean (ppb)	27	32	24

In Phase I, a number of factors appeared to be significantly ($p < 0.05$) associated with high formaldehyde levels in classrooms. These include higher levels in:

- Newer classrooms
- The warmer season
- Rooms with pressed wood cabinets, new carpet and flooring
- Rooms with chemicals present
- Larger classrooms
- Southern California
- Rooms with new furnishing odor.

These results are consistent with prior studies that have found that formaldehyde is emitted at higher rates at higher temperature and humidity; is commonly emitted at high rates from certain pressed wood products (those made with urea-formaldehyde resins); and off-gases over time such that newer materials have higher emissions, and emissions decrease over months to years, depending on the characteristics of the particular material or product. (Kelly et al., 1999; Godish, 1989; Sexton et al., 1989; National Research Council, 1981)

Phase II Results

Like the Phase I results, both school-level and classroom-level information was obtained in Phase II. Additionally, Phase II included classroom and HVAC inspections and extensive environmental measurements.

School Characteristics and Maintenance Practices

The following *school* characteristics for the total California population of schools were identified:

- The schools are mostly suburban, elementary schools;
- Many of the schools (40.1%) have 30 or fewer total classrooms, but 4.4% are estimated to have over 30 portable classrooms.
- Most schools (87.9%) perform regular HVAC inspection and maintenance.
- About half of the schools (58.7%) keep HVAC Maintenance Logs, which are required by State regulations.
- Many of the schools (41.7%) are aware of EPA's Tools for Schools program, but few (18.7%) use this program.

These results are consistent with the Phase I findings, except that the awareness and use of the EPA's Tools for Schools program was slightly higher in Phase II.

Classroom Characteristics and Results

The following general characteristics relate to the total California target population of *classrooms*:

- The classrooms are mostly in suburban schools (75.5% suburban, 17.8% urban, and 6.6% rural).
- The classrooms are mostly in elementary schools (59.0% elementary, 22.9% middle, and 18.1% high school, based on the highest grade offered).

These results are comparable to those observed in Phase I of the study.

Physical and Environmental Characteristics

Similar to Phase I results, portable classrooms usually were newer than traditional classrooms (29.1 percent versus 83.4 percent over 15 years old). Similarly, as shown in Table PES-5, portable classrooms more often had carpet or rugs on the floor, vinyl tackable wallboard, fiber/particle board or plywood walls, and pressed wood bookcases in the room. All of these materials are possible sources of formaldehyde, and some other VOCs. In addition, portable classrooms were again more likely to have a metal roof (28.5% versus 2.5%) and to have water stains on the floor (18.1% versus 2.0%); however, portable classrooms were more likely to have carpets, so would be more likely to have water stains on a carpeted floor.

Table PES-5. Percent of Classrooms with Characteristics Noted, Phase II

Characteristic	Portables	Traditionals	All
Carpeted floors	82.0	62.9	69.7
Vinyl tackable wallboard	36.5	16.4	23.5
Pressed wood bookcases	73.1	49.8	58.2
Metal Roofs	28.5	2.5	12.1

The estimated distribution of the height of the foundation skirt for portable classrooms is as follows: 42.6% are less than 2" above the ground, 22.2% are from 2" to 12" above ground, and 35.2% are over 12". Foundation skirts close to the ground have been reported to be more susceptible to surface water contact and wicking of water up wall materials, resulting in mold and moisture problems.

Phase II provided more in-depth information about HVAC characteristics and comfort indicators:

Ventilation / HVAC

- The mean difference in outdoor air flow, total supply air, and HVAC age were not significantly different between portable and traditional classrooms.
- Teachers were more likely to turn off the HVAC system due to high noise levels in portable classrooms (68.3% versus 42.2%), HVAC systems were generally wall mounted in portable classrooms (79.8% versus 9.3%) and electricity-based (94.6% versus 76.9%);
- The air filter for the HVAC unit in portable classrooms was more likely than traditionals to have a light or medium loading of dirt.
- During the Phase II inspections, portable classroom HVAC units were less likely to have clean condensate drain pans and lines (30.0 versus 56.7%), and were more likely to fail the "drain test" used by the inspector to test for blockage (58.5 versus 12.4%).
- Also, the air intake was blocked on the air handling units more often for portable classrooms than for traditional classrooms (10.8% versus 2.7%).

As can be seen in Table PES-6, both portable and traditional classrooms had school-day average concentrations of carbon dioxide (CO_2) greater than 1000 ppm, and both classroom types had one-hour average CO_2 levels above 1000 ppm for about 40% of the school day. Both classroom types had one-hour average CO_2 levels above 2000 ppm for about 10% of the school day. These results indicate insufficient ventilation in a substantial portion of California classrooms.

Table PES-6. CO_2 Levels as an Indicator of Ventilation Sufficiency, Phase II

	Portable	Traditional	All
mean ppm across school day	1064	1074	1070
% with one-hour average above 1000 ppm (mean)	42.1	43.2	42.8
% with one-hour average above 2000 ppm (mean)	9.2	10.1	9.8

Lighting

The mean light intensity in the center of the classroom was significantly lower for portable classrooms (55.7 foot-candles [f-c]) than for traditional classrooms (65.2 f-c). A total of 8.8% of the portable classrooms and 4.4% of the traditional classrooms failed to meet the Illuminating Engineering Society of North America's (IESNA, 2000) light guideline of 30 f-c for high contrast materials. Also, 38.3% of the portable classrooms and 27.2% of the traditional classrooms failed to meet the requirement of 50 f-c of light needed for low contrast materials. However, there was no significant difference between the opinions of teachers in portable and traditional classrooms regarding whether or not the classroom lighting was satisfactory.

Noise

All classrooms exceeded 35 dBA, the American National Standards Institute (ANSI, 2002) acoustic standard and World Health Organization (WHO, 1999) guideline for unoccupied classroom acoustics. In fact, 50% of the noise measurements taken indoors for the portable classrooms and 37.5% of the traditional classrooms failed to meet the outdoor noise nuisance standard of <55 dBA adopted by a number of cities in California (City of Sacramento, 2003; City of Davis, 2003; City of Los Angeles, 2003). None of the HVAC noise measurements were significantly different (at the 5% significance level) between portable and traditional classrooms, except that indoor noise near the return register with the HVAC off was significantly greater in the portable classrooms ($p \leq 0.10$).

Temperature and Relative Humidity (RH)

A relatively large percentage of the classrooms in California do not achieve the ASHRAE standards for acceptable temperature and relative humidity. Portable classrooms had temperatures below 17 EC (63 EF) for more of the time (6.3% versus 3.2%); and they had temperatures below 20 EC (68 EF) for more of the time (27.0 % versus 17.0%). Both portables and traditionals exceeded 23 EC (73EF) about 27% of the time, but traditionals had a higher percent of time at very high temperatures (> 26 EC [79 EF] and > 29 EC [84 EF]). None of the RH summary measures exhibited statistically significant differences between the means of the two types of classrooms; average RH measurements were 46.8% and 45.9% for portable and traditional classrooms, respectively, within the acceptable range. However, as can be seen in Table PES-7, California classrooms do not achieve the ASHRAE standards for acceptable relative humidity a substantial portion of the time.

Table PES-7. Average Percent of Time Outside ASHRAE Standards for Relative Humidity, Phase II

RH Level	Portable Classrooms	Traditional Classrooms	All
<30%	11.0	11.4	11.3
>50%	44.7	45.6	45.3
>60%	16.9	12.6	14.1

Airborne Pollutant Levels

Aldehydes

Of the 13 specific aldehydes included in the analysis, only two were detected in more than 75% of the samples – formaldehyde and acetaldehyde. Five other aldehydes were measurable in at least 25% of the samples. For virtually all of the aldehydes, the indoor levels were higher than the outdoor levels, indicating the presence of indoor sources. Formaldehyde, for example, had a an overall mean level of 13.3 ppb indoors, but only 3.5 ppb outdoors, while the indoor-air 95th percentile was 3 times higher than outdoors (see Table PES-8). Statistically significant differences (0.10 level of significance) between mean levels of portable and traditional classrooms (portable classroom averages were always higher) were found for formaldehyde (15.1 versus 12.3 ppb) and acetaldehyde (7.2 versus 6.4 ppb). Significant differences were also found in o,p-tolualdehyde (0.91 versus 0.21 ppb) and 2,5-dimethylbenzaldehyde (0.01 versus 0.00 ppb), but these aldehydes were measurable in only a very small percentage of classrooms.

Table PES-8. **Formaldehyde Results, Phases I and II**

	Sample size (n)		Mean (ppb)		Median (ppb)		95th Percentile (ppb)	
Location	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**	**Phase I**	**Phase II**
Outdoor	NA	62	NA	3.48	NA	2.4	NA	8.05
All classrooms	911	199	27.0	13.3	22.0	12.0	61.7	23.9
Portable	644	135	32.4	15.1	27.1	14.5	71.5	25.8
Traditional	267	64	23.7	12.3	20.0	11.6	55.0	22.4

Table PES-8 also shows that the Phase II formaldehyde concentrations were considerably lower than those observed in Phase I. The differences were not unexpected, and are likely attributable to seasonal differences, the different measurement methods used in the two Phases, and possibly other factors. For example, the Phase I measurements were obtained mostly in the spring and summer, when formaldehyde emissions and levels tend to be higher, whereas the

Phase II measurements were obtained in the fall and winter. The Phase I measurements used PF-1 passive monitoring tubes sampling over 7 to 10 days, including nights and weekends when the schools were closed and HVAC systems may have been off. Thus, the night and weekend periods might have raised the measured levels. However, the passive monitoring method has the advantage of sampling over at least a week long period rather than just one day, and because it could be conducted by mail, had the advantage of allowing for a much larger sample size, which would be more likely to capture classrooms with very high or very low formaldehyde levels. The Phase II measurements used an active monitoring device during the 6 to 8 hours when classes were in session, the HVAC systems were operating, and doors and windows would be opened. This would tend to yield lower levels than measured in Phase I. Additionally, the HVAC inspections during Phase II required that the ventilation system be operated so that it could be tested, so that the overall air exchange rates for the Phase II classrooms might have been somewhat higher than normal, resulting in lower measured formaldehyde levels. Because of all of these factors, annual average formaldehyde levels would be estimated to fall somewhere between the Phase I and Phase II levels.

VOCs (non-carbonyl)

Seven of the nine measured VOCs had at least 80% of their measured levels above the detection limit. The other two were detected in at least 50% of the samples. For all nine VOCs, the traditional classrooms had higher average concentrations than did the portable classrooms, but none of the differences in mean concentrations were significant statistically, even at a significance level of 0.10. As in most indoor air quality studies, the measured indoor VOC concentrations were higher than those observed outdoors. Average in-class room concentrations ranged from a high of 6 ppb for toluene (slightly less for m,p-xylene) to less than 0.5 ppb for chloroform. For all others, the averages were in the range of 1 to 2 ppb.

Particulate Matter

Real time counts of particles were measured in each classroom and outdoors. Although particle counts cannot be directly associated with mass concentration standards, the measurements provide a relative indication of mass for comparison purposes.

Mean counts of particles per minute for particles of 2.5µm or less and for particles of 10µm or less were not significantly different for portable and traditional classrooms. However, the average counts for the two particle sizes of interest, <2.5 µm and <10 µm, were higher in the portable classrooms, especially for the smaller size range. In addition, at the 95^{th} percentile, the difference is even more remarkable for the higher portable concentrations in both size ranges. One possible explanation is that, as mentioned before under the characteristics of the classrooms, carpets and rugs were more often found in the portable classrooms, and could be a source of the particles. Additionally, portable classrooms may be nearer outdoor sources such as busy roadways and parking lots, especially in urban areas where school site space is limited.

Pollens and Spores

In general there were few spore types that were observed frequently in either the outdoor or indoor environments. In the outdoor environment, only six were frequently seen (on 80% or more of the slides)—Amerospores, Ascospores, Cladosporium, Mycelial Fragments, Pollen Count, and Total Fungal Spores. Not too surprisingly, all of these except Ascospores were frequently found (80% or more of the slides) indoors. No significant differences between portable and traditional classrooms were found for mean Total Pollen Counts or mean Total Fungal Spores.

<u>Floor Dust Contaminants</u>

Samples were collected using a hand-held vacuum dust collector (Data Vac II), in each of the three classrooms sampled, using a specialized protocol to attain as great a consistency as possible in sample collection. The samples were stored on ice for shipping and frozen until analysis. The samples were sieved at two cut points, less than 500 microns for the portion sent to California DHS for analysis of allergens, and the remainder of the dust was sieved again at less than 150 microns for consistency with reported chemicals in house dust. Equal aliquots of the samples collected from the portable classrooms at each school were combined for further chemical analysis to reduce costs. Accordingly, for each school, there was one sample analyzed to represent the portable classrooms, and there was only one sample from the traditional classroom. Results are reported in concentration units (: g/g) and loading units (ng/cm^2).

Pesticides

Results were reported for 20 pesticides. Six pesticides were detected in over 80% of the samples: chlorpyrifos, cis- and trans-permethrin, o-phenylphenol, piperonyl butoxide, and esfenvalerate. Diazinon, 4,4' DDE, and propoxur were measurable in over 50% of samples. Dieldrin, pendamethalin, propetamphos, bifenthrin, cyhalothrin, cypermethrin, and delta/tralo-methrin were detected in 10-50% of the samples. Four of the pesticides were only rarely detected (<10% of samples): malathion, lindane, resmethrin, and cyfluthrin.

At the 95^{th} percentile, nine of the pesticides were measured at concentrations above 1.0 : g/g, although several of these had few measurable samples. There were no significant differences in the mean levels in portable and traditional classrooms.

Esfenvalerate, a commonly used insecticide, had the highest dust concentration and the highest median loading level (0.34 ng/cm^2), while many of the pesticides had median loading levels less than 0.01 ng/cm^2. No statistically significant differences between the means for the portable and traditional classrooms were found for either the concentration results or the loading results.

Metals

Fifteen of the 18 elements were above the detection limit for all of the samples analyzed. The only three that were not always above the detection limit were Selenium, Cobalt, and Palladium.

Of the 15 elements, the median concentration in portable classrooms was greater than the median concentration in samples from traditional classrooms for 8 of the 15 elements (arsenic, chromium, copper, manganese, vanadium, cesium, iron and strontium). Conversely, the samples from traditionals showed higher dust concentrations than the composite samples from the portable classrooms for the other 7 elements, including lead.

When the floor dust metals results are considered in terms of dust loading, all the elements show higher loadings in the samples from portable classrooms, except copper. However, none of these differences were statistically significant at the 0.10 level of significance.

Lead, arsenic and chromium concentration results (: g/g) and loading results (ng/cm^2) for the mean and 95th percentile are shown below in Table PES-9. The table illustrates that there are not clear patterns across the elements, and probably reflects the close proximity of sources. For example, since the portable classrooms are generally newer, the lower concentration of lead may reflect the number of years of particle accumulation in the traditional classroom. Arsenic, on the other hand, may indicate the closer proximity of portables to the school grounds, where there may be treated wood, or they may have treated foundations.

Table PES-9. Concentration and Loading Results for Selected Elements, Phase II

Element	**Concentrations (: g/g)**				**Loadings (ng/cm^2)**			
	Mean		**95th Percentile**		**Mean**		**95th Percentile**	
Lead	All	85.4	All	189.5	All	14.7	All	58.4
	Port	67.4	Port	151.6	Port	14.8	Port	57.9
	Trad	95.45	Trad	200.6	Trad	14.7	Trad	57.5
Arsenic	All	11.6	All	17.3	All	1.8	All	5.5
	Port	12.7	Port	18.6	Port	2.3	Port	5.5
	Trad	10.9	Trad	15.3	Trad	1.6	Trad	3.4
Chromium	All	36.6	All	72.8	All	5.9	All	17.8
	Port	35.8	Port	54.1	Port	7.2	Port	23.6
	Trad	37.0	Trad	74.0	Trad	5.1	Trad	12.6

Allergens

Dog and cat dander allergens (Can f1 and Fel d1) were detected in 56% and 74% of the samples, respectively, while the two dust mite allergens and cockroach allergen were detected less than 10% of the time. The Can f1 was measured on average about double the Fel d1concentrations measured (0.43 versus 0.26). The traditional classrooms had higher estimated concentrations for each species than the portables, but the differences were not statistically significant.

Polynuclear Aeromatic Hydrocarbons (PAHs)

Most of the 16 PAHs were detected in over 80% of the samples, but the loadings were generally very low. Only 5 of the PAHs had measured concentrations above 1.0 :g/g; these included chrysene, fluoranthene, pyrene, indo[1,2,3-cd]pyrene, and perylene/benzo[b]fluoranthene.

Comparing the portable classroom concentrations with the traditional classrooms, 9 of the PAHs were measured at higher median levels in the composite portable classroom samples, while two of the PAHs were measured at higher median levels in the traditional classrooms (fluorene and perylene/benzo[b]fluoranthene). Similar results can be seen using the 95^{th} percentile of the distribution as the statistic for comparison: 15 of the 16 PAHs were higher in the portable classrooms. (Naphthalene was measured at equal levels in both types of classrooms.)

<u>Factors Affecting Indoor Environmental Quality</u>

Although time and funding did not permit an extensive modeling effort, results from simplified ANOVA and ANACOVA models explored under this the contract resulted in the following key findings. (The modeling efforts did not include dust results.)

- *Factors Affecting Indoor-Air CO_2 Concentrations*. Based on modeling results, the indoor CO_2 levels were estimated to be approximately 30% lower when the teachers reported that the indoor air quality was acceptable. Models also showed a significant effect of school type, with high schools having the highest indoor CO_2 levels (and thus indicating the greatest likelihood of ventilation insufficiency).

- *Factors Affecting Noise Associated with HVACs*. Classroom age had a positive effect (older rooms had higher noise levels), and the portable classrooms had significantly higher noise levels than the traditional classrooms. This model only accounted for only about 11% of the total variation in the noise level, however.

- *Factors Affecting Indoor Temperatures*. Two temperature measures were modeled: percent of time that the room was below 20˚C (too cool) and percent of time that the room was above 23˚C (too warm). Portables and traditional classrooms were significantly different for the percent of time that the room was below 20˚C. The percent of time that the portables had less than 20˚C temperatures was larger (by about 10%) than for the traditional classrooms.

- *Factors Affecting Indoor-Air Aldehyde Concentrations*. Various models were fit for log (Formaldehyde Concentration), log (Acetaldehyde Concentration), and log (o,p-Tolualdehyde Concentration). The preferred models for the three species were quite different. For formaldehyde, the classroom age, and indoor CO_2 levels were statistically significant in the formaldehyde model only. Portable classrooms were significantly different than traditionals for nearly all the variables tested in the formaldehyde model, but none were for the other aldehyde models. The formaldehyde models generally did not show a relationship with the outdoor levels, while the models for acetaldehyde and tolualdehyde all displayed significant outdoor air associations, including some room-type and outdoor air interactions.

When adjustment for another indoor variable was made – namely the CO_2 and relative humidity variables – there was a significant positive relation between indoor and outdoor formaldehyde levels. These two models accounted for 22% and 32%, respectively, of the total variation in the indoor levels. Classroom age also had a significant positive association with indoor formaldehyde levels, apparently driven largely by traditional classroom levels. This association in portables was significantly different than that in traditional classrooms; it appeared to be a negative association. This is consistent with the Phase I results for 6-15 year old portables, which found higher formaldehyde levels in traditional classrooms, which may be due to construction, renovation, new building furnishings, laboratory activities, and reduced ventilation. Unfortunately, separating the effects of classroom age and room type was not feasible, because of the disparate classroom age distributions and the small sample sizes for newer traditional classrooms.

The model including "pressed wood bookcases" as a predictor, which also included a significant classroom age variable (positive slope), accounted for only about 14% of the total variation in the indoor formaldehyde levels. However, this model implied about a 30% increase in formaldehyde levels when pressed wood bookcases were present, and about 30% higher concentrations for portable classrooms. The model for acetaldehyde that included "pressed wood bookcases" as a predictor accounted for about 24% of the total variation in the indoor levels of that analyte, and indicated a significant increase in the indoor levels when pressed wood bookcases were present.

- *Factors Affecting Indoor-Air VOC Concentrations*. Models were fit for five VOCs (log-scale concentrations) using various candidate predictors. There were significant associations with outdoor levels in virtually all of the VOCs, except for benzene, and these associations appeared somewhat stronger than for the aldehydes. For toluene, significantly lower levels were estimated when new construction/repair activities were on-going (which may reflect the fact that doors and windows might be more frequently closed when those activities were outside of the immediate classroom). The variables in this model accounted for 69% of the total variation in indoor toluene levels.

- *Factors Affecting Indoor-Air Pollen and Spores*. A number of different models were fit for log (Pollen Count) and log (Total Fungal Spores). There was a statistically significant association between indoor and outdoor levels – with higher outdoor levels being associated with higher indoor levels. The tests for significance for the candidate predictors revealed that only one predictor exhibited statistical significance – namely "windows open," which indicated that classrooms with "windows open today" tended to have lower pollen counts. This may be due to days with high pollen levels coinciding with those having high wind speeds, allergic reactions among teachers, or other factors that would result in window closing.

- *Factors Affecting Indoor-Air Particle Counts*. Models were fit for log (average number of particles/minute ≤ 2.5 μm) and log (average number of particles/minute ≤ 10 μm). Among several potential predictors considered, the only predictor showing significance was (for the 2.5 μm case) the presence of carpet/rugs (rooms with carpet/rugs had lower levels). For that model, traditional classrooms exhibited lower particle counts than portable classrooms.

Conclusions

Phase I and Phase II were successful in providing extensive questionnaire and measurement data that constitute a wealth of information about environmental conditions in California classrooms. The stratified random sampling approach, the response rates, and assignment of appropriate weights to the data, combined with the many types of data collected, allow one to ascertain important conclusions regarding the conditions and characteristics of portable classrooms in California.

The target population of schools, an estimated 6,924 schools, is comprised of mostly suburban schools (73.8%) and mostly elementary schools (59.3%). Facility managers reported that only about 29% of the schools were less than 30 years old, that the majority (54.4%) of the schools have 10 or fewer portable classrooms, and that over half (52.1%) of them received some type of environmentally related complaint within the year. Very similar results were obtained in the Phase II study.

The estimated number of K-12 classrooms in California in the 2000-2001 school year was about 268,000, of which about 80,000 were portable classrooms. **The target population of classrooms** in Phase II is estimated to be 230,000 classrooms, 37% of which are portable classrooms. Portable classrooms were more prevalent for elementary schools than for middle or high schools. Most (90.4%) of the portable classrooms were devoted to general instruction, as compared to 75.1% of the traditional classrooms. Classroom age was not known for many classrooms; however, there is a dramatic difference in the estimated age distributions for portable and traditional classrooms. For instance, 55.3% of the portables are 10 years old or less whereas only 12.4% of the traditional classrooms are that new. This disparity is undoubtedly partly responsible for many other concomitant differences—e.g., differences in structural characteristics, HVAC characteristics, and types of environmental problems/complaints. As compared to traditional classrooms, for instance, portables tend to have more carpet, more tackable wallboard, more pressed wood bookcases, more exterior doors, more opening of windows, and more air conditioning (and thermostat control). Again, results were about the same for Phase II.

Most types of environmental complaints (roof leaks, air quality/odor, mold, temperature, noise) were reported more often for portable classrooms; an exception was plumbing leaks, which were more common in traditional classrooms. Pest related problems seemed to be about the same in portable and traditional classrooms.

The methods and materials used in the study were generally successful. The formaldehyde monitoring data in Phase I are of acceptable quality in terms of completeness, relative precision, and sensitivity, with 97% of the measurements above the LOD. The mean concentration for portable classrooms in Phase I was 32 ppb (median 27 ppb), compared to 24 ppb for traditional classrooms (median 20 ppb). Statistically significant associations were found for geographic region, season, overall air quality rating by the teacher, presence of new carpet and new flooring, presence of new furnishing odors, and nasal symptoms of the teacher.

Among all the ANOVA models in Phase I, the room type variable, adjusted for the other variable appearing in the model, was always highly significant except for the models involving classroom age. For these models the effect of room type, after adjustment, was non-significant, suggesting that at least part of the overall difference between the room types was due to the disparity in their age distributions and differences associated with age.

Phase II provided measurement and observational information in greater detail than was obtained from Phase I. The data base provides a robust basis for statistical inferences regarding the population of schools with portable classrooms because response rates and data completeness were quite good for most analytes and questionnaire items. The exceptions were relatively poor data completeness for HOBO data regarding on/off cycles of HVAC units, CO data, and outdoor relative humidity data.

Quality control: Analysis of field blank samples, control samples, and duplicate samples revealed that analyte recovery and precision were reasonably good for most analytes. Hence, the quality control samples verified that the environmental measurement and laboratory data quality were satisfactory.

With respect to the HVAC characteristics, there were a number of significant differences between portable and traditional classrooms. Those related to structure include: physical location of unit (portables more wall units), type of fuel (electricity), type of unit (heat pump), and accessibility (better for portables). For those characteristics with potential impact on environmental quality, air filter dirt loading was lower in portables, and portables generally had more tightly fitting filters. HVAC filters in portable classrooms showed a higher percentage of mildew or mold, dirtier condensate drain pans, clogged drains, and standing water. Also, teachers were more likely to turn off the HVAC system due to high noise levels in portable classrooms. The air flow measurements in traditional and portable classrooms were not significantly different at the 5% level; however, outdoor air flow (cfm/ft^2) was significantly higher for portable classrooms at the 10% level.

The mean light intensity measured in the traditional classrooms was significantly higher than that measured in the portable classrooms. However, a small percentage of both portable and traditional classrooms did not meet IESNA light guidelines for high-contrast materials, and approximately one-third of both portables and traditionals did not meet the IESNA light guidelines for low-contrast materials, indicating inadequate lighting in both types of classrooms.

All classrooms exceeded the new ANSI acoustic standard for **classroom noise levels** (35 dBA), and a substantial percentage of both portable and traditional classrooms exceeded outdoor noise limits (45 and 55 dBA) set by some California communities. Noise levels measured in both types of classrooms were not statistically different. However, the teachers in portable classrooms were more likely to turn off the HVAC unit due to noise. This noise effect in portable classrooms was supported in the statistical modeling.

Temperature levels were significantly different, with some portable classrooms experiencing levels much cooler than ASHRAE comfort standards and some traditional classrooms experiencing levels notably warmer than ASHRAE comfort standards. Portables also had **relative humidity measurements** above 60% more of the time than traditional classrooms; such levels are not only uncomfortable, but can lead to increased moisture and mold problems, increased dust mite populations (allergy and asthma triggers), and other problems.

Assessment of **contaminant levels** in classroom air and floor dust revealed the general findings shown in Table PES-10.

Table PES-10. Overall Results of Contaminant and CO_2 Levels in Air and Floor Dust, Phase II

Pollutant Type	Summary Statistics and Comparisons of Pollutant Levels			Modeling Results -- *For Selected Species and Selected Predictors*		
	Indoor Levels Vs. Outdoor Levels	**Exceeds health- or comfort-based guideline/ standard**	**Portable Classroom Mean Vs. Traditional Classroom Mean Test**	**Portable Classroom Vs. Traditional Classroom Test**	**Indoor Levels Related to Outdoor Levels**	**Other Significant Predictors**
CO_2 (air)	Indoor higher	Yes indicates inadequate ventilation in many classrooms	About the same	Depends on outdoor level (some models)	Yes (when applicable), depends on room type	Classroom age, and school type and teacher rating of indoor air quality (when classroom age included)
Particle Counts (air)	Outdoor higher	NA	About the same	About the same (most models)	NA	Presence of carpets/rugs
Microbiologicals (air)	Outdoor generally higher	NA	About the same	About the same	Yes	Open windows
Formaldehyde (air)	Indoors much higher	Yes, OEHHA draft Indoor REL, apparent cancer risk	Portables higher	Portables higher (most models)	Generally not	Classroom age, school type, general instruction classroom, others related to materials in room, indoor CO_2 levels, indoor RH
o,p-Tolualdehyde (low % measureable)	Indoor higher	Not yet reviewed	Portables higher	Depends on outdoor level	Yes	General instruction classroom, materials in room, school type
Other aldehydes (air)	Indoor generally higher	Not yet reviewed	About the same	About the same (acetaldehyde)	Yes (acetaldehyde)	General instruction classroom, indoor RH (acetaldehyde)
VOCs (air)	Indoor higher	Not yet reviewed	About the same	About the same, some depend on outdoor level	Yes, some depend on room type	Only a few, varies by analyte
Pesticides (dust)	NA	Many detected	About the same	NA**	NA	NA
Metals (dust)	*	Acceptable lead floor dust levels exceeded	Arsenic higher in P; Lead higher in T.	NA**	NA	NA
PAHs (dust)	NA	Many detected	Portables somewhat higher	NA**	NA	NA
Allergens (dust)	NA	Cat and dog dander in most	Traditionals slightly higher	NA**	NA	NA

* Outdoor soil samples were collected and analyzed for metals under funding from the California Office of Environmental Health Hazard Assessment. Those results will be incorporated as an addendum to this report.
** Modeling has not yet been conducted for dust analytes, but may be pursued under separate funding.

Indoor **formaldehyde air concentrations** in Phase II were lower than those in Phase I; this was largely due to the many differences in procedures and timing of the two data collections. However, indoor levels are routinely higher than outdoor levels, and average formaldehyde levels are likely to fall between the Phase I and Phase II measurements. Thus, most classrooms exceed health guidelines for chronic effects, and a substantial percentage exceed guidelines designed to address acute effects. Other aldehydes and VOCs have not yet been examined relative to health-based guidelines, but indoor levels generally exceeded outdoor levels (similar to results in other studies), indicating the presence of indoor sources that may need to be addressed.

Airborne pollens and spores (primarily fungi) were found at higher levels outdoors than indoors, as expected. Typically indoor levels of fungi are elevated primarily in cases of extreme mold or biological contamination. However, classroom wall, floor, and ceiling moisture measurements indicated excess moisture in building materials in about 17% of the classrooms, indicating potential mold problems in those locations. Traditional classrooms had excess wall, floor, and ceiling moisture more often than portables, but portables were reported to experience roof leaks more often, and over two-thirds of the teachers in portables reported musty odors at times.

Pesticide residues were found in all floor dust samples, indicating the widespread use of a variety of different products in or near classrooms. Six pesticides were detected in over 80% of the rooms, with esfenvalerate (a common insecticide) showing the highest concentration and loading levels. Some of the pesticides are persistent chemicals, lasting for years, while other have an environmental lifetime lasting just weeks; thus, some of the pesticides were likely applied just a week or two prior to the sampling period at some schools in 2001-2002.

Similarly, 15 of the 18 **metals** analyzed for were detected in the floor dust samples. Some, such as arsenic, were detected at higher levels in portables, while others, like lead, were higher in traditional classrooms. Some lead dust levels exceed acceptable levels for floor and window sill dust established by DHS and U.S. EPA to protect children's health. Some of the metals are known to have neurological or carcinogenic effects. Most of the 16 PAHs studied (some of which are also known or suspected carcinogens) also were found in over 80% of the classrooms, but the loading levels were low. Most were found at higher levels in the portable classrooms.

Some contaminants in dust, such as pesticides, can be ingested or absorbed through the skin, as well as inhaled, making them undesirable in the floor dust of classrooms, especially those used for younger children who spend more time on the floor.

Dog and cat allergens were found commonly in floor dust. Dust mite allergens and cockroach allergens were found much less often.

The Phase II study was successful in generating a massive amount of information about California schools and classrooms. Although the data summaries and analyses described in this report are quite extensive, they clearly represent only a small fraction of the analyses that could be undertaken to address environmental quality issues and related concerns.

Conclusions

From the above discussions of significant results, it is clear that there are differences in environmental factors between portable and traditional classrooms. Most importantly, some of both types of classrooms exceeded many of the environmental standards and guidelines available for judging the state of the environmental conditions in classrooms. Further analyses of this very rich data base will likely reveal other factors that could prove useful for further identifying sources and measures to be taken to reduce their potential effects.

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