California Environmental Protection Agency

Air Resources Board

California Department of Health Services

Report to the California Legislature

ENVIRONMENTAL HEALTH CONDITIONS IN CALIFORNIA'S PORTABLE CLASSROOMS

A joint report submitted by:

California Air Resources Board
California Department of Health Services

Pursuant to Health and Safety Code § 39619.6
(Assembly Bill 2872, Shelley, 2000)

October 2003

Gray Davis, Governor

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EXECUTIVE SUMMARY

INTRODUCTION

The California Portable Classrooms Study was a comprehensive study of environmental health conditions in California's public school classrooms. It was conducted jointly by the Air Resources Board (ARB) and the Department of Health Services (DHS) at the request of Governor Gray Davis and the State Legislature (AB 2872 Shelley; California Health and Safety Code §39619.6; see Appendix I). The study was prompted by concerns that California's schools, especially portable classrooms, might not provide healthful environments for students or teachers. These concerns were based on the potential for mold contamination, inadequate ventilation, poor temperature control, elevated levels of volatile chemicals, and excessive use of some pesticides. The study was funded to help understand the extent of these problems and to determine whether those problems warranted response by the state and/or schools or school districts.

The results of this comprehensive study provide important information for State and local decision-makers regarding the degree to which our classrooms provide a safe, healthful, and productive learning environment for California children. This report to the California Legislature provides an overview of the study, summarizes conditions identified in the study that need to be addressed at the State and local levels, and discusses options for improving conditions in both portable and traditional classrooms. The information presented in this report is based on the study results, findings from the scientific literature, and input provided by state agencies, school districts, consultants, manufacturers and interested stakeholders.

PURPOSE AND SCOPE OF STUDY

The purpose of the California Portable Classrooms Study was to:

- Conduct a comprehensive study and review of the environmental health conditions in portable classrooms.
- Identify any potentially unhealthful environmental conditions, and their extent.
- In consultation with stakeholders, identify and recommend actions that can be taken to remedy and prevent any unhealthful conditions identified.

The Legislature also directed that the study include a review of design and construction specifications, ventilation systems, school maintenance practices, indoor air quality, and potential toxic contamination including mold and other biological contaminants. Recommendations were to be developed to address the need for modified design and construction standards, emission limits for building materials and furnishings, and other mitigation actions needed to assure protection of children's health.

The study was conducted in two phases. Phase I consisted of a mail survey of 1000 schools randomly selected statewide. For each school, the facility manager and three

teachers (two from portable classrooms and one from a traditional classroom) were asked to complete detailed questionnaires on all aspects of the classrooms pertaining to environmental quality. Additionally, formaldehyde sampling tubes were sent to about two-thirds of the schools, for deployment in the three classrooms. In Phase II, comprehensive chemical, biological, and environmental measurements were obtained in 201 classrooms at 67 schools randomly selected statewide. As in Phase I, two portable classrooms and one traditional classroom were studied at each school.

The State contracted with Research Triangle Institute (RTI), a not-for-profit scientific research organization, to conduct the primary field work of the study for both Phase I and Phase II. ARB's Research Screening Committee, an external scientific peer review group that assures the quality of research funded by the ARB, reviewed and approved all experimental design and study materials related to RTI's participation. ARB and DHS each conducted certain tasks of the study as well. For example, ARB pre-tested the passive formaldehyde samplers used in Phase I, managed the RTI contract, and coordinated stakeholder participation, while DHS conducted a preliminary survey of school districts, analyzed dust samples for allergens, and reviewed the biological sampling protocols conducted by RTI and the related results. Both agencies were fully involved in project oversight, review of the results, and preparation of this report.

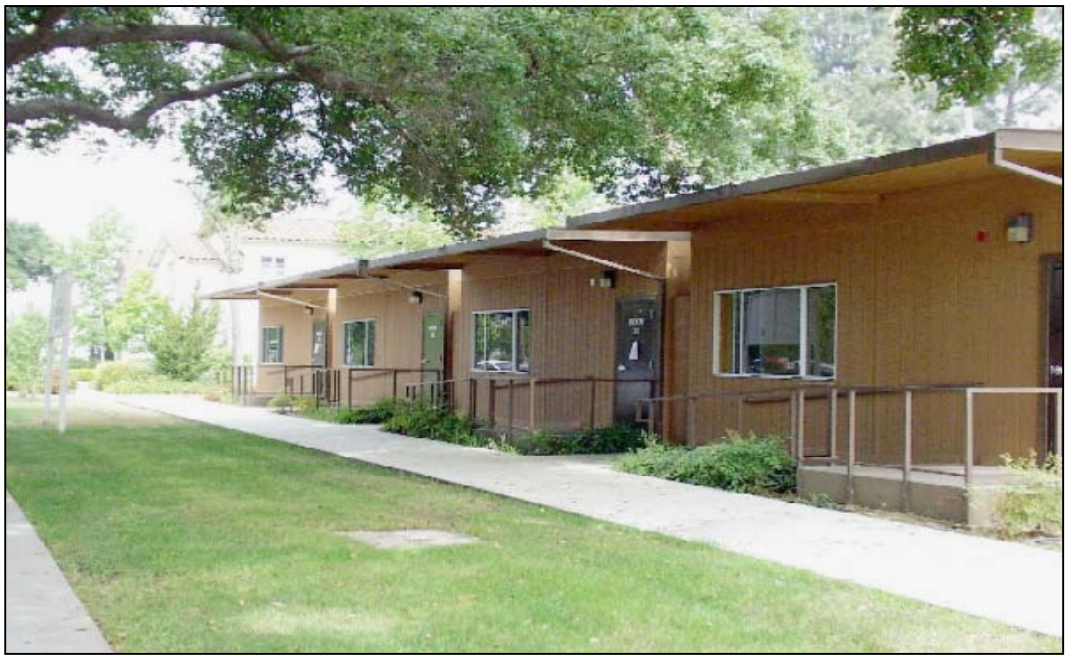
STAKEHOLDER PARTICIPATION

As directed in HSC §39619.6, ARB and DHS consulted with relevant state agencies and stakeholders at key points in the study. A website and email distribution list were established to keep interested stakeholders up to date on the progress of the study. ARB and DHS consulted with the Department of Education, the Department of General Services (including the Division of the State Architect and the Office of Public School Construction), the Office of Environmental Health Hazard Assessment, and other interested state agencies prior to the study regarding the overall study design and detailed information to be obtained, and upon completion of the final research report from RTI. Stakeholder input was obtained through comment periods and through several public workshops conducted both prior to the study and upon completion of the draft report.

BACKGROUND

A "portable classroom" is defined as "a classroom building of one or more stories that is designed and constructed to be relocatable and transportable over public streets…" (California Education Code, §17070.15[k]). Portable classrooms also are often referred to as relocatable classrooms, and occur in a variety of styles and forms. Based on a DHS survey of school districts, just under one-third (about 30%, or 80,000) of the State's 268,000 kindergarten to 12th grade (K-12) public school classrooms in the 2000-2001 school year were portable classrooms. It is estimated that about 80,000 to 85,000 are currently in use as classrooms in California.

Typical portable (relocatable) classrooms.



Portable classrooms serve an important need in California K-12 public schools. They are more quickly constructed and deployed to school sites, they can be moved from school to school, and they often have a lower first-cost than traditional, site-built buildings. These features allow schools great flexibility in meeting fluctuating enrollment levels. In the late 1990s, the availability of portable classrooms enabled the state to

achieve class size reductions aimed at improving learning achievement. Until 1998, the State required school districts that were requesting funding to design new schools with at least 30% of portable classrooms. This requirement was imposed as a cost-saving measure. With the Leroy F. Green School Facilities Act of 1998 and passage of Proposition 1A, this restriction was lifted, and school districts were given greater local control in the design of their schools, along with a revised formula for financing, based on per-pupil grants.

Health and Economic Impacts

In recent years, concerns have risen among teachers, parents, and the public regarding potential health risks at schools, especially associated with portable classrooms. The concerns have focused on immediate health complaints such as eye irritation, allergies, asthma, headache, and fatigue, as well as the carcinogenic, neurologic, and other risks of chronic exposures to air toxics, such as formaldehyde, lead, and pesticides. Chemical contaminants and biological agents, along with other indoor environmental problems in the classroom, have frequently been the focus of attention.

California public school buildings are used by more than six million children in grades K-12, close to 300,000 teachers, thousands of administrators and support staff, plus countless parent and community visitors on a daily basis. Many of these individuals spend a considerable portion of their time within the confines of school buildings over a period of years. Thus, ensuring healthful conditions inside classrooms is a critical factor in both teachers' and students' health and performance. Both groups may suffer the detrimental effects of poor environmental conditions; however, children generally are more vulnerable than adults to environmental contaminants and injury.

Asthma is among the most significant health problems associated with poor indoor environmental quality (IEQ) in schools. Asthma is a chronic disease of lung tissue involving inflamed airways and an increased sensitivity to contaminants in the air. Asthma is a leading cause of school absences, and it may account for as many as 3 million lost days of school missed by California students annually. In California, asthma prevalence for children is about 10%, and is highest among children 12 to 17 years of age. Schools with poor IEQ can contain many known asthma triggers – airborne particulate matter, chemical contaminants, and allergens such as dust mites, cockroaches, mold spores, and animal dander.

Poor environmental conditions in schools can also affect school productivity and student performance. The available evidence suggests that IEQ problems, such as low outdoor air ventilation rates and insufficient light, may reduce the performance of building occupants, such as students in schools.

An economic analysis of the costs of the impacts of poor IEQ on the educational sector has not been conducted. However, it is estimated that the benefits of improving IEQ in schools could total as much as $600 million – from reduced respiratory disease, reduced allergies and asthma, reduced eye and throat irritation, and worker

performance unrelated to health. This estimate only accounts for the impacts on teachers and school staff; it omits analogous effects on productivity and performance among the many more students sharing the school environment.

In addition to the benefits of improved health and productivity, properly maintained buildings prove to be more cost-efficient, because fewer resources are needed under prevention-oriented programs than when neglect leads to costly repairs or untimely replacement for major facilities.

Indoor Environmental Regulations and Guidelines for Public Schools

While school design and construction are subject to codes and regulations (discussed further below), there are few specific standards or guidelines on environmental conditions specifically addressing schools. Generally, Cal-OSHA (Department of Industrial Relations) enforces several regulations relevant to schools as workplaces: CCR Title 8 Section 3362 requires that workplaces be maintained in a sanitary condition, and subsection (g) requires that all types of water intrusion be avoided, and remedied when leakage occurs. Cal-OSHA also enforces the implementation of the Injury and Illness Prevention Program required under Section 3203, which requires development of a plan and training of appropriate staff to assure the health and safety of the school employees. Finally, Section 5142 requires ventilation systems to be operated continuously and maintained as they were designed to be, in order to provide sufficient fresh outdoor air.

The following guidelines and standards are applicable to, or can be applied to, school environmental conditions, but few are required to be met, and those that are in regulation are often not well enforced.

- **Ventilation**
  Requirements for heating, ventilating, and air conditioning (HVAC) systems in California stem from several sources.
  - Title 24 of the California Code of Regulation (CCR) addresses energy efficiency, and also specifies minimum outdoor air flows for different types of buildings; for classrooms, this is 15 cubic feet per minute (cfm) per person or 0.15 cfm per square foot, whichever is greater.
  - Cal/OSHA (CCR Title 8) enforces an HVAC standard for workplaces that requires that ventilation systems be operated and maintained to supply at least the minimum amount of outside air that was required at the time the system was last permitted.
  - The American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) provides professional guidance on minimum ventilation rates based largely on human health and comfort. While not regulatory, ASHRAE Standards, specifically Standard 62, *Ventilation for Acceptable Indoor Air Quality,* is an important reference for California's ventilation codes and recommended comfort levels. However, ASHRAE's standards are not set specifically to protect children.

- Carbon dioxide concentrations can serve as an indicator of ventilation sufficiency. Guidelines using indoor carbon dioxide concentrations as an indoor air quality indicator are available from ASHRAE and other sources, and range from about 800 to 1200 parts per million (ppm) as a "not to exceed" level.

♦ **Temperature and Relative Humidity**

Indoor thermal conditions are generally not subject to regulation. ASHRAE 's Standard 55-1992 provides guidance on thermal comfort, which can be a complex function of season, occupant activity, clothing, air movement, and other factors.

- ASHRAE's acceptable temperature range is 68-75°F in the heating season and 73-79°F in the cooling season under typical humidity and airflow conditions.
- ASHRAE's acceptable range for relative humidity is 30% to 60% under common conditions; higher humidity also should be avoided to prevent mold growth.

♦ **Air Pollutants**

There are standards set to protect workers in the work environment, and outdoor air quality standards and guidelines set to protect the general public. However, none of these are targeted toward protecting children, and only worker exposure levels are required to be met within school settings.

- Permissible Exposure Levels (PELs), developed by the California Occupational Health and Safety Standards Board, are limits for chemical air pollutants in industrial and other work environments.
- Federal and State ambient air quality standards (AAQS), established by U.S. EPA and the ARB, respectively, are developed to protect the general public from the harmful effects of traditional pollutants in outdoor air. California's AAQS are currently under review to ensure that they are protective of sensitive populations including children.
- Chronic and acute Reference Exposure Limits (RELs) developed by Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA) are non-regulatory guidelines developed to prevent harm from toxic air pollution.
- In the absence of indoor air quality guidelines or standards, the AAQS and OEHHA's RELs for acute and chronic effects may serve as useful guidelines for acceptable classroom air quality, but may not be fully protective of children.
- OEHHA has developed an interim 8-hour REL of 27 ppb, 8-hour averaging time, for formaldehyde, an almost ubiquitous indoor air pollutant, to identify the level below which irritant effects would not be expected to occur during typical day-time occupancy of buildings. Other 8-hour RELs are not yet available.
- Cancer potency factors developed by OEHHA can be used to judge potential cancer risk.

♦ **Noise**

Voluntary standards and guidelines for classroom noise have only recently been developed.

- The American National Standards Institute (ANSI) and the World Health Organization (WHO) recommend 35 decibels (dBA) as a limit for background classroom noise.

- The California Collaborative for High Performance Schools (CHPS) set the maximum noise level for unoccupied classrooms at 45 decibels as a prerequisite for the designation of a high performance classroom.
- The outdoor noise limit in many California communities is 55 dBA.

♦ **Lighting**
The Illumination Engineering Society of North America (IESNA) has established guidelines of a minimum of 30 foot-candles of light for large type/high contrast materials, and a level of 50 foot-candles for small type and/or low contrast materials.

♦ **Lead in floor dust**
The U.S. EPA standard is 40 micrograms of lead in dust per square foot for bare floors or carpets. The maximum allowable lead level is 250 micrograms per square foot for interior window sills. These standards are based on surface wipe samples and were developed for the protection of the most susceptible group, children under 6 years of age.

Design and Construction of Portable Classrooms

Portable classrooms used throughout California are typically 12x40 feet modular units fitting together in pairs (or more), with a metal roof, and a wall-mounted heat pump with air conditioning. Generally, the windows are relatively small, but they are usually operable. Exteriors and floors are usually plywood or composite wood siding, and interior walls are most often vinyl-covered tackboard. In recent years, designs with a concrete wall as well as two-stories have become more common. Most importantly, numerous improvements have been made in roofing, siding, windows, heating and air conditioning, lighting, and insulation.

All public school facility construction within the State of California, including portable classrooms, must comply with the California Building Standards Code. This code is contained in Title 24 of the California Codes of Regulation (CCR). The State has some of the nation's most stringent energy efficiency standards, which are contained in CCR Title 24 (Part 6) and include provisions on the building envelope, water-heating systems, lighting systems, and heating, ventilation and air conditioning (HVAC) systems. The Department of General Services (DGS) oversees the design, construction, and financing of educational facilities.

♦ The Division of the State Architect (DSA) is responsible for reviewing design plans and construction for all new school facilities, additions, alterations, and modernization projects, including portable classrooms. Although the building design plans and the State Building Standards Code address all aspects of the school design and construction, the DSA plan-check focuses on three areas: the structural design (i.e., seismic safety), handicap accessibility (i.e., compliance with the Americans with Disability Act and related standards), and fire & life safety concerns (e.g., sprinklers, fire alarms). DSA also certifies inspectors, which schools are required to hire to oversee on-site school construction and portable manufacture.

- The Office of Public School Construction (OPSC) administers state appropriations for public school facilities construction and modernization, leasing of relocatable classrooms, and funding for deferred maintenance. OPSC purchases and maintains a set of portable classroom units as part of the State Relocatable Classroom Program. This program was initially established to provide classrooms on an emergency basis, but portables now are also used by districts impacted by rapid growth and modernization projects. The State owns approximately 6000 portables that are leased to school districts on an as-needed/as-available basis. The State purchases about 200 new portables per year, on average. Funding for portables comes primarily from lease revenues. Current costs for a portable classroom range from about $25,000 to $47,000; districts lease them for $4000 per year.

  The OPSC continually reviews the classroom specifications to assure that they meet or exceed Title 24 requirements. Current OPSC specifications exceed the minimum Title 24 standards in several areas, including:
  - ✓ An interior moisture barrier is required at all metal roof structures to prevent moist interior air from contacting metal elements and producing condensation.
  - ✓ Wall insulation requirements have been upgraded from R-11 to R-13, and ceiling insulation has been upgraded from R-19 to R-22.
  - ✓ All windows are now dual glazed "low e".
  - ✓ Lighting systems include T8 fluorescent type with photoelectric control.

  State Relocatable Classrooms have always met or exceeded construction codes in effect at the time of approval. Additionally, they comply with ASHRAE standards for temperature control.

  OPSC also has taken, and plans to take, other steps to improve the state portable classroom specifications for their impact on indoor environmental quality. For example, all adhesives used for carpet or rubber baseboard installation must be water-based adhesives, and lighting systems are designed to provide 50 foot-candles at the desk level. OPSC's wallboard has been tested and contains no detectable formaldehyde residue. However, OPSC plans to require that tackboard wall material and fiberglass insulation contain no detectable formaldehyde. They are also considering several options for quieting noisy ventilation systems.

  OPSC is currently developing several relocatable classroom guides for schools that lease relocatables through the State Program. The guidebooks will provide information to custodians, maintenance staff, and teachers to help assure that classrooms are properly maintained. Additionally, OPSC has arranged for distribution of the guides whenever new relocatables are delivered to a site.

  OPSC also administers the Deferred Maintenance Program (DMF), which provides funding to school districts for major repairs and upgrades, such as new roofs and plumbing. However, funding for the DMF is variable, fluctuating from year to year.

Extreme Hardship Grants are available for urgent projects needed within one year for health and safety or structural reasons for traditional classrooms.

Programs for Improved School Buildings

Several programs in California are already addressing some of the problems identified in this study, and others are under development or have been proposed. Some new programs were begun either before or during the period of this study, and provide mechanisms to implement some of the recommendations discussed in this report. These programs include:

- State new school construction and modernization bonds. California has recently made historic investments in new school construction and modernization of older schools. Last year Governor Davis signed legislation to place a $25 billion school bond package on the state ballot. California voters approved the first bond in November, 2002, providing school districts with $11.4 billion in funding for new construction and modernization of K-12 schools. Already more than $6 billion has been allocated to school districts statewide to begin new construction and modernization projects. New bond funding will reduce the need for portable classrooms in California schools, and where the need remains, will provide funding to replace aged portable classrooms with classrooms that meet high environmental and health standards. The remaining $13 billion bond is scheduled to go before the voters on the March 2004 primary ballot.

- The Los Angeles Unified School District's (LAUSD) Facility Inspection Program is a comprehensive self-assessment of all district schools for basic health and safety conditions (Bellomo, 2003). After their first round of inspections, LAUSD officials determined that many of the basic problems found could be remedied by custodians or other school personnel, generally at less than $50 additional cost. Some of these basic problems included factors such as blocked fire extinguishers and improper use of electrical cords, important safety items critical to child safety not studied in the Portable Classrooms Study reported in this document. However, they also included items such as proper storage of chemicals and implementing an Illness and Injury Prevention Program, which also are handled by school personnel. LAUSD has developed a detailed tracking system to assure that problems identified are addressed. LAUSD's "Safe School Inspection Guidebook", a checklist, is provided in Appendix V, and can serve as a good starting point for other districts and schools undertaking a self-inspection. LAUSD also has adopted the CHPS criteria for new school construction (see next bullet).

- The Collaborative for High Performance Schools (CHPS) is a consortium of public agencies and energy utilities in California working to facilitate the design and construction of "high performance" schools. These schools serve as models of energy and resource efficiency, as well as provide a healthy and comfortable environment conducive to the learning process. The core of CHPS is a set of *Best Practices Manuals* that provides an array of options for improved school planning

and design. This approach allows school boards to declare their intentions to build high performance schools, despite a lack of explicit knowledge of specific components. The CHPS criteria give facility designers latitude to incorporate practices in a manner that best fits the district's needs and budget. Only a very small percentage of California districts and schools have utilized CHPS excellent guidance to date.

- U.S. EPA's *IAQ (Indoor Air Quality)Tools for Schools Program* is a program developed to help schools identify and prevent indoor air quality problems, using a team approach to school IEQ management. The program provides educational materials and tools for evaluating the impact of school maintenance functions and occupants' daily activities on indoor air quality. U.S. EPA makes their *IAQ Tools for Schools* action kits available at no cost, and has funded numerous training workshops, including many in California. Despite the outreach, awareness and use of the program among California schools are still relatively low: in this study, 35% of schools reported that they were familiar with the program, and 11% of California schools reported that they use all or part of the program. This may be due to a misperception regarding the level of effort required: the program is adaptable to any level of resources, and numerous schools in California have successfully implemented the program and demonstrated its cost-effectiveness.

- An Interagency State Workgroup on Relocatable Classrooms was recently formed to identify opportunities to implement Governor Davis' sustainable building goals with respect to portable classrooms. The workgroup is a subgroup of the State Sustainable Building Task Force formed to implement Executive Order D-16-00. The workgroup is in the early stages of reviewing and developing revisions to the State specifications for portable classrooms leased by OPSC. The workgroup will also be coordinating a program to upgrade existing classrooms.

- The Lead-Safe Schools Project was begun in 1998 by the UC Berkeley Labor Occupational Health Program, DHS's Childhood Lead Poisoning Prevention Program, and the state Department of Education. The Project provides training, focused documents and a hotline for training school maintenance department staff regarding sources (primarily old paint) and remediation of lead in California schools. Grant funding for the training recently ended. Starting in 2004, the Lead-Safe Schools Protection Act (SB 21, Escutia, Statutes of 2002) requires that schools certify that they will follow all standards for the management of lead hazards when they apply for state modernization funding.

- Integrated Pest Management (IPM). The Healthy Schools Act of 2000 (AB 2260, Shelley) mandated the Department of Pesticide Regulation (DPR) to promote voluntary school IPM programs. IPM includes the use of non-chemical practices to reduce pest populations, using least toxic pesticides to treat infestations above designated thresholds, and training relevant individuals regarding IPM approaches. The Act also directed schools to comply with certain requirements to reduce exposures to pesticides at schools, such as parental notification of pesticide

applications, warning signs, recordkeeping at schools, and reporting of pesticide use by licensed pest control businesses that apply pesticides at schools. Meeting these requirements is the responsibility of individual school districts, and DPR does not enforce compliance.

- Blueprint for School Facility Finance. In a 2001 report, the California Legislative Analyst recommended changes to the finance system for K-12 school facility capital outlay (LAO, 2001). The authors identified several key deficiencies with the existing finance system, and proposed a new "blueprint" for more effectively financing new school construction and modernization:

  - ✓ Annual appropriations for capital outlay, rather than the current approach of intermittent voter-approved bonds;
  - ✓ Allocation of funds to school districts based on a per-pupil formula, rather than the current project-specific, first-come, first-served basis;
  - ✓ More local control and responsibility through an accountability program; and
  - ✓ Transition funding to address current unmet facility needs.

  Because school facilities are such a substantial investment and it is the responsibility of the districts to ensure their maximum useful life, the LAO felt that facilities maintenance funding would be more efficient if there was greater local accountability. The LAO suggested that "districts should set aside a prescribed annual contribution from their operating budget to fund facility maintenance, or certify at a public hearing that a lower amount is sufficient to meet their maintenance needs." The LAO recommendations would lead to a more focused state role in technical assistance and oversight regarding planning, constructing, and maintaining school facilities.

METHODS

The sampling approach used in this study was designed to obtain a statistically representative sample of the "target" study population, which was defined as all public schools in California with at least one portable classroom in spring 2001. The study was conducted in two phases. Phase I consisted of a mail survey returned by 384 of more than 1000 schools randomly selected statewide. For each school, the facility manager and three teachers (two from portable classrooms and one from a traditional classroom) were asked to complete detailed questionnaires on all aspects of the classrooms. Additionally, formaldehyde sampling tubes were sent to about two-thirds of the schools, for deployment in the three classrooms. In Phase II, a comprehensive suite of chemical, biological, and environmental measurements were obtained in 201 classrooms at 67 schools statewide. Similar to Phase I, two portable classrooms and one traditional classroom were studied at each school. Quality control checks were performed for field and laboratory measurements, and for entry of questionnaire and inspection data.

RESULTS AND DISCUSSION

Both portable and traditional classrooms were found to have some environmental conditions that need improvement. However, the most serious problems occur only in a small percentage of classrooms. Remedies to address the problems identified are available; however, the solutions would require a combination of actions by the State, school districts, individual schools, manufacturers, and others. Many of the solutions are relatively low-cost. For example, improved operation and maintenance would go a long way to address many of the problems identified. Similarly, routine use of no- or low-emitting building and classroom materials would typically add only minimal cost, and quieter HVAC units can cost as little as $300-400 more per unit.

The results and recommendations presented below **apply to both portable and traditional classrooms** unless otherwise specified. The primary results include the following:

Ventilation

- In both types of classrooms, the amount of outdoor air exchange was inadequate over 40% of the time (carbon dioxide levels exceeded 1000 ppm), and seriously deficient for about 10% of classroom hours (carbon dioxide levels exceeded 2000 ppm). This is a critical finding; this latter group clearly did not meet state ventilation requirements for continued outdoor air, and such deficiencies have been associated with increased eye and throat irritation, lethargy, headache and other symptoms that are incompatible with an acceptable learning environment.
- 60% of teachers in portables indicated they turn off the ventilation system at times due to excess noise; 23% of teachers in traditional classrooms reported doing this.
- Portables had more HVAC problems than traditionals, including higher rates of dirty air filters (40% vs. 27%), blocked outdoor air dampers (11% vs. 3%), and poor condensate drainage (59% vs. 12%) which can lead to microbial contamination.

Overall, the HVAC systems delivered adequate outdoor air and total airflows when operated properly, so design capacity did not appear to be a common problem in this study. Complaints of stuffy room air usually result from the HVAC not being operated properly. This occurs primarily for three reasons: the thermostat control limits the amount of time the system fan is operating; the outdoor air damper is blocked or in a closed position; or the teacher simply turns off the system because the noise is disruptive to class activities.

Excessive noise is the primary issue that needs to be addressed by HVAC and portable classroom manufacturers; low noise levels should be specified by schools and the State when purchasing new portables. In addition, operation and maintenance of HVAC systems needs to be improved at many schools; training of facility staff and teachers should be undertaken and regular inspection and maintenance programs followed to avoid larger problems that can result when ventilation systems are not properly operated and maintained.

Dirty air filters can reduce airflow and provide a breeding ground for mold.

Temperature and Humidity

- 27% of portables and 17% of traditionals experienced temperatures below ASHRAE's thermal comfort standards for the heating season. Some classrooms of both types also experienced temperatures above the ASHRAE standard range for acceptable indoor temperature during cool weather.
- About 11% of all classrooms had relative humidity (RH) levels below 30%, and 14% had RH levels above 60%, outside of the ASHRAE standards range for acceptable RH. Portable classrooms had slightly higher RH than traditional classrooms.
- Properly operating and maintaining HVAC systems should remedy these problems in most classrooms.

Air Pollutants

- Formaldehyde and other aldehydes:
  - ✓ Indoor concentrations were elevated above OEHHA's interim 8-hour REL for acute eye, nose, and lung irritation in about 4% of the classrooms. This totals about 10,720 classrooms, or at least 214,400 children (assuming 20 children per classroom…there usually are more) exposed to formaldehyde levels that could potentially result in irritant effects.
  - ✓ Levels in virtually all classrooms exceeded OEHHA's chronic REL (1.3 ppb) for irritant effects and OEHHA's one-in-a-million excess lifetime cancer risk level (0.13 ppb) for formaldehyde. However, levels of formaldehyde in homes and offices virtually always exceed these levels as well, and it is generally not feasible to achieve levels below these guideline levels, because outdoor levels near schools average about 3-5 ppb.
  - ✓ Highest levels occurred primarily in the warmer seasons, which increases off-gassing of volatiles such as formaldehyde.
  - ✓ Portable classrooms generally had higher formaldehyde levels than traditionals.

- ✓ A higher percentage of portables have building materials known to emit formaldehyde, including pressed-wood materials and furniture, and carpets. Formaldehyde emissions and levels in new building materials are estimated to take about 3 to 5 years to off-gas before they reach relatively low levels.
- ✓ Alternative low- and no-emitting materials are available and should be used in constructing new portable classrooms.
- ✓ Other aldehydes (especially acetaldehyde) also were generally found in higher concentrations indoors than outdoors due to indoor sources.

- Volatile organic compounds (VOCs)
  - ✓ Many VOCs were present indoors due to numerous common indoor sources, but at levels similar to or lower than those in other indoor environments.
  - ✓ Levels were below acute (immediate effects) risk levels.
  - ✓ Some classrooms would exceed the one-in-a-million excess lifetime cancer risk level for benzene and chloroform if the exposure continued for a lifetime. However, the much shorter exposure in classrooms presents a much lower risk. Also, outdoor levels exceeded the one-in-a-million risk level, and most of the classroom risk is the result of emissions from common outdoor sources.

- Particulate matter
  - ✓ Total particle counts were similar for both types of classrooms for PM10 and PM2.5 size ranges, but the highest levels were seen in portables.
  - ✓ Outdoor particle counts were usually about twice the indoor counts.
  - ✓ Vehicle traffic was likely an important particle source for both types of classrooms: over 50% of both portables and traditional classrooms were within 50 feet of parking lots, roadways, and loading docks. Portables often are sited with their ventilation units and air intakes facing roadways and parking lots, which may account for the higher counts in some of the portables.

Dumpsters and loading docks next to classrooms: odors, dust, and motor vehicle exhaust often infiltrate into classrooms from outdoor sources.

Floor Dust Contaminants

Persistent contaminants were examined in floor dust samples collected with a specialized vacuum cleaner. Analyses of floor dust can provide insight into potential past and present contaminant exposures that cannot otherwise be obtained with a routine air sample. Metals, pesticides, polycyclic aromatic hydrocarbons (PAHs, a group of semi-volatile organic compounds emitted during combustion processes, many of which are known or suspected carcinogens), and a variety of allergens were examined in the dust samples.

- Metals
  - ✓ Elevated levels of lead were measured in some floor dust samples, most likely from tracked-in soil or paint chips from old paint indoors or outdoors.
  - ✓ Arsenic levels were slightly higher in portables; more importantly, levels in both types of classrooms appeared to exceed typical levels found in California soils. Arsenic is a natural soil contaminant, and the primary source would be soil track-in. The elevated levels indicate possible additional school ground contamination from fertilizers and wood preservatives, some of which contain arsenic.

- Pesticides
  - ✓ Residues of both generally available and restricted-use pesticides were found in all floor dust samples, indicating the recent and historical use of pesticides in and around schools.
  - ✓ Six pesticides were detected in over 80% of the samples: esfenvalerate, chlorpyrifos, *cis*- and *trans*-permethrin, *o*-phenylphenol, and piperonyl butoxide. The sale of chlorpyrifos for use in schools was banned in late 2001, but chlorpyrifos can last up to a year or more in the environment. The five other pesticides last just a few weeks.
  - ✓ Pesticides enter classrooms either during application or by being tracked in on shoes or clothing from the outdoors.
  - ✓ Children can be exposed to pesticides through inhalation, ingestion (hand-to-mouth activity), and dermal contact. Children in the lower grades tend to spend a substantial amount of time sitting on the floor, bringing them into closer proximity to pesticides found in floor dust.
  - ✓ Further assessment of these pesticide results is underway.

- Polycyclic Aromatic Hydrocarbons
  - ✓ Most of the 16 PAHs studied also were found in over 80% of the classroom samples, but levels in the floor dust were low relative to levels found in homes in recent studies.
  - ✓ Average levels were similar in portable and traditional classrooms, but portables had the highest levels. The reason for this is not known.

- Allergens
  - ✓ Cat and dog allergens were found in more than half of the classroom samples. The concentrations were generally below sensitization levels; however, classroom levels could cause symptoms in persons with pre-existing allergies.
  - ✓ Cockroach and dust mite allergens were found only infrequently.

Moisture and Mold

- In the Phase I mail survey, 69% of the teachers reported smelling musty odors in their classroom, 43% reported current or previous floods or leaks, and 11% reported visible mold.

- Field observations by the study technician in Phase II showed that:
  - ✓ 21% of the portable classrooms and 35% of traditionals had visible water stains on the ceiling, and 13% of portables and only a few traditionals had visible water stains on the floor.
  - ✓ 17% of all classrooms (12% portables, 20% traditionals) had excess moisture measured in the walls, ceiling, or floor. Excess moisture was measured as material moisture content above levels measured in comparable known dry material.
  - ✓ 3% of portables and almost no traditionals had visible mold on the ceilings; 3% of all classrooms had visible mold on exterior walls.

Water stains and measurements of excess moisture in building materials often indicate hidden mold, and at a minimum indicate a moisture problem such as a leak that needs to be remedied. Any mold present in a classroom or its wall voids, flooring or plenum should be properly remediated, since mold can trigger allergy symptoms and asthma attacks in individuals with those sensitivities. Proper remediation may range from scrubbing a small area with detergent and water to following procedures also used for asbestos remediation. In all cases, the moisture source must be corrected.

Water leaks in roofs and near HVAC units are common causes of moisture and mold problems.

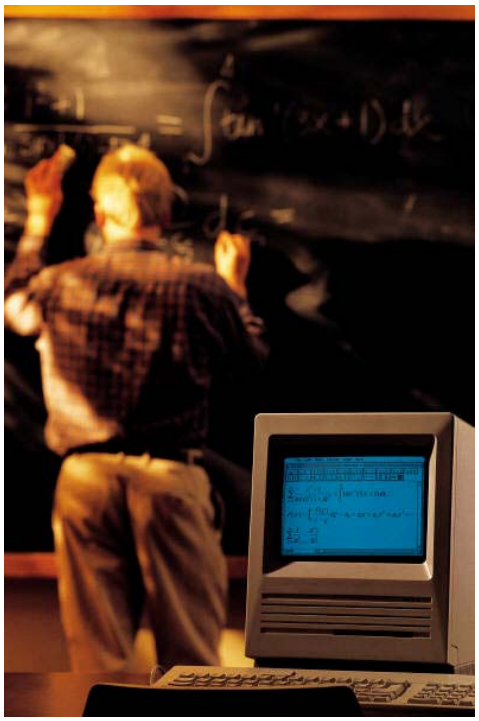
Noise

- All classrooms exceeded the recently developed ANSI acoustic standard and the WHO guideline of 35 decibels background noise for unoccupied classrooms.
- A substantial portion of unoccupied classrooms (50% portables, 38% traditionals) had measured noise levels exceeding the outdoor nuisance standard of 55 decibels used by some California cities. It is excessive noise levels that leads some teachers to turn off the HVAC systems.
- Stakeholders have indicated that a noise level of 45 decibels is achievable with some associated costs and focused effort; 35 decibels appears technologically and financially unattainable at this time. California does not have a noise guideline or standard for classrooms. CHPS has set a maximum level of 45 decibels as the goal for high performance schools.

Lighting

- About one-third of classrooms do not meet IESNA professional design guidelines of 50 foot-candles for low contrast materials, and a small percentage of classrooms do not meet the guideline of 30 foot-candles for high contrast materials.
- Portable classrooms had somewhat lower lighting levels than traditional classrooms.

Lighting was inadequate in one-third of the classrooms. Daylighting is best with proper design and location, but can lead to glare and shadows if not well-designed.



RECOMMENDATIONS

Actions are needed at all levels to provide classroom environments that are healthy and conducive to effective learning for K-12 students. Approaches to prevent and remedy most of the problems identified in this study are available; while some may be subject to fiscal constraints, most often what is needed is systematic review and attention to these issues. Many of the problems identified in this study can be addressed through meeting existing State standards and guidelines (primarily those of Cal-OSHA), including requirements to provide continuous outdoor air exchange; improved operation and maintenance programs; and focused training efforts. Many can be addressed at relatively low cost.

There are four key approaches needed to remedy the problems identified in this study, each with several specific recommendations for implementation. The four over-arching approaches are:

- Direct and assist schools to comply with State regulations, especially workplace regulations related to operation and maintenance.
- Develop and promote "Best Practices" for design, construction, operation and maintenance of school facilities.
- Improve support (funding and training) for school facilities and staff.
- Establish needed guidelines and standards for school environmental health.

Each specific recommendation below supports one or more of these over-arching approaches. The specific recommendations are presented in two groups:

> **Group 1**: includes actions that are high priority and would yield high benefits at relatively low cost. These recommendations should be pursued within the next one to two years.
>
> **Group 2**: these recommendations are also a priority, but will require a longer-term effort and/or additional resources in order to be fully implemented. These actions should be initiated in the next year or so, but may require four to five years to implement fully.

Group 1: High Priority, High Benefit Actions, with Relatively Low Cost

Group 1 recommendations build largely on regulations, programs and activities that are already in place but that are not fully met or utilized.

1. **Meet State Regulations.** Schools, districts, and the state should assure that all school buildings meet all relevant State regulations, particularly those related to

operation and maintenance. Many classrooms do not meet various existing State standards, and meeting those regulations would go far to provide healthful conditions in classrooms. For example, operating HVAC systems as they were intended to be operated to assure adequate outdoor air ventilation, per Title 8 Section 5142; developing a health and safety program and training employees to implement that program, per requirements of the Injury and Illness Prevention Program regulation; and maintaining sanitary conditions and correcting water intrusion, leakage, and uncontrolled accumulation of water to reduce the potential for mold growth – all workplace requirements enforced by Cal-OSHA – would correct several of the major problems seen in classrooms. To achieve this, many districts may need to increase their maintenance staffing: many districts do not meet the maintenance staffing ratios recommended by the California Association of School Business Officials (CASBO). Some remedies may not be low-cost, depending on the nature of the non-compliance.

2. **Conduct District and School Self-Assessments**. Districts/schools should conduct "self-assessments" of basic safety and health conditions, similar to the self-inspection program undertaken by the LAUSD. In addition to assessing whether state regulations are being met, self-inspections can also be used to remedy obvious problems that are not necessarily regulated, and as a first step to begin to incorporate "Best Practices" into operation and maintenance functions (see below). The LAUSD's basic checklist is provided in Appendix V; districts/schools can use all or part of it to conduct their own walk-throughs and identify key problems in the near term. Conditions that can be corrected with little or no cost should be remedied promptly. Plans should be developed to obtain resources to address those that require additional funds to remedy; for example, noisy HVAC units should be scheduled for modification or upgrade.

3. **Require IEQ Management Plans**. The State should require districts and schools to develop an IEQ Management Plan. Such a plan would complement and extend the benefits of the self-assessment discussed above. The U.S. EPA's *IAQ Tools for Schools Kit* provides guidance for developing such a plan: see http://www.epa.gov/iaq/schools/. Visalia, Saugus, and San Francisco, among others, have successfully and cost-effectively implemented *IAQ Tools for Schools* in their schools. Districts and schools should implement key provisions of the program and other preventive operation and maintenance measures that are high benefit/low cost, including:
    a. Appoint an IEQ manager and form an IEQ team.
    b. Establish a regular inspection and maintenance schedule; ensure that HVAC systems are thoroughly cleaned and inspected at least annually.
    c. Use checklists for core inspection and preventive actions.
    d. Educate the building occupants: e.g., ventilation systems should remain "on", and pollutant sources such as "air fresheners" should not be brought into the classroom.

   e. Implement procurement policies and practices for classroom furnishings and supplies that assure good indoor air quality, such as desks and bookcases that emit no formaldehyde.

4. **Establish "Best Practices" Policy**. The State should establish a policy to incorporate "Best Practices" into the design, construction, operation, and maintenance of new California schools, especially the measures developed by the Collaborative for High Performance Schools (CHPS). Because of the large number of new construction and renovation projects statewide at this time, there is a unique opportunity to foster a new generation of classrooms that provide a healthful environment conducive to learning. The CHPS *Best Practices Manuals* provide an array of options and information that can be used in designing, constructing, and renovating school buildings. CHPS-based schools have a high potential for reduced energy consumption, and thus save energy dollars as well. The CHPS manuals and videos are available at http://www.chps.net/; manuals for operation and maintenance are under development. Districts and schools should use CHPS Best Practices to the fullest extent feasible, at a minimum incorporating a few of the low-cost options that are suitable for their situation. Additionally, specific recommendations gleaned from this study and from stakeholders' input, are included in Appendix VI. Key examples are:
   a. Specify no- and low-emitting building materials and furnishings in construction contracts and solicitations. This should include using exterior grade wood products or other low-emitting materials in wall & floor materials; no-formaldehyde insulation, ceiling tiles, and cabinetry; and other low- or no-emitting materials to avoid elevated formaldehyde and VOC levels.
   b. Specify HVAC systems that provide sufficient airflow at less than 45 dBA.
   c. Design sprinklers and landscaping properly so water does not hit the building, and drains away from the structures.

5. **Expand State Design Review**. State-level design review for new buildings and major renovations should be expanded. Review and approval of elements such as ventilation system design and building materials should be added to the routine structural, fire and life-safety, and accessibility plan-check function of the Division of the State Architect (DSA). The DSA is currently initiating specification revisions and implementing a more proactive approach in plan reviews, but additional trained staff are needed for the additional work. DSA and OPSC should be permitted to hire the needed staff to the extent resources allow.

6. **Assure Proper Siting**. Portable classrooms should be sited appropriately, away from highways and busy roads, and with proper grading. Individual portable classrooms should not be placed over low drainage areas that experience flooding. The foundation skirt should be at least 6 inches or more above ground level to prevent wicking of water up the wall, and adequate crawlspace ventilation should be specified. Some of these measures may not be low cost for some schools.

7. **Limit Noise Levels in Classrooms.** Implement an interim state requirement for a maximum unoccupied classroom decibel level of 45 dBA in new classrooms, and encourage specific sound reduction measures, especially reduction of noise from HVAC systems and lights.

Group 2: Priority Actions Requiring a Longer Term Effort and/or Substantial Additional Resources

8. **Assure stable, long-term funding.** The State and districts need to develop stable, long-term funding mechanisms and sources for both school construction and preventive maintenance. Current funding programs are strained, fluctuating, and often function on a short timeframe. The current year-to-year fluctuation of the existing Deferred Maintenance Program does not provide stable, consistent funding for long-term planning and preventive maintenance. Implementation of the recommendations of *The California Master Plan for Education* drafted by a Joint Legislative Committee and *A New Blueprint for California School Facility Finance* by the Legislative Analyst's Office (May 2001) would provide some substantial progress, particularly for construction. However, preventive maintenance is not adequately addressed in these plans, and requires further action.

9. **Develop Focused Training.** The State should develop and offer coordinated training programs and materials for facility managers, custodial staff, and teachers, in cooperation with interested organizations. Those who are closest to the classroom are often not aware of current "best practices" for operation and maintenance of classrooms. For example, teachers inadvertently bring pollutant sources into the room, improperly adjust thermostats, or take other actions that can have a major impact on the environmental conditions of the classroom. Training is an important part of U.S. EPA's *Tools For Schools Program*. Focused statewide training programs are needed over the long-term to assure that key school staff receive appropriate training, so that they can routinely train new staff as they come on board. DSA and OPSC should develop training programs and materials in consultation with ARB, DHS, CEC, Cal-OSHA, and other relevant agencies, as well as CASBO, CASH, and other relevant external groups. These should include:
    a. A Training and Certification Program for School Facility Managers. Success in operation and maintenance is often a function of the strength and knowledge of facilities directors, yet there are few credentials districts can apply in their selection of key facility department personnel. Districts should hire trained, certified facility managers.
    b. Development and routine distribution of training materials for custodial staff on proper vacuuming and cleaning procedures. Effective vacuuming of carpets requires an efficient vacuum plus a reasonable "residence time" of the vacuum on the carpet surface in order to effectively remove particles. This can effectively reduce persistent contaminants in carpeted classrooms. Vacuums do not need to be true HEPA, but do need to be efficient, and have virtually no particle leakage in the exhaust. Additionally, use of "safe" liquid or spray cleaning products is a key component of a healthy building.

c. Development of training materials and programs for teachers that builds on information in EPA's *Tools for Schools Kit*, and includes more specific information on California ventilation requirements and sources of indoor pollutants.

10. **Implement Integrated Pest Management Programs.** Integrated Pest Management Programs should be implemented at all schools. The passage of the Healthy Schools Act of 2000 established requirements for schools to notify parents of pesticide use and to consider IPM. Successful application of IPM has been sufficiently widespread to support its implementation at all public schools, and to eliminate the use of pesticides with the greatest potential for toxic effects by school personnel. A program of preventive housekeeping practices and use of least-toxic pesticides when application is necessary has many benefits. See the Department of Pesticide Regulation website at http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/main.cfm .

11. **Retire older portable classrooms**. Classrooms should be removed and replaced when they become unserviceable or do not provide an adequate learning environment for children. Some older portables are well past the stage at which they should have been replaced with a new portable or a site-built classroom. New portable or site-built buildings will generally not only provide an improved environment but also will be more energy-efficient, with substantially reduced energy costs relative to the old buildings.

12. **Develop and require full building commissioning procedures**. These procedures are "best practices" for new buildings and classrooms. They should include complete testing of HVAC, lighting, and other building systems under normal and high-capacity operational conditions.

13. **Improve school facility database**. The State needs an effective system to inventory public school facilities. These represent among the State's greatest set of assets, yet there is no complete database on the condition, location, or even number of school buildings.

14. **Convene a task force on noise**. A task force of experts in audiology, medicine, education, and related fields should be convened by the State to develop a California indoor noise guideline or standard for K-12 schools. If needed, promote technology development to meet such a guideline or standard.

15. **Develop State-level chemical exposure guidelines or standards for classrooms.** There is a lack of benchmarks for fully assessing and assuring healthful environmental conditions specific to classrooms and to the children and teachers who occupy them. Currently available guidelines and standards applied in this report may not be fully protective of children.

16. **Re-design portable classrooms from the ground up**. Although many improvements have been made in recent years, many portable classrooms manufactured today are still based on designs and materials that have been available for 20-30 years or more, and on an assumption of a need for frequent relocation, which has not proven to be common. Southern California Edison, Lawrence Berkeley National Laboratory, and several portable classroom manufacturers have begun to develop very different styles of relocatable classrooms which use an integrated, "whole-building" approach. These should be fully developed and used on a trial basis under different conditions to determine if these newer designs might better meet future classroom needs.

Implementation of some of the recommendations above will clearly incur costs to those involved, and will require fiscal planning to achieve. However, the cost of not taking these actions appears high – potentially harmful impacts on children's and teachers' health, reduced learning, reduced educational progress, and, in some cases, higher costs to fix facility problems when they become more serious. Most importantly, State building, ventilation, and workplace regulations have been developed to assure safety and health, and must be met.

The LAUSD's self-inspection program has shown that much can be done at relatively low cost, and provides a good starting point. The CHPS *Best Practices Manuals* and U.S. EPA's *IAQ Tools for Schools Action Kits* provide readily available guidance that can be used by districts and schools at varying levels, based on their individual resources and situations. The experiences of Visalia, Saugus, San Francisco, and other districts have shown that *IAQ Tools for Schools* can work well in California.

More detailed recommendations for schools and districts are provided in Appendix VI, which is a working document that will be updated periodically and made available on ARB's website.

CONCLUSIONS

Environmental health conditions that require improvement were identified in this study. These include a variety of problems, such as inadequate design, operation, and maintenance of ventilation systems; contaminants present at undesirable levels in the air and floor dust; excessive noise levels; inadequate lighting; and mold and moisture problems. A number of programs initiated by the State, school districts, and others before or during the conduct of this study are already beginning to address some of these concerns. However, much more must be done to assure that existing problems are remedied and future problems prevented. The State, school districts, school administrators, school facility managers, teachers, parents, manufacturers of portable classrooms, manufacturers of ventilation systems, and others who provide materials and supplies used by our schools all have an important role in improving the environmental health conditions of our schools. Most importantly, California needs to transition from a focus on remediation to a focus on prevention.