California Environmental Protection Agency

Air Resources Board

Gray Davis, Governor

Department of Health Services

DRAFT

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)

July 18, 2003

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ACRONYMS

Acronym	Definition
AAAAI	American Academy of Allergy Asthma and Immunology
AAQS	Ambient Air Quality Standards
AB	Assembly Bill
ACSA	Association of California School Administrators
AHERA	Asbestos Hazard Emergency Response Act
ALA	American Lung Association
ANSI	American National Standards Institute
ARB	California Air Resources Board
ASHRAE	American Society of Heating, Refrigerating, and Air-conditioning Engineers
CAASA	California Asthma Among the School-Aged
Cal/OSHA	California Department of Industrial Relations, Occupational Safety and Health Administration
CASBO	California Association of School Business Officers
CASH	Coalition for Adequate School Housing
CCR	California Code of Regulations
CDC	Federal Center for Disease Control
CDE	California Department of Education
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CHPS	California Collaborative for High Performance Schools
CIWMB	California Integrated Waste Management Board
CLPPP	Childhood Lead Poisoning Prevention Program
DGS	California Department of General Services
DHS	California Department of Health Services
DOE	U. S. Department of Energy
DPR	California Department of Pesticide Regulation
DSA	California Division of the State Architect, Department of General Services
EPA, U.S. EPA	U.S. Environmental Protection Agency
GAO	U.S. General Accounting Office
HEPA	High efficiency particulate arrestance
HSC	California Health and Safety Code
HVAC	Heating, ventilating, and air conditioning
IAQ	Indoor air quality
IDEC	Indirect-direct evaporative cooling
IEQ	Indoor environmental quality
IESNA	Illumination Engineering Society of North America
IPM	Integrated Pest Management
IREL	Indoor Reference Exposure Level
LAUSD	Los Angeles Unified School District
LEED™	Leadership in Energy and Environmental Design
LBNL	Lawrence Berkeley National Laboratory

NAAQS	National Ambient Air Quality Standards
NIOSH	National Institute for Occupational Safety and Health
O&M	Operation and Maintenance
OEHHA	California Office of Environmental Health Hazard Assessment
OPSC	California Office of Public School Construction, Department of General Services
OSHA	U.S. Occupational Safety and Health Administration
PAH	Polycyclic aromatic hydrocarbon
PBO	Piperonyl butoxide
PCS	Portable Classrooms Study
PEL	Permissible Exposure Limit
PM	Particulate matter
PRG	Preliminary Remediation Guidelines
REL	Reference Exposure Limit
RH	Relative Humidity
RTI	Research Triangle Institute
SB	Senate Bill
SBS	Sick Building Syndrome
SCE	Southern California Edison
SFMA	School Facilities Manufacturers Association
UC	University of California
UCLA	University of California, Los Angeles
VOC	Volatile Organic Compound, Volatile Organic Chemical
WHO	World Health Organization

ABBREVIATIONS AND SYMBOLS

Term	Definition
^oC	degrees Celsius
CFM	cubic feet per minute
CFU	colony forming unit
cm^2	square centimeter
CO	carbon monoxide
CO_2	carbon dioxide
dBA	decibel (referenced to 1 ampere)
^oF	degrees Fahrenheit
kg	kilogram (one thousand grams)
l/min.	liters per minute (flow rate)
m^2	square meter
m^3	cubic meter
µg	microgram (one-millionth of a gram)
µg/g	micrograms per gram (concentration)
$\mu g/cm^2$	micrograms per cubic meter (surface area)
$\mu g/m^3$	micrograms per cubic meter (concentration)
mg	milligrams (one-thousandth of a gram)
mg/kg	milligrams per kilogram (concentration)
ml	milliliter (one-millionth of a liter)
ng	nanogram (one-billionth of a gram)
ng/g	nanograms per gram (concentration)
No.	number
pCi/l	picoCurie per liter
PM2.5 microns	Particulate matter with aerodynamic diameter less than 2.5
PM10 microns	Particulate matter with aerodynamic diameter less than 10
ppb	parts per billion (such as one grain of sand in a billion grains of sand)
ppm	parts per million (such as one grain of sand in a million grains of sand)
T	temperature

GLOSSARY OF TERMS

Term	Definition
Active/Passive Sampling	Active sampling depends on a mechanical process like pumping to collect the sample at a known rate, such as was used for VOC and aldehyde sample collection. Passive sampling involves non-mechanical processes, like diffusion, such as was used in Phase I for the formaldehyde sample collection.
Air Changes per Hour	ACH, the volume of air moved in one hour. One air change per hour in a room, home, or building means that the equivalent of the volume of air in that space will be replaced in one hour.
Air Flow Rate	The rate at which air moves into a space. Expressed in units of air changes per hour or cubic feet per minute.
Air Handling Unit	HVAC (heating, ventilation and air conditioning) unit. Refers to equipment that includes a blower or fan, heating and/or cooling coils, and related equipment such as controls, condensate drain pans, and air filters. Does not include ductwork, registers, or grilles, or boilers and chillers.
Allergen	A chemical or biological substance (e.g., pollen, animal dander, or house dust mite proteins) that induces an allergic state or reaction, characterized by hypersensitivity.
Ambient Air Quality Standards (AAQS)	State (ARB) and federal (EPA) enforceable regulations designed to protect the public from the harmful effects of traditional pollutants in outdoor air.
Asthma	A chronic disease of lung tissue involving inflamed airways and breathing difficulty, and an increased sensitivity to allergens and contaminants in the air.
Biological Contaminants	Agents derived from or that are living organisms (e.g., viruses, bacteria, fungi, and mammal, arthropod, and bird antigens) that can be inhaled and can cause many types of health effects including allergic reactions, respiratory disorders, hypersensitivity diseases, and infectious diseases. Also referred to as biological agents.
Comfort measures	Factors that determine human perception of thermal comfort, including temperature, relative humidity, and draft

Dampers	Controls that vary airflow through an air outlet, inlet, or duct. A damper may be immovable, manually adjustable, or part of an automated control system.
Detection Limit	Limit of detection, the lowest detectable concentration of a pollutant for a sampling and/or analytical procedure. This varies with different measurement methods.
Fungi	A group of organisms that lack chlorophyll, including molds, mildews, yeasts, mushrooms.
Integrated Pest Management (IPM)	An ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques including non-chemical prevention and control measures, habitat manipulation, modification of cultural practices, and use of least hazardous pesticides
Mail survey	An information gathering study that utilizes the mail for distributing and returning the information, using questionnaires or other written forms
Micron	A unit of length equal to one millionth of a meter; a micrometer.
Microorganism	A microscopic organism, especially a bacterium, fungus, or protozoan.
Natural ventilation	The movement of outdoor air into a space through intentionally provided openings, such as windows and doors, or through non-mechanical ventilators, by wind, air pressure differences, or other natural, non-mechanical means.
Permissible Exposure Limits (PELs)	Enforceable pollutant exposure limits determined by OSHA that are designed to protect healthy adult workers in industrial environments from adverse health effects associated with pollutant exposure. None of these limits are targeted toward protecting children.
Pesticides	A pesticide is any substance or mixture of substances intended to prevent, destroy, repel, or mitigate any pest. Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides, and various other substances used to control pests. Under United States law, a pesticide is also any substance or

	mixture of substances intended for use as a plant regulator, defoliant, or desiccant.
Polycyclic aromatic hydrocarbons (PAHs)	A class of stable organic molecules made up of only carbon and hydrogen. They are a standard product of combustion from automobiles, airplanes, woodburning, cigarettes, and some types of cooking. Many of these molecules are highly carcinogenic and very common.
Portable Classrooms	Classrooms that are designed and constructed to be moveable and transportable over public streets, also known as temporary or relocatable classrooms.
Quality Control (QC)	Internal checks on the operation of sample collection and/or sample analysis. Methods for determining the operation include blanks, spiked samples, flow checks, and duplicate samples. QC measures can be used to determine accuracy, bias, and precision of the data reported.
Real-time Monitoring	This type of environmental measurement gives instantaneous information at the point of sampling; measurements are recorded as often as every minute, every second, or in fractions of a second.
Reference Exposure Level (REL)	The concentration level at or below which no adverse health effects are anticipated for a specified exposure duration. RELs are based on the most relevant, adverse health effect reported in the medical and toxicological literature for the population group known to be most sensitive to the chemical. RELs are designed to protect the most sensitive individuals in the population by the inclusion of margins of safety. Since margins of safety are incorporated to address data gaps and uncertainties, exceeding the REL does not automatically indicate an adverse health impact will occur. OEHHA provides acute (1-hour) and chronic (lifetime, non-cancer), RELs for a number of chemicals, and has developed an 8-hour "indoor" REL for formaldehyde.
Relative Humidity	The measure of moisture in the atmosphere, expressed as a percent of the maximum moisture the air can hold at a given temperature.
Return Air	Air removed from a space by the HVAC system to be recirculated or exhausted.

Sick Building Syndrome	A set of symptoms (including headache, fatigue, and eye irritation) typically affecting workers in modern airtight office buildings, believed to be caused by indoor pollutants (such as formaldehyde fumes or microorganisms).
Stratified Random Sampling	The study samples are selected randomly from each of several subgroups (strata) of the target population, previously determined. The sampling rate or selection probability for each strata can differ, depending on the study design.
Supply Air	Air delivered to the conditioned space by the HVAC system and used for ventilation, heating, cooling, humidification, or dehumidification. It is usually a combination of outdoor air and return air.
Target study population	All California K-12 public schools that had portable classrooms in both the spring and fall of 2001 (spring of 2001 only for Phase I), and all classrooms in those schools.
Traditional classrooms	Classrooms in permanent, site-built school buildings.
Variable Air Volume System	Air handling system that conditions the air to a temperature using a varying amount of outside airflow based essentially on the outdoor temperature.
Ventilation	The process of intentionally supplying and removing air by natural or mechanical means to and from any space.
Volatile Organic Compounds (VOCs)	Compounds that evaporate quickly from the many housekeeping, maintenance, and building products made with organic chemicals. These compounds are released from products that are being used and that are in storage. Many are carcinogenic, neurotoxins, or mucous membrane irritants.
Weights (or sample weights)	Weighting factors that are used in statistical analyses to remove the bias due to differential sampling rates and to reduce the bias due to differential rates of non-response, providing results that reflect estimates for the entire population being studied.

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 any 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 such unhealthful conditions.

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 conducted by RTI. Both agencies were fully involved in project oversight, review of the results, and preparation of this report.

The final report was due to the Legislature in June, 2002. However, its completion was delayed for several reasons, including the September 11 attack, which delayed access to schools; the loss of some members of the study team; laboratory analysis delays for some environmental samples; and the organizational and practical difficulties associated with conducting, reporting, and reviewing such a comprehensive, statewide project.

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.

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, their availability enabled the state to achieve class size reductions aimed at improving learning achievement. Until 1998, the State required school districts 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 house 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 for years within the confines of school buildings. Thus, ensuring healthful conditions inside classrooms is a critical factor in both teachers' and students' health and performance. Both 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 the number one 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 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 rate and less daylight or 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 takes into consideration only 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 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.

♦ **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 Cal-OSHA 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 (REL) developed by Cal/EPA's Office of Environmental Health Hazard Assessment (OEHHA) are non-regulatory guidelines 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.

♦ **Ventilation**

Requirements for heating, ventilation, 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 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 targeted specifically toward 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 (except for extreme temperatures). 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.

♦ **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, although they are often 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 exclusively 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, relocatable classrooms leasing, and deferred maintenance funding. 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 excessive 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/or 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 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. 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 which address 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 application. 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 daily activities and maintenance functions and their impact on indoor air quality. U.S. EPA makes their *IAQ Tools for Schools* action kits available at no cost to schools, and has funded numerous training workshops, including many throughout 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 use all or part of the program. This may be due to a misperception regarding the level of effort that *IAQ Tools for Schools* requires: 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 pesticide use reporting 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 current 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.

  Given the substantial investment in school facilities and the importance that districts ensure their maximum useful life, greater local accountability highlights the need to more effectively fund facilities maintenance. The LAO suggests 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." This 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 at a small percentage of schools. Remedies to address the problems identified are available. The solutions would require a combination of actions by the State, school districts, individual schools, manufacturers, and others. Many of the solutions are low-cost. Improved operation and maintenance would go a long way to address many of the problems identified. Similarly, the use of no- or low-emitting building and classroom materials often adds only minimal cost, and quieter HVAC units may 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 was inadequate about 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 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 air flows when operated properly, so design capacity is not a problem. Complaints of stuffy room air usually resulted 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 manufacturers; low noise levels should be specified by schools when purchasing new portables. Operation and maintenance of HVAC systems needs to be improved at some 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.

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 a minimum of about 4% of the classrooms. This totals about 10,720 classrooms, or 214,400 children (assuming 20 children per classroom) exposed to formaldehyde levels that could potentially result in irritant effects.
  - ✓ Levels in nearly all classrooms exceeded OEHHA's chronic REL for irritant effects and OEHHA's one-in-a-million cancer risk level for formaldehyde. This was not unexpected, because levels of formaldehyde in most homes and offices exceed these levels as well.
  - ✓ 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 3-5 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 cancer risk level for benzene and chloroform if the exposure continued for a lifetime. However, shorter term exposures by children would be of limited concern. Additionally, outdoor levels also exceeded this risk level, so most of the risk is likely from 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.
  - ✓ This was likely due to the more frequent use of carpets and rugs in portables, which help to reduce noise but also can serve as a particle reservoir. Proximity to 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 and roadways.

Floor Dust Contaminants
Persistent contaminants were examined in floor dust samples collected with a specialized vacuum cleaner. Analyses of floor dust can provide insights 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, but 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 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. Chlorpyrifos can last up to a year or more in the environment; the other five are shorter-lived, lasting just a few weeks. Thus, at most schools, pesticides appear to 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 relatively low.

✓ 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 measured in more than half of the classroom samples, but the concentrations were generally below sensitization levels. Only two classrooms were above the sensitization level for dog allergens.
  ✓ Cockroach and dust mite allergens were only infrequently found.

Moisture and Mold

- In the 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 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 surface humidity 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 should be properly remediated, since mold can trigger allergy symptoms and asthma attacks in individuals with those sensitivities.

Noise

- All classrooms exceeded the recently developed ANSI acoustic standard and WHO guideline of 35 decibels background noise for unoccupied classrooms.
- A substantial portion of unoccupied classrooms (50% portables, 38% traditionals) were measured with noise 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 45 decibels may be 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.

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 new 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 appear to 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 *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: 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 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 45 dBA or lower.
    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 HVAC Noise.** Implement an interim state requirement for a maximum decibel level of 45 dBA from HVAC systems, and encourage other sound reduction measures such as reduction of noise from 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 EPA's *Tools For Schools Program* (no. 4, above). However, focused statewide training programs are needed over the long-term to assure that key school staff receive focused 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*, to include 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. Further, 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 ready-made 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 included 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; 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.

1. INTRODUCTION

The Air Resources Board (ARB) and the Department of Health Services (DHS) jointly conducted a study of environmental health conditions in California's portable classrooms from 2000-2003. This study, called the California Portable Classrooms Study, is the most comprehensive study of environmental conditions in kindergarten through 12^{th} grade (K-12) classrooms to date, and provides important information for State and local decision makers working to assure 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 assuring healthful conditions in both portable and traditional classrooms. The information presented in this report is based on the study results, as well as information provided by state agencies, school districts, consultants, and interested stakeholders.

1.1 Mandate and Need for the Study

The California Portable Classrooms Study was conducted at the request of Governor Gray Davis and the State Legislature (AB 2872 Shelley, 2000, California Health and Safety Code Section 39619.6; see Appendix I for full text), with an allocation of $1 million for the study. Their request was prompted by concerns that California's schools, especially portable classrooms, might not provide adequate environments for young students, and that they experienced unacceptable levels of problems such as mold contamination, inadequate ventilation, poor temperature control, elevated chemical contaminant levels, and excessive use of pesticides (Daisey and Angell, 1998; Ross and Walker, 1999; U.S. GAO 1995, 1996). Questions were raised regarding the true extent of these problems and whether they warranted state-level responses, school or school district level responses, or a combination of actions at all levels.

These questions and assertions posed a serious concern because portable classrooms have served an important need in California K-12 public schools. About one-third (30%, or 80,000) of the State's 268,000 K-12 public classrooms in the 2000-2001 school year were portable classrooms (DHS, 2003: see Appendix II). Portable classrooms are more quickly constructed and deployed to school sites. They have a lower initial cost than traditional, site-built buildings, and thus are often more affordable under the school budgeting processes in California. They can be obtained in a period of months rather than years, allowing schools to accommodate rapidly changing enrollment needs due to student population fluctuations. Their availability enabled the state to pursue class size reductions in the 1990s to help facilitate improved learning achievement.

Until 1998, the State required school districts requesting funding to design and construct schools with at least 30% of portable classrooms. This requirement was imposed as a cost-saving measure, with the expectation that districts would move classrooms rather than build new ones as student demographics changed. However, student growth continued and relatively few portables were being relocated. 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 flexibility in the design of their school, along with a revised formula for financing, based on per-pupil grants.

1.2 Definition of Portable Classrooms

The California Education Code (Section 17070.15 (k)) defines “portable classroom” as “a classroom building of one or more stories that is designed and constructed to be relocatable and transportable over public streets, and with respect to a single story portable classroom, is designed and constructed for relocation without the separation of the roof or floor from the building, and when measured at the most exterior walls, has a floor area not in excess of 2,000 square feet.” Portable classrooms also are often referred to as relocatable classrooms, and occur in a variety of styles and forms. However, “modular” classrooms, which typically have some elements constructed off-site, may be either permanent structures or movable, and thus are not necessarily synonymous with the terms “portable” or “relocatable”.

1.3 Purpose and Scope of the Study

The objectives of the California Portable Classrooms Study were 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 such unhealthful conditions.

The Health and Safety Code directed that the study include 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 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 chemical, biological, and environmental measurements were obtained in 201 classrooms at 67 schools randomly selected statewide. Similar to Phase I, two portable classrooms and one traditional classroom were studied.

The State contracted with Research Triangle Institute (RTI), a not-for-profit scientific research organization, through a competitively bid process to conduct the primary field work of the study for both Phase I and Phase II. For Phase I this included selecting and enrolling the sample of schools; formatting, mailing and analyzing the questionnaires; and analyzing the formaldehyde data. In Phase II, RTI planned the details of the field study; developed and refined sampling, analysis, and quality control protocols; handled the many contacts with schools and districts; conducted all on-site sampling and inspections; analyzed the samples collected; and prepared a final study report. ARB directed the field contract, air monitoring, and data analysis; obtained equipment used in the study; pre-tested the passive formaldehyde samplers used in Phase I; coordinated the stakeholder participation; and contributed funds for analysis of classroom carpet dust, a known reservoir for persistent contaminants such as pesticides and metals. DHS developed and administered a preliminary survey of districts to obtain key information on the numbers and ages of portables in each district; directed the school and classroom sampling approach and the assessment of ventilation systems; performed allergen analyses in the laboratory; and directed and reviewed the biological sampling conducted by RTI.

The study was endorsed by the Superintendent of Schools at the time, Ms. Delaine Eastin. The Superintendent's endorsement was a key factor in obtaining the cooperation of schools and school districts throughout the study.

ARB's Research Screening Committee, an external scientific peer review group that assures the quality of research funded by the ARB, reviewed and approved the Request for Proposals for the contractor, the proposals received, and the draft final report from RTI. Additionally, a small advisory panel was convened for review of the floor dust sample collection and analysis, because this is a relatively new area of investigation in the indoor air quality field.

The final report was due to the Legislature in June, 2002. However, completion was delayed for several reasons, including the September 11 attack, which delayed access to schools; the loss of some members of the study team; laboratory analysis delays for some environmental samples; and the organizational and practical difficulties associated with conducting, reporting, and reviewing such a comprehensive, statewide project.

A *Project Executive Summary* covering the key scientific results from the research study is attached as Appendix III. The two-volume Phase I and Phase II final reports from the field study are available on ARB's web site at http://www.arb.ca.gov/research/indoor/pcs/pcs.htm or upon request.

1.4 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 (CDE), the Department of General Services (DGS; primarily the Division of the State Architect [DSA] and the Office of Public School Construction [OPSC]), the Office of Environmental Health Hazard Assessment (OEHHA), 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.

Four public workshops were held at the beginning of the study—two each in northern and southern California—to obtain input from interested parties on the basic study design and specific information that should be obtained in the study. The information obtained resulted in some modifications to the study design and improvements in the questionnaires.

Four public workshops, again two each in northern and southern California, were also held during the review period for the public draft of this document. The first workshop was webcast, and all workshops included telephone accessibility, so that the public could participate without being physically present at the workshops. Many useful comments were received, and the report was modified as appropriate. Some of the information received highlighted new products that are low- or no-emitting.

Summaries of the comments received during both sets of workshops are provided in Section 6 of this report.

2. BACKGROUND

California public schools house more than six million children in kindergarten through 12th grade, 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 for years within the confines of school buildings. Because the key focus of school programs is the education of its pupils, it is important to note how school indoor environmental conditions – temperature, humidity, ventilation, lighting, noise, cleanliness, odor, and exposures to chemical contaminants and biological agents – can affect both the healthiness and productivity of the school environment, and thus support, or hinder, educational goals.

2.1 Indoor Environmental Conditions and Potential Health Effects

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 health complaints, similar to "sick building syndrome" or SBS (more currently called "building-related symptoms: allergies, eye or respiratory irritation , headache, lethargy, etc.), as well as the risks of chronic exposures to air toxics, such as formaldehyde, lead, mercury, and pesticides. The health impacts range from mild SBS symptoms and an array of respiratory symptoms , to the perception of poor indoor air quality, such as bothersome odors, to patent illness, such as increased rates of infectious diseases (e.g., influenza and the common cold), , asthma, and chronic sinusitis. Chemical toxins and biological agents, along with other indoor environmental problems in the classroom, are frequently the focus of concern.

Both students and school staff may suffer the detrimental effects of poor environmental conditions; however, children are far more vulnerable than adults to environmental contaminants and types of injury. Both their breathing rates and metabolic rates are significantly greater than adults relative to body mass. For example, in the same environment as adults, children will breathe in and absorb proportionally greater doses of airborne toxins. Because of their behavior, they also accidentally ingest more soil than adults. Their immune systems are less mature.

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. Notably, the prevalence rate increased in the U.S. 74% from 1980 to 1995 (CDC, 2002). Disproportionately higher rates are found among low-income populations, minorities, and children living in inner cities. Schools with poor IEQ contain many known asthma triggers – airborne particulate matter, chemicals, and allergens from dust mites, cockroaches, and mold spores. Asthma is the number one cause of school absences, and it may account for as many as 3 million lost days of school missed by California students annually (Taylor 1992). Currently, about 10% of California's children suffer from asthma (CHIS, 2003), with the highest prevalence found among 12-17 year olds.

Exposure to mold growth has been associated with worsening of asthma, allergies, and eye, nose or throat inflammation. However, health-based criteria for evaluating exposures to the spores, cell components, or chemical emissions from indoor mold growth are not currently available. Numerous studies have found that indicators of excess moisture such as musty odor and visible mold in buildings increase the risk for respiratory symptoms Aand other health effects, and some studies have found correlations of health effects with elevated levels of mold spores in schools and other buildings (Meklin 2002, Bornehag 2001, Haverinen 1999, Verhoeff 1999).

2.2 Potential Economic and Performance Impacts

Just as poor environmental conditions in schools may directly cause occupants' ill health, it also affects school productivity and student performance (U.S. EPA, 2000). An extensive literature review was recently published, which identified limitations in conclusive data; the available evidence suggests that IEQ problems, such as low ventilation rate and less daylight or light, may reduce the performance of occupants, including students in schools (Heath & Mendell, 2002).

An economic analysis has not been done specifically for the educational sector; however, Fisk (2000) determined that the impacts of poor IEQ across the U.S. workforce are as much as $250 billion per year (1996 dollars). Fisk's results, scaled to California educators, projects that accrued benefits from improved IEQ in schools are as great as $600 million (California Sustainability Blueprint report, 2002)-- from reduced respiratory disease, reduced allergies and asthma, reduced SBS symptoms, and worker performance unrelated to health. This takes into consideration only the impacts on teachers and school staff; it omits analogous effects on productivity and performance that could be expected among the many more students sharing the school environment.

Improved IEQ in schools can reduce asthma-related medical cost (e.g., emergency room visits and hospitalization) for children and staff, but it can also improve the productivity and academic performance. Smedje et al. (2000) reported that the incidence of asthmatic symptoms was lower in pupils who attend schools (in Sweden) in which new ventilation systems have been installed. Students with exacerbated asthma suffer chronic school absences, which can cause delays in academic progress. At the same time, school districts suffer an economic loss, because revenues to California schools are determined by student attendance.

It can be expected that a more comfortable setting would be more productive, but there is limited data to quantify this. Among comfort parameters (temperature, relative humidity, light, noise, and odor), a study of school lighting has produced the most striking results. Researchers investigating lighting in an Orange County (CA) school district determined that increasing/greater daylighting (natural light, such as that through windows) improved learning rates (Heschong Mahone Group, 1999). The effect, as determined by standardized test scores among elementary school students, was as much as a 12% improvement over the school year.

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. A recent demonstration project in a Washington, DC public school suggests that, when IAQ is allows to deteriorate because HVAC systems are not maintained, the required cost of repair after a 22 year period can be 5 to 30 times higher than the cumulative cost of annual maintenance neended to preserve IAQ throughout that period.

2.3 Indoor Environmental Regulations and Guidelines for Public Schools

While school design and construction are subject to codes and regulations (see next section), there are few specific standards or guidelines on environmental conditions specifically addressing schools. In fact, IEQ standards exist only for schools as workplaces, ostensibly to protect teachers and staff from potential health risks related to occupational exposure. Cal/OSHA (Department of Industrial Relations, Division of Occupational Safety & Health) sets and enforces the standards for workplaces in California, including General Industrial Safety Orders that buildings "… shall be kept clean, orderly and in a sanitary condition [and] maintained in such conditions as will not give rise to harmful exposure…" (CCR Title 8 Section 3362). Subsection (a) requires mold clean-up, and subsection (g) was recently added, requiring employers to correct exterior water intrusion, leakage from interior water sources, and other uncontrolled accumulation of water, in order to prevent mold growth. The State Education Code also establishes that it is the duty of the governing (school) board to furnish, maintain, and repair school facilities (Education Code Section 17565 et seq.).

Cal/OSHA also enforces Title 8 Section 3203, the Injury and Illness Prevention Program regulation, that requires employers to develop, implement, and maintain a health and safety program that includes periodic inspections, correction of hazards, communication with employees, training, and other actions. In addition, Cal/OSHA sets Permissible Exposure Limits (PELs), which are usually 8-hour time-weighted-average standards. These standards are developed for the protection of working adults, often for specific chemicals used in industrial processes/settings. They are generally based only on acute or irritant effects, and are not necessarily intended to address the effects of chronic (long-term) exposures.

Table 2.1 (at the end of this section) provides a summary listing of the standards and guidelines discussed below.

2.3.1 Environmental Contaminants

In general, PELs are usually much higher than indoor contaminant levels found in non-industrial settings, and Cal/OSHA rarely finds PEL violations in schools (an exception may be the occasional industrial arts classroom). However, these standards are likely insufficient to protect vulnerable school occupants such as pregnant teachers. School personnel include more vulnerable sub-populations than the "healthy worker", such as adults with chronic conditions, such as hypertention, and diabetes. Likewise, PEL standards are not designed to protect children.

For the general public, the National Ambient Air Quality Standards (NAAQS) are set by the U.S. EPA to regulate the outdoor concentrations of traditional pollutants to protect public health. These standards for outdoor air do not apply to indoor settings, but may serve as the minimum requrement for indoor air quality. California has its own state ambient standards set by the ARB that are equivalent to or more stringent than the federal NAAQS. With the California Senate Bill 25 (SB 25, the Children's Environmental Protection Act), existing California ambient air standards are being reviewed to ensure that children and infants are protected (ARB, 2000; ARB 2002). ARB also has developed indoor air quality guidelines for some pollutants in homes. National and state AAQS may be found at http://www.arb.ca.gov/aqs/aqs.htm, and ARB's indoor air quality guidelines are available at http://www.arb.ca.gov/research/indoor/guidelines1.htm.

OEHHA has developed and published Reference Exposure Limits (REL) as guidelines to prevent harm from air pollution. These non-regulatory health-based RELs were developed by reviewing available scientific evidence of toxic chemicals, considering both chronic and acute effects, to protect public health. In many cases, the REL is a factor of 100 to 1000 times less than the corresponding PEL. Acute RELS are usually applicable to exposures of about one hour, while chronic RELS address exposures that last many years. In the absence of indoor standards, OEHHA's RELs provide levels for comparison to assure a healthful environment. Some RELs have been specifically applied to indoor pollutants in non-industrial settings (Broadwin et al., 2000). For example, an 8-hour REL for formaldehyde, the most widespread of indoor pollutants, was set at 27 ppb to identify the level below which non-carcinogenic adverse health effects would not be expected to occur. OEHHA's RELs may be viewed at http://www.oehha.ca.gov/air/acute_rels/acuterel.html (acute) and http://www.oehha.ca.gov/air/chronic_rels/index.html (chronic).

Regulatory standards exist for lead and asbestos in schools, based on federal regulations (see Table 2.1). Lead is a toxin that can cause learning disabilities, decreased intelligence, kidney damage, and a host of other effects. U.S. EPA (2001a) set a limit on the maximum allowable amount of lead in surface dust, based on wet-wipe sampling. Children under 6 y are especially susceptible to its adverse impacts, and toddler-aged children are especially prone to ingesting lead through exposures to contaminated surface dust, as well as deteriorating lead-based paint surfaces.

In the absence of a regulatory standard for indoor radon, a voluntary guideline specifies concentrations of 4 pCi/l or more as an action level to trigger re-testing and remediation to reduce long-term indoor radon levels (U.S. EPA, 1993). Asbestos and radon were not measured in the Portable Classrooms Study because of cost considerations and because they are not expected to be a greater problem in portable classrooms relative to traditional classrooms. Furthermore, federal law requires the assessment of asbestos hazards in all schools (U.S. EPA, 1987), and a statewide investigation of radon in California schools is already available (Zhou et al., 1998).

2.3.2 Ventilation and Comfort

Requirements for heating, ventilation and air conditioning (HVAC) of schools are determined primarily by the California Energy Commission (CEC) and Cal-OSHA. Design requirements for outdoor air ventilation rates in public and commercial buildngs, including schools, are specified in the California Building Standards Code (CCR Title 24, §121). Although CEC's focus in regulating HVAC performance is on energy efficiency, minimum design levels are specified to assure sufficient *outdoor air* for specific indoor environments. For the typical classroom, 15 cubic feet per person is required; for special purpose classrooms such as laboratories or auto shops, higher rates may be required. While CEC's standards address equipment design, Cal-OSHA's HVAC Standard (CCR Title 8, §5142) addresses HVAC operation and maintenance in workplaces. The standard requires that ventilation systems supply at least the minimum amount of outside air as was required at the time the system was last permitted. It also requires that maintenance records of the HVAC system(s) be kept and be available during a Cal-OSHA inspection.

Non-regulatory guidelines exist for HVAC systems in school settings. The American Society of Heating, Refrigerating, and Air Conditioning Engineers' Standard 62, *Ventilation for Acceptable Indoor Air Quality*, sets professional standards for minimum outdoor air ventilation rates (ASHRAE, 2001), and Standard 55, *Thermal Environmental Conditions for Human Occupancy*, sets indoor comfort levels for temperature and humidity (ASHRAE 1992). While not intended as a health standard, ASHRAE Standard 62 has been historically adopted into state and local building codes, and continues to serve as a foundation for related elements of the California energy standard. With its continuous maintenance, addenda and appendices, Standard 62 continues to serve as the most explicit guideline available that address IAQ in schools and commercial buildings.

2.3.3 Noise and Lighting

Acceptable noise and lighting illumination levels for classrooms have been established by non-government organizations, similar to ASHRAE, and serve as target values in the absence of government standards. The American National Standards Institute (ANSI, a non-government standard-setting organization) and the World Health Organization (WHO) have established a standard and guideline, respectively, of 35 decibels (dBA) for background noise levels in (unoccupied) classrooms. This is a controversial noise limit, as it is not easily met in standard classroom construction. The Collaborative for High Performance Schools (CHPS), a California based non-profit organization, recommends a maximum unoccupied background noise level of 45dBA and a 0.6-second maximum (unoccupied) reverberation times. CHPS encourages designers to move beyond these minimum prerequisites and achieve background noise levels of 35 dBA for all classrooms. The ANSI and WHO recommendation for other indoor (non-school) settings is 45 dBA, and the outdoor community standard used in many cities is 55 dBA.

For lighting, the Illuminating Engineering Society of North America (IESNA) recommends lighting illumination levels for various kinds of visual tasks involving materials with different print sizes and of high or low contrast. The California Energy Code dictates the amount of lighting power (electricity) per classroom area that may be used, to require the use of efficient lighting equipment to meet IESNA recommended lighting illumination levels.

2.3.4 Mold

Floods, leaks, and water intrusion have long been concerns of school facility staff, because these problems can cause safety hazards, as well as degrade building structures and components. Recently, awareness has increased that dampness and indoor mold can cause a variety of health effects and symptoms, including allergic reactions, and can act as asthma triggers. Widespread publicity about "toxic mold" has served as stark encouragement to school facility staff to be especially vigilant in inspecting and repairing potential water intrusion problems quickly.

Unlike toxic chemicals, such as mercury or lead, there are no numeric standards to apply in situations where indoor mold contamination is found. Therefore, the results of this study cannot be compared to a standard. California recently passed legislation that directs DHS to consider the feasibility of adopting permissible exposure limits for indoor mold contamination (SB 732, Ortiz, Statutes of 2001). The form that SB 732 regulations might take remains uncertain, as a number of expert panels have stated that PELs are not appropriate for assessing mold exposure risk (ACGIH, 1999; NYC DOH, 2000). The current SB 732 implementation plan includes convening a task force to advise DHS on the development of practical guidelines to assess the health threat posed by the presence of mold and to establish guidelines for identification of mold, visible or hidden in an indoor environment, and for the remediation of mold. Despite the absence of PELs or numeric standards, practical guidance has been developed for assessment and clean-up procedures of indoor mold contamination (e.g., NYC DOH, 2000; U.S. EPA, 2001b).

Several guidance documents have been published specifically for school environments. DHS has produced "Mold in Your School," and the U.S. EPA released "Mold Remediation in Schools and Commercial Buildings" in March 2001. This document presents approaches for the assessment and remediation/cleanup of mold and moisture problems in schools, including measures designed to protect the health of building occupants and clean-up staff. It was designed primarily for building managers and custodians. Also published in 2001, the Minnesota Department of Health developed "Recommended Best Practices for Mold Investigations in Minnesota Schools". This guidance document was created to assist public school staff in investigating the causes of indoor mold concerns and in finding cost-effective solutions. This document is aimed at school staff, such as Indoor Air Quality Coordinators, facilities and maintenance

Table 2-1 Selected Guidelines and Standards Relevant to Schools Environments.

COMPOUND/ PARAMETER	STANDARD, CODE or GUIDELINE	SOURCE
Ventilation	**Mechanical: outside air ventilation rate**: 15 cubic feet per minute (CFM) per person or 0.15 CFM per ft^2, whichever is greater. **Natural ventilation**: allowed when openable window area is 5% or more of floor area, space is within 20 ft, and airflow is unobstructed. **Demand control ventilation (not required):** CO_2 below 1000 ppm or CO_2[outside]+600 ppm (effective 2005) **Thermal comfort (guideline)**: Temperature and Relative humidity **Operation & maintenance**: annual inspection and written log	CCR Title 24, §121(b) CCR Title 24, §121(c) ASHRAE 55-1992 CCR Title 8, §5142
Noise	**Classroom standard (unoccupied):** 35 dBA (decibels) **Classroom guideline**: 45 dBA, **WHO guidelines**: Classroom: 35 dBA Indoor community: 45 dBA Playground guideline: 55 dBA **CHPS classroom guideline**: 45 dBA and 0.6 s reverberation time (Max) **Outdoor community standard**: 55 dBA	ANSI (2002) Crandell (1992) WHO (1999) CHPS (2003) City of Los Angeles
Lighting	**Large/high contrast**: 30 foot-candles **Small/high contrast or large/low contrast:** 50 foot-candles	IESNA (2000)
Formaldehyde	**Acute REL**: 76 ppb (1-hr average) **Interim REL**: 27 ppb (8-hr average) **Chronic REL**: 2.4 ppb (long-term average) REL= Reference Exposure Limit ppb=part per billion **Proposition 65 "Safe harbor"**: 1.3 ppb	OEHHA (1992) Broadwin (2000) OEHHA (2001) OEHHA (1992)
Lead dust	**Federal standards**: 40 micrograms of lead per square foot (µg/ft^2) on bare floor or carpet; 250 µg/ft^2 for interior window sills.	U.S. EPA (2001a)
Asbestos	Asbestos Hazard Emergency Response Act (**AHERA)** **PEL**: 0.1 fiber per cubic centimeter (cc) of air	U.S. EPA (1987) CCR Title 5, §5208(c)
Radon	**Voluntary Action Level**: 4 picoCurie (pCi) per liter of air	U.S. EPA (1993)
Molds	Voluntary guidance for assessment and remediation – no numerical standards of limits	U.S. EPA (2001) NYC DOH (2000)

personnel, health and safety staff, and other school officials. Both documents counsel school officials to make reasonable judgments as to whether their situation can be handled in-house and to recognize their limits in addressing more serious, widespread problems, when they should hire professional services.

2.4 Design and Construction of Portable Classrooms

Since the mid-1970s, the basic shape of portable classrooms used throughout California has remained mostly unchanged: 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, although they are often 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.

General requirements for school facilities are given in regulations (CCR Title 5, Seciton 14001), which address educational goals, master planning and future needs, structural, fire and public safety requirements, siting to mitigate toxic hazards, “ (d) designed for the environmental comfort and work efficiency of the occupants; (e) designed to require a practical minimum of maintenance.” 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 among 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 and construction of educational facilities. The Office of Public School Construction (OPSC) within DGS administers the State funding of public school facilities construction and modernization, relocatable (portable) classrooms, and deferred maintenance.

The Division of the State Architect (DSA) within DGS is responsible for reviewing design plans and construction for new school facilities, additions, alterations, and modernization projects, including portable classrooms. Although the building design plans and the California Building Standards Code address all aspects of the school design and construction, the DSA plan check in the past has focused exclusively on three issues: 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 (e.g., sprinklers, fire alarms, etc.). Beginning in 2001, DSA has added compliance with the California Energy Code as an area of emphasis in plan check. In addition, throughout construction, school districts are required to retain a DSA-certified inspector to monitor all construction activities and to liaison between the building contractors and DSA regarding code compliance. In the case of portable classrooms, DSA offers an expedited review focused on the fire & life safety components, provided the classrooms will be duplicates of previously approved designs. Compliance with the California Energy Code is included in the review of relocatable school buildings.

2.4.1 State Relocatable Classroom Program

For the State Relocatable Classroom Program, the OPSC has purchased and maintains a set of approximately 6000 portable classroom units to make available to school districts on an as-needed/as-available basis. These classrooms are intended for districts impacted by excessive growth or for periods their facilities are closed during modernization or for unforeseen emergencies. The State purchases about 200 new portables per year, on average. Funding for portables comes primarily from lease revenues. Current costs range from about $25,000 to $47,000; districts lease them for $4000 per year. Districts are responsible for all maintenance of the leased units, which are retained by a district anywhere from less than one year to more than ten years. When a unit is returned to OPSC, they inspect the unit, make necessary repairs (charged to the former lessee), and generally deploy the unit to another district in need fairly quickly. In addition to the annual lease, school districts are responsible for the costs of installation, including site preparation and utility hook-up.

With DSA assistance, DGS issues bid specifications for contractors each time OPSC purchases units for the State program. Depending on funding, OPSC will issue a contract to build several hundred classrooms. The DGS specifications are for the "basic" classroom (DGS, 2000), and these often serve as the template for non-State program portable classroom purchases. Nonetheless, school districts may submit design plans of their own for approval when they are purchasing units for themselves.

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/or 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, such as insulated return air plenums. Finally, the exterior moisture barrier, currently saturated felt or Kraft building paper, may be changed to Tyvek.

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 of structural reasons.

2.4.2 California Collaborative for High Performance Schools

The Collaborative for High Performance Schools (CHPS) is a California consortium of public agencies and energy utilities working to facilitate the design and construction of “high performance” schools. These are school facilities that aim to be models of energy and resource efficiency, as well as healthy and comfortable settings supporting quality education. CHPS uses a whole building design approach, as well as providing designers with specific guidance on component systems, that incorporates the best of current knowledge and technologies. The core of CHPS is a set of *Best Practices Manuals,* which address high performance school planning and design (CHPS, 2003). Recently, the U.S. Department of Energy adapted the CHPS Best Practices Manual Volume II (Design) for a national audience (U.S. DOE, 2003). In addition to its publications, CHPS provides ongoing training to school facility staff, architects, and engineers.

CHPS developed their own grading criteria using a point system, similar to the U.S. Green Building Council’s Leadership in Energy & Environmental Design (LEED™) scoring (U.S. Green Building Council, 2003). This approach allows school boards to declare their intentions to build high performance schools, despite a lack of explicit knowledge of specify components. The CHPS scoring gives facility designers latitude to incorporate practices in the manner that best fits the district’s application. CHPS has helped secure funding for a number of demonstration projects throughout the state. Several school districts, notably Los Angeles Unified, have established policies to require all new facilities to meet the CHPS criteria.

2.4.3 U.S. EPA *IAQ Design Tools for Schools*

The U.S. EPA is about to unveil a new on-line resource called *IAQ Design Tools for Schools* to help school districts with information resources for designing new school facilities and repairing existing facilities. Its primary focus is on IAQ, but it is also develops the concept of designing High Performance Schools, an integrated, "whole building" approach to addressing each of the important – and sometimes competing – priorities, such as energy efficiency, indoor air quality, day-lighting, materials efficiency, and safety, plus doing so in the context of tight budgets and limited staff. *IAQ Design Tools for Schools* builds largely on the CHPS program (see above), but it adds value by being web-based, having a national focus, and containing a broader array of resource materials on IAQ issues. The web site is still under construction, though it can be viewed at: http://www.epa.gov/iaq/schooldesign/.

2.4.4 State Workgroup on Relocatable Classrooms

An interagency workgroup was started recently to identify opportunities to implement Governor Davis' sustainable building goals with respect to portables. This subgroup is part of the interdepartmental Sustainable Building Task Force comprised of representatives from more than 40 state agencies with fiscal, construction, energy, health, and environmental policy expertise, which was formed after Governor Davis issued an executive order to direct state agencies to address sustainable buildings in the planning, design, and construction of state facilities (State of California, 2000). The workgroup is reviewing and revising the DGS building specification for relocatable classrooms with respect to sustainability goals, including enhanced IAQ. For more information, see www.governor.ca.gov/state/govsite/gov_homepage.jsp.

2.4.5 Innovative Design Initiatives

There have been on-going efforts to "rethink" the design of portable classrooms. In 1998, Southern California Edison (SCE) sponsored a workshop with architects, engineers, manufacturers, and school district officials, as well as outside consultants with expertise in energy analysis, modular buildings, and lighting design. SCE funded a demonstration project incorporating ideas from the 1998 workshop (SCE, 1998). A follow-up workshop was conducted in April 2003, and additional pilot portable classrooms are in development (SCE, 2003).

In 2000, the California Energy Commission funded a project with Lawrence Berkeley Laboratory investigating both low VOC-emitting materials and novel HVAC system design, to reduce chemical sources and increase classroom ventilation rates (Apte, 2002). Starting in mid-2003, CEC anticipates funding several projects on classroom ventilation technology for K-12 schools, including applications for portable classrooms (CEC, 2003).

2.4.6 Portable Classroom Manufacturers

The School Facility Manufacturers' Association (SFMA), formed in 1987, is a trade organization for the manufacturers of modular school buildings, architects, suppliers and others in related businesses, specific to California. Because portable classrooms require DSA approval, units are infrequently imported from out-of-state. Essentially all portable classrooms purchased or leased by California school districts are manufactured by one of about 10 companies. Portable classrooms are one application of factory-built modular building construction; consequently, many of these manufacturers also build products for a variety of commercial applications, e.g., offices, emergency rooms, airports, clinics, and retail centers. The Modular Building Institute (MBI) formed in 1983 is the national trade organization for manufacturers, dealers and material suppliers in both the portable classroom and commercial factory-built structure industry.

In 1999, California manufacturers of portable classrooms were sued under Proposition 65 by “As You Sow” for alleged exposures to formaldehyde above the “Safe Harbor” limits. The manufacturers disputed the claims of the lawsuit, but in 2002 the parties reached a settlement under the direction of the State Attorney General’s Office. The manufacturers agreed to minimize the use of particle board (a common construction material that contains formaldehyde). This product does not meet the structural requirements of DSA and therefore was infrequently used in portable classrooms except in cabinetry. Many manufacturers also have shifted to using insulation that emits no formaldehyde.

2.4.7 LAO *Blueprint for School Facility Finance*

In a 2001 report, the Legislative Analyst recommended changes to the finance system for K-12 school facility capital outlay. They identified several key deficiencies with the existing finance system: (a) state funding levels are unpredictable, which impedes planning school construction projects, (b) the process for allocating state funds is inherently imprecise and controversial, and (c) rules of state-district partnership are not clear. The report proposes a new "blueprint" for more effectively financing new school construction and modernization:

- More predictable state funding by annual appropriations for capital outlay, rather than current 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.

Given the substantial investment in school facilities and the importance that districts ensure their maximum useful life, greater local accountability highlights the need to more effectively fund facilities maintenance (p 16). The LAO suggests 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." This would lead to a more focused state role in technical assistance and oversight regarding planning, constructing, and maintaining school facilities.

2.5 School Operation and Maintenance (O&M) Practices

Effective operations and maintenance (O&M) of school facilities are as essential as good design and construction to assure a safe and healthy learning environment. An effective maintenance plan requires adequate funding, properly trained facility maintenance staff, and administrative support to keep school facilities in good condition. The required activities include the daily janitorial services, routine inspection and maintenance of facilities including its subcomponents (e.g., HVAC systems, building envelope, landscaping, etc.), and planning for major repairs and modernization needs. Daily janitorial and routine maintenance services are funded from the general budget for school operations.

There is a relatively wide range in the services supported among districts, reflecting their relative wealth and commitment to O&M as a priority. Not surprisingly, budget cuts most often reduce facility maintenance programs first, as a way to “keep cuts out of the classroom”. Thus, during lean times, maintenance suffers disproportionately. Major repairs and modernization needs are funded separately from routine activities in most school districts. Districts apply to OPSC’s Deferred Maintenance Program for cost-sharing of major repairs, such as roof replacement, HVAC system upgrades, and other non-routine maintenance. However, funds are not always available in the Program.

2.5.1 LAUSD’s Facility Inspection Program

The Los Angeles Unified School District’s (LAUSD) Facility Inspection program is a broad self-assessment of all district classrooms for basic health and safety conditions. 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 unrestricted electrical cords, important safety items critical to school environments and child safety not studied in the Portable Classrooms Study. However, they also included items such as proper storage of chemicals and developing and implementing an Illness and Injury Prevention Plan, which also are handled by school personnel. Problems requiring experienced specialists from the main district office or from the private sector cost more to remedy. LAUSD has developed a detailed tracking system to assure that problems identified are addressed. LAUSD’s “Safe School Inspection Guidebook”, a set of checklists, are provided in Appendix V, and can serve as a good starting point for other districts and schools undertaking a self-inspection.

2.5.2 U.S. EPA’s *IAQ Tools For Schools Program*

In 1995, the U.S. EPA launched their *IAQ Tools for Schools Program* (U.S. EPA, 1995). In the absence of federal legislation on IAQ, this voluntary program provides schools with information they need to understand IAQ issues and to solve and prevent IAQ problems. The program uses a team approach to school IEQ management and emphasizes staff and occupant training, communication, and routine maintenance for school facilities. The *IAQ Tools for Schools Action Kit* contains instructional materials with modular components for use in starting a program at a school or throughout a district. The self-contained IAQ management plan contains materials and tools, such as occupant checklists, that can be used to perform a building walk-through, assess conditions, and take remedial and preventive actions. An important focus is occupant education and involvement, because occupant activities can have a major impact on indoor air quality: occupants can unwittingly contribute to contaminant and allergen levels in the air, and often improperly adjust or turn off ventilation systems. U.S. EPA makes their kits available at no cost to schools across the U.S., and has funded numerous training workshops.

In California, U.S. EPA has trained more than 2000 individuals from districts throughout the state. Despite the outreach, awareness and use of the *IAQ Tools for Schools* program among California schools is still relatively low: based on the Phase I survey data from this study, 35% of district facility staff were aware of *Tools for Schools*, and 10% of districts use all or part of the program. U.S. EPA attributes resistance among school decision-makers to the program to the following: (1) misperceptions that the program is labor- or resource-intensive; (2) lack of understanding that poor indoor environmental quality affects both health and productivity, including test scores; and (3) fear that raising awareness of IAQ will open a "Pandora's box" of complaints. U.S. EPA is partnering with organizations of school officials (e.g., ACSA, the Association of California School Administrators, and CASBO, the California Association of School Business Officers) to overcome these misperceptions.

Tools for Schools Programs have been successfully implemented by many schools and districts throughout California. Most notably, Saugus Union School District, which previously experienced tremendous community concerns regarding hazard in classrooms, is an EPA Tools for Schools Excellence Award Winner and a model for other districts. Visalia Unified School District has become a model for the cost-effective treatment of mold problems through its program, and San Francisco Unified School District has developed their program by utilizing groups such as the PTA and the United Educators of San Francisco, in light of understaffed custodial and maintenance levels. Fresno Unified School District and the Fresno Teachers Association, with assistance from EPA, are working jointly to implement the program throughout its 95 schools. At Northgate High School in the Mt. Diablo Unified School District, EPA is facilitating a pilot project in which the school's environmental club is implementing the program; already students have found problems that can be remedied at little or no cost.

Implementation has been successful in many other states. In the west, a pilot study was developed in the states of Washington and Idaho to create individualized, more streamlined *IAQ Tools for Schools* programs, with seemingly good results. School staff are assisted by an experienced IAQ/building science specialist to conduct walk-through assessments at each school, to identify actual problems plus provide as on-site training for staff. The modified program is practical and action-oriented, and the assistance of an unbiased and qualified expert is made available to give on-site guidance, training, and resources (Prill et al., 2002).

Assembly Concurrent Resolution No. 75 (Chan), enrolled in June 2003, recognizes the significance of school indoor environments to the childhood asthma problem, and "encourages California school districts to implement the *Indoor Air Quality Tools for Schools Program* for the benefit of asthmatic children and for the health, well-being, learning, and productivity of the entire school population".

2.5.3 Lead-Safe Schools

Lead exposure in the school environment is one of the few cases where an environmental toxin is regulated (see Section 2.3.1). In 1992, the Legislature directed DHS to conduct a study of lead hazards in the state's public elementary schools and childcare facilities, as part of the *Lead-Safe Schools Protection Act*. The CLPPP study surveyed a random sample of 200 schools and daycare facilities, and identified the prevalence of lead hazards, including lead-based paint, contaminated soil, and drinking water with lead concentration above the federal action level in a report issued in 1998 (DHS, 1998). Most notably, some lead-based paints was found in close to 80% of schools and daycare centers, although only 38% of these also have paint that is deteriorated.

The *Lead-Safe Schools Project* was established in October 1998 jointly by U.C. Berkeley's Labor Occupational Health Program, CLPPP and the state Department of Education. The program provides training, focused documents, and a hotline aimed at school maintenance staff. The joint project has conducted 81 training programs around the state for school maintenance department staff (as of March 2003), with participants representing 425 of the targeted 882 school districts in California.

The Lead-Safe Schools Protection Act (SB 21, Escutia, Statutes of 2002) requires that, starting in 2004, schools shall certify they will follow all standards for the management lead hazards, when they apply for state modernization funding. The Act allows districts to use deferred maintenance funds for the assessment of lead-containing materials and the management of specific lead hazards.

2.5.4 Integrated Pest Management (IPM)

The Healthy Schools Act of 2000 (AB 2260, Shelley) mandated the Department of Pesticide Regulation (DPR) to promote school Integrated Pest Management (IPM) programs. IPM includes implementing 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 pesticide at schools, such as parental notification of pesticide applications, warning signs, recordkeeping at schools, and pesticide use reporting 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. DPR started promoting school IPM earlier, but the Act lead to a more coordinated outreach program, production of guidance documents, formation of an advisory group, performance of baseline and follow-up surveys, and creation of a *California School IPM* web site (http://www.cdpr.ca.gov/cfdocs/apps/schoolipm/main.cfm)

According to the DPR's 2002 survey (Geiger and Tootelian, 2002), 87% of districts were aware of the Healthy School Act, 71% reported themselves to be in compliance with at least three of the four Act's requirements (posting, record keeping, annual notification, and maintaining lists for special notification), and 49% of school districts were fully compliant. Nonetheless, the Act does not explicitly require that schools alter their pest management program with respect to which pesticides are used. A survey by a public interest group identified that while district record keeping about pesticide use has improved under the Act, the use of pesticides with "very hazardous ingredients" has not decreased (McKendry, 2002).

2.5.5 School-based Asthma Management Program

As concern about the increase of childhood asthma has also risen, a number of programs have been developed to target school environments, both to reduce children's exposures to asthma triggers, plus as a convenient contact point to provide information and aid in medical management for the disease. The U.S. EPA (2002) provides resources and information on their web site *Managing Asthma in the School Environment*. The American Lung Association has conducted its *Open Airways for Schools* program since 1992 to informs to educate and empower students to better manage their asthma with the assistance of parents, teachers, school nurses, and physicians, through in-class lessons taught by trained volunteers. DHS has developed a "Strategic Plan for Asthma in California" in consultation with a variety of agencies and organizations. Many local agencies and non-profit organizations are partnering to support school-based asthma management activities, such as the *California Asthma Among the School-Aged* (CAASA) program, funded by the California Endowment.

2.5.6 Statewide Organizations

Several statewide organizations are active in providing guidance to school officials regarding facility O&M. The Coalition for Adequate School Housing (CASH) is an association of school districts, architects, attorneys, facility manufacturers and planners, financial institutions, consultants, and vendors (http://www.cashnet.org/). CASH's Maintenance Network focuses on strengthening maintenance efforts statewide and increasing public and legislative awareness and funding for school maintenance issues. The California Association of School Business Officers (CASBO) represents the group of school officials most directly involved in making O&M policy decisions: Chief Financial Officers and operations managers (http://www.casbo.org/). CASBO make recommendations about staff and budget needs for schools per their size (e.g., they publish manuals such as "Custodial Handbook" and "Maintenance Staffing Formula"). While committed individuals are working hard to promote these goals, there are no state regulations or guidelines on the O&M practices or minimum funding levels for school districts. CASBO has recently noted that districts in California continue to be understaffed relative to CASBO's recommended staffing levels. Their concerns are increased by the current fiscal crisis in the state: facilities are likely to suffer serious impacts as schools grapple with the deepest cuts in state history by reducing maintenance funds.

3. STUDY METHODS AND RESULTS

The study was conducted in two major phases, a mail survey followed by a field study. In the mail survey, Phase I, questionnaires for school facility managers and teachers and passive formaldehyde samplers were sent to randomly selected schools during April-June of 2001. In the field study, Phase II, field technicians inspected classrooms and obtained numerous environmental measurements from October 2001 through February 2002. In both phases, three classrooms (two portables and one traditional classroom) were randomly selected at each school to participate in the study. The following section summarizes the methods and results of the study. More detailed information is available in the final contractor reports for Phases I and II.

3.1 Methods

The sampling approach for this study was designed to be statistically representative of the "target" study population, which was defined as all public schools in California with at least one portable classroom in spring 2001. The sample of schools was drawn randomly from the California Public School Directory 2000 (CDE, 2002). A preliminary mail survey of all public K-12 school districts in 2000-2001 found that there were about 80,000 portable classrooms in California, or about 30% out of a total of 268,000 classrooms estimated to exist in California in 2001 (DHS, 2003).

To ensure that proportionate numbers of schools were selected among the school categories that might have different IEQ-related characteristics, the sample was also stratified by north-south regions of the state, by school type (elementary, middle, or high school), and by urbanization of the area (urban, suburban, or rural). The study data were weighted to adjust for this stratification, and for unequal response rates in certain categories, thereby providing a representative estimate for the target population. As shown in Table 3-1, Phase I included 1,133 classrooms across the state, and Phase II included 201 classrooms across the state.

Table 3-1. Study Design, Phases I and II.

Study Phase	Sampling Period	Sample Size	Question-naires	Building Inspection	Environmental Measurements
I: Mail Survey	April-July, 2001	1133 rooms; 384 schools	Teacher & Facilities	No	Formaldehyde only; 7-10 days
II: Field Study	Oct. 2001 – Feb. 2002	201 rooms; 67 schools	Teacher & Facilities	Yes	Numerous measurements; 6 hours (Table 3-2)

3.1.1 Phase I

Two questionnaires, a Facilities Questionnaire and a Teacher Questionnaire, were created collaboratively by ARB and DHS. The questionnaires were based on questionnaires from other studies, on guidance documents, and on information obtained during public workshops held across the state. The questionnaires were used during both study phases to obtain information from facility managers and teachers about classroom characteristics and the environmental quality conditions and complaints at the sampled schools. The Facility Questionnaire provided *school*-level and classrooms-level information on the physical conditions, operation, and maintenance of building facilities and grounds for 384 schools statewide. The Teacher Questionnaire provided *classroom*-level information, such as the presence of potential pollutant sources and observations of moisture, air quality, noise, and lighting problems.

In addition, airborne formaldehyde was measured in a sub-sample of the Phase I classrooms. ARB pre-tested the passive formaldehyde samplers (small glass tubes with a special adsorbent), and, in consultation with the manufacturer, developed protocols that achieved improved sensitivity and precision. These samplers have been widely used in previous mail survey studies, including those in a large study of manufactured homes conducted by DHS (Sexton et al., 1989; Liu et al., 1991). The samplers were mailed with the Phase I survey materials and placed in the classrooms by school or district personnel for approximately 10 days.

3.1.2 Phase II

Phase II was a field study of environmental conditions in classrooms from 67 schools in a stratified-random sample of all schools with at least one portable classroom both in the spring of 2001 and in the 2001-02 school year. Field technicians inspected the HVAC system and classroom interiors and exteriors, and recorded measurements of air flows, noise levels, lighting levels, and moisture content of the interior walls, floor, and ceiling. The field technicians also collected a wide array of environmental samples and measurements during one school day at each school, as summarized in Table 3-2. Indoor and outdoor data were collected for many of the measurements.

Most measurements were obtained across the six hours a day when the classrooms were typically occupied. HVAC testing, noise measurements, and sampling for culturable airborne molds and pollens were conducted during lunch breaks. Environmental samples were stored on ice and shipped weekly by overnight delivery. Quality control checks were performed for field and laboratory measurements, and for entry of questionnaire and inspection data. The measurements of air pollutants and dust contaminants showed good precision (an average of 10% or less across sample types). Only the measurements and data meeting acceptance criteria were used in the study.

Of the 67 schools studied in Phase II, 14 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.

Table 3-2. Phase II, Summary of Environmental Measurements.

Sample	Classroom Air	Outdoor Air	Floor Dust	Comments
Airborne				
Aldehydes	X	X		13 aldehydes, including formaldehyde
VOCs (volatile organic compounds)	X Note: only sampled in half the schools	X		9 VOCs, including benzene, toluene, xylenes, chlorinated hydrocarbons
Mold Spores & Pollens	X	X		22 mold and pollen species
Culturable microorganisms	X	X		Specially selected schools only
Particle counts	X	X		Continuous. 2 cut points: <2.5 and <10 um
Floor Dust				
Pesticides			X	20 species studied
Metals			X	18 elements, including lead
PAHs (polycyclic aromatic hydrocarbons)			X	16 species studied
Allergens			X	5 types (cat, dog, 2 dust mite, cockroach)
Environmental				
CO_2 (carbon dioxide)	X	X		Continuous
Temperature, Relative Humidity	X	X		Continuous
Noise	X	X		Unoccupied classroom and outdoor measurements
Light	X			3 locations in room
Moisture	X			Walls, floor, and ceiling measured

3.2 Results

Results from Phase I and II are discussed below. When portable and traditional classrooms are compared, the results are given as "portable vs. traditional." When results are compared among portable, traditional, and all classrooms, the results are weighted to provide the statewide estimates. When the results are characterized as statistically significant, this reflects a 95% confidence level.

3.2.1 Classroom and School Characteristics

There was a substantial difference in the estimated age distributions for portable and traditional classrooms. For instance, 55% of the portables were 10 years old or less, whereas only 12% of the traditional classrooms were 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, all of which are discussed below.

Portable classrooms were more prevalent in elementary schools than in middle or high schools. Most of the portable classrooms (90%) were devoted to general instruction; a smaller fraction (75%) of the traditional classrooms were used this way.

The schools were mostly suburban schools (74%) and mostly elementary schools (59%). Only about 29% of the schools were less than 30 years old, and the majority (54%) of the schools have 10 or fewer portable classrooms. Nearly all portables had air-conditioning systems installed, but only about three-fourths of traditional classrooms had air-conditioning.

3.2.2 Building Materials and Other Pollutant Sources

As shown in Table 3-3**,** portable classrooms were reported more frequently than traditional classrooms to have carpeted floors, vinyl tackable wallboard, and pressed wood bookcases -- building features that are associated with indoor aldehyde, VOC, and/or particle emissions. Portables were also reported more often to have suspended ceilings and metal roofs–building features associated with indoor moisture-related problems. Similar results were found in Phase II.

Table 3-3. Percent of classrooms with certain building characteristics, Phase I.

Classroom Type	Carpeted floors	Vinyl tackable wallboard	Pressed wood bookcases	Suspended ceilings
Portable	71	79	55	87
Traditional	34	28	48	62
All	48	47	51	72

3.2.3 Environmental Problems

Most types of environmental complaints were reported more often for portable classrooms than for traditional classrooms (Table 3-4). Teacher complaints of air quality (stuffy air and musty odors) and noise were reported more frequently in portable classrooms (Table 3-4). Plumbing leaks and thermal (temperature) complaints were more prevalent in traditional classrooms. Pest-related problems (not shown in table) were reported about the same in both room types (over 30%).

The dominant thermal complaint in portable classrooms in Phase I was that they were too cool, but in traditional classrooms it was that they were too warm. This difference is consistent with the lower occurrence of air-conditioners in traditional classrooms.

Also, a large fraction of teachers in portable classrooms (60%) reported that they turn off the HVAC system due to high noise levels, an activity that had previously been reported anecdotally and in other studies. This behavior was reported significantly less often for traditional classrooms (23%).

Table 3-4. Percent of classrooms with environmental problems reported by teachers, Phase I.

Classroom Type	Stuffy Air	Musty Odor	Roof Leaks	Plumbing Leaks	Thermal	Noise	Lighting
Portable	45	69	27	8	22	53	27
Traditional	33	59	21	18	35	41	13

3.2.4 Building Operation and Maintenance

Facility management staff reported a program of routine HVAC maintenance at most schools (94%), although only two-thirds of the facility managers (67%) kept HVAC maintenance logs. However, some schools may rely on their HVAC contractors to maintain logs. Annual HVAC inspection, maintenance, and record-keeping are required by Cal/OSHA regulations (CCR Title 8, Sec. 5142).

The majority of the schools conducted annual maintenance activities for the HVAC system (e.g., cleaning the coils, checking the condensate pan and heat exchanger), and most facility staff reported that the air filters were checked or replaced quarterly. 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; it is not clear if this maintenance was done by contractors instead. About half of the schools (57%) swept, vacuumed, and dusted the classrooms five days a week; most other schools did so several times a week.

Over half of the school facility managers (52%) received some type of environmentally related complaint within the last year. 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.

3.2.5 Classroom Ventilation

3.2.5.1 Ventilation Systems

Phase I surveyed the characteristics of HVAC systems and the use of doors and windows for ventilation in portable and traditional classrooms. Results showed that portables had more modern HVAC equipment and controls than did traditionals, i.e., they more often had air conditioning (95% vs. 77%) and an adjustable thermostat in the room (77% vs. 50%) controllable by the teacher (45% vs. 27%). These factors may help explain why teachers in traditional classrooms more frequently complained that the rooms were too warm.

"Natural ventilation" from open doors and windows can sometimes help remove indoor pollutants from classrooms, if the wind speed, direction, temperature differences, and cross-flow patterns are sufficient. More portables than traditionals had windows that open (87% vs. 66%), but the fractions of teachers reporting they kept their windows open "frequently" were very similar for the two room types. More portable had doors that open to the outside (100% vs. 77%), but exterior doors to portables were reported to be kept open less often, likely because of outside noise.

Portables are more often equipped with packaged HVAC systems with heat pumps (81% vs. 63%), have wall air handling units (81% vs. 32%) and have automatic supply fan operation (87% vs. 65%). Ease of access is an important factor in how well HVAC systems are maintained over time. The much higher prevalence of wall units in portables may help explain why portable classroom HVAC systems have better access for maintenance compared to traditional classrooms, which often have roof top units.

3.2.5.2 Ventilation Inspection

Phase II provided detailed measurement and observational information. As shown in Table 3-5, poor HVAC conditions were found more often in portables. A significant number of outdoor air dampers were blocked in portables (11%), and over half of the portables failed the test for the HVAC condensate drain (59%). Nearly half of the portables had air filters with medium or heavy loading. These conditions can have negative impacts on indoor environmental quality, e.g.:

- Closed outdoor air dampers result in insufficient outdoor air ventilation.
- Malfunctioning or blocked condensate drains result in standing water, a potential source of mold and bacteria.
- Increased dust loading on filters result in decreased air flows and may become a breeding ground for mold.

- Many of these problems are indications of inadequate maintenance and/or poor design.

Table 3-5. HVAC Maintenance Characteristics, Phase II.

Classroom Type	Outdoor Air Damper Blocked (%)	Drain Test Failure (%)	Filter Loading: Medium or Heavy (%)
Portables	11	59	40
Traditionals	3	12	27

3.2.5.3 Ventilation and Thermal Comfort Measurements

CO_2 Levels. Carbon dioxide (CO_2) levels were measured continuously throughout the day as an indicator of building ventilation sufficiency. Indoor CO_2 levels reflect the CO_2 exhaled by building occupants and the outdoor air CO_2 levels. Indoor levels typically are higher than outdoor levels, but substantially elevated indoor levels result from insufficient outdoor air ventilation of the classroom. Groups such as ASHRAE and Health Canada have recommended that indoor CO_2 levels not exceed 800-1200 ppm, depending on outdoor CO_2 levels; the 2005 California Energy Code for certain types of ventilation systems requires that CO_2 levels not exceed 1000 ppm (CEC, 2003).

Average CO_2 levels in portable classrooms were 1064 ppm; traditional classrooms were not significantly different (Table 3-6). Outdoor CO_2 levels were typically about 425 ppm over the day, with short-term peaks over 650 ppm. Indoor CO_2 levels were elevated over 1000 and 2000 ppm for a substantial portion of the day, indicating that nearly half the classroom hours have inadequate or marginal ventilation, and that about 10% of the classroom hours clearly have inadequate ventilation.

Table 3-6. HVAC Operation Characteristics, Phase II.

Classroom Type	Mean Indoor CO_2 (ppm)	Mean Outdoor CO_2 (ppm)	Mean % of Class Hours @ CO_2 > 1000 ppm	Mean % of Class Hours @ CO_2 > 2000 ppm	Outdoor Air Flow (mean cfm/ft^2)
Portables	1064	425	42	9	0.95
Traditionals	1074	425	43	10	0.80

Outdoor Air Flow. Study technicians measured outdoor, return, and total supply air flow rates for a subset of classrooms while the HVAC system was operating. The State design standard for classroom ventilation is typically 15 cfm of outdoor air per person, or

0.15 cfm/ft^2. Nearly all classrooms had outdoor air flow capacities greater than 0.15 cfm/ft^2. When the air flow capacity was expressed in cfm per chair in the classroom (a surrogate for cfm/person), about 10-20% of the classrooms had HVAC systems with outdoor air flow capacities of less than 15 cfm/chair.

The air flow measurements were also expressed per square foot of floor area. The typical portable classroom is ~1000 ft^2 and houses between 20 and 35 persons. The standard of 15 cfm/person converts to a required outdoor air flow rate of 300 to 525 cfm (or 0.3 to 0.5 cfm/ft^2). Flow rate measurements indicated that all classrooms with operational HVAC units were capable of providing outdoor air above this minimum requirement. No significant differences were found between portable and traditional classrooms, except that portables had higher flow rates per square foot of floor area (see Table 3-6).

Most HVAC systems were capable of delivering adequate outside air and total air flows when operated properly, but a small percentage of classrooms may have inadequate flow for maximum occupancies, due improper system design. The stuffy air complaints by teachers can result from inadequate outdoor air flow capacity, but they probably result most often from improper operation of the HVAC system. This occurs primarily for three reasons:

- the outdoor air dampers are closed or blocked;
- either the thermostat control is limiting the amount of time the system fan is operating (i.e., the fan operates only when the system needs to heat or cool the classroom); or
- the teacher simply turns off the system because the noise is disruptive to class activities.

Thermal Comfort. HVAC systems should not only provide healthful indoor air quality but also provide a comfortable thermal environment. Temperature levels were significantly different, with 27% portable and 17% traditional classrooms experiencing levels cooler than ASHRAE thermal comfort standards for the heating season. Both classroom types experienced temperatures notably warmer than the ASHRAE standard levels for a large percentage of the day, even though the weather was generally cool during sampling. About 14% of all classrooms had relative humidity (RH) measurements above 60% for a substantial part of the day; 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. About 11% of both types of classrooms had RH levels below 30%, which can lead to dry mucous membranes and increased susceptibility to respiratory infections.

3.2.6 Air Pollutant Measurements

Some classrooms had air pollutant levels that exceed levels of health concern. To assess the level of health concern, measured levels are compared to available guidelines and standards based on health and comfort. The cancer guidelines used here for comparison are based on unit risk estimates for pollutants that are carcinogens.

These cancer unit risk estimates assume a *lifetime exposure* to the pollutant at a concentration of 1 $\mu g/m^3$. Clearly students and teachers do not spend their entire life in classrooms, but the concentrations of these pollutants in other indoor environments such as homes and office buildings where they spend most of their time are often similar to those concentrations in schools, or even higher. The combined lifetime exposures to carcinogens in indoor and outdoor environments are of concern, but the cancer risks from indoor exposures may be somewhat lessened for those pollutants that off-gas from building materials over time. The measured levels of pollutants and the level of health concern are discussed below.

3.2.6.1 Aldehydes

Of the 13 specific aldehydes measured in the study, only two–formaldehyde and acetaldehyde–were detected in more than 75% of the samples. 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. ARB (1992) has identified formaldehyde as a Toxic Air Contaminant, based on its potential to cause cancer. Formaldehyde can also irritate the eyes and respiratory system, and affect the immune system. For these non-cancer effects, OEHHA has established an Acute REL of 76 ppb for 1-hour exposure, and a Chronic REL of 2 ppb for long-term exposure (Table 2-1). OEHHA has also extrapolated an 8-hour Interim Reference Exposure Level (IREL) of 27 ppb for 8-hour exposure to formaldehyde (Broadwin, 2000), which is the most directly relevant guideline for assessing Phase II results.

Indoor concentrations were routinely elevated over outdoor concentrations (measured in Phase II), as shown in Table 3-7. This is consistent with the findings of previous studies, indicating that indoor sources of formaldehyde emissions are ubiquitous and sizable. Modeling results showed that several factors were associated with indoor formaldehyde levels, including the following:

- Composite wood products in building materials or furnishings, including plywood and particleboard, vinyl tackboard, and pressed wood bookcases and cabinets, which can all emit large amounts of formaldehyde.
- Temperature and humidity, which affect the emission rate of formaldehyde.
- Classroom age, which reflects the off-gassing of formaldehyde sources over time. Formaldehyde typically off-gasses from building materials over a 3-5 year period.

Indoor formaldehyde air concentrations in portables averaged 32 ppb in Phase I, and 15 ppb in Phase II. Traditional classrooms were lower, averaging 24 ppb in Phase I and 12 ppb in Phase II. Both the means and 95th percentile concentrations were notably higher in Phase I, and higher for portables compared to traditional classrooms in both Phase I and II. The higher indoor levels in Phase I were expected because the Phase I sampling was conducted during warmer weather when indoor formaldehyde levels are

Table 3-7. Indoor Formaldehyde Concentrations, Phase I and II.

Location	Sample size (n)		Mean (ppb)		95th Percentile (ppb)		% Exceeding 27 ppb, IREL Health Guideline*	
	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II	Phase I	Phase II
Outdoor	NA	62	NA	3	NA	8	NA	0
Portable	644	135	32	15	72	26	50	4
Traditional	267	64	24	12	55	22	29	3
All Classrooms	911	199	27	13	62	24	37	~3 - 4

*IREL (Indoor Reference Exposure Level) for formaldehyde: 27 ppb, 8-hr average. Established by OEHHA, based on eye irritation and effects of the respiratory and immune system (Broadwin, 2000).

usually higher, and because the sample size was substantially larger, increasing the probability of including classrooms with more extreme levels in the sample. Phase I also included nights and one or two weekends in the sampling period, during which the classrooms were probably poorly ventilated. Also, in Phase II sampling, technicians operated the ventilation system to make flow measurements, which might have reduced formaldehyde levels relative to what they might have been under normal operation conditions. Average school-year levels of indoor formaldehyde are likely to fall between the Phase I and II measurements.

Using Phase II measurements over six hours during cooler weather as a very conservative estimate, a minimum of about 4% of the classrooms, and more likely a higher percentage, had indoor formaldehyde levels above the IREL of 27 ppb. This totals about 10,720 classrooms, or 214,400 children (assuming 20 children per classroom) exposed to formaldehyde levels that could potentially result in irritant effects.

All of the classrooms exceeded the Chronic REL. Also, as in most homes and offices, all classrooms greatly exceeded 0.13 ppb of formaldehyde, the level equivalent to a risk of one excess cancer case per million persons (ARB, 2002). These results indicate that a small but substantial percentage of classrooms have formaldehyde levels that may cause short-term irritant effects, and that nearly all classrooms have formaldehyde levels that may cause long-term irritation and contribute to cancer risk.

Acetaldehyde. ARB (1993) has identified acetaldehyde as a Toxic Air Contaminant, based on its potential to cause cancer. Additionally, short-term exposure to acetaldehyde can cause eye, skin, and respiratory tract irritation, while long-term exposure can affect the upper airway, red blood cells, kidneys, and growth (ARB, 1993). OEHHA (2000) has established a chronic REL for acetaldehyde of 5.0 ppb. Outdoor sources of acetaldehyde include combustion sources such as tailpipe exhaust, stacks, and fires, as well photochemical oxidation of hydrocarbons (smog). Indoor sources of acetaldehyde include combustion sources such as cigarettes, fireplaces, woodstoves, gas appliances, and cooking activities. Acetaldehyde can also be emitted from some building materials such as composite wood products, rigid polyurethane foams, and some consumer products such as adhesives, coatings, lubricants, inks, and nail polish remover (Kelly, 1996; ARB, 1997).

Acetaldehyde levels in portable classrooms in Phase II averaged 6.6 ppb. Outdoor levels averaged slightly less (4.4 ppb), and may be higher during warmer seasons due to increased photochemical production. Traditional classrooms had slightly lower indoor levels of acetaldehyde. Factors contributing to indoor levels included those identified for formaldehyde, except that outdoor air concentration was significantly correlated and classroom age was not.

About 75% of the portable and traditional classrooms exceeded the chronic REL, and about 25% of the outdoor measurements exceeded this guideline. Nearly all classrooms and outdoor concentrations exceeded 0.21 ppb, the concentration that poses a risk of one excess cancer case per million persons (OEHHA, 2002). These results also suggest that a large portion of the classrooms have indoor acetaldehyde levels that can cause chronic irritation and perhaps other health effects, especially when considering the concurrent exposures to formaldehyde and other aldehydes and irritants also found in the classrooms and other buildings.

3.2.6.2 Volatile Organic Compounds (VOCs)

Seven of the nine measured VOCs were measured above their detection limits in 80% of the samples. The other two were detected in at least 50% of the samples. As in most indoor air quality studies, the measured indoor VOC concentrations were higher than those observed outdoors. Average indoor classroom concentrations ranged from a high of 6 $\mu g/m^3$ for toluene (slightly less for *m,p*-xylene) to less than 0.5 $\mu g/m^3$ for chloroform. For all others, the averages were in the range of 1 to 2 $\mu g/m^3$.

Benzene. Benzene is a carcinogen; ARB (1984) has identified it as a Toxic Air Contaminant. Short-term exposure to benzene can cause mild irritation. Long-term exposure can reduce the numbers of blood cells, platelets, and immune system components in the blood. OEHHA (2000; 2002) has established an Acute REL of 1300 $\mu g/m^3$ for 6-hour exposures, and a Chronic REL of 60 $\mu g/m^3$.

Indoor benzene concentrations in portable classrooms averaged 1.3 $\mu g/m^3$, with a 95th percentile value of 3 $\mu g/m^3$. Outdoor levels of benzene averaged 1.0 ppb, while the 95th percentile value was 3 $\mu g/m^3$. In traditional classrooms, the mean was similar to that of portables, but the 95th percentile value was higher at 4.6 $\mu g/m^3$. Modeling results showed that indoor air benzene concentrations were associated with outdoor concentrations, and suggested that the presence of carpet and outdoor activities such as construction might contribute.

These results indicate that classroom levels of benzene are well below the RELs, and, hence, do not pose a risk of non-cancer hazards. However, both the outdoor and indoor concentrations of benzene exceeded by two orders of magnitude the level of 0.03 :g/m^3, the concentration that poses a risk of one excess cancer case per million persons (OEHHA, 2002). The results suggest that, because outdoor sources of benzene are the primary sources for both indoor and outdoor levels, schools should be carefully sited and operated to minimize exposure to vehicle and equipment emissions. Building materials and other products should be screened to assure they do not contain benzene.

Chloroform. Chloroform is a carcinogen; ARB (1990) has identified it as a Toxic Air Contaminant. Chloroform is released into indoor air by vaporization from a number of sources including: chlorinated tap water, pools, and spas; household bleach products; and office and household products manufactured using chloroform as a solvent. Short-term exposure to chloroform can affect the nasal lining, reproductive system, and development. Long-term exposure can affect the liver and kidneys. OEHHA (2000, 2002) has established an Acute REL of 150 :g/m^3 for a 7-hour exposure, and a Chronic REL of 300 :g/m^3.

Indoor chloroform concentrations in portable classrooms averaged 0.30 :g/m^3 in portables and 0.48 :g/m^3 in traditional classrooms. The 90th percentile values were lower in portables (0.42 vs. 0.91 :g/m^3). Outdoor levels of chloroform averaged 0.45 :g/m^3, while the 90th percentile value was over 1.12 :g/m^3. Modeling results showed that indoor air chloroform concentrations were associated primarily with outdoor concentrations, and to some extent with temperature, classroom age, school type, room age, ventilation, and outdoor activities such as construction.

These results indicate that classroom levels of chloroform are well below the RELs, and, hence, do not pose a risk of non-cancer hazards. However, about 75% of the outdoor and indoor concentrations were above 0.19 :g/m^3, the concentration that poses a risk of one excess cancer case per million persons (OEHHA, 2002). The results suggest that outdoor sources of chloroform are the primary source of indoor chloroform levels; thus, schools should be carefully sited and operated to minimize exposure to outdoor emissions of chloroform. In addition, use of cleaning products containing bleach should be minimized, and indoor areas of heavy tap water use should be well ventilated.

3.2.6.3 Particle Counts

Real time counts of particulate matter were measured in each classroom and outdoors. It should be noted that particle counts cannot be directly associated with mass concentration standards. However, the measurements provide a relative indication of mass for comparison purposes.

The mean counts for the two particle sizes of interest, <2.5 microns and <10 microns, were about the same, but portable classrooms showed higher counts at the upper percentile levels, especially for the smaller size range. One possible explanation for the increased particle counts in the portables 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, either due to resuspension of previously deposited particles or by chemical reactions at the carpet surface (Fan et al., 2003). Another possible source of particles, as well as of benzene and acetaldehyde, is vehicle traffic and portable equipment used for landscape maintenance. Over 50% of portable and traditional classrooms were within 50 feet of parking lots and roadways, and portables are sometimes sited with their air handling units near roadways and parking lots for security reasons. Recent research (Sioutas et al., 2003) has shown dramatically higher levels of fine particles very near roadways. Additionally, most schools maintain their landscaping and grounds with blowers and other equipment that are notorious dust producers. Further analysis is needed to confirm the relationships of potential indoor and outdoor particle sources, and examine the particle count patterns throughout the day.

3.2.7 Floor Dust Contaminants

Some persistent (long-lived) environmental contaminants can accumulate in floor dust over time. This is especially a concern for younger children who spend time on the floor and can be exposed to the dust contaminants by hand-to-mouth contact and skin contact, and by inhalation of resuspended floor dust by walking, vacuuming and other activities.

Floor dust was collected because it provides useful information on the deposition of persistent contaminants in the past. Floor dust was collected in this study by using a special vacuuming protocol – a measured area of the floor in the rooms' main foot traffic area was vacuumed with a hand-held vacuum containing a filter. Dust contaminants were expressed as concentrations (:g/g, microgram per gram of dust) and as loading (:g per cm^2 of sampled floor area). Contaminant levels in floor dust and soil can be indicators of *potential exposures in the past and present*. The estimated health risks from exposures to these pollutants depend in part on the age, toxicological vulnerability, and activity of the populations exposed.

Concentrations of some pollutants in the floor dust can be compared to the Preliminary Remediation Guidelines (PRGs) for residential soil concentrations developed by U.S. EPA Region 9 (EPA, 2002a) for screening carcinogenic and non-carcinogenic health hazards at hazardous waste sites. The PRGs for carcinogens are based on a risk of one excess cancer case in a million persons exposed for a lifetime. California State agency risk estimates are also used when available.

3.2.7.1 Pesticides in Floor Dust

Exposure to pesticides in sufficient quantities may affect the nervous system or the immune system. Some pesticides are also known to cause cancer, and some are suspected of being endocrine disruptors, i.e., they affect hormonal function. Selected pesticides of several types were measured: organochlorine, organophosphate, pyrethroid, carbamate, and synergist (DPR, 2003). Some of the pesticides have been banned or restricted in use.

Floor dust samples from the two portable classrooms at each school were combined for analysis due to cost constraints. Thus, there were two samples from each school, one containing dust from two portables and one containing dust from a single traditional. Pesticide residues were found in all floor dust samples, indicating the widespread use of a variety of different products in or near classrooms. Six of the 20 pesticides measured were detected in over 80% of the samples: esfenvalerate, chlorpyrifos, *cis*- and *trans*-permethrin, o-phenylphenol, and piperonyl butoxide. Three others–diazinon, 4,4,'DDE, and propoxur–were measured in over 50% of the samples.

At the 95th 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 samples. Many of the pesticides had median loading levels less than 0.01 ng/cm^2, nanograms per square centimeter of sampled floor surface). Esfenvalerate, a commonly used insecticide, had the highest dust concentration and the highest median loading level (0.34 ng/cm^2). No statistically significant differences between the means for the portable samples and traditional classrooms were found for either the concentration results or the loading results. Because some of the pesticides have an environmental half-life of a few weeks, some of the pesticides were likely applied within a few months before the sampling period at some schools in 2001-2002.

As expected, some very persistent pesticides that have been banned for some time were found in the floor dust – chlorpyrifos, DDE, and dieldrin. It is likely that dust levels of these pesticides in schools may be slowly decreasing after the bans, because the pesticides can persist in soils and dust for several years.

- Chlorpyrifos is an organophosphate insecticide once used regularly on school grounds. Before June 2000, when EPA issued its ruling to ban chlorpyrifos in non-agricultural settings including schools, chlorpyrifos was found in over 800 insecticide products; it was an ingredient in many lawn-care pesticides and in common household insecticide products.

- DDE is a break-down product of DDT, a widely used insecticide that was banned in 1972 (EPA, 2000a). Environmental sources of DDE include soil, atmospheric dispersion, sediment runoff, contaminated plants and animals, and improper use and disposal. Measurable levels of DDE (4,4'-DDE) in the floor dust were found in 48% of portable samples and 58% of traditional classroom samples.

- Dieldrin, an insecticide and a by-product of the pesticide Aldrin, was widely used from 1950 to 1974 to control insects on cotton, corn and citrus crops (EPA, 2000b). Also, dieldrin was used as to preserve wood, control termites, and control locusts and mosquitoes. Most uses of dieldrin were banned in 1987. Environmental sources of dieldrin include soil surrounding wooden structures treated for termites; soil or sediment; improper use or disposal; contaminated fish and shellfish; and contaminated dairy products and meat.

Since the discontinuation of chlorpyrifos, a class of insecticides called pyrethroids, which includes esfenvalerate and *cis*- and *trans*- permethrins, has been widely used as a substitute for chlorpyrifos and other organophosphate pesticides. Permethrin acts on a broad spectrum of insects, and is less persistent than chlorpyrifos in dust and soils with a half-life of 30 to 38 days. Esfenvalerate is equally short-lived in the environment. Many of the pyrethroid-containing insecticides are more effective with the addition of piperonyl butoxide (PBO) as a synergist. PBO is used in indoor fogging and termite control, and on gardens, lawns, and indoor plants. Like the pyrethroids, PBO is not a long-lasting contaminant of dust and soils.

Lindane, an organochlorine pesticide, was used on a wide variety of food crops, ornamentals, livestock, homeowner, and other sites until about 1985 (EPA, 2002c). Lindane is still used to treat head lice and scabies, and to treat seeds for six crops (barley, corn, oats, rye, sorghum, and wheat). Measurable levels of lindane in the floor dust were found in 6% of the portables samples and none of the traditional classroom samples. The highest lindane levels measured were at least two orders of magnitude less than the PRG of 0.44 ppm for cancer effects.

O-phenylphenol was the only fungicide measured in the study. *O*-phenylphenol's use in commercial disinfectants such as Lysol and in some common insecticides makes it an easily accessible and highly prevalent pesticide in school classrooms. Data were not available on its persistence in the environment.

Dieldrin was the only pesticide measured in floor dust that exceeded or nearly exceeded a PRG for cancer or non-cancer effects. It was found in measurable levels in 13% of the portables and 30% of the traditional classrooms. Compared to the PRG of 0.03 :g/g for cancer effects, less than 10% of portable samples but about 25% of traditional classroom samples had dieldrin levels above the PRG. This result suggests that, based on the conservative assumptions in the cancer risk calculations, the cancer risk from dieldrin is a potential health concern, especially in older classrooms.

3.2.7.2 Metals in Floor Dust

Some of the metals measured in this study are known to have neurological or carcinogenic effects. Fifteen of the 18 metals analyzed were detected in the floor dust samples. Some metals, such as lead, had higher median dust concentrations in samples from traditional classrooms; arsenic tended to have higher median dust concentrations in the portables samples.

Because the floor dust samples for the portable classrooms were combined before laboratory analysis in order to screen samples that would merit further analyses, only limited statistical comparison of floor dust results was conducted. Significant room-type differences at or near the 10% level were found for a few metals: aluminum, magnesium, and strontium concentrations in floor dust were significantly greater in traditional classrooms, but at levels not expected to be of health concern.

When comparing dust loading (:g/cm^2, micrograms per square centimeter of floor area sampled), all metals had higher dust loadings in portables samples than in traditional samples. This may be due to the higher frequency of carpeted floors and elementary school locations. However, only arsenic loadings showed a significant difference – portables were significantly higher. This difference may be due to the presence of arsenic-treated structural wood and playground equipment, as well as natural-occurring soil concentrations and arsenic in fertilizers.

<u>Lead.</u> Samples from portables averaged 67 :g/g (micrograms per gram; also equal to ppm) of lead with a 95^{th} percentile value of 152 :g/g, while traditional classrooms averaged 95 :g/g and showed a 95^{th} percentile value of 201 :g/g. Although these differences were not statistically significant, it is possible that the higher levels in traditionals are in part due to the presence of old paint.

Classroom dust samples in the PCS are not directly comparable to those used for compliance testing for the federal lead standard (U.S. EPA, 2001c), which use wet-wipes rather than vacuuming. The vacuum sampling in carpeted classrooms may tend to overestimate the lead accessible to children because it may include lead buried in the carpet fibers. The vacuum sampling of hard floors, which is more common in traditional classrooms, would have this problem to a lesser degree. Furthermore, the federal standard was established to protect children under six years of age who are most susceptible to lead toxicity, and especially infants and toddlers, who are most likely to ingest lead from surface dust exposures. Although PCS results cannot be compared against any state or federal standards, the amount of lead collected from the carpets does indicate the presence of lead-containing dust.

A DHS (1998) study of lead in California's public elementary schools found that 7% of schools had lead levels in soil exceeding the U.S. EPA hazard standard of 400 ppm. Lead paint and some paint deterioration were found in 37% of the schools. The frequency of elevated soil lead in the DHS study is similar to that for elevated levels of floor dust lead in this study. Recent inspections in the Los Angeles Unified School District have found that 34% of pre-1993 schools had environmental lead deficiencies, i.e., peeling or chalking exterior paint (Brakensiek, 2003).

One possible source of lead contamination in floor dust is lead-based paint, which is very common in older buildings. Lead from outdoor paint can contaminate soil that is tracked into classrooms, and it can be released and spread in older buildings during repairs and remodeling. However, because carpets are often fairly old, it is not possible to determine whether lead found in dust samples was recently or historically introduced into the classroom. These results suggest that some portable and traditional classrooms may require remediation to remove lead, especially where younger students or women of childbearing age are present.

<u>Arsenic.</u> Sources of arsenic include naturally occurring arsenic in soil, which can be significant in some areas, as well as certain pesticides and contaminated fertilizer and perhaps treated wood. The California Department of Food and Agriculture (CDFA ,

2002), has proposed standards for arsenic, lead, mercury, and cadmium levels in fertilizers.

Arsenic concentrations in floor dust in portables averaged 13 ppm, while traditional classrooms averaged 11 ppm. The 95%ile value was 19 ppm for portables, and 15 ppm for traditional classrooms. In comparison, median levels of arsenic in California agricultural soils (Bradford et al., 1996) are about one-third the mean floor dust concentrations measured in the classrooms, while 95th percentile values for arsenic in agricultural soils are about two-thirds of the values for floor dust in this study. Nearly all samples of floor dust had arsenic levels above 0.39 ppm, the estimated level in the PRG for residential soil that is equivalent to a risk of one excess cancer case in a million persons exposed.

3.2.7.3 Polycyclic Aromatic Hydrocarbons (PAHs) in Floor Dust

PAHs are ubiquitous products of combustion (e.g., wood smoke, diesel and gasoline exhaust, tobacco smoke, cooking). They are found in measurable quantities in the air, especially in urban areas. They are semivolatile compounds and therefore accumulate in soil and dust. 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 relatively low. The mean concentrations of most PAHs in the portables sample were similar to those in traditional classroom sample, but the portable samples had much higher 95th percentile values for nearly all PAHs measured. These differences between room types may be due to the higher prevalence of carpeted floors and nearby vehicle traffic in portables. The indoor PAH levels results were similar to those reported surface wipe loadings for the homes of 102 children in Minnesota (Clayton et al., 2002), and lower than those reported for floor vacuum samples in children’s homes in North Carolina (Chuang, et al., 1999).

3.2.7.4 Allergens in Floor Dust

Varying amounts of allergen levels were measured in floor dust samples. Dog and cat allergens (*Can f*1 and *Fel d*1) were detected most frequently: they were found in more than half of the classroom dust samples. However, their concentrations were generally below sensitization levels. Dust mite allergens (*Der f1* and *Der* p1) were detected in only 6-7% of dust samples. Levels of cat, dog, or mite allergens showed moderate concentrations in a small subset of classrooms, but only two classrooms had any allergen (dog) above an established sensitization level (IOM, 1993, 2000). This finding is consistent with previous studies indicating that allergens from pets can be carried into schools and other buildings on the clothes of pet owners, but that the concentrations of these allergens are seldom enough to cause sensitization (IOM, 1993, 2000). However, concentrations of these allergens as found in both traditional and portable classrooms may be sufficient to cause allergic responses in those with pre-existing allergies to dogs, cats or dust mites. Cockroach allergen was detected in only two samples (1%), in part because the detection limit was higher for this type of assay.

3.2.8 Moisture and Mold

The episodic and infrequent nature of roof leaks, plumbing leaks, floods, etc., the dependence of mold growth on temperature and humidity, and the influences of ventilation patterns and indoor activity on particle generation and distribution determine the likelihood of mold growth and concentration of spores in indoor air. Spot measurements of airborne mold spores provide limited information on the presence of mold growth in indoor environments. Therefore, we did not expect to measure elevated levels of airborne mold spores in classrooms during a one-day building inspection unless mold contamination was severe. In addition to sampling for culturable and non-culturable bacteria and fungi, the field technicians also inspected the classrooms for signs of mold growth or its predecessor (water damage), by searching for water stains, condensation, visible mold, and poor site drainage, and by measuring the moisture content of interior building surfaces.

3.2.8.1 Moisture-related Indicators

As discussed above, Phase I questionnaire data showed that teachers frequently observed signs of excess moisture and mold contamination. In Phase II, field technicians measured moisture content at one location in each wall, floor, and ceiling; preferred measurement locations were near water stains or other signs of water damage, or under windows. Because the large majority of the moisture readings were 0% and the rest were nearly all between 10-20%, excess moisture was defined operationally as at least 10% moisture. Observations of the field technicians sometimes confirmed the presence of leaks or spills nearby when moisture levels were in this range. The results of building inspections for moisture indicators in Phase II are summarized in Table 3-8.

Water stains on the ceiling were found in 21% of the portable classrooms, indicating current or previous roof leaks. This frequency seems high given that most portable classrooms are relatively new, but portable classrooms often have a full-length joint between modules that can leak at the roof level. Traditional classrooms had a higher frequency of water stain on the ceiling (35%), which may reflect their greater age. Water stains on the floor were observed in 13% of the portable classrooms, but very rarely in traditional classrooms, possibly due to the lower frequency of carpeted floors in traditional classrooms. This may also be due to poor performance of flashing and caulking used in the modular construction of portable classrooms.

Excess moisture in the walls, floors, or ceilings was found in 12% of the portable and 20% of traditional classrooms. This is consistent with the higher rate of ceiling stains and standing surface water near traditional classrooms. Visible mold was not commonly observed, but was seen on the ceiling in 3% of portable and 0.1% of traditional classrooms.

Other indicators of potential moisture problems were also examined. Mold was observed on HVAC filters infrequently (1.3% of portable and none in traditional

Table 3-8. Percent of Classrooms with Moisture Indicators, Phase II.

Classroom Type	Water Stains on Ceiling	Water Stains on Floor	Excess Moisture in Walls, Floor or Ceiling*	Visible Mold on Ceiling	Standing Water within 50 ft.
Portable	21	13	12	3	32
Traditional	35	2	20	0	43

* Operationally defined as a moisture meter reading of at least 10%.

classrooms). Many portable classrooms (43%) had foundation skirts less than two inches from the ground, which can lead to moisture problems with the walls and subfloor due to wicking action and/or poor crawlspace ventilation.

3.2.8.2 Mold Measurements

In the Phase II study, air samples for *non-culturable* mold spores and pollen grains were collected indoors and outdoors with the Allergenco sampler at all classrooms. In almost all cases, outdoor concentrations of mold and pollen were higher than indoor levels in both portable and traditional classrooms. The only exceptions were species of the mold *Botrytis* (higher in portable classrooms than outdoors) and *Curvularia* (higher in traditional classrooms than portable ones), although the differences were relatively small. Overall portable and traditional classrooms were very similar in the types and concentrations of mold spores and total pollen in indoor and outdoor air. *Stachybotrys* is a mold that has gained recent public attention as it may be associated with health effects other than allergies. Airborne *Stachybotrys* spores, were identified in 2 of 185 classrooms (1%) and 2 of 62 of the outdoor samples (3%); the portable-traditional classroom difference was not statistically significant. The two positive indoor air samples contained very few *Stachybotrys* spores. When very low airborne spore concentrations are found in rooms in which a thorough inspection has identified no water leakage, moldy odor or visible mold growth, it is likely that these spores have been brought indoors through open doorways or windows and no further action is needed.

Concentrations of total *mold spores* found in portable and traditional classrooms ranged from about 30 to approximately 2000 spores/m^3 (5th to 95th percentiles). Geometric mean values were about 290 spores/m^3. Compared to the interpretation guidelines for total outdoor mold spores (AAAI, 2003) shown in Table 3-9, the concentrations of total mold spores were in the Low Category, suggesting that only extremely sensitive persons may experience symptoms. While these guidelines were developed for the interpretation of outdoor air samples, the responses of mold-allergic persons to indoor exposures is likely to be similar.

Table 3-9. National Concentration Guidelines for Outdoor Airborne Mold Spores and Plant Pollen.*

Category (%ile of total distribution)	Persons who may experience allergy or asthma symptoms	Concentration (pollen grains/m^3 or mold spores/m^3)			
		Weed Pollen	**Grass Pollen**	**Tree Pollen**	**Total Mold Spores**
Absent (not detected)	None	Below detection	Below detection	Below detection	Below detection
Low (<50%)	Extremely sensitive persons only	0–9	0–4	0–14	0–6499
Moderate (50–90%)	Many sensitive persons	10–49	5–19	15–89	6500–12,999
High (90-99%)	Most sensitive persons	500–499	20–199	90–1499	13,000–49,999
Very high (>99%)	Almost all sensitive persons (extremely sensitive persons may experience severe symptoms)	>500	>200	>1500	>50,000

*Source: AAAAI (American Academy of Allergy & Asthma & Immunology), 2003. National Allergy Board, Reading the Charts. Available at http://www.aaaai.org/nab/index.cfm?p=reading_charts

Additional air samples of *culturable mold spores* were collected indoors and outdoors with the Mattson-Garvin sampler during lunch breaks in a subset of 14 schools. Airborne concentrations of five mold groups were reported in culturable samples: *Cladosporium* species, *Penicillium* species, *Aspergillus* species, Other and Unknown fungi. The results from these supplemental samples agreed with the findings from the Allergenco samples, that is, outdoor concentrations of mold spores were higher than indoor levels for both portable and traditional classrooms, except for the genus *Aspergillus*. This group was not observed in any outdoor samples, but was found at low concentrations in most indoor samples from both portable and traditional classrooms. This finding is probably due to the small number of outdoor samples (n=10) and detection limit of the measurement method.

3.2.9 Pollen

Airborne pollen grains were also collected in the Phase II study, using the Allergenco sampler indoors and outdoors at all classrooms. Total pollen concentrations were almost always lower indoors than outdoors. For example, the mean outdoor pollen level was 21 grains/m^3 while the indoor mean was 8 grains/m^3 for both portable and traditional classrooms. The 95th percentile values were 19 grains/m^3 for portable and 78 grains/m^3 for traditional classrooms, versus 276 grains/m^3 for outdoor air. This indicates that most classrooms were in the “Low” categories established by AAAI for different types of pollen (Table 3-9). Less than five percent of the portable classrooms were in the “Moderate” category, while traditional classrooms had somewhat higher extreme concentrations – less than five percent were in the “High” category, depending on the type of pollen. Differences between room types may be due to more mature and intensive landscaping near the traditional school buildings, which were more likely part of the original school construction. Alternatively, it may indicate cases where there was greater infiltration of outdoor air and pollen into traditional classrooms.

Because the AAAI sensitization classifications depend on pollen type and pollen type was not characterized in this study, it is difficult to assess the significance of these pollen results with respect to health impacts on students and teachers. Nonetheless, because few indoor pollen-producing plants were observed in classrooms, it is unlikely that children’s pollen exposures were higher in class than outside in the schoolyard or elsewhere in the community.

3.2.10 Noise

All classrooms exceeded the new ANSI acoustic standard for classroom noise levels -- 35 decibels A-weighted, or dBA. A substantial percentage of both portable and traditional classrooms exceeded outdoor noise limits of 55 dBA set by some California communities (see Table 3-10). Noise levels measured in both types of classrooms were not statistically different. However, the teachers in portable classrooms were much more likely to turn off the HVAC unit due to noise (68% versus 42% in traditional classrooms).

Table 3-10. Classroom Noise and Lighting Conditions Exceeding Standards, Phase II

Classroom Type	Noise Level Near HVAC > 55 dBA (%)	Mean Light Intensity < 30 Foot-candles (%)	Mean Light Intensity < 50 Foot-candles (%)
Portable	50	9	38
Traditional	38	4	27

3.2.11 Lighting

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 professional design guidelines (IESNA, 2000) of 30 foot-candles (f-c) for high-contrast materials. In addition, approximately one-third of both portables and traditional classrooms did not meet the IESNA light guidelines of 50 f-c for low-contrast materials, indicating inadequate lighting in both types of classrooms (see Table 3-10).

3.2.12 Specially Selected Classrooms

The specially selected classrooms at the 14 schools that were identified in Phase I were included in Phase II. Their environmental measurements and building characteristics were compared to the target population. The specially selected classrooms had much more moisture–related problems reported, such as musty odors and visible mold areas, when compared to target population. However, these classrooms had similar formaldehyde concentrations, and lower mean percentages of time when indoor CO_2 levels exceeded 1000 ppm.

Surface swab samples were also collected in the specially selected classrooms. Four mold groups were reported: *Aureobasidium* species, other Yeasts, *Cladosporium* species, and Other. Concentrations of surface microbes ranged from non-detectable to 4 million, depending on sampling sites (e.g., desk, window sill or ceiling). The highest values suggest some areas of patent mold contamination, as would be expected since some of the swab samples were taken in areas that visibly appeared moldy during the inspection process.

3.3 Summary

This study provides the first and only comprehensive investigation of classroom indoor environmental quality, ventilation, and HVAC system conditions for California's K-12 schools. The findings were drawn from both remote assessments (mailed questionnaires completed by the local facility staff in Phases I and II) and on-site assessments (inspections and measurements by PCS staff in Phase II). A summary of the results from measurements of contaminant levels in classroom air are shown in Table 3-11.

Both portable and traditional classrooms had indoor pollutant levels that exceeded those outdoors, and the indoor pollutant levels exceeded available environmental standards and guidelines in some cases. Building materials, classroom age, ventilation conditions, outdoor air, and other factors were associated with elevated pollutant levels. There were significant differences between portable and traditional classrooms in many of their environmental conditions and the associated factors.

The Phase II study was successful in generating a massive amount of information about California schools and classrooms. Further analyses of this very rich data base will likely reveal other factors that could prove useful for further understanding the IEQ problems in schools and the measures to be taken to reduce their potential effects.

Table 3-11. Summary of Contaminant Levels in Air and Floor Dust, Phase II.

Pollutant Type	Summary Statistics & Comparisons of Pollutant Levels			Modeling Results -- *For Selected Species and Selected Predictors*	
	Indoor Levels Vs. Outdoor Levels	**Exceeds health or comfort guideline/ standard**	**Portable V. Traditional Mean Test**	**Portable Vs. Traditional Test**	**Other Significant Predictors**
Formaldehyde (air)	Indoors much higher	YES OEHHA draft Interim REL , CREL	Portables higher	Portables higher (most models)	RH, temperature, room age, school type, genl. instruction classroom, others related to materials in room
Other aldehydes (air)	Indoor generally higher	Possibly acetaldehyde. Others detected.	About the same	Depends on outdoor level (acetald.)	Room age, school type; genl. instruction classroom, outdoor air (acetaldehyde)
VOCs (air)	Indoor higher	Possibly benzene and chloroform	About the same	About the same, some depend on outdoor level	Outdoor air, depending on room type; a few others that vary by analyte
Particle Counts (air)	Indoor generally higher	NA	About the same	About the same	Frequency of vacuuming/ sweeping/dusting; outdoor air, depending on room type
Pesticides (dust)	NA	Possibly dieldrin; many detected	About the same	NA**	NA
Metals (dust)	NA*	Possibly lead, arsenic	Lead higher in T; Arsenic higher in P	NA**	NA
PAHs (dust)	NA	Many detected	Some loadings higher in P	NA**	NA
Allergens (dust)	NA	Cat and dog dander in most	Traditional slightly higher	NA**	NA
Mold and Pollen (air)	Outdoor generally higher	Mold spores and pollens at low-moderate thresholds	About the same	About the same	Open windows

NA Data not available.
* Outdoor soil samples were collected and analyzed for metals under funding from OEHHA. 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.

4. RELATED STUDIES IN CALIFORNIA SCHOOLS

Prior to the PCS, there had been no comprehensive study of environmental conditions in California public schools. Various investigations had been conducted over the past decade that addressed specific components or looked at a limited subset of school facilities. These are summarized below:

- A nationwide survey of school facilities was last conducted by the federal General Accounting Office in 1995 (GAO, 1995). At that time, California was ranked last, having more unsatisfactory environmental conditions in schools than any other state. Seventy-one percent of California schools reported at least one inadequate building feature (HVAC, plumbing, roof, framing, floor, foundation, wall, window, door, interior and exterior finish), 41% of schools reported inadequate HVAC systems, and 40% reported roof problems. These surveys are summarized in a series of published reports. In the GAO studies, center-city schools and those with higher proportions of minority and poor students reported needing extensive repair or replacement at least 30% more than non-center-city/minority schools.

- Researchers at Lawrence Berkeley National Laboratory (LBNL) reviewed the available literature in 1997 on general school IAQ (Daisey and Angell, 1998). The report, contracted by OEHHA, was largely based on records of school investigations by NIOSH. They found that the most common building-related problem was inadequate ventilation with outside air. The second most common problem was water damage to building elements, leading to mold contamination and growth. The report also pointed out that measurements of indoor air pollutants were very limited, and quantitative analyses of their impacts on health were therefore difficult. However, respiratory and central nervous system symptoms were the most common health complaints. A similar analysis done for Oak Ridge National Laboratory highlighted the need for pollutant source control, proper ventilation, and humidity control to prevent IAQ problems in schools.

- The California Energy Commission investigated ventilation in California schools and other non-residential buildings. Their report found that schools consistently had lower ventilation rates than required and that one-third of the classrooms they tested had air exchange rates less than 50% of the level required by State regulations and industry standards (CEC, 1995).

- DHS conducted a survey of lead hazards from paint, soil and water in a representative sample of 200 elementary schools and child care facilities in California (DHS, 1998). The study found that nearly all schools had some lead-containing paint, and the lead content of paint is inversely related to school age (much less post-1979). Almost 40% of facilities had some paint that is deteriorated. Lead levels exceeding the U.S. EPA reference value (400 ppm) were found in 6% of surveyed schools, and, an estimated 18% of schools had lead in drinking water at or above the U.S. EPA action level (15 ppb).

- A California non-profit, public interest group published a survey of pesticide use information for 46 school districts (representing ~25% of state students) that documented the widespread use of pesticides in public schools (Kaplan et al., 1998). It found that 87% of the districts reported using one or more of 27 particularly hazardous pesticides (i.e., known or suspected to cause cancer, affect the reproductive system, mimic the hormone system, or act as nerve toxins).

- DHS estimated approximately 5% of California schools have one or more classrooms with long-term radon concentrations above the U.S. EPA's recommended *action level*, and for some regions (e.g., Santa Barbara County), the rate is as high as 16% (Zhou et al., 1998). An estimated 1% of classrooms statewide exceed the U.S. EPA limit.

- Another non-profit, public interest group released a critical report about the rising use of portable classroom, and their concerns received substantial media coverage (Ross and Walker 1999). The report postulates that the IEQ problems for portables, especially elevated exposures to formaldehyde and VOCs, are more serious than for permanent buildings, and that children are adversely affected by being housed in them. Incidents of sick-building syndrome complaints among teachers and students were described.

- A small study of portables in Los Angeles was conducted by UCLA in 1999-2000 (Shendell *et al*, 2003). Overall, the results found low concentrations of target toxic and odorous VOCs. The four most prevalent VOCs measured were toluene, *m-p*-xylene, *a*-pinene, and *d*-limonene, and their likely indoor sources in the school classroom environment were commercially available personal, teaching, and cleaning products. No daily-integrated samples of formaldehyde concentrations exceeded 33 $\mu g/m^3$. Weekly-integrated and daily-integrated acetaldehyde concentrations were higher in portables than in main building classrooms. These data suggested the main sources of aldehydes were interior finish materials and furnishings made of particleboard without lamination, though other non-material sources likely influenced high values in specific portables, e.g., outdoor sources such as vehicles as a function of ventilation.

- LBNL recently conducted a study of four brand-new relocatable classrooms installed at two separate locations (one coastal and one inland). Apte *et al* (2003) designed and constructed four energy-efficient relocatable classrooms for this study to demonstrate technologies with the potential to simultaneously improve energy efficiency and indoor environmental quality (IEQ). Two were installed at each of two school districts, and energy use and IEQ parameters were monitored during occupancy. Two portables (one per school) were finished with materials selected for reduced emissions of toxic and odorous volatile organic compounds (VOCs). Each had two HVAC systems, operated on alternate weeks, consisting of a standard heat-pump system and an indirect-direct evaporative cooling (IDEC) system with gas-fired hydronic heating. The IDEC system provides continuous outdoor air ventilation at 15 CFM per person or more, providing efficient particle filtration while using significantly less energy for cooling. School year-long measurements included: carbon dioxide (CO_2), particulate matter, VOCs, temperature, humidity, thermal comfort, noise, meteorology, and energy use. IEQ monitoring results indicate that important ventilation-relevant indoor CO_2 and health-relevant VOC concentration reductions were achieved while average cooling and heating energy costs were simultaneously reduced by 50% and 30%, respectively.

- The CIWMB funded a laboratory study to measure emissions from commonly used and alternative building products, including those most commonly used for school construction, to obtain data on whether or not alternative products with high recycled content adversely impact indoor air quality. DHS conducted the study (DHS et al., 2003). The testing protocol was designed to simulate volatile organic compound (VOC) emissions during the early stage of building occupancy. Over 70 products in material categories were tested for their emissions of 75 target chemicals. Predicted concentrations were calculated from laboratory emissions data and using typical dimensions, ventilation rates and material use scenarios (referred to as the “Section 01350 protocol”).

  The study concluded that safe, sustainable building materials are available for all categories of materials tested, although many of the tested products emitted chemicals at rates that result in calculated concentrations that exceed the concentration limits and screening criteria used in this study. The researchers found that emission limits were exceeded more or less equally by both standard and alternative products under the Section 01350 protocol as well as more stringent IAQ criteria. The majority of the products that exceeded the IAQ concentration limits did so by exceeding the limits of only one chemical, which suggests that product reformulation could readily improve performance. The one exception was rubber-based resilient products, such as used for flooring. These products emit substantially greater amounts of VOCs, and further refinement and testing of these products is necessary before they can be used safely in most indoor environments. Moreover, the investigators recommended that building product manufacturers should be encouraged specifically to reduce emissions of naphthalene, formaldehyde, and acetaldehyde from their products. Industry-supported product certification programs or product labels claiming low-or zero VOCs may not sufficiently protect building occupants. These concerns warrant frequent product testing through independent certified laboratories. A copy of the study may be found at http://www.ciwmb.ca.gov/GreenBuilding/Specs/Section01350.

- OEHHA recently conducted a school-based, cross-sectional epidemiological study to examine associations between proximity to traffic and respiratory health among children living and attending schools at varying distances from high-traffic roadways in Alameda County, California (Kim et al., 2003). Most of these children are nonwhite and of lower socioeconomic status. Outdoor concentrations of nitrogen oxides (NOx), nitric oxide (NO), and black carbon (BC) measured at neighborhood schools were used as surrogates for children's overall exposure to traffic pollutants. These pollutants were increased at schools nearby versus those more distant from (or upwind of) major roads, and were associated with both bronchitis and episodes of asthma. Another study by OEHHA examined the number and demographic profile of public schools in California by proximity to major roadways (Green et al., 2002). A substantial number of children in California attend schools that are close to major roads with very high traffic counts, and a disproportionate number of those students are economically disadvantaged and minority.

5. INFORMATION FROM OTHER STATES

The most comprehensive, previous statewide study of classrooms was conducted in Texas, including an assessment of environmental conditions in 115 classrooms. The investigators found that the use of chemical cleaning compounds and air fresheners, especially during after-hours custodial cleaning when there was likely inadequate ventilation, led to elevated VOC concentrations of several target compounds including *d*-limonene and *p*-dichlorobenzene (Torres *et al,* 2002). The Texas study found no statistically significant differences for mean school-day and peak carbon dioxide (CO_2) concentrations between portable and main building classrooms, or when data were separated by teacher responses to questions regarding classroom odors. About 2/3 of the classrooms had school-day averaged CO_2 concentrations above 1000 ppm (per ASHRAE 62), reflecting a prevalence of inadequate ventilation (Corsi et al, 2002).

In an IAQ assessment at a Texas public high school (Petronella et al, 2002), formaldehyde concentrations were measured above federal occupational guidelines in classrooms where the HVAC systems ran on normal daily cycles, and windows and doors were closed. Inspections, however, found 16 of 19 classrooms had ventilation rates below the ASHRAE 62 recommendation.

Several states have undertaken mandated or voluntary efforts to improve IEQ in public school buildings. Maryland's Department of Education (1987) established a program on IAQ in public schools in 1987, and it developed a seminal set of guidance documents on related school facility issues (such as ventilation systems, carpets, interior painting, and science laboratories) (Maryland, 1996). The State of Washington developed their "best management practices" for IAQ in 1994 (Washington DOH, 1995), and the Texas Health Department recently issued "voluntary guidelines" for IAQ in schools (Texas DOH 1998), under mandate from their legislature. The Minnesota Department of Health has developed extensive training and guidance for schools, including a streamlined inspection package, an IAQ Management Plan Development Package, and website links to funding source information (Minnesota, 2003).

Others states have conducted comprehensive review or evaluation of school IEQ to develop programs to solve noted problems, including Vermont (1999) and Delaware ((1998). Similar efforts have been successful even at the local level; the County of Montgomery (MD) (1998) developed its own IAQ Action Team and report with guidance and specific recommendations for achieving good IAQ in public schools. Healthy School Networks in Massachusetts, and New York were established to press for improvement in their state's facilities. These are coalitions of teacher, parent, and non-profit organizations. In New York, they successfully pressed their State Regents to sponsor an Advisory Committee on Environmental Quality in Schools. In contrast, there is no established *healthy schools* stakeholder group or advisory board in California, similar to those in other states.

6. SUMMARY OF STAKEHOLDER INPUT

As mentioned above, ARB and DHS consulted with other interested state agencies and stakeholders. Interested stakeholders included portable classroom manufacturers, environmental and health organizations, school district administrators and facility managers, teachers, school nurses, indoor air quality consultants, and ventilation companies.

6.1 Pre-Study Workshops

The first set of workshops were conducted in February and March, 2001, in Sacramento, Oakland, El Monte (Los Angeles), and San Diego. ARB and DHS staff presented information on the overall study design, as well as details regarding the intended schedule and scope of the project. The workshops were well-attended. Participants asked a variety of questions regarding the study, and also provided comments or suggestions regarding the planned study design, questions to include in the questionnaires, plans for external notice and review, and other topics. The following is a brief listing of some of the comments received during the initial workshops:

- Some schools wanted their results prior to the end of the study, others did not want them. (Results were provided by RTI directly to schools that requested them).

- Portable classroom manufacturers concerned regarding premature press and media coverage of results…wanted assurance they would be able to review the report ahead of time (report to be released to everyone at once).

- Requested on-line resources for parents and teachers regarding indoor air quality (DHS provided this online feature subsequent to the workshops).

- Would like to review detailed study protocols (general protocols could be reviewed, but detailed protocols not available for review prior to study due to tight study schedule).

- Be sure to consider age of the classrooms…old and new portables are very different (age was recorded for all classrooms and used regularly in analysis of the data).

- Please consider the type of installation and foundation…some portables have had mold and other problems because of improper installation, foundation skirts too close to the ground, etc. (Foundation skirt and installation information was included on the technician inspection checklist).

- Concerns were raised over how appropriate health thresholds would be selected and discussed in the final report. (OEHHA's acute and chronic Reference

Exposure Levels were used, along with other health and comfort standards and guidelines that are available, such as those of IESNA, ASHRAE, and others.)

6.2 Post-Study Workshops

Four public workshops, again two each in northern and southern California, plus webcast and phone access, were also held during the review period for the public draft of this document. Many useful comments were received, and the report was modified as appropriate. Comments frequently heard included the following:

- Not all Group I recommendations are low cost, and some are not easy to accomplish. It may cost some schools quite a bit of money to comply with state regulations.
- The recommendation for a task force to develop long-term funding sources and mechanisms for construction and preventive maintenance should be in Group I because it is a high priority: that effort should start now.
- Noise is a key factor. The State should set a standard of 45 dBA now.
- The issue is not just one of facility maintenance. Teachers should be trained regarding indoor environmental quality. They are a key part of the solution to classroom problems because they often turn off HVAC systems or adjust the thermostat improperly, and they bring in items such as “air fresheners” that actually contribute to indoor air pollution and degrade the indoor environment.
- Purchasing agents, janitors, and facility managers need to be trained too. Perhaps “distance learning” would work for these groups.
- Desks and other items added to the classroom can emit formaldehyde. Schools should purchase formaldehyde-free furnishings.
- Solutions and changes should be pursued through collaborative efforts, such as with the California Teachers Association, the NEA, the ALA, and others.
- HVAC systems can be made quieter by offsetting the return air vent, using baffling, and other actions. Systems need to be quiet to be usable.

These and the many other specific comments received during the workshops and comment period were used in revising the recommendations of this report. Some comments did not warrant changes to the report document, but rather were submitted to provide information regarding specific substitute products that are available and other useful information.

7. RECOMMENDATIONS AND DISCUSSION

The results of this study demonstrate that, on a statewide basis, many schools are not models of hygiene or healthfulness, and that there is a need for improvement in some areas. However, the picture is not dire: the most serious problems occur only at a small percentage of schools. The environmental problems identified in this study generally fall into the following key areas: (a) inadequate classroom fresh air ventilation (due to many causes); (b) unnecessary or uncontrolled sources of chemicals, particles, or other contaminants; (c) unchecked moisture intrusion; and (d) ineffective cleaning, maintenance, or repair practices. The most effective solutions require addressing the underlying causes of the problems, and promoting those systems that appear to be working well.

Actions are needed at all levels to provide classroom environments that are healthy and conducive to effective learning for K-12 students. Problems generally need to be resolved and prevented at the classroom and school level, but districts and the State must be partners in providing the tools and guidance for effective solutions. 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 new 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.

Because traditional classrooms had many of the same problems found in portable classrooms and a portion of both types of classrooms exceeded applicable guidelines for health and comfort, the recommendations below are directed toward preventing and resolving problems in all classrooms, unless otherwise noted.

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 appear to 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; 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, San Francisco, and Clovis, among others, have successfully and cost-effectively implemented *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: 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 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 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 45 dBA or lower.
   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 HVAC Noise.** Implement an interim state requirement for a maximum decibel level of 45 dBA from HVAC systems, and encourage other sound reduction measures such as reduction of noise from 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 EPA's *Tools For Schools Program* (no. 4, above). However, focused statewide training programs are needed over the long-term to assure that key school staff receive focused 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*, to include more specific information on California ventilation requirements and sources of indoor pollutants.

10. **Implement Integrated Pest Management.** 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, most 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. 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. Further, 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 *Tools for Schools Action Kits* provide ready-made 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.

Appendix VI provides more specific recommendations for schools and districts. It is a working document that will be updated periodically and made available on ARB's website.

8. SUMMARY AND CONCLUSIONS

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.

A preliminary 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.

The study was conducted in two phases: Phase I was a mailed survey in which questionnaires and passive formaldehyde monitors were sent to over 1000 randomly selected public schools with at least one portable classroom in the spring of 2001. Phase II was a field study of a wide array of environmental measurements obtained in 201 classrooms at 67 schools statewide, from October 2001 through February 2002. At each school, two portable classrooms and one traditional classroom were studied.

8.1 Results

Both portable and traditional classrooms were found to have some environmental conditions that require improvement. However, the picture is not dire: the most serious problems occur only at a small percentage of schools. Remedies to address the problems identified are available, although some will incur more than minimal costs. The solutions require a combination of actions by the State, districts, schools, manufacturers, facility managers, teachers, parents, and others. Adherence to state regulations, improved operation and maintenance, and enhanced training of school personnel, can go a long way to address many, but not all, of the problems identified.

The primary problem areas identified include the following:

1. Ventilation
    - Inadequate at times in about 40% of the classrooms, and seriously deficient in about 10% of classrooms.
    - A majority of teachers in portables have turned off the ventilation system at times due to excess noise.
    - Portables had more instances of dirty HVAC filters, closed dampers, and air-conditioner condensate drainage problems.
    - Overall, the HVAC systems deliver adequate flow, so sizing is not an issue.

- Noise is the primary issue that needs to be addressed by HVAC manufacturers, and lower noise levels (45 decibels or less) should be specified by schools.

2. Temperature and Humidity
   - A small percentage of portable classrooms had temperatures above or below the ASHRAE standard for acceptable indoor temperature, and about 11%-14% of classrooms had relative humidity levels outside the ASHRAE standard range for comfort.
   - Properly operating and maintaining HVAC systems should remedy these problems in most classrooms.

3. Air Pollutants
   - <u>Indoor formaldehyde concentrations</u> were elevated above OEHHA health guideline levels. Highest levels occurred primarily in the warmer seasons, as expected, and primarily in portable classrooms. Alternative low-emitting materials are available and should be used in constructing new portable classrooms
   - <u>VOCs</u> were present indoors at levels similar to other indoor environments. Levels were below acute (immediate effects) risk levels; although some classrooms exceeded the one in a million cancer risk level for a few VOCs, this is not a major concern because outdoor levels likely contributed most to these levels.
   - Real-time <u>particle counts</u> were somewhat higher in portable classrooms for PM10 and PM2.5 size ranges, likely due to the greater use of carpets in portables, and the proximity to vehicle traffic.

4. Floor Dust Contaminants
   - <u>Metals</u>: Levels of lead measured in floor dust in some classrooms were elevated. Arsenic levels were slightly higher in portables, and above the one in a million cancer risk level in most classrooms.
   - <u>Pesticides:</u> Residues of both generally available and restricted pesticides were found in all floor dust samples, and six pesticides were detected in over 80% of the samples: esfenvalerate, chlorpyrifos, *cis*- and *trans*-permethrin, *o*-phenylphenol, and piperonyl butoxide. Chlorpyrifos can last up to a year or more in the environment; the other five are shorter-lived, lasting just a few weeks. Children can be exposed to pesticides through inhalation, ingestion (fingers in the mouth), and dermal contact, and children in the lower grades tend to spend a substantial amount of time sitting on the floor; therefore the number of pesticides found in the floor dust are of concern, although it is not yet known whether levels are above exposure and risk levels of concern
   - <u>PAHs</u> also were found in over 80% of the classrooms. However, levels in the dust were relatively low.
   - <u>Allergens:</u> Cat and dog allergens were measured in more than half of the samples, but the concentrations were generally below sensitization levels. Cockroach and dust mite allergens were only infrequently found.

5. Moisture and Mold
   - In the mail survey, a large percentage of teachers reported smelling musty odors in their classroom, or current or previous floods or leaks, and 11% reported visible mold.
   - In the field study, 1-3% of classrooms were observed to have visible mold, and at least 21% had visible water stains on the ceiling and/or floor. About 17% of all classrooms had excess moisture measured in the walls, ceiling, or floor. Water stains and measurements of excess moisture in building materials often indicate hidden mold, and at a minimum indicate a moisture problem that needs to be resolved.

6. Noise
   - All classrooms exceeded the recently developed acoustic standards of 35 decibels background noise for unoccupied classrooms, and many exceeded outdoor nuisance standards of 55 decibels used by some California cities.
   - Stakeholders have indicated that 45 decibels, the level recommended by CHPS, may be achievable, but that 35 decibels appears technologically and financially unattainable at this time. California does not have a noise guideline or standard for classrooms.

7. Lighting
   - About one-third of classrooms do not meet IESNA professional design guidelines.
   - Portable classrooms had somewhat lower lighting levels than traditional classrooms

8.2 Recommendations

Approaches to remedy and prevent most of the problems identified in this study are available. Both state-level and district/school level actions need to be taken. Many of the problems can be addressed through meeting existing State level standards and guidelines (primarily those of Cal-OSHA), which include providing continuous outdoor air exchange; through improved operation and maintenance programs; and through focused training efforts. Many also can be addressed at relatively low cost, although some remedies will incur more substantive costs. A few, such as reducing the noise levels in HVAC systems below 45 decibels, may also require new technology.

There are four general 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 new guidelines and standards for school environmental health.

Specific recommendations are provided in support of each of these. They include seven recommended (Group 1) actions that are high priority, would yield high benefits, and be achieved at relatively low cost. These recommendations should be pursued within the next one to two years. The highest priority recommendation is that all school buildings need to be brought into compliance with existing state regulations. Districts and schools should start with "self-assessments" of basic safety and health conditions, similar to the program of self-inspections undertaken by the LAUSD. They also should develop and implement Indoor Environmental Quality Management Plans such as the IAQ plans included in U.S. EPA's Tools for Schools. "Best Practices" should become the policy for the State and all districts and schools for design, construction, operation, and maintenance of school facilities, and State-level design review for new buildings and major renovations should be expanded. Close attention needs to be paid to properly siting portables and other school facilities. Finally, an interim state requirement for HVAC noise levels not to exceed 45 dBA should be imposed until an appropriate task force of experts can identify an appropriate indoor level that is acceptable for California classrooms.

Another nine specific recommendations (Group 2) 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. Some of these recommendations include: assuring long term, stable funding for facility construction and maintenance; developing enhanced training materials and programs for facility managers, custodians, and teachers; and developing State-level chemical exposure guidelines or standards for classrooms. And finally, older portable classrooms that no longer provide acceptable learning environments should be retired, and support given to promoting new, more advanced portable classroom designs.

Some cost is involved with the recommendations discussed above for the State and for districts and schools: many are relatively low-cost, but some have substantial costs and require focused fiscal planning to address. However, the cost of not taking these actions may be much higher—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. The LAUSD's self-inspection program provides a good starting point for districts, and the CHPS *Best Practices Manuals* and U.S. EPA's *IAQ Tools for Schools Kit* provide valuable tools for designing, operating, and maintaining "high performance" schools.

8.3 Conclusions

The environmental health problems identified in this study ranged across several areas, including inadequate operation and maintenance of ventilation systems, contaminants present at undesirable levels in the air and floor dust, excessive noise levels, and mold and moisture problems. A number of programs initiated by the State, districts, and others before or during the conduct of this study are already beginning to address some of these concerns. However, increased effort and a more focused approach are needed to assure that existing problems are remedied and future problems prevented. The State, district and school administrators, school facility managers, teachers, 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 to true prevention programs that have stable funding.

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APPENDIX I: HEALTH & SAFETY CODE § 39619.6

The legislative mandate for the Portable Classroom Study is contained in the Health & Safety Code amendment contained in Section 11 of Assembly Bill 2872 (Shelley, 2000):

39619.6. (a) By June 30, 2002, the state board and the State Department of Health Services, in consultation with the State Department of Education, the Department of General Services, and the Office of Environmental Health Hazard Assessment, shall conduct a comprehensive study and review of the environmental health conditions in portable classrooms, as defined in subdivision (k) of Section 17070.15 of the Education Code.

(b) The state board and the department shall jointly coordinate the study, oversee data analysis and quality assurance, coordinate stakeholder participation, and prepare recommendations. The state board shall develop and oversee the contract for field work, air monitoring, and data analysis, and obtain equipment for the study. The department shall oversee the assessment of ventilation systems and practices and the evaluation of microbiological contaminants, and may provide laboratory analyses as needed.

(c) By August 31, 2000, the state board shall release a request for proposals for the field portion of the study. Field work shall begin not later than July 2001. The final report shall be completed on or before June 30, 2002, and shall be provided to the appropriate policy committees of the Legislature. The study of portable classrooms shall include all of the following:

(1) Review of design and construction specifications, including those for ventilation systems.

(2) Review of school maintenance practices, including the actual operation or non-operation of ventilation systems.

(3) Assessment of indoor air quality.

(4) Assessment of potential toxic contamination, including molds and other biological contaminants.

(d) The final report shall summarize the results of the study and review, and shall include recommendations to remedy and prevent unhealthful conditions found in portable classrooms, including the need for all of the following:

(1) Modified design and construction standards, including ventilation specifications.

(2) Emission limits for building materials and classroom furnishings.

(3) Other mitigation actions to ensure the protection of children's health.

APPENDIX II

DHS PRE-SURVEY

Survey of Portable Classrooms in California: Estimating Numbers and Ages for 2000-01

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

June 2003

ABSTRACT

A survey of all California school districts was conducted to acquire information about classroom facilities. Data for over 90% of state public schools were collected, and the following estimates of numbers and ages were determined: all classrooms totaled 268,030, and the number of portables totaled 79,191 (29.5% of all) for the 2000-01 school year. Older portables (more than 15 y) and newer portables (5 y or less) totaled 27.9 % and 39.3% of all portables, respectively. Districts reported plans to acquire an additional ~5% (4100) portables during the year; this estimate is based on less complete data than for numbers and ages of portables. Elementary schools were found to have lower numbers of students per classroom, to more frequently have portables, and to use a higher proportion of portables, compared to middle and high schools. The state's largest districts' classrooms used portables at the same proportion as the statewide average. However, the portables used at the largest districts were more frequently older units (44% versus 28%). The largest districts appear to have growth rates higher than the state average, and planned portable purchases were projected at somewhat higher rates. Updated estimates need to be made more readily available in the future. Information on classroom facilities (e.g., numbers, ages, areas, chairs, etc.) should be included in a state inventory (similar to the CBEDS database).

INTRODUCTION

Public kindergarten to 12th grade (K-12) education in California functions within a complex system of local, county, state, and federal authorities, regulations, and funding. Individual schools operate within semi-autonomous school districts, which are administrated under locally elected school boards. Notwithstanding state or federal mandates or financial resources, all aspects of school function, including school facility management, are under local control and responsibility. Central bodies, such as the Department of Education, and funding agencies, such as the State Allocation Board, can dictate what schools should or should not do, and what funds they will or will not receive. However, it ultimately falls to the local school officials to fulfill these mandates or suffer the consequences. Under very rare circumstances, the county or state education agency can take over daily district operations.

The semi-autonomous organization of public K-12 education has led to gaps in the information available on public school facilities in California. While there are centralized state databases on the districts and schools with respect to enrollment, staffing, demographics, state funding, compliance with some regulations, and standardized test scores, at present, there is no centralized database for public school facilities in the state. In the absence of this kind of database, there is no way to answer seemingly simple questions such as: How many portable classrooms are currently being used in the state? What is their age distribution? How many new portables are planned for purchase in a given year? And, what schools/districts use portables to a greater or lesser degree?

In mid-2000, the Department of Health Services (DHS) and the Air Resources Board started planning the California Portable Classrooms Study (PCS). The PCS was designed to enlist ~1000 schools in a mail survey, and ~70 schools for field study to investigate environmental conditions in portable classrooms as well as traditional classrooms. In order to extrapolate PCS results to statewide estimates of school conditions, information would be needed about how many (and which) schools had portables, as well as the total numbers of classrooms in the state. Hence, it was necessary to develop a survey instrument to query districts about portable classrooms at their schools. Sampling a subset of school districts would not have addressed the PCS planning goals, so a more labor-intensive "total enumeration method" was used. This pre-PCS (DHS) survey was conducted to acquire data to coincide with PCS Phase I (2000-01 school year).

METHODS

DHS staff initiated a mail survey directed to all school districts listed in the California Department of Education (CDE) list of public school districts and schools, which includes mailing addresses and district contacts[1]. CDE uses a cataloging system for schools and district with CDS codes, for which unique numbers are given for each County, District, and School in the state. There are 58 counties, almost 1,100 districts, and more than 10,000 schools (active and closed), and their 2-, 5-, and 6-digit codes, respectively, are combined into the 13-digit CDS code. A new database was created in ACCESS with records for each district and each school in the state using their CDS codes. Schools showing no current enrollment, or no grades between K and 12th (e.g., community colleges) were excluded from our database. Demographic information was acquired from the CBEDS (California Basic Education Data System) demographic data files[2].

District and school records were cross-referenced, and individual survey packets were generated for each district. Each district packet listed the individual schools for the district onto a data form. Survey packets included the data form with cover letter from the State Superintendent of Public Instruction, Ms. Delaine Eastin. Survey packets were mailed to district offices in late November 2000. Electronic files of the data form were supplied by DHS to the largest districts. Examples of the data form and letters are shown in the Appendix.

Table 1 lists the queried items requested on the survey form for each school within the district. The data form asked that a knowledgeable district staff person provide information "*as of November 1, 2000,*" for each school in the district. Portables were defined as relocatable

[1] **California Public School Directory, 2000.** available from CDE Press. Updated directories are available on-line at http://www.cde.ca.gov/demographics/files/schoolname.htm.
[2] Data files and additional information are available on-line at http://www.cde.ca.gov/demographics/files/index.html.

classroom structures, generally factory manufactured and without foundations. The form asked that the age be determined using the date of *manufacture,* not *delivery* date. Many districts contacted DHS for clarification, most often to determine whether or not to include units in non-instructional uses, e.g., teachers' lounges, bathrooms, offices, and storage, and staff was instructed to exclude these units.

Table 1. Survey Form Queries Sent to Each School

- Total number of classrooms in use
- Total number of portables in use as instructional classrooms
  - The number of portables *older* than 15 years (1985-86 or earlier)
  - The number of portables *newer* than 5 years (1995-96 or thereafter)
- Number of additional portables on order or planned for installation during 2000-01 school year.

The responses to the initial survey packet were received from about 30% of districts by the due date (December 8, 2000). Follow-up letters and/or faxes were sent to non-responding districts in January, February, April, and May 2001 (see example in Appendix), and each time additional data forms were acquired. Additionally, phone calls were made to medium and large districts. The largest districts were provided an electronic version of the database to complete. In June 2001, the response rate was up to 75%, and a decision was made to continue querying non-responsive districts in the following school year. Forms sent in the Fall 2001 were modified to determine the numbers of portables *added* in 2000-01. Hence, data acquired from school districts in 2001-02 were adjusted to the base year (2000-01).

RESULTS

The survey database included 1049 districts and 8554 individual schools. Enrollment in 2000-01 totaled just over 6 million (Table 2). More than 90% of districts provided information for the survey; these districts contained 92% of the state's schools and 94% of student enrollment (Table 3). Some responses were incomplete, omitting entries for portable of older/younger ages and/or new portables planned for the next school year, and the rates for these items are somewhat lower.

Table 2. California Public School Student Enrollment and Number of Teachers

	1999-2000	2000-01	2001-02	2002-03
Students	5,940,976	6,038,231	6,134,839	6,236,359
Teachers	290,547	297,277	300,032	n/a

Source: CBEDS Aggregated Data Files: "Enrollment by school" (enrsch**) and "Teacher by school": (tchcrd**).

Table 3. Response Rates for Classroom Survey Forms

	Any response (%)	Portable Classrooms (%)	Old vs. Young Portables (%)	New Portables planned (%)
Districts	90.2	-	-	-
Schools	92.3	91.9	89.2	65.1
Enrollment	94.0	93.7	91.3	61.5

Using the data provided for each school, number totals for each item were tabulated. Totals were then adjusted using the enrollment response rates. That is, estimates of statewide totals were determined by taking the data provided for schools reporting, then scaling it upward, proportional to the *enrollment* of responding schools (i.e., dividing by the response rate). For classrooms numbers and the number older/younger portables, the adjustment is small (e.g., 1/0.94 = 1.064 or +6% adjustment). Estimates of new portables planned have greater uncertainties, since the adjustment for missing schools is higher (+60%).

For 2000-01, DHS estimated there were 268,000 classrooms in use at the state's public schools (Table 4). The statewide average classroom occupancy was about 22 students per classroom. Actual occupancies cover a wide range, from the mandated 20 or less for K-3 grades in elementary schools to 30 or more students in some middle and high schools. About one-third of the total classrooms – almost 80 thousand– were portables used for instruction in California public schools. A small fraction of schools, under 13%, had no portables at all.

Table 4. Estimates of Classroom Numbers and Age for 2000-01

	Number	Note
All classrooms:	268,030	21.8 students per classroom
Portable classrooms:		
All	79,191	29.5 % of all classrooms
Older (more than 15 y)	22,061	27.9 % of all portables
Newer (5 y or less)	31,126	39.3 % of all portables
New Portables planned (for 2001)	4,109	5.2 % of current portables

<u>School Type</u>. Most schools in California house a standard subset of K-12 grades as follows: Elementary – K - 5th, Middle – 6th to 8th, and High – 9th to 12th grades. Some schools use less standard grade ranges, and notwithstanding their CDE designation, these were categorized as above or as follows: "Lower" – K to 8th; "Upper" – 7th to 12th; and "All" – K to 12th. CDE designates some schools as "alternative" or "continuation," and these were parsed according to their grade levels as given in CBEDS. The numbers and total enrolment for each school type are given in Table 5.

The average number of students per classroom was higher in middle and high schools than elementary and "lower" grade schools (22-24 versus 19-21 students per classroom). Classrooms at K-12 ("All") schools were the most crowded on average (29 students per classroom). Similarly, middle and high schools contained proportionally fewer portable classrooms than elementary schools and "lower" grade schools (~22% versus 35%). Portables were used more frequently at schools containing "All" grades (39%) and "Upper" grades (42%). While elementary schools used almost twice the proportion of portables than middle and high schools, the fraction of schools with at least one portable classroom was relative close (93% versus 82%).

Classroom Age. A large proportion of portable classrooms (39%) were manufactured in 1996 or later, while almost 28% were built before 1985. School districts anticipated purchasing more than 4000 new portable classroom units for 2001-02, which represented about a 5% growth in numbers (although how many units were planned for "retirement" was not determined).

Table 5. School, Enrollment, and Classroom Data by School Type for 2000-01

	School Type (by grade levels)						
	Elementary (K to 5)	Middle (6 to 8)	High (9 to 12)	"Lower" (K to 8)	"Upper" (7 to 12)	"All" (K to 12)	All schools
# Schools							
Schools	55.8%	14.3%	17.7%	7.3%	1.8%	3.1%	8,554
% w/portables	92.7%	83.7%	80.9%	73.0%	66.9%	71.6%	87.4%
Enrollment							
Students	48.5%	18.3%	27.4%	3.6%	0.4%	1.8%	6,007,002
% at schools with portables	95.7%	86.7%	91.0%	87.0%	80.0%	77.0%	92.2%
Students per classroom	21.1	24.1	22.4	19.4	16.5	29.0	21.8
Classrooms							
Total	51.6%	16.9%	25.6%	4.2%	0.4%	1.5%	268,030
Portables	60.9%	13.1%	18.7%	4.9%	0.5%	1.9%	79,191
% portables	34.8%	22.8%	21.6%	34.6%	42.4%	38.6%	29.5%

In the Portable Classroom Study (PCS), school and classroom age distributions were estimated from data for ~500 schools, weighted for the sampling frame and response rates. The respective age distributions are given in Table 6. The age distribution of traditional classrooms is very similar to the schools, while portable classrooms are characteristically younger. The data indicate that about 11% of traditional classrooms were added in expansion projects at older schools in recent years. Compare this to the more than 40% of portable classrooms added in the prior 10 years.

Table 6. Classroom & School Age Distribution (in Spring 2001)

Age Range	Portable	Traditional	Schools
0 to 3 y	22.6%	5.2%	11.0%
4 to 5 y	18.6%	1.8%	
6 to 10 y	14.1%	5.5%	
11 to 15 y	22.1%	7.6%	7.3%
16 to 20 y	8.4%	1.7%	
21 to 30 y	8.0%	18.8%	10.9%
31 to 40 y	4.9%	18.0%	22.0%
41+ y	1.3%	41.4%	48.7%

Source: California Portable Classrooms Study Phase I: Mailed Survey. Final Report (Appendix D). Prepared by Research Triangle Institute, RTP, NC. Contract No. 00-3017, March 2003.

The Pre-PCS study data is likely to be more accurate than the PCS data, because it used nearly complete enumeration, while the PCS used stratified sampling and acquired data for <10% of schools and <1% of classrooms. Nonetheless, while the Pre-PCS study used fewer age categories, the two studies are in close agreement regarding portable classroom age distribution:

Age Range	DHS survey	PCS survey
0 to 5 y	39%	41%
6 to 15 y	33%	36%
16+ y	28%	23%

Using the PCS data set to interpolate mid-range values, the statewide distribution for portable classroom age can be estimated for 2001 (Figure 1). More than half of all portable classrooms (in 2001) were 10 years or younger, while over 11,000 portables (14%) were 20 years or older. Statewide, almost 5,000 portables being used as classroom were 30 years or older.

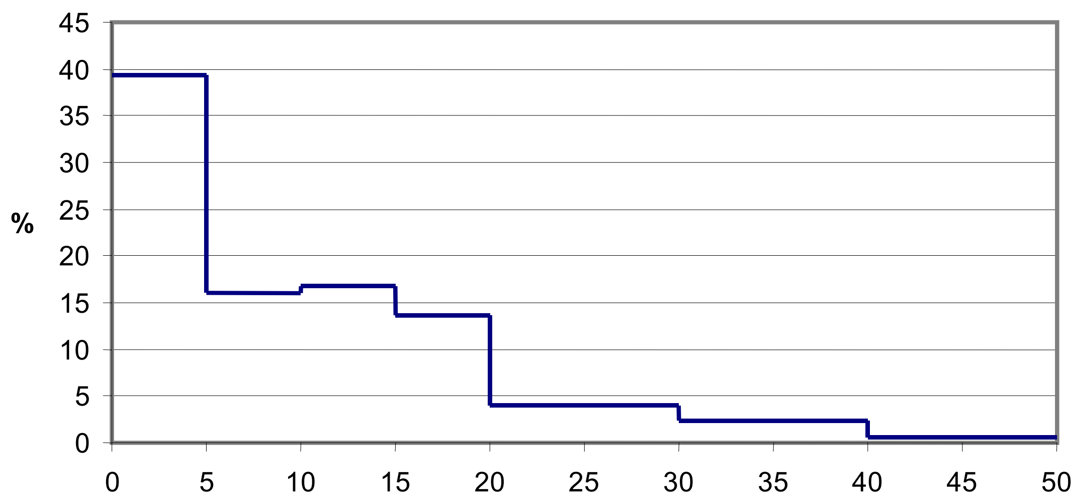

Figure 1. Statewide distribution of portable classroom ages (y) in 2000-01.

<u>Largest Districts</u>. Data for the state's largest districts are given in Table 7. These 20 districts contain 29% of the state's public school enrollment and 23% of the schools. Collectively, their enrollment growth rate was greater than statewide average (0.9% versus 0.3%). Six districts grew over 2% between school years. The largest districts' classrooms were somewhat more crowded (22.5 versus 21.8 students per classroom) and used portables at the same proportion as the statewide average (~30%). Notably, the portables used at the largest districts were frequently older units (44% versus 28%), and fewer of their portables were newer units (27% versus 39%). Information on "planned to purchase" portables was incomplete; the weighted mean for the districts providing data (n=6) was 7.7%, compared to 5.2% statewide. Subsequent to the 2000-01 survey, Los Angeles Unified reported purchasing 245 portables in 2001-02 or a ~3% increase per year.

Table 7. Data for 20 Largest School Districts in California (2000-01)

Rank	District	County	2000-01 Enrollment	Growth Rate[a]	# Schools	Average Students[b] per Classroom	# All Classrooms	Portables as % All	As % of Portables		
									Older	Newer	Planned
1	Los Angeles Unified	Los Angeles	720,534	1.7%	655	23.1	28,493	29.2%	63.5%	20.5%	n/a
2	San Diego City Unified	San Diego	140,328	-0.6%	175	19.8	7,043	34.9%	53.4%	37.0%	n/a
3	Long Beach Unified	Los Angeles	93,235	2.5%	85	21.0	4,268	28.8%	15.5%	61.7%	n/a
4	Fresno Unified	Fresno	77,588	1.3%	94	21.7	3,433	37.7%	17.4%	19.2%	n/a
5	San Francisco Unified	San Francisco	59,979	-2.4%	113	17.6	3,500	8.4%	N/a	n/a	n/a
6	Santa Ana Unified	Orange	59,837	-1.1%	50	24.5	2,527	31.4%	n/a	n/a	n/a
7	Oakland Unified	Alameda	54,264	-4.2%	92	23.3	2,262	29.1%	67.4%	35.3%	17.9%
8	Sacramento City Unified	Sacramento	53,693	0.9%	79	18.7	2,752	38.7%	38.8%	35.6%	n/a
9	San Juan Unified	Sacramento	50,167	2.0%	83	19.9	2,433	21.2%	42.6%	27.6%	n/a
10	Garden Grove Unified	Orange	48,742	1.6%	65	25.0	1,926	21.0%	27.5%	48.3%	n/a
11	San Bernardino City Unified	San Bernardino	52,031	0.5%	62	26.2	1,911	37.9%	45.5%	54.2%	n/a
12	Capistrano Unified	Orange	40,913	-2.7%	39	21.8	1,790	37.4%	24.3%	21.3%	6.3%
13	Elk Grove Unified	Sacramento	46,090	4.5%	50	26.0	1,723	54.6%	21.5%	20.7%	n/a
14	Riverside Unified	Riverside	38,124	4.1%	44	26.6	1,621	31.5%	8.2%	28.4%	2.0%
15	Mt. Diablo Unified	Contra Costa	36,614	0.3%	54	19.9	1,777	18.7%	86.3%	7.0%	n/a
16	Stockton City Unified	San Joaquin	37,322	2.9%	44	22.4	1,607	34.9%	18.7%	35.7%	2.9%
17	Saddleback Valley Unified	Orange	35,199	-0.2%	37	23.1	1,569	24.9%	12.0%	56.3%	-
18	Montebello Unified	Los Angeles	34,794	0.7%	28	25.2	1,350	37.0%	48.3%	21.4%	2.6%
19	Fontana Unified	San Bernardino	37,244	3.1%	34	25.4	1,440	35.3%	3.3%	34.0%	9.8%
20	West Contra Costa Unified	Contra Costa	34,499	-4.6%	59	21.1	1,650	26.1%	44.6%	32.7%	-
	LARGEST DISTRICTS		1,751,197	0.9%	1,942	22.5	75,076	30.1%	44.3%	27.0%	7.7%
	ALL DISTRICTS		6,007,002	0.3%	8,554	21.8	268,030	29.5%	27.9%	39.3%	5.2%

a. Enrollment increase from 2000-01 to 2001-02
b. District-wide average of school values

SUMMARY

When planning for the PCS commenced, no statewide inventory of portable classrooms existed. A labor-intensive enumeration method was used to survey all California school districts specifically about classroom facilities. Data for over 90% of state public schools were collected, and estimates were determined of the number of all classrooms and portable classrooms as follows: all classrooms totaled 268,030, and the number of portables totaled 79,191 (29.5% of all) for the 2000-01 school year. Older portables (more than 15 y) and newer portables (5 y or less) totaled 27.9 % and 39.3% of all portables, respectively. Districts reported plans to acquire an additional ~5% (4100) portables during the year; this estimate is based on less complete data than for numbers and ages of portables. Elementary schools were found to have fewer students per classroom, more likely to have portables, and use a higher proportion of portables, compared to middle and high schools. The state's largest districts' classrooms used portables at the same proportion as the statewide average. However, the portables used at the largest districts were more frequently older units (44% versus 28%). The largest districts appear to have growth rates higher than the state average, and planned portable purchases were projected at higher rates.

Construction and modernization of school facilities represent a substantial capital investment of state resources. Data on classroom facilities, including portable classrooms, should be collected routinely. It is needed for surveys of environmental conditions, as well as educational programs. These data are essential for long-range planning and to make informed policy decisions. Queries on classroom facilities (e.g., numbers, ages, areas, energy use, etc.) should be included in a state inventory system (similar to the CBEDS database), to ensure that this information is more readily available in the future.

Appendix

Portables Survey Form for ARB/DHS Study
(template)

Draft Letter CDE Cover Letter to Survey Form
(from Superintendent Delaine Eastin to District Superintendents)
October 2000

Example of Follow-up Letters Sent to
District Superintendents and District Facility Directors
January 2001

Portables Survey Form for ARB/DHS Study

Instructions: Please fill out the short form below. For each school within your district as of **November 1, 2000**, list

- Total number of classrooms in use
- Total number of portables in use (i.e., portables are defined as relocatable classroom structures, generally factory manufactured and without foundations)
  - Number older than 15 years (1985-86 or earlier) *use the date of manufacture, not delivery date*
  - Number newer than 5 years (1995-96 or thereafter) *use the date of manufacture, not delivery date*
- Number of additional portables on order or planned for installation during 2000-01 school year.

Please complete and return the questionnaire with two weeks (no later than December 8, 2000. Send the completed form to **Portable Study, c/o DHS-EHLB, 2151 Berkeley Way, Berkeley, CA 94704** (label enclosed). If you have any questions or concerns regarding this survey, please contact DHS at 510-540-3427 or portablestudy@cal-iaq.org.

Thank you for your help.

School district: (Filled by DHS) ____________ County: (Filled by DHS) ____________

Name of the respondent: ____________ Title: ____________

Phone number: ____________ FAX: ____________

Email: ____________ Date: ____________

School	CDS_CODE	Total # classrooms in each school	As of November 1, 2000)			
			Total # portable classrooms	# older than 15 yr.[C]	# newer than 5 yr.	Add'l # planned in 2000-01
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					
(filled by DHS)	(filled by DHS)					

CALIFORNIA DEPARTMENT OF EDUCATION
721 Capitol Mall
Sacramento
CA 95814
Phone: (916) 657-4766
Fax: (916) 657-4975

DELAINE EASTIN
State Superintendent of Public Instruction

November 20, 2000

Dear District and County Superintendents:

Survey of Environmental Conditions in California's Portable Classrooms

Your help is needed to improve the environmental conditions in schools for millions of California school children. As you may know, the state is facing rising concerns about environmental health conditions in California portable classrooms. Unfortunately, we lack sufficient information to determine whether publicized cases are isolated occurrences or system-wide problems.

To address these concerns, the State Air Resources Board (ARB) and Department of Health Services (DHS) are conducting a statewide study to better understand the key issues and to serve as the basis for administrative solutions to remedy systemic problems. AB 2872 (Shelley), passed by the Legislature and signed by the Governor in the 2000 legislation session requires "a comprehensive study and review of the environmental health conditions in portable classrooms" to be conducted by June 30, 2002 by ARB and DHS, with cooperation from my department and other key agencies. The findings from this study will form the primary basis for recommendations that ARB and DHS must make to the Governor and the Legislature regarding ways to "...remedy and prevent unhealthful conditions found in portable classrooms."

These recommendations will help shape future program and funding decisions at the state level.

The enclosed survey form is the first step in carrying out this study. The survey form is designed to require minimal effort on the part of your staff. Please direct this form to the key person on your staff who is responsible for classroom facilities. If you have any questions about this survey, please contact Dr. Jed Waldman at DHS (510-540-2469). You can find further information at the DHS web site: http://www.arb.ca.gov/research/indoor/pcs/pcs.htm.

Your prompt response to this request is sincerely appreciated since a good response is essential for the success of the ARB/DHS Portable Classrooms Study.

Sincerely,

Delaine Eastin

DELAINE EASTIN
State Superintendent of Public Instruction

DE:db

Enclosure

cc: Jed Waldman, Chief, Indoor Air Quality Program, California Department of Health Services
Peggy Jenkins, Manager, Indoor Exposure Assessment Program, California Air Resources Board

State of California-Health and Human Services Agency **GRAY DAVIS, Governor**

DEPARTMENT OF HEALTH SERVICES
Indoor Air Quality Section, Jed M. Waldman, Ph.D., Chief
Environmental Health Laboratory Branch
2151 Berkeley Way • Berkeley, CA 94704
510-540-2469 • FAX: 510-540-3022
E-mail: *Jwaldman@dhs.ca.gov*

DEPARTMENT OF HEALTH SERVICES

January 4, 2001

Dear Superintendent:

FOLLOW-UP – Survey of Environmental Conditions in California's Portable Classrooms

In November 2000, your office was sent a letter from **Delaine Eastin, State Superintendent of Public Instruction**, asking your help in completing a statewide survey on portable classrooms. With her letter (enclosed) was a survey form for your district.

The survey form for your district has not been received at this time. The form was designed to require minimal effort on the part of your staff. It is important that we receive this information as soon as possible. Please contact my office and let us know whether:

- You already sent us the form;
- You did not receive the letter and form (or are unable to locate them);
- You would like to receive the form in electronic format (EXCEL); or
- You need assistance or guidance in completing the survey.

You can reach me or my staff at 510-540-2469 or Portablestudy@CAL-IAQ.org. Completed forms should be sent to "Portables Study, CDHS-EHLB, 2151 Berkeley Way, Berkeley, CA 94704".

This survey is part of a joint study by the State Air Resources Board and Department of Health Services, sponsored by Governor Davis and supported by the Legislature in the 2000 session (Chapter 144). As stated in Delaine Eastin's letter, the findings from this study will form the primary basis for recommendations that ARB and DHS must make to the Governor and the Legislature. These recommendations will help shape future program and funding decisions at the State level. Further information about the study can be found on the web: http://www.arb.ca.gov/research/indoor/pcs/pcs.htm.

Your prompt response to this request is essential for the success of the ARB/DHS Portable Classrooms Study.

Sincerely yours,

Jed Waldman, Ph.D., Chief
Indoor Air Quality Program

Enclosure
cc: Peggy Jenkins, California Air Resources Board
Duwayne Brooks, School Facilities Planning Division, California Department of Education

APPENDIX III

RTI-ARB PROJECT EXECUTIVE SUMMARY

CALIFORNIA PORTABLE CLASSROOMS STUDY
PROJECT EXECUTIVE SUMMARY

FINAL REPORT, VOLUME III
CONTRACT NO. 00-317

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

May 2003

PROJECT EXECUTIVE SUMMARY
California Portable Classrooms Study

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 listed on California's Proposition 65 list of substances of known or suspected carcinogens and 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 for approximately 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 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 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)

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

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). 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 concentration levels, i.e., less than 6 ppb. Thus, nearly all of the classrooms had indoor, 10-day average formaldehyde levels greater than typical outdoor levels in California (3 ppb), the Proposition 65 notification level equivalent for air (1.3 ppb), and the California Chronic Reference Exposure Level (REL) of 2.4 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 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 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 longer-term averages, they are probably 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.

<u>School Characteristics and Maintenance Practices</u>

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.

<u>Classroom Characteristics and Results</u>

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

	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

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 microns and <10 microns, were higher in the portable classrooms, especially for the smaller size range. In addition, at the 95th 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.

Floor Dust Contaminants

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 (µg/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 95th percentile, nine of the pesticides were measured at concentrations above 1.0 µg/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. Some samples of both types had lead levels that exceed the DHS and U.S. EPA acceptable floor dust levels for protection of children's health.

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 median 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

Element	**Concentrations (: g/g)**				**Loadings (ng/cm^2)**			
	Median		**95th Percentile**		**Median**		**95th Percentile**	
Lead	All	85.4	All	189.5	All	6.5	All	58.4
	Port	67.4	Port	151.6	Port	5.8	Port	57.9
	Trad	95.45	Trad	200.6	Trad	7.1	Trad	57.5
Arsenic	All	11.6	All	17.3	All	1.3	All	5.5
	Port	12.7	Port	18.6	Port	1.6	Port	5.5
	Trad	10.9	Trad	15.3	Trad	1.1	Trad	3.4
Chromium	All	36.6	All	72.8	All	3.4	All	17.8
	Port	35.8	Port	54.1	Port	3.9	Port	23.9
	Trad	37.0	Trad	74.0	Trad	3.2	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 95th 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.)

Factors Affecting Indoor Environmental Quality

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 type of classroom was generally statistically significant, with portables having higher levels. Acetaldehyde showed no significant differences for portable and traditional classrooms, while tolualdehyde models included significant outdoor air by room-type interactions. On the other hand, they both showed significant associations with their outdoor levels, while the formaldehyde models generally did not show a relationship with the outdoor levels. When adjustments for some other indoor variables were made – namely the CO_2 and temperature variables – there was a significant relation with outdoor formaldehyde levels. These two models accounted for 22% and 32%, respectively, of the total variation in the indoor levels. 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.

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.

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

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.

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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APPENDIX IV

RECOMMENDATIONS TO SCHOOLS FOR REDUCING FORMALDEHYDE

REMEDIES FOR REDUCING FORMALDEHYDE IN SCHOOLS

Recommendations of the
California Air Resources Board
and Department of Health Services
March 2002

When a classroom has been measured with elevated formaldehyde levels (more than 27 parts per billion--ppb), we recommend that the school implement the basic measures listed below. Classrooms with formaldehyde levels below 27 ppb would benefit from these measures as well, because formaldehyde is a carcinogen, and it is desirable to achieve the lowest formaldehyde levels reasonably feasible. However, achieving very low indoor levels (below 5 -10 ppb) generally is not possible. Outdoor levels average about 3 ppb, but can range up to 20 ppb in some areas, such as near traffic.

1. Reduce the total amount of formaldehyde sources in the classroom.

Removing sources is often the most effective way to assure that formaldehyde concentrations are reduced in classroom air. The primary indoor sources are typically pressed wood building materials and furnishings; consumer products and combustion sources can also contribute to indoor levels.

- **Newer, removable sources such as new, freestanding bookshelves and desks made with pressed wood products (e.g., particleboard) should be aired out** in a different, well-ventilated location for as long as conveniently possible, preferably at least two to three weeks. This process will not remove all of the formaldehyde, but it can accelerate the initial off-gassing of formaldehyde, and keep the highest emissions out of the classroom.

- **Avoid using noxious consumer products in the classroom.** Cleaning products, carpet shampoos, surface cleaners, glass cleaners, markers, and cosmetics such as fingernail polish can emit formaldehyde as well as other undesirable chemicals. If some of these products must be used, make sure the ventilation is turned on and run at proper levels.

- **Assure that all combustion appliances are exhausted directly to the outdoors.** Combustion appliances such as gas heaters and ovens produce formaldehyde. They should be checked annually by a professional to assure proper functioning.

2. Provide sufficient ventilation to the classroom.

- **Check the outdoor air flow rate and controls.** An inspection should be conducted to assure that the heating and air conditioning (HVAC) unit is drawing 15 to 20 cubic feet per minute per person of outdoor air into the room. Keep motor vehicles and combustion engines away from the air intakes.

- **To be effective, the HVAC system must be used (turned on).** Verify that the HVAC fan is continuously operating whenever the classroom is being used. If HVAC noise is a problem, consider installing a rubber gasket between the air handler and building shell. Consult with the manufacturer for assistance with noise attenuation.

- **Keep doors and windows open as much as possible**. Additional ventilation can be provided by operating oscillating fans inside the classroom (or in a window) while doors and windows are open. Fleecy materials such as carpet, upholstery, and wall surfaces will adsorb formaldehyde that is in the air and re-emit it as environmental conditions change. Additional ventilation and air circulation will help accelerate the removal of formaldehyde from these surfaces and from the room.

- **Assure that the classroom is maintained at 30% to 50% relative humidity and a comfortable temperature.** Formaldehyde emissions generally increase with higher temperatures and higher humidity.

3. Testing the Air

The following information may be helpful to schools that wish to obtain a follow-up measurement in classrooms after taking steps to reduce formaldehyde levels:

- **Be sure to hire a qualified consultant** or obtain the services of a trained industrial hygienist from the district or a local government agency to conduct the testing. Private consultants may charge about $1000 - $1500 to test several classrooms for one day. Advice on hiring an indoor air quality consultant and lists to help locate consultants can be found on-line at http://www.cal-iaq.org/FIRMS/.

- **Use an accepted test method**. An active DNPH (dinitrophenylhydrazine) sampler is the preferred method, although other methods may be adequate.

- **Obtain measurements during school hours with the ventilation system in normal operating mode**. This will provide a good estimate of the levels the occupants are actually exposed to in their classrooms. Ideally, a 6-8 hour test is desired, to cover the hours the rooms are occupied.

If Levels Are Still Higher Than Desired

If test results show that formaldehyde concentrations remain elevated after the measures above have been taken, then some additional action may be necessary.

Sealing all exposed surfaces of particleboard furnishings with multiple layers of water resistant sealants--such as polyurethane, vinyl laminate, lacquers, alkyd paints or other water-resistant coatings--can reduce formaldehyde emissions. The effectiveness of these sealants varies greatly by product, thickness of the layer applied, and the thoroughness of application. It is advisable to seal all surfaces, including the back and edges of the board, and use multiple layers of coatings. Sealants themselves may release other chemicals for a period of time, so application and initial off-gassing during drying must be conducted under high ventilation conditions and/or at an alternate location.

For newer classrooms that show especially high formaldehyde levels even after the measures above have been taken, schools may also want to consider measures such as extensive airing out of the building or sealing of surfaces over the summer.

Future Purchases

When new classrooms or furnishings are ordered or constructed, materials can be specified that emit low or no formaldehyde and other volatile chemicals. Schools may also want to request that any furnishings that might emit chemicals be aired out prior to installation. Airing of carpet for several days at an alternate location, such as at a warehouse, can greatly reduce the chemical levels in the classrooms after installation of the carpet. Specification language for low formaldehyde elements was developed by the Collaborative for High Performance Schools (CHPS) and can be found at the website below.

For More Information

For more information on formaldehyde, visit:

http://www.arb.ca.gov/toxics/compwood/background.htm
http://www.arb.ca.gov/research/indoor/formald.htm and
http://www.arb.ca.gov/research/resnotes/notes/97-9.htm.

For information on designing, constructing, and maintaining healthier school buildings, visit:

CHPS: http://www.chps.net/.

Advisory on Relocatable and Renovated Classrooms
http://www.cal-iaq.org/ADVISORY.pdf

IAQ Tools for Schools, U.S. Environmental Protection Agency
http://www.epa.gov/iaq/schools/index.html

APPENDIX V

LAUSD CHECKLIST

Safe School Inspection Guidebook

LOS ANGELES UNIFIED SCHOOL DISTRICT

OFFICE OF ENVIRONMENTAL HEALTH AND SAFETY

Revised: April 15, 2002

SAFE SCHOOL INSPECTION GUIDEBOOK

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INTRODUCTION

OEHS SAFE SCHOOL INSPECTION PROGRAM

The education of our children requires a learning environment which is safe and health-protective. Maintaining a safe learning environment requires the commitment and active participation of school administrators, plant managers, central support staff, and an informed school community. The Safe School Inspection Program was established to provide comprehensive routine assessment of safety conditions in all Los Angeles Unified School District schools.

SAFE SCHOOL INSPECTION PROCESS

The Safe School Inspection process begins with a meeting between the OEHS safety officer and the site administrator. The meeting is followed by a brief walk-through of the school with the site administrator or plant manager. The safety officer then conducts a detailed inspection in accordance with the regulatory standards referenced in this Guidebook. The inspection concludes with a meeting between the safety officer and the site administrator to review the inspection findings and discuss any other safety concerns.

OBJECTIVE OF THE GUIDEBOOK

This Guidebook covers 18 safety areas and defines the mandatory health and safety standards applicable to schools. Although the Guidebook was designed primarily for OEHS use, it is also a useful tool for school administrators, plant managers, and other members of the school community. For copies of the Safe School Inspection Guidebook, please refer to the OEHS web site: www.laschools.org/oehs.

GENERAL PROVISIONS

Program Area	Reference	Corrective Action	Comments
School Safety and Health Committee	Bulletin N-53 California Department of Education "Safe Schools a Planning Guide for Action"	Verify the school has a safety committee. If so, verify the committee: 1. Meets regularly (at least quarterly). 2. Prepares written records of the issues discussed at the meetings and makes them available to affected employees. 3. Reviews results of the periodic, scheduled workplace inspections. 4. Reviews investigations of occupational accidents and the causes of incidents resulting in injury, illness, or exposure to hazardous substances and, where appropriate, submits suggestions to management for the prevention of future incidents. 5. Reviews investigations of alleged hazardous conditions brought to the attention of any committee member. 6. Submits recommendations to assist in the evaluation of employee safety suggestions. **Review safety committee meeting minutes and determine if recommendations have been implemented**	
Safe School Plan	Bulletin N-53	Verify the school has a Safe School Plan which is up-to-date and evaluated at least annually. **Review Safe Schools Plan and confirm it is up-to-date.**	
Written Emergency Communication Plan	Bulletin Q-48 Bulletin Q-50	Verify the school has an up-to-date written communication plan for implementation during an earthquake or disaster which outlines internal and external communication measures. **Review communication plan to ensure it is up-to-date.**	

General Provisions

Program Area	Reference	Corrective Action	Comments
Injury and Illness Prevention Program	8 CCR § 3203	Verify the facility has an Injury and Illness Prevention Program (IIPP) plan which is up-to-date and evaluated at least annually. **Review IIPP to determine if it accurately reflects school conditions.**	
Asbestos Management Plan	HSC § 25915; 40 CFR § 763.93	Verify the Asbestos Management Plan is kept up-to-date with ongoing operations and maintenance, periodic surveillance, inspection, reinspection, and response action activities. **Review Asbestos Management Plan to ensure it is up-to-date. See Asbestos Management Guidance to evaluate plan contents.**	
Exposure Control Program	8 CCR § 5193	If the school employees have occupational exposure to bloodborne pathogens such as conducting first aid or cleaning up bodily fluids, verify the facility has implemented, and maintains, an Exposure Control Plan designed to minimize or eliminate employee exposure. **Interview school nurse and plant manager and review Exposure Control Plan to ensure it is up-to-date.**	
Hazard Communication Program	8 CCR § 5194	Verify the facility has an up-to-date written Hazard Communication Program. **Review written Hazard Communication Program to ensure it is up-to-date**.	
Chemical Hygiene & Safety Plan Laboratories	8 CCR § 5191 Chemical Hygiene & Safety Plan Bulletin	If the school uses hazardous chemicals in a laboratory setting, verify the school has prepared a Chemical Hygiene & Safety Plan. **Review Chemical Hygiene Plan to ensure it meets requirements and is up-to-date.**	

GENERAL PROVISIONS

Program Area	Reference	Corrective Action	Comments
Crisis Intervention Documentation	Bulletin No. N-58 (Rev.)	Verify that the school maintains a copy of the Crisis Intervention Handbook (as a reference), an intervention notebook (which documents the specifics of each critical incident and the team response), and an updated community and District resource list. **Review Crisis Intervention Handbook, notebook, and resource lists to ensure they are updated.**	
Multicultural and Human Relations Education Plan	Bulletin No. DP-3	Verify that the school has developed and implemented a Multicultural and Human Relations Education Plan (MHREP). **Determine whether a MHREP is in place. Interview staff member responsible for managing the plan to determine whether the plan is properly implemented.**	
Hearing Conservation Program	8 CCR §§ 5097 and 5098	If personnel are exposed to noise levels greater than 85 dba verify a written hearing conservation program has been developed and is up-to-date. **Review hearing conservation program. Specifics of the program can be found in the Personal Protective Equipment Guidance.**	
Respiratory Protection Program	8 CCR § 5144	If personnel are provided respiratory protection verify a written respiratory protection program is developed and up-to-date. **Review respiratory protection program. Specifics of the program can be found in the Personal Protective Equipment Guidance.**	
Emergency Procedures		Verify that school has prepared and periodically updates emergency procedures.	

GENERAL PROVISIONS

Program Area	Reference	Corrective Action	Comments
Posting	Bulletin 21 Bulletin J-3 Bulletin P-11 Memorandum L-2 California State Constitution, Article I, Section 28	Verify signs regarding the following topics are posted on site. 1. Nondiscrimination and sexual harassment policies 2. Drug, tobacco, weapon, and violence free policies 3. Visitors policy 4. Injury Illness Prevention Program Summary 5. OSHA Poster 6. Access to medical and exposure records **Note location of the above postings.**	
Safety Suggestion	California Department of Education "Safe Schools a Planning Guide for Action"	Verify a Safety Suggestion Box or other mechanism is available to the school offices for students and parents to report safety concerns and recommendations. **Identify mechanism for students and parents to report safety concerns and recommendations.**	

ACCIDENT PREVENTION

Type	Subtype	Corrective Action	Reference
Injury and Illness Prevention Program	**IIPP Plan and Annual Review**	Develop an Injury and Illness Prevention Program (IIPP) plan and review at least annually. *Review IIPP to determine if it accurately reflects school conditions.*	8 CCR § 3203
	IIPP Training	Ensure all employees are trained and made aware of IIPP.	8 CCR § 3203
	Responsibilities	Assign persons with authority and responsibility to implement the IIPP. *Interview persons responsible to determine if they understand their roles.*	8 CCR § 3203
		Provide copy of IIPP certification statement with signature of site administrator to OEHS and maintain original on site.	8CCR 3203
	Records-IIPP	Maintain inspection records for three years as required under the IIPP. *Review inspection records and verify recommended corrective actions have been complied with.*	8 CCR § 3203
	School Safety Committee	Ensure school has a School Safety Committee to address injury and illness prevention issues in a timely manner pursuant to Bulletin N-53.	Bulletin N-53
	Site Inspection	Conduct a site walk-through at least semi-annually to ascertain if unsafe conditions to student or employee physical or mental well being exist. *Review reports generated during the walkthrough, minutes from the School Safety Committee Meeting and timeline for completion of corrective actions.*	8 CCR § 3203
		Ensure the School Safety Committee reviews the walk-through results within a month of the inspection, and the timeline for completion of identified correction actions at least quarterly.	8 CCR § 3203
	Accident Investigation/Report	Ensure an investigation is conducted and a report is prepared for each accident.	Reference Guide 12

ACCIDENT PREVENTION

Type	Subtype	Corrective Action	Reference
OSHA	**OSHA Log 300**	Maintain OSHA Log 300 as required by Cal/OSHA. Contact OEHS at (213) 743-5086. *Review OSHA Log 300 to ensure it is properly maintained.*	8 CCR § 14305
	OSHA Annual Summary	Post previous calendar year's OSHA 300 summary from February 1 through March 1 in a location frequented by employees. *Determine if appropriately posted.*	8 CCR § 14305 29 CFR § 1904
	Death/Serious Injury Report	Notify Cal/OSHA within 8 hours if any employee is seriously injured on the job or in connection with the job. *Interview staff to determine if they understand procedures for reporting a serious injury.*	8 CCR § 342; 29 CFR § 1904.8
	OSHA Poster	Post Cal/OSHA Safety & Health Protection Job poster in a conspicuous location.	8CCR 340
Medication Storage	**Security**	Ensure medication cabinet (s) is secured at all times.	

ACOUSTICAL QUALITY

Type	**Subtype**	**Corrective Action**	**Reference**
Classroom Noise	**HVAC Source**	Contact OEHS Industrial Hygiene Section at (213) 743-5086 to arrange follow-up evaluation of HVAC noise source. *Determine if HVAC system, while in operation, emits noise potentially above noise level guidelines. Make referral to OEHS/IH section for follow-up noise evaluation, as appropriate.*	
	Outdoor Source	Contact OEHS Industrial Hygiene Section at (213) 743-5086 to arrange follow-up evaluation of outdoor noise sources. *Determine if outdoor noise sources emit noise potentially above noise level guidelines. Make referral to OEHS/IH section for follow-up noise evaluation, as appropriate.*	
Outdoor Noise	**Transportation Source**	Contact OEHS Industrial Hygiene Section at (213) 743-5086 to arrange follow-up evaluation of transportation noise sources. *Determine if transportation noise sources emit noise potentially above noise level guidelines. Make referral to OEHS/IH section for follow-up noise evaluation, as appropriate.*	
	Industrial Source	Contact OEHS Industrial Hygiene Section at (213) 743-5086 to arrange follow-up evaluation of industrial noise sources. *Determine if industrial sources emit noise potentially above noise level guidelines. Make referral to OEHS/IH section for follow-up noise evaluation, as appropriate.*	
	Construction Source	Contact OEHS Industrial Hygiene Section at (213) 743-5086 to arrange follow-up evaluation of construction noise sources. *Determine if construction sources emit noise potentially above noise level guidelines. Make referral to OEHS/IH section for follow-up noise evaluation, as appropriate.*	

AIR QUALITY

Type	Subtype	Corrective Action	Reference
Indoor Air Quality	**Chemical**	Ensure that rooms are properly maintained to minimize chemical smells and objectionable odors. *Interview staff and inspect school facilities.*	
		Ensure vehicles are not idling in the vicinity of classrooms. *Interview staff and inspect school facilities.*	
	Mold/Fungi	Mitigate mold and mildew infestation. *Interview staff and inspect school facilities.*	
		Correct all unresolved water damage. *Interview staff and inspect school facilities.*	
	General-IAQ	Remove all items blocking air vents to ensure adequate HVAC system ventilation. *Interview staff and inspect school facilities.*	
		Perform periodic preventative maintenance on HVAC systems. *Interview staff and inspect school facilities.*	
		Ensure adequate exhaust ventilation for all activities emitting air contaminants. *Interview staff and inspect school facilities.*	

AIR QUALITY

Type	Subtype	Corrective Action	Reference
		Maintain log (date, description and agency contacted) of all nuisance odors or other emissions from off-site sources. Report all events to OEHS at (213) 743-5086 and South Coast Air Quality Management District (SCAQMD) at (800) 288-7664.	
	Complaints-IAQ	Develop complaint procedures and inform staff of procedures to be followed. *Review complaint log and interview school staff.*	
Air Quality Permits	**Equipment Permits**	Ensure all equipment subject to South Coast Air Quality Management District (SCAQMD) permit is lawfully permitted.	(SCAQMD) Rules and Regulations
	Expired Permits	Ensure all South Coast Air Quality Management District (SCAQMD) equipment permits are current.	(SCAQMD) Rules and Regulations
Outdoor Air Quality	**Industrial**	Maintain log (date, description and agency contacted) of all industrial odor events from off-site sources. Report all events to OEHS at (213) 743-5086 and South Coast Air Quality Management District (SCAQMD) at (800) 288-7664.	
	Transportation	Maintain log (date, description and agency contacted) of all transportation odor events from off-site sources. Report all events to OEHS at (213) 743-5086 and South Coast Air Quality Management District (SCAQMD) at (800) 288-7664.	
	Construction	Maintain log (date, description and agency contacted) of all construction odor events from off-site sources. Report all events to OEHS at (213) 743-5086 and South Coast Air Quality Management District (SCAQMD) at (800) 288-7664.	
	Air Pollution Episodes	Develop procedures to notify staff and students in the event of a "Smog Alert" pursuant to Bulletin C-6. *Review school procedure for Air Pollution Episodes.*	SCAQMD Rule VII

ASBESTOS MANAGEMENT

Type	**Subtype**	**Corrective Action**	**Reference**
Asbestos Planning	**Asbestos Management Plan**	Ensure that an Asbestos Management Plan is available pursuant to 40 CFR, and that the plan is kept up-to-date.	HSC § 25915; 40 CFR § 763.93
		Ensure that all ACM locations are listed in the Asbestos Management Plan. *Review Asbestos Management Plan.*	HSC § 25915; 40 CFR § 763.93
		List the potential health risks or impacts that may result from exposure to ACM in the Asbestos Management Plan.	HSC § 25915; 40 CFR § 763.93
		Prohibit non-qualified personnel from handling ACM.	HSC § 25915; 40 CFR § 763.93
	Training-ACM	Provide custodial and maintenance staff who work in buildings known to contain ACM with a 2-hour awareness training within 60 days of commencement of employment. *Review training records in Asbestos Management Plan.*	8 CCR § 5208; 40 CFR § 763.92
Inspections	**Periodic Surveillance-ACM**	Contact ATU (213) 763-1450 to conduct 3 year survey of potential asbestos containing materials. *Review updated survey in Asbestos Management Plan.*	HSC § 25915; 40 CFR § 763.85
		Contact ATU (213) 763-1450 to conduct 6 month visual surveillance of each building known or suspected to contain ACM.	HSC § 25915; 40 CFR § 763.85
	Records	Following any asbestos survey, record the surveillance date, the inspector's name, and any changes in materials in the Asbestos Management Plan. *Review surveillance records in Asbestos Management Plan.*	HSC § 25915; 40 CFR § 763.85

ASBESTOS MANAGEMENT

Type	**Subtype**	**Corrective Action**	**Reference**
Operations	**Care and Maintenance**	Maintain all floors and other surfaces constructed of ACM in good condition to prevent deterioration. *Inspect at least five areas with suspected ACM for dust and note areas inspected. Visually observe condition of floors and interview custodial staff to determine frequency of floor polishing.*	8 CCR § 5208
		Do not sand floors or other surfaces known to contain asbestos. Remove the finish only using a wet method and low-abrasion pads at speeds lower than 300 rpm.	8 CCR § 5208
		Burnish or dry buff only on floors with sufficient finish to ensure the pad does not contact the asbestos containing material.	8 CCR § 5208
	Restricted Access	Restrict access to students and staff to areas identified with friable ACM until ACM is removed. *Interview plant manager and custodial staff to determine if areas of friable ACM exist. Visually observe activities in the areas.*	8 CCR § 5208
		Secure the areas where ACM is being removed to prevent access to individuals except those conducting abatement activities. *Visually observe areas undergoing abatement activities to determine if they secured.*	8 CCR § 5208

ASBESTOS MANAGEMENT

Type	Subtype	Corrective Action	Reference
	ACM Warning Signs	Attach warning labels adjacent to any friable and nonfriable known or suspected ACM located in routine maintenance areas (such as boiler room). The warning labels must be clear conspicuous and state: "CAUTION: ASBESTOS. Cancer and lung disease hazard. Do not disturb without proper training and equipment." *Inspect routine maintenance areas suspected of containing ACM.*	CHSC § 25915; 40 CFR § 763.95

CAMPUS SECURITY AND CRIME PREVENTION

Type	Subtype	Corrective Action	Reference
Policies/Plans	**Visitation Policy**	Ensure school visitation policy is posted and distributed annually to parents and staff. *Note where visitation policy is posted.*	Bulletin N-2
		Ensure visitors entering school grounds sign-in and receive a visitor's pass. *Review visitor sign in sheets.*	Bulletin N-2 California State Constitution, Article I, Section 28
	Locked Campus	Lock all fences and gates at the beginning of classes each morning and keep them locked until the end of the school day, pursuant to Bulletin 33.	Bulletin 33
	Discipline Code	Ensure the school has established a discipline code and distributed it to all students, parents and employees. *Review discipline code and interview administration staff to determine how it is distributed.*	Collective Bargaining Agreement, UTLA & LAUSD, Articles XXIV and XXVIII
	Attendance Plan	Ensure the school has developed a school attendance plan. The plan should include the attendance policies and procedures. *Review school attendance plan.*	Bulletin 13 Bulletin Z-54
		Ensure the school has developed a school attendance plan. The plan should include the use of Student IDs. *Review school attendance plan.*	Bulletin 13 Bulletin Z-54
		Ensure the school has developed a school attendance plan. The plan should include truancy ordinances. *Review school attendance plan.*	Bulletin 13 Bulletin Z-54

CAMPUS SECURITY AND CRIME PREVENTION

Type	Subtype	Corrective Action	Reference
		Ensure the school has developed a school attendance plan. The plan should include the safety issues related to tardiness and leaving campus prior to the end of the day. *Review school attendance plan.*	Bulletin 13 Bulletin Z-54
		Ensure the school has developed a school attendance plan. The plan should state that students caught off campus without proper permission will be issued a citation. *Review school attendance plan.*	Bulletin 13 Bulletin Z-54
		Ensure the Principal or designee notifies school police immediately prior to a suspension or expulsion recommendation provided the student possessed or sold narcotics or a controlled substance. *Interview Principal to determine knowledge of policy.*	Bulletin 38
		Ensure Principal or designee notifies school police immediately prior to a suspension or expulsion recommendation provided the student possessed a firearm at school. *Interview Principal to determine knowledge of policy.*	Bulletin 38
		Ensure the Principal or designee notifies school police immediately prior to a suspension or expulsion recommendation provided the student has possession of a dirk, dagger, ice pick, knife having a fixed blade longer than 2.5 inches, folding knife with a blade that locks into place, razor with unguarded blade, taser or stun gun, BB or pellet or other type of air gun or spot maker. *Interview Principal to determine knowledge of policy.*	Bulletin 38
		Ensure the Principal or designee notifies school police immediately prior to a suspension or expulsion recommendation provided the student has threatened or assaulted school employees. *Interview Principal to determine knowledge of policy.*	Bulletin 38

CAMPUS SECURITY AND CRIME PREVENTION

Type	Subtype	Corrective Action	Reference
	Violence Reports	Ensure the Principal or designee reports incidents of violence emergencies, and other safety related matters to school police, and administrators supervising operations, personnel at other school sites and traveling students who may be affected. *Interview Principal to determine how incidents of violence are reported.*	
	Random Metal Detection	Ensure random metal detection searches are conducted and documented at secondary schools. *Review documentation of random metal detection searches.*	
	Random Metal Detection	Ensure posting of signs advising persons at the school that they are subject to search for weapons by a metal detector. *Note locations of signs.*	
	Traffic Assistance	Ensure the school obtains local or school police assistance for traffic enforcement as necessary during school drop-off and pickup times to ensure student safety. *Interview school administrator to evaluate the use of police assistance during drop-off and pickup times.*	
Smoking	**Smoking Prohibition**	Prohibit smoking on school premises pursuant to Bulletin 66.	Bulletin 66
Security	**Parking**	Ensure parking permits are issued by site administrator for non-District vehicles parked on playgrounds and restricted areas.	
		Do not double park or block other cars.	
Student Safety	**Student Notification**	Ensure school personnel discuss how to report incidents of drug or weapon possession, child abuse, suicidal behavior, hate motivated incidents or hate crimes, dissemination, harassment, threats, intimidation or sexual harassment with students within four weeks of the beginning of school. *Interview school administrator to determine how students are provided the above information.*	

CAMPUS SECURITY AND CRIME PREVENTION

Type	Subtype	Corrective Action	Reference
		Ensure school personnel discuss standards relating to zero-tolerance policies regarding sexual assault, sexual harassment, drugs, weapons and alcohol on campus, including prevention and intervention programs with students within four weeks of the beginning of school. *Interview school administrator to determine how students are provided the above information.*	
		Ensure school personnel discuss conflict resolution with students within four weeks of the beginning of school. *Interview school administrator to determine how students are provided the above information.*	Bulletin N-24
		Ensure school personnel discuss procedures for administering medication at school with students within four weeks of the beginning of school. *Interview school administrator to determine how students are provided the above information.*	Bulletin N-17 Inter-Office Correspondence, Superintendent, "Implementation of Board Policy Regarding Students Leaving Classrooms," 2-15-95 amended 12-16-96
		Ensure school personnel discuss use and possession of electronic signaling devices, e.g. pagers, cellular phones with students within four weeks of the beginning of school. *Interview school administrator to determine how students are provided the above information.*	Bulletin N-17
		Ensure school personnel discusses AAA traffic safety and pedestrian brochures, bicycle safety, bus safety and rider rules, pedestrian routes to and from school, driving drop off, pickup and parking procedures, car safety, and seat belt use with students and written materials are distributed or posted as needed or available. *Interview school administrator to determine how students are provided the above information.*	Memorandum CT-1

CAMPUS SECURITY AND CRIME PREVENTION

Type	Subtype	Corrective Action	Reference
	Safety Supervision	Ensure the school has a campus supervision plan clearly delineating the times and areas of the campus that require specific supervision such as during scheduled activities and bus loading areas. The plan must be on display. *Review campus supervision plan to determine if it is up-to-date and interview administrators to determine knowledge of plan.*	Bulletin Z-10, Bulletin Z-36, Bulletin DP-1, Bulletin L-4, Bulletin L-5, Bulletin 61, Bulletin Z-19, Memorandum L-2 Memorandum Z-6

CHEMICAL SAFETY

Type	Subtype	Corrective Action	Reference
Hazard Communication Program	**Hazard Communication Plan**	Ensure that Hazard Communication Program is developed and maintained current. *Review written Hazard Communication Program to ensure it is up-to-date.*	8 CCR § 5194; 29 CFR § 1910.1200
	Warnings-HazCom	Label each hazardous substance container with the identity of the hazardous substance(s) contained and appropriate hazard warnings. *Review a random number of chemicals to determine if they are labeled properly.*	8 CCR § 5194; 29 CFR § 1910.1200
	Material Safety Data Sheets	Maintain current Material Safety Data Sheets (MSDSs) for each hazardous substance used on site. *Compare the MSDSs maintained to a random number of chemicals on-site.*	8 CCR § 5194; 29 CFR § 1910.1200
Chemical Handling	**Use of Prohibited Chemicals**	Do not use chemicals that have not been approved by OEHS. *Compare chemical products used to the list of approved and disapproved chemicals developed by LAUSD Office of Environmental Health and Safety.*	8 CCR § 5194; 8 CCR § 5228; 29 CFR 1910.1450;
	Spill Management	Ensure that all chemical storage areas are provided with a spill kit containing absorbent, neutralizing chemicals and other spill-control materials. *Inspect spill kits.*	8 CCR § 5191
	Flammable Material Dispensing	Ensure that all containers dispensing flammable materials are bonded and grounded. *Inspect flammable dispensing containers for grounds.*	LA Fire Code § 57.30.64; 29 CFR § 1910.106

CHEMICAL SAFETY

Type	**Subtype**	**Corrective Action**	**Reference**
	Chemical Inventory	Maintain written inventory of chemicals on site.	8CCR 5191
Chemical Storage	**Chemical Material Storage**	Store flammables and combustible liquids in approved cabinets with self-closing doors. *Inspect flammable storage cabinets.*	8 CCR § 5417 and 19 CCR § 3.15; 29 CFR § 1910.106(d)(3)(I); Chemical Hygiene & Safety Plan Bulletin
		Ensure no more than 60 gallons of Class I or Class II and, 120 gallons of Class III liquids are stored in approved cabinets. *Inspect flammable storage cabinets.*	8 CCR § 5533;29 CFR § 1910.106
		Label all cabinets storing flammable or combustible materials with "FLAMMABLE--KEEP FIRE AWAY." *Inspect flammable storage cabinets.*	8 CCR § 5533; 29 CFR § 1910.106
		Ensure exhaust ventilator systems in all flammable material storage rooms provide 6 air exchanges per hour, and that the control switch is located outside the room. *Inspect flammable storage rooms.*	8 CCR § 5533; 29 CFR § 1910.106
		Ensure aisles are at least 3 feet apart in flammable storage rooms to provide for emergency egress. *Inspect flammable storage rooms.*	8 CCR § 5533; 29 CFR § 1910.106
		Ensure flammable material storage rooms are not located in buildings occupied by students. *Inspect flammable storage rooms*	8 CCR § 5533; 29 CFR § 1910.106
	Food Storage	Avoid storage, handling, or consumption of food and beverages in chemical storage areas or areas used for laboratory operations.	8CCR 5191 Appendix A
	Incompatible Storage	Store chemical materials by compatibility type as described in Material Safety Data Sheets (MSDSs).	8 CCR § 5533 and 19 CCR § 3.15; 29 CFR § 1910.106

CHEMICAL SAFETY

Type	Subtype	Corrective Action	Reference
	Gas Cylinder Storage	Provide current certification for all compressed gas cylinders. *Inspect compressed gas storage area.*	8 CCR § 4649; 29 CFR § 1910.101
		Ensure compressed gas cylinders are free of corrosion, dents, cuts, gouges, bulges and leaks. *Inspect compressed gas storage area.*	8 CCR § 4649;29 CFR § 1910.101
		Ensure compressed gas cylinders are stored upright, by hazard class, secured, capped and kept at least 20 feet from flammable liquids, oxidizers, and other sources of ignition. *Inspect compressed gas storage area.*	8 CCR § 4649; 29 CFR §§ 1910.101, 1910.102, 1910.103, 1910.104
		Post "NO SMOKING" sign, identify hazard classes, and list all gases stored in the compressed gas storage areas. *Inspect compressed gas storage area.*	8 CCR § 4649; 29 CFR §§ 1910.101, 1910.102, 1910.103, 1910.104
		Store oxygen cylinders in a well ventilated area away from other flammables. *Inspect compressed gas storage area.*	8 CCR § 4649; 29 CFR § 1910.104
		Separate compressed flammable gases and oxidizing gases by either a 1-hour fire wall or distance of 25 feet. *Inspect compressed gas storage area.*	8 CCR § 5533; 29 CFR § 1910.106
Lab Safety	**Chemical Hygiene Plan**	Develop a written Chemical Hygiene & Safety Plan and ensure it is readily available to all employees. The plan should identify a "coordinator" and be revised at least annually. *Review Chemical Hygiene Plan*	8 CCR § 5191; 29 CFR 1910.1450; Chemical Hygiene & Safety Plan Bulletin

CHEMICAL SAFETY

Type	Subtype	Corrective Action	Reference
		Post floor plan drawings of science laboratories in a conspicuous area. *Review posting and compare to laboratory operations.*	8 CCR § 5191; 29 CFR 1910.1450; Chemical Hygiene & Safety Plan Bulletin
		Post locations of waste disposal containers and safety equipment in a conspicuous area.	8 CCR § 5191;29 CFR 1910.1450;Chemical Hygiene & Safety Plan Bulletin
	Lab Chemical Inventory	Maintain written inventory of all chemicals used in laboratories and do not use chemicals defined by Chemical Hygiene Plan as prohibited.	8CCR 5191
	Training-CHP	Ensure training of all employees on hazardous chemicals used in their respective work areas. **Review training records and interview staff.**	8 CCR § 5194; 29 CFR § 1910.1200
		Ensure all employees working in laboratory areas participate in a chemical hygiene and safety training program. *Review training records and interview laboratory instructor and Chemical Safety Officer to determine their knowledge of the Plan.*	8 CCR § 5191; 29 CFR 1910.1450; Chemical Hygiene & Safety Plan Bulletin
	Lab Waste	Contact OEHS (213) 743-5086 to arrange for proper disposal of outdated, retrograde, or otherwise expired lab chemicals. *Interview Chemical Hygiene Officer.*	22 CCR § 66262.11; 40 CFR 262.11
	Lab Incompatible Storage	Store laboratory chemicals by compatibility type as described in Appendix D (Tables 1 and 2) of the Chemical Hygiene & Safety Plan.	Chemical Hygiene & Safety Plan Bulletin
	Lab Chemical Storage	Store all volatile laboratory chemicals in an explosion-proof cabinet.	Chemical Hygiene & Safety Plan Bulletin
		Label all laboratory cabinets and storage areas to identify contents.	Chemical Hygiene & Safety Plan Bulletin

CHEMICAL SAFETY

Type	Subtype	Corrective Action	Reference
		Lock all laboratory chemical storage cabinets when not in use.	Chemical Hygiene & Safety Plan Bulletin
		Keep all laboratory chemical storage areas cool (between 55 and 80 degrees F) and dry (relative humidity between 30 and 60 percent).	Chemical Hygiene & Safety Plan Bulletin
	Lab Safety Equipment	Install permanent, hands free eyewash stations in all laboratories using chemicals. *Inspect laboratories for eyewash stations.*	Chemical Hygiene & Safety Plan Bulletin

ELECTRICAL SAFETY

Type	Subtype	Corrective Action	Reference
Appliances	**Non-approved Items**	Remove unauthorized electrical appliances pursuant to Bulletin C-26.	Bulletin C-26
Electrical Practices	**Equipment Clearance**	Maintain at least 3 ft clearance around all electrical equipment (e.g., electrical panels, switchgear, transformers). *Inspect electrical equipment such as switchboxes, transformers etc.*	8 CCR § 2340; 29 CFR § 1910.303
	Unlabeled Electrical Panels	Ensure all electrical panels are labeled indicating the associated use. *Inspect electrical panels.*	29 CFR § 1910.303
	Guarding-Electrical Equipment	Provide enclosed guard for live electrical components operating at 50 volts or above. Alternatively, all such components may be located minimum 8 ft above floor or working surface or confined to rooms only accessible to qualified persons. *Check electrical equipment.*	8 CCR § 2340; 29 CFR § 1910.303
Electrical Equipment	**Connections**	Provide approved covers for all pull boxes, electrical equipment junction boxes and fittings. *Inspect equipment for covers.*	8 CCR § 2340; 29 CFR § 1910.305
	Flexible Cords	Ensure that extension cords and cables are UL approved and suitable for the conditions of use. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305
		Ensure that flexible cords and cables are not used for permanent wiring. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305
		Ensure that multiple electrical extension cords are not used in series. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305

ELECTRICAL SAFETY

Type	**Subtype**	**Corrective Action**	**Reference**
		Ensure that flexible cords and cables are not run through holes in walls, ceilings, or floors, through doorways, windows or similar openings. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300 29 CFR § 1910.305
		Ensure that flexible cords and cables do not hang on metal hangers or supports. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305
		Destroy electrical cords that are frayed, spliced, taped, or otherwise deteriorated. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305
		Ensure that flexible cords and cables are not used near sources of water i.e., sinks or pools. *Inspect areas throughout schools (classrooms, offices, storage areas) to evaluate use of flexible cords.*	8 CCR § 2300; 29 CFR § 1910.305
	Exterior Wiring	Use only circuits protected by a ground fault interrupter (GFI) when operating power tools/equipment. *Inspect areas where power tools are used.*	29 CFR § 1910.304

EMERGENCY PREPAREDNESS

Type	**Subtype**	**Corrective Action**	**Reference**
Planning	**Emergency Procedures**	Prepare and maintain emergency procedures. *Review emergency procedures.*	CEC § 35294; Bulletin Q-48 Bulletin Q-50
	Training-Emergency	Ensure all employees are trained within the first three months of the school year on the subject of emergency preparedness. *Review training program and training records.*	CEC § 35294 Bulletin Q-48 Bulletin Q-50 Collective Bargaining Agreement UTLA & LAUSD Articles XXIV and XXVIII
		Provide emergency preparedness training documentation that includes date of training, agenda, training materials and sign-in sheet.	CEC § 35294
		Obtain signed acknowledgement from individuals who missed training noting they have reviewed training materials. *Review training program and training records.*	CEC § 35294
Earthquake	**Supplies-Earthquake**	Provide dedicated emergency supply storage containers. *Inspect dedicated storage container for earthquake supplies.*	Bulletin Q-48 Bulletin Q-50 BMP
		Ensure emergency supplies include flashlights, batteries, battery powered radio(s), first aid bin for every 400 persons, drinking water ratio 1.5 gallons per person, wrenches, pumps, pitchers, cups, bleach, search and rescue kit for every 500 persons, canned foods and personal hygiene products.	Bulletin Q-48 Bulletin Q-50 BMP
		Ensure emergency supplies are inspected and/or refreshed on a regular basis. Label water drums with expiration date. Change out untreated tap water every 6 months and disinfected water every 3 years.	Bulletin Q-48 Bulletin Q-50 BMP

EMERGENCY PREPAREDNESS

Type	Subtype	Corrective Action	Reference
	Other-Earthquake	Ensure all chemical storage shelves or cabinets are equipped with lips or other devices to prevent stored materials from falling. *Inspect classrooms, offices, equipment rooms and other storage areas throughout the school.*	8 CCR §§ 3209, 3210, 3211, and 3212
		Provide seismic bracing for furniture and appliances.	Memorandum N8
		Provide seismic bracing for HVAC units and hot water heater tanks. *Inspect classrooms, offices, equipment rooms and other storage areas throughout the school.*	Bulletin Q-48 Bulletin Q-50 BMP
		Remove all materials and objects stored on the top of cabinets or upper shelves unless such objects are fastened to the shelf or otherwise restrained from falling. *Inspect classrooms, offices, equipment rooms and other storage areas throughout the school.*	Bulletin Q-48 Bulletin Q-50 BMP

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
Maintenance	**Trouble Calls**	Ensure trouble call procedure is in place, and that trouble calls are being made in a timely manner. *Review trouble call log and interview Plant Manager to determine timeliness of log entries.*	Annual Campus/ Facilities Inspection Form
	Trouble Call Log	Maintain call log and maintenance and operations (M&O) response requests for minimum period of 2 years. *Review trouble call log and maintenance records.*	Annual Campus/ Facilities Inspection Form
	Roof and Gutter	Ensure roofs and gutters are intact and well maintained. *Visually inspect roofs and gutters note areas inspected. (If a large number of roofs exist randomly inspect at least 5.)*	Annual Campus/ Facilities Inspection Form
	Lighting	Ensure all areas within the school have adequate lighting. (Areas include classrooms, stairways, hallways, gyms, locker rooms, shops, library, offices, restrooms, and exterior grounds). *Visually inspect at least 20 rooms to determine if lighting is adequate. Note areas inspected.*	Annual Campus/ Facilities Inspection Form
	Cleanliness	Ensure all school areas are maintained in a clean manner. (Areas include classrooms (including sinks), lockers, hand rails, auditorium, multipurpose rooms, shops, library, administrative office, and restrooms). *Visually inspect areas throughout the school to determine if they are clean. Note areas observed which are not clean.*	Annual Campus/ Facilities Inspection Form

FACILITIES MAINTENANCE

Type	**Subtype**	**Corrective Action**	**Reference**
	Condition of Equipment and Facilities	Ensure school grounds and equipment are in good repair. (Areas include lockers, handrails, gyms, locker rooms, and drapes, dimmer boards (in auditoriums and multi-purpose rooms)). *Visually inspect these areas to determine the condition of these facilities and equipment.*	Annual Campus/ Facilities Inspection Form
Maintenance	**Hot Water Supplies**	Ensure hot water is available in gym showers and in shops. *Visually inspect showers and water faucets in the gym and shop areas to determine the availability of hot water.*	Annual Campus/Facilities InspectionForm
	Classrooms	Ensure classrooms are free of broken furniture. *Visually inspect classrooms in accordance with sampling strategy and note areas inspected.*	Annual Campus/Facilities Inspection Form
	Broken Windows	Ensure broken or cracked windows are reported and that broken windows are repaired within 72 hours. *Interview Plant Manager to identify the procedure for fixing windows and if they are fixed within 72 hours.*	Annual Campuses/ Facilities Inspection Checklist
	Blinds	Maintain venetian blinds in good repair. *Visually inspect venetian blinds in at least 20 rooms to determine their condition. Note rooms that have been inspected and any concerns identified.*	Annual Campuses/ Facilities Inspection Checklist

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
	Kitchen Cleanliness	Ensure kitchens are maintained in a clean manner, and are "deep cleaned". (For lunch shelters, Ensure that tables, trash receptacles, and decks are clean. For kitchens and lunch shelters, ensure that drains are clean, if they exist). *Review records reflecting the kitchen cleaning schedule to determine the most recent deep cleaning date. Visually inspect the tables, trash receptacles, drains, and decks in the lunch shelters for cleanliness.*	Annual Campuses/ Facilities Inspection Checklist
	Lunch Shelters	Ensure heaters in lunch shelters are functioning. *Examine heaters to determine if they are functioning properly.*	Annual Campuses/ Facilities Inspection Checklist
	Gyms and Locker Rooms	Maintain gyms and locker rooms free of odors. *Visually inspect the gym and locker rooms for odors and cleanliness.*	Annual Campuses/ Facilities Inspection Checklist
		Ensure that blackboards are properly attached. *Visually inspect the blackboards in the gym and locker rooms to determine whether they have been properly attached.*	Annual Campuses/ Facilities Inspection Checklist
	Auditorium and Multi-purpose Rooms	Ensure auditorium and multi-purpose rooms are free of broken and loose seats. *Visually inspect the condition of the seats in the auditorium and multipurpose rooms to determine if they are broken. Note the rows that were inspected and problems identified.*	Annual Campuses/ Facilities Inspection Checklist
	Libraries	Ensure library carpeting is in good condition (i.e., there are no stains, broken seams, etc.). *Visually inspect library carpeting to determine its condition.*	Annual Campuses/ Facilities Inspection Checklist

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
	Libraries	Ensure that library shelving is in good repair. *Visually inspect library shelving to determine their condition.*	Annual Campuses/ Facilities Inspection Checklist
	Hopper Rooms	Ensure hopper rooms are organized and well stocked. *Visually inspect hopper rooms to determine whether they are organized and well stocked.*	Annual Campuses/ Facilities Inspection Checklist
	Parking Lines	Ensure that parking lines and game lines are clear. *Visually inspect the parking and game lines.*	Annual Campuses/ Facilities Inspection Checklist
	Perimeter Fencing	Ensure that the perimeter fencing of the school site and the collection bin area are in good repair. *Visually inspect the fencing around the school site and collection areas.*	Annual Campuses/ Facilities Inspection Checklist
	Housekeeping	Maintain all areas in a neat and orderly manner, free of fire, health and safety hazards.	Annual Campuses/ Facilities Inspection Checklist
	Housekeeping	Ensure that the site is free of weeds and that litter is removed daily. *As you tour the school, visually inspect the grounds for weeds and litter.*	Annual Campuses/ Facilities Inspection Checklist
	Permits	Post valid operating permit near air compressor, air pressure tank, elevator, boiler, or other equipment subject to permitting.	8CCR 461 8CCR 344.2 8CCR 344.1
	Salvage items	Contact District Salvage at (323) 752-6719 to remove waste and other unusable items (e.g., old computers, desks).	8CCR 3221
	Sewer and Storm Drains	Ensure that the sewer and storm drains are clear of debris. *Visually inspect the condition of sewer and storm drains.*	Annual Campuses/ Facilities Inspection Checklist
	Fencing and Gates	Ensure that the fences and gates are in good repair (i.e., confirm that they are on track, have locks, and that there are no holes or rust). *Visually inspect fences and gates to determine their condition.*	Annual Campuses/ Facilities Inspection Checklist

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
	Asphalt Condition	Ensure that the asphalt is in good condition (i.e., has no significant cracks, holes, standing water, loose gravel or mulch, etc.). *Visually observe asphalt to determine its condition.*	Annual Campuses/ Facilities Inspection Checklist
	Machine Guarding General Requirements	Ensure that one or more methods of guarding are provided on all machines that present injury to operators, such as from point of operation, ingoing nip points, rotating parts, flying chips and sparks. *Visually observe equipment to confirm the presence of machine guards. Also, visually inspect mounted cutter heads, and tool collars to confirm that the tool is the correct size and shape for that machine.*	29 CFR 1910.212
		Ensure that machine guards, when provided, are securely affixed to the machines. *Visually inspect machine guards to confirm that they are securely affixed to the machinery.*	29 CFR 1910.212
	Fan Guards	Ensure that all fans whose blades are less than 7-feet above the floor or working level are equipped with blade guards. *Visually inspect fans less than 7-feet high to ensure that they are equipped with blade guards.*	29 CFR 1910.212
	Securing Equipment	Ensure that equipment designed to be located in a fixed position is secured to prevent its "walking" or moving. *Visually inspect stationary equipment to ensure that it is properly secured.*	29 CFR 1910.212
	Restricted Access	Prevent access to crawl spaces, roof access, or other passageways not intended for use by students or unauthorized staff.	8CCR 1541
	Restrooms - Adequate Facilities	Ensure male restrooms in elementary schools built prior to 1994 have 1 urinal for every 30 students; 1 toilet for every 100 students; and female restrooms have 1 toilet for every 35 students.	

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
		Ensure male restrooms in secondary schools built prior to 1994 have 1 urinal for every 30 students; 1 toilet for every 100 students; and female restrooms have 1 toilet for every 35 students.	
		Ensure male restrooms in Kindergarten schools built prior to 1994 have 1 urinal for every 30 students; 1 toilet for every 100 students; and female restrooms have 1 toilet for every 35 students.	
		Ensure male restrooms in secondary schools built after 1994 have 1 urinal for 35 every students; 1 toilet for every 40 students; and female restrooms have 1 toilet for every 30 students.	UBC Appendix C
		Ensure male staff restrooms have 1 urinal for 50 men; 1 toilet: for 15 men; 2 toilets: 35 men; 3 toilets: 55 men; and 1 additional toilet for every 40 men. *Visually inspect restroom facilities to confirm adequate number of facilities.*	UBC Appendix C
		Ensure female staff restrooms have 1 toilet for 15 women; 2 toilets: 35 women; 3 toilets: 55 women; and 1 additional toilet for every 40 women. *Visually inspect restroom facilities to confirm adequate number of facilities.*	UBC Appendix C
	Restroom Designation	Provide gender-segregated restrooms in all facilities which have more than five employees.	8CCR 3364
	Restrooms - Fixture Operation	Ensure toilets and faucets operate properly. *Flush a representative number of toilets.*	
	Restrooms - Supplies	Ensure bathrooms are adequately stocked with supplies. *Check supplies in restrooms.*	
	Restroom - Water Leaks	Ensure there are no signs of water leaks or standing water on the floor. *Inspect restroom floors.*	
	Restrooms - Ventilation	Ensure vents in restrooms work. *Turn on vents in restroom to determine if they operate.*	

FACILITIES MAINTENANCE

Type	Subtype	Corrective Action	Reference
	Restrooms - Mold	Ensure there no signs of mold in the restrooms. *Inspect restrooms.*	
	Landscaping	Ensure tree canopies are adequately raised, plants adequately trimmed and landscape is free of obvious hazards. *During site tour, observe landscaping and note areas of concern.*	Annual Campus/Facilities Inspection Checklist
	Solid Waste Management	Ensure the facility has an ongoing solid waste recycling program for paper, aluminum cans, plastic, cardboard, and/or other recyclable materials. *Interview staff to determine solid waste recycling records.*	
	Solid Waste Dumpsters	Ensure that dumpsters are closed when not in use. *Inspect dumpsters.*	
	Trash Cans	Ensure trash cans are not overflowing with waste. *Inspect trash cans.*	
	Solid Waste Dumpsters Area	Ensure areas surrounding dumpsters and trash cans are clean. *Inspect areas around dumpsters.*	
Animals	**Animal Care**	House and care for all caged animals in a humane and safe manner.	Bulletin 83
	Authorization	Obtain authorization from site administrator prior to bringing animals into the classroom.	Bulletin 83

FIRE/LIFE SAFETY

Type	Subtype	Corrective Action	Reference
Access and Egress	**Emergency Egress**	Provide visible exit signs or directional signs for all exit doors and escape pathways. *During site tour, observe exit path lighting and exit signs in a representative number of buildings. Identify signs that are not operating properly.*	8 CCR § 3216 LA Fire Code § 57.33.15 29 CFR § 1910.36
		Place "NO EXIT" signs on non-exit doors or signs that indicate its actual use. *Inspect passageways and identify doors not labeled.*	8 CCR § 3216 LA Fire Code § 57.33.15 29 CFR § 1910.36
		Ensure all rooms have at least two exit pathways leading to an outside exit or into hallways leading to an outside exit. *Inspect classrooms and identify rooms that do not have at least two exits.*	8 CCR § 3225; LA Fire Code § 57.33.11; Section 305.2.4; 29 CFR § 1910.36
		Ensure the maximum distance from any point in the building to an exterior exit path or an enclosed stairway does not exceed 150 feet without an automatic sprinkler system or 200 feet with an automatic sprinkler system. *Inspect buildings and identify areas where exits are located greater than the above distances.*	8 CCR § 3222
		Provide exits that discharge directly to an open space, and are free of obstructions to ensure safe egress. *Inspect exit outlets and identify obstructed exits.*	8 CCR § 3227; LA Fire Code § 57.33.11 29 CFR § 1910.37
		Provide at least one security grill with emergency breakaway capacity for classrooms equipped with security grills. Emergency breakaway window must be constructed of glass, located furthest from the exit door, and clearly identified as an emergency exit.	CBC Section 305.2.4, UBC Section 305.2.4, District Policy

FIRE/LIFE SAFETY

Type	Subtype	Corrective Action	Reference
		Clear all objects placed over exit doors that may conceal or obscure exit signs. *Inspect buildings, rooms and offices and identify obstructed exits.*	UBC Section 305.2.4
		Ensure all windows are operable, safe, clear and provide light and unobstructed view. *During the site tour, visually inspect windows to confirm they are operable, safe, and clear.*	Annual Campuses/ Facilities Inspection Checklist
	Emergency Vehicle Access	Ensure school perimeter has one or more gates with an opening width of 20 ft and fire lane marked 20-ft long. Identify gates and determine if at least one opens a minimum of 20 feet.	LA Fire Code § 57.111.07
	Exit Signs	Post on all main exit doors readily visible signs that indicate "This Door to Remain Unlocked During Business Hours" or equip the door with emergency panic hardware. *During the tour, inspect a representative number of exits.*	LA Fire Code § 57.33
		Post approved "In Case of Emergency" instructions adjacent to the elevator call device on each floor. *Inspect signs next to elevator call device.*	
	Posted Occupancy Limit	Post maximum occupant load signs and usage signs above all assembly room doors as listed on the Certificate of Occupancy. *Inspect assembly areas for occupancy load signs.*	LA Fire Code § 57.33.04

FIRE/LIFE SAFETY

Type	Subtype	Corrective Action	Reference
	Unobstructed Walkways and Aisles	Clear aisles and walkways to provide unobstructed access. *During the tour, inspect walkways throughout the facility.*	8 CCR § 3215; 29 CFR § 1910.36
		Cover aisles and walkway surfaces prone to moisture with non-slip materials.	8 CCR § 3232; 3272; 29 CFR § 1910.22
	Ground/Floor Surfaces	Repair, cover or provide guardrails to ensure safety for holes in floors, sidewalks, or other walking surfaces.	8 CCR § 3232; 3272; 29 CFR § 1910.22
		Clear all walking surfaces of tripping hazards.	8 CCR § 3232; 3272; 29 CFR § 1910.22
		Cover ramp surfaces with non-slip materials.	8 CCR § 3232; 3272;29 CFR § 1910.22
	Interior/Exterior Lighting	Ensure all areas within the school have adequate and functioning lighting i.e., classrooms, stairways, hallways, gyms, locker rooms, shops, library, administrative office, restrooms, lunch shelters, and grounds. *Visually inspect at least 20 rooms to determine if lighting is adequate. Note areas inspected.*	8 CCR § 3215; 29 CFR § 1910.37; Annual Campus/ Facilities Inspection Form
Elevated Surfaces	**Access Lifts**	Develop maintenance procedures to check all special access lifts (wheelchair lifts, auditorium stage lifts and swimming pool immersion lifts) at least weekly. *Inspect lifts and review maintenance inspection records*	29 CFR§ 1910.68
	Portable Ladders	Repair or replace damaged ladders. *Inspect ladders and review results of ladder inspection. If ladders do not meet these requirements remove from use.*	8 CCR §§ 3278, 3279 29 CFR §§ 1910.25, 1910.26

FIRE/LIFE SAFETY

Type	Subtype	Corrective Action	Reference
		Ensure all portable ladders are routinely inspected for damage.	8 CCR §§ 3278, 3279 29 CFR §§ 1910.25, 1910.26
		Ensure ladders are equipped with non-slip safety feet.	8 CCR §§ 3278, 3279 29 CFR §§ 1910.25, 1910.26
		Ensure metal ladders are marked with signs reading "CAUTION: Do Not Use Around Electrical Equipment" or equivalent wording.	8 CCR §§ 3278, 3279 29 CFR §§ 1910.25, 1910.26
	Fall Prevention	Provide standard guard rails for surfaces elevated more than 30 inches above any adjacent floor or ground surface (with the exception of the auditorium side of a stage). *Inspect elevated walkways and floor openings for appropriate guarding.*	8 CCR §§ 3209, 3210, 3211, and 3212
		Install standard 4-inch toe boards for elevated surfaces to prevent objects from falling.	8 CCR §§ 3209, 3210, 3211, and 3212
		Provide a permanent means of access and egress to elevated storage and work surfaces.	8 CCR §§ 3209, 3210, 3211, and 3212
	Posted Load Capacity	Post signs indicating load capacity for elevated surfaces. *Inspect elevated surfaces.*	8 CCR §§ 3209, 3210, 3211, and 3212
Fire Prevention	**Portable Fire Extinguishers**	Fully charge and mount portable fire extinguishers and ensure signs are posted for accessibility. *Inspect a random number of fire extinguishers.*	8 CCR § 6151; 29 CFR § 1910.157

FIRE/LIFE SAFETY

Type	Subtype	Corrective Action	Reference
		Conduct and document monthly visual inspections; perform an annual maintenance inspection of the portable fire extinguishers. *Conduct inspections of a random number of fire extinguishers and associated records.*	8 CCR § 6151; 29 CFR § 1910.157
		Perform hydrostatic testing at the required interval of 5 or 12 years, depending on the fire extinguishing media.	8 CCR § 6151; 29 CFR § 1910.157
		Ensure all fire extinguishers are provided certification decal.	8 CCR § 6151
		Provide fire extinguisher training to new employees, and at least annually thereafter.	8 CCR § 6151; 29 CFR § 1910.157
	Combustibles	Remove all combustible materials (e.g., paper decorations, hanging mobiles, boxes) from exit doors, electrical panels, light fixtures and fire sprinklers.	LAMC 57.22.01
	Curtains	Remove non-flame retardant curtains or provide certification that curtains are flame-resistant.	LAMC 57.110.12
	Fire Door	Do not impair function of self-closing fire doors.	LAMC57.20.41
	Equipment Clearance	Maintain a minimum 3-foot clearance around heater/furnace.	UFC 1107
		Maintain a minimum 3-foot clearance around fire extinguishers, fire hoses and pull stations.	8CCR 6151 LAMC 57.140.09
	Fire Sprinklers	Maintain a minimum 18-inch clearance between overhead sprinklers and materials below. *Visually inspect a random number of sprinkler heads and note areas inspected.*	8 CCR § 6170; Annual Campus/ Facilities Inspection Form
	Flammable Storage	Utilize safety cans, flammable material cabinets or storage bunkers to store flammable materials. *Inspect flammable storage areas.*	8 CCR §§ 5531, 5532, 5533, 5534, 5535, 5538, 5541
	Fire Alarm	Develop procedures to ensure all fire alarms are in working order.	LA Fire Code § 57.01.22 ;29 CFR § 1910.165
		Conduct and document weekly inspections of fire alarms to ensure they are in good working order.	8CCR 6184 (Alarms) LAMC 57.138.041 & .09
	Emergency Evacuation Plans	Develop a fire emergency plan to identify the appropriate response to a fire alarm. *Review fire alarm procedures, manual pull box testing records, evacuation plans, and earthquake drill records for each building or facility.*	8 CCR § 3215; LA Fire Code § 57.33.19; 29 CFR § 1910.38

HUMAN AND MULTICULTURAL RELATIONS

Type	Subtype	Corrective Action	Reference
Crisis Management	**Crisis Intervention Documentation**	Ensure the school administrator has a copy of the most recent Crisis Intervention Handbook (2001). *Inspect site administrator's most recent crisis intervention notebook.*	Bulletin No. N-58 (Rev.)
	Crisis Intervention Training	Ensure that school crisis teams meet regularly for training and review of the crisis intervention plan. *Review training records.*	Bulletin No. N-58 (Rev.)
		Ensure training documentation is maintained with name of trainer, trainer affiliation, location of training and date of training. *Review training records.*	
		Ensure that the site administrator is aware of key terms defined in Bulletin No. Z-29 (Rev.) as follows: "crisis", "organization of crisis intervention teams", "crisis intervention strategies", and "threat assessment procedures." *Interview site administrator to confirm whether she/he is familiar with the crisis definitions and terminology.*	Bulletin No. N-58 (Rev.)
	Crisis Intervention Teams	Ensure that the school has established a crisis intervention team and that the site administrator has identified crisis team members. *Interview site administrator to determine whether team members have been identified.*	Bulletin No. N-58 (Rev.)
	Agency Interaction	Ensure that the site administrator has initiated at least one visit with the local police agency to prepare in the event of an emergency. *Interview site administrator and review meeting notes or correspondence if any.*	Bulletin No. N-58 (Rev.)

HUMAN AND MULTICULTURAL RELATIONS

Type	**Subtype**	**Corrective Action**	**Reference**
	Human Relations Leadership Team	Ensure that the school has established a Human Relations Leadership Team (HRLT) and assigned a staff member to coordinate its work. *Interview site administrator to confirm the existence of an HRLT and staff coordinator.*	Bulletin No. N-58 (Rev.)
		Ensure that the HRLT has developed a calendar to implement strategies and programs to maintain and improve the MHREP. *Review HRLT calendar for implementation strategies and milestones.*	Bulletin No. N-58 (Rev.)
	HRLT Annual Assessment	Ensure that the HRLT annually (end of year) submits an assessment and evaluation of the MHREP to the site administrator and school governance council. *Review annual HRLT submittal.*	Office of Intergroup Relations, "Educating for Diversity: A Framework for Multicultural and Human Relations Education, School Assessment Checklist," pages 76-79, 4-92.

INFECTIOUS DISEASE CONTROL

Type	Subtype	Corrective Action	Reference
Bloodborne Pathogen Control	**Written Program-BBP**	Implement and maintain Bloodborne Pathogen Exposure Control Plan designed to minimize or eliminate employee exposure to bloodborne pathogens pursuant to Title 8 CCR. *Interview school nurse and plant manager and review Exposure Control Plan to ensure it is up-to-date.*	8 CCR § 5193; 29 CFR § 1910.1030
	Training-BBP	Provide all employees with annual bloodborne pathogen awareness training. *Review training records*	8 CCR § 5193; 29 CFR § 1910.1030
		Ensure employees in the primary exposure category of the BBP Exposure Control Plan are trained on bloodborne pathogens upon initial assignment and annually thereafter. *Review records.*	8 CCR § 5193; 29 CFR § 1910.1030
	Record Keeping-BBP	Maintain records of employee BBP training. The records should include name of employee, social security number and a copy of the employee's hepatitis B vaccination status or Declination Form.	8 CCR § 5193; 29 CFR § 1910.1030
		Maintain employee BBP training records including: training date, outline of presented material, name and title of person conducting training, and a list of employees attending training including job titles and ID numbers.	8 CCR § 5193; 29 CFR § 1910.1030
	Equipment-BBP	Provide personal protective equipment to employees at risk of exposure to bloodborne pathogens. *Interview nurse or members who provide first aid and identify if personal protective equipment is provided.*	8 CCR § 5193; 29 CFR § 1910.1030
	Communication of Hazards to Employees	Affix warning labels to all containers used to store, transport, or ship potential BBP materials. Ensure biological waste is placed in red biohazard bags. *Review warning labels.*	8 CCR § 5193; 29 CFR § 1910.1030

INFECTIOUS DISEASE CONTROL

Type	Subtype	Corrective Action	Reference
	Sharps use	Ensure sharps are only used by trained personnel. *Interview school nurse or medial contact and determine policy for using sharps.*	8 CCR § 5193; 29 CFR § 1910.1030
	Sharps disposal	Ensure that contaminated sharps are disposed in approved containers. *Check for sharps container.*	8 CCR § 5193;29 CFR § 1910.1030
	Contamination	Ensure a post-exposure evaluation is conducted following all potential employee exposures to bloodborne pathogens. *Interview nurse and review post-exposure evaluation procedure.*	8 CCR § 5193; 29 CFR § 1910.1030
		Provide bloodborne pathogen cleanup kits for the disposal of body fluids and medical waste. Kits will include, at minimum, personal protective equipment (gloves, goggles, clothing protection) and biohazard bags. *Inspect cleanup kits.*	8 CCR § 5193; 29 CFR § 1910.1030
		Clean and sanitize areas that may have been exposed to bloodborne pathogens. *Interview nurse or other first aid personnel to determine cleaning procedures.*	8 CCR § 5193 29 CFR § 1910.1030

LEAD MANAGEMENT

Type	Subtype	Corrective Action	Reference
Procedures	**Paint**	Identify all locations of peeling paint or otherwise deteriorated paint surfaces, and ensure appropriate repairs. *Inspect school and note building and classroom number(s) where peeling paint is observed.*	
	Drinking Water	Ensure staff flushes drinking fountains each morning pursuant to Bulletin 55.	Bulletin 55
	Exposure-Lead	Develop and maintain complaint procedure for potential lead exposure. *Review complaint logs. Identify corrective action taken.*	8 CCR § 5198
Restrictions	**Occupancy Removal**	Prohibit occupancy by kindergarten through third grade students of rooms with severe peeling paint.	

MOBILE SAFETY EQUIPMENT

Type	Subtype	Corrective Action	Reference
Carts	**Wheel Chocks**	Ensure that wheel chocks are placed in front and behind one wheel of motorized carts when stationary. Chocks must be attached to the cart with an aircraft cable. *Review inspection records and inspect carts to ensure they are properly equipped and operating.*	
	Keyed Access	Ensure hand-held brake is capable of holding parked motorized cart in place. *Review inspection records and inspect carts to ensure they are properly equipped and operating.*	
		Ensure motorized carts are disabled when ignition key is removed. *Review inspection records and inspect carts to ensure they are properly equipped and operating.*	
Landscape Equipment	**Storage of Landscape Equipment**	Ensure landscape equipment is in locked area. *Inspect lawn equipment storage area.*	
Cleaning Equipment	**Use of Cleaning Equipment**	Ensure personal protective equipment is utilized when motorized cleaning equipment is used. *Interview staff who conducts landscaping activities.*	
		Train operators in the proper use of steam cleaners, pressure washers, wet abrasive washers and other cleaning equipment.	
		Ensure that only OEHS approved solvents and detergents are used with steam cleaners, pressure washers, wet abrasive washers, and other motorized equipment.	

MOBILE SAFETY EQUIPMENT

Type	Subtype	Corrective Action	Reference
		Ensure that gasoline powered equipment is only operated in areas where exhaust gases do not accumulate.	
		Develop and implement procedures to inspect equipment for frayed electrical cords, leaking fittings, damaged hoses, and safety devices. *Interview personnel, who use equipment, inspect personal protective equipment and review inspection records.*	
		Place guards on all fan blades that are less than 7-feet above the working level. *Visually inspect fans less than 7-feet high to ensure that they are equipped with blade guards.*	29 CFR § 1910.212
	Storage-Cleaners	Secure equipment designed to be located in a fixed position. *Visually inspect stationary equipment to ensure that it is properly secured.*	8 CCR § 4184; 29 CFR § 1910.212

PERSONAL PROTECTION

Type	Subtype	Corrective Action	Reference
Hearing Conservation	**Program-Hearing Conservation**	Ensure all personnel exposed to noise levels greater than 85 dba are informed of the Hearing Conservation Program. *Review Hearing Conservation Program. Interview staff to identify complaints and determine actions taken to address noise issues.*	8 CCR §§ 5097; 29 CFR § 1910.95
	Complaint Procedures	Develop and maintain complaint procedures for excessive noise levels and ensure the procedures are understood by school staff. *Interview staff to identify complaints and determine actions taken to address noise issues.*	8 CCR § 5096; 29 CFR § 1910.95
		Ensure all excessive noise level complaints are evaluated by proper agency.	8 CCR § 5096; 29 CFR § 1910.95
Respiratory Protection Program	**Written Program-Respiratory Protection Program**	Develop and maintain a written Respiratory Protection Program to accompany usage of respiratory protective equipment. *Review Respiratory Protection Program.*	8 CCR § 5144; 29 CFR §§ 1910.134
Personal Protection Equipment	**Face/Eye Protection**	Provide face/eye protection for persons at risk of injury from airborne objects, particulate matter or hazardous substances.	8CCR 3382
	Respiratory Protection Equipment	Provide respiratory protection equipment when engineering/operational controls are not feasible for limiting exposure to airborne contaminants.	8CCR 5144

Pest Management

Type	Subtype	Corrective Action	Reference
Planning	**Program-IPM**	Obtain a copy of the District's Integrated Pest Management (IPM) program. *Review IPM Program.*	AB2260
	Training-IPM	Ensure staff members are trained on the implementation of the IPM program. *Interview staff and review training records.*	California Education Code (CEC) § 17610
Operations	**Notification-IPM**	Provide a written notification to staff and parents listing pesticide products expected to be used during the school year. *Interview staff and review notification records and review list of staff and parents who wish to receive notification.*	CEC § 17612
	Rodent Control	Contact District Pest Management and place a trouble call to provide rodent proofing.	IPM
	Insect Control	Contact District Pest Management and place a trouble call to mitigate insect infestation.	IPM
	Birds	Contact District Pest Management and place a trouble call to mitigate bird nesting.	IPM
	Fans	Provide air curtains, fly fans and/or self-closing screen doors for all cafeteria doors opening to the outside.	CURFFL 114030
	Warning Signs-IPM	Develop procedures for posting warning signs 24 hours prior to pesticide application and remain posted for 72 hours after application. *Review posting procedures with Plant Manager.*	CEC § 17612
	Recordkeeping-IPM	Maintain records for the past 4 years of pesticides used at the site. *Review records.*	Integrated Pest Management Program CEC 17611
	Pesticide Application	Ensure only District Integrated Pest Management Technicians apply pesticides. *Interview Plant Manager and review chemical storage area for pesticides.*	CEC § 17612
	Approved Pesticides	Post list of approved pesticide products in the main office. *Observe posting and verify list is the most up-to-date document.*	CEC § 17612

Sports and Playground

Type	**Subtype**	**Corrective Action**	**Reference**
Sports	**Equipment-Sports**	Train students on proper use of required safety equipment. *Review documentation related to safety equipment training.*	Bulletin M-66 42, 44
Playground	**Inspection-Playground**	Develop an action plan to remove, replace or retrofit playground equipment. Ensure school playgrounds have been inspected by a certified inspector. *Review playground inspection report and action plan. Evaluate if action plans are on schedule.*	
		Contact District Maintenance and Operations to have school playgrounds inspected by a certified inspector.	
Athletics	**Medical Clearance**	Ensure appropriate medical clearance for students prior to participating in interscholastic athletics. *Review procedures of medical clearance.*	Bulletin Z-9
		Develop procedures to evaluate and address heat stress in athletes. *Review school procedure associated with heat stress.*	Bulletin Z-52

WASTE MANAGEMENT

Type	Subtype	Corrective Action	Reference
Hazardous Waste	**Characterization**	Ensure that all waste is properly characterized as "hazardous" or "nonhazardous". *Review waste characterization procedures.*	22 CCR § 66262.11; 40 CFR § 262.11
		Label hazardous waste with the words: "HAZARDOUS WASTE", the physical state of the waste, hazard class, accumulation date and the address of the generator. *Inspect containers collecting hazardous waste.*	22 CCR § 66262.34; 40 CFR § 262.34
	Waste Storage	Supply hazardous waste storage area with spill kits, fire extinguishers, communication systems, decontamination equipment, and maintain unobstructed aisle space. *Inspect waste storage area and inspection records.*	22 CCR § 66262.34; 40 CFR § 262.34
		Ensure that tanks accumulating hazardous waste are inspected daily, and that containers in the hazardous waste storage are inspected weekly. *Inspect waste storage area and inspection records.*	22 CCR § 66262.34; 40 CFR § 262.34
		Ensure all hazardous waste containers have secondary containment, are in good condition, and free of leaks. *Inspect waste storage area and inspection records.*	
		Keep hazardous waste containers closed except when adding or removing waste. *Inspect waste storage area and inspection records.*	22 CCR § 66262.34; 40 CFR § 262.34
	Waste Disposal	Dispose hazardous waste generated at schools at least every 180 days. *Interview schools staff and review disposal records.*	22 CCR § 66262.34; 40 CFR § 262.34

WASTE MANAGEMENT

Type	Subtype	Corrective Action	Reference
Wastewater	**Sewers**	Ensure that debris is periodically cleared from sewer and storm drains. *Visually inspect the condition of sewer and storm drains.*	Annual Campuses/ Facilities Inspection Checklist
	Storm Water	Ensure only storm water is discharged to storm drains.	
Food Services Waste	**Kitchen BMPs**	Implement best management practices (BMPs) guidance for industrial waste disposal as defined by the Food Services Branch. *Implement Best Management Practices (BMPs) for industrial waste disposal as defined by the Food Services Branch.*	LAMC Article 4 Section 64.30
	Food Disposal	Ensure food waste is disposed into trashcans.	LAMC Article 4 Section 64.30
		Ensure fats, oils, and grease are frozen prior to disposal.	LAMC Article 4 Section 64.30
	Kitchen BMP Training	Verify that cafeteria staff is trained and aware of the BMPs for industrial waste disposal.	LAMC Article 4 Section 64.30
	Recordkeeping	Maintain industrial waste disposal BMP training records/sign-in sheets. *Review training records to ensure that staff has received training and records are current and properly maintained.*	LAMC Article 4 Section 64.30
	Posting	Conspicuously post industrial waste disposal BMPs in the cafeteria kitchen and/or food prep area. *Determine if appropriately posted.*	LAMC Article 4 Section 64.30
Solid Waste	**Recycling**	Develop and maintain solid waste recycling program for all recyclable materials. *Interview staff to determine solid waste recycling records.*	
	Trash Receptacles	Keep dumpsters closed when not in use. *Inspect dumpsters.*	

WASTE MANAGEMENT

Type	Subtype	Corrective Action	Reference
		Ensure trash cans do not overflow with waste. *Inspect areas around dumpsters.*	
		Clean areas surrounding dumpsters and trash cans. *Inspect areas around dumpsters.*	

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APPENDIX VI

DRAFT SUGGESTIONS FOR PREVENTIVE AND REMEDIAL ACTIONS BY SCHOOLS AND LOCAL GOVERNMENTS

JULY 17, 2003

This list provides additional, more detailed suggestions for preventing and remedying IEQ problems in schools. It is based on information from various sources, including school district staff who participated in public workshops during this project, consultants, state agency staff, and others. This list is a draft working document. Further comments are welcomed and can be sent to ARB at tphillip@arb.ca.gov or capcs@arb.ca.gov.

GENERAL

1. For new school design or retrofits, also see CHPS Best Practices Manual sections on siting, materials selection, and ventilation (www.chps.net)
2. Apply for financial assistance through local utility programs and the California Energy Commission (see AB 549 program for energy efficiency in existing buildings, http://www.energy.ca.gov/ab549/index.html).
3. Set up communication and tracking system for reporting IEQ problems immediately and ensuring their resolution. The Los Angeles USD database program for tracking environmental health complaints is available at no cost.
4. Educate teachers, maintenance staff, custodial staff, and administrative staff on the causes and prevention of poor IEQ. EPA's IAQ Tools for Schools, a free package, can help accomplish this.
5. Identify asthmatics and other individuals who are more sensitive to indoor air pollution, and work with the local American Lung Association to reduce pollutant and allergen exposures at school and at home (http://www.lungusa.org/events/astopen.html.)

VENTILATION AND AIR CLEANING

1. Meet Cal OSHA regulations, Sec. 5142, which require provision of constant ventilation at a rate specified in the building design, as well as annual inspection, maintenance, and record keeping.
2. Ensure constant supply of outdoor air and pre-occupancy flushing, per CEC Title 24 regulations and Cal OSHA regulations.
3. Conduct annual cleaning and inspection of HVAC: dampers, drains, flow imbalance, coils, filters, ductwork, etc. (see EPA Tools for Schools).
4. Assure thermal comfort (T & RH, drafts) through annual inspections and testing.
5. Improve user-friendliness of control systems; educate teachers on use of timers and post simple instructions.
6. Consider separate, low-noise exhaust ventilation systems for providing constant ventilation when the central system is inefficient or too noisy. Include air intakes in locations away from outdoor pollutant sources.

7. During high humidity conditions (warm and wet or muggy, and high occupant load), reduce residual indoor moisture by running HVAC or dehumidifier after classes for an hour or two, as needed.
8. Replace or retrofit the HVAC system if it is too noisy.

NOISE
1. Specify low-noise, low-vibration HVAC systems (new and retrofit), e.g., systems with baffles, vibration dampers, insulation, etc. Systems should be rated at 45 dBA or less.
2. Specify windows, doors, and other building components with low-noise transmission characteristics, wherever possible.
3. Test and demonstrate low-noise, low-vibration HVAC systems; track long-term performance.

MOISTURE
1. Repair leaks immediately, to avoid major damage later. Moisture meters can be used to find damp areas of building. Infrared cameras may be available on loan from utilities to identify less accessible leak locations.
2. Inspect EPDM and metal roofs annually for tears, leaks, interior condensation, and degradation.
3. Inspect buildings, especially roofs, gutters, and crawlspaces, before each wet season, and after every heavy rain.
4. Specify at least 6 inch flashing and mastic sealant around roof HVAC units, a common source of water leakage. Inspect routinely.
5. Test condensate drain pan routinely: pour 1 cup of water in pan, check for flow at end of drain line and for any standing water left in pan.
6. Specify and verify proper siting, drainage, and pad with concrete or asphalt surface or a plastic vapor barrier. Add drainage features to site if necessary.
7. Specify and verify effective crawlspace ventilation area and location:
   -- Sufficient ventilation area per building code.
   -- Non-louvered vents
   -- Proper location – avoid corners, stagnant areas, and close spacing between vents.
8. Do not drain the roof and HVAC to the surface near the building; route to sub-surface drains, or if necessary, at least several feet away from building in area with permeable soil and a slope away from building.
9. Inspect roof gutters for proper drainage.
10. Specify portable skirt height at least 6 inches above ground, preferably higher, to avoid wicking and improve ventilation; avoid wood or other absorbent material for skirting.
11. Do not allow sprinklers to hit buildings or drain next to or under building.
12. Specify adequate flashing for roofs, walls, windows, and doors, and specify adequate roof overhangs.
13. Avoid carpet in areas with the potential for high moisture such as areas with sinks, entrances, coatrooms, etc.

14. Specify and verify low moisture content in building materials such as wood, concrete, and wallboard. Protect these materials from moisture and dust before and during installation.
15. Avoid cold spots in building shell (insulation gaps, thermal bridges) through better QC at factory, and by commissioning (infrared camera).
16. Avoid flat roofs. Add slope to roofs during retrofits, if possible.
17. Use moisture resistant materials in subfloor (e.g., if wood product, should be exterior grade.)

VOCs, INCLUDING FORMALDEHYDE AND OTHER ALDEHYDES

1. Specify low- or non-emitting building materials and furnishings, including items after original installation. Have manufacturers confirm emission rates.
2. Follow ARB-DHS recommendations for reducing indoor formaldehyde levels (see Appendix IV).
3. Control emissions from remodeling and construction through isolation and negative pressure (exhaust ventilation).
4. Select low-emitting carpets and glues; air out the carpet before installation; flush room out during and after installation and before occupancy.
5. Caulks and sealants: apply during school vacations, flush out after installation.
6. Ensure that teachers do not use or store products or materials that can be significant sources of indoor pollutants, such as room deodorizers, cleaning products, pressed wood, candles, pesticides, hair spray, aromatherapy oils, etc.
7. Program the HVAC controls for daily pre-occupancy flush, per CEC ventilation standard.

PARTICULATE MATTER AND FLOOR DUST

1. Place ground cover on open soil.
2. Include walk-off mats inside and outside of each classroom.
3. Upgrade HVAC filters & frequent replacement; seal leaks/bypasses around filters.
4. Perform daily vacuuming, sweeping, and dusting.
5. Dust with damp mops and cloths.
6. Vacuum with efficient vacuum cleaners that capture more of the dust (see Consumer Reports)
7. Consider hard flooring with washable area and runner rugs

LIGHTING

1. Encourage day-lighting.
2. Replace old ballasts.
3. Add solar shades and/or awnings to reduce glare and heat load.
4. Assure illumination levels and quality are sufficient. Refer to IESNA standards for classrooms.

BIOLOGICAL POLLUTANTS

1. Do not keep animal pets in classrooms for extended periods, especially reptiles and turtles.

2. Plant trees and bushes that produce:
   -- little or no allergens (see American Lung Association and local allergists; see example at the Tulare School District, http://www.visaliatimesdelta.com/news/stories/20030630/localnews/568385.html).
   -- reduced amounts of ozone precursors (see ARB Research Division, Biogenic Research, http://www.arb.ca.gov/research/ecosys/ecosys.htm).