# INDOOR AIR QUALITY ASSESSMENT

**East Gloucester Elementary School**
**8 Davis Street Extension**
**Gloucester, Massachusetts**

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
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## Background/Introduction

At the request of the Gloucester Public Schools (GPS), the Massachusetts Department of Public Health's (MDPH) Bureau of Environmental Health (BEH) conducted an indoor air quality (IAQ) and health evaluation at the East Gloucester Elementary School (EGES), 8 Davis Street Extension, Gloucester, Massachusetts. On June 7, 2011, a visit to conduct an IAQ assessment was made to the EGES by Michael Feeney, Director and Sharon Lee, an Environmental Analyst/Inspector in BEH's IAQ Program. BEH/IAQ staff were accompanied by Christine Gorwood, an Environmental Analyst/Risk Communication Specialist in BEH's Community Assessment Program (CAP). The request was prompted by concerns regarding skin rashes experienced by staff members.

The EGES is a single-story building constructed in 1948. Additions to the building include a wing in 1974 and modular buildings in 2001 and 2007. Renovations to the building also added four additional classrooms in 2008. Most areas are constructed on slab; however, a crawlspace runs below a portion of it. The school consists of classrooms, a gymnasium, auditorium, library and offices. Windows throughout the school are openable.

The BEH/IAQ Program previously assessed the building in October 2010. A report detailing conditions observed at that time, as well as recommendations to improve IAQ was released (MDPH, 2011). Please refer to this initial report for general recommendations regarding IAQ. As mentioned, this assessment was prompted by concerns of rashes experienced by staff and focuses on the aforementioned health concerns as well as indoor environmental conditions that could contribute to irritant symptoms.

## Methods

Air tests for carbon dioxide, carbon monoxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 7565. Air tests for airborne particle matter with a diameter less than 2.5 micrometers were taken with the TSI, DUSTTRAK™ Aerosol Monitor Model 8520. BEH staff also performed a visual inspection of building materials for water damage and/or microbial growth.

## Results

The school houses approximately 260 students in kindergarten through grade 5 and approximately 45 staff members. Tests were taken during normal operations, and results appear in Table 1.

## Discussion

### Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 2 of 24 areas, indicating adequate air exchange at the time of the assessment. In some areas, ventilation equipment was found deactivated, therefore no means of mechanical ventilation was being provided to these areas at the time of testing. However, open windows in these room provided natural ventilation/air exchange. Open windows can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher occupancy, windows closed and ventilation equipment deactivated.

Fresh air to classrooms in the original building (1948) as well as the 1974 and 2008 additions is supplied by unit ventilator (univent) systems. A univent draws air from the outdoors through a fresh air intake located on the exterior wall of the building. Return air from the classroom is drawn through an air intake located at the base of the unit (Figure 1). Fresh and return air are mixed, filtered, heated and provided to classrooms through an air diffuser located in the top of the unit. As mentioned, univents were found deactivated in the some rooms at the time of assessment (Table 1). In addition, univents remain obstructed by furniture and other items on top of air diffusers and/or in front of return vents along the bottom of the units. In order for univents to provide fresh air as designed, they must remain "on" and operating while rooms are occupied. Furthermore, units must remain free of obstructions.

Staff reported that some individuals experiencing irritant symptoms when univents are reactivated. BEH staff examined and noted the conditions of 1948 and 1974 univents. BEH staff could not open the main (filter) compartment to any of the 1948 univents due to stripped screws (Picture 1), which indicates that maintenance staff would have great difficulty in changing filters in these univents. The side cabinets of the 1948 univents had significant amounts of accumulated dust (Picture 2), possibly indicating lack of filters or spaces in the equipment that allows air to bypass filter media.

The design and manner in which univents in the 1974 addition were installed allows a significant amount of air to bypass the filter (Picture 3). It appears that the sides of the univent cabinets were cut open to attach the heating pipes to the coils (Pictures 4 and 5). This allows accumulated dust, dirt and other debris to be drawn into the univents post filter and aerosolized. In addition, BEH staff observed utility holes in the divider that separates the side cabinets of the univent from the fan cabinet (Picture 6). These holes can allow air, dust, debris and odors from wall cavities to be drawn into the univent's main compartment post-filtration, resulting in the distribution of unfiltered air and debris that may accumulate in the side cabinet. As mentioned in the previous report, spaces were also observed around pipes (MDPH, 2011). These spaces can allow materials and odors to be drawn from the pipe chaseways and/or crawlspace below. Measures should be taken to render univent cabinet walls airtight and seal breaches around pipes to prevent distribution of unfiltered air.

Further, the age of the equipment makes service and repairs of these units difficult. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the service life[1] for a unit heater, hot water or steam is 20 years, assuming routine maintenance of the equipment (ASHRAE, 1991). Despite attempts to maintain the univents, the operational lifespan of the equipment in the 1948 and 1974 sections has been exceeded. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages and as replacement parts become increasingly difficult to obtain.

Exhaust ventilation for school is provided by switch activated cubby exhausts ducted to rooftop motors. At the time of this assessment, exhaust ventilation in some classrooms was deactivated. As discussed in the previous report, measures should be taken to ensure exhaust vents are activated during school hours (MDPH, 2011). Any remaining obstructions to exhaust ventilation should also be removed. In order to function properly, exhaust vents must be activated and allowed to operate while rooms are occupied. Without adequate supply and exhaust ventilation, excess heat and environmental pollutants can accumulate, leading to indoor air/comfort complaints.

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[1] The service life is the median time during which a particular system or component of …[an HVAC]… system remains in its original service application and then is replaced. Replacement may occur for any reason, including, but not limited to, failure, general obsolescence, reduced reliability, excessive maintenance cost, and changed system requirements due to such influences as building characteristics or energy prices (ASHRAE, 1991).

Mechanical ventilation for modular classrooms and common areas (e.g., gymnasium, auditorium) is provided by rooftop, ceiling or side-mounted air-handling units (AHUs). Fresh air is distributed via ceiling-mounted air diffusers and ducted back to AHUs via ceiling or wall-mounted return vents. As discussed in the previous report, AHUs for modular classrooms are controlled by thermostats, which have fan settings of "on" and "auto" (MDPH, 2011). Thermostats were set to the "on" setting in all but one modular room surveyed during the assessment, which is recommended by the MDPH.

The AHUs for the gymnasium and auditorium were also found deactivated at the time of the assessment; therefore, there was no means of mechanical air exchange. As with univents, AHUs should be activated and allowed to operate continuously during occupied periods.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that heating, ventilation and air conditioning (HVAC) systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times that the room is occupied. Providing adequate fresh air ventilation with open windows and maintaining the temperature in the comfort range during the cold weather season is impractical. Mechanical ventilation is usually required to provide adequate fresh air ventilation.

Carbon dioxide is not a problem in and of itself. It is used as an indicator of the adequacy of the fresh air ventilation. As carbon dioxide levels rise, it indicates that the ventilating system is malfunctioning or the design occupancy of the room is being exceeded. When this happens, a buildup of common indoor air pollutants can occur, leading to discomfort or health complaints. The Occupational Safety and Health Administration (OSHA) standard for carbon dioxide is 5,000 parts per million parts of air (ppm). Workers may be exposed to this level for 40 hours/week, based on a time-weighted average (OSHA, 1997).

The MDPH uses a guideline of 800 ppm for publicly occupied buildings. A guideline of 600 ppm or less is preferred in schools due to the fact that the majority of occupants are young and considered to be a more sensitive population in the evaluation of environmental health status. Inadequate ventilation and/or elevated temperatures are major causes of complaints such as respiratory, eye, nose and throat irritation, lethargy and headaches. For more information concerning carbon dioxide, consult Appendix A.

Temperatures ranged from 72° F to 76° F, which were within the MDPH recommended range in all areas surveyed (Table 1). The MDPH recommends that indoor air temperatures be maintained in a range of 70° F to 78° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply. Occupants experiencing temperature issues should work with school administration, custodial staff and the Gloucester Department of Public Works to resolve such issues.

Relative humidity measurements in the building ranged from 51 to 67 percent at the time of the assessment, all but one of which were within the MDPH recommended comfort range in (Table 1). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. Relative humidity levels in the building would be expected to drop during the winter months due to heating. The sensation of dryness and irritation is common in a low relative humidity environment. Low relative humidity is a very common problem during the heating season in the northeast part of the United States.

### Microbial/Moisture Concerns

A slight musty odor was detected in the auditorium. As mentioned, the ventilation for this area was not operating at the time of assessment. The previous MDPH report noted evidence of active water leaks observed in the auditorium (MDPH, 2011). Water-damaged porous materials (i.e., paper products) should be discarded. Consideration should be given to operating exhaust ventilation *only* in this area to remove odors and moisture/humidity. By operating the exhaust ventilation, negative pressure is created to prevent movement of odors into occupant areas (i.e., principal's office).

Water-damaged ceiling tiles were also observed in a number of areas, including modular classrooms (Table 1). This water damage is likely related to roof leaks. These roofs appear to not have been replaced for some time. At the time of assessment, GPS officials indicated that a proposal for roof replacement was in the process of being put out to bid. Additional damage related to the roof, including damaged flashing (e.g., where the main and modular buildings meet), should be examined/remediated during the roof replacement project.

Some open seams were observed between backsplashes and countertops (Table 1). If not watertight, water can penetrate through the seam, causing water damage. Improper drainage or sink overflow can lead to water penetration into the countertop, cabinet interior and areas behind cabinets. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell and show signs of water damage. Many classrooms were also found to have porous materials (e.g., cardboard, paper, cloth) stored beneath sinks, which is a humid environment. Repeated moistening of porous materials can result in mold growth.

Water-damaged wood paneling was observed near the window in the Principal's office. It appears that damage has resulted from a combination of materials placed on the paneling as well as condensation/moisture from the windows. Given the age and condition of paneling, consideration should be given to replacing it.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If not dried within this time frame, mold growth may occur. Once mold has colonized porous materials, they are difficult to clean and should be removed/discarded.

Plants were observed in several areas (Table 1). Plants should be properly maintained and equipped with drip pans. Plants should also be located away from ventilation sources to prevent aerosolization of dirt, pollen or mold. Finally, they should not be placed on porous materials, since water damage to porous materials may lead to microbial growth.

Plants were growing in close proximity to the building's exterior, in some instances near univent fresh air intakes. Univents can draw in pollen and mold from these plants and distribute them throughout the classroom. Furthermore, the growth of roots against exterior walls can bring moisture in contact with the foundation. Plant roots can eventually penetrate the wall, leading to cracks and/or fissures in the sublevel foundation. Over time, these conditions can undermine the integrity of the building envelope and provide a means of water entry into the building via capillary action through exterior walls, foundation concrete and masonry (Lstiburek & Brennan, 2001). The freezing and thawing action of water during the winter months can also create cracks and fissures in the foundation resulting in additional penetration points for both water and pests.

**Other IAQ Evaluations**

Indoor air quality can be negatively influenced by the presence of respiratory irritants, such as products of combustion. The process of combustion produces a number of pollutants. Common combustion emissions include carbon monoxide, carbon dioxide, water vapor and smoke (fine airborne particle material). Of these materials, exposure to carbon monoxide and particulate matter with a diameter of 2.5 micrometers (μm) or less (PM2.5) can produce immediate, acute health effects upon exposure. To determine whether combustion products were present in the indoor environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

*Carbon Monoxide*

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within a rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE) has adopted the National Ambient Air Quality Standards (NAAQS) as one set of criteria for assessing indoor air quality and monitoring of fresh air introduced by HVAC systems (ASHRAE, 1989). The NAAQS are standards established by the US EPA to protect the public health from six criteria pollutants, including carbon monoxide and particulate matter (US EPA, 2006). As recommended by ASHRAE, pollutant levels of fresh air introduced to a building should not exceed the NAAQS levels (ASHRAE, 1989). The NAAQS were adopted by reference in the Building Officials & Code Administrators (BOCA) National Mechanical Code of 1993 (BOCA, 1993), which is now an HVAC standard included in the Massachusetts State Building Code (SBBRS, 1997). According to the NAAQS, carbon monoxide levels in outdoor air should not exceed 9 ppm in an eight-hour average (US EPA, 2006).

*Carbon monoxide should not be present in a typical, indoor environment*. If it *is* present, indoor carbon monoxide levels should be less than or equal to outdoor levels. Outdoor carbon monoxide concentrations were non-detect (ND) at the time of the assessment (Table 1). No measureable levels of carbon monoxide were detected inside the building during the assessment (Table 1).

*Particulate Matter*

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment.

Outdoor PM2.5 concentrations the day of the assessment were measured at 24 $\mu g/m^3$. PM2.5 levels measured inside the building ranged from 17 to 33 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM 2.5 levels were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of activities that occur indoors and/or mechanical devices can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

*Volatile Organic Compounds*

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. For example, chemicals evaporating from a paint can stored at room temperature would most likely contain VOCs. In an effort to identify materials that can potentially increase indoor VOC concentrations, BEH staff examined rooms for products containing these respiratory irritants.

Of note is the floor cleaning practices at the EGES. Custodial staff reportedly discontinued the use of petroleum distillate mop treatment for floor cleaning sometime during the 2010-2011 school year. In its place, staff use furniture polish on dust mops in an effort to clean dust from floors. Some furniture polishes may also contain petroleum distillates and other related compounds, which can be respiratory and skin irritants. Residual dust may become saturated with furniture polish/wax, which would result in exposure for building occupants.

Cleaning products were found in several rooms throughout the building (Table 1). Cleaning products contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. These products should be properly labeled and stored in an area inaccessible to children. In addition, a Material Safety Data Sheets (MSDS) should be available at a central location for each product in the event of an emergency. Consideration should be given to providing teaching staff with school issued cleaning products and supplies to prevent any potential for adverse chemical interactions between residues left from cleaners used by the facilities staff and those left by cleaners brought in by others.

The majority of classrooms contained dry erase boards and related materials. Materials such as dry erase markers and dry erase board cleaners may contain VOCs, such as methyl isobutyl ketone, n-butyl acetate and butyl-cellusolve (Sanford, 1999), which can be irritating to the eyes, nose and throat.

In an effort to reduce noise from sliding desks/chairs, tennis balls had been sliced open and placed on the base of the legs. The covering for some tennis balls had been removed, exposing the rubber. Tennis balls are made of a number of materials that are a source of respiratory irritants. Constant wearing of tennis balls can produce fibers and cause VOCs to off-gas. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients)

(SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997).

### Other Conditions

Other conditions that can affect indoor air quality were observed during the assessment. In several classrooms, items were observed on windowsills, tabletops, counters, bookcases and desks. The large number of items stored in classrooms provides a source for dusts to accumulate. These items (e.g., papers, folders, boxes) make it difficult for custodial staff to clean. Items should be relocated and/or be cleaned periodically to avoid excessive dust build up. In addition, these materials can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

Finally, a number of air diffusers, exhaust vents and personal fans in classrooms were observed to have accumulated dust/debris. Re-activated supply vents/fans can aerosolize dust accumulated on fan blades/housing. If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize dust particles.

### Health Concerns

As mentioned, BEH received reports of staff health concerns in the EGES. BEH conducted interviews with EGES staff at the time of the IAQ inspection. The type and frequency of the symptoms experienced by some EGES employees were obtained through administration of a questionnaire by BEH/CAP staff. The questionnaire elicited information on those symptoms that have been reported in the scientific/medical literature as commonly experienced in buildings with indoor air quality problems. These types of questionnaires are used to systematically collect building-related health and environmental complaints. The information collected, in conjunction with the assessment of the indoor environment, can be used to evaluate possible associations between indoor air quality and health and to recommend appropriate follow-up if warranted.

The questionnaire was developed by BEH to assess the types of symptoms reported among a group of concerned employees of the EGES. The questionnaire was closely modeled on surveys used previously by BEH as well as those used by the National Institute of Occupational Safety and Health (NIOSH) and the U.S. Environmental Protection Agency (USEPA). It included questions on specific symptoms (those commonly experienced by occupants of buildings with indoor air problems), on perceived air quality, and on personal factors.

The EGES have a combined employee population of approximately 45. On June 7 and 15, 2011 BEH staff conducted in-person interviews with interested EGES employees. Fourteen individuals originally asked to participate in the BEH interview however, only partial survey information was provided by one individual and for that reason analytic results are presented for the 13 individuals who fully participated. The interviews took approximately 30 minutes each over the course of the two days. All responses were reviewed to identify the types of diseases and symptoms reported, their frequency of occurrence, and whether any unusual patterns emerged suggestive of a possible association with indoor environmental conditions in the EGES (Appendix B).

### *Employee Interview Results*

Information from the thirteen individuals, for whom complete survey information was obtained, is summarized below. Under both state and federal regulations, personally-identifying information shared by employees is confidential; thus, the following discussion provides summary information only.

*Health Effects*

Of the 13 employees interviewed, 12 were female and one was a male. The average age of the employees was approximately 40 years old and the average length of employment with EGES was 7 years.

Smoking status was obtained in the interviews due to the role of smoking in respiratory health. Among the 13 employees, two people reported to be current smokers, one person reported that they were a former smoker, and ten people reported that they have never smoked.

The most commonly reported symptoms (with at least 7 of the 13 employees reporting that they experienced the symptom at least once a month in the last six months) were: skin irritation, dryness, redness, or rashes; itchy, runny or watery eyes; stuffy or runny nose and sinus congestion; and pain or stiffness in the neck, shoulders or back. Most of these employees reported that their symptoms were worse while inside the building and their symptoms did improve once they left the building.

Other symptoms that were reported by at least four of the 13 employees to have been experienced at least once a month in the last six months included the following: sore, dry or hoarse throat; tingling in the hands or feet; dizziness, lightheadedness or loss of balance; difficulty remembering things or concentrating; and headaches. Respondents were asked if there was a particular time of day or week when their symptoms usually became worse or more frequent; most employees reported no pattern.

Employees who participated in the MDPH interview were also asked if they had been diagnosed by a doctor with any of the following conditions: asthma, eczema, hay fever/allergies, migraine headaches, chronic bronchitis, pneumonia or sinusitis. Of the 13 participating employees, seven reported being diagnosed with sinusitis, four with hay fever, four with migraine headaches, three with asthma, and two with eczema. All of the individuals with a reported diagnosis of either asthma or hayfever/allergies reported to MDPH that they had been diagnosed with their condition prior to working at EGES. The majority of the individuals who reported a diagnosis of either sinusitis or eczema also reported that they were diagnosed prior to starting at EGES. Two individuals reported having pneumonia at some point in their lives prior to working in the school. No employees reported being diagnosed with chronic bronchitis.

*Building Concerns*

The 13 EGES employees were also asked about their perceptions of environmental conditions in their work environment. Their responses were as follows:

- 10 reported unusual or unpleasant dust
- 8 reported that the air was too stuffy
- 8 reported that the air was too dry
- 8 reported roof leaks and/or stained ceiling tiles
- 8 reported damage to floors tiles, including mold and regular wear and tear
- 6 reported other unusual or unpleasant odors, particularly musty or moldy smells
- 3 reported that the air was too humid
- 3 reported damage to the windows, including the lack of screens in the windows

Of the 13 employees surveyed, three reported that the indoor temperature was consistently too hot, while five individual reported that it was consistently too cold. Three employees reported that the temperature tends to be inconsistent and is often too hot or too cold.

*Symptomology and Building Location*

The locations where individuals reported working in the building and their health concerns were evaluated with respect to the results from the environmental testing conducted by BEH/IAQ staff. Thirteen of the fourteen employees reported that there were specific locations within the EGES where they spend the majority of their time. Three individuals reported working in a different room in the building for a substantial portion of the day. Carbon dioxide measurements were available for all of the rooms reported as a work space by an EGES employee. Carbon dioxide levels ranged from about 470 ppm to 770 ppm; none of the rooms used by the 13 individuals had carbon dioxide levels above the recommended 800 ppm. Additionally, temperature and relative humidity levels were consistent with IAQ comfort guidelines in all of these rooms.

*Medical Record Review Findings*

Medical record reviews were conducted by MDPH's physician for three individuals who provided written consent. Of the 13 employees interviewed, three returned signed medical record release consent forms. Dr. Burstein's review included all submitted medical records and interview questionnaires; special attention was given to diagnoses and complaints of the respiratory system or skin irritation reflecting possible allergic/irritant symptoms.

In summary, all three patients have been noted in the past to have symptoms potentially attributable to allergy, especially environmental allergy. None seem to have any pre-existing dermatologic or rheumatologic issues; none appear to be especially susceptible to infection. Dr. Burstein concluded that the most likely common agent, if it is environmental, would be an allergen rather than a toxic exposure or an infectious exposure.

## Conclusions/Recommendations

### Health Conclusions

The respiratory/irritant and other symptoms reported among participants in this health investigation are generally those most commonly experienced in buildings with indoor air quality problems. These included sore, hoarse or dry throat; dry, itchy eyes; sneezing, stuffy or runny nose; as well as headaches. Such symptoms are commonly associated with ventilation problems in buildings, although other factors (e.g., odors, microbiological contamination) may also contribute (Stolwijk et al. 1991; Burr et al. 1996; Nordstrom et al. 1995).

During BEH's inspection on June 7, 2011, carbon dioxide was found below 800 ppm in 22 of the 24 test sites. As mentioned, carbon dioxide is not a problem in and of itself, however, it is used as an indicator of the adequacy of the fresh air supply.

Four of the 13 individuals with completed surveys reported having allergies. The onset of allergic reactions to mold/moisture can be either immediate or delayed. Allergic responses include hay fever-type symptoms such as runny nose and red eyes. All of the individuals were diagnosed with allergies prior to working at the EGES; however, exposure to mold/moisture and dust can exacerbate pre-existing allergy symptoms.

Results from the environmental sampling indicate a number of opportunities for exposure to allergens, i.e., mold growth from water damage and the presence of plants and dust. Given that exposure to excessive dust and mold can exacerbate pre-existing symptoms (e.g., asthma, allergies) and promote skin irritation, it is possible that some individuals may be reacting to mold and excessive dust differently that the general population.

### IAQ Conclusions

The health concerns discussed reported, combined with the building conditions suggest that lack of filtration in the univent may be contributing to rashes experienced by staff. Without proper filtration, normally occurring dust/particulates are redistributed by classroom univents. Furthermore, these dusts are likely coated with furniture/polish waxes used to clean the classrooms. These coated particulates would likely produce more irritant symptoms to the skin as well as and the eyes, nose and respiratory system.

Regarding the building itself, the conditions observed at the EGES suggest that the roofs at the school may be nearing the end of their useful life. A number of active leaks were identified throughout the building, in areas of varying age. Long-term measures should be taken to replace the roofs to prevent future leaks. In view of the findings at the time of the visit, the following recommendations are made:

1. Discontinue the use of furniture polish as a mop treatment. Consider acquiring vacuum cleaners equipped with high efficiency particle arrestance (HEPA) filters for dust control.
2. Render air-tight all univent cabinets to prevent air by-pass of filters.
3. Seal spaces around pipes in univent cabinets with a fire-rated sealant.
4. Clean accumulated debris from the univent interiors.
5. Repair/replace stripped fasteners for Nesbitt (1940's era) univents. Replace filters if univents are equipped for them.
6. Ensure all exhaust ventilation is operating during school hours. Repair/replace exhaust fans/belts if they are not working properly.
7. Consult with an HVAC engineering firm regarding the feasibility of repair vs. replacement of ventilation system components given their age. In the interim, work with

an HVAC engineering firm to adjust/repair univents and exhaust vents to improve air exchange in classrooms.

8. Operate all ventilation systems (e.g., AHUs, exhaust vents and univents) throughout the building continuously during occupied periods. To increase airflow in classrooms, set univent controls to "high".
9. Particular attention should be made to ensure classroom exhaust vents are turned on at the start of school and are allowed to operate during occupancy. Consider contacting an electrician or HVAC firm to install timer for exhaust vents.
10. Remove all blockages from univents and exhaust vents to ensure adequate airflow.
11. Operate thermostats for AHUs in the fan "on" position to increase fresh air supplied to these areas.
12. Use openable windows in conjunction with mechanical ventilation to facilitate air exchange. Care should be taken to ensure windows are properly closed at night and weekends to avoid the freezing of pipes and potential flooding.
13. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
14. Work with city officials to develop a preventative maintenance program for all mechanical ventilation equipment. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Write date of filter change directly on filter housing. Ensure filters fit flush in racks with no spaces between to allow bypass of unfiltered air into the unit. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates.

15. For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a high efficiency particulate arrestance (HEPA) filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Avoid the use of feather dusters. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).
16. Continue with plans to replace roof.
17. Ensure plants have drip pans and avoid over-watering. Examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary. Remove plants from univent air diffusers.
18. Remove plants growing in close proximity of the building. Repair any damage to the building's foundation to prevent water/pest intrusion.
19. Seal areas around sink in kitchen to prevent water damage to the interior of cabinets and adjacent wallboard. Repair/replace countertop as necessary. Consider replacing with a one piece/seamless molded countertop.
20. Clean mold growth from sink cabinets with a mild detergent or anti-microbial agent. Replace damaged building components as necessary. Refrain from storing porous items (e.g., cardboard, paper) beneath sinks.
21. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled. Consider providing school issued cleaning products to staff.

22. Relocate or consider reducing the amount of materials stored in classrooms to allow for more thorough cleaning of classrooms. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.

23. Clean personal fans, univent air diffusers, return vents and exhaust vents periodically of accumulated dust.

24. Replace latex-based tennis balls with latex-free tennis balls or glides.

25. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.

26. Refer to resource manual and other related indoor air quality documents located on the MDPH's website for further building-wide evaluations and advice on maintaining public buildings. These documents are available at: http://mass.gov/dph/iaq.

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**Picture 1**

**1948 univent, note ajar grate for access to side cabinet**

**Picture 2**

**Dirt/dust in 1948 univent side cabinet**

**Picture 3**

**Filter in 1974 univent**

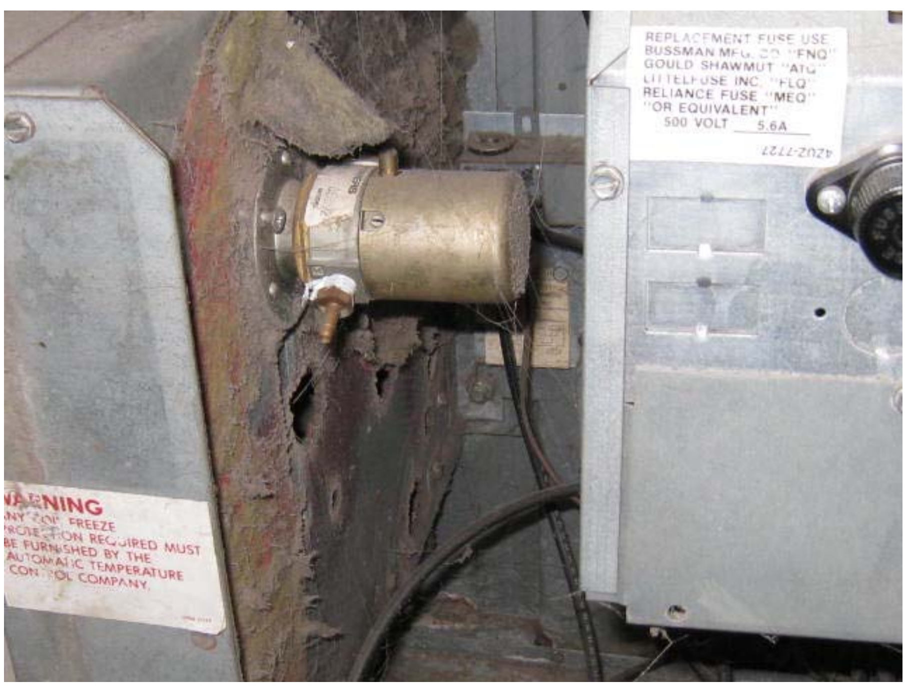
**Picture 4**

**Hole cut in exterior of 1974 univent case, note space around protruding pipe**

**Picture 5**


**Interior view of 1974 cabinet, note dust/debris and breach at bottom of case**

**Picture 6**




**Breaches allowing air into the main/filter compartment**

**Location: East Gloucester Elementary School** **Indoor Air Results**

**Address: 8 Davis St Ext, Gloucester, MA** **Table 1** **Date: June 7, 2011**

| Location | Carbon Dioxide (ppm) | Carbon Monoxide (ppm) | Temp (°F) | Relative Humidity (%) | PM2.5 ($\mu g/m^3$) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| Background | 470 | ND | 78 | 54 | 24 | | | | | Sunny, light breeze |
| Admin/main office | 689 | ND | 75 | 54 | 24 | 3 | Y 1/2 open | N | N | Exterior door open |
| Principal's office | 654 | ND | 74 | 53 | 19 | 0 | Y | N | N | WD paneling |
| Auditorium | 674 | ND | 72 | 60 | 17 | 0 | N | Y | Y | Musty/stale odor |
| Cafeteria | 500 | ND | 74 | 56 | 31 | 100 | Y | Y | Y | Exterior door open |
| Nurse's office | 615 | ND | 74 | 59 | 33 | 2 | Y | N | N | DO, CPs, plants |
| Timeout room | 728 | ND | 75 | 54 | 23 | 0 | Y | N | N | TB |
| Speech | 555 | ND | 74 | 52 | 19 | 0 | Y | N | Y | DO |
| Speech entrance room | 883 | ND | 74 | 52 | 20 | 0 | N | Y | N | CP odors, DO |
| Psychology room | 548 | ND | 75 | 54 | 19 | 3 | Y | Y | Y | DO |
| Library | 430 | ND | 74 | 53 | 20 | 0 | N | Y | DNL | DO |

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
CPs = cleaning products
CT = ceiling tile
DNL = did not locate
DO = door open
ND = non detect
PF = personal fan
TB = tennis balls
UF = upholstered furniture
WD = water-damaged

**Comfort Guidelines**

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
> 800 ppm = indicative of ventilation problems

Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

| Location | Carbon Dioxide (ppm) | Carbon Monoxide (ppm) | Temp (°F) | Relative Humidity (%) | PM2.5 ($\mu g/m^3$) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| Mixed offices (art, SPED) | 477 | ND | 75 | 53 | 19 | 2 | Y | Y | N | WD-CT |
| 1 | 744 | ND | 74 | 57 | 27 | 23 | Y 1/8 open | Y Off | Y Items | DO, 4 WD-CTs, CPs |
| 2 | 644 | ND | 74 | 54 | 23 | 23 | Y | Y 2/4 open | Y | TB, plants, CPs, DO, WD- sink |
| 3 | 511 | ND | 73 | 55 | 23 | 20 | Y | Y Items | Y Off | Exterior DO, DO, UF |
| 5 | 469 | ND | 74 | 53 | 24 | 18 | Y 2/4 open | Y | Y | Plants |
| 6 | 456 | ND | 74 | 54 | 21 | 24 | Y 3/3 open | Y Off, blocked | Y off | Plants, DO, TB |
| 7 | 444 | ND | 74 | 53 | 24 | 23 | Y 3/3 open | Y Off, items | Y Blocked | Plants, DO |
| 8 | 708 | ND | 76 | 53 | 25 | 21 | Y 3/3 open | Y | Y | Exterior DO, DO, TB, PF, sink/breach |
| 9 | 498 | ND | 75 | 51 | 23 | 21 | Y 3/3 open | Y | Y | TB, sink/breach |
| 10 | 561 | ND | 74 | 58 | 23 | 23 | Y 2/3 open | Y Debris | Y | Plants, PF |
| 11 | 766 | ND | 76 | 53 | 21 | 22 | Y 3/3 open | Y Weak | Y | Sink/breach |

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Relative Humidity: 40 - 60%

| Location | Carbon Dioxide (ppm) | Carbon Monoxide (ppm) | Temp (°F) | Relative Humidity (%) | PM2.5 (μg/m³) | Occupants in Room | Windows Openable | Ventilation | | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Supply | Exhaust | |
| 12 | 527 | ND | 74 | 53 | 21 | 2 | Y | Y Items | Y | Items, WD-CT |
| 18 | 967 | ND | 74 | 67 | 19 | 24 | Y | Y | Y | WD-CT, CPs, TB |
| 22 | 427 | ND | 72 | 60 | 21 | 0 | Y | Y | Y | WD-CT |

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CPs = cleaning products
CT = ceiling tile
DNL = did not locate
DO = door open
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PF = personal fan
TB = tennis balls
UF = upholstered furniture
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**Comfort Guidelines**

| | | | |
|---|---|---|---|
| Carbon Dioxide: | < 600 ppm = preferred<br>600 - 800 ppm = acceptable<br>> 800 ppm = indicative of ventilation problems | Temperature:<br>Relative Humidity: | 70 - 78 °F<br>40 - 60% |

# Appendix B

**Skin Irritation, Dryness, Redness or Rashes**

| Response | Number | Percent |
|---|---|---|
| Yes | 8 | 57% |
| No | 6 | 43% |
| Total | 14 | 100% |

**Itchy, Runny or Watery Eyes**

| Response | Number | Percent |
|---|---|---|
| Yes | 7 | 50% |
| No | 7 | 50% |
| Total | 14 | 100% |

**Stuffy or Runny Nose and Sinus congestion not related to an Infection**

| Response | Number | Percent |
|---|---|---|
| Yes | 7 | 50% |
| No | 7 | 50% |
| Total | 14 | 100% |

**Pain or Stiffness in your Neck, Shoulders or Back**

| Response | Number | Percent |
|---|---|---|
| Yes | 7 | 50% |
| No | 7 | 50% |
| Total | 14 | 100% |

**Sore, Hoarse or Dry Throat**

| Response | Number | Percent |
|---|---|---|
| Yes | 5 | 36% |
| No | 9 | 64% |
| Total | 14 | 100% |

**Tingling in the Hands and Feet**

| Response | Number | Percent |
|---|---|---|
| Yes | 5 | 36% |
| No | 9 | 64% |
| Total | 14 | 100% |

**Headaches**

| Response | Number | Percent |
|---|---|---|
| Yes | 5 | 36% |
| No | 9 | 64% |
| Total | 14 | 100% |

**Dizziness, Lightheadedness, or Loss of Balance**

| Response | Number | Percent |
|---|---|---|
| Yes | 4 | 29% |
| No | 10 | 71% |
| Total | 14 | 100% |

**Difficulty Remembering Things or Concentrating**

| Response | Number | Percent |
|---|---|---|
| Yes | 4 | 29% |
| No | 10 | 71% |
| Total | 14 | 100% |

**Breathing Problems when you did not have a Cold or the Flu**

| Response | Number | Percent |
|---|---|---|
| Yes | 3 | 21% |
| No | 11 | 79% |
| Total | 14 | 100% |

**Nausea or Upset Stomach**

| Response | Number | Percent |
|---|---|---|
| Yes | 2 | 14% |
| No | 12 | 86% |
| Total | 14 | 100% |

**Unusual Tiredness, Fatigue or Drowsiness**

| Response | Number | Percent |
|---|---|---|
| Yes | 2 | 14% |
| No | 12 | 86% |
| Total | 14 | 100% |

# Appendix B

**Wheezing in your Chest**

| Response | Number | Percent |
|---|---|---|
| Yes | 2 | 14% |
| No | 12 | 86% |
| Total | 14 | 100% |

**Tightness in your Chest**

| Response | Number | Percent |
|---|---|---|
| Yes | 2 | 14% |
| No | 12 | 86% |
| Total | 14 | 100% |

**Coughing**

| Response | Number | Percent |
|---|---|---|
| Yes | 2 | 14% |
| No | 12 | 86% |
| Total | 14 | 100% |

**Sneezing**

| Response | Number | Percent |
|---|---|---|
| Yes | 1 | 7% |
| No | 13 | 93% |
| Total | 14 | 100% |