INDOOR AIR QUALITY ASSESSMENT

Gloucester High School
32 Leslie O. Johnson Rd
Gloucester, MA 01930

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Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
August 2008

Background/Introduction

At the request of Jack Vondras, Director of the Gloucester Health Department, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation at the Gloucester High School (GHS), 32 Leslie O. Johnson Road, Gloucester, Massachusetts. Concerns about cancer and its potential association with environmental conditions, particularly issues regarding former land use, at the GHS prompted the assessment.

On May 30, 2007, a visit to conduct an indoor air quality assessment was made to the GHS by Michael Feeney, Director of BEH's Indoor Air Quality (IAQ) Program. Mr. Feeney was accompanied by Cory Holmes and Sharon Lee, Indoor Air Inspectors within the IAQ Program and Joshua McHale and Patricia Walsh, epidemiologic researchers and risk communication specialists within BEH's Community Assessment Program (CAP). Mr. Feeney returned on May 31, 2007 to conduct a crawlspace examination. Mr. McHale also returned to the GHS on May 31, 2007 to collect additional health data.

Following these visits, BEH staff returned to the building on January 22, 2008 to conduct indoor air quality testing during the heating season; air-sampling was also conducted in the GHS crawlspace. Mr. Feeney, Mr. Holmes, Ms. Lee, Ms. Susan Koszalka and Mr. James Tobin, Indoor Air Quality Inspectors within the IAQ Program, and Christine Gorwood, an epidemiologic researcher within BEH's CAP, were present during the January 22, 2008 site visit. IAQ staff were also accompanied by Mr. Eugene Benoit, Tools for Schools Program Coordinator, US EPA Region 1 Office.

During the May 2007 assessments, BEH staff noted areas within the crawlspace that had odors thought to be related to the boiler. For that reason, a request for assistance for targeted

testing for volatile organic compounds (VOCs) was made by the Department of Labor and Workforce Development (DLWD), Division of Occupational Safety (DOS). The DOS has an analytic laboratory that can identify specific compounds. Air-sampling of the crawlspace and occupied areas was conducted by Patricia Sutliff, DOS.

The GHS was originally constructed in 1940. In 1996, the building underwent extensive renovations, which included the construction of a field house and other additions, as well as replacement of the heating, ventilating, and air conditioning (HVAC) system. The main GHS complex is a three-story structure consisting of a main building with the science wing connected to the west side of the building and the field house connected to the east side. A freestanding vocational building is situated to the north of the main GHS complex (Map 1). Windows are openable throughout the building. A crawlspace exists beneath the main building complex. A second crawlspace that is situated under the footprint of the science wing appears to be separate from the main crawlspace. A mechanical ventilation system that exhausts air from the crawlspaces was retro-fitted (Picture 1).

BEH has conducted several previous assessments at the GHS. In 1997, BEH conducted an extensive investigation related to exposure concerns of building occupants related to isocyanate compounds off-gassing from the field house after floor installation (MDPH, 1997a; MDPH 1997b). In 2005, BEH staff returned to GHS to investigate condensation problems in the administration/guidance offices related to the heating, ventilating and air-conditioning (HVAC) system (MDPH, 2005).

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were conducted with the TSI, Q-Trak, IAQ Monitor, Model 8551. Screening for total volatile organic compounds (TVOCs) was conducted using a Thermo Environmental Instruments Inc., Model 580 Series Photo Ionization Detector (PID). 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.

Air-sampling for environmental pollutants was conducted by DOS using calibrated rotameters. Each rotometer is equipped with two different types of air-sampling tubes; air is drawn simultaneously across sample media in these tubes. The rotameters were placed in six locations and allowed to run for two hours, after which they were taken to the DOS laboratory, where samples were analyzed for volatile organic compounds (VOCs) using gas chromatography analysis.

Results

The school houses approximately 1,160 students in grades nine - twelve with over 120 staff members. Tests were taken during normal operations at the school. Results for the assessments conducted on May 30, 2007 and January 22, 2008 appear in Tables 1 and 2 respectively. Crawlspace air sampling results appear in Appendix A.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 14 of 103 areas on May 30, 2007, generally indicating adequate ventilation in the majority of areas surveyed. Carbon dioxide levels were above 800 ppm in 27 of 72 areas surveyed on January 22, 2008(Table 2). It is important to note that several areas were empty or sparsely populated at the time of the assessments. During the May 2007 assessment a number of areas had open windows. Low occupancy and opened windows can greatly reduce carbon dioxide levels. With increased occupancy and windows shut, carbon dioxide levels would be expected to rise.

Fresh air in classrooms is supplied by unit ventilator (univent) systems (Picture 2). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building (Picture 3) and return air 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. Many univents were not operating at the time of the MDPH visits (Tables 1 and 2). Obstructions to airflow, such as papers and books stored on univents and bookcases and carts and desks located in front of univent returns, were seen in several classrooms (Picture 4). In order for univents to provide fresh air as designed, units must be allowed to operate and remain free of obstructions.

Exhaust ventilation in classrooms is provided by ducted and grated 'cubby', wall or ceiling vents powered by rooftop motors. Exhaust ventilation was not operating in some areas during the assessment (Tables 1 and 2). A number of wall and cubby exhaust vents were obstructed by furniture, books and other items (Pictures 5 and 6). Some classroom exhaust vents were located above hallway doors (Picture 7). The location of these exhaust vents may limit the

efficiency of the exhaust system. When doors are open, these vents will tend to draw from the hallway, rather than from the classroom. As with the univents, in order to function properly, exhaust vents must be activated and remain free of obstructions.

Mechanical ventilation to common areas, offices, and interior rooms is provided by rooftop air handling units (AHUs). Fresh air is distributed via ductwork connected to ceiling-mounted air diffusers. Air is returned to the AHUs through ceiling-mounted return vents. In some areas, supply vents were sealed and blocked with duct tape and manila folders (Picture 8). Some areas did not have mechanical supply and/or exhaust (Tables 1 and 2). Without sufficient supply and exhaust ventilation, environmental pollutants can build up, leading to indoor air quality/comfort complaints.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of school 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 HVAC systems be re-balanced every five years (SMACNA, 1994). The date of the last balancing was not available at the time of the assessment.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or openable windows (SBBRS, 1997; BOCA, 1993). The ventilation must be on at all times 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, see Appendix B.

Temperature measurements ranged from 69^{o} F to 78^{o} F on May 30, 2007 (Table 1), which were within or very close to the lower end of the MDPH recommended comfort range. Temperature measurements on January 22, 2008 ranged from 66^{o} F to 74^{o} F (Table 2), which were several degrees below the MDPH recommended comfort range in some areas. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. Several occupants had temperature complaints (Tables 1 and 2). Of note were complaints of excessive heat expressed relative to classroom 3306, which is a computer classroom. Waste heat is generated from personal computers, printers and other associated equipment. Consideration should be given to increasing fresh air supplied to this classroom; or if temperature problems persist, consider installing a wall/window-mounted

air conditioner. 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.

Relative humidity measurements ranged from 40 to 67 percent on May 30, 2007 (Table 1), which were within the MDPH recommended comfort range in all but one area. Relative humidity measurements on January 22, 2008 ranged from 10 to 30 percent (Table 2), which were below the MDPH recommended comfort range. 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.

Moisture/Microbial Concerns

During the BEH assessments, staff observed conditions indicating water penetration in the building. Of note is the condition of the gypsum wallboard (GW) observed in the day care center during the May 30, 2007 assessment. The day care is located on the ground floor in the southeast corner of the science wing and showed signs of repeated water damage (Picture 9). BEH staff examined the exterior wall and window system corresponding to this wall and observed the following conditions that indicate that the source of water damaging the GW is most likely moisture through the window system.

- The stone window sills were installed flat, which prevents water from draining away from the window frame (Picture 10).
- Window drip caps, which direct water away from the window frame, do not appear to have been installed in the corners of the windows' sills.

- No flashing exists in or around the window to direct water away from the window frame.
- Spaces between the exterior wall and the window sills and frames appear to be sealed with a caulking material that was damaged or missing.

As a result of aforementioned conditions, rain, particularly wind-driven rain from the southwest, can penetrate through the window system and chronically moisten GW. Evidence of water penetration through the window system was also observed in other areas of the GHS (Tables 1 and 2).

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommends that porous materials be dried with fans and heating within 24 to 48 hours of becoming wet (US EPA, 2001; ACGIH, 1989). If porous materials are not dried within this time frame, mold growth may occur. Cleaning cannot adequately remove mold growth from water-damaged porous materials. The application of a mildewcide to mold contaminated, porous materials is not recommended.

BEH staff observed rust stains around a file cabinet in classroom 1218 during the May 30, 2008 assessment (Picture 11). The classroom occupant reported that these stains were related to repeated water penetration from the exhaust vent. Water penetration through the exhaust vent duct work is an indication that the exhaust fan in no longer functioning and/or a breach in the roof membrane.

Several classrooms had a number of plants. Standing water was also noted in drip pans (Picture 12). Moistened plant soil and drip pans can be a source of mold growth. Plants should be equipped with drip pans; the lack of drip pans can lead to water pooling and mold growth on windowsills. Plants are also a source of pollen. Plants should be located away from the air

stream of ventilation sources to prevent the aerosolization of mold, pollen or particulate matter throughout the classroom.

A number of classrooms had water-damaged/missing ceiling tiles which can indicate roof or plumbing leaks (Picture 13; Tables 1 and 2). Water-damaged ceiling tiles can provide a source for mold growth and should be replaced after a water leak is discovered and repaired.

Breaches were observed between the counter and sink backsplashes in some classrooms (Tables 1 and 2). If not watertight, water can penetrate through these seams. 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 (Picture 14), which can subsequently lead to mold growth.

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 school environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

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, 1997c).

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) during both dates of testing. Indoor carbon monoxide levels measured were also ND during both dates of testing (Tables 1 to 2).

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 microgram 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.

BEH conducted PM2.5 testing on January 22, 2008. Outdoor PM2.5 concentrations the day of the assessment ranged from 25 to 50 $\mu g/m^3$ (Table 2), which were above the NAAQS PM2.5 level of 35 $\mu g/m^3$. PM2.5 levels within the school ranged from 8 to 25 $\mu g/m^3$ which were which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$ (Table 2). Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of mechanical devices and/or activities that occur in schools 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, cooking in the cafeteria stoves and microwave ovens; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Indoor air quality can also be negatively influenced by the presence of materials 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 determine whether VOCs were present in the building, BEH staff conducted air monitoring for TVOCs throughout the school during the May 30, 2007 assessment. An outdoor air sample was taken for comparison. Outdoor TVOC concentrations were ND (Table 1). Indoor TVOC concentrations ranged from ND to 0.1 ppm on (Table 1). A slight level of TVOCs (0.1 ppm) was measured in a classroom where BEH staff noted dry erase material usage/odors. The majority of classrooms contained dry erase boards and dry erase board markers. 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.

As mentioned, DOS conducted TVOC testing in the crawlspace and surrounding areas during the January 2008 assessment. These results are discussed in the *Crawlspace Examination* section of this report.

In an effort to identify materials that can potentially increase indoor TVOC concentrations in occupied areas of the building, BEH staff examined classrooms for products containing these respiratory irritants. Cleaning products were found on countertops and in unlocked cabinets beneath sinks in some classrooms. Like dry erase materials, cleaning products contain VOCs and other chemicals that can be irritating to the eyes, nose and throat of sensitive individuals.

The odor of photograph developing chemicals was noted in the classroom outside the darkroom. A number of photographic chemicals were observed in the darkroom, an area with either non-functional or poorly functioning exhaust ventilation. In addition, local exhaust vents should be located at the level of the wash sink and developing pans to draw odors away from

users. The location of the exhaust fan in the exterior wall will tend to draw odors towards users of the wash sink and developing pans (Figure 2). Photographic chemicals contain volatile organic compounds (VOCs), which can be irritating to the eyes, nose and throat which should be vented from the building.

Several other conditions that can affect indoor air quality were noted during the assessment. During the May 30, 2007 assessment, BEH staff observed lead-containing pottery glazes in the art room (Table 1). During the pottery firing process, lead fumes can be emitted from kilns. Lead exposure to women of reproductive age poses a number of risks to developing fetuses (ATSDR, 1999). Lead exposure, particularly in the early stages of pregnancy when a woman may not know that she is pregnant, may result in adverse effects from *in utero* exposure to lead. Lead exposure in males has been associated with reduced fertility because of effects on sperm (ATSDR, 1999). It is highly recommended that the use of non-lead containing materials be substituted for lead-containing glazes/materials. It is worthwhile to note that *lead-free* glazes were observed during the January 22, 2008 assessment (Table 2). A complete inventory of glazes should be conducted to ensure that *all* lead-containing glazes have been removed/replaced by lead-free products.

In several classrooms, items were observed on the floor, 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.

Several personal fans and return/exhaust vents were occluded with dust and debris (Pictures 15 and 16). Similarly, debris was observed in univent diffusers (Picture 17). Dust can be a source for eye and respiratory irritation. Re-activated univents personal fans can serve to distribute dust. If exhaust vents are not functioning, backdrafting can occur and aerosolize dust particles.

A number of classrooms contained upholstered furniture. Upholstered furniture is covered with fabric that comes in contact with human skin. This type of contact can leave oils, perspiration, hair and skin cells. Dust mites feed upon human skin cells and excrete waste products that contain allergens. In addition, if relative humidity levels increase above 60 percent, dust mites tend to proliferate (US EPA, 1992). In order to remove dust mites and other pollutants, frequent vacuuming of upholstered furniture is recommended (Berry, 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis.

Window or wall-mounted air conditioners are located in a number of areas throughout the school. These units are equipped with filters. BEH staff observed the conditions of several filters and noted they were occluded with dust/debris (Picture 18). Filters should be cleaned or changed as per manufacturer's instructions to avoid the build-up and re-aerosolization of dirt, dust and particulate matter.

High efficiency particulate air (HEPA) purifiers were observed on the floor in several locations (Picture 19). Air purifiers should be placed within the breathing zone rather than at floor level. In addition, this equipment is normally equipped with filters that should be cleaned or changed as per manufacturer's instructions to prevent build up and re-aerosolization of dirt, dust and particulate matter.

Also of note was the storage of univent filters. Open boxes of univent filters were stored in the crawlspace (Picture 20), and in various parts of the boiler room (Pictures 21 to 23), in some instances near standing water. HVAC system filters should be stored in a clean, dry environment to prevent cross-contamination prior to installation.

Missing/ajar ceiling tiles were observed in classrooms throughout the GHS (Picture 24). Missing/ajar ceiling tiles can provide pathways for materials (e.g., odors, dust, particulates) to migrate into occupied areas. Missing tiles should be replaced to maintain the integrity of the suspended ceiling tile system. Ceiling tiles should be flush with ceiling system to prevent such movement. Occupants should also refrain from hanging items from the ceiling tile systems to prevent potential pathways for materials into occupied areas.

Similarly, utility holes were observed in a number of classrooms (Picture 25). Utility holes can also serve as pathways for odors/materials to migrate from floor/wall cavities into occupied areas and should be sealed.

Lastly, BEH staff observed tennis balls that had been sliced open and placed on chair legs, in an effort to reduce noise from sliding chairs (Picture 26). 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 off gas VOCs. 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). A question and answer sheet concerning latex allergy is attached as

Appendix C (NIOSH, 1998). Consideration should be given to using latex-free tennis balls or alternative glides.

Crawlspace Examination

Main Building

A crawlspace runs beneath the original footprint of the main building (Map 2). The crawlspace can be accessed through a fire door in the boiler room (Picture 27). Building occupants expressed concerns that potential crawlspace pollutants were migrating into occupied areas of the building. During the course of the May 30, 2007 assessment, BEH staff detected a distinct boiler odor in the auditorium, thereby confirming a means of communication between the crawlspace and auditorium.

BEH staff also found ventilation ducts beneath the auditorium that were open to the crawlspace (Picture 28) and, in one instance, sealed with cardboard that had become dislodged (Picture 29). In addition, BEH staff examined univent interiors and observed spaces around heating and electrical conduits, (such as in Room 1205) (Picture 30). Breaches in the floor of univent cabinets can serve as pathways for crawlspace air to enter first floor classrooms.

Upon finding these pathways, BEH staff arranged to have air-sampling conducted in the crawlspace, boiler room, auditorium, and classroom 1205. Air-sampling of the aforementioned locations was conducted by DOS during the January 22, 2008 assessment. VOC sampling was conducted in a number of crawlspace areas (Map 2), including beneath the main hallway (Picture 31), beneath the hallway outside the auditorium near the lowest point of the crawlspace (Picture 32), and in the open duct beneath the auditorium (Picture 33). Samples were also taken in

classroom 1205 and the auditorium to ascertain whether potential crawlspace contaminants were infiltrating to occupied areas. As discussed, VOCs are carbon-containing substances that have the ability to evaporate at room temperature and are frequently found in dump sites. VOCs are also materials that will move with airflow. Therefore, VOCs were chosen for air-sampling since these materials, if present, would be the most likely contaminants to migrate into occupied areas of the building. Sample results from gas chromatography indicate that there were no significant peaks for VOCs (Appendix A).

However, other normally occurring pollutants exist in the crawlspace, including water vapor, dust particles and likely mold growth. The crawlspace beneath the GHS is approximately 150 feet from the Blynman Canal (Map 1); therefore, it is likely subject to water vapor intrusion during wet/humid weather. The crawlspace has a dirt floor and contains heating pipes, water/drain pipes and electrical conduit. As part of the renovations, it appears that a mechanical exhaust ventilation system was retro-fitted through the foundation wall to vent the crawlspace area beneath the classroom wing. A motorized exhaust fan (Picture 1) appears to be connected to a candy cane-shaped pipe (Picture 34). Each vent appeared to be functioning; however, a steady air stream could be detected from the fan/pipe joint along the north wall of the building. This breach may indicate that the vent pipe is obstructed. These vents are designed to draw air directly from the crawlspace, thereby drawing any accumulating odor/materials and ejecting them outdoors. While crawlspace exhaust vents were operating, BEH staff identified a condition that may result in crawlspace air being drawn by univents into classrooms (i.e., holes in univent cabinet floors).

Of note is classroom 1205, where room occupants reported odors. BEH staff found aforementioned spaces in the floor of the univent cabinet through which the heating pipe and

electrical conduit pass (Picture 30). In this condition, crawlspace air is likely being drawn into the classroom via the univent. BEH staff also identified an opening in the exterior wall of GHS beneath Room 1205 (Picture 35). This opening may have been for a water spigot, which was likely removed during the renovations. Since the exterior wall of Room 1205 is facing southwest, it is likely that air is forced into this area of the crawlspace during windy conditions, which can then stir up dust and other pollutants to be captured by the univent through the hole in the floor. A number of abandoned pipes were found open in the crawlspace (Pictures 36 and 37). These open pipes can serve as a means for crawlspace pollutants into occupied areas. Dust, dirt and other particles commonly found in crawlspaces can serve as irritants to the eyes, nose and respiratory system.

Science Wing Crawlspace and First Floor

The crawlspace of the science wing is separate from the main building and appears to be subject to chronic water infiltration, as evidenced by the existence of pooling water (Picture 38). The likely source of water infiltration is along the north and west walls due to the topography surrounding the science wing. A substantial rock outcropping/hillock is located along the north and west walls of the science wing (Map 1). In addition, a tarmac driveway exists uphill to the northeast of the science wing. The outcropping/hillock tends to direct rainwater toward the science wing, as evidenced by marshy ground along the west wall of the science wing (Picture 39). The driveway directs runoff to the rear of the building (Picture 40), which under certain circumstances can enter the building through the rear door and floods a significant portion of the first floor. Sand deposition on the floor of the science wing north stairwell floor (Picture 41) and water damage to hallway walls confirm this observation. Of note is the apparent lack of a

foundation drain system around the north or west wall of the science wing. The ground of the east wall of the science wing is lined with crushed rock (Picture 42), which can indicate the existence of a French drain, which would redirect water away from the foundation wall. No such structure could be identified for both the north and west walls of the science wing.

In an effort to provide exhaust ventilation for the science wing crawlspace, a large exhaust fan is installed in the south wall door system (Picture 43). This fan is enclosed by a plywood barrier beneath the science wing south stairwell (Picture 44). Air is drawn from the crawlspace through an open hatch, which is also the sole crawlspace entrance (Picture 45). This arrangement would tend to draw air from the science wing hallways and classrooms, thereby making temperature control in these areas difficult.

Health Concerns

A representative of the teachers' union provided the MDPH, Bureau of Environmental Health's Community Assessment Program (CAP) with a list of 15 individuals who were current or former employees at Gloucester High School and who reported having been diagnosed with cancer. CAP staff reviewed the most recent data available from the Massachusetts Cancer Registry (MCR) to confirm the diagnoses of cancer reported among Gloucester High School employees and to determine whether these diagnoses may represent an unusual pattern of cancer incidence. The MCR, a division within the MDPH Bureau of Health Information, Statistics, Research and Evaluation, is a population-based surveillance system that has been monitoring cancer incidence in the Commonwealth since 1982. All new diagnoses of invasive cancer, along with several types of in situ (non-invasive) cancer, among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (M.G.L. c.111. s

111b). This information is collected and kept in a confidential database. Data are collected on a daily basis and reviewed for accuracy and completeness. This process corrects misclassification of data (i.e., city/town misclassification) and deletes duplicate case reports.

Of these 15 individuals, CAP staff were able to confirm the diagnoses of eight individuals. Although the MCR data for cancer diagnoses for the individuals reported to the CAP through the present time was reviewed, there are several reasons why some of these individuals may not be included in the MCR files. For example, some of these individuals may have been diagnosed prior to 1982 when the MCR began collecting information on individuals in the state diagnosed with cancer. Similarly, some individuals with recent cancer diagnoses may not yet have been reported to the MCR. For any diagnoses that occurred during 2005 through 2007, it is possible that the individual's diagnosis is under review by MCR staff, as part of is quality control process, and not yet part of the MCR database. Finally, if an individual was diagnosed when he/she was a resident of another state, that individual's cancer diagnosis would not be reported to the MCR.

Five of the eight individuals were diagnosed with prostate cancer; this was the most common cancer diagnosis among the reported individuals. According to the American Cancer Society, one in six males will be diagnosed with prostate cancer in their lifetime (ACS, 2007). In Massachusetts, prostate cancer accounted for approximately 28% of new cancers among males in the state from 2001 to 2005, making it the most common type of newly diagnosed cancer among Massachusetts males. Additionally, environmental risk factors have not been suggested as playing a major role in the development of this cancer type. However, age, race and family history have been suggested to play large roles in the development of this cancer.

The remaining three individuals had different cancer types, each type having its own set of risk factors. In brief, they include cancers of the central nervous and lymphatic systems, as well as a connective tissue cancer. These cancers do not share common risk factor associations with their development, so it is unlikely that potential exposure at Gloucester High School played a primary role their occurrence.

While at Gloucester High School, CAP staff met with eight individuals who reported health problems that they associated with working in the school. The problems ranged from nose and throat irritation to cancer diagnoses. There was no information provided by these individuals that would indicate one common exposure at the school was responsible for the range of illnesses mentioned.

Understanding that cancer is not one disease, but a group of diseases is very important. Research has shown that there are more than 100 different types of cancer, each with different causative (or risk) factors. In addition, cancers of a certain tissue type in one organ may have a number of causes. Cancer may also be caused by several factors acting over time. Tobacco use has been linked to lung, bladder, oral and pancreatic cancers. Other factors related to certain cancers may include lack of crude fiber in the diet, high fat consumption, alcohol abuse, and reproductive history. Family history (or genetics) is an important risk factor for several cancers. In addition, some occupational exposures, such as jobs involving contact with asbestos, have been shown to increase the risk of developing cancer. Environmental contaminants have also been associated with certain types of cancers.

According to statistics from the American Cancer Society, cancer is the second leading cause of death in Massachusetts and the United States. Not only will one out of three females and one out of two males develop cancer in their lifetime, but cancer will affect three out of

every four families. For this reason, cancers often appear to occur in "clusters," and it is understandable that someone may perceive that there are an unusually high number of cancer diagnoses in their surrounding neighborhood or town. Upon closer examination, many of these "clusters" are not unusual increases, as first thought, but are related to such factors as local population density, variations in reporting or chance fluctuations in occurrence. In other instances, the "cluster" in question includes a high concentration of individuals who possess related behaviors or risk factors for cancer. Some, however, are unusual; that is, they represent a true excess of cancer in a workplace, a community, or among a subgroup of people. A suspected cancer cluster is more likely to be a true cluster if it involves a large number of diagnoses of one type of cancer diagnosed in a relatively short time period rather than several different types diagnosed over a long period of time (i.e., 20 years), a rare type of cancer rather than common types, and a large number of diagnoses among individuals in age groups not usually affected by that cancer. These types of clusters may warrant further public health investigation.

Based upon our review of the available diagnostic information, length of employment, and IAQ test results, as well as the most current literature, there does not appear to be an atypical pattern of cancer among employees of the Gloucester High School. It does not appear that a common factor (either environmental or non-environmental) is likely related to the diagnoses of cancer among these individuals. While potential indoor air quality problems may have been noted in this report, these issues are not likely to be related to the incidence of cancer among employees at the Gloucester High School, but may have contributed to common symptoms associated with poor indoor air quality (e.g., headaches, fatigue and irritant symptoms).

Conclusions/Recommendations

Based on air sampling conducted throughout the building both during and after the heating season and testing for VOCs conducted in the crawlspace, it does not appear that pollutants related to former land use (e.g., dump) exist in a form that can be drawn into occupied space by the GHS HVAC system. Other pollutants that are normally found in crawlspaces (e.g., mold spores, dirt/dust and water vapor) may have an effect on occupied spaces if given a means to enter such space. The presence of holes in univent cabinet floors for pipes and electrical conduit are likely creating a pathway for crawlspace air to migrate into first floor classrooms.

The general building conditions, maintenance, work hygiene practices and the condition of HVAC equipment, if considered individually, present conditions that could degrade indoor air quality. When combined, these conditions can serve to further degrade indoor air quality. Some of these conditions can be remedied by actions of building occupants. Other remediation efforts will require alteration to the building structure and equipment. For these reasons, a two-phase approach is required for remediation. The first consists of **short-term** measures to improve air quality and the second consists of **long-term** measures that will require planning and resources to adequately address the overall indoor air quality concerns. In view of the conditions found at the time of the assessments, the following recommendations are made:

Short-Term Recommendations

1. Seal all possible routes of migration for dusts, vapors and gasses from the crawl space to occupied areas of the school with an appropriate fire rated sealant. In particular, the floors of univent cabinets.
2. Seal all open pipes in the crawlspace.

3. Ensure that the exhaust ventilation system for the crawlspace beneath the main building is functional. Clean the termini (Picture 32) of these vents annually.
4. Improve ventilation to remove photography developing chemical odors from building; examine and make repairs/adjustments to the ventilation system as necessary. An automatic rather than a manually operated ventilation system should be considered.
5. Operate both supply and exhaust ventilation continuously during periods of school occupancy, independent of classroom thermostat control to maximize air exchange.
6. Restore exhaust ventilation in classrooms and common areas; make repairs as necessary.
7. Remove all blockages from univents and exhaust vents/cubbies to ensure adequate airflow.
8. Ensure classroom doors are closed to maximize air exchange.
9. 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.
10. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
11. Change filters for air-handling equipment (e.g., univents, AHUs and ACs) as per the manufacturer's instructions or more frequently if needed. Vacuum interior of units prior to activation to prevent the aerosolization of dirt, dust and particulates. Ensure filters fit flush in their racks with no spaces in between allowing bypass of unfiltered air into the unit.
12. Do not store HVAC system filters in the crawlspace or boiler room. Discard existing stock and store in a clean/dry location.

13. Consider increasing air intake or providing air conditioning to computer classroom 3306 to mitigate heat issues.

14. 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 HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all non-porous surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

15. Seal the hole in the exterior wall outside room 1205.

16. Ensure leaks are repaired and remove/replace water damaged ceiling tiles. Examine the areas above and around for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.

17. Inspect exhaust vent near room 1218 and seal to prevent water infiltration.

18. Remove/replace water-damaged GW from the day care centers and science wing hallway ground floor.

19. Move plants away from univents in classrooms. Avoid over-watering and examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.

20. Seal areas around sinks to prevent water damage to the interior of cabinets and adjacent wallboard. Inspect wallboard for water damage and mold growth, repair/replace as necessary. Disinfect areas with an appropriate antimicrobial, as needed.

21. Replace missing/damaged ceiling tiles.

22. Seal utility holes in classroom walls/floors.

23. Conduct a complete inventory of pottery glazes to ensure that all lead-containing glazes have been removed/replaced by lead-free products.

24. Clean upholstered furniture on the schedule recommended in this report. If not possible/practical, remove upholstered furniture from classrooms.

25. 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.

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

27. Replace latex-based tennis balls with latex-free tennis balls or alternative glides.

28. Consider adopting the US EPA document, "Tools for Schools" to maintain a good indoor air quality environment on the building (US EPA, 2000). This document can be downloaded from the Internet at: http://www.epa.gov/iaq/schools/index.html.

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

Long-Term Recommendations

1. Examine the feasibility of extending the drainage system or install an interceptor drain along the outside of the science wing to reduce/eliminate water penetration into the north stairwell.

2. Consider re-grading the area behind the science wing to redirect water away from the north stairwell entrance, include the installation of raised curbing in the driveway.
3. Examine and repair window systems to prevent water infiltration.
4. Consider re-seating the window sills in the east wall of the science wing to create a slope to allow for water to pour away from the sill. Each window frame should have window drip caps to prevent water penetration. Given the type of driven wet weather experienced in the greater Gloucester area, each windowsill should be flashed to direct water away from the window frame.
5. Examine the feasibility of installing a duct system to connect the science wing crawlspace exhaust vent directly to the crawlspace. Close the crawlspace hatch once the installation is completed. In addition, consider reorienting the terminus of the science wing crawlspace exhaust vent to direct crawlspace air away from the science wing south stairwell entrance.

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Picture 1

Crawlspace exhausted via motorized fan

Picture 2

Classroom univent

Picture 3

Univent fresh air intake

Picture 4

Items placed on top of univent

Picture 5

Exhaust vent blocked by cabinet

Picture 6

File cabinet and items stored in cubby exhaust

Picture 7

Exhaust vent located above hallway door

Picture 8

Supply vent sealed/blocked with duct tape and manila folder

Picture 9

Damaged GW in the day care center

Picture 10

Window sills installed with minimal outward pitch

Picture 11

File cabinet blocked exhaust vent; rust staining along bottom/front of cabinet from water penetration through exhaust vent

Picture 12

Standing water in drip pan

Picture 13

Water-damaged ceiling tile and GW

Picture 14

Breach between sink countertop and backsplash

Picture 15

Fan blades/cage occluded with dust

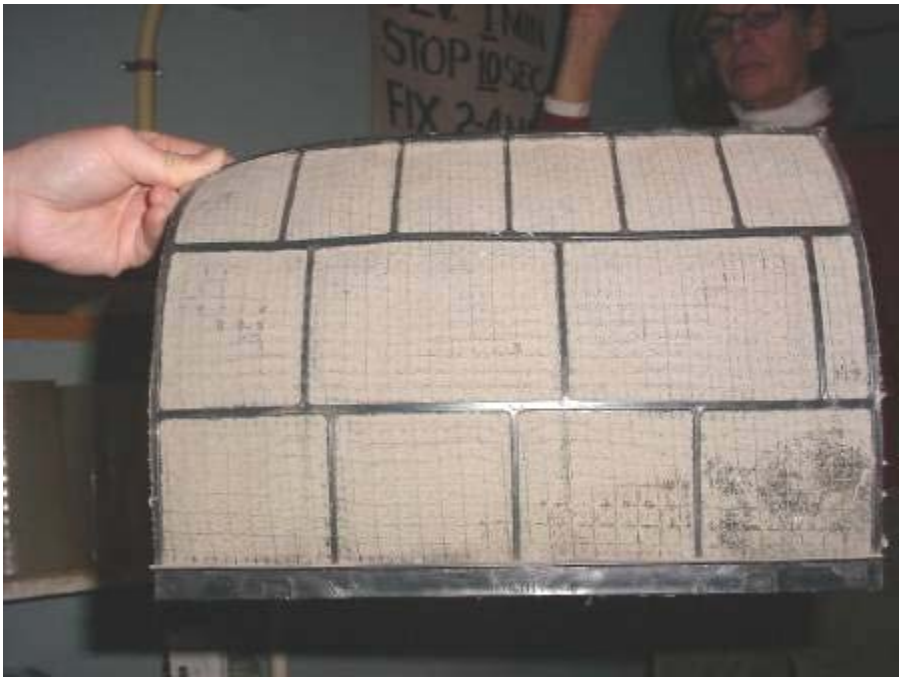
Picture 16

Exhaust vent occluded with dust

Picture 17

Debris in univent diffuser

Picture 18



Air-conditioning filter occluded with dust/debris

Picture 19

HEPA filtered air purifier placed on the floor

Picture 20

Open boxes of univent filters where found stored in the crawlspace

Picture 21

Univent filter storage

Picture 22

Univent filter storage

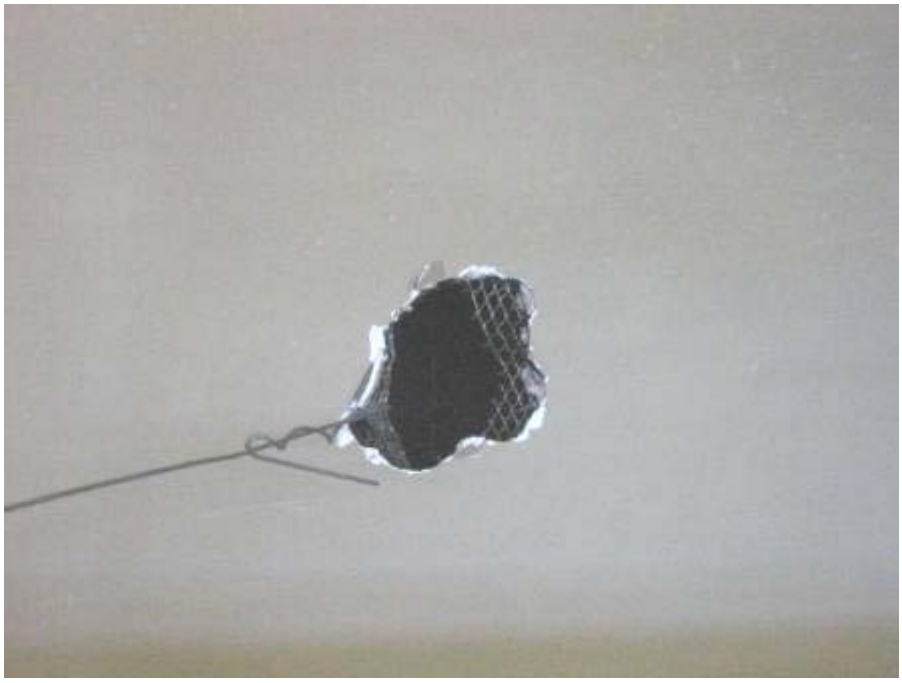
Picture 23

Univent filter storage

Picture 24

Ajar ceiling tiles

Picture 25



Utility hole

Picture 26

Tennis balls on chair legs

Picture 27

Main building crawlspace access door in boiler room

Picture 28

Open duct in crawlspace beneath auditorium

Picture 29

Cardboard used to seal duct in crawlspace beneath library

Picture 30

Hole in floor of room 1205 univent

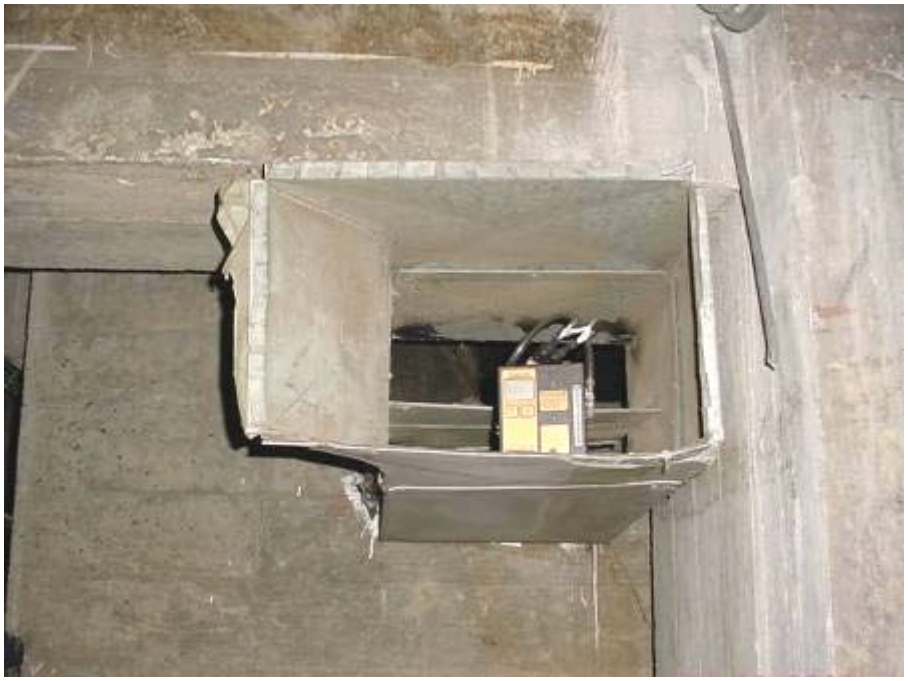
Picture 31

Rotometer in crawlspace beneath main hallway

Picture 32

Rotometer near lowest point of crawlspace, main building

Picture 33

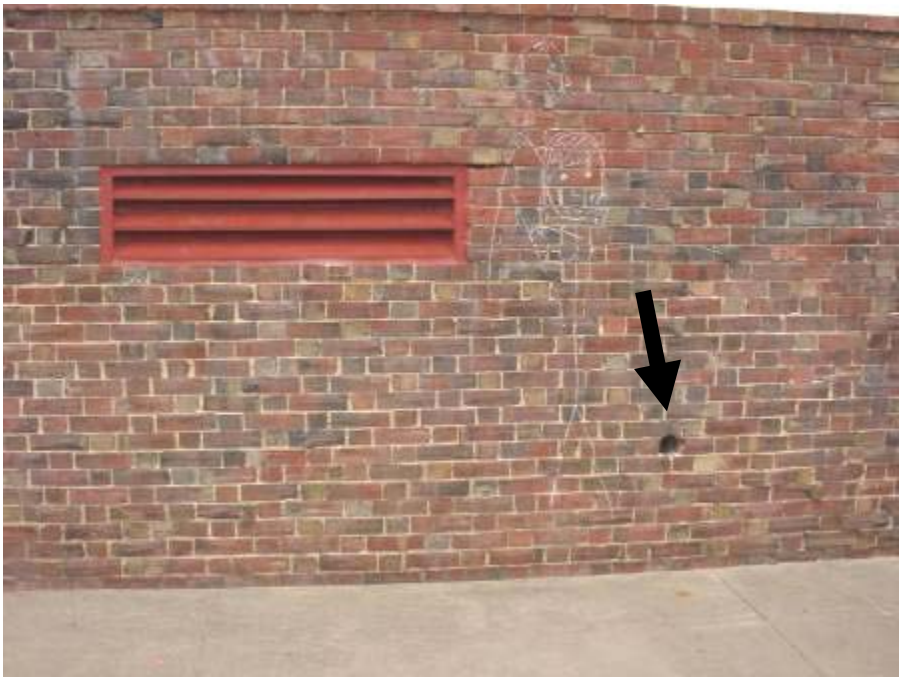


Rotometer in duct in crawlspace beneath auditorium

Picture 34

Crawlspace exhaust vent terminus

Picture 35



Open hole in exterior wall outside room 1205

Picture 36

Open pipe in crawlspace

Picture 37

Open pipe in crawlspace

Picture 38

Pool of water in crawlspace beneath science wing

Picture 39

Marshy ground along the west wall of the science wing

Picture 40

Driveway behind science wing sloped toward rear door

Picture 41

Sand deposition in north staircase floor of science wing

Picture 42

Crawlspace exhaust vent termini occluded with debris,
Note no crushed rock at rear of building

Picture 43

Science wing crawlspace exhaust fan

Picture 44

Plywood barrier beneath the science wing south stairwell

Picture 45

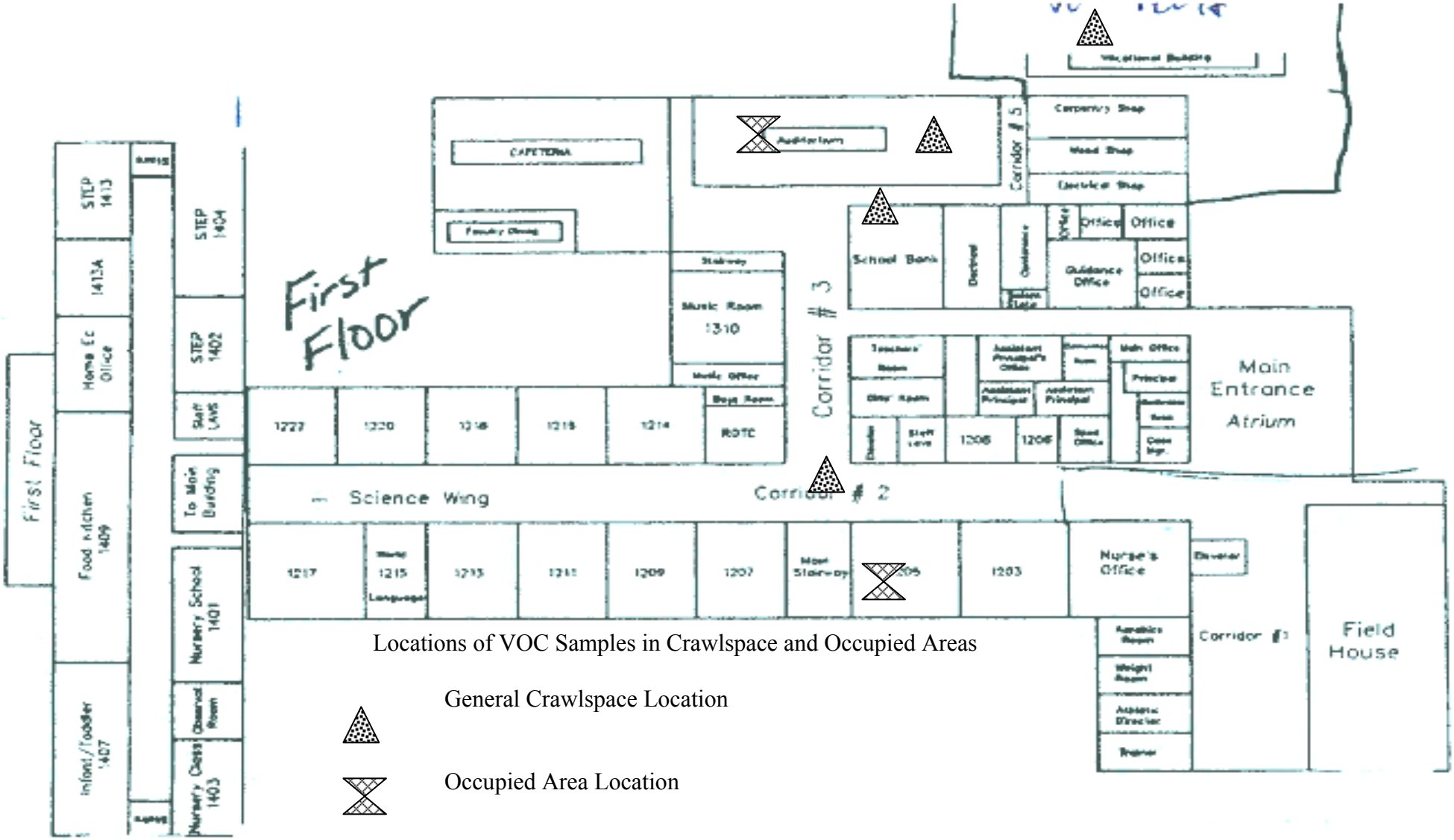
Crawlspace air is drawn through open hatch, into space behind the plywood wall in Picture 24, Note debris accumulation on grill of vent

Map 1

Aerial view of Gloucester High School

Map 2

Location of VOC Sampling conducted in Crawlspace and Occupied Areas on January 22, 2008



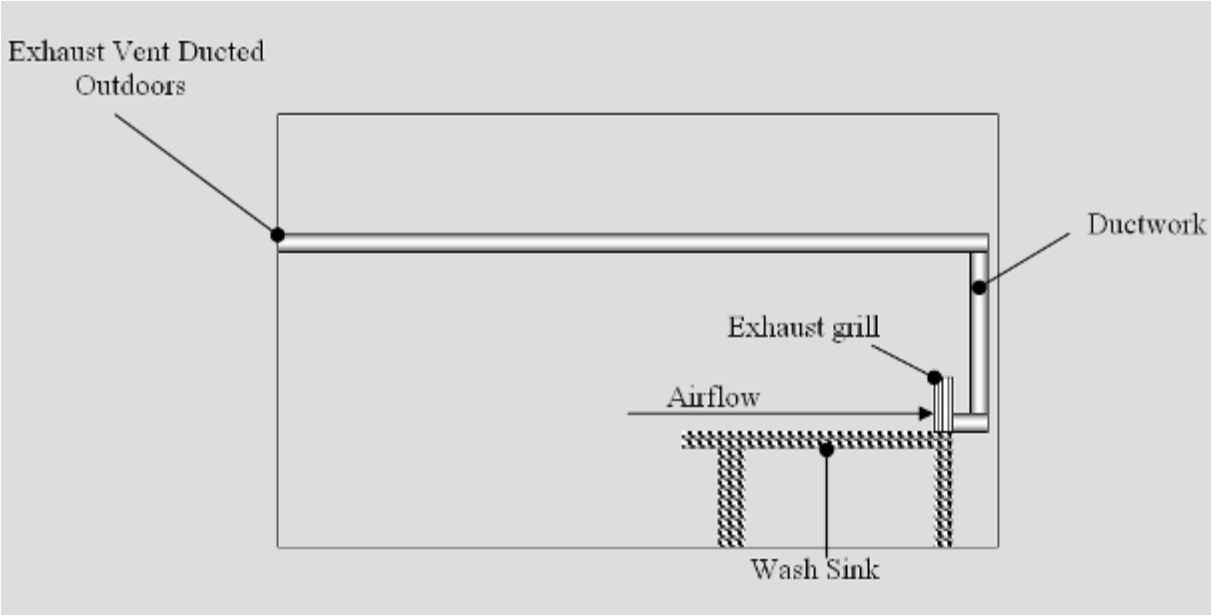
Locations of VOC Samples in Crawlspace and Occupied Areas

General Crawlspace Location

Occupied Area Location

Figure 2

Suggested Reconfiguration of Dark Room Exhaust Ventilation



(Drawing is an example, not an actual representation)

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background		73	43	377	ND	ND				Clear, sunny
Book storage room	0	78	42	563	ND	ND	N	N	N	Heat from computer network, dusty
Cafeteria	60	77	50	723	ND	ND	Y 4/16 open	Y	Y	Exterior DO, 20 WD-CT
Custodian's Office	0	72	43	498	ND	ND	N	Y	Y	Storage of cleaning/ maintenance materials
Dr. Goodwin's office	0	73	45	503	ND	ND	Y	N	Y Sealed	DO
Faculty Dining	0	75	50	1039	ND	ND	Y Open	Y Off, return blocked	Y Dust/debris	
Guidance, main office	4	70	52	599	ND	ND	Y	Y	Y	DO
History office	1	74	47	517	ND	ND	N	N	Y Clogged with Dust/debris	4 WD-CT
JROTC office	9	72	49	707	ND	ND	N	Y	Y Off	DO, PC, 2 WD-CT

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect

AP = air purifier
AT = ajar ceiling tile
CD = chalk dust
CT = ceiling tile

DEM = dry erase materials
DO = door open
MT = missing ceiling tile
PF = personal fan

PS = pencil shavings
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%
Particle matter 2.5 < 35 ug/m^3

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Lecture hall	0	73	40	360	ND	ND	N	Y	Y	DEM
Main office	4	70	52	595	ND	ND	N	Y	Y	2 WD-CT
Math office	1	74	46	525	ND	ND	N	Y	Y Dust/debris	DO, 2 WD-CT
Media center	50	75	44	626	ND	ND	Y	Y	Y dust/debris	
Nurse's office	1	72	50	610	ND	ND	Y	Y	Y	DO
SADD office	2	70	51	653	ND	ND	N	Y	Y	DEM
STARR	2	74	42	502	ND	ND	N	Y	Y Dust/debris	DEM
Teachers' workroom	1	74	44	599	ND	ND	N	Y	Y	1 WD-CT, 2 MT
1202A	1	70	51	614	ND	ND	Y	Y Dirt/debris	Y VL	DO, dust

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Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1202C	1	70	51	589	ND	ND	N	Y	Y VL	DEM, UF
1203	8	71	52	653	ND	ND	Y	Y	Y	DO, DEM, plants
1204	0	71	50	582	ND	ND	N	Y	Y	DO
1205	3	73	42	409	ND	ND	Y Open	Y	Y	Dust
1206	0	69	52	545	ND	ND	N	Y	Y	
1207	8	74	48	696	ND	ND	Y Open	Y	Y	DEM
1211	0	72	49	461	ND	ND	Y Open	Y Off, plants	Y	Plants in standing water
1213	0	72	46	381	ND	ND	Y Open	Y Off	Y	DO, DEM particles in tray, 3 WD-CT near window
1215	4	72	44	384	ND	ND	Y Open			DO, 1 WD-CT

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Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1216	4	74	48	682	ND	ND	Y 2/6 open	Y	Y dust/debris	DO
1217	0	72	47	363	ND	ND	Y Open	Y Off	Y	DO, DEM
1218	6	75	52	908	ND	ND	Y	Y Off accumulated dirt/debris	Y Off furniture	DO, univent turned off by occupant due to heat, water infiltration via exhaust, DEM, cleaners, dust
1220	18	75	51	880	ND	ND	Y	Y Clutter	Y Items	DEM, clutter, plants
1222	19	74	52	987	ND	ND	Y	Y Off, plants, clutter	Y Furniture	DEM, clutter, dust, plants, 2 MT/AT
1302A	1	69	53	635	ND	ND	Y 1/2 open	Y	Y	DO
1302B	0	69	53	693	ND	ND	Y 2/2 open	Y	Y	AD, plants
1302C	1	70	53	759	ND	ND	Y	Y	Y	

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								Supply	Exhaust	
1302D	1	70	53	655	ND	ND	N	Y	Y	DO, AP
1302E	0	70	52	581	ND	ND	N	Y	Y	Inter-room DO
1310 Music	11	75	43	861	ND	ND	Y	Y Off	Y Off	13 WD-CT along window, DEM
1401	3	71	47	550	ND	ND	Y	Y	Y	Dryer Vent, DO
1402	0	71	50	517	ND	ND	Y	Y	Y	Musty Odor, TB
1403	4	72	49	745	ND	ND	Y Open	Y	Y	Musty Odor, WD-GW, DEM
1403	21	72	50	848	ND	ND	Y	Y	Y	WD-GW, DEM, 10 WD-CT, DO
1409	1	71	49	476	ND	ND	Y	Y	Y	Unvented Dryer, DEM
1411	5	71	47	467	ND	ND	Y Open	Y Off	Y	

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								Supply	Exhaust	
2201	20	76	48	994	ND	ND	Y Open	Y Off items	Y File cabinet	
2202B	2	74	44	601	ND	ND	N	Y	Y	DO, AT
2203	25	76	52	1153	ND	ND	Y	Y	Y	CD, DEM, odors corkboard: remove board and inspect behind/in wall
2205	0	71	46	484	ND	ND	Y 2/6 open	Y Off Clutter	Y Boxes, clutter	DO, AP
2207	1	75	43	884	ND	ND	Y	Y Off, clutter	Y Boxes, clutter, furniture	DEM, clutter, 2 MT/AT, bowed CT, 2 WD-CT
2209	8	75	47	528	ND	ND	Y 1/6 open	Y Off	Y Furniture	DEM, 2 WD-CT, 1 MT/AT
2210	5	75	49	888	ND	ND	Y	Y Clutter	Y Dust/debris	DEM, cleaners, clutter, plants, odor from balloons hanging from CT

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	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2211	7	75	47	593	ND	ND	Y 1/5 open	Y Noisy fan belt	Y	DEM, cleaners, clutter, 7 WD-CT, 2 MT/AT
2212	0	75	67	745	ND	ND	Y	Y Off	Y dust/debris	DO, DEM
2214	14	76	47	823	ND	ND	Y 4/16 open	Y off	Y Weak	WD-floor, utility holes
2215	17	73	49	464	ND	ND	Y 1/6 open	Y Off	Y Dust/debris, furniture	DO, 2 MT/AT
2215	17	73	49	464	ND	ND	Y 1/8	Y	Y Dust/debris, furniture	DO, 2 MT/AT
2216	0	73	49	832	ND	ND	Y	Y Items	Y	DEM, 2 MT/AT
2217	1	73	46	378	ND	ND	Y 4/6 open	Y Off	Y Dust/debris, furniture	DO, DEM
2217	1	73	46	378	ND	ND	Y 4/6 open	Y Off	Y Dust/debris, furniture	DO, DEM

ppm = parts per million
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ND = non detect

AP = air purifier
AT = ajar ceiling tile
CD = chalk dust
CT = ceiling tile
PF = personal fan

DEM = dry erase materials
DO = door open
MT = missing ceiling tile

PS = pencil shavings
TB = tennis balls
UF = upholstered furniture
WD = water-damaged

VL=
AD

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2218	10	74	48	812	ND	ND	Y 1/7 open	Y	Y	DO, DEM, PS
2225D	1	73	43	508	ND	ND	N	Y	Y Dust/debris	DEM
2301	1	75	43	446	ND	ND	Y Open	Y Off	Y	1 WD-CT, 1 AT
2303	12	75	43	523	ND	ND	Y Open	Y off	Y Dust/debris	DEM, DO, 1 WD-CT
2305	0	75	44	523	ND	ND	Y Open	N	N	
2308	3	76	43	566	ND	ND	Y	Y	Y	
2401	16	74	45	486	ND	ND	Y	Y	Y	DO
2402	1	74	46	495	ND	ND	Y Open	Y Off	Y	DO
2403	1	74	45	398	ND	ND	Y	Y Off	Y	WD-GW, DEM, 6 WD-CT, DO

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VL=

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CT = ceiling tile
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PS = pencil shavings
TB = tennis balls
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Comfort Guidelines

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	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
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Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2407	1	74	45	445	ND	ND	Y Open	Y Off	Y	DEM, DO
2411	1	74	40	452	ND	ND	Y Open	Y	Y	DO
2413	1	74	48	444	ND	ND	Y	Y Off	Y Off	DEM, DO
2415	2	73	48	437	ND	ND	Y Open	Y Off	Y Off	2 WD-CT
3105	2	74	42	432	ND	ND	Y Open	Y	Y	
3107	4	74	42	413	ND	ND	Y Open	Y	Y	25 Computers, DO
3109	13	74	45	438	ND	ND	Y Open	Y	Y	Lead Glazes, DEM, 4 WD-CT, Kiln Vented
3111	1	76	46	425	ND	ND	Y Open	Y Off	Y Off	DO
3202	1	74	51	622	ND	ND	Y	Y Off, furniture	Y Dust/debris	DEM, 1 MT/AT

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3202	0	75	42	391	ND	ND	Y	Y Off	Y Dust/debris	DO, DEM, 1 MT/AT
3204	18	76	49	862	ND	ND	Y	Y Off	Y Dust/debris	DO, DEM, 29 computers, 1 MT/AT
3204	10	78	43	460	ND	ND	Y Open	Y Off	Y	DO, DEM, MT, dust accumulation
3205	15	73	47	498	ND	ND	Y Open	Y Off	Y Furniture, dust/debris	DO, 1 WD-CT
3207	1	72	47	445	ND	ND	Y Open	Y Off, items	Y Furniture	DO, DEM, 2 WD-CT
3210	1	75	47	535	ND	ND	Y	Y	Y Dust/debris	
3211	1	76	48	643	ND	ND	Y	Y Off	Y Dust/debris	DO, 4 WD-CT
3212	1	75	45	438	ND	ND	Y 2/4 open	Y Dust/debris	Y Dust/debris	DO

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3213	13	76	49	781	ND	0.1	Y 1/7 open	Y Off, dust/debris	Y Dust/debris	DO, DEM, DEM odors
3215	1	75	48	384	ND	ND	Y 1/6 open	Y Off, clutter	Y Furniture	DO, DEM
3216	0	73	46	534	ND	ND	Y 1/6 open	Y Clutter	Y Clutter	DEM
3218	1	77	49	685	ND	ND	Y	Y Off	Y VL	DO, utility hole
3301	12	75	45	460	ND	ND	Y Open	Y Off, items	Y	1 AT, 3 WD-CT (damaged during heavy rains), occupant reported temp extremes
3303	1	76	43	440	ND	ND	Y Open	Y Potting soil	Unable to identify	3 WD-CT, WD plaster, peeling paint
3305	4	74	45	591	ND	ND	N	Y Dust/debris	Y Clogged dust/debris	DO, DEM
3306	6	76	45	580	ND	ND	Y 2/6 open	Y Off	Y	DO, DEM, 4 WD-CT

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Comfort Guidelines

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Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3307	1	74	45	489	ND	ND	N	Y	Y	2 WD-CT, breach between sink countertop/backsplash
3307A	0	75	45	523	ND	ND	N	Y	Y Dust/debris	1 AT, PC
3308	0	76	45	580	ND	ND	Y 2/6 open	Y	Y	DO
3312	4	76	45	718	ND	ND	Y 5/6 open	Y Off	Y Dust/debris	DO, 3 WD-CT
3402	0	76	40	528	ND	ND	Y Open	N	Y	Food, DO
3403	0	74	47	400	ND	ND	Y Open	Y	Y	DO
3404	7	70	48	645	ND	ND	Y Open	Y Off	Y	7 MT, DBV, DEM, DO
3407	13	74	50	518	ND	ND	Y Open	Y Off	Y	DO, DEM, 3 WD-CT, DO
3407 Prep	0	75	48	509	ND	ND	Y	Y	Y	

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Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 1 (continued)** **Date: 05/30/2007**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	TVOCs (ppm)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3410	23	76	48	769	ND	ND	Y Open	Y Off	Y	DEM, DO
3411	14	75	47	572	ND	ND	Y Open	Y Off	Y	DBR, DEM

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	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 2** **Date: 01/22/2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 ($\mu g/m^3$)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
background		29	58	357	ND	25-50				
Health Exam Room	0	70	14	662	ND	10	Y	Y	Y	
Health Office	0	70	14	673	ND	8	Y	Y	Y	DO
Health Suite Main	1	69	14	765	ND	11	N	Y dirt	Y	
Lecture Hall 3rd Floor	0	71	21	459	ND	11	N	Y dust	Y	8 CT-WD
Library	15	69	16	638	ND	13	Y	Y	Y	4 CT-WD
Lounge 2nd Floor	15	68	15	508	ND	12	Y	N	Y	UF
Math Office	0	71	15	810	ND	18	N	Y dust	Y dust	4 CT-WD
Office 3rd Floor, Corridor 3	0	71	21	629	ND	12	N	Y	Y	No Air Flow

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Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
ROTC	1	69	14	695	ND	10	N	Y dirt	Y	DO; 1 AT; PF
Science Office	0	71	21	862	ND	19	Y	N	Y weak	Radiator unit; 2 copiers
1201	5	70	20	634	ND	11	Y	Y	Y	
1203	1	67	14	579	ND	12	Y	Y	Y	DO; DEM
1204	1	70	19	637	ND	12	N	Y dust, debris	Y	DO
1205	3	67	14	587	ND	12	Y	off clutter	Y dusty	DEM; Plants
1205A	0	68	14	537	ND	11	Y	Y	Y	2 CT-WD; DO
1206	3	70	18	571	ND	11	N	Y	Y	DO
1208	2	70	19	559	ND	12	N	Y dust, debris	Y	DO; UF; carpet

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DO = door open
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TB = tennis balls
UF = upholstered furniture
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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
600 - 800 ppm = acceptable
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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%
Particle matter 2.5 < 35 ug/m^3

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1211	15	71	24	873	ND	21	Y	off dust, plants	Y	
1213	16	69	22	793	ND	18	Y	off	Y	1 CT-WD
1216	12	69	22	1105	ND	17	Y	off dust, debris	Y	
1217	11	71	23	952	ND	22	Y	off panel removed	Y	
1218	21	70	23	1095	ND	17	Y	off panel removed	Y	
1220	4	69	21	819	ND	20	Y	off	Y	
1401	0	70	20	523	ND	15	Y	Y	off	WD along window & exterior wall; 9 broken CTs; Cleaners; Plants
1402	0	71	20	554	ND	16	Y	Y	off	PF; TB; DEM

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Carbon Dioxide: < 600 ppm = preferred
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Temperature: 70 - 78 °F
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Particle matter 2.5 < 35 ug/m^3

Location: Gloucester High School **Indoor Air Results**

Address: 32 Leslie O'Johnson Rd., Gloucester, MA **Table 2 (continued)** **Date: 01/22/2008**

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
1403	3	70	21	667	ND	15	Y	Y	off	Water penetration along exterior windows; HEPA-AP on floor; DO
1404	5	68	22	602	ND	17	Y	Y	off	8 occupant gone 5 minutes; 1 CT-WD; DEM; DO
1407	6	67	21	797	ND	15	Y	Y blocked	Y dust	
1409	2	68	23	931	ND	25	Y	Y blocked	off	18 occupants gone 20 min.; HEPA-AP not plugged in; breach between sink and backsplash; 1 WD-CT
1413	3	68	23	623	ND	16	Y	Y	off	DO; PF-dusty
2207	18	69	15	526	ND	14	Y	Y pottery atop vent	off	2 CT-WD
2213	1	67	16	536	ND	13	Y	off	Y	1 CT-WD
2215	25	70	20	869	ND	15	Y	off	Y	DEM; DO

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2217	26	69	20	833	ND	15	Y	off	Y	DO
2218	3	69	17	597	ND	13	Y	Y	Y	DO
2225D	1	70	15	592	ND	12	Y	Y	Y	DO
2301	21	71	18	1092	ND	15	Y	off	Y	
2303	24	70	19	1065	ND	13	Y	Y	Y	1 CT-WD; DO
2308	0	69	15	734	ND	12	Y	Y	Y	DEM; DO
2404	2	67	22	1148	ND	12	Y	Y	Y	DO
2407	11	69	18	892	ND	15	Y	Y	Y	DO
2407	1	68	22	1786	ND	14	Y	Y	Y	Clutter; DO

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
2411	19	71	18	889	ND	15	Y	Y	Y	DO
2413	20	71	18	900	ND	16	Y	Y	Y	DEM; DO
3105	1	71	15	542	ND	16	Y	Y	Y	Clutter; DO; DEM; Photo chemical odors; 1 MT
3105 Darkroom	1	73	19	582	ND	12	N	Y	Y dust	1 CT-WD; AC on wall, dirty filters
3107	2	73	19	463	ND	15	Y	Y	off	2 CT-WD; DEM; 22 computers
3109	0	74	15	441	ND	12	Y	Y	Y	Lead-free glazes; 5 CT-WD; 1 AT
3109A	0	74	15	442	ND	13	N	Y	Y	Ducted Kiln; 2 CT-WD; DO
3111	1	70	15	485	ND	10	Y	Y	Y	2 CT-WD; 1 AT; DO
3203	17	69	16	507	ND	17	Y	Y blocked	Y	1 AT; PF; DO

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3205	23	69	16	942	ND	12	Y	Y	Y blocked	DEM; DO; Clutter
3207	2	69	16	528	ND	11	Y	off	Y blocked	DEM; 3 CT-WD
3209	6	66	16	734	ND	11	Y	Y blocked	Y blocked	2 MT; 2 CT-WD; DO
3211	5	66	17	532	ND	13	Y	off	Y dust	DEM; 25 computers
3212	7	71	23	912	ND	16	Y	off dust	Y	Univent parts on order; DEM
3213	24	68	10	1095	ND	21	Y	off blocked, plants, dust, debris	Y blocked	DEM
3214	17	70	30	1852	ND	15	Y	off	Y vent shut	CD; DEM
3216	18	70	26	1188	ND	14	Y	off	Y	DEM

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Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3217	1	67	16	534	ND	12	Y	Y clutter	Y blocked	DO; 2 CT-WD
3218	3	72	21	667	ND	16	Y	Y dust	Y	Dust/Debris along windowsill; DEM
3301	2	72	20	566	ND	14	Y	Y	N	DEM; 3 CT-WD
3303	28	71	28	2250	ND	12	Y	off	off	DEM; 3 CT-WD
3305	1	70	20	590	ND	12	N	Y	Y dust	DEM; DO; Room always cold
3306	2	74	15	828	ND	10	Y	off	Y	DO; Temp. concerns during computer operation time and full classroom; 4 CT-WD
3307	7	71	23	938	ND	13	N	Y	Y	Breach between sink and backsplash
3308	1	73	16	788	ND	9	Y	Y blocked	Y	DEM; 1 AT; items; 24 computers
3312	19	71	20	1153	ND	8	Y	Y	Y	DO; DEM; 24 computers

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Comfort Guidelines

Carbon Dioxide: < 600 ppm = preferred
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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%
Particle matter 2.5 < 35 ug/m^3

Location/ Room	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (µg/m^3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
3403	2	69	17	640	ND	12	Y	Y	Y dust	DO; DEM
3404	5	71	22	1039	ND	18	Y	Y clutter	Y weak	objects hanging from ceiling; 2 MT; many CTs cracked
3411	0	69	16	555	ND	10	Y	Y clutter	Y	1 AT; DEM; Items on tables
3415	1	68	16	544	ND		Y	off clutter	Y dust	DEM; DO; Chemical storage in hoods, Sign: "when not in use turn off"; Breach around exhaust duct in CT

ppm = parts per million
µg/m^3 = micrograms per cubic meter
ND = non detect

AP = air purifier
AT = ajar ceiling tile
CD = chalk dust
CT = ceiling tile

DEM = dry erase materials
DO = door open
MT = missing ceiling tile
PF = personal fan

PS = pencil shavings
TB = tennis balls
UF = upholstered furniture
WD = water-damaged

Comfort Guidelines

Carbon Dioxide:	< 600 ppm = preferred	Temperature:	70 - 78 °F
	600 - 800 ppm = acceptable	Relative Humidity:	40 - 60%
	> 800 ppm = indicative of ventilation problems	Particle matter 2.5	< 35 ug/m^3