INDOOR AIR QUALITY ASSESSMENT

Massachusetts Rehabilitation Commission
6 Clinton Avenue
Pittsfield, Massachusetts 01201

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 Kate Angelini, Area Director of the Massachusetts Rehabilitation Commission (MRC), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the MRC office located at 6 Clinton Street, Pittsfield, Massachusetts. The request was prompted by concerns of chronic water damage as well as the potential for mold growth and respiratory irritants in the building. On April 10, 2009, a visit to conduct an assessment was made to the MRC by Lisa Hébert and James Tobin, Environmental Analysts/Indoor Air Quality Inspectors in BEH's Indoor Air Quality (IAQ) Program.

The MRC is one of several agencies located within a one-story, brick building that was originally built in the early 1900s as a car dealership. Renovations took place in the 1970s converting the dealership into office space. As can be seen in Figure 1, the central section of the building has a basement and the remainder of the building is slab on grade. The building has a flat, rubber membrane roof. Windows are not openable in the MRC office.

Methods

Air tests for carbon dioxide, temperature, relative humidity and carbon monoxide 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 visual inspection of building materials for water damage and/or microbial growth. Moisture content of porous building materials was measured with a Delmhorst, BD-2000 Model, Moisture Detector equipped with a Delmhorst Standard Probe.

Results

The MRC has an employee population of 12 and can be visited by up to 20 people daily. Tests were taken under normal operating conditions and results appear in Table 1. Moisture readings appear in Table 2.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed at the time of the assessment, indicating adequate air exchange in the MRC office. It is important to note, however, that several offices were empty/sparsely populated, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with full occupancy.

The heating, ventilating and air-conditioning (HVAC) system reportedly consists of two air-handling units (AHUs) located on the roof (the rooftop AHU configuration could not be confirmed by BEH staff, as there was no access to the roof on the day of the assessment). Conditioned air is distributed throughout the MRC via ducted air diffusers. Exhaust air is ducted back to the AHUs via wall mounted return vents (Pictures 1 and 2). AHU filters and heating coils are reportedly serviced on a quarterly basis.

As can be seen in Picture 1, MRC occupants have attempted to adjust the airflow within their space by obstructing the air diffuser in an effort to reduce the volume of air entering the room. This alteration can create an imbalance in the system, resulting in uneven heating/cooling conditions leading to comfort complaints.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of building 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 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 20 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.

Temperature measurements in the MRC ranged from 71° F to 75° F, which were within the MDPH recommended comfort range (Table 1). 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. 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.

The relative humidity measured in the building ranged from 19 to 24 percent, which was below the MDPH recommended comfort range (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

In order for building materials to support mold growth, a source of water exposure is necessary. In order to control mold growth, it is necessary to identify and eliminate water moistening building materials. Materials with increased moisture content *over normal* concentrations may indicate the possible presence of mold growth. BEH staff conducted moisture testing of water damaged/stained window sills, walls adjacent to the windows and carpeting below windows in several areas (Pictures 3 through 5). These building materials had above normal moisture content in Kate Angelini's office and the main office at the time of the assessment (Table 2), which may be an indication of chronic water penetration. It is important to note that prior to the assessment, the last measurable rain in the Pittsfield area was April 7, 2009, three days prior to the assessment date of April 10, 2009 (Weather Underground, 2009), indicating that the window had been moistened for greater than 48 hours.

It is important to note that moisture content of materials is a real-time measurement of the conditions present in the building at the time of the assessment. Repeated water damage to porous building materials (e.g., GW, ceiling tiles, and carpeting) can result in microbial growth. 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.

BEH staff examined the building to identify breaches in the building envelope that could provide a source of water penetration. The following conditions were identified:

- sealant and caulking around the window system was damaged and/or missing;
- an abandoned mail slot was covered with a piece of wood paneling (Picture 6);
- a wall-mounted air conditioner had gaps around it (Picture 7);
- exterior brick and mortar was damaged and/or missing (Picture 8); and,
- downspouts and gutters were damaged and rusted.

These conditions can undermine the integrity of the building envelope and provide a means of water entry by capillary action into the building through exterior walls, foundation concrete and masonry (Lstiburek & Brennan, 2001).

BEH staff noted musty odors emanating from the electrical outlets located on the floor of the main office. Tape appeared to have been placed over outlets not in use in order to prevent the odors from entering the office (Picture 9). Since any moisture gaining entry to the building envelope, particularly under the slab, can contribute to the musty odors emanating from the floor-mounted electrical outlets, every attempt should be made to eliminate moisture from entering the building envelope. Likewise, any open utility holes within the MRC should be identified and properly sealed. Since the building was formerly used as a car dealership, the building may have originally contained floor drains or abandoned plumbing drains that exist in wall cavities. It would be prudent to examine the original floor plans (if available) to determine the presence and location of any existing floor drains, in that the drain is not adequately sealed.

Numerous plants, some lacking drip pans, were observed in the office. Plants should be equipped with drip pans to prevent water pooling. In one instance, paper was placed beneath a plant to absorb excess water (Picture 10). Paper is a porous material that can grow mold if wetted repeatedly. Plants should be properly maintained and located away from the air stream of mechanical ventilation to prevent aerosolization of dirt, pollen or mold.

A water cooler was located over a carpeted area in the main office. Overflow of the water basin or spills that often occur can moisten carpeting, which can lead to mold growth. It is also important that the catch basins of water coolers be cleaned regularly as stagnant water can be a source of odors, and materials (i.e., dust) collected in the water can provide a medium for mold growth.

BEH staff found water-damaged ceiling tiles in a number of areas (Table 1/Picture 11), which can indicate leaks from the roof or plumbing system. Water-damaged ceiling tiles can provide a source of mold and should be replaced after a water leak is discovered and repaired.

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 PM 2.5.

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. On the day of assessment, outdoor carbon monoxide concentrations were non-detect (ND) (Table 1). No measurable levels of carbon monoxide were detected inside the building during the assessment.

Particulate Matter (PM2.5)

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.

Outdoor PM2.5 concentrations the day of the assessment were measured at 11 $\mu g/m^3$. PM2.5 levels measured inside the MRC ranged from 3 to 6 $\mu g/m^3$ (Table 1). Both indoor and outdoor PM2.5 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 mechanical devices and/or activities that occur in the MRC 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.

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 the office for products containing these respiratory irritants.

Deodorizing materials were observed in the rest room. Air deodorizers contain chemicals that can be irritating to the eyes, nose and throat of sensitive individuals. Many air fresheners contain 1,4-dichlorobenzene, a VOC which may cause reductions in lung function (NIH, 2006). Furthermore, deodorizing agents do not remove materials causing odors, but rather mask odors that may be present in the area.

Other Conditions

Other conditions that can affect indoor air quality were observed during the assessment. A number of air diffusers, return vents and personal fans were observed to have accumulated dust. Re-activated air diffusers and fans can aerosolize dust accumulated on diffuser and fan blades.

A white, insulating material in a state of disrepair was observed in the basement. If the material is found to contain asbestos, it should be remediated in conformance with all applicable Massachusetts asbestos abatement and hazardous materials disposal laws.

Lastly, broken fluorescent light bulbs were found in the basement. Fluorescent light bulbs contain mercury, and must be properly handled and stored in order to prevent breaks and mercury spills. After speaking with the owner of the building regarding the hazards associated with exposure to mercury, BEH staff forwarded the Massachusetts Department of Environmental Protection's (DEP's) guidance document for cleaning broken fluorescent light bulbs to the owner. Since fluorescent light bulbs are utilized throughout the MRC, care must be taken to handle, store and dispose of these bulbs in accordance with DEP guidelines.

Conclusions/Recommendations

In view of the findings at the time of the assessment, the following recommendations are made to improve indoor air quality:

1. Operate the HVAC system continuously during periods of occupancy to maximize air exchange.
2. Remove obstructions from air diffusers. To improve thermal comfort/temperature control, it is highly recommended that MRC staff work in conjunction with building

management and their HVAC vendor to examine the configuration of floor space and the placement of diffusers/vents/thermostats.

3. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).

4. Change filters for air-handling equipment (e.g., ACs, AHUs) as per the manufacturers' 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.

5. 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).

6. Ensure roof/plumbing leaks are repaired. Remove/replace water damaged ceiling tiles. Examine the areas above and around for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial if necessary.

7. Consider replacement of window system in the MRC office. During the replacement process, ensure all water damaged materials, (e.g., window sills, casings,) are replaced. Investigate materials adjacent to the windows, including insulation and gypsum wall board, and remove any additional materials that appear to have been water damaged.

8. Seal gaps around the wall mounted AC.

9. Remove and properly seal abandoned mail slot.
10. Repair and replace damaged and/or missing exterior brick and mortar. Consider having exterior walls re-pointed and waterproofed to prevent water intrusion. This measure should include a full building envelope evaluation.
11. Examine gutter/downspout system for damage/leaks and repair/replace as necessary. Ensure downspouts do not deposit water at the base of the building.
12. Examine original building plans, if available, in order to determine whether floor drains were installed in the building. If so, examine the integrity of the seal between the floor and the drain. If necessary, seal any open penetrations.
13. Seal all open utility holes in basement in order to eliminate musty odors emanating into office from floor mounted electrical outlets.
14. Consider providing plants with drip pans and avoid over-watering. Examine drip pans periodically for mold growth. Disinfect with an appropriate antimicrobial where necessary.
15. Discontinue the use of air deodorizers in order to avoid respiratory irritation from chemicals contained in the products.
16. Clean air diffusers, return/exhaust vents and personal fans periodically of accumulated dust.
17. Determine if insulating material in basement contains asbestos. If so, the material should be remediated in conformance with all applicable Massachusetts asbestos abatement and hazardous materials disposal laws.
18. Handle, store and dispose of fluorescent light fixtures in accordance with the Massachusetts Department of Environmental Protection’s guidelines.

19. 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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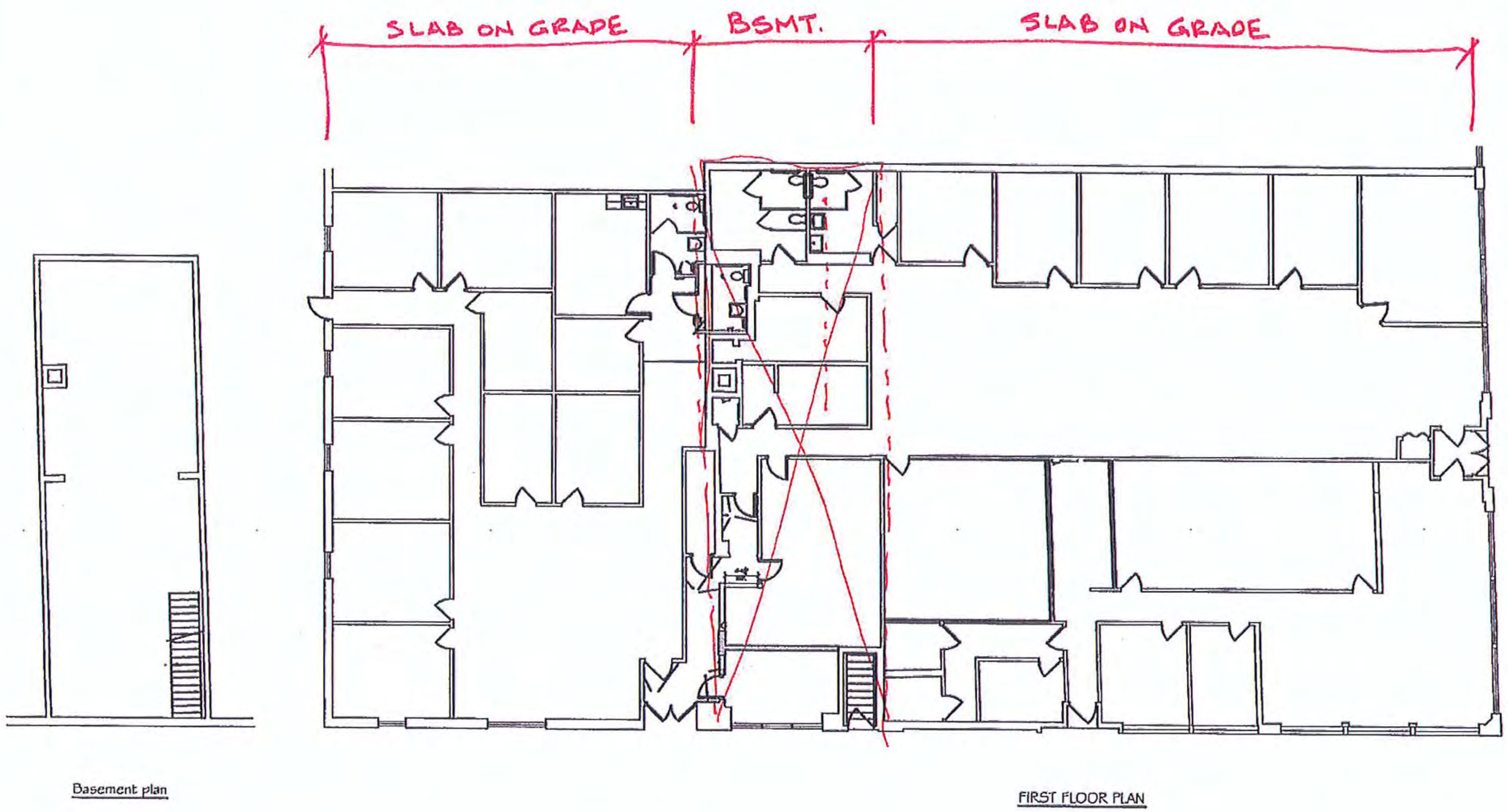
Figure 1



Floor Plan of Building that Houses Pittsfield MRC Office

Picture 1

Fresh Air Diffuser, Note Diffuser is Obstructed

Picture 2

Return Vent

Picture 3

Water Damaged Window Sill

Picture 4

Water Stains on Wall

Picture 5

Water Stained Carpet

Picture 6

Abandoned Mail Slot Covered by Paneling

Picture 7

Wall-Mounted Air Conditioner with Gaps around it

Picture 8

Missing/Damaged Mortar around Exterior Brick

Picture 9

Musty Odors Emanating From Electrical Outlet

Picture 10

Plant Resting on Paper

Picture 11

Water Damaged Ceiling Tile

Location: Massachusetts Rehabilitation Commission **Indoor Air Results**

Address: 6 Clinton Avenue – Pittsfield, MA **Table 1** **Date: April 10, 2009**

Location	Occupants in Room	Carbon Dioxide (ppm)	Temp (°F)	Relative Humidity (%)	Carbon Monoxide (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Outside (Background)		393	61	25	ND	11				
Kate Angelini's Office	2	601	74	21	ND	3	N	Y	N	DO, PF, DEM
Vacant Office	0	547	74	19	ND	3	N	Y	N	DO, plastic covering on air diffuser, PF
Main Office (near copier)	1	593	72	21	ND	4	N	Y	Y	DC, plants, odor from electrical outlet
Main Office (near door)	1	590	73	21	ND	5	N	Y	Y	DC, cooler on carpet, mail slot, wall AC
Main Office (near hall)	1	605	73	21	ND	4	N	Y	Y	DC, PF
Hall Office 1	0	613	73	21	ND	4	N	Y	N	DO, DEM, PF
Hall Office 2 (Bob Walsh)	0	592	73	21	ND	4	N	Y	N	DO, PF
Hall Office 3	0	610	73	21	ND	4	N	Y	N	DO, PF, odor
Hall Office 4	1	605	73	21	ND	4	N	Y	N	DO, PF
Hall Office 5	0	658	73	22	ND	4	N	Y	N	DO, plants
Office 1	0	632	73	21	ND	5	N	Y	N	DO, PF, paper, water stain on

ppm = parts per million
μg/m^3 = micrograms per cubic meter
AC = air conditioner
CT = ceiling tile
DEM = dry erase materials
DC = door closed
DO = door open
ND = non detect
PC = photocopier
PF = personal fan
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

Table 1 (continued)

Location	Occupants in Room	Carbon Dioxide (ppm)	Temp (°F)	Relative Humidity (%)	Carbon Monoxide (ppm)	PM2.5 (μg/m3)	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
(Off main office)										carpet
Office 2 (Mark Dore)	0	657	74	22	ND	5	N	Y	N	DO
Computer Hall	0	614	74	21	ND	4	N	Y	Y	DO
Storage Rm/Office	0	681	74	22	ND	4	N	Y	N	DO, PF
Kitchen	0	638	75	21	ND	4	N	Y	N	DO, PFs
Storage (near conf. room)	0	696	71	24	ND	5	N	N	Y	DC
Conf. Room	0	605	74	21	ND	6	N	Y	Y	DO, DEM

ppm = parts per million
μg/m^3 = micrograms per cubic meter
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TABLE 2

Moisture Test Results
Massachusetts Rehabilitation Commission, 6 Clinton Ave Pittsfield, MA
April 10, 2009

Location	Moisture Measurement (Low = Normal)	Material/Comments
Kate Angelini's Office		
10" from edge of window sill	Low	Wood
12" from edge of window sill	Medium	Wood
Mary's Old Office		
2" from edge of window sill	Low	Wood
4" from edge of window sill	Low	Wood
9" from edge of window sill	Low	Wood
Water damaged wall below window	Low	Wood
Main Office		
10" from edge of window sill	Medium	Wood
11" from edge of window sill	High	Wood
Hallway Office 1		
10" from edge of window sill	Low	Wood
Hallway Office 2		
10" from edge of window sill	Low	Wood
Hallway Office 5		
10" from edge of window sill	Low	Wood