INDOOR AIR QUALITY ASSESSMENT

Results of 24-hour Monitoring

Massachusetts Department of Mental Health
Shetland Park Office Complex
35 Congress St
Salem, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health
Indoor Air Quality Program
September 2010

Background/Introduction

At the request of Lana Jerome, Director of Human Resources Office of Health for the Executive Office of Health and Human Services (EOHHS), the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality concerns at the Salem Offices of the Massachusetts Department of Mental Health (DMH) located in the Shetland Park Office Complex at 35 Congress Street, Salem, Massachusetts. On July 19, 2010, Michael Feeney, Director of BEH's Indoor Air Quality (IAQ) Program, and Suzanne Condon, Associate Commissioner and Director of BEH, visited the DMH Salem Office to discuss health and indoor environmental concerns with DMH staff and EOHHS Human Resources representatives. The result of that meeting was a commitment by MDPH to conduct further IAQ tests and a medical record review/consultation by BEH's physician Dr. John Burstein.

On July 26, 2010, a visit was made to the DMH offices by Mr. Feeney and Sharon Lee, an Environmental Analyst within BEH's IAQ Program. At the time of the visit, Mr. Feeney provided self-addressed envelops for distribution to staff to ensure confidentiality of medical records review participates.

The Shetland Park Complex at 35 Congress Street is a four-story office building, originally constructed as a cotton mill in the early 1930s. The building was renovated in the mid-1990s, prior to occupancy by state offices. The DMH occupies space on the ground floor. Windows are openable throughout the building.

Methods

BEH staff conducted numerous tests for several IAQ parameters. Tests for carbon dioxide, temperature and relative humidity were conducted with a TSI, Q-Trak, IAQ Monitor, Model 7565X. Screening for total volatile organic compounds (TVOCs) was conducted using a RAE Systems MiniRAE 2000 Photo Ionization Detector (PID). Air tests for airborne particle matter with a diameter less than 2.5 micrometers (PM2.5) 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.

BEH staff also conducted real-time testing for relative humidity, temperature, carbon dioxide, carbon monoxide, TVOCs, and PM2.5. These results are listed in Table 1. In addition, 24-hour monitoring for each IAQ parameter was conducted in a central area from approximately noontime on July 26, 2010 to approximately 9:20 AM on July 30, 2010. Graphical representations of 24-hour monitoring conducted from July 26 to 30, 2010 are included in Figures 1 to 5.

Results

The DMH offices have an employee population of approximately 20 and can be visited by up to 10 individuals daily.

Discussion

Ventilation Related Air Sampling

It can be seen from Table 1 that carbon dioxide levels measured during the initial visit on July 26, 2010 were above 800 parts per million (ppm) in 25 of 30 areas surveyed during the assessment (Table 1), indicating air exchange is less than optimal. Carbon dioxide levels of 24-hour monitoring conducted at the DMH from July 26 to July 30, 2010 showed that the a minimum carbon dioxide reading was 308 ppm, while the maximum 904 ppm. Please refer to Figure 1 for a graphical representation of carbon dioxide levels.

Fresh air is distributed by ceiling-mounted air diffusers ducted to air-handling unit (AHU). Return air is drawn into ceiling-mounted vents and ducted back to AHU. It is important to note that the configuration of the HVAC system servicing the DMH offices is different than the Department of Revenue (DOR) offices located on the third floor and previously evaluated by MDPH. The DOR office space is serviced by approximately 12 separate AHUs that are also gas-fired furnaces suspended from the ceiling of that office space. The DMH AHU is configured and constructed in a conventional manner that would not result in the venting of products of combustion into occupied space during its operation. The DMH shares a single AHU that also services offices of the Massachusetts Department of Transitional Assistance (DTA) and Massachusetts Rehabilitation Commission (MRC), which are adjacent to the DMH offices on the first floor of 35 Congress Street. The DMH/DTA/MRC AHU is located in a mechanical room located in the DTA entrance lobby.

To maximize air exchange, the MDPH recommends that both supply and exhaust ventilation operate continuously during periods of occupancy. In order to have proper ventilation with a mechanical supply and exhaust system, the systems must be balanced to

provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. It is recommended that HVAC systems be re-balanced every five years to ensure adequate air systems function (SMACNA, 1994). The date of the last balancing was not available at the time of the assessment, but should have occurred prior to the DMH occupying the space in early 2010.

The Massachusetts Building Code requires that each room have a minimum ventilation rate of 20 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 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, please see Appendix A.

Temperature readings during the real-time assessment conducted on July 26, 2010 ranged from 74° F to 77 ° F (Table 1), which were within the MDPH recommended comfort guidelines in the majority of areas surveyed. The temperature reading for the 24-hour monitoring period of July 26 to July 30, 2010 demonstrated a minimum of 72.6 ° F and a maximum of 81.4 ° F. Please refer to Figure 2 for a graphical representation of temperature measurements. The MDPH recommends that indoor air temperatures be maintained in a range of 70 ° F to 78 ° F in order to provide for the comfort of building occupants. In many cases concerning indoor air quality, fluctuations of temperature in occupied spaces are typically experienced, even in a building with an adequate fresh air supply.

The relative humidity measured in the building during the real-time assessment conducted on July 26, 2010 ranged from 41 to 47 percent, were within or very close to the lower end of the MDPH recommended comfort range. The humidity readings for the 24-hour monitoring period of July 26 to July 30, 2010 demonstrated a minimum of 36.4% and a maximum of 57.1%. Please refer to Figure 3 for a graphical representation of relative humidity levels. 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

BEH staff examined the ceiling, interior walls and floors for signs of water damage. No signs of water staining/damage and/or visible mold growth were noted within the DMH space.

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 and acute health effects upon exposure. To determine whether combustion products were present in the indoor environment, BEH staff obtained measurements for carbon monoxide and PM2.5.

Carbon Monoxide

Carbon monoxide is a by-product of incomplete combustion of organic matter (e.g., gasoline, wood and tobacco). Exposure to carbon monoxide can produce immediate and acute health affects. Several air quality standards have been established to address carbon monoxide and prevent symptoms from exposure to these substances. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. An operator of an indoor ice must take actions to reduce carbon monoxide levels, if those levels exceed 30 ppm, 20 minutes after resurfacing within a rink (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. No measureable levels of carbon monoxide were detected inside the building during the real-time assessment conducted on July 26, 2010 (Table 1). No measurable levels of carbon monoxide was detected during the 24-hour monitoring period of July 26 to July 30, 2010.

Although no detectable carbon monoxide levels were measured during the assessment, it is important to note that cars in the parking spaces immediately below the DMH windows could be a potential source of carbon monoxide and particulates. If vehicles are idling in these parking spaces, vehicle exhaust may enter the DMH space through windows under southerly/westerly wind conditions. Massachusetts law limits vehicle idling to 5 minutes (M.G.L. 1986).

Particulate Matter

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter is airborne solids that can be irritating to the eyes, nose and throat. The NAAQS originally established exposure limits to particulate matter with a diameter of 10 μm or less (PM10). According to the NAAQS, PM10 levels should not exceed 150 micrograms per cubic meter ($\mu g/m^3$) in a 24-hour average (US EPA, 2006). These standards were adopted by both ASHRAE and BOCA. Since the issuance of the ASHRAE standard and BOCA Code, US EPA established a more protective standard for fine airborne particles. This more stringent PM2.5 standard requires outdoor air particle levels be maintained below 35 $\mu g/m^3$ over a 24-hour average (US EPA, 2006). Although both the ASHRAE standard and BOCA Code adopted the PM10 standard for evaluating air quality, MDPH uses the more protective PM2.5 standard for evaluating airborne particulate matter concentrations in the indoor environment. The PM2.5 measured outdoors was 3 $\mu g/m^3$ on July 26, 2010 (Table 1). PM2.5 levels measured inside the building during the real-time assessment conducted on July 26, 2010 ranged from 1 to 4 $\mu g/m^3$ (Table 1), which were well below the NAAQS PM2.5 level of 35 $\mu g/m^3$. The PM2.5 level measured for the 24-hour monitoring period of July 26 to July 30, 2010 demonstrated a minimum of 5 $\mu g/m^3$ and maximum of 33 $\mu g/m^3$. Please refer to Figure 4 for a graphical representation of PM2.5.

The increase in PM2.5 coincides roughly in a change of wind direction. During July 28-29, 2010, the wind direction appears to be mostly from the southwest, which would direct air from the parking lots towards the windows and air intake for the DMH space. 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 indoors can generate particulate

during normal operations. Sources of indoor airborne particulates may include but are not limited to: particles generated during the operation of fan belts in the HVAC system; use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner; and, heavy foot traffic indoors.

Volatile Organic Compounds

Indoor air concentrations can be greatly impacted by the use of products containing volatile organic compounds (VOCs). VOCs are carbon-containing substances that have the ability to evaporate at room temperature. TVOCs measured outdoors was non-detectable on July 26, 2010 (Table 1). TVOC levels measured inside the building were non-detectable during the real-time conducted on July 26, 2010 (Table 1). The TVOC measurement readings for the monitoring period of July 26 to 30, 2010 demonstrated a minimum of 2 ppm and maximum of 2.9 ppm. However, the PID has an accuracy of ± 2 ppm; to determine the sensitivity of the PID for purposes of this VOC evaluation, the instrument was run in another building. Those readings showed that 2 ppm was more likely to equal zero. For that reason, the TVOC range is closer to non-detectible to 0.9 ppm. Please refer to Figure 5 for a graphical representation of TVOCs.

Several possible sources of measurable TVOCs exist in the DMH space. Various office supplies and incomplete combustion of fuel from vehicles parked outside the DMH office may account for these measurements.

Conclusions/Recommendations

Indoor environmental tests for carbon dioxide, temperature, relative humidity, carbon monoxide, Pm2.5 and VOCs in the DMH offices did not demonstrate that health impacts would

likely be associated with occupancy in the building. Based on the observations made during this assessment, the following is recommended:

1. To prevent entrainment of vehicle exhaust, consider posting signs in parking area adjacent to the building instructing vehicle operators to shut off engines as required by Massachusetts General Laws 90:16A.
2. If DMH would like to pursue medical record consultation, please contact the MDPH. These activities may allow for a clearer understanding of whether medically confirmed symptoms are likely to be associated with occupancy at 35 Congress Street.

References

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US EPA. 2006. National Ambient Air Quality Standards (NAAQS). US Environmental Protection Agency, Office of Air Quality Planning and Standards, Washington, DC. http://www.epa.gov/air/criteria.html.

Figure 1: Carbon Dioxide Levels for the Monitoring Period of July 26 - 30, 2010

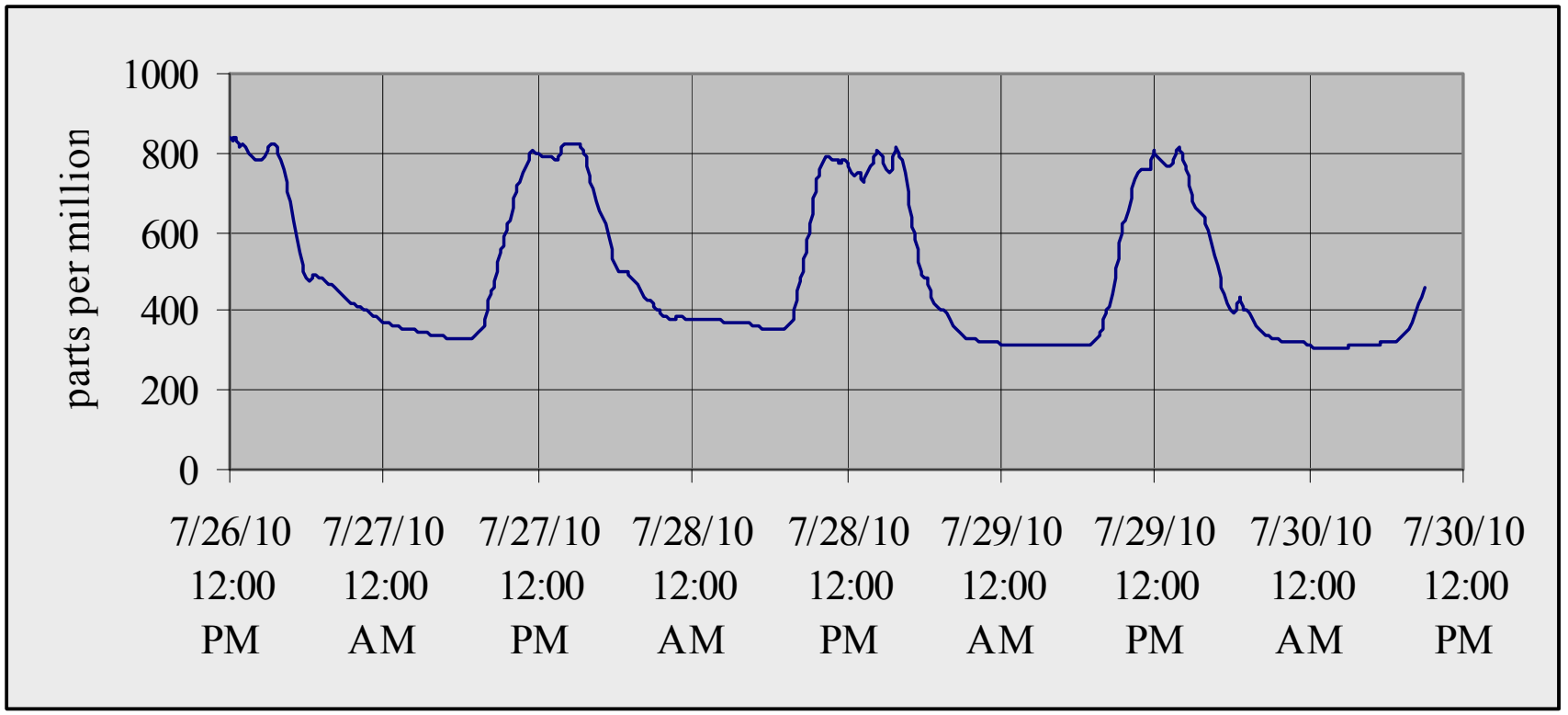

Figure 1

Figure 2: Temperature Measurements for the Monitoring Period of July 26 - 30, 2010

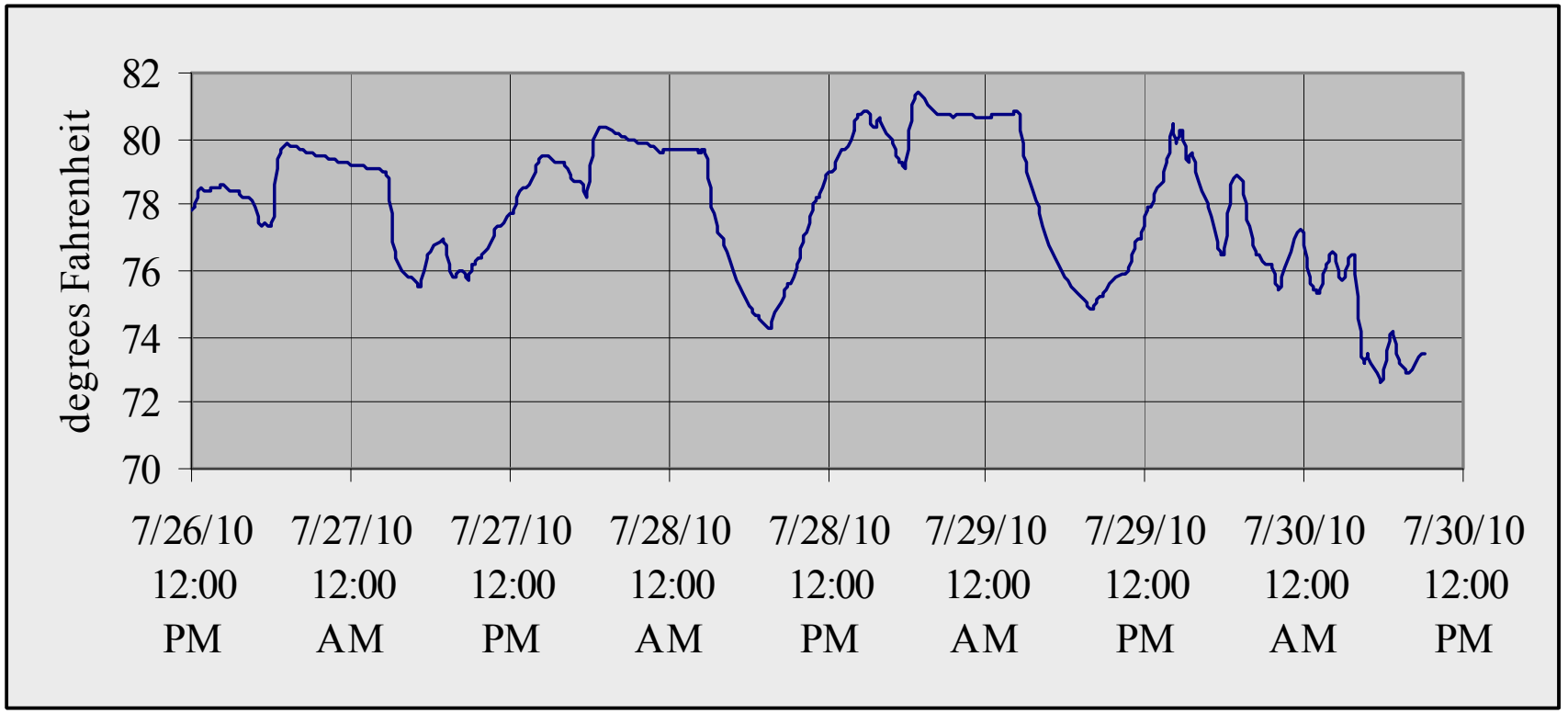

Figure 2

Figure 3: Relative Humidity Measurements for the Monitoring Period of July 26 - 30, 2010

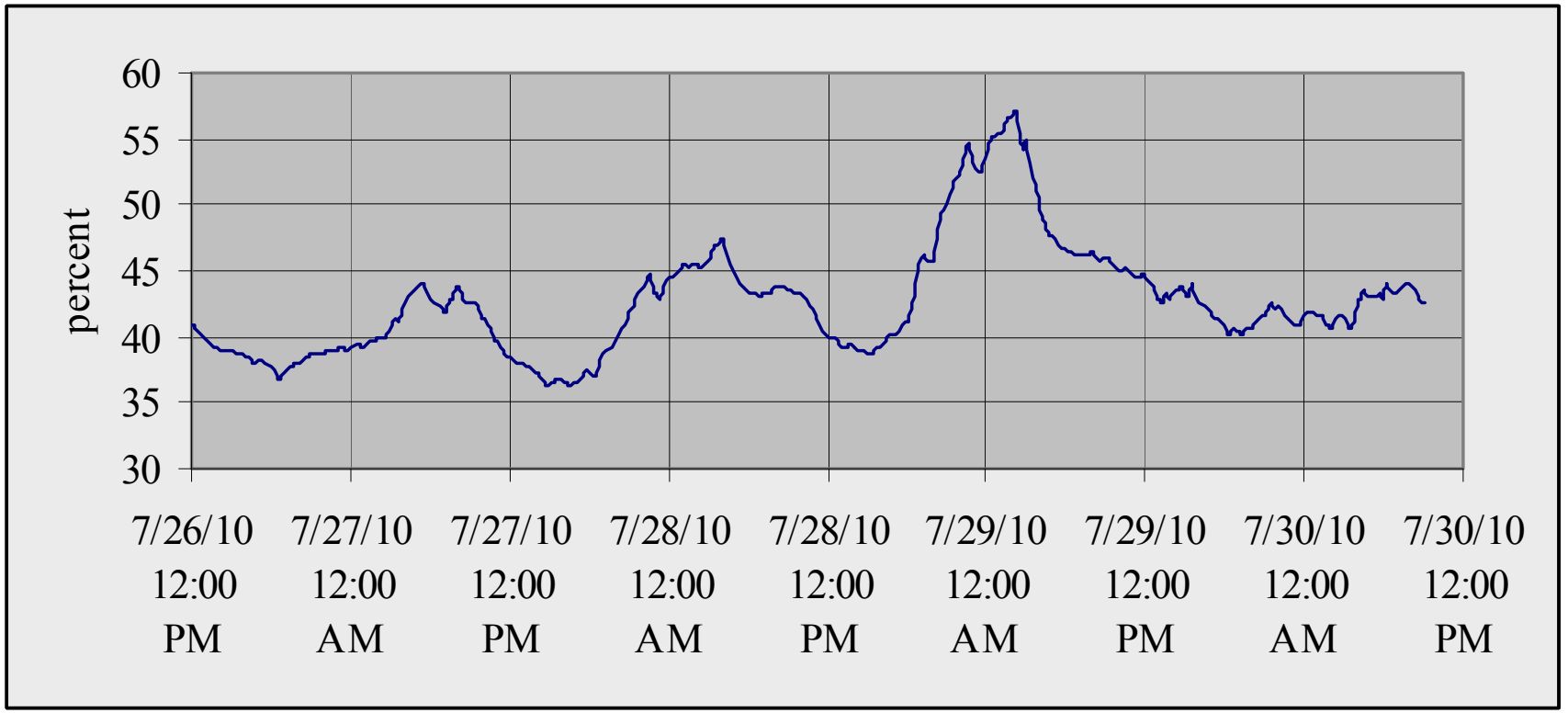

Figure 3

Figure 4: PM2.5 Levels for the Monitoring Period of July 26 - 30, 2010

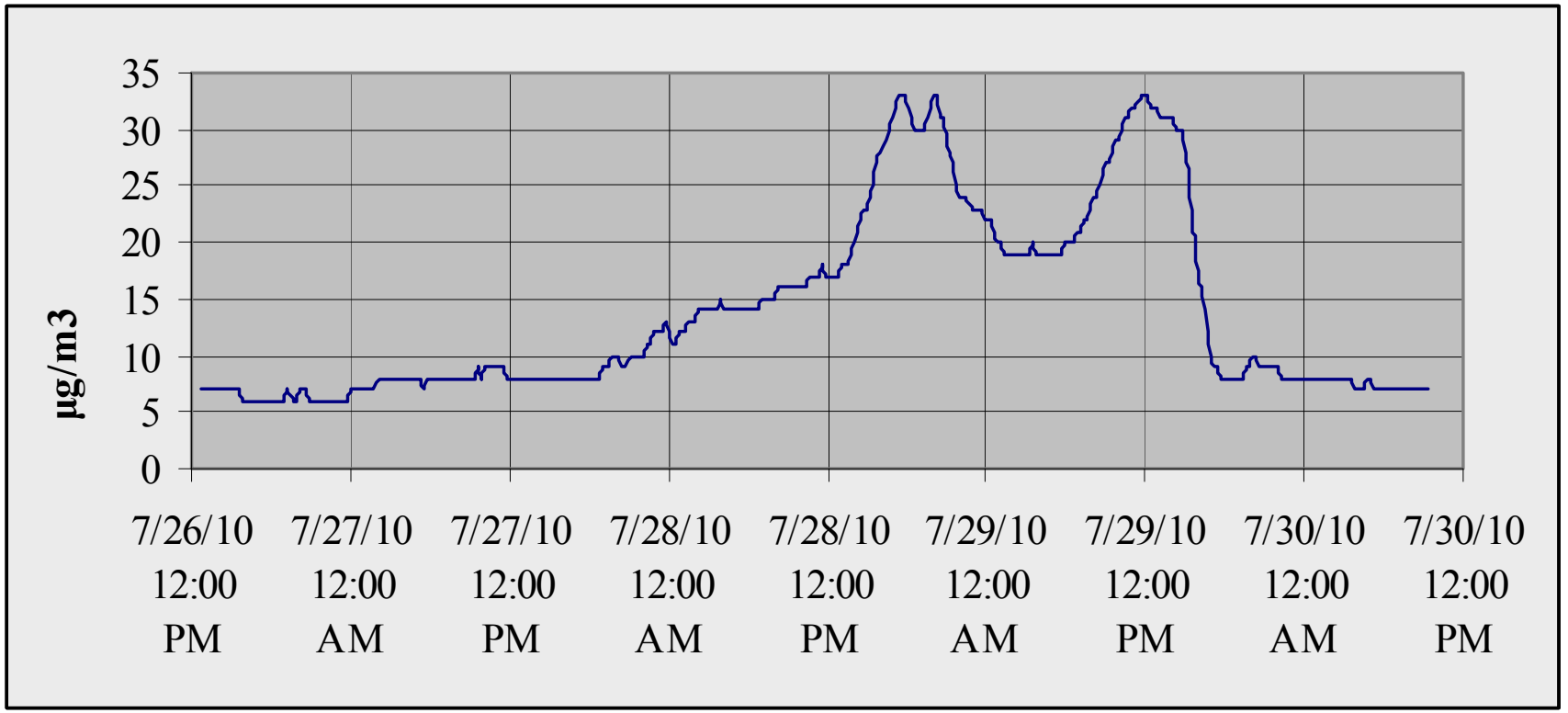

Figure 4

Figure 5: TVOC Levels for the Monitoring Period of July 26 - 30, 2010

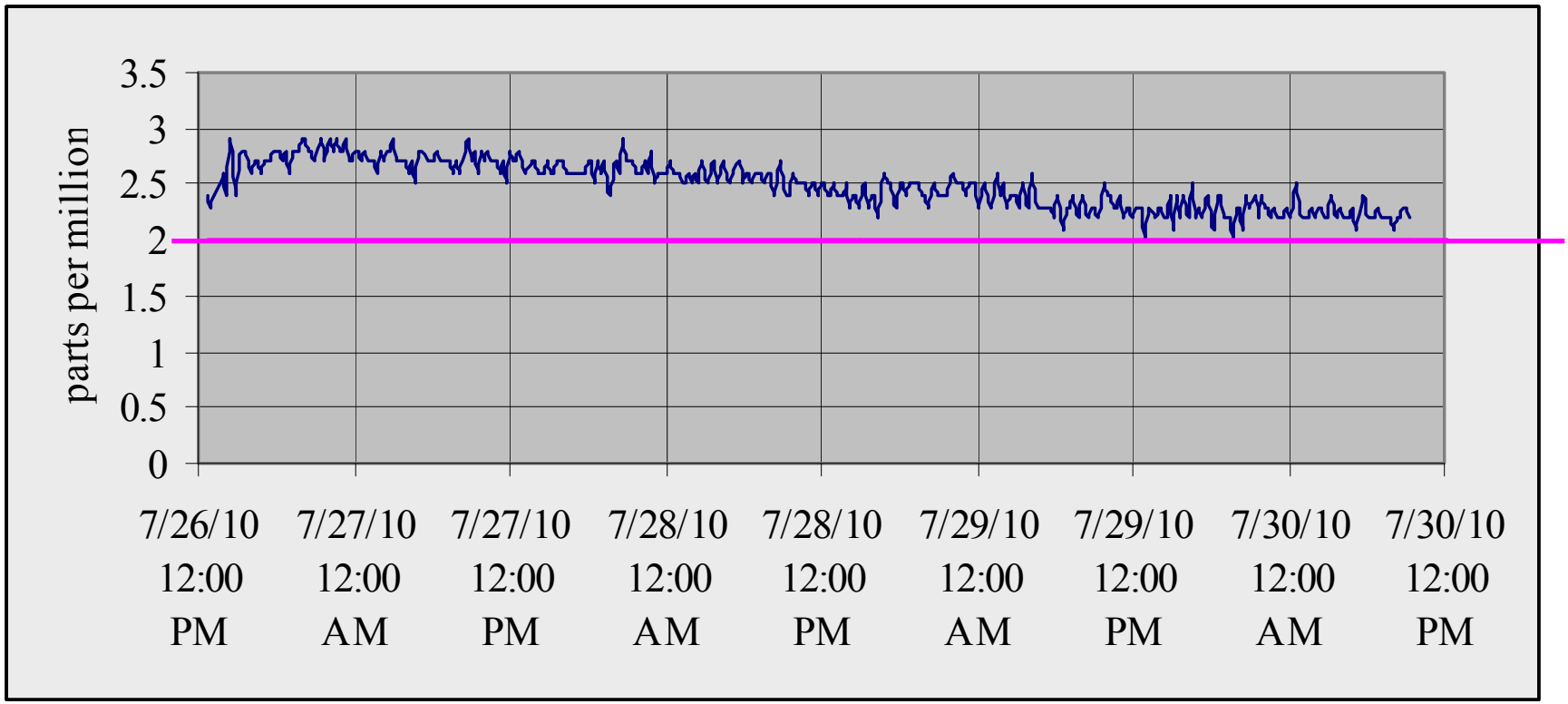

Figure 5

Location: DMH Offices

Address: 35 Congress St, Salem, MA

Indoor Air Results

Date: 7.26.2010

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (ug/m3)	Total Volatile Organic Compounds (ppm)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
Outside (Background)		77	37	352	ND	3	ND				
Restroom Hall	0	76	44	761	ND	2	ND	N	Y	Y	
Entrance		74	42	670	ND	4	ND	Y	Y	Y	
101	0	76	41	790	ND	1	ND	N	Y	Y	
102	0	75	46	861	ND	2	ND	N	Y	Y	
103	0	77	43	878	ND	2	ND	N	Y	Y	
104	0	76	43	828	ND	2	ND	N	Y	Y	
106	2	75	47	920	ND	2	ND	N	Y	Y	
108	0	76	46	861	ND	2	ND	Y	Y	Y	
109	1	76	45	847	ND	1	ND	Y	Y	Y	
110	0	76	44	871	ND	3	ND	Y	Y	Y	

ppm = parts per million µg/m3 = micrograms per cubic meter DO = door open ND = non-detect

Comfort Guidelines

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

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

Location: DMH Offices

Address: 35 Congress St, Salem, MA

Indoor Air Results

Date: 7.26.2010

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (ug/m3)	Total Volatile Organic Compounds (ppm)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
111	1	77	44	879	ND	1	ND	Y	Y	Y	
112	0	77	42	897	ND	2	ND	Y	Y	Y	
113	0	77	43	914	ND	1	ND	Y	Y	Y	
114	0	77	42	874	ND	2	ND	Y	Y	Y	
115	0	77	41	842	ND	2	ND	Y	Y	Y	
116	1	77	41	856	ND	1	ND	Y	Y	Y	
117	0	77	42	883	ND	1	ND	Y	Y	Y	
119	1	77	42	853	ND	2	ND	Y	Y	Y	
120	0	74	43	781	ND	2	ND	Y	Y	Y	
124	1	75	46	901	ND	2	ND	N	Y	Y	
127	0	75	46	821	ND	2	ND	N	Y	Y	

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Date: 7.26.2010

Table 1 (continued)

Location	Occupants in Room	Temp (°F)	Relative Humidity (%)	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	PM2.5 (ug/m3)	Total Volatile Organic Compounds (ppm)	Windows Openable	Ventilation		Remarks
									Supply	Exhaust	
128	2	74	46	830	ND	2	ND	N	Y	Y	
131	1	76	44	902	ND	2	ND	Y	Y	Y	DO
132	1	77	45	895	ND	2	ND	Y	Y	Y	
133	0	77	42	853	ND	3	ND	Y	Y	Y	
134	0	77	41	867	ND	2	ND	Y	Y	Y	
135	0	75	46	821	ND	2	ND	N	Y	Y	
136	0	75	46	835	ND	3	ND	N	Y	Y	
137	0	75	46	851	ND	4	ND	N	Y	Y	
140	0	74	43	777	ND	2	ND	Y	Y	Y	

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