INDOOR AIR QUALITY ASSESSMENT

Billerica Town Hall
365 Boston Road
Billerica, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Center for Environmental Health
Emergency Response/Indoor Air Quality Program
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Background/Introduction

At the request of Richard Berube, Director of Public Health for the town of Billerica, the Massachusetts Department of Public Health (MDPH), Center for Environmental Health (CEH) provided assistance and consultation regarding conditions at the Billerica Town Hall (BTH), 365 Boston Road, Billerica, Massachusetts. Concerns about thyroid disorders and their potential association with environmental conditions at the BTH prompted the assessment.

On February 14, 2004, a visit to conduct an indoor air quality assessment was made by Michael Feeney, Director of Emergency Response/Indoor Air Quality (ER/IAQ), CEH. Mr. Feeney was accompanied by Joshua McHale, a Risk Communication Specialist in CEH's Community Assessment Program (CAP).

The BTH is a two-story, red brick building, originally constructed in 1915 as a high school. The building was converted into the BTH in 1989 and appeared to have had significant interior modifications to the building, including the construction of floors and the installation of a heating, ventilating and air-conditioning (HVAC) system. The BTH shares a common wall with the Billerica Police Department (Picture 1). Windows are openable throughout the building.

Methods

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

Results

The BTH has a staff of approximately 80-100 and can be visited by several hundred people each day. Tests were taken under normal operating conditions. Results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were below 800 parts per million (ppm) in all areas surveyed, indicating adequate air exchange. Ventilation is provided by an air-handling unit (AHU) located in a mechanical room in the basement. Fresh air for the building is drawn through vents located at the rear of the building (Picture 2). The AHU delivers air via ducted wall-mounted air diffusers. Air is returned to the AHU by wall-mounted vents in each office suite.

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 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 AHU 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 has 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 Department of Public Health 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 on the day of the assessment ranged from 70° F to 77° F, which were within the MDPH recommended comfort guidelines. 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. In one area, the thermostat for the room was deactivated, making temperature control difficult.

Relative humidity readings on the day of the assessment ranged from 14 to 22 percent, 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 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 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 moisture is necessary. No active leaks were observed, however, water damage was noted on ceiling tiles in room 210 (Picture 3). Wallpaper was also found peeling from the wall in the school department conference room, indicating a possible source of moisture beneath the paper. The US Environmental Protection Agency and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g. carpeting) 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. Once mold has colonized porous materials, they are difficult to clean and should be removed.

Plants were observed in several areas. Plants, soil and drip pans can serve as sources of mold growth, thus should be properly maintained. Over-watering of plants should be avoided and drip pans should be inspected periodically for mold growth. A few areas had

water coolers installed over carpeting. Water spillage or overflow of catch basins can result in the wetting of the carpet. Repeated wetting of the carpet can result in mold growth.

Other Concerns

In order to determine whether an unusual source of chemicals were present within the BTH, air sampling for the presence of materials containing volatile organic compounds (VOCs) was conducted. VOCs are substances that have the ability to evaporate at room temperature. For example, solvent-based chemicals that rapidly evaporate at room temperature and would likely contain VOCs. Frequently, exposure to low levels of total VOCs (TVOCs) may produce eye, nose, throat and/or respiratory irritation in some sensitive individuals. CEH staff conducted TVOC sampling in offices and all common areas (Table 1). Outdoor measurements were taken for comparison. In addition, TVOC screening was also conducted around the basement floor where the building AHU is located**.** All outdoor TVOC concentrations were non-detect or ND (Table 1). Indoor TVOC concentrations throughout the building were also ND.

Several other conditions that can affect indoor air quality were noted during the assessment. Of note is the location of the fresh air supply vent immediately adjacent to the parking lot (Picture 2). In this configuration, idling vehicles can produce vehicle exhaust that can be drawn into the BTH. M.G.L. chapter 90 section 16A prohibits the unnecessary operation of the engine of a motor vehicle for a foreseeable time in excess of five minutes (MGL, 1986).

CEH staff inspected the AHU in the basement and found that the condensation drain was drawing air (Picture 4). As air is forced through the AHU it becomes depressurized and

can draw in unfiltered air, dirt, dust and debris into the unit through the condensation drain, which can then be distributed throughout the building via the ventilation system.

An ozone generator was observed in an office area. At this time, the efficacy of ozone as an indoor air cleaner is being examined by several government agencies. While ozone may be effective in removing some odors of biological origin (e.g. skunk), its use as a universal air cleaner has not been established (US EPA, 2003). As discussed, ozone is a highly irritating substance to the respiratory system. Until more definitive information becomes available, the use of ozone generators in occupied areas should be done with caution.

Accumulated items were observed in a number of areas. In rooms throughout the BTH, items were observed on windowsills, tabletops, counters, univents, bookcases and desks. The large amount of materials stored provide surfaces for dust to accumulate. Accumulation of these items makes cleaning difficult for custodial staff. Dust can be irritating to eyes, nose and respiratory tract.

Health Concerns

Information provided to the MDPH from local health officials relative to investigating thyroid cancer and other thyroid disorders among staff at the town hall included a list of five employees who were reportedly diagnosed with one of several disorders related to the thyroid. For each of the five individuals, names were provided along with information on the type of thyroid disease (cancer or otherwise), date of diagnosis, age at diagnosis, current age, gender, approximate length of employment in the building, location of employment in the building, and city or town of residence.

As described earlier, Mr. McHale from the CAP accompanied Mr. Feeney on the building inspection. While at the BTH, Mr. McHale met with three of the five individuals mentioned above who had previously provided information to the CAP. In addition, Mr. McHale met with another individual who had not been previously reported to the CAP as also problems with his/her thyroid. Information on this individual's health concerns (i.e., diagnosis, employment history, work location) was also collected. BTH employees also provided anecdotal information to Mr. McHale during his visit that another staff person had been diagnosed with a thyroid disorder. Therefore, a total of seven BTH employees were reported to have had a diagnosis of at least one disorder related to their thyroid. Three other BTH employees also met with Mr. McHale and described symptoms frequently associated with IAQ problems (i.e., dry eyes and respiratory problems).

Of these seven employees with a condition affecting the thyroid, two individuals reported a diagnosis of thyroid cancer. The remaining five individuals were diagnosed with non-cancerous conditions of the thyroid. Most non-cancerous thyroid conditions include thyroid nodules, hypothyroidism, and hyperthyroidism. Two of these three thyroid disorders were reported among the five staff members diagnosed with non-cancerous thyroid conditions. However, because of confidentiality concerns, diagnosis information related to employees will not be provided. For completeness, general information about all three conditions is contained in this report.

Thyroid Cancer

The CAP reviewed the most recent data available from the Massachusetts Cancer Registry (MCR) to confirm the diagnoses of thyroid cancer reported among BTH employees

and to determine whether these diagnoses may represent an unusual pattern of cancer incidence. The MCR, a division within the MDPH Center for 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 on an annual basis. This process corrects misclassification of data (i.e., city/town misclassification) and deletes duplicate case reports.

In recent years the incidence of many cancers has been declining (ACS 2006). However, thyroid cancer is one of the few cancers with an increasing incidence during recent years (ACS 2005). The risk of an individual developing thyroid cancer can change over time due to many factors, some of which are dependent upon well-established risk factors for this cancer type. Gender plays a role as females are more likely than males to develop thyroid cancer. Thyroid cancer is also a cancer that affects individuals at a younger age than most cancers. Nearly two-thirds of thyroid cancer diagnoses occur in individuals between the ages of 20 and 55. A family history of thyroid cancer is also another risk factor for the development of thyroid cancer. Gender, age and family background are not modifiable risk factors. Employees at the BTH who reported a diagnosis of thyroid cancer are all female and within the age range that would be expected based on state and national trends for thyroid cancer.

There is only one established environmental risk factor related to the development of thyroid cancer. Ionizing radiation has been shown to increase the incidence of thyroid cancer. The opportunities for exposure to ionizing radiation are limited. In the United States, most studies of radiation exposure looked at children treated with radiation for another illness during childhood. These children had a higher incidence of thyroid cancer when they reached adulthood.

When trying to determine if a particular environmental exposure (e.g., ionizing radiation) could have contributed to a specific disease outcome it is important to consider the latency period of the disease involved. A latency period is defined as the interval between first exposure to a disease-causing agent and the appearance of symptoms of the disease (Last 1995). Cancers in general have long latency periods that can range from 10 to 30 years and in some cases may be more than 40 to 50 years for solid tumors (Bang 1996; Frumkin 1995). The latency period between exposure to ionizing radiation and the diagnosis of thyroid cancer ranges from 10 to 25 years or more (Upton 1998). As a result, past exposures are more relevant than current exposures when considering potential risk factors for cancer. Although it is not possible to determine the cause of one's cancer diagnosis, the length of time in which an individual worked in a particular building prior to diagnosis can help evaluate the importance of exposure to potential environmental risk factors at the place of employment. Using information provided by the employees, length of employment at the BTH was examined for those who reported a thyroid cancer diagnosis. For those individuals diagnosed with thyroid cancer, the time from first employment to diagnosis was less than ten years. Based on the latency periods for thyroid cancers, the relatively short work histories at the

BTH would indicate that it is not likely that the building played a primary role in these individuals developing thyroid cancer.

Other Thyroid Conditions

A systematic surveillance system for the reporting of thyroid conditions (other than cancer) does not exist in Massachusetts. Therefore, the CAP is unable to review diagnoses of non-cancerous conditions reported by BTH employees. However, it is possible to review the health outcomes reported to the CAP in the context of what has been reported in the literature, including any known environmental or non-environmental risk factors.

All thyroid disorders, including but not limited to nodules on the thyroid, hypothyroidism or hyperthyroidism, are more common among females than males (Wartofsky 1994; Lazarus and Obuboie 2000; McCaffrey 2000). Reasons why females experience a higher incidence of thyroid disorders are unknown. Thyroid disorders also typically affect individuals in their 30's and 40's. It is important to note that thyroid disorders typically have different causative (or risk) factors associated with their development. For example, hypothyroidism may be caused by several different factors acting over time, while benign nodes may have different causes. The ages and gender of individuals reporting thyroid disorders in the BTH are what would be expected based on trends for all thyroid disorders.

The term thyroid nodule (nodes) refers to any abnormal growth of thyroid cells that creates a mass on the thyroid gland. These nodules on the thyroid gland are a common occurrence in the general population. The prevalence of solitary nodules of the thyroid gland increases with age, averaging 6.4 percent of women and 1.5 percent of men (Wartofsky 1994). This prevalence rate makes it the most common endocrine problem in the United

States. However, 90% of all nodules are benign. For a few individuals, the cause of nodule development is a genetic defect that causes the nodules to grow, but the causes of most thyroid nodules are unknown.

Hypothyroidism is a condition in which the thyroid gland does not produce adequate levels of thyroid hormone. There are numerous disorders that can lead to hypothyroidism. One of the most common causes can be autoimmune diseases, such as Hashimoto's thyroiditis or atrophic thyroiditis, where the immune system incorrectly recognizes the thyroid gland as a foreign body. This leads to the destruction of the thyroid gland. There is also congenital hypothyroidism when children are born without a complete thyroid or their thyroid is in the wrong place. Various medicines and medical treatments can also lead to hypothyroidism. Physical damage to the pituitary gland can also cause hypothyroidism. The pituitary gland is the master gland that controls the hormone production of the thyroid gland. All of these disorders or diseases have different causes but they can all produce hypothyroidism (Wartofsky 1994).

Hyperthyroidism, the exact opposite of hypothyroidism, occurs when the thyroid gland produces an overabundance of thyroid hormone. However, similar to hypothyroidism there are numerous disorders that can cause hyperthyroidism. Approximately 70% of the total diagnoses of hyperthyroid conditions are caused by Grave's disease (Wartofsky 1994). Grave's disease tends to run in families and is most commonly found in young females. There is little epidemiologic information as to why certain individuals develop Grave's disease. Other hyperthyroid diagnoses are due to toxic nodules that grow on the thyroid and increase the production of thyroid hormone by the thyroid. All of these disorders or diseases have different causes but all can produce hyperthyroidism.

Understanding that all thyroid disorders are not caused by one disease, but a group of diseases is also very important. Research indicates that each thyroid disorder is different and each has different causative (or risk) factors. For example, some genetic disorders may predispose an individual to developing thyroid nodules while other individuals may not have a hereditary basis for this disease. Other factors, such as radiation exposure, are related specifically to the development of thyroid cancer. Therefore all thyroid disorders, such as hypothyroidism or thyroid cancer, can be caused by many different factors acting over time but not necessarily the same factors.

Based upon our review of the available diagnosis 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 thyroid disorders among current employees that appears to be associated with the BTH. That is, it does not appear that a common factor (either environmental or non-environmental) is likely related to the diagnosis of thyroid disorders 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 thyroid disease among employees at the BTH, but probably have contributed to common symptoms associated with poor indoor air quality (e.g., headaches, fatigue and irritant symptoms).

Conclusions/Recommendations

Based on the observation made during the assessment, the following recommendations are made.

1. Ensure water is poured into the AHU floor drains every other day to maintain the integrity of the traps.

2. Seal the condensation drain for AHU during the heating season. Please note that this drain must be unsealed during the air-conditioning season in odor to drain condensation. Failure to remove the condensation drain seal can result in water back up into AHU and produce mold growth.

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

4. Inspect behind peeling wall paper in school department conference room for mold growth. If moldy replace water damaged building materials in a manner consistent with recommendations found in "Mold Remediation in Schools and Commercial Buildings" published by the US EPA (2001). Copies of this document can be downloaded from the US EPA website at: **http://www.epa.gov/iaq/molds/mold_remediation.html**.

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. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

6. Place rubber/plastic matting beneath water coolers to prevent water damage to carpeting. Clean and disinfect reservoir periodically to prevent mold/bacterial growth.

7. Avoid over watering of plants. Ensure flat surfaces around plants are free of potting soil and other plant debris. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial where necessary.
8. Consider prohibiting parking in the general areas of AHU air intakes to minimize/prevent vehicle exhaust entrainment. If not, feasible consider posting signs instructing occupants/visitors not to back into parking spots and to cease idling after 5 minutes as per M.G.L. chapter 90 section 16A.
9. Consider discontinuing the use of ozone generators.
10. Relocate or consider reducing the amount of materials stored in offices and common areas to allow for more thorough cleaning. Clean items regularly with a wet cloth or sponge to prevent excessive dust build-up.
11. For further building-wide evaluations and advice on maintaining public buildings, see the resource manual and other related indoor air quality documents located on the MDPH's website at http://mass.gov/dph/indoor_air.

References

ACGIH. 1989. Guidelines for the Assessment of Bioaerosols in the Indoor Environment. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

American Cancer Society (ACS). 2006. Cancer Facts & Figures 2006 Available at http://www.cancer.org.

American Cancer Society (ACS). 2005 Detailed Guide: Thyroid Cancer. Available at http://www.cancer.org.

Bang KM. 1996. Epidemiology of occupational cancer. J Occup Med; 11(3):467-85.

BOCA. 1993. The BOCA National Mechanical Code-1993. 8th ed. Building Officials & Code Administrators International, Inc., Country Club Hills, IL.

Frumkin H. 1995. Carcinogens. In: Occupational Health, 3rd ed.; Levy BS and Wegman DH, Eds.; Little Boston: Brown and Company

Last JM. 1995. A Dictionary of Epidemiology. International Epidemiological Association, Inc. New York: Oxford University Press

Lazarus JH. Obuobie K. 2000. Thyroid disorders-an update. Postgraduate Medical Journal; 76:529-536

McCaffrey TV. 2000. Evaluation of the thyroid nodule. Cancer Control; 7(3):223-228

MGL. 1986. Stopped motor vehicles; Operation of Engine; Time Limit; Penalty. Massachusetts General Laws. M.G.L. c. 90:16A.

OSHA. 1997. Limits for Air Contaminants. Occupational Safety and Health Administration. Code of Federal Regulations. 29 C.F.R 1910.1000 Table Z-1-A.

SBBRS. 1997. Mechanical Ventilation. State Board of Building Regulations and Standards. Code of Massachusetts Regulations. 780 CMR 1209.0

SMACNA. 1994. HVAC Systems Commissioning Manual. 1st ed. Sheet Metal and Air Conditioning Contractors' National Association, Inc., Chantilly, VA

Upton AC. 1998. Ionizing Radiation. In: Occupational and Environmental Medicine 3rd ed. Rom WN, Ed.; Philadelphia: Lippincott-Raven

US EPA. 2001. Mold Remediation in Schools and Commercial Buildings. US Environmental Protection Agency, Office of Air and Radiation, Indoor Environments Division, Washington, D.C. EPA 402-K-01-001. March 2001. http://www.epa.gov/iaq/molds/mold_remediation.html

US EPA. 2003. “Ozone Generators That Are Sold As Air Cleaners. An assessment of Effectiveness and Health Consequences”. Indoor Environments Division, Office of Radiation and Indoor Air Programs, Office of Air and Radiation (6604j). Washington, DC. Available at http://www.epa.gov/iaq/pubs/ozonegen.html

Wartofsky L. 1994. Diseases of the Thyroid. In: Harrison’s Principles of Internal Medicine, Vol 2. 13th Edition. Isselbacher KJ, Braunwald E, Wilson JD, Martin JB, Fauci AS and Kasper DL, eds. New York: McGraw-Hill

Picture 1

Rear of BTH

Picture 2

Fresh Air Intake for BTH

Picture 3

Water Damaged Ceiling Tiles in Room 210

Picture 4

Condensation Drain Pipe

AHU Condensation Drain Drawing Air

TABLE 1
Indoor Air Test Results
Billerica Town Hall, Billerica, MA
February 14, 2006

Remarks	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Outside (Background)	374	47	21	ND					
Town Manager	540	70	22	ND	1	Y	Y	Y	Door open
Town Manager outer reception	653	71	22	ND	4	Y	Y	Y	Door open
Town Manager inner reception	564	73	20	ND	0	Y	Y	Y	Window open
Selectmen's reception	492	73	18	ND	1	Y	Y	Y	Window open Door open
Systems administrator	493	72	19	ND	1	Y	Y	Y	
210	567	74	19	ND	0	Y	Y	Y	5 water damaged ceiling tiels Dry erase markers
Mail room	483	74	18	ND	0	Y	Y	Y	Photocopier Door open
Credit union	518	75	17	ND	2	N	Y	Y	Water cooler on carpet
105	488	76	16	ND	1	N	Y	Y	Door open
Census	534	77	16	ND	1	Y	Y	Y	Door open

*** ppm = parts per million parts of air**

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%

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Indoor Air Test Results
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February 14, 2006

Remarks	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	TVOCs (*ppm)	Occupants in Room	Windows Openable	Ventilation		Remarks
							Supply	Exhaust	
Town clerk	559	76	16	ND	4	Y	Y	Y	Door open
115	488	75	17	ND	1	Y	Y	Y	Humidifier
Billing	526	74	16	ND	1	Y	Y	Y	Window open Door open Thermostat deactivated
Treasurer	530	76	17	ND	1	Y	Y	Y	Door open
Treasurer private office	713	76	17	ND	0	Y	Y	Y	
Accountant	451	77	15	ND	2	Y	Y	Y	Water cooler on cartpet Plants Window open
Meeting room	514	75	15	ND	0	N	Y	Y	
109	432	75	14	ND	2	Y	Y	Y	3 water damaged ceiling tiles
Assessors	424	74	15	ND	3	Y	Y	Y	
Assessors private office	525	76	17	ND	0	Y	Y	Y	

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							Supply	Exhaust	
Building department	470	74	15	ND	2	Y	Y	Y	Photocopier
Board of health	525	74	17	ND	2	Y	Y	Y	
Superintendent reception	530	74	17	ND	2	Y	Y	Y	Personal fans
Assistant Superintendent	543	74	17	ND	1	Y	Y	Y	Door open
School dept. photocopier room	548	74	17	ND	0	N	N	Y	Photocopier
School dept. kitchen	597	75	19	ND	0	N	Y	Y	
School dept. break room	691	75	19	ND	0	N	Y	Y	Door open
School dept. administrative assistant	638	75	18	ND	0	Y	Y	Y	Ozone generator Door open
School dept. main office	539	75	16	ND	1	Y	Y	Y	Photocopier
Superintendent	539	74	17	ND	1	Y	Y	Y	Door open

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							Supply	Exhaust	
School dept. conference room	587	72	18	ND	0	Y	Y	Y	Peeled wallpaper
Planning board	460	74	15	ND	2	Y	Y	Y	Plants
Nurse office	550	74	18	ND	1		Y	Y	
G11 DPW	527	72	17	ND	1	Y	Y	Y	Air cleaner
DPW office	565	72	17	ND	0	Y	Y	Y	
DPW director's office	625	72	17	ND	0	Y	Y	Y	Door open
G09 reception	477	73	16	ND	1	N	Y	Y	Photocopier
G09 cubicles	549	73	17	ND	2	Y	Y	Y	1 water damaged ceiling tiles Photocopier
Kitchen	447	72	16	ND	0	N	Y	Y	
Basement Mechaical room, drain for AHU				ND					

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