INDOOR AIR QUALITY ASSESSMENT

Lake Street Elementary School
17 Lake Street
Spencer, Massachusetts

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

At the request of Lee Jarvis, Health Agent for the Town of Spencer, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health (BEH) provided assistance and consultation regarding indoor air quality (IAQ) at the Lake Street Elementary School (LSS) located at 17 Lake Street, Spencer, Massachusetts. On January 10, 2014, Michael Feeney, Director of BEH's IAQ Program visited the school to perform an assessment. He was accompanied by Ruth Alfasso, Environmental Engineer/Inspector in BEH's IAQ Program.

The LSS is a two-story, red, brick and stone building constructed in 1957. An addition was built in 1977. Reportedly there have been no other renovations to the building since that time; therefore, the majority of building materials (e.g., flooring, heating and ventilation components and window systems) appear to be original. The school contains general classrooms, kitchen, a multi-purpose room (cafeteria/auditorium/gymnasium), library, art room, computer rooms, and office space.

This building was previously visited by BEH/IAQ Program staff in 2006, and a report was issued (MDPH, 2006). Appendix A describes actions taken in response previous report recommendations.

Methods

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

Results

The school houses approximately 340 students in grades 1 through 3 with a staff of approximately 70. Tests were taken during normal operations at the school. Results appear in Table 1.

Discussion

Ventilation

It can be seen from Table 1 that carbon dioxide levels were above 800 parts per million (ppm) in 16 out of 34 areas, indicating poor air exchange in nearly half of the areas examined. It is also important to note that several areas were empty/sparsely populated, which can greatly reduce carbon dioxide levels. Carbon dioxide levels would be expected to increase with higher occupancy and windows closed.

Fresh air in the majority of classrooms is supplied by unit ventilators (univents) (Picture 1). A univent is designed to draw air from outdoors through a fresh air intake located on the exterior wall of the building. Return air is drawn through an air intake located at the base of each unit where fresh and return air are mixed, filtered, heated or cooled and provided to classrooms through an air diffuser located in the top of the unit (Figure 1). At the time of the assessment, univents were found deactivated or obstructed with classroom items in a number of areas (Table 1). In order for univents to provide fresh air as designed, intakes/returns must remain free of obstructions. Importantly, these units must remain on and be allowed to operate while rooms are occupied.

Please note that the univents are original equipment; units are over 50 years old in the original wing and over 30 years old in the 1977 wing. Function of equipment of this age is difficult to maintain, since compatible replacement parts are often unavailable. As an example, fan belts in univents appeared to be loose (Picture 2), which can lead to decreased fan velocity and increased noise. According to the American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE), the service life[1] for a unit heater, hot water or steam is 20 years, assuming routine maintenance of the equipment (ASHRAE, 1991). Despite attempts to maintain the univents, the operational lifespan of the equipment has been exceeded. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages and as replacement parts become increasingly difficult to obtain.

Exhaust ventilation in most classrooms is provided by wall-mounted vents (Picture 4). In some classrooms, exhaust vents are located in coat closets (Picture 5). Exhaust vents were also found obstructed in some areas and many of them appeared to be off or drawing very weakly (Table 1).

Mechanical ventilation to some areas is provided by air-handling units (AHUs) located above the ceiling tile system. Air is ducted to supply vents located in the ceiling (Picture 3). Some air is returned to the AHU via return vents that are ducted to the AHU.

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

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

Minimum design ventilation rates are mandated by the Massachusetts State Building Code (MSBC). Until 2011, the minimum ventilation rate in Massachusetts was higher for both occupied office spaces and general classrooms, with similar requirements for other occupied spaces (BOCA, 1993). The current version of the MSBC, promulgated in 2011 by the State Board of Building Regulations and Standards (SBBRS), adopted the 2009 International Mechanical Code (IMC) to set minimum ventilation rates. **Please note that the MSBC is a minimum standard that is not health-based**. At lower rates of cubic feet per minute (cfm) per occupant of fresh air, carbon dioxide levels would be expected to rise significantly. A ventilation rate of 20 cfm per occupant of fresh air provides optimal air exchange resulting in carbon dioxide levels at or below 800 ppm in the indoor environment in each area measured. MDPH recommends that carbon dioxide levels be maintained at 800 ppm or below. This is because most environmental and occupational health scientists involved with research on IAQ and health effects have documented significant increases in indoor air quality complaints and/or health effects when carbon dioxide levels rise above the MDPH guidelines of 800 ppm for schools, office buildings and other occupied spaces (Sundell et al., 2011). 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 B.

Indoor temperature measurements ranged from 71°F to 75°F (Table 1), which were within the MDPH recommended comfort range on the day of assessment. 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 addition, it is difficult to control temperature and maintain comfort without operating the ventilation equipment as designed (e.g., univents/exhaust vents deactivated/obstructed).

The relative humidity measured in the building ranged from 15 to 23 percent, below the MDPH recommended comfort range (Table 1). The MDPH recommends a comfort range of 40 to 60 percent for indoor air relative humidity. 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

The Library

Due to expressed concerns, the BEH/IAQ staff examined the library for water damage, possible microbial growth, and other conditions that may contribute to indoor environmental quality. According to school officials, the library was originally constructed as a workshop. Several features within the library are consistent with features found in workshops, including tool closets and a garage door on the south wall. Of note is the floor, where carpeting was installed directly on the below-grade slab. In general, floor on slab is prone to the generation of condensation during hot, humid weather. In the experience of BEH/IAQ staff, cement floor surfaces are typically painted or covered with floor tile. The carpeting in the library was installed when the space was converted for its current use.

The US Environmental Protection Agency (US EPA) and the American Conference of Governmental Industrial Hygienists (ACGIH) recommend that porous materials (e.g., carpeting, gypsum wallboard) 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.

Adding to the potential condensation issue are other conditions noted in and around the library. As mentioned, the south wall of the library has a garage door opening (Picture 6). The exterior face of this garage door is currently covered with plywood panels (Picture 7). The base of the plywood showed water damage. In addition, leaves were found accumulated against the bottom of the paneling. Little sealant was observed in the seams of the plywood panels. Without proper sealant, moisture can penetrate through the seams.

Within the library, a wooden frame with paneling was installed to conceal the garage door (Picture 8). The wood cover was installed around the original pull-down garage door rails. This covering appears to be hollow and not thoroughly insulated. Since the exterior plywood is unsealed and the interior lacks insulation, moisture, pests, and dusts can enter the library. Hot, moist air that penetrates through the exterior plywood can moisten debris accumulated within the wood-framed structure. If not dried within a 24 to 48 hour period, this moistened debris as well as water-damaged wood paneling can serve as a source of mold growth.

The univent can also draw moist air into the library. The univent fresh air intake is located above a tool shed, which is flush against the exterior wall (Picture 6). The space between the back of this shed and exterior wall would be prone to moisture accumulation. Without airflow, the wood backing of the shed and debris accumulated in this gap cannot readily dry, allowing mold growth to occur. The univent can then draw in moisture, odor, and materials from this area via the fresh air intake and subsequently distribute these products throughout the library.

A number of other items in the library can become colonized with mold if moistened by condensation during hot, humid weather. These materials include books, cardboard boxes (Picture 9), upholstered furniture, and beanbags (Picture 10). If these materials are in close proximity to the return vent of the library univent, dust, mold spores and odors may be entrained and then distributed when the univent is operating.

A garage is located adjacent to the library. This garage contains an industrial-sized lawn mower (Picture 11), washer, dryer (Picture 12), and various other materials. The door separating this garage from the library was not airtight. The worn/damaged weather-stripping (Picture 13) can allow hot, moist air from outside, as well as vapors and odors from the stored materials and the lawn mower to penetrate into the library. In addition, the dryer vent exhausts directly into the garage area, which would add additional moisture to the garage, which can then migrate into the library via the interior garage door.

Other Locations in the Building

It was reported that during winter break approximately two years ago, a plumbing leak caused damage in several second floor classrooms; water that flowed downwards also damaged the lower level. Water-damaged building materials were reportedly either dried using fans or removed and discarded before school reopened after break. Some water-damaged ceiling tiles were observed.

Water-damaged ceiling tiles were also observed in several other areas (Table 1); these can indicate active/historic leaks from either the roof/building envelope 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.

Floor tiles in some areas showed signs of historic water damage, including mastic that had dissolved and come up to the top of tiles (Picture 14). This material is a sign of past water affects to the tiles, but is not mold.

Open seams between the sink countertop and backsplash were observed in several rooms (Table 1). If seams are not watertight, water can penetrate the seam, causing water damage. Water penetration and chronic exposure of porous and wood-based materials can cause these materials to swell, show signs of water damage and lead to potential mold growth. Some of the sinks had cabinets beneath them containing large amounts of items, including porous items. The area underneath sinks is a moist environment and should not be used to store items that can become colonized with mold. Large amounts of items stored under sinks can also make detecting leaks difficult.

BEH/IAQ staff examined the exterior of the building to identify breaches in the building envelope and/or other issues that could provide a source of water penetration. Damage was noted to brickwork (Picture 15) and concrete (Picture 16) along the edge of the building. 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). In addition, these breaches in exterior areas can provide a means of drafts and pest entry into the building.

Plants were noted in some classrooms (Table 1). Plants can be a source of pollen and mold, both of which are respiratory irritants for some individuals. Plants should be properly maintained and equipped with drip pans and should be located away from univents to prevent the aerosolization of dirt, pollen, and mold.

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/IAQ 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 effects. 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, 2011). 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 (Table 1).

Particulate Matter

The US EPA has established NAAQS limits for exposure to particulate matter. Particulate matter includes airborne solids that can be irritating to the eyes, nose, and throat. The NAAQS originally established exposure limits to PM with a diameter of 10 μm or less (PM10). In 1997, US EPA established a more protective standard for fine airborne particulate matter with a diameter of 2.5 μm or less (PM2.5). 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 PM concentrations in the indoor environment.

Outdoor PM2.5 concentrations were measured at 25 $\mu g/m^3$ (Table 1). PM2.5 levels measured in the school were between 9 to 23 $\mu g/m^3$ (Table 1), which were below the NAAQS PM2.5 level of 35 $\mu g/m^3$. Frequently, indoor air levels of particulates (including PM2.5) can be at higher levels than those measured outdoors. A number of activities that occur indoors and/or mechanical devices can generate particulate during normal operations. Sources of indoor airborne particulates may include but are not limited to particles generated during the operation of fan belts in the HVAC system, use of stoves and/or microwave ovens in kitchen areas; use of photocopiers, fax machines and computer printing devices; operation of an ordinary vacuum cleaner and heavy foot traffic indoors.

Volatile Organic Compounds

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

Classrooms contained dry erase boards and related materials (Table 1). 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.

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

Laminators and photocopiers were found in the school (Table 1). Lamination machines melt plastic and give off odors and VOCs. VOCs and ozone can be produced by photocopiers, particularly if the equipment is older and in frequent use. Ozone is a respiratory irritant (Schmidt Etkin, 1992).

In a few areas, tennis balls were found sliced open and placed on chair legs (Table 1). 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 to reduce the potential for symptoms in sensitive individuals (NIOSH, 1997). Latex-free glides should be used for this purpose.

Other Conditions

Other conditions that can affect IAQ were observed during the assessment. The univents in classrooms 6 and 7 were opened and examined. There were large gaps around the pipes to the univent where they entered through the floor (Pictures 17 and 18). Directly below these two classrooms is the boiler room. Occupants of these classrooms had complained of exhaust-like odors. Gaps around pipes provide a pathway for odors and pollutants from the boiler room to migrate into occupied areas. These breaches should be sealed with an appropriate fire-rated sealant and checked for tightness every time the univents are serviced.

In the univents examined, filters were occluded with debris and the interior of cabinets had dust and debris. Univent filters should be changed regularly, at least twice a year and more if needed. The cabinets should be vacuumed at every filter change.

Breaches were also observed in chimney of the main boiler located in the boiler room (Picture 19). This hole should be sealed to prevent the escape of exhaust gases to the indoor environment.

When examining the outside of the building, BEH/IAQ staff noted a diesel odor in the area adjacent to the fuel tank (Picture 20). It also appears that the chimney for the building's furnace systems is shorter than expected. These two conditions can potentially result in odors, particulates, and products of combustion entering the building through windows and air intakes. The kitchen in particular may be susceptible to the infiltration of odors and exhaust, due to the location of the air intakes. The influx of oil odors and combustion products into the kitchen is enhanced by the kitchen hood, which would tend to draw more make-up air into the building.

The strong diesel odor in this area may indicate a leak or malfunction of the tank or associated equipment. One of the recommendations of the 2006 report was to raise the fuel pipe vent higher than the school roof, which appears to have been done. Additional measures to reduce odors could be taken, including raising the chimney height. The Spencer Public Schools should contact a professional regarding potentially increasing the height of the chimneystack to further reduce the potential for entrainment of odors.

Window and wall-mounted air conditioners (WAC) were observed in a few locations (Table 1). These units have filters that need to be cleaned on a regular basis. It appears that some of these units remain in the windows or walls even though it was well within the heating season. These units are exposed to weather outside, which can result in degradation. Further, penetrations around WACs can be a source for water and cold air to enter the building during the heating season. In addition, air purifiers were also noted (Table 1). These should be placed in the breathing zone and maintained in accordance with manufacturer's instructions.

In many classrooms, and particularly in the library, a large number of items were on flat surfaces (e.g. floors, windowsills, tabletops, counters, bookcases, and desks), which provide a source for dusts to accumulate (Picture 21). 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, dust and debris can accumulate on flat surfaces (e.g., desktops, shelving and carpets) in occupied areas and subsequently be re-aerosolized causing further irritation.

A number of air diffusers, exhaust/return vents, and personal fans were found to have accumulated dust/debris (Table 1). If exhaust vents are not functioning, backdrafting can occur, which can re-aerosolize accumulated dust particles. Re-activated supply, exhaust/return vents, and fans can also aerosolize dust accumulated on vents/fan blades.

Upholstered furniture, pillows/cushions and large stuffed animals were seen in several classrooms and the library (Picture 21). Upholstered furniture, pillows, and cushions are 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). Frequent vacuuming of upholstered furniture is recommended to remove dust mites and other pollutants (Berry, 1994). It is also recommended that upholstered furniture (if present in schools), be professionally cleaned on an annual basis. If outdoor conditions or indoor activities (e.g., renovations) create an excessively dusty environment, cleaning frequency should be increased (every six months) (IICRC, 2000).

Accumulations of pencil shavings were observed in some areas (Table 1; Picture 22). Pencil shavings can become a respiratory irritant if airborne.

In a number of other classrooms, items were seen hanging from the suspended ceiling tile system (Table 1). Items should not be suspended from ceiling tile systems; movement of ceiling tiles may aerosolize dust above ceiling tiles. Moreover, the accumulated weight of items may damage the ceiling tile frames.

A number of fluorescent light bulbs that were stored in the boiler room area are not properly contained (Picture 23). This could lead to breakage of the bulbs, which would release mercury into the indoor environment. Both new and used fluorescent bulbs should be stored in a secure manner to prevent breakage.

Conclusions/Recommendations

A number of conditions noted in the library may contribute to the quality of the indoor environment. Of note is that the library was constructed to be a workshop. As mentioned, a workshop is likely to have a cement or tile floor and have materials used/ stored that are not generally prone to moisture damage. In contrast, the library contains a number of materials that can be prone to water damage, such as wall-to-wall carpeting, furniture, and paper products. The library is also located next to a facilities garage that can be a source of moisture (e.g., the univent dryer), combustion (e.g., the lawn mower), and mold/pollen (e.g. when the garage door is open). For this reason, a number of short-term and long-term recommendations are made in view of the findings at the time of the visit:

Short-Term Recommendations

1. Review and implement remaining items from the recommendations in the 2006 report, as discussed in Appendix A.

2. Investigate the source of the diesel odors near the fuel tank shown in Picture 20.

3. Repair/seal holes where pipes enter univent cabinets using appropriate fire-rated sealant.

4. Repair the hole in the chimney for the furnace.

5. Reseal the door leading from the library to the garage with weather-stripping and a door sweep.

6. Consider housing the lawn mower in a different location to avoid exhaust entrainment by the univent fresh air intake located above the garage door.

7. Install a means to vent the dryer in the garage directly outdoors.

8. Render the wood plug over the library former garage door watertight with an appropriate sealant.

9. Open the paneling box in the library and remove any water-damaged materials. Insulate the interior of the wall with a sufficient amount of insulation.

10. Move tool shed below library fresh air intake to another location.

11. Consider replacing the floor covering in the library with an appropriate material that will not be prone to mold colonization (e.g., floor tile).

12. Discard boxes stored on library floor. Examine material in boxes and discard if water-damaged/mold colonized.

13. Remove upholstered furniture from the library.

14. Remove beanbag and other similar type of seats from library floor.

15. Operate all ventilation systems throughout the building (e.g., gym, cafeteria, classrooms) continuously during periods of occupancy to maximize air exchange. If increased airflow is desired, operate univents in fan “high” mode.

16. Consider upgrading ventilation equipment. Maintaining the balance of fresh air to exhaust air will become more difficult as the equipment ages (i.e., classroom univents, exhaust vents, and AHUs in common areas) and as replacement parts become increasingly difficult to obtain. Based on the age, physical deterioration, and availability of parts, BEH recommends that an HVAC engineering firm evaluate options to determine feasibility of repairing/replacing the equipment.
17. Remove blockages/items from the surface of univent air diffusers and return vents (along front/bottom).
18. Remove blockages/items from wall and coat closet exhausts to ensure adequate airflow.
19. Ensure classroom doors are closed for proper operation of mechanical ventilation system/air exchange.
20. Continue to change filters for air-handling equipment (univents and AHUs) 2-4 times a year. Vacuum univent cabinets during filter changes.
21. Consider adopting a balancing schedule of every 5 years for all mechanical ventilation systems, as recommended by ventilation industrial standards (SMACNA, 1994).
22. Use openable windows in conjunction with classroom exhaust vents 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.
23. 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 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).

24. Ensure roof/plumbing leaks are repaired and replace any remaining water-damaged ceiling tiles. Examine the area above these tiles for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial, as needed.

25. Seal breaches, seams, and spaces between sink countertops and backsplashes to prevent water damage. Consider eventual replacement with a one-piece molded countertop. Refrain from storing porous materials (e.g., paper, cardboard) under sinks.

26. Have repairs made to the exterior of the building envelope, including brick and concrete damage.

27. Ensure indoor plants are equipped with drip pans. Examine drip pans periodically for mold growth and disinfect with an appropriate antimicrobial, as needed. Move plants away from the air stream of mechanical ventilation equipment.

28. When possible, move laminators and photocopiers to areas with exhaust ventilation and away from sensitive individuals.

29. Replace tennis balls with latex-free glides.

30. Refrain from hanging objects from ceiling tile systems.

31. 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.

32. Refrain from using air fresheners and deodorizers to prevent exposure to VOCs.

33. Store cleaning products properly and out of reach of students. Ensure spray bottles are properly labeled. All cleaning products used at the facility should be approved by the school department with MSDS' available at a central location.
34. Clean personal fans, air diffusers and return vents periodically of accumulated dust.
35. Clean upholstered furniture, cloth curtains, stuffed animals, pillows and curtains on a regular schedule. If not possible/practical, consider removing from classrooms.
36. Consider adopting the US EPA (2000) document, "Tools for Schools", as an instrument for maintaining a good indoor air quality environment in the building. This document is available at: http://www.epa.gov/iaq/schools/index.html.
37. 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.

Long-Term Recommendations

1. Contact a professional regarding the possibility of increasing the height of the furnace stack to avoid entrainment of odors.
2. Consider sealing the former garage door with a watertight wall equipped with appropriate drainage.
3. Consult with an HVAC engineering firm for a plan to replace ventilation system components. Take into consideration the current and likely future uses of spaces to determine the placement of supply and exhaust ventilation to maximize airflow and removal of pollutants and odors, including dedicated exhaust ventilation in areas where copy machines and laminators are used.

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Picture 1

Unit ventilator (univent)

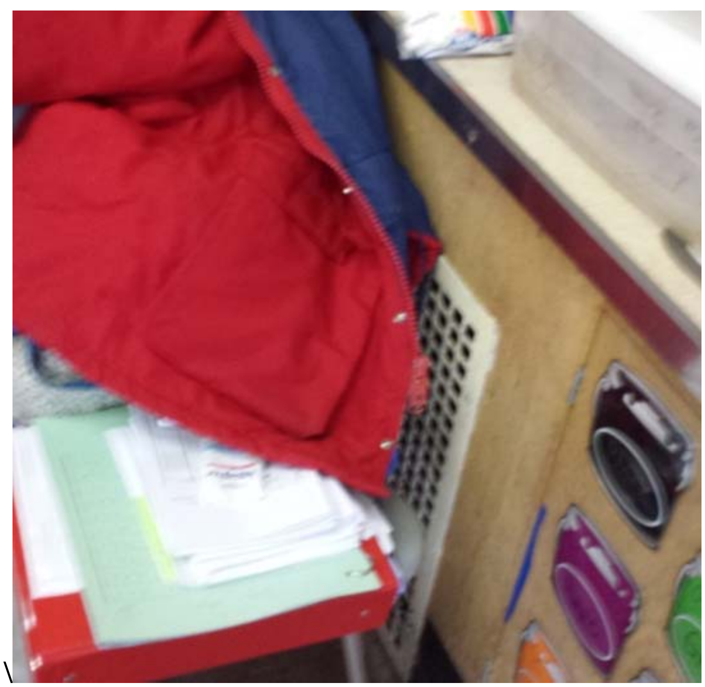
Picture 2

Univent with loose fan belt

Picture 3

Ceiling-mounted supply diffusers; note dust on louvers/ceiling tiles and missing ceiling tile

Picture 4



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Exhaust vent, obstructed by items

Picture 5

Exhaust vent located in closet, note grill is ajar

Picture 6

Exterior south wall of library with adjacent garage door, note tool shed below library fresh air intake (arrow)

Picture 7

Original door opening appears to be sealed with plywood on its exterior face

Picture 8

Former garage door covered by a wood paneling, note garage door railings (arrow)

Picture 9

Books in cardboard boxes on floor

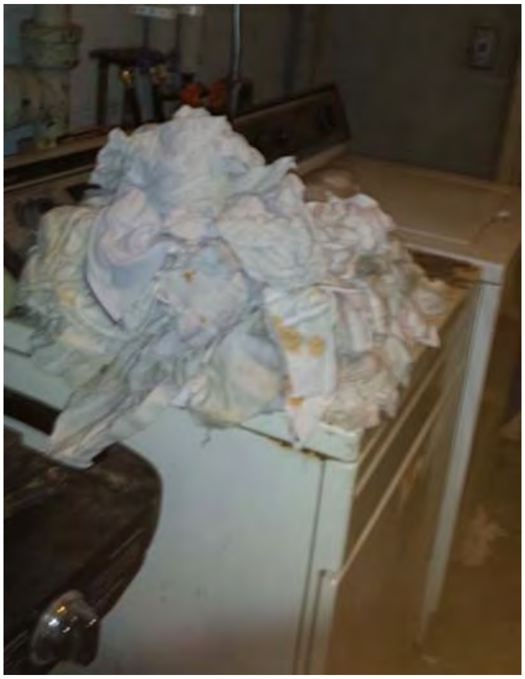
Picture 10

Upholstered furniture in front of univent fresh air intake, note bean bag chairs and similar items on floor

Picture 11

Lawn mower in garage

Picture 12



Washer and dryer in garage

Picture 13

Door to garage area from library; note damaged weather-stripping

Picture 14

Floor tiles showing water damage/lifted mastic

Picture 15

Damaged brickwork

Picture 16

Damaged concrete

Picture 17

Gap in univent cabinet leading to boiler room

Picture 18

Gap where pipe enters univent cabinet

Picture 19

Hole in boiler chimney

Picture 20

Location of fuel tank and chimney

Picture 21

Plush items and other items stored in the library

Picture 22

Pencil shavings

Picture 23

Fluorescent bulbs improperly stored

Location: Lake Street School

Address: 17 Lake Street, Spencer, MA

Indoor Air Results

Date: 1/10/2014

Table 1

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
Background	442	2.5	32	39	25					Light snow
Library	928	0.7	71	19	12	3	Y	UV	Y	Carpet, plush chairs, items, cardboard on floor, old blocked off garage door, pencil shavings, HS, AP
Library Area Art Storage										Items
Garage area adjacent to Library										Lawn mower, other power equipment, dryer venting inside, other storage of chemicals, door to outside and door to library both not airtight
Book room										Copier, items
Cafeteria	1004	0.7	72	23	14	~200	Y	Y	Y	
Copy area										
Counseling	906	ND	74	21	17	0	Y	N	N	DO, area rug, beanbag chairs, attached bathroom with exhaust,(not working)
Family advocate	711	ND	73	16	23	0	N	N	N	Transfer air vent, DO

ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter
ND = non detect
AP = air purifier
CD = chalk dust
CP = cleaning products
CT = ceiling tile
DEM = dry erase materials
DO = door open
HS = hand sanitizer
WAC = window air conditioner
WD = water-damaged
UV = univent

Comfort Guidelines

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

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

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
Girls bathroom										Odors, DO
Art	673	ND	73	15	14	0	N	Y	Y	Former locker room
Main office	784	ND	74	18	15	1	Y	N	N	
Meeting room	696	ND	73	16	17	0	N	Y	Y	Former locker room./shower
Music room	819	ND	73	16	10	0	Y	UV	Y off	Area rug, porous items under sink, PF
Speech	733	ND	74	19	13	0	Y	N	N	Attached bathroom with exhaust not working
Speech	693	ND	72	20		0	Y	N	N	Radiator
Storage										AT, paper and items, WD CTs
Teacher's lunchroom	955	ND	75	19	13	11	Y	Vent obstructed	Y off	Laminator, microwave, fridge, boxes on floor
01	839	ND	73	20	13	2	Y	UV	Y	Area rug, art supplies, sink

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Comfort Guidelines

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

Location: Lake Street School **Indoor Air Results**

Address: 17 Lake Street, Spencer, MA **Table 1 (continued)** **Date: 1/10/2014**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 ($\mu g/m^3$)	Occupants in Room	Windows Openable	Ventilation Supply	Ventilation Exhaust	Remarks
02	985	ND	73	22	14	6	Y	UV	Y	DEM, PF dusty, area rug
03	937	ND	73	23	13	1, class just left	Y	UV	Y off	Area rug, WAC, DO, plant, sink, microwave
04	724	ND	73	19	13	0	Y	UV	Y off	Sink, microwave, food, DO, fridge (clean)
05	858	ND	73	23	15	0	Y	UV noisy	Y obstructed	WAC, area rug, food, computers
06	804	ND	74	21	15	20	Y, 2 open	UV	Y	Items on UV, microwave, sink, CP, complains of exhaust smell
07	671	ND	73	16	19	0	Y	UV		WAC, DEM, CD, exhaust smell
08	820	ND	74	20	19	22	Y	UV	Y	Area rug, HS, water dispenser
09	686	ND	71	19		0	Y	Y	Y	30 computers
10	773	ND	72	21		9	Y	Y	Y	DEM, DO
11	658	ND	73	19		16	Y	Y	Y	DO

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Comfort Guidelines

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

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

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m³)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
12	657	ND	73	18		19	Y	Y	Y	DO
13	750	ND	73	19		18	Y	Y	Y	Material on UV, DO
17	603	ND	75	17	14	0	Y	UV	Y	DO, sink, fabric wall divider
18	560	ND	72	16	14	0	Y	UV on	Y	HS, fabric wall divider, area rug
19	755	ND	73	15	11	3	Y	Y	Y	Rugs, items, door to outside, sink, plush items
20	866	ND	74	17	13	2	Y	UV	Y	DEM, area rug, WD CT, sink backsplash open, CP under sink
21	1210	ND	74	21	9	15	Y	UV on	Y ajar grill	Area rug, WD CT, sink backsplash, AT, plants
23 Preschool	686	ND	72	17	11	0	Y	UV	Y off	Items on UV, paper under sink, area rug, plants, plush items, items hanging from ceiling tiles
24 Preschool	845	ND	72	19	13	10	Y	UV	Y off	Area rug, items on UV, PF, sink, art supplies, WD CT
25	858	ND	73	20	14	2	Y	UV	Y off	Gloves on UV, area rug, items

ppm = parts per million
µg/m³ = micrograms per cubic meter
ND = non detect
AP = air purifier
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Carbon Dioxide: < 600 ppm = preferred
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Temperature: 70 - 78 °F
Relative Humidity: 40 - 60%

Location: Lake Street School | **Indoor Air Results**

Address: 17 Lake Street, Spencer, MA | **Table 1 (continued)** | **Date: 1/10/2014**

Location	Carbon Dioxide (ppm)	Carbon Monoxide (ppm)	Temp (°F)	Relative Humidity (%)	PM2.5 (µg/m^3)	Occupants in Room	Windows Openable	Ventilation		Remarks
								Supply	Exhaust	
26	814	ND	72	18	17	8	Y	UV on	Y	WD CT, plant, paper under sink
27	700	ND	73	16	9	0	Y	UV on	Y off	DEM, chalk, open sink backsplash, AT, HS, items under sink

ppm = parts per million
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AP = air purifier
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CT = ceiling tile
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Appendix A

Actions on MDPH Recommendations, Lake Street School, 17 Lake Street, Spencer, MA

The following is a status report of action(s) taken on recommendations made in the 2006 MDPH IAQ report (**in bold**) based on reports from maintenance staff, and BEH/IAQ staff observations

Short-Term Recommendations

Contact a HVAC engineering firm to investigate and provide recommendations regarding the freezing of pipes and sealing of univent fresh air intakes in problem areas. In some cases the MDPH has recommended installation of a sheet metal awning that can direct cold air/wind away from intake vents.

- **Action:** Freezing of univent pipes was not reported as an ongoing issue.

Ensure univent air intakes are unsealed after the heating season to provide fresh air as designed.

- **Action:** One univent was found sealed.

Survey classroom univents to ascertain function and determine whether an adequate air supply exists for each room. Consider consulting a heating, ventilation and air conditioning (HVAC) engineer concerning the calibration of univent fresh air control dampers throughout the school.

- **Action:** It could not be determined if this had occurred.

Operate all ventilation systems throughout the building (e.g., gym/cafeteria, classrooms) continuously during periods of school occupancy and independent of thermostat control to maximize air exchange. To increase airflow in classrooms, set univent controls to "high".

- **Action:** Most univents were operating at the time of the 2014 visit, but exhaust vents were either turned off or inoperable/weakly operating.

Continue with plans to replace exhaust motor on repair list. Inspect rooftop exhaust motors and belts periodically for proper function, repair and replace as necessary.

- **Action:** Exhaust motors were not inspected during this visit so it could not be determined if they were operational.

Appendix A

Remove all blockages from univents and exhaust vents. Remove cardboard from exhaust vent in 2nd floor book room and restore local exhaust ventilation above photocopier.

- **Action:** Some univents and exhaust vents were found blocked by items. This is an ongoing educational issue for staff.

Use openable windows in conjunction with classroom univents and exhaust vents to increase 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.

- **Action:** Windows were found open in one classroom, however, weather conditions were not conducive to use of open windows in most areas.

Consider discontinuing use of the spare room as classroom space. If not feasible, make provisions to install mechanical ventilation to provide air exchange.

- **Action:** The spare room appears to be used for storage at this time**.**

Close classroom doors to maximize air exchange.

- **Action:** Some classrooms doors were found open during the 2014 assessment.

Consider balancing mechanical ventilation systems every 5 years, as recommended by ventilation industrial standards (SMACNA, 1994).

- **Actio**n: It is unknown if this was performed.

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).

- **Action:** It could not be determined what kind of vacuum cleaners are being used.

Contact a masonry firm or general contractor to repair breaches in exterior wall outside classroom 27 to prevent water penetration, drafts and pest entry.

- **Action:** No breaches were noted in classroom 27.

Consider removing floor tiles in areas of chronic water damage (e.g., classroom 27) to determine if visible moisture and/or microbial growth are present. If so, the removal of all affected tiles followed by cleaning with an appropriate antimicrobial agent may be necessary.

- **Action:** Floor tiles in some areas show signs of chronic water damage which may be existing from the time of this report.

Appendix A

Consider contacting a reputable flooring contractor to remove/replace old tiles and mastic. Slab should be completely cleaned and sealed with a proper sealant and/or vapor barrier.

- **Action:** It did not appear as though this was performed.

Consider contacting a building engineer for an examination of possible moisture remediation/prevention strategies if moisture accumulation/damage to floor tiles in the building recurs.

- **Action:** It did not appear as though this was performed.

Ensure bird's nest is removed from art room exhaust vent. Inspect to ensure surfaces are free of nesting materials and bird wastes. Clean and disinfect with an appropriate antimicrobial where necessary. Consider installing wire mesh or seal permanently to prevent further roosting.

- **Action:** No birds nests were observed during the 2014 visit.

Ensure any roof/plumbing leaks are repaired. 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.

- **Action:** Only a few water-damaged ceiling tiles were observed, but they need to be replaced and inspected as discovered.

Repair/replace broken windows; re-seal loose window frames to prevent drafts and water penetration.

- **Action:** No broken windows were observed during the 2014 assessment.

Move plants away from univents in classrooms and away from air intakes on the exterior of the building. Ensure all plants are equipped with drip pans. Examine drip pans for mold growth and disinfect areas of water leaks with an appropriate antimicrobial where necessary.

- **Action:** Plants were not found on most univents.

Consider storing gas powered snow/lawn equipment and fuel containers in a location outside the building (e.g., storage shed). If not feasible, consult with local fire officials to determine compliance with local/state fire codes.

- **Action:** Gas-powered equipment was found in the garage area adjacent to the library.

Seal utility holes/breaches in walls in storeroom to prevent the migration of fuel and/or combustion odors.

- **Action:** The inside of this storeroom could not be accessed.

Appendix A

Consider sealing access door to storeroom in library. If not feasible install weather stripping/door sweeps around exterior doors to prevent, drafts and odor migration. Ensure tightness of doors by monitoring for light penetration and drafts around doorframes.

- **Action:** Weather stripping on this door was found damaged during the 2014 visit ad the door did not seal tightly.

Store cleaning products properly and out of reach of students.

- **Action:** Cleaning products were observed in a few classrooms.

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.

- **Action:** Dust and debris was observed inside univent cabinets. Those filters observed appeared in need of changing.

Clean univent air diffusers/return vents, portable air conditioners and exhaust vents periodically of accumulated dust to prevent the accumulation/aerosolization of dirt, dust and particulates.

- **Action:** Dusty vents/fans and other HVAC equipment were observed in a number of areas.

Consider removing carpet or clean annually (or semi-annually in soiled high traffic areas) as per the recommendations of the Institute of Inspection, Cleaning and Restoration Certification (IICRC). Copies of the IICRC fact sheet can be downloaded at: http://www.cleancareseminars.com/carpet_cleaning_faq4.htm (IICRC, 2005).

- **Action:** Some carpeting remains, including in sub-grade areas.

Continue with plans to raise fuel tank vent pipe above the roof. Schedule oil deliveries after school or when school is not occupied. If not feasible, notify school staff including those whose classrooms are in close proximity to oil tank, in advance of scheduled delivery so occupants can take precautions (e.g., deactivate univents, close windows). This should reduce/eliminate fuel odors and/or vehicle exhaust entrainment into classrooms.

- **Action:** It appears as though the vent has been raised above the roof line, however fuel odors were detected outside the building in this area at the time of the 2014 visit.

Consider developing a written notification system for building occupants to report indoor air quality issues/problems. Have these concerns relayed to the maintenance department/ building management in a manner that allows for a timely remediation of the problem.

Appendix A

- **Action:** No demonstration of management systems were observed during the 2014 visit.

Store nests in resealable bags to prevent aerosolization of irritants or consider bring in on an "as needed" basis.

- **Action:** No nests were observed during the 2014 assessment.

Enforce antismoking policies in accordance with Massachusetts General Laws. M.G.L. c. 270, sec. 22.

- **Action:** No smoking or smoking materials were observed during the 2014 assessment.

Consider discontinuing the use of tennis balls on furniture and replacing tennis balls with alternative "glides".

- **Action:** Tennis balls were observed in one classroom, but were not in widespread use in the school during the 2014 assessment.

Long-Term recommendations:

Contact an HVAC engineering firm for a full evaluation of the ventilation system. Considering the age, physical deterioration and availability of parts of the HVAC system, an evaluation is strongly recommended for proper operation and/or repair/replacement of the ventilation system.

- **Action:** It does not appear as though this was conducted.

Repair and/or replace thermostats and pneumatic controls as necessary to maintain control of thermal comfort. Consider contacting an HVAC engineer concerning the condition and calibration of thermostats and pneumatic controls school-wide.

- **Action:** It could not be determined if this was performed.

Consider having a full building envelope evaluation to determine the source moisture contributing to damaged floor tiles.

- **Action:** It could not be determined if this was performed.