INDOOR AIR QUALITY REASSESSMENT

John R. Briggs Elementary School
96 Williams Road
Ashburnham, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Vice Principal Candice Wright, the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA) conducted a reassessment of the indoor air quality at the John R. Briggs Elementary School (the school), 96 Williams Road, Ashburnham, Massachusetts. Ms. Wright indicated that a number of remedial steps had been taken in the school, but an increased number of complaints were received from occupants in classrooms located within a modular building. The increase in complaints occurred after the school and surrounding areas experienced heavy snowfall.

On March 21, 2003, Michael Feeney, Chief of Emergency Response/Indoor Air Quality (ER/IAQ), BEHA, visited the school to conduct an indoor air quality reassessment. Mr. Feeney was accompanied by Ms. Wright.

The school is a brick and steel structure constructed in 1968. Three classrooms (105, 106 and 107) and offices were added in 1991. Two modular classrooms were added within the last several years. The school contains general classrooms, an art room, a library, a cafeteria, a music room and various offices. Classroom windows are openable.

Actions on Recommendations Previously Made by MDPH

BEHA staff had previously visited the building in November 1999 and issued a report that made recommendations to improve indoor air quality (MDPH, 2000). A summary of actions taken on previous recommendations is included as Appendix I of this reassessment.

Methods

Air tests for carbon monoxide, carbon dioxide, temperature and relative humidity were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551.

Results

This school houses kindergarten through 5th grade and has a student population of approximately 500, as well as a staff of approximately 60. The tests were taken during normal operations at the school. Test results appear in Table 1.

Discussion

Ventilation

It can be seen from the tables that carbon dioxide levels were elevated above 800 parts per million (ppm) in 28 of 29 areas surveyed, which indicates an overall ventilation problem in this school. These measurements mirror carbon dioxide air sampling results measured during the previous indoor air quality assessment. Fresh air in classrooms is supplied by a unit ventilator (univent) system (see Figure 1). Univents were turned "off" in a number of classrooms. Obstructions to airflow, such as books, papers and posters placed on top of univents and bookcases, tables and desks located in front of univent returns, were seen in a number of classrooms, however the majority of these units were free of obstructions. To function as designed, univents and univent supply and return components must remain free of obstructions. More importantly, these units must be activated and allowed to operate.

Exhaust ventilation in classrooms is provided by a mechanical exhaust system. Classroom air is drawn through a space beneath the closet door and into the closet. The exhaust vents are located in the upper portions of coat closets in classrooms (see Picture 1). This design allows the vents to be easily blocked by materials stored on shelves situated beneath the exhaust vent. Some of these vents were not drawing air. It appears that the exhaust system is not coordinated with univent function, but rather is set for deactivation by the thermostat. Exhaust vent deactivation prevents removal of air from the building, which can increase carbon dioxide levels.

Ventilation in the modular classrooms is provided by two rooftop air handling units (AHUs) (see Picture 2). The ability of the AHUs appears to be limited by the design of the fresh air intake. The fresh air intake is configured to introduce a minimal amount of fresh air. The sheet metal encasing the fresh air intake was noticed to be loose on both AHUs. It is likely that fresh air is drawn through space in the cover, bypassing the fresh air intake vent. The Ashburnham area had an extensive snow cover of several feet during the past winter. It is likely that the drifting snow covered the AHUs, providing an airtight seal that would prevent fresh air intake. Since the AHUs do not have the ability to exhaust air, the operation of the AHUs would be expected to recirculate air. In these conditions, concentrations of normally occurring environmental pollutants could increase, resulting in increased comfort complaints for some individuals.

Modular classrooms are designed to be energy efficient; therefore, little outside air penetration occurs, except when windows are open. The thermostat-controlled HVAC system is the primary source of fresh air supply. The modular thermostat has a fan switch that can be set to either “auto” or “on”. The thermostats were found in the "auto" position, which deactivates the HVAC system once the pre-set temperature on the thermostat is reached. As a result, the AHUs were deactivated and fresh air circulation in these classrooms was limited.

To maximize air exchange, the BEHA recommends that both supply and exhaust ventilation operate continuously during periods of school occupancy. In order to have proper ventilation with a univent and exhaust system, these systems must also be balanced to provide an adequate amount of fresh air to the interior of a room while removing stale air from the room. The date of the last balancing of these systems was not available at the time of the assessment.

The Massachusetts Building Code requires a minimum ventilation rate of 15 cubic feet per minute (cfm) per occupant of fresh outside air or have openable windows in each room (SBBRS, 1997). 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 at levels measured in this building. It is used as an indicator of the adequacy of the fresh air ventilation. Rising carbon dioxide levels rise indicate 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 II.

The BEHA recommends that indoor air temperatures be maintained in a range between 70 ^{o} F to 78 ^{o} F in order to provide for the comfort of building occupants. Temperature readings in the school were measured between 70^{o} F to 78^{o} F, which is within the BEHA recommended range. 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 in this building was within a range of 33 to 43 percent, which is below the BEHA recommended comfort range in all areas. The BEHA recommends a 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 common problem during the heating season in the northeast part of the United States.

Microbial/Moisture Concerns

Water continues to penetrate the school through window frames, as evidenced by signs of water damage. In one instance water dripping through a gutter was striking a sill for a window frame (see Picture 3), resulting in water penetration into the classroom (see Picture 4). In another instance, a damaged gutter allowed for water to directly impact on tarmac, wetting the exterior wall system (see Picture 5). Water that has penetrated through window frames can serve as a mold growth medium.

The roof of the portable classrooms is outfitted with a drainage system that is connected to downspouts. Downspouts are configured to allow rainwater to accumulate at the base of the modular classrooms. This causes chronic wetting of the exterior wall (see Picture 6). Downspouts should be designed to direct rainwater away from the base of the portable classroom exterior walls to prevent rainwater from penetrating through the asphalt/exterior wall seam into the classroom crawl space. The wetting of exterior walls and crawlspace soil can result in mold growth.

Several classrooms have sinks that have a seam between the countertop and wall. If the seam is not watertight, water can penetrate the countertop seam and collect behind this board. Water penetration and chronic exposure to water on wood, plywood and corkboard cause these types of materials to swell and serve as a growth medium for mold.

Other Concerns

In an effort to reduce noise from sliding chairs, tennis balls were sliced open and placed on chair legs. 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 to off-gas

TVOCs. Tennis balls are made with a natural rubber latex bladder, which becomes abraded when used as a chair leg pad. Use of tennis balls in this manner may introduce latex dust into the school environment. Some individuals are highly allergic to latex (e.g., spina bifida patients) (SBAA, 2001). It is recommended that the use of materials containing latex be limited in buildings to reduce the likelihood of symptoms in sensitive individuals (NIOSH, 1997). A question and answer sheet concerning latex allergy is attached as Appendix A (NIOSH, 1998).

Several other conditions that can potentially affect indoor air quality were also identified. The ongoing renovations at this building can result in the introduction of particulates, gases and vapors. If not properly contained, these materials can adversely affect indoor air quality in occupied areas of the school.

Of note is the use of cleaning materials in this building. Cleaning products frequently contain ammonium compounds or sodium hypochlorite (bleach-products), which are alkaline materials. The use of these products can provide exposure opportunities for individuals to a number of chemicals, leading to irritation of the eyes, nose or respiratory tract. Cleaning products containing respiratory and skin irritants appear to be used throughout the building.

Conclusions/Recommendations

In order to address the conditions listed in this assessment, the recommendations made to improve indoor air quality are divided into **short-term** and **long-term** corrective measures. The short-term recommendations can be implemented as soon as practicable. Long-term solution measures are more complex and will require planning and resources to adequately address overall indoor air quality concerns.

In view of the findings at the time of this assessment, the following **short-term** recommendations are made:

1) Operate both the univents and exhaust ventilation system continuously during school hours.
2) Operate the modular AHUs continuous during school hours.
3) In order to improve indoor air quality, an increase in the percentage of fresh air supply into the univent system may be necessary. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.
4) Clear a three-foot space around all exhaust vents where feasible, and reduce stored materials in classroom closets such that airflow is not impeded. Exhaust ventilation is necessary to remove pollutants from the interior of classrooms. If exhaust ventilation cannot be run continuously, adjust exhaust unit ventilator to have exhaust run as much as this equipment will allow.
5) Repair leaks in gutters. Examine the area above and around exterior wall leaks for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.
6) Examine windows for water penetration and repair where needed. Remove/replace water damaged wood and tiling. Examine areas underneath water-damaged materials for mold growth. Disinfect these areas with an appropriate antimicrobial.
7) For buildings in New England, periods of low relative humidity during the winter are often unavoidable. Therefore, scrupulous cleaning practices should be adopted to

minimize common indoor air contaminants whose irritant effects can be enhanced when the relative humidity is low. To control for dusts, a HEPA filter equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended. Drinking water during the day can help ease some symptoms associated with a dry environment (throat and sinus irritations).

8) Examine the feasibility of directing downspout water away from the base of the portable classroom's exterior wall.
   a) Improve the grading of the ground away from the foundation at a rate of 6 inches per every 10 feet (Lstiburek, J. & Brennan, T.; 2001).
   b) Install a water impermeable layer on ground surface (clay cap) to prevent water saturation of ground near foundation (Lstiburek, J. & Brennan, T.; 2001).
9) Consider replacing the countertop over water-damaged cabinets. Consider using molded countertops to minimize seams where water and dirt can accumulate, thereby decreasing the chance of mold growth.

The following **long-term** measures should be considered:

1) Based on the age, physical deterioration and availability of parts for ventilation components, the BEHA strongly recommends that an HVAC engineering firm fully evaluate the ventilation system. It is possible that restoration of the current univents in this building is not feasible from a technical standpoint or may be cost prohibitive since the manufacturer appears to be out of business. If repair is technically not feasible or is cost prohibitive, consideration should be give to replacing the ventilation system.

References

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MDPH. 2000. Indoor Air Quality Assessment, John R. Briggs Elementary School, Ashburnham, MA. Massachusetts Department of Public Health, Bureau of Environmental Health Assessment, Boston, MA. July 2000.

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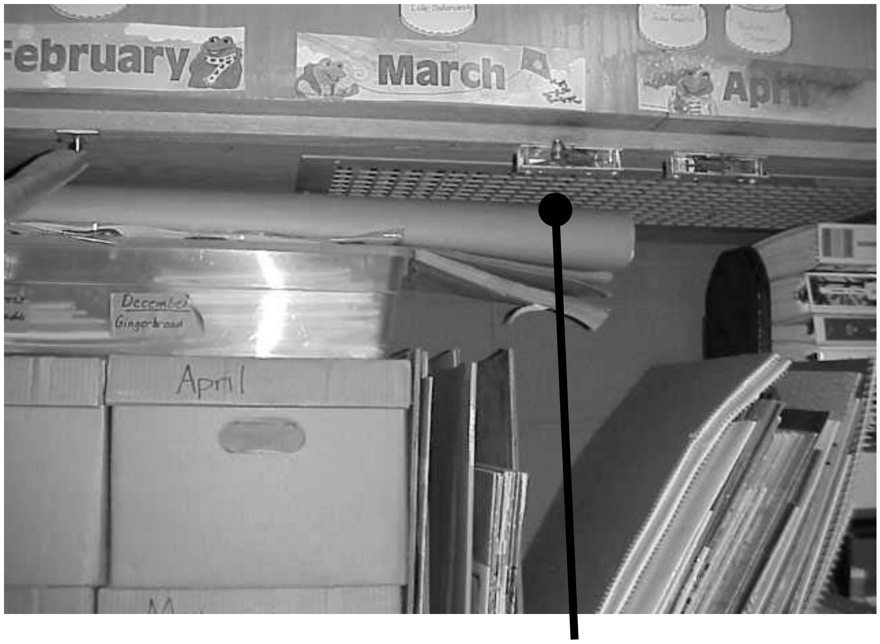
SBAA. 2001. Latex In the Home And Community Updated Spring 2001. Spina Bifida Association of America, Washington, DC.
Http://www.sbaa.org/html/sbaa_mlatex.html

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

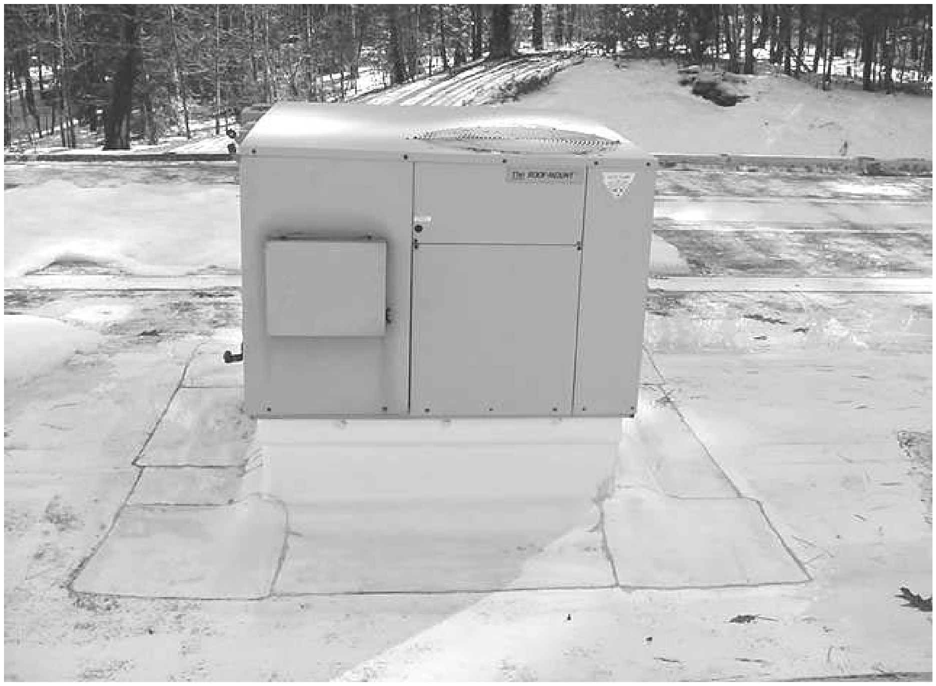
Picture 1



Exhaust Vent

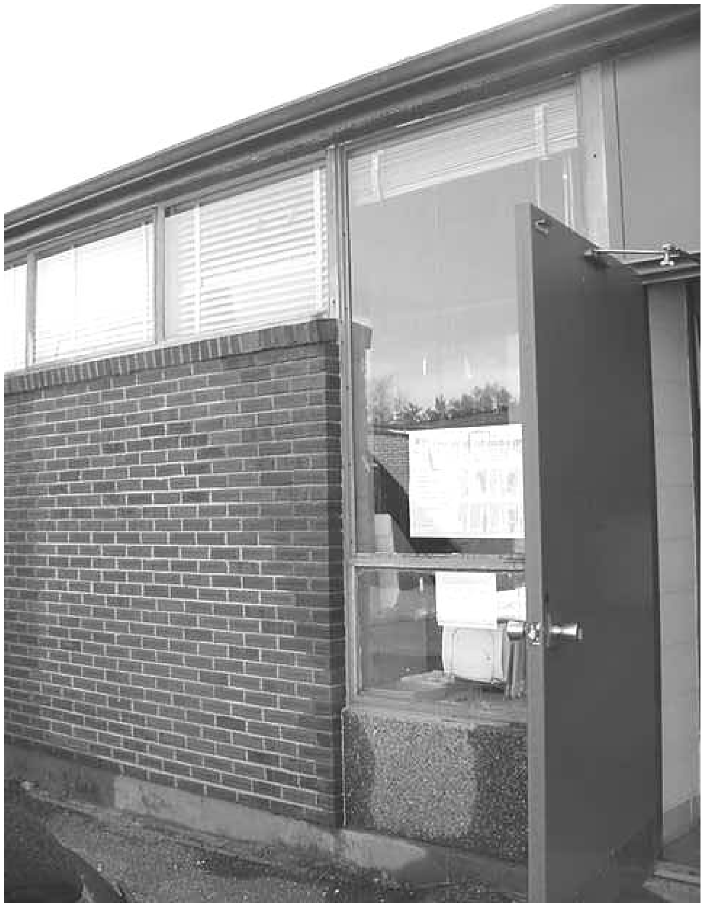
Exhaust Vent in the Ceiling of the Classroom Closet

Picture 2



Modular Classroom AHU

Picture 3



Water Dripping Through a Hole in the Gutter Wetting the Sill, Window Frame and Exterior Wall

Picture 4

Close Up Of Water Damage in Picture 3

Picture 5

Damaged Gutter Wetting the Exterior Wall System

Picture 6

Downspout of Modular Roof Emptying at Base of Exterior Wall

TABLE 1-1

Indoor Air Test Results – John R. Briggs Elementary School, Ashburnham, MA March 21, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Outside (Background)			45					
Main Office	1281	71	39	4	Y	N	N	Window AC, photocopier
Art Room	1019	71	41	0	Y	Y	Y	Supply and Exhaust off, door open
Library	1218	72	34	19	Y	Y	N	Door open, exhaust ventilated through door vent
Room 125	1978	71	36	17	Y	Y	Y	Supply and Exhaust off, stored materials blocking exhaust
Room 121	1145	72	35	16	Y	Y	Y	Exhaust off, door open, tennis balls on chair legs, stored materials blocking exhaust
Room 120	1780	71	33	21	Y	Y	Y	Supply and exhaust off, supply under repair, stored materials blocking exhaust
Room 122	1108	70	33	19	Y	Y	Y	Exhaust off, door open, chair blocking
Room 119	893	71	35	20	Y	Y	Y	Door open
Room 123	1054	72	37	0	Y	Y	Y	Door open
Room 118	1197	71	35	14	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%

TABLE 1-2

Indoor Air Test Results – John R. Briggs Elementary School, Ashburnham, MA March 21, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 124	1327	72	39	14	Y	Y	Y	Exhaust off
Room 117	1176	71	34	19	Y	Y	Y	Door open
Room 116	1233	71	35	21	Y	Y	Y	Door open
Computer Room	1549	71	38	18	Y	Y	Y	Window open, exhaust off, 22 computers
Teachers Room	1528	73	37	10	Y	Y	N	
Work Room	1150	73	32	2	Y	N	Y	
Room 126	618	73	35	0	Y	Y	N	Door open
Room 135	831	72	34	0	Y	Y	Y	Door open
Room 134	1283	72	32	0	Y	Y	Y	Door open, exhaust off
Room 127	1343	72	34	0	Y	Y	Y	
Room 133	834	72	36	20	Y	Y	Y	Door open, tennis balls on chair legs
Room 132	869	71	38	18	Y	Y	Y	

*** 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%

TABLE 1-3

Indoor Air Test Results – John R. Briggs Elementary School, Ashburnham, MA March 21, 2003

Location	Carbon Dioxide (*ppm)	Temp. (°F)	Relative Humidity (%)	Occupants in Room	Windows Openable	Ventilation		Remarks
						Supply	Exhaust	
Room 129	1118	72	38	12	Y	Y	Y	Window AC
Room 131	1637	72	38	25	Y	Y	Y	Tennis balls on chair legs
Room 5-B	1252	74	40	0	Y	Y	Y	
Room 5-A	909	73	45	0	Y	Y	Y	Plants
Room 105	973	73	47	14	Y	Y	Y	
Room 106	1539	74	43	13	Y	Y	Y	Supply off
Room 107	1342	73	42	20				

*** 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%

Appendix I

The following is a status report of action(s) taken on previous BEHA recommendations (**in bold**) based on reports from town/building staff, documents, photographs and BEHA staff observations.

1. **The majority of rooftop-mounted exhaust ventilation motors were either deactivated or broken. Each of the motors should be repaired and/or reactivated to provide exhaust ventilation in all classrooms.**

   Action taken: Exhaust vents were reported by school personnel to be repaired, however, the control system appears to deactivate these fans independent of univent operation.

2. **Discontinue wet cleaning of carpeting to prevent further mold growth. Evaluate carpeting in other classrooms for mold growth and consider removing carpet in a manner consistent with asbestos remediation laws and regulations.**

   Action taken: Carpet was removed from classroom. No further concerns were expressed about mold odor from carpeting.

3. **Remove materials blocking the fresh air diffusers or return vents of univents. Univents must remain clear of obstructions in order for the equipment to function properly.**

   Action taken: Most univents and exhaust vents were cleared of obstructions.

4. **In order to improve indoor air quality, increase the percentage of fresh air supplied into the univent system. Survey classrooms for univent function to ascertain if an adequate air supply exists for each room.**

Action taken: See results listed in report.

5. **Repair the exhaust ventilation motors.**

   Action taken: See results listed in report.

6. **Examine the feasibility of providing both fresh air supply and exhaust ventilation for the modular classrooms.**

   Action taken: See results listed in report.

7. **Clear a three-foot space around all exhaust vents where feasible and reduce stored materials in classroom closets such that airflow is not impeded. Exhaust ventilation is necessary to remove pollutants from the interior of classrooms. If exhaust ventilation cannot be run continuously, adjust exhaust unit ventilator to have exhaust run as much as this equipment will allow.**

   Action taken: Exhaust vents were mostly clear of obstructions.

8. **Once both the fresh air supply and the exhaust ventilation are functioning, the ventilation system should be balanced.**

   Action taken: See results listed in report.

9. **Door vents in bathrooms should be repaired and blockage removed. To prevent bathroom odors from penetrating halls and classrooms, ensure exhaust ventilation is functional.**

   Action taken: restroom passive door vents were opened.

10. **Replace any remaining water-stained ceiling tiles and wall plaster. Examine the area above and around these areas for mold growth. Disinfect areas of water leaks with an appropriate antimicrobial.**

Action taken: Water damaged materials were removed/replaced, with some exceptions (see main report).

11. **Examine windows for water penetration and repair where needed. Remove/replace water damaged wood and tiling.**

    Action taken: See results listed in report.

12. **Reconnect the portable classroom downspouts to the roof drains. Examine the feasibility of directing downspout water away from the base of the portable classroom's exterior wall.**

    Action taken: Downspouts were installed to gutter system. Drainage around the exterior of the modular classrooms remains problematic, with water pooling along exterior walls.

13. **Consider removing clinging vines from the exterior of the building.**

    Action taken: Vines were cutback/reduced from wall.

14. **Replace missing or dislodged ceiling tiles to prevent the egress of particulate matter into classrooms.**

    Action taken: Ceiling tiles were replaced.

15. **Clean chalkboards and chalktrays regularly to prevent the build-up of excessive chalk dust.**

    Action taken: Chalk trays are cleaned regularly.