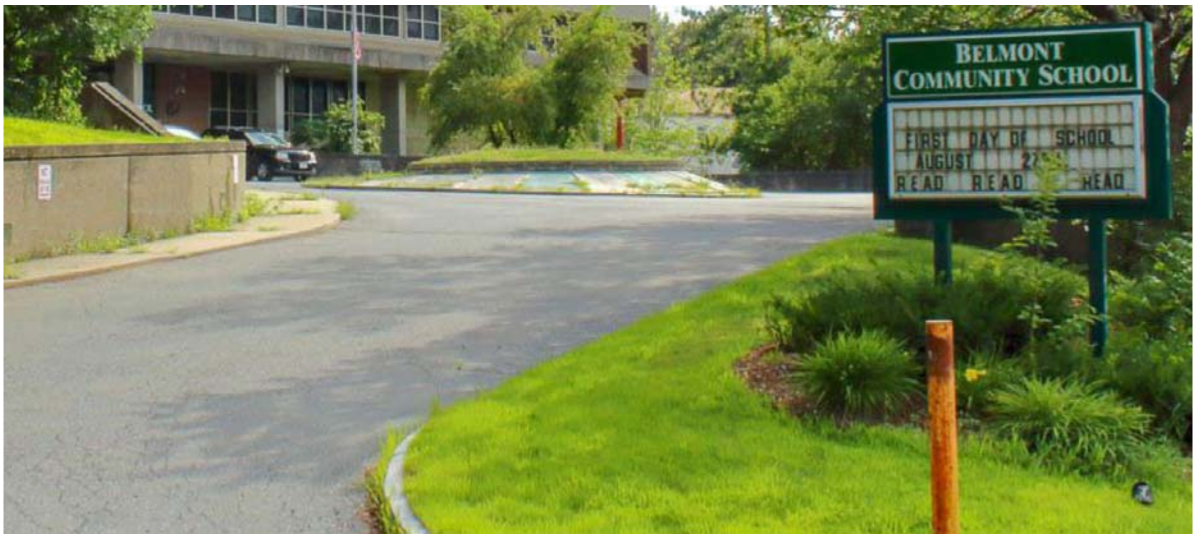
Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Belmont Community School
Worcester, MA



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Worcester Public Schools

A. Preface:

Worcester Public School has as Nault Architects Inc. and their consultant Seaman Engineering Corporation (SEC) to review all of their occupied buildings and comment on existing natural and mechanical ventilation.

The first part of the report is SEC's evaluation of the existing mechanical systems.

The second part of the report is an evaluation of the natural ventilation. The Building Code requires ventilation of each occupied space and that can be achieved either through mechanical of natural ventilation methods. If the natural ventilation path is chosen, there must be a clear opening(s) in the space that meet or exceed the 4% of the total room square footage. After the field survey of each room / window type was complete, the ventilation information was added to a spread sheet for calculation of the 4% and color-coding. The calculations were also color-coded on a floor plans of the building for a better overall understanding of the existing conditions.

The natural ventilation color-coding (on the spreadsheet and plans) is as follows:

- **Green Spaces**: meets or exceed the code minimum natural ventilation.
- **Yellow Spaces**: does **not** meet the code minimum natural ventilation, but does have operable window to allow some natural ventilation.
- **Red Spaces**: does not meet the code minimum natural ventilation and does not have any operable windows.

It should be reiterated that the second part of this report is only measuring natural ventilation. Therefore, newer buildings or buildings with large amounts of fixed windows may have large amounts of red and/or yellow spaces, but that doesn't mean they are not code compliant, they may be relying on mechanical ventilation. However, for this part of the report, were asked to show a baseline for all schools without mechanical equipment.

B. Building Description:

Belmont Community School:
Belmont Community School is located in the North Quadrant of the Worcester at 170 Belmont Street. The School was built in 1970, houses grades PK-06, has 25 classrooms and the building is 92,988 square feet. The original widows have been replaced.

C. Table of Contents:

1) Mechanical Ventilation Report

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I. EXECUTIVE SUMMARY

This report briefly describes the existing ventilation systems at the Belmont Street Community School in Worcester, MA as well as their capabilities to support current code required ventilation rates. In addition, we have evaluated the systems ability to support recommendations in accordance with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020). Several of the ASHRAE recommendations as well as those from the Harvard T.H. Chan School of Public Health and other industry sources have been presented for consideration to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

Our inspection of the existing systems was limited to visual observations coupled with review of original design drawings, when available. The findings presented in this report presume the systems are operational and delivering air quantities indicated on the original design drawings. Proper operational testing of each piece of equipment and airflow measuring would be required to confirm such operation.

During, our visual inspection we also took several spot measurements of air quality in various locations throughout the school. Measurements taken were limited to Temperature (°F), Relative Humidity (% RH), CO_2 (carbon dioxide in ppm), CH_2O (formaldehyde in ppm) and Total Volatile Organic Compounds (TVOC in ppm).

The results of the readings taken during our inspection were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

COVID-19 Control Measures:

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems. The following descriptions are abbreviated with additional detail found later within the report.

As of the writing of this report, the city of Worcester Public Schools (WPS) has already begun implementation of several of the measures noted below where possible. For enhanced measures WPS has begun to incorporate Bipolar Ionization (see ECCM-#3) extensively throughout the Belmont Street Community School to address the current pandemic condition.

CCM #1 – Pre & Post Purge Ventilation - Pre and post purge ventilation of occupiable spaces using outside air introduced thru the HVAC systems for an extended period of time prior to and after occupancy.

Most of the HVAC systems supporting the Belmont Street Community School are capable of implementing this measure.

CCM #2 – Increased Ventilation - Increase the quantity of outdoor air ventilation for improved space dilution where systems allow. Disable demand ventilation reset. The Harvard T.H. Chan School of Public Health identifies 3 outdoor air changes per hour (ACH) as the "bare minimum" during a pandemic condition.

We cannot confirm the existing system design outdoor air (OA) rate as the existing drawings do not reflect these rates. However, a majority of the classrooms supported by unit ventilators as well as many other areas supported by air handlers (gymnasium, cafeteria etc.…) have the ability to increase outdoor air (OA) for higher OA ventilation and air exchange rates, subject to outdoor ambient conditions and equipment limitations. Areas not supported by air ventilation systems, such as the offices along exterior walls cannot support this measure without system work. Any CO2 demand ventilation reset controls or occupancy based should be adjusted during pandemic conditions to allow for elevated outdoor air levels regardless of occupancy.

CCM #3 – Improved Filtration - Improve filtration to up to MERV-13 or higher on recirculating air handling systems which can support such filtration.

Many of the air handling systems supporting the school are old and do not appear to be able to support filtration above MERV 8. However, air handlers could be tested to verify fan capacity and ability to support filtration up to a maximum of MERV 13. Unit ventilators and fan coil units cannot support filtration above MERV 8 either due to physical equipment limitations (i.e., fan coils limited to 1" filters) or fan capacity limitations. Increased filter efficiency can lead to faster filter loading and a potential reduction in ventilation air for systems not designed to support this filtration level.

In addition to the above suggested measures, we have also presented Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Where the above CCM's cannot be employed, one or more of the ECCM measures outlined herein may be utilized to improve indoor air quality. The following descriptions are abbreviated with additional detail found later within the report:

ECCM #1: Portable Room Purifiers - Portable room air purifiers may be used in select areas and rooms to help clean the air within the room. These can be especially helpful where rooms have low outdoor air changes per hour and cannot be supplied with additional outdoor air or where existing systems cannot accommodate improved filtration.

ECCM #2: UV-C Light Sterilization - UV-C lights may be considered for insertion in equipment and ductwork to help neutralize viruses when exposed to the light.

ECCM #3: Bipolar Ionization - Air ionizers may be installed in air handling systems or portable units installed in rooms to improve indoor air quality. These systems cause particles and airborne contaminants to bind together thereby increasing their size, so they tend to either drop out of the breathing zone or be better removed by air filtration. Recent studies have also shown Bipolar Ionization may inhibit the COVID-19 viruses' ability to infect.

WPS has begun to incorporate Bipolar Ionization extensively throughout the Belmont Street Community School to address the current pandemic condition.

Recommendations Summary:

Based on our site inspections, sample air quality readings and review of original drawings we found that a majority of the occupied areas of the Belmont Street Community School comply with current ventilation codes with few exceptions noted herein. However, in order to address the pandemic level conditions currently in place the following table summarizes our recommendations, several of which, align with the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health.

WPS has already begun to incorporate Bipolar Ionization (ECCM-#3) extensively throughout the Belmont Street Community School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	Unit Ventilators & Air Handlers	CCM - #1 & #2 (#3 for AHU's only) ECCM - #1 or #3 (*see note below)
Science and Art Classrooms	Unit Ventilators	If used as science lab and art rooms, increase O.A. ventilation to code minimum (may require system work). CCM - #1 & #2 ECCM - #1 or #3 (*see note below)
Gymnasium	Packaged Rooftop Units	CCM - #1 & #2 ECCM - #3
Cafeteria	Air Handler	CCM - #1 & #2 ECCM - #3
Exterior Offices	None	ECCM - #1 or #3 (*see note below)

<u>Note</u>: For individual classrooms and other areas noted, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization, are noted as possible options to improve air cleaning and changeover during pandemic conditions. Regardless, we highly recommend outdoor air of some level be provided in areas indicated as having none, even if via windows as there is no substitute for proper ventilation.

Inevitably, during a pandemic, the best approach is a multi-faceted one which should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

II. HVAC VENTILATION ASSESSMENT

A. GENERAL

Over the last several weeks we performed site inspections of the existing school building to assess the ventilation systems in place. Manufacturer and model information was obtained from the existing ventilation equipment, when available/accessible, and visual conditions were noted.

For our review, original design drawings as well as drawings of various modifications over the years for the school were received from school facilities. In addition, we have also received and reviewed the available HVAC control drawings to ascertain current control configuration. We have used these documents to ascertain the original design ventilation rates so as to compare them to current ventilation codes and standards.

Our inspection was limited to visual assessment of systems and did not include operational testing of each piece of equipment or airflow measuring. We have however, taken some spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

These readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

TVOC's sources can vary widely and include but are not limited to paints, finishes, adhesives, cigarette smoke, pesticides, personal care products, car exhaust, new furnishings, wall coverings, cleansers, and cooking fuels. The meter used included the following chemicals in its TVOC analysis: Acetone, Ethylene Glycol, Formaldehyde, Xylene, 1,3-Butadiene, Tetrachloroethene, Hydrogen Sulfide, Ammonia, Toluene, Benzene, Methylene Chloride, Perchloroethylene, and MTBE. The meter cannot read every possible VOC nor quantify percentages of various VOC's. In addition, we did notice the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

The report ventilation calculations presume, the existing systems are operating to the levels reflected on the original design drawings. Testing and balancing by a certified balancer would be required to confirm actual airflows.

For ventilation calculations, data from current codes including the International Mechanical Code (IMC) 2015 and ASHRAE 62.1-Ventilation for Acceptable Indoor Air Quality were used. The outdoor airflow values have been corrected to adjust for the distribution systems ability to get the outdoor air to the space breathing zone with the breathing zone being within 6 feet of the occupied floor. This correction factor also known as the Zone Air Distribution Effectiveness (ZDE), varies based on how and where the air is introduced and removed from the room as well as the temperature of the air entering the room. Some examples of ZDE for various systems are as follows:

Distribution Configuration	ZDE
Ceiling supply of cool air (air below room temp.)	1.0
Ceiling supply of warm air & floor return	1.0
Clg. supply of warm Air >15F above space temp. & clg. return	0.8
Floor supply of warm air & floor return	1.0
Floor supply of warm air & ceiling return	0.7
Displacement cooling floor supply & ceiling return	1.2

For example, a displacement cooling system with a ZDE of 1.2 would require 17% (1.0 / 1.2) less outside air to properly ventilate a space than a system with warm air supplied at the ceiling level being that the displacement system is more effective in getting the outdoor air into the breathing zone. A room with a ZDE of 0.8 would require 25% (1.0 / 0.8) more outdoor air to comply with ventilation standards.

This report contains a brief description of the types of ventilation systems serving the building as well as makes recommendations, where applicable, to improve ventilation of area served by these systems. Our evaluation considered the recommendations made by the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) as well as those from the Harvard T.H. Chan School of Public Health and other industry sources. All to assist in further mitigating virus transmission through the buildings heating, ventilation, and air conditioning (HVAC) systems.

B. EVALUATION

The following evaluation is based on visual observation of systems and equipment and excludes any operational testing which we understand is on-going by WPS. Evaluation includes information obtained from Worcester Public Schools on current air filters as well as existing building mechanical plans when available. In some cases, equipment was not accessible, and assessment was based only on original design drawings where available.

General Classrooms & Misc. Areas:

A majority of the classrooms in the building are heated and cooled with 2-pipe classroom unit ventilators. These units are fed with hot water from a central boiler plant. Most of the units are fitted with air 1" thick filters with an estimated MERV rating of 7 or 8 which is typical for units of this type. These units can support a maximum filter efficiency of MERV 8.

The classroom unit ventilators are located along exterior walls with each having an outdoor air louver and associate control dampers to allow outdoor air to enter the classroom space through the unit ventilator. During occupied periods, the unit fans run continuous to provide space ventilation and electric operators modulate the hot water valve, face & bypass dampers (where applicable) and mixing dampers to maintain space temperature setpoint. During unoccupied periods, the fans cycle off and only cycle on with the associated water valve opening when there is a need for heating or economizer (OA) cooling.

Although classrooms vary in size and airflow, for an average classroom size of 900 SF, the system delivers approx. 520 CFM of outdoor air to the classroom spaces via the unit ventilator. Where unit ventilators are present, exhaust is generally supported by classroom exhausters discharging thru wall louvers. We have no design information on the size and capacity of the exhauster however often times they are sized to support an airflow matching the unit ventilators minimum OA airflow.

For a standard classroom, current code would require 10 CFM per person of outside air plus 0.12 CFM per SF. For a system with a zone air distribution effectiveness of 1.0, as most classrooms with the current unit ventilator system are, a room size of 1,000 SF with 26 occupants (25 students + 1 teacher) would require 380 CFM of outdoor. Although there is no design data on the current units, they do appear to be capable of providing this level of outdoor air.

Bathroom and local exhaust requirements are supported by roof mounted centrifugal exhaust fans. These exhaust systems appear to meet or exceed the current ventilation codes for the spaces serviced.

Science & Art Rooms:

The science and art room areas are supported by the same types of unit ventilators and exhausts as the normal classroom systems.

Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms with a driving factor being the required exhaust air. For science laboratories, 1 CFM per SF of exhaust is required and for art rooms, 0.7 CFM of exhaust is required along with the associated make-up air. It appears the buildings ventilation levels for these rooms may be non-compliant, especially if they are used as art rooms or science labs with chemical use. If the rooms are not used as labs, lower typical classroom ventilation levels may apply.

Cafeteria/All Purpose Room, Gymnasium, etc.…:

Outdoor air ventilation for the cafeteria, gymnasium and many other areas which do not have UV's are supported by multiple air handling units. The units are mixed air systems each configured with mixing dampers, filter sections, hot/chilled water coil and supply fan along with a remote return fan. The design drawings do not reflect the quantity of outdoor air introduced by these systems. However, the units do appear to the have the capability to introduce a fair percentage of outdoor air.

The units have 2" thick pleated filters with an estimated MERV rating of 8. These units are old, and we are not confident that they can support higher filtration rates however, testing could be done to evaluate each unit's capabilities for enhanced filtration.

For a cafeteria space, current code would require 7.5 CFM per person of outside air plus 0.18 CFM per SF. One of the existing cafeterias, encompasses approx. 2,697 SF which, with 150 occupants, would require 1,610 CFM of outside air. This would be equivalent to approx. 18% of the systems supply air. This percentage of outside air is not excessive, and we suspect the cafeteria air handler would be able to support this quantity of outside air

For the gymnasium, the current code requires 0.3 CFM per SF of outdoor air for play area coupled with a separate value for spectator area. As the bleachers were retracted during our visit, the spectator area capacity is unknown. However, if we presume the entire space as play area, the required outdoor air volume for the 9,106 SF space is 2,732 CFM which is approx. 20% of the units listed supply capacity. This percentage of outside air is not excessive, and we suspect the gym air handler would be able to support this quantity of outside air.

Existing plans do reflect energy recovery segments incorporated into two or more air handlers. The capacity or performance of these devices is not reflected on the plans. Any modifications to increase outdoor air should confirm these devices are operating and that their design capacity is not exceeded.

Controls:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS). The EMS system is currently supported by Automated Building Systems, Inc (ABS). Although a further review with the EMS vendor would be required to ascertain the extent of this system it is our current understanding that the system controls all the air handlers, unit ventilators and fan coil units.

The operating schedule for much of the equipment is based on the school's occupancy schedule. The schedule is adjustable via the front-end computer workstation.

C. IAQ & Ventilation Summary

IAQ Summary:

During our inspection we obtained spot measurements of air quality in various locations throughout the school. Measurements taken were limited to:

- Temperature (°F)
- Relative Humidity (% RH)
- CO_2 (carbon dioxide in ppm)
- CH_2O (formaldehyde in ppm)
- Total Volatile Organic Compounds (TVOC in ppm)

The readings were taken at a specific moment in time and may vary during the day based on space occupancy, use and activities as well as the operational state of the HVAC systems. For example, most all spaces surveyed were unoccupied or very lightly occupied and as such most all CO_2 levels were low since space CO_2 is primarily generated by occupants.

In addition, we noted some elevated TVOC levels and/or formaldehyde levels in areas which would not generally be expected to have such elevated levels. Although TVOC's (which includes formaldehyde) may come from varied sources such as cleaners, air fresheners and such, formaldehyde levels are often from off-gassing of furnishings or building materials. It is important to note that elevated levels of TVOC's may have been partially caused by recent enhanced cleaning measures or due to ventilation systems that were not in full operation at the time.

Measurements taken included space humidity. Humidity levels has been found to play a role in the controlling the spread of COVID-19. ASHRAE recommends winter humidity levels be kept between 40% to 50% and summer humidity levels between 50% and 60% with a summer target of 50%. Maintaining humidity levels within the above ranges has been found to limit the growth and transmission of certain bacteria and viruses as well as supports respiratory function. The below chart is taken from the 2020 ASHRAE Handbook – HVAC Systems and Equipment and reflects the impact of space humidity on the increase or decrease of effect on various space contaminants. This chart only reflects increase or decrease of effect from humidity and does not intend to imply that there is zero growth or impact of a certain contaminant when the sloped bar graph zero's out.

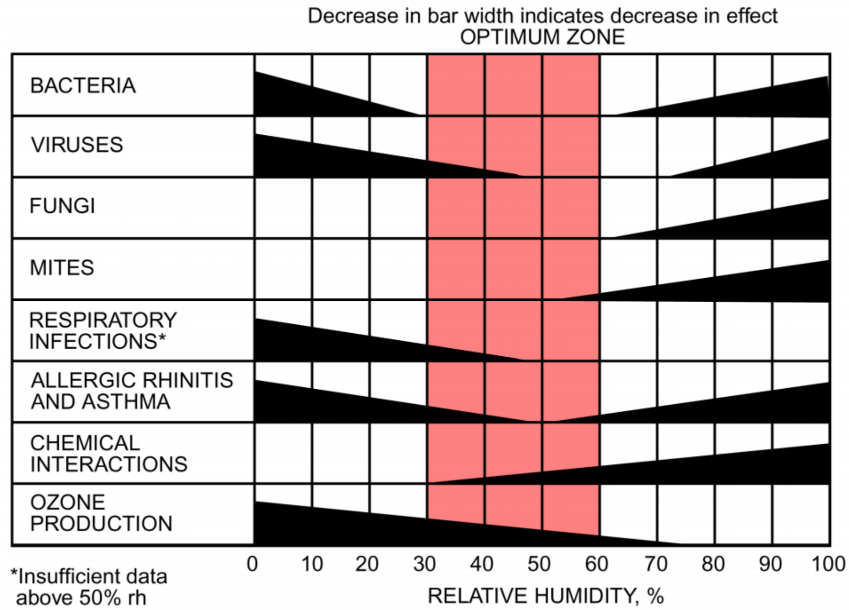

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Belmont Street Community School HVAC systems have no active humidity control. Space dehumidification is limited only to those areas which have air conditioning cooling. However, this dehumidification is not actively controlled by a humidity setpoint. Moisture removal only occurs when these systems are operating in the cooling mode. As such, space humidity may climb above 60% during periods when low thermal loads require less cooling (i.e., a cool damp day) or swing above and below 60% as the systems cycle based on space temperature.

Caution must be taken when considering adding active humidification to existing buildings as it is imperative that the buildings thermal envelope and vapor barriers be reviewed. Although newer structures, such as Belmont Street Community School often have a fair vapor barrier the varying wall and window construction and thermal characteristics may limit the ability for active humidification. Adding humidity in the wintertime without consideration of the building construction could result in moisture condensation on windows and within wall assemblies which may create a damaging and unhealthy condition for the building and its occupants. Review of the building envelope should take place prior to consideration of the addition of any humidification system. As such, our recommendations contained with this report exclude active humidification control until such time as the envelope can be reviewed.

The IAQ readings taken during the time of the inspection are contained within the table below. In addition, the table reflects the outdoor air exchange rate in the rooms based on design data from existing plans.

The document entitled “5-Step Guide to Checking Ventilation Rates in Classrooms” from the Harvard T.H. Chan School of Public Health recommends a target outdoor air exchange rate during these pandemic conditions. The document identifies 5 air changes per hour (ACH) and above as “excellent” down to a 3 ACH being considered “bare minimum”. The general classrooms in the Belmont Street Community School have an unknown outdoor air exchange rate but may be able to achieve the bare minimum criteria of 3 ACH pending testing. When the outdoor air exchange rate is lower than the target 5 ACH, the document recommends the following strategies:

1. Increase outdoor air (see CCM #2)
2. Use MERV 13 filters (or greater) on recirculated air (see CCM #3)
3. Add portable air cleaners with HEPA filters to the classroom (see ECCM #1)

It should be made clear however, that a room that has less that what this document considers the bare minimum outdoor air exchange rate may meet or exceed the most current ventilation standards and therefore is not under ventilated. The 5 ACH or greater recommendation is meant to address the pandemic conditions being experienced as this level of ACH would equate to nearly 100% outside air requirement for a conventional mixed air cooling & heating system.

The following tables describe areas and systems where the above measures as well as others presented in this report may be applied.

Belmont Elem. School IAQ Sampling Summary											
Space Tested	**Temp. °F**	**Humidity % RH**	**CO2 %**	**TVOC ppm**	**HCHO ppm**	**Room Area SqFt**	**Room Ht. Ft**	**Volume Cubic Feet**	**Design OA CFM**	**OA Air ACH**	**Notes**
Level 1											
Coaches Room (old principal)	70.3	22.7	495	2.18	0.51	162	9	1458	0	0	
General Office	70.1	23	501	1.98	0.42	417	7.33	3057	na	na	
Health Suite	67	23.6	452	1.33	0.18	426	7.33	3123	na	na	
Principal (old conference)	71.4	22.9	471	1.77	0.42	271	9	2439	0	0	
Level 2											
Classroom Grade 3	70.1	24.4	450	-	-	2222	9.66	21465	na	na	
Kitchen	70.1	21.6	455	1.3	0.13	507	8.83	4477	na	na	
All Purpose Room	73.2	20.2	449	1.31	0.13	2697	12.33	33254	na	na	
Room 232 Preschool	72.1	21.7	445	1.35	0.12	1869	9.33	17438	na	na	
Rainbow Room (old 231 preschool)	72.3	22.7	458	1.36	0.16	2444	9.33	22803	na	na	
Level 3											
Classroom Grade 4	72.1	19	438	1.32	0.06	2135	9.75	20816	na	na	
Classroom Special Ed.	73.9	20.4	548	1.34	0.08	1787	9.66	17262	na	na	
Classroom Grade 5 (bottom)	74.5	20.3	446	1.39	0.09	1708	9.66	16499	na	na	
Classroom Grade 6 (top corner)	69.1	21.8	468	1.34	0.08	1027	9.66	9921	na	na	
Classroom Grade 6 (middle)	66.5	22.7	450	1.33	0.08	1201	9.66	11602	na	na	
Faculty Lounge	67	21.2	439	1.33	0.05	668	9.83	6566	na	na	
Sara Ella Wilson Library	71.1	25.2	454	1.35	0.07	2180	9.66	21059	na	na	
Gymnasium	70	29.2	465	1.36	0.05	9106	24.5	223097	na	na	
Office	62.4	25.5	446	1.35	0.05	132	7.5	990	na	na	
Level 4											
Classroom Grade 2 (top)	72.7	20.4	445	1.76	0.05	1755	9.66	16953	na	na	
Classroom Grade 2 (bottom)	73.9	20.2	445	1.54	0.05	1661	9.66	16045	na	na	
Classroom Grade 1 (top)	72.8	22.1	467	1.53	0.05	1660	9.66	16036	na	na	
Classroom Kindergarten (top)	70.1	30	495	1.44	0.05	882	9.66	8520	na	na	

Note: As noted previously, the TVOC readings tended to drift up during the study, possibly due to a calibration issue, as such, the readings in this report were only used to identify areas where possible ventilation issues may exist and/or to identify areas where a source contaminant may be causing elevated levels.

<u>Ventilation System Summary & Recommendations</u>:

The following table is based on original design drawings and reflect most of the systems which provide ventilation air to the building. The units ID tag, area served, ventilation data and filter efficiencies are listed. The table also reflects possible COVID Control Measures (CCM) and Enhanced COVID Control Measures (ECCM) described later in this report which may apply to such systems to improve performance either during pandemic conditions and/or post pandemic conditions.

Belmont School Ventilation System Summary

Unit ID	Area Served	Exist. Supply CFM	Exist. O.A. CFM	Exist. O.A. %	Exist. Filter Qty & Size	Exist. Filter MERV Rating	Exist. Filter Vel. (FPM)	Proposed CCM #	Proposed ECCM #	Notes
AHU-GS-1	Gymnasium	14,000	N/A	N/A	(2) 25x20x2 (2) 16x20x2 (1) 20x20x2	8	Filters sizes for ERW?	#1, #2	#2 or #3	a, c
AHU-APS-1	All Purpose Room	8867	N/A	N/A	(8) 20x20x2	8	399	#1, #2	#2 or #3	a, c
AHU-LS-1	Library	4,085	N/A	N/A	N/A	8	N/A	#1, #2	#2 or #3	a
AHU-FGS-1	Gallery +	2,370	N/A	N/A	N/A	8	N/A	#1, #2	#2 or #3	
AHU-HGS-1	Health & Office	1780	N/A	N/A	N/A	8	N/A	#1, #2	#2 or #3	a
AHU-GLS-1	Girls Locker & Shower	1100	N/A	N/A	N/A	8	N/A	#1	#3	
AHU-BSS-1	Boys Shower	735	N/A	N/A	N/A	8	N/A	#1	#3	
AHU-BLS-1	Boys & Men's Locker	910	N/A	N/A	N/A	8	N/A	#1	#3	
AHU-TS-1	Toilet	1060	N/A	N/A	N/A	8	N/A	#1	#3	
AHU-KS-1	Kitchen	3000	N/A	N/A	N/A	8	N/A	#1	#3	
AHU-CS-1	Community Room	9974	N/A	N/A	(6) 16x25x2 (4) 20x25x2	8	449	#1, #2	#2 or #3	c
UV's	Classrooms	varies	varies	varies	varies	8	varies	#1, #2	#1, #3	a
	Exterior Office	none	none	none	N/A	N/A	N/A		#1, #3	b

Ventilation System Summary Notes:

a. *For individual classrooms, ECCM #1 – Portable Air Filtration and/or ECCM #3 – Ionization is noted as a possible option to improve air cleaning and changeover during pandemic conditions.*

b. *We highly recommend outdoor air of some level be provided, even if via windows as there is no substitute for proper ventilation regardless of other measures employed.*

c. *Although there are no control drawings indicating such, modify any CO2 demand ventilation reset or occupancy sensor-based system shutdown (during scheduled occupied periods) during pandemic conditions to ensure increased outdoor air.*

II. COVID-19 HVAC MITIGATION MEASURES

A. HVAC COVID-19 CONTROL MEASURES

In line with the current American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE) Epidemic Task Force Building Readiness Guidelines (updated 10-20-2020) and those from the Harvard T.H. Chan School of Public Health - 5-Step Guide to Checking Ventilation Rates in Classrooms, as well as other industry recommendations the following HVAC COVID Control Measures (CCM's) are presented for consideration to assist in mitigating virus transmission thru the HVAC systems.

The ASHRAE Epidemic Task Force recommends several measures to assist in COVID-19 mitigation with more aggressive action with epidemic conditions in place (ECiP) and post-epidemic conditions in place (P-ECiP). For ECiP conditions in place the HVAC COVID-19 Control Measures (CCM) that could be readily applied to the Belmont Street Community School surveyed are outline herein. Refer to the Ventilation System Summary Table for applicable CCM recommendations.

It is imperative that all systems be maintained and checked to confirm proper operation in line with their original design, adjusted where applicable, as described herein. In addition, a Testing and Balancing company should be enlisted to adjust and confirm all systems are properly achieving their design outdoor air, supply air and exhaust air levels.

CCM #1 – Pre & Post Purge

Pre and post purge ventilation of occupiable spaces using outside air introduced the HVAC systems. This would be accomplished by starting the ventilation systems in occupied mode (i.e., OA at design or higher) 4 hours prior to schedule building occupancy and maintain the occupied mode for 4-hours after occupancy ends.

Most of the HVAC systems supporting the Belmont Street Community School are capable of implementing this measure.

CCM #2 – Increased Ventilation

Increase outdoor air ventilation for improved space dilution where systems allow. This would entail increasing the minimum outdoor air damper positions on all mixed air style systems within the limits of the equipment capacity and overriding any demand ventilation reset schemes (i.e., CO_2 reset). A control sequence would need to be implemented for the respective air handlers which would limit the outdoor air volume to the unit's respective capability such that proper control of the discharge air can be maintained as well as freeze protection of coils. In addition, sequence would need to include limitation based on boiler plant and cooling system capabilities and summertime moisture limitations. For buildings which have anti-freeze in water-based heating and/or cooling systems concern of unitary coil freeze up is reduced.

The classroom UV systems as well as many of the air handlers appear to have the ability to increase outdoor air for higher outdoor air ventilation and air exchange rate.

CCM #3 – Improved Filtration

Improve filtration to up to MERV-13 on air handling systems, especially those which recirculate air. In addition, if possible, as filters are replaced provide sealant or gasketing between and/or around filters to reduced air bypass around filter sections.

Based on the air handlers age they may not be capable of supporting higher filtration levels however, testing of them could be done to confirm unit fan capabilities. The classroom unit ventilators and fan coil units cannot support filtration in excess of MERV 8. All replacement filters for these terminal units should meet MERV 8 requirements.

Prior to implementation of higher filtration levels in excess of MERV 8, existing equipment capabilities must be reviewed to verify it can support the added pressure drop imposed by MERV-13 filtration. Testing and balancing to confirm current airflow, pressure drops, and fan motor power coupled with manuf. published data would be required to confirm the unit's capability for improved filtration.

B. ENHANCED HVAC COVID-19 CONTROL MEASURES

In addition to the suggested above measures below are some Enhanced HVAC COVID-19 Control Measures (ECCM) which could be considered for implementation. Refer to the Ventilation System Summary Table under the respective schools for applicable recommendations.

ECCM #1: Portable Room Purifiers

Portable room air purifiers could be used in select areas and rooms to help clean the air within the room. These could be applied in areas such as those where the population is in a higher risk group of developing COVID-19 complications or anywhere where real time space cleaning is required such as the nurse's office. Products which include HEPA filters and fans with air exchange rate appropriate for the size room should be selected.

ECCM #2: UV-C Light Sterilization

UV-C lights can be inserted in equipment and ductwork to help neutralize viruses as it is exposed to the light. UV technology has been studied and used extensively, primarily in hospital settings for virus and bacteria control and in the general HVAC primarily to prevent build-up on coils. To properly mitigate the virus an extended run of return air duct would need to be identified to allow for adequate exposure to UV-C light since a light bar just at the unit coil or filter will primarily just prevent build-up of mold, bacteria, and viruses on those surfaces.

ECCM #3: Bipolar Ionization

Air ionizers are meant to be installed in the supply air duct or plenum downstream of fans and filters. They are also offered as portable units for room application. In Belmont Street Community Schools case they could be installed in the supply air duct of the respective mixed air handling systems and unit ventilators. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Belmont Street Community School to address the current pandemic condition.

Air ionizers appear to be showing quite a bit of promise for low system impact in retrofit applications. For years, these products have been used to primarily clean air of dust and particles by forcing the particles to bind together and either drop out of the breathing zone and/or better be able to be captured by HVAC system air filters by making particles larger. Recently, there are studies which claim to show that ionizers work on neutralizing viruses in the space prior to needing to draw these pollutants back to the units where filters and/or other cleaning technology such as UV-C could occur.

ASHRAE has not taken a definitive stance on Bipolar Ionization with regard to virus mitigation as of yet and has deferred to CDC's comment that it is still considered an emerging technology in this regard. Bipolar Ionization has been used for decades primarily for the removal of particles within the air. During that period its use was focused more in facilities such as convention centers, airports, casinos and the like as there are large amounts of occupant and activity generated pollutants. Only recently has Bipolar Ionization been looked at for virus mitigation which is why ASHRAE and CDC still view it as an emerging technology being that there are not extensive 3rd party studies and reviews of its capability in this regard.

That said, even ignoring its potential virus neutralizing capabilities, the ability of the product to bind smaller particles into larger particles results in an overall desirable indoor air quality benefit in that it increases the capabilities of air filters to filter the air as well as promotes particles to drop out of the breathing zone. We do, however, recommend the technology be provided on systems that meet code required outdoor air ventilation levels as this technology is not a replacement for outdoor air.

Inevitably, during an epidemic, the best approach is a multi-faceted one and should include the above HVAC strategies as well as proper housekeeping (cleaning of spaces and surfaces), occupant actions (hand cleaning, wearing masks, social distancing, following recommended CDC guidelines) and other mitigation strategies.

2) Natural Ventilation Summary

Belmont Street School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	A 4.50 HOPPER	B 4.22 HOPPER	C 4.16 AWNING	D 4.06 HOPPER	E 3.79 HOPPER	F 4.30 HOPPER	G 3.78 HOPPER	J 2.24 HOPPER	K 4.16 HOPPER	L 3.79 HOPPER	Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
Level - 1																	
Lobby	entry	219	8.76											0.00	8.76	NO	
General Office	office	417	16.68											0.00	16.68	NO	
Office Comp Room	office	159	6.36									1		4.16	2.20	NO	
Coach (formally Principal's office)	office	161	6.44									3		12.47	-6.03	YES	
Conference (formally Spec Curr)	conference	157	6.28									2	1	12.10	-5.82	YES	
Assistant Principal	office	161	6.44									3		12.47	-6.03	YES	
Guidance	office	159	6.36									2	1	12.10	-5.74	YES	
Principal (formally conference)	office	271	10.84						3					12.91	-2.07	YES	
Women's Room	toilet	25	1											0.00	1.00	NO	
Cust	support	35	1.4											0.00	1.40	NO	
Men's Room	toilet	25	1											0.00	1.00	NO	
Closet	storage	10	0.4											0.00	0.40	NO	
Health Suite	support	426	17.04											0.00	17.04	NO	
Health Suite - Toilet	toilet	25	1											0.00	1.00	NO	
Health Suite - Closet	storage	21	0.84											0.00	0.84	NO	
Custodian Closet	storage	135	5.4											0.00	5.40	NO	
Office	office	68	2.72											0.00	2.72	NO	
Office Toilet	toilet	25	1											0.00	1.00	NO	
Storage	storage	137	5.48											0.00	5.48	NO	
Level - 2																	
Lincoln House Wing																	
Grade 3	classroom	2222	88.88	12										53.96	34.92	NO	
Grade 3 - Storage	storage	74	2.96											0.00	2.96	NO	
Grade 3	classroom	1899	75.96	12										53.96	22.00	NO	
Grade 3 - Spec Edu	classroom	300	12											0.00	12.00	NO	
Grade 3 - Storage	storage	58	2.32											0.00	2.32	NO	
Grade 3 - Office	office	67	2.68											0.00	2.68	NO	
Girl's	toilet	125	5											0.00	5.00	NO	
Cust	support	20	0.8											0.00	0.80	NO	
Boy's	toilet	125	5											0.00	5.00	NO	
Main Wing																	
Curriculum	office	219	8.76				1				1			6.30	2.46	NO	
Success	office	105	4.2								2			4.48	-0.28	YES	
LD	office	104	4.16								2			4.48	-0.32	YES	
Speech	office	104	4.16								2			4.48	-0.32	YES	
Storage	storage	216	8.64											0.00	8.64	NO	
Stage Storage	storage	364	14.56											0.00	14.56	NO	
All Purpose Room	aud	2696	107.84											0.00	107.84	NO	
Stage	aud	926	37.04											0.00	37.04	NO	
Storage	storage	709	28.36											0.00	28.36	NO	
Cafe Storage	storage	160	6.4											0.00	6.40	NO	
Storage	storage	60	2.4											0.00	2.40	NO	
Storage	storage	127	5.08											0.00	5.08	NO	
Alert Center	support	173	6.92											0.00	6.92	NO	
Boutique / Storage	storage	138	5.52											0.00	5.52	NO	
Cust	support	30	1.2											0.00	1.20	NO	
Men's	toilet	130	5.2											0.00	5.20	NO	
Women's	toilet	130	5.2											0.00	5.20	NO	
Kitchen	kitchen	506	20.24											0.00	20.24	NO	
Kitchen - Storage	storage	25	1											0.00	1.00	NO	
Kitchen - Locker Room + Toilet	support	60	2.4											0.00	2.40	NO	
Community (Mott - Manley) Wing																	
Room 230 - Preschool	classroom	2065	82.6							6				22.69	59.91	NO	
Room 231 - Preschool	classroom	2443	97.72											0.00	97.72	NO	
Storage	storage	81	3.24											0.00	3.24	NO	
Room 232 - Preschool	classroom	1868	74.72							6				22.69	52.03	NO	
Room 232 - Storage	storage	170	6.8											0.00	6.80	NO	
Level - 3																	
Goddard House Wing																	
Grade 4	classroom	2135	85.4			4	12							65.38	20.03	NO	
Grade 4 - Office	office	74	2.96											0.00	2.96	NO	
Grade 4	classroom	1855	74.2			2	12							57.06	17.14	NO	
Storage	storage	67	2.68											0.00	2.68	NO	
Storage	storage	58	2.32											0.00	2.32	NO	
Girl's	toilet	135	5.4											0.00	5.40	NO	
Cust	support	20	0.8											0.00	0.80	NO	
Boy's	toilet	125	5											0.00	5.00	NO	
Keller House Wing																	
Grade 6	classroom	1026	41.04				8							32.50	8.54	NO	
Grade 6 - Combined Storage	storage	47	1.88											0.00	1.88	NO	
Grade 6	classroom	764	30.56				6							24.38	6.19	NO	
Girl's	toilet	130	5.2											0.00	5.20	NO	
Cust	support	30	1.2											0.00	1.20	NO	
Boy's	toilet	140	5.6											0.00	5.60	NO	
Christa McAuliffe House Wing																	
Grade 6	classroom	1201	48.04				12							48.75	-0.71	YES	
Grade 6 - Storage	storage	150	6											0.00	6.00	NO	
Cust	support	25	1											0.00	1.00	NO	
Grade 6	classroom	1357	54.28				12							48.75	5.53	NO	
Grade 6 - Prep Room	support	224	8.96											0.00	8.96	NO	
Sara Ella Wilson Library	media	2179	87.16						4					17.22	69.94	NO	
Library Office	office	100	4						2					8.61	-4.61	YES	
Foyer	common	809	32.36											0.00	32.36	NO	
Materials Center	support	550	22											0.00	22.00	NO	
Faculty Lounge	support	667	26.68					11						41.72	-15.04	YES	AC in one window
Women's	toilet	140	5.6											0.00	5.60	NO	
Men's	toilet	130	5.2											0.00	5.20	NO	
Gymnasium	gym	9105	364.2											0.00	364.20	NO	
Girl's Locker Room	gym	401	16.04											0.00	16.04	NO	
Girl's Locker Room Office + Toilet	office	132	5.28											0.00	5.28	NO	
Apparatus Storage (Gym)	storage	439	17.56											0.00	17.56	NO	
Boy's Locker Room	gym	200	8											0.00	8.00	NO	
Boy's Locker Room Office + Toilet	gym	116	4.64											0.00	4.64	NO	
Boy's Locker Room Shower	gym	252	10.08											0.00	10.08	NO	
Men's Locker Room	gym	187	7.48											0.00	7.48	NO	
Barton House Wing																	
Special Edu + ESL	classroom	1047	41.88		8									33.75	8.13	NO	
Storage - A	storage	56	2.24											0.00	2.24	NO	
Storage - B	storage	59	2.36											0.00	2.36	NO	
Grade 5	classroom	1047	41.88		4									16.88	25.01	NO	
Grade 5	classroom	1710	68.4		8									33.75	34.65	NO	
Grade 5 - Storage	storage	95	3.8											0.00	3.80	NO	
Girl's	toilet	125	5											0.00	5.00	NO	
Boy's	toilet	130	5.2											0.00	5.20	NO	
King House Wing																	
Grade 5	classroom	1708	68.32		8									33.75	34.57	NO	
Grade 5 - Office	office	94	3.76											0.00	3.76	NO	
Girl's	toilet	125	5											0.00	5.00	NO	
Boy's	toilet	130	5.2											0.00	5.20	NO	
Kindergarten	classroom	1046	41.84		4									16.88	24.97	NO	
Grade 1 + Spec Edu	classroom	1540	61.6		6									25.31	36.29	NO	
Computer Room	classroom	173	6.92											0.00	6.92	NO	
Storage	storage	62	2.48											0.00	2.48	NO	
Storage	storage	60	2.4											0.00	2.40	NO	
Level - 4																	
Carver House Wing																	
Grade 2	classroom	1754	70.16		8	2								42.06	28.10	NO	
Office	office	56	2.24											0.00	2.24	NO	
Storage	storage	56	2.24											0.00	2.24	NO	
Grade 2	classroom	1001	40.04		4	2								25.19	14.85	NO	
Grade 2	classroom	1660	66.4		8	2								42.06	24.34	NO	
Grade 5 - Storage	storage	95	3.8											0.00	3.80	NO	
Girl's	toilet	125	5											0.00	5.00	NO	
Boy's	toilet	130	5.2											0.00	5.20	NO	
Kennedy House Wing																	
Grade 1	1659	1708	68.32		8	2								42.06	26.26	NO	
Grade 5 - Storage	storage	94	3.76											0.00	3.76	NO	
Girl's	toilet	125	5											0.00	5.00	NO	
Boy's	toilet	130	5.2											0.00	5.20	NO	
Grade 1	classroom	995	39.8		4	2								25.19	14.61	NO	
Grade 1	classroom	1662	66.48		6	2								33.63	32.86	NO	
Grade 1 - Office	office	62	2.48											0.00	2.48	NO	
Grade 2 - Storage	storage	60	2.4											0.00	2.40	NO	
Armstrong House Wing																	
Storage A	storage	451	18.04											0.00	18.04	NO	
Storage B	storage	50	2											0.00	2.00	NO	
Kindergarten	classroom	882	35.28				9							36.56	-1.28	YES	
Kindergarten - Ward	support	49	1.96											0.00	1.96	NO	
Boy's	toilet	25	1											0.00	1.00	NO	
Girl's	toilet	25	1											0.00	1.00	NO	
Kindergarten - Storage	storage	57	2.28											0.00	2.28	NO	
Kindergarten	classroom	881	35.24				9							36.56	-1.32	YES	
Kindergarten - Ward	support	72	2.88											0.00	2.88	NO	
Kindergarten - Storage	storage	63	2.52											0.00	2.52	NO	
Boy's	toilet	25	1											0.00	1.00	NO	
Girl's	toilet	25	1											0.00	1.00	NO	
Kindergarten - Storage	storage	57	2.28											0.00	2.28	NO	

Window Type	Width	Height	Projection	Venting
A - Hopper	42	28	9.25	4.50
B - Hopper	44	23.5	9	4.22
C - Awning	32.5	30.5	9.5	4.16
D - Hopper	40.5	24.5	9	4.06
E - Hopper	40.75	23.5	8.5	3.79
F - Hopper	41.5	23.75	9.5	4.30
G - Hopper	37	23.5	9	3.78
J - Hopper	40.5	24	5	2.24
K - Hopper	39	24	9.5	4.16
L - Hopper	35	24	9.25	3.79

Room Color Key	
Green	Rooms that meet or exceed the minimum code required ventilation
Yellow	Rooms that do not meet the code required ventilation, but have operable windows.
Red	Rooms that do not have operable windows (either fixed or none present)