Worcester Public Schools

Ventilation Assessment
&
COVID-19
Mitigation Strategies

for

Gates Lane Elementary School
Worcester, MA

January 31, 2021

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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:

Gates Lane Elementary School:
Gates Lane Elementary School is located in the South Quadrant of Worcester at 1238 Main Street. The School was built in 1995, houses grades K-06, has 39 classrooms and the building is 96,000 square feet. The widows are original to the 1995 construction.

C. Table of Contents:

1) Mechanical Ventilation Report

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I. EXECUTIVE SUMMARY

This report briefly describes the ventilation systems at the Gates Lane Elementary 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 Gates Lane Elementary 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 Gates Lane Elementary 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.

Many of the classroom HVAC systems supporting the school are below the 3 ACH requirement at approximately 2ACH. However, most of the building areas are supported by either classroom unit ventilators or air handlers all of which have the ability to introduce additional outdoor air for higher O.A. ventilation and air exchange rates subject to outdoor ambient conditions and equipment limitations. According to control drawings the cafeteria and Gates Lane room units have CO2 demand ventilation reset controls that should be disabled during pandemic conditions.

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

The cafeteria and gymnasium HV air handling systems is aged and would not appear to be able to support improved filtration of up to MERV 13 however testing and verification could verify this capability. Most other classroom and office RTU systems in the building will not support increased filtration above MERV 8 either due to physical equipment limitations (i.e., fan coils & UV's limited to 1" filters) or due to 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.

Systems retrofitted with MERV 13 must be tested and adjusted to accommodate the pressure drop associated with the increased filter efficiency. In addition, more frequent filter changes would be expected to limit reduction in ventilation air as the filters load.

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 to help clean the air within that space. 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 as it is 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 virus's ability to infect.

WPS has begun to incorporate Bipolar Ionization extensively throughout the Gates Lane Elementary 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 Gates Lane Elementary School either comply with or fall slightly short of current ventilation codes dependent on occupancy with 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 Gates Lane Elementary School to address the current pandemic condition.

Space	Exist. O.A. Vent. Systems	Recommendations
General Classrooms	Unit Ventilators	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)
Gymnasium	HV Unit	CCM - #1 & #2 ECCM - #3
Cafeteria	Rooftop HV Units	CCM - #1 & #2 ECCM - #3
Offices	Packaged Rooftop Unit	CCM - #1 & #2 ECCM - #1 or #3 (*see note below)

**Note*: 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.*

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 930 SF, the system delivers approx. 300 CFM of outdoor air to the classroom spaces via the unit ventilator. Where unit ventilators are present, exhaust is generally supported by roof exhaust fans connecting to the supporting rooms via above ceiling ductwork and vertical duct chases. The exhaust fans and ductwork appear to have been sized to supporting up to 90% of the unit ventilators maximum airflow which would be required when the units go into free cooling/economizer mode thereby placing the rooms under a slight positive pressure.

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 930 SF with 26 occupants (25 students + 1 teacher) would require 372 CFM of outdoor. Hence the current systems operating at approx. 300 CFM+/- provide below the code required outdoor air dependent on space occupancy.

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 current building has no designated art or science rooms. Per the current code, science rooms and art rooms require higher ventilation levels than general use classrooms with a driving factor being 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.

Cafeteria and Gym:

Outdoor air for the gymnasium and cafeteria is supported by HV air handling units (rooftop style for the cafeteria) labeled as HV-1 and HV-3 (type of 2) respectively. The systems include filter/mixing box, gas-fired furnaces, supply fan and return fan. The filters on the air handler are 2" thick pleated filters with an estimated MERV rating of 8.

Current code would require the following outdoor air for the respective spaces:

- Gymnasium: 0.3 CFM per SF play area (+ undetermined spectator area)
- Cafeteria: 7.5 CFM per person of outside air plus 0.18 CFM per SF

The existing drawings do not reflect a percentage of outside air introduced by these systems, so verification of OA exchange rate is not possible. All systems have a zone air distribution effectiveness of 0.8, due to the high supply and return distribution and as such the code required OA noted above would need to be increased by 25% (1/0.8) to account for this. Although occupant loads in each space are unknown, the systems do appear to be capable of supporting the code required ventilation with modest occupant loading.

The HV units do not appear capable of supporting additional filtration beyond MERV 8. However, testing and confirmation of the fan capabilities could prove if increased filtration is an option. If increased to MERV 13, more frequent replacement of the filters shall be required to avoid reduction in airflow as filters load.

Offices:

The main office space is supported by a packaged rooftop unit labeled as AC-1. The unit incorporate a filter/mixing box with MERV 8 filters, DX coil with condensing section and supply fan. The outdoor air is not listed in the schedule however based on a duct mounted hot water coil we suspect the outdoor air percentage is 28%. This percentage of outdoor air should support normal office occupant loading. The system appears relatively small and would not typically have the ability to support increased filtration efficiencies.

Controls:

Most of the major HVAC systems supporting the school are controlled by a building energy management system (EMS) to some degree. 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 HV and unit ventilators.

The control drawings for the gymnasium and cafeteria systems reflect the utilization of CO_2 sensors for outdoor air demand ventilation reset off of space return air CO_2. The CO_2 reset should be disabled during this pandemic condition so as not to reduce the amount of outdoor air. In addition, the gymnasium system incorporates occupancy sensor control of the HV which should be disabled to maintain ventilation levels at normal occupied levels for improved purge during occupied periods.

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.

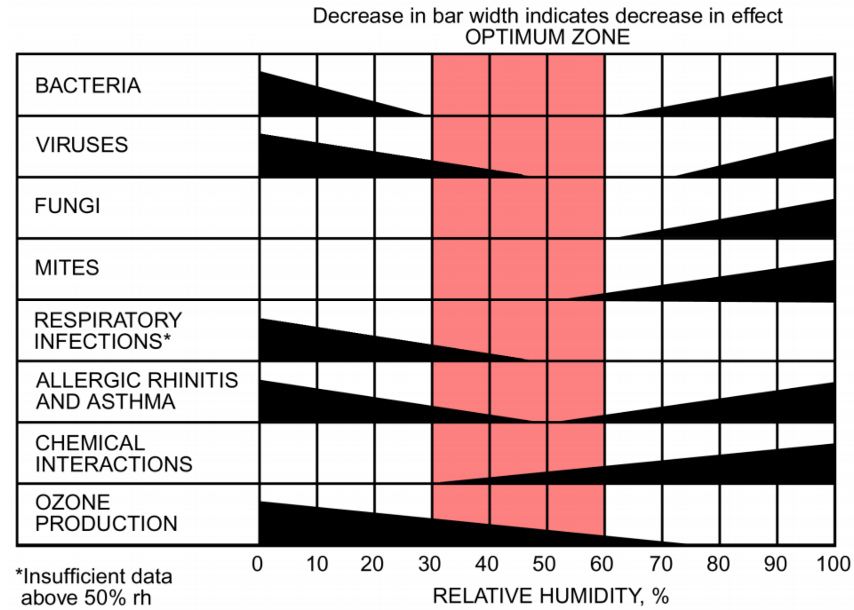

Fig. 1 Optimum Humidity Range for Human Comfort and Health
(Adapted from Sterling et al. 1985)

The Gates Lane Elementary 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 moderately aged structures, such as Gates Lane Elementary 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". Many of the general classrooms in the Gates Lane Elementary School have a design outdoor air exchange rate of 2 falling below this bare minimum criterion. 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 dependent on the pace occupancy and therefore may not be considered under ventilated by code standards. 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.

Gates Lane 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	Original Design OA CFM	Original OA Air ACH	Notes
Basement Floor											
Cust 002	61.2	29.6	494	1.31	0.16	160	8.75	1400	N/A	N/A	
1st Floor											
Gym 119/120	61.7	35.6	504	1.68	0.33	6268	31.25	195875	N/A	N/A	
Gym Lobby 117	66.7	28.2	490	1.49	0.22	874	9.66	8443	N/A	N/A	
Teachers Station 116	68.3	28.1	457	1.32	0.18	464	9.583	4447	150	2	
Preschool 114	70.1	30.9	479	1.37	0.19	1168	9.583	11193	300	1.6	
Principal 110	70.3	29.7	498	1.53	0.23	359	9.583	3440	N/A	N/A	
Nurse 108	70.7	29.9	508	1.58	0.23	170	9.583	1629	N/A	N/A	
Conference 102A	70.1	29.4	471	1.48	0.22	386	9.583	3699	N/A	N/A	
Office 102	68.8	31.4	478	1.61	0.2	691	9.66	6675	N/A	N/A	
Teachers Dining 100	70.1	32.9	477	1.46	0.17	1030	9.583	9870	N/A	N/A	
Kindergarten 107	70.3	31	460	1.36	0.19	1244	9.583	11921	300	1.5	
Kitchen 103	65.6	31.5	470	1.74	0.16	1373	9.66	13263	N/A	N/A	
Cafeteria 101	69.1	32.4	467	1.74	0.16	3980	9.66	38447	N/A	N/A	
2nd Floor											
Classroom 217	71.7	28.5	445	1.32	0.15	933	9.66	9013	300	2	
Classroom 208	72.1	28.1	444	1.3	0.14	526	9.66	5081	0	0	
Classroom 206	72.1	28.5	446	1.11	0.15	915	9.66	8839	300	2	
Library 202	71.4	28.1	448	1.32	0.19	2530	9.583	24245	800	2	
3rd Floor											
Classroom 316	69.3	29.9	450	1.35	0.18	933	9.66	9013	300	2	
Classroom 310	70	29.5	443	1.34	0.16	525	9.583	5031	0	0	
Teachers 307	70.3	30.1	450	1.35	0.18	766	9.66	7400	300	2.4	
Classroom 302	70.9	28.1	439	1.36	0.18	1072	9.75	10452	300	1.7	
4th Floor											
Classroom 416	66.6	32.3	455	1.42	0.17	933	9.583	8941	300	2	
Classroom 413	69.3	30.1	452	1.39	0.15	915	9.75	8921	300	2	
Girls Tlt 409G	68.6	31.6	451	1.39	0.16	416	9.66	4019	0	0	
Classroom 408	68.9	30.7	454	1.4	0.15	525	9.66	5072	0	0	
Classroom 402	68.3	29.2	447	1.38	0.15	1072	9.83	10538	300	1.7	

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.

Gates Lane Elem. 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
HV-1	Gym	11600	N/A	N/A	N/A	8	N/A	#1, #2	#3	b
HV-2	Center Classrooms	3,000	N/A	N/A	N/A	8	N/A	#1, #2	#3	
HV-3 (incl 2)	Cafeteria	7000 x 2	N/A	N/A	(4) 20x20x2 (X2)	8	630	#1, #2	#3	b
HV-4	General	5,400	N/A	N/A	N/A	8	N/A	#1, #2	#3	
HV-5	Basement	2360	N/A	N/A	N/A	8	N/A	#1, #2	#3	
HV-6	Kitchen	2000	N/A	N/A		8	N/A	#1, #2	#3	
MAU-1	Kitchen Hood	3030	3030	100	N/A	8	N/A	N/A	N/A	
AC-1	Offices	3,750	1013	27	(3) 20x20x2 (3) 16x20x2	8	250	#1, #2	#2, #3	a, c
Misc. FC's	varies	varies	varies	varies	varies	8	varies	#1, #2	#1, #3	a
Misc. UV's	Classrooms	varies	varies	vaires	varies	8	varies	#1, #2	#1, #3	a

Ventilation System Summary Notes:

a. *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.*

b. *Disable any CO2 demand ventilation reset or occupancy sensor-based system shutdown (during scheduled occupied periods) during pandemic conditions.*

c. *Return duct run is long enough on this system to take advantage of ECCM #2 UV-C.*

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 Gates Lane Elementary 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 Gates Lane Elementary 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.

Most of the classroom UV systems as well as the HV and AC systems 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.

Higher filtration on most of the HV and AC units is not considered viable due to the systems age however systems could be tested to verify their fan capabilities for this measure. Most, other HVAC systems including the classroom unit ventilators 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 manufacturer 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 to help clean the air within that space. 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: Bi-Polar 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 Gates Lane Elementary Schools case they could be installed in the supply air duct of the respective mixed air handling systems as well as in UV units. WPS has already begun to incorporate Bipolar Ionization extensively throughout the Gates Lane Elementary 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 virus’s 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 on 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

Gates Lane Elementary School

Room Name / Number	Space Use	Net Floor Area (SF)	4% of Net Area	Number of Windows by Type 1 HOPPER	5.56	2 HOPPER	8.13	3 HOPPER	2.08	Total open Area (SF)	Difference between actual and required SF	PASS?	Additional Notes
Basement													
B002 - Custodian	support	160	6.4							0.00	6.40	NO	
B004 - Locker Room	support	153	6.12							0.00	6.12	NO	
B006 - Non Food Storage	storage	159	6.36							0.00	6.36	NO	
First Floor													
100V - Vestibule	entry	102	4.08							0.00	4.08	NO	
100 - Teacher's Dinning	café	1030	41.2		3		2			32.92	8.28	NO	
100W - Women's	toilet	80	3.2							0.00	3.20	NO	
100M - Men's	toilet	80	3.2							0.00	3.20	NO	
100W - Women's	toilet	45	1.8							0.00	1.80	NO	
100M - Men's	toilet	45	1.8							0.00	1.80	NO	
101 - Cafeteria	café	3980	159.2						12	25.00	134.20	NO	
101 - Stage	aud	486	19.44							0.00	19.44	NO	
102 - Office	office	691	27.64		3		1			24.79	2.85	NO	
102A - Office	office	386	15.44				4			32.50	-17.06	YES	
103 - Kitchen	kitchen	1373	54.92							0.00	54.92	NO	
103A - Dish Wash	kitchen	83	3.32							0.00	3.32	NO	
103D - Waste	kitchen	59	2.36							0.00	2.36	NO	
104 - Assistant Principal	office	212	8.48				3			24.38	-15.90	YES	
105 - Office	office	67	2.68							0.00	2.68	NO	
105A - Cooler	kitchen	69	2.76							0.00	2.76	NO	
105D - Freezer	kitchen	104	4.16							0.00	4.16	NO	
105F - Lockers	support	94	3.76							0.00	3.76	NO	
105T - Toilet	toilet	36	1.44							0.00	1.44	NO	
106 - Office	office	333	13.32							0.00	13.32	NO	
107 - Kindergarten	classroom	1244	49.76		2		2			27.36	22.40	NO	
107T - Toilet	toilet	46	1.84							0.00	1.84	NO	
108 - Nurse	nurse	170	6.8							0.00	6.80	NO	
108A - Exam	nurse	100	4							0.00	4.00	NO	
110 - Principal	office	359	14.36		4					22.22	-7.86	YES	
112 - Kindergarten	classroom	1269	50.76		5					27.78	22.98	NO	
112T - Toilet	toilet	45	1.8							0.00	1.80	NO	
113 - Kindergarten	classroom	1258	50.32		2		2			27.36	22.96	NO	
113T - Toilet	toilet	46	1.84							0.00	1.84	NO	
114 - Preschool	classroom	1168	46.72		4					22.22	24.50	NO	
114T - Toilet	toilet	45	1.8							0.00	1.80	NO	
115 - Preschool	classroom	1168	46.72				2			16.25	30.47	NO	
115T - Toilet	toilet	46	1.84							0.00	1.84	NO	
116 - Teacher's Station	support	464	18.56		3					16.67	1.89	NO	
116A - Storage	storage	143	5.72							0.00	5.72	NO	
117 - Gym Lobby	lobby	874	34.96							0.00	34.96	NO	
118 - Gym Storage	storage	612	24.48							0.00	24.48	NO	
118C - Cust	support	124	4.96							0.00	4.96	NO	
118M - Men's	toilet	170	6.8							0.00	6.80	NO	
118W - Women's	toilet	170	6.8							0.00	6.80	NO	
119 / 120 - Gymnasium	support	6268	250.72							0.00	250.72	NO	
Second Floor													
200 - Library Work Room	classroom	160	6.4							0.00	6.40	NO	
201	classroom	933	37.32		3					16.67	20.65	NO	
202 - Library	media	2530	101.2		6					33.33	67.87	NO	
203	classroom	980	39.2		3					16.67	22.53	NO	
205 - Storage	storage	745	29.8		3					16.67	13.13	NO	
205C - Cust	support	45	1.8							0.00	1.80	NO	
206	classroom	915	36.6		3					16.67	19.93	NO	
207 - Teacher's Room	support	766	30.64		3					16.67	13.97	NO	
207T - Toilet	toilet	54	2.16							0.00	2.16	NO	
208	classroom	526	21.04		3					16.67	4.37	NO	
209G - Girl's	toilet	416	16.64							0.00	16.64	NO	
210	classroom	526	21.04		3					16.67	4.37	NO	
211B - Boy's	toilet	418	16.72							0.00	16.72	NO	
212	classroom	915	36.6		3					16.67	19.93	NO	
213-1 / 213-2	classroom	915	36.6		3					16.67	19.93	NO	
214	classroom	915	36.6		3					16.67	19.93	NO	
215	classroom	915	36.6		3					16.67	19.93	NO	
216	classroom	933	37.32		3					16.67	20.65	NO	
217	classroom	933	37.32		3					16.67	20.65	NO	
Third Floor													
300	classroom	933	37.32		5					27.78	9.54	NO	
301	classroom	933	37.32		3					16.67	20.65	NO	
302	classroom	1072	42.88		3					16.67	26.21	NO	
303	classroom	980	39.2		3					16.67	22.53	NO	
304	classroom	915	36.6		3					16.67	19.93	NO	
305 - Storage	storage	745	29.8		3					16.67	13.13	NO	
305C - Cust	support	74	2.96							0.00	2.96	NO	
306	classroom	915	36.6		3					16.67	19.93	NO	
307 - Teacher's Room	support	766	30.64		3					16.67	13.97	NO	
307T - Toilet	toilet	54	2.16							0.00	2.16	NO	
308	classroom	525	21		3					16.67	4.33	NO	
309C - Girl's	toilet	416	16.64							0.00	16.64	NO	
310	classroom	525	21		3					16.67	4.33	NO	
311B - Boy's	toilet	416	16.64							0.00	16.64	NO	
312	classroom	915	36.6		3					16.67	19.93	NO	
313-1 / 313-2	classroom	915	36.6		3					16.67	19.93	NO	
314	classroom	915	36.6		3					16.67	19.93	NO	
315	classroom	915	36.6		3					16.67	19.93	NO	
316	classroom	933	37.32		5					27.78	9.54	NO	
317	classroom	933	37.32		3					16.67	20.65	NO	

Fourth Floor

	400	classroom	933	37.32		5					27.78	9.54	NO	
	401	classroom	933	37.32		3					16.67	20.65	NO	
	402	classroom	1072	42.88		3					16.67	26.21	NO	
	403	classroom	980	39.2		3					16.67	22.53	NO	
	404	classroom	915	36.6		3					16.67	19.93	NO	
	405 - Storage	storage	745	29.8		3					16.67	13.13	NO	
	405C - Cust	support	74	2.96							0.00	2.96	NO	
	406	classroom	915	36.6		3					16.67	19.93	NO	
	407 - Teacher's Room	support	766	30.64		3					16.67	13.97	NO	
	407T - Toilet	toilet	54	2.16							0.00	2.16	NO	
	408	classroom	525	21		3					16.67	4.33	NO	
	409C - Girl's	toilet	416	16.64							0.00	16.64	NO	
	410	classroom	525	21		3					16.67	4.33	NO	
	411B - Boy's	toilet	416	16.64							0.00	16.64	NO	
	412	classroom	915	36.6		3					16.67	19.93	NO	
	413-1 / 413-2	classroom	915	36.6		3					16.67	19.93	NO	
	414	classroom	915	36.6		3					16.67	19.93	NO	
	415	classroom	915	36.6		3					16.67	19.93	NO	
	416	classroom	933	37.32		5					27.78	9.54	NO	
	417	classroom	933	37.32		3					16.67	20.65	NO	

Window Type	Width	Height	Projection	Venting
1 - Hopper	30	20	16	5.56
2 - Hopper	45	20	18	8.13
3 - Hopper	30	20	6	2.08

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)