Assessment of HVAC - Ventilation System in Wheatley Hall
University of Massachusetts Boston
(11/30/2021 –12/2/2021)

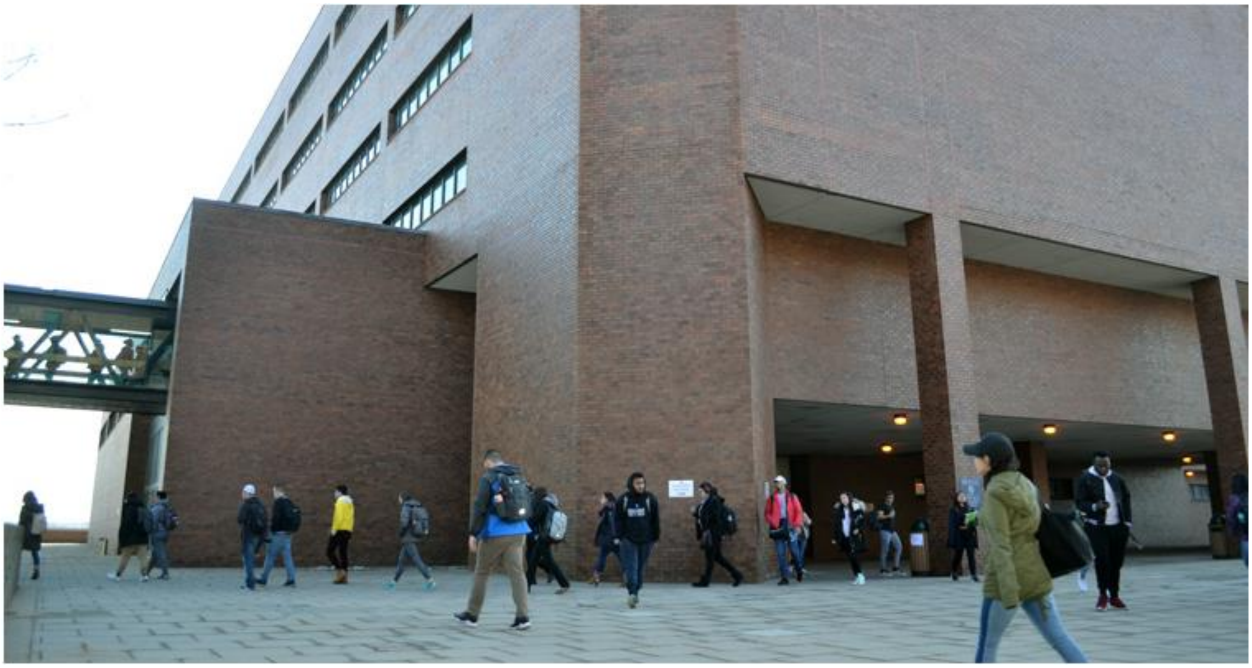

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Table of Contents

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I. Executive Summary and Recommendations

The MTA assessment evaluated ventilation (HVAC System-Air Changes per Hour, ACH) in thirty-five (35) building spaces at Wheatley Hall, UMASS Boston distributed on 6 floors. In addition, particulate, carbon dioxide, relative humidity and temperature readings were also taken in all 35 spaces. The objective was to have an overview of the performance of the HVAC system and to measure environmental conditions in spaces where members had air quality concerns. The main overriding Indoor Air Quality (IAQ) issue is to optimize supply air to building spaces to decrease the risk of spreading the airborne current viral infection of SARS-Cov-19 and any future viral infections. Results, calculations, and data tables (room by room) are presented in the APPENDIX of this report. Extended recommendations appear under V. Recommendations include suggestions for evaluating and improving HVACs.

General Recommendations:

1. UPDATE HVAC SYSTEM: The HVAC at Wheatley Hall needs to be updated if regular activities with normal room occupancy are to be continued. Currently 60% of the academic spaces assessed are below the basic guideline of 4 Air Changes per hour (> 4ACH). Of special concern is that seventeen of these spaces are active Classrooms/Labs. Ventilation in these classrooms and offices should be a priority. Classrooms with low air supply require immediate priority attention. The most viable action would be to determine if additional fresh air can be supplied to highly occupied classrooms by increasing the power of the ventilation fans of the seven H & C units. Improving ACHs by increasing outside air –while properly maintaining filtration through MERV 13 filters ---has limited effects given the heating needs of the building. Increasing fan power, and thus supply air flow, seems the most immediate action necessary to decrease COVID Pandemic risk. This might require the replacement of underpowered and aging roof ventilation fans.

2. CONDUCT OVERALL EVALUATION OF HAVC SYSTEM: In preparation to an overhaul of supply air capacity, UMASS Boston should consider engaging an engineering consulting firm for advice and to conduct a building-wide HVAC assessment. Based on historical issues with air exchange/IAQ complaints, age, physical deterioration, and availability of parts for ventilation components, such an evaluation is necessary to determine the feasibility of improving or replacing the current equipment.

3. BALANCING HVAC SYSTEM: UMASS Boston should have the HVAC system balanced every 5 years in accordance with SMACNA recommendations (SMACNA, 1994). Balancing requires adjusting supply and exhaust air flows to achieve > 4 ACH, and the removal of obstructions and cleaning of fans and air ducts.

4. SUPPLEMENT WITH PORTABLE AIR PURIFIERS: Although the priority is for the HVAC system to achieve 4 ACH, portable air purifiers with HEPA filters may be used to supplement air supplied by the HVAC system. The size of the portable air cleaner should be

appropriate to meet 4 ACH. Use the tool https://tinyurl.com/portableaircleanertool to purchase the correct portable air purifiers.

5. COVERING COSTS OF IMPROVEMENTS: UMASS Boston should apply for federal and state funds earmarked for ventilation improvements related to the COVID Pandemic. The U.S. Department of Education has released new guidance encouraging the use of American Rescue Plan (ARP) funds to improve ventilation systems and make other indoor air quality improvements in schools. More information can be found at this link: https://www.ed.gov/coronavirus/improving-ventilation.

Specific Recommendations:

1. SUPPLY AIR IMPROVEMENTS ON UNDERVENTILATED ROOMS: UMASS Boston should upgrade air supply in spaces where 4 ACH are not reached. Specifically, the evaluated rooms identified (numbers in **red**) on the Tables Results IA and IB. This includes, but not be limited to: Six classrooms and three offices in the 1^{St} Floor; Four classroom on the 2^{nd} floor; Three classrooms and one office on the 3^{rd} Floor; One classroom/lab on the fourth floor. In the interim, HEPA Portable Air Cleaning devices must be considered. All under ventilated classrooms/labs below 4 ACH require immediate attention.

2. BATHROOM VENTILATION IMPROVEMENTS: The lack of ventilation in the women's bathroom on the 6^{th} Floor (Room 6-99) should be remedied as soon as possible. The extremely low exhaust in the Men's bathroom on the first floor should also be addressed (1-18). For complete results see Table Results 2 below. Studies of bathrooms have shown that toilets can be a risk of generating airborne droplets and droplet residues that could contribute to transmission of pathogens. Recommendations for safe bathrooms are listed below.

a. Bathrooms should be kept under negative pressure
b. Keep toilet room doors closed, even when not in use.
c. Put the toilet seat lid down, if there is one, before flushing.
d. Vent separately where possible (vent directly outdoors and run fan continuously
e. Keep bathroom windows closed--open windows could lead to re-entrainment of air into other parts of the building.

3. HIGH CO2 CONCENTRATION ON ACADEMIC SPACES: UMASS Boston should consider conducting a full CO2 concentration survey in all spaces with rooms occupied with the students regularly present in classes and laboratories. Concentration of CO2 collected in this survey show seven out of 35 spaces above the MDPH recommendation of 800 ppm. This is in spite of the fact that all rooms evaluated were unoccupied. See complete results of the MTA survey on Table Results 3 below.

4. PARTICULATES PM2.5 IN ACADEMIC SPACES: Special attention to improvement of air supply must be paid to 16 spaces (out of 35- 46%) where concentrations ranged from 2.5 to 23 ugm/m3. This elevated level of particles raises concerns -that because of their size – they could be carriers of SAR-Cov-19 viral particles, increasing the risk of infection. For specifics, see Table of RESULTS 3 below.

II. Introduction

This ventilation assessment was conducted on November 30 and December 2, 2021, in Wheatley Hall at the University of Massachusetts Boston. The assessment was requested by the FSU union officers to the MTA Environmental Health and Safety Committee. Wheatley Hall is six stories high, housing classrooms, laboratories, common spaces, and staff offices.

The Columbia Point campus of UMass Boston was constructed between 1971 and 1974, sitting on approximately one hundred acres of land. The lot had been part of the City of Boston's Mile Road landfill. The campus was originally designed for 10,000 students, as a series of five buildings including the Healey Library, McCormack Hall, Quinn Administration Building, Science Center and Wheatley Hall. Currently the campus includes thirteen buildings and approximately 3,000,000 GSF of space. Enrollment as of the fall of 2020 was just under 16,000 students along with 2,500 faculty and staff.

The objective was to have an overview of the performance of the HVAC system and to measure environmental conditions in spaces where faculty, staff and students have air quality concerns. The main overriding Indoor Air Quality (IAQ) issue is to optimize supply air to building spaces to decrease the risk of spreading the airborne current viral infection of SARS-Cov-19 and any future viral infections.

i. Diminishing the Risk of COVID-19 through Ventilation

The current overriding concern is the protection of students, faculty, and staff during the developing COVID-19 pandemic. However, the key, long-term, institutional strategy to permanently diminish the risk of any virus transmission indoors should be to improve the air quality by maintaining ACH (based on OA) on the range of 4-5 ACH. This strategy, combined with CDC recommended "layers of protection," includes vaccination, masking, distancing, and testing. These layers must be deployed simultaneously and in parallel with ventilation – a key layer of protection; all of them are necessary to decrease risk of airborne disease. The most effective institutional means of airborne contamination control—from a primary prevention point of view—is a functioning HVAC providing adequate ventilation. It is a primary prevention strategy that prevents disease –not only from the current COVID-19 virus pandemic-- but also from any contaminants including future viral epidemics and any toxic airborne substances.

The COVID-19 particles are emitted with the liquid droplets created when people cough, sneeze, sing, talk and even just breath through our noses. SARS-CoV-2, the virus that causes COVID-19, is thought to spread mainly from person-to-person through respiratory droplets. The large visible mist and droplets settle to the surface quickly and are unlikely to be drawn up into the ventilation system. But smaller ones, especially those under ten microns in diameter can float in the air for extended periods of time. The longer the very small droplets remain in the air, the more the water in them evaporates, leaving only small mucous droplets containing the virus particles that can be inhaled to the inner lung (virus size < 0.125 microns in diameter). These dehydrated particles of virus and dry secretions can be in the range of 0.3 to 1.0 microns. Some of these particles have been documented to have remained airborne for longer than 2 hours. One study showed the particles were capable of infecting people after 16 hours. (Fears AC. Et al. Persistence of Severe Acute Respiratory Syndrome Coronavirus 2 in Aerosol Suspension. EID. Volume 26, Number 9 – September 2020. https://wwwnc.cdc.gov/eid/article/26/9/20-1806_article?deliveryName=USCDC_331-DM35835).

ii. Filtration for COVID-19

Two scientific and technical institutes have published guidance for control of virus carrying aerosols in indoor environments through filtration, the T. Chan Harvard School of Public Health (HSPH) and the American Society of Heating Refrigeration and Air Conditioning Engineers (ASHRAE). ASHRAE and HSPH recommend installing MERV 13 filters. Filters consist of media with porous structures of fibers or stretched membrane material to remove particles from airstreams. The fraction of particles removed from air passing through a filter is termed "filter efficiency" and is provided by the Minimum Efficiency Reporting Value (MERV). MERVs ranges from 1 to 16, with the higher the MERV the higher the efficiency. MERV ≥13 (or ISO equivalent) is efficient at capturing airborne viruses and are recommended by HSPH and ASHRAE. Increased filter efficiency results in increased pressure drop through the filter. It is possible, then, that the HVAC systems could have difficulties to accommodate filter upgrades without negative impacts to pressure differentials and/or air flow rates.

Air supply in the rooms evaluated in this HVAC survey were reported to have been filtered through MERV 13 filters throughout the building. It was also observed that all the supply streams were 20% outside air (20% OA). According to Harvard T.H. Chan School of Public Health guidance you can assume an 80% capture rate when using a MERV 13. Based on that recommendation we counted 80% of recirculated cfm air flows as "fresh air" in our calculations for Air Changes Per Hour.

Notice that higher than the current 20% OA might not be sustainable when temperatures are very low in the winter. For improvements of ACH values the settings OA can only be increased slightly due to potential freezing considerations in cold weather (and air conditioning in warmer weather). Increasing the power of the fans to improve the volume of supply air is the most effective strategy to improve ACH, even with only low % of OA—as long as return air is filtered through MERV 13 rated filters or better.

III. Risk Assessment of Airborne Viral Infections

i. Ventilation-HVAC-Air Changes per Hour Assessment

Classrooms- Laboratories and Offices Evaluation

The table below (Results 1) summarizes the findings of the survey. Of the (35) spaces (bathrooms in separate Results 2 Table) where ventilation was evaluated ---in the six floors, 21 (60%) were below the recommended guideline of 4 ACH. The lower floors had a consistently low flow of supply air. Measurements of exhaust streams in the 35 spaces appear on Table 2A in the APPENDIX.

Results 1- Summary ACHs Ventilation Assessment Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))			
Floor	Rooms Evaluated	**Rooms Below** <4.0 ACH OA	**Rooms Above** >4 ACH OA
1st	6 Classrooms 3 Offices	9	0
2nd	6 Classrooms	4	2
3rd	3 Classrooms/Lab 3 Offices	5	1
4th	2 Class/Lab 4 Offices	2	4
5th	2 Offices	1	1
6th	2 Offices	0	2
3 Floors	4 Bathrooms	2 – “0” minimal ventilation 2 -- significant ventilation	
TOTALS	35	21 (60%)	14

See summary <u>Results 1A, 1B, 1C</u> in the APPENDIX with the ranges of ACH below and above 4 ACH identifying **in red** by specific room, and floor. The measurements of ventilation parameters and calculations for each of the thirty-five spaces presented room by room are recorded in the APPENDIX in Tables 1, 1A, 1B, 1C, 1D (for 1st Floor): Tables 2A, 2B (2nd Floor); Tables 3, 3A (3rd Floor); Tables 4, 4A (4th Floor): Tables 5, 5A (5th and 6th Floors). Detailed results of ACH calculations appear on the Tables labelled A in this list. Two sample calculations for the rooms on the first floor are also in the APPENDIX.

<u>ACH Discussion</u>

In general, the supply air flow into 60% of the spaces evaluated do not provide adequate protection to students and faculty during the COVID pandemic. Specifically, none of the six classrooms and 3 offices in the 1St Floor are in compliance with the guideline. On the 2nd floor 4 of 6 all were below 4 ACH; On the 3rd Floor all 3 classrooms and 1 out of 3 offices were below 4 ACH. On the fourth floor, 1 Classroom/ Lab out of 2 were below 4ACH. Four offices were above the 4 ACH guideline. On the 5th floor, 1 office was above and the other below the 4ACH guideline. On the 6th floor, the 2 offices assessed were above the guideline. See Table below.

It is remarkable that two classrooms (3rd Floor—3-124 and 4th Floor –4-144) had "0" air supply. The identification of the spaces below the guidelines are in Results 1A.1B Tables in the APPENDIX.

21 Spaces Recommended for Improvement of Supply Air Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))		
Floor	Rooms Evaluated	Rooms below <4.0 ACH OA (range)
1st	6 Classrooms (**10, 19,20, 36,58, 61**)	6 (1.8 –2.7)
	3 Offices (**77-P, R, V**)	3 (2.0 - 3.4)
2nd	4 Classrooms (**46,98, 124, 206)**	4 (1.7-- 3.1)
3rd	2 Class & 1 Lab (**122, 124*, 97**)	3 (0.0 – 1.6)
	3 Offices (**6, 54/25,**)	2 (1.6 – 2.5)
4th	1 Laboratory/classroom (**151**)	1 (1.8)
	1 Office (**144*--**no supply air)	1 (0)
5th	1 Office (**56**)	1 (2.8)
Totals	35	**21 (60%)**

<u>Bathrooms Evaluations</u>

Among the 35 spaces, four were bathrooms. One women's bathroom on the sixth floor has "0" exhaust flow. No supply air was apparent in any of the four bathrooms evaluated. Measurements appear in Results 2 Table below. The results show no supply air to the four bathrooms and one women's bathroom with no exhaust ventilation whatsoever (BR-6 - 99). Of the other three bathrooms 2 showed adequate exhaust air (4-78, and 6-100) and one, inadequate exhaust (1-18).

Results 2- Three Bathrooms Exhaust Ventilation Assessment Guidelines for Bathrooms: >10 Vol Change/hour No Supply Air				
Floors	Bathroom Evaluated	Changes of Air below <4.0 Vol Changes per hour	Changes of Air above >4.0 Vol Changes per hour	Notes
1st	1--018	1 (1.1)	-	Minimal air movement
4th	4 - 78	-	1 (8.0)	Moderate Air movement
6th	6-99	**1 (0.0)**	-	**Women's Room No air movement**
	6 -100	-	1 (5.2)	Minimal air movement

ii. CO2 Measurements

CO_2 concentrations were measured in the thirty-five spaces assessed. It was remarkable that despite the spaces being without occupants seven spaces measured concentrations of CO_2 above the Massachusetts Department of Public Health guidance of 800 ppm CO_2. <u>Of special</u>

concern is that 4 of these spaces are active Classrooms/Labs (2 in the 1st and 2 in 2nd Floor), and one an unventilated women's bathroom on the 6th floor (6-99). These elevated levels of CO_2 are an indicator of stagnant air and poor ventilation in those rooms. This confirms the very low ACH detected in 60% of the spaces evaluated. See Results 3 Table below for room identification. The remaining rooms (28) showed moderately high CO_2 concentrations ranging from 560 to 765 ppm CO2.

The rest of the twenty-eight spaces showed relatively elevated levels of CO_2 more than 100 ppm above the outside CO_2 concentration. The concentrations of these 28 rooms ranged from 560 to 765 ppm of CO_2. See Table Results 3 with detailed Results in the APPENDIX.

Since all the rooms were unoccupied, it can be predicted that the spaces with a full complement of students could read CO2 levels easily above 1,000 ppm of CO_2. Results appear below on Table: Results 3. For specific concentrations by room in each floor see tables 1 to 5 in the APPENDIX .

Results 3- CO_2 ppm Concentration Assessment Guidelines MDPH: 800 ppm fully Occupied Room Outside Conditions: CO_2 ppm (414-485) (11-12/2021)		
Floor	Rooms Evaluated **(All Unoccupied)**	**Above** 800 ppm CO_2
1st	(2 Classrooms **1-1**- and **1-20**)	809-818
2nd	(2 Classrooms **2-60** and **2-124**)	1082-920
5th	(1 Office **5-58**)	814
6th	(1 Office **6-113**)	820
6th	Women's Bathroom **6-99**	821
TOTALS	35 measurements (28 below 800 ppm CO2 Guideline)	7

iii. Particulates PM2.5 Measurements

Thirty-five spaces were evaluated for particulate concentrations measured as PM2.5 in ugm/m3. Fourteen spaces (40%) were in the high range between 5.0 and 23 ugm/m^3. Of those, 8 (23%) were in the remarkably high range from 11 to 23 ugm/m3. The rooms with the highest concentrations were: (Rooms: 77R & V-1st Floor; 60, 124-2nd Floor; 122, 124, 154/7-154/25, 3rd Floor; 78-4th Floor; 61, 113-6th Floor). Four of them were classrooms (see table below). The rest of the rooms (21) had concentrations with less elevated concentrations in the range between 2 to 5ug/$m^{3.}$

EPA recommends a maximum concentration of 35 ugm/m3 measured in 24-hr period in outdoors air. It is an air pollution standard, and it is mentioned here for reference. The high PM2.5 values in Wheatley Hall are above the outside levels of PM2.5 measured in this survey. These elevated concentrations indicate the presence of available respirable particulates in the rooms surveyed.

Results 4- Particulates PM2.5 Outside Conditions: PM2.5 (2.0 ugm/m3) **35 Rooms Evaluated November 30 and December 2, 2021, all unoccupied**		
Floor	Rooms with PM2.5 > 10ugm/m^3	Range
1st	77R-77V	2-11
2nd	60*-124*	2-25
3rd	122*-124* 154-25/07	2-11
4th	78-144	2-15
5th	56-58	6-6
6th	61-113	5-23
Totals	14 (40% of sampled rooms) > 10 ugm/m3	2-25

iv. %RH, Temperature Assessments

Percentage of Relative Humidity (%RH) values in the thirty-five spaces assessed were comparable to outside %RH values. In general, they tend to indicate very dry environments. Temperatures were also in the temperatures' comfort zone. Results room by room can be found in the APPENDIX.

v. Ventilation Surveys Methods

An Alnor Electronic EBT730/EBT731 balometer was used to measure exhaust and supply air flows from the air handler air supply and the exhaust diffusers. The balometer was placed over the supply and exhaust diffusers and blocked out any remaining open spaces in the hood with a plastic board as needed. Volumes of the rooms (LxWxH) were measured with a laser measuring tool. The assumption is that all the air supplied by ceiling diffusers is a combination of "fresh air" (OA) and recirculated "return" air. The calculations in this survey add OA to filtered recirculated return air when calculating ACH. See sample calculations after Table 1 in APPENDIX.

When the volume of fresh air coming through the diffuser equals the volume of the air in the room, one air exchange is achieved.

The following formula was used to calculate ACH from both supply and exhaust:

ACH = [**Equivalent Outdoor air flow (CFM)** X 60 (minutes)] / [Room Volume (ft3)

Equivalent Outdoor air = [% Outside Air in Supply (%OA) + Equivalent Filtered non outside as outside air (OA) air calculated by MERV Filter type] (Sample Calculation in APPENDIX)

In the case of UMASS Boston, %OA is 20% of all supply streams in the HVAC system. The contribution to OA from the MERV 13 filtered air (remanent 80%) is 80% OA equivalent. See sample calculations in the APPENDIX.

The MTA November 30 and December 2 , 2021, Survey calculated ACHs based on supply air measurements measured that day. The results appear in detail in the APPENDIX

V. Recommendations

A. General Recommendations

1. UPDATE HVAC SYSTEM

The HVAC at Wheatley Hall needs to be updated if regular activities with normal room occupancy are to be continued. Currently 60% of the academic spaces assessed are below the basic guideline of 4 Air Changes per hour (> 4ACH). Of special concern is that seventeen of these spaces are active Classrooms/Labs. Ventilation in these classrooms and offices should be a priority.

The most viable action would be to determine if additional fresh air can be supplied to highly occupied classrooms by increasing the power of the ventilation fans of the seven H & C units. Improving ACHs by increasing outside air –while properly maintaining filtration through MERV 13 filters ---has limited effects given the heating needs of the building. Increasing fan power, and thus supply air flow, is the most immediate action necessary to decrease COVID Pandemic risk. This might require the replacement of underpowered and aging roof ventilation fans.

2. CONDUCT OVERALL EVALUATION OF HAVC SYSTEM

In preparation to an overhaul of supply air capacity, UMASS Boston should consider engaging an engineering consulting firm for advice and to conduct a building-wide HVAC assessment. Based on historical issues with air exchange/IAQ complaints, age, physical deterioration, and availability of parts for ventilation components, such an evaluation is necessary to determine the operability and feasibility of improving or replacing the current equipment.

3. BALANCING HVAC SYSTEM

Have the HVAC system balanced every 5 years in accordance with SMACNA recommendations (SMACNA, 1994). Balancing requires adjusting in-supply air flows to school spaces to achieve > 4 ACH, removal of obstructions at fans and cleaning air duct network of debris and obstructions.

5. COVERING COSTS OF IMPROVEMENTS

UMASS Boston should apply for federal and state funds earmarked for ventilation improvements related to the COVID Pandemic. The U.S. Department of Education has released new guidance encouraging the use of American Rescue Plan (ARP) funds to improve ventilation systems and make other indoor air quality improvements in schools. More information can be found at these links: https://www.ed.gov/coronavirus/improving-ventilation https://nailor.com/corporate/news/ventilation-strategies-controlling-fresh-airhttps://enviroaircleaning.com/hvac-commercial/tried-true-ways-increase-hvac-air-flow/

6. GENERAL RECCOMENDATIONS FOR EVALUATING HVAC SYSTEMS

* Work with an HVAC contractor to determine if additional fresh air can be supplied to the 1st, 2nd, 3rd, and 4th floor. Adjustments or renovations may be necessary to improve the air flow in the space.

* Examine the fan speed. Most HVAC systems have multiple speed connections, and it may be possible to increase the unit's fan speed to improve air flow. Fans can be replaced, or air booster fans can be installed, if the current primary fan does not have the power to push air through long or complicate ductwork. Consideration should be made for increased air flow noise.

* Check for possible ventilation blockages. Employees sometime block vents and registers in an attempt to control their immediate environment. This can have an impact on how the entire air flow system works. It is important that all vents and registers remain open and are not blocked by machinery or other equipment.

* Clean any debris from outdoor HVAC units. Heat pumps and air conditioning units located outside can collect debris which compromises efficient air flow throughout the system.

*Change HVAC filters on a regular basis. HVAC systems rely on filters to remove dust, debris, and other foreign objects from entering and doing damage to the unit. When a filter is clogged, it also prevents air from entering the system too and proper air flow can come to a halt. The MERV 13 filters now being used may need to be replaced more often that lower rated MERV filters.

*Visibly inspect the air ducts. It is possible that the ductwork could have developed some cracks or holes where air might be escaping. Ducts can also get filled with dust, which can impact the proper flow of air. Have the system coils and ductwork cleaned. HVAC system's coils become dirty from outside soot and pollution and then do not work efficiently. Check thermostats for working batteries.

* Consider updating the HVAC system. Sometimes renovations such as the ones made to Wheatley Hall to accommodate additional office space and/or other changes to space layout, do not take HVAC requirements into consideration. Walls were erected and new offices were made at Wheatley that clearly fell outside the original design of the HVAC system. The current ductwork may not be capable of accommodating the new office space to efficiently move air where it is now most needed. Ductwork adjustments may be necessary to maximize air flow.

Improving Fan System Performance: A Sourcebook for Industry was developed by the U.S. Department of Energy's (DOE) Industrial Technologies Program and the Air Movement and Control Association International, Inc. (AMCA). This 92-page document provides potential performance improvements, some practical guidelines, and details where the user can find more help. You can find it at: https://www.nrel.gov/docs/fy03osti/29166.pdf

C. Specific Recommendations:

1. SUPPLY AIR IMPROVEMENTS ON UNDREVENTILATED ROOMS

Upgrade of air supply on the academic spaces where 4 ACH are not reached. Specifically, the evaluated rooms identified (numbers in **red**) on Table below. This includes, but not be limited to: Six classrooms and three offices in the 1St Floor; Four classrooms on the 2nd floor, Three classrooms and one office on the 3rd Floor. One classroom/lab on the fourth floor. In the interim, HEPA Portable Air Cleaning devices must be considered. <u>Of special concern is that seventeen of these spaces are active Classrooms/Labs</u>. Ventilation in classrooms should be improved as soon as practicable.

21 Spaces Recommended for Improvement of Supply Air Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))		
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Totals	35	**21 (60%)**

2. BATHROOM VENTILATION IMPROVEMENTS

The lack of ventilation in the women's bathroom on the 6th Floor (Room 6-99) should be remedied as soon as possible. The extremely low exhaust in the men's bathroom on the first floor should also be addressed (1-18). For complete results see Table Results 2 below. Studies of bathrooms have shown that toilets can be a risk of generating airborne droplets and droplet residues that could contribute to transmission of pathogens. Recommendations for safe bathrooms are listed below.

a. Keep toilet room doors closed, even when not in use.

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4. PARTICULATES PM2.5 IN ACADEMIC SPACES

Special attention to improvement of air supply must be paid to the 14 academic spaces (out of 35- 40%) where concentrations ranged from 6 to 23 ugm/m3. This elevated level of particles raises concerns; because of their size, they could be carriers of SAR-Cov-19 viral particles, increasing the risk of infection. For room-by-room concentrations see Table of RESULTS 4 below.

VI. Guideline Documents

A. COVID-19 Assessment in Schools

The COVID-19 particles are emitted with the liquid droplets created when we cough, sneeze, sing, talk and even just breath through our noses. SARS-CoV-2, the virus that causes COVID-19, is thought to spread from person-to-person through respiratory droplets. The large visible mist and droplets settle to the surface quickly and are unlikely to be drawn up into the ventilation system. But smaller ones, especially those under ten microns in diameter can float in the air for extended periods of time. The longer the tiny droplets remain in the air, the more the water in them evaporates, leaving only tiny mucus and other secretions from our lungs the virus itself (which is 0.125 microns in diameter). These dehydrated particles of virus and dry secretions can be in the range of 0.3 to 1.0 microns. Some of these particles have been documented to have remained airborne for more than 2 hours. One study showed the particles were capable of infecting people after 16 hours.(Fears AC. Et al. Persistence of Severe Acute Respiratory Syndrome Coronavirus 2 in Aerosol Suspension. EID. Volume 26, Number 9 – September 2020. https://wwwnc.cdc.gov/eid/article/26/9/20-1806_article?deliveryName=USCDC_331-DM35835).

MTA relied on the following guidance document to make clear the findings and recommendations:

Ventilation in Schools: The Harvard School of Public Health (HSPH) recommends a target of 5 ACH and characterizes ACH targets as follows: Ideal (5 ACH), Excellent (5-6 ACH), Good (4-5 ACH) Bare Minimum (3-4 ACH) and Low (3 ACH) Harvard School of Public Health, 5 Step Guide to Checking Ventilation Rates in Classrooms, https://schools.forhealth.org/ventilation-guide/ 8/28/20, p. 27.

Guidance from the American Hygiene Association (AIHA) characterize 3 ACH as correlating to 78% relative risk reduction of COVID-19 infection, 4.5 ACH correlates to a 90% relative risk reduction: six correlated to a 95% relative risk reduction, and 10 ACH correlates to a 99% relative risk reduction. Reference: American Industrial Hygiene Association, Reducing the risk of COVID-19 Using Engineering Controls, htpps://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Guidance-Documants/Reducing-the risk-of-COVID-19-using Engineering-Controls-Guidance-Dociment.pdf, 8/11/20.

AIHA and HSPH recommend school buildings maintain 40% to 60% relative humidity. In the nurses COVID room and other indoor environments where infectious people are likely present, delivering between 6 and 12 air changes per hour of outside or clean air significantly reduces the spread of infectious air-borne diseases. American Industrial Hygiene Association, Reducing the risk of COVID-19 Using Engineering Controls, https://aiha-assets.sfo2.digitaloceanspaces.com/AIHA/resources/Guidance- Documents/Reducing-the risk-of-COVID-19-using Engineering-Controls- Guidance- Document.pdf, 8/11/20. p.5ASHRAE’s Core Recommendations for Reducing Airborne Infectious Aerosol Exposure concisely summarize the main points found in the detailed guidance documents produced by the ASHRAE Epidemic Task Force. They are based on the concept that ventilation, filtration, and air cleaners can be combined flexibly to achieve exposure reduction goals. https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-building-readiness.pdf

Center for Disease Control, Ventilation in Buildings; updated June 2, 2021, https://www.cdc.gov/coronavirus/2019-ncov/community/ventilation.html

ASHRAE Filtration Disinfection https://www.ashrae.org/file%20library/technical%20resources/covid-19/ashrae-filtration_disinfection-c19-guidance.pdf

B. ASHRAE Position Document on Infectious Aerosols (April 2020)

1. Indoor Quality Guidelines

ASHRAE recommends: "Facilities as a minimum should comply with ASHRAE 62.1 and 62.2." These guidelines were developed before the COVID Pandemic and are designed to provide comfortable indoor spaces for temperature (70-78 F) and Relative Humidity % (%RH 40-60%). These two guidelines recommend "fresh air" but do not give guidance to evaluate the efficacy of an HVAC ventilation system.

2. ASHRAE and Infectious Diseases

The document states: "Infectious diseases can be controlled by the interruption of the transmission routes used by a pathogen. HVAC has a key role in protecting building occupants by interrupting the indoor dissemination of infectious aerosols.

On **ASHRAE Section 3.1 Varying Approaches by Facility,** the document states: "ASHRAE does not provide specific requirements for infectious diseases control on homes, **schools**, prisons, shelters, transportation or other public facilities."

ASHRAE further states: "Diseases that clearly follow airborne transmission model (measles, TB) call for environmental controls in health care facilities. Similar strategies may be appropriate for non-healthcare spaces such as airplane, **schools**, and shelters with close contact of occupants. Natural Ventilation (open windows) is variable and unpredictable, so its ability to manage risks in buildings is much reduced.

On ASHRAE Section 3.2 Ventilation, " Ventilation (with effective airflow patterns is a primary infection disease control strategy through dilution of infection agents." It refers the user to the CDC: *"Guidelines for Environmental Infection Control in Health Care Facilities, USDHHS, CDC Atlanta, Updated in July 2019.*

Disclaimer

This document was designed to follow current known industry, academic and government guidelines for interpretation of air flows, %RH, CO2 concentrations, Temperatures and Particulates (PM2.5). Michael Sireci, Rafael Moure-Eraso and the Massachusetts Teachers Association make no express or implied warranties as to the health of persons or property from only the measurements performed at UMASS Boston (UMB) on November-December 2021. A comprehensive sampling of all environments and environmental conditions is not included in this report. The conclusions and recommendations are based in the conditions observed on November 30 and December 2, 2021. It is assumed that the circumstances in that day are representative of the average indoor environmental conditions of Wheatley Hall, UMB building while UMB is in normal operation. The client and all others reviewing this document are hereby notified that due to the variability of air flow measurements and other indoor air quality measurements, and interpretations thereof, can be subjected to change over time

Tables of Results

Wheatley Hall

University of Massachusetts Boston

Assessment of Indoor Air Quality in 35 Wheatley Hall Spaces

Results 1	--	Summary ACH Ventilation Assessment
Results 1A	--	Ranges of ACHs in Floors 1,2 and 3
Results 1B	--	Ranges of ACHs in Floors 4, 5 and 6
Results 2	--	Three Bathrooms Exhaust Ventilation Measurements
Results 2A	--	Exhaust Ventilation Measurements
Results 3	--	CO2 Concentrations Six Floors
Results 4	--	%RH and Temperature Results in Six Floors
Results 5	--	Particulate Concentrations PM2.5 in Six Floors

Results 1- Summary ACHs Ventilation Assessment Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))			
Floor	Rooms Evaluated	**Below** <4.0 ACH OA	**Above** >4 ACH OA
1st	9 (6 Classrooms-3 Offices)	9	0
2nd	6 (6 Classrooms)	4	2
3rd	6 (2 Classrooms & 1 Lab, 3Office)	5	1
4th	6 (2 Class/Lab, 4 Offices)	2	4
5th	2 (2 Offices)	1	1
6th	2 (Offices)	0	2
3 Floors	4 (4 Bathrooms)	2 – "0" and minimal ventilation 2 -- significant ventilation	
TOTALS	35	21 (60%)	14

Results 1A- Ventilation Assessment Ranges (ACHs) Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))			
Floor	Rooms Evaluated	Rooms below <4.0 ACH OA (range)	Rooms above >4 ACH OA (range)
1st	6 Classrooms (**10, 19,20, 36,58, 61**)	6 (1.8 –2.7)	0
	3 Offices (**77-P, R, V**)	3 (2.0 - 3.4)	0
2nd	6 Classrooms (**46**, 60, **98,** 107, **124**, **206**)	4 (1.7-- 3.1)	2 (5.1 – 5.8)
3rd	2 Classrooms & 1 Lab (**122, 124*, 97**)	3 (0.0 – 1.6)	0
	3 Offices (**6, 54/25,** 54/07)	2 (1.6 – 2.5)	1 (6.1)

Results 1B- Ventilation Assessment Ranges (ACHs) Guidance TC-HSPH/AIHA—4-5 ACH (supply outside air (OA))			
Floor	Rooms Evaluated	Rooms below <4.0 ACH OA (range)	Rooms above >4 ACH OA (range)
4th	2 Laboratory/classroom (74, **151**)	1 (1.8)	1 (4.7)
	4 Offices (07, **144*,** 147/15, 144/14)	0	4 (4.7 – 16)
5th	2 Offices (**56**, 58)	1 (2.8)	1 (6.6)
6th	2 (Offices) (61, 113)	0	2 (5.9 – 7.9)
Totals	35	**21 (60%)**	14

Note: **Room Numbers in RED are below ACHs Guidelines (<4.0 ACH) --** 21 of 35 **(60%)** of all the rooms assessed. * Two classrooms (3rd Floor 3-124) and (4th Floor 4-144) had "0" supply air

Results 2- Three Bathrooms Exhaust Ventilation Assessment Guidelines for Bathrooms: >10 Vol Change/hour No Supply Air				
Floors	Bathroom Evaluated	Changes of Air below <4.0 Vol Changes per hour	Changes of Air above >4.0 Vol Changes per hour	Notes
1st	1--018	1 (1.1)	-	Minimal air movement
4th	4 - 78	-	1 (8.0)	Moderate Air movement
6th	6-99	**1 (0.0)**	-	**Women's Room No air movement**
	6 -100	-	1 (5.2)	Minimal air movement

Results 2A- Exhaust Ventilation Assessment			
Floor	Rooms Evaluated	**Below** <4.0 Change/hour	**Above** >4.0 Change/hour
1st	9 (6 Classrooms-3 Offices)	5 (0.9-3.8)	4 (4.0-7.8)
2nd	6 (6 Classrooms)	4 (1.7-3.1)	2 (5.1-5.8)
3rd	6 (2 Classrooms & 1 Lab, 3Office)	6 (0.0-2.2)	0
4th	6 (2 Class/Lab, 4 Offices)	3 (0.0-3.1)	3 (4.4-8.0)
5th	2 (2 Offices)	1 (2.0)	1 (5.9)
6th	2 (Offices)	0	2 (5.5-5.9)
3 Floors	4 (4 Bathrooms)	2 (0.0-1.1)	2 (5.2-8.0)
TOTALS	35	21 (60%)	14

Note: Exhaust Grilles in six rooms have “0” flow. ((Rooms 77R-1st Floor; Room206-2nd Floor; Rooms 54/25-/07-3rd Floor; Room 147/5-4th Floor and Room 99-6th Floor)

Results 3- CO_2 ppm Concentration Assessment Guidelines MDPH: 800 ppm fully Occupied Room Outside Conditions: CO_2 ppm (414-485) (11-12/2021)			
Floor	Rooms Evaluated **(All Unoccupied)**	**Above** 800 ppm CO_2	**Below** 800 ppm CO_2
1st	9 (6 Classrooms-3 Offices)	2 (809-818)	7 (631-797)
2nd	6 (6 Classrooms)	2 (1082-920)	4 (561-777)
3rd	6 (2 Classrooms & 1 Lab, 3Office)	0	6 (629-630)
4th	6 (2 Class/Lab, 4 Offices)	0	6 (629-630)
5th	2 (2 Offices)	1 (814)	1 (560)
6th	2 (Offices)	1 (820)	1 (754)
3 Floors	4 (4 Bathrooms)	1 (821)	3 (730-765)
TOTALS	35	7	28

Results 4- Particulates PM2.5 Outside Conditions: PM2.5 (2.0 ugm/m3) **35 Rooms Evaluated November 30 and December 2, 2021, were all unoccupied**				
Floor	Rooms Evaluated	Range	PM2.5 (5-10)	PM2.5 >10
1st	9 (6 Classrooms-3 Offices)	2-11	1	1
2nd	6 (6 Classrooms)	2-25	-	2
3rd	6 (2 Classrooms & 1 Lab, 3Office)	2-11	2	2
4th	6 (2 Class/Lab, 4 Offices)	2-15	1	1 (BR)
5th	2 (2 Offices)	6-6	2	-
6th	2 (Offices)	5-23	2	2 (BR)
Totals	35 (16 (46%) above 5 ugm/m3)	2-25	8	8

Note: Eight spaces (23% samples-8/35) have significantly high PM2.5 concentrations (fifth column above) ranging from 11 to 25 ugm/m3— (Rooms: 77R-1st Floor; 60, 124-2nd Floor; 1-154/2 , 122-3rd Floor; 78-4th Floor; 61, 113-6th Floor). Eight spaces (23%- 8/35) have high concentrations (fourth column above) ranging from 5 to 9 ugm/m3 – (Rooms: 77v-1st Floor, 124, 154/07-3rd Floor, 144-4th Floor, 58, 56-5th Floor and 99,108-6th Floor).

Results 5- Relative Humidity Percentage (%RH), Temperatures (F) Outside Conditions: %RH (34-47), T (47-64) **35 Rooms Evaluated November 30 and December 2, 2021, were all unoccupied**			
Floor	Rooms Evaluated	**%RH**	**T (F)**
1st	9 (6 Classrooms-3 Offices)	22-43	59-76
2nd	6 (6 Classrooms)	22-26	69-72
3rd	6 (2 Classrooms & 1 Lab, 3Office)	35-42	69-72
4th	6 (2 Class/Lab, 4 Offices)	37-50	71-75
5th	2 (2 Offices)	32-35	76-75
6th	2 (Offices)	36-39	72-75
3 Floors	4 (4 Bathrooms)	38-42	72-76

APPENDIX

Tables of Measurements taken Room by Room

and

Results and Calculations for each floor

Wheatley Hall –UMASS Boston

Table 1. Data MTA-UMASS Boston-Wheatley 1st Floor (11/30/2021) Data for Air Changes per Hour (ACH)-Flow measurements (CFM) **Outside conditions: RH: 34.3% —Temperature: 47.2F – CO_2: 414 ppm - PM2.5 = 2 ugm/m3**							
Room	**Volume ft3**	**HVAC Supply CFM**	**%RH**	**Temp F**	**CO_2 ppm** **No occupancy**	**PM 2.5 ug/m3**	**Notes** **HVAC Supply 20% OA** **80%Recycled Filtered through MERV 13** **(80% OA)**
W-1-010	4,271	217	29.7	59	888	2	Max Occupancy (40)
W-1-019	4,393	230	34	61	797	2	Max Occupancy (35)
W-1-020	4,382	211	27.2	67	809	2	Max Occupancy (25)
W-1-056	4,546	161	23.2	68	631	2	Max Occupancy (30)
W -1-058	5,119	309	23.3	69	674	2	Max Occupancy (35) (2 Diffusers)
W – 1- 061	4,690	249	24	68	734	2	Max Occupancy (22)
W – 1 – 018	4,177	0	43	76.5	765	2	(Bath room) Only exhaust

Table 1A. Results-UMASS Boston-Wheatley 1st Floor (11/30/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **HVAC Supply 20% OA -- Recycled Filtered Air 80% through MERV 13 (80% OA)**							
Room	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
W-1-010	182	2.6	-66	2.8	-0.9	H&C 1	
W-1-019	194	2.7	-368	0.5	-5.0	H&C 1	
W-1-020	177	2.4	-345	0.5	- 4.7	H&C 1	
W-1-056	136	1.8	-286	0.5	-3.8	H&C 1	
W -1-058	260	3.0	-344	0.8	-4.0	H&C 1	2 Supply Diffusers
W – 1- 061	209	2.7	-612	0.3	-7.8	H&C 1	
W – 1 – 018	0	0	-75	-	-1.1	H&C 1	Bath room Only exhaust

Sample Calculation Table 1A Room W-1-010

SUPPLY STREAM

ACH = [**Equivalent Outdoor air flow (CFM)** X 60 (minutes)] / [Room Volume (ft3)]

Equivalent Supply Outdoor Air (OA) = [% Outside Air in Supply (%OA) + Equivalent Filtered recycled air counted as outside air (OA) based on MERV Filter type]

In the case of UMASS Boston %OA was 20% of a supply stream of W- 1- 010 --at the day of the survey-- measured as 217 CFM (11/30/21). The recycled portion of supply air is filtered by a MERV 13 rated filter. This grade filter filters the aerosol particles associated with SARS-COV- 2 viral with an efficiency of 10% for the particles on the range of 0.3 to 1.0 um.

Then, **Equivalent Supply Outdoor Air (OA** is the sum of two quantities:

1. OA from 20% of supply stream: (217 * 0.2) = 43.4 CFM

2. OA equivalent from recycled stream 217 * 0.8 = 173.6 CFM (80% of supply) multiplied by 80% (Equivalent OA from recycled air due to filtration through MERV 13 Filters): (217) * (0.8) * (0.8) = 138.88 CFM

Equivalent Supply OA CFM (ft3/min) = *(217)* (0.2) + (217) * (0.8) * (0.8) = 182.28 CFMACH = Equivalent OA Supply(CFM) X 60 / Room Volume (ft3) = 182.28 * 60 / 4,271 = 2.56* ***ACH = 2.56***

EXHAUST STREAM

Exhaust Stream (CFM) = - 66 CFM --- CHe = 66 * 60 / 4,271 = 0.9 ***CHe = 0.9***

Ratio OA Supply to Exhaust: 182/ 66 2.78

(*Reference: School and Universities--ASHRAE Epidemic Task Force, Filtration Basics- Pages 24-25, Updated 10-24-20)*

Table 1C. Data MTA - Wheatley 1st Floor - UMASS Boston (11/30/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **Outside conditions: RH: 34.3% —Temperature: 47.2F – CO2: 414 ppm - PM2.5 = 2 ugm/m3**							
Room	**Volume ft3**	**HVAC Supply CFM**	**%RH**	**Temp F**	**CO2 ppm** **No occupancy**	**PM 2.5 ug/m3**	**Notes** **HVAC Supply 20% OA 80%Recycled Filtered through MERV 13 (80% OA)**
W-1-77 P/Q	1,255	75	22.9	69.9	630	2	Office
W-1-77 R	1,036	70	23.3	69.7	706	11	Office
W-1- 77 V	1,708	68	24.4	69.2	631	8	Office

Table 1D. Results MTA - Wheatley 1st Floor - UMASS Boston (11/30/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **HVAC Supply 20% OA -- 80%Recycled Filtered Air through MERV 13 (80% OA)**							
Room (Max Occupancy)	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
W-1-77 P/Q	63	3.0	-48	1.3	-2.3	H&C 1	office
W-1-77 R	59	3.4	0	-	-	H&C 1	Exhaust Flow: 0 CFM office
W-1- 77 V	68	2.0	-19	3	-0.7	H&C 1	Office

Table 2. Data MTA – Wheatley 2nd Floor - UMASS Boston (11/30/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **Outside conditions: RH: 34.3% —Temperature: 47.2F – CO_2: 414 ppm - PM2.5 = 2 ugm/m3**							
Room	**Volume ft3**	**HVAC Supply CFM**	**%RH**	**Temp F**	**CO2 ppm** **No occupancy**	**PM 2.5 ug/m3**	**Notes** **HVAC Supply 20% OA 80%Recycled Filtered through MERV 13 (80% OA)**
W - 2 - 046	9,692	590	23,1	71.5	699	2	Max Occupancy (35)
W- 2- 060	9,289	931	26.4	69.8	1,082	25	Max Occupancy (7) 4 Diffusers
W – 2 -098	6,390	306	22.3	71.2	658	2	Max Occupancy (50)
W- 2- 107	5,833	678 (5 Diff)	24	69.7	777	2	Max Occupancy (36)
W- 2- 124	4,343	255 (2 Diff)	22.2	70.3	920	13	Max Occupancy (28)
W- 2- 206	5,534	188 (5 Diff)	23.5	72.1	561	2	Max Occupancy (30)

Table 2A. Results MTA – Wheatley 2nd Floor - UMASS Boston (11/30/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **HVAC Supply 20% OA --- 80%Recycled Filtered through MERV 13 (80% OA)**							
Room	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
W - 2 - 046	496	3.1	-112	4.4	-0.7	H&C 4	
W- 2- 060	782	5.1	-306	2.6	-2.0	H&C 5	
W – 2 -098	257	2.4	-464	0.6	-4.4	H&C 1	
W- 2- 107	434	5.8	-187	2.3	-1.9	H&C 1	5 Supply Diffusers
W- 2- 124	211	2.9	-602	0.4	-8.3	H&C 1	2 Supply Diffusers
W- 2- 206	153	1. 7	0	-	-	H&C 3	5 Supply Diffusers

Table 3. Data MTA- Wheatley 3rd Floor - UMASS Boston (12/02/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **Outside conditions: RH: 46.4% —Temperature: 63.6F – CO_2: 485 ppm - PM2.5 = 2 ugm/m3**							
Room	**Volume ft3**	**HVAC Supply CFM**	**%RH**	**Temp F**	**CO2 ppm** **No occupancy**	**PM 2.5 ug/m3**	**Notes** **HVAC Supply 20% OA 80%Recycled Filtered through MERV 13 (80% OA)**
W- 03-06	1,121	36	36.5	74.1	671	2	Office
W- 03 -097	2,514	76	35,7	73.8	720	3	Max Occupancy 3
W- 03- 122	7,225	64	36	72.2	663	9	Max Occupancy 10 desks
W- 03 - 124	7,248	0	42.2	73.1	581	6	Max Occupancy 25 4 Ceiling, 2 wall diffusers all exhaust No supply into room
W-03-1-54-25	1,067	53	38.5	73.6	610	11	Office Exhaust = - 0 CFM
W- 03 -1 -54-07	926	112	36.8	73.8	635	7	Office Exhaust = - 0 CFM

Table 3A. Results MTA- Wheatley 3rd Floor - UMASS Boston (12/02/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **HVAC Supply 20% OA -- 80%Recycled Filtered through MERV 13 (80% OA)**							
Room	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
W- 03-06	30	1.6	-23	1.31	-1.2	H&C 1	Office
W- 03 -097 (3)	63.8	1.5	-53	1.2	-1.3	H&C 5	2 supply diffusers
W- 03- 122 (10 desks)	53.8	0.5	-59	0.9	-0.5	H&C 6	4 Ceiling Diffusers "0" flow 1 active diffuser wall
W- 03 - 124 (25)	0	0	-264	-	-2.2	H&C 7	6 Diffusers 4 Ceiling, 2 wall All exhaust No supply into room
W-03-154-25	45	2.5	0	-	0	H&C 7	Office Exhaust = 0 CFM
W- 03 -1 54-07	94	6.1	0	-	0	H&C 7	Office Exhaust = 0 CFM

Table 4. Data MTA- Wheatley 4th Floor - UMASS Boston (12/02/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **Outside conditions: RH: 46.4% —Temperature: 63.8F – CO2: 485 ppm - PM2.5 = 2 ugm/m3**							
Room **(Max Occupancy)**	**Volume ft3**	**HVAC Supply CFM**	**%RH**	**Temp F**	**CO2 ppm** **No occupancy**	**PM 2.5 ug/m3**	**Notes** **HVAC Supply 20% OA 80%Recycled Filtered through MERV 13 (80% OA)**
W – 4 – 07	769	104	37	73	627	0	Office
W- 4 – 074	8,597	799	35.2	74.8	676	2	Laboratory 20 desks
W – 4- 078	1,063	0	37.7	74.8	730	15	Mens Bathroom
W- 4 – 144/16	777	0	37.8	72.6	629	8	Office 1 window
W- 4 – 147-15	877	221	50	73	542	2	Office 2 supply diffusers
W- 4 – 147-14	810	258	41	72.7	575	4	Office Windows along one wall
W – 4 -151	4,984	182	40.1	71.5	553	2	Lab Max Occupancy (10) 2 ceiling supply diffusers

Table 4A. Results MTA- Wheatley 4th Floor - UMASS Boston (12/02/2021) Air Changes per Hour (ACH)-Flow measurements (CFM) **HVAC Supply 20% OA -- 80%Recycled Filtered through MERV 13 (80% OA)**							
Room	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
W – 4 – 07	104	6.8	-34	3.0	-2.7	H&C 4	Office
W- 4 – 074	671	4.7	-681	1.0	-4.8	H&C 5	4 supply ceiling diffusers Laboratory 20 desks
W – 4- 078	0	0	-141	-	-8.0	H&C 5	(Mens Bathroom)
W- 4 – 144/16	0	0	-40	-	-3.1	H&C 7	Office 1 window
W- 4 – 147-15	186	12.7	0	-	0	H&C 7	2 supply diffusers Office
W- 4 – 147-14	217	16	-60	3.6	-4.4	H&C 7	Windows along one wall Office
W – 4 -151	153	1.8	-113	1.4	-1.4	H&C 7	Max Occupancy 10 2 ceiling supply diffusers

Table 5. Data MTA Wheatley 5th & 6th Floors - UMASS Boston (12/02/2021)

Air Changes per Hour (ACH)-Flow measurements (CFM)- Temp -%RH-CO2

Outside conditions: RH: 34.3% —Temperature: 47.2F – CO2: 414 ppm - PM2.5 = 2 ugm/m3

Room (Max Occupancy)	Volume ft3	HVAC Supply CFM	Supply based ACH	%RH	Temp F	CO2 ppm No occupancy	PM 2.5 ug/m3	Notes HVAC Supply 20% OA 80%Recycled Filtered through MERV 13 (80% OA)
FITH FLOOR								
W – 5 – 058	1,333	174	6.6	32.8	76.1	814	6	Office
W - 5 – 056	734	41	2.8	35.2	75.8	560	6	Office
SIXTH FLOOR								
W- 6 -61	1,207	189	7.9	32.7	75.5	754	13	Office
W- 6 -113	634	74	5.9	36.1	74.1	820	23	Office
W -6 -99	1,062	0	0	38.7	73.8	821	5	Women’s Bathroom No ventilation
W- 6 - 100	1,055	0	0	39.7	72.3	742	5	Men’s Bathroom

Table 5A. Results MTA Wheatley 5th & 6th Floors - UMASS Boston (12/02/2021) Air Changes per Hour (ACH)-Flow measurements (CFM)- Temp -%RH-CO2 **HVAC Supply 20% OA -- 80%Recycled Filtered through MERV 13 (80% OA)**							
Room	**Equivalent Supply CFM**	**Supply based ACH**	**Exhaust Flow CFM**	**Ratio OA Supp/Exhust**	**CHe Exhaust**	**H&C System**	**Notes**
5th Floor							
W – 5 – 058	146.5	6.6	-130	1.1	-5.9	H&C 14	Office
W - 5 – 056	41	2.8	-25	1.6	-2.0	H&C 9	Office
6th Floor							
W- 6 -61	159	7.9	-130	1.2	-6.5	H&C 12A	Office
W- 6 -113	62.2	5.9	-63	1.0	-5,9	H&C 12	Office
W -6 -99	0	0	-	-	0	None	Women's Bathroom No Ventilation 0 ACH
W- 6 - 100	0	0	-91	-	-5.2	None	Men's Bathroom