QA+M architecture

Root Cause Analysis of
Moisture/Water Conditions & Resulting Mold

John Winthrop Middle School

Regional School District No. 4 | Deep River, CT | December 20, 2023

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Referenced Reports:

The referenced reports below have been issue to the design team for our review and utilization for the analysis within this report. Information provided within the below documents have assisted with confirming suspected root causes of the moisture and mold propagation within the building noted within this report. Any questions regarding the contents of these reports shown below should be directed to the report authors directly.

Infrared Roof Inspection- JJC Drones – *December 7, 2023*

Thermal Building Envelope Inspection- JJC Drones – *December 8, 2023*

EnviroMed – Mold & Indoor Air Quality Report – *Oct. 4, 2023*

DRA Architects – Facilities Assessment – *Oct 23, 2022*

H2M Architects + Engineers – Investigation Report – *Nov. 22, 2023*

EFI Global – Engineering Report – *Sept. 20, 2023*

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TAB 1 | EXECUTIVE SUMMARY

TAB 1.0 EXECUTIVE SUMMARY

John Winthrop Middle School – Root Cause Analysis

In October of 2023, Regional School District #4 submitted an RFQ/ RFP to engage professional services in providing a Root Cause Analysis report as it relates to the infiltration of water & presence of moisture within the building resulting in mold propagation in the building. Indoor air quality samples were obtained on September 7, 2023, confirming elevated levels of mold within J.W.M.S. Upon award of this project, QA+M Architecture along with its Mechanical and Structural Engineers at RZ Design Associates have conducted a review of the facility and have noted various areas of concern contained within this report. Multiple site visits were conducted to the school to review both interior and exterior conditions.

The charge for our team as outlined in the RFP is as follows:

1) *Conduct a thorough investigation and determination of the root causes of the water/ moisture condition that resulted in mold contamination of the JWMS, which caused the evacuation of students and staff.*
2) *Once the root causes of the water/ moisture conditions have been identified, the Board reserves their right to amend the contract to include the preparation of remedial designs and specifications to address and prevent the root causes of the water/ moisture conditions.*

As part of our due diligence, the team reviewed previously issued reports to the district, as well as retained the services of a consultant to conduct updated building envelope and roof infrared thermal scans to help pinpoint areas of concern within the building. Through analysis of these various reports and multiple on-site observations from the team starting from November 10th – December 13th, 2023. The following items noted are what the design team believes to be contributing causes to the presence of moisture within the building, and the resulting mold.

Our report findings suggest that there may not be any singular cause for the presence of moisture within the building, and resulting mold, but multiple issues that contributed to this current condition within the school.

<u>ITEM #1: Visible signs of Mold Growth on Pipe Insulation</u>

Above the ceiling plenum the two-pipe heating and cooling lines are observed to have visible mold growth on the insulation covers around the pipes. Based on our team's investigation it is believed that due to improper installation and insufficient pipe insulation, and exposure to humid air inside the building allowed moisture to condense on the pipes saturating the insulation. The saturated insulation created an environment conducive for mold growth and propagation.

As it relates to remediation work, we recommend the removal of damaged pipe insulation should be performed, and appropriate pipe insulation with a vapor-barrier jacket and self-sealing closure caps to fully encapsulate the pipe system. Regional District #4 should adhere to the recommendations provided by Environmental Consultant as it relates to removal of all contaminated insulation, piping etc. and any existing finishes that are suspected to be compromised by the existing mold within the building. It is the opinion of the design team that the existing HVAC system is inefficient, many components are in need of replacement, lacks controls and does not meet the current ASHRAE ventilation and indoor air quality standards and should be replaced and/or modified to meet the current standards.

ITEM #2: Overall Tightness of the Building Envelope

Based on conclusions noted within the report, it is our opinion that an improperly/ poorly sealed building envelope is a contributing factor to moisture present within the building. The suspected high levels of air infiltration into the building through existing window openings, and wall penetrations makes it very difficult to properly condition the building. The existing school does not currently have an HVAC system that dehumidifies the building interior, and during the cooling season the high humidity levels outside along with the cool temperatures within the building create a high potential for condensation of moisture within the building.

As it relates to remediation work, we recommended that existing window and door assemblies throughout the building be replaced with thermally broken windows and are properly sealed preventing air infiltration into the building. If true air conditioning is desired within the entire school, it would be recommended that operable windows not be reinstalled to remove potential human error in leaving windows open overnight.

The existing roof membrane is nearing the end of its warranty period and shows some signs of early failures and potential sources for water infiltration. It is suspected that some moisture could be entering into the building from some of the roof connections as noted in the report. Roof flashing and building geometry flashing conditions that are compromised should be repaired or replaced to prevent any water from entering the building envelope. The existing roof design with ponding water, excessive vegetative growth, compromised flashing etc., as detailed in the existing conditions section, create an environment that elevates the possibility of water infiltrating the building. Although there are limited areas where there were visible signs of water infiltration, the conditions are prone for additional failures in the future. The design team recommends the full replacement of the entire roof and drainage infrastructure should be implemented as part of the overall solution.

The above-mentioned items in our professional opinion are 2 of the main root causes for the mold propagation within the school. The culmination of issues seen and noted within this report begins to identify compounding issues present within the school in conjunction with a Summer where the region received an above average rainfall creating heightened levels of humidity within the building creating ideal conditions for moisture formation & growth of mold within the building.

It should be noted that as part of our observations of the exterior and interior of the building, our team cited other areas of concern that should be addressed by the district in the near future. The analysis within this report is based on the conditions observed during the time window outlined above and is expected that conditions may change and evolve as issues are resolved. The district is encouraged to continue to monitor the conditions within the school and notify the Design Team of any new conditions that arise within the facility. It is our opinion that the appropriate solution for mold mitigation at JWMS is to address all the concerns identified in the report.

TAB 2 | J.W.M.S.- EXISTING CONDITIONS EVALUATION

TAB 2.1 Existing Building Evaluation

John Winthrop Middle School

BUILDING INFORMATION

Grade Range:	**7^{th}- 8^{th}**
Enrollment:	****221+**
Constructed:	**1970**
Additions*:	**2003**
Building Area:	***129,600 GSF**
Site:	**66.05 Acres**

**Note: Approximate values pulled from DRA Architects Facilities Assessment dated 10/23/2022*
*** Enrollment projects pulled from NESDEC report in DRA Architects Facilities Assessment dated 10/23/2022*

John Winthrop Middle School located at 1 Winthrop Road in Deep River; CT is an approximate 129,600 Gross Square Foot (G.S.F.) educational facility. The original building was constructed in 1970, with two small additions that were part of a 2003 renovation & additions project. This facility evaluation is based on a review of prior reports and documentation and in person site walk-through conducted by the design team. The design team also had discussions with the facility maintenance staff and Regional District #4 Administration, to confirm recent updates to the buildings that were not part of the written reports. The QAM team focused its efforts on the building envelope, HVAC and controls systems to determine the root cause for moisture in the building that propagated the mold within the school building.

Section 1: Existing Roof Evaluation

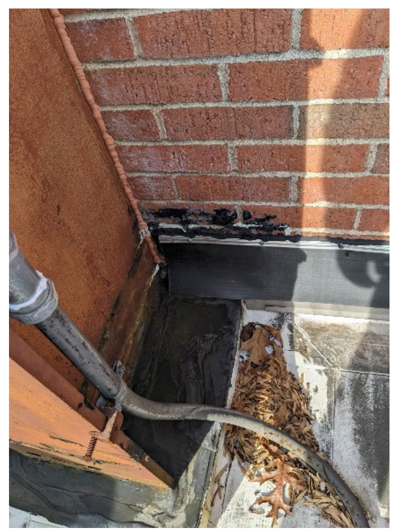
EPDM Roof System:

The existing roof is an EPDM – White roof that was installed in 2005 during the last significant renovations to the building. Per the Addition/ Renovation's contract documents provided to the design team dated 3/1/03, the existing roof assembly is comprised of a ½" sheet of cover board over metal deck, with tapered roof insulation, and the EPDM roof membrane. The existing drawings appear to indicate an average roof insulation of 5 inches +/- depending on where you are in the building. The warrantee period for the roof system is slated to expire in 2025, based on the DRA Facilities Assessment report.

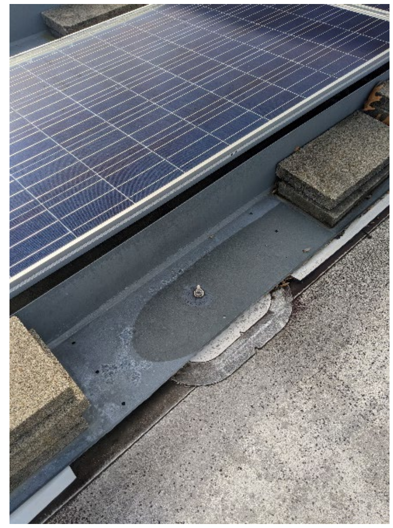
Initial observations of the roof show significant amounts of vegetative growth covering the entire surface of the roof membrane. Vegetative growth to this extent can be partially attributed to a lack of cleaning of the roof membrane over the years but would also indicate that moisture is present on the surface for prolonged periods of time. This is suspected to be caused by low roof pitches, as well as the installation of the solar roof panels across the building.

Roof flashing and seams at building geometry transitions appear to be in poor condition. At many locations where the roof membrane meets an existing vertical wall, the roof membrane only appears to be

		
Image 1.1: Loading Canopy Peeling away roof membrane & clogged roof scupper & downspout & ponding	Image 1.2: Ponding & Growth Vegetative growth on membrane & standing water present on membrane.	Image 1.3: Rip in Membrane Rip in roof membrane Located at S.W. Interior Corner of Classroom Wing & Library

		
Image 1.4: Holes in Membrane Pin hole's were observed in the membrane by the mechanical room chimney stack. Bubbles observed in small amount of water on the membrane.	Image 1.5: Patches & Seams Compromised patches and trench drain above gymnasium roof. Patches and seals are failing and could be letting water in below the roof membrane.	Image 1.6: Flashing & Holes Gymnasium exposed structure, compromised flashing & holes in sealant.

flashed into the wall 4-5 inches above the roof plane which is generally lower than the typical 8 inches expected to maintain roof warranties. Where roof geometry changes planes/ directions such as inside or outside corners and edges, there are areas that show signs of cracks in the roof membrane and peeling roof seams. It is suspected that these locations are allowing water to infiltrate the roof membrane, and eventually find its way into the building. Examples of these locations are shown in the referenced images, along with general locations of where they occur. At many transition locations, a topical black sealant appears to have been applied to prevent moisture from finding its way under the roof membrane. One

		
Image 1.7: Sloped Roof Trench East side roof drain trench, directs water to it within 4’ of either side of the drain, but standing water visible past that point.	Image 1.8: Flashing Conditions Compromised wall flashing, failing sealant at top of counter flashing cleat. Sill flashing sloping into glass block.	Image 1.9: PV Panel Fastening Flat PV panels are connected periodically with through bolts. Standing water visible at penetration. Depending on fastening method, water could be infiltrating at these locations.

location of concern that was observed is at the Exercise Gym, where structural steel is exposed to the elements, and penetrates the roof system. Currently there is only a 3 to 4 inch curb at the base of the roof, and then a black sealant has been applied to fit around the steel section. The concern seen is that the sealant has deteriorated over the years and has started to peel away from the steel allowing water/ snow to collect on the surface and find its way into the building following the structural steel. In general, there were many improper or compromised flashing conditions around the roof that could be contributing to infiltration of water in the school and further investigation by cutting into the roof assembly would be recommended to determine if in fact water has found its way below the roof membrane.

Tapered Roof Insulation:

As it relates to the existing roof pitches, there does not appear to be any significant slopes to the roof, except at the perimeter where it appears to be generally built up to shed water back towards the center of the roof. The only other significant slopes that were observed occurred at a roughly 4’ wide trough area around the roof drains as documented on the existing roof plan drawings. The minimal slope of the roof observed has caused low spots in the roof that show visible signs of ponding water. The presence of standing water on any roof is always an item of concern, given that over time the presence of standing water can deteriorate seams in a roof membrane over time, and through hydrostatic pressure allow water to find its way into the building envelope.

Based on documented weather data in Deep River, the region did not receive any significant rain event since November 24th, 2023. Our walk of the roof occurred a week later on December 1st, 2023 where the roof was generally observed to be dry with exception of areas shown to have standing water present. If the roof area had a positive slope towards the roof drains throughout the roof, we would not be seeing patches of standing water away from the roof drains. Although standing water is not a key indicator of moisture infiltration, it does present a heightened concern in these areas as hydrostatic pressure can over time force water between seams and into the building.

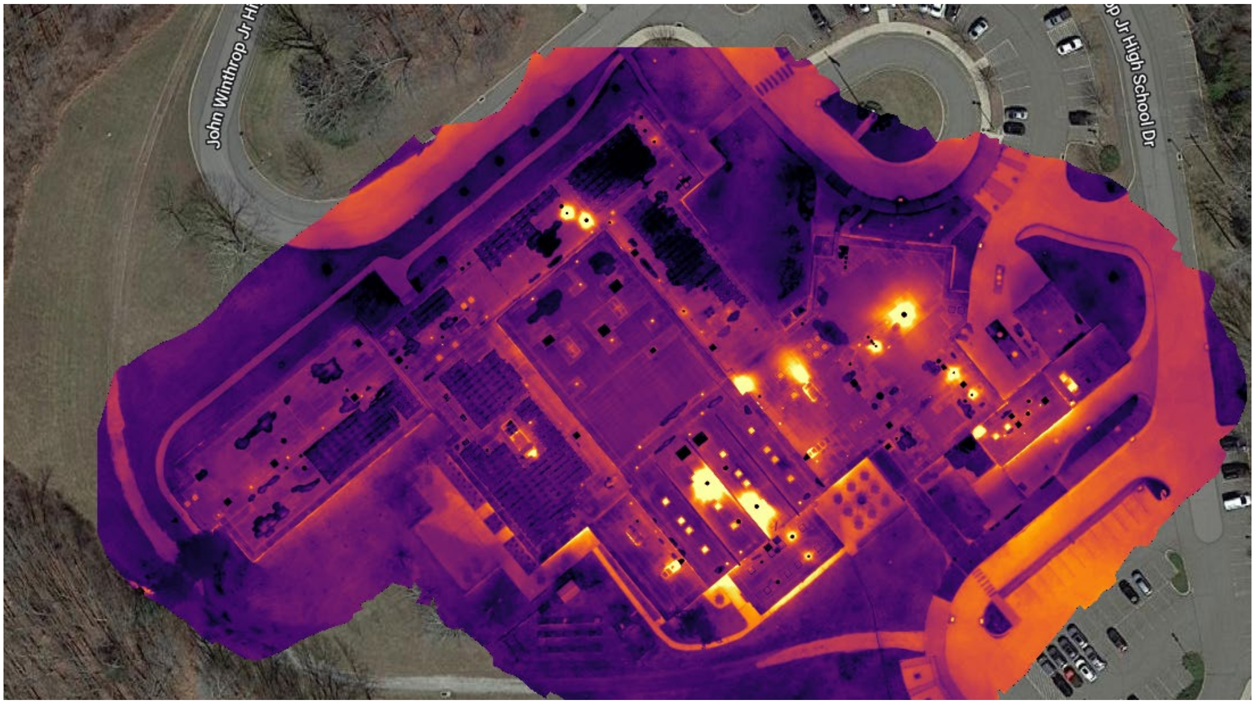


Image 1.10: Infrared Roof Plan of JWMS

The attached image is pulled from the JJC Drone Infrared Roof Inspection report. Zooming into the map, areas that are darker indicate cooler temperatures, and potential presence of standing water or moisture. Note areas with flat PV Panels installed show up darker, indicating potential presence of stagnant water under the panels where tube style PV arrays on the Auditorium and Café which do not show as much moisture beneath the panels. Insulation gradient appears pretty uniform indicating minimal build up of tapered roof insulation.

Thermal Performance:

Reviewing the Thermal Roof Scan report conducted by JJC Drones, the overall thermal performance of the roof generally appears uniform, indicating that there are not any significant areas of heat loss through the roof system. A majority of heat loss through the roof appears to be concentrated around all roof top MEP equipment, exhaust vents, roof drains, and skylights.

In review of the thermal scans provided, the results shown support our assumption regarding the tapered roof insulation, and that there is not any significant pitch to the roof to properly drain water off the roof. If any significant level of tapered roof insulation was provided from the edge of the roof to the centerline of the drains, we would typically expect to see a gradated color showing less heat loss along the perimeter where the built up of insulation is thicker, and more heat loss occurring closer to the roof drains where insulation is thinner. What we are observing is a buildup of tapered insulation along the perimeter of approximately 3'-0" which appears darker than the rest of the roof. This leads us to believe that the overall sloping of the roof is a contributing concern for standing water remaining on the roof.

The thermal scans do not give conclusive evidence if there is moisture present under the roof membrane itself. As no visible signs of moisture were observed on the inside of the building attributed to a roof leak it is not believed that significant moisture has made its way into the roof insulation. However, it would be our recommendation to perform some core samples within the roof membrane to confirm this rationale.

		
Image 1.11: Clogged Drain Roof Drains around the entire building show lots of vegetation blocking the strainer bowls. Regular maintenance needed to ensure these drains remain clear.	Image 1.12: Standing Water Around Drain The sloped drain channel above the gymnasium has low spots allowing water to sit on the roof membrane rather than sloping to the drain.	Image 1.13: Clogged Scupper & Downspout Significant amount of standing water is present on the loading entrance canopy due to clogged scuppers and downspouts.

Roof Drains:

The roof drains on the existing building are in critical need of being cleaned out. Leaves and other natural elements have accumulated around many of the roof drains which restricts the flow of water. Per the existing contract documents, the roof drains throughout the building appear to have 4” diameter drain lines. Roofs do not have any overflow drains, but rather utilize scuppers along the parapet edges, which is an acceptable backup provision.

The scupper and rain leader above the loading area canopy structure had excessive vegetation debris on the roof which have all clogged the path for water to properly drain off the roof. Due to the drainage area not being cleaned out, excessive ponding of water is present on the roof at this location. The scupper and downspout need to be cleaned out to allow for proper drainage of the roof surface.

One item of concern that was observed above the Gymnasium Roof was it appears that a roof drain was removed on the South side in the 2^{nd} bay from the right, and a makeshift trench has been cut into the insulation which directs water off the roof surface to the lower roof of the Exercise Gym. The concern is that a significant surface area of roof has now been added to the lower roof below, with no increase in roof drain size/ capacity. In heavy rain events the roof drains above the Exercise Gym may not be able to keep up with the volume of water being directed to the drain, causing ponding, and potential structural loading concerns. It would be recommended that this condition be corrected to have its own individual drain.

Solar Panels:

The solar panels installed on the roof appear to be in good condition, but it is important to note the impact they have had on the overall roof system. There are 2 different types of solar panels installed on the roof, the first being flat panels that are slightly pitched at a shallow angle above the roof plane. The second type of solar panels installed are a tube style panel which has gaps between the solar arrays. Each of these types of solar panels have created different conditions under them.

		
Image 1.14: Debris Under Panels Standing water & debris collecting under the solar panels on the North Classroom Wing.	Image 1.15: Tube PV Panels The Tube style PV panels although show a significant amount of vegetation growth under them, there is no standing water observed under them.	Image 1.16: Crushed Insulation Suspected that the weight of the solar panels is depressing the insulation creating a low spot for water to collect.

The flat panel solar panels noted above are installed on top of the existing roof membrane utilizing a ballasted support system. A slip sheet has been applied under any of the bracket supports as to not damage the roof membrane, and then paver pedestals have been installed at the gaps between the panels to weight down the supports as ballasts. The flat panel type solar arrays which make up approximately 50% of the solar arrays on the building appear to allow vegetation, leaves, dirt, and areas of standing water to accumulate under the panels. Given these panels do not allow for any light under them, the surface area under the panels show consistent signs of moisture and potential for ponding. The flat panels also pose a potential concern structurally as it is suspected that the weight of the PV panels over time has depressed the roof insulation, creating low spots for water to collect. In the images attached you can see the presence of moisture under the panels, and the staining of depressed areas of insulation where water puddle staining appears to have occurred.

The second type of PV panels installed on the roof are installed parallel to the roof surface and raised off the membrane approximately 8”. The panel array supports are much smaller and provide less of a surface obstruction on the roof allowing water and debris to freely move under the panels as compared to the flat panels noted above.

Although heightened levels of vegetative growth were observed under this type of panel, these areas were generally seen to be dry. The one noticeable difference with these panels is the tube style array which allows natural light to penetrate the roof surface below the unit allowing the roof to dry out. The weight of this type of PV array did not seem to show as much deflection in the insulation as the flat panel arrays.

Skylights:

On the roof surface the design team observed a significant number of skylights within the roof assembly that provide the benefit of natural light into the building. From a review of the roof plans there appear to be a total of 43+ sky lights on the roof that are all in various states of disrepair. While walking on the roof, condensation was observed to be building up on the inside of the double walled skylight system on multiple skylight fixtures. One area in particular where the condensation was very noticeable was at the

		
Image 1.17: Failing Gasket Seal Seals around the existing skylights were showing signs of cracking and dry rot. A compromised gasket would allow moisture into the building at these locations.	Image 1.18: Growth In Skylight It is suspected that there is some mold growth on the interior face of the double wall skylight. Located above Gymnasium	Image 1.19: Skylight Moisture Condensation was observed on the inside of the interior face of the double wall of the skylight. The presence of moisture is suspected to be a path for moisture into the building.

Exercise Gym. A contributing cause for the condensation building up within the double wall skylight assembly could be the failing of the exterior perimeter gasket seals around the fixture. In review of many of these openings the gasket seals were observed to show visible signs of dry rot, and cracking. When gaskets show these signs of failure it is reasonable to suspect that water will eventually find its way through the seal and into the building envelope.

The other item of concern that was observed with the skylights was that it appears that some type of growth has started to sprout on the interior surface of the outer layer of the double walled skylight. Visible signs were observed at some of the skylights above the Exercise Gym. It would be recommended to further investigate these areas to test for possible mold propagation at these elements.

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Section 2: Existing Building Shell Evaluation

Image 2.1: North Elevation Classroom Wing
The above image is of the North Elevation of the Classroom Wing to the School constructed in 1970. Some slight staining has occurred on the surface of the masonry where water/ drain channels direct water onto the face of the wall. This portion of the building has virtually no masonry control joints or masonry weeps installed restricting thermal expansion & water mitigation within the wall assembly.

Masonry

In the exterior review of the building envelope, the masonry around the building generally appears to be in satisfactory condition, but there are areas around the building envelope that require some attention. Visible signs of mortar deterioration were observed at many different locations around the building with most conditions occurring adjacent to windows, openings, and mechanical unit ventilator grille locations. Both moisture and some vegetative growth/ staining was observed on the masonry materials around the building.

Portions of the building that were constructed as part of the 1970's original school construction, did not show any visible signs of masonry weeps within the wall assembly. Masonry weeps at the bottom of the wall assembly, allowing water that finds its way into the wall cavity a way out without having it leach through the mortar bed. Over time, water that accumulates within that wall cavity will find its way into the building, or to the outside through the mortar joints in the masonry, slowly deteriorating those conditions. The more recent building elevations and additions constructed in 2003 do have masonry weeps installed in the wall assemblies. These areas generally do not show as much visible signs of wear and tear on the mortar joints, but there are some areas to do show visible signs of significant compromise which could be contributing to some of the moisture issues present within the facility.

At the main entrance vestibule and stair tower, there is a 2 ½" story high divider wall that projects above the roof plane by about 10' that shows some significant signs of mortar failure, and presence of moisture.

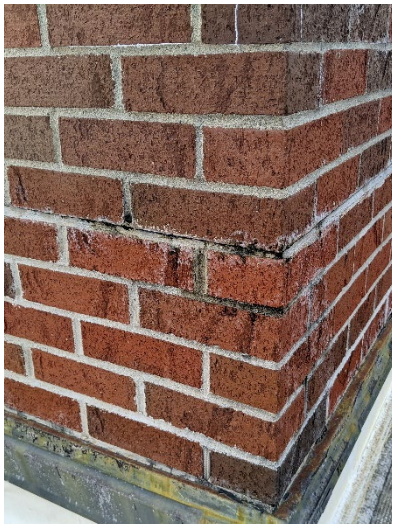


Image 2.2: Failing Mortar Joints
Image taken at the mechanical room chimney stack. No weeps installed within the assembly, and moisture is finding its way out through a joint.

Image 2.3: Efflorescence
Efflorescence was observed at mechanical room chimney stack indicating moisture is present behind the assembly & leaching out through the brick.

Image 2.4: 1970's No Weeps
No masonry weeps were observed in the walls constructed in the 1970's building. Trapped water in the cavity has no way to exit the wall except at mortar joints at the bottom.

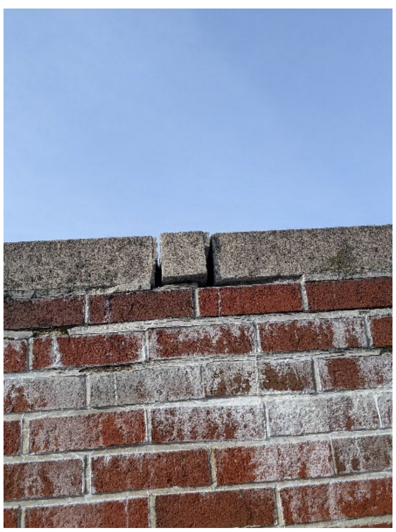


Image 2.5: Failing Mortar Joints
Image taken at the 2.5 story divider wall at the Main Entrance stair. Concrete cap joints have failed allowing moisture into the wall cavity down into the building. Suspected cause of 1st floor issues observed adjacent to this location.

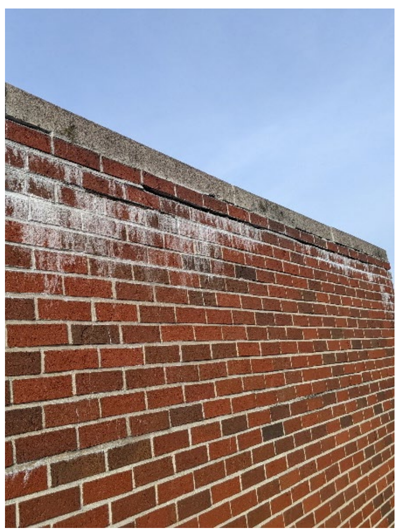


Image 2.6: Efflorescence
Image is of the 2.5 story divider wall at the Main Entrance Stair. Excessive Efflorescence is an indicator that moisture is within the wall assembly, and is evaporating through the brick.

Image 2.7: Main Entrance
The image above shows the divider wall in question referenced in images 2.5 & 2.6.

The concrete masonry cap installed at the top of the wall shows significant signs of compromise with mortar joints that have all been eroded away. Based on the existing construction documents, the 8"

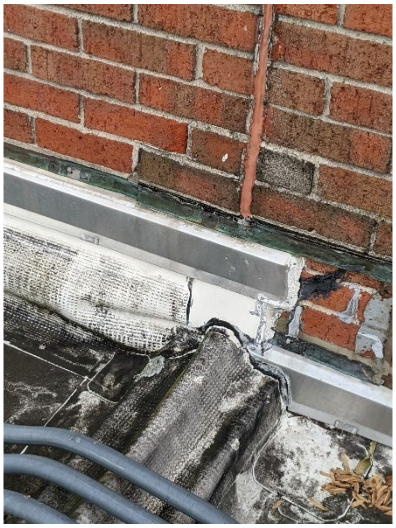


Image 2.8: Failing Control Joints Image taken at the roof to wall transition at the North Classroom Wing & the Band Room Wall. Joint sealant is showing signs of failure and is in need of replacement.	Image 2.9: Failing Control Joints Image is taken at the mechanical room exterior wall on the South Elevation. Sealant joints are failing & show visible signs of dry rot & cracking. Recommended to be replaced.	Image 2.10: Failing Control Joints Image taken at the North Elevation of the Classroom wing. Backer rod is all that is left of this sealant joint. Recommended to be replaced.

CMU block backup to the brick should be grouted solid, but it is suspected that water is finding its way into the building from this location given the visible signs of moisture within the building at the 1st floor level against this wall assembly. With no physical barrier to protect the interior cavity of the wall assembly, these open joints serve as a direct conduit for water to find its way into the building. The significant presence of efflorescence is a supporting indicator that moisture is finding its way into that cavity and evaporating through the brick leaving the salt behind.

It was also observed that there are very few or no masonry control joints installed within the masonry around the building exterior. Portions of the building constructed in 1970 do not have any masonry control joints present which are a contributing factor to the visible cracks present around the building. The existing control joints present around the building are in need of replacement as most show signs of dry rot & deterioration.

Window & Door Assemblies/ Openings

The windows and doors within the facility appear to either be of original vintage to the building or were replaced with the renovations & addition work in 2003. A majority of the window assemblies appear to be of original vintage, especially in the 2-story classroom wing. These assemblies are comprised of single panes of glass in a steel frame. These window assemblies have exceeded their useful life expectancy and need replacement. Some window sills were observed to have negative pitches, directing water back into the window frame assembly allowing water to collect and deteriorate any perimeter window seals that currently remain. Sealant around all wall openings are either non existent or are showing significant signs of deterioration allowing for wind driven rain to infiltrate the wall assembly. Window assemblies replaced during the 2003 renovations and additions appear to be in good condition. These windows are doubled paned insulated glazing units in aluminum frames. Perimeter seals around the windows need replacement as some have begun to fail, one area in particular is by the Main Office.

Other openings were observed penetrating the wall assembly that could also be contributing factors in bringing moisture into the building. Below every typical classroom with a unit ventilator grille assembly, condensation drain lines puncture the building envelope. These penetrations have no form of sealant/ protection from the elements allowing water to saturate the exposed pipe insulation within the wall. The pipe insulation was observed to be wet to the touch, and is acting like a sponge, bringing water & moisture into the building from the outside into the wall cavity.

Image 2.11: Perimeter Seals
Image taken at the North roof level at the glass block openings into the Band Room. Perimeter seals show visible signs of dry rot and window sill flashing slopes back into the glass block assembly.

Image 2.12: Sloped Window Sills
Image is taken at the North Classroom wing showing a negative slope at the window sills. Current installation directs any surface water back into the window assembly deteriorating window seals.

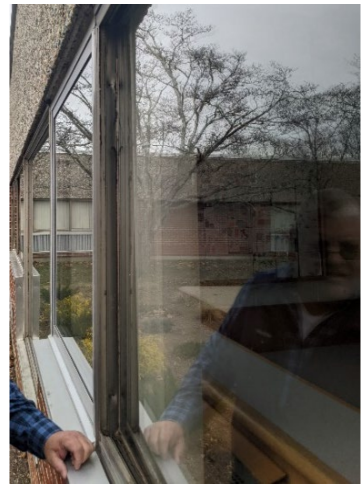


Image 2.13: Broken Window
Image taken at the Library/ Media Center. We found a complete window assembly open and wracked in the frame. A whole hand could enter in the gap created by the damaged window assembly.

Image 2.14: Perimeter Seals
Image taken East Elevation at the Main Office area. Newer windows are installed, but failing perimeter seals provide an opportunity for moisture to enter the building.

Image 2.15: Door Seals
Image is taken at the Exercise Gym door exiting to the South Entrance. Perimeter seals partially installed.

Image 2.16: Wall Penetration
This is a typical example showing exposed pipe insulation that is saturated. Allows moisture to enter the wall cavity with improper seals.

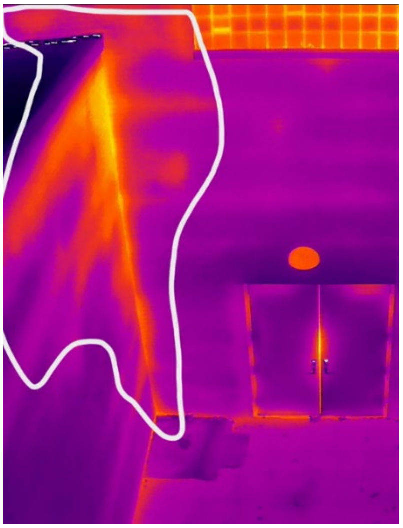
Image 2.17: Northwest Classroom Elevation Thermal Scan
Image taken at the Northwest Corner of the Classroom Wing. Significant heat loss is observed through the window assemblies & header conditions. Overall block & brick wall assembly appears to be performing in a uniform fashion in this area.

Thermal Performance

As part of the building evaluation, a third-party building envelope scan was performed by JJC Drones. Their report/ evaluation is provided at the end of this report for reference. With the building heat being turned up to try and combat the further propagation of mold growth most of the masonry elements have been tempered to a warmer condition showing a more uniform thermal gradient in the wall assembly. Overall, the walls around the entire building appear to be performing in a uniform fashion with excessive heat loss occurring at window surrounds and building geometry transition points.

The wall between the Gymnasium & Exercise Gym, Auditorium, Band Room as well as the Library/ Media Center exterior wall assembly appear to be other areas of concern based on the thermal images provided. All of these areas show significant signs of heat loss through the wall assembly which affects the dew point of the wall assembly, and potentially can be contributing to condensation within the building.

Gymnasium/ Exercise Gym: Based on both the interior and exterior thermal scans conducted, significant heat loss can be seen through the structural steel within the wall assembly. As noted on the roof analysis, the structural steel is completely exposed to the elements on this wall above the roof plane and is a direct conduit for heat loss & condensation. The exterior thermal images within the report show significant heat loss at these structural elements and can primarily be attributed to poor insulation/ thermal isolation of structural steel. As moisture condenses on the colder element, condensation could be building on the steel surface inside the wall assembly and in the building. The warmer zones shown not around the structural may be indicators of moisture present within the wall assembly.



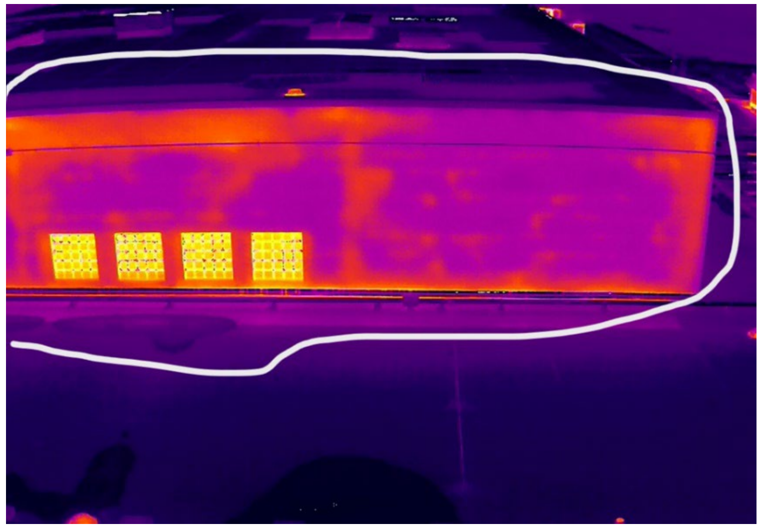


Image 2.18: S.E. Exercise Gym Corner
Image is of the S.E. Exercise Gym intersecting with the Gym wall. Lots of heat loss is observed providing potential condensation within the wall assembly.

Image 2.19: North Band Room Elevation
Image is taken at the North Band Room exterior elevation above the roof plane. General heat loss appears to be present at structural column locations, but spotty thermal readings could indicate the presence of moisture within the wall. Otherwise a more uniform gradation would be present.

Image 2.20: Thermal of Main Entrance Divider Wall
Divider wall shows a thermal scan of an masonry location suspected of infiltrating water into the building.

Image 2.21: Library Exterior Wall Thermal Image
Thermographic image shows excessive heat loss above and below the window assembly which is out of characteristic with adjacent locations. With the temperature variations shown, moisture & condensation could be occurring within the wall cavity & above the ceiling in this area. Further investigation recommended.

Auditorium/ Band Room: The thermal scans of the elevated wall above the 1st floor roof also show significant heat loss at the roof/ wall transition, as well as at window sill transitions. The spotty thermal results within the wall assembly is cause for concern as it may indicate an increased level of moisture present within the wall assembly.

Library/ Media Center: The exterior thermal scans at the window assembly is out of characteristic for the wall type assembly in this area. Heightened levels of heat loss are being observed throughout the window header, as well as the entire wall assembly below the window system. When you compare the interior and exterior thermal scans you notice that the window system and the wall above and below the window are virtually performing similarly which should not be the case. Further investigation within the wall assemblies in this location is recommended to see if condensation & moisture is building up in the wall cavity.

These areas of heat loss make for an inefficient building and are a key indicator that the building envelope is not tight, making it very difficult to regulate temperatures and humidity levels within the building. Every single one of these transmission points is cause for concern because when temperature swings like this are present, and humidity levels either inside or outside the building are high, condensation occurs which can create an environment for mold propagation in concealed spaces within the building.

Exterior Structural Observations

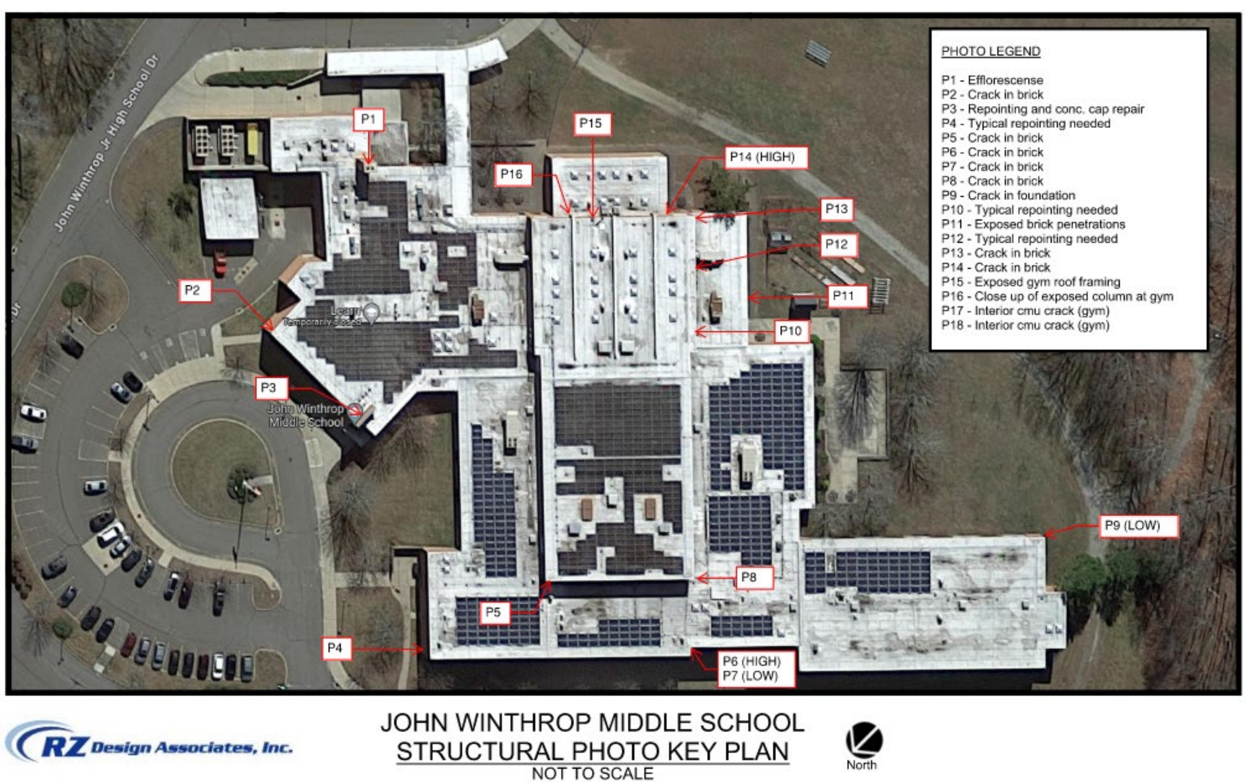


Image 2.22: Structural Image Reference Plan
The above facility plan shows general locations for the following images related to the exterior structural investigation.

The existing structural system based on the structural drawings of the 2003 Additions and Alterations to the original building is roof construction of steel roof deck on prefabricated open web steel joists supported by structural steel beams and columns, except in the gym area, where the roof construction is tectum roof panels on bulb tees supported by structural steel beams and columns. The existing floor construction is concrete slab on steel floor deck supported by structural steel beams and columns. The foundation construction is reinforced concrete slab on grade with reinforced concrete foundation walls on reinforced concrete spread footings. The exterior walls are exterior brick veneer with non-bearing masonry block backup. The exterior masonry block back-up walls typically have a running bond, while the existing masonry block back-up walls around the gymnasium have a stacked bond.

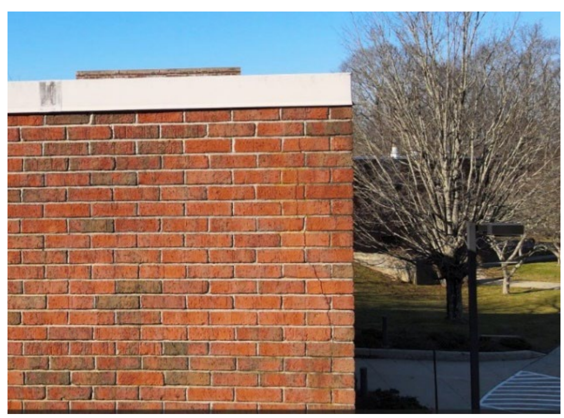
We observed areas of exterior brick, at masonry walls, which projected up above the main roof, showing the presence of efflorescence. We witnessed a vertical crack in the exterior brick, near a wall corner, with cracks through some of the bricks. Cracked bricks will need to be removed and replaced with the new brick toothed in. Cracks were probably due to settlement issues.

We observed deteriorated concrete caps on top of some of the masonry walls, along with areas of masonry walls requiring re-pointing of the mortar joints. There were vertical cracks near wall corners, which have been patched, however, some bricks that had cracks through them were also patched, when those cracked bricks should have been removed and replaced with new bricks.

One exterior wall corner had the existing concrete foundation wall cracked with some spalled concrete. This foundation corner needs to be repaired, removing any spalled concrete until solid concrete is encountered, then forming, and patching the corner. There was a wall with a missing brick, along with a brick with a large core hole, both of which will require replacement with new bricks to match existing, as required. The cracks in the foundation wall corner were probably due to settlement issues.

The construction of the support framing of the gymnasium roof is unique: the tectum roof deck on bulb-tees is supported by continuous rows of structural steel beams, which are hung from 3 rows of continuous structural steel beams above the roof. The 3 rows of continuous structural steel support beams are supported at each end by structural steel wide flange columns. The 3 rows of beams, exposed to the outside, are covered with a fabric material; however, the structural steel columns are not covered and are exposed to the outside elements. Though the columns presently don't appear to show signs of deterioration from the elements, we are concerned that if left unprotected, the columns will deteriorate.

Following photos show the conditions observed along the exterior building:

	
Image 2.23: P1- Efflorescence Efflorescence along the face of masonry wall.	Image 2.24: P2 – Crack in Brick Vertical crack near the wall corner with cracks through the brick. The cracked bricks need to be replaced, and re-pointing of mortar joints will be required.

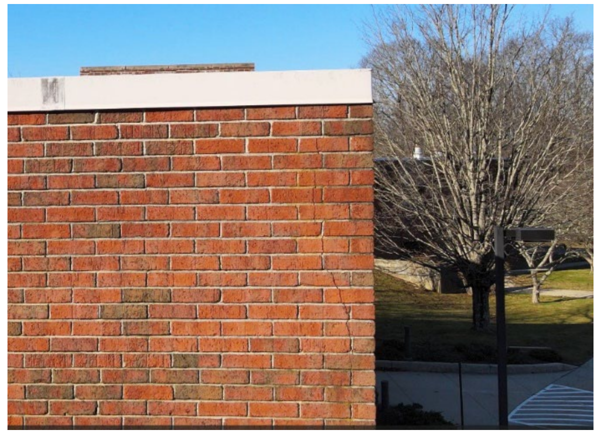
	
Image 2.25: P3- Repointing and Concrete Cap Repointing of mortar joints at existing brick wall and repair of deteriorated concrete cap is required.	Image 2.26: P4 – Repointing of Mortar Joints Re-pointing of mortar joints at existing brick wall.

	
Image 2.27: P5- Repointing and Concrete Cap Repointing of mortar joints at existing brick wall and repair of deteriorated concrete cap is required.	Image 2.28: P6 – Repointing of Mortar Joints Re-pointing of mortar joints at existing brick wall.

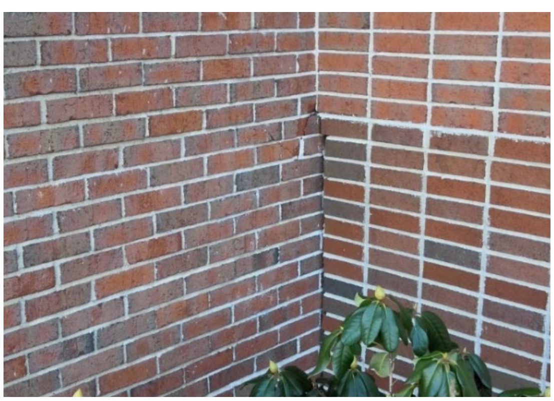
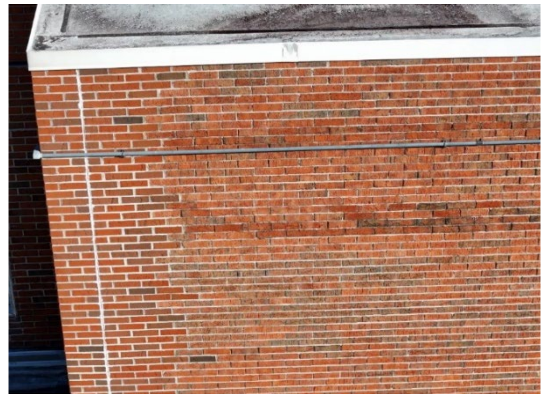


Image 2.29: P7- Repointing and Concrete Bricks that have cracks through them need to be replaced with new brick and cracked mortar joints patched.	Image 2.30: P8 – Repointing of Mortar Joints Some bricks have cracks through them, which were patched. Cracked bricks need to be replaced with new bricks.

	
Image 2.31: P9 – Crack in Foundation Crack at each side of existing concrete foundation wall corner, with some spalling concrete. Walls need repair.	Image 2.32: P10 – Typ. Repointing Needed Existing brick wall needs mortar joints repointed.
	
Image 2.33: P11 – Exposed Brick Penetration Missing brick and brick with cored hole needs to be replaced with new brick.	Image 2.34: P12 – Crack in Brick Existing brick wall needs mortar joints repointed.

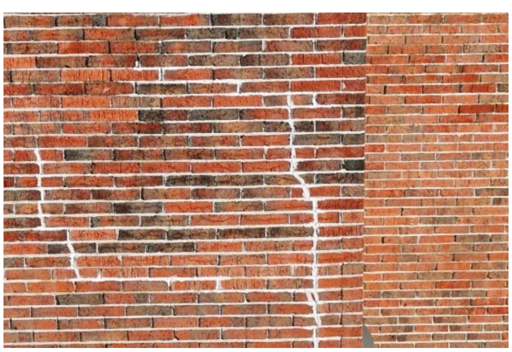



Image 2.35: P13 – Crack in Brick Vertical and horizontal cracks in brick wall were patched. Cracked bricks need to be replaced with new bricks. Existing brick walls need mortar joints re-pointed.	Image 2.36: P14 – Crack in Brick Crack in brick wall need to be replaced with new bricks. Existing brick needs to have mortar joints repointed.

	
Image 2.37: P15 – Exposed Gym Roof Framing Two out of three rows of existing structural steel support beams and columns of the gymnasium roof shown. Beams wrapped with fabric & roof membrane, with columns exposed to the elements. Column protection recommended.	Image 2.38: P16- Exposed Column Close up of existing exposed structural steel column supporting the gymnasium roof framing. Concern that continued exposure to the elements will deteriorate column. Column protection recommended.

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Section 3: Existing Interior Evaluation

Architectural Finish Conditions

Overall the architectural finishes within the building are in very good condition and have been maintained well over the years. Upon initial walkthrough and inspection of the school, no major 'finish' related concerns jumped out immediately. With further review of areas of noted concern by the school administration, some spots of moisture related damage could be observed.

In some rooms within the building, staining can be seen on the acoustic ceiling tiles caused by persistent moisture above the ceiling. Some of these stains can be attributed to potential condensation build up from the 2 pipe heating and cooling lines that are not properly insulated. This will be further explored in the MEP portion of this report. Although a majority of ceiling tiles show no signs of moisture damage from the underside, the heightened presence of mold spores present in the ceiling plenum is a significant concern, and consideration should be given to replacing the ceiling tiles throughout the building.

Other potential sources of dripping water above the ceiling can correspond to leaks observed within the roof drain system as noted in the H2M Architects + Engineers report provided by the insurance company. During that evaluation, a sample drain line was scoped which indicated excessive corrosion within the roof drain pipes, and minor hole within the pipe. It appears that has section of pipe has been replaced, and no further issues were observed since. The moisture present from this leak caused some minor damage to the gypsum wallboard wall in the corridor which has been painted over multiple times.

In the Facilities Assessment report provided by DRA back in 2022, visual signs of moisture were observed in the brick masonry outside of the Nurses Office, as well as staining of the carpet. The Nurses Office appears to be directly adjacent to the Band Room, where multiple concerns of water infiltration

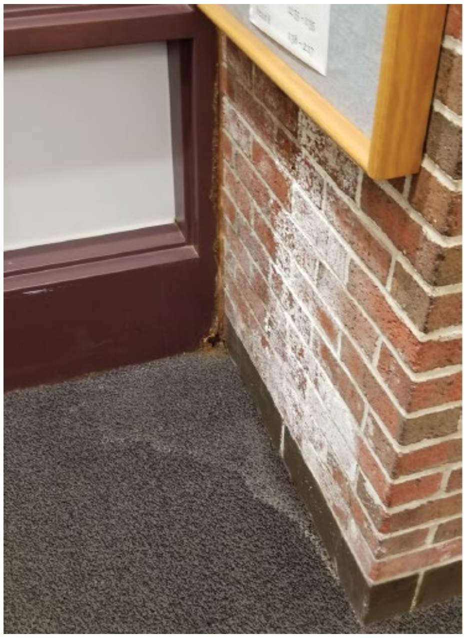


Image 3.1:Nurse Efflorescence Image is provided from the DRA Facilities Assessment Report. Efflorescence in this location confirms that moisture is getting into the building from above the roof plane and traveling through the wall cavity into the building.	Image 3.2: Hole in Existing Roof Drain Line Image above is referenced from the H2M Investigation Report. The section of pipe has since been replaced, but can directly correlate to moisture issues observed within the adjacent corridor location.

were cited above. Based on the conditions observed at the roof level, it is reasonable to suspect that moisture is finding its way down the Band Room wall assembly and causing efflorescence on the brick and damaging the carpet.

Damage to any architectural finishes as it relates to moisture or water within the building appears to be minimal, and only affecting localized areas at this point in time. As the building continues to age, already compromised systems will continue to deteriorate, and conditions will worsen.

Interior Structural Observations

The existing structural steel system that we were able to observe, especially in the gymnasium, where the roof construction is tectum roof panels on bulb-tees supported by structural steel beams and columns, appears in satisfactory condition. The interior concrete floor slab, whether a slab on grade or elevated slab on steel floor deck over the lower floor area, appear in satisfactory condition. The existing masonry non-bearing partition block walls throughout the building have a running bond system, except around the gymnasium, where the masonry non-bearing block walls, which include the backup masonry block walls with exterior brick veneer, along exterior walls, have a stacked bond system.

The interior masonry non-bearing block walls appear in satisfactory condition, with the exception, in some areas where we observed cracks in some of the masonry block walls in the mortar joints and cracks through the masonry blocks, themselves. These areas will require the mortar joints to be patched and the masonry blocks with cracks through them, to be replaced with new masonry blocks.

We observed two walls of the gymnasium, where the masonry blocks appear to have shifted slightly inward, towards the interior gym side, but believe this was done at installation time, for an unknown reason. The cracks in the mortar joints in these areas should be patched, but the masonry block left as installed. Masonry blocks of the walls around the gymnasium, which have cracks through them, whether vertical or horizontal cracks, should be removed and replaced with new masonry blocks.

Following photos show the conditions observed along the interior of the building:

Image 3.3: P17 – Vertical Cracks in CMU Block
Vertical cracks through mortar joints and masonry blocks of masonry walls in Room 721. Removal of cracked block and patching of mortar joints is required.

Image 3.4: P18 – Vertical Cracks in Corner
Vertical cracks through the inside corner of masonry walls in Room 708 Cafeteria. Patching of vertical mortar joint is required.

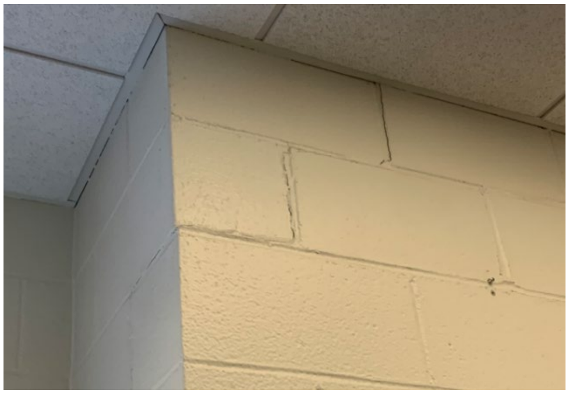
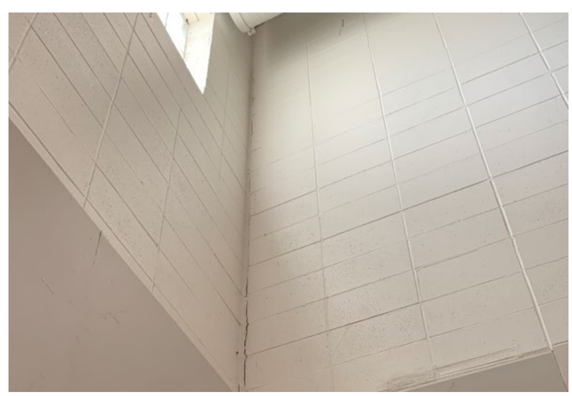


Image 3.5: P19 – Stepped Cracking Stepped cracking in mortar joints in room 510. Patch and repair mortar joints.	Image 3.6: P20 – Vertical & Horizontal Cracks Vertical & Horizontal cracks around inward shifted masonry blocks of Gymnasium room 606. Patch vertical and horizontal mortar joint.
	
Image 3.7: P21 – Stepped Cracking Stepped cracking in mortar joints of masonry block in Gymnasium room 606. Patch vertical and horizontal mortar joints.	Image 3.8: P22 – Stepped Cracking Stepped cracking and vertical cracks in masonry block wall & mortar joints in Gymnasium room 606 near corner of room. Patch mortar and replace any cracked block.
	
Image 3.9: P23 – Horizontal Masonry Cracks Horizontal crack in masonry block along mortar joints and masonry blocks in Gymnasium 606. Patch mortar and replace	Image 3.10: P24 – Vertical Crack Inside Corner Vertical crack at inside corner of masonry block walls of Gymnasium 606. Patch vertical mortar joint.

cracked blocks.	
	
Image 3.11: P25 – Stepped Cracking Stepped cracking in mortar joints of masonry block wall in Gymnasium 606. Patch vertical and horizontal mortar joints.	Image 3.12: P26 – Vertical Crack Inside Corner Vertical cracks through the inside corner of masonry walls in Gymnasium 606. Patching of vertical mortar joint is required.

Section 4: Existing Mechanical Evaluation

Existing HVAC System Description

The existing HVAC systems in the building were installed as part of the 2003 additions and alterations project. Hot water, produced by an oil-fired cast-iron sectional boiler plant, is used to heat the building. Chilled water, produced by a packaged outdoor air-cooled chiller plant, is used as the primary source to cool the building. The hot water and chilled water plants share a common distribution piping system, also known as dual temperature or 2-pipe system. These two pipes, one supply pipe and one return pipe, are only capable of delivering either the heating hot water or the chilled water to the air handling and terminal equipment in the zones and rooms at any given time. Generally, the changeover from heating to cooling is performed once in the spring and the changeover from cooling to heating is performed once in the fall.

HVAC in the cafeteria and classrooms on both the lower and main levels is provided by unit ventilators. The unit ventilators are connected to the dual temperature system and provide heating or cooling to the room served. A few unit ventilators (mostly serving computer classrooms) are also equipped with a separate direct-expansion refrigerant cooling coil piped to a roof mounted condensing unit allowing them to provide cooling independent from the dual temperature piping system. The unit ventilators provide minimum outdoor ventilation to the space and ducted roof mounted fans provide exhaust air from the space. The unit ventilators are also capable of providing “free” economizer cooling when outdoor temperatures are suitable. The excess outdoor air brought into the building through the unit ventilators for economizer cooling is transferred to the cafeteria ceiling plenum and main level corridor ceiling plenum via ductwork where an exhaust fan or gravity roof vents provide exhaust or relief of the air to the outside atmosphere.

HVAC in the Main Office/Guidance/Nurses area and Media Center are provided by 25-ton packaged multi-zone rooftop units (RTU-1 serves the main office/guidance/nurses area and RTU-2 serves the media center). The units are not connected to the dual temperature system but use a direct-expansion refrigerant cooling system integral to the units. The compressors in the rooftop units are staged on and off to cool the air being supplied to the space. The units are ducted to variable air volume (VAV) boxes in the spaces that form separate temperature zones. As the cooling loads change in the zones, the VAV boxes modulate the supply air from the rooftop units to match the load and variable speed drives on the rooftop unit’s supply fans modulate the airflow from the unit to match the zone requirements. The VAV boxes are equipped with hydronic reheat coils, that work in conjunction with perimeter radiant heating equipment, to provide heat to the spaces. The reheat coils are connected to the dual temperature piping system and are only available for use when the dual temperature system is in heating mode.

HVAC in the Gymnasium is provided by two single-zone VAV rooftop air handling units (RT-AHU-1 and RT-AHU-2). HVAC in the exercise gym is provided by two constant volume air handling units (AHU-4 and AHU-4a) mounted at the roof structure exposed in the space. Each air handling unit has a pair of exhaust fans associated with it; one fan to remove the minimum ventilation air and one fan to remove the economizer air. HVAC in the boys and girls locker rooms adjacent to the gymnasium are provided by two constant volume rooftop heat-recovery air handling units (HR-RTU-1 and HR-RTU-2). These units include a supply fan, an exhaust fan and an air-to-air heat exchanger that allows the unit to run at 100% outside air / 100% exhaust air while recovering heat from the exhaust air and transferring it to the incoming outside air to reduce heating and cooling load requirements. The units also include a bypass damper that directs the outside air around the heat exchanger during economizer operation. All these units are connected to the dual temperature water system.

HVAC in the Auditorium is provided by a single-zone VAV air handling unit (AHU-5) located in the fan room at the south end of the auditorium. HVAC in the lower level and main level common areas and corridors in the classroom wing is provided by a multi-zone VAV air handling unit (AHU-1). HVAC in the band/choral room is provided by a single-zone VAV air handling unit (AHU-2). Both AHU-1 and AHU-2 are located in the fan room at the north end of the auditorium. Similar to the office and media center systems, AHU-1 has multiple zones each served with a VAV box with reheat coil and perimeter radiant heat. HVAC in the core (no exterior exposure) industrial arts areas on the lower level is provided by a constant volume air handling unit (AHU-3). All units are connected to the dual temperature water system, and unlike the other HVAC units in the building, utilize a return fan economizer rather than an exhaust fan economizer.

Other systems in the building include roof mounted exhaust fans for toilet rooms and science prep rooms; heating only cabinet unit heaters for entrance vestibules, corridors and stair towers; unit heaters for utility spaces; and a split system air conditioning unit for the MDF room.

Existing HVAC System Evaluation

The HVAC equipment at JWMS generally appears to be in good condition despite being in service for approximately 20 years. The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) publishes a life expectancy chart for HVAC equipment. The chart indicates the median life expectancy in years that a particular type of equipment is expected to have. Life expectancies vary depending on the type of equipment; light commercial equipment such as packaged rooftop equipment and electronic (DDC) temperature controls have a life expectancy of 15-years; commercial equipment such as pumps, unit heaters, VAV boxes, heating cooling coils, exhaust fans and chillers have a life expectancy of 20-years; ductwork and diffusers, grilles and registers has a life expectancy of 30-years; and cast-iron boilers have a life expectancy of 35-years.

While life expectancy information provides a baseline for equipment replacement determinations, the age of the equipment alone is not necessarily a reason for replacement. Other factors such as the need for frequent repairs, visible signs of wear and tear or corrosion, utilization of obsolete refrigerants or technologies and dissatisfaction with equipment performance *(i.e., noise level and comfort)* also need to be considered in replacement decisions. At JWMS, some of these other factors are present and support the idea of equipment replacement:

- The two existing chillers and the existing packaged rooftop units that serve the office and media center utilize R-22 as their refrigerant. The production of R-22 was phased out in 2010 and the remaining supply of the refrigerant is low making any repairs to the refrigerant side of systems containing R-22 very expensive.
- The refrigeration compressors in the media center rooftop unit were replaced within the last couple years, so it is fair to anticipate similar repairs may be required to the other unit in the near future.
- Multiple motors have been replaced in the rooftop exhaust fans. At least a dozen roof exhaust fans are not currently in operation as their motors have failed and need to be replaced. The existing fans are belt-driven and most of them could be replaced with modern direct-drive fans with high-efficiency EC motors which can significantly reduce operating and maintenance costs.
- Unit ventilators in classrooms tend to be a source of noise. As such, unit ventilators are no longer typically used in school construction as they do not meet current acoustical standards.
- During COVID, like many schools, modifications were made at JWMS to run the HVAC systems continuously at very high outdoor air ventilation rates. While the actual effects of this running the HVAC equipment in this mode of operation is hard to quantify, it would have certainly made the systems operate longer and harder than they otherwise would have under normal conditions which could have a negative effect on the service life of the equipment.

Dual Temperature (2-pipe) systems are typically more economical to install than a 4-pipe system *(where the cooling and heating distribution piping systems are independent from each other)*. Thermal comfort can become an issue with dual temperature systems particularly in the swing seasons *(spring and fall)* when outdoor temperatures can create a simultaneous demand for heating and cooling, but the system is only capable of operating in either the heating or cooling mode.

Humidity control is also difficult to achieve with dual temperature systems, particularly with unit ventilators

	
Image 4.1: Rust & Condensation on Diffuser Rust formation from condensation on the diffuser and stained ceiling tiles from condensation on top of the diffuser. This occurs at a couple locations within the Main Office Suite	Image 4.2:Condensation on Diffuser Boot Condensation staining on the uninsulated diffuser boot and top of the diffuser.

due to the large fraction of outdoor air that must be introduced through the unit ventilator to meet the high ventilation requirements of classrooms. Only through careful manipulation of the face and bypass dampers, modulation of fan speed, directing all the outside air though the cooling coil and maintaining the cooling coil well below the dewpoint of the outside air is there a chance of keeping humidity levels in check. As designed, according to the original building drawings and control system shop drawings, the existing unit ventilators had a high level of control, including occupancy sensor demand controlled ventilation, but the controls are not sophisticated enough as they only look at the interior and exterior dry-bulb temperatures and do not take humidity levels in the air into account and only modulate the chilled water 2-way valve to maintain the space cooling temperature setpoint. Modulating chilled water flow through the coil can result in coil temperatures that are not cold enough to dehumidify the outside air and can lead to higher space humidity levels.

Similarly, the air handling equipment and package rooftop equipment were also designed with a high level of control, which included demand-controlled ventilation *(DCV)* reset of the outdoor air damper minimum position based return CO2 levels and return air relative humidity measurement to limit the space relative humidity from rising above 65% during economizer operation. However, the controls again only look at space temperature and not space humidity levels and modulate the 2-way chilled water valve *(air handling units)* or stage the dx-cooling coil *(packaged rooftop units)* to maintain the temperature setpoint. As stated above, modulating chilled water flow through the coil can result in coil temperatures that are not cold enough to dehumidify the outside air and can lead to higher space humidity levels. Staging dx-cooling can also result in the outdoor ventilation air passing through the coil without being conditioned at times when the space temperature is satisfied, and the compressors are staged off.

Infiltration is unconditioned outside air that directly enters the conditioned building spaces. Infiltration can also be a source of humidity. As noted in the architectural portion of this report, the existing windows in a significant portion of the building are old and very leaky and are a source of infiltration. Exhaust fans, such as the prep room exhaust fans that run 24/7, can induce infiltration of outside air even when the building is unoccupied. Unit ventilators with manually open outside air dampers are also a potential source of infiltration. On September 7, 2023 when Enviromed took a measurements of the very high humidity levels in the building, they also measured the outdoor temperature and relative humidity of 91.7°F and 51.2%. While that outside air is very hot, it is not very humid, but it does contain a significant amount of moisture. If that air were to infiltrate into the building and be allowed to cool down to the building space temperature, that retained moisture in the air would certainly cause the relative humidity in the building to rise.

High space relative humidity can also lead to condensation on cold surfaces in the space. Dewpoint is the temperature at which moisture condenses out of the air. If the surface temperature of an object is below the dewpoint of the surrounding air *(i.e., glass of ice water on a humid summer day)* condensation will form. Take again, for example, September 7, 2023, when Enviromed took measurements of the space temperatures and relative humidities. On that day, the library was measured to have a space temperature of 69.5°F and a space relative humidity of 79.1% and the main office was measured to have a space temperature of 71.2°F and a space relative humidity of 72.8%, which corresponds to a dewpoint temperature of 62.7°F and 62.0%, respectively. Air conditioning systems typically supply air at or below 60°F, which is below the dewpoint of the air in the space which would allow condensation to occur on the exposed surfaces of the supply diffusers and the uninsulated sheet metal boots that connect the insulated flexible ductwork to the diffuser. This condensation can lead to water stains on the ceiling tiles and formation of rust on the steel surfaces of the diffuser at imperfections in the protective paint coating.

The air handling systems *(i.e., unit ventilators, air handling units and rooftop units)* at JWMS are only capable of providing dehumidification by the process of passing the mix of the space return air and ventilation air over the equipment cooling coils. Unfortunately, the amount of dehumidification provided by the cooling coils is limited as the systems are controlled to only satisfy the space setpoint temperature setpoint. To thoroughly dehumidify, the air would have to be subcooled to remove the required amount of moisture and reheated to maintain the space temperature setpoint. One way to explain this is to consider how a residential basement dehumidifier works. A basement dehumidifier, has a cooling coil that sub-cools the basement air that the dehumidifier fan blows across it to wring out the moisture in the air. Before the air is discharged back to the space, the dehumidifier reheats the air by another coil to prevent the space from overcooling. Comparing this albeit simple analogy to the cooling systems at JWMS, missing in cooling systems at JWMS is the ability to reheat air supplied to the spaces to prevent them from overcooling at times when there is a need for dehumidification.

HVAC System Controls Evaluation

	
Image 4.3:Failed Actuator Image shows a failed and disconnected unit ventilator valve actuator in one of the typical classrooms.	Image 4.4:Failed VAV Actuator Image shows a failed and disconnected VAV box damper actuator above the ceiling.

The HVAC systems in the building are controlled by a Building Management System *(BMS)*. The current BMS is a mix of the original Honeywell XL system controllers and newer Honeywell Spyder system controllers that have been used to gradually replace some of the old XL controllers. Both the old and new system controllers are integrated onto the current generation Niagara JACE headend controller and utilize the most current Niagara 4 operating system. According to ESC *(Environmental Services Corporation)*, the BMS vendor that services the school, most of the control system still has the old Honeywell XL controllers aside from approximately 25% of the unit ventilators and a handful of VAV boxes that have had the controllers replaced. ESC has indicated that the Honeywell XL controllers are obsolete and recommends that they should be replaced. In addition to the controllers, many of the terminal input and output devices such as sensors, control valves, control dampers, and valve/damper actuators have also failed or are in need of replacement as they fall out of calibration over time. According to school facilities staff, much of the school has been under manual control due to the failed components and limitations of the obsolete components. While the preceding “Existing HVAC Systems Evaluation” section of the report described how the control system was designed to work, and discussed the limitations that the system has with controlling humidity, one can only imagine how the system is operating under manual control. The lack of a fully functional automatic temperature control system for the HVAC systems is very likely a contributing factor to the high relative humidity levels in the building.

During our facility walk-though on November 10, 2023, we observed at least one failed unit ventilator valve actuator and VAV damper actuator *(See attached photos)*.

Dual Temperature Water System Pipe Insulation Evaluation

The dual temperature piping system in the building delivers chilled water during the cooling season and hot water in the heating season. According to the 2003 renovations drawings, the dual temperature water system has a design chilled water supply temperature of 45°F and a design heating water supply temperature of 180°F, which is pretty typical. The dual temperature piping is insulated with fiberglass pipe insulation with a factory-applied vapor-retarder all-service jacket (ASJ). Fittings, for the most part, appear to be pre-molded fiberglass with a PVC cover. Although a comprehensive survey of the existing insulation thicknesses was not performed, insulation thicknesses of ¾” was measured on the runouts to perimeter HVAC equipment, 1.5” thickness on mains less than 3” intermediate mains and 2” thickness on mains larger than 4”. The insulation thickness on the mains appears appropriate, but the ¾” insulation is marginal as a minimum of 1” thick insulation is recommended for condensation control.

Image 4.5: Improper Insulated Pipe
Elbow fitting cover not sealed to ASJ with vapor seal tape or mastic; tee insulation not sufficiently sealed with mastic; stapes penetrate ASJ vapor barrier; breach in end seal *(likely occurred post-insulation and repaired with duct tape).*

Image 4.6: Improper Insulated Pipe
Elbow fitting cover not sealed to ASJ with vapor seal tape or mastic. Tee insulation not sufficiently sealed with mastic. Ball valve stems and handles not thermally isolated *(tape insulation not effective at preventing condensation, aluminum roasting pans used to collect condensation).*

The goal of pipe insulation on heating pipes is to reduce the flow of heat from the piping fluid to the surrounding environment, thus maintaining design water temperatures and system efficiency. As the hot water heating system temperature is above ambient conditions, moisture migration is not a concern as any moisture will migrate out of the insulation to the dry surrounding environment. For chilled water systems, the goal of the insulation is not only to prevent the flow of heat from the surrounding environment to the below-ambient temperature piping fluid, but to prevent moisture migration from the typically warm/moist surrounding environment into the pipe insulation where it can condense.

Condensation in a chilled water insulation system can negatively impact energy efficiency (as water degrades the thermal efficiency of the insulation), propagate mold growth and catalyze corrosion of the pipe material under the insulation. While it is possible for condensation to occur on the outside of the pipe insulation, should the insulation thickness not be sufficient to keep the surface temperature of the insulation above the dewpoint of the surrounding air, condensation typically occurs inside the pipe insulation at the point where the insulation temperature is at or below the dewpoint of the surrounding air.

	
Image 4.7: Improper Insulated Pipe Elbow fitting cover not sealed sufficiently to ASJ with vapor seal tape or mastic. Ball valve stem and handle are thermally isolated but breach in vapor barrier where stem penetrates pipe insulation. Heavily rusted pipe hanger due to condensation as insulation is compressed at hanger.	Image 4.8: Improper Insulation & Rust Pipe insulation is not continuous through pipe guide. Rust on pipe guide due to condensation on the bare pipe. Aluminum roasting pans are used to collect condensation above ceiling.
	
Image 4.9: Improper Insulation The above images shows an improper attempt to insulate over the pipe guide. Vapor seal is insufficient and insulation is not continuous through the pipe guide.	Image 4.10: Lack of High-Density Insulation The lack of high density insulation insert has led to compression of insulation at the pipe saddle and a breach of the vapor barrier jacket.

To reduce the potential of condensation inside the pipe insulation, straight sections of pipe insulation are manufactured with a vapor-barrier jacket and a longitudinal self-sealing closure lap that secures the jacket together. Insulation manufacturers also offer pre-molded fiberglass fitting insulation with PVC covers for a complete system. Beyond this, the success of a chilled water insulation system lies with the installing contractor's capabilities to provide a vapor-tight system.

To aid the installing contractor, insulation manufacturer's as well as NAIMA *(North American Insulation Manufacturers Association)* provide guidelines for chilled water piping systems insulation. The guidelines include descriptive details on how to properly insulate and vapor seal straight sections of pipe, fittings, couplings, elbows, tee and valves and how to properly support insulated pipe to control condensation.

Image 4.11: Typ. Unit Ventilator Piping
Image above shows pipe insulation in the unit ventilator compartments for typical classroom locations. Tight space, combined with multiple valves and fittings poses a challenge to properly insulate and install.

The attached photos of the dual temperature piping system insulation at JWMS are examples of improper insulation installation as the vapor barrier is not continuous allowing moisture in the surrounding air to penetrate the insulation and condense to support mold growth.

The presence of stachybotrys mold on some sections of the pipe insulation, as identified by the September 1, 2023, and October 4, 2023, Enviromed reports, is an indicator that portions of the insulation were very wet for an extended period of time; likely throughout the entire cooling season. At the time of our site visit on November 10, 2023, all the insulation in the building was dry since the system had already been changed to heating. If there is one positive to this poorly insulated piping system, those same breaches in the vapor barrier that led to condensation in the insulation during the cooling season in the first place are also instrumental in allowing the moisture to escape and dry out the insulation during the heating season.

There appears to be multiple factors related to the HVAC equipment and systems that have contributed to high moisture levels and mold growth in the building, or portions thereof, this past summer.

The HVAC systems at JWMS are inherently not capable of dehumidifying the building as they can only respond to controlling temperature in the building; any form of humidity control is consequential to the cooling of the building. Infiltration of outdoor air from a leaky building envelope coupled with a wetter than average summer also were key contributors to the high building humidity levels. The lack of a fully operating automatic temperature control system also likely played a major role.

The presence of this high humidity level in the building coupled with poor installation of the insulation of the dual temperature water system, caused sustained condensation to occur in the fiberglass pipe insulation and appears to be the root cause of the mold on the pipe insulation.

TAB 2.2 Remediation Recommendations

Overview

Based on our observations of the existing conditions, it is our opinion that there are several contributing factors rather than a singular root cause of the mold propagation within the school. The following recommendations are in our professional opinion items that are contributing factors to the infiltration of water/ moisture into the building that can create an environment contusive for the growth of mold. The goal behind each of these recommendations is to provide a solution to creating a weather tight building envelope. Each of the recommendations below includes a summary of recommended work to be performed but will require a deeper level of investigation and documentation in order for corrective action to be taken.

Corrective Work Overview

1) Repair/ Replace Roof System
2) Window/ Door Replacement
3) MEP System & Control Upgrade
4) Masonry Repointing
5) Masonry Repairs/ Replacement

Section 1: Existing Roof Evaluation

EPDM Roof System Recommendations:

In review of the existing conditions noted in section 2.1 that relates to the roof system, our initial recommendation would be the installation of a new roof system in order to provide a proper watertight envelope for the building. The significant concerns observed with standing water, and potential ponding of water under the solar panels is of heightened concern as hydrostatic pressure of standing water on roofing membranes will eventually find its way into the building. Proper wall flashing should also be performed at the roof and wall geometries to ensure moisture is not allowed to pond on the roof for extended periods of time ad be directed to the roof drains and backup systems. In addition to the complete re-roofing of the school, proper tapered insulation, and cover boards should be installed to adequately support the additional weight of the solar panels being installed on the roof. In doing so, some locations may require that the building parapets be built up to facilitate proper insulation thickness, and slopes to roof drains.

Existing roof drains should also be further evaluated or replaced. Based on the scoping of some of the existing roof drain lines provided by the insurance companies inspection, significant corrosion within the pipe was observed. The replacement of roof drain primary lines and the inclusion of overflow drains is recommended to minimize concerns of moisture entering the building.

Section 2: Existing Building Shell Evaluation

Masonry Repairs:

In review of the exterior masonry, it is recommended that a repointing of the masonry around the building be performed. Replacing the failed/ failing mortar joints of the brick would help reduce moisture from

entering the building envelope within the wall assembly. While this effort is being conducted, it would be recommended that the installation of drainage weeps be installed around the entire building envelope to allow water that finds its way into the wall cavity a way to escape.
To prevent further expansion cracks from propagating through the brick, the installation of masonry control joints is recommended. This will give some movement within the wall and prevent cracks from forming.

Exterior Structure

The existing structural steel framing system appears in satisfactory condition. As mentioned previously: we recommend that the existing structural steel wide flange columns supporting the 3 rows of main structural steel support beams of the Gymnasium's roof framing, be covered for protection against outside elements, to reduce possible deterioration of the structural steel columns, due to the exposure to the outside elements. This work is recommended to occur with any roof replacement project.

The cracking of the exterior brick walls and interior masonry block walls, along with the cracking of a corner of the existing concrete foundation walls, in our opinion, is due to initial settlement issues and insufficient amount of vertical control joints in the masonry walls; hence, the patching of the cracked mortar joints and replacement of cracked brick and masonry block is recommended. Repointing of the masonry around the building would allow for the installation of masonry weeps to be installed, and an opportunity to correct cracks within the building façade.

Concrete foundation walls should be evaluated and repaired at damaged areas, priority focusing on the missing section of foundation at the Media Center exterior wall where the brick veneer which shows significant cracking due to a lack of appropriate structural supported. Concrete foundation corners with cracks present should be patched, as well as any locations with spalling concrete.

Window & Door Assemblies/ Openings

The windows and doors throughout the school are in urgent need of repairs/ replacements. In an effort to properly tighten up the building envelope, existing doors and window assemblies should be replaced with a double insulated glazing unit, with a thermally broken window frame system. In the process of the replacement, proper window flashing should be installed around the perimeter of the opening to direct any water away from the openings and provide an airtight seal.

Sealing around any opening within the wall assembly is strongly encouraged in an effort to provide a water and airtight building envelope. All existing and new through wall penetrations should have seals installed around them. The sealing up of the building's exterior will minimize the transmission of moisture and air from the exterior into the building. The replacement of the windows will require testing for asbestos and PCBs in the caulking. If the caulk contains hazardous material, specifically PCBs, the adjacent masonry will need to be tested and replaced. We recommend that a Hazmat consultant be retained for the testing and any final recommendations.

Thermal Performance

As thermal performance of a building is an important component to maintaining a proper climate-controlled interior, it would be recommended that additional insulation be added to the existing exterior wall assemblies to meet current Energy Code requirements. Based on the existing documentation provided, the 1970's original school construction does not include insulation within its wall cavity. Based on the current International Energy Conservation Code, for a CMU block & brick cavity wall assembly, walls should have a continuous insulation value of R-11.4. This could be achieved by furring out the interior face of the exterior wall assemblies and installing spray foam insulation, improving the energy efficiency of the building, as well as providing a tight seal to the building envelope. Although this would be recommended, it is understood that this solution would be more invasive, and therefore would be a lower priority item compared to other deficiencies observed. However, it should be noted that on state funded projects exceeding two million dollars, the project must meet high performance building standards, which will require energy efficiency of the building envelope.

It would also be recommended that any exposed structural steel members be wrapped, to provide a thermal brake from the exterior elements to prevent condensation. This particular issue must be addressed at the Gymnasium/ Exercise Gym above the roof plane. Encasing those exposed columns with continuous rigid insulation, as well as flashing the enclosure into the roof membrane would provide a tighter seal to the building in these areas and minimize thermal loss through the structural elements. This work is recommended to protect the existing structure from further deterioration/ compromise.

Section 3: Existing Interior Evaluation

Architectural Finish Conditions

From an interior architectural finish standpoint, most of the building finishes are in good condition. Only a few areas affected by direct moisture damage show visible signs of compromise. Although visible signs may not be present, we would advise the Town to follow the recommendations of their Environmental Engineer for systems that need to be replaced due to the heightened levels of mold within the building. It is suspected that the acoustic tile ceilings throughout the entire building will require replacement due to extensive mold growth within the ceiling plenum around the pipe insulation and the repair work required above the ceilings. If the Unit Ventilators are replaced with an alternate system, the wall openings will need to be closed and adjacent wall finishes will need to be addressed. It should be noted that if a new HVAC system is to be installed, the selection of the system, ductwork, controls and other components will impact the final finishes in each space.

Interior Structural Observations

Similar to the exterior masonry, some interior masonry block walls show visible signs of cracking. As previously noted, it is believed that this is primarily caused by the settlement of the building. Recommendations for repairs would be to review the walls for control joints and replace any cracked blocks and to patch any existing mortar joints where cracks are present throughout the interior of the building.

Section 4: Existing Mechanical Evaluation

HVAC & Controls

In our opinion, the existing HVAC systems in the building should be replaced. One potential replacement option for the classroom unit ventilators is to decouple the ventilation air from the classroom heating and cooling systems. Packaged rooftop dedicated outside air system (DOAS) units which would contain their own variable capacity refrigeration system that includes a dx-cooling coil and hot gas reheat coil (for dehumidification) and hot water coil for winter heating could be used to deliver space neutral ventilation air to the spaces. The classroom rooftop exhaust fans would be removed and the exhaust would be returned to the DOAS units that would also contain an energy recovery device to exchange heat and moisture between the outside supply air and exhaust air to reduce system capacity and reduce energy consumption. Cooling and swing season heating could be provided by a variable flow refrigerant (VRF) heat pump system that consists of central outdoor heat pumps coupled to multiple indoor fan coils in the classrooms. Hybrid VRF systems are proposed as they limit the amount of refrigerant in the system by using water as the heat transfer medium to the indoor fan coils. Hydronic radiant ceiling heating panels would be provided along the perimeter of the classrooms for cold weather heating.

The packaged rooftop equipment serving the offices and media center, the rooftop air handlers serving the gymnasium and locker rooms, and possibly even all the indoor air handling units could also be replaced with packaged rooftop units that would also contain a variable capacity refrigeration system, heating coil and energy recovery device similar to the DOAS units, except that these units would provide cooling and heating to the spaces and not just space neutral air like the DOAS units. The expansive PV array on the building roof may complicate this approach and would need to be taken into consideration.

New exhaust fans with direct drive high efficiency EC motors would replace those fans that would not be replaced by the DOAS equipment.

Aside from the head-end equipment, installation of a new BMS system throughout the building is also recommended. System to include new unitary controllers, VAV controllers, control valves, control dampers and temperature, pressure, humidity and CO2 sensors.

Assuming the condensation on the dual temperature water system has not corroded the existing piping to the point of it needing to be replaced, the dual temperature water piping system could potentially be reused but only for heating as the chiller plant would no longer be required due to the use of the packaged rooftop and VRF equipment. The existing boilers would remain, but the main distribution pumps would likely be replaced. New insulation would be provided on the piping system, but because the pipes would no longer be used for chilled water, the critical installation of a vapor barrier for chilled water systems would no longer be necessary.