HISTORIC FORT SNELLING

SAINT PAUL, MINNESOTA

VISITOR CENTER BUILDING EVALUATION

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INTRODUCTION

Located at Historic Fort Snelling, St. Paul, Minnesota the Fort Snelling Visitor Center was built in 1980. Designed in the Brutalist style, the building is a subterranean two-story structure constructed primarily of cast-in-place concrete and is sited in the bluffs above the Mississippi river. The structure has been in continued use since 1980 and has not received major updates or renovations. The building has experienced various types of moisture issues over the years, culminating recently in a mold-related employee complaint. It is our opinion that the current building environment does not pose a hazard to the average visitor. However the extent of the visible mold and the chance of larger un-seen mold colonies could pose a health risk to more sensitive "full-time" occupants. This adds great urgency to the strategic question of the building's future.

Collaborative Design Group was retained by Minnesota Historical Society to perform a building evaluation of the Visitor Center. Previous evaluations, including the 2003 Master Plan, were based primarily on building space and configuration needs for programming and staff functions.
The purpose of this evaluation was to review and document existing conditions at the Visitor Center to compare two options: invest in a major reconstruction of the existing Visitors Center or move the operations into the vacant Buildings 17 and 18. Architectural, Structural, and Heating, Ventilation and Air Conditioning (HVAC) systems were evaluated in this building review.

EXECUTIVE SUMMARY

Methodology

The building evaluation took place in the summer and fall of 2004. The evaluation was conducted through document review, site visits, and dialogue with staff and maintenance personnel. Site visits were conducted in varying weather conditions, including days of heavy rain, to gather a more accurate portrait of how the building currently functions. The intent of this summary is to provide an overview of the following report. The report must be reviewed in its entirety for a complete understanding of our conclusions and recommendations.

Data

The structure appears to be in average condition, exhibiting some problems. These include cracks in the concrete walls and slabs, which are evident throughout the interior and exterior of the building. Some cracks appear large and significant, but pose no immediate threat of structural instability or failure. There is evidence of movement in some of the retaining wall panels. Staining and efflorescence present throughout the structure give evidence of chronic moisture infiltration.

Other issues range from minor seasonal flooding to a constant stream of water flowing into the elevator shaft. In addition, occasional drainage system back-ups result in lower level flooding. These issues, in part, fostered moisture infiltration into the HVAC system. This HVAC system is over 24 years old and has reached the end of its expected useful life. Design considerations from 25 years ago do not reflect today's concerns regarding indoor air quality. To provide a HVAC system that meets today's indoor air quality design standards would require the replacement of the entire HVAC system an option not financially cost effective.

The end result is that the building as a whole has relative high humidity and shows significant water damage in many areas. There is no clear evidence whether the ongoing water infiltration is due to static pressure in the bluff, the location of the building on an underground spring, the fact that the building roof is the lowest point on the site, or more likely a combination of issues.

Conclusion

The type and scope of damage present in the structure did not occur within the last five years, rather the Visitor Center at Fort Snelling has been in an accelerated state of decline since it was put into operation in 1980. While a subterranean building has its place, it has proved impractical and costly in this application. Submerging the building into porous bluffs littered with springs with an ineffective drainage plan has relegated this structure to the role of catch basin for water.

The results of this building assessment have a direct and significant impact on the 2003 Master Plan which identified a substantial expansion of the current Visitor Center to meet the programmatic needs of the Fort while developing Buildings 17 and 18 for a hotel and conference center. The original building space review indicated that the only way the Visitors Center could meet future programming needs was through construction of a substantial addition. However, due to the mechanical and structural issues outlined in this current report, the previous conclusions reached as to the cost effectiveness for continued use of the building are changed.

Investing substantial amounts of money to replace the HVAC system, remove the soil from on top of and around the structure, and redesign the drainage system would leave the Historical Society with a building that is wholly inadequate to meet their needs in terms of size and function. In these circumstances it is apparent that adding to the structure (as originally proposed) would be throwing "good money after bad." If rehabilitated, the underground structure will begin its accelerated decline again, and MHS would be faced with this same discussion in 15 years.

In light of the recent building issues it is the recommendation of Collaborative Design Group that the Owner not allocate any future investment towards long- term occupation of the current Visitor Center. Furthermore, we recommend the rehabilitation of Buildings 17 and 18 for the new Visitor Center. Recommendations for remedial steps appear at the end of this report.

BUILDING CONDITION REVIEW

OVERVIEW

The Visitor Center exhibits a number of problems both physically and programmatically. The programmatic issues include poor visibility of the entrance to the site, way finding, lack of views to the surrounding site, lack of visitor amenities, and poor pedestrian circulation to the rest of the fort. These issues are covered in the Fort Snelling Master Plan report of 2003. This report deals with the building's physical concerns.

METHODOLOGY

A number of trips were made to the site by the project team. Walkthroughs of the building interior and exterior were conducted to visually verify the condition of the building and related system elements. One walkthrough occurred shortly after a significant rain event. The building's construction drawings were also reviewed.

Observations are documented through narrative within this report, and through plans and photographs located in the Appendix. Types of documentation include:

- Mapping and documenting locations of water infiltration. This included investigation and documentation of exterior walls with specific interest in staining and efflorescence, water infiltration, and material failure. Material failure includes cracking, spalling, and crushing of materials, as well as wall deformation.
- Documenting interior walls, with specific interest in staining and efflorescence, water infiltration, and material failure. Again, material failure includes cracking, spalling, and crushing of materials, as well as wall deformation.
- Document interior finishes, with specific interest in water damage and apparent mold and other damage or wear.
- Investigate and document auditorium with specific interest in staining and efflorescence, water infiltration, and material failure.
- Investigate and document gallery with specific interest in staining and efflorescence, water infiltration, and material failure.
- Investigate and document skylights with intent of locating apparent seal failures, staining, and rusting.

SITE OBSERVATIONS

- Minor cracks are present throughout the structure in cast in place concrete walls, flat slabs and waffle slabs.
- Staining from previous water seepage is evident at most cracks locations.
- Cracks are evident at the underside of the large cantilevered slabs above both entrances of the concourse.
- Some spalling of the concrete wall surfaces is occurring at construction joints and at joints between panels.
- The sealant in many joints in the wall panels is deteriorated.

- Movement of the top of some retaining walls is evident. The top of the retaining wall near the southeast corner of the building has moved approximately 2 ½" relative to the adjacent building wall.
- The cantilever beams at the concourse entrances are not entirely visible for observation.
- The cracks in the cantilever slabs are not in locations indicative of structural failure.
- The building roof appears to be at a low spot compared to the surrounding area. The parking lot to the north is higher, thereby draining water toward the building.
- The adjacent building to the west has a roof scupper that discharges water directly toward the building.
- No current or impending structural failure of any portion of the building was observed during this site visit.

REVIEW OF STRUCTURAL DRAWINGS

- The West Segment Foundation Plan shows the installation of a 6" diameter drain tile system both below the slab and around the perimeter of the foundation.
- The floor slab elevation is 789'—9 ½"".
- The invert of the drain tile near the elevator pit is 789'-8".
- The elevator pit elevation is 785'-9 ½"".
- The plan shows the drain tile exiting the west foundation area to the north, between grids D & E, but does not indicate where the drain tile terminates.
- The East Segment Foundation Plan shows drain tile around the perimeter only. The floor slab elevation is 802'-11 ½".
- The roof plans indicate that the top of the structural slab slopes. The west portion of roof slopes to the southwest, the east portion of roof slopes to the northeast, and the concourse roof slopes toward drains.
- The intent appears to be that any water on the roof would drain off of the sloped roof and down the exterior walls.
- Water stops are shown at the construction joint intersections of the slabs and walls.

DATA ANALYSIS

This section of the report will discuss issues discovered during the investigation. These include:

1. Assessing the building structure and envelope using information from the above mapping and documentation combined with visual inspections to determine structural integrity of the building and envelope.
2. Performing an assessment of the site and related drainage issues including investigating and documenting the drainage system for the following elements:
   A. Roof (scuppers, ponding, animal infestation, flashing, and membrane condition)
   B. Landscape (soil grading, animal infestation, flashing)
   C. Sidewalks and other hardscape (drains, heaving, material failure)

The structure appears to be in average condition. Cracks in the concrete walls, flat slabs and waffle slabs are evident throughout the interior and exterior of the building. Most cracks are minor, and considered normal. A few cracks appear large and significant, but pose no threat of structural instability or failure.

Cracking in concrete structural elements occurs when excessive stresses build up in a localized area. These stresses can be created by shrinkage, temperature change, stiff elements providing restraint to normal building movements, or overloading. The cracking throughout the structure is likely caused by shrinkage, temperature change or restraint. Cracks due to overloading would occur in different locations than what are evident. The cracks would be less noticeable if water were not dripping from them!

The building was constructed underground, with adjacent portions of land sloping toward the building. This undesirable slope is directing a large amount of water toward the building. In addition, the building roof to the west has a scupper directing water directly at the west wall of the building.

According to the drawings, the roof structure slopes to the northeast and southwest. Any rainwater falling on these surfaces would drain in those directions, run down the foundation walls, and accumulate at the ground floor levels. The structural roof on the concourse area is indicated to slope towards drains. One drain was observed, but was located higher that the soil elevation. It is unknown if any drains are effective to remove water from the concourse roof.

A 6” diameter drain tile was installed beneath the floor slab on the west segment of the building, and around the entire perimeter of both the east and west segments of the building. All drain tiles appear to be connected at the low point, and remain a 6” diameter pipe. It is unclear where the drain pipe discharges. It is unlikely that a 6” diameter pipe has sufficient capacity to remove all of the water around the base of the building. Blockage in any portion of the drain tile is also possible.

Personnel from Historic Fort Snelling Visitor Center report that water flowing from natural springs in the area is what periodically fills the elevator pit. While this may be true, the same effect would be evident simply from heavy rains. The elevation of the drain tile is roughly four feet above the elevator pit slab, which would not drain this area. With water being directed from the parking lot, adjacent building to the west, and the water from the roof, it is easy to understand why the elevator pit would often have standing water and why the sump pump operates continually to move the water out.

Inadequate drainage from behind the retaining walls is likely what is causing the noticeable movements at the top of the walls. Saturated soils are heavier than free draining soils, and will exert higher pressures on the walls.

CONCLUSIONS

The visible signs of water damage and evidence of mold in the building are symptoms of a larger problem. Furthermore, some of moisture infiltration observed indicates that the water repelling system (drainage, sealants, glazing, etc…), designed to prevent water from penetrating the structure, has failed. According to studies done by the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) there are four commonly identified sources of moisture infiltration in buildings:

1. Liquid water from rain, melting snow, etc… or piping leaks.
2. Liquid and vapor from the soil adjoining a building.
3. Moisture built into the materials of construction (exposure to elements prior to installation).
4. Water vapor (humidity) from outside air and from activities and processes in the building.

It is apparent that the Visitor Center has been subjected to at least three of the four sources of moisture infiltration listed above for some time. While these water issues occasionally affect building foundations and basements, the fact that this whole structure is below grade compounds the problem. Attempting to mitigate the sources of moisture is an extremely large and complicated task that may not prevent future infiltration.

MECHANICAL CONDITION REVIEW

This portion of the report addresses HVAC issues, and provides guidance to improve HVAC systems with respect to the building air quality, and to minimize the opportunity for mold growth and distribution within the HVAC system.

OVERVIEW

It is imperative that a subterranean building have a properly designed and working system. 2004 testing of the HVAC system revealed the presence of mold in drip pans and mechanical units. The HVAC system requirements to maintain a healthy environment include effective distribution of adequate ventilation air into the breathing zone; control of airborne contaminates; maintenance of acceptable temperature and relative humidity. The Visitors Center has a number of deficiencies with respect to managing these air quality issues:

- The visitor center's HVAC system is comprised of equipment that is over 20 years old. The equipment is reaching its expected useful life, and there is general degradation of equipment.
- Based on the most recent balancing report (2000) The HVAC systems do not provide the original design intent airflow.
- Control components are not operating properly thus preventing the system to operate as intended.
- The air handling units, in general are not designed to allow proper internal casing, drain pan, or coil cleaning.
- The basic HVAC system design and control strategies do not provide for an environment that meets today's established standards for environmental quality.

To provide a HVAC system that meets today's indoor air quality design standards would require the replacement of the vast majority of the equipment, ductwork and controls that distribute conditioned air to the occupied spaces.

While it is not possible, in our opinion to provide this required environment with the current HVAC system, there are steps that could be taken to minimize the further degradation of the HVAC system, and minimize the environment that breeds mold within the existing system. Recommendations for improvements are organized into short term plans (implemented within 6 months), long term plans (implemented within a year), and ongoing maintenance plans:

AIR HANDLING SYSTEMS

In general, the buildings HVAC system can be a site for the growth of molds and other microorganisms. During periods of high outdoor humidity levels (dew points at 60 degree F or greater), the conditioned supply ductwork's relative humidity will increase to 70% RH or greater, possibly up to 90% RH. This moist environment in the ductwork is an ideal environment for growth of mold, particularly if the duct has a surface layer of dust/dirt (a food source for the microorganisms).

The most common sites for growth of microorganisms include the air handling unit and sites immediately downstream of the unit where the cooling coil generates moisture. Unfortunately, the air handling units in this building are very limited in access to air handling unit components. With the exception of the largest unit S-4, the units themselves are not made for easy maintenance, or for easily replacing the existing internal lining with new closed cell insulation. With these units, and the coil components so closely packed, coil cleaning becomes difficult, if not impossible. Debris becomes trapped between coil fins during the cleaning process, increasing fan static, reducing heat transfer rates, still without a clean coil.

This building is unique in that such a large part of the building is underground with relatively small solar heat gains. With small heat gains in the space the air handling unit cooling coils satisfy the loads before the cooling coil can "wring out" the moisture in the air, thus leaving the occupants with a cooler, but more humid space. This type of environment, particularly in hot humid weather, can promote the propagation of mold. Coupled with low air flow, (or no air flow in areas such as the auditorium back corridor, or artifact storage room), the potential for mold growth becomes greater, as evidenced by the PEER Engineering August 5, 2004 report.

HVAC systems, when properly designed for maintaining relative humidity (RH) levels, are capable of maintaining required space temperatures and removing humidity, both in the spaces and in the ducts. In some cases additional measures and/or means of dehumidification other than mechanical cooling may be required (desiccant cooling). In addition new HVAC equipment is designed with maintenance in mind, thus allowing operators the ability to clean systems on a regular basis, an important component to good air quality. The existing units do not meet these criteria. Without significant changes to the entire HVAC system, improvements will only be modest, at best.

DUCT CLEANING

The same HVAC system that distributes conditioned air throughout a building can also distribute dust and other pollutants. Dirt and dust accumulation on the ductwork, specifically the conditioned supply air ductwork may lead to contamination of the air supply.

While there is agreement that maintenance precautions must be taken to prevent dirt and dust accumulation in the ductwork, there is less agreement about what should be cleaned, or what the long term effectiveness of duct cleaning is. Research is still being conducted on the efficacy and potential unintended exposure to building occupants from various cleaning techniques, including worker safety associated with the cleaning/treatment process.

With that in mind, and understanding that the presence of dust/dirt in the ductwork does not necessarily indicate a microbial problem, the best course of action would be first to determine if specific areas of the ductwork are contaminated (such as ductwork with water damage, where debris in the duct restricts air flow, or duct discharging from supply diffusers show signs of dust/dirt or contamination). Additional spore sample tests may be required in these areas to determine if mold is a concern.

Where problems exist, clean-up and repair work should be undertaken. Where work is undertaken, cleaning methodology must be such that it protects worker and occupant safety.

BUILDING PRESSURIZATION

During the hot humid months of summer if the building is under negative pressure relative to outdoors, the high latent outdoor moisture can be drawn into the building through the building envelope. As this moisture migrates into the building, it condenses and is deposited onto wallboards and other building materials of the building envelope. The presence of moisture on the building material could create a potential for mold growth. The problem is exasperated by poor ventilation rates in the affected space.

Balancing tests conducted in 2000 indicate that a number of the rooms are significantly short of air. Outdoor air quantities are unknown as are the pressure relationships between the building and outdoors. There are no active airflow monitors. Maintaining a balanced airflow is critical to maintaining proper pressure relationships.

In addition, there is a problem with the buildings relief air system. Air is leaking into the building through these relief louvers, particularly the louvers over the office area corridor. The relief louvers over the entry doors have been modified due to building renovations. These modifications have hampered the ability of the louvers to function properly. These louvers which are introducing untempered air into the building have detrimental effects on comfort, and air quality.

Finally, it was observed that the Auditorium air handling unit S-1 is not properly delivering air to the space. It appears a combination of a dirty outdoor air louver, in addition to a common outdoor air duct connection with nearby unit S-1 is preventing outdoor air/ return air from entering into the unit, thus “starving” the unit, and reducing total airflows.

DEHUMIDIFICATION

The American Society of Heating Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) recommends indoor summer indoor temperatures be maintained between 72-80 degree F with a relative humidity between 30% and 60% RH.

Space relative humidity in excess of 60% can potentially promote the growth of mold, bacteria, pollen, fungi in the occupied space. Because the building is below ground, there is less sensible cooling than what would be found in an above ground building. This is due to reduced solar gains (less fenestration), and less heat transfer through the building envelope. Consequently, with a low sensible load in the space, the cooling coil satisfies space temperatures before it “wrings out” the moisture. Thus the space relative humidity rises, potentially above 60%.
Negative pressure relationships between the building and outdoors, low ventilation rates, infiltration through the relief louvers may also contribute to this problem.

Adding reheat coils to the air handling system has been used as a strategy for improving temperature and RH space conditions. By sub-cooling and the reheating the system has the opportunity to dehumidify and provide satisfactory space temperatures. However, that strategy may not be practical in this building due to limitations in available space, due to limitations in the heating system infrastructure, and due to the high electrical loads if electric heat were to be considered. The building has added electric reheat coils to assist in improving conditions in the gift shop and exhibit area, but the Owner has indicated the coils have not properly controlled temperature and humidity in these areas.

As a longer term solution, reheat may benefit the Owner by providing more precise temperature and humidity control, however that option would need further study.

SPECIFIC SPACE ISSUES

Entry Level in the Hallway Behind the Auditorium

The PEER Engineering Report dated August 5, 2004 identified this area this area as having a high level spore count relative to the exterior control sample. While no reason for this high level was identified, it was noted that low air circulation and moisture damaged carpet were potential causes.

With respect to the HVAC system, there in fact is no air circulation in this area.
There does not appear to be a practical solution to conditioning this space through an existing air handling unit due to physical constraints, and current deficiencies in the unit's ability to deliver design air flow. However, this is not an occupied space, and is not required to receive any ventilation. As such, in order to reduce the space RH levels, it is recommended that portable dehumidifiers be installed to condition this space.

Costume Storage Room

The PEER Engineering Report dated August 5, 2004 identified this area as having a high overall particle density and background level spore count. While no reason for this high level was identified, it should be noted that this room does not appear to have air circulation. However, this is not an occupied space, and is not required to receive any ventilation. As such, in order to reduce the space RH levels, it is recommended that portable dehumidifiers be installed to condition this space.

Mechanical Rooms

The insulation on the chilled water piping in the mechanical rooms and where piping passes through walls shows signs of mold growth. Some chilled water piping is missing insulation. Other piping which shows mold on the insulation might be due to poor vapor barriers, or insulation is missing where the piping penetrates the walls. Condensation on these un-insulated pipes is visible.

The existing, un-insulated piping and valve components within and outside of the mechanical room should be reinsulated.

CONCLUSIONS

In order to provide the Visitors Center with a quality HVAC system that maintains proper environmental conditions that minimize air quality problems, new HVAC systems are required. There are a number of systems and control strategies that can be designed to accommodate these requirements. New control strategies, and components should be incorporated to monitor and maintain space temperatures, humidity levels, and ventilation airflow rates. It is also important to incorporate new design practices that accommodate maintenance of the HVAC systems and to do so while minimizing energy use. New designs would include access panels in the ductwork and HVAC equipment, eliminate the use of lined supply ductwork, provide air handling units with drain pan assemblies and provide high efficiency filters to name a few strategies.

The modifications identified in this reports summary are recommended for improving existing conditions. However, they are modest in nature, as it appears only major modifications or replacement of existing systems will provide the type of environment desired by MHS.

Further study is required to determine the extent of duct cleaning/insulation removal that may be required in the supply ductwork. Further testing for the presence of mold spores downstream of the HVAC units are recommended. If any ductwork shows signs of mold, water damage, and high amounts of dirt/dust or obstructions in the ductwork, cleaning or removal of the insulation should be considered.

Maintenance is a critical part of maintaining proper indoor air quality. Systems should be periodically re-commissioned to verify proper operating performance. Cleaning of the filters and as much as practical, cleaning air handling units, the ductwork, and air intakes should be a regular part of the building operator's maintenance program. A specific program for Indoor Air Quality (IAQ) building maintenance has been developed by the US Environmental Protection Agency. The Indoor Air Quality Building Education and Assessment Model (I-BEAM) is a downloadable program designed to be used by building professionals and others interested in indoor air quality in commercial buildings. One important component of this program is a Housekeeping Program which highlights specific IAQ maintenance tasks along with recommended frequency for the tasks. This program can be found at: **http://www.epa.gov/iaq/largebldgs/ibeam_page.htm**

RECOMMENDATIONS

For this report the Fort Snelling Visitor Center was evaluated on a building performance, structural, and construction perspective and is strongly influenced by recent events. Previous evaluations, including the 2003 Master Plan, were based on building programming and function. These reviews indicated that, were the building functionally sound, it could be adapted to meet future programming needs with a substantial addition. However, due to the functional issues outlined in this report, even if the additional spaces required to meet the programming needs of the Owner were constructed, the underlying problems which led to the need for this report would still need to be addressed. As a result, the previous conclusions reached as to the feasibility and cost effectiveness for continued use of the building are changed.

The results of this building assessment have a direct and significant impact on the 2003 Master Plan. The 2003 Master Plan had identified a substantial expansion of the current visitor center to meet the programmatic needs of the Fort while developing buildings 17 and 18 for a hotel and conference center. Understanding the volatility of developing a hotel on the Fort, the planning team also developed an alternative plan that identified building 17 and 18 as a site for the visitor center and called for the demolition of the current visitor center.

In light of the recent building issues it is the opinion of Collaborative Design Group that the Owner not allocate any future investment towards continued occupation of the current visitor center. Furthermore, we recommend the rehabilitation of buildings 17 and 18 for the new visitor center.

As stated earlier, the type and scope of damage present in the structure did not occur within the last five years, rather the Visitor Center at Fort Snelling has been in an accelerated state of decline since it was put into operation in 1980. Buildings are designed to move water through systems that direct it away from the building. In this case, the porous bluffs littered with springs, and the ineffective drainage plan, have relegated this structure to the role of catch basin for water.

Investing substantial amounts of money to replace the HVAC system, remove the soil from on top of and around the structure, and redesign the drainage system would leave the Historical Society with a building that is wholly inadequate to meet their needs in terms of size and function. In these circumstances it is apparent that adding to the structure (as originally proposed) would be throwing “good money after bad.” If rehabilitated, the underground structure will begin its accelerated decline again, and MHS would be faced with this same discussion in 15 years.

The following recommendations were developed to limit and slow the development of the problems while a long range plan for a future visitor center is finalized. They are categorized into Short Term, which should be implemented within two years, and long-term recommendations in the event that political and financial circumstances dictate extended use of the building. The short term recommendations are not a permanent fix, nor are they designed to “solve” the problem. These recommendations are designed to help the water draining system to work more efficiently. The following short term recommendations are currently being implemented:

Monitoring

- Contract with a testing company to conduct periodic air quality testing. The frequency and type of tests should be determined by the testing company and MHS staff.
- Contract with testing agency to test carpet samples and develop proper abatement plan for carpet and acoustic tiles.

Removing

- Remove the lining of air handling unit S-4, and replace with closed cell insulation (S-4 was identified in PEER Engineering's August 5, 2004 report with mold spores in the interior casing lining adjacent to the cooling coil.) Insulation should be cleanable, closed cell foam such as IMCOA, or equivalent
- Replace duct liner that is or becomes damaged in the cleaning process, or has friable material, mold or fungus growth. The insulation shall be well coated with Foster 40-20 (white antifungal coating material).
- Replace the existing filters with clean 40% efficient pleated filters. Clean all outdoor air intake louvers.
- Remove carpet from hallway behind auditorium.
- Remove carpet in specific high problem areas on concourse level such as Library and open office area adjacent to stair "A".
- Remove and replace all ceiling tiles showing signs of moisture related damage and repair leaks (to be performed by qualified contractor).

Clean

- Clean the lined ductwork within the outdoor intake ducts. It is recommended that the ductwork shall be cleaned per the National Air Duct Cleaners Association (NADCA) standards, and that the work be performed by a certified member of NADCA. Clean the ductwork with HEPA vacuuming equipment.
- Lined ductwork downstream of all 5 air handling units were recently removed immediately downstream of the supply units (approximately 15 feet). It was observed that the ductwork appears to have remnants of duct lining attached to the ductwork at various spots. This remaining insulation downstream of all 5 air handling units should be removed, and this portion of ductwork properly cleaned. These metal duct systems shall be cleaned using mechanical cleaning methods that extract contaminants from within duct systems using mechanical agitation to dislodge debris, and a continuously operated HEPA vacuum device. Clean per NADCA standards by a certified member of NADCA.
- Clean air handling unit S-4's internal components including the heating coil, cooling coil and drain pan. Clean coils and drain pans according to NADCA 1992. Cleaning of coils may require agitation with compressed air; fan blades may require wiping with a soft brush to remove adhered dust. Comb and straighten fins.

Short Term Recommendations 0-2 years

Notify

- Persons with known sensitivities to moisture related air quality issues should be relocated.

Monitor

- Contract with a testing company to conduct periodic air quality testing. The frequency and type of tests should be determined by the testing company and MHS staff.
- Contract with testing agency to test carpet samples and develop proper abatement plan for carpet and acoustic tiles.

Remove

- Remove the lining of air handling unit S-4, and replace with closed cell insulation (S-4 was identified in PEER Engineering's August 5, 2004 report with mold spores in the interior casing lining adjacent to the cooling coil.) Insulation should be cleanable, closed cell foam such as IMCOA, or equivalent
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- Replace the existing filters with clean 40% efficient pleated filters. Clean all outdoor air intake louvers.
- Remove carpet from hallway behind auditorium.
- Remove carpet in specific high problem areas on concourse level such as Library and open office area adjacent to stair "A".
- Remove and replace all ceiling tiles showing signs of moisture related damage and repair leaks (to be performed by qualified contractor).

New

- Provide de-humidifiers in the costume storage room and the hallway behind the auditorium, both areas which have been noted in a recent report as having high spore sample counts, and which currently are not ventilated. Price reflects commercial grade dehumidifiers that are directly connected to the plumbing system.

Clean

- Clean the lined ductwork within the outdoor intake ducts. It is recommended that the ductwork shall be cleaned per the National Air Duct Cleaners Association (NADCA) standards, and that the work be performed by a certified member of NADCA. Clean the ductwork with HEPA vacuuming equipment.
- Lined ductwork downstream of all 5 air handling units were recently removed immediately downstream of the supply units (approximately 15 feet). It was observed that the ductwork appears to have remnants of duct lining attached to the ductwork at various spots. This remaining insulation downstream of all 5 air handling units should be removed, and this portion of ductwork properly cleaned. These metal duct systems shall be cleaned using mechanical cleaning methods that extract contaminants from within duct systems using mechanical agitation to dislodge debris, and a continuously operated HEPA vacuum device. Clean per NADCA standards by a certified member of NADCA.
- Clean air handling unit S-4's internal components including the heating coil, cooling coil and drain pan. Clean coils and drain pans according to NADCA 1992. Cleaning of coils may require agitation with compressed air; fan blades may require wiping with a soft brush to remove adhered dust. Comb and straighten fins.

Maintenance

- Clean the lined ductwork within the outdoor intake ducts; clean outdoor air louvers. The cleaning procedure should meet NADCA standards.
- As much as practical, and on a regular basis, visually inspect all 5 air handling unit coils, drain pans, and internal housing. Check for bacterial growth. Check for proper operation of the drain pans. Provide the services of a NADCA certified cleaner should it be warranted.
- On a regular schedule, check the outdoor air, return air, supply air ductwork for dirt, dampness, mold, signs of insects or rodents or deterioration. Provide the services of a NADCA certified duct cleaner should it be warranted.
- Replace Air Handling Unit filters.

Long-term Plans if necessary

Remove/replace ($85,000)

- Re-balance existing HVAC units' to original design intent conditions. Re-sheave, replace motors as necessary to restore airflow to existing conditions.

New ($453,000)

- Modify the outdoor air ductwork configuration serving S-1 and S-2. Isolate the outdoor air stream serving the two units to allow S-1from overpowering unit S-2.
- Increase threshold height and/or divert water from the exterior doorway of stair "A". Reseal door frame (can be performed by MHS staff).
- Re-commission controls to maintain a building with positive space pressure relative to outdoors. This re-commissioning process would include verifying that all control components operate per the original design intent. The process would also include minor modifications to control components and re-calibration of control components. The re-commissioning process also should include upgrading existing relief louvers in the building to allow proper travel and operation of relief dampers. This may require replacement of existing controllers should the re-commissioning process reveal deficiencies.
- Add chilled water piping insulation in the mechanical rooms, where insulation is missing, to eliminate surface condensation. Include insulated valve box covers for all valves as part of the insulation process. Repair insulation where there is a break in the chilled water insulation.

Excavate and upgrade ($1.5Million)

- Hand excavate roof, properly insulate roof and slope roof to drainage, and install waterproof membrane (to be performed by qualified contractor).
- Leave roof exposed
- Re-grade soil around perimeter of building to slope away from the structure (to be performed by qualified contractor).
- If practical, incorporate the use of reheat utilizing available hot water or install electric reheat coils to provide for proper temperature and humidity control for each thermal zone.

Maintenance ($20,000)

- Clean the lined ductwork within the outdoor intake ducts; clean outdoor air louvers. The cleaning procedure should meet NADCA standards.
- As much as practical, and on a regular basis, visually inspect all 5 air handling unit coils, drain pans, and internal housing. Check for bacterial growth. Check for proper operation of the drain pans. Provide the services of a NADCA certified cleaner should it be warranted.
- On a regular schedule, check the outdoor air, return air, supply air ductwork for dirt, dampness, mold, signs of insects or rodents or deterioration. Provide the services of a NADCA certified duct cleaner should it be warranted.
- Replace Air Handling Unit filters.

* Other useful IAQ maintenance procedures, and suggested maintenance schedules can be found using the US EPA's Indoor Air Quality "I-BEAM" program found at: ***http://www.epa.gov/iaq/largebldgs/ibeam_page.htm***