MICHIGAN STATE CAPITOL

Existing Conditions Assessment & Engineering Systems Recommendations

For:

MICHIGAN STATE CAPITOL
LANSING, MICHIGAN

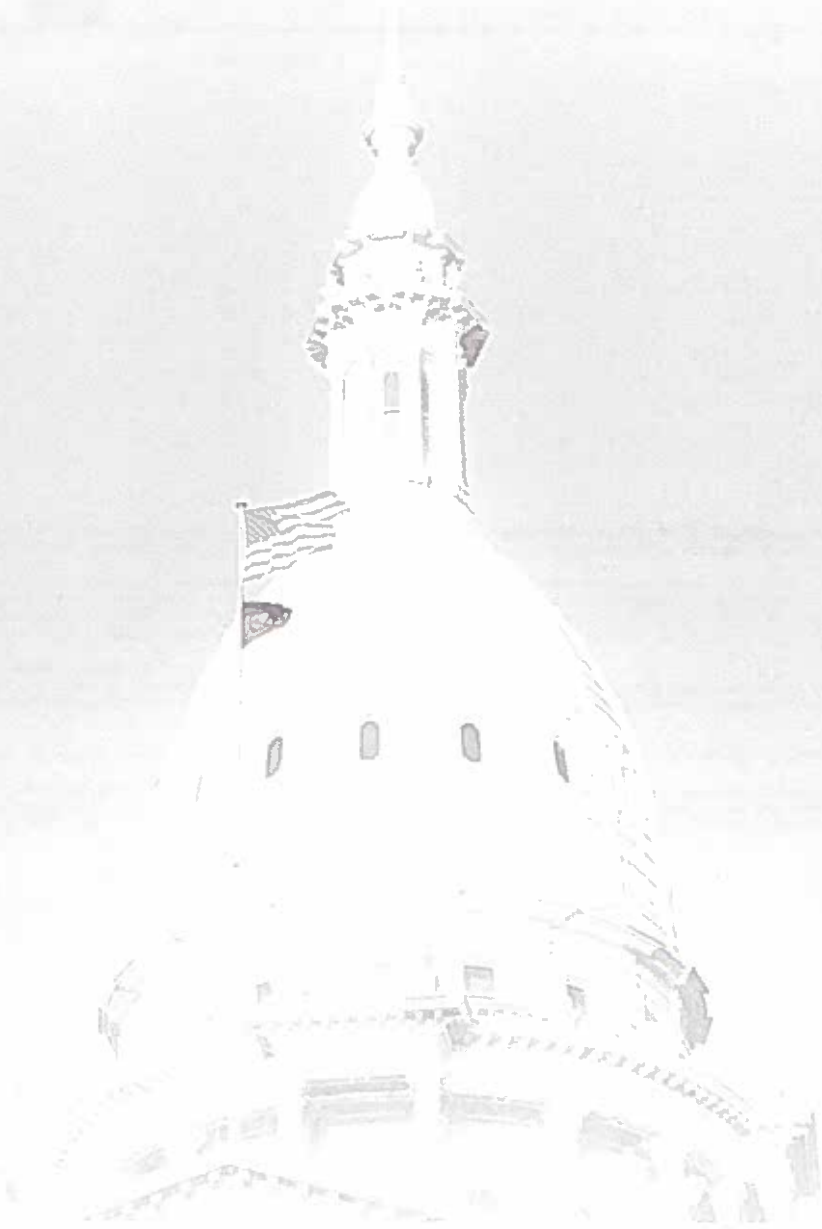
Michigan State Capitol Commission
Michigan Capitol Building

Prepared for:

CHRISTMAN
SINCE 1964

Submittal Date:
May 12, 2016

LORING
CONSULTING ENGINEERS



May 12, 2016

Mr. Gary Randall
Chair, Michigan State Capitol Commission
State Capitol, Room H-70
Lansing, Michigan 48909

Re: Existing Conditions Assessment & Engineering Systems Recommendations
Michigan State Capitol, Lansing, Michigan

Dear Mr. Randall:

On behalf of Loring Consulting Engineers, Inc. (LORING) and our sub-consultants, we are pleased to submit to the Michigan State Capitol Commission and to The Christman Company our findings and recommendations related to our assessment of the mechanical, electrical, plumbing and fire protection systems (MEP & FP) within the Michigan State Capitol Building. Our study includes all building systems; HVAC, plumbing, temperature controls, building automation, fire suppression, power, distribution, lighting and lighting controls, life safety, building envelope, and accounts for preservation of historic fabric, artifacts and furnishings housed within this National Historic Landmark.

As conservators of historic structures across the country, LORING & our consultants value the importance of maintaining these treasured structures – buildings that welcome our governments, its employees, users, and visitors each day.

The Michigan State Capitol's last major restoration occurred between the time period of 1986 and 1992. The earliest portion of this restoration project is now 30 years old. Our team's investigation has revealed that many of the MEP & FP systems are old & tired. Many of these systems, despite ongoing maintenance, no longer perform properly. Portions of the MEP & FP systems serving this Capitol Building do not currently provide the level of redundancy & reliability expected, and do not function as intended or needed for its users and its guests.

LORING and our consultants have included recommendations that are respectful of the Capitol's historic significance, serve to improve the energy efficiency of the building, improve the reliability of the systems infrastructure serving the building, protect the structure and its contents, enhance the life safety of the Capitol occupants, while providing environmentally responsible solutions. We recommend implementing these enhancements in ways to minimize the impact to the historical character of the building, its architecture, and its historic artifacts. As important as it is to protect the Capitol Building, doing so is no more important than protecting its occupants. Advancements in life safety technologies, and updates to building codes over the last 30 years continue to enhance the safety of our buildings. These opportunities should be considered as enhancements for the Capitol as well.

There is no better example of a historic structure more revered than the Michigan State Capitol. We thank the Michigan State Capitol Commission and The Christman Company for entrusting our team with the task of recommending the path forward for this most remarkable building. We encourage each of you to review our assessment and recommendations carefully, and provide Christman with your questions, comments, & feedback.

Sincerely yours,

LORING CONSULTING ENGINEERS, Inc.

J. Michael Galway, PE, LEED AP, CPD
Principal

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Michigan State Capitol
Introduction & Executive Summary
May 12, 2016

0.0 Introduction

The Michigan State Capitol, designed by Elijah E. Myers and dedicated on January 1, 1879; is undoubtedly Michigan's most widely recognized building. As a National Historic Landmark, it is a symbol of the state itself, and is recognized for its architectural and artistic importance. It is celebrated as one of the nation's most historically significant and beautiful buildings.
Loring Consulting Engineers, Inc. (LORING) and our sub-consultants are honored to have been selected by the Michigan State Capitol Commission to provide Mechanical, Electrical and Plumbing (MEP) & Fire Suppression Engineering Design Services to evaluate and analyze the condition of your Capitol, with the following goals:

- Perform an existing conditions survey and document building MEP/FP systems, including interior lighting and lighting controls
- Provide an analysis and assessment of existing conditions findings
- Develop recommendations for treatment
- Prioritize recommended treatment
- Develop a phased implementation plan for recommended treatments

LORING and our team of expert professionals has been assembled, with each firm providing specific expertise in landmark buildings in historic settings as well as significant experience related to rotunda and atria designs. LORING and our team members have an acute understanding of environmental effects of a massive masonry building with center rotunda and metal-framed drum, deep appreciation for preservation of historic finishes and historic artifacts. We thank all of our team members for their amazing expertise and their contributions to this analysis and recommendation effort:

- LORING Consulting Engineers – Mechanical, Electrical, Plumbing Systems
- AON – Life Safety, Fire Suppression and Fire Alarm Systems
- Gary Steffy Lighting Design – Interior Lighting and Lighting Controls
- Watson & Henry Associates – Building Envelope and Environmental Comportment
- Wendy Jessup & Associates - Historic Artifacts
- Building Conservation Associated – Historic Plaster and Decorative Paint Finishes

LORING also thanks our friends and associates in their numerous roles within the State Capitol system - the Michigan State Capitol Commission, the state employees working at the State Capitol, the Christman Company, Hopkins Burns Design Studio, and others. We thank you all for the passion, commitment, and your untiring efforts to ensure that we collected the data necessary to assemble and produce the best recommendation report possible. The team synergy is "*second-to-none*," LORING and its consultants were warmly welcomed, and we look forward to participating as part of the Capitol team for many years to come.

The initial phase of this project included surveys of the Capitol during the first quarter of 2016, including discussions with Capitol facilities personnel, as well as review of existing building documentation made available by the Capitol and the Program Manager (The Christman Company).

This report serves to establish system performance criteria, code compliance, sustainability/energy conservation benchmarks, and user comfort level expectations for this historically significant and unique building. Our LORING team conducted an existing conditions assessment, and prepared recommendations that serve to improve the energy efficiency of the building, improve the reliability of the system infrastructure serving the building, protect the structure and its contents within the building, and enhance the life safety of the Capitol occupants, all while protecting the building. In some circumstances, we have also encouraged additional analysis, results of which could lead to additional subsequent recommendations.

Baseline Analysis

Since the State of Michigan is undergoing adoption of the 2015 I-Codes and this assessment is likely the first step of a multiple-year project, the design team has proceeded using the 2015 codes in expectation of their adoption. The applicable codes in which this assessment was performed include the following:

- 2015 International Building Codes (IBC)
- 2015 International Existing Building Code (IEBC)
- 2015 International Mechanical Code (IMC)

Based on the findings of LORING and our sub-consultants, we have assembled and provide the following report with our recommendations to address the existing MEP and fire suppression conditions. Our study has incorporated analysis and recommendations for all of the following building systems; HVAC, plumbing, temperature controls, building automation, fire suppression, power, distribution, lighting and lighting controls.

The 1986 – 1992 Restoration

The Capitol's last major upgrade occurred between the time period of 1986 and 1992, as part of a phased implementation. The Capitol restoration received national attention and many honors for the extensive level of restoration executed at the time. Though there have been updates and modifications over the years to accommodate changing needs in the building, the last 30-years have not been kind to the Capitol and its building MEP/FP systems.

Though our initial visual "walk-through" of the building suggested that existing systems were in pretty good condition, our more detailed investigation revealed that many of the building's mechanical and electrical systems were in a much greater need of upgrade than originally observed. The design team cannot stress enough the importance of keeping the Michigan State Capitol building alive by updating its MEP/FP systems.

0.1 Executive Summary

Existing Environmental Conditions

Environmental conditions within the building are extremely unstable, raising numerous concerns regarding the ability of the existing systems to control building thermal conditions and to provide adequate comfort for the building occupants. The current outdoor ventilation intake locations, the large swings in building relative humidity levels and the propensity for moisture migration through the building exterior skin all cause significant concern about the ability of the building and its systems to maintain the integrity of the building structure, its historic finishes, and its furnishings. Documented temperature and relative humidity swings occur on daily, weekly and monthly cycles, resulting in the continued contribution to the deterioration of decorative paint, cracked plaster, and loss of plaster integrity. Current mitigation procedures are currently underway to repair some of this ongoing damage.

Mechanical Considerations

Replacement and upgrade of the existing HVAC system is paramount because of current unwanted side effects need to be addressed to avoid further deterioration.

Numerous maintenance related repairs and/or replacements are encouraged to avoid nuisance failures or shutdowns at inopportune times, most notably items including the leaking steam-to-hot water control valves, the corroded equipment supports in the boiler room mechanical room and sub-basement areas. Several areas within the Capitol have inadequate space temperature and humidity levels due to insufficient chilled water flow and distribution to mechanical equipment. Additionally, air handling units serving east and west wings of the Capitol as well as the north areas appear to be unbalanced. LORING recommends replacement of mechanical equipment and piping, and testing and balancing of other air systems serving the east and west wings and north annex.

Since the internal condition of HVAC piping is impossible to predict by visual observation, and our experience has found that some systems exhibit little if any deterioration, while other similar systems of similar age and duty show aggressive and significant levels of piping deterioration, LORING recommends isolating and removing sample sections of steam, hot water, and chilled water piping in order to access the internal condition of the piping. Without doing so, determining the remaining life expectancy of the piping systems would be nearly impossible.

Ventilation changes are very important to improve the performance of the HVAC system serving the Capitol. These improvements include the introduction of dedicated outdoor air systems (DOAS), the relocation of plumbing vents away from building intakes to minimize odor re-entrainment, the removal of recirculating exhaust fans in favor of ducted exhaust systems, the ventilation of the sub-basement space, and the replacement of the fan coil units throughout the building to improve the conditioning and control of outside ventilation air. One (1) of three (3) ventilation schemes are recommended for our fan coil unit upgrade, depending on the criticality of the space and its contents within the area that the fan coil unit serves.

Other HVAC maintenance recommendations include sealing up the edges of the raised floor supply plenums in the House Appropriations Committee room to avoid recirculation and false coil loading, and the checking and cleaning of VAV box reheat coils. As also noted in the fire protection recommendations below, the units serving the stair pressurization systems (OAH-2 & AHU-HA-1) should be re-circuited to emergency power.

The existing Capitol temperature control and building automation system (BAS) is in great need of upgrade. An open protocol energy management control system (EMCS), BAS is recommended. In the interim, LORING recommends immediate retro-commissioning efforts to uncover, 1) failed control sequences, 2) improper system control, 3) unnecessary system operation, 4) control strategies that are operating while causing increased energy consumption at no added value (and possibly to the detriment of the building and its historic fabric). Numerous upgrades such as replacement of the existing pneumatic air dryer and the installation of a global outside air (OA) station should be completed right away.

LORING has investigated and proposes three (3) alternative HVAC options. In all three (3) options, we recommend the design and development of a new central utility plant (CUP) in the south west corner of the existing Capitol building, just to the west of the existing boiler room. This proposed CUP would accommodate the installation of new HVAC systems, allowing for a swing space during the period of construction, and would allow for the installation of new mechanical systems while the existing mechanical systems and the existing services would remain operational. Designing a new CUP would reduce the complexity associated with the remedial foundation work required within the existing boiler room vault area, since portions of the mechanical equipment would be relocated to the new CUP space.

The final size and configuration of the CUP would be determined by the selected HVAC system, and whether the capacity of the future welcome center could be included. LORING recommends incorporating the estimated heating, cooling, electrical, and domestic capacity of the future welcome center within the CUP as part of the Capitol restoration design. Including both the capacities of the Capitol and the Welcome Center in the sizing of the CUP equipment and the new electrical substation equipment would allow for equipment consolidation, providing for a more efficient and a reduced maintenance operation. LORING proposes reusing the recently installed chillers should the proposed Option 1 or Option 3 alternatives be chosen (see descriptions below).

Loring's preferred three (3) HVAC options for the Capitol infrastructure upgrade include:

1. Option #1 - Electric Chillers, Cooling Towers, Gas Boilers in the CUP
2. Option #2 - District Chilled Water, District Steam Systems with Pumping & Accessories in the CUP
3. Option #3 - Geothermal Well Field, with Electric Chillers, Pumping & Accessories in the CUP

Loring's HVAC Recommendation

After factoring in maintenance and operational costs, the relative Cost/BTU of the district steam and district chilled water option (Option #2 above) reflects a higher life cycle cost than the site installed high efficiency boiler with electric chillers and site installed cooling tower option (Option #1 above). These results are due in large part to the Cost/BTU of electrical power and the relatively low Cost/BTU of the natural gas.

The only variable preventing LORING from recommending Option #1 (best life cycle) is the extreme difficulty in integrating the boiler flues, the refrigerant and gas relief piping, and the "outdoor" cooling towers into the site without adversely impacting the historic character of the site and the Capitol building.

Due to our sensitivity related to the Capitol and its site-lines, Loring prefers and recommends the HVAC Option #3 (Geothermal Well Field, with Electric Chillers with Pumping & Accessories in the CUP). This option significantly reduces the site impact issues by substituting both the "outdoor" cooling towers and the gas boilers for the ground-coupled geothermal well field. Because of the relative cost of the well field, and the relatively low Cost/BTU of the natural gas, Option #3 (the Geothermal Well Field) does not result in the best overall Life Cycle Cost (LCC). In spite of this, LORING believes this solution would be optimal for the Michigan State Capitol and will require further investigation for final consideration by the team.

Building Life Safety

The ability to quickly detect and alert building occupants of a fire or smoke event in the Capitol will enhance the safety of its occupants. The design team recommends the further study and implementation of security monitoring, the feasibility of adding fire & smoke early detection systems, and encourage further exploration with Hopkins Burns Design Studio to improve the building's life safety features by providing additional building compartmentalization, the possibility of modifying the enclosure above the 8th floor oculus, the ability of adding a second means of egress from both the House & Senate Chambers, etc.

There are a number of decisions made during the 1986-1992 restoration (for example - the use of photo luminescent exit signs) that the design team recommends should again be reviewed with the local Fire Marshal and/or authority having jurisdiction (AHJ), to insure continued agreement with previous decisions made.

To increase the building's life safety features, the building's two (2) stairwell pressurization systems should be tied to a recommended emergency power system upgrade, and lighting scenes in public corridors and exits should be reset to their maximum footcandle output to more closely approximate the code prescribed emergency lighting levels.

Observed sprinkler head coverage conditions and sprinkler head locations showing signs of localized oxidation should be repaired to insure sprinkler coverage, while reducing concern from water damage associated with potential future pipe leaks.

Antiquated Halon 1301 systems, where still deemed important to protect equipment and valuables, should be replaced with current and equivalent type protection (FM-200 systems).
Standard response sprinkler heads should be replaced with quick-response type heads throughout the Capitol. Doing so will insure quicker response should the air temperature at the respective sprinkler head reach the high-temperatures related to a fire or a smoke condition.

A new point-addressable fire alarm system with emergency voice and alarm communication should be installed to replace the existing system, thus improving the building's life safety system in the event of an incident.

An early warning fire detection system should be considered for the Rotunda and open areas. Use of beam smoke detectors, aspirating type smoke detection, camera imaging detection systems, etc., should be studied further to facilitate a more rapid detection of fire and/or smoke (to alert the building occupants more quickly).

The possibility of incorporating a high pressure water mist fire protection system within the Zone-1 Preservation areas (Governor's suite, Senate Chamber, House Chamber, and the Zone-1 Corridors) to better protect the finishes and valuables contained within these areas may be considered.

Electrical Considerations

A separate and independent electrical service to the fire pump should be provided, tapped ahead of the main breaker, to improve system reliability.
A Transient Voltage Suppression System (TVSS) should be provided with devices on the low voltage switchgear, and in other sensitive locations such as the Command Center (for example). Doing so will protect electrical gear from high voltage inrush associated with events such as lightning strikes.

An Arc Flash risk analysis (short circuit & coordination study) as added to the NFPA 70E Code requirements should be performed, to better protect the building maintenance personnel and contracted service personnel who work on the gear and allow for incorporation of strategies that limit or eliminate the risk of arch-flash incidents.

Miscellaneous electrical modifications including ordering and stocking of spare overload protection fuses, adding panic hardware to the existing substation doors, and performing infra-red scans of switchgear and panelboards (to identify hot spots and load imbalance situations), will be of great benefit to improving safety and reducing response time to possible outages.
Electrical loads should be metered for at least a year to better understand the origin of the observed and ongoing power quality issues.

The existing Capitol emergency generators are currently in a location vulnerable to accidental or deliberate damage, and they are currently inadequately sized to support new loads being recommended for addition to the emergency/standby power system. Loring Recommends a new below grade generator plant to support and maintain the building operational during power outage. LORING recommends that all elevators, currently supported by the emergency/ standby power through manual switching methods, be provided with automatic access to generator power and enhance the operational flexibility of the fire department to use these systems during evacuation.

LORING also recommends that the existing electrical distribution equipment currently located in the Sub-Basement be relocated into a new electrical switchgear space. Accessibility to its current location is limited, maintainability is difficult at best, safety in its current location and installation arrangement is compromised, and an extended loss of service due to a building domestic water, chilled water, sprinkler activation, or other building leak could have devastating impacts should the electrical service be knocked out for an extended period of time.

LORING recommends relocating this distribution equipment and developing an expanded underground electrical substation to the south, with separate electrical distribution rooms serving the Capitol, and with a new underground emergency generator plant to the north.

LORING also recommends upgrading electrical service entrance equipment and substation distribution equipment to enhance the electrical systems reliability, robustness and minimize single points of failure.

Lighting Considerations

LORING and our consultants recommend resetting all of the existing egress lighting scenes to their maximum settings, to demonstrate intent to meet the egress code lighting levels.
We recommend upgrading the Broadcast cameras within both the Senate chambers and the House chambers (if not already done) to enable the existing broadcast lighting systems to be turned off and removed. Doing so will reduce the damage associated with the high lamp temperatures, and will reduce unnecessary energy usage.

LORING and our consultants recommend a full-scale implementation of LED's throughout the Capitol along with an associated lighting systems control upgrade. Having done this in numerous State Capitol's has proven very successful in significantly reducing energy consumption and heat output, while extending lamp life without adversely effecting lamp color temperature.
Improving the ability to introduce natural daylighting should be further investigated. Doing so should be accomplished in conjunction with photocell control. The application of UV/IR reduction films on glazing should be included with this option in order to avoid solar fading and bleaching of finishes and furnishings.

The rotunda picture lights should be refurbished using "*qualified*" historic luminaires with LED socket modules to reduce heat and light picture degradation.

Temperature, Humidity & Moisture Migration Monitoring

The addition of low levels of humidity for control within the House chambers, the Senate chambers, the historic Supreme Court (the Senate Appropriations Committee Room) and the Governor's suite should be evaluated further as a consideration.

LORING and their consultants recommend the addition of temperature and humidity monitoring at the Rotunda, and encourage the development of a computational fluid dynamic (CFD) model to simulate air movement, temperature change, and moisture transfer throughout the Rotunda.

Plumbing Considerations

Since the internal condition of plumbing piping is impossible to predict by visual observation, and experience has found that some systems exhibit little if any deterioration, and other similar systems of similar age and duty show aggressive and significant levels of piping deterioration, LORING recommends isolating and removing sample sections of the existing domestic water supply piping, and the sanitary sewer piping in order to access the internal condition of the piping. Without doing so, determining the remaining life expectancy of the piping systems would be nearly impossible.

Sanitary piping in the existing boiler room exposed in the concrete floor and visibly deteriorated should be repaired, and abandoned piping located in the sub-basement should all be removed. Note, existing storm water piping has been recently lined to address previous problems with the storm water piping conditions.
LORING recommends that the Capitol's maintenance staff continue their ongoing replacement of the point-of-use domestic water heaters at 8-year intervals. Doing so will likely prevent many of the premature failures associated with these type of heaters.

Additionally, LORING recommends replacing the central water storage generator located in the existing boiler room with a device consistent with the fuel source selected to provide the building heating. The existing domestic water booster pumping system should be removed and replaced with a skid-mounted pump package. The existing fire jockey pump should be disconnected from the metered domestic water service, and should be connected to the fire water service to avoid water usage charges.

Building Envelope / Environmental Comportment

Further studies of the building are encouraged to better understand and document the "*chimney effect*," and to better understand the conditions related to the existing drum and dome, conditions related to thermal bridging and associated condensation, and conditions related to window sill and leak interception.
LORING and their consultants recommend the addition of real-time monitoring to assist with the fine-tuning of new HVAC systems and their controls once installed, and to reduce air and vapor exchange between the interior and exterior.

The installation of entry weather-stripping, the replacement of outside air dampers in air handling units and fan coil units with motorized, low-leak dampers are imperative. Enforcing standard of protocols (SOP) such as keeping vestibule doors and access hatches to the sub-basement space closed are very important.
The addition of dehumidification capabilities and the associated control strategies as part of the replacement HVAC systems are important to reduce vast swings in building relative humidity levels.

Historic Artifacts

LORING and their consultants recommend changing some operational protocols to protect and extend the life of some of the historic artifacts, including turning off the picture lights when the building is closed to the public, closing the Senate chambers, the House chambers, the Supreme Court chambers, the Governor's suite, and the committee rooms when they are not in use.
Further study of the Allegories in the rotunda is encouraged, to understand ways to better protect these treasured artifacts from damage. Further consideration toward providing discrete microclimate enclosures around priceless and/or treasured portraits and framed artwork is encouraged.

Historic Furnishings and Finishes

In addition to previous recommendations above including the addition of low-level humidification in sensitive, Preservation Zone 1 areas, the use of LED lighting fixtures, the addition of environmental monitoring, it will also be extremely important to properly protect the artifacts and furnishings during construction activities.

Signs of past or present water damage have been detected in a dozen or so locations, and signs of cracked plaster cornices are evident in the Senate chamber, and the south wall of the House chamber. Each location should be further investigated to determine if any of the damage is active and ongoing.

For historic recordation and for restoration purposes, additional study is encouraged to determine where original historic building fabric remains (plaster, wood work, and sheetmetal).

Implementation

LORING and our consultants have evaluated our recommended MEP/FP & Life Safety upgrades with respect to the implementation process.
Our assessment of the mechanical, electrical, plumbing and fire protection systems within the Capitol has resulted in two (2) distinct categories of recommendations. These two (2) distinct categories include, 1) items that shall be designed and/or implemented as quickly as possible, and 2) items that should be sequenced as part of appropriated/ funded plan. A third category is not discussed herein since it would comprise future recommendations not being considered for 25-years or more.

All items included in Category 1) include MEP/FP and Life Safety system upgrades that could be accommodated without significantly impacting the building, without significant disruption to its occupants, or without requiring large cost. These Category 1 items could be described as the "low-hanging fruit." Implementing these recommendations would have an immediate impact on energy reduction, improved

comfort control, improved system reliability, and/or improved occupant safety. Several of these recommendations would be temporary until the Category 2 recommendations are designed and implemented. Items in this Category 1 also include our recommendations described above for further monitoring, further testing, commissioning and research.

Items included in Category 2, though they may have equal or more importance, are more difficult and costly to implement. These recommendations require time to provide the design effort, require close coordination with the Michigan State Capitol Commission, The Christman Company, Hopkins Burns Design Studio, etc. and require study to establish the construction work plan, manage the occupant moves, complete the Construction Documents, obtain Lansing City & Michigan State approvals, and must be sequenced properly to not exceed the allotted budget & funding.
Though many of our recommendations are best documented as one design package with the intent of awarding one (1) construction package, it will be imperative to develop a sequenced implementation plan to accommodate the system upgrades without "*shocking*" the building or its occupants, while maintaining many of the building's critical building functions, and without compromising the historic fabric. It is the intent for the building to remain occupied and functional as the seat of government throughout the implementation of the construction changes and system upgrades.

The recommendations contained in Category 2, particularly those related to the heating, ventilating, and air conditioning (HVAC) systems and the electrical systems, do not lend themselves easily to multiple construction related projects spread out in stages over the next 10-15 years. Substantial infrastructure upgrades (most notably the emergency power upgrade, fire/life safety enhancements, central utility plant upgrades, normal electrical power distribution improvement, and ventilation enhancements) point more favorably toward a comprehensive design and implementation plan that can integrate and sequence the construction activities without protracting construction schedules, and without risk of duplication or doubling up on time, effort, or the funding required.

Michigan State Capitol
Summary of Recommendations
May 12, 2016

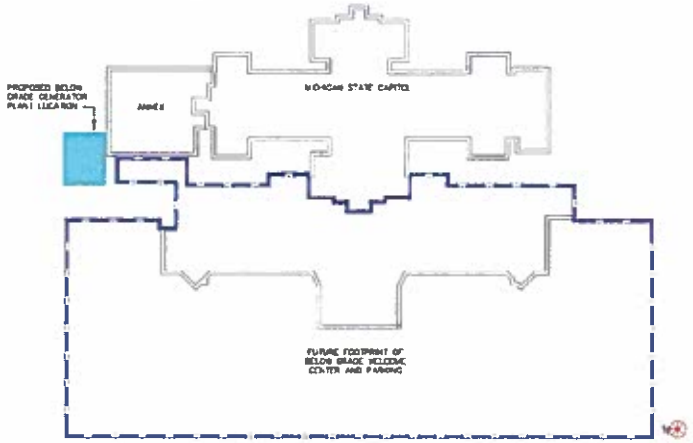
1.0 Summary of Recommendations

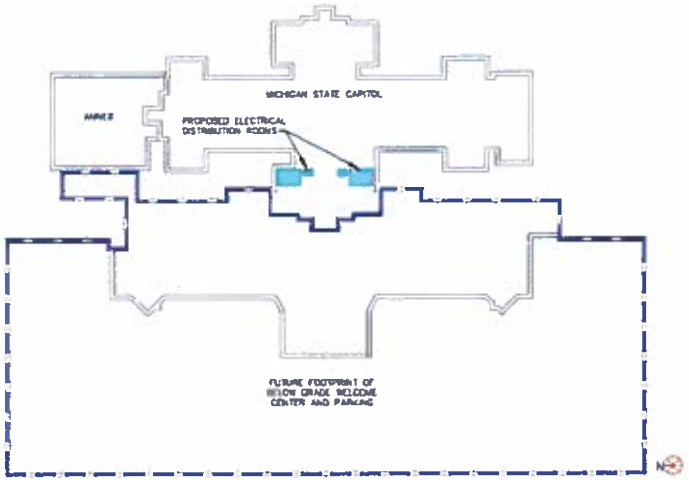
This report is being issued to The Michigan State Capitol Commission and Program Manager (The Christman Company). It includes an assessment of existing engineering systems at the Michigan State Capitol and a life safety analysis. This report also provides concepts for upgrades and modernization of systems with recommendations arranged in order of priority. These recommendations take into consideration a sequenced approach to implementation. The report also includes an assessment of the building envelope, historic artifacts and plaster finishes intended to guide the conceptual development of engineering systems. The following matrix represents a summary of recommendations and includes an order of priority for each; Immediate recommendation, with numerical values assigned to order of priority with (1) being the highest priority to follow "immediate" recommendations.

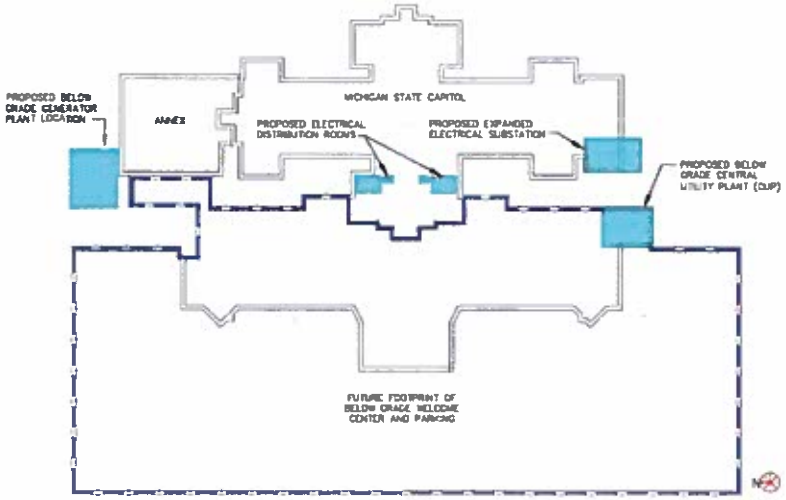
System	Section No.	Item No.	Order of Priority	Recommendation
Life Safety	2.0	2.4.1	N/A	The first through fourth floors are open to each other via the Rotunda floor opening, the monumental stairs and the exit access stairs. It is recognized that large floor openings can contribute to increased smoke and fire spread throughout a building; subsequently, current building codes have requirements for building compartmentation or other active systems to help mitigate smoke/fire spread. There are no requirements in the IEBC that would require a retrofit of the existing building to include a smoke control system or additional action to remedy the lack of building compartmentation. Recognizing the potential threat to life safety, it is recommended that further analysis of smoke behavior within the single fire area of the building be completed. Should incorporation of mechanical smoke control system in the Capitol be deemed not feasible given the historic nature of the Building, then consideration should be given to the following passive strategies • Security Monitoring; • Early Detection, • Additional Compartmentation, • Modification of enclosure at eighth floor oculus
		2.4.2		It was noted during the site survey that only one means of egress is identified in the House and Senate Chambers' galleries. There is the potential for a second path of egress as both Chambers have exit access stairs located at the rear of the Chambers. However, in the House Chambers access to the stairs is through a private office, which is not permitted as it is an intervening space and subject to locking. In the Senate Chambers, access to the stair is through a corridor and, the door to the corridor has a key lock. Therefore it is recommended that a code-compliant second means of egress and exit sign for the secondary route from the galleries be provided in both of the Chambers.
		2.4.3		The majority of the building was observed to have photoluminescent exit signs nearing the end of their life spans. These signs are known to deteriorate and become less reliable over time. It is recommended to update or replace exit signs with new illuminated exit signs that are compliant with current building codes. It is understood that the current configuration and location of exit signs was discussed and approved by the Authority Having during the 1986-1992 restoration.
		2.4.4		Two new fire-resistance rated enclosed exit stairs were provided as part of the 1986-1992 restoration and provided with stair pressurization systems as required for high-rise buildings. However, the stair pressurization system is not currently connected to a standby power source as is required by the current building code and was probably required at the time of installation. It is recommended that the stair pressurization equipment be connected to the building s generator load (See Section 4.0) – Refer to interim recommendation and long term recommendation for upgrades to the generator backup system.
		2.4.5		As the building lighting is updated or replaced, it is recommended that the emergency lighting levels be tested for compliance with the code prescribed emergency lighting levels. It is understood the emergency lighting was updated approximately 16 years ago. Refer to Lighting upgrade recommendation listed under Section No. 5

System	Section No.	Item No.	Order of Priority	Recommendation
Fire Alarm & Fire Suppression	3.0	3.3.1.1	Immediate	Sections of the sprinkler piping were observed to be in a state of deterioration. To determine the extent of the internal damage it is recommended to remove sections of the piping and visually inspect the inside. Corrosion and deterioration can worsen over time causing unwanted leaks in the system, which can cause water damage to historically sensitive building fabric. Where the piping or sprinklers are observed to have significant deterioration, it is recommended to replace these sections immediately.
		3.3.1.2		A sprinkler pipe is installed directly above the electrical equipment in the main switchgear room. A leak in the sprinkler pipe in this area could cause significant damage to the electrical equipment. The sprinkler pipe should be reconfigured so it is not located directly above this equipment.
		3.3.1.3		Halon 1301 is an effective agent for suppressing and extinguishing fires; however, it is no longer produced. Accordingly, in the event of system activation, it can be difficult and very expensive to procure replacement Halon to replenish the system. It is recommended to replace the Halon 1301 systems with a clean agent system such as FM-200, INERGEN, etc., that accomplish the same fire protection objective as Halon 1301.
		3.3.1.4		It is recommended to replace all standard response sprinklers in the light hazard occupancies with quick-response sprinklers. Quick-response sprinklers activate quicker than standard response sprinklers and are beneficial for cooling and suppressing a fire. By applying water early in fire development, quick-response sprinklers improve suppression likelihood and help minimize the damage from fire and the products of combustion.
		3.3.2	1	The current fire alarm system panel is no longer in production, making obtaining replacements parts difficult and costly. The current fire alarm system is not point-addressable, nor does it utilize the voice alarm. A new point-addressable fire alarm control panel with emergency voice / alarm communication is recommended for the Capitol Building. This improves occupant response to fire alarm as well as fire department response to a fire. All existing initiating devices are recommended to be replaced with new point-addressable initiating devices and monitored by the new fire alarm control panel. All existing notification appliances are recommended to be replaced with new appliances that provide the required visual and audible coverage in accordance with current codes and standards. It is recommended the existing fire alarm system remain operational until the new fire alarm system is fully installed and operational. If the fire alarm system is replaced in "phases", the incorporation of Phase I automatic elevator recall, stairway pressurization monitoring, and monitoring of the emergency generator should be a priority.
		3.3.3	2	Provide an early warning fire detection system in the Rotunda (Refer to Recommendation No. 2.4.1). It is recommended to utilize either a video imaging smoke detection system or an aspirating-type smoke detection system. Both types of detection systems have advantages and disadvantages for the proposed application. A video imaging smoke detection system consists of line-of-sight cameras that must be spaced to capture a full view of the Rotunda space. These cameras may also be used in a dual role for building surveillance. An aspirating-type smoke detection system is an active system that continually samples the air for the presence of smoke particles, thus allowing for slightly quicker alarm time than a video imaging smoke detection system. The air aspirating system does not require line-of-sight detection; however, the air sampling tubes required for smoke detection represent a slightly more intrusive installation than a video imaging smoke detection system. Since the Rotunda is a large open space that connects several floors of the Capitol Building, an early warning fire detection system benefits occupant notification for evacuation. It also is beneficial for the building personnel response to a fire and apply suppression through manual means.
		3.3.4	3	There are several areas in the Capitol Building where artwork, artifacts, finishes, and other historically significant items are at a risk of water damage in the event of a sprinkler system discharge. An effective method to mitigate this type of risk without decreasing the level of fire protection for the building is to provide a high pressure water mist fire protection system (Figure 9) in culturally significant areas. It is recommended to consider replacing the existing wet sprinkler system with a high pressure water mist system in "Preservation Zone 1" that include the following areas: • Governor's Suite • Senate and House Chambers • Preservation Zone 1 Corridors An alternative to the water mist system would be to maintain the automatic wet sprinkler system that is currently present in these areas.
		3.3.5	4	Provide entirely independent fire pump supply conductors (Refer to Recommendation No. 4.7.2). Independent fire pump supply conductors is a NFPA 70 code requirement and provides protection from potential damage from fire or other hazards to ensure successful operation of the fire pump during a fire scenario.

System	Section No.	Item No.	Order of Priority	Recommendation
Electrical Systems	4.0	4.7.1.1	Immediate	To protect the building and electrical distribution against voltage transients, it is recommended the Capitol install a Transient Voltage Suppression Device at the LV switchgear as well as localized distribution deemed critical by the Capitol (such as Command Center). It is noted these voltage transients can cause damage to electrical distribution equipment in the Capitol.
		4.7.1.2		Current Electrical Codes (NFPA 70 and NFPA 70E) put a lot of emphasis on the importance of protection of personnel from risk and injury resulting from exposure to arc flash energy. Designs for new electrical distribution systems (for new construction or within existing buildings) require arc flash risk analysis and arc flash reduction strategies be incorporated into the design. NFPA 70E which is the Code that governs maintenance and operation of existing electrical distribution and equipment requires facilities provide all electrical equipment with arc flash warning labels as well as have a plan that guides on protective clothing while working on energized equipment. To implement this, the following is implemented 4.7.1.2.1 Perform a short circuit and coordination study to provide guide design parameters for an overall electrical system upgrade and modernization that may be undertaken by the Capitol in the future. 4.7.1.2.2 The outcome of the short circuit and coordination study will be used to perform an arc flash risk analysis which in-turn will provide labeling and protective clothing (PPE) criteria for maintenance personnel working on energized equipment. Outcome of this study will also guide arc flash reduction strategies for future upgrades of the electrical distribution system.
		4.7.1.3		The existing electrical distribution system predominantly relies on fuse overload protection. To provide faster response time to a blown fuse condition, it is recommended that a cabinet for storing spare fuses be provided and stocked with a variety of fuses and that this cabinet be located in the vicinity of the electrical substation room (south boiler room). It is understood that spare fuses available on-site, however, this was not verified and no information is available on inventory.
		4.7.1.4		Code requires rooms housing electrical equipment with ratings 800A or above to be equipped with two (2) discharge exit doors with panic hardware. While the existing room layout provides the required discharge, the doors lack the required panic hardware. It is recommended the existing substation doors be retrofitted with panic hardware.
		4.7.1.5		To better understand power quality shortcomings that have been reported in the form of brown-out conditions or voltage dips, the following is recommended: ▪ As part of the investigative Continue to monitor the loads at the substation for (1) year period via metering requested by this team, as well as obtain information from the utility for that same period for comparison. • Perform an infra-red scan of the electrical distribution system. This scan will identify hot spots within the distribution, identify distribution where significant load imbalance exists, and will ultimately assist intervention should an issue be uncovered.
		4.7.1.6		To better understand power quality shortcomings that have been reported in the form of brown-out conditions or voltage dips, the following is recommended: • Continue to monitor the loads at the substation for (1) year period via metering requested by this team, as well as obtain information from the utility for that same period for comparison. • Perform an infra-red scan of the electrical distribution system. This scan will identify hot spots within the distribution, identify distribution where significant load imbalance exists, and will ultimately assist intervention should an issue be uncovered.
		4.7.1.7		As an interim enhancement to the Capitol life safety, it is recommended stair pressurization fan systems and Sub-Basement sump pumps be supported by Standby Power. This may require shedding of existing loads that are currently provided with backup that are deemed not critical such as fan coil units. This recommendation may be eliminated should the Capitol move forward with implementing recommendation 4.7.2 for a new generator plant.

System	Section No.	Item No.	Order of Priority	Recommendation
Electrical Systems (Cont.)	4.0	4.7.2	1	New Standby Generator System – Due to shortcomings resulting from the current location and coupled with the power quality and outage concerns reported by facilities personnel, this report examines several strategies for backup power with a desired goal of 100% generator backup. Should other recommendations included within this report pertaining to improving energy efficiency be implemented; such as changing lamp sources to LED (see Section No. 5), then generator capacity and size of system should be reevaluated. The following options for generator backup are listed for consideration and examined in this report: Option 1a (100% Backup to the Capitol via Diesel Generators) Option 1b (100% Backup to the Capitol via Natural Gas Generators) Option 2 (100% Backup to the Capitol and Capacity for Future "Welcome Center") – Preferred Option 
		4.7.3	2	To provide all elevators within the Capitol with automatic access to generator backup, and to minimize the operational concerns with manual switching of power sources to elevators, it is recommended that the standby distribution for the elevators be grouped under a separate automatic transfer switch. This recommendation is intended to be implemented concurrently with recommendation 4.7.2 (i.e. new standby generator system). Space designated for Fire and Rescue personnel (such as fire equipment room) should include an elevator control panel that allows for automatic selection of any elevator at any given time. Refer to Fig. Nos. 11a, 12a, and 13a for electrical distribution associated with this recommendation.
		4.7.4	3	Lighting Inverters – These are systems providing battery backup to selected emergency lighting throughout the Capitol to provide a lighted path of egress during power loss and until the generator is energized and can provide backup. Due to age and dispersed nature of the lighting inverters within the Capitol, the following are options are intended to be evaluated concurrently with recommendation 4.7.2 for generator backup system: Option No. 1a – Emergency backup provided via (2)-500kW diesel generators - Remove lighting inverters though-out the Capitol. New lighting inverter system will not be required. Option No. 1b – Emergency backup provided via natural gas fired generators. Provide (2)-50kVA lighting inverters located in a 2hr rated room. Option No. 2 - Emergency backup provided via (2)-600kW diesel generators - Remove lighting inverters though-out the Capitol. New lighting inverter system will not be required.

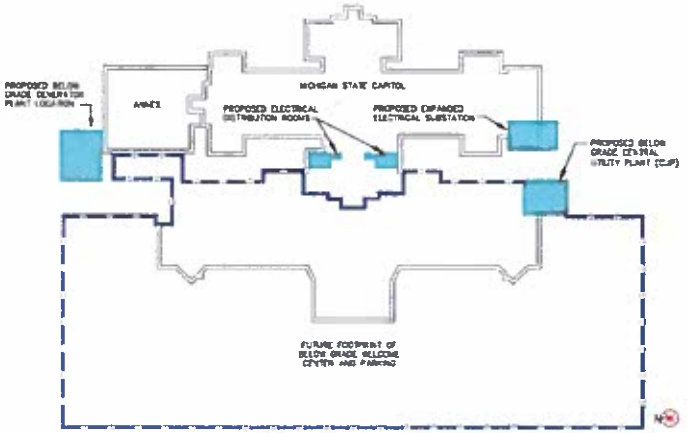
System	Section No.	Item No.	Order of Priority	Recommendation
Electrical Systems (ConL)	4.0	475	4	New Sub-Basement Distribution – Due to the limited accessibility and maintainability concerns and to improve the safety and expandability of the electrical distribution system, it is recommended that sub-basement electrical distribution equipment be relocated from the Sub-Basement to the Ground floor. It is recommended that the upgraded of electrical distribution equipment include molded case circuit breakers with adjustable trip units that have been optimized for selective coordination. Include power monitoring features. For planning purposes, this reports provides an approximate size for electrical distribution equipment rooms to be housed on the Ground floor or incorporated within the footprint of the Welcome Center. 

System	Section No.	Item No.	Order of Priority	Recommendation
Electrical Systems (Cont.)	4.0	4.7.6	5	Service Entrance Equipment and Substation Upgrades – The intent of this recommendation is to provide a separate 2-hour rated room to house service entrance equipment and MV switchgear as well as provide a separate room to house the remainder of substation components, i.e. transformers and Low Voltage (LV) switchgear. It is recommended these upgrades are integrated with, and include infrastructure to support future plans a below-grade "Welcome Center" project. It is recommended this service upgrade occur in a sequenced manner to minimize disruption of power and maintain Capitol operations to the extent possible. The sequencing of work is dependent upon implementation of Recommendation No. 6.2.2.3 (Central Utility Plant) and takes advantage of the spaces vacated by the mechanical equipment. 
		4.7.7	6	New Fourth Floor Distribution - Create separate 1-hour rated room(s) to house electrical equipment at the Fourth floor with Code required clearances, as well as upgrade of electrical distribution relying on fuse protection to distribution with molded case circuit breakers with adjustable trip units that have been optimized for selective coordination. Include power monitoring features.
		4.7.8	7	Uninterruptable Power Supply – Current systems are dispersed throughout the Capitol and do not include centralized battery monitoring and alarm capabilities. Should the Capitol prefer to retain the current configuration and zoning of the UPS systems due to preferred end-user maintenance and operation programs, then battery monitoring systems should be incorporated. To be further discussed with the Capitol. For planning purposes, the initial capacity estimate for a centralized UPS system is 60kVA.
		4.7.9	8	Lightning Protection System - Continue to investigate existing lightning protection system and grounding method – Lightning protection should be tied to building main ground service and TVSS system. If this investigative effort were to reveal otherwise, then building grounding system should be upgraded including the installation of a ground loop around the building and the work can be concurrent with 4.7.6 or future "Welcome Center".

System	Section No.	Item No.	Order of Priority	Recommendation
Interior Lighting	5.0	5.8.1.1	Immediate	On all interior scenes used during building occupancy, program maximum dimmer settings for all general circulation luminaires in circulation spaces to 100% and confirm that all Lutron factory programmed governors are set to 100%. Anticipated to be no or low cost implementation. RATIONALE: Increase illuminances. BENEFIT: Demonstrate intent to meet egress lighting code.
		5.8.1.2		Reset scene schedule to extinguish accent lights in rotunda 6th level illuminating muses at public closing time (e.g., 5 p.m.) and re-energize at public opening time (e.g., 8 a.m.) every weekday and Saturday, remaining OFF at other times. Anticipated to be no or low cost implementation. RATIONALE: Limit duration of light exposure on muses. BENEFIT: Reduce degradation from UV, IR, and visible light exposure from existing lamps.
		5.8.1.3		Reset scene schedule to extinguish or dim picture lights in rotunda at public closing time (e.g., 5 p.m.) and re-energize at public opening time (e.g., 8 a.m.) every weekday and Saturday, pending onsite illuminance review. Picture light to remain OFF at other times. Anticipated to be no or low cost implementation. RATIONALE: Limit duration of light exposure on governors' portraits. BENEFIT: Reduce degradation from UV, IR, and visible light exposure from existing lamps.
		5.8.1.4		Switch off or dim broadcast lighting as determined acceptable by AV operators pending camera technology advancements. This will reduce damage to the decoratively painted ceilings and wall panels adjacent to these luminaires. Anticipated to be no or low cost implementation. Repair surrounding ceiling/wall and decorative paint - see Section 2 for more information. RATIONALE: Limit duration of light exposure on architectural finishes, furnishings, and artworks in chambers. BENEFIT: Reduce or eliminate degradation from UV, IR, and visible light exposure from existing lamps.
		5.8.1.5		Commission photographic/architectural survey of every Preservation Zone 1, 2, and 3 space with detail views of key artifacts, including all luminaires, cross-referencing luminaire types and room numbers, and pinpointing camera location/orientation on plan). Note anomalies. RATIONALE: Establish a comprehensive archival record of the restored Capitol's architecture, finishes, furnishings, and luminaires at this point in time for posterity. BENEFIT: Future restoration and renovation work scopes will be more definitive with documented evidence/provenance of the restored visual/physical setting. Future generations have a visual reference record of the Capitol's architecture and contents leaving less to the imagination.
		5.8.2.1	1	Full-scale implementation of LEDs throughout: 5.8.2.1.a UL/NRTL-listed higher-lumen LED retrofit lamps for many historic luminaires (requires calculations, specifications, mockup[s]). To procure 2200K/90CRI medium screw-base retrofit lamps, all lamps and at least one complete set of replacement lamps need to be ordered at one time to make minimum quantity threshold and avoid color differences between lamp production batches. RATIONALE: Address efficiency and overall illuminances with existing historic luminaires. BENEFIT: Improve lighting system efficiency by up to 90%, maintain or improve illuminances by 7 to 60% (may negate need for additional luminaires in monumental stairs), reduce IR to zero, and reduce lighting-related cooling load by up to 90%. 5.8.2.1.b Dedicated, purpose-built LED luminaire replacements for most modern luminaires at 6th Level and back-of-house (requires calculations, specifications, mockup[s]). NOTE: There may be implications to condensation at rotunda windows - see Section 8 for more information. RATIONALE: Address efficiency, maintenance cycles, and deleterious effects of existing historic luminaires. BENEFIT: Improve lighting system efficiency by up to 90%, lengthen maintenance cycles by up to 2800% (more than two thousand percent), maintain illuminances, reduce UV and IR to zero, and reduce lighting-related cooling load by up to 90%.
		5.8.2.2	2	Upgrade/replace/combine the two lighting control systems. Pending the extent to which, if any, LED lighting upgrades described above and related to the site and facade lighting are made, a review of the necessary control capabilities can be made and modifications to the existing systems or a combined upgraded or new system specified to address various zones, potentially some new, and address various LED loads, including, likely, phase dimming, 0-10V dimming, and DMX512a dimming/tuning. Similarly, as such modifications and/or upgrades are made, revise the preset scene schedule. RATIONALE: Provide a control system compatible with and capable of controlling LED loads. BENEFIT: Robust dimming and on/off operation of lighting without flicker or reduced lamp life.
		5.8.2.3	3	Improve daylighting: 5.8.2.3.a New chambers' skylights (requires calculations, specifications, mockup[s], skylights not accounted in the Budget Valuation in Table 5.9). RATIONALE: Address efficiency and overall illuminances. BENEFIT: Improve illuminances to better meet industry-practice for legislative discourse while reducing energy use and lighting-related cooling load. 5.8.2.3.b Introduce photocell control to electric light zones where daylight is a part of the original architectural intent and the electric light is considered deleterious to finishes, fabrics, furnishings, and artworks and unnecessary for "setting the visual scene" such as chamber laylight backlighting during certain situations and rotunda muse lighting. RATIONALE: Address deleterious effects from electric light and address efficiency by dimming/switching-off electric lighting in response to daylight at the rotunda 6th level and the chambers' laylights backlighting. BENEFIT: Limit use of electric lighting to preserve historic finishes, furnishings, and artwork and save energy. 5.8.2.3.c Introduce UV/IR reduction film on fenestration not presently treated. RATIONALE: Address deleterious effects from daylight where not presently used in Preservation Zone 1, 2, and 3 areas. BENEFIT: Limit UV/IR radiation to better preserve historic finishes, furnishings, and artwork and reduce cooling load.
		5.8.2.4	4	Refurbish rotunda picture light using a qualified historic luminaire vendor to rework the luminaire to accommodate a dedicated-socket LED module and, if necessary, optics, and lensing and to UL/NRTL list the refurbished luminaire. RATIONALE: Address deleterious effects from electric light and improve maintenance cycles. BENEFIT: Eliminate UV radiation to better preserve portraits.
		5.8.2.5	5	Broadcast lighting removal or upgrade. Pending review with Capitol AV technicians, remove 1992 broadcast lighting or upgrade it to LEDs (requires calculations, layouts, specifications, mockup[s], upgraded broadcast lighting not accounted in Budget Valuation in Table 5.9). RATIONALE: Address deleterious effects from electric light and address efficiency. BENEFIT: Eliminate UV and IR to preserve historic finishes, furnishings, and artwork and save energy.

System	Section No.	Item No.	Order of Priority	Recommendation
Mechanical Systems	6.0	The existing HVAC systems and controls are nearing the end of useful life or have past their useful life expectancy. The recommendations noted below address the immediate needs and also provide a comprehensive approach to provide a reliable, energy efficient HVAC system that takes into account the current issues of large temperature and relative humidity fluctuations which ultimately impacts the historic architectural fabric, paint, plaster and artifacts within the building.		
		6.2.1.1	Immediate	Heating System a. Existing steam control valves at the steam to hot water converters are leaking and do not operate properly. Replace the leaking steam control valves at the steam to hot water converters b. Existing steel supports in the Sub-Basement close to the steam to hot water converters are corroded due to water infiltration or condensation. Remove existing corroded steel supports used to hang the steam piping and control valves and provide new floor mounted supports. c. Test representative samples of the existing hot water piping by measuring the wall thickness to understand existing condition of piping for the heating system. Testing would summarize the cumulative effects of all forms of corrosion over the lifetime of the pipe and help us evaluate if the existing piping within the vertical shafts can be maintained and re-used to minimize the disruption to the historic fabric.
		6.2.1.2		Cooling System a. Free cooling can be provided without the operation of the chillers by using just the cooling towers and plate and frame heat exchangers when the outside air conditions permit. The cooling tower and plate and frame heat exchange controls are still being worked on and does not allow the Capitol to make use of this energy saving feature. Activate the operation of the free cooling plate and frame heat exchanger by re-working the controls. Limit the use of air side economizer by changing the sequence of operations so that outside air is only used for cooling when the exterior dew point temperature is below target levels for the interior as recommended in Section 8.0 and using water side economizer as much as possible. *This work has been completed and the free cooling mode has been activated since the issuance of the preliminary recommendations.* b. Existing piping and valving configurations and rework of the piping to accommodate immediate needs in the past have caused water flow issues in the chilled water loop in the North Wing Sub-Basement. Re-pipe and re-valve chilled water piping in the North Wing Sub-Basement close to ACU-N-5 (by pumping station P-NC-7 and 8) where there is no chilled water flow. c. Test representative samples of the existing chilled water piping by measuring the wall thickness to understand existing condition of piping for the cooling system. Testing would summarize the cumulative effects of all forms of corrosion over the lifetime of the pipe and help us evaluate if the existing piping within the vertical shafts can be maintained and re-used to minimize the disruption to the historic fabric.
		6.2.1.3		Ventilation System a. Existing plumbing vents are located close to outside air intakes in multiple locations and causes re-entrainment of vented gases into the ventilating system. Extend plumbing vents a minimum of three feet above the outside air intake hoods at the roof level per code requirement to prevent re-circulation of vented gases into the building via intake openings. b. Air handling units HVAC-1 serving the East Wing and the North Annex air handling units do not provide the required air flows to the various spaces based on information from the Building Management System (BMS). Test air handling units HVAC-1 serving the East Wing and the North Annex air handling unit to understand the actual air flows to each space. Once the testing report is available, additional work might be required to correct issues that are identified and then systems re-balanced. c. A majority of the toilet exhaust fans are provided with charcoal filters and the exhaust air is re-circulated within the toilet rooms. Per current codes, toilet exhaust cannot be re-circulated within the space. Replacement of existing re-circulating toilet exhaust fans with a ducted exhaust system that discharges exhaust air to the exterior is recommended.
		6.2.1.4		Existing HVAC Systems a. Seal the edges of the raised floor supply plenum located in the House Appropriations Committee Room so that the fan coil units located depressed into the plenum at the perimeter do not see supply air temperature in the plenum and inadvertently trigger the fan coil units into a mode of operation that causes simultaneous heating and cooling. The return air temperature sensor probes should be checked on all fan coil units installed in a similar configuration and adjusted so that the probes read the room temperature instead of plenum temperature. b. Facilities personnel have noted that access is limited at the variable air volume (VAV) terminal boxes and therefore regular maintenance is not possible. Reduction of air flow to spaces might be due to dirty coils which prevent air flow. Check and clean VAV box reheat coils. Test and re-balance HVAC-1 and North Annex air handling units.

System	Section No.	Item No.	Order of Priority	Recommendation
Mechanical Systems (Cont.)	6.0	6.2.1.5	Immediate Immediate (Cont.)	Ductwork and Air Distribution System – Existing roof mounted ductwork serving air handling unit HVAC-1 is supported on wood blocks in multiple locations and is a safety concern. Properly secure and support ductwork from roof structure.
		6.2.1.6		Stair Pressurization System – Air handling units OAH-2 and AHU-HA-1 that provide stair pressurization for the emergency stairs is not backed up on stand-by power. Recommend backing up these air handling units on back-up power from the emergency generator. In addition, the ductwork serving these units and mechanical room housing these units should be provided with the same rating as the stair it is serving.
		6.2.1.7		Building Automation System a. Optimize the Heating Plant Control sequence. Work involved: 1. Manually isolate a single HX at a time to function in true lead/lag parallel manner. This will require monitoring and adjustment, and both heat exchangers may need to be active when the utility steam pressure is low. 2. Replace steam control valves and steam traps. 3. Add a temperature sensor at the HWS outlet for each HX. 4. Program the HX steam control valves to control to their respective HWS temperature sensors. Optimize the Heating Plant Control sequence. Work involved: b. In order to reduce the amount of simultaneous heating and cooling occurring in the air handlers, perform retro-commissioning on the AHU coil controls and bridge pumping stations and implement repairs on discovered deficiencies. Work involved: 1. Conduct retro commissioning to determine specific deficiencies. 2. Implement programming fixes during commissioning process, such as PID loop tuning to stabilize supply air temperature. 3. Hardware deficiencies may be discovered during RCx (leaky valves, pump sizing issues, temperature sensor deficiencies, etc.). Replace defective equipment. c. Repair or replace the pneumatic control tube air dryer. The failure of this unit has resulted in excessive condensation throughout the pneumatic controls system. Removing the moisture from the control air will improve system functionality until it is replaced by a digital system. d. Provide a global outdoor air conditions station. This will allow for better control of the BAS mode of operation and reset schedules. The OA conditions station should be located on a north-facing building wall, away from exhaust outlets and vents, and should sample both temperature and relative humidity. e. During our survey, the building's water side economizer was non-functional due to lack of connectivity between the cooling tower controls and the BAS. Work has since been progressing on bringing this system on-line, Loring recommends completing this work expeditiously to take advantage of favorable spring conditions, and performing commissioning functional testing to ensure proper implementation protocols are in place –(This work has been completed since the issuance of the preliminary recommendations.) f. Consider adjusting unoccupied hour setback temperatures and settings to reduce after-hours energy use.
		6.2.2.1	N/A (The following are options to be considered as a subset of overall recommendation 6.2.2.3)	Upgrade Heating System • Option 1: District Steam from BWL with steam to hot water convertors • Option 2: Natural gas fired condensing hot water boilers
		6.2.2.2	N/A (The following are options to be considered as a subset of overall recommendation 6.2.2.3)	Upgrade Cooling System • Option 1: Water cooled electric chillers with cooling towers • Option 2: District chilled water from BWL • Option 3: Water cooled electric chillers with geothermal well field

System	Section No.	Item No.	Order of Priority	Recommendation
Mechanical Systems (Cont.)	6.0	6.2.2.3	1	Central Utility Plant (CUP) Currently the heating and cooling systems serve the Capitol Building only. The addition of the Welcome Center would require an additional heating and cooling plant to serve its heating and cooling loads. To reduce the amount of heating and cooling plants serving different portions of the same building, a centralized approach is recommended. An on-site CUP provides the following advantages: Enables the inspection, maintenance and adjustment of equipment in one centralized location which reduces waste of time and increases efficiency. • Reduces cost by reducing the number of units • Provides redundancy • Reduces the environmental impact • Increases efficiency and better monitoring of equipment. • Ability to control noise from equipment in a central location. Options for the CUP are based on different combinations of the heating and cooling system options described under items 6.2.2.1 and 6.2.2.2. Option A: District steam and water-cooled electric chillers with cooling towers (Baseline) Option B: District steam and district chilled water Option C: Natural gas fired hot water boilers and district chilled water Option D: Natural gas fired hot water boilers and water-cooled electric chillers Option E: Water cooled electric chillers with geothermal well field 

System	Section No.	Item No.	Order of Priority	Recommendation
Mechanical Systems (Cont.)	6.0	6.2.2.4	2a	Ventilation System a. Sub-Basement spaces are not provided with ventilation. The Sub-Basement spaces have issues with condensation as piping and insulation has corroded and deteriorated due to the lack of ventilation. Provide the code required ventilation system for the Sub-Basement. A dedicated outside air system (DOAS) will be utilized to provide tempered air for make-up and ventilation and an exhaust system will be used to discharge the air from the space. DOAS and exhaust system will operate to maintain temperature and humidity within the Sub-Basement. The dedicated outside air units can be used to serve the ventilation of the Sub-Basement as well as provide ventilation to the fan coil units that serve the ground floor and interior spaces on the first floor. b. Existing vertical fan coil units under the windows at the first floor level and above are provided with outside air intake slots. Fan coil units are not provided with any motorized dampers to control the intake of outside air into the space. The outside air intake slots are noted to have dirt and lime build up causing it to be in-effective. Re-activate the fan coil unit outside air intake slots at the exterior wall. Provide motorized damper to control the outside air into the fan coil unit and sequence the damper to be open only when the unit is in operation.
		6.2.2.5	2b	HVAC Systems To provide a reliable HVAC system that provides the controllability, features and sequences to improve the temperature and humidity control within the building, the following changes to the HVAC systems are recommended. Fan coil unit arrangements listed below can be used in a stand-alone arrangement or a combination of the options. a. Fan Coil Units 1. Option 1 – Fan Coil unit arrangement for Non-Critical spaces 2. Option 2 – Fan Coil unit arrangement for Critical spaces on the Perimeter – Ventilation air ducted to the fan coil units 3. Option 3 – Fan Coil Unit with ventilation air ducted directly to the space b. Humidity Control – Humidity control strategies are included in this report for the following spaces. Low level humidification might be required during winter and de-humidification during summer to maintain humidity within these spaces within the ranges specified (humidification and de-humidification sequences should only be finalized after additional monitoring data has been reviewed). 1. *House and Senate Chambers*: Provide dedicated air handling units with capabilities for humidification and dehumidification and one of the fan coil unit options listed above for supplemental heating and cooling. For fan coil units under windows, the existing outside air intake slots are recommended to be blanked off to prevent outside air infiltration via these slots. 2. *Historic Supreme Court (Senate Appropriations Committee Room)*: Dedicated outside air unit will be used to provide ventilation air for the space. Fan coil units will be used to handle the remaining loads for the space. For fan coil units under windows, the existing outside air intake slots are recommended to be blanked off to prevent outside air infiltration via these slots. 3. *Governors Suite*: Dedicated outside air unit will be used to provide ventilation air for the space. Fan coil units will be used to handle the remaining loads for the space. For fan coil units under windows, the existing outside air intake slots are recommended to be blanked off to prevent outside air infiltration via these slots. 4. *Attic space*: Provide dedicated air handling unit with capabilities for humidification and de-humidification. c. Rotunda – The Rotunda is not provided with any direct air flow currently. This space is noted to be a transitory space and there are no complaints of the space being uncomfortable for the occupants. There is a large stack effect through this space due to the large open volume. Additional monitoring of temperature and humidity is recommended in Section 8.0 of the report. The additional monitoring of temperature, humidity and a computational Fluid Dynamics (CFD) analysis could identify how the space behaves and what additional strategies can be employed to reduce energy consumption and how to better protect the artifacts. d. East Wing fourth floor offices: The East wing offices are served by air handling unit HVAC-1 located in a penthouse mechanical room. The air handling unit and associated VAV boxes do not have adequate maintenance access. It is recommended that the air handling unit and VAV boxes be replaced with a Dedicated Outside Air System (DOAS) that serves ventilation air directly to the spaces. Heating and cooling loads for the spaces will be handled by fan coil units. Removing the VAV boxes and locating the DOAS unit in the location of the existing air handling unit will provide additional maintenance space for the unit.
		6.2.2.6	1	Building Automation System - The entire BAS system is in need of replacement with a new, open protocol based digital system. a. The pneumatic air compressor should be demolished, and the pneumatic tubing abandoned in place. b. The new control system should be based on an open, BACnet based protocol, compliant with ASHRAE Standard 135. Proprietary controls systems should not be utilized. c. New control panels should be added to the building as necessary to accommodate the needs of the new digital control system. d. The FCU throughout the building will require entirely new controls, including: Fan motor start/stop, OA damper open/close and position, CHW valve modulation, HW valve modulation, space temp/humidity, and alarms. e. The differential pressure sensors currently being used as a proof of flow device should be replaced with current sensors and VFD feedback points. f. The building leak detection system should be replaced, and should cover an expanded area. New areas to be monitored should include crawlspaces, attic MER's, and other difficult to access areas prone to mechanical, plumbing or foundational leaks.

System	Section No.	Item No.	Order of Priority	Recommendation
Plumbing Systems	7.0	7.13.1.1	Immediate	To assess the interior condition of the existing domestic water piping throughout the building, several locations shall be identified and a section of piping in these preselected locations should be removed to determine enable the interior condition of the piping to be visually inspected to determine whether the piping systems are in good condition, or whether they need to be replaced.
		7.13.1.2		The sanitary system mains should be video scoped for damaged / cracked piping. The sanitary piping shall be replaced where applicable. The sanitary sewer ejector pumps shall be inspected for possible replacement if required.
		7.13.1.3		The storm system piping along the perimeter of the building shall be video scoped for cracked piping or blockage for tree roots. The storm piping shall be snaked upon confirmation of any blockage shown on the video examination.
		7.13.1.4		All of the existing point of use water heaters on the upper floors serving lavatories and sinks shall be inventoried, and those installed more than 8-years ago should be replaced. Any point of use water heater that has signs of damage and/or leaks shall be disconnected and removed. The replacement shall be done collectively or separately at their current location. The building engineers are doing a good job overall maintaining the point of use water storage heaters and replacing the units at the time before their failure.
		7.13.1.5		Samples of the incoming domestic water should be obtained and tested to determine its content, and it is recommended that the local water authority be contacted for an explanation as to why the water pH has changed.
		7.13.2.1	1	The hot water generator equipment shall be replaced. The hot water storage tank shall be replaced with a storage tank properly sized to accommodate the hot water demand of the building. The hot water storage tank temperature shall be increased to 140 degrees- F and then delivered to the building through a thermostatic mixing valve at 120 Degrees-F to prevent the growth of legionella within the water storage tank.
		7.13.2.2	1	Existing sanitary piping and the sanitary lift station in the boiler room should be reconfigured to "clean" up the current installation and repair the damaged sanitary line from the condensate cooler floor sink.
		7.13.2.3	1	The domestic water piping insulation shall be inspected for pipe wall integrity and replaced where applicable. All gate valves that are leaking and/or oxidized shall be removed and replaced with full-port, two-piece construction ball valves. During the valve replacement the domestic water piping shall be investigated for damage and defective sections to be replaced.
		7.13.2.4	2	The existing triplex booster pump shall be replaced. The replacement booster pump shall be duplex pump setup with a hydroCumulator/bladder tank that will allow the pumps to remain off when the demand is low. The booster pump assembly shall be provided with the options that can be connected to the building automation system for monitoring water usage and tracking power consumption.
		7.13.2.5	2	The fire protection jockey pump supply shall be disconnected from the potable water supply and reconnected to the incoming fire water service downstream of the backflow preventer.
		7.13.2.6	3	Pipe insulation shall be provided to all domestic water piping that is not insulated or has experienced damage.
		7.13.2.7	3	It is recommended the two (2) water meters on the domestic water service shall be removed be replaced with remote reading meters. This will require coordination with the utility.
		7.13.2.8	3	The backflow preventers serving the mechanical make up water and the irrigation system shall be replaced with the new isolation valves.
		7.13.2.9	4	All abandoned water piping which are capped dead ends shall be remove and discarded appropriately. All removed copper piping shall be recycled
		7.13.2.10	5	The building domestic hot water needs shall be provided using the same fuel source as is used for HVAC building heating systems. The storage tank shall be equipped with an expansion tank sized for the total volume of water to be stored. The hot water system shall be furnished with a thermostatic mixing valve connected to the outlet piping from the hot water tank to serve the lavatories and sinks within the building. The hot water generator and thermostatic mixing valve equipment shall be provided with options that can be connected to the building automation system for monitoring of water temperature, usage and tracking power consumption.

System	Section No.	Item No.	Order of Priority	Recommendation
Building Envelope & Environmental Comportment	8.0	8.9.1.1	Immediate	Investigate and document several unknowns which will impact stack effect (also known as "chimney effect") in the building: • The cause of the strong air movement observed entering the cavity behind the *Allegories*; • Supply, return and outside air paths for HVAC-1 in the fourth floor East Wing attic. Determine if there are duct leaks that would pull air from the cavity behind the *Allegories*; • The location and extent of the four large vent shafts surrounding the Rotunda base wall, including possible connections to the interstitial space between the inner and outer domes at the base of the drum; • The location and extent of all other vertical chases and small airshafts in the interior and exterior walls of the building.
		8.9.1.2		Investigate and document the construction of key locations in the Drum and Dome of the upper Rotunda which may lead to condensation or leaks in the interstitial space of the upper Rotunda: • The possible thermal-bridging at the balcony deck at level seven; • The window sill and leak interception and drainage behind the windows in the dome.
		8.9.1.3		Expand the existing environmental monitoring program to include real time monitoring of exterior conditions, critical envelope and interior conditions to assess condensation risk, stack effect and related environmental performance issues – Several areas and criteria were recommended for monitoring and are detailed in recommendation 8.9.1.3
		8.9.2.1	1	Reduce Air and Vapor Exchange between the Interior and Exterior • Weather-strip all entry doors to the building; • Enforce use of vestibules at entry points, including staff and delivery entrances; • Install low-leakage, fully closing modulating dampers on all outside air intakes for AHUs and FCUs; • Reduce reliance on "Free Cooling" or "Economizer Mode". Change the sequence of operations so outside air for "free cooling" is activated when exterior dew point temperature is below target levels for the interior; • Implement measures and improvements necessary to resolve issues identified by 8.9.1.1 investigations and 8.9.1.3 Monitoring.
		8.9.2.2	2	Resolve Thermal Bridges and Leaks in the Rotunda - Implement measures and improvements necessary to resolve issues identified by 8.9.1.1 investigations and 8.9.1.3 Monitoring.
		8.9.2.3	2	Implement the proposed ASHRAE A23 Classes of Control (See Section No. 8.7 and Section No. 5) • Provide improved dehumidification in the identified zones. Expect that dehumidification will be required in Summer as well cool humid periods in Spring and Fall; • Plan for future introduction of low-level humidification in the identified zones; • Introduce low-level humidification when all envelope issues are resolved

System	Section No.	Item No.	Order of Priority	Recommendation
Historic Artifacts	9.0	9.3.1	Immediate	All of the Historic Artifacts, Paintings and Furnishings are light sensitive. This damage is cumulative and irreversible. Although these materials have been exposed to light for many years, reducing illumination when it is not required will greatly improve their longevity while simultaneously provide savings in energy costs. • Turn off picture lights and all other lighting that directly illuminates the portraits, the Allegories and the historic furniture when the building is closed to the public. • Ensure that all draperies, shades, blinds and other window treatments are closed when the Senate, House and Supreme Court Chambers, the Governor's Suite, and the committee rooms are not in use.
		9.3.2	N/A	Allegories - The Allegories are especially challenging because of their location, unknown method of installation and their integral importance to the overall interior decoration of the building. Their location and the limitations of the building envelope increases their vulnerability to deterioration from improper environmental conditions, which is exacerbated because of the difficulty to accurately observe condition changes. Improved understanding of the artist's painting techniques, the method of installation in the building and the paintings' response to environmental conditions in the building will help to inform stewardship efforts for preservation of these important resources. • Continue to assemble documentation about the techniques of the paintings and their installation in the building and the conservation treatment completed in the 1986 – 1992 Restoration: contact the Detroit Institute of Arts for copies of the pre-treatment condition assessment and treatment proposal as well as paperwork authorizing treatment; • Expand the environmental monitoring program to include: space conditions for relative humidity and temperature near the painted surface and in the interstitial space behind the paintings; infrared monitoring for thermal expansion and contraction of the painted surface and the metal substrate; and pollutant deposition monitoring. • Contract with a paintings conservator to surface clean and complete a detailed condition assessment of each painting using high definition photography to document baseline conditions for the paintings against which condition changes can be evaluated; • Contract with a paintings conservator to develop and train staff in inspection and maintenance program; • Evaluate condition observations against collected environmental monitoring data to determine correlations and develop interventions if necessary; • Install UV reduction materials on the windows in the Rotunda; • Consider installing transmission reduction film on the windows in the Rotunda to reduce overall exposure to high intensity illumination; • Replace the high-intensity and hot illumination sources in the Rotunda with LED fixtures as recommended in Section 5 Interior Lighting; • Provide protection during construction.
		9.3.3		Portraits – Take protective measures at the painting level. Priority should be given to the paintings located in the Rotunda and corridors because they are at greatest risk to damage from uncontrolled conditions. • Modify the picture frame lights to allow for use of LED lamps to reduce spot heating and light damage; • Continue the program of conservation treatment for the paintings and include fabrication of protective microclimate enclosures as part of each project; • Budget for conversion of the frames of previously conserved paintings to create protective microclimate enclosures; • Specify that all future Governor's portraits include fabrication of protective microclimate enclosures as part of the project; • Provide protection for the portraits during construction.
		9.3.4		Historic Furnishings in the House, Senate and Supreme Court Chambers - As objects subjected to daily use, the standards of care for the historic furnishings in the House, Senate and Supreme Court Chambers differ from those that are recommended and necessary for the portraits and the historic furnishings in the Governor's Suite. However, they must be protected from damage caused by environmental extremes; water; fire; excessive illumination; dust and gaseous pollutants; and improper and aggressive cleaning. • Provide low level winter-time humidification in these three areas; • Change the TV Illumination sources to LED fixtures to reduce cycling of heating and relative humidity which can exacerbate damage to wooden furnishings in Supreme Court Chamber; • Thoroughly document the condition of each piece of furniture to provide baseline conditions against which future condition changes can be made; • Conduct annual inspections to document condition changes; • Reduce/moderate natural light entry into the spaces to reduce light damage and solar gain with associated relative humidity changes; • Expand the environmental monitoring program to include the Supreme Court; • Provide protection during construction.

System	Section No.	Item No.	Order of Priority	Recommendation
Historic Artifacts (Cont.)	9.0	9.3.5	N/A	Historic Furnishings in the Governor's Suite – • Expand the environmental monitoring program to include this space; • Relocate the tables from their current locations immediately in front of the windows where they are exposed to elevated levels of natural illumination; • Keep the window coverings closed to exclude daylight at all times, except when the space is occupied; • Follow recommendations in Section 8 Building Envelope and Environmental Comportment for inclusion of low level winter-time humidification in the Governor' Suite; • Contract with Michigan Antique Preservation Co. Inc. for conservation treatment of the pieces; ensure that the conservators are aware of the conditions into which the pieces will be returned after conservation treatment so that the treatment can be designed for the conditions; • Conduct annual inspections to document condition changes; • Provide protection during construction.
Historic Plaster & Finishes	10.0	10.2.1.1	Immediate	Observed several areas of apparent damage from either water infiltration through the building envelope or from internal plumbing or sprinkler leaks. Therefore, it is recommended the following locations of water damage be reviewed and investigated to determine whether there is an active problem. • Room S103, North Wall • Room E224, Southeast Corner • Rooms H260/262. • Room S307, South Wall: • Room H375, North Wall • Rooms H424/H432 and H428 • Room S405 • Room S404 • Room S301
		10.2.1.2		Investigate the condition of the cracked plaster cornices below the viewing balconies along the north wall of the Senate chamber and the south wall of the House chamber. Given the importance and active use of the two chamber rooms, understanding the stability of these cornices is of particular importance.
		10.2.2.1	1	In order to get baseline information on current environmental conditions, monitor locations where the existing finishes are believed to be original (the Governor's Parlor/Room E220, the Supreme Court/Room S320 and the north end entry of corridor CN100). Refer to the specific monitoring recommendations listed in Section 8.0. Until the baseline environmental information is gathered, the following is recommended; • Avoid large or rapid fluctuations in temperature that might negatively impact the paint finishes. • For spaces that contain original distemper finishes, control the relative humidity of the room generally. In addition, avoid high localized relative humidity at the boundary layer of air at the painted surface, as the animal glue-based distemper finishes can be a nutrient for mold. Refer to Section 10.2.2 for details.
		10.2.2.2	2	Identify locations where historic fabric remains in the building (plaster, woodwork, sheetmetal) to guide future alterations in the building and protect areas of remaining, historically significant architectural fabric.
		10.2.2.3	3	Once the locations of original fabric have been documented for the entire interior, document areas where historic paint evidence remains (whether currently exposed or overpainted) through in situ investigation and cross-section microscopy of removed paint samples. This critical baseline documentation of all historic decorative finish locations will allow for more definitive preservation priorities to be developed for the remaining historic fabric and subsequently guide future decision-making.
		10.2.2.4	4	In locations where the existing finish is believed to be largely original (the Governor's Parlor/Room E220, the Supreme Court/Room S320 and the north end entry of corridor CN100), the extent of remaining original paint should be documented by identifying areas of touch-up painting, restoration infill painting and wholesale surface over-painting. The type of paint (i.e. distemper, oil, acrylic) used in the original and any subsequent restoration campaigns should also be documented in order to guide recommendations related to appropriate environmental conditions or treatment.
		10.2.2.5	5	After original decorative finish locations have been identified and documented, a thorough conditions assessment of the existing original decorative finishes should be performed, and an appropriate conservation treatment plan should be developed.