EXECUTIVE SUMMARY

ZS was commissioned by Milwaukee County to perform an inspection and develop repair recommendations for the glazing system at the Mitchell Park Conservatory Domes. The Domes are in need of extensive rehabilitation, and Milwaukee County is pursuing a series of studies to determine a long-term plan for the future of the facility. The glazing system investigation focuses on the wire glass and aluminum frame, and is divided into Task 1 – Glazing System Investigation and Recommendations, and Task 2 – Installation and Testing of Mockup. This report is the culmination of the findings and recommendations associated with Task 1.

The Domes are three identical conoidal structures completed in 1965. They form the primary part of the Mitchell Park Horticultural complex, which also includes support spaces, greenhouse buildings, and educational spaces. Each Dome is approximately 85 feet high by 140 feet in diameter and encloses an area of 15,400 square feet. The Show Dome, Tropical Dome, and Desert Dome each house a distinct environment which is maintained year-round.

Each Dome displays extensive repair and maintenance issues including broken glass panes, failed gaskets, failed sealant joints, organic growth, and leaks. Spalls falling from the concrete structure necessitated the temporary closure of all three Domes and installation of a protective mesh on the interior. Leaks are reported to be worsening over time, and are contributing to accelerating degradation of the aluminum frame and concrete structure in each Dome.

The Domes have been named by the National Trust for Historic Preservation as a National Treasure, and they are eligible for designation by the National Register of Historic Places as a National Historic Landmark. Public feedback in the form of signed petitions, comments at public hearings, and survey responses has been overwhelmingly in favor of preserving and repairing all three Domes. An optimal long-term plan for the Domes would therefore involve a historically sensitive rehabilitation of all Domes.

The glazing system study in Task 1 involved a comprehensive internal and external investigation of the existing wire glass, gaskets, and aluminum frame.

The investigation methodology included a series of tasks as follows:

1) Document Review – Collection and review of every available construction document and prior study or report.
2) Visual Investigation – Comprehensive examination of every surface on the interior and exterior of all three Domes using visual photography, infrared photography, binoculars, and an Unmanned Aerial Vehicle (drone).
3) Water Testing – An accessible section of each Dome was tested for water penetration through the glazing system using an AAMA 501.2 hose nozzle.
4) Investigative Openings – Selective disassembly and reassembly of a portion of each Dome in the area used for water testing. Assessment of system components and verification of adherence to original construction drawings.
5) Analysis – Engineer's assessment of the current glazing system including design intent, current functionality, engineering loads and capacity, life span of components, and long-term viability of the system.

The major findings of the visual investigation are as follows:

- Hundreds of panes of broken glass.
- Extensive areas of corrosion and staining on the aluminum hubs and pressure bars on the exterior.
- Failure of gaskets and sealant joints at all locations.
- Extensive areas of corrosion, staining, and solids buildup on the aluminum frame and hubs on the interior.
- Fogged glass panes, especially at ground level.
- Extensive areas of organic growth on the gaskets and the glass on the interior.
- Leaks from the intersection of the hub body with the aluminum rafters, including multiple leaks per Dome.

Water testing produced leaks on the interior within minutes at all testing locations. The current glazing system has been determined to lack integrity against water infiltration at all areas.
The major findings of the investigative openings are as follows:

- Standing water was present in all opened hubs up to the level of the drain lock nut.
- Black staining and solids accumulation were present in all hubs up to the level of the drain lock nut. Solids had completely clogged the drain in multiple hubs.
- All gaskets on the hub interiors, pressure plates, and aluminum rafters have failed due to age and exposure.
- All original components of the assembly conform to the construction drawings.
- The glass panes have compressed the gaskets and are effectively in direct contact with the aluminum frame. There is effectively no glazing pocket in the existing system.

Analysis of the existing system has determined that the condensation collection and drainage system is functioning as intended in the original design. The primary causes of failure in the system are the age of the gaskets, lack of maintenance, and the construction of the intersection of the exterior hub cover with the pressure plates. The existing aluminum frame is in good condition with no significant corrosion or degradation and is capable of supporting a moderate increase in structural loads. The aluminum frame was designed to accommodate large amounts of structural movement, however the lack of a glazing pocket at the edges of the glass panes results in the glass absorbing movement stresses and consequently cracking. The original wire glass has experienced fogging and cracking as a result of its age and the inherent qualities of ¼” wire glass.

Elements of the current glazing system assembly are not capable of providing a water-tight enclosure as they were originally designed. The intersection of the exterior hub cover with the aluminum pressure plates forms a significant height differential which cannot be sealed by the original gasket. The condensation collection and drainage system is functioning as designed, however numerous failures have occurred as a result of age and deterioration of the gaskets and the lack of maintenance. The lack of a glazing pocket in the original system results in cracking of glass panes or disengagement of the glass panes from the gaskets from structural movement. One-quarter-inch wire glass is brittle and prone to spontaneously fogging and cracking over time as micro-cracks develop in the glass. As a result of these and additional factors, a repair program consisting of replacing original components with identical new pieces cannot be considered a viable long-term strategy.

The viable long-term repair options for the Domes are summarized as follows:

1) **Concept 1** – Replace all original glass with new 7/16" laminated glass with low emissivity (low-e) coating. Install new aluminum extrusion onto existing aluminum frame. Install new exterior flush structural silicone joint. Remove all exterior hub covers and pressure plates. Install new redesigned hub cover plates. Clean all hub bodies. Install new redesigned interior gaskets.
   Estimated Cost: $18,876,000

2) **Concept 2** – Replace all original glass with new 7/16" laminated glass with low-e coating. Install new EPDM/PVC extrusion with integrated gutter onto existing aluminum frame. Remove all exterior hub covers and pressure plates. Install new redesigned hub covers and pressure plates. Clean all hub bodies and install inspection ports on each hub body interior.
   Estimated Cost: $18,845,000

3) **Concept 3** - Replace all original glass with new 7/16" laminated glass with low-e coating. Install new aluminum extrusion onto existing aluminum frame. Install new exterior flush structural silicone joint. Remove all exterior hub covers and pressure plates. Install new redesigned hub cover plates. Install new aesthetic/non-functional pressure plates. Clean all hub bodies. Install new redesigned interior gaskets.
   Estimated Cost: $19,500,000

The primary benefits of Concept 1 include the use of an industry-standard glazing system, reduction of potential failure points, and relative ease of future examination and maintenance. A flush structural sealant joint will shed water off the exterior surface of the Dome more efficiently, thereby reducing the potential for leaks from water collection. Redesigned hub covers will feature an improved gasket and sealant system, and will allow for integration of the structural and hub cover sealant, providing a continuous exterior sealant barrier. A new interior frame extrusion would increase the size of the glazing pocket to modern standards. Concept 1 would result in a significant alteration of the exterior appearance of the Domes.

Concept 2 involves replacing the original hub covers and exterior pressure plates with a new engineered dry-gasket pressure plate system. This system would involve standardized components and require less highly skilled labor to install than the structural sealant joint in Concept 1. The new interior frame extrusion would increase the glazing pocket to the largest possible extent. The new frame extrusion would also function as an integrated condensation control system and eliminate the individual interior gaskets. Concept 2 would result in the closest resemblance to the appearance and functionality of the original system. Long-term examination and maintenance of this system would be slightly more labor intensive.

Concept 3 is similar to Concept 1 but features aesthetic/non-functional exterior pressure plates to more closely replicate the original appearance of the Domes. This concept should be considered in the event that the benefits of the flush structural silicone joint are desired but the State Historic Preservation Officer determines that the Domes would not be eligible for historic designation or tax credits if Concept 1 is selected.

Each of the repair concepts would result in an extended life span, elimination of all current issues, and improved efficiency and functionality for the Domes. The existing aluminum structural components of the glazing system are in good condition and have a long useful life span. Replacement of the existing wire glass with new laminated glass will improve the durability, clarity, and efficiency of the glazing. Replacing the existing exterior pressure plates and hub covers with new designed hub covers and a new structural sealant joint or new pressure plates will eliminate leaks and will provide a larger glazing pocket to accommodate movement and allow for standardized glass sizes. An extended maintenance plan and budget should be developed with each of these options, including regular examinations. Each of these options can potentially provide a life span far in excess of the 20-year warranty on the system. Implementation of any of these repair concepts will provide a new extended life for the Domes and ensure that they remain an iconic Milwaukee landmark for generations to come.