SEALED ENVIRONMENT
Climate Control of Historic House Museums

by

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ABSTRACT

Horaceville, a nineteenth-century stone masonry historic structure in Kanata, was transformed in the late twentieth century from a farm residence to a public house museum. Today, it exhibits a permanent collection of furniture, paintings, and historical artifacts. The optimal environmental conditions for such collections are not always ideal for the building, leading to pronounced conflicts between preservation of the building's historic fabric and the housed artifacts. Exhibiting a collection of artifacts in an older building, however, creates a new life and purpose for the building and at times saves it from demolition. This thesis will investigate and document the performance of Horaceville through **scientific practices** and **cultural analysis**, and propose ways to create **appropriate environmental conditions** for the collection without impacting the integrity of the historic structure of the building.

1. **Pinhey's Point, Horaceville and the barn** (Huntley, 2011)

ACKNOWLEDGMENTS

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PREFACE

Many historic homes have been transformed from a residence to a house museum. House museums are a type of museum that displays a dwelling's historic fabric, furnishings, household equipment, and fittings (Young, 2007). A historic house was designed with a certain type of construction and systems to provide the required indoor environment for a residence. After transformation to house museums, these buildings face the challenge of providing a stable and museum-quality indoor environment for the occupying artifacts. Fluctuations of relative humidity and temperature have a negative impact on the museum collection. To create a museum environment, often house museums install new climate control systems. These modern climate control systems, however, were designed for new construction and work best paired with sealed building envelopes (Kerschner, 1992).

On the contrary, historic buildings are breathable constructions and are compatible with building materials that allow the fabric to absorb and release moisture. Retrofitting historic fabrics with moisture impermeable building materials such as thermal and vapour barriers will restrict the movement of moisture, leading to physical damage of the historic fabric (Historic Scotland). A house museum not only contains a museum's collection, but the historic structure itself constitutes a museum.

2. **Horaceville** (Karimi, 2015)

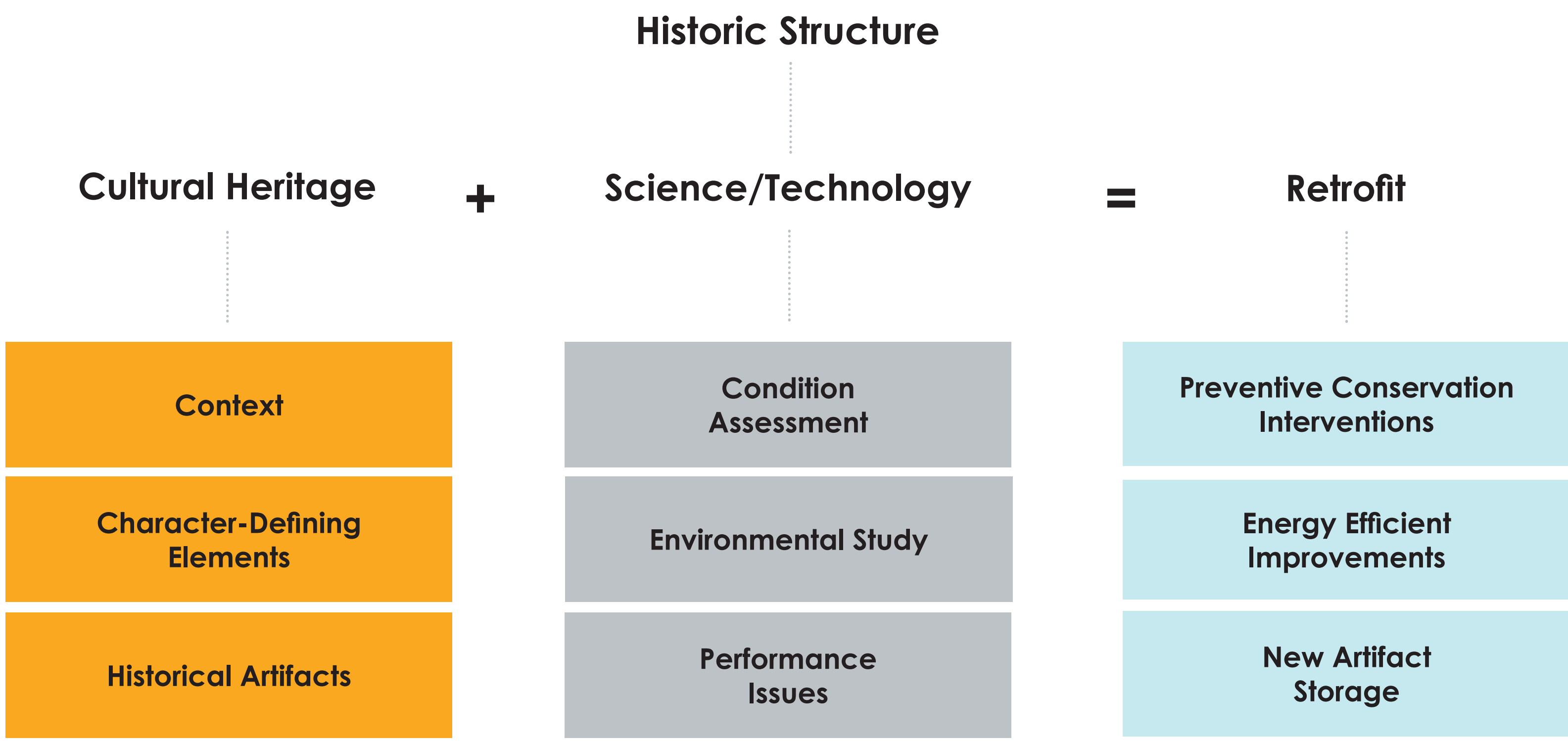
Appropriate conservation principles recognize that historic structures and the contents placed within them deserve equal attention in preservation planning. The main objective of preservation of a house museum and artifacts is to maintain them in a condition that allows future generations access, study, and enjoyment (Cassar, 1994).

This research consists of cultural heritage analysis and scientific studies of Horaceville, a house museum in Kanata. The cultural heritage evaluation of the historic structure assists in the understanding of the historical, contextual, and architectural values. This analysis also includes a collection survey of the artifacts housed in Horaceville. Additionally, scientific practices and techniques are used to evaluate the existing performance of the building and its indoor museum environment. The evaluation involves condition assessment, environmental study, and comprehensive performance analysis. The integration of the cultural studies and the technical findings will help this thesis to propose appropriate retrofits for the building and the artifacts. Retrofit measures include preventive conservation strategies to minimize the environmental impacts on the historic elements, as well as a proposal for a new artifact storage facility on site.

3. **Original heating system** (Karimi, 2015)

4. **Implemented heating system** (Karimi, 2015)

THESIS STRUCTURE



THESIS QUESTION

Many significant historic structures are used to house and display artifacts. It is well recognized that historic structures and the contents placed within them deserve equal attention in care and conservation planning. This thesis attempts to address/propose appropriate measures and strategies needed for the preservation of both historic structures and the artifacts housed in them.

CULTURAL HERITAGE

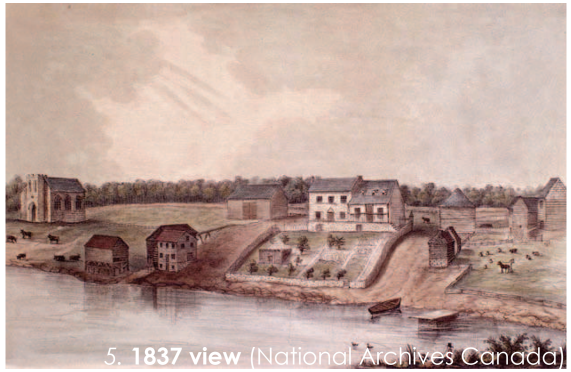
1.1 INTRODUCTION

The following chapter is an overview of the context and history of the site. The historical, contextual, architectural, and functional values of the historic place are briefly explained to get a feel for the significance of the site. Understanding the character-defining elements of the building and the housed historical artifacts is the baseline for the condition assessment study in the next chapter.

1.2 CONTEXT

HISTORICAL VALUES

According to historical records and previous investigations, Hamnett Pinhey, an English merchant and a veteran of the Napoleonic Wars, immigrated to Upper Canada in1820 to take ownership of a thousand-acre military land granted to him for services to the crown. In 1847, Pinhey entered politics as a member of the Canadian Legislature. He established one of the first agricultural settlements, Pinhey's Point, on the Ottawa River. Throughout the nineteenth century and early twentieth century, Pinhey's settlement developed as a farm complex with log cabins, a stone house (Horaceville), barns, mills, a church, a fort terrace, a powder house, a smoke house, and other related agricultural outbuildings. The estate became one of greater Ottawa's commercial, industrial, religious, and educational settlements (Gerrard, 1981). Today, Horaceville, the barn, and several other agricultural outbuildings are still standing on the site; others, such as the stone kitchen, the church, the fort terrace, and the powder house are in a state of ruins. The original layout of the land is of historic value and showcases some of the first examples of agricultural settlements in Northern Ontario. Ontario Heritage Trust issued a heritage easement in 1988 to conserve the stone house. The City of Ottawa has also designated Horaceville under the Ontario Heritage Act.



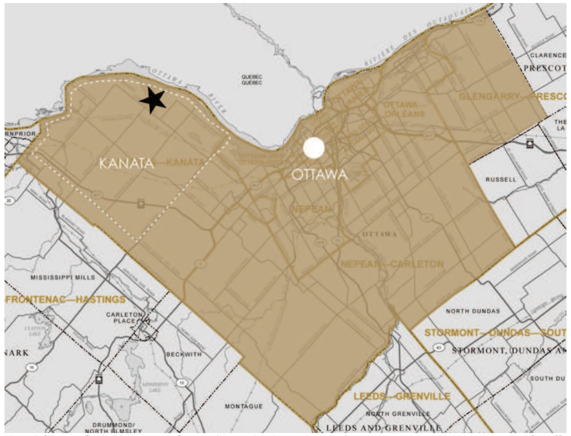
5. **1837 view** (National Archives Canada)

6. **1925 view** (National Archives Canada)

7. **2011 view** (Huntley, 2011)

CONTEXTUAL VALUES

Pinhey's Point is located on the southwest bank of the Ottawa River. It is approximately eighteen kilometres from downtown Kanata and thirty-eight kilometres from downtown Ottawa. The Pinhey's Point property consists of eighty-eight acres of mainly open agricultural land, similar to an agricultural village with Horaceville as the central element of the complex. There are two ways to access the site: by a country road from the south side, and by the river from the north side of the estate. There is a relatively flat and open land on the south side of the site, whereas on the north, the land slopes away from the property towards the river. Horaceville is located on high grounds to offer an unobstructed view across the river towards Aylmer. The natural grade of the site was one of the most important factors for Pinhey in choosing the location for placing the house (Maclennan Associates Architects, 1981).



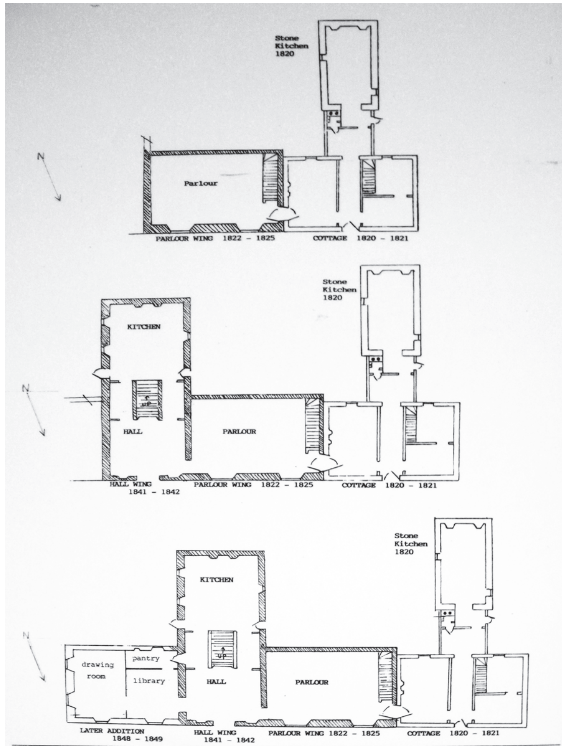
8. **City of Ottawa** (Federal Electoral Map, add-on: Karimi)

9. **Pinhey's Point view** (Huntley, 2011)

FUNCTIONAL VALUES

In the nineteenth century, Horaceville and the surrounding outbuildings expanded as a result of the growth of the family and their wealth. In the twentieth century, the Pinhey family size and wealth declined and eventually they sold the estate to the Township of March in 1971. In 1983, the Pinhey's Point Foundation developed the estate as a historic site and passive recreation area. In 1990, the City of Kanata (now part of the City of Ottawa) took ownership of Pinhey's property and commissioned the well-known Canadian conservation architect Julian Smith for the Master Plan Study and restoration of Horaceville. The City approved to upgrade the building as little as possible. The restoration project began in 1995 with the implementation of contemporary functions such as mechanical, electrical, and plumbing systems, a fire wall, public washrooms, restoration of finishes, and installation of display rails and cases. The house was reopened in 1999 as a seasonal public house museum with furnished period rooms, exhibiting a permanent collection of historical artifacts of the region. The house museum is also a venue for temporary exhibitions, special events, and celebrations (Pinhey's Point Foundation). The house museum operates from May to August, but the site stays open throughout the year.

10. **Farm complex** (National Archives Canada)



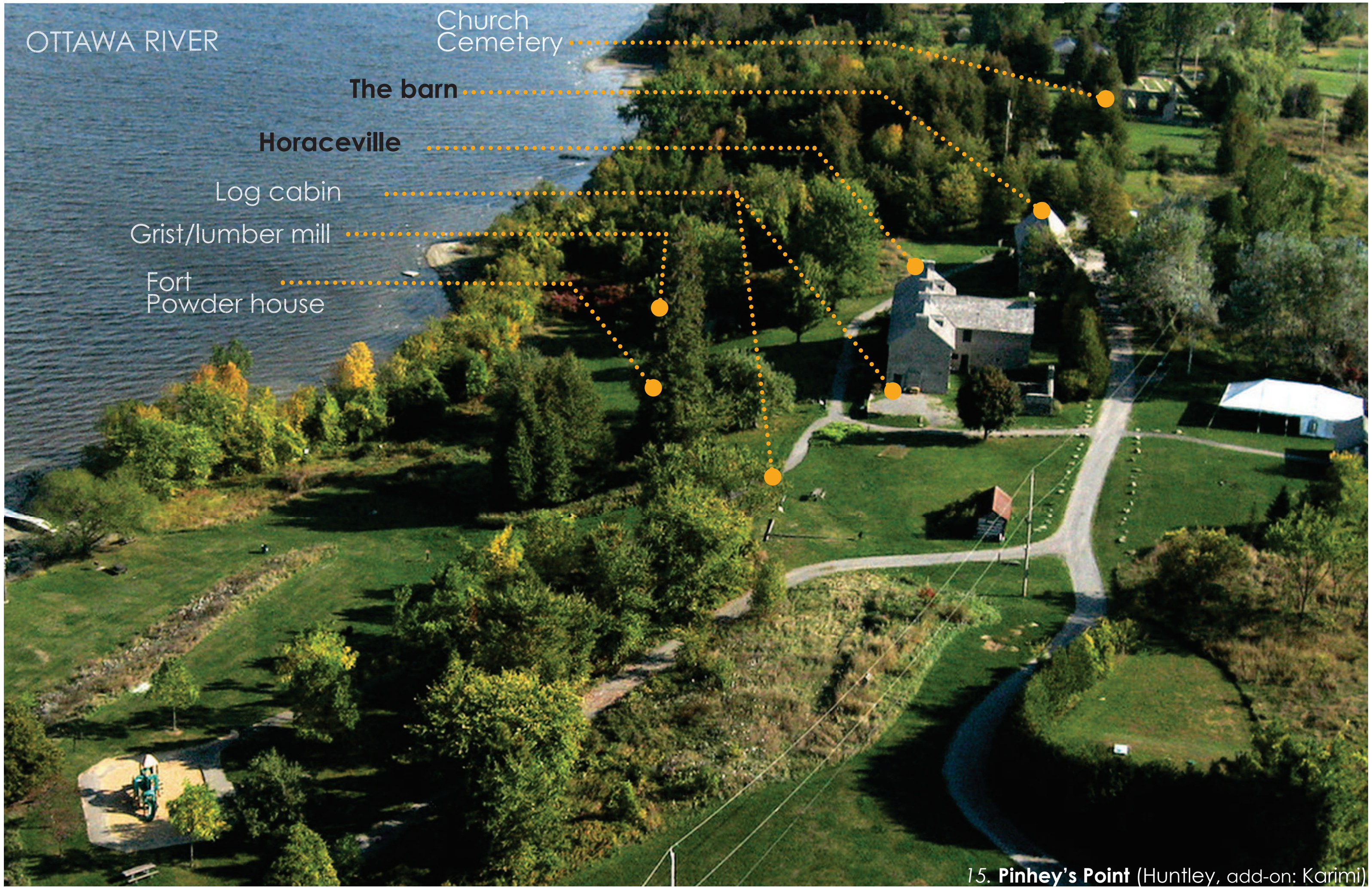
11. **Horaceville evolution** (National Archives Canada)

Today, the City of Ottawa owns and manages the building, and the Pinhey's Point Foundation owns the artifacts. The dual ownership of Horaceville is a successful model for house museums. The City maintains and programs the building with multiple events throughout operating and off-peak seasons. The Foundation preserves the artifacts and organizes historical exhibits during the operating seasons. The Foundation also publishes the Horaceville Herald, a newsletter related to the history of the site and the current activities of the foundation.

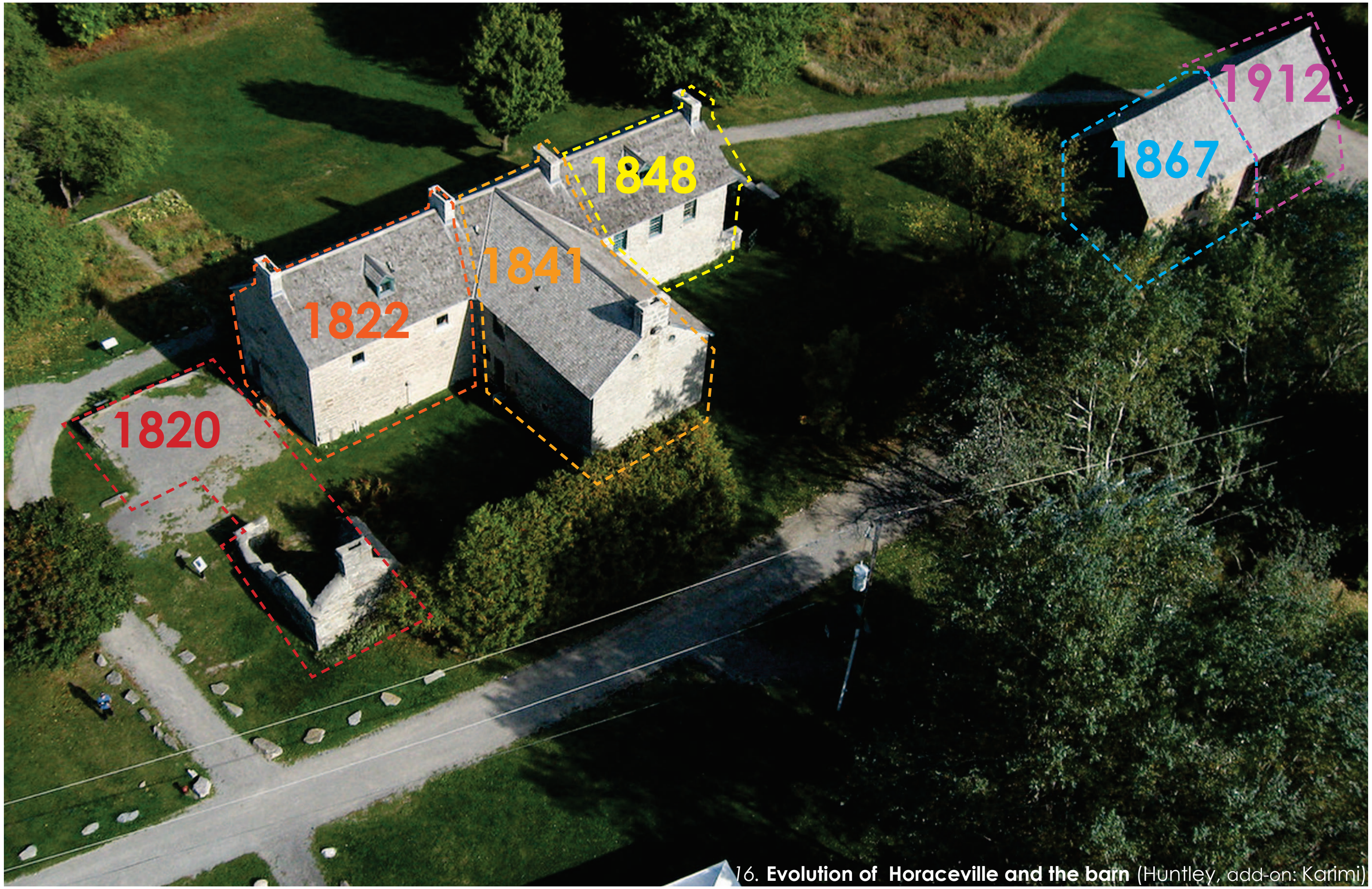
12. **Entrance hall, 1980** (Maclenna Associates)

13. **1999 restoration** (PPF)

14. **Exhibition room** (Karimi, 2015)



15. **Pinhey's Point** (Huntley, add-on: Karimi)



16. **Evolution of Horaceville and the barn** (Huntley, add-on: Karimi)

1.3 CHARACTER-DEFINING ELEMENTS

Horaceville is a two-and-a-half storey masonry house constructed in four phases, three of which still exist today. The first phase was the construction of the log house in 1820 (demolished in the 1970's), followed by the stone parlour in 1822, the central stone wing with south side kitchen in 1841, and the east stone wing in 1848 (Smith, 1991). The building's fabric is of stone masonry, dressed in two different methods; the main façade facing the river is clad in fine squared ashlar stone with regular coursing, and all other walls are in rubble stone partially covered with stucco, which was removed during the stabilization work of 1989.

Another significant physical element of the house is the original heating system and its network of flues. The house was originally heated with a series of fireplaces and wood stoves to make the house relatively more comfortable in its harsh environment. Every section of the house has its own chimney stack which acts as a separation between various wings that still exist today. There are also remains of floor and wall openings and ceiling grilles throughout the house that showcase the original network of stovepipes. There is an oak staircase in the entrance hall of the centre wing, which acts as the main access to the second floor. The overall dimension and structure of the staircase give it a grand appearance.






17. **Stone masonry** (Karimi, 2015)
18. **Entrance door** (Karimi, 2015)
19. **Coal operated fireplace** (Karimi, 2015)
20. **Flue opening** (Karimi, 2015)
21. **Lillonium flooring** (Karimi, 2015)
22. **Oak stair** (Karimi, 2015)

The original interior finishes and plaster cornices are of significant historic value (Smith, 1991). The interior finishes include lath and plaster of different types: plain, painted, wallpapered, and stained. The wood surfaces of floor boards and interior doors were hand grained. The 1995 restoration project revealed half of the kitchen ceiling lath that was sawn differently from the other half, confirming two different methods of craftsmanship. It was also indicated in Hamnet Pinhey's diary that two workmen were involved in the construction of the kitchen (Smith, 1991). The house was constructed with hand-forged nails and handpicked beams. According to Julian Smith,

"The preponderance of stove pipe holes, the absence of lighting fixtures, the lack of a proper bathroom or other plumbing facilities – features such as this reflect the rustic and almost preindustrial life style of the Pinhey's. At the same time the quality of the original plaster detailing, the hand wrought wood work of the centre and west wings, the fine graining in the east wing, other intact early finishes, and details such as the early hardware attest to the aspirations and the taste of the first inhabitants."

23. **Reversed floor boards** (Karimi, 2015)
24. **Lath&plaster finishes** (Karimi, 2015)
25. **Stained finishes** (Karimi, 2015)
26. **Painted finishes** (Karimi, 2015)
27. **Hand grained finishes** (Karimi, 2015)
28. **Wallpaper finishes** (Karimi, 2015)

1.4 HISTORICAL ARTIFACTS

Pinhey's Point Foundation owns the collection of artifacts exhibited at the Horaceville house museum. The artifacts belonged to the Pinhey family and other riverfront families from the Kanata area (former Township of March). The Pinhey family's artifacts are a record of Hamnett Pinhey and his family members' life in England and Canada (Pinhey's Point Foundation). The collection is a historical record of the development of the their estate, their daily account, and their values. The collection consists of approximately 5000 artifacts including domestic items, furniture, textiles, paintings, library and archival materials, and archaeological specimens from on-site excavations (Lundholm Associates, 2015).

The house museum was planned to stage a few period rooms such as the drawing room, dining room, kitchen, bedroom, and servants' quarters. A small portion of the collection including domestic items, china, kitchenware, paintings, and furniture are displayed in these period rooms as part of the permanent collection. The remaining artifacts are stored in three rooms on the second floor and two attic spaces in the east and west wings. Additionally, numerous wardrobes and cupboards situated throughout the house are used for storage. Also, a number of fragile and valuable artifacts are stored in a secure off-site storage locker.

29. **Map** (Karimi, 2015)
30. **Painting on canvas** (Karimi, 2015)
31. **Wooden bed** (Karimi, 2015)
32. **Wooden buffet** (Karimi, 2015)
33. **Wood stove** (Karimi, 2015)
34. **Canon** (Karimi, 2015)

1.5 CONCLUSION

Pinhey's Point, founded by Hamnet Pinhey in 1820, is one of the first agricultural settlements on the Ottawa River in Eastern Ontario. Today, the site is owned and operated by the City of Ottawa as a museum and recreational historic site, designated under the Heritage Ontario Act with the recognition of the cultural values of the agricultural land and the nearly 200 year-old stone house which acts as a historic house museum exhibiting a permanent collection of historic artifacts of the region. Studying the cultural and contextual values of the site is the first step in conservation practices, as understanding the significance of the site helps with decision-making and executing appropriate interventions for the heritage built-environment.

SCIENCE/ TECHNOLOGY

2.1 INTRODUCTION

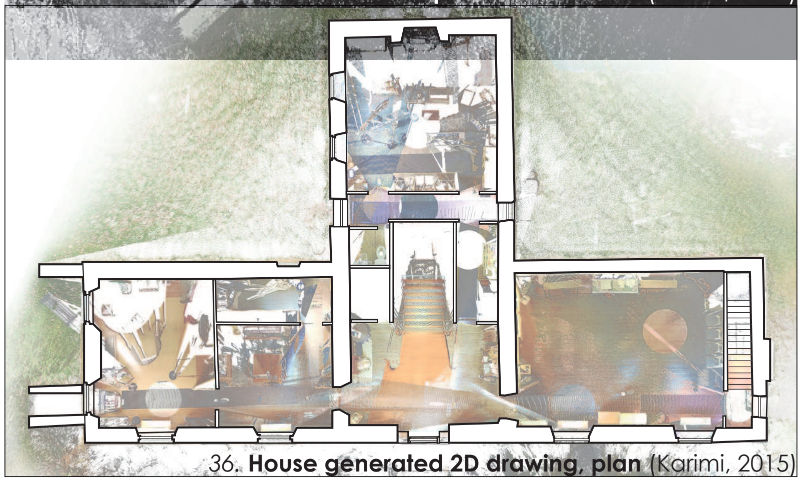
This chapter contains a physical audit of Horaceville, starting with documentation and surveying of the historic fabric and a condition assessment study to understand the construction and performance of the building. Environmental monitoring and testing was conducted to analyze the building performance leading to the discovery of various performance issues. Furthermore, environmental classification for museums and artifacts is explained as well as the existing environmental condition of Horaceville. The chapter ends with a summary of the New Orleans Charter on suitable conservation practices for house museums.

2.2 SURVEYING

This thesis planned and conducted a survey of the house museum (Horaceville) and the adjacent barn with a 3D laser scanner in collaboration with Azrieli School of Architecture and Urbanism and Carleton Immersive Media Studio (CIMS). Laser scanning is a simple and quick way for an effective and proper documentation and condition assessment of historic structures. This innovative technology scans the details of the exterior and interior fabric, resulting in a comprehensive documentation of current conditions of historical finishes dating from both the original construction and the 1999 restoration project. This survey can be a base point study for future restoration projects and surveys. Another benefit of this survey is the visual and cultural value of the generated 3D model and 2D drawings that can be used for educational and experiential purposes such as creating virtual tours, museum programing, and fly/walkthroughs of the site.

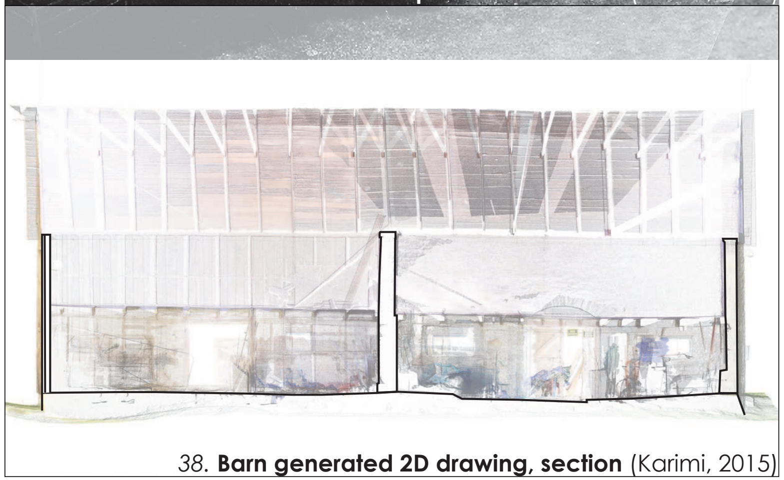
The house and barn were scanned with an accurate laser scanner (model FARO Focus3D). The scanner took multiple individual scans from the exterior elevations and the interior rooms, corridors, and stairways. In preparation of each scan, reference points and targets were manually installed which would later be used to merge together all the scans in an image processing software (called SCENE) to create a 3D model of the building and its surrounding landscape. Every scan measured and collected millions of points in space and later transformed the points into a point cloud data file. The point cloud is a starting point to draft and model the site in a CAD application to create accurate 3D models and 2D drawings. A 3D building simulation ArchiCAD model of the barn was generated from the point cloud data file, demonstrating the existing condition of the structure with every detail. The barn model is a precise and detailed platform for the proposal to retrofit the adjacent barn with an artifact storage facility.

35. **House point cloud model** (Karimi, 2015)



36. **House generated 2D drawing, plan** (Karimi, 2015)

37. **Barn point cloud model** (Karimi, 2015)



38. **Barn generated 2D drawing, section** (Karimi, 2015)

2.3 CONDITION ASSESSMENT

A comprehensive physical assessment of Horaceville was conducted at the early stages of this research to determine the as-found condition of the physical fabric. The condition assessment study aims to understand how the building was constructed via visual inspection and examination of previous condition assessment studies, particularly Julian Smith's 1991 Master Plan Study. A condition audit also provides a context to reveal the building's state and the performance issues of the structure, and whether the building and the occupying artifacts suffer from any environmental causes.

As mentioned above, Horaceville consists of three separate wings connected through wall openings. The exterior walls were constructed of load-bearing stone masonry on stone foundation placed on bedrock. There has been an ongoing passage of groundwater on the surface of the bedrock causing excessive amounts of humidity in the basement (Smith, 1991). The exterior walls are dressed in two different methods: squared ashlar limestone with regular coursing and rubble limestone with irregular coursing (fig. 39). The interior separation walls between each wing are also of stone masonry raised to the underside of the roof. There are signs of water penetration through the upper part of the east and west end walls (fig. 42), requiring immediate remedial measures to avoid further damage to the fabric.

The interior structure (floor, roof and some of the interior partitions) was built with hand-hewn log beams and hand-sawn lumber. The ground floor is supported on log joists, which have gradually suffered from excessive humidity levels in the basement.






39. **Ashlar vs. rubble** (Karimi, 2015)
40. **Foundation walls** (Karimi, 2015)
41. **Log beam with additional supports** (Karimi, 2015)
42. **Water penetration** (Karimi, 2015)
43. **Rafters** (Karimi, 2015)
44. **Cedar shingles** (Karimi, 2015)

Later, supplementary floor joists were installed on steel jack-posts in the basement to support the rotten floor log beams (fig. 41). The roof structure was built with lap-jointed and pegged rafters of varying dimensions with collar ties and wood boards. The roof was recently finished with eastern white cedar shingles with no water collection system (fig. 44).

The majority of the interior finishes are composed of lath and plaster (fig. 46) with different types of finishes, including plain, painted, wallpapered, and stained. The ceilings are also covered in various finishes and are detailed with plaster cornices. The hardwood floors and interior door surfaces were hand grained. The historic finishes are generally in good condition, but there are some physical signs of thermal and moisture stresses such as cracks and stains on the surface of several walls and ceilings.

The original heating systems included coal and wood operated fireplaces, and wood stoves. The heating systems were connected by a network of flues through wall and floor openings and ventilated via chimneys at the roof level. The major system change was the implementation of a modern mechanical system in the 1990's. The new heating/cooling system is comprised of furnaces in the attics and the basement (fig. 47). Until the 1950's, the house had no electricity, indoor plumbing or running water (Smith, 1991). A plumbing and electrical system, three bathrooms, and a small kitchen were installed during the restoration project of the 1990's (fig. 49).



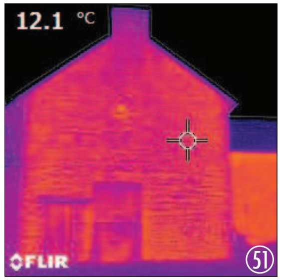


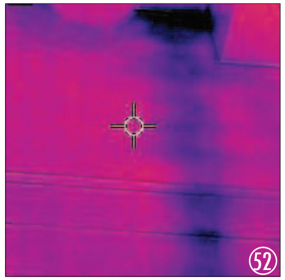

45. **Fireplace** (Karimi, 2015)
46. **Damaged plaster** (Karimi, 2015)
47. **Furnace in attic** (Karimi, 2015)
48. **New plumbing system** (Karimi, 2015)
49. **New kitchen** (Karimi, 2015)
50. **New bathroom** (Karimi, 2015)

2.4 ENVIRONMENTAL STUDY

The condition assessment study was the first step to understand the construction of Horaceville, and it also provided a context to understand the building performance. Certain building performance issues such as pest infestation can be detected visually; others such as high indoor relative humidity cannot be assessed visually and require further environmental studies. Various field investigation techniques were used to confirm the existing issues and their sources. The means of investigation included thermography, moisture detection, and indoor humidity monitoring. These tests were performed on various occasions and climate conditions to achieve optimum results and to have enough data to compare and comprehend potential issues.

A thermal camera was used to detect moisture on the exterior and interior surfaces of the physical fabric, such as high temperature differentials on wall surfaces and moisture patterns in the floor and ceiling spaces from the mechanical system. Additionally, a weather station was used to measure and monitor the relative humidity and temperature in various rooms. The monitoring began from September and continued through December. A moisture metre was used on various occasions to detect points having high amounts of moisture on the interior side of the building's perimeter walls, such as the bottom of the external walls close to the grade, below window sills, and exterior end walls in the attics.





51. **Thermal image, exterior** (Karimi, 2015)
52. **Thermal image, wood floor** (Karimi, 2015)
53. **Weather station** (Karimi, 2015)
54. **Moisture metre** (Karimi, 2015)

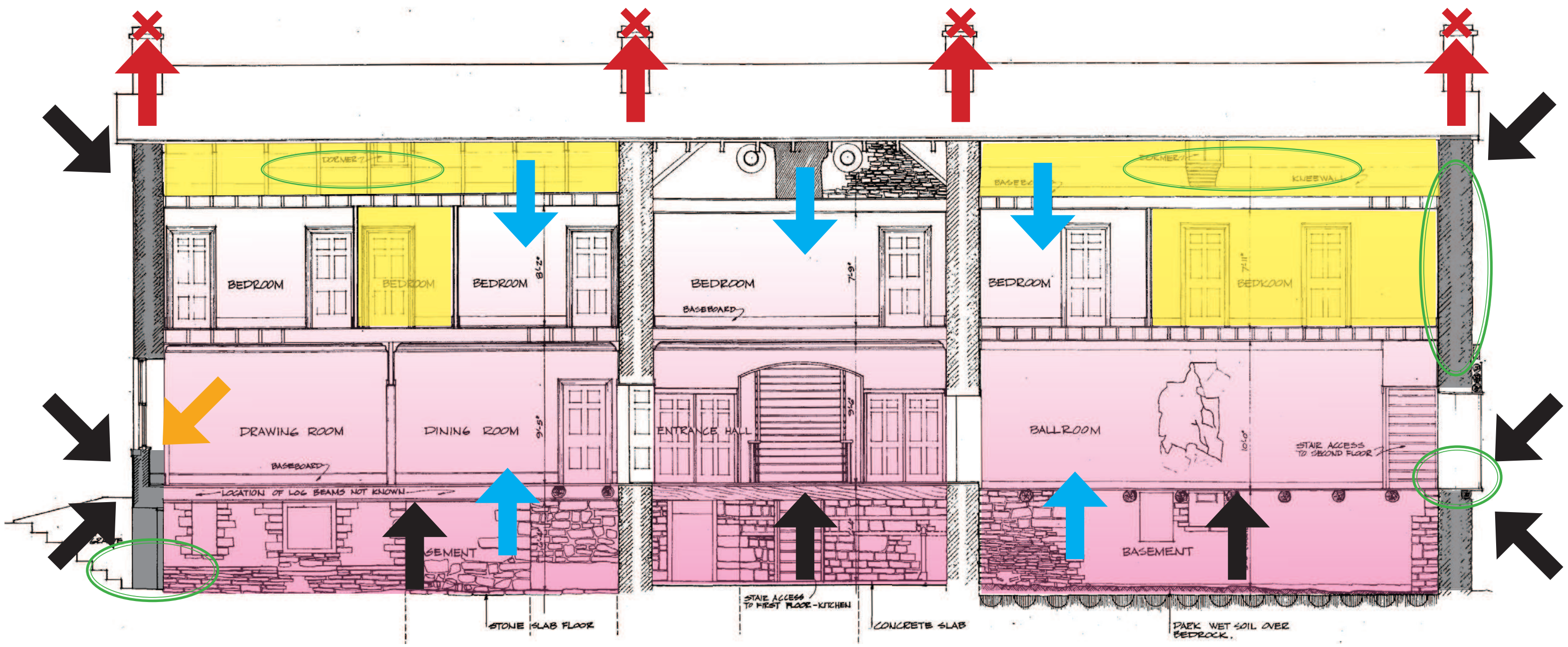
2.5 PERFORMANCE ISSUES

The site investigations and environmental studies identified many noticeable performance issues in the house museum. The main performance issues are highlighted in a sectional diagram of Horaceville (fig. 55). Through independent research and discussions with John Ward, a consultant from the Canadian Conservation Institute, a list of performance issues was prepared and ranked by their level of risk. The detected issues include uncontrolled moisture, high relative humidity, inappropriate artifact storage, poor ventilation, deficiencies with the climate control system, and condensation on windows. The majority of these issues relates to the high levels of moisture in the fabric, which can gradually cause deterioration. Other deficiencies such as fire hazards caused by inappropriate artifact storage can lead to sudden loss of the historic fabric and artifacts. Understanding the performance issues and their associated risks can help to determine preventive conservation measures and maintenance strategies (Karsten, 2002). The performance assessment is also a useful guide for short-term and long-term museum planning. In addition, the general advice and preventive conservation strategies from this case study can be used for other Canadian house museums.

High risk

1 Uncontrolled moisture
2 High relative humidity
3 Inappropriate artifact storage
4 Poor ventilation
5 Issues with climate control system
6 Pest infestation
7 Condensation on windows

Low risk



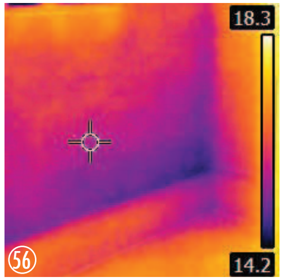
55. **Section, performance issues** (Smith, add-on: Karimi)

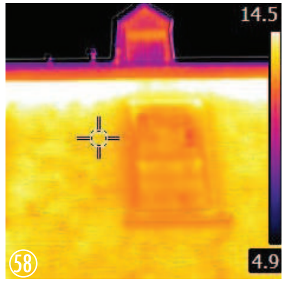
UNCONTROLLED MOISTURE

Managing moisture is the first step to stabilize the indoor environment in a house museum. Several entries of liquid water were noticed throughout the building envelope. To confirm the visual signs of moisture damage, a moisture metre was used to determine locations with high moisture levels in the exterior wall at all levels. As indicated in the diagram (fig. 62), high moisture levels were observed in the basement walls, the north wall at grade, the south central kitchen wall at grade, and areas below the window sills. Various estimated factors are affecting the excessive levels of humidity and moisture in these locations, caused by one or more sources. Generally, a number of performance issues can be interconnected and related; similarly, one issue can perpetuate the risk of others. The goal of this section is to briefly explain the primary sources for uncontrolled moisture.

There are currently no gutters and downspout systems for handling surface rain run-off (fig. 58). Controlling the rainwater is one of the most important measures in controlling the unwanted moisture for any historic building. Uncontrolled rainwater saturates the soil around the building and eventually wets the base of the building. The moisture will seep through any cracks in the foundation walls, leading to a damp basement that can increase the level of relative humidity in the entire building (Park, 1996).

The slopes and grading around the foundation walls also contribute to the high moisture levels in the basement. The ground slopes downward at the south elevation (fig. 61)



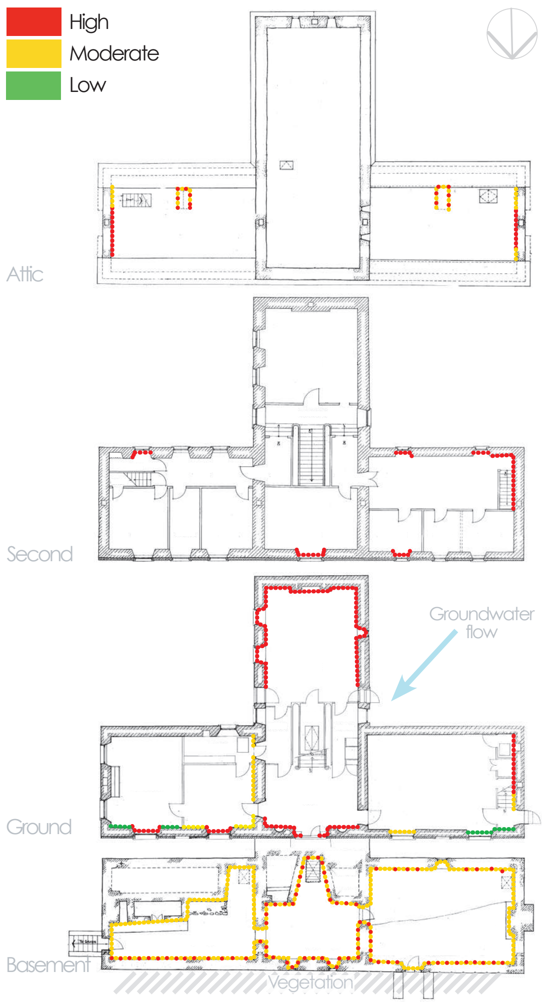


56. **Rising damp, ground** (Karimi, 2015)
57. **Rising damp, basement** (Karimi, 2015)
58. **Missing gutters** (Karimi, 2015)
59. **Water penetration** (Karimi, 2015)
60. **Exterior vegetation** (Karimi, 2015)
61. **Grade drainage toward the house** (Karimi, 2015)

and directs rain and groundwater toward the building, leading to damp masonry walls in the basement and the south wing's central kitchen at grade (fig. 57). Additionally, rising damp appears at the base of the foundation walls and up to about one-and-a-half metres above ground level in the south wing's kitchen walls. The visual evidence of the rising damp is a band of discolouration or physical damage on the surface of internal walls (Bagg, 2006).

Other factors affecting the damp problem are raised grade and exterior vegetation growing against the masonry walls (fig. 60). Raised ground levels outside the walls increase the moisture levels inside the walls and will not allow the moisture in the soil to evaporate beneath the ground floor. Also, overly raised flowerbeds and vegetation at the north side of the building keep excess moisture levels at the subsurface level, leading to deterioration of the walls and the ground floor log beams.

Deteriorated mortar joints were observed at the base of all exterior walls close to grade. Water and moisture penetrates thorough deteriorated mortar joints and saturates the masonry walls, leading to a reduction in the thermal performance of the walls. Also, sections of the walls have been repointed over the years with cement-based mortars, which restrict the breathability of the fabric. Traditionally, stone masonry buildings were constructed to breathe in order to accommodate moisture, using materials such as lime mortars and renders (Mitchell, 2007).

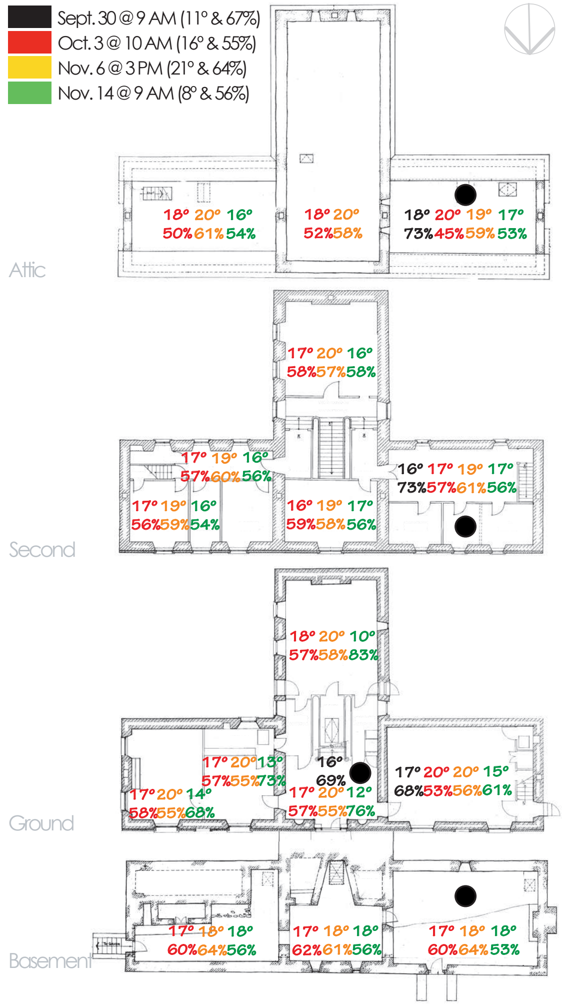


62. **Plans, moisture test** (Smith, add-on: Karimi)

HIGH RELATIVE HUMIDITY

A single-season monitoring program was undertaken with a weather station to measure the temperature and relative humidity (RH) inside the house museum. The data collection started in September 2015 and was performed once a month for three months in the morning at various rooms of the house (fig. 63). All three levels of the building had consistently high RH levels, predominantly over 50% in all rooms. The basement had the highest RH levels, never going below 60% likely due to damp foundation walls. As discussed in the previous section, moisture can be absorbed by foundation walls from the soil through capillary action and evaporate into the basement, causing damp walls and floors.

RH normally decreases on upper floors due to natural stack ventilation that assists air circulation and moisture dilution throughout the house (Curtis, 2008). Despite the standard decrease of RH above the basement level, the RH at the central wing's south kitchen was once measured at 83%. This level of RH can easily facilitate the growth of mold and other fungi on organic materials such as wood, paint, and paper. Depending on their materials, the collections can have different levels of sensitivity to RH. The outstanding challenge for most house museums is to find an appropriate level of RH for the best preservation of the content as well as the historic structure. RH is not an agent of deterioration, but an incorrect level of RH can threaten the historic structure and the collection.



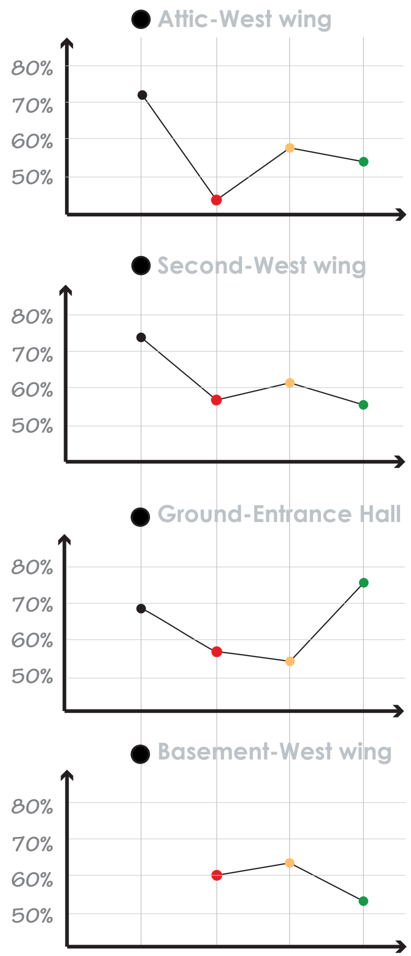
63. **Plans, humidity test** (Smith, add-on: Karimi)

The Canadian Conservation Institute (CCI) determined that the practical boundary for damp is 75% RH, and the damaging forms of RH include: above 75% RH; above or below a critical RH value for an object; and RH fluctuations. CCI further explains,

"Relative humidity is a measure of the thing we call "humidity" in everyday speech. It is that quality of the air that ranges between damp and dry. We don't actually perceive RH (relative humidity) itself, we perceive the dampness or dryness of our bodies in reaction to ambient RH (relative humidity)."

A relatively high level of RH fluctuations was observed within a short period of time during the monitoring season. The RH ranges of one room on each level are presented in the humidity test graph (fig. 64). The RH in the west wing attic space fluctuates between 45% and 73% during the three-month observation period. A rapid change in RH causes the moisture contents of organic materials to change sharply, which in turn causes their size to alter, resulting in cracking of their surfaces (Michalski). Currently, the east and west wing attics are used for artifact storage. These attic spaces are poorly ventilated with high temperatures in cooling seasons and low temperatures in heating seasons. The temperature fluctuations result in high RH fluctuations that can be threatening to the stored historic artifacts. As Michalski points out,

"It is sufficient for most purposes here to know that when warm air is cooled, the RH (relative humidity) climbs. This leads to problems of damp when warm humid air finds cool spots in a building. The converse is that when cold air is heated, the RH (relative humidity) falls. This leads to low indoor RH (relative humidity) in winter, and drives the need for humidifiers."



64. **Humidity test graphs** (Karimi, 2015)

INAPPROPRIATE ARTIFACT STORAGE

Horaceville houses a collection of approximately 5000 artifacts. Currently, adequate space is not available for displaying and storing artifacts in the house. This has forced the Pinhey's Point Foundation to store a small number of fragile and valuable artifacts in a secure locker off-site. The diagram on the right (fig. 55) illustrates the arrangement of the exhibition and storage areas throughout the house museum. Three rooms on the second floor have been converted to store artifacts: one in the east wing for books and archival materials, and two in the west wing for small artifacts, framed works, and paintings. Additionally, numerous wardrobes and cupboards situated throughout the house are used as extra storage space. Previously, attic spaces in both the east and west wings were used to store a large number of furniture pieces of different materials (Lundholm Associates, 2015). As mentioned previously, storing artifacts in poorly ventilated attic spaces is inappropriate due to the damaging levels and rapid fluctuation of RH. The house's attic spaces are not heated during the heating season, and artifacts are kept in these areas due to the lack of winter storage. The low temperature of the attics is not detrimental to most artifacts, but sudden temperature changes can be (Kerschner, 2007). These changes can rapidly affect the RH level, leading to condensation on objects' surfaces and the inside layers of the exterior walls. A thermal investigation was conducted with a thermal camera to further assess the conditions of the historic fabric.

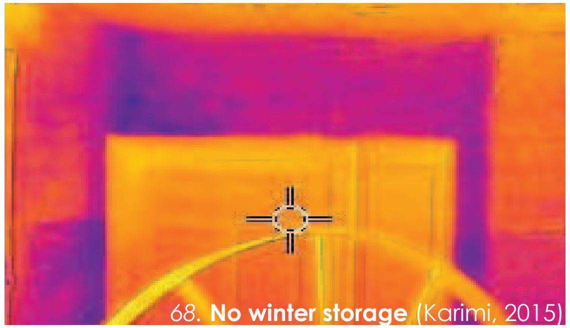
65. **Plans, program study** (Smith, add-on: Karimi)

The outcome shows different ranges of colours due to different levels of either temperature or humidity on the wall surfaces (fig. 67 and 68). This can lead to condensation on wall surfaces that are in contact with the artifacts or the wardrobes containing artifacts. Condensation occurs when moisture condenses on a surface with a lower temperature compared to the surrounding air. The colder a surface, the higher the RH is adjacent to that surface (Lstiburek, Carmody, 1993). Currently, paintings are hanging on walls and furniture is positioned near the exterior walls. Based on the thermal images, these surfaces are at risk of forming condensation. Condensation can provide the environment for mold growth, leading to deterioration of the building and objects' materials. These factors can be detrimental to the preservation of the museum fabric and the collection.

Furthermore, storing artifacts in the attics increases the risk of fire hazards (fig. 66). Numerous issues contribute to the occurrence of fire in house museums, including lack of a proper fire protection system, high combustibility ratings of wood structures, lack of building compartmentalization, and storing artifacts in the attics (Baril, 1998). The 1990's restoration project implemented some fire protection measures through the house, but the attic spaces remain unprotected. Currently a large number of combustible wood furniture pieces are stored in the attics, which can potentially catch fire and spread it to the rest of the building.


66. **Storage in attics** (Karimi, 2015)

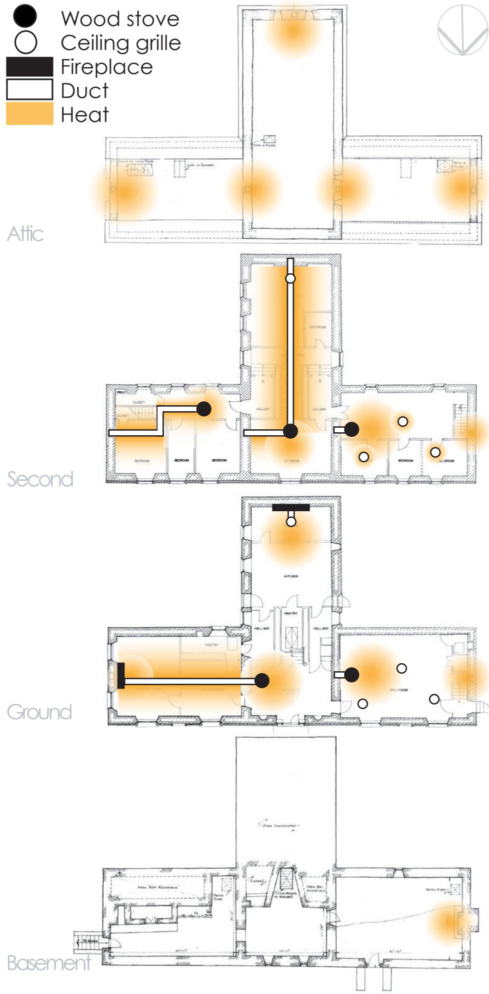

67. **Unstable indoor environment** (Karimi, 2015)


68. **No winter storage** (Karimi, 2015)

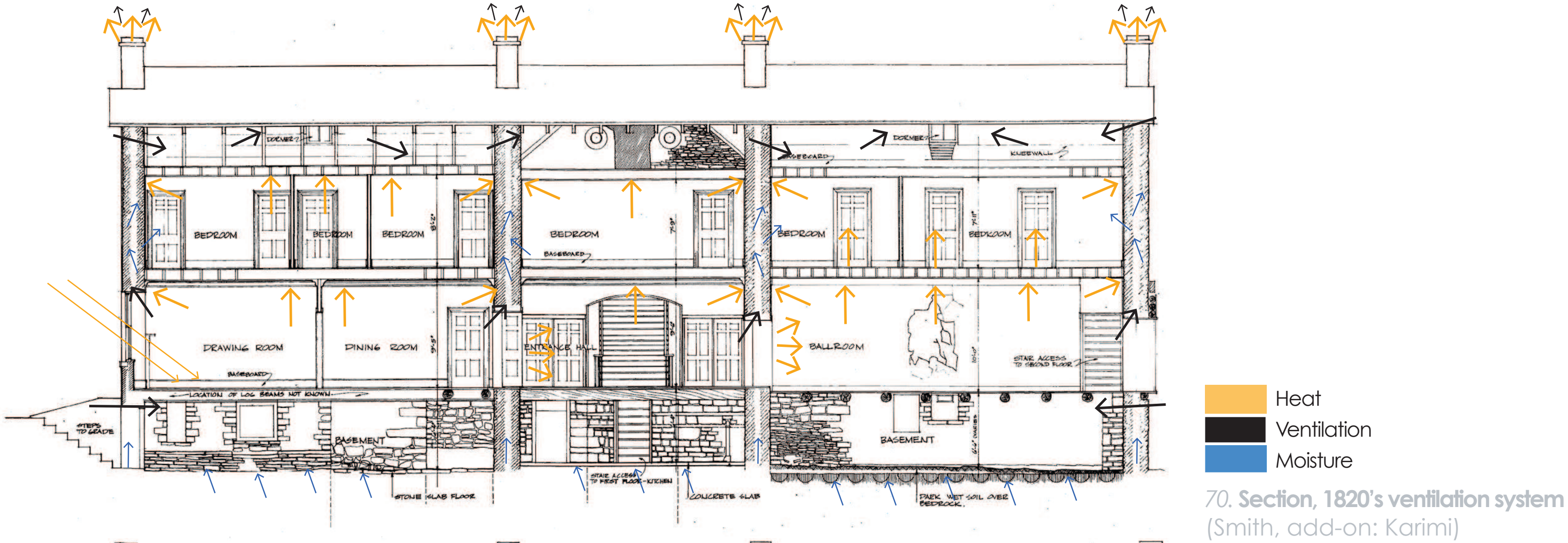
POOR VENTILATION

Free movement of moisture and ventilation are important principles in any building design, both for the good health of its users and the correct performance of its components. Lack of air circulation can contribute to the buildup of stagnant air and moisture leading to decay of materials (Curtis, 2008). Fireplaces and associated flues remain an important element in moisture control and ventilation of historic structures. Horaceville's fireplaces and stoves were connected through a network of flues (fig. 69) to circulate the flow of heat and air. The key component of the original heating system was the chimneys, which are designed to assist drawing out moisture from the building envelope. The chimneys are no longer in use and they require further investigation to see if they have been closed off to block airflow. Leaky windows and walls allow air to pass through the building, but blocking the chimneys can be the leading cause of poor ventilation throughout the house, as the chimney flues can no longer draw air into the rooms.

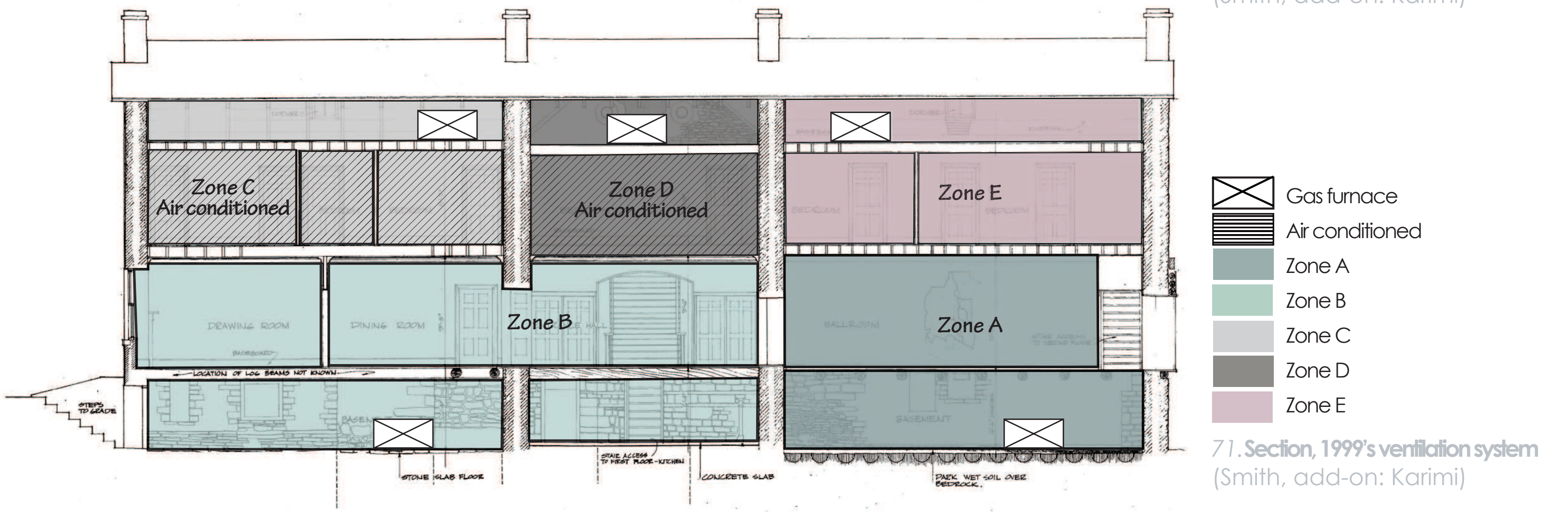
The two section diagrams (fig. 70 and 71) show the estimated performance of the 1850's and 1990's ventilation systems. It is safe to say that the original ventilation system allowed free movement of air and moisture through the whole building, in comparison to the modern mechanical system that was designed to control partial areas of the house. Also, the air-conditioned spaces may draw moisture into assemblies from non air-conditioned spaces, which will cause periodic condensation and thermal stress in assemblies.



69. **Plans, 1820's heating system** (Smith, add-on: Karimi)



70. **Section, 1820's ventilation system**
(Smith, add-on: Karimi)

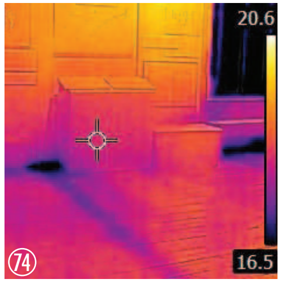


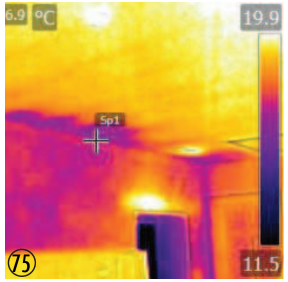
71. **Section, 1999's ventilation system**
(Smith, add-on: Karimi)

ISSUES WITH CLIMATE CONTROL SYSTEM

As previously indicated, several conventional mechanical systems with heating, ventilation, and air conditioning (HVAC) were implemented in the 1990's restoration project based on the best practice of the day. To minimize the physical and visual damage associated with these systems, the furnaces were installed in the basement and attic spaces. Nonetheless, there are still disadvantages in their installation such as the removal of historic materials for installation of new ductworks and openings (fig. 73). To date, however, the only solution to create a balanced environmental condition for the artifacts is to integrate these systems into historic structures and tailor them to the collection's needs. The other reason to install modern climate control systems in historic structures is to provide comfort for the occupants and visitors influenced by today's standards of comfort.

The condition assessment study detected certain moisture-related signs that can be associated with the HVAC systems. Some rooms smell musty due to a lack of ventilation, and some wall surfaces show staining and other signs of moisture damage from condensation (fig. 72) (Park, AIA, 1991). Air conditioning was installed only in a few rooms without a clear planned use of the rooms, leading to periodic condensation and thermal stress on the interior finishes (fig. 76). Also, there are some detected leaks from plumbing in the basement and other concealed areas that can cause deterioration. Some of the mechanical ductworks are lacking insulation, causing periodic condensation on the surface of the ductwork (fig. 74). The condensation can eventually cause decay in the surrounding wood surfaces.





72. **Surface staining** (Karimi, 2015)
73. **Visual damage** (Karimi, 2015)
74. **Uninsulated ductwork** (Karimi, 2015)
75. **Condensation in ceiling space** (Karimi, 2015)
76. **Periodic condensation** (Karimi, 2015)
77. **Leaks from internal plumbing** (Karimi, 2015)

PEST CONTROL

Pest control is of central importance of the management of museums. Integrating pest control as part of the museum's maintenance system assists with long-term preservation of the artifacts (Strang, 1992). The current environmental study intended to discover the main deterioration agents including pest infestation. Several vermin entry points were discovered during the site visits (fig. 80 and 81). The largest entry point was found under the basement door, which connects the basement floor to the outside through a dogged channel under the door frame. Once, it was observed that a squirrel entered the basement through this channel and made its way to one of the exhibition rooms to hide. These rodents can damage objects and increase the incidence of infestation. Pest infestation in the attics has been an ongoing issue (Smith, 1991). The building's custodian has applied some measures to control this issue. Various insect sticky traps and rodent traps have been installed in the attics. These systems are effective at reducing further infestation if they are periodically inspected and maintained.

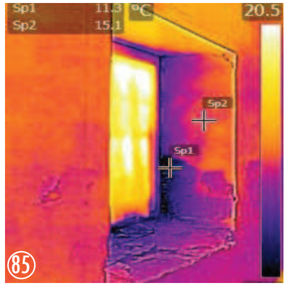
High levels of humidity and lack of air circulation can also cause pest infestation. Dampness provides an ideal environment for fungi and mold growth. The exterior north wall is suffering from adjacent growing vegetation and high garden beds, leading to moisture saturation and growth of fungi on limestone surfaces (fig. 78). The exterior end walls are saturated due to water penetration contributing to the high level of humidity in the attics. The artifacts that have been stored near these saturated walls have increased risk of mold infestation on the surfaces that are in contact with saturated walls (fig. 79).

78. **Exterior vegetation and fungi** (Karimi, 2015)
79. **Environment for mold** (Karimi, 2015)
80. **Rodent entry** (Karimi, 2015)
81. **Stone decay and pest entry** (Karimi, 2015)
82. **Pest trap infestation** (Karimi, 2015)
83. **Pest entry in the attic** (Karimi, 2015)

CONDENSATION ON WINDOWS

Some of the windows show signs of paint blistering, cracking, and flaking . These symptoms are usually caused by moisture penetration and saturation (fig. 86). Moisture is the primary contributing factor to window decay; due to lack of a roof water collection system, exterior rainwater runs downward along the window, entering and collecting at points where the flow is blocked. Interior condensation can also occur at the wall surfaces surrounding a window opening due to thermal differentials. Thermal images confirm the cold surfaces around the window openings (fig. 85).

Damp surfaces occur where water in the air inside a building condenses on a cooler surface. This is usually indicative of cold spots in the building. It can also occur where there is poor ventilation or where short intense heating cycles do not allow the walls to fully warm up. This situation allows the heated air to retain more water, which condenses when the temperature drops. Maintaining a steady level of heating inside a building (15-20 degrees centigrade) allows the walls to warm up sufficiently to prevent cyclical condensation on hidden surfaces (Park, 1996). Once the paint and glazing putty are cracked or loosened, they will allow water to saturate the wood. Subsequently the windows' timber parts become vulnerable to decay where paint breaks down and exposes the timber to weather elements. Other conditions, including poor original designs, such as window sills not having drip lines, also contribute to the deterioration of the windows (Myers, 1981).



84. **Condensation on window** (Karimi, 2015)
85. **Interior condensation** (Karimi, 2015)
86. **Moisture collection**(Karimi, 2015)
87. **Exterior rain water**(Karimi, 2015)
88. **Paint failure** (Karimi, 2015)
89. **Paint failure** (Karimi, 2015)

2.6 ENVIRONMENTAL CLASSIFICATION

INDOOR CLIMATE CLASSIFICATION

Fine art museums were the only group of museums that practiced ideal environmental conditions in the 1960's and 1970's with temperature set points of 18˚C to 21˚C and 50% RH ± 3% (Kerschner, 1992). Over the past thirty years, many museums have sought guidance to address the environmental conditions for the historic structures and the collections. CCI published an environmental guideline in 1979 for Canadian museums, art museums, and archives. The guideline promoted specific environmental norms intended both for new construction and renovation projects. The optimum temperature set point for storage and exhibition areas was outlined as 21˚C ± 1.5˚C, and the RH set point was defined as 47% to 53% with 2% daily fluctuations (Lafontaine, 1979). Conservators found that the ideal climate for the artifacts housed in historic houses in colder climates are not the ideal climate for the building, and maintaining 50% RH can have a negative impact on the building envelope, such as formation of condensation within wall cavities (Kerschner, 1992). In 1980, Ralph Eames, a Canadian conservator, offered the following advice,

"It is now generally acknowledged that to demand an unvarying temperature of 20˚C and relative humidity of 50% can be counter-productive since these constant levels are almost impossible to maintain in Canada…It would be far better to advocate what could be physically and financially achieved, i.e. an annual range of temperature between 7˚C in winter and 26˚C in summer and relative humidity between 35% and 60% with changes being retarded as much as possible."

In 1979, the Royal Ontario Museum (ROM) classified five levels of sensitivity for the museum's collection. The type of artifacts determined the required environmental conditions including the temperature and RH ranges that would be safe for the buildings and the artifacts. According to ROM's publication, most artifacts that belong to a house museum are safe under stable conditions of 35% to 50% RH (ROM, 1979), which is also suitable for the conservation of the buildings.

Later, the American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook (2008) broadly describes the performance targets and specifications for museums, libraries, and archives. ASHRAE classified five groups of temperature and humidity specifications for the collections in accordance with the best knowledge available at the time. The five classes of museum's indoor climate include: AA, A, B, C, and D (fig. 90). Class AA is called a precision class and it is considered to consume very high levels of energy to operate. The set point for this class is 50% RH with no seasonal changes that consequently will put historic buildings at high risk of condensation. Class A is also a precision control with lower energy consumption and it allows some seasonal changes with 50% RH set point ±10%. Classes B and C are the most feasible options for historic buildings. The class B RH is set at 50% with ±10% fluctuations with a setback during winter temperatures. The C class only prevents high-risk extremes and allows the RH to fluctuate between 25% and 75% throughout the year. Class D only controls dampness and has limited potential for environmental improvements and keeps the RH below 75%.

AA class of control
Precision control, minimal seasonal changes to temperature only.
± 5% RH
± 2˚C
RH no change. Up 5˚C and down 5˚C.

A class of control
Good control, some gradients or seasonal changes.
± 5% RH
± 2˚C
Up 10% RH and down 10% RH.
Up 5˚C and down 10˚C.

B class of control
Some gradients plus winter temperature setback.
± 10% RH
± 5˚C
Up 10% RH and down 10% RH.
Up 10˚C (but not above 30˚C) and down as low as necessary to maintain RH control.

C class of control
Prevent all high risk extremes.
Within range 25-75% RH year round.
Rarely over 30˚C, usually below 25˚C.

D class of control
Prevent damp. Reliably below 75% RH.

90. **Class of control** (ASHRAE, 2008)

BUILDING CLASSIFICATION

ASHRAE's five classes of environmental controls for museums was described in the previous section. The classified temperature and humidity requirements are provided by HVAC systems. The optimal HVAC system maintains the specified temperature, RH, air circulation, and air filtration with minimum risk of damage to the collection. Maintaining the preservation environment also depends on the building envelope, which plays an important role in controlling the moisture through the fabric. ASHRAE (2008) recommends integrating heavy insulation, vapour barriers, and controls of openings for building envelope design to help with controlling the preservation environment, however, historic structures similar to Horaceville are generally not compatible with such measures.

The tolerance of a building in a given environment is dependent on the local climate as well as the moisture and thermal performance of that building (ASHRAE, 2008). Conrad (1995) classified buildings into six categories based on their type of structure and tolerance of the environmental elements. The building classification is as followed:

- Class 1 buildings provide D class of control, and have no potential for environmental improvements. Examples are open structures such as sawmills and bridges.
- Class 2 buildings can be ventilated and provide class C or D control. Examples are sheathed post-and-beam structures such as cabins and barns.
- Class 3 buildings require low-level heating. Summer exhaust ventilation can be implemented to afford C or D class of control. Examples are uninsulated masonry structures, wooden structures with framed and sided walls and single-glazed windows such as a rough framed house.
- Class 4 buildings can support a basic HVAC system to provide B, C, or D class of control. Examples are heavy masonry or farmed structures with composite plastered walls and storm windows such as finished historic houses or churches.
- Class 5 buildings can support complete HVAC systems to provide AA, A, or B class of control. Examples are newly built structures with insulated walls, vapour barriers, and double-glazed windows.
- Class 6 structures are specifically built to support precision controlled heating, cooling, and RH control systems. Examples are double-wall constructions with insulated and sealed walls such as storage vaults.

HORACEVILLE ENVIRONMENTAL CLASSIFICATION

In order to evaluate a house museum's environmental limitations and possibilities a full year monitoring program is required to comprehensively understand the thermal and vapour characteristics of the building and its response to the outdoor environment. A heavy masonry construction with interior plaster walls such as Horaceville can retain and release a certain amount of moisture during each season. This study accomplished a single-season monitoring program to record the ranges of indoor RH. Due to thesis time limitations, the data was recorded between the months of September and December. During the monitoring period, the measured indoor RH was consistently higher than the outdoor RH, and on the span of these four months the indoor temperature changed ±10˚C with 30% RH fluctuations. Based on previous discussions and the single-season monitoring, Horaceville classifies as a class 4 building and can safely afford a C class of control in Ottawa's cold winter climate. ASHRAE (2008) specifies the following for this class of building,

"High risk of mechanical damage to high vulnerability artifacts, moderate risks; moderate risks to most paintings, most photographs, some artifacts, some books; tiny risk to many artifacts and most books."

Horaceville is open to the public from May through August and has limited access in winter. From discussions with the building's custodian, it can be assumed that during the winter months the house museum temperature is kept at 18˚C with no specific moisture control actions. Heating buildings without adding levels of moisture can result in extremely low levels of RH such as 5% to15% (Kerschner, 1992).

By allowing the temperature to drop down during the closing season, the RH will remain at acceptable levels. The challenge is that the building should remain a certain temperature and needs to be heated even when it is unoccupied because it contains a water system and the pipes cannot be left to freeze. The temperature should be low enough to keep the RH at an adequate level for the artifacts. Low levels of RH can be detrimental to the long-term preservation of artifacts; certain artifacts such as paintings on canvas are extremely sensitive to RH fluctuations and must be kept in rooms with narrower ranges of RH and away from exterior walls (Kerschner, 1992). However, the building has no vapour barrier and it is impossible to maintain the 50% RH in the winter months. Any such attempts will cause condensation inside the walls, specifically around the windows, due to cold surfaces.

2.7 NEW ORLEANS CHARTER FOR THE JOINT PRESERVATION OF HISTORIC STRUCTURES AND ARTIFACTS

The New Orleans Charter promotes integrated conservation approaches to apply equal considerations to the preservation of museum buildings and their collections. The desire to investigate suitable conservation responses for the coexistence of museum buildings and their collections started when threatened historic buildings were converted into museums. Consequently these historic structures had to meet certain environmental standards for the safety of the collection, which at times can be a risk to the health of the building. Heritage professionals started to face this issue in the 1980's, leading to discussions and analyses of technical requirements of historic structures and objects. The New Orleans Charter is a strategy resulting from a series of conferences and meetings by the American Institute for Conservation of Historic and Artistic Works (AIC) and the Association for Preservation Technology International (APTI) in 1992.

The Charter is a framework for managers and administrators of museums to recognize their stewardship responsibilities and provide the highest levels of care for the structures and the artifacts stored in them. The Charter specifies that the preservation of objects is an ongoing process and the technologies and approaches will continue to change. The main points of the document include (The New Orleans Charter, 1996, p.57):

- The requirements of both historic structures and the artifacts housed therein must be taken into consideration in any preservation effort;
- Provisions for the care of both should be included in institutional mission statements;
- Interdisciplinary collaboration in preservation efforts should be encouraged; and
- Measures must not be taken which favour either the preservation of artifacts or the preservation of the structure at the expense of the other.

2.8 CONCLUSION

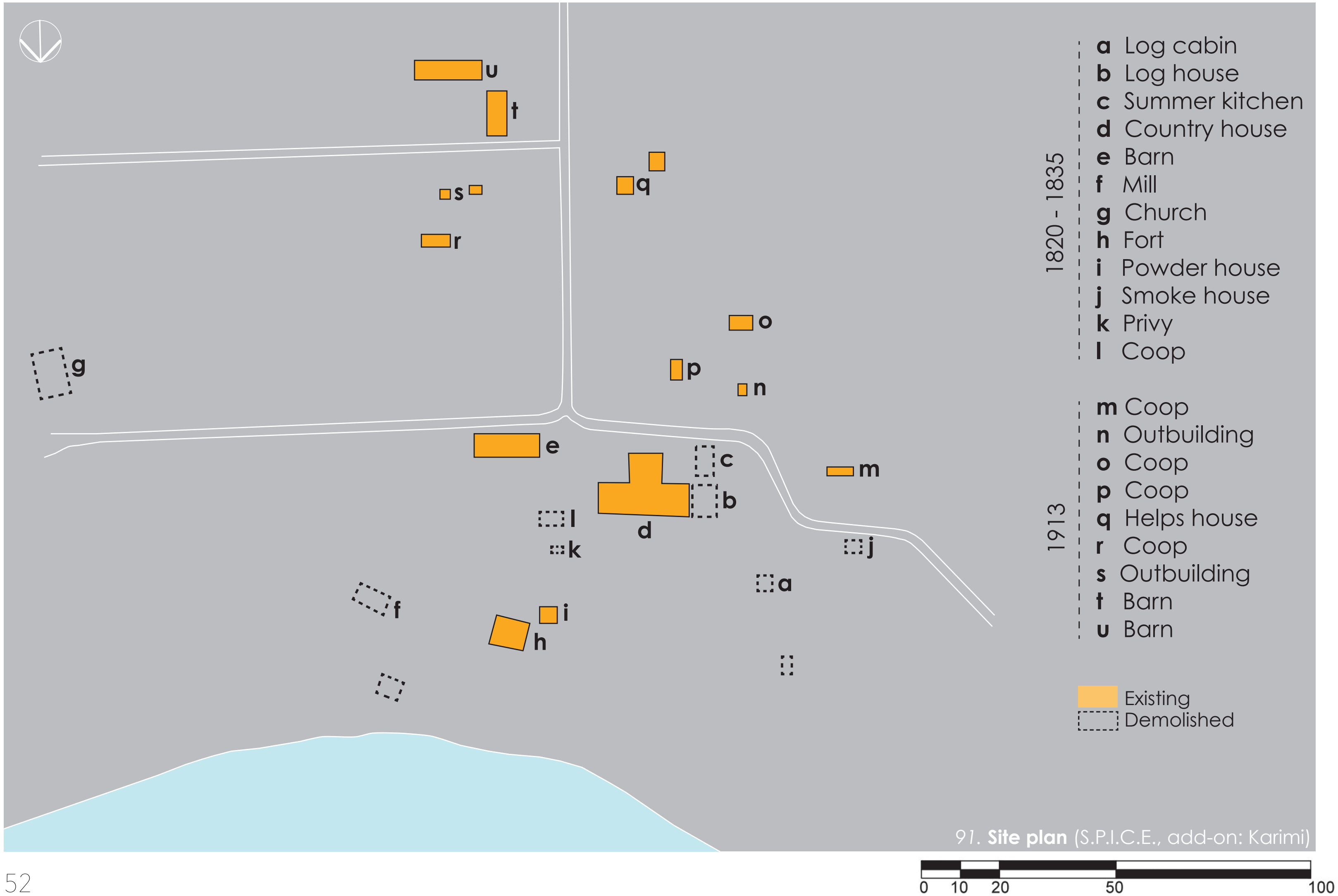
A survey of the house museum and the barn was conducted to document the existing conditions of the fabric, and to provide accurate dimensions and detailed information to create a 3D model of the site that is used in the next chapter for proposed interventions. Additionally, a physical audit and performance analysis were conducted to understand the performance and environmental conditions of the building. Horaceville's environmental conditions were evaluated with a single-season monitoring program to record the ranges of indoor RH. During the monitoring period, the measured indoor RH was consistently higher than the outdoor RH, and on the span of these three months the indoor temperature changed ±10˚C with 30% RH fluctuations. According to ASHRAE (2008), Horaceville classifies as a class 4 building and can safely afford a C class of control in Ottawa's cold winter climate. Class C provides a high risk of mechanical damage to high vulnerability artifacts; moderate risks to most paintings, photographs, some artifacts, and some books; tiny risk to many artifacts and most books. On the contrary, Horaceville's wall assembly has no vapour barrier and it is impossible to maintain consistent RH. Certain artifacts such as paintings on canvas are extremely sensitive to RH fluctuations. The New Orleans Charter recognizes that house museums and the housed artifacts deserve equal attention in conservation planning, and measures must not be taken which favour one at the expense of the other.

RETROFIT

3.1 INTRODUCTION

Ideal environmental conditions for preservation of historic structures often differ from ideal preservation environment for artifacts. In the current thesis, a comprehensive scientific environmental evaluation was performed for Horaceville and determined the required environmental conditions for the building and its occupying artifacts. Further discoveries estimated Horaceville as a type 4 building structure that can afford C class of control for the occupying artifacts, which means the building can only provide a certain level of environmental control due to its construction. This section first suggests climate control improvements for the house museum with the purpose of eliminating the RH extremes. The preventive conservation measures will reduce the risk of damage and will maintain the house museum as a suitable venue for exhibiting artifacts for the foreseeable future.

This study also highlighted the need for an artifact storage facility. The current artifact storage is dispersed throughout the house with inappropriate ranges of RH. Additionally, it is evident that the building's capacity for artifact storage is limited, and it minimizes the opportunity to expand the exhibitions. The climate control recommendations that will be introduced in this chapter present simple and efficient ways to reduce the environmental instabilities in the house. It should be noted, however, that these recommendations are not meant as long-term solutions for preservation and storage of sensitive artifacts. The second part of the retrofit section proposes a new artifact storage facility adjacent to the house museum for the storage of sensitive objects and artifacts that are currently stored in the house.



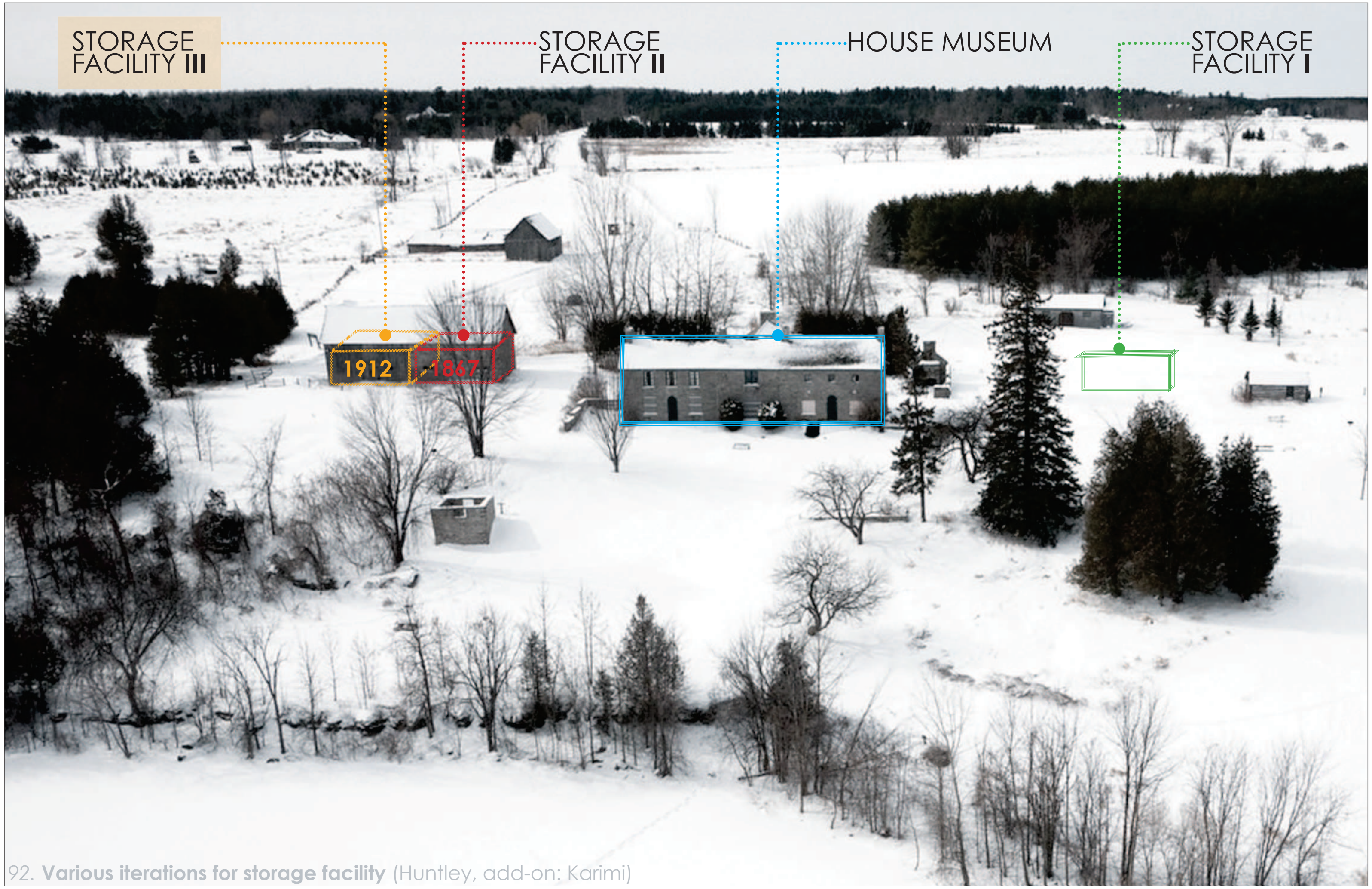
91. **Site plan** (S.P.I.C.E., add-on: Karimi)

3.2 CONSERVATION PROCESS

There are three proposed options for planning the new artifact storage facility adjacent to the house museum (fig. 92). The first proposal offers a new-built storage building on site whereas the second and third proposals rehabilitate the adjacent barn. All proposed options have their associated pros and cons; however, the chosen option has been determined to be the most suitable solution for this site.

In option I, the construction of a new structure is proposed between the house museum and the existing outbuildings near the southwest corner of the site. The benefit of a new facility is that it will be well insulated and equipped with practical climate control systems built to today's standards, resulting in a precision indoor environment for the stored artifacts. However, introducing a new building on site would conflict with the existing historic layout of the site. From the site plan of Pinhey's Point in figure 91, it is evident that the majority of the buildings were constructed between 1820 and 1913 (S.P.I.C.E., 1974). Options II and III aim to rehabilitate the adjacent barn by inserting a new built structure inside the barn shell. The barn was built in two phases and composed of two separate wings with different types of construction. In order to preserve the inherent division between the two wings, options II and III are placed at separate sections of the barn. Option II situates the new storage structure inside the old section (1867) of the barn with a gap between the new facility shell and the barn's stone walls. Since the older section of the barn contains higher heritage value, option III places the structure at the newer section (1912) of the barn, which is made of timber framing with brick infill. Although option III will remove the interior partitions of the existing barn, it was chosen as the final scheme. This option not only creates an opportunity to restore the older section of the barn, but it also respects the historic layout of the land.

The proposed retrofit measures are based on preventive conservation practices that protect the heritage values of the historic place and its character-defining elements. The preventive conservation approaches include the preservation and rehabilitation of the historic structures, the artifacts, and the historic landscape. In accordance to the Standards and Guidelines for the Conservation of the Historic Places in Canada (2013), conservation practices that include documentation, protection, maintenance, stabilization, and repairs are all covered under the umbrella of preservation. Upgrading and creating new life for a structure is considered rehabilitation. The climate control improvements and preservation efforts for the house museum and the artifacts are integrated with the rehabilitation of the historic barn with a new storage facility. These preservation and rehabilitation measures create a dynamic cycle for conservation of this historic site.



92. **Various iterations for storage facility** (Huntley, add-on: Karimi)

3.3 HORACEVILLE CLIMATE CONTROL INTERVENTIONS

Climate control improvements are listed below based on the detected performance issues and include broad general interventions to reduce the environmental extremes for the historic structure and the artifacts. Managing environmental extremes such as high RH levels requires before all else that there would be no entry of liquid water through the building foundation walls (Rose, 1994). Hence, the initial step for successful climate control improvements is to remediate the uncontrolled moisture in the building.

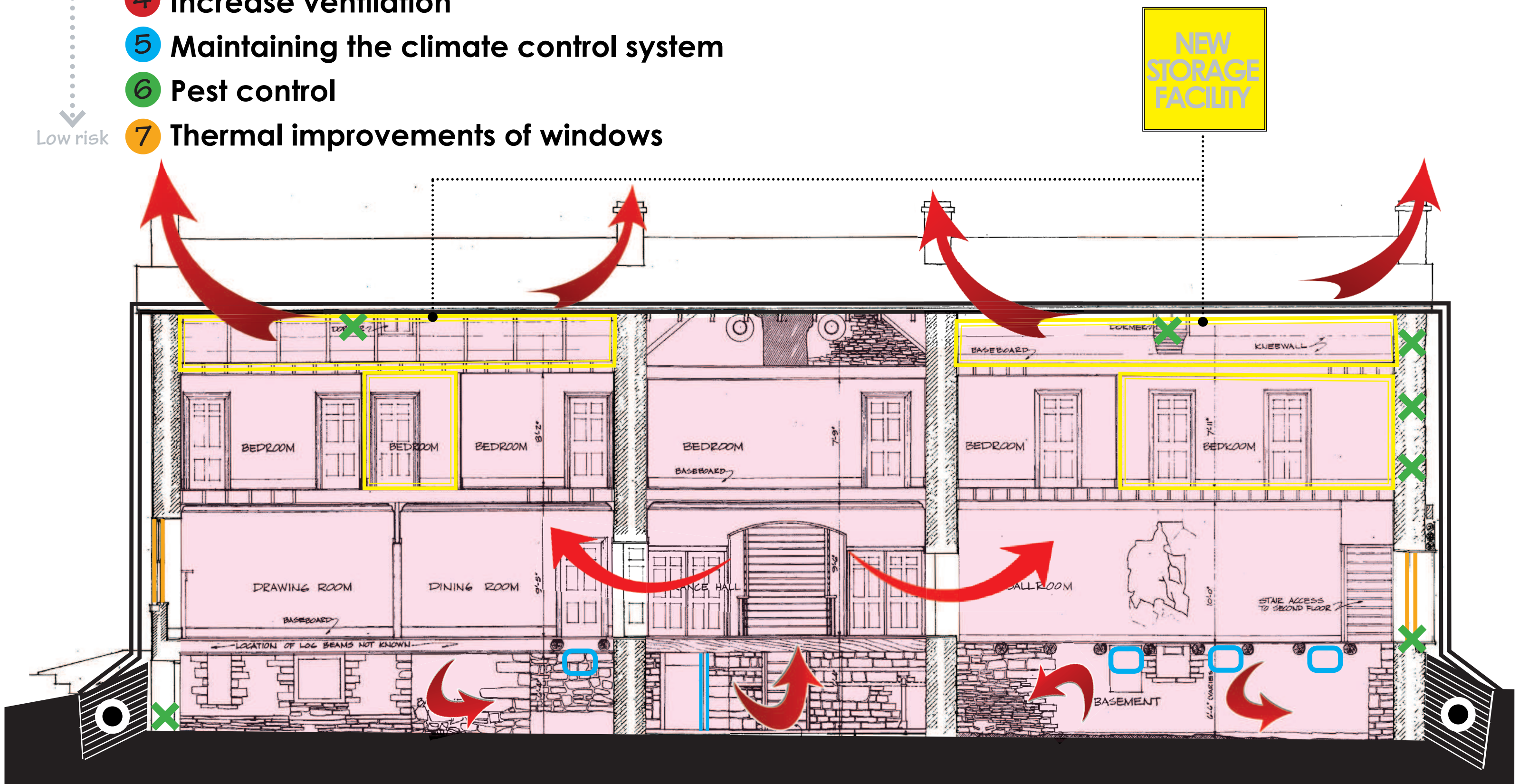
CONTROLLING MOISTURE

The highest priority climate control recommendation is to reduce the moisture problem at the source. It was identified that the basement is damp and causing high RH levels in the entire building. Directing rainwater away from the foundation walls will help in reducing the groundwater in the surrounding soil. Installing a roof water collection system with gutters and downspouts can help with directing the water to a storm water system with a perimeter drainage system at the subsurface level (Kerschner, 1992). The next necessary intervention is lowering and sloping the grades in a manner that will direct water away from the foundations, and help reduce the rising damp around the south side of the building. Also, bushes and vegetation close to the north wall must be trimmed or relocated away from the building to help with air circulation around the building. Furthermore, the air flow and ventilation should be increased in the basement with fan-operated system that is controlled by a humidistat; when the RH levels inside the barn exceed the outside RH levels, the fans will be activated to replace the indoor humid air with drier air supplied from the outside. Regular maintenance is required for early detection of any source of damage. Examining the masonry walls is the important part of the regular maintenance program. Decayed stones should be replaced with a matching unit. Also, any cement-based mortars should be removed and repointed with appropriate formulated mortars (Mitchell), as explained above in the Uncontrolled Moisture section.

MONITORING RELATIVE HUMIDITY

Mitigating the basement's moisture problems will automatically reduce the high RH in the building. However, a suitable monitoring system with temperature and RH sensors should be installed inside the exhibition rooms to collect a full year of data to ensure safe levels of RH (Lafontaine, 1979). The existing climate control system should be equipped with a humidistat-controlled digital device instead of a thermostat. It is generally acknowledged that controlling the RH is more effective than controlling the temperature (Kerschner, 2007).

High risk
1 Controlling moisture
2 Monitoring relative humidity
3 New artifact storage facility
4 Increase ventilation
5 Maintaining the climate control system
6 Pest control
7 Thermal improvements of windows
Low risk



93. **Climate control interventions** (Smith, add-on: Karimi)

When humidity rises above a certain level, such as 50% during the heating season, the heating system is activated to heat the room, which results in a decrease in the RH level. Also, the ventilation system should be controlled by humidity or dew point sensors so that it operates only when the outside air is drier than the inside air. A modified use of conventional climate control systems can assist in keeping the winter and summer humidity at preferred levels.

NEW ARTIFACT STORAGE FACILITY

An artifacts storage area must be clean, secure, free of pests, uncluttered, and ventilated. No artifacts should be placed directly on the floor (Alberta Museums Association). The existing conditions of the attics and other storage spaces throughout the house are not suitable for storing artifacts, and in the long term can be detrimental to their preservation. Relocating the stored artifacts from the house to a new artifact storage facility is beneficial both to the building and the artifacts. In addition, designating a suitable storage facility for the collection will create he opportunity to rotate items on display to help attract more visitors. This in turn can generate additional attention to the artifacts, which can lead to allocation of increased funds for their preservation.

INCREASE VENTILATION

Fireplaces and chimneys are important elements in providing air movement in traditional buildings. It is common practice to close off the chimney when the fireplace is no longer in use, leading to accumulation of moisture and reduction of ventilation. An energy efficient solution to this problem is to close off the chimney in the winter season with an inflated chimney balloon to reduce draft, and remove it in the summer to retain the air flow. The chimneys should be covered with a ventilated cap to allow air movement and to block them from vermin and rain (Historic Scotland).

MAINTAINING THE CLIMATE CONTROL SYSTEM

Scheduled routine maintenance is a common solution for detecting system failures such as frozen or damaged plumbing pipes. Any uninsulated pipe or forced-air sheet metal ductwork should be insulated to avoid condensation in the ceiling and wall cavities.

The mechanical system's dust filters, condensation pans, and drains should be inspected and cleaned regularly to avoid any disruption (Park, 1996). The museum management staff should reassess the use of air-conditioning in the building as it contributes to periodic condensation in spaces between the air-conditioned and not air-conditioned rooms. Cooling and heating loads can be reduced by thermal improvements such as installation of secondary glazing and shutters that are explained further below in the Thermal Improvements of Windows section. Furthermore, upgrading the existing system with humidification and dehumidification systems such as a digital humidistat control system will support the overall health of the fabric and the artifacts.

PEST CONTROL

Immediate and routine maintenance is very important in preventing pest infestation. The initial step is to detect and block the entry points. Any holes should be covered with appropriate materials such as insect screens. The next step is to manage a sanitation program that would include cleaning and replacing rodent and insect traps as they can become a source of infestation. Mechanical traps are preferred for the control of rodent populations since they enclose the carcass. Sticky insect traps have a limited lifespan and should get replaced periodically. The plants and vegetation next to the north wall should be removed to avoid dremestids, and the garbage inside the museum should be removed daily (Strang, 1992).

THERMAL IMPROVEMENTS OF WINDOWS

The condensation on windows is the indication of excessive indoor humidity on cold surfaces (Rose, 1994). The above-mentioned interventions will improve the environmental extremes as well as the condensation problem. Standard window repairs such as replacement of broken glazing and damaged putty should be performed to improve the window performance. Additional thermal improvements can be made using secondary glazing; retrofitting windows with secondary glazing in conjunction with other methods such as blinds and shutters will reduce heat loss by 75% (Jenkins, 2008).

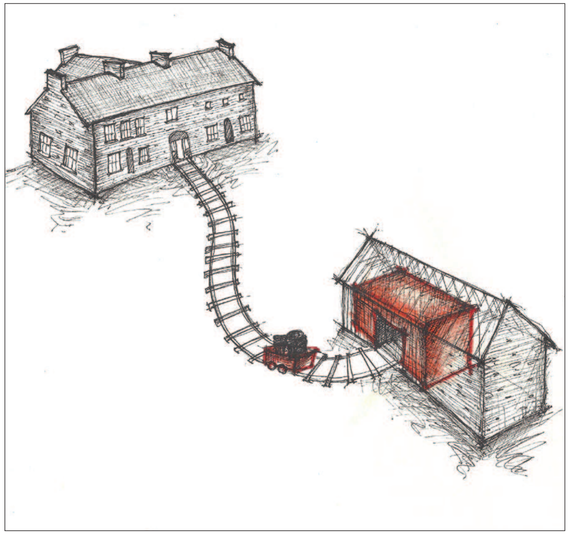
94. **The barn and the house, point cloud model** (Karimi, 2015)

3.4 NEW ARTIFACT STORAGE

The new artifact storage provides a complementary facility to the house museum containing an artifact storage area, archives, artifact preparation and examination areas. Relocating the stored artifacts from the house museum to the new storage facility will create additional exhibition/event space at the house museum. Also, designating a proper storage area for the artifacts assists with rotating items on display and changing exhibits more regularly to attract more visitors. The Standards Practices Handbook for Museums (2001) states,

"Museums cannot, nor is it desirable to, display all of their collection at one time; therefore, proper storage facilities are required. Objects are best preserved in a storage facility where specific attention is paid to the storage area, its environment, and the methods and materials of storage."

Most of the museum collection has been stored at Horaceville for almost two centuries. As a result, these items have become accustomed to that environment. The new storage facility will contain a sealed environment designed in accordance with recommended museum standards to ensure the ongoing preservation of the artifacts. Transferring the artifacts from their old environment to the new environment will naturally introduce a form of fluctuation. It is crucial that the change in environment be very gradual to avoid unnecessary stress to the artifacts (Slade, 2003). The new facility will initially be controlled to provide similar environmental conditions to the house museum. Later, the conditions will be gradually changed to the new recommended environment.



95. **Transferring artifacts to the barn** (Karimi, 2015)

96. **Stone and timber sections** (Karimi, 2015)

THE BARN

The barn is located at the southeast side of Horaceville, at a distance of approximately twenty metres. It consists of two adjoined structures of comparable size, one with stone walls and the other constructed of timber. Due to a lack of historic documentation, the exact date of construction is unknown. However, Bruce Elliot, a local historian, explained at one of the site visits that the stone section was constructed in the 19th century (approx.1867), and the timber section was built in the twentieth century (approx. 1912). Both sections of the barn are two storeys and have similar layouts consisting of a stable on the ground floor and a hay storage on the second floor. The two sections are not connected except under a continuous pitched gable roof that covers both sections of the barn.

The stone section is built of rubble limestone with contrasting dressed sandstone quoins, sills, jambs, and lintels at the windows and doors. The stone walls are partially covered with tongue and groove wood boards inside the barn. The wood frame section is composed of timber framing with brick infill on a stone foundation clad with board and batten siding. The ground floor of both sections are covered with wood boards over log sleepers, and fitted up with stalls built out of random wood boards on wood studs. The second floor of both sections contains a large space with random wood boards on exposed floor joists. The pitched gable roof is covered with eastern white cedar shingles and roof boards over wood trusses.

97. **The barn, timber section** (Karimi, 2015)

98. **The joint between two sections** (Karimi, 2015)

99. **Roof trusses, point cloud model** (Karimi, 2015)

In recent years, the barn has been used as a storage space for the City of Ottawa and is occupied by large items and ground-work equipment. The overall physical condition of the barn is suffering due to a lack of maintenance. It appears that limited maintenance measures have been implemented over the years except for reroofing and repointing. The lack of maintenance in addition to inappropriate use of the barn is increasing the deterioration rate of the fabric. Before implementation of the new artifact storage, several remedial works are required to secure and stabilize the asset. Stabilization will be divided into two phases: immediate and future remedial works. The immediate works involve removal of all stored items, removal of all ground floor boards, refurbishment of windows and doors, and repairs of the damaged boards and battens cladding to prevent vermin entry and minimize air leakage. Stone repairs and repointing of the masonry walls are part of the future remedial works.

100. **Damaged boards and battens** (Karimi, 2015)

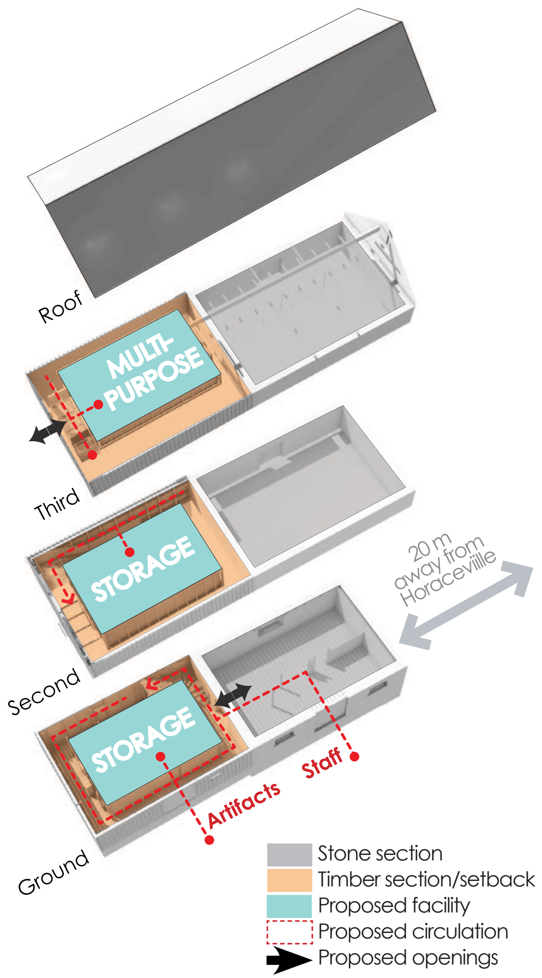
101. **Stone wall needs repointing** (Karimi, 2015)

102. **Rotten floor boards** (Karimi, 2015)

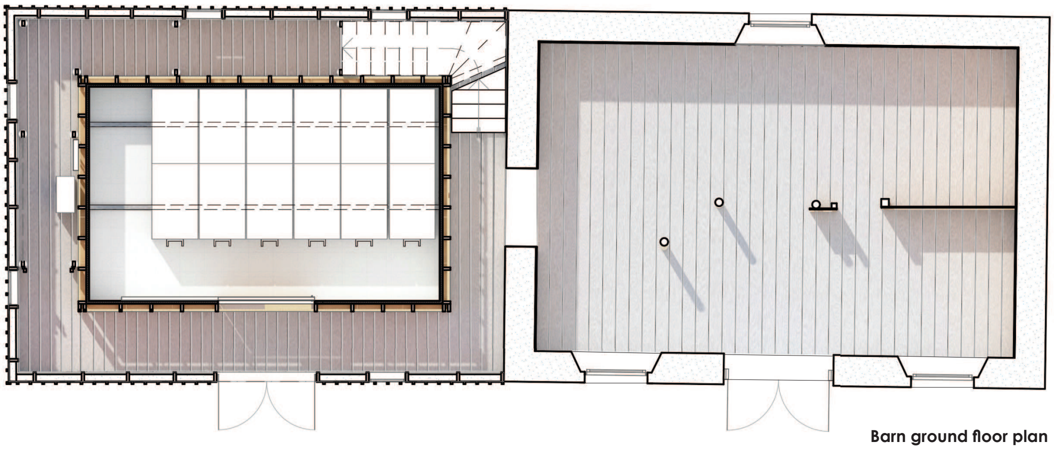
3.5 DESIGN PROPOSAL

After the immediate stabilization work in the barn, the interior structure of the timber section will be documented, removed and stored for future use/reconstruction. The new artifact storage facility will be assembled inside the vacant timber section with a set back from the existing shell to preserve the barn's exterior fabric. The gap between the new and old structures will be an integral part of the proposal and carries several functions; it will allow air to circulate between the two structures to reduce harmful moisture and provide future access to the existing fabric. The gap will also be used as utility space during and after construction.

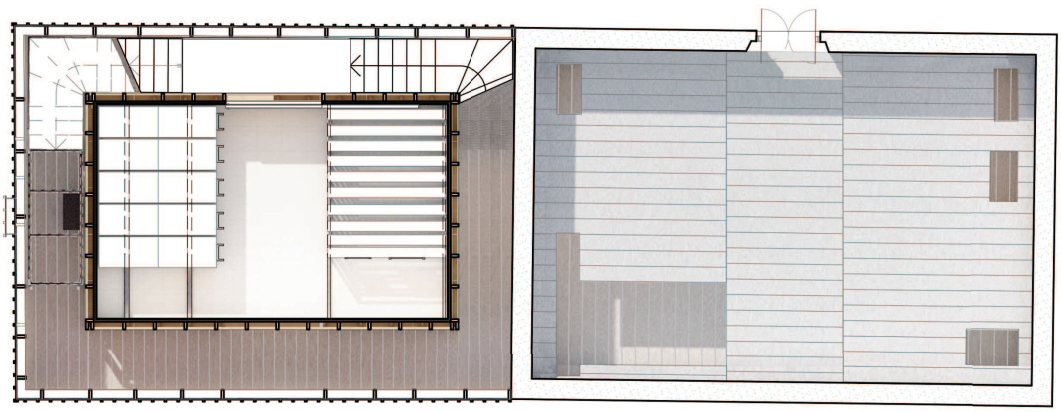
The new facility will be a three-storey rectangular container-type structure constructed using conventional wood framing construction. It will provide forty square metres of space on each floor connected by perimeter stairs located in the space between the old and new structures. The first two floors of the new storage facility will contain storage spaces for artifacts, and the third floor will offer a multi-purpose room planned for artifact preparation, examination and workshops. As mentioned previously, the house museum visitation areas, offices, and workspaces are closed during the winter months. The storage facility's multi-purpose room is intended to be accessible all year round for the museum and conservation related activities. The storage areas are based on Pinhey's Point Foundation's assessment of storage requirements conducted by Lundholm Associates in 2015.



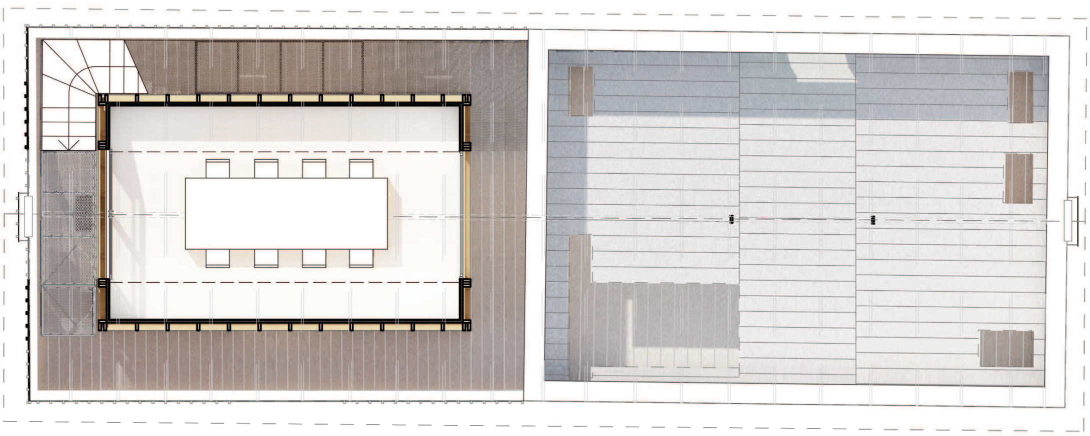
103. **Concept diagrams** (Karimi, 2016)



Barn ground floor plan



Barn second floor plan



Barn third floor plan

104. **Plans** (Karimi, 2016)

Barn north-south section

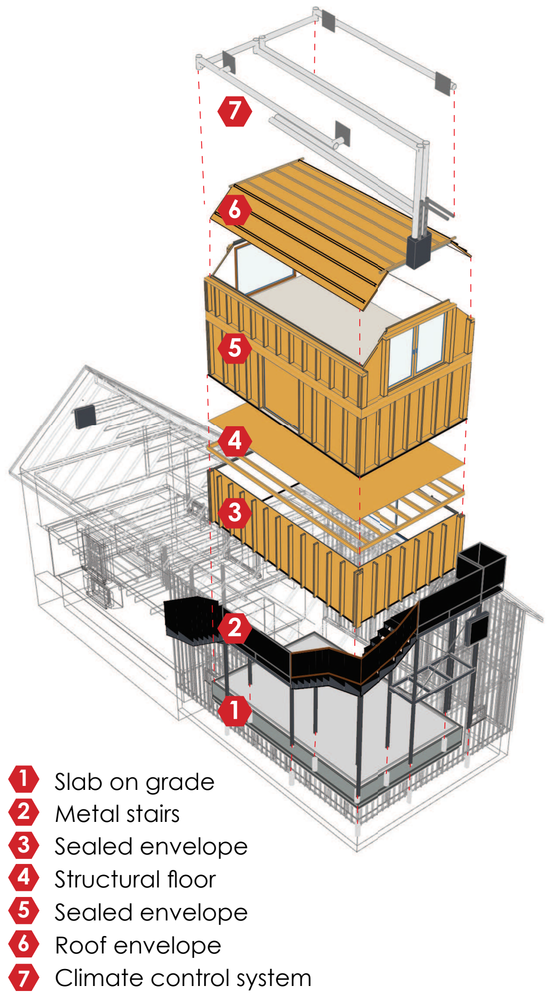
Barn east-west section

105. **Sections** (Karimi, 2016)

The first level will contain a compact storage system with wide shelves for heavy and large artifacts such as furniture pieces. The lighter and smaller items like framed artifacts and archival materials will be arranged on a specialized compact storage system on the second level.

CLIMATE CONTROL SYSTEMS

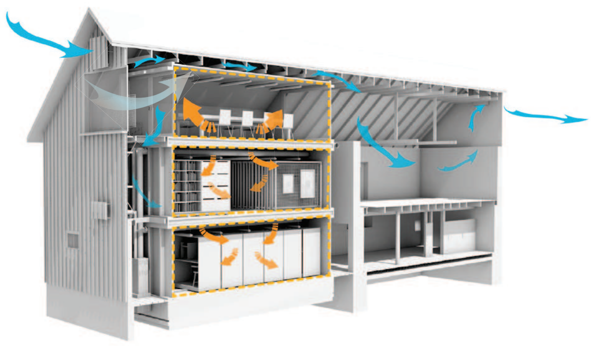
The new facility will be assembled on a new insulated concrete slab on grade with a setback from the existing barn's foundation. The insulated slab on grade will be constructed manually on inserted gravel to avoid intrusion of the existing foundation and to reduce the cost and complications associated with excavations inside the barn. The new facility's envelope system and floors will be constructed with wood framing internally sealed with continuous insulation and gypsum panels that provide a continuous thermal barrier to block thermal bridges and air leakage (fig. 108). Providing a sealed environment is easily achievable with highly insulated walls, which also help with maintaining the recommended indoor environment with steady RH levels. The barn and the facility's walls will play a significant role in providing a stable environment for storage as they offer two layers of protection against external forces. The shell-within-a-shell approach not only creates a safer environment for the storage, but it also reduces heating and cooling loads resulting in a reduction of operation costs.



106. **Facility assembly** (Karimi, 2016)

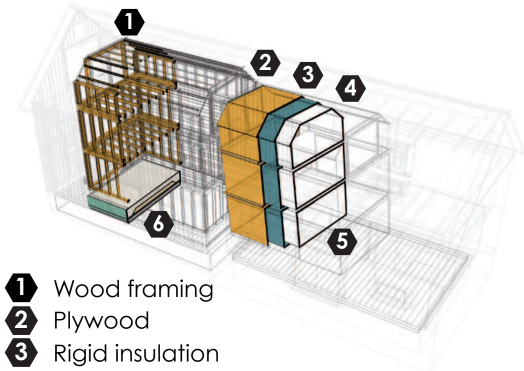
Furthermore, Conrad's building classification list (mentioned previously in the building classification section), considers the barn as a class 2 building, and the new facility as a class 5 building. It is safe to conclude that the environmental outcome of the new facility will be approximately equal to a class 6 structure, which are built to support precision controlled heating, cooling, and RH control systems (Conrad, 1995).

In conjunction with the envelope design, the climate control system is a important contributor to the environmental performance of the storage as well as the barn. 'Conservation ventilation' is a fan-operated system that is controlled by a humidistat; when the RH levels inside the barn exceed the outside RH levels, the fans will be activated to replace the indoor humid air with drier air supplied from the outside. This is a practical climate control system for type 2 (barn-type) structures. The fans must be equipped with dust filters to avoid dust from entering into the storage areas (Kerschner, 2007). Conservation ventilation is an efficient method to control the barn's environmental conditions, and it should be implemented in addition to the facility's proposed climate control system, called 'conservation heating'. Conservation heating controls the indoor RH levels by adding or suppressing heat to the environment by a furnace. Operated by digital controls and monitoring devices, this system keeps the RH below 55% in storage areas by simply withholding heat, and if the RH level exceeds 55% it will release heat to reduce the RH (Staniforth, 2007).



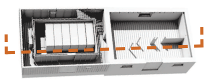
Conservation heating system
Conservation ventilation system
Natural ventilation

107. **Climate control system** (Karimi, 2016)



1 Wood framing
2 Plywood
3 Rigid insulation
4 Gypsum
5 Linoleum flooring
6 Slab on grade

108. **Facility envelope** (Karimi, 2016)



109. **Section perspective, shell within shell** (Karimi, 2016)

CIRCULATION

Other design considerations include the circulation route and access point. The barn is accessed by two main double barn doors at the north elevation. It is proposed to connect the interior of the two sections in the barn by creating an opening in the interior separating wall. The new entry will provide an additional means of egress as well as a separate entrance for the artifacts and staff. The stone section barn door will be the main entry for staff, and the timber section double door will be used for transferring artifacts in and out of the storage facility. The circulation route connects the preserved old section to the new rehabilitated section containing the storage facility. The circulation route continues to wrap around the facility surrounded by the existing barn structure. In addition to the practical benefits of having a gap between the two structures, it also preserves the visual connection to the barn fabric.

The visual link is also maintained on the third floor between the proposed multi-purpose room and the existing attic space through a wide glazed opening at the facility's west wall. Across from the glazed opening, a glazed entry door to the multi-purpose room will be installed to allow in ample natural light from the barn's existing hay door. The circulation route will also be lit by small existing window openings on all three elevations. The only source of lighting in the storage areas will be artificial lighting to protect the artifacts from light damage.

110. **Circulation** (Karimi, 2016)

111. **The gap between two structures** (Karimi, 2016)

112. **Interior views** (Karimi, 2016)

113. **Multi-purpose room's view towards the barn's attic** (Karimi, 2016)

CONCLUSION

Every building is originally designed and constructed with a certain function and indoor environmental condition in mind. But with time, the function of a building may change, consequently requiring adjustments to the environment. Such is the case for Horaceville when its function changed from a farm country residence to a public house museum. Both the building and its systems were repurposed and reprogramed. This transformation significantly altered the performance of the house and its indoor climate. A museum requires a stable indoor environment for the long-term preservation of its collection, typically provided by modern climate control systems. These systems were designed for new-built structures and work best in pair with sealed building envelopes. The implementation of these systems in historic house museums without retrofitting their traditional fabric is not a practical solution as it does not consider the potential negative impact on the traditional building. Also, every building can naturally provide a certain type of environment based on their construction and local climate factors. Buildings located in extreme climates such as Ottawa face more challenges in providing a desired museum environment. Museums' management must be aware of their assets' environmental capabilities and base the museum planning on realistic factors and achievable goals.

This thesis aimed to showcase a comprehensive methodology for conservation strategies and preservation planning of house museums. The framework was a crossroad of three disciplines: cultural analysis, scientific practices, and retrofits for the historic structure and the collection without impacting the integrity of the historic objects. The methodology included:

- Cultural heritage evaluation as the baseline study for any historic structure's conservation planning to understand the historical, contextual, and architectural values of the site.
- Scientific practices and techniques to evaluate the existing performance of the building and its indoor museum environment, including:
    - Documentation and surveying of the historic fabric.
    - Condition assessment study to understand the construction and performance of the building.
    - Environmental monitoring and testing to analyze the building performance.
    - Comprehensive performance analysis to determine issues.
    - Environmental classification analysis of the building and its occupying artifacts.
- Integration of the cultural studies and the technical findings to propose appropriate retro fits for the building and the artifacts, including:
    - Preventive conservation strategies to minimize the environmental impacts on the historic elements.
    - Climate control improvements for the house museum with the purpose of eliminating the RH extremes and to reduce the environmental instabilities.
    - Long-term solution for preservation and storage of sensitive artifacts, including a new artifact storage facility.

This methodology introduced appropriate preventive conservation strategies involving preservation planning, monitoring and maintenance programs, and new energy efficient technologies to eliminate indoor environmental extremes while preserving the historic integrity of the collection and the building for future generations. With additional documentation and comprehensiveness, it can potentially be applied to other similar historic house museums or case studies.

PROGRESS

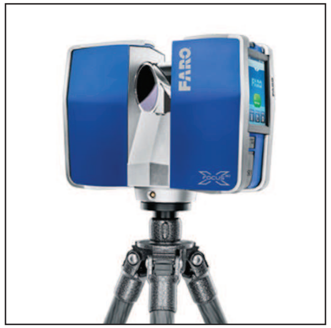
One of the limitations that was introduced by the scheduling constraints of the thesis was the single-season monitoring that was conducted. Ideally, this monitoring should span a full year in order to more comprehensively capture the environmental conditions of Horaceville.

During the thesis defence, it was suggested by the committee that more focus should be given to the material used in the new artifact facility. Selecting an appropriate material for the wall assembly of the new facility is crucial because it has a direct impact on the indoor climate of the facility. The thesis proposed that the new facility's envelope be composed of wood framing and plywood, insulation, and gypsum panels. However, this material may be vulnerable to pests and termite. In order to mitigate this issue, the plywood, insulation and gypsum panels can be potentially replaced with hempcrete, which is a concrete-type material composed of hemp hurds and lime. It has been used in France since the 1990's to construct non-load-bearing wall infill that can be supported by wood framing. It is also used for floor slabs and ceiling insulation. The assembly will be plastered from the interior and rendered with lime on the exterior. Hempcrete is a breathable material and can control moisture and condensation. It acts as a thermal mass and keeps the indoor temperature 2° C higher than a conventional structure in the heating season. Hempcrete construction blocks any thermal bridging and air leakage across a building's framework as the wood framing is completely isolated by the mixture, meaning there is no thermal bridging.

APPENDIX

1.1

3D Laser Scanner



Model: FARO Focus ^{3D} X330

Software: FARO Scene

Distance: accuracy up to ±2mm

Range: from 0.6m up to 330m

Noise: reduction 50%

1.2

Pinless Moisture Detector

Model: Mastercraft

Measurement mode:
drywall, masonry, softwood, and hardwood

Measurement depth: up to 1.3 cm

Readings: percentage

1.3

Infrared Camera (2013)

Model: FLIR E6
Software: FLIR Tools⁺
Resolution: 19,200 pix (160 x 120)
Temprature range: -20°C to 250°C
Thermal sensitivity: <0.06°C
Accuracy: 2%

1.4

Weather Center (2013)

Model: ACURITE 00436/00634/00634CA
Temperature range:
outdoor -40°C to 70°C
indoor 0°C to 50°C
Humidity range:
outdoor 1% to 99%
indoor 16% to 98%
Wind speed: 0 to 159 kph
Wireless range: 100 m
Data reporting: 18 second updates

2.1

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook (2008)

Table 3/21.13 / Museums, Galleries, Archives, and Libraries

Tamprature and relative humidity specifications for collection

Table 3 Temperature and Relative Humidity Specifications for Collections

Type	Set Point or Annual Average	Maximum Fluctuations and Gradients in Controlled Spaces: Class of Control	Short Fluctuations plus Space Gradients	Seasonal Adjustments in System Set Point	Collection Risks and Benefits
General Museums, Art Galleries, Libraries, and Archives All reading and retrieval rooms, rooms for storing chemically stable collections, especially if mechanically medium to high vulnerability.	50% rh (or historic annual average for permanent collections) Temperature set between 59 and 77°F *Note*: Rooms intended for loan exhibitions must handle set point specified in loan agreement, typically 50% rh, 70°F, but sometimes 55% or 60% rh.	**AA** Precision control, no seasonal changes	±5% rh, ±4°F	Relative humidity no change Up 9°F; down 9°F	No risk of mechanical damage to most artifacts and paintings. Some metals and minerals may degrade if 50% rh exceeds a critical relative humidity. Chemically unstable objects unusable within decades.
		A Precision control, some gradients or seasonal changes, not both	±5% rh, ±4°F	Up 10% rh, down 10% rh Up 9°F; down 18°F	Small risk of mechanical damage to high-vulnerability artifacts; no mechanical risk to most artifacts, paintings, photographs, and books. Chemically unstable objects unusable within decades.
			±10% rh, ±4°F	RH no change Up 9°F; down 18°F	
		B Precision control, some gradients plus winter temperature setback	±10% rh, ±9°F	Up 10%, down 10% rh Up 18°F, but not above 86°F	Moderate risk of mechanical damage to high-vulnerability artifacts; tiny risk to most paintings, most photographs, some artifacts, some books; no risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 86°F, but cold winter periods double life.
		C Prevent all high-risk extremes	Within 25 to 75% rh year-round Temperature rarely over 86°F, usually below 77°F		High risk of mechanical damage to high-vulnerability artifacts; moderate risk to most paintings, most photographs, some artifacts, some books; tiny risk to many artifacts and most books. Chemically unstable objects unusable within decades, less if routinely at 86°F, but cold winter periods double life.
		D Prevent dampness	Reliably below 75% rh		High risk of sudden or cumulative mechanical damage to most artifacts and paintings because of low-humidity fracture; but avoids high-humidity delamination and deformations, especially in veneers, paintings, paper, and photographs. Mold growth and rapid corrosion avoided. Chemically unstable objects unusable within decades, less if routinely at 86°F, but cold winter periods double life.
Archives, Libraries Storing chemically unstable collections	Cold Store: –4°F, 40% rh	±10% rh, ±4°F			Chemically unstable objects usable for millennia. Relative humidity fluctuations under one month do not affect most properly packaged records at these temperatures (time out of storage becomes lifetime determinant).
	Cool Store: 50°F 30 to 50% rh	(Even if achieved only during winter setback, this is a net advantage to such collections, as long as damp is not incurred)			Chemically unstable objects usable for a century or more. Such books and papers tend to have low mechanical vulnerability to fluctuations.
Special Metal Collections	Dry room: 0 to 30% rh	Relative humidity not to exceed some critical value, typically 30% rh			

Note: Short fluctuations means any fluctuation less than the seasonal adjustment. However, as noted in the section on Response Times of Artifacts, some fluctuations are too short to affect some artifacts or enclosed artifacts.

2.2

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Handbook (2008)

Table 4/21.14 / HVAC Applications

Classification of climate control potential in buildings

Table 4 Classification of Climate Control Potential in Buildings

Category of Control	Building Class	Typical Building Construction	Typical Type of Building	Typical Building Use	System Used	Practical Limit of Climate Control	Class of Control Possible
Uncontrolled	I	Open structure	Privy, stocks, bridge, sawmill, well	No occupancy, open to viewers all year.	No system.	None	D (if benign climate)
	II	Sheathed post and beam	Cabins, barns, sheds, silos, icehouse	No occupancy. Special event access.	Exhaust fans, open windows, supply fans, attic venting. No heat.	Ventilation	C (if benign climate) D (unless damp climate)
Partial control	III	Uninsulated masonry, framed and sided walls, single-glazed windows	Boat, train, lighthouse, rough frame house, forge	Summer tour use. Closed to public in winter. No occupancy.	Low-level heat, summer exhaust ventilation, humidistatic heating for winter control.	Heating, ventilating	C (if benign climate) D (unless hot, damp climate)
	IV	Heavy masonry or composite walls with plaster. Tight construction; storm windows	Finished house, church, meeting house, store, inn, some office buildings	Staff in isolated rooms, gift shop. Walk-through visitors only. Limited occupancy. No winter use.	Ducted low-level heat. Summer cooling, on/off control, DX cooling, some humidification. Reheat capability.	Basic HVAC	B (if benign climate) C (if mild winter) D
Climate controlled	V	Insulated structures, double glazing, vapor retardant, double doors	Purpose-built museums, research libraries, galleries, exhibits, storage rooms	Education groups. Good open public facility. Unlimited occupancy.	Ducted heat, cooling, reheat, and humidification with control dead band.	Climate control, often with seasonal drift	AA (if mild winters) A B
	VI	Metal wall construction, interior rooms with sealed walls and controlled occupancy	Vaults, storage rooms, cases	No occupancy. Access by appointment.	Special heating, cooling, and humidity control with precision constant stability control.	Special constant environments	AA A Cool Cold Dry

Source: Adapted from Conrad (1995).

3

New Orleans Charter for Preservation of Historic Structures (1992)
The New Orleans Charter

New Orleans Charter for Preservation of Historic Structures

The New Orleans Charter is the product resulting from the two symposia: *Museums in Historic Buildings* held in Montreal, Quebec (1990) and New Orleans, Louisiana (1991) and co-sponsored by the American Institute for Conservation of Historic and Artistic Works (AIC) and The Association for Preservation Technology International. This Charter has been officially adopted by the Board of Directors of both AIC and APTI.

The New Orleans Charter was subsequently adopted by the National Conference of State Historic Preservation Officers at its Annual Meeting in Washington, D.C. in March, 1992.

In 1992 this Charter was presented by a panel of symposium participants at a half-dozen conferences.
American Institute for Conservation, Buffalo, June 1992
American Association of State and Local History, Miami, Sept 1992
International Council of Museums, Sept 1992
Association for Preservation Technology, Philadelphia, Sept 1992
Joint meeting of the Mid-Atlantic Association of Museums/New England Museum Association, Albany, Nov 1992
—APT Communiqué 21(2): May 1992

The New Orleans Charter

Arising from a concern for the coexistence of historic structures and the artifacts housed within them;

Recognizing our responsibility as stewards to provide the highest levels of care for the structures and other artifacts placed in our care;

Recognizing that many significant structures are used to house, display and interpret artifacts;

Recognizing that historic structures and the contents placed within them deserve equal consideration in planning for their care;

Recognizing that technologies and approaches will continue to change; and

Recognizing that those involved in preservation are part of a continuum, and are neither the first nor the last to affect the preservation of historic structures and artifacts;

We, therefore, adopt these principles as governing the preservation of historic structures and the artifacts housed in them:

1. Institutions' statements of mission should recognize the need to preserve the unique character of both the historic structure and artifacts.
2. The preservation needs of the historic structure and of the artifacts should be defined only after study adequate to serve as the foundation for the preservation of both.
3. Requisite levels of care should be established through the interdisciplinary collaboration of all qualified professionals with potential to contribute.
4. Appropriate preservation must reflect application of recognized preservation practices, including assessment of risk before and after intervention, and the expectation of future intervention.
5. Measures which promote the preservation of either the historic structure or the artifacts, at the expense of the other, should not be considered.
6. Regarding public use, the right of future generations to access and enjoyment must outweigh immediate needs.
7. Appropriate preservation strategies should be guided by the specific needs and characteristics of the historic structure and artifacts.
8. Appropriate documentation of all stages of a project is essential, and should be readily accessible and preserved for the future.
9. The most appropriate action in a particular case is one which attains the desired goal with the least intervention to the historic structure and the artifacts.
10. Proposed preservation strategies should be appropriate to the ability of the institution to implement and maintain them.

4

Lundholm Associates (2015)

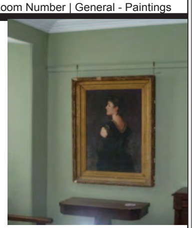
Collections storage survey summary

Room	Zone	Description	Recommended Storage Furniture	Recommended Environment	Net Existing Storage Footprint		Net Adjusted Footprint Required		Net Adjusted Area w/ Growth		Net Adjusted Area w/ Compact	
					ft2	m2	ft2	m2	ft2	m2	ft2	m2
General - Artefacts In-Situ in House (0 sf)												
Gen.	1	framed paintings	wall &/or mobile racks	general museum env.	0	0.0	24	2.2	29	2.7	20	1.9
Gen.	2	m-l, furniture	rack shelves, 4'0"d	general museum env.	0	0.0	62	5.8	68	6.3	51	4.7
Gen.	3	s-m, household	utility shelves, 2'0"d	general museum env.	0	0.0	48	4.5	53	4.9	37	3.4
Gen.	4	m-l, furniture	rack shelves, 4'0"d	general museum env.	0	0.0	193	17.9	212	19.7	159	14.8
Gen.	5	archaeological	utility shelves, 1'6"d	general museum env.	0	0.0	40	3.7	40	3.7	28	2.6
Gen.	6	archival - rare books	pull-out racks 10' x 10'	general museum env.	7	0.7	7	0.7	8	0.7	6	0.6
		Subtotal General In-Situ *net storage footprint*			**7**	0.7	**374**	34.7	**410**	38.1	**301**	28.0
Main Artefact Storage, Second Level West (165 sf)												
Main	1	s, miscellaneous	utility shelves, 1'6"d	general museum env.	69	6.4	106	9.8	117	10.9	82	7.6
Main	2	framed works	wall racks	general museum env.	25	2.3	90	8.4	108	10.0	81	7.5
Main	3	m-l, paintings	wall racks	general museum env.	9	0.8	14	1.3	17	1.6	12	1.1
Main	4	framed works, photos	slot storage bins, 2'0"d	general museum env.	33	3.1	21	2.0	26	2.4	18	1.7
Main	5	s, high-value	drawers in utility 1'6"	general museum env.	8	0.7	8	0.7	9	0.8	6	0.6
Main	6	collection records	relocated	human comfort	8	0.7	0	0.0	na	na	na	na
Main	7	oversize, flat	utility shelves, 1'6"d	general museum env.	0	0.0	11	1.0	12	1.1	8	0.7
		Subtotal Main Artefact Storage *net storage footprint*			**152**	14.1	**250**	23.2	**289**	26.8	**207**	19.2
Book Room, Second Level East (78 sf)												
Book	1	archival - books, docs	utility shelves, 1'4"d	general museum env.	34	3.2	40	3.7	48	4.5	31	2.9
Book	2	archival - photos, docs	utility shelves, 1'4"d	general museum env.	16	1.5	16	1.5	20	1.9	14	1.3
		Subtotal Book Room *net storage footprint*			**50**	4.6	**56**	5.2	**68**	6.3	**45**	4.2
Off-Site Storage												
Off-Site	1	to be confirmed	utility shelves, 1'4"d	general museum env.	0	0.0	31	2.9	34	3.2	24	2.2
		Subtotal Off-Site *net storage footprint*			**0**	0.0	**31**	2.9	**34**	3.2	**24**	2.2
		Subtotal Artefact 1, 2, & 3, "A", & Office *net storage footprint*			**209**	19.4	**711**	66.1	**801**	74.4	**577**	53.6
		plus 15% circulation			na	na	107	9.9	120	11.2	87	8.0
		Subtotal *net storage w/ circulation*			na	na	**818**	**76.0**	**921**	**85.6**	**664**	**61.6**
		plus 10% allowance - configuration			na	na	71	6.6	80	7.4	58	5.4
		TOTAL *net storage area - planning*			na	na	**889**	**82.6**	**1001**	**93.0**	**721**	**67.0**

5.1

Lundholm Associates (2015)

Collections storage survey

Collection Storage Survey Form				Date Surveyed	21-Apr-15	Storage Zone	1
Building | 270 Pinney's Point Road		Floor	House 1, 2	Room	Pinhey's Point	Room Number | General - Paintings	
STORAGE DATA / ASSUMPTIONS	Collection Description	framed paintings					
	Present Packaging Format	framed, hanging on walls					
	Recommended Packaging Format	framed, hanging on walls and/or independantly supported racks					
	Present Storage Furniture	in situ, on site					
	Recommended Storage Furniture	wall racks and/or independantly supported racks by area required – 10'0" x 1'0" x 10'0" with 42" access aisle					
	Present Environment	15 to 22°C range - up to 60% RH in summer		Recommended Environment		general museum environment: 40-55% RH seasonally adjusted	
						Net Existing Zone Footprint	0
ADJUSTMENTS TO PROPER STANDARDS	Format	convert area of paintings to new format - 50sf		Adjustment	na	calculation is cumulative	22
	Density	allow 10% for placement of works on rack		Adjustment	10%		2
	Height	included in format calculation		Adjustment	0%		0
	Access	included in format calculation		Adjustment	0%		0
	Other	n/a		Adjustment	0%		0
						Total Adjusted Zone Requirement - Existing Collection	24
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	1.0%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	5
	One Time Growth	n/a		% of Existing	0%	n/a	0
						Total Adjusted Zone Requirement Including Growth Allowance	29
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70		
						Total Zone Area Requirement w/ Growth Using Compact Storage	20
NOTES							

5.2

Collection Storage Survey Form				Date Surveyed	21-Apr-15	Storage Zone	2
Building | 270 Pinney's Point Road		Floor	House 1, 2	Room	Pinhey's Point	ı Number | General - Artefact	
STORAGE DATA / ASSUMPTIONS	Collection Description	furniture items					
	Present Packaging Format	open					
	Recommended Packaging Format	open					
	Present Storage Furniture	on floor, in situin the house					
	Recommended Storage Furniture	rack shelves 6'0" to 10'0" x 4'0" x 10'0" back to back with 36" half aisle access allowance					
	Present Environment	15 to 22°C range - up to 60% RH in summer		Recommended Environment		general museum environment: 40-55% RH seasonally adjusted	
						Net Existing Zone Footprint	0
ADJUSTMENTS TO PROPER STANDARDS	Format	convert to new format based on 300 ft³ volume allowance **		Adjustment	na	calculation is cumulative	56
	Density	allow 10% for placement of artefacts on shelves		Adjustment	10%		6
	Height	included in format calculation		Adjustment	0%		0
	Access	included in format calculation		Adjustment	0%		0
	Other	n/a		Adjustment	0%		0
						Total Adjusted Zone Requirement - Existing Collection	62
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	6
	One Time Growth	n/a		% of Existing	0%	n/a	0
						Total Adjusted Zone Requirement Including Growth Allowance	68
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.75		
						Total Zone Area Requirement w/ Growth Using Compact Storage	51
NOTES							

5.3

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	3
Building | 270 Pinney's Point Road	Floor | House 1, 2	Room | Pinhey's Point		Room Number | General - Artefacts 2 *	

STORAGE DATA / ASSUMPTIONS				
Collection Description	small to medium artefacts: household, china, kitchen, furniture, personal, etc.			
Present Packaging Format	open, solander boxes, and wrapped			
Recommended Packaging Format				
Present Storage Furniture	miscellaneous: display cases,wardrobes, and cabinets - see dimensions on plans			
Recommended Storage Furniture	utility shelves 3'0" to 6'0" x 2'0" x 10'0" back to back with 42" access aisle allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	0

ADJUSTMENTS TO PROPER STANDARDS				
Format	convert to new format based on estimate of existing shelf area - 250 ft^3	Adjustment	na	44
Density	allow 10% for placement of artefacts on shelves	Adjustment	10%	4
Height	included in format calculation	Adjustment	0%	0
Access	included in format calculation	Adjustment	0%	0
Other	n/a	Adjustment	0%	0

calculation is cumulative

					Total Adjusted Zone Requirement - Existing Collection	48
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth: 5
	One Time Growth	n/a		% of Existing	0%	n/a: 0
					Total Adjusted Zone Requirement Including Growth Allowance	53
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70	
					Total Zone Area Requirement w/ Growth Using Compact Storage	37

NOTES

5.4

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	4
Building | 270 Pinney's Point Road	Floor | Attic East&West	Room | Pinhey's Point		Room Number | General	

STORAGE DATA / ASSUMPTIONS				
Collection Description	medium to large: miscellaneous furniture			
Present Packaging Format	covered with drop sheets			
Recommended Packaging Format	open on shelves			
Present Storage Furniture	floor			
Recommended Storage Furniture	rack shelves 6'0" to 12'0" x 4'0" x 10'0" back to back with 60" access aisle allowance			
Present Environment	range in excess of that stated for rooms in house (see Zone 1)	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	0

ADJUSTMENTS TO PROPER STANDARDS				
Format	convert to new format by storage volume - 920 ft^3	Adjustment	na	175
Density	allow 10% for placement of artefacts on shelves	Adjustment	10%	18
Height	included in format calculation	Adjustment	0%	0
Access	included in format calculation	Adjustment	0%	0
Other	n/a	Adjustment	0%	0

calculation is cumulative

					Total Adjusted Zone Requirement - Existing Collection	193
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth: 19
	One Time Growth	n/a		% of Existing	0%	n/a: 0
					Total Adjusted Zone Requirement Including Growth Allowance	212
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.75	
					Total Zone Area Requirement w/ Growth Using Compact Storage	159

NOTES

5.5

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	5
Building | 270 Pinney's Point Road	Floor | Attic East	Room | Pinhey's Point		Room Number | Archaeology	

STORAGE DATA / ASSUMPTIONS				
Collection Description	archaeological materials			
Present Packaging Format	bankers boxes (100)			
Recommended Packaging Format	bankers boxes - 3 per shelf			
Present Storage Furniture	on floor in east attic			
Recommended Storage Furniture	utility shelves 3'6" x 1'6" x 10'0" back to back with 42" access aisle allowance			
Present Environment	range in excess of that stated for rooms in house (see Zone 1)	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	0

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	convert to new format based on number of boxes	Adjustment	na	40
Density	included in format calculation	Adjustment	0%	0
Height	included in format calculation	Adjustment	0%	0
Access	included in format calculation	Adjustment	0%	0
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	40

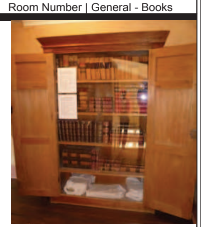
GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	0.0%	Number of Years to Planning Horizon	0	Additional Area for Incremental Growth	0
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	40

COMPACT				
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70
			Total Zone Area Requirement w/ Growth Using Compact Storage	28

NOTES

5.6

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	6
Building | 270 Pinney's Point Road	Floor | Second East	Room | Pinhey's Point		Room Number | General - Books	



STORAGE DATA / ASSUMPTIONS				
Collection Description	archival - rare books			
Present Packaging Format	open on shelves, behind glass			
Recommended Packaging Format	open on shelves			
Present Storage Furniture	wood cabinet 4'0" x 1'6" x 6'0" with full access from corridor			
Recommended Storage Furniture	utility shelves 3'6" x 1'6" x 10'0" with 42" access aisle allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	7

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	convert to new format - no change +/-	Adjustment	0%	0
Density	decrease density by 20%	Adjustment	-20%	-1
Height	increase height from 6'0" to 10'0"	Adjustment	-40%	-2
Access	provide access allowance of 21" half aisle	Adjustment	120%	4
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	7

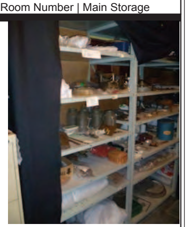
GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	1
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	8

COMPACT				
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70
			Total Zone Area Requirement w/ Growth Using Compact Storage	6

NOTES

5.7

Collection Storage Survey Form			Date Surveyed	21-Apr-15	Storage Zone	1
Building | 270 Pinney's Point Road	Floor	2nd West	Room	Pinhey's Point	Room Number | Main Storage	



STORAGE DATA / ASSUMPTIONS				
Collection Description	small, miscellaneous artefacts			
Present Packaging Format	open on shelves, and some custom packaging			
Recommended Packaging Format	open on shelves with custom packaging as necessary			
Present Storage Furniture	utility shelves 3'0" x 2'0" x 7'0" with minimal aisle allowance			
Recommended Storage Furniture	utility shelves 3'0" x 1'6" x 10'0" with 42" access aisle allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	**69**

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	convert to new shelf depth of 1'6" - no change, new shelf area is equivalent to existing	Adjustment	0%	0
Density	decrease density by 10%	Adjustment	10%	7
Height	increase height from 7'6" to 10'0"	Adjustment	-30%	-23
Access	provide access allowance of 21" half aisle	Adjustment	100%	53
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	**106**

GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	11
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	**117**

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70	
				Total Zone Area Requirement w/ Growth Using Compact Storage	**82**

NOTES

5.8

Collection Storage Survey Form			Date Surveyed	21-Apr-15	Storage Zone	2
Building | 270 Pinney's Point Road	Floor	2nd West	Room	Pinhey's Point	Room Number | Main Storage	

STORAGE DATA / ASSUMPTIONS				
Collection Description	framed works on paper, photographs			
Present Packaging Format	vertical slot storage, individually wrapped			
Recommended Packaging Format	haning on racks			
Present Storage Furniture	slot storage bin 2'6" x 3'0" x 6'0" with 42" access allowance			
Recommended Storage Furniture	wall and/or independently supported painting racks, 10'0"h			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	**25**

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	convert to new storage furniture based on 400 sf +/- area of works to be hung	Adjustment	260%	65
Density	included in format calculation	Adjustment	0%	0
Height	included in format calculation	Adjustment	0%	0
Access	included in format calculation	Adjustment	0%	0
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	**90**

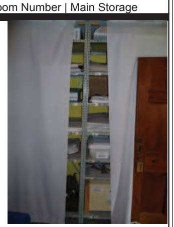
GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	1.0%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	18
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	**108**

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.75	
				Total Zone Area Requirement w/ Growth Using Compact Storage	**81**

NOTES

5.9

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	4
Building | 270 Pinney's Point Road	Floor | 2nd West	Room | Pinhey's Point		Room Number | Main Storage	



STORAGE DATA / ASSUMPTIONS	Collection Description	framed works on paper, photographs			
	Present Packaging Format	individually wrapped and/or in solander boxes or plastic containers, stored flat, stacked on shelves			
	Recommended Packaging Format	individually wrapped and/or custom packaging appropriate for each type and size of work			
	Present Storage Furniture	utility shelves 3'0" x 2'0" x 7'0" with 36" access aisle allowance			
	Recommended Storage Furniture	utility shelves with combined slot storage below and shelves above, 4'0" x 2'0" x 10'0" back to back with 24" half aisle access allowance *			
	Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
				Net Existing Zone Footprint	33
ADJUSTMENTS TO PROPER STANDARDS	Format	no change - existing footprint equivalent to new format	Adjustment	0%	0
	Density	increase density by 15%	Adjustment	15%	5
	Height	increase height from 7'0" to 10'0"	Adjustment	-30%	-11
	Access	decrease half aisle access from 36" to 24"	Adjustment	-20%	-5
	Other	n/a	Adjustment	0%	0
				calculation is cumulative	
				Total Adjusted Zone Requirement - Existing Collection	21
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	1.0%	Number of Years to Planning Horizon 20	Additional Area for Incremental Growth 4
	One Time Growth	n/a	% of Existing	0%	n/a 0
				Total Adjusted Zone Requirement Including Growth Allowance	26
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70
				Total Zone Area Requirement w/ Growth Using Compact Storage	18
NOTES					

5.10

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	5
Building | 270 Pinney's Point Road	Floor | 2nd West	Room | Pinhey's Point		Room Number | Main Storage	

STORAGE DATA / ASSUMPTIONS	Collection Description	valuable small artefacts (silver)			
	Present Packaging Format	custom individual packaging in drawers			
	Recommended Packaging Format	custom individual packaging			
	Present Storage Furniture	utility shelves 3'0" x 2'0" x 7'0" with 36" access aisle allowance			
	Recommended Storage Furniture	secure drawers integrated into shelving systems (example: shelves 1'4"d or 1'6"d)			
	Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
				Net Existing Zone Footprint	8
ADJUSTMENTS TO PROPER STANDARDS	Format	new shelving format is assumed to be equivalent to existing footprint	Adjustment	0%	0
	Density	no change	Adjustment	0%	0
	Height	included in format calculation	Adjustment	0%	0
	Access	included in format calculation	Adjustment	0%	0
	Other	n/a	Adjustment	0%	0
				calculation is cumulative	
				Total Adjusted Zone Requirement - Existing Collection	8
GROWTH ALLOWANCE	Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon 20	Additional Area for Incremental Growth 1
	One Time Growth	n/a	% of Existing	0%	n/a 0
				Total Adjusted Zone Requirement Including Growth Allowance	9
COMPACT	Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70
				Total Zone Area Requirement w/ Growth Using Compact Storage	6
NOTES					

5.11

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	6 *
Building | 270 Pinney's Point Road	Floor | 2nd West	Room | Pinhey's Point		Room Number | Main Storage	

STORAGE DATA / ASSUMPTIONS				
Collection Description	collections records			photo not available
Present Packaging Format	file cabinet			
Recommended Packaging Format	file cabinet			
Present Storage Furniture	vertical file cabinet 1'6" x 2'4" x 4'6"			
Recommended Storage Furniture	vertical file cabinet 1'6" x 2'4" x 4'6" with 42" access aisle			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	human comfort	
			Net Existing Zone Footprint	8

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative	
Format	collections records not included in collections storage	Adjustment	-100%		-8
Density	n/a	Adjustment	0%		0
Height	n/a	Adjustment	0%		0
Access	n/a	Adjustment	0%		0
Other	n/a	Adjustment	0%		0
				Total Adjusted Zone Requirement - Existing Collection	0

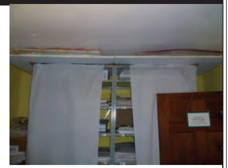
GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	0.0%	Number of Years to Planning Horizon	0	Additional Area for Incremental Growth	0
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	0

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	no	Factor	1.00	
				Total Zone Area Requirement w/ Growth Using Compact Storage	0

NOTES

5.12

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	7
Building | 270 Pinney's Point Road	Floor | 2nd West	Room | Pinhey's Point		Room Number | Main Storage	



STORAGE DATA / ASSUMPTIONS				
Collection Description	oversize, flat - maquetts, textile boxes			
Present Packaging Format	miscellaneous: open, solander boxes, etc.			
Recommended Packaging Format	miscellaneous packaging appropriate to type of collection to be stored			
Present Storage Furniture	on top of Zones 1, 2, 4			
Recommended Storage Furniture	utility shelves 4.0 to 6'0" x 2'6" x 10'0" back to back with 54" access aisle allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	0

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative	
Format	convert to new shelf format based on estimated volume of 45 ft^3	Adjustment	na		10
Density	allow 10% for placement of artefacts	Adjustment	10%		1
Height	included in format calculation	Adjustment	0%		0
Access	included in format calculation	Adjustment	0%		0
Other	n/a	Adjustment	0%		0
				Total Adjusted Zone Requirement - Existing Collection	11

GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	0.5%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	1
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	12

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70	
				Total Zone Area Requirement w/ Growth Using Compact Storage	8

NOTES

5.13

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	1
Building | 270 Pinney's Point Road	Floor | 2nd East	Room | Pinhey's Point		Room Number | Book Room	

STORAGE DATA / ASSUMPTIONS				
Collection Description	archival materials: books, documents			
Present Packaging Format	open on shelves, some solander boxes with dust blackout sheet cover			
Recommended Packaging Format	open on shelves, solander boxes for documents and photographs			
Present Storage Furniture	utility shelves 3'0" x 2'0" x 6'0" with 12" half aisle access allowance			
Recommended Storage Furniture	utility shelves 3'0" x 1'4" x 10'0" back to back with 18" half aisle access allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	34

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	adjust for narrower shelf depth of 1'4"	Adjustment	-25%	-9
Density	decrease density by 110% (existing shelf has books 2 deep)	Adjustment	110%	28
Height	increase height from 6'0" to 10'0"	Adjustment	-40%	-21
Access	increase half aisle access allowance from 12" to 18"	Adjustment	25%	8
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	40

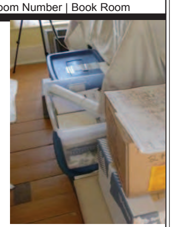
GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	1.0%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	8
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	48

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.65	
				Total Zone Area Requirement w/ Growth Using Compact Storage	31

NOTES

5.14

Collection Storage Survey Form		Date Surveyed	21-Apr-15	Storage Zone	2
Building | 270 Pinney's Point Road	Floor | 2nd East	Room | Pinhey's Point		Room Number | Book Room	



STORAGE DATA / ASSUMPTIONS				
Collection Description	archival materials: photographs, ducuments			
Present Packaging Format	in plastic tubs			
Recommended Packaging Format	solander boxes, bankers boxes			
Present Storage Furniture	plastic tubs on floor			
Recommended Storage Furniture	combined slot storage (below) with shelves (above) – similar to Main Storage Zone 4 – 4'0" x 1'6" x 10'0" back to back with 21" half aisle allowance			
Present Environment	15 to 22°C range - up to 60% RH in summer	Recommended Environment	general museum environment: 40-55% RH seasonally adjusted	
			Net Existing Zone Footprint	16

ADJUSTMENTS TO PROPER STANDARDS				calculation is cumulative
Format	convert to new storage format by 60 ft3 volume of storage	Adjustment	-15%	-2
Density	allow 20% for decrease in density	Adjustment	20%	3
Height	included in format calculation	Adjustment	0%	0
Access	included in format calculation	Adjustment	0%	0
Other	n/a	Adjustment	0%	0
			Total Adjusted Zone Requirement - Existing Collection	16

GROWTH ALLOWANCE						
Incremental Growth	% Incremental Growth Per Year	1.0%	Number of Years to Planning Horizon	20	Additional Area for Incremental Growth	3
One Time Growth	n/a		% of Existing	0%	n/a	0
					Total Adjusted Zone Requirement Including Growth Allowance	20

COMPACT					
Potential Adjustment for Compact Storage	Candidate for Compact?	yes	Factor	0.70	
				Total Zone Area Requirement w/ Growth Using Compact Storage	14

NOTES

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GLOSSARY

3D scanner: A 3D scanner is a device that analyses a real-world object or environment to collect data on its shape and possibly its appearance (e.g. colour). The collected data can then be used to construct digital three-dimensional models.

Agricultural: of or relating to agriculture.

ArchiCAD: ArchiCAD is an architectural BIM CAD software for Macintosh and Windows developed by the Hungarian company Graphisoft. ArchiCAD offers computer aided solutions for handling all common aspects of aesthetics and engineering during the whole design process of the built environment, buildings, interiors, urban areas, etc.

Artifacts: An object made by a human being, typically an item of cultural or historical interest.

Ashlar stone: Ashlar is finely dressed (cut, worked) masonry, either an individual stone that has been worked until squared or the masonry built of such stone. It is the finest stonemasonry unit, generally cuboid, mentioned by Vitruvius as opus isodomus, or less frequently trapezoidal.

Basement: means a storey (or storeys) of building located below the first storey.

Character-defining elements: The materials, forms, location, spatial configurations, uses cultural associations or meanings that contribute to the heritage value of a historic place, which must be retained in order to conserve its heritage value.

Climate control system: A technology that provides thermal comfort and acceptable indoor air quality.

Computer Aided Design (CAD): Computer-aided design (CAD) is the use of computer systems to aid in the creation, modification, analysis, or optimization of a design.

Condensation: Condensation is the change of water from its gaseous form (water vapor) into liquid water. Condensation generally occurs in the atmosphere when warm air rises, cools and loses its capacity to hold water vapor. As a result, excess water vapor condenses to form cloud droplets.

Cornice: A cornice (from the Italian cornice meaning "ledge") is generally any horizontal decorative molding that crowns a building or furniture element, the cornice over a door or window, for instance, or the cornice around the top edge of a pedestal or along the top of an interior wall. A simple cornice may be formed just with a crown molding.

Conservation: All actions or processes that are aimed at safeguarding the character-defining elements of a cultural resource so as to maintain its heritage value and extend its physical life. This may involve Preservation, Rehabilitation, and Restoration, or a combination of these actions or processes.

Cultural Analysis: As a discipline, cultural analysis is based on using qualitative research methods of the arts, humanities, social sciences, in particular ethnography and anthropology, to collect data on cultural phenomena and to interpret cultural representations and practices; in an effort to gain new knowledge or understanding.

Cultural Heritage: Cultural Heritage is an expression of the ways of living developed by a community and passed on from generation to generation, including customs, practices, places, objects, artistic expressions and values.

Energy Efficiency: Efficient energy use, sometimes simply called energy efficiency, is the goal to reduce the amount of energy required to provide products and services

Environmental Studies: Environmental Studies is a multidisciplinary academic field – which systematically studies human interaction with the environment in the interests of solving complex problems.

Flues: a duct for smoke and waste gases produced by a fire, a gas heater, a power station, or other fuel-burning installation.

Historical Value: Measure of the importance of a document or item that justifies its permanent retention. Also called archival value, continuing value, or enduring value.

Historic House Museum: A historic house museum is a house that has been transformed into a museum. Historic furnishings may be displayed in a way that reflects their original placement and usage in a home. Historic house museums are held to a variety of standards, including those of the International Council of Museums.

Intervention: Any action, other than demolition or destruction that results in physical damage to an element of a historic place.

Lath and plaster: A building process used to finish mainly interior walls and ceilings in Canada and the United States until the late 1950s. After the 1950s, drywall began to replace the lath and plaster process in the United States.

Laser Scanning: The controlled steering of laser beams followed by a distance measurement at every pointing direction. This method, often called 3D object scanning, 3D laser scanning is used to rapidly capture shapes of objects, buildings and landscapes.

Linoleum: A floor covering made from renewable materials such as solidified linseed oil, pine rosin, ground cork dust, wood flour and mineral fillers.

Maintenance: Routine, cyclical, non-destructive actions necessary to slow the deterioration of a historic place.

Medieval: Of or relating to the Middle Ages: of or relating to the period of European history from about A.D. 500 to about 1500.

Parlour: Parlor (or parlour) is a name used for a variety of different reception rooms and public spaces in different historical periods.

Point Cloud: A point cloud is a set of data points in some coordinate system. In a three-dimensional coordinate system, these points are usually defined by X, Y, and Z coordinates, and often are intended to represent the external surface of an object. Point clouds may be created by 3D scanners.

Historic Preservation: Historic preservation (US), heritage preservation or heritage conservation (UK), is an endeavour that seeks to preserve, conserve and protect buildings, objects, landscapes or other artifacts of historical significance. The term tends to refer specifically to the preservation of the built environment.

Rehabilitation: The action or process of making possible a continuing or compatible contemporary use of a historic place or an individual component though repair, alterations, and/or additions, while protecting its heritage value.

Relative humidity: The term used to describe the amount of water vapour existing within a mixture of air and water vapour and expressed as a percentage.

Repointing: The process of renewing the pointing (the external part of mortar joints) in masonry construction. Over time, weathering and decay cause voids in the joints between masonry units (usually bricks), allowing the undesirable entrance of water.

Retrofit: To outfit (a device, vehicle, building, or system) with newly developed or previously unavailable parts or equipment.

Rubble stone: Rubble is broken stone, of irregular size, shape and texture; undressed especially as a filling-in.

Stucco: Stucco or render is a material made of aggregates, a binder, and water. Stucco is applied wet and hardens to a very dense solid. It is used as decorative coating for walls and ceilings and as a sculptural and artistic material in architecture. Stucco may be used to cover less visually appealing construction materials such as metal, concrete, cinder block, or clay brick and adobe.

Surveying: Examine and record the area and features of (an area of land) so as to construct a map, plan, or description.

Vapour barrier: The elements installed to control the diffusion of water vapour.

Water vapour permeable: The ability of water vapour to diffuse through a material.