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Christ Church Cathedral Building Conditions and Issues Report

Project 21272 Revision 0

Lead Consultant:

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HERITAGE STANDING INC.
Engineering for Old Buildings

ENGLOBE

RSEI Consultants Ltd.

This report was prepared for

Christ Church Cathedral, 168 Church St., Fredericton, NB
c/o Mr. Charles Ferris
Chair – Property Committee of the Bishop &
Chapter of Christ Church Cathedral

by

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EXECUTIVE SUMMARY

Christ Church Cathedral is one of a small number of institutions that are so central to the community of Fredericton that they are often taken for granted. The nationally and provincially recognized historic Cathedral building and grounds are a focal point of the city, both as a destination and as a defining aspect of the character of downtown Fredericton. The active Cathedral community engages individuals and the general public through outreach, social programs, community events, and spiritual congregation. The importance of the Cathedral to the community is illustrated by widespread public interest in the building (although it is often only seen when changes are being discussed).

All buildings decay over time, and the Cathedral is no exception. Our research indicates there have been at least three major construction projects since it was built in 1845: one post fire in the early 1900s, one in the mid-1900s, and one in the 1990s. This report is the result of newly obtained information which indicates extensive deterioration and the need for interventions, many of which are related to deferred maintenance and incompatible past repairs. Instead of addressing urgent issues in an ad hoc manner, the Cathedral engaged Heritage Standing Inc. (HSI) to create a holistic picture of the current state of the building and grounds by analyzing all building systems, conditions, and issues. Therefore, the issues identified in this report do not all require prompt intervention, and some could be deferred if necessary.

The report that follows provides a summary of recommendations and projected costs with discussion included to provide context. The first section of the report provides the background information and general summary. This is followed by three separate sections for Major Repairs, Maintenance Work, and Revitalisation. This allows the Cathedral to consider separate funding and financing paths for each of these areas. For initial consideration, this report provided a multi-year plan and costing, shown in the following table. **A conservation project to look at all the items covered in this report will cost between $ 9.95 and $ 12 Million**.

	Major Repairs Funding Requirements*	Maintenance Work Cost Requirements	Revitalisation Costs
Spring 2022		$ 16,250	$ 863, 500.00 (Not Time Sensitive)
Year 1	$ 1,636,800	$ 146,425	
Year 2	$ 3,253,475	$ 142,500	
Year 3	$ 3,698,725	$ 161,000	
Year 4		$ 27,500	
Sub-Total	$ 8,589,000	$ 493,675	$863,500
Total			$ 9,946,175.00

*Please note that potential accessibility improvements for the Cathedral were not considered in this project scope.

Part 3: Required Maintenance Work

Part 4: Revitalisation

Part 1: Project Overview

This section is part of the Christ Church Cathedral Building Conditions and Issues Report - Project 21272 Revision 0

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1.0 INTRODUCTION

Christ Church Cathedral in Fredericton, NB, is an icon of the City of Fredericton and of the Province of New Brunswick. Maintaining the Cathedral so that it can continue to serve the community as a place of worship and as a cultural heritage site is a continuous challenge. This Conditions and Issues Report is primarily a technical document to guide the first step towards a major implementation of necessary repairs, maintenance, and conservation of the Cathedral through the identification and documentation of work that is required. This work is either essential for the physical health of the structure or is designed to create improvements that will assist the congregation in continuing to offer spiritual support and to allow them to play a more active, prominent role in the community at large.

The design of any work on the building and grounds must be guided by the fact that the Cathedral is a heritage structure. On January 15, 1981, the Cathedral was formally recognized as a National Historic Site of Canada, and its heritage value noted as being a "superior example of the Gothic Revival style in Canada".[1] The impact of any and all work on the Cathedral's heritage value and Character Defining Elements must be evaluated and balanced with that work. The Character Defining Elements are discussed in more detail later in this report.

Figure 1: Christ Church Cathedral

The holistic approach taken for this Conditions and Issues Report started with repairs, maintenance or refurbishment identified through Building Condition Assessments completed over the last several years. Other items deemed important to the goal of an active, vibrant role in the community were included: the required refurbishment of the organ, the possibility of replacing pews with chairs, and considerations regarding landscaping around the Cathedral. Mechanical and electrical engineers were engaged to evaluate the existing conditions of the mechanical and electrical and systems and how those systems could be improved to support future plans for activities and events at the Cathedral. Options for improving the overall carbon footprint of the Cathedral were also considered. Because the

[1] https://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=11974, sourced 2022-01-21

mechanical and electrical systems were reviewed here for the first time, in some instances there is an option to undertake further investigations.

1.1 OBJECTIVES

The stated objectives for the development of this report were:

Objective 1. Identification of projects to be undertaken in the foreseeable future with the scope of work defined for each.

Objective 2. Determination of sequencing of projects to balance the level of urgency of the item and the ability to tap into available economies of scale or shared requirements for construction such as scaffolding.

Objective 3. A rough order of magnitude Opinion of Probable Cost (OPC) developed for the design and construction for each project.

Objective 4. Identification of key ongoing maintenance requirements.

The scope of services was to undertake assessments in line with the following charters, standards, and codes:

- ICOMOS Charter and the ISCARSAH Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage[2]
- Standards and Guidelines for the Conservation of Historic Places in Canada, 2nd Edition, Parks Canada[3]
- 2015 National Building Code, National Research Council Canada[4]

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[2] ICOMOS (the International Council on Monuments and Sites) is a non-governmental international organization dedicated to conservation, noted for advising UNESCO on World Heritage Sites. ISCARSAH (the International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage) was founded by ICOMOS in 1996 as a forum for engineers involved in the restoration and care of heritage buildings. The ISCARSAH Principles are a ratified international standard which outlines appropriate analysis and repair methods for heritage structures that respect their cultural context. They are available for free download at:
https://iscarsah.org/documents/

[3] Based upon international best practices and lessons but with a focus on Canada, this document was developed to aid all groups involved with Conservation projects, including owners, consultants, and contractors. They outline the conservation decision-making process and provide guidance for maintaining the authenticity of historic places in Canada. They are available for free download at:
https://www.historicplaces.ca/en/pages/standards-normes.aspx

[4] The 2015 National Building Code of Canada has been adopted by the Province of New Brunswick as the governing document for the construction industry. The document is predominately designed for new construction, although it applies to construction on existing buildings as well. The Code is objective based and defines the performance objectives that must be met to ensure acceptable levels of safety and includes the most commonly referenced acceptable solutions. It provides a means to address structures that are not typical in processes focused on meeting the overall code objectives.

1.2 SCOPE

Heritage Standing Inc. (HSI) was the lead consultant in the delivery of this report. HSI identified a number of projects outlined in this report through the Building Condition Assessment process conducted in 2015, work on several small projects over the last several years, and through an update of the 2015 Condition Assessment in 2021. Additional items or projects were identified through site visits, reviews, and discussions with Cathedral stakeholders as a part of this process. The direction for this report was to articulate necessary conservation projects and other items deemed of importance to the work of the Cathedral to develop a comprehensive plan. The Cathedral would then use this information to consider an organized, planned approach to raise funding for the work to be carried out over several years.


Figure 2: View of the steeple from the south

The Fredericton office of Englobe (formerly Crandall Engineering), an engineering consulting company, was engaged as part of the team with HSI to conduct a review of the mechanical and electrical systems of the Cathedral and has provided an overview of its findings with recommendations. Englobe engaged electrical engineering firm RSEI to provide electrical content as they have experience working with the electrical systems of larger older churches in New Brunswick. They were engaged to review the electrical, lighting, and communication systems. An overview of those findings and recommendations has also been provided.

The consultants involved were of the understanding that it is the desire of the stakeholders of Christ Church Cathedral to consider multiple factors when creating a broad list of required repairs, maintenance, and conservation work for the Cathedral. As well as measures to ensure the building was in good repair, additional consideration was given to practical ways to improve the building's overall sustainability and to increase its ability to host musical concerts or other public events. The consideration of upgrades, particularly in the mechanical and electrical areas, included all these factors.

Some information presented in this overview report was developed by the cathedral rather than the consultant team. The potential chair layouts as well as the organ information fall into this category.

To start such a large undertaking, the consulting team required the equivalent of a map to guide the process, delineating the areas and systems which would be reviewed. The areas and systems identified are provided in the table below.

AREAS AND SYSTEMS WITHIN THE SCOPE OF SERVICE

COPPER ROOFING AND LEAD FLASHING

- Copper roofing of the steeple and lower areas around the steeple (installed in 1990s)
- Copper roofing on the nave and other areas (installed circa 1911)
- Copper cladding on facia boards
- Lead flashing

STRUCTURAL

- South clerestory walls where movement is indicated
- Wood arches in the nave which show indications of movement

STEEPLE LOUVRES

- Deteriorated wood louvres
- Damaged louvre screens

MASONRY

- Pinnacles
- Steeple
- Buttresses
- Doors (section includes non-masonry repairs as well)
- Exterior vestry stairs
- Cracking in sacristy wall
- General required masonry repairs on exterior walls

STAINED GLASS WINDOWS

- Deteriorated tracery and mullions
- Damage and deterioration of the stained glass
- General masonry deterioration on exterior walls

MECHANICAL

Review of existing heating and ventilation system with the objective of developing recommendations aimed at heating, energy efficiency, sustainability, ventilation, air movement, humidity control, and occupant comfort.

ELECTRICAL

Review of the existing power entrance/distribution, lighting, and sound systems with the objective of developing recommendations in line with the Cathedral's goals of having a music/performance centric venue.

REVITALISATION

Consideration for the replacement of most pews with chairs*
Flooring
Organ refurbishment*

LANDSCAPING

Cathedral property landscaping and how it impacts structural elements of the building, and Character Defining Elements.

*Items where the Cathedral provided information to be summarized in this report

This report provides documentation of identified work or projects for the Cathedral with recommendations. The report will also provide information for each item concerning:

- Rough order of magnitude probable costs
- Priority
- Consequences of inaction
- Impacts on long term sustainability
- Impacts to the building's Heritage Value

It is currently assumed that the repairs will be undertaken in an upcoming major project, which would be phased over several years. Suggestions for which items should fall inside identified phases will be included. This will create the outline for upcoming conservation and improvement work.

The report will provide information on long term maintenance considerations, which could be used for the development of a future maintenance plan.

1.3 SITE VISITS AND INTERVIEWS

Numerous site visits, small projects site reviews, and discussions with Cathedral stakeholders have been used in the development of this report. Data from initial visits in 2015 continue to be used in evaluation, along side data collected in 2020 and 2021. Investigations used during site visits included: visual inspection, the use of drone photography for analysis and photogrammetry, a thermal camera for monitoring the temperature of windows and moisture migration in walls, borescope investigations, damage mapping, measurement of specific issues, and documentation of conditions found.

Figure 3: Deterioration of stained glass window and frame in south vestibule entry

In the past two years, multiple on site meetings and interviews with Cathedral stakeholders also provided additional background in our evaluation. Consultants include: Thomas Gonder regarding music, Ken Howlett regarding heating and electrical systems, John Leroux regarding heritage and seating, Eric Hadley regarding trees and the green, and Hugh McKinnon regarding stained glass windows.

1.4 CONSERVATION APPROACHES

Recommendations in this report are based upon national and international conservation best practices, derived from hundreds of years of experience with old buildings. Properly applied, they should result in solutions that are practical, high quality, environmentally sound, and cost effective.

It is important to understand a building before designing interventions. Interventions should focus on minimizing actual construction to achieve desired results. This generally makes conservation design costs higher than new construction design costs. Every project is different, but a rule of thumb for good conservation design is 15% to 25% of total project costs. When conservation is appropriately applied, the higher design costs allow construction scope to be reduced and made more effective and long lasting. Therefore, the end savings on the total project can be extremely significant.

Conservation design must be done more rigorously than new design because optimized repair procedures are typically different from the conventions the construction industry follow for new construction. The additional costs result from more detailed assessments, the development of construction documents, regular site visits during construction to monitor progress, and thorough documentation.

Because conservation design is tailored to the needs of each unique building, it is the recommended approach for extending a building's lifespan, reducing construction costs, and preventing new and expensive problems from arising in the future.

1.5 SUSTAINABILITY

Adapting historic buildings for new uses is inherently more environmentally sustainable than new construction. New construction materials such as glass, steel, and concrete are high in embodied carbon. Embodied carbon is the carbon associated with the extraction, manufacturing, and transportation of construction materials in a building. It significantly contributes to greenhouse gas emissions and climate change. Maintaining and adapting existing buildings, such as Christ Church Cathedral, is essentially a form of reusing and recycling. As such it is contributing to the fight against climate change.

Any interventions to the building should consider the sustainability impacts. This is most noticeable with mechanical, plumbing, and electrical systems which should aim to be energy efficient to reduce operational carbon emissions. There may be opportunities to find other improvements in the building envelope and structure.

2.0 SITE BACKGROUND

It is important to understand the evolution of a building over time, including knowledge of any past interventions. Many historic buildings are adapted for new purposes over time, and sometimes this results in changes to the structure. Inappropriate interventions to the structure or building envelope can sometimes damage a building. In addition, it is valuable to be able to distinguish between the original building fabric and more recent interventions.

Understanding what makes a building valuable should always be a starting point in any plan. In new construction this is taken for granted, but when working with existing structures value should be defined in some form to ensure it is maximized during the project. For a historic site such as the Cathedral, value is multifaceted. It includes the social and community value to the congregation and the greater public as well as the heritage value of the site. Because heritage value can be abstract, official historic designations determine and list the most important elements that create a building's heritage character. These become the Character Defining Elements and represent physical manifestations of more abstract value. Examples include elements of craftsmanship rarely seen today which have become cherished aspects of the building or an element that contributes to how people relate to the building.

Ultimately buildings are about people, and existing buildings already have a story that can spark engagement or interest in the people who use them. How that story is treated during any project, which parts are highlighted or obscured, will change how people react to the building, often on a subconscious level.

2.1 HISTORIC SITE DESIGNATION

In 1845, Bishop Medley began building Christ Church Cathedral on 2.5 acres by the Saint John River.[5] The majority of the land around Christ Church Cathedral is still intact and owned by the church. The elegant cathedral on its historic green is an icon of Fredericton and New Brunswick history.

Christ Church Cathedral received national historic site of Canada designation in 1981.[6] The heritage value of the Cathedral is an example of the gothic revival of ecclesiological architecture, related to the development of the Anglican church in Canada and the unique connections between this site and a changing philosophy of what a church should be. The key character-defining elements of the Cathedral as listed on the Canadian Register on April 2, 2009, are:[7]

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[5] From the History of Fredericton: the last 200 Years, W. Austin Squires, 1980.
https://en.wikipedia.org/wiki/Christ_Church_Cathedral_(Fredericton), sourced 2021-10-26

[6] https://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=11974, sourced 2021-12-02

[7] https://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=11974, sourced 2021-12-02

- its location in the historic heart of Fredericton
- its picturesque sitting on a green sward, overlooking the Saint John River
- its relatively large scale for its time and place, making it an influential architectural model in Canada
- its integrated Gothic Revival style, evident on its exterior in the tall, elegant spire, historically accurate decorative details, steeply pitched roof, deeply carved mouldings, pointed arch windows, elaborate window tracery, steep gables, integrated buttresses, niches, and finials
- architectural elements that conform to ecclesiological principles, including a cruciform plan, high nave, flanking side aisles, short transept arms, sanctuary, porch entrance, single tower over crossing, Gothic Revival style detailing, and clear articulation of interior spaces through exterior forms
- interior elements in the Gothic Revival style, including large octagonal piers, ribbed and pointed arches, the organization of piers and arches to create an arcade between the nave and side aisles, exposed wood trusses, and curved wood brackets
- interior elements that confirm to ecclesiological principles, including the organization of the building into distinct parts, the high alter at the east end, the communion rail, the crossing beneath the tower, and the deep chancel

Figure 4: Detailed stone carvings in the apse

- its stonework, including rough-dressed and smooth faced sandstone masonry composed of stone quarried from Grindstone Island in the Bay of Fundy and other parts of New Brunswick, and its Gothic-inspired window tracery composed of Caen stone
- the craftsmanship of its interior decoration, including decorative tile work, lectern, chandelier lighting, woodwork, wooden furnishings and church plate
- its stained glass windows

2.2 PAST INTERVENTIONS

There have been numerous repairs, both large and small, to the Cathedral over its more than a hundred-and seventy-five-year life. The most significant documented repairs are:

- the replacement of the steeple and much of the roof after the 1911 fire and the refurbishment of the organ following the fire
- A conservation project in the mid 1900s
- extensive repairs to the masonry, roof, and stained glass in the 1990s.
- Past HSI Reports

Figure 5: Post 1911 fire damage, could not be sourced

HSI has been assisting the Cathedral with its heritage structure for many years now, enabling us to gain an in-depth understanding of the complex issues affecting the building. The following are the significant HSI reports:

- 2015-09-29 Christ Church Cathedral Condition Assessment
- 2020-08-04 Roof Repair Notes
- 2020-11-20 Updates: Roof, Masonry & Stained Glass
- 2021-04-09 Medley Monument
- 2021-05-07 Update of 2015 Condition Assessment

2.3 PAST REPORTS BY OTHER CONSULTANTS

Over the years multiple other documents have been created on the Cathedral. A total of 42 past documents have been collected by HSI from sources including the Cathedral and various archives. These cover photographs, history reports, structural evaluations, and one construction specification. The most significant of the past reports include:

1. 1996 Conservation Report by Roberts Duncan Caunter Architects. This condition assessment provided the groundwork for a phased serious of projects to follow.
2. 1998 Restoration of Christ Church Cathedral Report by Holly Young, a UNB undergraduate engineering student. This report covers work in more detail and outlines why it was done.

2.4 PRIORITIZATION

For each future construction project, a level of urgency has been applied so that the plan to execute the work could be prioritized. The levels of urgency are defined below:

LEVEL OF URGENCY	
EMERGENCY	Urgent health and safety items or operational disruptions – natural disasters or fire, power or water loss, major safety issue, etc.
HIGH	Items that will directly affect the functional of the building or the ability to use the building – such as leaking roofs – or items that are not currently emergency items but could become so if not addressed in coming years.
MEDIUM	Preventive maintenance work that is not urgent not but will impact the building use if not performed – painting, cleaning, equipment general maintenance, etc. Over time if not addressed some medium urgency items could become high urgency.
LOW	Non-critical repairs or day to day items – cosmetic painting or other cosmetic work, etc.
OPERATIONAL	Items that are not associated with the maintenance of the building but will impact how the Cathedral is able to be used in an operational sense – improving the sound system, the use of chairs instead of pews, etc. Some operational items could provide saving in operation of the building over time, however, are not required.

The levels of urgency used in this report are from a building point of view. To ease project coordination, the activity-based Operational category has been added to what is a standard four level list. This should allow the Operational items to be considered as separate and distinct, so the Cathedral can determine when Operational projects could be undertaken in combination with urgent or high priority tasks as available finances allow. It should be noted that some Operational items will actually assist in the generation of funding for building related items. This prioritizing is intended to provide feedback on the condition of various building elements at the time of the site visits and may not exactly match future construction projects.

2.5 COSTS

To provide conservative estimates for budgeting purposes, a rough order of magnitude cost has been applied to each of the projects identified. The Cathedral could use these to develop target figures for the raising of funds to complete the work.

These costs have been developed by using available cost information from similar projects and projecting future costs by adjusting for time, size of project, complexity, and other factors. At this point, without even preliminary designs it is very challenging to improve the accuracy of the estimate. A rough order of magnitude cost could generally be in the range of -25% to +75%. Essentially these order of magnitude costs represent a judgement based on historical information and experience.

Much of the work on the Cathedral requires highly skilled craftspeople. The current labour shortage has made obtaining these craftspeople exceedingly difficult. This has also caused greater unpredictability in costs for these services. Furthermore, materials such as copper have also been seeing greater than normal fluctuations in cost. Efforts will be made to account for these. Typically for such a large project the total cost estimate will be more accurate than individual items.

Figure 6: Fine stone tracery inside supporting stained glass

It was pointed out in the Mechanical and Electrical report that at the time of writing, cost estimates of skilled trades and labour were relatively stable. However, the costs of materials (metals, equipment, pipe, conduit, wiring and devices) were 20% to 40%+ higher than the same month in 2020 and are projected to remain high and perhaps volatile through 2022. Estimates provided were based on previous costing with inflation only. Recent higher pricing is not captured. Further, the high demand for material has created follow up problems of long delivery times, low inventories, or no stock.

2.6 PROJECTS, MAINTENANCE WORK, AND REVITALISATION

Following discussions with representatives of Christ Church Cathedral, projects were grouped into three distinct categories relating to the nature of the work required:

- Major Repairs (Part 2): Primarily structural and building envelope work, the expense of this work will require a major funding campaign. This work is vital to the continued existence of the structure itself. The path forward in any direction starts with these repairs.
- Maintenance Work (Part 3): Much of the needed maintenance work is in the neglected electrical and mechanical systems. Many of these projects will improve the efficiency of the building, increase the comfort of building users, and support the future vision of a community space. Because these are maintenance and operational projects, finding will be provided by the Cathedral.
- Revitalisation (Part 4): Two large projects that are relevant to the future direction of the Cathedral are the shift from pews to chairs and the refurbishment of the Cathedral organ. Because some congregants will potentially be concerned about the impact of these changes, these projects will require vetting by the Cathedral community.

This report has been organized based on the input above into the three distinct sections which cover the assorted details related. Major repairs are covered in Part 2, required maintenance work in Part 3, and revitalisation in Part 4. It is possible for each section to be viewed individually or as part of the larger report.

Figure 7: Stained glass detail

3.0 RECOMMENDATIONS

Recommendations are based upon an understanding of the current building and evaluations against future needs. Details of the existing conditions and evaluations are provided in Parts 2-4, which can be viewed individually as stand alone sections.

It is important to note that there is a potential for reduced costs if phasing of the work includes combining tasks when beneficial. If phasing is used to maximum advantage, the total approximate cost could be reduced by $ 1.4 million. Of particular note, the cost of scaffolding is so significant that using a single set up for multiple projects should greatly reduce costs.

3.1 RECOMMENDATIONS FOR MAJOR REPAIRS WITH PHASING

Recommendations for Major Repairs are shown below in Table 1, broken out by year for phasing of the work. Where a given recommendation is carried out in multiple years, the portion of the work to be done that year is noted. For example, during the year in which design should be done, "DESIGN" is placed as a label.

In the phasing where Design has been identified as a separate item, the design costs will likely be spread out over the construction period as well. However, this is all shown in the first year of design as that year will have the largest cost and it avoids confusion when looking at future budgets.

Table 1: Combined table for Major Repairs by year

Year 1: Major Repairs

	RECOMMENDATION	URGENCY	COST
1	**DESIGN:** Roofing and Flashing	EMERGENCY	$ 600,000.00
2	Tension rods	EMERGENCY	$ 175,000.00
3	**DESIGN:** Louvers	MEDIUM	$ 7,800.00
4	**DESIGN**: Repair pinnacles	HIGH	$ 127,500.00
5	**DESIGN**: Repair steeple masonry	HIGH	$ 75,000.00
6	**DESIGN**: Repair buttresses	HIGH	$ 45,000.00
7	**DESIGN**: Repairs to wood exterior doors	HIGH	$ 10,500.00
8	**DESIGN**: Sandstone doorways	MEDIUM	$ 12,000.00
10	**DESIGN**: Repairs to choir vestry stairs	HIGH	$ 8,250.00
12	**DESIGN**: General masonry	MEDIUM	$ 450,000.00
13	**DESIGN**: Repair of framing and tracery	MEDIUM	$ 90,000.00

9 & 14	Engage stained glass conservator to prepare detailed report on condition and conservation of stained and antique glass.	HIGH	$ 32,000.00
16	**DESIGN** Improve venting of external protective glazing	MEDIUM	$ 3,750.00
		TOTAL YEAR 1	**$ 1,636,800.00**

Year 2: Major Repairs

	RECOMMENDATION	URGENCY	COST
1	**EASTERN SECTION:** Roofing and Flashing	EMERGENCY	$ 1,700,000.00
3	Louvers	MEDIUM	$ 52,000.00
4	**EASTERN SECTION:** Repair pinnacles	HIGH	$ 361,250.00
5	Repair steeple masonry	HIGH	$ 500,000.00
6	**EASTERN SECTION:** Repair buttresses	HIGH	$ 127,500.00
7	**EASTERN SECTION:** Repairs to wood exterior doors	HIGH	$ 5,950.00
8	**EASTERN SECTION:** Sandstone doorways	MEDIUM	$ 10,200.00
10	Repairs to choir vestry stairs	HIGH	$ 55,000.00
12	**EASTERN SECTION:** General masonry	MEDIUM	$ 1,020,000.00
13	**EASTERN SECTION:** Repair of framing and tracery	MEDIUM	$ 102,000.00
15	**EASTERN SECTION:** Allowance for necessary repairs to stained glass and antique glass	TBD	$ 100,000.00
16	**EASTERN SECTION:** Improve venting of external protective glazing	MEDIUM	$ 10,625.00
		TOTAL YEAR 2	**$ 4,044,525.00**
	POTENTIAL REDUCTION BECAUSE OF SEQUENCING OF WORK YEAR 2		**$ 700,000.00**
	TOTAL WITH POTENTIAL SAVINGS APPLIED YEAR 2		**$ 3,344,525.00**

Year 3: Major Repairs

	Recommendation	Urgency	Cost
1	**WESTERN SECTION:** Roofing and Flashing	Emergency	$ 1,700,000.00
4	**WESTERN SECTION:** Repair pinnacles	High	$ 361,250.00
6	**WESTERN SECTION:** Repair buttresses	High	$ 127,500.00
7	**WESTERN SECTION:** Repairs to wood exterior doors	High	$ 53,550.00
8	**WESTERN SECTION:** Sandstone doorways	Medium	$ 57,800.00
12	**WESTERN SECTION:** General masonry	Medium	$ 1,530,000.00
13	**WESTERN SECTION:** Repair of framing and tracery	Medium	$ 408,000.00
15	**WESTERN SECTION:** Allowance for necessary repairs to stained glass and antique glass	TBD	$ 150,000.00
16	**WESTERN SECTION:** Improve venting of external protective glazing	Medium	$ 10,625.00
		Total Year 3	**$ 4,398,725.00**
		Potential Reduction because of Sequencing of Work Year 3	**$ 700,000.00**
		Total with Potential Savings Applied Year 3	**$ 3,698,725.00**

3.2 Recommendations for Maintenance Work with Prioritization

The projects associated with Maintenance Work is shown in Table 2, below.

Table 2: Recommendations for Maintenance Work with prioritization over four years

		Recommendation	Priority	Order of Magnitude Cost
Spring	27	Repairs and Improvements to Exterior Flood Lighting	Emergency	$15,000.00
	11	Sacristy wall interior crack should be repaired, and the area monitored for future cracking or other evidence of movement	Low	$ 500.00

	17	Purge the basement of debris and clutter	MEDIUM	$ 750.00
			SPRING 2022 TOTAL	**$ 16,250.00**
YEAR 1	18	Collect and source mechanical system documents and provide ongoing systems training for two or three people	MEDIUM	$ 1,925.00
	19	Repairs to the boiler and burner: repair leaking piping, remove rust and staining on boiler housing, and install burner shroud	HIGH	$ 4,500.00
	20	The heating zone repairs should be addressed at the same time: replace the zone distribution piping with the purpose of using a higher efficiency hydraulically separated header at the boiler, replace existing zone control valves with motorized control valves and add water balancing valves to the zone loops, and replace the zone distribution piping and zone control valves with higher efficiency sensorless pumps	HIGH	$ 60,000.00
	23	Replace existing service entrance equipment and distribution equipment in the basement complete with metering, fed from the existing pole with the existing conductors	MEDIUM	$ 30,000.00
	25	Review of existing lightning protection system by lightning protection designer	MEDIUM	$ 30,000.00
			Year 1 Total	**$ 126,425.00**
YEAR 2	21	Design and install a Building Energy Management System (BEMS)	MEDIUM	$ 82,500.00
	24	Repairs to wiring devices and surface conduit as described	MEDIUM	$ 20,000.00
	26	Improve electrical identification and labelling	MEDIUM	$ 5,000.00
	28	General improvements to lighting	MEDIUM	$ 35,000.00

	30	Improvements to fire alarm system	MEDIUM	$ 20,000.00
			YEAR 2 TOTAL	**$ 162,500.00**
YEAR 3	22	Replace existing ceiling fans with large, low velocity fans, put the existing operable windows into operations, possibly through the use of an automated actuator connected to the BEMS to bring fresh air into the building; and replace existing basement vent openings with motorized dampers.	MEDIUM	$ 83,500.00
YEAR 3	29	Installation of theatrical lighting in keeping with program plans for the Cathedral	OPERATIONAL	$ 32,500.00
YEAR 3	32	Improvements to sound system	OPERATIONAL	$ 35,000.00
YEAR 3	33	Improvements to communication system	LOW	$ 10,000.00
			YEAR 3 TOTAL	**$ 161,000.00**
YEAR 4	31	Improvements to security/intrusion alarm system	OPERATIONAL	$ 12,500.00
YEAR 4	37	Development and ongoing maintenance of a landscaping plan that commits to maintaining the open greenspace setting	MEDIUM	$ 15,000.00
			YEAR 4 TOTAL	**$ 27,500.00**
			TOTAL	**$ 493,675.00**

3.3 REVITALISATION PROJECTS

The summary of projects associated directly with the revitalisation of the Cathedral are shown below in Table 3, below.

Table 3: Summary of Revitalisation projects

	RECOMMENDATION	URGENCY	COST
34	Rehabilitation of seating to improve use of space	OPERATIONAL	$ 110,000.00
35	Repair existing flooring	LOW	$ 3,500.00

36	Organ Intervention (Repair and Improve existing as a median cost)	OPERATIONAL	$ 750,000.00
		TOTAL YEAR 3	**$ 863,500.00**

4.0 CONCLUSIONS

This building conditions and issues report provides a summary of a wide range of problems, concerns, and hopes. Conservation of the Cathedral will be a major undertaking. However, it will result in a building of much greater value than the cost of conservation, and it will preserve the longevity and continuity of heritage that can not be easily matched by any similar new construction.

The community and trustees of Christ Church Cathedral will chart the course of action with this report as a tool and source of information. Through that process, priorities and considerations may change. As a starting point, however, the funding and cost requirements as presented for this major undertaking are:

Table 4: Summary of funding and cost requirements by year

	MAJOR REPAIRS FUNDING REQUIREMENTS*	MAINTENANCE WORK COST REQUIREMENTS	REVITALISATION COSTS
SPRING 2022		$ 16,250	$ 863, 500.00 (Not Time Sensitive)
YEAR 1	$ 1,636,800	$ 146,425	
YEAR 2	$ 3,253,475	$ 142,500	
YEAR 3	$ 3,698,725	$ 161,000	
YEAR 4		$ 27,500	
SUB-TOTAL	$ 8,589,000	$ 493,675	$863,500
TOTAL			$ 9,946,175.00

* COSTS SHOWN FACTOR IN THE POTENTIAL SAVING FOR THE SEQUENCING OF PROJECTS.

Part 2: Major Repairs

This section is part of the Christ Church Cathedral Building Conditions and Issues Report - Project 21272 Revision 0

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Engineering for Old Buildings

5.0 MAJOR REPAIRS

The identified major repairs are in the areas of building stabilisation, repairs to the roofing, significant masonry repairs, repairs to the traceries of the stained glass windows, repairs to the louvres in the steeple tower, and repairs to exterior doors and framing. The continued viability of the structure is dependent on the execution of these projects.

All projects should be undertaken following the *Standards and Guidelines for the Conservation of Historic Places in Canada, 2nd Edition* (Parks Canada), ideally using professionals recognized by the Canadian Association of Heritage Professionals, the Association for Preservation Technology, or ICOMOS. All projects will require careful design to get long lasting solutions at a practical cost. As the work moves from design into execution phases it is often possible to find locations to optimise costs using good conservation practice.

5.1 COPPER ROOFING AND LEAD FLASHING

5.1.1 ZINC ROOFING AS AN ALTERNATIVE TO COPPER ROOFING

This report provides a plan and costing for replacement of the current copper roof with a new copper roof. It is recommended that the Cathedral also consider zinc roofing during the design process. There is credible historic information that indicates that the original roof was zinc rather than copper and that it was perhaps changed after the 1911 fire.

St. Anne's Chapel of Ease on Westmorland St. was constructed at the same time as Christ Church Cathedral with similar materials. The Chapel roofing was recently replaced with a new Rheinzink® roof in a diamond shaped roof tile pattern as shown in Figure 8. HSI has reached out to the local Rheinzink supplier for a rough cost to replace the roof at Christ Church Cathedral with the same material and profile. This information will be provided to the Cathedral for their consideration during the design period.

Figure 8: New zinc roofing St. Anne's Chapel of Ease

5.1.2 REPLACEMENT OF ROOFING WITH NEW COPPER AND LEAD FLASHING

Currently the entirety of the copper roof of Christ Church Cathedral requires replacement. This report breaks down the copper roofing into two distinct areas, as shown in Figure 9, because of the different nature of their problems. The first section is the main lower section of the Cathedral (primarily the nave), and the second is the steeple and roofing in the area of the chancel. Design for both should be combined, even if the project is phased.

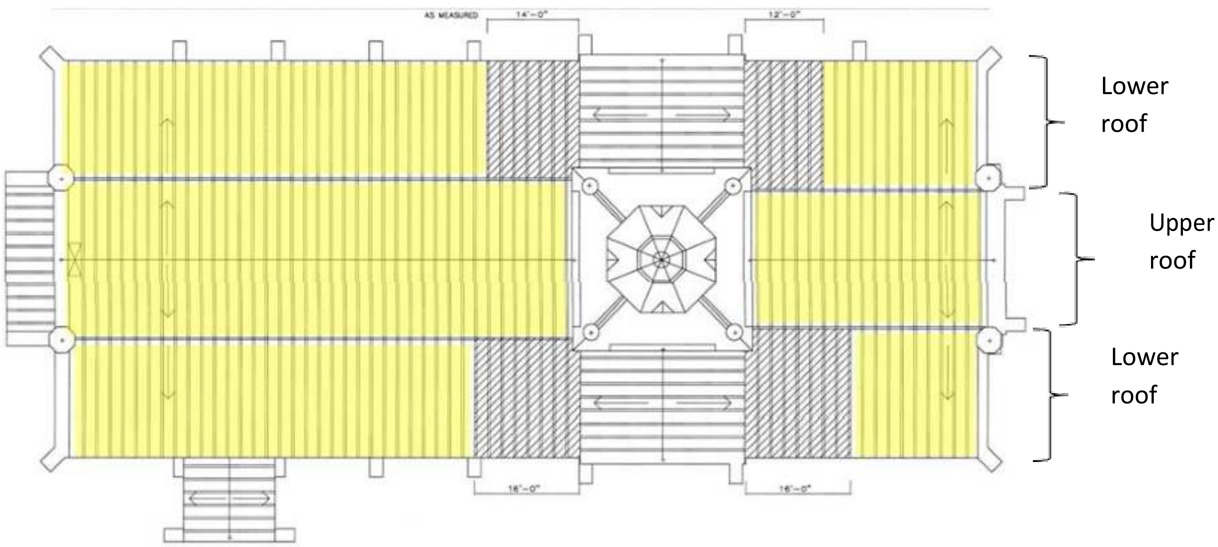

Figure 9: Cathedral roof sections: yellow areas date from ca.1911 or before, grey shaded areas and steeple date from the 1990s.

5.1.3 LOWER ROOF

The copper roofing over the main lower section is assumed to have been installed after the 1911 fire but could well be older. As described in the 2021 HSI Update of the 2015 Condition Assessment Report, the older part of the roof has been extensively patched and is beyond the end of its expected life. It has decayed to the point that there are at least three areas of water infiltration into the sanctuary, the one at the southwest corner being the most significant. Leaks have been active since at least 2015, and some personal interviews suggests there may have been leaks occurring a decade earlier.

Figure 10: Water splashing onto the southwest corner of the nave

It is not advisable to make continued attempts to patch the roof of the nave to stop the infiltration of water. The effort will be wasted given: the expanse of the roof, the deterioration of the materials over more than a century, the deterioration of flashing and past repairs, and the ability of water to travel sometimes great distances from the point of entry to the point where it is visible in the interior.

Inaction is not advisable either. Continued water infiltration and the probability of increased infiltration over time will be extremely damaging to the structural elements of the building as well as the interior finishings and systems. The roof installed in 1911 (or earlier) has reached its effective life span and must be replaced.

This section of the copper roof alone is a major undertaking. It is unfortunate that the copper roof of the steeple and chancel must also be replaced at this time.

5.1.4 ROOF CA. 1990S

As reported in the 2020-08-10 Heather and Little Site Visit report and the 2020-08-04 HSI Roof Repair Notes letter, the steeple and immediate surrounds were replaced in the 1990s as part of the large conservation project undertaken by the Cathedral. The existing copper roof, as noted by Heather and Little, has "large scale issues due to installation procedures that are not in line with industry standards." Their report found that the installation would promotes wind and water infiltration and there are serious concerns about the effect this has on the deterioration of the substrate. The existing roofing material is considered to be not salvageable and there is concern about the integrity of the roofing system.

The steeple is roofed in copper, but there are indications that the lower roof over the chancel may not even be a true copper roof, creating compatibility issues and long term performance concerns. An (undated, assumed date 1996) report by J. E. Swanton, Chairman of the Cathedral Restoration Steering Committee, notes that the lower roofs that were done in 1993 or 1994 were not covered in pure copper but instead were covered in a rolled metal roofing that has a thin copper film on the top surface. His report noted that they could not create a joint between this and the true copper regions.

5.1.5 FLASHING AND FACIA

Replacement of the roof includes complete replacement of the lead flashing, which shows damage or is completely detached in numerous places, Figure 11.

Figure 11: Example of missing lead flashing on south clerestory

The northeast and southeast lower roof facia boards are decaying because they are missing the protective copper cladding that should be present, as shown in Figure 12 and Figure 13. The wooden facia boards should be inspected, repaired or replaced where damaged, then covered with copper cladding.

Figure 12: Missing copper cladding on facia along the northeast lower roof

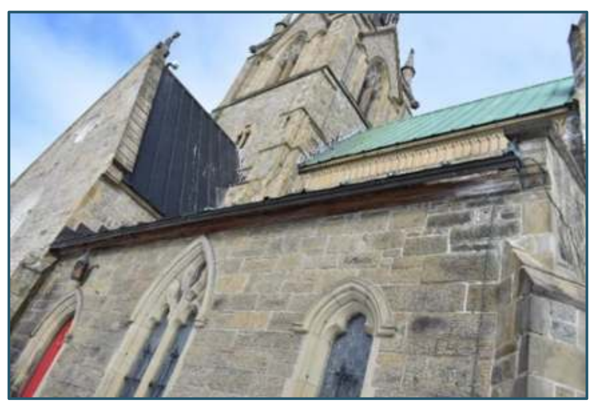

Figure 13: Missing copper cladding on facia along the southeast lower roof

5.1.6 CONSEQUENCES OF INACTION

Inaction regarding the replacement of the copper roofing of the steeple and the areas below may result in serious consequences. If the integrity of the roofing system is lost, the steeple itself could reach the point where it is not salvageable and would either be lost completely through removal or need to be replaced, a staggering undertaking. There could also be loss of integrity of interior elements through biological decay of the structure if water infiltrating the building continues unmitigated over the long term. A more remote possibility is that portions of the copper roofing could detach in high winds and cause damage to adjacent properties or people. Failure to replace the remaining copper roofing and the lead flashing will inevitably lead to deterioration of the roof structure and damage to the structure of the Cathedral and interior finishings.

5.1.7 Impacts on Heritage Value

The copper roofing contributes to the heritage value of Christ Church Cathedral, informing its architecture, logic, and decorations. The iconic presence of the Cathedral in the heart of Fredericton is difficult to imagine without its distinctive roof cladding. Also relevant is the durability of copper roofing, lasting decades beyond the effective service life of more commonplace metal roof materials. The cost of access, the scaffolding required, supports the installation of a roof that has the life span of a copper roof.

5.1.8 Order of Magnitude of Probable Cost

HSI reached out to Heather and Little for support in determining an order of magnitude probable cost for complete replacement of the copper roofing and lead flashing. Heather and Little pointed out that since the work was completed on the steeple in the 1990s, the requirements for the installation of scaffolding has increase significantly, driving the cost up by orders of magnitude. The price of copper has also been volatile, and the cost of materials increased substantially in the intervening years. General construction costs in the Atlantic provinces have increased over the last few years, further exasperating the matter. All these conditions have conspired to drive up the overall cost of replacing the copper roofing and the lead flashing.

Recommendation 1

Replacement of the entirety of the copper roofing and lead flashing

Priority	High to Emergency
Order of Magnitude Cost	$ 4,000,000.00

5.2 Structural

Christ Church Cathedral is primarily unreinforced stone masonry with heavy timber floor structure and timber roof structure. Much of the unreinforced stone masonry serve multiple purposes, and so is discussed at different points in this report.

5.2.1 CLERESTORY WALLS & WOOD ARCHES

Two important and related issues identified during condition assessments include the movement of the heavy and ornate timber truss systems that provide an arch like appearance in the nave and the outwards movement of the south clerestory wall.

The first known documentation of a tilt in the clerestory wall was related to projects on the building during the 1980s and 1990s. At that time, it appears to have been looked at closely, including structural evaluation by Eastern Designers Ltd. (focused on roof, but included upper walls), and a monitoring program run through the University of New Brunswick (although that data sadly has been lost). In 2015 some benchmark measurements were taken with the hope of providing a reference for future site visits, and this data was remeasured in 2021 with additional data collected on the exterior face of the wall. The resulting conclusion was that the south clerestory wall is moving outwards very slowly.

Figure 14: Photogrammetric model of exterior wall used for analysis of clerestory level

Concerns about the wood roof truss system were raised during the 1980s and 1990s evaluations and interventions. It was documented as having shifted, and it appears to have been the impetus for the Eastern Designers Ltd. evaluation of the roof structure. Findings during that period were that the roof structure should be able to adequately carry loading if its ends are pin connections. This requires that the ends of the truss not be able to move laterally or vertically, while slight twisting is not a problem. Without the constraint on either side of the roof truss the roof system will be liable to continue moving.

Figure 15: Roof trusses

Evaluation of movements and damage related to this report find both issues to be a concern, and related. The movement in the upper wall removes the necessary support for the roof truss. Both issues contribute to the problem, and at this time it cannot be determined whether the original cause of instability is movement in the roof, deterioration of the clerestory wall, or the two acting in concert. After investigating potential interventions, it was determined that knowing the precise cause is only valuable if it would change the ultimate intervention options. In this case it is unnecessary since all are most practically addressed through reducing the potential for movement where the roof structure connects to the masonry. This can be done through installation of tension ties at these locations, a well tested technique used for more than a hundred years in Italy. The tension rod can be installed at low cost, in a minimally invasive manner, and creates minimal impact to the interior aesthetic of the space. By engaging both the masonry and the heavy timbers it is possible to address both issues. Based upon the data gathered, it is possible to do this without extensive rebuilding of either, although in situ repairs will be necessary for both.

Figure 16: Photogrammetric model of exterior wall used for analysis of Clerestory level

Other potential intervention strategies investigated included:

- Strengthening the roof structure so that it would not be prone to unacceptable outwards movement under wind and gravity loads, and then using the strengthened roof structure as a restraint to the masonry
- Using fibre reinforced strips to improve the tensile capacity of the masonry walls to constrain the roof
- Creating localized strengthened regions in the masonry

These other options were seen as causing more harm than benefit, having greater unknowns, having greater costs, and having less demonstrated performance.

5.2.1.1 Consequences of Inaction

Continued movement of the clerestory walls will lead to eventual collapse of the wall and roof. Collapse of this wall and roof may trigger failure of the lower wall and roof section as well. A monitoring regime can be used to control this risk of failure if the potential intervention must be delayed.

Further movement of the roof truss could lead to collapse of the roof structure. A monitoring regime could be used to control the risk of failure if the potential intervention must be delayed.

5.2.1.2 HERITAGE VALUE

Addressing the movement of the clerestory walls is essentially tying the building together so the continued movement will not cause structural failure. The building itself is the concern and therefore the impact on the heritage value all encompassing.

The roof truss contributes to the heritage value and Character Defining Elements for the carved structural elements.

5.2.1.3 ORDER OF MAGNITUDE OF PROBABLE COST

The order of magnitude cost was developed assuming that exterior work for the installation of the tension rods through the exterior walls would not be carried out during the winter season. Because of the height of the work, access will be a significant cost component. Engineering design fees and engineering design support during construction would be higher than normal to allow for greater control and focusing of the intervention. This cost is seen as being very closely linked to the right match in craftspeople, needing both specialized historic mason and historic carpenter.

RECOMMENDATION 2

Install tension rods through the south exterior clerestory wall extending to the exterior of the north exterior clerestory wall to provide the required tensioning to halt movement of the clerestory wall. Done at each roof truss to address truss issues and provide symmetry.

PRIORITY	HIGH TO EMERGENCY
ORDER OF MAGNITUDE COST	$ 175,000.00

A certain amount of flexibility is possible in the design of this project. Dividing the project into immediate and aesthetic issues is possible. Repairs to the wood truss will require some pinning of joints and creating a matching finish will require study. There will be more than one option for anchoring the tension tie into the masonry walls.

5.3 STEEPLE LOUVRES

The 2021 HSI Update of the 2015 Condition Assessment Report identified two louvers in the steeple which needed repair. The louvres allow for good airflow which dries infiltrating moisture and for the clear sounding of the bells. Properly installed screens act as a barrier for birds and animals and do not significantly detract from the mechanics of the louvres. A screen is missing from the west facing steeple louvre above the bell, shown in Figure 17.

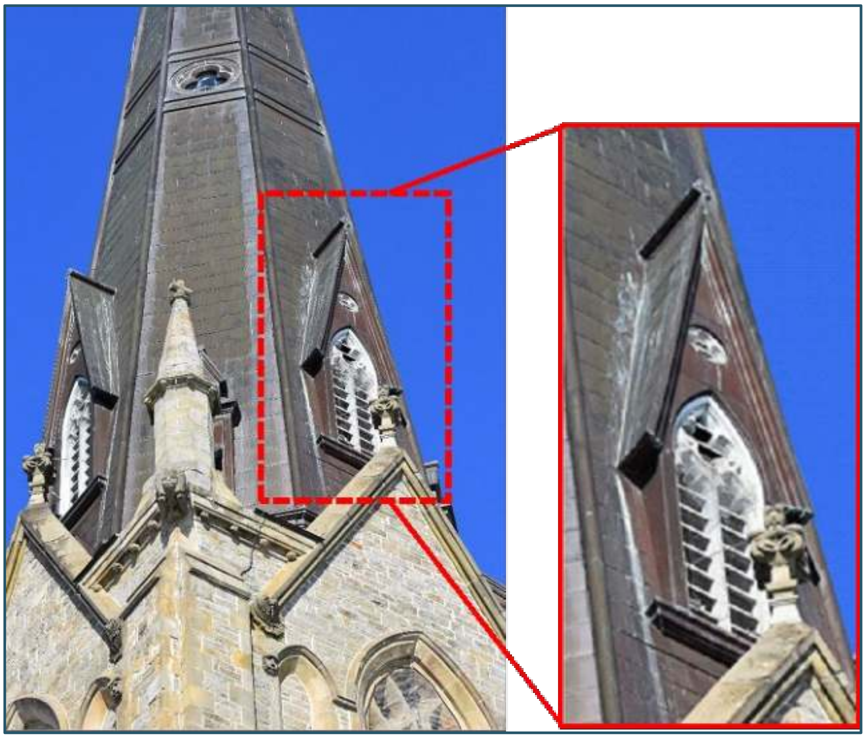

Figure 17: West facing louvre steeple window. Insert shows missing screen.

The missing louvre screen is enabling animal entry to the steeple and should be replaced. Two good options are available. One is to install a strong, UV stable, weatherproof mesh such as Galebreaker FarmFlex M75[8] inside the louvres. This mesh is 25% permeable, reducing the moisture entering the tower and reducing the airflow to the level of a tight window screen. The other option is to use a type 304 or 316 stainless steel mesh of approximately 5mm. This will allow greater airflow with correspondingly more drying capacity but will not reduce the moisture entering the tower. Mesh should be installed from the interior of the steeple, improving the appearance of the tower windows. The current screens are installed on the exterior and visible. Replacement of screens in all eight of the louvred tower windows would be beneficial for long-term structural health of the steeple. It is unknown if the finer screen could have an impact on the sounds of the bells, but any effect is suspected to be imperceptible to negligible. Because there does not appear to be a moisture issue in the tower, the recommendation is that the stainless steel mesh is sufficient and will avoid the extra cost of the weatherproof mesh.

[8] https://galebreaker.com/agriculture/off-the-roll/farmflex/

Figure 18: Broken louvre on south facing tower window

The south facing tower window has two broken and misaligned louvres, Figure 18, which are enabling excessive moisture to enter the building. It is likely a detailed inspection of the louvres will reveal more louvres that require repair.

As identified in the HSI 2020-08-04 Roof Repair Notes letter, the louvres need to be repainted or replaced. If the repainting option is chosen, all louvres should be scraped, repaired, primed, and painted properly before the new screens are installed. Some study should be undertaken to determine the most durable paint options for this use. Alternately, as noted in the 2020-08-04 letter, the current louvres could be replaced with seamless stamped copper louvres, which have increased longevity and reduced maintenance over wood. The copper louvres are presented here as an option, with the recommendation being the less expensive repair of the existing wood louvres. Due to access limitations the Church could consider use of copper as a means to reduce maintenance needs.

5.3.1 Consequences of Inaction

Protecting the interior of the tower from excessive moisture is a vital component to protecting the structural stone and interior wood elements of the tower. Allowing excess moisture to infiltrate will eventually cause deterioration of substantial and costly elements. It is important to maintain the existing louvres so that point is not reached.

Animal entry into the tower can cause major problems and become a health hazard. The most common problem in a church steeple is pigeon entry, which can result in considerable damage to the interior.

5.3.2 Impacts on Heritage Value

The louvres of the bell tower contribute to the heritage value of the Cathedral. Repairing the existing wood louvres and installing interior screens will restore the elegance of the tower openings.

5.3.3 Order of Magnitude Costs

For the rough order of magnitude cost for screening, the square footage cost of the stainless-steel mesh was used to develop an installed cost. A rough cost for the louvres was developed considering requirements for the creation of wood replacement louvers, some repairs of the existing louvres and frames such as wood filling and tightening joints, preparation of the existing wood louvres and frames for priming, priming, and painting. The price assumes the repairs can be undertaken at the same time as the steeple roof repair so that the same scaffold can be used.

RECOMMENDATION 3

Repair existing louvres in the steeple and replace existing screening

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 52,000.00
COMMENT	Assumed to be undertaken when scaffold is present for other work

5.4 MASONRY: PINNACLES, STEEPLE, BUTTRESSES, SACRISTY, AND GENERAL

Much of the exterior masonry at Christ Church Cathedral show some deterioration, including in some areas that were more recently repaired. This report discusses some of the most prominent concerns and leaves the other areas as general concerns.

5.4.1 PINNACLES

Damage to pinnacles is particularly concerning because the function of pinnacles in stone masonry was originally to provide a greater dead load at a given point to weigh down forces that may otherwise push outwards or overturn a given section. It is suspected that these pinnacles are functional and not purely aesthetic. The location of pinnacles is shown in Figure 19.

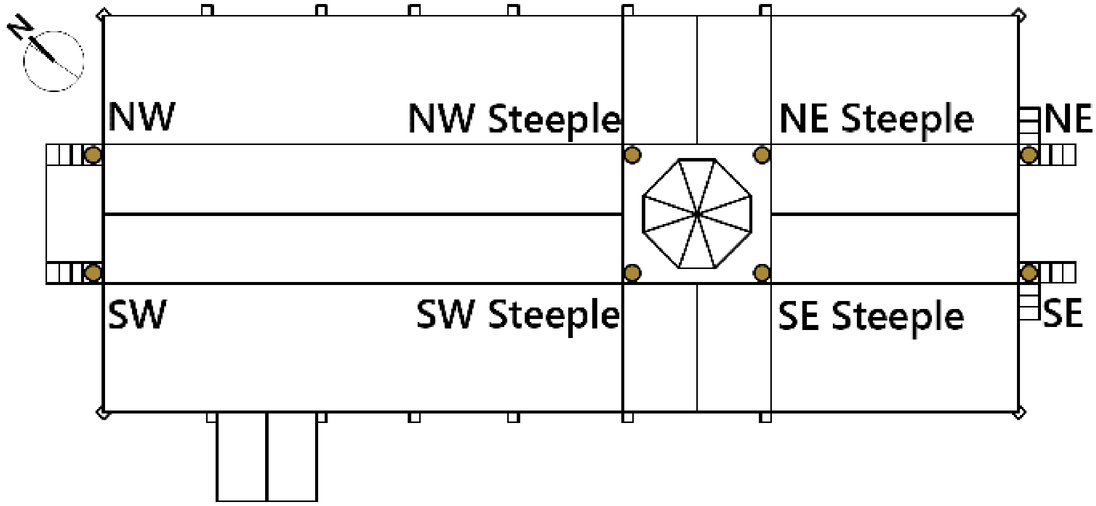

Figure 19: Location of Christ Church Cathedral pinnacles with pinnacles highlighted in gold

As described in the HSI 2020-08-04 Roof Repair Notes letter, the masonry of the steeple and pinnacles shows debonding failure of the masonry joints in many locations and instability consistent with incompatibility of prior repair materials, shown in Figure 20. There are also instances of poorly executed repairs to the stonework, shown in
Figure 21. The most recent documented repairs were completed in the 1990s.

Figure 20: Failed mortar joints in NE pinnacle

Figure 21: Masonry element with stainless steel threaded rod inserted into wood louver and epoxied to the top of stone

As documented in the 2021 Update to the 2015 Christ Church Cathedral Condition Assessment, the pinnacle masonry has continued to decay and repairs are necessary, as illustrated by comparative examination of the mortar in the SW pinnacle in 2015, shown in Figure 22, and in 2021, shown in Figure 23. The vertical cracking down the header joints in this pinnacle shows that the stones have begun to shift. This type of deterioration was seen at multiple pinnacles around the building during the 2021 evaluation.

Figure 22: Detail of SW pinnacle deterioration in 2015

Figure 23: Detail of SW pinnacle deterioration in 2021

These masonry elements should not be failing in this manner. When properly addressed, the pointing gradually wears away as a sacrificial element and would require repointing every fifty years (approximate number based upon weathering location and stone), with minimal damage to the stones or core of the wall. However, the level of damage observed on site appears to be more significant than just sacrificial mortar deterioration.

The eight masonry pinnacles should be repaired by removing the incompatible mortar and repointing the masonry with a compatible mortar. The majority of this work will be done without removal of any stones, however, some additional pinning should be used. Ensuring adequate bedding will be necessary and may require deep pointing and or grouting. Some strategic dismantling of the pinnacles and reinstatement in place may be required in the worst-case locations. The cost of the scaffolding will be an important aspect of the cost of the work as the pinnacles are at significant heights, with the four located at the corner of the steeple a challenge to reach across lower building roofs. Coordination with roofing would provide some efficiency of costs. It will be important to provide engineering design and construction support as unanticipated conditions will need to be identified and addressed quickly.

5.4.1.1 Consequences of Inaction

As the photographs show, there is movement in some of the stones of the pinnacles. It should be anticipated that the rate of movement will increase should repairs go unaddressed. At some point, the pinnacles could become so unstable that falling stones are a serious concern. Given the assumption that the pinnacles also form part of the structural mass of the building, applying a downward force where needed, failure of the pinnacle could also lead to structural failure of surrounding masonry walls.

5.4.1.2 Heritage Value

The pinnacles are an important component of the Gothic Revival architecture of Christ Church Cathedral. Care should be taken to ensure that the pinnacles are repaired so that the overall style of the Cathedral is not impacted. Careful design of repair mortars and selection of repair techniques will be required to ensure compatibility with the structure as well as aesthetic compatibility. All design and work should be documented.

5.4.1.3 Order of Magnitude Probable Cost

It is assumed that the masonry work on the pinnacles will not be carried out at the same time as the replacement of the copper roofing. Therefore, the required scaffolding, which will have to be designed to carry the weight of the masonry, will be a cost on its own for this project. The height of work and the difficulty in reaching some areas will impact that cost. Overall, the scaffolding will be a significant cost to the project, so combining work with other masonry projects would reduce almost half of the cost. An allowance has been included to address the various specialized stone repairs. Design will be necessary.

Recommendation 4

Repair the eight pinnacles

Priority	High

ORDER OF MAGNITUDE COST	$ 850,000.00

5.4.2 STEEPLE

Figure 24: Exterior masonry of steeple, note deterioration of sandstone on right side of photograph

The exterior masonry around the lower steeple will need general repairs. A small number of stones are deteriorating and need either consolidation or replacement. Joints are worn and must be addressed. Information could only be gathered through drone photographs.

Concerning the interior masonry, the 2015 Christ Church Cathedral Condition Assessment recorded the deterioration of the masonry above the nave roof level in the steeple. The most noticeable interior deterioration was found at the bell level, likely due to the steel structure supporting the bells which is embedded in the masonry. Four mechanisms are acting together to accelerate deterioration at this location: moisture ingress, freeze / thaw, steel corrosion, and bell-induced vibrations. The mechanisms are as follows:

- The steel is embedded in the masonry without anything to absorb the vibrations induced by the bell.
- The ensuing cracking allows increased infiltration of moisture and corrosion of embedded common steel elements, which creates further cracking.
- Increased moisture infiltration in turn exacerbates the freeze-thaw damage occurring in the unheated steeple, including the disintegration of the inner rubble layer.

Fortunately, the bell frame connections do not appear to have deteriorated since 2015. This suggests that deterioration is much slower than originally thought, making repairs a lower priority.

5.4.2.1 CONSEQUENCES OF INACTION

Without action the exterior masonry will continue to deteriorate. While not urgent at this time, the conditions at this location are more severe than lower sections of masonry due to both weather and wind effects around the tower and vibrations from the bells. Therefore, once problems become more serious, they will progress more rapidly. Loss of stone and eventual loss of structural stability are possible.

In the interior the deterioration does not appear urgent. If not monitored, developing problems that lead to eventual structural instability could be overlooked. However, so long as regular structural inspections occur, any potential problems should be identified early enough for planning interventions.

5.4.2.2 Heritage Value

The steeple is a critical component of the heritage value and Character Defining Elements. Any interventions should be understood, planned, and documented. Repair materials and techniques must be compatible, and the aesthetic impacts must be considered.

5.4.2.3 Order of Magnitude Probable Cost

Costs are based upon requiring independent scaffolding and based upon necessary conjecture regarding the condition of the wall core as well as the extent of deterioration.

Recommendation 5

Repair steeple masonry

Priority	High
Order of Magnitude Cost	$ 500,000.00

5.4.3 Buttresses

As documented in the 2021 Update to the 2015 Christ Church Cathedral Condition Assessment, most of the buttresses have vertical cracking between the outer most stones and the main buttress (Figure 25 and Figure 26), causing stones to be pushed away from the Cathedral. The deterioration has become more evident since the original 2015 Condition Assessment. Cracking around the buttresses suggests either overloading of the buttress, failure of the mortar, or a combination of the two. The repair design will likely need to consider the use of different mortars in different regions of the building to get best performance. Other simple strengthening measures can be included as part of the repair design for the buttresses, such as using stainless steel helical ties in the joint beds grouted to better engage the wall interior to the stone. Detailed design will be required for the intervention.

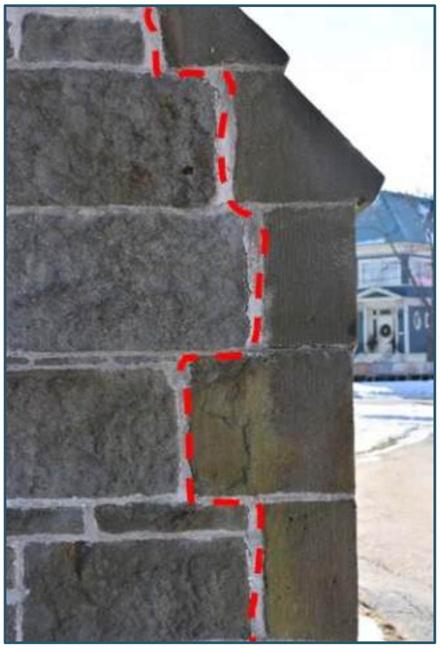

Figure 25: Southwest corner buttress

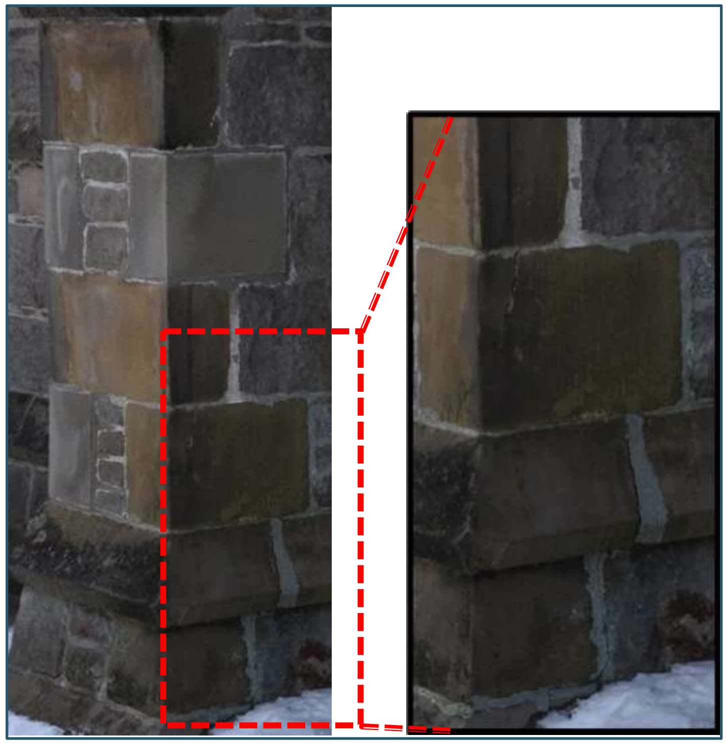

Figure 26: Northwest buttress

Cracks were found in all buttresses and walls around the northeast corner in the 2021 site visits. An additional possible cause of cracking at the northeast corner is the loss of trees on the property. A substantial tree close to the sacristy wall was lost between 2005 and 2008. The death of a tree near a building on soils with a high clay content can result in less water being taken up from the soil, which can in turn cause the ground to swell under wet conditions. In this case, swelling of the ground could cause the northeast corner of the Cathedral to lift upwards, creating visible cracks. Monitoring could continue to determine if the condition is changing as an aid to understanding changes on the greater site. This deficiency, regardless of its relationship to the vegetation, has created a vulnerability that is creating an instability and must be repaired.

Visual inspection and monitoring of cracking in the buttresses should be included as part of regular reviews of Christ Church Cathedral. For the buttresses, reviews monitoring cracking should be conducted every five years.

5.4.3.1 CONSEQUENCES OF INACTION

The purpose of the buttresses is to provide additional constraints where the walls are pushing outwards. This outwards thrust relates to the pure compressive function of arched systems and their generation of outwards thrust lines. Vertical cracking of a buttress decreases its ability to confine the structure. Inaction will lead to structural failure and potential collapse of all structural elements dependent upon that load path.

5.4.3.2 HERITAGE VALUE

The buttresses contribute to the building's heritage value and are a character defining element. Interventions should be documented and based upon a clear understanding of the issues. Minimising the extent of work required will be an important aspect of the conservation. Repairs should be compatible in materials, techniques, and aesthetic.

5.4.3.3 ORDER OF MAGNITUDE PROBABLE COST

Costs are based upon the assumption that specialized shoring and repairs will be necessary at many locations.

RECOMMENDATION 6

Repair the buttresses

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 300,000.00

5.4.4 DOORS

Masonry repairs are needed at all doors of the Cathedral, although some repairs are not urgent. To keep relevant information together, this section also includes non-masonry repairs to the doors.

5.4.4.1 MAIN SOUTH ENTRANCE

In the 2021 HSI Update of the 2015 Condition Assessment Report, it was recommended that the wooden door of the main south entrance be removed for repair. The condition of this door was poor in 2015 and continues to deteriorate (Figure 27). Deterioration has developed over time due to numerous causes, including moisture, salts, ultraviolet light, and biological attack. The preferred approach is to repair and reinstall the door instead of replacing the door. Holes would be filled using wood filler recommended for heritage woodwork, large cracks would be stitched together, and hardware would be removed for repair and reinstallation. Where portions of the door (such as at the bottom edge) are not salvageable, the area would be removed and replaced with new wood. Once all repairs are made, the door would be finished using an approach compatible with the building, for example, by using a heritage finish rather than a modern varnish. This decision would be part of the design. The door is rapidly deteriorating at this point and there will be a point where the door is not salvageable. At this time authors are not aware of any local heritage carpenters that have demonstrated repair ability on this size of door. Some do exist in Ontario and Quebec.

Figure 27: Example of poor condition of wooden door at main south entrance

Figure 28: Damage to sandstone framing the south main door

General in-situ repairs should be made to the remaining exterior doors of the Cathedral to maintain the doors in good condition. The sacristy door should be rehabilitated so that it is weather tight, secure, and functional.

Also recommended was the repair of the badly damaged carved base of the sandstone door frame, shown in Figure 28. The damage is evident on both sides of the frame and reaches to a height of approximately 80cm on each side. Approximately 2 linear metres of carved sandstone will be needed to replace the decayed area.

The sandstone framing doors around the perimeter of the Cathedral should be repaired. Sections of the sandstone that have deteriorated past the point where repair is not possible should be removed and replaced with sandstone carved to match the original shaping. Simpler repairs should be made where possible.

The church may also make the decision to have a stone carver restore the sandstone face adjoining the door on the east. The lower part of the face has decayed significantly, Figure 29. The face on the west, Figure 30, is in much better condition with only minor weathering.

If a stone carver is engaged, the condition of other carvings could be reviewed for potential necessary repairs. Collaboration with such highly skilled artisans in planning stages can provide great benefit to creating successful projects.

Figure 29: East figure at main south entrance

Figure 30: West figure at main south entrance

All masonry repairs will require design, documentation, and involvement of designers during repairs.

The glass of the inner door, Figure 31, has been damaged in multiple areas as described in the 2021 HSI Update of the 2015 Condition Assessment Report. Various panes have been broken by impacts and there has been movement withing the frame. The 2012 *Standards and Guidelines for the Preservation of Stained (and Leaded) Glass Windows* by the Stained Glass Association of America (SGAA) describes the production and preservation of this type of stenciled glass windows, Figure 32.

Figure 31: Detail of inner glass doors of main south entrance

Figure 32: Example of a stenciled glass window from the SGAA 2012 report

Because they were cheap (for their purpose), mass produced windows, intended as a placeholder until stained glass could be installed, stenciled glass windows are generally made of very thin, poorly fired glass. This glass is fragile, prone to fading patterns, and difficult to match when broken. It can be challenging and expensive to repair or replace broken panes. The repair of these windows should be included in the stained glass conservator's evaluation of window damage.

Because of their limited value from a stained-glass perspective, the 2012 SGAA report suggests considering the replacement of stenciled glass windows when damage is extensive. However, the value of the windows from a historical perspective is different. If the conservator determines that the windows will require extensive expense and effort to save, the church may consider replacing them. A discussion with both HSI and the conservator would be valuable before any final decisions are made.

As discussed in the 2021 HSI Update of the 2015 Condition Assessment Report, impact damage is occurring when items are stored in the vestibule adjacent to the glass. Nothing should be stored close enough to any glass in the church that accidental damage can occur to the glass.

5.4.4.2 SOUTH CHOIR VESTRY DOOR

The sandstone sill, shown in Figure 33, and the base of the doorframe to the height of approximately 90 cm, shown in Figure 34 are decayed. Approximately 2.25 linear metres of carved sandstone will be needed to replace the decayed area of the frame and another 1.5 metres for the sill. Repair will eventually be needed but is not urgent.

Figure 33: Sandstone sill damage on south vestry door

Figure 34: Sandstone frame damage on south vestry door

5.4.4.3 MAIN WEST DOOR

The sandstone carving at the base of the main door frame exhibits damage to a height of approximately 70cm from weathering and/or mechanical damage such as shoveling and salting (Figure 35 and Figure 36). The replacement of the bottom two sections of the door frame will be required at some point.

Figure 35: Damage to left side of main door frame

Figure 36: Damage to right side of main door frame

5.4.4.4 EXTERIOR CHOIR VESTRY STAIRS

The south choir vestry stairs are in poor condition and rapidly continue to deteriorate (Figure 37 and Figure 38). They should be considered unsafe for use.

Figure 37: South vestry stairs 2015

Figure 38: South vestry stairs 2021

HSI prepared guidelines for repairs dated 2021-04-27 to be used, not as a public tender, but to facilitate initial discussions with qualified masons and ensure a similar situation is being described to all parties so that repairs could be proposed and priced. This stair is sufficiently separate from the structure that detailed engineered design is not required, although HSI provided general specifications and intended to oversee and outline requirements as an owner's representative. Repairs were not pursued at that time as the costs were higher than anticipated and the Cathedral needed additional time to determine a preferred approach. Options included repair using more modern materials and techniques while still maintain the heritage appearance or restoration of the stairs using salvaged materials and traditional techniques. Although work did not go ahead, this preliminary investigation did provide a good understanding of the associated costs.

In addition to repairs to the stairs, there is also damage occurring to the church around the building (Figure 39, Figure 40, and Figure 41). It would be prudent to address this masonry damage at the same time as the stairs are being repaired.

Figure 39: Cracking on adjacent wall to the east of the bounding wall

Figure 40: Failed repair to east of door

Figure 41: Failed repair to east of boundary wall

All work on and around the Cathedral must consider that the building was built using materials and techniques that are different from those used today. In this instance, work on the support structure of the stair must take into account that neither were the foundations of the Cathedral built in the same way we currently build a foundation nor was the surrounding ground filled in line with current practice. There will be differences in how the structure supports load and how moisture movements in the building occur. All design and construction activities are required to consider compatibility between the repaired stair and the historic Cathedral because mistakes can cause extensive damage.

The stairs should not be removed, nor the door blocked from use because it is important to maintain a serviceable exit at this end of the building. The stairs should not be allowed to deteriorate further, and it is advised against replacing stairs with modern materials as these options would directly impact negatively on the heritage value of the Cathedral. It is preferred that the stairs are repaired in such a manner that the heritage value is maintained. Repairs to damaged stone and masonry immediate to the location of the stairs should be included in this work. Based upon response to date and timing with the other projects, HSI now suggest undertaking more detailed design of the repair.


Figure 42: Top of north side door arch with visible crack along a 45 degree mortar joint at centre.

5.4.4.5 North Sacristy Door

A crack is visible at top left of the arch of the sandstone door frame (Figure 42). Masonry repair is needed here and elsewhere on the door frame. The door itself is warped and does not sit in the door frame. At this time the door is not in general use. Masonry repair for this area is included under general masonry.

5.4.4.6 Consequences of Inaction

The immediate concern is for the wood door at the main south entrance and the condition of the south choir vestry stars. For the wood door, deterioration from salt, UV light, shovelling, and water is now extensive and will continue. Repairs should be made before the door is no longer salvageable. The south choir vestry stairs are no longer usable and continue to deteriorate. The longer the repairs are delayed the greater the amount of work will be required. This will decrease the ability to salvage what is existing and increase the cost of doing so. The same concern exists for the sandstone framing around the doors, primarily at the east main entrance and the south main entrance. The sandstone should be repaired before more extensive lengths are no longer able to be repaired in-place but need to be replaced. The decorative carvings should also be repaired before the details weather away.

5.4.4.7 HERITAGE VALUE

The decorative wood doors, carved sandstone framing, and carved heads and other details are identified Character Defining Elements and contribute to the buildings heritage value. Neglect of these elements has a direct negative impact on the heritage value of the Cathedral. Any work on these elements should be well documented and planned.

5.4.4.8 ORDER OF MAGNITUDE PROBABLE COST

Costing of the following recommendations depend upon rare skillsets and costs are variable, some accommodation was given to this in pricing.

RECOMMENDATION 7

Extensive repairs should be made to the south main entrance wood door in preparation for reinstalment. General repairs should be made to the remaining exterior wood doors of the Cathedral.

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 70,000.00

RECOMMENDATION 8

The sandstone framing the exterior doors, including cut and sculpted stone, should be repaired or replaced as required

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 80,000.00

RECOMMENDATION 9

The condition of the stenciled glass in the interior door at the main south entrance should be included in the conservator evaluation of the stained glass windows of the Cathedral.

PRIORITY	LOW
ORDER OF MAGNITUDE COST	Included in “Stained Glass Windows”

RECOMMENDATION 10

Repair the south choir vestry stairs with techniques and material that maintain the heritage value of the Cathedral.

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 55,000.00

*Please note that at the Cathedral's request Recommendation 11 has been moved into Part 3: Maintenance Work

5.5 GENERAL REVIEW OF MASONRY

As discussed previously, repairs to the masonry of the steeple and pinnacles are required before stones move or fall and repairs to the buttresses are required soon as well. The exterior stone walls also require repointing in general as some cracks are visible, but this work is less urgent. It is, however, necessary for the long term performance of the building. In some areas it is likely that moderate deterioration of the middle wythe, or wall core, is occurring and will need to be addressed. All masonry repairs should be designed holistically to ensure compatibility in material, function and aesthetic. Similarly, use of experienced heritage masons will be important. The mortar mix may need to vary with location, and each location may require its own adjustment to sand, grading of sand, and adjustment to binders. Mortars will be different than those used in similar new construction.

Figure 43: Failed header joint and bedding joint, repairs to be treated under general masonry

Design will be required, along side regular collaboration during construction between designers and contractors. Design of masonry repairs should encompass the entire building, including the areas singled out in this report for special discussion. While phasing is possible, design should ensure a consistent approach to improve compatibility and ensure a logically progression that can be well documented. There will be areas where combining projects to reduce setup costs is possible.

5.5.1 CONSEQUENCES OF INACTION

The masonry functions as both building envelope and structure for Christ Church Cathedral. Inaction in repairs will allow deterioration to continue, typically occurring at an ever faster rate. Unchecked problems can quickly become large.

Design should be used to identify specific areas needing treatment. While the entire building should be considered in the repair scope, that does not mean that 100% of mortar joints or stones need to be repaired – instead a holistic map of repairs should be created, aiming to minimise interventions while achieving desired results.

5.5.2 HERITAGE VALUE

The masonry has a high heritage value, generally affecting the outside appearance of the Cathedral.

5.5.3 ORDER OF MAGNITUDE PROBABLE COST

Costing of masonry repairs includes conjecture. Design will better establish scope and allow improved cost estimates, however even with design many of the larger masonry conservation projects to occur in Atlantic Canada in recent years have come at higher than anticipated costs. Some accommodation for this has been given.

RECOMMENDATION 12

General repair of masonry

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 3,000,000.00

5.6 STAINED GLASS WINDOWS

Extensive window repairs on Christ Church Cathedral are necessary for the long term survival and health of the stained glass. The first step is to repair and stabilize the exterior walls and framing so that the stained glass windows have a solid framework and support. The immediate work for the stabilization of the clerestory walls is discussed in Section 5.2 Structural. This section will outline the necessary repairs to the stone frames and tracery of the stained glass windows and then address what steps should be taken with the stained glass.

The global steps for conserving the stained glass windows are as follows:

- Stabilize the building envelope so that repairs will be less likely to fail due to continued movement of the surrounding walls.
- Have a qualified stained-glass conservator conduct a comprehensive analysis of all stained glass to determine both the extent of the damage and a plan for long lasting repair. This should produce a detailed plan and costing for repairs.
- Repair the window glass and masonry concurrently for those windows where repairs to both are necessary.
- Clean and replace the exterior protective glazing, adding vents where necessary (venting should be done earlier if process is to be prolonged).

5.6.1 Repairs to Frames and Tracery

During construction of the Cathedral, a soft pale Caen Stone was imported from France to meet a specific aesthetic for the new building. This stone was found to not perform well in the New Brunswick climate. Multiple repairs were done before the Cathedral began replacing the stone with Indiana Limestone during the 1990s repairs. The replacement comprised only a small number of windows, and those where the Caen Stone remains are typically deteriorated and failing. HSI has identified 39 windows in which the stone frames and or tracery are still the original Caen Stone (Figure 45). This stone continues to decay over time, as for example seen in Figure 44.

Figure 44: Decayed Caen Stone on Window 48. Note the failed cement overlay patch at lower left.

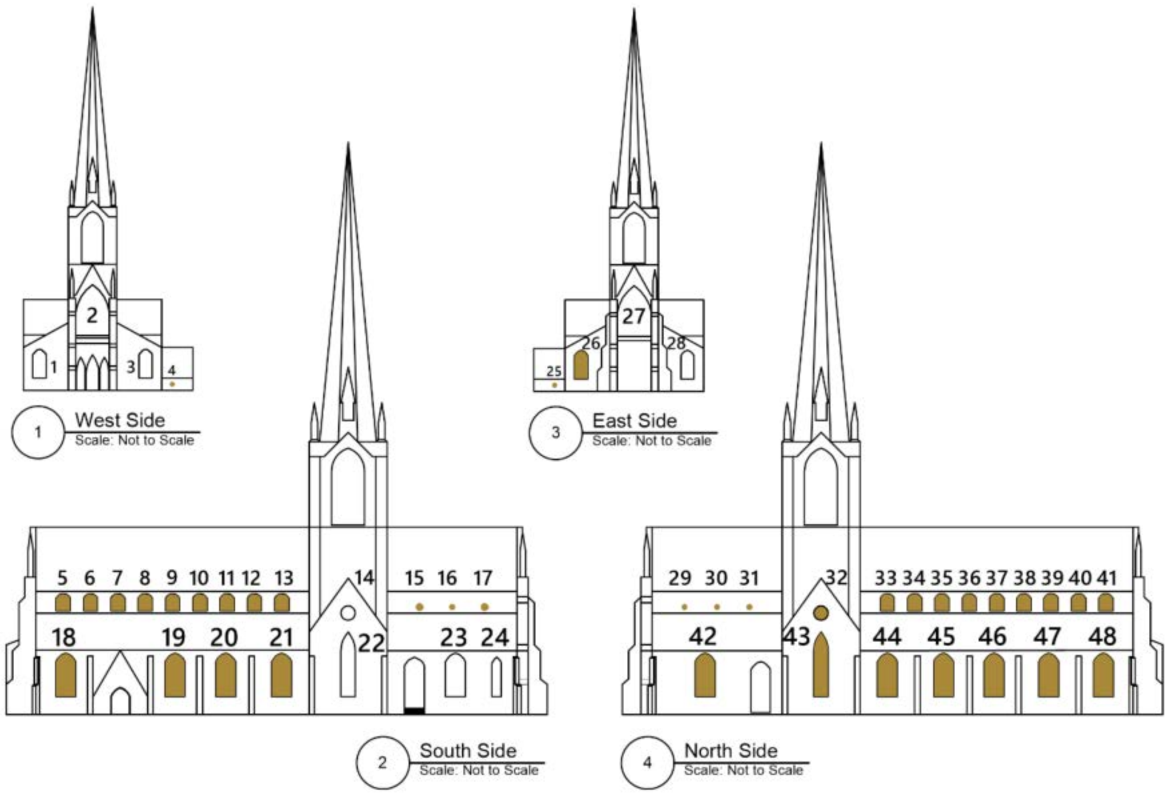

Figure 45: Locations where original Caen Stone used in the tracery and frames require replacement. Note east and west window tracery have all been replaced.

Seven of the Cathedral windows (Windows 1, 2, 3, 14, 22, 28, and 28) were fully replaced with Indiana Stone in the 1990s. One other, Window 26, the Caen Stone appears to have been repaired and partially replaced with Indiana Stone. It provides an excellent illustration of what can happen over time if the windows are not fully replaced with the more durable stone. As illustrated in Figure 46 and Figure 47, the remaining Caen Stone has continued to decay and must now be replaced. The time, effort, and money spent on the repairs would have been better spent on complete replacement.

Figure 46: Window 26 frame damage, note the more durable Indiana Stone sill

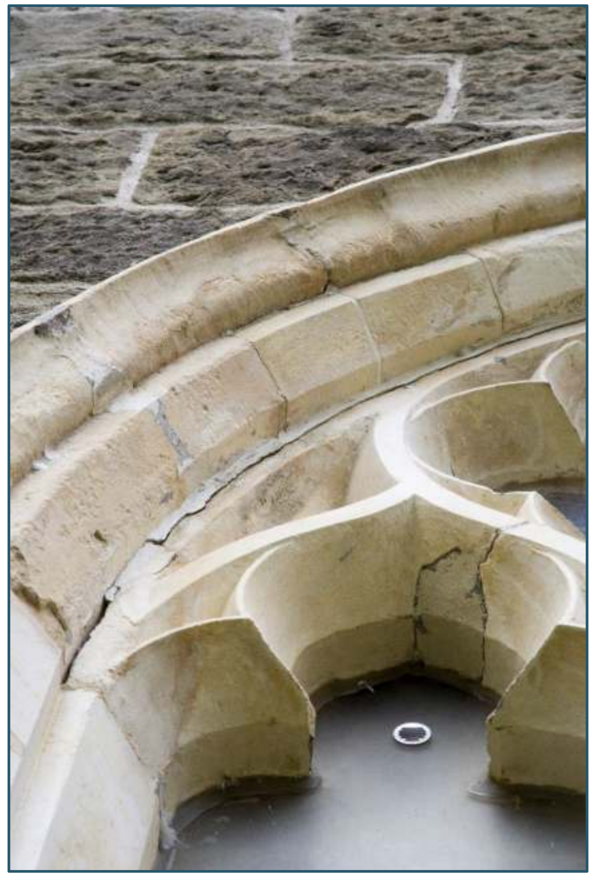

Figure 47: Window 26, tracery damage

Some of the small, round clerestory windows (Windows 16, 29, 30, and 31) do not appear to be as badly decayed as some of the larger windows, perhaps due to their small size, although because it is difficult to view them clearly from the ground, it is hard to tell how badly decayed they may be. Regardless they should be replaced to avoid further deterioration as occurred with window 26.

Windows 23 and 24 (Figure 48 and Figure 49) and the four tower windows, not pictured in the schematic illustration of Figure 45, appear to be older but carved of a more durable stone than the Caen Stone. These stone frames do not need replacement at this time, and in contrast with the Caen Stone appear to underscore its long term problems.

Figure 48: Window 23

Figure 49: Window 24

To establish a method of measurement to estimate the amount of stone required, HSI used a 3d photogrammetric model generated from drone images to generate measurements of upper windows in a CAD (Computer Assisted Drawing) program. An aspect of this process is shown in Figure 50 and Figure 51. Other window measurements were estimated by using photographs calibrated to the size of the photogrammetry model. Two small windows within easy reach were simply measured by hand.

Figure 50: Generating measurements for main floor window

Figure 51: Generating measurements for clerestory window

Some of the windows that do not need to be replaced have areas of failed mortar. While masons are on site and using mortar appropriate to Indiana Stone, it would make good economic sense to have any failed mortar repaired.

5.6.1.1 CONSEQUENCES OF INACTION

Failure to replace the existing Caen stone will lead to continued deterioration, opening cracks which will allow water to penetrate the exterior envelope of the Cathedral. Eventually the stone framing will not be sufficient to hold the stained glass windows in place, leading to movement of the windows and potentially irreparable damage to the stained glass.

5.6.1.2 HERITAGE VALUE

The Cathedral would have significantly less value as a historic place if the stained glass windows were lost. As artwork they require careful treatment and conservation; as structure they require design and detailing. Both together in a unique assembly require an integrated and detailed design and execution process that is well documented for future conservation projects.

5.6.1.3 ORDER OF MAGNITUDE PROBABLE COST

Costing of masonry repairs was based upon the approximate volume of stone and carving necessary, assuming that access can be done at a reasonable cost. This will benefit from being combined with other repair projects in similar areas.

RECOMMENDATION 13

Repair of window framing and tracery

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 600,000.00

5.6.2 STAINED GLASS

Retired Fredericton stained glass artisan Hugh McKinnon identified in his letter evaluation summary of July 21, 2020, that damage to the stained glass panels includes impact breaks, border breaks (perhaps due to movement of stonework), and severe distortion out of plumb. He advised that this repair work should be completed when the tracery and mullions are being replaced. As can be seen in Figure 52 below from the 1995 Stone Restoration report by Maritime Canstone, the removal of the original stone frames allows the stained glass to become easily accessible. Once the stone is replaced, that window is no longer as easily accessible (Figure 53).

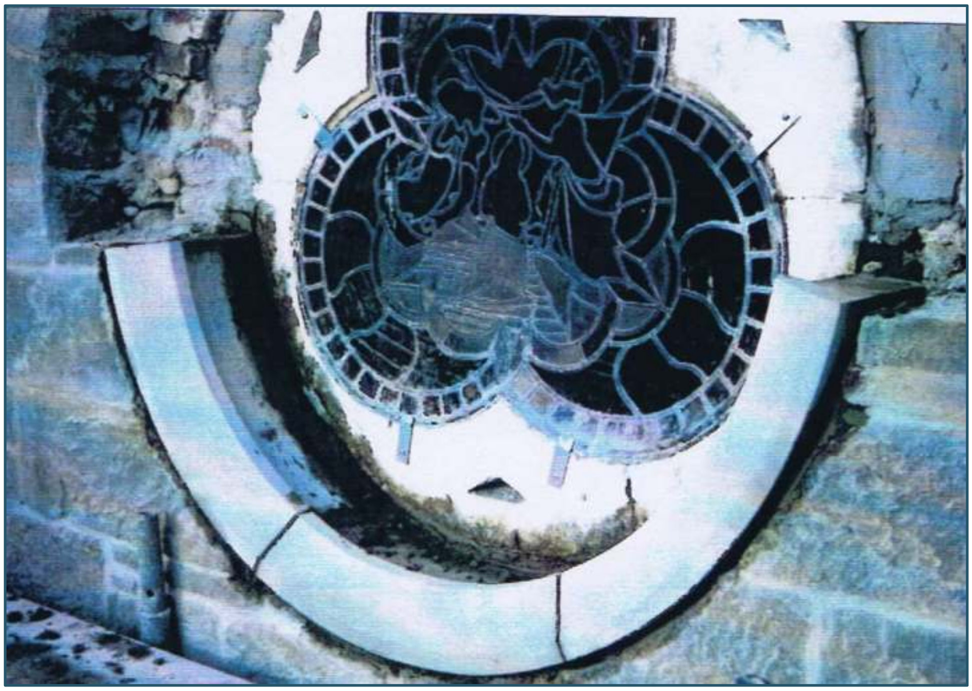

Figure 52: Replacement of circular window stone frame and tracery. From 1995 Stone Restoration report by Maritime Canstone.

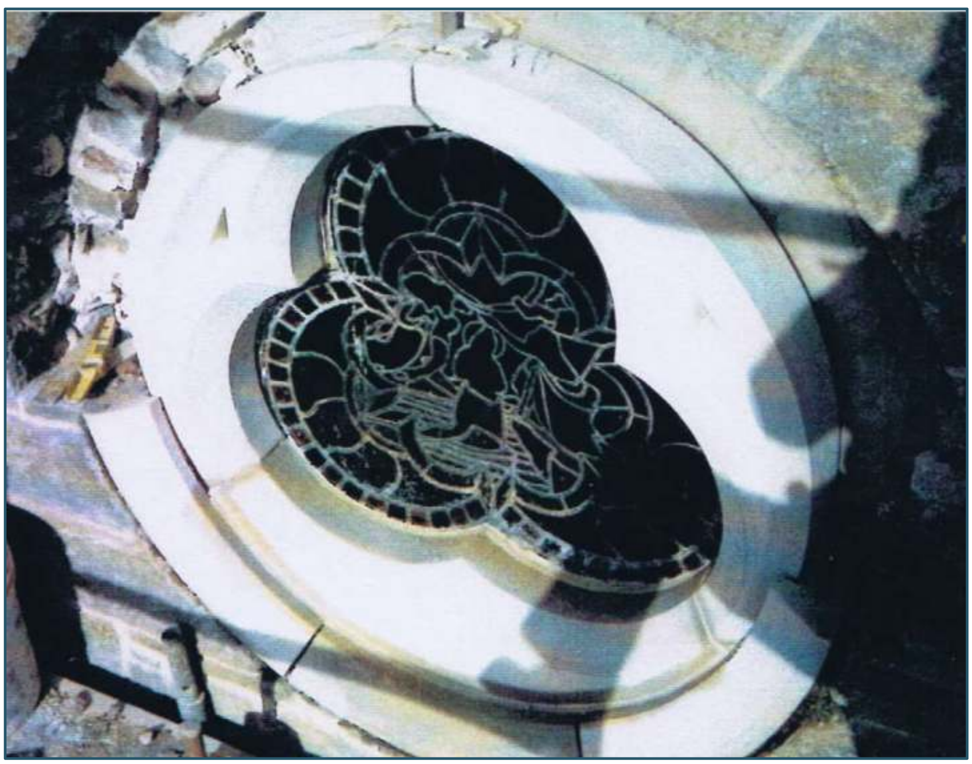

Figure 53: Replacement of circular window stone frame and tracery. From 1995 Stone Restoration report by Maritime Canstone.

A comprehensive analysis of damage to the stained glass windows is needed from a qualified conservator to determine both the extent of the damage and a plan for long lasting repair. This should be done before the stone tracery and frames are removed so that the stained glass repair work can be done concurrently with the masonry repair.

Although repair work was done on the windows in the mid-1990s, some of these repairs have failed, as seen in Figure 54.

These earlier repairs should be evaluated by the conservator and redone using longer-lasting techniques where possible.

The conservator should also evaluate the stenciled glass windows in the south entrance vestibule as described in report section Main South Entrance.

All glass should be cleaned inside and out wherever possible.

For reduced energy consumption, Stephen Collette in his Green Audit Report, 2015 recommended ensuring that windows are tightly sealed to prevent air leakage. The conservator should be able to establish where sealing is insufficient around the stained glass and seal those areas.

Figure 54: A glazing overlay repair that has separated from the original stained glass on Window 2, the main west window. Note the presence of debris or biological material between the stained glass and repair layers.

Windows should be cleaned at the same time to improve lighting in the sanctuary. As much of the repair work as possible should be done in-situ.

5.6.2.1 CONSEQUENCES OF INACTION

Greater unknowns and potential missed opportunities for combining project work.

Potential loss of valuable artwork.

5.6.2.2 HERITAGE VALUE

The heritage value of the stained glass in this building is high. For conservation and the retention of heritage value, it will be important to engage in a study to understand and document the detailed conditions so that planning can minimise interventions.

5.6.2.3 ORDER OF MAGNITUDE PROBABLE COST

The cost provided here is for the engagement of a qualified stained glass conservator to evaluate the current condition of the stained glass windows and identify required repairs. At this point because the extent of repairs is unknown, an allowance for repairs has been provided. This differs from an order of magnitude cost as the amount is not based on what the work is believed to ultimately cost, but on an amount that either the Cathedral is willing to spend or is able to budget for this work. That allowance provided here is $ 250,000.00, which would be applied to repairs that are deemed to be of high importance.

RECOMMENDATION 14

Engage stained glass conservator for detailed report on condition and conservation

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 32,000.00

RECOMMENDATION 15

Engage stained glass conservator for detailed report on condition and conservation

PRIORITY	TBD
ALLOWANCE FOR NECESSARY REPAIRS	$ 250,000.00

5.6.3 Exterior Protective Glazing

Figure 55: Larger view of Figure 51 above. Insect and arachnid debris on stained glass and exterior protective glazing on Window 2. Note the wasp nest on the right is adjacent to a failing stained glass patch that appears to contain debris or biological growth.

All of the ground floor windows in the Cathedral and the main east and west windows are covered by exterior protective glazing (EPG). In order to reduce damage to the stained glass windows, HSI has recently designed the venting of the EPG. While in a bucket truck overseeing the installation of the venting, HSI was able to observe and document the condition of otherwise unreachable windows.

In many places the EPG has been affected by environmental and biological agents making it very grimy (Figure 55). This not only affects the stained glass it is protecting, but it dims and reduces the vibrancy of the light reaching the sanctuary. Once the EPG is removed for window repair, it should be left off until the stained glass has been cleaned on the exterior and/or repaired. Then the EPG and the interstitial space should be cleaned both inside and outside, replaced, and sealed properly.

Figure 56: Moss, fungi, animal, and moisture damage in Window 25. Note the lack of sealants at the edge of the EPG.

Because the EPG is not currently well sealed, in many places moisture and unwanted materials have built up in the inner space between the two glazing surfaces. In window 25, moss, arachnid and insect debris, and at least three types of fungi were visible in a terrarium like environment with visible moisture on the inner surface of the EPG (Figure 56).

Damaged sealants (Figure 57) should be repaired and/or replaced and areas that were originally left unsealed (Figure 58) should be closed off so that biological entities and moisture cannot enter and create damage or grime.

Figure 57: failed vertical and horizontal sealant between EPG and masonry

Figure 58: simple original vents lacking screens or louvres

Because they were the most urgent, the large stained glass panels were the first windows to be properly vented with gridded vents. This leaves quite a lot of stained glass with unvented EPG. The stained glass conservator should be able to determine which of these need vents for window health and to develop a plan for venting them with appropriate screened and louvered vents.

The tracery has not been vented with gridded vents. In some cases, it has not been vented at all (Figure 59). In other places, gaps have been left at the top likely to enable airflow to cool the glass (Figure 60). These have enabled insect habitation as well.

Figure 59: Unvented tracery. Note that it has required repairs in the past (areas of frosted glass overlay) possibly due to excessive heat buildup.

Figure 60: original simple vents left at top of tracery. Note the wasp nests (light shapes at end of finger) and debris between the layers of glazing.

The EPG covering Window 2, the main west window, is warped (Figure 61), likely due to insufficient flattening of the rolled sheet of acrylic before installation. Window 27, the main east window, also shows warping in the EPG (Figure 62). If it proves too difficult to properly seal the warped EPG sheets over the main windows, they may have to be either removed, flattened properly, and reinstalled or completely replaced.

Figure 61: Warping visible in the reflections on the EPG on Window 2

Figure 62: warping visible in the shadows on the EPG on Window 27. Note also that the EPG is so hazed that it is almost impossible to make out the stained glass behind it.

The church may want to replace any excessively yellowed or hazed EPG for aesthetic reasons.

Where the EPG needs to be replaced, best practice would be replacement with laminated glass for improved long term aesthetic. Because it will not yellow or haze like acrylic, laminated glass will improve the strength and vibrancy of light through the stained glass and will not detract from the beauty of the exterior façade. However, laminated glass is expensive, and acrylic is a sufficient, though not ideal, protective glazing.

5.6.3.1 CONSEQUENCES OF INACTION

Without action, the lack of venting of the EPG can lead to gradual failure of the lead window came. As this weakens and deforms, greater stress can be placed upon the glass until glass fractures can occur. Ultimately, the stained glass may be damaged beyond easy repair.

5.6.3.2 HERITAGE VALUE

Same as Section 5.6.1.2 Stained Glass Heritage Value.

5.6.3.3 ORDER OF MAGNITUDE PROBABLE COST

Costing based upon work done to vent glazing during the summer of 2021. Higher costs would depend upon treatment selected and would each come with a different service life and performance level.

RECOMMENDATION 16

Improve condition and venting of external protective glazing

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	Dependent upon recommendation and discussion with stained glass conservator. Low estimate $ 25,000.00

5.7 MAJOR REPAIRS RECOMMENDATIONS

Addressing the necessary major repairs to Christ Church Cathedral will be a significant undertaking for the congregation. A planned approach is necessary to allow the Cathedral time to develop support for the required funding and be able to share the vision for the future. The plan for the work must also sequence the work so that the more urgent issues are addressed first and that the projects are completed in a logical fashion. Organizer energy is another consideration. It helps to have the major portions of the work completed at the start with smaller, finishing, projects at the end to take advantage of the early energy of a major undertaking.

Generally, for the major repairs, stabilizing the structure is the first concern, followed by ensuring that the building envelope is tight. A considerable percentage of the repair costs is the provision of scaffolding required to complete roof and masonry repairs, particularly for the steeple and clerestory walls.

HSI is proposing a sequencing of the projects that takes advantage of the configuration of the Cathedral's structure. Work will start in the area of the steeple with the replacement of the roof, repairs to the masonry, repairs to the louvres, and repairs to the window frames and tracery.

The recommendations provided for Major Projects are listed in Table 5

Table 5: Listed Recommendations for Major Repairs

	Recommendation	Urgency	Cost
1	Roofing and Flashing	Emergency	$ 4,000,000.00
2	Tension rods	Emergency	$ 175,000.00
3	Louvers	Medium	$ 52,000.00
4	Repair pinnacles	High	$ 850,000.00
5	Repair steeple masonry	High	$ 500,000.00
6	Repair buttresses	High	$ 300,000.00
7	Repairs to wood exterior doors	High	$ 70,000.00
8	Sandstone doorways	Medium	$ 80,000.00
10	Repairs to choir vestry stairs	High	$ 55,000.00
12	General masonry	Medium	$ 3,000,000.00
13	Repair of framing and tracery	Medium	$ 600,000.00
9 & 14	Engage stained glass conservator to prepare detailed report on condition and conservation of stained and antique glass.	High	$ 32,000.00
15	Allowance for necessary repairs to stained glass and antique glass	TBD	$ 250,000.00
16	Improve venting of external protective glazing	Medium	$ 25,000.00
		Total	**$ 9,989,000.00**
		Potential Reduction because of Sequencing of Work	**$ 1,400,000.00**
		Total with Potential Savings Applied	**$ 8,589,000.00**

It is recommended that this work be completed over a three year period. Year one would focus on the design of the work for all of the Major Repairs projects and the installation of tension rods on the interior of the Cathedral to halt movement of the clerestory wall. Year 2 would focus on the remaining exterior work from the steeple to the eastern exterior wall of the Cathedral. Year 3 will be the remaining exterior work from the start of the nave to the western exterior wall. This is shown in Figure 63.

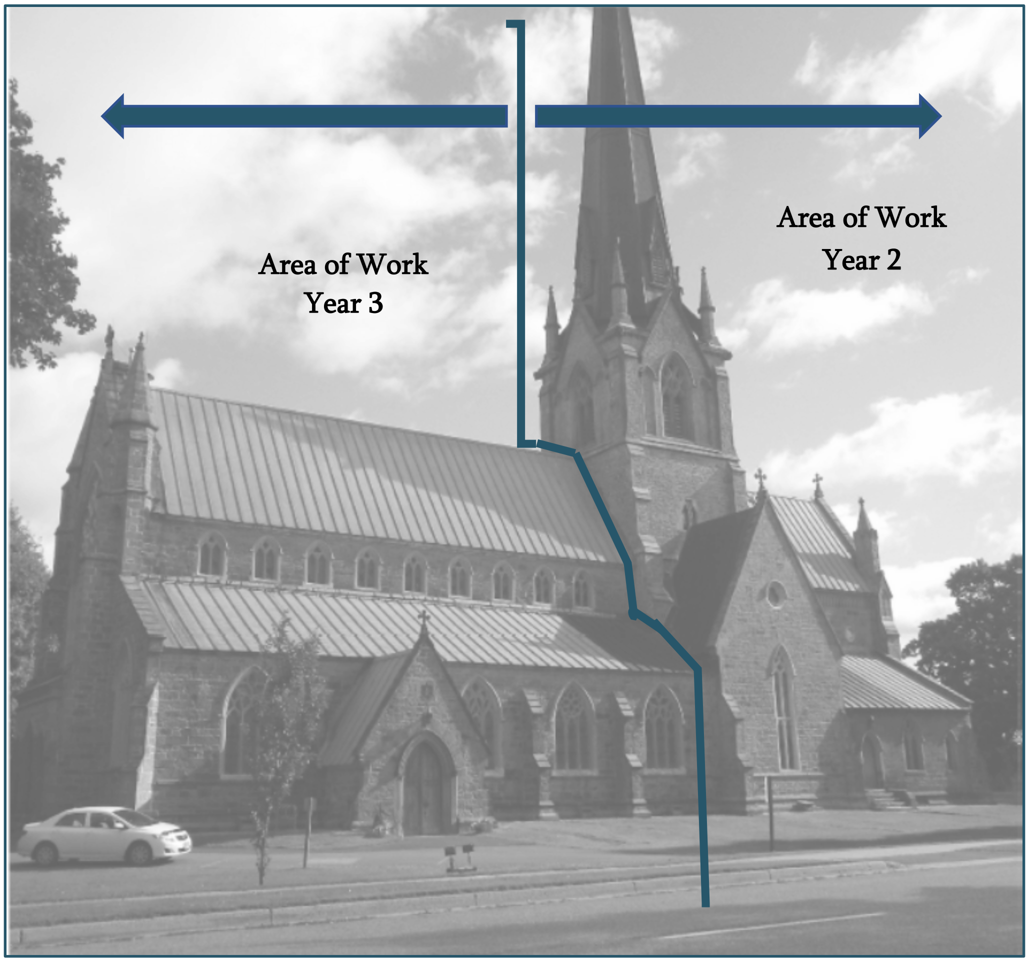

Figure 63: Areas of Work in Year 2 and Year 3

The breakdown of the projects and work in each year is shown in Table 6, Table 7, and Table 8.

Year 1 includes the design work for the Major Repairs projects. The estimated design costs for the projects was estimated to be 15% of the order of magnitude costs provided. Note that the full order of magnitude cost is provided for the installation of the tension rods to stabilize the clerestory walls as this should be completed before repairs to the exterior roof and walls. The full order of magnitude cost to have a stained glass and antique glass conservator provide a conditions and recommended repairs report for the Cathedral is also included in this year. This report needs to be in hand before the start of Year 2 and 3 so that the scaffolding in place may be used for any necessary repairs to the stained and antique glass.

Design costs for repairs to glazing is not included in Year 1 as it is also a necessary outcome of the report, while other design costs in Year 1 will continue over multiple years but are located in Year 1 as it will be the major year for costs and this provides greater clarity.

Table 6: Year 1 Major Repairs Projects and Order of Magnitude Costs

	RECOMMENDATION	URGENCY	COST
1	**DESIGN:** Roofing and Flashing	EMERGENCY	$ 600,000.00
2	Tension rods **(Design and Install)**	EMERGENCY	$ 175,000.00
3	**DESIGN**: Louvers	MEDIUM	$ 7,800.00
4	**DESIGN**: Repair pinnacles	HIGH	$ 127,500.00
5	**DESIGN**: Repair steeple masonry	HIGH	$ 75,000.00
6	**DESIGN**: Repair buttresses	HIGH	$ 45,000.00
7	**DESIGN**: Repairs to wood exterior doors	HIGH	$ 10,500.00
8	**DESIGN**: Sandstone doorways	MEDIUM	$ 12,000.00
10	**DESIGN**: Repairs to choir vestry stairs	HIGH	$ 8,250.00
12	**DESIGN**: General masonry	MEDIUM	$ 450,000.00
13	**DESIGN**: Repair of framing and tracery	MEDIUM	$ 90,000.00
9 & 14	Engage stained glass conservator to prepare detailed report on condition and conservation of stained and antique glass.	HIGH	$ 32,000.00
16	**DESIGN** Improve venting of external protective glazing	MEDIUM	$ 3,750.00
		TOTAL YEAR 1	**$ 1,636,800.00**

Table 7: Year 2 Major Repairs Projects and Order of Magnitude Costs – Repairs on Eastern Portion of Cathedral

	RECOMMENDATION	URGENCY	COST
1	**EASTERN SECTION:** Roofing and Flashing (Construction)	EMERGENCY	$ 1,700,000.00
3	Louvers (Construction)	MEDIUM	$ 44,200.00
4	**EASTERN SECTION:** Repair pinnacles	HIGH	$ 361,250.00
5	Repair steeple masonry	HIGH	$ 425,000.00
6	**EASTERN SECTION:** Repair buttresses	HIGH	$ 127,500.00
7	**EASTERN SECTION:** Repairs to wood exterior doors	HIGH	$ 5,950.00
8	**EASTERN SECTION:** Sandstone doorways (Construction)	MEDIUM	$ 10,200.00
10	Repairs to choir vestry stairs	HIGH	$ 46,750.00
12	**EASTERN SECTION:** General masonry (Construction)	MEDIUM	$ 1,020,000.00
13	**EASTERN SECTION:** Repair of framing and tracery	MEDIUM	$ 102,000.00

15	**EASTERN SECTION:** Allowance for necessary repairs to stained glass and antique glass	TBD	$ 100,000.00
16	**EASTERN SECTION:** Improve venting of external protective glazing	MEDIUM	$ 10,625.00
		TOTAL YEAR 2	**$ 3,953,475.00**
		POTENTIAL REDUCTION BECAUSE OF SEQUENCING OF WORK YEAR 2	**$ 700,000.00**
		TOTAL WITH POTENTIAL SAVINGS APPLIED YEAR 2	**$ 3,253,475.00**

Table 8: Year 3 Major Repairs Projects and Order of Magnitude Costs – Repairs on Western Portion of Cathedral

	RECOMMENDATION	URGENCY	COST
1	**WESTERN SECTION:** Roofing and Flashing	EMERGENCY	$ 1,700,000.00
4	**WESTERN SECTION:** Repair pinnacles	HIGH	$ 361,250.00
6	**WESTERN SECTION:** Repair buttresses	HIGH	$ 127,500.00
7	**WESTERN SECTION:** Repairs to wood exterior doors	HIGH	$ 53,550.00
8	**WESTERN SECTION:** Sandstone doorways	MEDIUM	$ 57,800.00
12	**WESTERN SECTION:** General masonry	MEDIUM	$ 1,530,000.00
13	**WESTERN SECTION:** Repair of framing and tracery	MEDIUM	$ 408,000.00
15	**WESTERN SECTION:** Allowance for necessary repairs to stained glass and antique glass	TBD	$ 150,000.00
16	**WESTERN SECTION:** Improve venting of external protective glazing	MEDIUM	$ 10,625.00
		TOTAL YEAR 3	**$ 4,398,725.00**
		POTENTIAL REDUCTION BECAUSE OF SEQUENCING OF WORK YEAR 3	**$ 700,000.00**
		TOTAL WITH POTENTIAL SAVINGS APPLIED YEAR 3	**$ 3,698,725.00**

Undertaking the major project items will address deterioration and extend the building's life for future generations.

Part 3: Required Maintenance Work

This section is part of the Christ Church Cathedral Building Conditions and Issues Report - Project 21272 Revision 0

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HERITAGE STANDING INC.
Engineering for Old Buildings

ENGLOBE

RSEI Consultants Ltd.

6.0 REQUIRED MAINTENANCE WORK

Required maintenance work impacts the regular use of the building and would be undertaken through Maintenance budgets. Items identified relate to deferred maintenance, to end of service life issues, and to opportunities to improve Cathedral systems. Most recommendations relate to mechanical and electrical systems.

6.1 SACRISTY - INTERIOR

Vertical cracking is visible in both the interior (Figure 64) and exterior north wall of the sacristy. This could indicate differential settlement in the northeast corner, as discussed in Section 5.4.3 Buttresses. There appeared to be no significant changes in the cracking between the time of the 2015 Condition Assessment and the 2021 Update. As recommended in the 2015 Christ Church Cathedral Condition Assessment, the exterior cracks should be repointed and both interior and exterior cracks monitored. General exterior masonry repairs will address repairs to masonry.

Figure 64: Crack on interior sacristy wall

6.1.1 CONSEQUENCES OF INACTION

Repairing the interior and interior cracking is good general maintenance. If the cracking is stable and no longer moving, as suspected, the largest consequence for the interior wall would be aesthetic.

The exterior cracking is a source of moisture ingress that will continue to cause deterioration if not repaired and made water-tight. While not urgent, it can increase damage to the masonry, both stones and mortar, in this location.

The potential consequence of not monitoring the wall over time is that if settlement continues and is not identified, repairs will become more expensive.

6.1.2 HERITAGE VALUE

Repairs to the exterior crack will keep the exterior cladding in good repair. Since the stone exterior is a Character Defining Element, it is important to maintaining the heritage value of the Cathedral.

6.1.3 ORDER OF MAGNITUDE COST

Only the cost for the repair of the interior crack was considered here. The exterior crack should be repaired when the general exterior maintenance repairs are completed. The interior crack repair cost was seen as sufficiently low enough to fall under regular maintenance budget.

RECOMMENDATION 11

Repair of the sacristy wall interior crack. Users to monitoring the area for future cracking or other evidence of movement.

PRIORITY	LOW
ORDER OF MAGNITUDE COST	$ 500.00

6.2 MECHANICAL

The Mechanical section was prepared by Englobe and is presented here as provided in their "Draft - Christ Church Cathedral Fredericton, New Brunswick Mechanical & Electrical: Conditions and Issues Report" submitted to HSI on 2022-01-13 and with further input through consultation.

The mechanical assessment identified items that would provide benefit to operations. Some of these improvements would reduce day to day costs providing long term benefit. While manufacturers will outline potential savings from new systems this often lacks the rigour necessary for unique buildings. Therefore, determining the order of magnitude saving potential of new systems was not possible without further study.

It was noted that there may be times when water infiltrates the basement during the spring freshet or during other periods of heaving rain. For mechanical systems, such as work on the existing boiler, piping, or improvements to the controls, this should be considered during the design process. The response to this concern may be to provide mitigation measures such as the ability to pump out water if needed.

6.2.1 APPROACH

For the mechanical and electrical building systems, the focus of attention has been placed on the heating, ventilation, power entrance/distribution, lighting, and sound systems with the objective of assessing the existing systems and developing recommendations aimed at energy efficiency, sustainability, occupant comfort, expandability, and safety regarding the Cathedral objective of growing into a music/performance centric venue. A review of available information coupled with site visits were performed to gain familiarity with the systems, assess their condition and function, and make inquiries regarding the operations of the systems.

It is important to note that the purpose of the assessment portion of this report is not to make determination of "Pass" or "Fail". This report focuses on a visual opinion of condition and function and not current code. While industry life cycle values were used in assessing the replacement of systems and components, some equipment may last longer with regular monitoring and maintenance. For instances where rehabilitation has been recommended, as an added measure of thoroughness it is recommended to engage qualified factory technician(s) to conduct a detailed inspection of the equipment to determine suitability of deferment to a following year.

Note that this report is a snapshot in time. Components may include any combination of mechanical, structural, electrical, plumbing, or other essential systems of the facility. The assessment is based on observation of the visible and apparent condition of the facility and its components and not the prediction of future conditions.

6.2.2 HEATING

The Cathedral requested that the potential of using a geothermal heating system be investigated as an option to consuming natural gas as a heating fuel. Downtown Fredericton, including the area around the Cathedral is within the Wellfield Protected Area and falls within the Designation Order. The use of a ground source heat pump system is not permitted within the area and therefore was not pursued further for assessment or recommendation.

6.2.2.1 BOILER/BURNER

The heating system of the Christ Church Cathedral is a four (4) zoned hydronic (hot water) system utilizing a natural gas fired boiler using municipal water as the working fluid. No connected domestic hot water tank was observed during site visits, so it is concluded that the boiler is used for heating of the occupant spaces only. This was confirmed by the Sexton and a member of the congregation familiar with the operation of the boiler who reported that the system is started up each autumn and shut down each spring – the heating season. At the time of the site visit, the system was not operating, so operating pressures, temperatures, and flows could not be observed.

The boiler Is a Viessmann Vitorond 200 Sectional Cast Iron Hot Water Heating Boiler–- manufactured in 2007 and installed at the Cathedral in 2008 with a Riello burner. The boiler manufacturers labels show the capacity of the boiler as 794,000 Btuh. With the Cathedral having approximately 10,800 sqft. of occupant space the Btuh/sqft is approximately 70 Btuh/sqft. This value is on the high side of heating capacity (generally 30 to 40 Btuh/sqft) when compared with most other buildings, but, given the age, size, volume, and type of construction of the Cathedral, the 70 Btuh/sqft is seen as appropriate for the facility.

The condition of the boiler and burner can be described as average – meaning minor repairs are visibly recommended. However, all major parts still function and the effective age of approximately 15 years is similar to other boiler/burner systems of the same type and age. Initial observation of the boiler, however, shows evidence of water leakage on the top of its housing causing rust and staining (Figure 65). The water leaking is being mitigated by the placement of a bucket on top of the boiler housing. This is a concern because the boiler housing may be subject to corrosion damage and potential premature failure necessitating a major repair.

The burner blower and internal electronics were observed to be exposed. The protective shroud for the burner assembly which protects the equipment from moisture and mechanical damage is not in place. This is a concern because the exposed burner may be subject to water damage from the boiler piping, corrosion damage, mechanical damage from inadvertent impacts caused by activity in the area, and potential failure necessitating a major repair.



Figure 65: Boiler and burner (left), top of boiler housing showing rust (centre), exposed burner (right)

6.2.2.2 Zoning

The four (4) heating zones of the Cathedral are identified by hand writing as: Zone 1 – Northwest Half of Nave, Zone 2 – Southeast Half of Nave, Zone 3 – BSMT Office Chapel Hall-Way, Zone 4 - Sanctuary. The zone distribution consists of a supply header, 'Flo-Trol' zone valves, perimeter cabinet convectors, zone circulation pumps and a return header, all piped in black iron pipe, fittings, and valves. A schematic of the heating system is shown in (Figure 66).

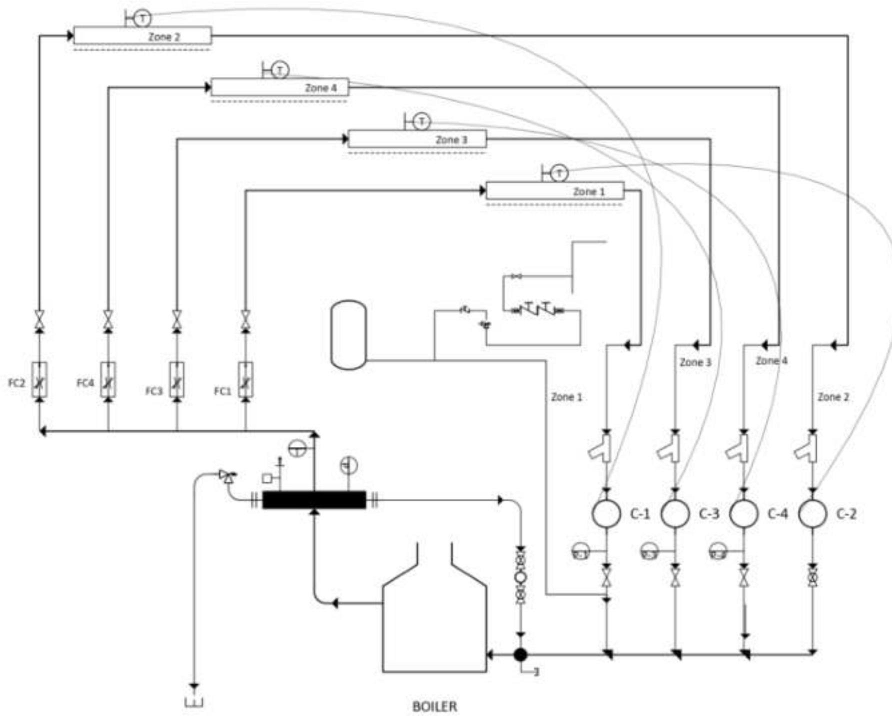

Figure 66: Schematic of heating system

The condition of the heating zone distribution piping and components can be described as fair – meaning repairs are visibly recommended however all major parts are still functioning, and the effective age is similar to other hydronic distribution systems of the same type and age.

Observation of the piping reveals corrosion at exposed pipe joints. The corrosion was likely caused by pipe joint leaks which have been repaired however much of the pipe insulation has been removed either to repair or modify the piping system, or the insulation was otherwise damaged, removed, and not replaced. This is a concern in terms of safety and energy efficiency. The safety concern is the possibility of personnel or others coming into contact with bare pipe while the boiler system is running. The energy efficiency concern is the loss of heat energy through the bare pipe into the basement space rather than being delivered to the heating zones.

The 'Flo-Trol' zone control valves (Figure 67) are located at the supply header and used for preventing heating or overheating of zones due to gravity flow in hydronic heating systems and will permit summer-winter operations. These valves appear functional and there is no concern regarding the present system configuration.

The perimeter cabinet convectors were not able to be accessed, but from observation they appear to be a combination of 1-row and 2-row heating element units. These types of heating appliances are standard for hydronic systems, they are reported as functioning with no blanked off sections, and there is no concern regarding the present system configuration.

The zone circulating pumps are 1 ½ horsepower, 1½ inch vertical in-line pumps (Figure 68, Figure 69, and Figure 71). These types of heating appliances are standard for hydronic systems, they are reported as functioning. There is a minor concern regarding age of these pumps. The casings show corrosion and discolouration which indicates moisture, possible leaking, and potential operation outside their temperature range in the past (Figure 70). This observed damage will eventually lead to failure necessitating repairs and/or replacement, however, as the pumps are reported to be functioning, the concern is only minor.

Figure 67: Supply header, Flo-Trol valves

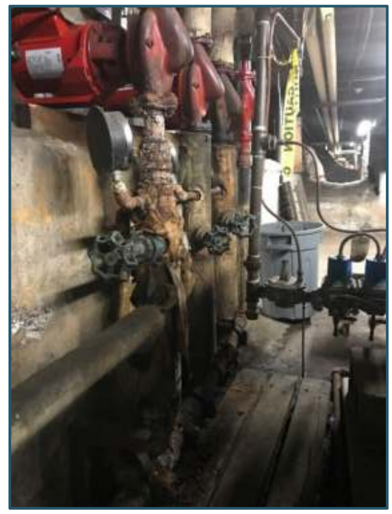

Figure 68: Return header, circulating pump

Figure 69: Circulating pumps, zone identification

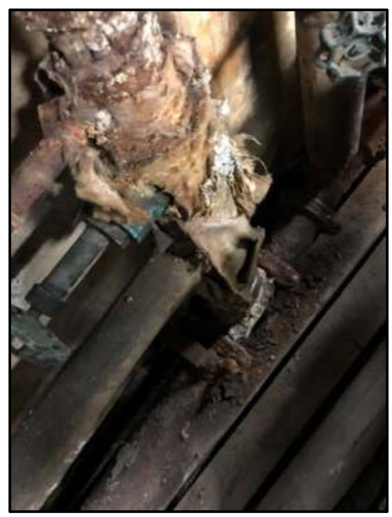

Figure 70: Insulation damage

Figure 71: circulating pumps 1 (left) and 4 (right)

6.2.3 Controls

The four (4) heating zones of the Cathedral are controlled by four (4) manual mechanical thermostats connected to a circulating pump each. The locations of the thermostats are shown in Figure 72. When the bi-metal spring contracts in a thermostat, an electrical connection is made, and the corresponding circulating zone pump starts to deliver hot water to the convectors. When the demand is met, the spring has expanded, and an electrical disconnect occurs, shutting off the corresponding zone pump. This is a common set up in older buildings and has worked reliably for decades. The concern here is energy usage and efficiency through a lack of controlled management and monitoring. With only independent manual control, the Cathedral's heating energy is not monitored or controlled to the building's needs. A building energy management system is a serious consideration to improve efficiency. A building energy management system (BEMS) is a control system and method to monitor and control a building's energy needs. Examples of functions are heating, ventilation, and air conditioning (HVAC), lighting or security measures.

Figure 72: Thermostats shown (left to right) in the Vestry, east Nave, the Chapel, and the west Nave

6.2.4 VENTILATION

The basic constructional and architectural features that characterize most heritage churches are wide, uninsulated walls with large heat capacity, lots of high, single glazed windows with high heat transfer, high rooms with large volume compared to a very small zone occupied by people, and the feature of their function.

Christ Church Cathedral relies on natural ventilation by way of six (6) operable windows in the clerestory walls of the Nave, shown in Figure 73, and the natural infiltration, exfiltration, and breathability of the building envelope. There is a hatch leading upwards into the steeple that would have been used for summer ventilation, creating a chimney effect, however it is unknown if this is still used. The Cathedral has no mechanical ventilation, humidification, or dehumidification systems and, from observation (alone), the building likely does not require complex systems. There are three (3) small destratification fans in upper reaches of the Nave and Chancel, however these were observed to be small commercial fans and ineffective in achieving the goal of air movement within the spaces. There are also four (4) basement vent openings in the foundation (Figure 74) to provide ventilation to and from the basement. From observation these openings may be blanked off to some extent with pressure treated plywood.

Figure 73: Operable window in clerestory wall

Figure 74: Basement vent opening

The main ventilation concern is the lack of air movement in the Cathedral. In concert with the operable windows for ventilation, larger low velocity fans to provide air circulation throughout the Cathedral would prevent air stratifications from floor to ceiling, improving the temperature, humidity, and air quality. For the basement, the openings could be modified to provide and control ventilation to the basement space.

6.2.5 OPERATIONS AND MAINTENANCE

The maintenance and operation of the building mechanical systems is reported to be by the Sexton, by a volunteer, and by contacting local service providers when the maintenance task requires a qualified tradesperson or technician. It was reported that only one person has the knowledge to start and shutdown the boiler, and unfortunately there does not seem to be a central location for Operations & Maintenance Manuals, operating instructions, or maintenance records.

It was also observed that the basement has become a cluttered space with debris, parts, appliances, trash, wood, pipe, hose, and general items stored in basement haphazardly.

There are a number of concerns in this regard. The basement is a low ceilinged, cramped, and constrained space housing the building's heating system, fire protection equipment, electric equipment, and communications gear. There is a safety concern related to trips and falls hazards due to the amount items in the basement blocking pathways of ingress and egress. Further, the building systems equipment crowding is exacerbated by the storage and debris (Figure 75 right and Figure 76). Another observance is of boiler documents left on the foundation next to the boiler (Figure 75 left). The concern is an absence of a central location and completeness of Operations & Maintenance Manuals and materials. A last maintenance concern is the potential that only one person has systems operation experience, history, and knowledge. If that one person becomes unavailable in the event that they are needed, the Cathedral would be in the poor position of having few operational options.

Figure 75: Boiler Documents (left) and debris (right)


Figure 76: Debris

6.2.6 MECHANICAL SYSTEMS RECOMMENDATIONS

For the mechanical building systems, the focus of attention has been placed on the heating, control, and ventilation systems with the objective of assessing the existing systems and developing recommendations aimed at energy efficiency, sustainability, occupant comfort, expandability, and safety.

The following recommendations are made to the Cathedral with the intent of providing guidance on continued safe operation of the building. These recommendations are made based on our professional opinions regarding safety, codes, equipment life expectancies, good installation practices, capital expenditure, energy efficiency advancements and building operation and maintenance practices.

6.2.6.1 OPERATIONS & MAINTENANCE MATERIALS

It is a good habit and practice to keep the areas the building clear and free of unnecessary material, debris, and clutter. It is recommended that the basement space be purged of the collected debris, parts, appliances, trash, wood, pipe, hose, and any unnecessary items.

A good maintenance practice is also to collect, organize, and store operations, maintenance, and training materials for building systems. Given the concerns expressed regarding safety, equipment crowding, the absence of a central location for Operations and Maintenance Manuals and materials, it is recommended that these materials be sourced, organized, and stored in a central and accessible location.

It is also recommended that two or three persons receive training on the operation of the boiler and fire protection system. System training is generally available through service providers or by manufacturers factory trained personnel.

RECOMMENDATION 17

Purge the basement of debris and clutter

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 750.00

RECOMMENDATION 18

Collect and source mechanical system documents and provide ongoing systems training for two or three people

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 1,925.00

6.2.6.2 BOILER/BURNER

The condition of the boiler and burner can be described as average and minor repairs are recommended. It is recommended to repair the piping leaks with a view to preparing to reconfigure the supply and return headers and zone piping to utilize a higher efficiency hydraulically separated header. It is also recommended to remove the rust and staining on the top of the boiler housing to avoid potential premature failure necessitating a major repair.

The protective shroud for the burner assembly which protects the equipment from moisture and mechanical damage is not in place. It is recommended that this shroud be put in place to avoid water damage, corrosion damage, and mechanical damage from inadvertent impacts.

RECOMMENDATION 19

Repairs to the boiler and burner: repair leaking piping, remove rust and staining on boiler housing, and install burner shroud

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 4,500.00

6.2.6.3 HEATING ZONES

The condition of the heating zone distribution piping and components can be described as fair, and repairs are recommended. It is recommended that the zone distribution piping be replaced and reconfigured with the purpose of using a higher efficiency hydraulically separated header at the boiler. This addresses the corrosion at joints and insulating the distribution piping especially in the basement. This will address the safety and energy efficiency concerns.

The 'Flo-Trol' zone control valves are recommended to be replaced with motorized zone control valves and adding water balancing valves to the zone loops to control and adjust the water flow being delivered to the cabinet convectors based on individual zone heating demand. This recommendation would be in conjunction with replacing the zone distribution piping and headers and partially addresses the goal of energy efficiency.

The zone circulating pumps are also recommended to be replaced at the time the zone distribution piping and zone control valves are being replaced with higher efficiency sensorless pumps. These types of pumps are variable flow and, when matched with the system served, address energy efficiency through pumping only required flow.

RECOMMENDATION 20

The heating zone repairs should be addressed at the same time: replace the zone distribution piping with the purpose of using a higher efficiency hydraulically separated header at the boiler, replace existing zone control valves with motorized control valves and add water balancing valves to the zone loops, and replace the zone distribution piping and zone control valves with higher efficiency sensorless pumps.

PRIORITY	HIGH
ORDER OF MAGNITUDE COST	$ 75,000.00

6.2.6.4 INTEGRATED BUILDING ENERGY MANAGEMENT SYSTEM - BEMS

The Cathedral heating is controlled by manual mechanical thermostats connected to a circulating pump each. Although this is a common set up in older buildings and has worked reliably for decades, the concern here is energy usage and efficiency through a lack of controlled management and monitoring. With only independent manual zone control, the Cathedral's heating energy is not controlled, managed, or monitored to the needs of the building.

It is recommended a BEMS be designed to match the heating system renovations described above and installed. A BEMS is a control system and method to control, monitor and manage a building's energy needs. Examples of functions foreseen are heating, ventilation, potentially lighting, and security measures.

A Building Energy Management System is designed for control and can have a variety of characteristics. All buildings require and have some form of control system. The main point in which a Building Energy Management System differs from other control systems is the characteristic of communication: information of the processes and functions of the building can be received and controlled at a central, single operating unit. Therefore, building decisions can be made based upon the received information through sensors. This allows for optimization of the system. For example, the central and single operating unit can receive information on temperature and building occupancy and can make the decision to lower the temperature in parts of the building that are not occupied. This improves energy use and efficiency.

RECOMMENDATION 21

Design and install a Building Energy Management System (BEMS)

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 90,000.00

6.2.6.5 VENTILATION

Christ Church Cathedral relies on natural ventilation through operable windows in the clerestory walls of the Nave, and the natural infiltration, exfiltration, and breathability of the building envelope. As mentioned, the Cathedral has no mechanical ventilation, humidification, or dehumidification systems and likely does not require complex systems.

It is recommended that the existing destratification fans in upper reaches of the Nave and Chancel be replaced with larger, low velocity destratification fans designed especially for the spaces being served. It is also recommended that the existing operable windows be put into operation to provide outdoor air to the space. This could be achieved through re-working the operating mechanism and adding an automated actuator connected to the BEMS to control ventilation air into the building.

The basement vent openings in the foundation are recommended to be repaired and fitted with motorized dampers to provide controlled ventilation for the basement.

These recommendations would prevent air stratifications from floor to ceiling improving the air circulation, temperature, humidity, and air quality.

RECOMMENDATION 22

Replace existing ceiling fans with large, low velocity fans; put the existing operable windows into operations, possibly through the use of an automated actuator connected to the BEMS to bring fresh air into the building; and replace existing basement vent openings with motorized dampers	
PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 90,000.00

6.2.6.6 SOLAR

The Cathedral requested that the potential of using a Photovoltaic (PV) panel system be investigated as an option to generate electricity rather than consume electricity solely from the utility grid. The south facing roof would be a good candidate for panel exposure for most of the year, however, the roof structure would require assessment to determine if the loads could be carried safely. There is also the question of housing inverters in a room with regulated one (1) metre clearance for servicing and manufacturers clearance for installation. The space for inverters would have to be found in the basement or on the grounds in a separate building, or roof mounted inverters would be required. In any event, roof mounted equipment or equipment stored in a separate building should be evaluated for heritage value impacts and the impact on heritage designation.

6.3 ELECTRICAL

The Electrical section was prepared by Englobe, using RSEI Consultants Ltd. as sub consultants to them for the electrical portion, and is presented here as provided in their "Draft - Christ Church Cathedral Fredericton, New Brunswick Mechanical & Electrical: Conditions and Issues Report" submitted to HSI on 2022-01-13 and with further input through consultation.

As the Cathedral has unique values, both in its mission and in the heritage context of the space, it is important that careful design ensures those values are met. Meeting the minimum requirements or application of previsions without considerations could lead to long term frustrations. In terms of building requirements for electrical and fire safety the following findings are based upon a preliminary assessment where systems were compared to what a typical comparable new building would require. This will facilitate discussion regarding specific needs and where alternative design or evaluation may provide benefit.

For this initial electrical review, this unique building was compared to fire and life safety requirements that would be necessary for a current building for public occupancy of similar size. Further study would be necessary if alternatives were desired.

The electrical assessment identified a number of areas where operational improvements would be possible. Some of these, such as changes to more efficient lights, would provide energy savings. Industry publications estimate LED lights to be able to provide similar performance using 75% less energy and last longer. The rigour required for the electrical assessment to determine potential savings for the proposed changes was not possible.

6.3.1 DISTRIBUTION

The electrical service to Christ Church Cathedral is a 400A, 120/240V, 1PH, 3W service, which is fed from the overhead secondary line across Brunswick Street to a lighting pole on the Cathedral side of the street (Figure 77). At the lighting pole, the secondary line enters conduit and is routed underground into the basement electrical room. Once in the electrical room, the service goes through a 400A disconnect switch followed by a metering cabinet. After the metering cabinet, the service arrives at a splitter which acts as the distribution hub. Fed from the splitter is a 200A disconnect with 200A fuses which feeds the lighting panel located behind the curtain in the Lady Chapel. Exterior building flood lights are the next feed off the splitter and go through a small disconnect switch. Another feed taken from the splitter is a 200A disconnect switch feeding the boiler panel. The boiler panel has single phase surge protection which appears to be connected and working (Figure 79). This provides much needed protection to the building's electrical distribution system. As can observed in Figure 81, there are additional feeds coming from the distribution splitter; however, due to the disorderly (idiosyncratic/irregular) arrangement and questionable (uncertain/vague) labelling practices, it is difficult to determine what is connected. The various pieces of electrical equipment in the building appears to have been installed at different times and has had upgrades and/or been repaired on an as needed basis. As a result, a large portion of the electrical work is disordered, vague, unorganized, and difficult to trace. For example, an existing fire alarm panel which appears to no longer be connected is still installed on the wall with various cables entering its enclosure.

The current location of electrical service equipment does not meet code requirements for ceiling height. This means that if any of that gear were to be upgraded or replaced it would have to be moved to another location within the Cathedral unless the provincial electrical inspector decides to provide a deviance (variance) based on the historical significance of the Cathedral.

There is a large (hydronic) heater located directly below the electrical service entrance and distribution gear which can lead to overheating and premature electrical equipment failure.

Figure 77: Incoming service overhead to underground

Figure 78: 400A main switch

Figure 79: Surge protection device

Figure 80: Detached fire alarm panel

Figure 81: Electrical service / distribution equipment

6.3.2 Wiring Devices and Surface Conduits

For the most part throughout the Cathedral, the number of available receptacles and their placement is not sufficient. The number of devices plugged into various power bars from single receptacles is an unsafe condition in terms of fire hazard and potential current code violation depending on the electrical loads. In the Clergy Vestry and Sacristy room, the receptacle behind the sink is not GFI (Figure 82). This is a code violation if the circuit is not protected by a GFI breaker. Floor boxes throughout the Nave are neatly and properly secured to the floor (Figure 83); however, the receptacle box by the computer station is a code violation as it is not in a floor box and the armored cable is not protected which could lead to accidental mechanical damage to the feed. Many of the light switches and receptacles are nearing the end of their safe and useful life expectancy (for example Figure 85), which is approximately 30 years.

Surface conduit throughout the building was well secured and painted to match the surfaces that it was secured on. If a retrofit of the electrical system were to be done, device boxes should be checked for a ground wire. Pending a ground wire investigation, if a ground wire is present, most of the wiring and conduit would be reusable. If no ground wire is run inside the conduits between the box and panel, then this would be a code violation and new wiring would need to be run for those devices being upgraded.

During the exterior building walk-around, it was observed that on each side there were copper conductors (likely to be ground wires), shown in Figure 89, that had been cut near the base of the building up to about 2 meters. These grounding wires appear to be connected to the Cathedral's lightning protection air terminals, Figure 90. This condition leaves the building at a severe risk to fire, or serious damage associated with a lightning strike. An exterior receptacle near the side door has begun to pull off the building, as shown in Figure 86, which will eventually lead to exposed wires and a safety hazard.

Figure 82: Non-GFI receptacle

Figure 83: Floor box receptacle

Figure 84: Old surface mounted light switch

Figure 85: Switch / receptable in basement

Figure 86: Damaged exterior receptacle box

Figure 87: Sound system receptables

Figure 88: Boiler system control

Figure 89: Damaged lightning protection cable

Figure 90: Lightning protection air terminal

6.3.3 IDENTIFICATION & LABELLING

Disconnect switches and panels are labeled but it is unknown how accurate the labelling is due to the distribution system being very difficult to trace. It appears that older, no longer in service infrastructure has not been removed when disconnected.

The light switch bank behind the curtain is very neatly labeled along with the lighting control diagram (Figure 91). The lighting panel does not have a written panel schedule. The audio jacks and cables around the Cathedral appear to be carefully labeled but again the accuracy of this labelling is not certain.

Conduits throughout the building are absent labelling and colour coding to indicate what type of wiring is carried within, which is a common good practice.

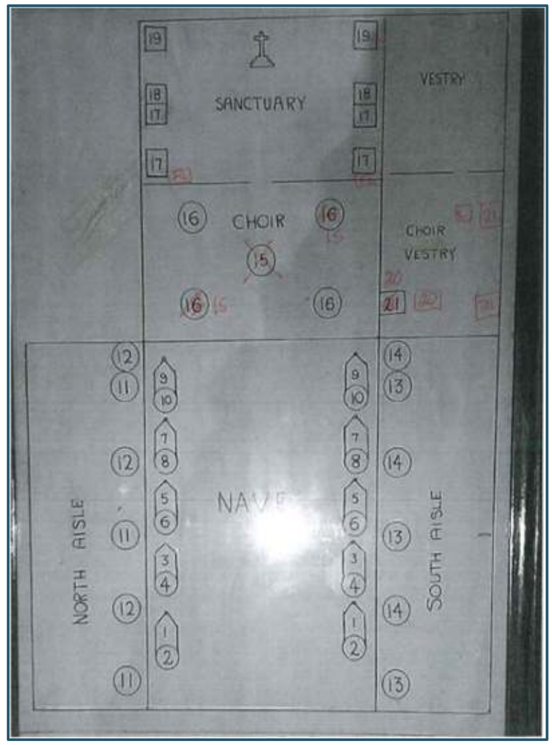

Figure 91: Light switch bank (left) and Nave and aisle lighting control diagram (right)

6.3.4 LIGHTING AND LIGHTING CONTROLS

Light fixtures within the Cathedral are T12 fluorescent (for example Figure 92) or incandescent (for example Figure 93), which are both inefficient sources of light compared to LED lighting. A few LED fixtures have been added along the north and south aisles and it was indicated by the Sexton that the pendant lights down the Nave have been converted, or partially converted, to LED bulbs, but this must be verified. The lighting for the main open areas in the Cathedral is controlled from behind the curtain in the Lady Chapel, where a bank of light switches is located next to the lighting panel (Figure 91). A lighting control layout drawing is conveniently located on the wall. The corresponding light switches are also labeled to help so that anyone can operate the lights correctly and conveniently. It was noted that there are a few lights that have been added and a couple of controls that have changed and have not been updated on the lighting control diagram. The remaining spaces in the Cathedral have local controls to the room in which the lights are located. In addition to this, there are a few task lights (Figure 94) which have local switches close to the task. Most of the local light switches found throughout the Cathedral are nearing their end of life.

Figure 92: Choir Vestry T12 fixtures

Figure 93: Tower stairwell light

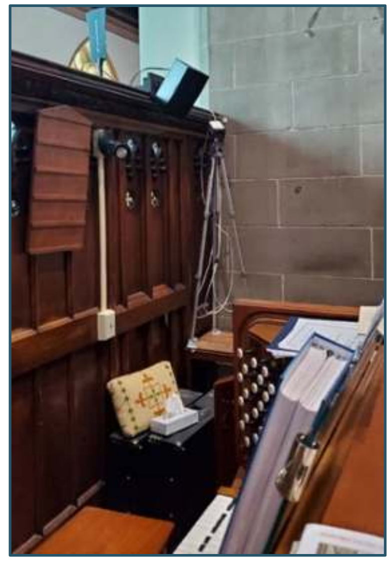

Figure 94: Organist's task light and switch

The overall light level throughout the Cathedral is low but likely does meet the minimum light level of 10 lux required by the National Building Code for safe movement throughout the facility. However, this does not address functional lighting for this space. The Illuminating Engineering Society (IES) is the leading authority on lighting. Lighting designs are based on the function of the space, tasks to be performed in the space and the demographic of the occupants. The lighting in the front areas where performances and sermons take place is considerably underlit compared to the IES recommended illumination levels of between 1000 – 2000 lux for focal areas where the visual observers are above the age of 65. The current light level in the Choir area is approximately 100-200 lux and even lower back towards the Chancel and Altar areas. Seating areas within the Cathedral were also considered underlit, with an illumination level varying between 40-100 lux. Illumination levels in these areas are recommended to be between 300-600 lux to permit reading for observers with an age greater than 65.

The Cathedral does have some emergency lights, shown in Figure 95, but likely not enough to meet the minimum light levels for egress during an emergency. Also, there are no exit lights installed anywhere in the Cathedral. Consideration in design will need to ensure lighting does not interfere with special services. For exterior lights on the building there are some wall sconce fixtures by the doors and there are a few high-pressure sodium flood lights on the roof (Figure 96, left).


Figure 95: Emergency light with battery unit (left) and remote head emergency light (right)

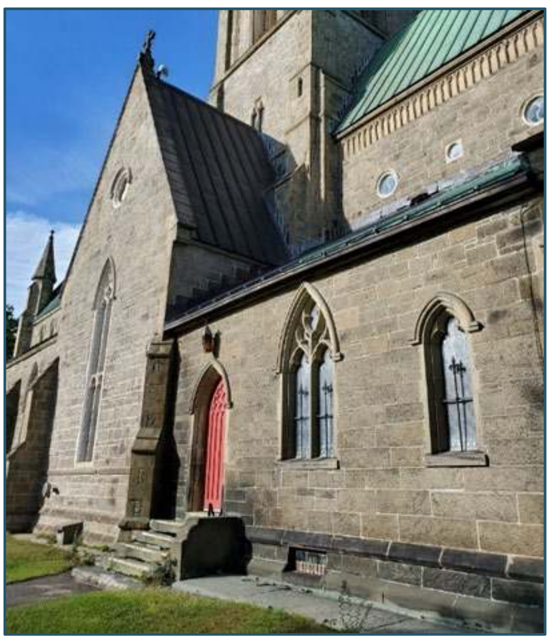


Figure 96: Exterior lighting at Choir door (left) and main front door lighting (right)

The exterior flood lights shining on the Cathedral are observed to have exposed electrical connections as shown in Figure 97. The feeder wires are connected using wire nuts outside of a junction box and just covered with electrical tape. This is a code violation and a very dangerous condition to have with the high probability of potential passersby walking through this area (Figure 98). The control of the exterior lights is done through a contactor and a time clock which is shown below in Figure 99. This infrastructure is located behind access panels in the basement that are not clearly identified.

Figure 97: Exterior flood light taped connection

Figure 98: Exterior light exposed connection

Figure 99: Exterior lighting controls

6.3.5 FIRE ALARM SYSTEM

Christ Church Cathedral is primarily protected by a sprinkler system with a few smoke detectors throughout the building (Figure 100). The primary issue observed in the Cathedral regarding the fire alarm system is that only two exits have pull stations present and one of those pull stations is taped over, shown in Figure 101 and Figure 102. All building exits and exits from floor levels must be equipped with a fire alarm pull station. An audible alert for a fire alarm is generated by bells, which is a good device for the space; however, only two bells are in the main space, and they are both in the Lady Chapel which likely will not produce the required 65dBA at the rear of the Nave (Figure 103). Audibility is required throughout all occupied spaces of the building which is not possible with the existing system configuration.


Figure 100: Basement smoke detector (left) and tower smoke detector (right)

Figure 101: Taped pull station

Figure 102: Missing pull station

Figure 103: Fire alarm bell

It was also observed that no visual signaling devices are installed. This is a concern as the Cathedral is used by the public, and anyone with a hearing impairment may not be alerted of a fire. This is not a code violation; however, it is good practice to incorporate visual signaling devices into the fire alarm system.

The fire alarm control panel (Figure 104) is in the electrical room and is the only annunciator in the building. Not having an annunciator at one of the main entrances is a code violation that should be addressed. The system is a Potter PFC Series and appears to be working correctly as it was inspected January 20th, 2021, by National Alarm Systems Fredericton LTD. The circuit breaker feeding the fire alarm panel is missing a locking device to prevent it from being accidentally turned off, shown in Figure 105.

Figure 104: Fire alarm panel

Figure 105: Fire alarm panel with no lock device

6.3.6 SECURITY SYSTEMS

Christ Church Cathedral has a few security cameras placed at key locations throughout the building interior (Figure 106). The Cathedral is currently planning the upgrade of this system to address some known deficiencies. In the basement, there is a rack for all the security system cabling (Figure 107).

The doors to the Choir Vestry and the Clergy Vestry are both fitted with local integrated keypad door locks (Figure 109 and Figure 110).

The DSC panel is fitted with an auto dialer that is tied into the fire alarm panel in case of alarm (Figure 111).

Figure 106: South side entrance security camera

Figure 107: Security system rack

Figure 108: Intrusion/security system equipment

Figure 109: Rear door lock

Figure 110: Rear door interior lock

Figure 111: DSC security panel

6.3.7 Sound System

The sound system is controlled from a central sound booth (Figure 112 and Figure 113). From the booth, the user can remotely control the main system amplifier located in the Organ room (Figure 114). There are speakers mounted to the ceiling near the top of the walls on both sides of the aisles (Figure 115). On each side there are three speakers mounted, followed by one on each side of the Choir area and one on each side of the Chancel area.

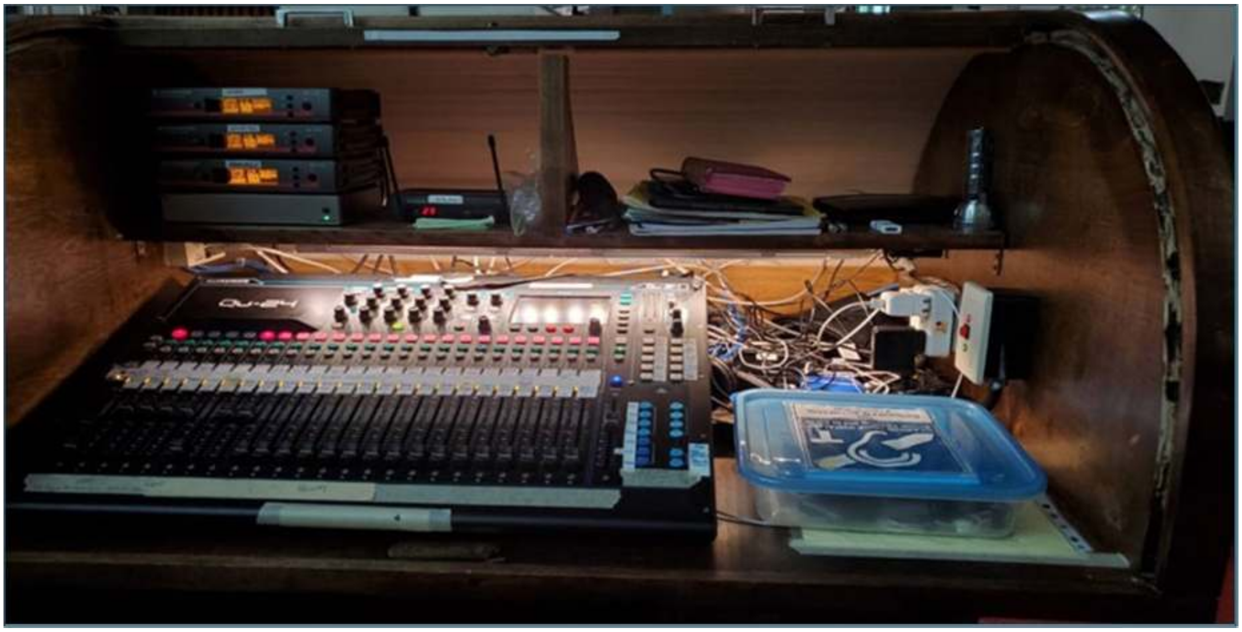

Figure 112: Sound system controls

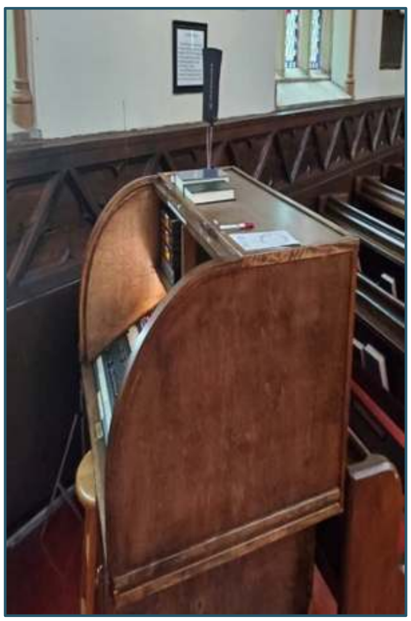

Figure 113: Audio booth

Figure 114: Main amplifier

Figure 115: Ceiling speakers

The sound system is reported to have been designed and built by one of the members of the Cathedral's congregation. As a result, the sound system should be verified by a licensed audio installer/commissioning agent (if not already verified), to assure that the sound system is suitably installed, and no code violations exist.

The sound system is powered through a relay button that turns on the sound booth gear and the main amplifier back in the Organ Room. This relay appears to work correctly and is secured in an accessible location in both the sound booth and the Organ Room. From observation it appears that the equipment located in the sound booth is running off one power bar which, depending on the ratings of the equipment, is likely a code violation and fire hazard.

Another observation is that the audio cables in the basement that are connected to floor boxes throughout the main area (Figure 116) are free hanging. These cables should be supported by j-hooks or run within conduit to prevent inadvertent damage to these cables. Cables should be carefully labeled which most appeared to be (Figure 117 and Figure 118).

Figure 116: Basement audio cables

Figure 117: Audio cable

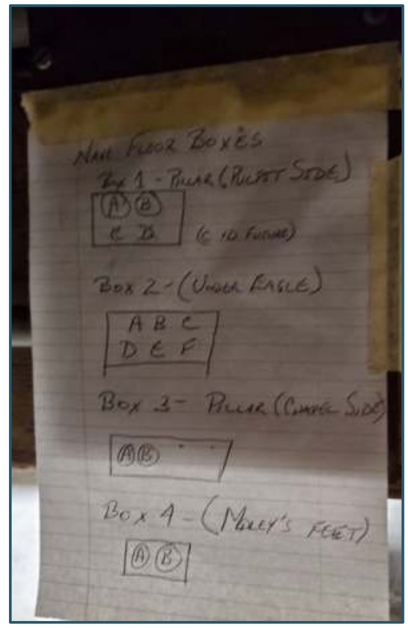

Figure 118: Audio floor box diagram

Most of the equipment within the sound booth appears to be new; however, the speakers and amplifier equipment are viable candidates for upgrades. All equipment should be compatible and properly sized for any upgrades undertaken.

6.3.8 Communication System

The communication service comes into the Cathedral and is terminated in a BIX panel, shown in Figure 119, which is in the basement, in the same room where the electrical equipment is located. Throughout the Cathedral there are a few telephone jacks with phones connected to them (Figure 120) and the computer and sound booth stations are complete with network cables. In the basement where the security panel is located, the communication wiring appears to be labeled but most of the infrastructure is dated and is another viable candidate for upgrade.

The Cathedral has recently installed new cameras for streaming services online (Figure 121). This investment was necessary as COVID-19 made it impossible at times for members of the congregation to gather in the Cathedral for services. This infrastructure appears to be securely mounted in suitable locations.

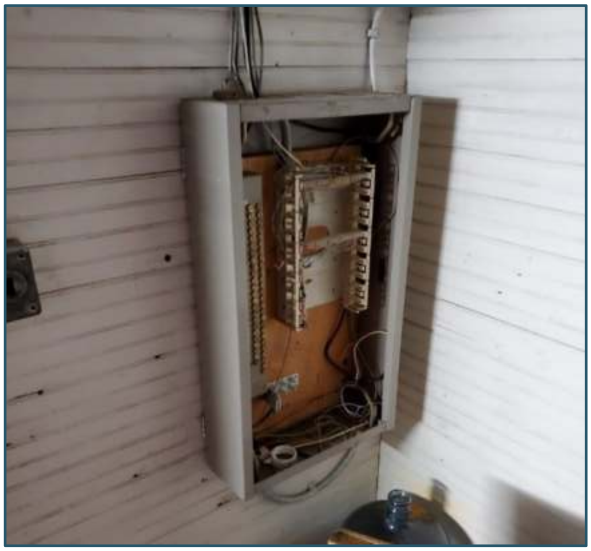

Figure 119: BIX panel

Figure 120: Telephone in choir vestry

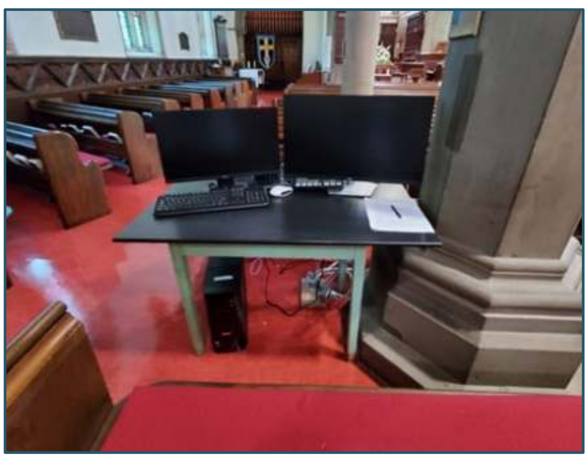

Figure 121: Streaming computer station

Figure 122: Service streaming camera

6.3.9 ELECTRICAL RECOMMENDATIONS

Having introduced the relevant systems within previous paragraphs, the following paragraphs provide recommendations for these systems based on our professional opinions regarding codes, equipment life expectancies, installation good practices, energy efficiency advancements, and building operational efficiency.

6.3.9.1 ELECTRICAL DISTRIBUTION

The expected useful life of service equipment is approximately 30 years. This life expectancy is based on appropriate regular maintenance being carried out. There is no evidence showing that regular maintenance has been carried out, and most equipment is near or over 30 years old. Considering the above, it is our recommendation that the existing service entrance equipment and distribution equipment in the basement be replaced complete with metering, fed from the existing pole with the existing conductors. To perform any upgrades to this electrical infrastructure, a new electrical room will have to be found within the building or a variance will be required from the electrical authority having jurisdiction. This is due to the existing electrical room not having 2.2 meters of head room. After initial talks with the Chief Electrical Inspector of New Brunswick, it appears as though a variance would be achievable to receive as the building is a National Historic Site of Canada. There would be limitations to this variance, such as only being able to do a one for one replacement of the infrastructure. This would still be highly beneficial as it would replace the infrastructure that is due for replacement, and it would allow for equipment not being used to be removed. Removing the heater below new equipment is highly recommended as the heat will reduce the efficiency and life expectancy of the equipment. Having the option to reuse the existing room would allow for a contractor to pull back equipment feeders, correctly label everything and then reinstall everything that is required back into the new distribution equipment. This would substantially save money on labour and materials as rewiring everything in the Cathedral back to new panels in a different location would be a substantial and expensive undertaking. It would also be an undesired undertaking as it appears most of the wiring and conduit are in good condition and are candidates for reusage. Older devices fed through conduit versus BX should be investigated to assure that a ground wire has been installed. In instances where the ground wire is missing, new wiring will be required to be installed.

RECOMMENDATION 23

Replace existing service entrance equipment and distribution equipment in the basement complete with metering, fed from the existing pole with the existing conductors.

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 30,000.00

6.3.9.2 WIRING DEVICES AND SURFACE CONDUIT

All wiring devices incur wear and tear from everyday use and over time can potentially be hazardous to the safety of users. It is recommended that each receptacle be replaced with a tamper proof device as a measure to replace older worn receptacles and mitigate the potential safety risk to users. All surface mounted devices should be installed in a new cast FS type outlet box to prevent anything from entering the box and contacting live wires.

To correct violations of the current Canadian Electrical Code, receptacles within 1.5m of any sink must be protected by a ground fault circuit interrupter (GFI). Additionally, the receptacle box feeding the computer station in the Nave should be replaced with a floor receptacle box, appropriately secured, protecting the feeder from mechanical damage. It is also recommended to add additional receptacles throughout to improve the spacing and power availability in the Cathedral. It is understood that additional receptacles cannot be placed just anywhere due to the architectural features and character of the building, so new receptacles should specifically be added in spaces where power bars are currently being used, because, when inappropriately loaded and used, power bars can be extremely hazardous.

The building's lightning protection system appears to be compromised (by observation) as copper conductors on each side of the building have been severed. This should immediately be repaired as the current condition may not protect the Cathedral from lightning strikes. It is recommended to repair the damaged conductors by thermal weld to a new section of wire of the same gauge running up to the air terminals. To mitigate risk of copper theft, the portion of cabling that is accessible from the ground could be run within conduit. Additionally, having the entire lightning protection system re-examined by a lightning protection designer would be beneficial to assure that the Cathedral is adequately protected from lightning strikes.

RECOMMENDATION 24

Repairs to wiring devices and surface conduit as described

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 20,000.00

RECOMMENDATION 25

Review of existing lightning protection system by lightning protection designer

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 30,000.00

6.3.9.3 IDENTIFICATION AND LABELLING

Since it is recommended that devices and distribution equipment be replaced, it is also recommended that devices, outlet boxes and equipment be identified and labeled with a lamicoid nameplate or foam backed plastic label indicating the panel and circuit that the device is connected to. This will greatly aid in ongoing building maintenance. All conduits are recommended to be identified and labeled with tape or paint on either side of every wall penetration so that it is clear what systems and/or service are contained within. Lastly the lighting control diagram behind the curtain in the Lady Chapel is recommended to be updated to reflect the current configuration of lighting fixtures and controls.

RECOMMENDATION 26

Improve electrical identification and labelling

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 5,000.00

6.3.9.4 LIGHTING

Lighting loads make up 30 - 40% of a typical building's energy consumption and, through suitable installation/use of lighting controls, consumption due to lighting can be reduced by up to 75%. The Cathedral currently is predominantly using incandescent and T12 fluorescent lighting fixtures. Upgrades present a good opportunity for energy savings as well as improved quality of light.

Within the basement, Choir and Clergy Vestry rooms, it is recommended to replace the existing T12 fluorescent strip lights with ceiling mounted LED fixtures. Light switches with integrated occupancy sensors would be an ideal upgrade for washrooms and the Choir and Clergy Vestry rooms to prevent lights from being left on. This could also be done in the hallway leading to the Clergy Vestry and Organ rooms.

For the exterior of the building, the existing lighting presents as high-pressure sodium and is recommended to be replaced with exterior LED lighting. The existing perimeter lighting is orange in colour indicative of high-pressure sodium - this equipment is energy efficient but has little colour rendering. The replacement option would be an LED type of fixture, which would provide a 'whiter' light with improved colour rendering.

The wiring for the exterior lights, regardless of a fixture upgrade, is recommended to be corrected as the current state of them is highly dangerous and a code violation due to the connections being exposed. Exterior lights are recommended to be wired through a new lighting contactor and centralized photocell complete with an astronomical time clock control if lights are not required to be on all night. An astronomical time clock is recommended as an upgrade from the existing time clock because it factors the geographical location and automatically adjusts the trigger times to accurately reflect the local dusk to dawn times.

Exits throughout the facility are recommended to be fitted with LED exit lights complete with battery packs. Further, the current number of emergency lighting units does not provide sufficient light level coverage of egress paths, therefore it is also recommended that additional emergency lights be installed, and existing units be replaced with new battery pack units to assure minimum emergency light levels are met.

In the main areas of the Cathedral, the current light level does not meet IES recommendations for Places of Worship. To achieve a greater level of illumination throughout the seating areas it is recommended to install new shallow profile, high output, LED surface pot lights mounted high up on the ceiling, concealed against beams and factory painted to match the wood finish. This style of lighting would be installed down the main Nave as well as the North and South Aisles. This would bring up the light levels to a more ideal range for the congregation to be able to read from their seats. Lighting from this high angle will also further highlight the stunning architecture throughout the space. Additionally, as part of the Cathedral Conditions and Issues Report, lighting near the front area where performances take place is recommended to be revamped. Currently, the light level in this area is less than the seating areas. According to IES, the focal areas of the Cathedral should have the capability of an illuminance level of 1000 – 2000 lux. To accomplish this level of light, strategically placed RGB (colour changing) LED theatrical lights and/or LED flood lights are recommended so that performances not only can create a focal point, but they will also add creativity with the RGB LEDs to enhance the music/performance venue experience. By using the ceiling arches, selecting appropriate fixture colours, and choosing the locations strategically, it is possible that this type of lighting can be added bringing much needed light to various spaces without adversely affecting the historical architectural appearance.

RECOMMENDATION 27

Repairs and Improvements to Exterior Flood Lighting

PRIORITY	EMERGENCY
ORDER OF MAGNITUDE COST	$ 15,000.00

RECOMMENDATION 28

General improvements to lighting

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 35,000.00

RECOMMENDATION 29

Installation of theatrical lighting in keeping with program plans for the Cathedral

PRIORITY	OPERATIONAL
ORDER OF MAGNITUDE COST	$ 32,500.00

6.3.9.5 FIRE ALARM SYSTEM

The National Building Code (NBC) has undergone extensive reviews and changes since the installation of the Cathedral's current system. The installation of new bells and visual signaling devices adequately placed throughout the building is recommended to meet audibility requirements which are currently not met, and to provide visual signaling to those with hearing impairment.

Since the building is complete with a sprinkler system, the only requirement for detection devices is to be at the top of each stairway. It is recommended that all heat detectors throughout the building are removed and the smoke detectors at the top pf each stairwell be replaced complete with new wiring. It is also recommended that all manual pull stations be replaced and mounted to meet accessibility standards. New pull stations are also recommended to be installed in the Choir and Clergy Vestry rooms as there are exits from the building from those rooms that currently do not have pull stations. Pull stations should also be added within the bell tower and at the bottom of the stairwell to basement.

The fire alarm control panel is located within the electrical room which is not near the main entrance. The Fire Marshall typically requires the control panel or an annunciator panel to be located near the entrance in which the fire department would enter. With the age of the system, it is recommended that the panel be replaced, and a new panel be installed in the main entrance vestibule or just inside the main doors if the vestibule doesn't provide a suitable installation location.

RECOMMENDATION 30

Improvements to fire alarm system

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 20,000.00

6.3.9.6 SECURITY/INTRUSION ALARM SYSTEM

The age of this system is unknown, however, the main control panel and keypad located in the basement seem to be in good condition. When upgrades to the fire alarm panel are performed, it is advisable to install a new auto dialer in the security panel.

Two rear doors to the Choir Vestry and Clergy Vestry rooms have local integrated keypad door locks installed. These door locks are in good condition and do not need to be upgraded unless additional monitoring of the doors is requested. The CCTV cameras appear to be in fair condition and are installed in key locations. If the Cathedral is satisfied with the quality of video capture and video capture storage capabilities of the system, the system can remain in service without need to upgrade. It is recommended to add exterior cameras to the building to deter or help identify any vandalism or thefts from the Cathedral. If compatible exterior camera are found for the existing system, it is recommended for the Cathedral to have the existing system reviewed with the intent being compatibility of any new cameras and storage capacity with a full system upgrade package in the future. This will result in a position to make informed decision on cameras only versus a new full system, which may provide a better long-term solution for the Cathedral.

RECOMMENDATION 31

Improvements to security/intrusion alarm system

PRIORITY	OPERATIONAL
ORDER OF MAGNITUDE COST	$ 12,500.00

6.3.9.7 SOUND SYSTEM

The sound system is recommended to be replaced with high quality sound equipment that will assist the Cathedral in delivering high end musical performances. To begin, the front-end control gear is recommended to be upgraded to include a multi-channel power amplifier and digital stereo mixer. A digital speaker processor is recommended to provide highly applicable equalizing and delay functions to maximize the quality of sound throughout the space. The speakers throughout the Cathedral are recommended to be upgraded to compact array style speakers with adjustable sound dispersion and individual wide dispersion speakers. These speaker upgrades will dramatically increase the sound quality experience within the Cathedral.

New microphone technology is also available and would provide additional flexibility for performances. It is recommended that the Cathedral carefully discuss with a sound designer during the design phase what types of microphones would best fit their specific situation. Wireless microphones with a 16-channel wireless microphone receiver would allow for movement throughout a performance or seamless transitions between singers/performers avoiding cables. Fixed microphone technology has improved as well, a new gooseneck microphone would be a suitable replacement for church services, or it could be upgraded to a real-time steering array microphone system. A real-time steering array microphone provides clear voice capture while allowing speakers to move freely around the vicinity of the podium using a voice tracking technology.

If the existing sound system is determined to be acceptable by the Cathedral, at minimum the following upgrades are recommended. For the current setup, a dedicated circuit or two, depending on the device loads, should be run to the sound booth. All the wiring within the sound booth should be disconnected and neatly labeled and reinstalled so any audio personnel can troubleshoot the system if a problem occurs. It is recommended, where possible, to have wiring associated with the sound system be run in conduit to protect the wiring from mechanical damage and to have the conduits clearly labeled.

RECOMMENDATION 32 Improvements to sound system	
PRIORITY	OPERATIONAL
ORDER OF MAGNITUDE COST	$ 35,000.00

6.3.9.8 COMMUNICATION SYSTEM

Although the communication system is not new, it is recommended it not to be replaced until the operation of the system fails. Very few systems within the Cathedral require a network connection, and, if there are no issues with network speed during the streaming of services which has a high network upload speed requirement, then the service can be deemed adequate. The primary recommendation for the communication system is to ensure all cables are supported and where possible run in conduit to protect them from mechanical damage. These conduits should be identified and labeled so that the system within the conduit can be easily identified.

RECOMMENDATION 33 Improvements to communication system	
PRIORITY	LOW
ORDER OF MAGNITUDE COST	$10,000.00

*Please note that at the Cathedral's request Recommendations 34, 35, and 36 have been moved into Part 4: Revitalisation

6.4 LANDSCAPING: THE IMPORTANCE OF THE CHRIST CHURCH SURROUNDS

In 1845, Bishop Medley chose a conspicuous location on the Saint John River upon which to build his new cathedral. The majority of the land around Christ Church Cathedral is still intact and owned by the church. The Cathedral Green, both adjacent to the church and along the river, remain one of the last sizable green spaces in downtown Fredericton, bridging the history of early Fredericton with the current urban centre (Figure 123).[9]

Figure 123: "Christchurch Cathedral, Fredericton", ca. 1850. Lithograph by R. Carrick (William Day & Sons Lithographers). Artist: Lady Anna Maria Head.

Still set apart on its island of grass and trees, Medley's magnificent cathedral draws the eyes without distraction. In the National Historic Site description, the first two Character Defining Elements of the Cathedral's heritage value are listed as:

- its location in the historic heart of Fredericton, and
- its picturesque siting on a green sward, overlooking the Saint John River.[10]

The handsome steeple rising out of the green is a notable, and much photographed, landmark of the city skyline particularly along the river (Figure 124).[11]

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[9]https://www.familyheritage.ca/Images/Fredericton/Christ%20Church%20Cathedral%20in%20Fredericton,%20ca.%201850,%20by%20Lady%20Anna%20Head.jpg, sourced 2021-10-26

[10] https://www.historicplaces.ca/en/rep-reg/place-lieu.aspx?id=11974

[11] https://en.wikipedia.org/wiki/Fredericton

Figure 124: Fredericton Skyline 2013 by Knoxfordguy, Wikipedia

The Cathedral Green has been an important community gathering place for generations, both organized and spontaneous. Events that have been held over the years range from the pomp of the Prince of Wales' 1860 visit (Figure 125)[12] to the solemnity of the annual Remembrance Day celebrations at the cenotaph, to the sociable atmosphere of the long-running 1980s-90s Cathedral Festival of Arts. Other events include military and community commemorations, city celebrations, musical and theatrical productions, summer camps, and of course religious events.

Figure 125: Prince of Wales visit to Fredericton in 1860, disembarking and festivities on the Cathedral Green. Artist Unknown, Provincial Archives of Nova Scotia.

[12] Image provided by Cora Wolsey, 2021 Report on Monitoring at the Beaverbrook Art Gallery Expansion, York County, New Brunswick Final Report

Just as important, individuals and families use the green space as a meeting place for picnics, walks, and peaceful contemplation. A search of TripAdvisor's reviews of Christ Church Cathedral turned up the following sample of comments:

- Alex L, Tampa Florida: The building is gorgeous and full of history, with lovely and uplifting atmosphere. The surroundings are beautiful too. After the afternoon concert on a Friday you can take a tour of the cathedral and then stroll along the river and across the bridge to the north side of Fredericton
- Chrisaaa119, Fredericton: Well worth a stop and visit. This cathedral is well maintained. Great place to spend a few hours to visit the building and rest in the park-like entourage next to the beautiful Saint John River and The Green.
- Nickd18, Calgary: Beautiful, graceful and imposing all at the same time. The church stands in a large green space near the St John River. The lack of anything around it makes it look even larger than it is. Worth taking a detour from the walking path along the river to look at the Cathedral from all sides.
- Dwight D, Largo Florida: Well worth the time to stop by and see and have a few moments of quiet and enjoy its beauty! Beautiful architecture and grounds around it.
- Linda C, Fredericton: This Cathedral is picturesque inside and out. A very old Cathedral nestled on a green space along the Saint John River at Fredericton.

The parklike quality of Cathedral Green is maintained through a close relationship with the city. Native species of trees are planted to replace those that die, and the shrubs along the riverbank are carefully thinned to avoid erosion. The city is in the process of wiring the green with electricity which should enable more elaborate productions such as music or theatre festivals than are currently possible.[13] This type of gathering would be a possible source of revenue for the Cathedral.

The surrounds are a significant part of the Cathedral's appeal both to individuals and the surrounding community. The development and ongoing maintenance of a landscaping plan is an important part of protecting the heritage value of the site.

Included in the landscaping plan should be replacement of large trees that are lost. This is important not only for the esthetics of the green space but also to assist with management of the groundwater in the area. Consideration should also be given to plantings and possibly appropriate fencing to keep people away from the areas of the building where snow falling off the roof could be dangerous. Any consideration for the addition of structures of any size on the property should be approached with a great deal of caution as the setting for the jewel that is Christ Church Cathedral, once lost, will in all probability never be regained.

[13] Communication with Eric Hadley 2021-10-27

6.4.1 CONSEQUENCES OF INACTION

Without a landscaping plan which has been vetted and has the support of the guiding bodies of the Cathedral, there is risk that small actions will be taken which will lead in the opposite direction of maintaining the historical, natural, and valuable space surrounding the Cathedral. The priority level applied is medium, as opposed to a lower priority level, as the consequences of inaction could very likely be irreversible.

6.4.2 HERITAGE VALUE

The green space around the Cathedral is a Character Defining Element and should be protected.

6.4.3 ORDER OF MAGNITUDE PROBABLE COST

There will be an initial cost to develop a landscaping plan with a qualified planner or landscape architect. Ongoing maintenance of the plan will have minimal costs as that could be an activity of a volunteer committee. As the plan evolves over time, however, it should be revisited periodically, approximately every 10 years with the assistance of a qualified professional.

RECOMMENDATION 37

Development and ongoing maintenance of a landscaping plan that commits to maintaining the open greenspace setting.

PRIORITY	MEDIUM
ORDER OF MAGNITUDE COST	$ 15,000.00

6.5 PRIORITIZATION RECOMMENDED MAINTENANCE WORK

The recommendations provided in Section 3 have been organized to provide Christ Church Cathedral with suggestions for completion of the work over the next four years. The Cathedral is able to re-evaluate the progression of the work to reflect available funding and shifting priorities. The recommendations in Table 9 takes into consideration the Engineers' opinion of which items should be approached first and which items could be combined for efficiency and cost savings.

Table 9: Required Maintenance Recommended Project Flow

		Recommendation	Priority	Order of Magnitude Cost
Spring 2022	27	Repairs and Improvements to Exterior Flood Lighting	Emergency	$15,000.00
	11	Sacristy wall interior crack should be repaired, and the area monitored for future cracking or other evidence of movement	Low	$ 500.00
	17	Purge the basement of debris and clutter	Medium	$ 750.00
			Spring 2022 Total	**$ 16,250.00**
Year 1	18	Collect and source mechanical system documents and provide ongoing systems training for two or three people	Medium	$ 1,925.00
	19	Repairs to the boiler and burner: repair leaking piping, remove rust and staining on boiler housing, and install burner shroud	High	$ 4,500.00
	20	The heating zone repairs should be addressed at the same time: replace the zone distribution piping with the purpose of using a higher efficiency hydraulically separated header at the boiler, replace existing zone control valves with motorized control valves and add water balancing valves to the zone loops, and replace the zone distribution piping and zone control valves with higher efficiency sensorless pumps	High	$ 60,000.00
	23	Replace existing service entrance equipment and distribution equipment in the basement complete with metering, fed from the existing pole with the existing conductors	Medium	$ 30,000.00
	25	Review of existing lightning protection system by lightning protection designer	Medium	$ 30,000.00

	33	Improvements to fire alarm system	MEDIUM	$20,000
			Year 1 Total	**$ 146,425.00**
YEAR 2	21	Design and install a Building Energy Management System (BEMS)	MEDIUM	$ 82,500.00
YEAR 2	24	Repairs to wiring devices and surface conduit as described	MEDIUM	$ 20,000.00
YEAR 2	26	Improve electrical identification and labelling	MEDIUM	$ 5,000.00
YEAR 2	28	General improvements to lighting	MEDIUM	$ 35,000.00
			YEAR 2 TOTAL	**$ 142,500.00**
YEAR 3	22	Replace existing ceiling fans with large, low velocity fans, put the existing operable windows into operations, possibly through the use of an automated actuator connected to the BEMS to bring fresh air into the building; and replace existing basement vent openings with motorized dampers.	MEDIUM	$ 83,500.00
YEAR 3	29	Installation of theatrical lighting in keeping with program plans for the Cathedral	OPERATIONAL	$ 32,500.00
YEAR 3	32	Improvements to sound system	OPERATIONAL	$ 35,000.00
YEAR 3	33	Improvements to communication system	LOW	$ 10,000.00
			YEAR 3 TOTAL	**$ 161,000.00**
YEAR 4	31	Improvements to security/intrusion alarm system	OPERATIONAL	$ 12,500.00
YEAR 4	37	Development and ongoing maintenance of a landscaping plan that commits to maintaining the open greenspace setting	MEDIUM	$ 15,000.00
			YEAR 4 TOTAL	**$ 27,500.00**
			TOTAL	**$ 493,675.00**

Addressing the major maintenance items in a systematic appraoch will help the Cathedral reduce operating costs and realize savings over time.

Part 4: Revitalisation

This section is part of the Christ Church Cathedral Building Conditions and Issues Report - Project 21272 Revision 0

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HERITAGE STANDING INC.
Engineering for Old Buildings

7.0 Revitalisation

The Cathedral community is justifiably proud of its heritage site and wants to ensure that it remains relevant to Fredericton for many more generations. In order to do so, the Cathedral is considering revitalization of the sanctuary space to increase its community use. To that end, HSI was asked to look into two major interventions (seating and organ refurbishment) and a related issue (flooring).

7.1 Chairs as a Seating Option

Christ Church Cathedral is looking into the possibility of replacing many of the pews with chairs to make the sanctuary a more flexible space. HSI was asked to source potential suppliers and options available. To assist the Cathedral in narrowing the search, HSI developed the comparison table below with the information that has been developed to date and obtained sample chairs from two of the companies, New Holland and Rattigan-Schottler.

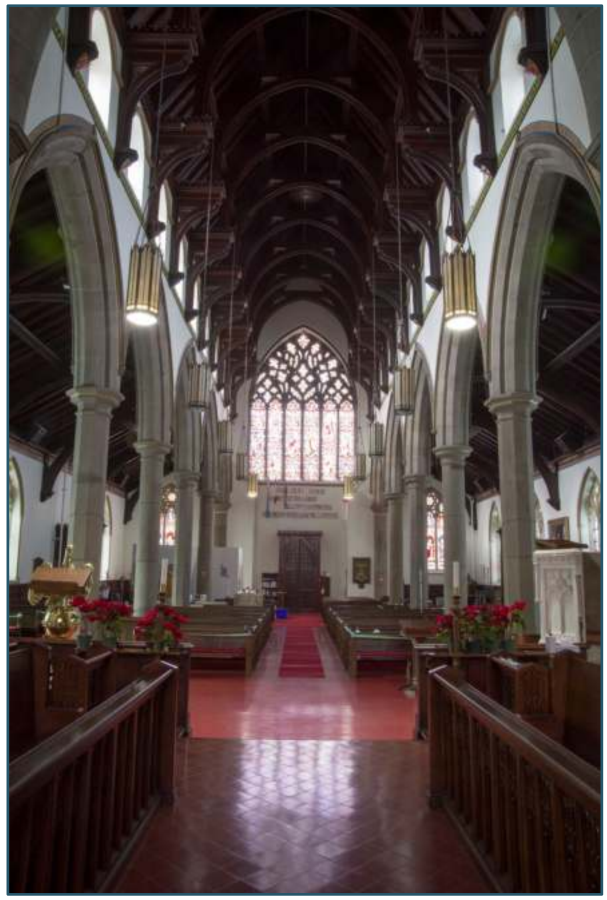


Figure 126: Looking west down the nave

Manufacturers contacted:

- Sauder Manufacturing Company
  Archbold, Ohio
  https://sauderworship.com/
- Rattigan-Schottler
  Beatrice, Nevada
  http://ratiganschottler.com/
- Hew Holland Church Furniture
  New Holland, Pennsylvania
  https://www.newhollandwood.com/

Local options and Canadian manufacturers were sought at the early stages. Local options such as local wood workers were determined to be cost prohibitive. There are very few Canadian manufacturers of this specific type of furniture, and the ones that could be found online did not make the type of high-quality wood furniture that would match the ambiance of the sanctuary (e.g. https://www.firstchoicechairs.com/church.php). Other Canadian companies were merely suppliers for the US manufacturers listed above (e.g. http://kbilt.ca/wood-chairs/).

To provide a comparison of approximately similar products, HSI worked with a representative of the Cathedral to develop a general type of chair to be sourced. The following were the chairs from each manufacturer identified by the Cathedral for follow up, with details shown on a summary table for ease of comparison:

Sauder Manufacturing Company

Figure 127: Sauder 2022200 Oaklok Side Chair

Rattigan-Schottler

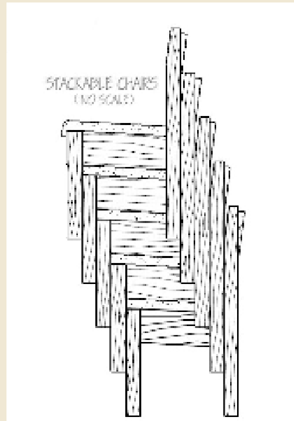
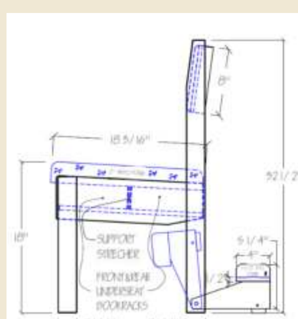
Figure 128: Ratigan-Schottler Solid Oak #1

New Holland

Figure 129: New Holland 310

Figure 130: New Holland 510 (note that the main difference between the 310 and the 510 is the amount of wood visible on the seat back)

		SAUDER	RATIGAN-SCHOTTLER	NEW HOLLAND
MODEL		2022200 Oaklok Side Chair	Solid Oak #1	310 / 510 - Note that the main difference is in the amount of wood visible on the chair back
EXPENSE	PRICING	US $255-265 per chair depending upon fabrics. 299 chairs in layout (total of US $76,245 to $79,235).	US $206.10 per chair if ordering 340 chairs (total of US $81,459) Requested quote for 100. Supplier has not yet provided.	Pricing is variable depending upon number ordered: US $273.61 per chair if ordering 332 chairs to fill the sanctuary (total of US $90,836.65) and US $337.65 if ordering 100 chairs (total of US $33,765.40)
	TAXES AND FEES	Customs tax included, local taxes not included	Tax and import fees not included	Tax and broker fees not included
	DELIVERY	Delivery included, not unloading	Delivery and set in place included (note that set in place is minimal with chairs)	Delivery and installation included (note that installation is minimal with chairs)
SPECIFICATIONS	COMPOSITION	Solid Wood (choice of species) Fabric / finish of choice	Solid oak Fabric / finish of choice	Red oak Fabric / finish of choice
	MEASUREMENTS	Height 31 ¾” Depth 20 ½" Width 20 ¼”	Height 32 ½” Depth 18 3/16” Width 19 ½”	310 Height 32” 310 Depth 22” 310 Width 20” 510 Height 32 ¼” 510 Depth 21 ¾” 510 Width 20”
	WEIGHT	16 lbs	18 lbs	23 lbs

	SAUDER	RATIGAN-SCHOTTLER	NEW HOLLAND
STACK HEIGHT	7 chairs 	5 chairs 	310: 6 Chairs / 510: 5 Chairs 
KNEELER	Included Flip Up / removeable Must be removed to stack.	Included Flip Up / removable Must be removed to stack.	Included Flip Up / removable Must be removed to stack.
BOOK RACK	Included Side attached  Must be removed to stack.	Included 2 underseat book racks, front and rear access  	Included Underseat rear access 
INTERLOCKING	Yes, through side bookrack	Yes, ganging devices	Yes, front of leg ganging pins

	SAUDER	RATIGAN-SCHOTTLER	NEW HOLLAND
WARRANTY	10 years (Replaceable seat and back pads)	25 years	15 year (5 on kneelers)
CERTIFICATION: SUSTAINABILITY / ENVIRONMENTAL HEALTH / PROFESSIONAL	Greenguard Low VOC https://spot.ul.com/greenguard/ BIFMA e3 Level 2 https://www.intertek.com/testing/furniture/bifma-level/	N/A	Architectural Woodwork Institute Premium Grade manufacturer https://awiqcp.org/
SALES SERVICE	Through regional representative: Kevin Carrier kcarrier47@gmail.com Poor response to communications, slow and requires multiple reminders	Through president: Patrick Ratigan patrick@ratiganschottler.com	Through regional representative: Andrew Gale agale@newhollandwood.com Extremely responsive with helpful suggestions
COMFORT	Will provide a sample for $150 plus shipping	Provided a sample chair free of charge	Provided a sample chair free of charge as well as a Manufacturer's Rep site visit to respond directly to questions

After the preceding information was provided to the Cathedral. John Leroux acting direction on behalf of the Cathedral (outside the HSI design team) drew up a seating analysis for the sanctuary based on the measurements of the New Holland chairs and determined that 240 chairs would be a proper fit if seven entry pews were kept. Please note that the layout is a bit different from what HSI was requested to provide suppliers when gathering initial information. Figure 131, Figure 132, and Figure 133 are the layouts provided by John Leroux, included here for documentation.

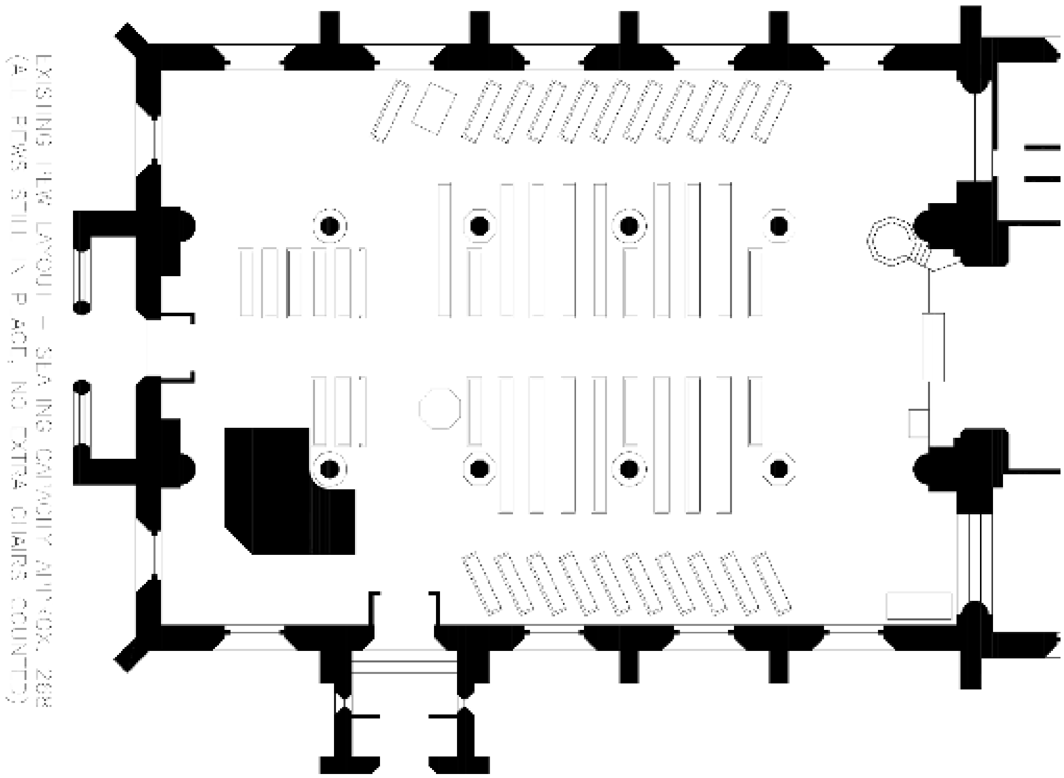


Figure 131: J. Leroux drawing of the existing pew layout with seating capacity of 268

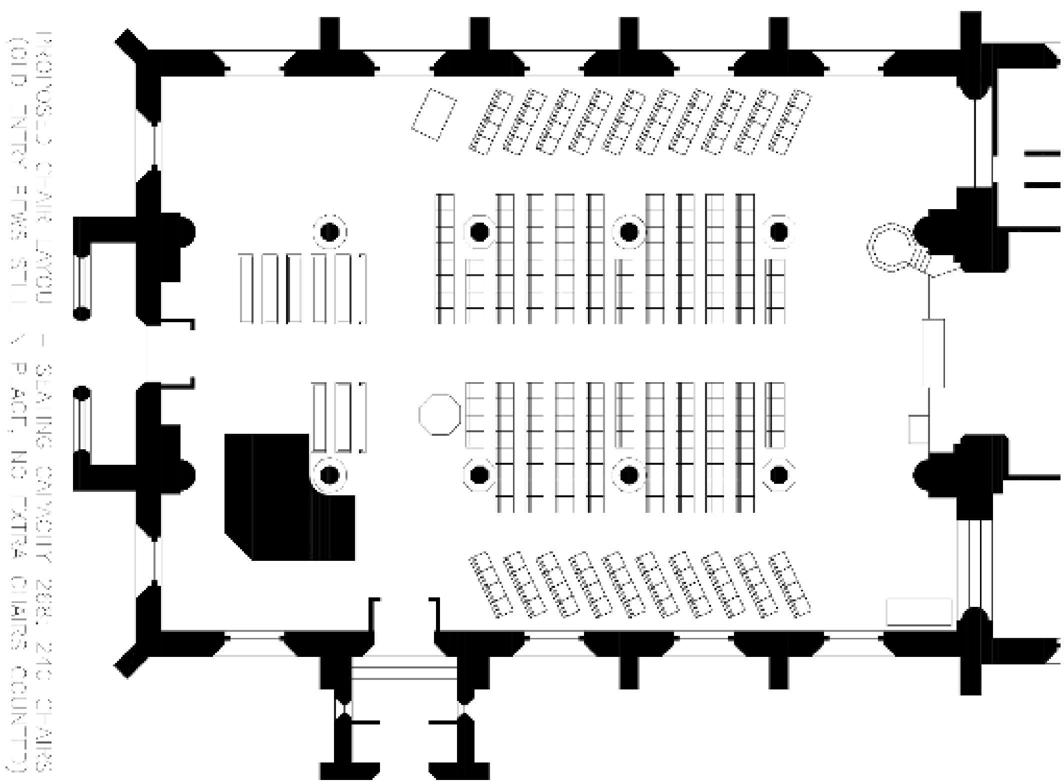


Figure 132: J. Leroux drawing of proposed chair layout with remaining 7 entry pews and 240 New Holland chairs, seating capacity 268

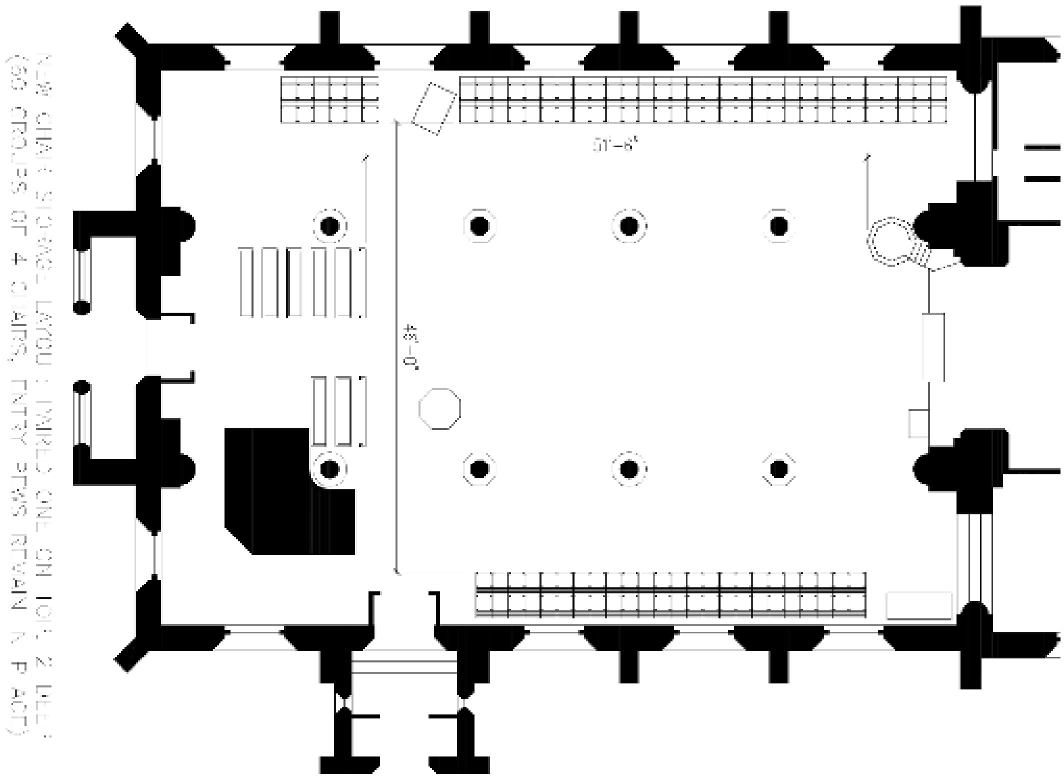


Figure 133: J. Leroux drawing of proposed chair layout with chairs stacked along walls to create flexible space in the centre of the sanctuary

7.1.1.1 Consequences of Inaction

The consequence of inaction is no increase in the flexibility of interior space.

7.1.1.2 Heritage Value

Any changes in the church pews will impact a Character Defining Element of the building. Changes to any Character Defining Element should not be made without careful consideration. In this instance there is some conflict between different conservation objectives and end goals that should be considered. On the one side, changes in any Character Defining Element should be avoided where possible because changes can adversely impact the heritage value of a site. The interior furnishing of the Cathedral affects people's attachment to the building and the emotional impact it produces. Contrary to this is the question of ensuring the space is used. The Venice Charter stresses the importance of a site having a use, and if the fixed pews are creating a challenge for the site's continued use as a place of faith this is relevant for the long-term heritage value. The fact that the Cathedral is an active place of faith is similarly connected to its heritage value.

Regarding the pews, it is outside the scope of this report to evaluate and determine which approach would be the best solution in terms of more benefit and less harm to the site's heritage value, looking at internal integrity versus its ability to house a vibrant congregation. Because these discussions occurring transparently can be an important part of any major conservation topic, some context to consideration was provided.

7.1.1.3 ORDER OF MAGNITUDE PROBABLE COST

The order of magnitude cost is based on the costs submitted by suppliers with a nominal amount added for shipping and other potential costs.

RECOMMENDATION 34

Rehabilitation of seating to improve use of space

PRIORITY	OPERATIONAL
ORDER OF MAGNITUDE COST	$ 110,000.00

7.2 FLOORING

As described in the 2021 HSI Update of the 2015 Condition Assessment Report, the flooring and the anchoring mechanism for the pews were reviewed on 2021-05-04 to consider if the flooring needs to be replaced.

The flooring was sheet or rolled flooring (Figure 134) with welded seams glued to what appeared to be a second plywood sub-floor on top of the original sub-floor (Figure 135). The narrow strip of flooring behind the effigy of Bishop Medley was the only section found that had lifted, allowing the plywood subfloor to be visible. The flooring is sealed around the edges of columns and other permanent elements. Generally, the flooring was in good condition. There were no readily visible points where the flooring was torn, worn through, or where there were large cuts. Some of the welded seams are separating (Figure 136) and the flooring is scuffed in front of pews and a few other areas (Figure 137).


Figure 134: General view of flooring


Figure 135: Visible floor layers at basement trap door


Figure 136: Failed welded seam at base of column

A review of photos indicates that the flooring was installed after 1983, and a review of written documentation suggests it may have been installed in the 1990s. The life expectancy of commercial sheet flooring is approximately 30 years. With the light use of a church setting, this could be longer.

Pews were attached to the floor with the use of steel angle braces and screws into the floor and the pews (Figure 138 and Figure 139). The size of the screw heads was approximately 0.25 inches in diameter. The length of the screws is unknown. No screws were visible extending from the original sub-floor from the vantage point of the basement. Where pews had been removed, the screws had been countersunk in place (Figure 138 and Figure 139). At these points, the flooring was in good condition. It appears that the screws had not caused tearing or cracking, although at times the brackets made deep impressions or small cuts into the flooring.


Figure 137: Scuffed area in front of a pew


Figure 138: Angle brace and screws attaching pew to floor


Figure 139: Countersunk screw remaining after pew removal

If more pews are removed, it is recommended that upon removal the flooring should be thoroughly stripped, cleaned, waxed, and polished. Areas where the seams have failed should be repaired. There will probably be raised ridges where the pews were attached to the floor. Care will have to be taken to remove as much of that build up as possible. A thorough cleaning and finishing of the flooring may also significantly reduce visible scuff marks. Anticipate replacement in the next 15 years.

When the floor does require replacement, consideration should be given to the recommendation made by Roberts Duncan Caunter Architects in their 1989 Christ Church Cathedral Renovation Plan in which it was recommended that the flooring of the Cathedral be replaced with slate or quarry tile.

When the existing flooring is ultimately removed, a hazardous materials assessment should be undertaken beforehand. Although asbestos use in flooring was phased out during the 1980s, if old stock was used, there is the possibility that the vinyl could contain asbestos. The adhesive should be assessed for asbestos as well. Asbestos in flooring is considered to be nonfriable when intact, and in good condition the flooring is not considered hazardous. Therefore, continued use of the space presents no risk to the public.

7.2.1 Consequences of Inaction

Continued wear of the floor surface, scuffing and visual impacts. Where damage already exists tears are likely to increase.

7.2.2 Heritage Value

The current floor is seen as having limited heritage value.

7.2.3 Order of Magnitude Probable Cost

The costing for repair is based upon assumed conditions and minor damage in line with what was visible.

Recommendation 35

Repair existing flooring

Priority	Low
Order of Magnitude Cost	$ 3,500.00

As the flooring will likely need to be replaced in the next twenty years the cost of replacement was also calculated. The cost is based on the installation of linoleum sheet flooring with welded seams. An allowance has been included for demolition/removal, possible repairs to the sub floor, and other costs such as shipping. Estimated cost of floor replacement is $150,000. This value was not used in the global project numbers, those using the repair cost instead.

7.3 Organ Refurbishment

The information in this section of the report was provided to HSI by the Cathedral's Director of Music and Organist Thomas Gonder. Information he provided is captured here for the record and to ensure a complete report.

The original pipe organ in Christ Church Cathedral, Casavant Frères Ltée. (Opus 302, 1907) (Pipe Organ Database, 2021), was damaged beyond repair in the fire in the church in 1911. It was replaced in 1912 by Casavant Frères Ltée. (Opus 488, 1912). The current organ is listed as Casavant Frères Ltée. (Opus 2399, 1957) as alterations and repairs to the 1912 organ were extensive. It is an electro-pneumatic (EP) organ with 43 ranks (2,671 pipes, 5 divisions, 4 manuals, 39 stops and 43 registers).[14] The pipes themselves are of two types of material depending on the pipe; wood and an alloy of zinc, lead, and tin. The organ's mechanism is now failing in the following ways:

- The leather pouches in the wind chests are deteriorating and leaking.
- The combination action (thumb pistons below the key or toe pistons located above the pedalboard used to switch from one combination of stops to another) needs to be updated.
- A rank of pipes is missing.
- Some stops[15] are duplicated.
- The zinc, lead, and tin alloy pipes generally do not hold up well in colder climates.
- The echo division, which are the pipes located on a high platform to the right (south side) of the chancel, do not seem to be adding much to the sound.

Continuous minimal repairs and urgent corrective measures will not result in effective repair. As well, the costs build up. Each time a small repair is needed that can be dealt with by the local Moncton service technician, there is a minimum $3000 cost.

In its current condition, the organ is considered musically mediocre. Its sound is primarily in the rich and warm range. It lacks both the bright upper range and the very deep low range.

7.3.1 MUSIC AT THE CATHEDRAL

Churches and cathedrals have long been treasured venues for musical performances, and Christ Church Cathedral is no exception. The tradition at Christ Church Cathedral has been to have a resident organist who has also guided the overall music program. In line with tradition, the current Director of Music, Thomas Gonder, performs as an organist and develops the Cathedral's music program. During services, the congregation enjoys ecclesiastic music performed variously by a choir, a modern worship band, and T. Gonder as organist. The Cathedral also hosts public music events such as the summer recital series Music at the Cathedral, the New Brunswick Summer Music Festival, and a variety of other musical performances throughout the year.

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[14] A rank is a graduated set of organ pipes of like tone quality.

[15] A stop is the component that admits pressurized air(wind) to a set of organ pipes.

The long range vision for Christ Church Cathedral is to enhance its musical programming to position the Cathedral as a prominent New Brunswick venue for music. When considering how to achieve this vision, it is important to keep in mind the truism that a good instrument attracts good musicians. A good organ is needed for the Cathedral to progress in the development of strong music programming.

Figure 140: Organ pipes. Image credit Christ Church Cathedral website.

7.3.2 OPTIONS FOR THE ORGAN

The Cathedral will need to determine both what caliber of organ is desired and how to obtain it. This will need to be a decision based on input from the Cathedral community. T. Gonder is developing terms of reference for the creation of a committee which will review options for the organ and develop a recommendation for its repairs and/or replacement. At the time of this writing those terms of reference are still in the development stage and the committee has not been struck.

Options that have been identified to date are, in no particular order:

- REPLACE WITH NEW PIPE ORGAN
  Entirely replace the current organ with a new pipe organ.
- REPLACE WITH NEW DIGITAL ORGAN
  Entirely replace the current organ with a digital organ.
- DEVELOP A HYBRID ORGAN
  Some of the original organ pipes would remain operational. A digital organ would replace other ranks and add new ranks.
- REPAIR AND IMPROVE EXISTING PIPE ORGAN
  Repair what can be repaired to a “very good” condition, replace what cannot be repaired, and add new ranks and pipe stops to improve the overall sound of the organ.
- REPAIR EXISTING PIPE ORGAN
  The organ as it exists now will be repaired. No improvements will be made.

7.3.3 PROJECT COSTS

Until the Cathedral decides which option to pursue and determines the full scope of work, it will be very difficult to apply an estimate of cost due to the variation of costs between and within the different options. Numbers for budgeting are needed immediately, however, as the Cathedral develops a long range plan for major repairs and upgrades. Therefore, a conservative opinion of the probable cost (OPC) for each option has been provided for budgeting purposes and for fundraising planning. These projected costs are based on those provided by Thomas Gonder.

In the final determination of the level of funds that will need to be raised for the organ, the Cathedral can factor in the amount which has already accumulated in the Organ Fund. At the time of this writing, the total amount in this account was thought to be in the range of $65,000 to $75,000. Recent donations are a good indication of the value the congregants place on the organ and music in the Cathedral.

OPTIONS	OPINION OF PROBABLE COST (OPC)
Replacement with New Organ	$ 1.5 to $ 2.0 Million
Replacement with Digital Organ	$ 110,000
Develop a Hybrid Organ	$ 350,000 0 $ 450,000
Repair and Improvement of Existing	$ 650,000 to $ 750,000
Repair Existing	$ 500,000 to $ 600,000

7.3.4 SEQUENCING

The timing of the organ project will need to be considered for appropriate sequencing with any construction projects underway at the time. Dust and debris are not good for organs. A good time to complete work on the organ is after any scheduled construction work in the Cathedral itself is completed. Because its mechanisms will need to be protected, the organ may have to "fall silent" during these construction periods even if it is not being worked on directly.

RECOMMENDATION 36

Organ intervention

PRIORITY	OPERATIONAL
ORDER OF MAGNITUDE COST	$ 750,000.00

7.4 ACCESSIBILITY

Late in the development of this report the question of accessibility was raised. Concerns linked to how limited accessibility can impact involvement and inclusion. Two current questions related to the ability for worshipers to approach the communion rail for high communion, and the risks posed by multiple dark areas becoming tripping hazards. Improving accessibility while protecting what people love about a space can require careful thought and consideration of benefit and harm from different concepts. However, when well balanced and achieved it brings benefits to all users.

It is important to note that accessibility was not considered inside the scope of this report.

7.5 REVITALISATION RECOMMENDATIONS

The recommendations provided for the section for Revitalisation are shown below in Table 10.

Table 10: Recommendations in the Area of Revitalisation with Order of Magnitude Costs

	RECOMMENDATION	URGENCY	COST
34	Rehabilitation of seating to improve use of space	OPERATIONAL	$ 110,000.00
35	Repair existing flooring	LOW	$ 3,500.00
36	Organ Intervention (Repair and Improve existing as a median cost)	OPERATIONAL	$ 750,000.00
		TOTAL YEAR 3	**$ 863,500.00**

Revitalisation of the sanctuary aims to adapt the space to the Cathedral's changing needs while maintaining its heritage character and historic value.