MORRISON HERSHFIELD

BUILDING CONDITION AUDIT and STRUCTURAL ASSESSMENT

Main Library
120 Metcalfe Street

Ottawa, Ontario

Presented to:

City of Ottawa
c/o Richard Davis, C.E.T.
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1. INTRODUCTION

1.1 Terms of Reference

Morrison Hershfield Limited (Morrison Hershfield) was retained by the City of Ottawa to conduct a Building Condition Audit and Structural Assessment of the Main Library located at 120 Metcalfe Street, Ottawa, Ontario. Authorization to proceed with this assignment was provided by Purchase Order No. 45070783 from the City of Ottawa.

1.2 Objectives

The objective of the Building Condition Audit and Structural Assessment was to conduct a detailed review and assessment of the current condition of the facility. The analysis was to include exploratory openings, as required, to provide a detailed assessment, including recommendations for repairs or replacements necessary to maintain the building for a period of 10 years. The assessment was to provide comment on the building's 'end of life', expansion potential, flexibility and structural soundness. The Building Condition Assessment included the building exterior, building envelope (roofing, windows, cladding, doors), building interior, structure, parking garage, life safety systems, mechanical and electrical systems and elevating devices.

1.3 Scope of Work

The Building Condition Assessment included:

- a review of available documents and drawings,
- a visual review of the general condition of major systems and their components,
- interviews with persons familiar with the history and operation of the facility,
- a detailed visual review and 'chain drag' and hammer sounding survey of the parking garage,
- exploratory openings to review condition of precast panel anchors,
- thermographic scan of exterior walls,
- a detailed analysis of the structural capacity to add floors to the building, and
- a seismic assessment of the facility.

This report summarizes our observations and recommendations for repairs and replacements within the next 10 years.

Our scope of work specifically excluded:

- Code compliance study,
- Material sampling and testing,
- Inspection of concealed elements, intrusive openings, or opening of system components for internal inspection, except where specifically noted,
- Verifying operation of systems,
- Engineering design/analysis,

- Energy performance audit,
- Routine maintenance tasks and repairs, and associated costs, and
- Specialized equipment that is not part of the base building.

1.4 Costing

Where repair or replacement items are identified, our opinion of probable cost for the work has been given (reported in 2012 dollars). The total project costs that have been indicated include the construction cost of each item of work, plus an allowance for contingencies and consulting fees, where appropriate. We typically budget an allowance of 15% to 20% of the construction costs.

All budgeted costs are based on prices of similar projects and on costing manuals. Wherever possible, actual contract prices from recent similar projects have been used to develop the cost estimates presented in this report. More precise cost estimates would require more detailed investigation to define the scope of work.

All costs are identified in **2012 Canadian dollars**, and do not include applicable taxes. All cost estimates assume that regular annual maintenance and repairs will be performed to all elements at the facility.

1.5 Project Team

This Condition Assessment has been prepared and/or reviewed by various personnel within Morrison Hershfield. The following are the reviewers and the respective disciplines for which each was responsible.

- Ms. Heather Penner, C.E.T. and Ms. Allison Huffman, P.Eng. addressed the building envelope, structure and building interior elements and drafted these sections of the report,
- Mr. Dan MacDonald, P. Eng., addressed the mechanical systems and drafted this section of the report,
- Mr. Wm Jeff Siddall, LEL CET, addressed the electrical systems and drafted this section of the report, and
- Ms. Allison Huffman, P.Eng, reviewed the report for compliance with contractual obligations.

The review of the elevators, escalators, and other conveying systems was conducted by Rooney, Irving and Associates during a separate site visit. Their report is included as Appendix B.

Adjeleian Allen Rubeli completed the assessment of the structural feasibility of adding floors to the Library, as well as completed the seismic assessment. Their complete report is included in Appendix C.

The review of the mechanical and electrical systems was completed on January 24, 2012. The review of the building envelope, structure and building interior elements was completed on February 2, 2012. During our reviews of the facility, we were accompanied by Mr. Maurice Gauthier who provided access to all areas of the facility and background information. Mr. Gauthier has been with the facility for approximately seven years.

1.6 Documentation Reviewed

The following drawings or documents were provided for our review to assist in the preparation of this Building Condition Assessment:

- Parking Garage Audit, prepared by Trow Consulting Engineers Ltd., dated November 2002;
- Communication and Counsel to the Board, prepared by Barbara Clubb, City Librarian, dated December 3, 2002;
- Communication and Counsel to the Board, prepared by Barbara Clubb, City Librarian, dated April 7, 2003;
- Communication and Counsel to the Board, prepared by City Librarian, dated January 30, 2004;
- Addendum 5, Communication and Counsel, prepared by Barbara Clubb, City Librarian, dated February 8, 2008;
- Contractor for Main Renovations, prepared by Linda Standing, A/Division Manager, Main Library and Centralized Services, dated September 5, 2003
- Building Condition Review: Type II Audit, prepared by the City of Ottawa Real Property Asset Management and Comprehensive Asset Management, dated January 2004;
- Proposal for the Installation of Self-Check-Out Kiosks, prepared by David S. McRobie Architects, Inc., dated January 2, 2003;
- Renovation Furniture Plans AD1.1.9, AD1.1.10, and AD1.1.11, prepared by David S. McRobie Architects, Inc., dated August 20, 2003;
- Structural Assessment Report, prepared by Adjeleian Allen Rubeli Limited, dated June 20, 2008;
- 3rd Floor Structural Loading Review, prepared by Adjeleian Allen Rubeli Limited, dated September 25, 2008;
- Shoring Update, prepared by Concentric Associates International Incorporated, dated November 30, 2007;
- Report, prepared by Concentric Associates International Incorporated, dated December 4, 2007;
- PowerPoint Presentation, Interim Structural Assessment Update, prepared by City of Ottawa, dated January 21, 2008;
- Quantities and Costing for Parking Garage Repairs;
- Specifications for Garage Rehabilitation;
- Precast Cladding Connection Review, prepared by Adjeleian Allen Rubeli Limited, dated February 9, 2009;
- Indoor Air quality Assessment, prepared by Jodi Johnson, City of Ottawa Occupation Safety Consultant, dated November 4, 2011;
- Designated Substances and Hazardous Materials Survey Report, prepared by T. Harris Environmental Management Inc., dated May 2011;
- Ottawa Public Library Fit-Up Standards Manual, dated July 2011;

- 2009 Planned Projects, prepared by Marco Manconi, City of Ottawa Life Cycle Renewal, dated May 5, 2009;
- 2013 to 2017 Forecast for Main Library;
- Challenges and Issues for the Current Main Library: Assessment of the OPL Downtown Branch;
- Main Library Fact Sheet, dated May 20, 2008;
- Main Library Building Condition Assessment, prepared by Elaine Condos, System-Wide Services and Innovation, dated September 12, 2011;
- Architectural drawings A-01 to A-39 (39 sheets), prepared by George E. Bemi Architect, dated December 1970 and January 1971;
- Electrical drawings E-1 to E-17 (17 sheets), prepared by Goodkey Weedmark and Assoc. Ltd., dated December 1970;
- Mechanical drawings M-1, M-4, M-6 to M-13 (10 sheets), prepared by Goodkey Weedmark and Assoc. Ltd., dated January 1971;
- Plumbing & Fire Protection drawings PD-1 to PD-8 (8 sheets), prepared by Goodkey Weedmark and Assoc. Ltd., dated December 1970;
- Structural drawings S1 to S15 (15 sheets), prepared by Adjeleian Allen Rubeli Limited, dated January 1971;
- Mechanical drawings M-3, M-2 and M-5 (3 sheets), dated September 22, 2004.

1.7 Terminology

The current condition of the major systems and components were rated using the following terminology:

- **excellent** - functioning as intended; no deterioration observed.
- **good** - functioning as intended; normal deterioration observed based on age and general environment; no maintenance anticipated within the next five years.
- **fair** - functioning as intended; evidence of serious collective degradation or deficient operation; maintenance will be required within the next five years to maintain functionality.
- **poor** - not functioning as intended; potential for imminent failure, system at end of life cycle; maintenance and some repair required within the next year to restore functionality.
- **failed** – systems no longer operating to design intent or exhibiting total failure; significant deterioration and major distress observed, possible damage to support structure; may present a risk to people or materials; must be dealt with without delay.

A *good* rating would be considered a normal result, while an *excellent* rating indicates unusually superior ageing performance. Ratings of *fair* and *poor* respectively indicate that maintenance will be required within the next five years or repair within the next year to maintain functionality. A *failed* rating indicates that the system or component requires attention without delay.

The following ratings were used to set a priority for repair or replacement items.

Priority A – *essential* requirement – life safety, imminent failure, user operations will be greatly affected; work recommended within the next year.

Priority B – *necessary* but not essential – to avoid escalating future costs or to maintain functionality of the building.

Priority C – *desirable* but not necessary – to enhance functionality, improve aesthetics, and/or projects that are subject to operational priorities.

1.8 Limitations

It is a basic assumption that any correspondence, material, data, evaluations and reports furnished by others are free of latent deficiencies or inaccuracies except for apparent variances discovered during the completion of this report.

Unless specifically noted in this report, no testing, detailed analysis or design calculations were done, nor were they within the scope of this review.

Any comments or conclusions within this report represent our opinion, and this opinion is based upon the documents provided, our field review of apparent physical conditions, specifically identified testing, and our experience.

Some of the findings herein are based on a random sampling and some of the findings are based on a visual review of the surface conditions. Deficiencies existing but not recorded in this report were not apparent given the level of study undertaken. Components not included have not been reviewed; further study will be required if their conditions need to be known.

Morrison Hershfield Limited prepared this report for the account of the City of Ottawa. The material contained within reflects the best judgment of Morrison Hershfield Limited in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions made based on it, are the responsibilities of such third parties. Morrison Hershfield Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based upon this report.

1.9 Building Description and Background

The Ottawa Main Library, located at 120 Metcalfe Street, opened in 1974. Based on the documentation provided, the parking garage was constructed in 1971 and the library building was constructed in 1973. The three-storey building has a total area of approximately 88,000 square feet. The library building is connected to the Sir Richard Scott Building, and includes an underground parking garage; photographs 1 and 2 show different elevations of the building.

The building has a rectangular footprint with an atrium space at the main entrance. The building is clad with insulated precast concrete panels and aluminum strip windows. The parking garage consists of three split-level suspended slabs and a fourth slab-on-grade level with a capacity of 174 vehicles.

The Library is located on the first to third floors of the building, administrative and technical services for the Library are located on the fourth and fifth floors of the Sir Richard Scott Building. Access between these floors is provided by central staircases, up-only escalators, and elevators. One elevator is located within the library, a second elevator provides access from the garage to the first floor for the public (second and third floors can be accessed by staff only). In the basement of the building are the auditorium, a meeting room, distribution area, and the FOPLA Bookstore.

2. SITE

2.1 Sidewalks

Around the building are cast-in-place concrete sidewalks. At the main entrance, along Metcalfe Street and Laurier Avenue, the sidewalk has an exposed aggregate finish. The sidewalk along the west elevation is located adjacent to a concrete retaining wall with a metal fence. It is unclear if the retaining wall is the responsibility of the library or the adjacent property. The sidewalks are in fair condition. Cracking and localized spalled areas were observed near the bike racks along Metcalfe Street and at the northwest corner. The sidewalks are located above the podium deck of the parking garage and will be replaced in conjunction with the podium deck waterproofing membrane (refer to item 3.3.1.2).

2.2 Stairs

There are concrete stairs on the north side of the building. The stairs are cast-in-place concrete and are provided with painted metal hand and guardrails.

The stairs, landings and handrails are in generally fair condition. The stairs at the northeast corner have corrosion staining on the bottom riser. The stairs at the northwest corner appear to have shifted, resulting in cracking in the surface of the adjacent sidewalk and a sloped surface. Concrete spall was noted adjacent to the anchor for the railing, and concrete spall and scaling was noted on the stair risers.

Surface corrosion and peeling paint was noted on the railings. We recommend budgeting for repairs to the stairs, landings and handrails in coordination with repairs to the sidewalks and replacement of the podium deck membrane (refer to item 3.3.1.2).

2.3 Planters

There are two planters adjacent to the main entrance of the building. The planters are enclosed with precast concrete panels with an exposed aggregate finish. The planters are in fair condition. The sealant at the joints and corners of the planters is detached. The precast panels enclosing the planters appear to have shifted position and the corners are no longer aligned. As the planters are located above the podium deck, any repair work to the planters should be completed in conjunction with the replacement of the podium deck waterproofing membrane (refer to item 3.3.1.2).

3. BUILDING ENVELOPE & STRUCTURE

3.1 Building Structure

A general evaluation of the building structure was performed. Our site review consisted of a visual walk-through survey of the building to review a sampling of readily accessible structural components in an attempt to identify the symptoms of structural distress (e.g. wide cracks or excessive displacement). Given that our review has been made on a random sampling basis and that structural members were generally not subjected to their full design live loads (including wind and seismic effects), this type of review is very limited in identifying hidden or latent structural defects. All structural elements are assumed to last the life of the complex.

3.1.1 Foundation

As the building is situated over the parking garage, the foundation of the building consists of the concrete foundation walls, slab-on-grade, and footings. The foundation walls and slab-on-grade are visible within the parking garage. The parking garage structure is discussed in *Section 3.3: Parking Garage*.

3.1.2 Building Superstructure

The building structure consists of a reinforced concrete flat slab system with reinforced concrete shear walls, reinforced concrete columns and transfer beams. Due to interior finishes, only a limited amount of the structure was visible. In the service rooms, the concrete floor slabs are visible. In a few locations, we noted surface hairline cracking of the floor slabs which can likely be attributed to shrinkage during the curing process. Throughout the library spaces, the concrete columns are unfinished and exposed; the columns appeared to be in good condition. In the server room, behind the installed panels, step cracking of the concrete block wall was observed.

In 2007, issues with precast panels located above the parking garage door were identified. Investigations by Concentric and Adjeleian Allen Rubeli identified concerns with structural loading on the third floor of the building. The precast panels and anchors above the parking garage were repaired. Further assessment was undertaken by Adjeleian Allen Rubeli Limited to assess the interior stacking and loading profile within the library. The assessment determined that higher deflections were occurring at the edge bays. The assessment concluded that the edge bay deflection was not a structural concern but could affect the precast panels. It was recommended that loading be reduced at the edge bays to prevent stress on the precast panel connections in these areas.

No major deterioration, cracking, or settlement was observed that would be indicative of a structural concern at the building. The structure is anticipated to last the life of the building; as such no major capital expenditures are anticipated within the time frame of this report. It is recommended that any major re-location of the library stacks be reviewed by a structural engineer.

3.2 Stairs

There is a main staircase located in the atrium and three stairwells which provide access within the library. A fourth stairwell provides access from the parking garage to the tower. All of the stairs are in good condition. All stairs are expected to last the life of the buildings. Painting and replacement of finishes can occur as part of the building maintenance or in conjunction with other interior finishes work (refer to *Chapter 4: Building Interior*).

The main staircase is cast-in-place concrete with cast-in-place concrete guards. The main staircase has ceramic tile treads. The guards are capped with stained wood. Handrails with a brushed aluminum finish are provided on both sides of the main staircase.

The stairwells consist of cast-in-place stairs and landings. The finishes of the stairwells are painted concrete or concrete block. An anti-slip strip is provided at the leading edge of the stair treads. A combination painted metal hand and guard rail is provided at the stair interior; at the exterior, a wall mounted painted metal handrail is provided. Scratches in the finish and chipped paint were observed on the railings.

There are additional stairs in the building including from the basement to the P1 level of the parking garage and from the ground floor to the basement (adjacent to the Laurier Street entrance). The stairs to the parking garage are cast-in-place concrete with anti-slip treads. Aluminum handrails with a brushed finish are provided on both sides of these stairs. The stairs adjacent to the Laurier Street entrance are metal pan stairs with in-filled concrete treads finished with ceramic tile. The risers are a wired mesh; corrosion staining was visible on the risers and at the edges of the treads. At the interior of the stairs, a metal picket style guard with a stained wood handrail cap is provided; a brushed finish aluminum handrail is provided on the other side.

The stairs are expected to last the life of the building and no major repairs or replacements are anticipated within the timeframe of this report.

3.3 Parking Garage

The parking garage at 120 Metcalfe Street is a cast-in-place concrete underground structure. There are five spilt-levels of parking (Levels P1 to P5) as well as lower level parking on the slab-on-grade (Levels P6 and P7). The three suspended slabs of parking space and interconnecting ramps are protected with a thin-set membrane waterproofing system. The slab-on-grade is concrete and no waterproofing membrane has been installed on this level. The entrance to the parking garage is located at the southwest corner of the building, via a heated concrete ramp, and accessed from Laurier Avenue.

The parking garage was reviewed on February 23, 2012; the review included soffit hammer sounding and slab chain dragging. Hammer sounding and chain dragging are sonic methods of detecting areas of delaminated concrete identified by a tonal change. The parking garage review was conducted by Mr. Paul Cheney and Ms. Heather Penner, both of Morrison Hershfield. For specific information regarding the condition of the parking garage, refer to Appendix D. Overall, the parking garage is in fair condition with some areas of delamination and cracking observed.

Repairs to the parking garage undertaken in 2009 included:

- localized concrete and traffic topping repairs as directed by the consultant,
- replacement of the traffic topping membrane in localized areas,
- installation of two layers of wear course over existing traffic topping system in localized areas, and
- replacement of ramp concrete topping.

Concrete

At the concrete slab-on-grade, there were localized areas of water ponding and delaminated concrete. The surface of the concrete slab-on-grade was pitted. We typically observed localized areas of delaminated concrete slab, delaminated concrete at the soffit, cracking at the soffit, and previous epoxy injection repairs of the suspended slabs. Efflorescence and corrosion staining was associated with the cracking of the suspended slab soffits (photograph 3). On the P4 Level, water was dripping through the suspended slab from the mechanical room of the P2 Level. The mechanical room was not accessed to identify the source of moisture.

The concrete walls and columns were in generally good condition with some areas requiring repairs, as were the intermediate stairs between levels. Generally we observed peeling paint and scaling at the base of the walls and behind the mechanical equipment (photograph 4). Localized areas of spalled or delaminated concrete were observed at the bottom of the walls. We did note wall cracks with efflorescence, corrosion staining, and dampness (photograph 5). At the P1 Level, the half wall by the entrance ramp has spalled concrete and corroded reinforcing steel (photograph 6).

It is our understanding that concrete repairs were completed in 1996 and 2009. Based on the current condition, we recommend budgeting for repairs in the next few years to address spalled and delaminated concrete. This work should be conducted in coordination with repairs to the podium deck membrane or repairs to address the noted water leakage below grade.

Number	Event	Priority	Years	Cost/ Occurrence
3.3.1.1	An allowance to complete concrete repairs in the parking garage.	B	2018	$240,000

Podium Deck – Waterproofing Membrane

The parking garage extends beyond the building on three sides. The sidewalks and planters are situated above the podium deck. Based on the drawings provided, the podium deck consists of the concrete sidewalk on a compacted base, fibre board protection, waterproofing membrane, and insulation above the concrete slab. At the planters, the construction consists of wire mesh, crushed stone, asphalt impregnated fibre board, and three-ply built-up waterproofing membrane on the concrete slab.

The age of the waterproofing membrane of the podium deck is unknown; it is assumed to be original to the construction of the parking garage. The typical life expectancy of the waterproofing membrane of the podium deck is between 25 and 35 years. No signs of water infiltration through the podium deck was observed; however, based on the age it is recommended that the podium deck waterproofing membrane be replaced within the next five years. It is prudent to plan for the replacing the podium deck waterproofing membrane prior to signs of extensive membrane failure to minimize water infiltration and concrete degradation of the slab. Repairs to the podium deck will include replacement of sidewalks and will require removal and reinstatement of the planters.

Number	Event	Priority	Years	Cost/ Occurrence
3.3.1.2	Replace the waterproofing membrane of the podium deck.	B	2014	$150,000

Suspended Slabs – Waterproofing Membrane

The waterproofing membrane of the suspended slabs and interconnecting ramps is a thin set waterproofing system. The waterproofing membrane was in generally good condition with localized areas of delaminated membrane. Throughout, areas of patch repairs were observed (photograph 7). Based on the documentation provided, the waterproofing membrane was installed in 1984 and localized repairs were completed in 1991, 1996 and 2009.

Typically, the life expectancy of a waterproofing membrane on a suspended slab is between 15 and 20 years provided that repairs are completed. Generally, repairs are required in high traffic areas including driving lanes and ramp turns. We recommend including for complete replacement of the waterproofing membrane of the suspended slabs; this work should be completed in conjunction with concrete repairs of the parking garage (refer to item 3.3.1.1).

Number	Event	Priority	Years	Cost/ Occurrence
3.3.1.3	Replace the waterproofing membrane of the suspended slabs.	B	2018	$500,000

3.4 Building Envelope

3.4.1 Below Grade

It is assumed that the foundation walls are protected with dampproofing and that weeping tiles are provided around the perimeter for drainage. In the parking garage, wall cracks associated with efflorescence, corrosion staining, and dampness were observed (refer to Appendix D).

The first level below grade is occupied by the book store, theatre, meeting rooms, washrooms, etc. Most of the foundation walls in these areas are covered by interior finishes. We noted evidence of water penetration along the east elevation – water staining, corrosion of light casings and efflorescence were noted (photograph 8). Water penetration was reported in the storage area.

In addition, we noted evidence of water staining below the office tower lobby. We understand that the water penetration has been addressed during recent renovations to the office lobby.

Due to the location of the library, excavation to address water leakage through the foundation walls is not feasible. Epoxy injection is the most economical method of addressing water penetration through cracks in the concrete foundation walls. This work should be undertaken in coordination with the concrete repairs within the parking garage.

3.4.2 Exterior Walls

Concrete Block

At the west roof, there is an exposed concrete block exterior wall. It appears this was an infill that occurred sometime after the original construction. The details of the wall construction are unknown. The concrete block wall is in fair condition. Sections of missing mortar were observed (photograph 9) and there are openings through the wall to the exterior; these areas should be repaired as part of the operating and maintenance budget for the facility.

Precast Concrete Panels

The building is clad with precast concrete panels which are anchored back to the structure. The anchors are connected to base plates which bear on and are connected to the slabs. The angled concrete panels are connected by a threaded rod and adjustment assembly. The panels at the building have a smooth finish with exposed aggregate; the exposed aggregate is consistent and uniform in condition. Accent panels have vertical ribs with an exposed aggregate finish.

According to the drawings provided the panels are either:

- precast insulated sandwich panels consisting of a 2-½ inch exterior face panel, 1-½ inches of styrofoam insulation, and a 4 inch interior panel;
- 6 inch exterior precast panel, 1-½ inches of styrofoam insulation in a 3 inch cavity, and 10 inch concrete wall or concrete block structure;
- 7 inch exterior precast panel with vertical ribs, 1-½ inches of styrofoam insulation in a 2 inch cavity, and 10 inch concrete wall structure.

The precast panels are a face-sealed cladding system; no second layer of defence against water penetration or provision of drainage is provided. The integrity of the panels and the sealant is required to mitigate the potential for air leakage and water penetration, as well as to extend the service life of the panels.

Generally, the panels are in good condition. From the exterior, we observed a few cracks and areas of concrete scaling (photographs 10 and 11). Some discoloration or staining of the panels was observed which is likely attributed to dirt and water run-off (photograph 12). It appears that the majority of the items noted correlate to observations made in 2009 when Adjeleian Allen Rubeli completed the last detailed review of the precast panels, except for a cracked panel located at grid line H on the south elevation, at the main entrance (photograph 13). The noted cracking may be a result of movement of the panel above, putting undue stress on the ground floor panel, resulting in the cracking. We recommend undertaking repairs to this area in the near future. During the repairs, a review of the anchors should be undertaken.

On the north elevation, at the lower floors of the Sir Richard Scott Building, it appears that one panel is bowed (photograph 14). Due to the location of this panel, it is very difficult to get a clear visual of the panel, and due to the wall construction, it is not possible to review the anchor connections from the interior at this location. We recommend further investigation of this area.

It does not appear that the observed deficiencies have worsened in severity since 2009. For specific information regarding the observed condition of the precast panels during the exterior review, refer to Appendix E.

Surface concrete repairs were completed on the precast concrete panels in 2009 (in combination with the parking garage repairs). In addition, we understand that repairs to the panels and anchors above the parking garage entrance were conducted in 2007, at the time of the structural loading assessment.

As part of our review, Morrison Hershfield undertook a thermographic survey of the Library. Details regarding the survey are included in Appendix F. A thermographic survey can identify thermal anomalies in the building envelope that may be an indication of air leakage or conductive heat loss, which can be indicators of building envelope problems. As shown in the photographs in Appendix F, significant areas of air leakage and thermal bridging were noted around the facility. The majority of the air leakage is occurring at transitions in the cladding, and the thermal bridging is noticeable at the panel anchor locations. This is not unexpected for this type of building, the precast panels provide the main resistance against air leakage; therefore, the weak point of the air barrier system is at the joints and transitions. Failure of the sealant between precast panels results in a breach in the air barrier system, resulting in heat loss.

Air leakage and thermal bridging can result in increased energy costs due to heat loss; they can also be potential locations for condensation. As noted below, in areas reviewed we did not observe any indication of issues or concerns associated with the precast connections with respect to corrosion (which would be indicative of condensation).

Precast concrete panels are typically very durable, and can last the life of a building, with periodic repairs. Replacement of the precast panels is not anticipated, although we have included an allowance for repairs to the insulated precast concrete sandwich panels, as required, within the next five years. It is recommended that this work be completed in conjunction with the replacement of the sealant between the precast panels (refer to item 3.4.4.1). Repairs should include the sloped concrete at grade, which is showing signs of deterioration, including cracked and spalled concrete.

Number	Event	Priority	Years	Cost/ Occurrence
3.4.2.1	An allowance for repairs to the insulated precast concrete panels as required.	B	2014	$30,000

Panel Connections

The precast panel connections consist of a plate and steel bar cast into the precast panel. The steel bar rests on and is welded to a cast-in plate on the slab.

The cast-in plate is recessed in the slab and the entire connection is covered with a patching grout. Due to the patching grout, only small portions of the anchors are visible for review.

Adjeleian Allen Rubeli Limited completed a review of the precast panel connections in 2008 and 2009. Their investigations found no signs of cracked welds or distress at the connection points of the panels. The anchors reviewed appeared properly connected to the base plates which bear on and were connected to the slab. At the angled panels, Adjeleian Allen Rubeli noted surface corrosion on the entire threaded rod and adjustment assembly. The review determined that the panel connections were in good condition and no remedial work was required.

Morrison Hershfield conducted interior openings on April 18, 2012 to review the condition of the anchors. Anchors were also reviewed on the fourth floor where they are exposed within the mechanical areas and at the angled panels along Laurier Street via a crawl space area.

The panel connections observed are in good condition; with no signs of distress or any other significant structural damage or deterioration (photograph 19). On the fourth floor, some of the connection points are misaligned on the cast-in plate in the slab (photograph 20). This misalignment appears to be an as-constructed condition and does not appear to be the result of shifting panels. Surface corrosion was observed on a few of the anchors on the fourth floor and at the anchors of the angled panels within the crawl space (photograph 21). The observed condition of the panel connections is consistent with Adjeleian Allen Rubeli's previous findings.

Based on our observations, no additional investigations or repairs associated with the precast panel anchors are required, except at the repair location at the main entrance and the bowed panel on the lower floor of the Sir Richard Scott Building.

3.4.3 Windows

The windows at the building include fixed strip and punched windows as well as sloped glazing. The windows of the building consist of double glazed sealed insulating glass (IG) units within aluminum frames. The windows are set within openings of the precast concrete panels. Based on the available drawings, sealant is the primary air and weather seal between the windows and the precast concrete panels. Failure of the sealant can result in water penetration and air leakage around the windows. The available drawings provide limited details regarding the windows and the connection to adjacent cladding components. Generally, it appears that the windows have limited, if any, thermal break and due to the configuration of the precast concrete panels, there is some discontinuity of the plane of thermal resistance around the windows. The window frames are original to the building construction, and therefore do not provide the level of performance that would be achieved with windows manufactured today. This is likely contributing to the reported issues regarding drafts and condensation on the windows.

At the time of our site review, a few fogged units were observed indicating that the hermetic seals of the insulating glass units' edge seals have failed or that the internal desiccant is exhausted. The edge seals that create the hermetic seals of the fixed insulating glass (double-glazed) units will deteriorate with time, resulting in increased condensation accumulation within the unit as the internal desiccant is exhausted. Based on the date stamps of the IG units, it appears that the IG units have been replaced on an as-needed basis.

We noted the interior and exterior glazing tape around the IG units was in poor condition in most locations. We did not observe any evidence of water penetration at the windows, although most windows are protected by building overhangs, and therefore would not be exposed to significant precipitation.

The sloped glazing is of similar construction as the windows, but includes wired glass. No evidence of leakage was noted or reported at these locations.

Aluminum framed window systems have an expected service life of 30 to 40 years. The windows are original to the building, and are at the end of their expected service life and can no longer provide the level of performance expected today. Replacement of the windows would allow for the new windows with improved thermal performance, as well as provide the opportunity to improve the continuity of the thermal insulation and air barrier around the perimeter of the windows. This would result in improved performance, minimizing issues associated with drafts and condensation. It would also improve overall aesthetics of the building, and reduce maintenance costs. If the existing windows are maintained, budgets associated with repairs (including replacement of IG units and sealant) will be necessary. We recommend including for the replacement of the windows within the next five years.

Number	Event	Priority	Years	Cost/ Occurrence
3.4.3.1	Replace the aluminum framed windows.	B	2015	$175,000

3.4.4 Sealants

Sealant is installed between the precast concrete panels and around the perimeter of windows, doors and other penetrations. The majority of the sealant is in poor condition. We observed the following:

- “Alligator cracking” (photograph 22),
- Adhesive failure (photograph 23),
- Cohesive failure, and
- Localized areas of missing sealant (photograph 24).

Maintaining the integrity of the sealed joints between the concrete panels and around the windows and exterior doors is essential to ensure the weather-tightness of the building envelope. In addition, the sealant is a critical component of the air barrier system of the exterior cladding, and failure of the sealant may lead to heat loss or drafts associated with air leakage (as noted within the thermographic scan). The life expectancy of any sealed joint is dependent on several factors, including the exposure (e.g. direct sunlight), the amount of movement, and the quality of the original materials and workmanship. The range of these factors results in a wide range of realized life, from 5 to 20 years.

We would expect a typical life expectancy of between 10 and 15 years for a building of this type. The timing of the last sealant installation at this building is unknown. Between sealant replacement projects, there will be a number of localized failures that will need to be repaired as part of regular maintenance.

Based on the current condition, we recommend budgeting for replacement of the sealant between the precast panels in the next five years. It is recommended that the sealant replacement be completed in conjunction with the repairs to the precast concrete panels (refer to item 3.4.2.1).

Number	Event	Priority	Years	Cost/ Occurrence
3.4.4.1	Replace the exterior sealants between the precast concrete panels.	B	2014	$25,000

The remaining sealants at the building will be replaced in conjunction with, and have been included in the allowances provided for, the replacement of the windows, main entrance doors, and exterior secondary doors. Refer to items 3.4.3.1, 3.4.5.1, and 3.4.5.2 accordingly.

3.4.5 Exterior Doors

Main Entrances

There are two main entrances to the building; from Metcalfe Street on the east and Laurier Avenue on the south. From Metcalfe Street, the entrance doors consist of two exterior swing doors with double insulated glazing in aluminum frames. The age of these doors is unknown; it is assumed that these doors are original. From Laurier Avenue, access to the building is provided by two sliding doors which are automatically activated. The sliding doors are double glazed insulated glazed units in aluminum frames. The sliding doors were installed in 2004.

The main entrance doors are in good condition. There are localized surface scratches on the frame finish of the exterior doors. No problems with air leakage or operability were reported or observed.

The life expectancy of exterior entrance doors of this type ranges between 15 and 40 years. The wide range for the realized service life is largely due to level of maintenance received (cleaning, repairs), use of de-icing salts, and the level of use (and abuse) that the doors receive.

We have included for the replacement of the main Metcalfe Street entrance doors within the next 10 years. Replacement of the Laurier Street entrance doors are not anticipated within the time frame of this report. As the timing of replacement approaches, it is recommended that the condition of the doors be reevaluated and the scheduled replacement adjusted as necessary as the life expectancy is largely dependent upon the level and type of use that the doors receive.

Number	Event	Priority	Years	Cost
3.4.5.1	Replace the main entrance door systems (Metcalfe Street and Laurier Avenue entrances).	B	2018	$12,000

Service Doors

The service doors consist of painted metal swing doors in painted metal frames and provide access to the roof, parking garage, and exterior at grade. The condition of the service doors varies with location. The roof access doors are in poor condition with surface corrosion observed on the doors and frames (photograph 25). Within the parking garage the doors are in fair to poor condition with corrosion observed on the doors and the frames. We also noted broken vision panels and difficulty with the operation of the doors in the parking garage. The service doors to the exterior from the ground floor are in fair condition; localized areas of surface corrosion were observed (photograph 26).

These doors are assumed to be original to the construction of the building. The typical life expectancy of this type of exterior door is 35 to 40 years but this life expectancy is dependent upon the level of use and maintenance. We have included an allowance for the replacement of the service doors as required; at that time the frames and associated hardware can be replaced as required.

Number	Event	Priority	Years	Cost
3.4.5.2	An allowance to replace the service doors that provide access to the roof, parking garage, and exterior at grade as required.	B	2014	$25,000

Overhead Door

At the parking garage, an overhead door provides vehicular access from Laurier Avenue. The oversized door is a roll-up rubber system, and includes a steel frame and a thick rubber curtain. The overhead door of the parking garage appeared to be in good condition, although light surface corrosion on the frame was noted. No problems with the operation of the door were reported to, or observed by, us. The age of the overhead door is unknown; based on the current condition replacement is not anticipated within the time frame of this report.

3.4.6 Roofs

The east roof at the building consists of a combination of sloped and flat roofs protected by modified bitumen or single ply membrane. The west roof of the building has a modified bitumen membrane. No cut tests were completed on the roofs due to the inclement weather conditions.

The north side of the east roof consists of a protected membrane roofing system (where the membrane is located below, and protected by the insulation) with a single ply membrane. The ballast coverage appeared adequate and no weathering was noted. We noted some ridges in the membrane at the high parapet wall on the east elevation. This is typical in a single ply membrane, it shrinks as the membrane ages, pulling the membrane from the parapet walls. We did not observe any evidence of ponding on this roof level. The roof is drained via area drains, and parapets and penetrations have prefinished metal counter and cap flashings.

The typical life expectancy of a single ply membrane within a protected membrane roof assembly is between 20 and 25 years. It was reported that the single ply membrane roof system was installed around 1996. It was reported to us that prior to roof replacements, there had been water infiltration in the basement and damage occurring to the 3rd floor ceiling finishes. We were informed that there are no current issues with water infiltration from the roof. Replacement of the single ply roofing system is recommended within the next few years.

The south portion of the east roof appears to consist of a protected membrane roofing system with modified bitumen membrane. The remainder of the roof levels consist of conventional roofing systems (with the insulation located below the membrane) with modified bitumen waterproofing membrane.

The modified bitumen sheets appeared to be adequately lapped; no damage or deterioration was noted. At the west roof, the modified bitumen membrane continues up the parapet wall and is covered by the cap flashing; we noted some wrinkles in the parapet membrane. There was some evidence of ponding on west roof. No reports of water penetration or issues with these roofs were received.

Based on the information provided, the modified bitumen roofing systems were installed approximately four or five years ago. The typical life expectancy of a protected membrane roofing system, with modified bitumen membranes is between 25 and 30 years. The typical life expectancy of a conventional roofing system with modified bitumen membrane is between 20 and 25 years. We do not anticipate full replacement of the modified bitumen roofing membranes within the next ten years, although repairs may be required.

Number	Event	Priority	Years	Cost
3.4.6.1	Replace single-ply roofing membrane.	B	2014	$125,000
3.4.6.2	Allowance for repairs to the roof membranes.	B	2017	$35,000

Drainage

Drainage from the east and west roofs is managed by area drains. All roof drains were equipped with metal covers and the drains were observed to be clear of debris at the time of our review. Some evidence of water ponding was noted on the west roof. Standing water may reduce the life expectancy of the roofing system.

Flashings

At the east roof, prefinished metal flashing is installed at the base of the high parapet wall, as a cap flashing at the top of the parapet, around the base of mechanical equipment and vent penetrations, and at the edges of the sloped roofs. At the west roof, prefinished metal flashing is installed as a cap flashing at the parapet.

The flashings of the roofs were in good condition. Scratches in the surface finish of the flashings were noted. The parapet flashings appeared to be adequately sloped. The replacement of the metal flashings should be conducted concurrently with replacement of the roof membrane.

There are duct enclosures located on the north side of the east roof level. According to the drawings provided, these duct enclosures are constructed of concrete block, clad with cement parging. The parging was in fair condition; there were areas of surface cracking and evidence of previous patch repairs. Localized damage to the parging at the base of the wall flashing was observed (photograph 27). Repairs should be completed in conjunction with any roof repair or replacement project.

Access

A walkway with metal stairs provides access over the south duct enclosure on the east roof. The walkway consists of wooden planks with painted metal guardrails on both sides. The wood planks appeared to be in good condition with minor weathering observed. The wood planks are situated on a rigid insulation base; the insulation is deteriorating due to UV exposure at the edges. The painted metal guardrails were in good condition with localized areas of surface corrosion and scratches in the painted finish.

The stairs are painted metal open riser stairs with combination hand and guard rails provided on both sides. The two stairs are in poor condition. Localized areas of surface corrosion were observed on the railings. Corrosion was visible on all of the treads. One tread has corroded through (photograph 28). It is recommended that the two stairs be replaced. Due to the level of corrosion visible, the replacement should occur in the near future.

Number	Event	Priority	Years	Cost
3.4.6.3	Replace the two metal service staircases providing access to the east roof.	A	2012	$5,000

Access to the flat roof on the west side of the building is provided by a single staircase. These stairs are painted metal with open risers and a combination hand and guard rail provided on both sides of the stairs. The staircase is in good condition with surface corrosion observed on the treads. The staircase and railings should be abrasively cleaned and painted as part of the facility's operating and maintenance budget to prevent further deterioration. Complete replacement is not anticipated within the time frame of this report.

4. BUILDING INTERIOR

Upgrading of interior finishes is largely dependent on the aesthetic preferences of the owner. We have based our recommendations on our visual review of the interior finishes and expected service lives of similar types of interior finishes.

4.1 Ceilings

The majority of the ceiling finishes within the building consist of suspended tiles. Other ceiling finishes include painted drywall and drywall with a painted stipple finish. In the service areas, the ceiling finishes are unfinished or painted drywall or concrete.

Overall, the ceiling finishes are in good condition. Physical damage was observed on localized tiles. On the third floor localized water stained tiles were observed; it was reported to us that this damage had occurred prior to the replacement of the roof. In the basement meeting room, corrosion was observed on the T-bar grid of the suspended ceiling tile system (photograph 29). The drywall ceiling is cracked in the hallway providing access to the west roof; we were informed that this damage had occurred from contractors completing work above. There are areas of surface damage to the stipple finish in the staff lunch room. In the auditorium and staff lunch room, previous patch repairs of the stipple finish were noted.

We recommend including an allowance within the next 10 years for repairs to, and/or replacement of, the ceiling finishes. This work should be coordinated with the replacement of the light fixtures.

Number	Event	Priority	Years	Cost
4.1.1.1	An allowance for repairs to, and/or replacement of, the ceiling finishes.	B	2014	$25,000

Asbestos is contained within the drywall filling compound throughout the building. Appropriate measures should be taken when completing repairs to or renovation of the drywall ceiling finishes.

4.2 Walls

The wall finishes throughout the library, and associated office areas, consist of painted drywall or exposed concrete. In the computer lab, one wall has a painted finish allowing it to be used as a dry erase board. In the atrium, the predominant wall finish is precast concrete panels. In the auditorium, acoustic fabric covered wall panels and a decorative accent wall of vertical stained wood are installed. Ceramic tile is installed within the staff and public washrooms. In the service areas, the wall finishes are painted or unfinished drywall, concrete block, or concrete.

We have assumed that the wall finishes within the library were painted at the time of the carpet replacement between 2004 and 2006. The ceramic tile in the public washrooms was installed within the last three years; however, in the staff washrooms, the ceramic tile is assumed to be original. All other wall finishes are assumed to be original to the construction of the building.

The wall finishes are generally in good condition with the following exceptions observed. In a third floor library storage room, wood panelling is installed on the walls and the panels are no longer attached securely at the top and bottom of the walls. In localized areas the drywall finish was scuffed or damaged. We were informed that the majority of this damage is due to library service carts. In these locations, lower wall protection could be installed.

We recommend budgeting for repainting of, and localized repairs to, the wall finishes within the next 10 years. If extensive renovations are completed, it is recommended that the painting of the walls be coordinated with that work.

Number	Event	Priority	Years	Cost/ Occurrence
4.2.1.1	An allowance for repainting of the wall finishes, localized repairs to the wall finishes, and installation of lower wall protection (as required).	B	2019	$100,000

According to the Designated Substances Report provided for our review, asbestos is assumed to be contained within the drywall filling compound throughout the building. Additional testing is recommended prior to major renovation or demolition to determine the presence of asbestos in the work area. Appropriate measures should be taken when completing repairs to, demolition of, or renovation of the walls.

According to the provided documentation, lead in varying concentrations is contained in the paint used throughout the facility. Any demolition or renovation work should be completed under controlled conditions to ensure that the lead particles do not exceed maximum airborne levels.

4.3 Interior Doors

The majority of the doors within the facility are painted hollow core swing doors in painted metal frames, with or without wired glazed inserts or vision panels. In a few locations, decorative doors are installed. The decorative doors, and associated wall panels, are wood with a pattern of clear and frosted glass inserts.

Generally, the doors are in good condition. Typically, we observed localized areas of peeling paint and scuff marks at the bottom of the doors where kick plates were not installed. Surface corrosion was noted on a few doors.

The expected service life of the interior doors is upwards of 50 years and as such the replacement of those doors is not required within the time frame of this report. Repairs to the doors, or localized replacement, can be completed as required from the operating and maintenance budget for the building. The frequency of painting of the interior doors, and frames, is dependent upon the level of use and abuse to which the door is subject and the aesthetic preferences of the user. We have included for the painting of the interior doors and frames in the allowance provided for the painting of the interior walls; refer to section *4.2: Walls*.

Interior Door Hardware

Interior door hardware includes closers, D-pulls, push plates, pull handles, push bars, lever handles, twist knobs, and locksets. Generally, lever handles have been installed in the public access areas while twist knobs are installed in the staff access only areas. Overall, the door hardware was in good condition and replacement should be completed out of the operating and maintenance budget on an as-needed basis.

The twist knobs in the staff areas appear to be original; operational discomfort due to the size and shape of the knobs was reported to us. It is recommended that staged replacement of these twist knobs be completed from the operating and maintenance budget, with the areas with the highest use being replaced first.

4.4 Flooring

Floor finishes include carpet, carpet tile, rubber sheet flooring, vinyl flooring, hardwood, ceramic tile and painted concrete.

Carpet

The most predominant flooring type installed in the building is carpet tile. Carpet tile is installed in the first to third floors of the library and in the auditorium. In the public areas of the library, we were informed that the carpet tile was installed approximately six to eight years ago. In the staff areas of the library, the majority of the carpet tile was installed between 10 to 12 years ago, with portions replaced in conjunction with the carpet replacement of the public library areas between 2004 and 2006. There are localized areas where the carpeting is original to the construction of the building.

Generally, the carpet tile is in good condition. It was reported to us that localized damaged tiles are replaced as required as part of the regular maintenance of the building. With the older carpet, localized areas of staining and fraying at edges were observed.

The typical life expectancy of carpeting ranges between 12 and 20 years. The actual service life is dependent upon the level of use and aesthetic preferences. We recommend including for replacing the carpeting within the building in the timeframe of this report

Number	Event	Priority	Years	Cost/ Occurrence
4.4.1.1	Replace the carpeting within the building.	B	2019	$275,000

Rubber Sheet

At the main entrance to the library, anti-slip rubber sheet flooring is installed. Based on the documentation provided, the rubber flooring was installed in 2004. The rubber flooring is in good condition; replacement is not required within the time frame of this report.

Vinyl Tile

Vinyl tile flooring is installed at the basement level in the corridors and storage areas. All vinyl tile flooring is assumed to be original to the construction of the building. The vinyl tile flooring is in fair condition with localized areas of stained, cracked, depressed, and chipped tiles observed.

Typically, vinyl flooring is replaced prior to life expectancy for aesthetic reasons and not due to functionality or performance. Replacement of the vinyl flooring is not anticipated within the time frame. If repairs or localized replacements are required, this can be achieved under the operating budget for the facility.

According to the documentation provided, the 12” x 12” light beige vinyl tile visible in various storage and maintenance rooms and installed beneath the carpet in the staff lunch room and other locations in the facility contains asbestos. Appropriate procedures should be taken regarding the removal and disposal of the asbestos containing vinyl tiles.

Hardwood

The stage of the auditorium consists of hardwood parquet flooring. We were informed that the flooring was installed in 2011. The hardwood flooring is in good condition; there are a few scuff marks in the surface finish. Complete replacement of the hardwood flooring is not expected within the next 10 years.

Ceramic Tile

Ceramic tile flooring is installed within the staff and public washrooms. We were informed that the public washrooms have been completely renovated within the last three years. The ceramic tile in the staff washrooms is assumed to be original. The ceramic tile is in good condition; although we noted areas of grout discolouration in the staff washrooms. The ceramic tile flooring should last the life of the building, although repairs will likely be required and replacement may be desired for aesthetic reasons. Repairs to, or replacement of, the ceramic tile is not anticipated within the next 10 years.

Service Rooms

The floors of the service rooms are painted concrete. The painted finish was generally in good condition. We noted localized areas of peeling paint and staining, the extent of which varied from room to room. The service room floors can be painted as part of the regular maintenance for the facility.

4.5 Interior Trim

Interior Trim

Where carpet abuts a painted drywall finished wall, carpet or vinyl baseboards are installed. Ceramic tile baseboards are installed with ceramic tile flooring. The interior trim is in good condition with the exception of the carpet baseboards. The carpet baseboards are wavy and are detaching from the walls. At the library carrels, the carpet baseboard is frayed and torn.

Minor repairs of the trim can be completed as required from the operating and maintenance budget, to minimize damage to the drywall finish of the interior walls this work should coincide with repairs to or repainting of the interior walls. It is recommended that replacement of the baseboards be completed at the same time as repairs to or replacement of the adjacent flooring (carpet, vinyl, tile). The cost of repairing or replacing the trim, as required, has been included under section *4.4: Flooring*.

Furnishings

Interior furnishings include floor mounted washroom partitions, lavatory countertops, lockers, and built-in cupboards and countertops. The age of the furnishings within the building is unknown; lockers, built-in cupboards, countertops, and the washroom partitions and lavatory countertops in the staff washrooms are assumed to be original. In the public washrooms these fixtures are assumed to have been replaced during the washroom renovations within the last three years.

The furnishings are in generally good condition. There are scratches in the metal finish of the staff washroom partitions. Localized chips in the melamine countertops and painted wood cupboards were observed. In the third floor office area of the library, the wood cupboards are damaged in one location. Dents and corrosion staining at the bottom of the lockers was noted.

We recommend including a periodic allowance for upgrades and/or repairs to the miscellaneous interior furnishings within the next five years.

Number	Event	Priority	Years	Cost/ Occurrence
4.5.1.1	An allowance for upgrades and/or repairs to the miscellaneous interior furnishings.	B	2016	$5,000

In the auditorium, fabric covered folding seats are installed. It was reported to us that the auditorium has 192 seats including three accessible spaces. We were informed that the auditorium seating was installed in 2011 and that the seating was salvaged from the Centrepointe Theatre. The auditorium seating is in good condition. Localized areas of fabric discolouration or staining were observed. Replacement is not anticipated within the time frame of this report.

Interior Windows

Interior windows are installed between the library and the atrium. These windows are single glazed wired glass units in aluminum frames. Adjacent to the Metcalfe Street entrance there is a stained glass window. All of the interior windows are in good condition. As they are not exposed to the elements, they should last upwards of 50 years unless physically damaged. As such, no provision for the replacement of these windows has been included in this report.

Compact Shelving

A floor mounted compact shelving storage system is installed in a basement storage room. The compact shelving appeared to be in good condition; no problems with the system were reported to us. Due to the insertion of shelving between the storage banks, the compact shelving system is not currently functional. Replacement of the compact shelving storage system is not anticipated within the time frame of this report.

4.6 Indoor Air Quality

We received reports of concerns associated with the indoor air quality within the building. This included reports of odours and issues with maintaining temperatures. It was reported that areas of the building are too hot during the heating season and too cold during the cooling season.

An investigation, including monitoring temperature, relative humidity and carbon dioxide levels within the borrower section was completed in October 2011. The report found all measured levels were within recommended ranges, although temperature readings were above the referenced ASHRAE comfort range.

Morrison Hershfield measured interior temperature and relative humidity at various locations throughout the library during our site visit on February 2, 2012. A table of measurements is included in Appendix G. We generally noted that a number of the interior temperature readings were near or above the upper comfort range referenced in ASHRAE.

Modifications to the temperature setting may be warranted in some areas. As noted in Section 6.5, we recommend replacement of the main air handler coil unit control valves, which may also be a contributing factor in the noted temperature discomfort. In addition, the local thermostats, sensors and control dampers in the areas where discomfort is noted should be reviewed to confirm operation.

5. ELECTRICAL SYSTEMS

5.1 Electrical Site Services

Hydro Ottawa provides the building with an electrical service via a single 13.2 kV loop from their distribution system. The electrical service enters the building at street level and runs through a concrete encased duct at the basement ceiling level to the main electrical vault in the basement. A customer owned 15 kV switchboard manufactured by Federal Pacific (photograph 30) contains the loop load breaking switches and a medium Voltage minimum oil breaker that supplies the step down transformers. The switchboard is located in a dedicated vault with access controlled by Hydro Ottawa. The vault opens off of the parking garage on the first level.

The main 15 kV switchboard is in poor/fair condition. It is 40 years old and has reached the end of its normal service life. It is due for its regular maintenance. However, it is still functioning as intended and has only normal wear and tear due to age. Its life span could be extended with a major refit to replace insulation systems, protective relaying and main oil circuit breaker. However, this work would require an extended power outage to the building and costs would be similar to replacement with all new equipment.

The conductor from the medium Voltage breaker to the transformers is bare copper IPS bus supported by ceiling mounted porcelain standoff insulators connected to single conductor shielded cable with stress cones. The cable is a replacement for the original bare IPS bus (photograph 31) which appears to have been damaged in an electrical failure at some time in the past.

The service is transformed to a 2,500 Amp, 600/347 volt, 3-phase service through three single phase 13.2 kV to 347 Volt 833 kVA transformers. The secondary of the transformers is connected via multiple runs of single conductor cable to an overhead bus duct that runs to the 600 Volt main electrical room. The portion of the bus duct (photographs 31 and 32) located over the transformers appears to have been replaced or rebuilt. This probably occurred at the same time as the replacement of the bare IPS bus.

Hydro Ottawa provided vault access for a visual inspection. The vault has a dust build up on all surfaces including the standoff insulators. This is a risk for electrical tracking and failure. Vault cleaning and service is required. Additionally it was observed that water leakage has occurred in the vault from the roof at some time in the past. Temporary drip shields (photographs 31 and 32) have been put in place to redirect the water away from the transformers and bus duct. The water leakage should be addressed and these temporary shields removed. The building staff was made aware of the risk.

The medium voltage switchgear in the hydro vault, medium Voltage conductors and 600 Volt Main bus duct are, with the exception of the repairs described previously, from original construction. They are estimated to be greater than 40 years old. The equipment as observed is in poor condition.

The industry accepted manufacturer lifespan for this type of equipment is typically 40 years. Existing equipment is beyond this age. Aged equipment has an increased risk of failure due to the breakdown of the insulation systems. Parts and service for the equipment will also become expensive or unavailable.

Number	Event	Priority	Years	Cost/ Occurrence
5.1.1.1	Maintenance of Hydro Vault and equipment.	A	Every 3 years	$5,000
5.1.1.2	Replace main 15 kV switchboard including transformer primary conductors.	B	2013	$350,000
5.1.1.3	Correct water leaks in Vault.	A	2012	$10,000

5.2 Electrical Power Distribution System

Main Switchboard:

Power is supplied from the transformer vault through a 3000 Amp bus duct to the main buildings 4000 A, 600/347 volt, 3 phase, 4 W Federal Pacific switchboard. The main switchboard (photograph 33) is located in the main electrical room situated on Level B and consists of four sections:

- Section One: 3000A, 600V, 3-pole main breaker, 1600 Amp 3 Pole breaker and utility metering supplying the tower bus duct riser (tower distribution is not included in this report) and analogue Volt and Ammeters.
- Section Two: 1600 Amp 3 Pole breaker (main breaker for Library) and utility metering supplying moulded case breaker distribution section (back of switchboard). The moulded case breakers in this section supply the emergency power transfer switch (see Emergency Power Section for description of transfer switch and supplied loads), penthouse mechanical room 600 Volt switchboard, MCC#2, 300 kVA transformer in section 3 and a new breaker supplying the new chiller in the penthouse.
- Section Three: 300 kVA dry type transformer 600 to 120/208 Volts supplying section four.
- Section Four: Fused disconnect switches supplying basement, first and second floor lighting and receptacle panels.

Penthouse Mechanical Room 600 Volt Switchboard:

The three section switchboard in the penthouse (photograph 34) has:

- Section One: Fused disconnect switches supplying MCC#3, 450 kVA transformer in section two, old chiller (this may now be a spare) and a spare disconnect.
- Section Two: 450 kVA dry type transformer 600 to 120/208 Volt supplying section three.
- Section Three: Fused disconnect switches supplying lighting and receptacle panels on the second, third and penthouse floors.

The single line diagram posted in the 600 Volt main electrical room has not been updated with changes to the electrical distribution system. Service personnel use the single line diagram for identifying which devices to open to isolate power. Incorrect and out of date single line diagrams may lead to the wrong device being opened resulting in exposing workers to hazardous conditions.

The main breaker for the library in section two of the main switchboard has been replaced with a modern breaker. This suggests that the original breaker failed. It further suggests that failure of the other similar breakers may be expected in the future. This approach to replacement is problematic. It is more expensive to replace equipment piecemeal than to do a complete replacement. Additionally, there is the risk of failure of original equipment damaging replaced equipment. Overall replacement of the equipment based on revised and modernized distribution plan is recommended over piecemeal replacement.

The main 600 Volt and the penthouse 600 Volt switchboards are original to the building and are greater than 40 years old.

The industry accepted manufacturer lifespan for this type of equipment is typically 40 years. Existing equipment is beyond this age. Aged equipment has an increased risk of failure due to the breakdown of the insulation systems. Parts and service for the equipment will also become expensive or unavailable.

Based on end of lifespan condition and evidence of recent significant repairs the main 600 Volt switchboard is in poor condition. Based on end of lifespan condition, the penthouse 600 Volt switchboard is in poor condition.

The style of 600/120/208 Volt switchboard and distribution utilizing large dry type transformers (transformers greater than 112.5 kVA) has fallen out of favour due to the high available fault currents and high arc flash incident energies. We recommend replacement of these systems include redesigning the system for a distributed design using smaller dry type step down transformers to reduce incident energy and arc flash risk.

Number	Event	Priority	Years	Cost
5.2.1.1	Update posted single line diagrams.	A	2012	$3,000
5.2.1.2	Replace main 600 Volt switchboard and associated conductors.	B	2013/14	$450,000
5.2.1.3	Replace penthouse 600 Volt switchboard and associated conductors.	B	2013/14	$350,000

5.3 Emergency Power Systems

Emergency back-up power is supplied by a 60 Kw, 75 KVa, 600/347 volt, 3 phase diesel generator (photograph 35) located in an open mezzanine off of the parking garage first level. Also located in the mezzanine is MCC#2 (photograph 36). This MCC contains the transfer switch that in turn supplies the MCC. This is a 600 Volt, 100 Amp main bus MCC. It contains the starters and disconnects supplying:

- building exhaust fans,
- garage exhaust fans,

- sump pumps,
- 30 kVa transformer supplying panel “1EM”, and
- garage doors.

Panel 1EM supplies the 120 Volt emergency loads such as:

- fire detection and alarm system,
- garage gas detection system,
- emergency lighting, and
- exit signs.

This generator is original to the building. Industry standard life span for an emergency generator is 25 years. It is not an issue of the machine wearing out. Typically standby or emergency generators have very low operating hours. The problem is the manufacturer stops supporting the machine with replacement parts. When a part fails, the machine is unavailable. If the replacement part is unavailable or not available for an extended period, the emergency power system is not functioning. This may drive an emergency replacement or rental of a temporary machine to provide emergency power. There are life safety loads supplied by this generator.

In addition to age, the engine is currently leaking fluids (observe the staining under the machine and the absorbent pads under machine to collect leakage in photograph 35) and the generator alarm panel appears to be lying loosely on the generator frame. Adjacent to the alarm panel is a duplex receptacle that is mounted facing up. We recommend providing an outdoor weatherproof receptacle cover to prevent foreign material from dropping into the receptacle.

During the site inspection it was observed that surplus material is lying on top of the fuel lines to the generator. This risks the material damaging the fuel lines and causing a leak. This material should be removed. The generator fuel system consisting of the day tank fill lines and output and return line to the generator are all of single wall construction without any form of spill containment. TSSA has been condemning fuel systems of this type. Once condemned, suppliers are no longer allowed to fill the tank. The machine therefore becomes unavailable for use.

The current generator location is an open mezzanine that also contains the transfer switch and emergency distribution. During generator replacement, it will be necessary to bring the installation up to current codes. This will require construction of a dedicated fire rated room to house the generator and its fuel system. The transfer switch and emergency distribution are required to be located external to the room. Therefore this is not a simple replacement of an existing generator with a matching machine. The new machine may also increase in size once the loading is reviewed as the requirement for loads on emergency power may have changed since the original installation.

The transfer switch MCC#2 combination and Panel 1EM are all original to the building and greater than 40 years old. Motor control centers and transfer switches due to the many moving parts, have an industry accepted life span of 25 to 30 years. Panels have an industry accepted lifespan of 40 years.

The existing emergency power installation does not conform to current life safety system codes. Any replacement would require an upgrade to current standards. Chiefly this would require separation of life safety and non-life safety loads onto different distribution systems. For example: sump pumps are asset preservation loads and not life safety loads such as a fire detection and alarm system or emergency lights and exit signs.

Number	Event	Priority	Years	Cost
5.3.1.1	Replace emergency power system transfer switch, distribution and associated conductors.	B	2013/14	$225,000
5.3.1.2	Replace emergency generator and associated fuel, exhaust and ventilation systems. Provide new fire rated room to house generator.	B	2013/14	$350,000
5.3.1.3	Remove material stored on top of fuel lines.	A	2012	$0
5.3.1.4	Provide outdoor weatherproof receptacle cover.	A	2012	$100

5.4 Dry Type Transformers

Dry type transformers form part of the main 600 Volt switchboard assembly and the penthouse 600 Volt switchboard assembly. Refer to Section 5.2 for descriptions, conditions and recommendations.

5.5 Panelboards

Lighting and receptacle panels (photograph 37) used throughout the building are CGE commercial grade panels and have capacities of 42, 36 or 24 circuits. These panels are located in electrical closets on each level. The lighting panels are equipped with a main contactor controlled by remote switch/relays to allow control of lighting groups. This was the typical style of bulk lighting control when the building was constructed. All panels are supplied from the large dry type transformers in the main 600 Volt switchboard and the penthouse 600 Volt switchboard. These panels are original to the building and are greater than 40 years old.

The industry accepted manufacturer lifespan for this type of equipment is typically 40 years. Existing equipment is beyond this age. Aged equipment has an increased risk of failure due to the breakdown of the insulation systems. Parts and service for the equipment will also become expensive or unavailable.

Supplying panelboards utilizing large dry type transformers (transformers greater than112.5 kVA) has fallen out of favour due to the high available fault currents and high arc flash incident energies. We recommend that replacement of these systems includes redesigning the system for a distributed design using smaller dry type step down transformers to reduce incident energy and arc flash risk.

The bulk control of lighting panels using main contactors has fallen from favour due to the inflexible nature of the control. Modern practice is a lighting/relay panel combination that allows finer control (individual circuits of lights) of lights to facilitate energy management strategies such as day light harvesting, occupancy sensor control, etc. We recommend replacement of the existing lighting control system with such a system.

The receptacle panels have fewer circuits than would currently be installed in a facility of this type. The wide spread use of computers, printers, etc. has required an increase in the number of circuits provided. We recommend replacing the existing panels with panels that provide more circuits. During the site inspection it was evident that few spare circuits remained available.

The existing electrical closets are too small to accommodate much increase in panel size and number. Reconfigure electrical closets to accommodate space for more panels and telecom equipment.

Number	Event	Priority	Years	Cost
5.5.1.1	Replace lighting, receptacle panels and associated conductors.	B	2013/14	$400,000
5.5.1.2	Construct/renovate electrical closets to accommodate more panels and telecom equipment.	B	2013/14	$125,000

5.6 Conduit & Raceways

Branch circuits are wired in conductor in conduit and BX type cable. The conductor in conduit is mostly original to the building. The BX is a combination of original and new construction.

Industry best practice is to replace conductors when feasible during distribution equipment replacement. Typically the conductors will have an age and condition similar to the equipment being replaced. The same problem of insulation system degradation that reduces the reliability of distribution equipment also affects conductors. Therefore, a typical life span of 40 years may also be applied to conductors.

As an exception to this practice, motor supply conductors are not always replaced when they appear to be in good condition and have been professionally installed. Motor control equipment life span is typically 25 to 30 years. This leaves the conductors with significant life when the motor control is replaced. However, in this building, the motor control equipment is of original construction. Therefore the associated conductors will have also exceeded a 40 year life span.

For purposes of this report conductor replacement cost has been included in the replacement of supply/distribution equipment, motor control equipment and lighting equipment.

5.7 Motor Control Centres

MCC#2 (photograph 38) is located in the main electrical room. This four section 600 Volt, 400 Amp main bus, integrated motor control center controls loads on the lower levels of the building. Examples of these loads are: sewage pumps, basement exhaust and supply fans, air compressors, heating cables, etc. It is of original building construction and is greater than 40 years old.

MCC#3 (photograph 39) is located in the penthouse mechanical room. This five section 600 Volt, 800 Amp main bus, integrated motor control center controls loads in the mechanical penthouse, second and third floors. Examples of these loads are: elevators, exhaust and supply fans, pumps, etc. It is of original building construction and is greater than 40 years old.

Miscellaneous loose starters/variable speed drives are located throughout the building for individual motor loads. Examples of these would be the new chiller VSD in the mechanical penthouse, which is of new construction and less than 10 years old.

MCC#2 and 3 are in poor condition (equipment at or past its lifespan). MCC#2 does not appear to have sufficient code mandated access clearance. During replacement, it may be necessary to find a new location for the MCC. This will add to the replacement cost.

Loose starters/VSDs are in poor to good condition. However, given the simplicity of replacement for equipment of this type, operation to failure is not an unreasonable strategy. Therefore, no replacement/upgrade is recommended.

Number	Event	Priority	Years	Cost
5.7.1.1	Replace/relocate MCC#2 including conductors.	B	2013/14	$175,000
5.7.1.2	Replace MCC#3 including conductors.	B	2013/14	$250,000

5.8 Fire Detection and Alarm

The existing Siemens fire detection and alarm system is an addressable single stage system. The main panel is located in the main 600 Volt electrical room (photograph 40) on the first basement level. It is a replacement system and is not original to the building. It is estimated to be less than 15 years old. Smoke and heat detectors are used as fire detectors. Horns are used as notification devices. There is an annunciator panel located at the front entrance ground floor.

The fire detection and alarm system is in good condition with an estimated 10 to 15 years of service life remaining.

5.9 Interior Lighting Systems

Fluorescent lighting is used throughout the facility. There are approximately 5000 2’X2’ “lay in” fluorescent fixtures (photograph 41) installed in the public and administration areas of the library. All of these fixtures have recently been converted to T8 electronic type.

All other areas, maintenance rooms and corridors are lit by 2’X4’ strip or commercial T12 type fluorescent fixtures.

Ornamental fixtures, pot lights (photograph 42) and two lamp (photograph 43) 1'x4' surface mounted wrap around lens fixtures also are used in the building.

Lighting control is through a combination of line Voltage switched and low Voltage lighting panel main contactor bulk control. The bulk control of lighting panels using main contactors has fallen from favour due to the inflexible nature of the control. Modern practice is a lighting/relay panel combination that allows finer control (individual circuits of lights) of lights to facilitate energy management strategies such as day light harvesting, occupancy sensor control, etc. We recommend replacement of the existing lighting control system with such a system.

Generally, despite ongoing upgrades to T-8 Lamps and electronic ballasts the light fixtures are in poor condition. Acrylic lenses have become opaque and yellowed. This reduces the transmission of light. Illumination levels are low. The use of multiple fixture and lamp types adds cost and complexity to the maintenance program. Light fixtures are normally considered to have a life span of 25 years. Most of these fixtures are greater than 25 years old.

Number	Event	Priority	Years	Cost
5.9.1.1	Redesign lighting system and replace.	B	2013/14	$1,250,000

5.10 Exit Signs

Exit signs are red lettered (photograph 44) brushed aluminum case with unilingual English "Exit" illuminated. They are supplied from the emergency power system. They are not original to the building and are estimated to be greater than 10 years but less than 20 years old. The exit signs use incandescent lamps.

The exit signs are obsolete and energy inefficient. Incandescent lamps are less efficient than a modern LED style exit sign.

Number	Event	Priority	Years	Cost
5.10.1.1	Replace exit signs with bilingual or symbol based exit signs to modern energy efficient standard.	B	2013/14	$75,000

5.11 Emergency Lighting

Emergency lighting is provided by a combination of un-switched fluorescent lights connected to the emergency power system and emergency battery units (photograph 45). The un-switched fixtures are described under section *5.9 Interior Lighting*.

The emergency battery units are of various vintages and manufacture. Typically they have integral heads with incandescent lamps.

Emergency battery units are tested regularly and replaced as required. No condition issues are noted.

5.12 Telecom Infrastructure

At time of original construction, telecom consisted of telephones. As with most buildings of this vintage, data conductors (both fibre and copper) have been added on an ad-hock basis without an overall infrastructure plan or standard. Refer to photograph 46 for typical data conductor installation. The usual conduit, cable tray, and jay hook wire management do not exist. Conductors lay in ceiling spaces or are tied (using zip ties) to convenient structure. No plan exists to guide installation of new or removal of old data conductors.

Data conductors are not properly supported.

Number	Event	Priority	Years	Cost
5.12.1.1	Develop data conductor infrastructure plan in conjunction with future renovation modernization plans.	B	2013/14	$50,000
5.12.1.2	Provide data conductor wire management systems in conjunction with light fixture replacement to take advantage of disturbance of ceiling grid. Remove surplus conductors from ceiling spaces. Note conductors and systems not included.	B	2013/14	$150,000

6. MECHANICAL SYSTEMS

The service life of the mechanical equipment given in this report is the median service life according to American Society of Heating, Refrigeration and Air-Conditioning Engineers and based on the apparent year of installation, current condition, and the evaluation by Morrison Hershfield. This is the time that the equipment might be expected to remain in operation before replacement. Replacement may occur for any reason including, but not limited to, failure, general obsolescence, or reduced liability (excessive maintenance costs).

6.1 Heating Systems

Heating for the building is by hydronic radiators and forced air. There are two Cleaver Brooks Model CB-700 gas fired fire tube water boilers, each with 5,230,000 btu/hr input, and they are original to the building construction. One boiler is used as the lead boiler; the other is used as a lag for standby. The boilers were originally sized to match the heating needs of the library and adjoining office tower combined; however the office tower was later equipped with its own stand-alone heating systems. As a result, there is spare heating capacity.

Regular maintenance including annual cleaning of the tubes has kept the boilers in good condition. Both boilers have been regularly and periodically overhauled with new parts and should have an expected service life well beyond the report threshold period.

The boiler and air handling unit preheat coil circulation pumps, located in the penthouse mechanical room, are original Leitch model centrifugal base mounted types. These pumps were noted to be in fair to good condition; however there is evidence of fluid leakage at shaft seals, out dated parts, and the inefficient pumps have exceeded their expected service life. Replacement of these pumps should be anticipated within the threshold period of this report.

The main entrance and lobby is heated by forced air convection units and radiators. For the most part, these units are original and noted to be in poor to fair condition. Replacement of these units should be anticipated within the threshold period of this report.

The main entrance to the public library appears to have had an original forced air curtain over the main entrance door replaced with a new infra-red heating unit during the 2004 renovation.

The entire underground garage exit ramp heating system was refurbished in 2009 with a new boiler, in slab PEX tubing, controls and distribution. Replacement is not foreseen as being necessary within the time frame of this report.

Number	Event	Priority	Years	Cost/ Occurrence
6.1.1.1	Replace four heating circulation pumps.	B	2016	$25,000
6.1.1.2	Replace cabinet force flow and perimeter convection heaters.	B	2016	$15,000

6.2 Cooling Systems

The original Trane Centravac 300 ton centrifugal chiller was replaced with a new 110 ton Carrier screw type chiller in 2009, utilizing R134a refrigerant. The new chiller capacity was downsized from original in order to match the cooling load of the main library spaces. The condition of the chiller was noted to be good and there were no operating issues reported. The chiller circulating pump was replaced as well as associated piping and trim. Replacement is not foreseen for the chiller or any of its components during the report horizon.

The original cooling tower was also replaced in 2009 with a new BAC model 15162 induced draft single cell unit, having 160 tons nominal capacity. The cooling tower main circulation pump as well as piping and valve trim were also replaced at this time. Replacement of the cooling tower and associated equipment is not foreseen over the report horizon.

6.3 Air Handling Systems

Two high volume, high pressure Sheldons centrifugal fans, mounted inside the main common air handling system located in the penthouse, provide heating ,cooling and ventilation to the public library floors and supplemental make-up air to the basement garage levels. One fan, equipped with a 60 hp motor having 36000 cfm capacity, serves the west side of the complex while the other fan, having a 75 hp motor and 43,000 cfm maximum capacity, supplies the east side library floors. Ceiling return air picked up from the library ceiling spaces is mixed with outside air, filtered, tempered or cooled, and is either fed down as supplementary make-up air to unit handlers serving the garage levels, or as supply air to the four floors of the main library.

The centrifugal fans are original to the building and were originally oversized to accommodate the future ventilation requirements of the adjoining Tower. The adjoining tower was equipped with its own stand-alone HVAC air supply systems. As a result, these two central air handling units are currently oversized and have had their operating speeds adjusted down to minimal levels in order to provide ventilation air for the four floors of the public library and supplemental make-up air to air handling units in the lower garage levels.

The fan motors appear to have been changed within the last four years and the units were equipped with ABB variable speed drives in 2008 for capacity control.

The Sheldons large centrifugal supply air fans were noted to be in very good condition considering their age and appear to have had regular scheduled maintenance. With regular scheduled preventive maintenance on these units, replacement of the air handlers is not foreseen within the report horizon.

The cooling coil inside the main air handling unit appears to have surface corrosion developing on its tube ends (photograph 47), as well as elbows, and will need replacement within the report horizon.

The first and third levels of the parking garage are each equipped with a Sheldons suspended heating and ventilating make up air handling unit supplying heated make up air for the garage exhaust. The capacity of each unit was listed at 18,000 cfm and the units are original. The condition of each unit was noted to be fair to good. With regular maintenance and overhauls, replacement of these units is not anticipated during the report horizon.

Number	Event	Priority	Years	Cost/ Occurrence
6.3.1.1	Replace main air handling unit cooling coil.	B	2015	$25,000

6.3.2 Fans

The garage levels are equipped with two suspended cabinet type exhaust fans per level. The fans are original, are manufactured by Sheldons Co. Ltd and have a listed capacity of 4500 cfm each. The exhaust fans operate on a call from an Armstrong CO monitoring system sensor, two sensors on every garage floor level. Generally, the fans were in good condition; however several fans located on the north side lower floor levels were noted to be corroding heavily (photograph 48).

An allowance for replacement of at least three of the 12 original garage exhaust fans should be allowed for within the report horizon. The remaining fans appear in good condition and useful service life can be extended with routine maintenance.

Washrooms are exhausted via one of two spun aluminum mushroom dome fans on the roof. The exhaust fans appear to be recent replacements for the original ones and are in good condition. No replacements are foreseen within the time frame of this report.

There are several miscellaneous small exhaust fans serving transformer rooms, storage spaces and electrical rooms. The ages and conditions of these fans vary and replacements, if required, can be handled through the maintenance budgets.

Number	Event	Priority	Years	Cost/ Occurrence
6.3.2.1	Replace three lower level garage cabinet exhaust fans.	B	2015	$9,000

6.3.3 Humidification Systems

Library space humidification is provided by two gas fired Nortec steam humidifiers located in the penthouse mechanical room. The units are model GSTC types with maximum capacity output of approximately 220 lb/hr and 440 lb/hr. The units inject steam vapour, when required, into each of the two supply air ducts via a steam bar inside the duct.

The units were replacements for the original humidifiers in the air handlers and are believed to have been installed in 2008. They are in good condition. Replacement is not anticipated during the report horizon.

6.3.4 Variable Air Volume (VAV) Boxes

The supply air for the library is distributed throughout the floors through variable air volume and constant volume terminal boxes manufactured by Buensod. Each is equipped with individually pneumatically controlled actuators controlled via wall thermostats. We were informed that approximately 90% of the terminal boxes are still original and the remainder have been replaced over time as they failed. Where observed, the boxes appear to be in good condition. Considering the high reliability of these types of terminal boxes, good availability of parts, replacement of these boxes and associated parts should be easily managed through the operation and maintenance budget. An allowance for replacement of these boxes is not foreseen over the duration of the report horizon.

6.4 Plumbing

6.4.1 Domestic Hot Water Systems

Domestic hot water needs are provided by a single electric 85 US gallon domestic hot water storage tank manufactured by Rheem Ruud Ltd. The year of the tank manufacture appears to be 2008. It was noted to be in excellent condition. An older Ruud domestic hot water tank appears to be deployed as a spare tank and is used for peak demand purposes only.

Replacement of the domestic hot water tanks are not foreseen as being required over the report horizon.

6.4.2 Sump Pumps

Three sump pits are located in the lowest level of the parking garage floor beside the main stairwell, and comprise of two sets of duplex pumps. One set of duplex sump pumps is used to collect and pump out ground water runoff and the other duplex sump pump system is for handling garage sanitary floor drainage collection and pumping.

The sump pits and associated sump pumps were not accessible at the time of review. We were informed that the duplex sump pumps for the ground water drainage sump were recently replaced. The age and condition of the sanitary garage floor drainage sump pit and pumps were not known, however no concerns about their operation were reported.

Replacement of the sump pumps and associated controls can be completed within the operating and maintenance budgets.

6.4.3 Domestic Water Distribution and Drainage

Sanitary and storm water drainage piping in the building is cast iron and is mostly original. Approximately 30% of the original sanitary drainage piping appears to have been replaced with fire rated IPEX XFR pipe in the garage spaces. With the exception of the remaining sanitary drainage piping in the garage levels, the drainage piping appears to be in good condition. Much of the remaining sanitary cast iron risers and horizontal piping in the lower garage levels are corroding and visible signs of leaking were noted in numerous locations (photograph 49).

Replacement of the remaining sanitary piping in the garage spaces is foreseen as being required during the time frame of this study.

Potable domestic water piping, where observed, was noted to be in generally good condition. The four inch diameter incoming piping appears to be original galvanized material. Incoming main isolation valves on the water services are outside screw and yoke type. These are original and were observed to be in fair condition. These types of valves can typically expect to have 35 to 40 years of service life before requiring replacement.

An allowance for the replacement of six outside screw and yoke main service valves, as well as replacement of the remaining segments of the original galvanized piping within the mechanical room is anticipated to be required within the time frame of the report.

Number	Event	Priority	Years	Cost/ Occurrence
6.4.3.1	Replace remaining sanitary drainage piping in parking garage lower levels.	B	2014	$25,000
6.4.3.2	Replace main incoming domestic isolation valves and galvanized piping.	B	2015	$15,000

6.4.4 Washroom Plumbing Fixtures

All of the plumbing fixtures reviewed did not appear to be original but fairly recently replaced. The majority of urinal and water closet fixtures appear to be low water consumption types and flush valves were noted to be equipped with water saving automatic controllers. As well, lavatories and sinks were observed to be equipped with automatic hand sensors. The condition of the plumbing fixtures was noted to be excellent.

Replacement of washroom plumbing fixtures is not foreseen within the report horizon.

6.5 Building Automation System (BAS) & System Controls

The building controls for the mechanical system consist of stand-alone systems. At the time of the replacement of the Trane chiller two years ago, controls for the chiller system were upgraded to a DDC front end system supplied through Carrier and is an I-VU system. The system did not appear configured to control additional mechanical equipment other than the new chiller, circulation pumps and cooling tower. DDC control systems have an expected service life of approximately 15 years; replacement is typically driven by technological changes.

The existing controls associated with the air handling systems are equipped with the original pneumatic end controlled devices. Control valves and damper actuators appear to be a mix of new, overhauled and original devices. Pneumatic controls have a typical service life of 25 years.

The air compressor for the pneumatic air compressor appears to have been replaced within the last few years and is in good condition. Replacement is not anticipated.

Older preheat and cooling coil air handling unit control valves appear worn and dated. Replacements of these items are recommended.

Pneumatically controlled space thermostats, sensors and control dampers should be replaced as they fail, under the operation and maintenance budget.

Number	Event	Priority	Years	Cost/ Occurrence
6.5.1.1	Replace main air handler coil unit control valves.	B	2014	$10,000

6.6 Fire Protection

The underground parking garage levels are protected throughout by a dry pipe sprinkler system equipped with upright heads having glycerine filled bulbs. There are four zones in total. The first floor and perimeter area around the escalator on the second floor are protected by individual wet sprinkler zones. We were informed the wet system sprinklers were recently replaced whereas the dry pipe system heads are original.

In the sprinkler room, the majority of the fire sprinkler components appeared to be original with some replacements of alarm check valves and tamper switches.

As well, the garage spaces and library floors are equipped by a fire standpipe system comprising of fire hose cabinets and fire extinguishers throughout.

Sprinkler and standpipe fire protection equipment appeared to be in good condition, where observed.

With a typical life expectancy of 50 years for fire system components, an allowance for replacement of the dry pipe sprinkler system heads is not foreseen within the report horizon. However, replacement of the remaining dry pipe sprinkler system alarm check valves is anticipated.

Number	Event	Priority	Years	Cost/ Occurrence
6.6.1.1	Replace remaining three sprinkler dry pipe system alarm check valves.	B	2018	$12,000

6.7 Emergency Diesel Generator Mechanical Accessories

As per recommendation 5.3.1.2, replacement of the diesel generator system located in the second level lower parking garage should be completed within the next two years. Item 5.3.1.2 includes for the diesel fuel storage tank, fuel delivery system, exhaust muffler and radiator cooling system.

7. CONVEYING SYSTEMS

Rooney Irving and Associates (RIA) completed a review of the conveying systems in February 2012. Their complete report is included within Appendix B.

The conveying system consists of two passenger elevators, three dumbwaiters, and two escalators. The south dumbwaiter has been locked out of service and is currently not in operation.

The elevators were completely modernized in 2009, escalator number 1 was retrofitted in 2011, and escalator number 2 is to be retrofitted this year. The dumbwaiters were installed circa 1972 and modernization is recommended. Some additional maintenance repairs for the conveying systems are recommended, and should be completed by the current service providers.

Number	Event	Priority	Years	Cost/ Occurrence
7.1.1.1	An allowance for future mandatory work required by the B44 Safety Code.	B	2014, 2019	$3,500
7.1.1.2	Complete modernization of existing dumbwaiters.	B	2013	$150,000

8. CODE COMPLIANCE ISSUES

Although a detailed Code Compliance Review is not included within the scope of this work, during the course of our review, the following conditions were noted that may not be in compliance with prevailing legislation.

- The hand and guard rail configuration at the exterior exit stairs is not in compliance with the current requirements of the Ontario Building Code; however, the staircase is not required to meet the current legislation.
- The guard rail configuration at the stairwells promotes climbing and is not in compliance with the current requirements of the Ontario Building Code; however, the guard rail is not required to meet the current legislation.
- The existing emergency power installation does not conform to current life safety system codes. Any replacement would require an upgrade to current standards. Chiefly this would require separation of life safety and non-life safety loads onto different distribution systems. Upgrades to comply with current legislation have been included recommendation 5.3.1.2.
- MCC#2 as it is currently located may not have sufficient code mandated access clearance. Modifications to address this have been included within item 5.7.1.1.

We note that a detailed analysis for compliance with applicable Codes is required to identify items that require modifications or upgrades. The requirement to implement modifications to meet current Codes varies depending on the applicable legislation (i.e. Building Code, Fire Code, Electrical Code, etc.) as well as the extent of repairs or renovations being implemented. All recommended repairs and replacements must be designed to current applicable Codes. If a major renovation or rehabilitation of the facility is undertaken, a detailed and comprehensive Code assessment will be required.

Number	Event	Priority	Years	Cost/ Occurrence
8.1.1.1	Complete a Code and Life Safety Review of the Library.	B	2013	$10,000

9. FUNCTIONALITY

The Ottawa Public Library worked on plans for a new central library from 2001-2010. During that time, the following milestones were achieved: completion of several planning studies (detailed functional building program, critical path study, conceptual plan and massing), Council approval of a recommended site, and funding to acquire the site. Negotiations for the site were not successful; combined with fiscal constraints and increasing e-services the Ottawa Public Library is undertaking a detailed condition assessment of its existing Main Library to determine the potential for renovation and/or modest expansion.

The primary concerns appear to be the functionality, accessibility and efficiency of the existing configuration and systems, as well as the lack of public meeting rooms/spaces and parking.

Adjeleian Allen Rubeli Limited completed a structural review of the library, including an analysis of potential additions or alterations to the library. Adjeleian's complete report is included in Appendix C.

Adjeleian's analysis identified that it would be feasible to add a one or two storey vertical addition to the northern half of the lower library building. A one storey addition (of approximately 420 m^2) would require minimal structural reinforcement of columns in the three garage levels, and no seismic remedial work would be necessary. A two storey addition (of approximately 820 m^2) would require the columns to be reinforced as well as possibly a number of footings. A review and approval by the City of Ottawa plans review/building permit committee would be required.

To provide access to the new addition, stairs and an elevator would likely be required. Adjeleian has determined that Stair 4 can be extended upward, but structural intervention would be required to add an elevator. Limitations to the proposed expansion would include Code requirements for egress and exiting, exposure conditions and fire separations. We anticipate that these items could be addressed within the design of the new space. The existing mechanical systems (heating and cooling) have excess capacity and could be reconfigured to accommodate the additional space; although the new spaces will require appropriate new mechanical distribution systems, and additional cooling would be required. A detailed design of the proposed space, including anticipated use, is required to accurately determine the full extent of upgrades necessary. The electrical systems and components are nearing the end of their service life and require replacement; as such, the replacement components could be designed to accommodate the additional space. A detailed design would be required to identify the necessary upgrades. This option would impact the Sir Richard Scott Building, as it is anticipated that provision of a secondary exit through the tower would be required.

Provision of a new elevator to access the additional floor space would likely address a number of the current concerns associated with the accessibility of the existing library. The new elevator would provide access to all floor levels, and potentially allow for the removal of the escalators, increasing the available floor space within the existing library.

Rough order of magnitude costs to add a vertical addition to the library are difficult to predict at this stage. More detailed design and investigation is necessary to more accurately predict the costs associated with the expansion, and are largely dependent on the type of space to be accommodated within the addition. Based on basic interior finishes (drywall and carpet), a basic light cladding system, a new elevator, extension of the existing stairwell, basic mechanical and electrical systems, and the outlined structural work, we anticipate that a one storey addition would be in the order of $2.75 Million; and the two storey addition would be in the order of $5.0 Million. These costs do not include for a second stairwell, renovations/repairs that may be necessary to connect to the existing Sir Richard Scott Building, and no specialty systems.

Adjeleian also analyzed the potential of altering the raised floor area on the ground floor and infilling the atrium area. Altering the raised floor area on the ground floor appears to be a feasible option and would improve accessibility as well as providing additional usable floor space, although it may impact the use of the theatre below or introduce a wall at the ground floor. Rough order of magnitude costs associated with this work is estimated at $600,000. We note that there would be costs savings associated with combining this work with a major rehabilitation within the library.

The infilling of the atrium space does not appear to be a feasible option.

The library building is in generally good condition. Recent replacements of the mechanical systems and the durable cladding components result in minimal expenditures anticipated for these components within the next 10 years. The electrical systems are approaching the end of their service life and due to changes in current infrastructure uses, upgrades and expansion of these systems are required. Replacement of many of these components would impact adjacent finishes (such as ceiling and wall finishes) and this would be an opportune time to reconfigure the existing space.

Other than the walls surrounding the elevators, stairwells and the atrium, the space within the library is open concept. This means that existing interior partition walls can be relatively easily reconfigured and the space divided as needed. The large open spaces on the first, second and third floor provide flexibility for the division of space.

The basement level of the library is constructed with concrete block interior walls, which significantly limits the flexibility and the ability to alter the existing layout.

The atrium space is also limited in flexibility, although the potential of altering the raised floor would improve the potential use and accessibility of the first floor of the atrium.

A moderate expansion to the library, combined with removing the raised floor area, a new elevator, and replacement of obsolete and insufficient components would present an opportune time to capitalize on the flexibility of the space and reconfigure the library to improve functionality, accessibility and efficiency of the space; and may result in sufficient additional space to accommodate added public meeting rooms/spaces.

10. LIFE CYCLE RENEWALS SUMMARY

10.1 Annual Budget Requirements

Table 1, on the following page, summarizes the repairs or replacements recommended within the next 10 years for the Main Library at 120 Metcalfe Street in Ottawa.

MORRISON HERSHFIELD LIMITED

LICENSED PROFESSIONAL ENGINEER
A.A. HUFFMAN
July 24/17
PROVINCE OF ONTARIO

Allison Huffman, P.Eng.
Project Manager

Heather Penner, CET
Building Structure, Envelope, Site & Finishes

Shahrokh Farzam, P.Eng.
Mechanical Elements

Jeff Siddall, LEL, CET
Electrical Elements

Table 1: Annual Budget Requirements
Main Library - 120 Metcalfe

Number	Event	Priority	Life Expect (yrs)	Cycle (yrs)	Total $ (10 Yrs)	2012 yr 0	2013 yr 1	2014 yr 2	2015 yr 3	2016 yr 4	2017 yr 5	2018 yr 6	2019 yr 7	2020 yr 8	2021 yr 9	2022 yr 10
3	**Building Envelope & Structure**															
3.3.1.1	An allowance to complete concrete repairs in the parking garage.	B	6	10	**240,000**							240,000				
3.3.1.2	Replace the waterproofing membrane of the podium deck.	B	2	25	**150,000**			150,000								
3.3.1.3	Replace the waterproofing membrane of the suspended slabs.	B	6	15	**500,000**							500,000				
3.4.2.1	An allowance for repairs to the insulated precast concrete panels as required.	B	2	10	**30,000**			30,000								
3.4.3.1	Replace the aluminum framed windows	B	3	35	**175,000**				175,000							
3.4.4.1	Replace the exterior sealants between the precast concrete panels.	B	2	10	**25,000**			25,000								
3.4.5.1	Replace the main entrance door systems (Metcalfe Street and Laurier Avenue entrances).	B	6	15	**25,000**							25,000				
3.4.5.2	An allowance to replace the service doors that provide access to the roof, parking garage, and exterior at grade as required.	B	2	35	**25,000**			25,000								
3.4.6.1	Replace single-ply roofing membrane.	B	2	20	**125,000**			125,000								
3.4.6.2	Allowance for repairs to the roof membranes.	B	5	10	**35,000**						35,000					
3.4.6.3	Replace the two metal service staircases providing access to the east roof.	A		25	**5,000**	5,000										
4	**Building Interior**															
4.1.1.1	An allowance for repairs to, and/or replacement of, the ceiling finishes.	B	2	10	**25,000**			25,000								
4.2.1.1	An allowance for repainting of the wall finishes, , and localized repairs to, the wall finishes, and installation of lower wall protection (as required).	B	7	10	**100,000**								100,000			
4.4.1.1	Replace the carpeting within the building.	B	7	12	**275,000**								275,000			
4.5.1.1	An allowance for upgrades and/or repairs to the miscellaneous interior furnishings.	B	4	10	**5,000**					5,000						
5	**Electrical Systems**															
5.1.1.1	Maintenance of Hydro Vault and equipment.	A		3	**20,000**	5,000			5,000			5,000			5,000	
5.1.1.2	Replace main 15 kV switchboard including transformer primary conductors.	B	1	40	**350,000**		350,000									
5.1.1.3	Correct water leaks in Vault.	A			**10,000**	10,000										
5.2.1.1	Update posted single line diagrams.	A			**3,000**	3,000										
5.2.1.2	Replace main 600 Volt switchboard and associated conductors.	B	1	40	**450,000**		225,000	225,000								
5.2.1.3	Replace penthouse 600 Volt switchboard and associated conductors.	B	1	40	**450,000**		225,000	225,000								
5.3.1.1	Replace emergency power system transfer switch, distribution and associated conductors.	B	1	40	**225,000**		112,500	112,500								
5.3.1.2	Replace emergency generator and associated fuel, exhaust and ventilation systems. Provide new fire rated room to house generator.	B	1	40	**350,000**		175,000	175,000								
5.3.1.4	Provide outdoor weatherproof receptacle cover.	A			**100**	100										
5.5.1.1	Replace lighting, receptacle panels and associated conductors.	B	1	40	**400,000**		200,000	200,000								
5.5.1.2	Construct/renovate electrical closets to accommodate more panels and telecom equipment.	B	1	40	**125,000**		62,500	62,500								
5.7.1.1	Replace/relocate MCC#2 including conductors.	B	1	25	**175,000**		87,500	87,500								

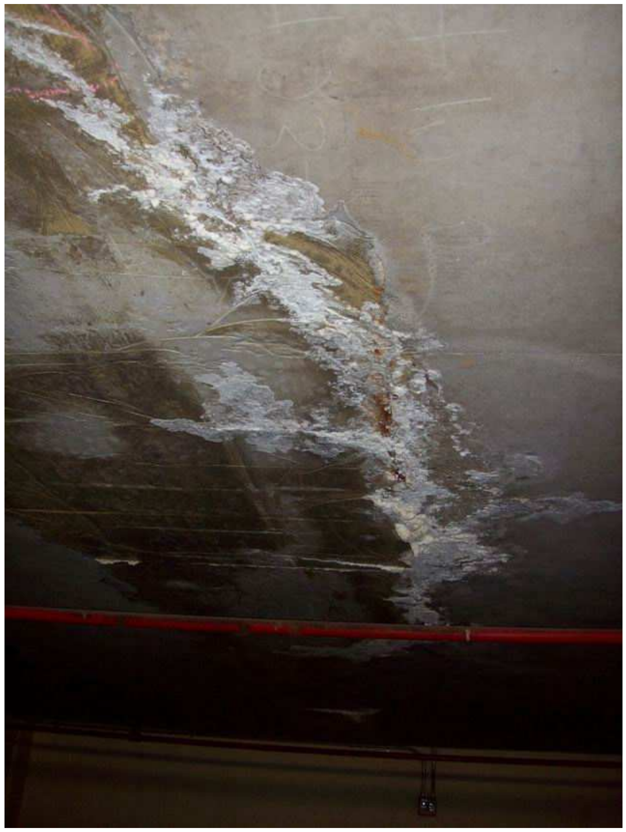
Table 1: Annual Budget Requirements
Main Library - 120 Metcalfe

Number	Event	Priority	Life Expect (yrs)	Cycle (yrs)	Total $ (10 Yrs)	2012 yr 0	2013 yr 1	2014 yr 2	2015 yr 3	2016 yr 4	2017 yr 5	2018 yr 6	2019 yr 7	2020 yr 8	2021 yr 9	2022 yr 10
5.7.1.2	Replace MCC#3 including conductors.	B	1	25	**250,000**		125,000	125,000								
5.9.1.1	Redesign lighting system and replace.	B	1	25	**1,250,000**		625,000	625,000								
5.10.1.1	Replace exit signs with bilingual or symbol based exit signs to modern energy efficient standard.	B	1		**75,000**		37,500	37,500								
5.12.1.1	Develop data conductor infrastructure plan in conjunction with future renovation modernization plans.	B	1		**50,000**		25,000	25,000								
5.12.1.2	Provide data conductor wire management systems.	B	1		**150,000**		75,000	75,000								
6	**Mechanical Systems**															
6.1.1.1	Replace four heating circulation pumps.	B	4	20	**25,000**					25,000						
6.1.1.2	Replace cabinet force flow and perimeter convection heaters.	B	4	35	**15,000**					15,000						
6.3.1.1	Replace main air handling unit cooling coil.	B	3	30	**25,000**				25,000							
6.3.2.1	Replace three lower level garage cabinet exhaust fans.	B	3	35	**9,000**				9,000							
6.4.3.1	Replace remaining sanitary drainage piping in parking garage lower levels.	B	2	40	**25,000**			25,000								
6.4.3.2	Replace main incoming domestic isolation valves and galvanized piping.	B	3	35	**15,000**				15,000							
6.5.1.1	Replace main air handler coil unit control valves.	B	2	25	**10,000**			10,000								
6.6.1.1	Replace remaining three sprinkler dry pipe system alarm check valves.	B	6	50	**12,000**							12,000				
7	**Conveying Systems**															
7.1.1.1	An allowance for future mandatory work required by the B44 Safety Code.	B	2	5	**7,000**			3,500					3,500			
7.1.1.2	Complete modernization of existing dumbwaiters.	B	1	30	**150,000**		150,000									
8	**Code Compliance**															
8.1.1.1	Complete a Code and Life Safety Review of the Library	B	1		**10,000**		10,000									
TOTAL PROJECTED EXPENDITURES					**6,376,100**	**23,100**	**2,485,000**	**2,393,500**	**229,000**	**45,000**	**35,000**	**782,000**	**378,500**		**5,000**	

APPENDIX A
PHOTOGRAPHS

Photograph 1 - Metcalfe Street elevation


Photograph 2 - Laurier Avenue Elevation



Photograph 3 - Soffit cracking with efflorescence and corrosion staining

Photograph 4 - Concrete wall damage

Photograph 5 - Wall cracking with corrosion staining

Photograph 6 - Spalled concrete at half wall

Photograph 7 - Membrane patch repairs

Photograph 8 - Water damage in server room

Photograph 9 - Deteriorated mortar at exterior block wall

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Photograph 11 - Cracking of precast panel

Photograph 12 - Staining of precast panel

Photograph 13 - Cracked panel at grid line H

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Photograph 15 - Chipped corner and corrosion staining

Photograph 16 - Crack in precast panel

Photograph 17 - Scale on precast panel

Photograph 18 - Crack in precast panel

Photograph 19 - Panel connection at floor slab

Photograph 20 - Misaligned connection with cast-in plate

Photograph 21 - Anchor for angled panel

Photograph 22 - Alligator cracking of sealant

Photograph 23 - Sealant adhesive failure

Photograph 24 - Missing sealant at soffit


Photograph 25 - Corrosion of roof access door


Photograph 26 - Corrosion of exterior door frame

Photograph 27 - Damaged parging at parapet wall

Photograph 28 - Corroded stairs

Photograph 29 - Corrosion staining of T-bar grid

Photograph 30 - 15 kV switchboard in Hydro Vault

Photograph 31 - IPS bus and bus duct

Photograph 32 - Bus duct and drip shields

Photograph 33 - Main switchboard

Photograph 34 - Penthouse Mechanical room switchboard

Photograph 35 - Diesel generator

Photograph 36 - MCC#2

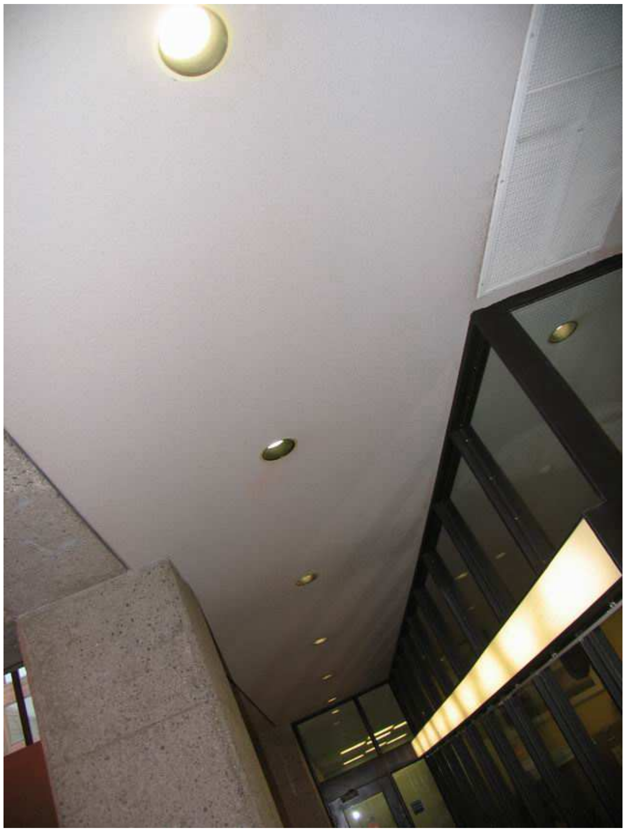
Photograph 37 - Typical panelboard


Photograph 38 - MCC#2

Photograph 39 - MCC#3

Photograph 40 - Main fire alarm panel


Photograph 41 - Lay-in fluorescent fixtures


Photograph 42 - Pot lights

Photograph 43 - Surface mounted wrap around lens fixtures

Photograph 44 - Typical exit sign

Photograph 45 - Emergency battery unit

Photograph 46 - Typical data conductor installation

Photograph 47 - Tube end corrosion on cooling coil

Photograph 48 - Corrosion of parking garage exhaust fans

Photograph 49 - Corrosion of drainage piping in the parking garage

APPENDIX B
ELEVATOR REPORT

1.0 PURPOSE

In February 2012, a site review of the elevator systems at 120 Metcalfe Street was performed. The purpose of the review and of this report was to assess the technical aspects of the elevator system, determine the capital costs likely to be encountered by the City of Ottawa, assess the operation of the system, note upgrades required to meet current Code[1] and to itemize deficiencies to be corrected. The review undertaken was predominantly visual and system components were not disassembled under the scope of our work.

2.0 DESCRIPTION OF ELEVATOR SYSTEM

The elevator system consists of two (2) passenger elevators, three (3) dumbwaiters and two (2) escalators. The south dumbwaiter has been locked out of service and is currently not in operation.

2.1 TECHNICAL DATA

A description of technical and nameplate data is as follows:

Passenger Elevator Designation:	1
Government Numbers:	23083
Class:	Passenger
Capacity:	2000 pounds
Speed:	200 fpm
Floors Served:	B4, B3, B2,B1, 1, 2, 3
Car Door Opening:	36” wide x 84" high One speed - side opening

[1] CAN/CSA-B44-07 *Safety Code for Elevators*

Technical Data contd.

Car Door Re-opening Device:	Solid State Multi beam Detector
Power Supply:	600 Volt (nominal), 3 Phase, 60 Hz
Machine:	*Hollister Whitney* *Model 54 OH, 2000 lbs, 200fpm* *Geared 87:2* Geared overhead
Hoist Motor:	*Reuland AC* *Type A000, Frame 286T* 1200 rpm, 20 HP 450 volts / 3 phase / 60 Hz
Drive:	*VVVF*
Control:	*GAL* *Model 13SX-480V-20HP* 20 HP 600 volts / 3 phase / 60 Hz
Roping:	1:1 4 x 5/8" diameter
Door Operator:	*GAL MOVFR* Closed loop
Elevator Manufacturer:	
Original:	*Otis Elevator*
Modernized:	Hollister Whitney / GAL
Date Installed:	Circa 1972
Modernized:	Circa 2009 -2010 Regional Elevator
Maint. Contractor:	*Kone Elevator*

Technical Data contd.

Passenger Elevator

Designation:	2
Government Numbers:	23202
Class:	Passenger
Capacity:	4500 pounds
Speed:	100 fpm
Floors Served:	B1, 1, 2, 3
Car Door Opening:	36” wide x 84" high One speed - side opening
Car Door Re-opening Device:	Solid State Multi beam Detector
Power Supply:	600 Volt (nominal), 3 Phase, 60 Hz
Machine:	*Hollister Whitney* *Model 54 OH, 2000 lbs, 200fpm* *Geared 87:2*, Geared overhead
Hoist Motor:	*Reuland AC* *Type A000, Frame 286T* 1200 rpm, 20 HP 450 volts / 3 phase / 60 Hz
Drive:	*VVVF*
Control:	*GAL* *Model 13SX-480V-20HP* 20 HP 600 volts / 3 phase / 60 Hz
Roping:	1:1 4 x 5/8" diameter

Technical Data contd.

Door Operator:	*GAL MOVFR* Closed loop
Elevator Manufacturer:	
Original:	*Otis Elevator*
Modernized:	Hollister Whitney / GAL
Date Installed:	Circa 1972
Modernized:	Circa 2009 -2010 Regional Elevator
Maint. Contractor:	*Kone Elevator*

Designation:	Dumbwaiters		
Government Numbers:	23167	23173	South Unit
Class:	Dumbwaiter -floor loading type		
Capacity:	400 pounds		
Speed:	50 fpm		
Car Door Opening:	Vertical Bi Parting		
Power Supply:	208 Volt (nominal), 3 Phase, 60 Hz		
Machine:	Overhead Traction		
Hoist Motor:	Otis type 35ES, 1.5 HP 7.2 FLA, 1800 RPM		
Drive:	Over Head Traction		
Control:	*Otis Relay based Model 10 NOW* *Auto Call and Send*		
Elevator Manufacturer:	*Otis Elevator*		
Date Installed:	Circa 1972		

Technical Data contd.

Designation:	Escalators UP	 Down
Government Numbers:	23108	23109
Class:	Escalator	
Capacity:	5000 persons per hour	
Angle:	30 degress (approx)	
Power Supply:	600 Volt , 3 Phase, 60 Hz	
Drive:	Direct Chain Drive	
Speed:	0.46 m/s	
Manufacturer:	Otis Elevator	
Date Installed:	Circa 1972	
Maint. Contractor:	Kone Elevator	

2.2 EXISTING CONDITIONS

The elevators were originally manufactured by the Armor Elevator Company circa 1973 and completely modernized in 2009 by Regional Elevator. The elevators were modernize to a very high quality non proprietary control system and outfitted with similarly high-quality machines and motors.

The elevators are fitted with overspeed and uncontrolled speed protection for car and counterweight, in the form of *Hollister Whitney* rope brakes. These features help prevent the elevators from over speeding in the up direction or moving away from a landing with doors open in certain instances.

The car door re-opening devices are solid state multi beam detectors. Physical contact with the door re-opening device is not required to initiate the re-opening cycle.

The elevator cabs consist of hard tile flooring, raised panelling on the sides and back, a stainless steel front return, steel kick plates and reveals, and suspended egg crate ceilings with florescent lighting. The cabs may be considered to be in excellent condition.

Elevator #2 (23202) was off line at the time of our visit. A pipe had burst in the mechanical room above and the hoist way, car top and door equipment was potentially exposed to water. The extent of the damage was being assessed by Kone and had yet to be determined.

The three (3) dumbwaiters were manufactured and installed by Otis circa 1972. These over head traction units are driven by a single speed AC motor. The south dumbwaiter has been off line for some period of time and there was no record as to when it was last serviced. It remains out of operation and as a result we were limited as to the extent of our review on this unit.

The two (2) escalators were manufactured and installed by Otis circa 1972. The escalator labelled number 1 and with TSSA designation #23108 was upgraded and substantially retrofit by Regional in 2011. Escalator #2 remains as original however the same scope of work is planned. For the purposes of this report we assume this will be implemented over the next few months.

3.0 MAINTENANCE

The elevators, escalators and dumbwaiters are maintained by Kone Elevator. We assume work is completed under the terms of Kone's standard full-service preventive maintenance contract.

The maintenance contractor's completion of the machine-room safety-work logs requires attention. The logs are used in the Province of Ontario in order to document safety work completed on elevator installations. The applicable legislation puts the onus of completion of the logs on the property.

Monthly Maintenance: 2011 Missed April and October

Annual Maintenance: 2010 and 2011 Incomplete

60 Month Maintenance: No verification of completion

3.1 Maintenance Deficiencies

The deficiencies noted below should be corrected by the maintenance contractor under the terms of a standard full maintenance contract, at no additional cost.

1. Provide monthly maintenance as a minimum.
2. Provide overdue annual maintenance.
3. Provide overdue 5 year maintenance.
4. Complete entries of preventive maintenance undertaken beyond basic safety tasks (i.e. oil changes, etc)
5. Verify completion of Phase I and Phase II Fire Service operation and record in log book.
6. Secure Peele hall call stations.
7. Clean full length of car and hall sills hoist side.
8. Clean the pits.

4.0 PERFORMANCE DATA

The performance parameters defined on the following page below were measured. Any found not to reasonably fall within the normal range of values are listed as deficiencies in Section 3 of this report.

Table 1 - ELEVATOR PERFORMANCE DATA

PARAMETER	REQUIRED	ELEV. 1 27661	ELEV. 2 23202
Car speed UP:	200/100 fpm ±5%	209	100
Car speed DOWN:	200/100 fpm ±5%	208	98
Flight time UP:	≤12.5 sec	14.3	15.2
Flight time DOWN:	≤12.5 sec	14.4	15.3
Average Accel. UP:	0.06 g	0.1	0.03
Maximum Jerk:	≤10 f/s_3	11.7	6
Door time out:	20 sec	22	25
Door stall force:	≤ 30 lbs	23	27

Table Definitions

Car Speed:
The normal maximum running speed of the elevator, measured in both the up and down directions. The measured value is compared to the design speed of the elevator system.

Flight Time:
The time elapsed for an elevator to serve two consecutive floors, in either the up or down direction, measured from the time the elevator doors begin to close until they are 3/4 open at the next floor. The flight time measurement is compared to a maximum suggested value which is determined by parameters such as car speed, elevator door type and building floor heights.

Average Acceleration:
The average acceleration experienced in the car when approaching top speed. The acceleration measurement is compared to a suggested value which is dependent on the type of elevator system - hydraulic, geared or gearless.

Maximum Jerk:
The maximum change in acceleration experienced in the car over the ride including start, acceleration, deceleration and stop. The Jerk measurement is compared to a suggested value which is dependent on the type of elevator system - hydraulic, geared or gearless.

Door time-out:
The time elapsed from the initiation of a door re-open cycle until the time any light activated door protection device times itself out. The door time-out setting should be 20 seconds.

Door Stall Force:
The force exerted by the elevator car door, during a door close cycle but after the door has been manually brought to a stop. The force is measured while the door is approximately 1/3 closed. The measured force is compared to the maximum force allowed by The CSA Safety Code For Elevators.

5.0 COST DISCUSSION AND RECOMMENDATIONS

Immediate recommendations

The deficiencies noted in section 3 of this report be forwarded to the maintenance contractor for their corrective action.

Recommendations Elevators:

We would recommend that the elevator recall system be tested on a quarterly basis and the testing entered into the machine room log.

Now at an age of 3 years, the existing motor control equipment is current technology and well within the engineered life expectancy of this type of equipment. Based on their vintage and method of control, other than correcting maintenance deficiencies outlined in the report, we would not recommend any major upgrades in the short term.

As almost all of the major components of the existing elevator system are covered under typical full parts and labour maintenance program, there should be no major capital expenditures to replace or repair these components assuming such a contract exists. Notable exceptions are vandalism and replacement of obsolete parts. Another common source of extra costs occurs when one maintenance contractor's services are terminated by the property owner (or the contractor themselves terminate their contract). This can lead to the new contractor requiring extras to the monthly maintenance fee to cover major components left in poor condition by the outgoing contractor. Vigilant ongoing policing of the performance of the maintenance contractor is an effective method of avoiding this source of extra costs.

If these elevators are properly maintained under the terms of full maintenance contract, they should continue to operate in a safe and acceptable manner for approximately another twenty to twenty-three years. At such time the existing drive control system, machines and controllers may require replacement. A full modernization would cost approximately $ 170,000 per elevator (total $ 340,000).

Recommendations Dumbwaiters:

The three dumbwaiters were installed in 1972. Now at an age of 40 years they are past their engineered life expectancy and should be considered for modernization or replacement in the short term: 1 - 3 years. At such time the existing drive control system, machines and controllers may require replacement. A full modernization would cost approximately $ 50,000 per dumbwaiter (total $150,000).

Recommendations Escalators:

Unlike elevators, escalator drive and control technology has not changed radically since the date of installation. There are, however, some notable safety requirements of present-day Code that do not exist on these escalators. Examples are devices to sense objects forced unusually against the comb plates at the end of the escalators, as well as devices to sense unusual changes in the handrail speed and stop the escalator accordingly.

The Up escalator with provincial number 23108 was modernized in 2011. For the purposes of this report we assume this will be implemented over the next few months.

6.0 PROJECTED CAPITAL COST TABLE

Predicted Work \ Year	1-5	6-10	11-15	16-20	21-25	26-30
Future mandatory work required by B44 Safety Code	$3,500	$3,500	$3,500	$3,500	$3,500	$3,500
Complete modernization of existing elevators including B44 Code upgrades and cab interiors					$340,000	
Upgrade of cab interior finishes (discretionary)					$ 28,000	
Complete modernization of existing dumbwaiters	$150,000					
Complete modernization of escalators					$500,000	

Notes of Costs: HST not included;
Based on year 2012 dollars;
Work not the responsibility of the elevator trade not included.

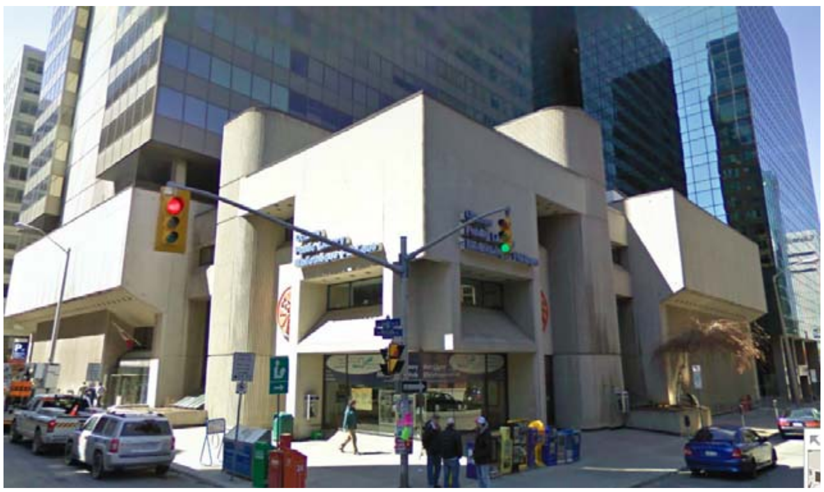
- end of report -

APPENDIX C
STRUCTURAL FEASIBILITY AND SEISMIC ASSESSMENT REPORT

STRUCTURAL REVIEW

OF

OTTAWA PUBLIC LIBRARY



PREPARED FOR

CITY OF OTTAWA

BY

ADJELEIAN ALLEN RUBELI LIMITED

Consulting Engineers Ottawa, Toronto

Final Report

June 7, 2012

AAR Project Number 0636-36

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1. INTRODUCTION

The objective of this report is to present the results of the seismic review of the Ottawa Public Library building located at 120 Metcalfe St. Ottawa, Ontario. In addition, this study also evaluates the performance of the existing building under gravity and seismic loads as a basis for the feasibility of construction of new addition to the building. The review of gravity loads are based on dead and live loads as indicated on the original structural drawings while the seismic evaluation is based on requirement per the National Building Code of Canada 2010 (NBCC 2010). The dynamic structural properties of the building are evaluated based on the requirements of the code, and an appropriate method was selected to analyze the effects of the design earthquake on the structural elements.

The original structure was designed based on the 1970 building code, which was relevant at the time. There have been numerous changes to the code in the past 40 years, in particular with design for seismic loads – and as such building built in the 1970's are not expected to meet current seismic design requirements.

In essence, the review and report have been undertaken to provide the following information:

1. What is the current seismic performance level of the existing structure based on the current requirements of NBCC 2010.
2. What is the capacity or limitations of the structure to support a proposed 2 storey addition over a portion of the library (above the lower portion of the building). This is evaluated both with respect to gravity loads and effects on the seismic performance of the building.

The gravity and seismic demands on all structural elements are obtained using a computer model of the structure subjected to the above mentioned loads. The structural computer model is constructed based on the information provided on the architectural and structural drawings. Computer software ETABS version 9.7.2 (developed by Computers and Structures, Inc.) was used in this study for the analysis of the structure under different load cases. All main beams, secondary beams, columns, and shear walls were modeled in order to simulate a realistic behavior of the structure under different load cases.

It is our understanding that the client intends to use the outcomes of this report to examine the possibilities for future renovation and extension of the library. Therefore, based on the results of the structural evaluation, the areas for seismic rehabilitation and upgrade are highlighted and the feasibility of new connected addition to the building is discussed.

2. DESCRIPTION OF THE BUILDING

The building structure that houses the central branch of the Ottawa Public Library was constructed in 2 phases in the early 1970's. The building can be divided along the general basis of this phased construction. The overall building is a 20-storey building with penthouse and 4 basement levels. The building is divided generally based along the

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phased construction and tenant. The first phase of construction included all basement levels and the construction up to the 4th and 5th level roof levels – and in general, this section of the building houses the Ottawa Public Library. We will refer to this portion of the building as the Ottawa Public Library. The second phase of construction included the addition of the 'tower' portion of the building which is the 20 level portion of the building on the west side of the building. This portion of the building is typically referred to as the Sir Richard Scott building and is at address 191 Laurier – this will be referenced in our report as the 'Tower'. The basis of our review is limited to the lower 5 storeys of the building for the Ottawa Public Library; however, the seismic analysis needs to include the loads and structure of the entire building, and as such the entire building was included in our model. And although discussions and recommendations discuss the 'tower' the focus of the study remains the lower portion of the building.

The structure is designed to resist the gravity loads using a flat slab system, while reinforced concrete shear walls are to resist the lateral forces. The slabs are supported by reinforced concrete column and wall elements and there are a few local transfer beams to pick up columns on the lower levels. A plan layout of the building of the second floor is shown in Figure 1. Only the portion of the plan between gridlines B to F and 1 to 7 are extended above the fifth floor to the penthouse roof which will be referred to as the Tower as discussed above.

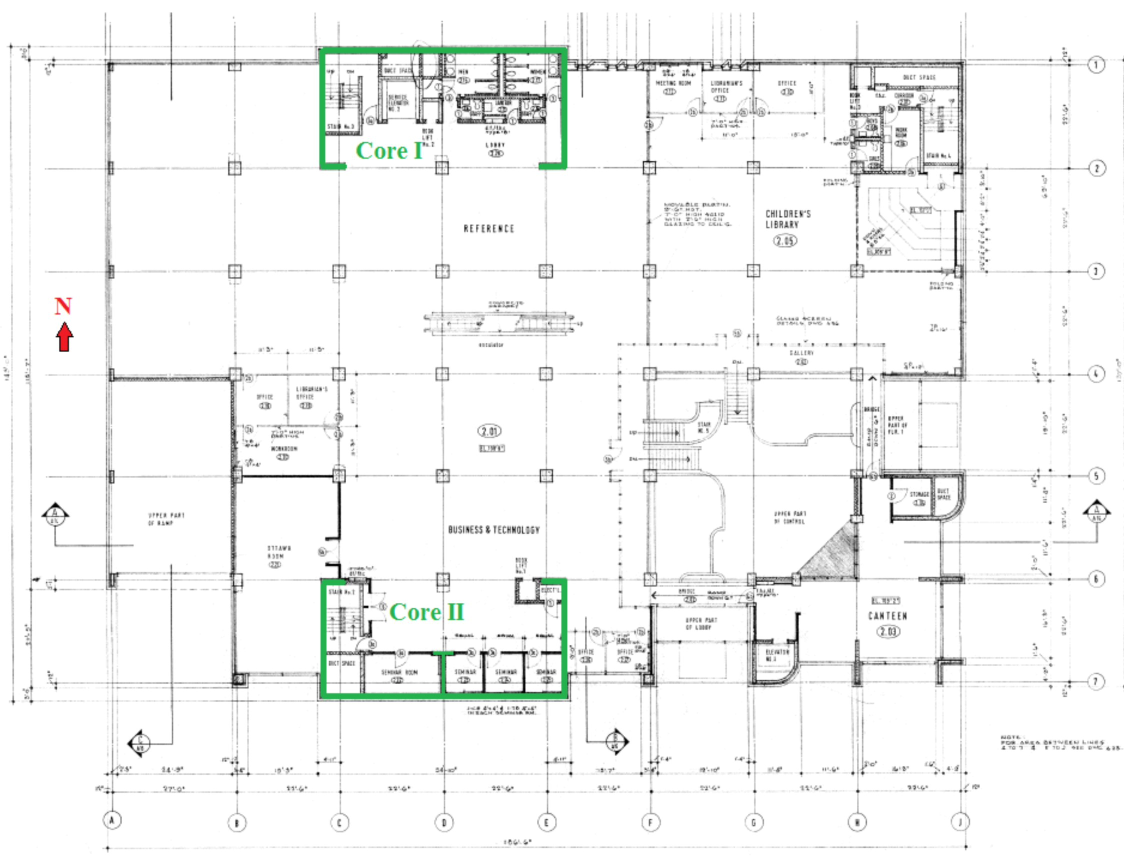

Figure 1 Second floor plan layout

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As can be seen in Figure 1, there are two elevator cores in the North and South side of the building which are extended up to the roof level (noted as Core 1 and Core 2). The shear walls around these cores form the seismic resisting system to resist the seismic forces. On the South-East of the building is the main entrance lobby where there is an atrium opening in the slab up to the 4th floor.

3. STRUCTURAL ANALYSIS PROCEDURE

3.1 Structural Properties and Model

The following have been considered in the evaluation of the structural elements. These are based on information in the structural record drawings.

1. Concrete strength for columns are 27.58, 34.47, and 41.37 MPa
2. Concrete strength for slabs and beams is 27.58 MPa
3. Concrete strength for shear walls are 27.58 and 34.47 MPa
4. The reinforcing steel has the yield stress of 414 MPa

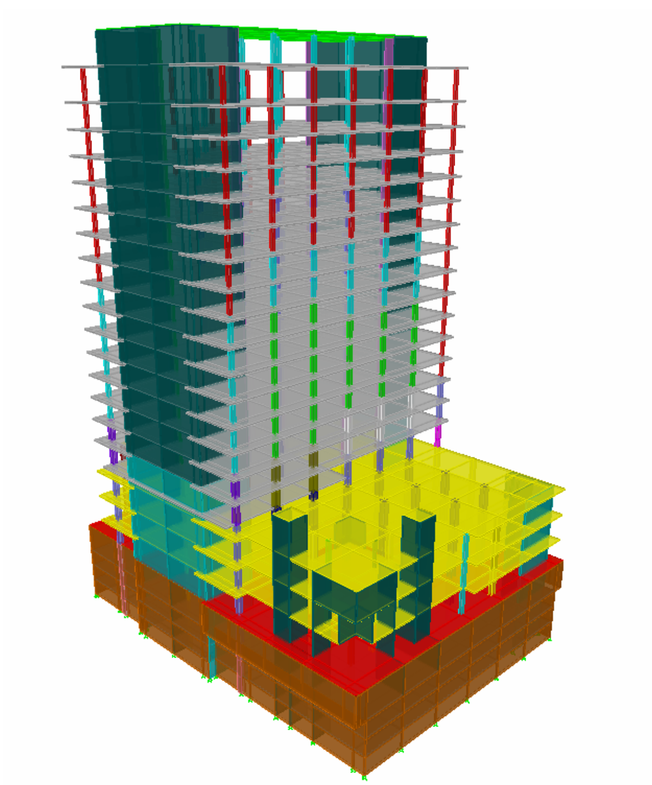

Figure 2: 3-D view of the building ETABS model

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A 3-D model of the structural elements has been constructed as shown in Figure 2. This model is used in calculation of the effect of gravity loads on beams and columns and seismic loads on the shear wall elements.

3.2 Seismic Loads Analysis

3.2.1 *Earthquake ground motion*

Seismic hazard on Site Class C soil, for a Maximum Considered Earthquake (MCE) with 2% chance of exceedance in 50 years is provided by NBCC 2010 for Ottawa downtown region. This design earthquake has a returning period of 2475 years. It is assumed that the seismic site class for the site of the Ottawa Public Library is site Class C. Based on information provided in the original structural drawing, it is our opinion that the Site Class C is a conservative assumption for this site. However, a geotechnical evaluation should be done to confirm this value, as the results of the current study are dependent on the seismic site class. Our seismic evaluation has been done with Site Class C as suggested by the code; however, where relevant in our evaluation of the results we will present the impact on the performance levels should it be found that the site has a 'better' site class of B or A. Figure 3 shows the spectral acceleration for city of Ottawa per NBCC 2010 for site Class C, B, and A.

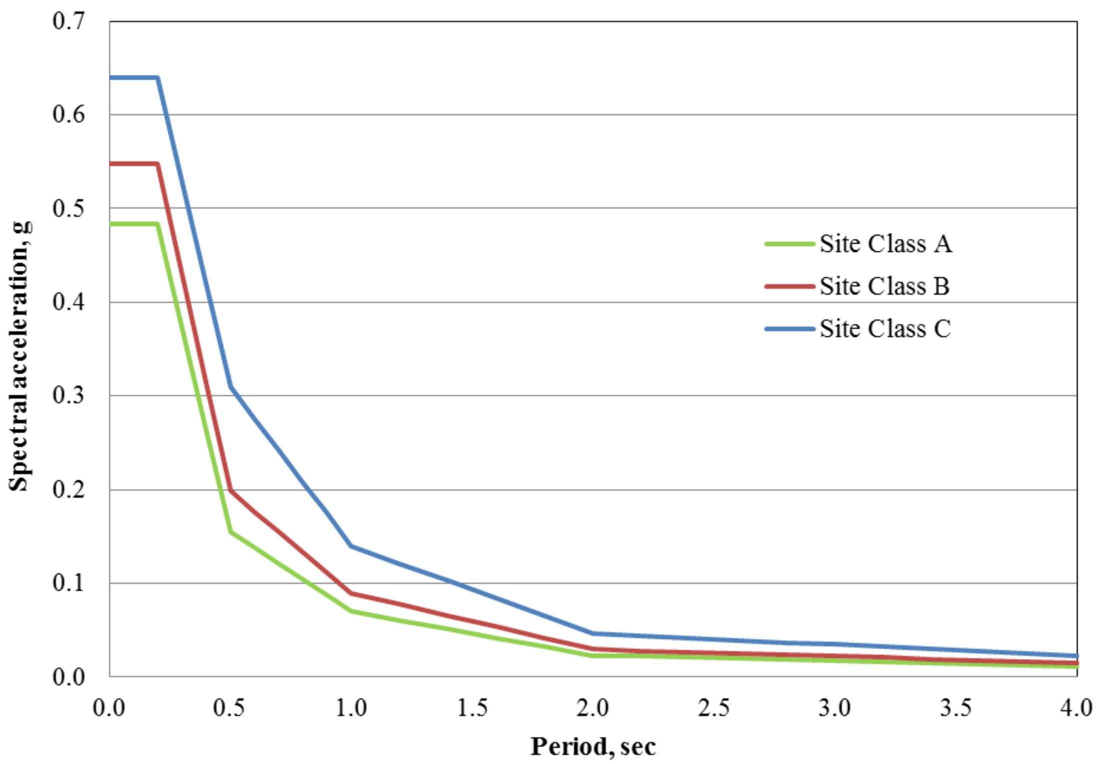

Figure 3 Design spectra for the city of Ottawa on Site Class A, B and C

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The following seismic parameters and modification factors have been used to form the response spectrum as shown in Figure 3:

NBCC 2010, Table C-2 (Ottawa, ON): PGA=0.32,	$S_a(0.2)=0.64$,	$S_a(0.5)=0.31$,
	$S_a(1.0)=0.14$,	$S_a(2.0)=0.046$
NBCC 2010, Site Class C, Table 4.1.8.4.B	$F_a=1.0$	
NBCC 2010, Site Class C, Table 4.1.8.4.C	$F_v=1.0$	

3.2.2 *Seismic Force Resisting System (SRFS)*

3.2.2.1 Code requirements

NBCC 2010 applies some restrictions on the height of the building with different SFRS located on sites with different seismicity. Seismicity of the site is usually expressed with two seismic hazard indices, $I_E F_a S_a(0.2)$ and $I_E F_v S_a(1.0)$. In these indices, I_E is the Importance Factor for earthquake loads and effects that equals to 1.0 for normal importance category as per Table 4.1.8.5 of NBCC 2010. In case of better site Class than Class C, the value of the IE Fa Sa(0.2) will work out to be 0.484, and 0.548 for site Class A and B, respectively. These values are still within the same limits and the allowable height of the building for the conventional reinforced concrete shear wall buildings would still be 40 meter.

Table 1 shows the limitation on the height of the building with conventional shear wall system, as per Table 4.1.8.9 of NBCC 2010. As it can be noted, the value of $I_E F_v S_a(1.0)$ is less than 0.3, therefore this parameter does not impose any limitation on the permitted height of the building. However, $I_E F_a S_a(0.2)$ dictates the permitted height for conventional construction of reinforced concrete shear walls. In case of better site Class than Class C, the value of the $I_E F_a S_a(0.2)$ will work out to be 0.484, and 0.548 for site Class A and B, respectively. These values are still within the same limits and the allowable height of the building for the conventional reinforced concrete shear wall buildings would still be 40 meter.

Table 1 Limitation on the height of buildings

SFRS	$0.35 < I_E F_a S_a(0.2) = 0.64 < 0.75$	$I_E F_v S_a(1.0) = 0.14 < 0.3$
Conventional reinforced concrete shear wall	40 meter	NOT LIMITED

As such, based on the current NBCC 2010 code, a building of this type of construction could not be constructed to the current 20 level (70m) height of the existing building. These guidelines were not imposed in the 1970s when the building was designed and constructed.

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3.2.2.2 Available SFRS

As mentioned before Ottawa Public Library (and Tower) building has conventional shear walls as the main SFRS. The building is more than 70 meter in height. Based on NBCC 2010, for this height, a moderate ductile shear wall system with ductility factor of 2.0 is required. However, based on the detailing of the existing shear walls they would be classified as conventional shear walls with ductility factor of 1.5. In our evaluation the current state of the building is considered and the value of 1.5 is used as the ductility factor. Also since there are continuous foundation wall along the perimeter of the building from ground level down to B4 level, the structure is considered to be very rigid below ground. Therefore for the purpose of the seismic evaluation the base of the building is considered to be the ground level.

3.2.3 *Method of analysis*

As per NBCC 2010 clause 4.1.8.7 (1-b) analysis for design earthquake shall be carried out in accordance with Dynamic Analysis Procedure for structures that are more than 60 meter in height. The Ottawa Public Library (and Tower) is more than 70 meter in height above the ground, therefore modal response spectrum method is used as the Dynamic Analysis Procedure as directed by NBCC 2010 clause 4.1.8.12. In our dynamic analysis procedure, the center of mass was displaced ±0.1 D_n to simulate accidental torsional effects in both directions. Where, D_n is the plan dimension at nth floor perpendicular to the direction of the applied earthquake.

4. RESULTS OF SEISMIC EVALUATION

4.1 Linear Dynamic Analysis

In order to estimate the seismic demand on the structural shear walls, a linear modal spectral analysis is used as dynamic analysis procedure, employing the design spectrum as described in section 3.2.1. Table 2 shows the dynamic parameters of first 12 modes of vibration of the structures. Vibration periods and Modal Participation Mass Ratios (MPMR) in both X and Y directions of different modes are tabulated. In spectral analysis, Complete Quadratic Combination (CQC) rule is used to combine the effects of different modes as the periods of higher modes of vibration are quite close to each other (see Table 4). The first 12 modes cover about the 90% of the total mass of structures, a limit that is considered to be adequate in seismic design practice. Here and henceforth X is parallel to East-West direction and Y is parallel to North-South direction.

Table 2 Dynamic parameters of structural vibration modes

Mode	Period (Sec)	MPMR U_X (%)	MPMR U_Y (%)	Sum MPMR U_X (%)	Sum MPMR U_Y (%)
1	2.304	0.00	44.16	0.00	44.16
2	1.314	44.99	0.00	44.99	44.16

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3	0.863	0.04	0.00	45.03	44.16
4	0.544	0.00	16.57	45.03	60.72
5	0.318	18.70	0.00	63.73	60.72
6	0.244	0.00	9.83	63.73	70.55
7	0.189	0.03	0.51	63.77	71.06
8	0.160	9.89	0.02	73.66	71.09
9	0.139	0.08	7.21	73.74	78.30
10	0.101	6.68	0.22	80.42	78.52
11	0.073	0.41	17.46	80.82	95.98
12	0.059	15.92	0.27	96.75	96.25

As can be seen in the above table, the first mode is the fundamental mode for vibration in the Y direction and the second mode the fundamental mode of vibration for the X direction. Periods of both the first and the second modes are larger than the code prescribed period obtained from the empirical relation for shear wall buildings which works out to be 1.224 sec. However, Clause 4.1.8.11 (3-d-iii) of NBCC 2010, allows the application of periods calculated by other established methods of mechanics up to twice of the one obtained from empirical relations for shear wall buildings. Therefore, the periods reported in Table 4 is used in estimation of the seismic demands on the structure.

4.2 Seismic Demands

The seismic demand on a structure is represented by the design base shear, obtained either from and equivalent static procedure or a dynamic analysis procedure. According to NBCC 2010 Clause 4.1.8.12(8), the design base shear calculated from dynamic analysis in accordance with Clause 4.1.8.7, should not be less than 80% of the one obtained from equivalent static procedure. In this study, the dynamic base shears are larger than those calculated from equivalent static procedure. Therefore, the demand is governed by dynamic analysis. Table 3 shows the dynamic and the static base shear at ground level in both X and Y directions.

Table 3 Equivalent static and dynamic design base shears

	Equivalent Static Procedure		Dynamic Analysis Procedure	
	V_X (kN)	V_Y (kN)	V_X (kN)	V_Y (kN)
Storey shear at ground level	18,700	11,800	20,000	14,800

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4.2.1 *Seismic demand ratios*

Reinforced concrete shear walls included in the Core I and II, as shown in Figure 1, are made of concrete with compressive strength of 34.47 MPa as per drawing S14-71. The thicknesses of these walls are 300 mm from footing to 1st floor, and 250 mm from 2nd floor all the way up to the roof. The 250-walls are reinforced horizontally with #4 bars at 380 mm, while the 300-walls have #4 bars every 250 mm as horizontal reinforcing steel. This amount of reinforcement is only equivalent to the minimum reinforcement requirements for horizontal reinforcing of CSA 23.3-04, and as such not appropriate per current standards for shear wall elements. On the other hand, the concentrated vertical reinforcing at the end of the walls are from 8#11 at the roof level to 22#11 at the base of the walls, which provide sufficient bending capacity to resist the seismic demands all along the height of the building.

Table 4 Capacity demand ratio of the shear and overturning effects on the walls

Shear wall ID	Direction	Shear		Overturning	
		C/D Ratio	Critical section	C/D Ratio	Critical section
Core I	X	40.9%	2nd Floor	265.6%	1st Floor
	Y	55.5%	2nd Floor	356.6%	1st Floor
Core II	X	45.4%	2nd Floor	286.3%	1st Floor
	Y	103.0%	2nd Floor	285.7%	1st Floor

The capacity demand (C/D) ratios, calculated for the effects of shear and overturning due to design earthquake, are shown in Table 4 for shear wall core I and II in both X and Y directions. These ratios are presented in percentage; if the ratio is greater than 100% it implies that the capacity is greater than the demand and the element is safe, et vice versa. As it can be seen, the C/D ratios due to shear are all less than 100% except for the core II in the Y direction. These C/D ratios are less than 100% between 1st and 4th floor in the Y direction, while in the X direction they are less than 100% between 1st up to the 8th floor.

As such, the 'weak' point of the shear wall elements can be considered to be from the 1st to 4th floor in the North-South direction and from the 1st to 8th floor in the East-West direction. This 'weakness' is mainly due to the insufficient horizontal steel and limited thickness (only 250mm at these levels) of the shear walls.

4.3 Seismic Performance Level and Site Class

Based on the evaluation of the results, it would generally be termed that the building has a seismic performance level of 41% per NBCC 2010 requirements, as this is the performance level of the 'weakest' point in the Seismic Force Resisting System (SFRS). This 'weakest' point is based on the shear capacity of the shear walls in the East-West (X) direction at Level 2 in the building.

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It should be noted that the capacity demand ratios of the structural elements resisting seismic loads are for the demands calculated assuming Site Class C for the location of the Ottawa Public Library. However, in case of confirmation of Site Class B or A by a geotechnical investigation of the site, the estimated seismic demand on the building will decrease by about 20% or 30% respectively. This would increase the capacity demand ratios to about 50% or 60% of the NBCC 2010, respectively. The following table compares the performance level of the structure based on possible different site classes.

Table 5 Performance level of the building with respect to site soil classification

	Site Class C	Site Class B	Site Class A
Performance level	40.9%	51.6%	59.5%

As can be seen, confirmation by a geotechnical engineer of the site class is important in the final evaluation of the seismic performance level of the building. The values reported in the table above present the current state of the building. Any addition to the building will decrease the seismic performance level due to an increase in the seismic demands on the resisting elements. The increase of seismic demands would be due to the increase in mass of the building and the fact that the recommended area for expansion would apply additional torsion on the SFRS. The effect from an addition to the seismic performance of the building is further discussed in the next section.

5. ADDITION OR ALTERATIONS TO THE LIBRARY

In the effort to gain more usable space for the Library, AAR has been asked to review the feasibility of a few options of increasing the occupancy space. The option include for a vertical addition, alterations to the raised floor area at the ground floor entrance area and infilling of the floor plates within the atrium space.

5.1 Vertical Addition

5.1.1 *Description of addition*

General guidelines for a possible vertical addition and alterations at the ground floor, were presented by the Library staff members at the start up meeting on January 17th, 2012 with further direction and discussions following some preliminary structural review at a meeting with the staff on April 4th, 2012.

The initial discussed addition was for a 2 storey addition above the roof east of gridline F (low roof above the library). Based on preliminary review of the structure below, the structural scope required to include an addition above the higher roof portion of this area (gridlines F-J/4-7) were considered to be unfeasible/impractical. The major problems were linked to the following structural items:

- Atrium space with large beams to have an open space without the column at grid G-5.

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- Cantilevered beam elements supporting roof and precast panels at the front entrance area. Remedial structural work to support these elements and the addition above would require new column elements at the sidewalk entrance and have a large impact on the architecture and existing precast feature entrance.
- This higher roof and precast architectural features would restrict floor area for the first floor of the addition.
- Transfer beams at the garage level at ramp areas to pick up loads from above would be inadequate and structural alterations to compensate for this would interfere with the drive aisles of the garage.

These issues were discussed at the follow up meeting on April 4th with the staff members at which time AAR indicated that restricting the vertical addition to the area of gridlines F-J/1-4 may be more feasible. It was discussed that this area would represent approximately 420 m^2 (4500 square feet) per level for a total of 840 m^2 (9000 square feet) of new addition and this was agreed by all to be a suitable approach. Where relevant discussions on adding only 1 new level or 2 new levels will be reviewed.

As such, the new vertical addition used for our review would generally consist of the following. This type of structure was chosen to have lighter construction so as to have less effect on existing columns, walls, footings and less impact on the seismic performance of the building.

- Steel framed construction including open web steel joists to support the new floor and roof.
- The existing 4th floor roof would be enclosed and become interior space. The existing rooftop unit would be relocated to the new roof. This reinforced concrete slab was originally designed for 150 psf (7.2 kPa) snow loading. This live load capacity of 7.2 kPa is what is required for 'Library' use, and as such this area could be used for open book shelves if required.
- The new 5th floor addition slab would consist of concrete on steel deck assembly for lighter construction and we have assumed on 4.8 kPa live loading which allows for public assembly, but no book storage. For the case of only adding one new level of space, this floor assembly is not included.
- The new roof would consist of steel deck and reinforcing required for the existing relocated rooftop unit. Roof would be designed for snow loading and drifting per current code requirements.
- Cladding for the addition was assumed to be a light cladding system such as a curtain wall system.
- Architectural finished within the space would be drywall partition where required and a light flooring system such as carpeting.

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5.1.2 *Structural elements supporting gravity loads*

From the computer model developed, the new loads from the proposed addition as described above was added to the existing column and beam element to determine changes to loading on these elements. In presenting the results from our review, we have presented both existing capacity/demand ratios of the key elements (for current layout) and compared these to capacity/demand ratios for adding 1 or 2 extra levels.

A review of the footing capacity was also checked based on original bearing capacities provided for the original design. Further review by a geotechnical engineer should be done to confirm the bearing capacities prior to moving further with more detailed design or implementation.

Table 6 Capacity demand ratio for columns

Column	Level	Current state	Adding 1 Deck	Adding 2 Decks	Remark
1G	B4	176.4%	173.4%	165.4%	
	Ground	295.2%	287.9%	268.1%	
2G, 3G, 2H	B4	111.7%	109.2%	102.1%	4-35M in 457x610 Col. at ground
	Ground	147.9%	142.9%	129.9%	
3H	B4	134.4%	131.4%	123.0%	
	Ground	334.6%	323.5%	294.4%	
4G	B4	99.8%	97.5%	91.3%	Overstressed at B4
	Ground	456.2%	441.4%	401.9%	
4H	B4	124.4%	121.6%	113.9%	4-35M in 457x813 Col. at B4 to B2
	Ground	456.2%	441.4%	401.9%	
3J	B4	---	---	---	Rests on transfer beam 1B9
	Ground	317.5%	308.8%	286.2%	
4J	B4	---	---	---	Rests on transfer beam B9
	Ground	227.8%	217.9%	203.0%	
2F, 3F	B4	106.8%	103.9%	103.4%	
	Ground	150.8%	146.1%	145.2%	

As it can be seen from Table 6, the C/D ratio for the column at 4G is already at 100% at B4 level, so any new loads to this column would require reinforcing of the column. All other column C/D ratios are above 100% under the existing condition and remain above 100% even with the 2 level addition. As such, the column at grid 4G is the only column requiring reinforcing to support the proposed addition. Also note that we have provided the capacity at ground level as well as at level B4, as there is a change in column dimensioning and properties at the ground level; as such, the column at grid 4G has ample capacity at the ground level, the B1 level and all levels above ground, but would need reinforcing at level B4, B3 and B2 which are in the garage levels.

One method of reinforcing the column which would be suitable for this case would be to add a reinforced concrete jacket around and tied into the existing column. As this column lines up at the central wall dividing the staggered parking levels, it is not expected that this type of reinforcing would have any significant effect on use of the parking spaces at this location.

Table 7 Capacity demand ratios for transfer beams

Beam	Effect	Current state	Adding 1 Deck	Adding 2 Decks
B9	Positive moment	149.1%	142.6%	132.8%
	Negative moment	146.7%	140.3%	130.7%
	Shear	112.5%	107.6%	100.2%
1B9	Positive moment	159.9%	155.5%	144.1%
	Negative moment	143.3%	139.3%	129.1%
	Shear	212.6%	206.7%	191.6%

Transfer beams B9 and 1B9 support columns at grid 4J and 3J as noted in Table 6 above. As it can be seen from Table 8, the C/D ratios remain above 100% even with the proposed 2 level addition, and as such as structural capable of supporting these loads. Note that transfer beam B9 is very close to 100% level with the 2 level addition, so care on keeping loads reduced is important for this element.

Table 8 Capacity demand ratio for spread footings

	Current state	Adding 1 Deck	Adding 2 Decks
F5	108.8%	106.1%	93.6%
F10	105.6%	104.5%	99.3%

Footing type F10 supports columns at grids 2F, 3F and 4F. With the 2 level addition the C/D ratio falls just below the 100%, and as such may require reinforcing. We would suggest that a geotechnical review be done to confirm allowable bearing pressure, as a new survey of condition of rock may provide updated values that could affect whether reinforcing work is required.

Footing type F5 supports columns at grids 4G, 3G, 2G and 2H. For a 1 level addition, these footings are still adequate, but as can be seen in Table 8, for a 2 level addition reinforcing would be required. Reinforcing of footing would consist of locally removing

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the slab on grade and excavating to expose around the footing and reinforcing the footing to extend the bearing area of the footing.

5.1.3 *Stair access to addition and possible elevator access to all levels*

5.1.3.1 Stairs

AAR has not undertaken a review of number of access point or egress requirements; however, as Stair No.4, near grid J between 1 and 2 is within the area of the addition, we have reviewed the existing structure of the stairwell. Stair No. 4 starts at level B4 and serves up to level 3. The structural walls for the stairwell extend to the underside of the level 4 – the roof. Based on our review, the existing structure is sufficient to extend the stairwell up another 2 levels to serve the proposed addition. An opening in the existing roof slab (level 4) would be required, but as the walls extend to the underside of this level, it is expected that there would be little to no local reinforcing of the existing slab required in order to make this opening.

Review of egress requirements and possible access to other existing stairwells at these levels should be reviewed but is not in our current scope.

5.1.3.2 Elevators

Based on discussions, it appears that there are currently no elevators that are in service for patrons of the library. The one elevator near grid 1D is intended mainly as a service elevator for book distribution, but when required serves for patrons requiring this assistance. As such, a public elevator within the library to serve all floors would be desirable. As this review comes as part of the vertical addition to the building, we have only reviewed general feasibility and structural scope required for elevators that would service the library and this proposed addition.

As the addition is within the gridlines F-J/1-4, the possible locations for an area reviewed are within these gridlines or directly adjacent to them. At this stage we have assumed that the elevator shaft would be extended to the B4 level, and that the base of the elevator pit would be at the same level as the slab on grade at level B4 and as such, the elevator could not provide service to level B4. From a functional perspective for the library, we are not sure that the library operations would want a direct link for the public from the library to the garage, as this would pose a functionality issue for the security of their materials. Further review of code requirements could be done for elevators stopping at higher levels above floors, but for this review, we have reviewed bring all loads down to the lowest basement level, as this is structurally the most workable.

Within the garage, the drive aisle runs between gridline 2 and 3 and the ramp extends from gridline 2 to 6 between gridlines H and J. As such, an elevator within these gridlines was not considered.

The option that appears to have the least construction impact to the library would be an elevator directly adjacent to the column on grid 4H with the elevators south and west of this column. Within the existing library space, the elevator would be within the atrium space, and as such, no work at level 2 or 3 would be required. However, at this location, the elevators would impact on the Theatre space at level B1. At levels B2 to B4, 2

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parking spaces would be lost at each level. The structural work would include for new footings, new load bearing walls for the elevator and to support new slab openings above. Slab openings would be required though level 4 roof and at level 1. If the elevator did not service lower floors that the work below would only consist of building the new walls. The opening through level 1 slab would still be required for an elevator pit below.

Other possible locations could be in the same bay as Stair No. 4 (H-J/1-2) or in any of the bays F-J/1-2 or 3-4. scope of structural work would be the same as noted above, except that openings in level 2 and 3 slabs would also be required. These locations would not interfere with the Theatre at level B1 but all would reduce 2 parking spots at all levels of parking B2-B4.

The elevator in bay E-F/3-4 could also be considered especially in infilling of escalator slabs would be done once elevators were installed, as this would localise both these works to the same area. However, this may impact the mechanical room at level 4.

The area in bay E-F/1-2 would be the last option within the option guidelines used. As this location is adjacent to an existing shear wall, there may be possibility of combining the new elevator shaft with reinforcing of shear wall or addition of shear wall elements. However, this may impact the mechanical room at level 4.

5.1.4 *Structural elements supporting seismic loads*

There is no code requirement to upgrade existing buildings to meet the current code requirements. However, a seismic performance level of less than 60% is often used by governing bodies as a trigger point for requirements of upgrading the seismic performance of a building when large scale renovations are being proposed. As such, many seismic evaluations are undertaken to determine the base seismic performance level in light of possible future work.

The NBCC (and OBC) stipulates that alterations to the structure shall not 'decrease' the performance level of a structure. For additions, in order to have a reasonable approach to the 'effect' on the performance level, a review of percentage change in mass and area that an addition would add to the building is often used as an evaluation tool to determine the 'significance' of the magnitude of the project and effects of an addition on the seismic performance level of a building.

For the proposed 2 level addition, the change in mass and area would be as follows:

- Increase in mass of 1.6% when compared with mass of entire building (above ground level).
- Increase in area of 840m^2 which represents less than a 3% increase in area when compared with the floor area of the building (above ground level).

For just 1 level addition, the change in mass and area would be as follows:

- Increase in mass of 0.4% when compared with mass of entire building (above ground level).

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- Increase in area of $420m^2$ which represents less than a 1.5% increase in area when compared with the floor area of the building (above ground level).

This magnitude of addition is generally considered to be small and would be expected to only have a small impact on seismic performance of the building. Reinforcing for all gravity loads as previously discussed would be required, but upgrading the building for seismic loads may not. However, confirmation of site class by a geotechnical engineer and review with the City of Ottawa plans review/building permit committee would be a logical next step in assessing whether this proposed addition would be accepted by the governing body (City of Ottawa).

To confirm the level of effect on the seismic performance of the building, the model of the building in ETABS has been updated with the described addition to compare the C/D ratios in the shear wall elements. As the shear capacity on the shear walls was the limiting factor, Table 9 presents the change to these C/D ratios only. As well please note that this table has been prepared for assumed Site Class C.

Table 9 Shear Capacity Demand Ratio of Core Shear Walls (Site Class C)

Shear wall ID	Direction	Existing Structure		Adding 1 Deck		Adding 2 Decks	
		C/D Ratio	Critical section	C/D Ratio	Critical section	C/D Ratio	Critical section
Core I	X	40.9%	2nd Floor	40.7%	2nd Floor	35.9%	2nd Floor
	Y	55.5%	2nd Floor	55.5%	2nd Floor	54.6%	2nd Floor
Core II	X	45.4%	2nd Floor	45.2%	3rd Floor	38.9%	3rd Floor
	Y	103.0%	2nd Floor	103.0%	3rd Floor	97.2%	5th Floor

As can be seen from this table, the impact of adding only 1 additional slab level has virtually no impact on the seismic performance. There is a slightly higher effect with the addition of 2 slab levels. This is still a small impact and the following should be considered when reviewing the numbers from this table:

1. The addition and its load transfer on the building has been modelled based on the worst scenario in that all loads from the addition get transferred through the slab diaphragms to the existing shear wall element. During the detailed design, the new addition would be designed to NBC 2010 standard and framing from the new addition could be designed to transfer some lateral loads down through other structural elements.
2. The shear capacity demand ratio of the Core 1 in the X direction is at 41% at level 3 and higher at higher floors. So the only area of the building that would be less than the original 41% performance level would be this section of wall from level 2 to 3. So if some remedial work would be required to maintain the performance level, it would only be to this small section of wall.

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Based on this review it is our opinion that seismic retrofit would not be required for the addition and if it were deemed required to maintain the current performance level, the work would be limited to one wall from the 2nd to 3rd floor. This additional analysis information can be included in the discussions with the City of Ottawa plans review/building permit committee.

5.2 Ground Floor – Alterations to Raised Floor Area

AAR was also asked to review the feasibility of altering the raised floor area at the ground floor from gridlines F-H/4-6. This area currently consists of stairs at the entrance of the Library near grid H6 to a raised floor area and then stairs back down near grid F4. This area appears to have been constructed in this manner to accommodate the theatre below. It does not appear that the raised floor is required for headroom issues, but appears to be more related to not having a column at grid G5 which would be at the centre of the theatre area below. The construction includes for 1500mm (5’) deep beams that span from columns at grid G6 to G4 and F5 to H5.

Based on our review of the structure at this location, there would be 3 options for structurally renovating this space to lower the slab to be flush with surrounding ground floor slab. These options would include:

1. Removing and reinstating the slab at the lower elevation with new beams below as per existing construction. This option does not appear practical, as the current theatre space below this area would be unusable as the new deep beams would not have required headroom.
2. Removing and reinstating the slab at the lower elevation with the addition of a new column at grid G-5 is feasible and likely the least expensive approach but would put a column in the middle of the theatre.
3. Removing and reinstating the slab and adding a 13.7m (45’) long and 1200-1500mm (4’ – 5’) high stand-up reinforced concrete beam from grid G-6 to G-4 along grid G would be feasible and may be a useable space the library would like to review. At the ground floor level this stand-up beam would essentially look like a 1500mm (5’) high wall along this length. If desired it could be capped architecturally and may be useable as a separation of entrance or exit or become a display area on each side of the wall, etc…

Further confirmation of exact ceiling and slab elevations for the theatre and control booth would be required - ceiling height in the control booth may be a problem. As well a mechanical and electrical review would be required to understand the true scope and costs associated with this work and confirm that existing systems could fit within a reduced ceiling space..

5.3 Atrium – Infill of Atrium Slabs

Infill of the atrium slabs at level 2 and 3 would in large part share the same complications as a vertical addition above this level. The structural framing in this area includes for cantilevered beams to pick up the area above the entrance, there are no column elements

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at grids 5G and 6H. Additional loads on the columns would impose too much load on the transfer beams at the garage level, and alterations at this level would impact on the driving lanes.

The addition to this space would contribute 330m^2 (3500 sq.ft.) if level 2 and 3 were infilled. These alterations would be much more costly and have a much higher impact on the current space in the library than adding the 2nd floor of vertical addition. The infilling of these slabs may only be feasible with the addition of columns at grid 5G and 6H, which would impact the Theatre at level B1 and would require reinforcing of columns, footings and transfer beams. This proposed infill would also have a large impact on the architecture of the building and the current natural light in the atrium space.

6. CONCLUSIONS AND RECOMMENDATIONS FOR EXPANSION

6.1 Conclusions

6.1.1 *Original Building Seismic Performance Level*

The original structure for the Ottawa Public Library consists of a reinforced concrete structure which include the Library Portion and the Sir Richard Scott tower portion. The building was built in the 1970 but an evaluation of the seismic performance of the building was done based on the 2010 National Building Code of Canada (NBCC 2010). The Seismic Force Resisting System of the structure consist of reinforced concrete shear walls and based on our analysis of the structure, the seismic performance is limited by the shear capacity of these walls. Our analysis has concluded that the building has a seismic performance level of 41% per NBCC 2010 requirements – based on the assumption of a Site Soil Classification (Site Class) C. In our opinion this is a conservative assumption and Site Class B is likely more realistic and possibly Site Class. The seismic performance level of the building based on these site classes would be 52% if Site Class B were assumed and 60% if Site Class A were assumed.

6.1.2 *Vertical addition to Library*

The feasibility of a 1 or 2 storey vertical addition has been reviewed for structural aspects. The 1 storey addition would consist of enclosing the 4th floor (existing roof) with a new roof. The 2 storey addition would consist of enclosing the 4th floor and adding a 5th floor with a roof above. Based on our review and analysis of the building for gravity and lateral loads, we have the following conclusions:

- The vertical addition should be limited to the northern half of the lower library building (gridlines F-J/1-4). This area would provide approximately 420 m^2 of floor area per additional storey added.
- The addition would require to be of light construction – steel framing and concrete slab of steel deck – and have a light cladding system and finishes. The new enclosed 4th floor could have 7.2 kPa of live load capacity (typical library loading) but the 5th floor would be limited to 4.8 kPa of live load capacity (typical assembly capacity).

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- For a 1 storey addition, the only structural remedial work required would be to reinforce the columns at gridline 4G in the 3 garage levels. This remedial work would be required for gravity loads. For the 1 storey addition, no remedial work is required for lateral (seismic) loads.
- For a 2 storey addition, the column at grid 4G would have to be reinforced at the 3 garage levels, and possibly up to 7 footing would need to be reinforced – but further geotechnical review is recommended. For lateral loads, it is our opinion that the effect of the addition on the performance level is small and can likely be mostly mitigated during the design of the addition, but approvals would be required from the City of Ottawa plans review/building permit committee.
- The structure of Stair 4 was reviewed and can be extended up to serve the addition. Further review on egress requirements for additional stairs is required (by others).
- Various alternatives were reviewed for the structure required for an elevator that would serve the new addition and existing floors in the Library. Each alternative requires some structural intervention for slab openings and new load-bearing wall elements for the shaft.

In our opinion the reinforcing required to the existing structure to accommodate the vertical addition are minor structural modifications which would not have an impact on the library space as the remedial work would all be at the B4, B3 and B2 levels. The work required for an elevator would be more disruptive to the library and use.

6.1.3 *Alterations to the Library*

The feasibility of structural modifications to the existing Library space was reviewed for 2 different alterations.

The first alteration consists of levelling out the raised floor area at the ground floor. Based on our review 3 structural options were discussed. Two of these options would have an impact on the theatre space below and the 3rd option included for an upstand beam (short wall) element in this area to reframe the structure. Structurally there are options, but further review of the current space and layout would be required by the Library Board. As well further more accurate surveys by a qualified surveyor would be required to confirm exact ceiling heights and review by a Mechanical and Electrical Engineer for mechanical/electrical equipment in and around the theatre at the B1 level to confirm all the implications of any of the structural options presented.

The second alternative consists of infilling the atrium slabs at level 2 and 3. Based on our review, it is our opinion that there would be significant structural complications and work required to achieve this and that it would be cost prohibitive and have a large impact on the architecture and space around this area as well as impact on the theatre and use of the garage levels below. In our opinion, from a structural perspective, this option is not worth pursuing.

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6.2 Recommendations on Expansion

In order to further complete this structural review, some addition information and confirmations are recommended. Notably:

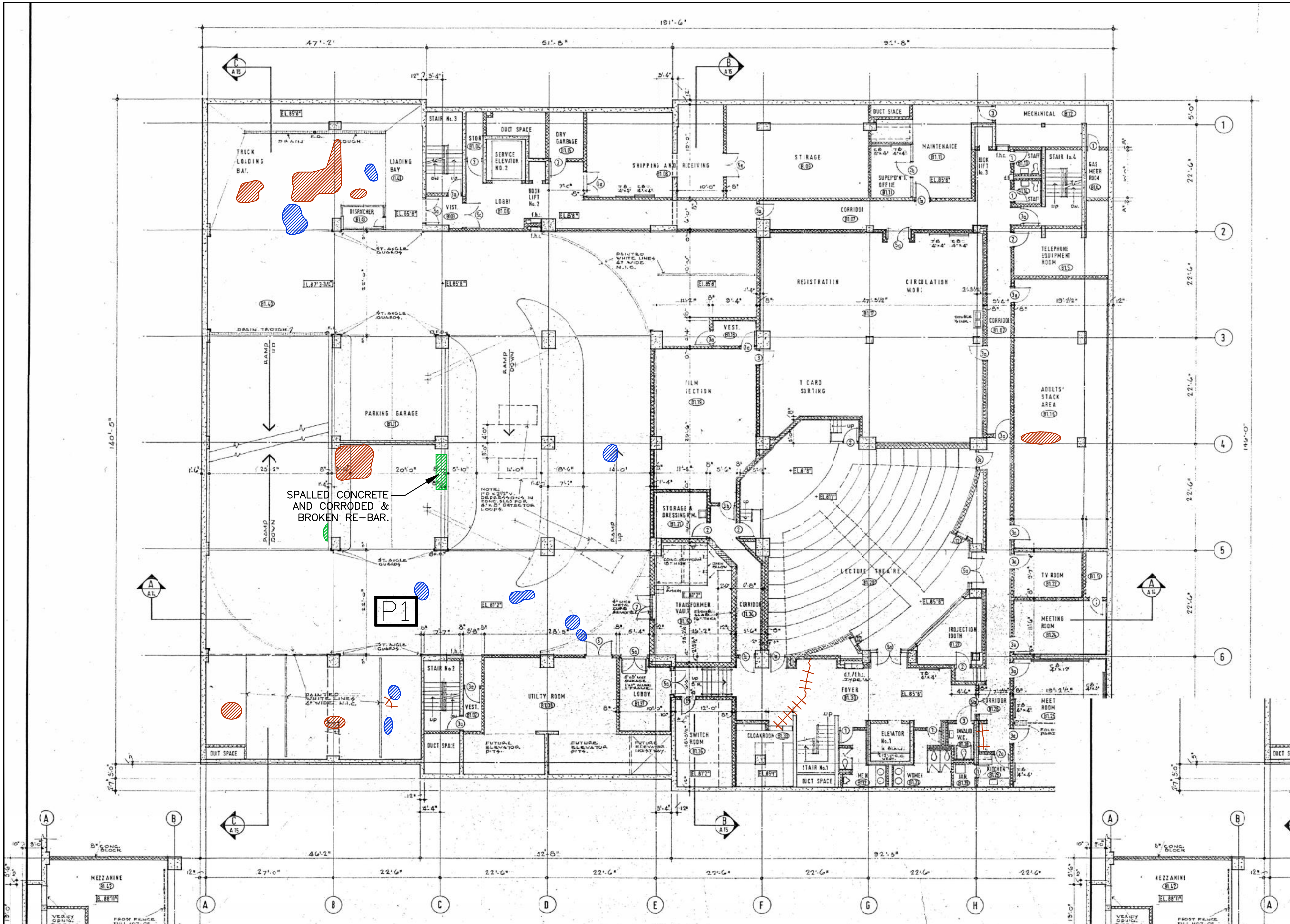
- Geotechnical review of bearing capacity of the rock to confirm if or how many of the footings may require reinforcing to accommodate the 2 storey addition. It may be found that the bearing value of the rock is greater (or less) than the original assessment at time of original construction.
- Geotechnical review to confirm the appropriate Seismic Site Class to use for this site. Our analysis assumed Site Class C, but a geotechnical engineer would confirm whether Site Class A or B would be more appropriate. This information would help in discussion with the City's Plans Review/Building Permit Committee and would be required prior to any design work for the addition.
- Discussions and review with the City's Plans Review/Building Permit Committee on their general acceptance with our review and finding with respect to requirements for seismic reinforcing of the existing structure.

With respect to future planning and assessment for the addition, review of egress, stairs, elevators would be required to develop further requirements for the architectural layout and structure. Any additional concept and preliminary design or planning for the architecture or structure should include the limitations on weight of the addition and the general guidelines for the structure which were used for our model.

7. REFERENCES

1. National Building Code of Canada (NBCC), 2010, National Research Council Canada.
2. CSA A23.3, 2004, Design of Concrete Structures, Canadian Standard Association.
3. CAN/CSA S16-01, 2001, Limit Sates Design of Steel Structures, Handbook of Steel Construction, Canadian Institute of Steel Construction.

APPENDIX D
PARKING GARAGE CONDITION SURVEY



DO NOT SCALE DRAWING. DIMENSIONS TO BE VERIFIED ON SITE. DRAWING TO BE READ IN CONJUNCTION WITH WRITTEN SPECIFICATION.

LEGEND

(red hatch)	DELAMINATED CONCRETE AT UNDERSIDE OF SLAB
(red cross marks)	CRACKING AT UNDERSIDE OF SLAB
(blue hatch)	DELAMINATED CONCRETE ON TOP OF SLAB
(green hatch)	DELAMINATED CONCRETE AT WALL

ISSUE	DESCRIPTION	DATE (DD/MM/YY)
1	ISSUED FOR DRAFT REPORT	30/04/12

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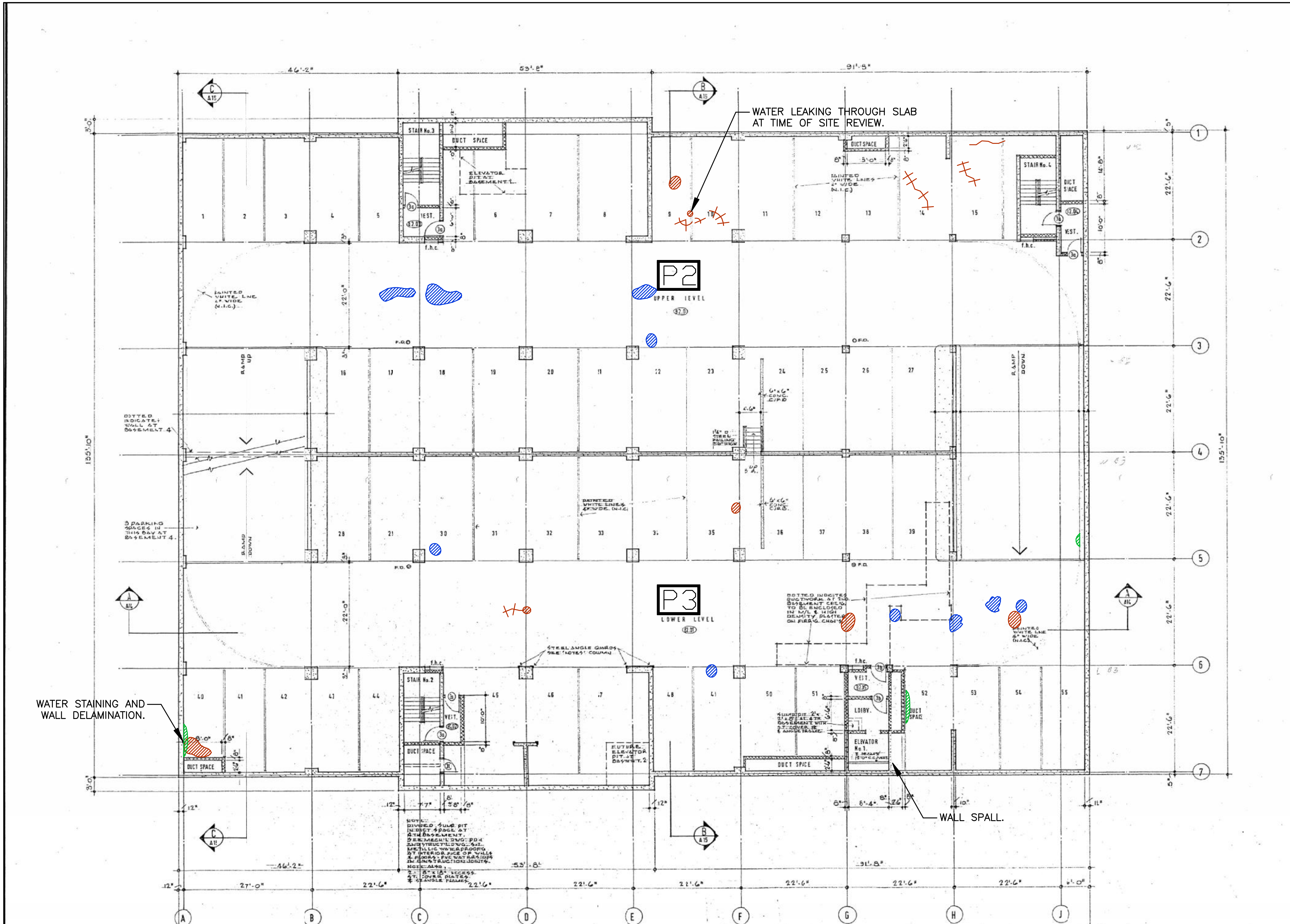
www.morrisonhershfield.com

PARKING LEVEL P1

OTTAWA MAIN PUBLIC LIBRARY

120 Metcalfe Street, Ottawa, Ontario



DO NOT SCALE DRAWING. DIMENSIONS TO BE VERIFIED ON SITE. DRAWING TO BE READ IN CONJUNCTION WITH WRITTEN SPECIFICATION.

LEGEND

(red hatch)	DELAMINATED CONCRETE AT UNDERSIDE OF SLAB
(red cross lines)	CRACKING AT UNDERSIDE OF SLAB
(blue hatch)	DELAMINATED CONCRETE ON TOP OF SLAB
(green hatch)	DELAMINATED CONCRETE AT WALL

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1	ISSUED FOR DRAFT REPORT	30/04/12

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LEGEND

(red hatch)	DELAMINATED CONCRETE AT UNDERSIDE OF SLAB
(red cross lines)	CRACKING AT UNDERSIDE OF SLAB
(blue hatch)	DELAMINATED CONCRETE ON TOP OF SLAB
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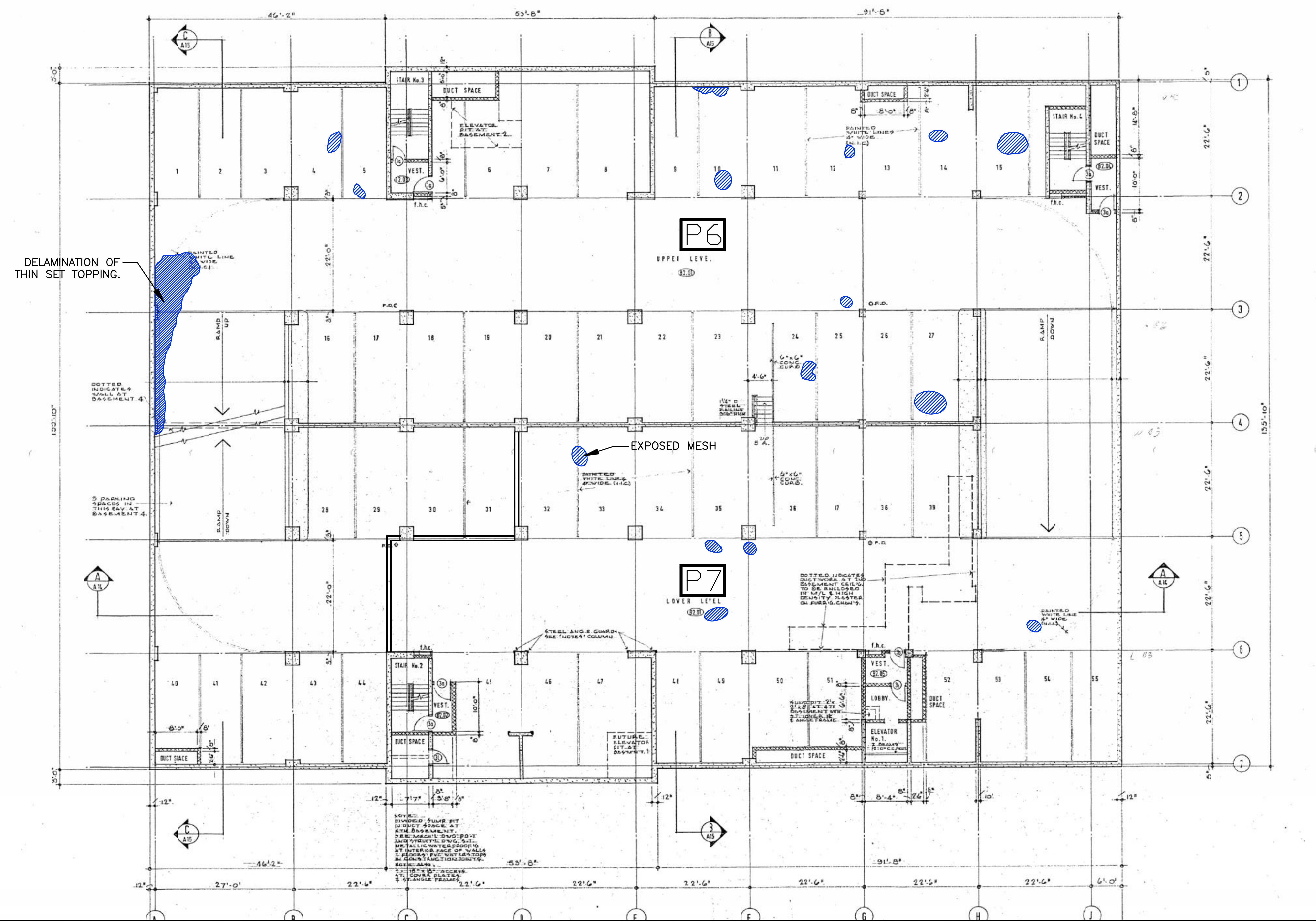

LEGEND

(red hatch)	DELAMINATED CONCRETE AT UNDERSIDE OF SLAB
(red cross lines)	CRACKING AT UNDERSIDE OF SLAB
(blue hatch)	DELAMINATED CONCRETE ON TOP OF SLAB
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PARKING LEVELS P6 & P7

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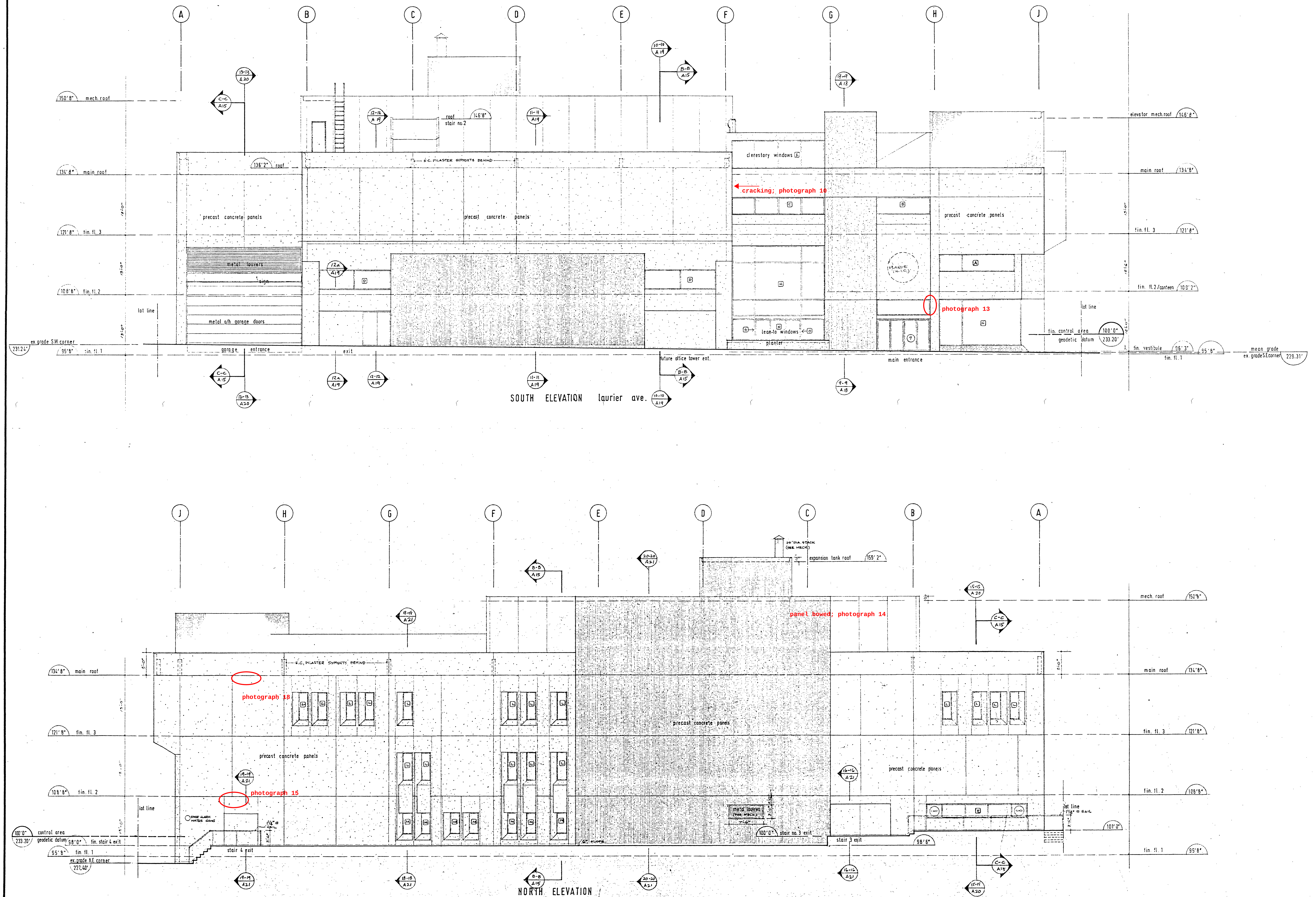
APPENDIX E
EXTERIOR REVIEW OF PRECAST PANELS



REVISIONS

No	DATE	DESCRIPTION

NOTES

AAA9302

CONTRACTOR TO VERIFY ALL DIMENSIONS CONDITIONS AND QUANTITIES ON THE JOB, & BRING ANY DISCREPANCIES TO THE ARCHITECT'S ATTENTION PROMPTLY.

GEORGE E. BEMI
ARCHITECT
OTTAWA - ONTARIO

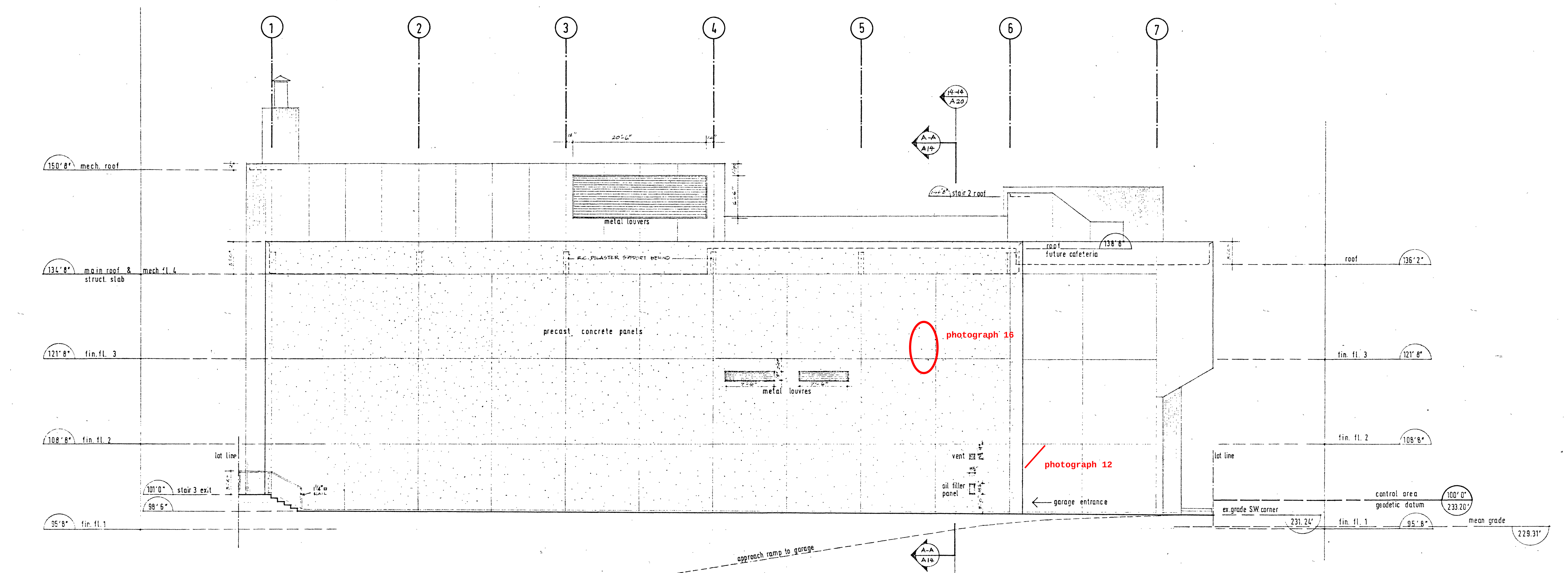
PROJECT: OTTAWA PUBLIC LIBRARY

SUBJECT: NORTH & SOUTH ELEVATIONS

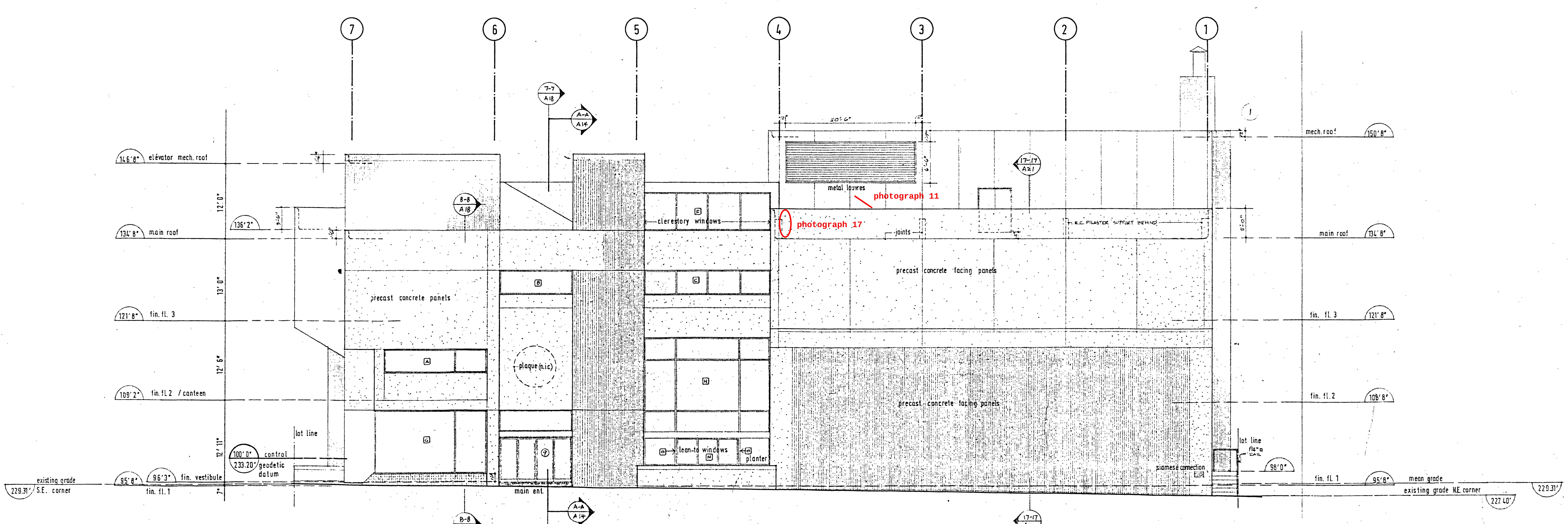
DRAWN BY: m.t. | DATE:

CHECKED BY: | SCALE: 1/8" = 1'0"

PROJECT No: 69-71 | DRAWING No: A-16



WEST ELEVATION



EAST ELEVATION metcalfe street

REVISIONS		
No	DATE	DESCRIPTION

NOTES

AAA9303

CONTRACTOR TO VERIFY ALL DIMENSIONS CONDITIONS AND QUANTITIES ON THE JOB & BRING ANY DISCREPANCIES TO THE ARCHITECT'S ATTENTION PROMPTLY.

GEORGE E. BEMI
ARCHITECT
OTTAWA - ONTARIO

PROJECT
OTTAWA PUBLIC LIBRARY

SUBJECT
EAST & WEST ELEVATIONS

DRAWN BY m.t.	DATE DEC. 70.
CHECKED BY	SCALE 1/8" = 1'0"
PROJECT No 69 - 71	DRAWING No A-17

APPENDIX F
THERMOGRAPHIC IMAGES

A thermographic survey was conducted in the evening of March 6, 2012. The purpose of the thermographic survey was to identify thermal anomalies in the building envelope that may be an indication of air leakage or conductive heat loss, which can be indicators of building envelope problems. The IR survey was conducted by Mr. Michael McKay, CET and Ms. Heather Penner, CET both of Morrison Hershfield.

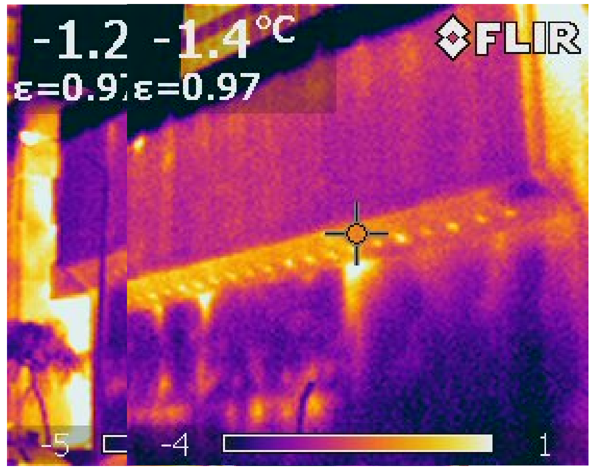
During a thermographic survey, it is beneficial to generate pressure differentials across the envelope to increase the volume of air flow through air leakage points. The operation of the mechanical systems was adjusted; however, no significant positive pressure was measured across the main entry doors.

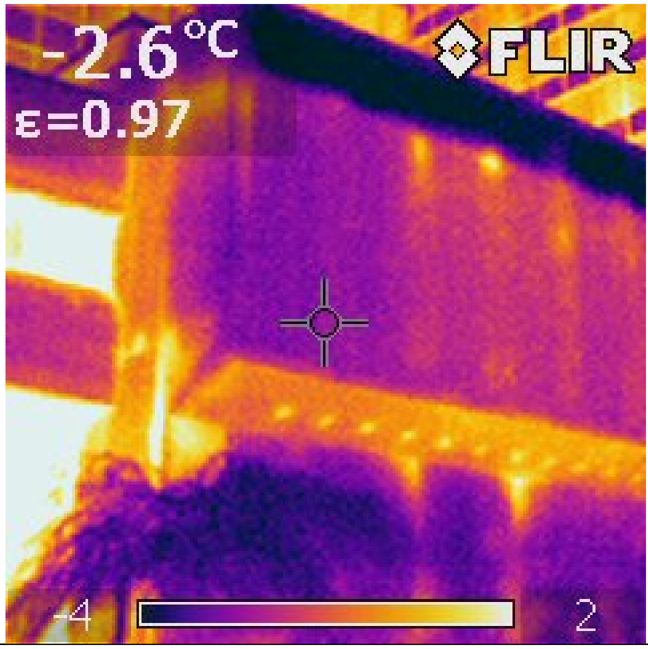
The environmental conditions at the time of the thermographic review were as follows:

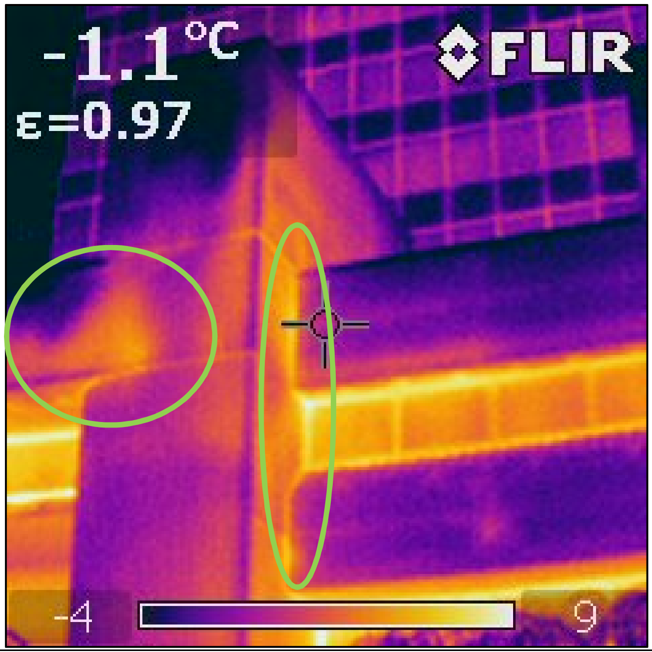
- Temperature: -5°C
- Wind: E 19 km/h
- Relative humidity: 63%

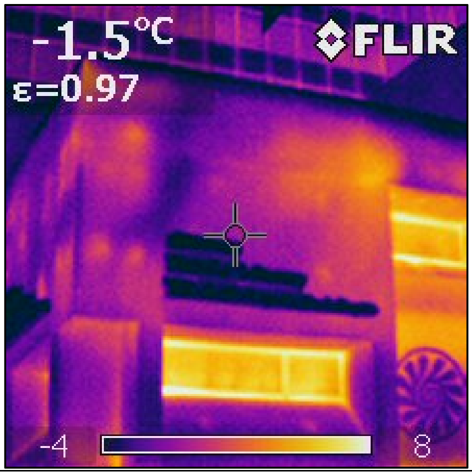
All objects at temperatures above absolute zero radiate energy to their surroundings. Both the frequency and intensity of radiation are functions of absolute temperature. The sensor in the thermographic camera absorbs infrared radiation given off by objects in its field of view. This information is captured by the camera for analysis. Since the infrared system can determine the surface temperature of an object, a physical process that affects the surface temperature can be detected. For example, a low-resistance thermal bridge that conducts heat, raising the temperature of the outside surface, can be detected. In the same way, warm air impinging on cool outer cladding produces a warm zone that can be detected.

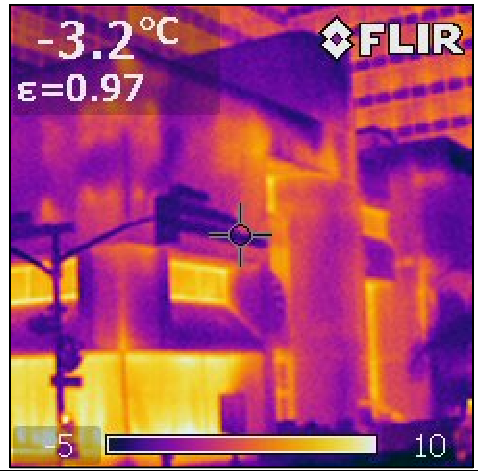
Irregular thermographic patterns are referred to as thermal anomalies. Typical anomalies that can be identified include air leakage and thermal bridging. Air leakage is the passage of air through elements of the building envelope such as walls, windows and joints. Leakage from the interior is referred to as exfiltration. Thermal bridging is generally caused by missing or damaged thermal insulation, or structural components which penetrate the insulation. As a result, conduction of heat takes place along these thermal short circuit paths through the insulation. Air leakage areas often take on a loosely defined, feathered pattern in an IR image, while thermal bridges show up as light (warm) areas with distinct, well-defined edges generally in the shape of the structural components causing the bridge.

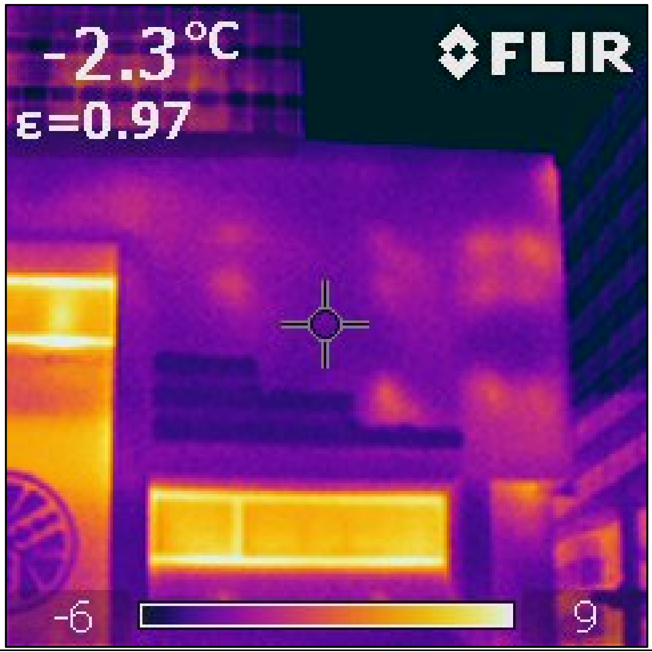
Thermographic Image 1	
Daylight Photo	
Remarks	East elevation – air leakage beneath slope portion of wall, air leakage at parapet, air leakage above line of floor slab.

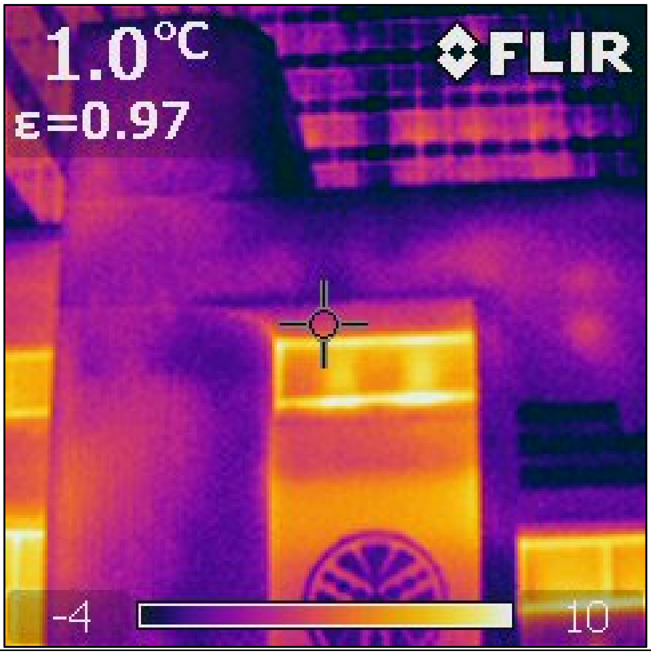
Thermographic Image 2	
Daylight Photo	
Remarks	East elevation – air leakage at parapet, air leakage at wall intersection

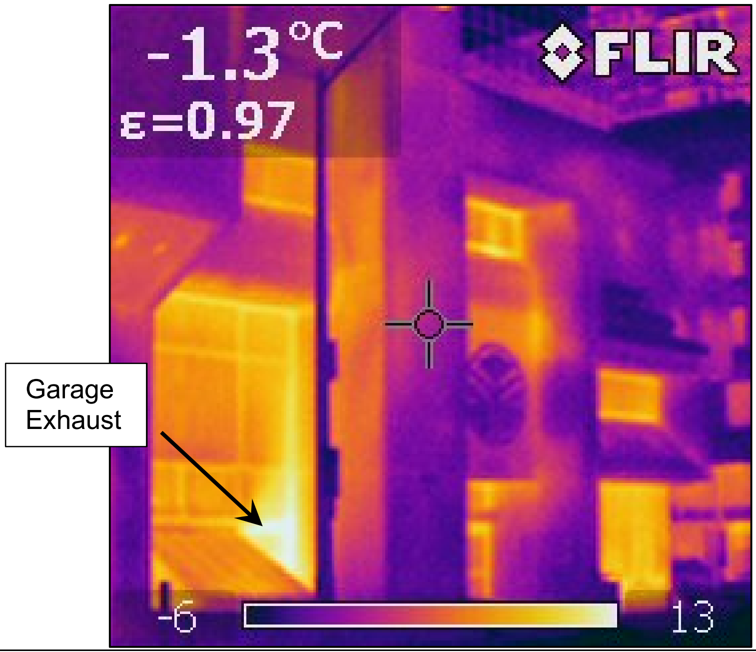
Thermographic Image 3	
Daylight Photo	
Remarks	Air leakage at intersecting walls, air leakage adjacent to soffit

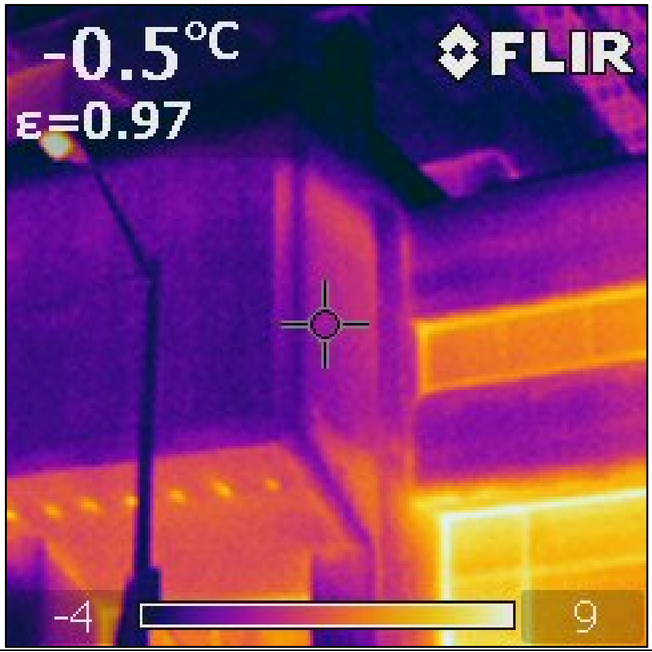
<table>
<tr><td>Thermographic Image 4</td><td>

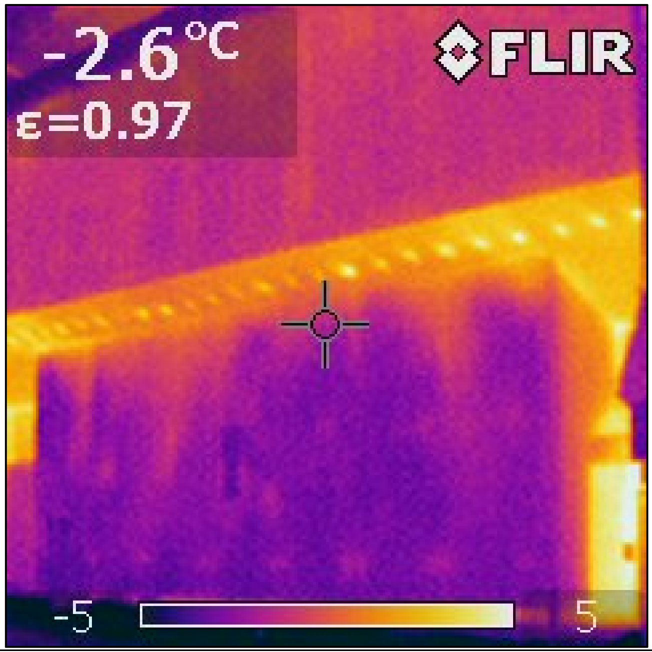

</td></tr>
<tr><td>Daylight Photo</td><td>
</td></tr>
<tr><td>Remarks</td><td>East elevation – air leakage/thermal bridging</td></tr>
</table>

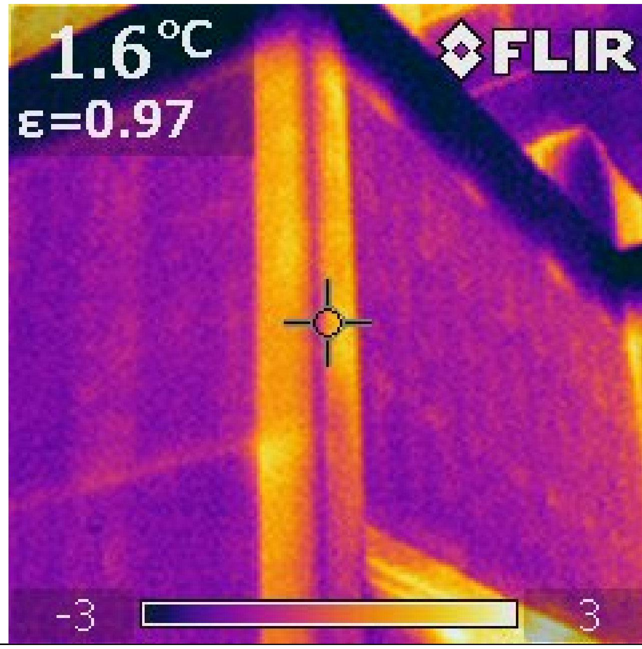
Thermographic Image 5	
Daylight Photo	
Remarks	South elevation – thermal bridging at precast anchors, air leakage at top corner

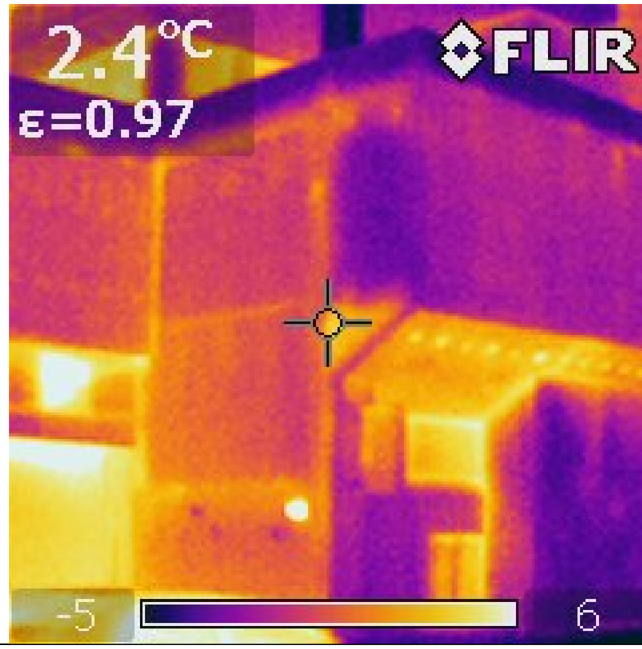
Thermographic Image 6	
Daylight Photo	
Remarks	South elevation – thermal bridging of anchors

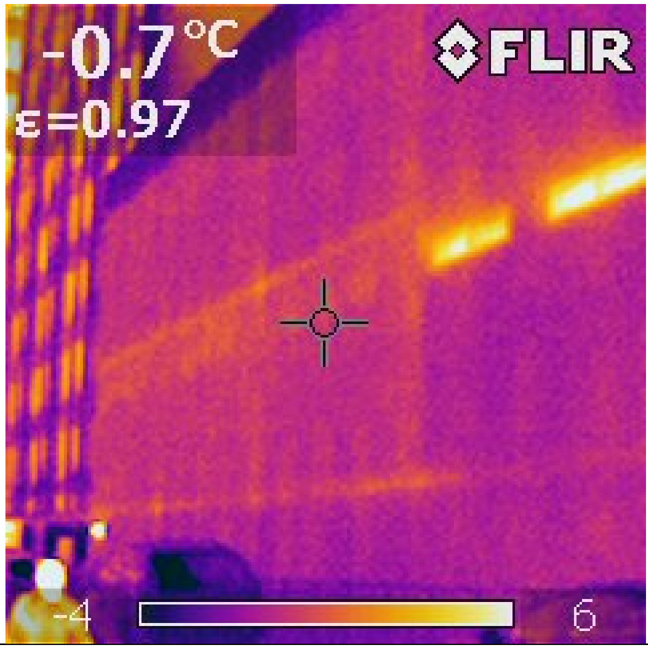
Thermographic Image 7	
Daylight Photo	
Remarks	South elevation - Air leakage at inset. Note: a garage exhaust is the cause of the warm area adjacent to the sloped glazing.

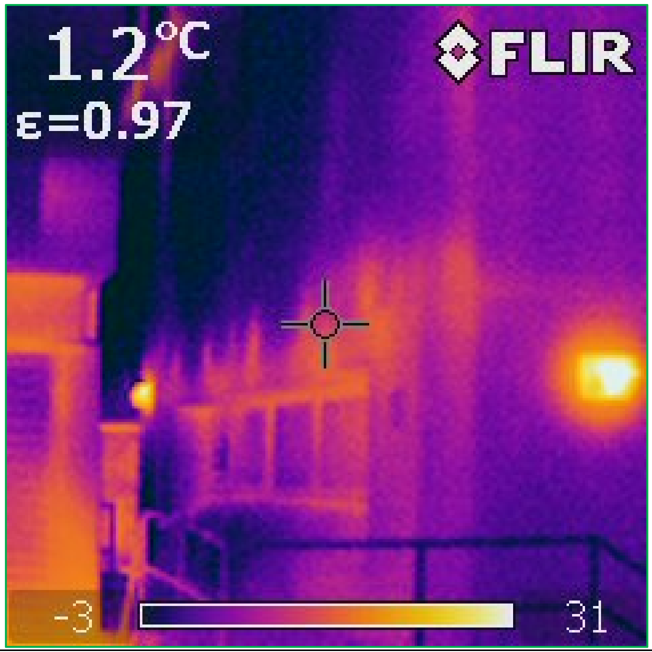
Thermographic Image 8	
Daylight Photo	
Remarks	South elevation – air leakage on end wall.

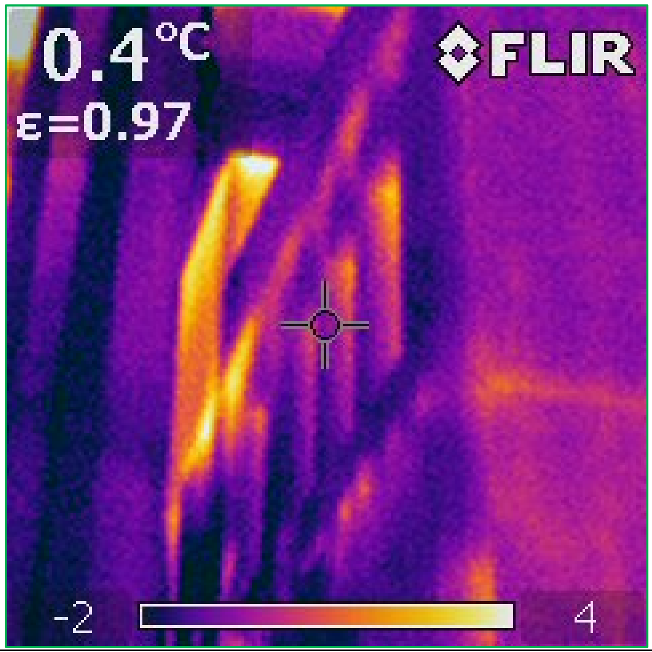
Thermographic Image 9	
Daylight Photo	
Remarks	South elevation – air leakage below sloped portion of wall

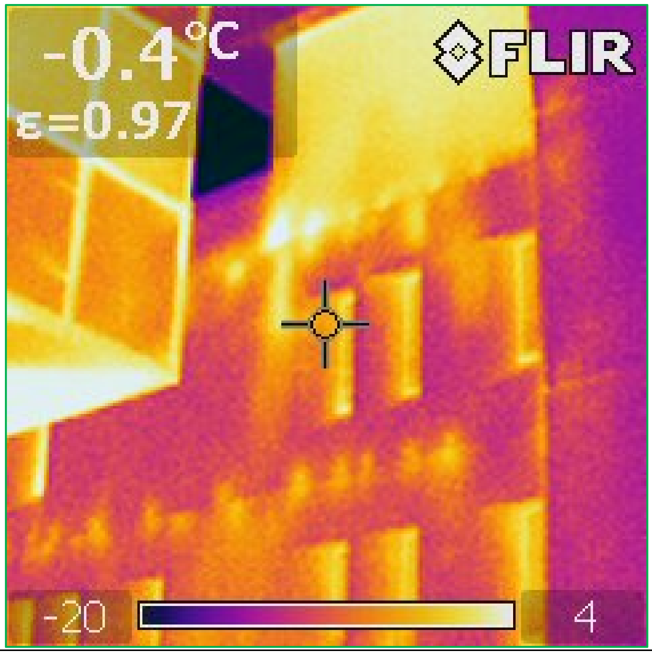
Thermographic Image 10	
Daylight Photo	
Remarks	Southwest corner – Thermal anomaly at corner of building

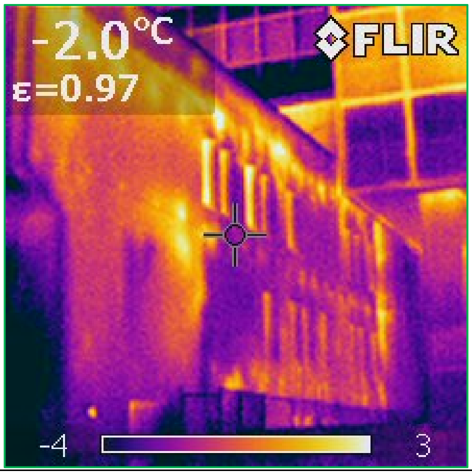
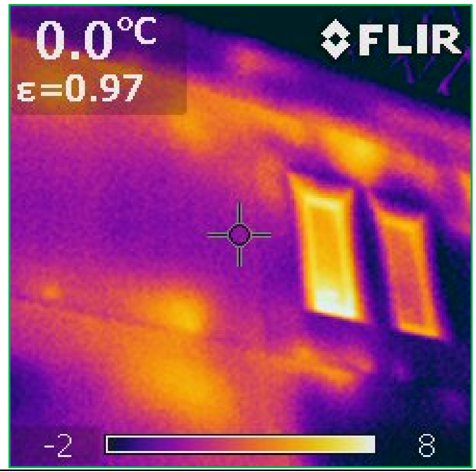
Thermographic Image 11	
Daylight Photo	
Remarks	South elevation – air leakage around precast panels on end wall.

Thermographic Image 12	
Daylight Photo	
Remarks	West elevation – air leakage.

Thermographic Image 13	
Daylight Photo	
Remarks	North elevation at northwest corner – air leakage above ground floor windows

Thermographic Image 14	
Daylight Photo	
Remarks	North elevation at northwest corner – air leakage above second floor

Thermographic Image 15	
Daylight Photo	
Remarks	North elevation east of tower – air leakage

Thermographic Image 16	 
Daylight Photo	
Remarks	North elevation west of Metcalfe St. – air leakage

APPENDIX G
TEMPERATURE AND RELATIVE HUMIDITY READINGS

Interior Conditions at Main Public Library, 120 Metcalfe Readings Taken on February 2, 2012		
Temperature	Relative Humidity	Approximate Location of Reading
21.7°C	26.2%	Theatre stage, basement level
21.9°C	27.1%	Theatre entrance, centre top of seating, basement level
21.6°C	30.2%	FOPLA bookstore, near north wall, centre of room, basement level
21.8°C	29.6%	Staff only door, corridor, basement level
19.1°C	16.4%	Main entrance vestibule, first floor
22.6°C	23.3%	Library entrance, first floor
22.7°C	25.3%	Self-check out area, first floor
23.4°C	23.0%	Stair bottom, near café, first floor
22.7°C	24.6%	Northeast corner of library, first floor
22.6°C	24.9%	Centre of library, near escalator, west side, first floor
23.1°C	24.2%	Near south wall, centre of library, first floor
22.7°C	24.4%	Southwest corner of library, first floor
22.4°C	25.8%	Near west wall, centre of library, first floor
22.3°C	25.3%	Northwest corner, near stairwell, first floor
23.0°C	21.0%	Reading lounge, centre
24.1°C	29.5%	Inside library, library entrance from atrium, west side, second floor
24.1°C	24.8%	Near south wall, centre of library, second floor
24.3°C	24.5%	At ramp corner, second floor
24.0°C	23.2%	Centre of library, near escalator, east side, second floor
23.9°C	23.4%	Centre of library, near escalator, west side, second floor
24.0°C	35.5%	Centre of library, north of escalator, second floor
23.9°C	24.3%	Near west wall, centre of library, second floor
23.3°C	24.0%	Northwest corner, second floor
23.7°C	24.7%	Children's reading area, second floor
23.8°C	23.0%	Inside library, southeast corner, second floor
23.8°C	22.3%	East side, bridge to staff room, second floor
23.6°C	23.4%	Main staircase, landing between second and third floors
23.4°C	24.2%	Inside library, library entrance from atrium, east side, third floor
23.7°C	24.6%	Near south wall, centre of library, third floor
20.1°C	36.5%	Centre of library, near escalator, west side, third floor
22.8°C	29.0%	Near west wall, outside computer lab, third floor
22.4°C	38.4%	Near north wall, elevator lobby, third floor
22.8°C	25.4%	Ottawa room, centre of room, near north wall, third floor
-6°C	60.0%	Exterior (at noon)