Comparing Three Building Life Cycle Assessment Tools for the Canadian Construction Industry

By

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Major Research Project

Presented to Ryerson University

In part fulfillment of the requirements for the degree of
Master of Building Science (MBSc.)
in the Building Science Program

Toronto, Ontario, Canada, 2017

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Abstract

This research aims to contribute to quantifying whole building life cycle assessment using various software tools to determine how they can aid the construction industry in reducing carbon emissions, and in particular embodied emissions, through analysis and reporting. The conducted research seeks to examine and compare three whole building life cycle assessment tools; *Athena Impact Estimator*, *Tally* and *One-Click LCA* to relate the input variability to the outputs of the three programs. The three whole building life-cycle assessments were conducted using a case study building with an identical bill of materials and compared to determine the applicability and strengths of one program over another. The research confirmed that the three programs output significantly different results given the variability in scope, allowable program inputs and generated “black-box” back-end calculations, where the outputted whole building life cycle carbon equivalents of *One-Click LCA* is less than half than of *Tally* meaning the programs outputs cannot be simply compared side-by-side.

Acknowledgments

I would like to first and foremost thank my MRP advisor Professor Mark Gorgolewski for his guidance over the past year and ongoing support as I navigated my way through this process. He is a model example of putting students first in his practice, and I felt this first hand as his student.

To my second reader Professor Russell Richman, who was so much more than just my second reader over the past year. It was such a pleasure to work with a professor who treats you like a peer. I learned so much from Russell both in and outside the classroom.

To the EllisDon Corporation team, Andrew Bowerbank and Natasha Arsenijevich, who not only had the confidence in me to take on their research, but have introduced me to such a wide network of interesting people, companies and projects along the way. It was a pleasure to work with their team and I look forward to doing it again.

And to the friends I met this past year- I never could have imagined meeting such wonderful people and making such meaningful lifelong friendships.

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1 Introduction

This research aims to contribute to quantifying whole building life cycle assessment using various software tools to determine how they can aid the construction industry in reducing carbon emissions, and in particular embodied emissions, through analysis and reporting. Utilizing appropriate tools and research to make educated material selection choices, change construction processes, reduce travel distances by specifying regional products and manufacturers, and waste processing choices, are becoming more relevant and necessary as governments set legislation to meet carbon reduction targets nation-wide (De Wolf, Pomponi, & Monc, 2017). The following research study seeks to contribute to how the Canadian construction industry can use life cycle assessment tools to meet sustainability targets and achieve carbon neutrality.

1.1 Canada's Commitment to Climate Change

Worldwide, nations are striving to establish new strategies to reduce dependence on fossil fuels and conserve natural resources, particularly following the significant global commitment demonstrated at the 2015 Paris Climate Conference (COP21), where over 190 nations signed a legally binding and universal agreement on climate; the primary outcome being the commitment to keeping global warming below 2°C, while urging efforts to limit the increase to 1.5°C (World Bank Group, 2017). In regard to national application, the conference established binding commitments by all parties to make nationally determined contributions (NDCs), and for all countries to report regularly on their emissions and progress made in implementing and achieving their NDCs, and to undergo international review.

Globally, over 40 national jurisdictions are now implementing some form of carbon pricing to combat climate disruption and manage our natural resources (World Bank Group, 2017). Canada's Federal government has followed suit by committing Canada to reducing total greenhouse gas emissions by 30 percent from the 2005 levels by 2030 (Government of Canada, 2016). The Canadian Government intends to reach these ambitious goals in various ways including passing legislation to have a price on carbon. Provincial leaders are also demonstrating leadership toward a low carbon economy by establishing new legislation to curb carbon emissions: Ontario and Quebec have aligned with California to establish a carbon cap and trade system and British Columbia and Alberta has successfully implemented a carbon tax structure; Saskatchewan and Alberta are emerging as global leaders in carbon capture and storage technologies.

Given Canada's highly variable climate, space heating and cooling in buildings contributes greatly in compared to other centralized countries. As well, Canada's sparse population over a large geographical area generally means longer travel times to destinations and high demand on the transportation industry. (Government of Canada, 2017). Despite these challenges, Canada has seen a dissociation between economic growth and GHG emissions, where Canada's share of total global GHG emissions has remained below 2% over the past two decades (Government of Canada, 2017), attributed to technological improvements, regulation and policy implementation by sector to help reduce emissions. Improved efficiency of equipment and practices as well as consumer understanding and knowledge about environmental choices have greatly influenced Canada's ability to reduce emissions incrementally while managing a growing population and economy.

1.2 The Canadian Construction Sector

Employing 7.1% of all working Canadians and accounting for 6% of Canada's overall gross domestic product (GDP) contributing $76.5 billion in 2011, the construction industry plays an important role in Canada's economic stability where the country's infrastructure development has a direct effect on the country's' long term prosperity (Statistics Canada, 2016).

With rapid population growth – 9 billion expected by 2050 worldwide – the demand for large infrastructure projects in both the public and private sectors is not expected to slow. According to the United Nations, the Buildings and Construction sectors account for 40% of global energy use, 30% of energy-related GHG emissions, approximately 12% of water use, nearly 40% of waste (United Nations Environment, 2016). Buildings and infrastructure provision is directly and indirectly related to almost all sectors of the economy based on the materials and energy used in its construction, operation, and resulting built environment (Government of Ontario, 2016).

While recent innovations and regulation have helped to reduce operational energy and carbon impacts, embodied impacts, which include the process of creating the materials and components, have been paid significantly less attention, lacking in comparable methodologies, data and regulation (De Wolf, Pomponi, & Monc, 2017). Advancement in technology and building material performance have been significantly improved, however by increasing the capabilities of technology and materials, the embodied carbon emissions of the improved systems often substantially increase, creating a shift in high emitting phases from the operating phase to the manufacturing phase (Amiri, Caddock, & Whitehead, 2013).

Given the ambitious goals set out by provincial and federal governments, the construction industry is under increased pressure to change the way in which infrastructure is constructed in order to meet the demands of the low carbon economy (Government of Ontario, 2016). In Ontario's Climate Change Action Plan (OCCAP), which was released in June of 2016, the former Minister of Environment and Climate Change, Honorable Glen Murray, stated "Our actions will help more Ontario households and businesses adopt low- and net zero carbon energy solutions in homes, vehicles and workplaces. We will [….] halt rising greenhouse gas pollution from buildings by retrofitting existing buildings and ensuring that future buildings have the lowest possible emissions. We will continue to be a strong centre of modern, clean manufacturing and jobs — and a leader in the clean-tech sector. We will become a leading North American hub for low- and net zero-carbon technology companies" (Government of Ontario, 2016).

What this means is that the provincial and national government is committed to transforming the buildings sector. With a growing number of incentives, impending changes in the building code, binding international commitments, and a national price on carbon, there is a growing need to accurately and effectively monitor and document GHG impacts. The Government of Ontario has put forward a call for action to industry to create a universally adaptable carbon accounting tool that can be implemented in all new and existing infrastructure to aid in creating realistic and achievable baseline carbon reduction targets and form incentives for future construction. The upcoming January 2018 roll out of the Cap and Trade program in Ontario will put emphasis on the required level of accuracy and inclusions or exclusions from the program, making advancements in carbon accounting in the construction industry critical in parallel with the roll out.

The recent release of the Canadian Green Building Council's Zero Carbon Building Standard is the first of its kind in Canada to require whole building life cycle assessment report (Canadian Green Building Council, 2017). While the program does not specify a carbon savings target like the LEED v4 materials credits, it familiarizes the industry with life cycle assessment tools and their capabilities.

1.3 Whole Building Life Cycle Assessment

As cities and communities continued to be built, it is imperative that there is an understanding of the true environmental impact of a building's over its lifecycle. Once the impact is quantified, informed decisions about how to reduce or offset emissions can be implemented. By analyzing and identifying the most harmful building materials and processes, the knowledge to better predict environmental externalities of future construction projects can encourage the adoption of alternative and sustainable clean-tech products and processes (Johnson, Jowitt, Grenfell, & Moir, 2012).

The purpose of the assessment is to inform design decisions by understanding the environmental impacts over the whole life of a project based on the available data at the time of the decision and a more accurate report at project completion when all design information and project changes have been finalized.

Worldwide, the construction industry is putting increased focus on the importance of whole building life cycle assessment, however given the currently un-regimented boundary conditions and scope, the purpose of the exercise is being lost in the inconsistency of the data outputted. Jowitt, Johnson, Moir and Grenfell of ICE Institute of Civil Engineers Publishing have put forward a global protocol for whole building life carbon assessment of infrastructure project that establishes a defined and consistent scope of the greenhouse gases that should be counted and by whom. The purpose of creating a common protocol or framework is to create consistency and transparency among the industry allowing projects to be compared side-by-side, determine accurate benchmarking and be adaptable across different construction sectors.

The protocol is a conglomerate of numerous guidance documents, industry research and current life-cycle assessment tool parameters. The protocol addresses the need for best estimate carbon accounting during the early phases of a project, but should be followed up with accurate and verified inputs upon project completion. This point is integral when analyzing the value of life-cycle assessment tools, as an early stage whole building life-cycle assessment can achieve significantly different results than the as-built condition (Johnson, Jowitt, Grenfell, & Moir, 2012).

2 Background

2.1 Quantifying Greenhouse Gas Emissions

Given the unique atmospheric lifetime and heat-trapping potential of each GHG, the Global Warming Potential (GWP) is a unit-less metric that has been developed to compare the heat trapping capacity of a GHG to that of carbon dioxide over an agreed period of time – usually 100 years (Government of Canada, 2017). Carbon dioxide equivalences are determined by multiplying the total mass of a particular GHG released into the atmosphere by the GWP of the GHG and summing the total carbon dioxide equivalences within a defined scope.

$$CO_2eq = GWP*GHG\ emission\ (tonnes) \qquad \text{Equation 1}$$

The six most common greenhouse gases contributing to global warming are referred to as the "Kyoto six pack" including carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride, which all have differing global warming potentials. In buildings, the most predominant contributor is carbon dioxide released from burning fossil fuels, solid waste and wood, as well as the result of certain chemical processes for example in the manufacturing of cement (United States Environmental Protection Agency, 2017).

Emission factors vary significantly by province due to the high variability in population, energy sources and economic sectors. When considering electricity generation provinces that rely heavily on fossil fuels will have higher emissions than provinces relying more on renewable sources (Government of Canada, 2017).

Greenhouse gas (GHG) emissions in Ontario were lower in 2015 than in 1990 by a total of 15 Mt CO_2eq (6% reduction) largely due to the change from its reliance on the manufacturing industry to the economic centre it is now, and the closure of coal-fired electricity generation plants shifted the provinces electricity production to renewable sources. In 2015, Ontario represented 23% of the national total greenhouse gas emissions (Government of Canada, 2017).

2.2 Greenhouse Gas Emissions Accounting

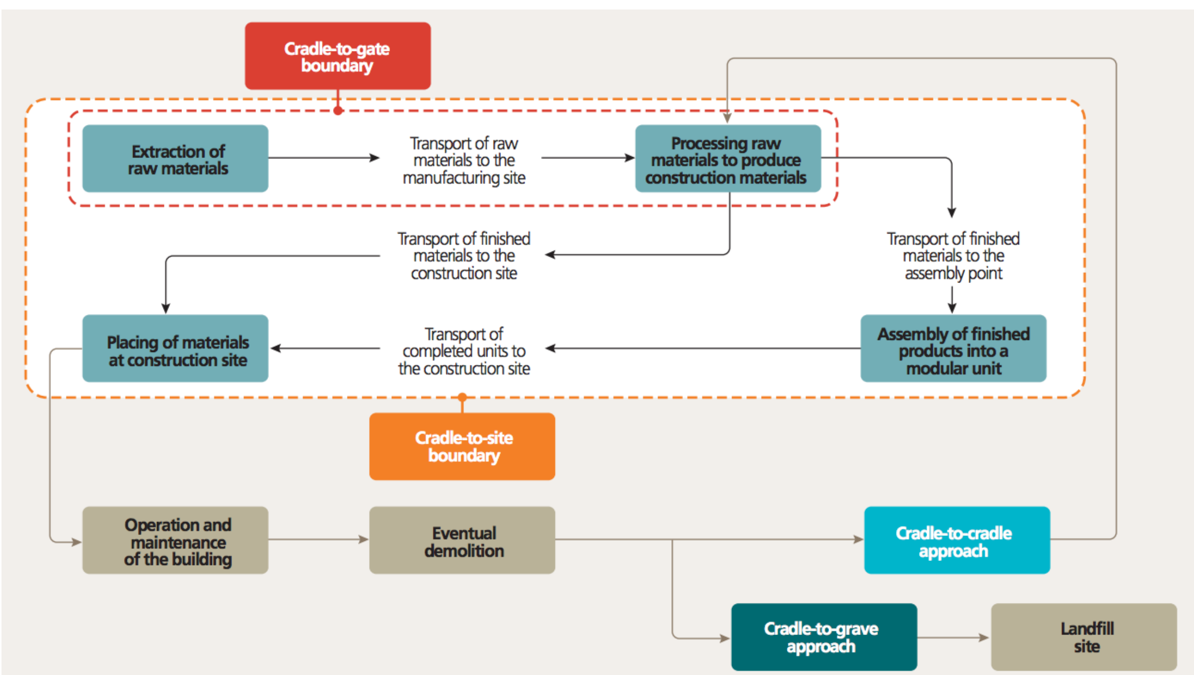

Figure 1: Life Cycle Assessment Boundary Conditions (Amiri, Caddock, & Whitehead, 2013)

Determining and defining carbon neutrality requires a comprehensive and accurate accounting method that considers all stages of a projects life within a pre-defined scope. As depicted in the diagram in Figure 1, the boundary conditions define which project stages are included in the scope. A cradle-to-gate boundary considers all works that take place in the creation of the materials used on site including raw material extraction and material processing and manufacturing, including any transportation between such stages. A cradle-to-site boundary condition further includes material assembly of modular units and placement of materials on the site, including all transportation between stages. A cradle-to-grave boundary further includes the construction processes, operation and maintenance, and demolition and waste over the lifetime of the project. A cradle-to-cradle boundary condition further considers the reuse potential of materials at the project's end-of-life (Amiri, Caddock, & Whitehead, 2013).

The widely adapted method of identifying emissions into three scopes aid in understanding the roles of emissions ownership responsibility of an organization, building, or project of any type, as summarized in Table 1 (Johnson, Jowitt, Grenfell, & Moir, 2012). The total emissions accounted in a project is the sum of the three scopes and can be quantified using a cradle-to-grave life-cycle assessment tool to determine the total emissions accumulated over the lifespan of the project.

Table 1: The Scope of Emissions Based on their Direct or Indirect Relation to the Reporting Organization or Project Owner (Johnson, Jowitt, Grenfell, & Moir, 2012)

Scope	**Definition**	**Example**
Scope 1	Direct emissions from activities owned or controlled by the reporting organization	On-site energy generating processes, on-site fossil fuel combustion in boilers or furnaces
Scope 2	Indirect emissions from electricity, heat, steam and cooling purchased by the reporting organization	Operational heating and cooling loads, energy utilized during construction process
Scope 3	Other emissions from sources that are not owned or controlled by the organization	Waste disposal, embodied emissions of materials, business travel

2.3 Carbon Neutrality Definition

Carbon neutrality is defined as a balance between the measured amount of equivalent carbon emissions released from the "Kyoto Six-Pack" greenhouse gases with an equal and opposite offset or sequestration to create a net-zero carbon footprint (Carruthers & Casavant, 2013). The impact each greenhouse gas has on the atmosphere is expressed in terms of carbon dioxide equivalence (CO_2eq), allowing the unified unit to be summed and reported as a total carbon dioxide equivalent, simplifying and streamlining the reporting process.

The U.S. Department of Energy's defines a net-zero source energy building as a building which, on a source basis, the annual delivered energy is less than or equal to the on-site renewable exported energy. Source energy is defined as the total site energy plus the energy consumed in the extraction, processing and transport of primary fuels such as coal, oil and natural gas; energy losses in thermal combustion in power generation plants; and energy losses in transmission and distribution to the building site (U.S. Department of Energy, 2015). While an official definition of net-zero carbon buildings is not readily accepted in the same way, carbon neutrality is defined as the sum of all operational carbon and embodied carbon of all life cycle phases, or in other words the sum of Scope 1, 2 and 3 emissions as defined in Table 1.

2.4 Life Cycle Assessment Phases

The life cycle of a project can be defined as the chronological stages of a product or service, from raw material extraction to end-of-life decommissioning and final disposal. Life cycle assessment (LCA) is a method used to determine any associated environmental impacts and externalities that can be attributed in the manufacturing and functionality of a product or service (Gan, Cheng, & Lo, 2016). This systematic approach accounts for all inputs and outputs of energy and greenhouse gas emissions during the entire lifecycle, expressing a total impact that can be stated in total energy or carbon dioxide equivalence. It is critical to identify the source and associated owner of each process, whether upstream or downstream to accurately assign ownership and responsibility at each stage of the assessment. ISO 14040, the international standard on environmental management and life cycle assessment defines the principles and framework for life-cycle assessment including the scope and goal of life cycle assessment, and describes the relationship between each life cycle phase.

A building's lifecycle can best be depicted in Figure 2, where a cradle-to-grave full lifecycle assessment considers stages A1 through to C4. The internationally recognized annotation system from EN 15978 will be used from here forward in this report when referring to the life cycle stages.

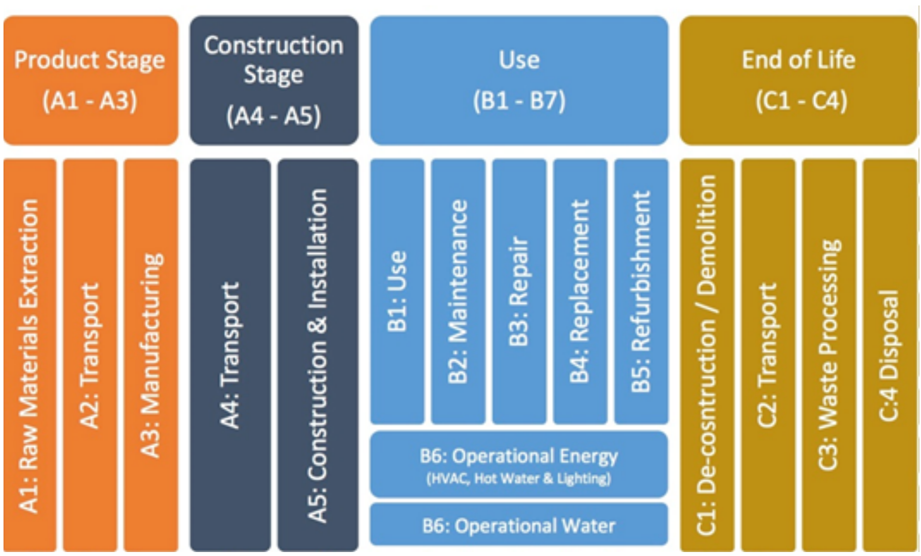

Figure 2: Cradle-to-Grave Life Cycle Assessment Stages (Johnson, Jowitt, Grenfell, & Moir, 2012)

2.4.1 Product Stage: A1-A3

The product stage of life cycle assessment includes the carbon dioxide emitted to extract the raw materials for new material manufacturing, the transportation between the extraction site and the manufacturing site, and the emissions exhausted during the manufacturing process. Life cycle inventories are often of mixed quality, or of generic materials rather than specific products and manufacturers, however as organizations adopt standardized methods and program ambassadors such as LEED enforce third party verified life cycle assessment data, the quality and abundance of material embodied carbon is expected to improve (De Wolf, Pomponi, & Monc, 2017).

2.4.2 Construction Stage: A4-A5

The construction phase of life cycle assessment includes the emissions associated with the transportation of material to site and the project construction processes. The construction phase is difficult to quantify into a total carbon dioxide equivalence because under current construction practices and regulation, it is not obligatory to meter motorized vehicles to and from site or to sub-meter the construction site to accurately state the associated emissions due to construction (ThinkStep Gabi, 2017).

Construction generally involves a substantial amount of transportation including transport of materials and equipment from the supplier's site to the construction site, transport of materials, equipment and workers around the construction site, and transport of project employees to and from the construction site. The emissions due to transportation vary significantly depending on the site's geographic location, size and complexity, and method of transportation (ThinkStep Gabi, 2017).

Equation 2 is used to quantify the total carbon emissions due to transport of materials, waste and equipment, in tons CO_2. Where EC_T is the total carbon emissions, Q_j^k is the amount of building material, waste or equipment in tonnes to be transported by vehicle k, T_j^k is the total distance for item j in vehicle k in kilometers, and f_k^T is the emissions factor for transportation using vehicle k in kilograms of CO_2eq per tonnes kilometer (ThinkStep Gabi, 2017).

$$EC_T = \sum_j \sum_k Q_j^k \, x \, (T_j^K x \int {}_k^T)/1000 \qquad \textit{Equation 2}$$

The carbon emissions associated with on-site construction processes are difficult to accurately estimate in advance of the completion of the project or activity as the need for availability for actual site data such as the amount of electricity, fuel, water and various other materials used by different trades is required and often not monitored. On-site construction carbon emissions vary substantially depending on the type and energy efficiency of equipment used, amount of material, characteristics of the building project and construction site restrictions (Xiao, 2017).

Figure 3 summarizes the emission sources relevant to the construction phase that should be considered in the total carbon emissions in phase A5. The schematic includes temporary materials used such as concrete forms and considers their reuse potential and life span before requiring replacement (Xiao, 2017).

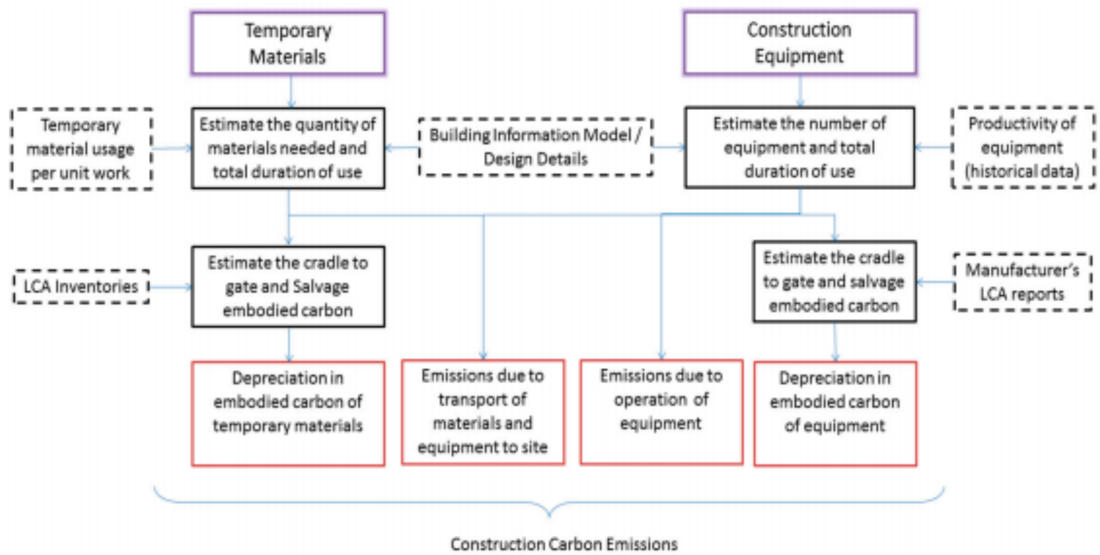

Figure 3: A Framework for the Estimation of Carbon Emissions Incurred During the Construction Phase

Equation 3 depicts the total emissions incurred due to the operation of equipment during on-site construction. E is the total emissions incurred in CO_2eq, EP is the available engine power of the equipment in horsepower, OT is the duration of operation, ER is the emissions factor for the specific equipment and fuel type used and LF is the load factor, referring to the average fraction of the engine that is actually used including idling and partially loaded equipment (ThinkStep Gabi, 2017).

$$E = EP \times OT \times ER \times LF \qquad \textit{Equation 3}$$

The construction phase poses high uncertainty and site-specific conditions that cannot simply be assumed by project typology or site location. Specifically, during the demolition process, it is often unknown to what extent the site requires grading, trenching or excavation prior to the commencement of works. Additional uncertainty can arise based on the project size, equipment type and reuse potential of material or site works from previous site work (Xiao, 2017).

2.4.3 Use: B1-B7

The operations phase of life cycle assessment includes the emissions associated with the building during its period in use. These emissions include the electricity, water and fuel required to operate the conditioning system, lighting and equipment and the emissions associated with maintenance, repair, replacement and refurbishment of the building. Operational energy and water use is readily understood and attainable data given energy modelling software's and post occupancy sub-metering (Xiao, 2017). Material maintenance, repair, replacement and refurbishment can be estimated based on a typical lifespan of a particular product, however is variable depending on the climate, exposure to human contact, mould, rot and other contributors. Mechanical and electrical equipment have a typical lifespan, however when worked over capacity, in extreme weather or improperly commissioned, the lifespan can be variable.

2.4.4 End-Of-Life: C1-C4

The end-of-life phase of life cycle assessment includes the emissions associated with the deconstruction and demolition process, transportation to local waste facilities, waste processing and disposal. The end-of-life strategy is highly dependent on the building parameters such at the type of materials used, the original design and connections of building components, availability of technologies to optimize reuse and recycling, availability of landfills for sorting and disposal (Xiao, 2017).

Estimating the carbon emissions associated with a building's end-of-life poses challenges given that the estimation is often done on average 50 years prior to the time at which the emissions will be emitted, as the assessment is completed at the start of the project. Projected improvements to technologies, landfills site locations, transportation routes and material reuse and recycling potential is estimated at the time of construction based on current predictions, meaning results are reported with a high level of uncertainty.

Where available, Environmental Product Declarations (EPDs) are used to estimate the end-of-life emissions of each material, based on third-party assessments conducted on present-day projects documented emissions at the end-of-life stage (Xiao, 2017).

This report focuses principally on the product and construction stages of the building life to better understand their impacts and how they can be analyzed.

2.5 Life Cycle Emissions Quantification

Life cycle assessment (LCA) is the overarching term that quantifies the environmental impact of a material or product over its life time. LCA are informed by a thorough life cycle inventory (LCI) of all the processes undertaken to manufacture the material or product, which are then multiplied by the associated emissions factor to convert flow quantities into environmental impact quantities through life cycle impact assessment (LCIA). Environmental Product Declarations (EPDs) are third-party verified LCAs of a particular product or material manufacturer.

2.5.1 Life Cycle Assessment (LCA)

Life cycle assessment is conducted on a product or service to determine its environmental impact over its lifetime. The multi-step procedure compiles and examines the inputs and outputs of materials and energy and their associated environmental impacts directly attributed to by the product or service (Athena Sustainable Materials Institute, 2011).

2.5.2 Life Cycle Inventory (LCI)

Life cycle inventory is the quantification of input and output flow of materials, energy or raw resources throughout the lifetime of a specified product or service (Athena Sustainable Materials Institute, 2011).

2.5.3 Life Cycle Impact Assessment (LCIA)

Life cycle impact assessment converts each LCI process into the environmental impacts associated with the particular process. The sum of the environmental impacts from all processes in the LCI is the basis of a product's LCA (Athena Sustainable Materials Institute, 2011).

2.5.4 Environmental Product Declarations (EPDs)

When available, emissions inventories such as Environmental Product Declarations (EPDs) can be used as the basis for estimating cradle-to-gate embodied carbon and other emissions. EPDs use the reporting format outlined by the ISO 14025 standard, providing a standardized set of information categories for reporting LCA results and allow side-by-side product comparisons of products of similar typology. EPDs are performed by certified third party assessment company and distinguish the embodied carbon of a particular product based on its composition, extraction and manufacturing locations, core upstream and downstream processes and use of resources (Hardy & Owens, 2013).

Requirement of EPDs on construction sites is yet to be widely adapted where product databases are not specific to a particular manufacturer, but rather a generic product. It should be noted that the embodied carbon of materials can vary significantly by the manufacturing processes used, depending on technologies used and the properties of the raw material. As well, the transport requirements may vary considerably from one manufacturer to another depending on the location of the processing sites, location of material quarries and suppliers, and layout of the facilities, leading to different transport-related carbon emissions for different manufacturers (Xiao, 2017).

2.6 Life Cycle Assessment Criterion

Life cycle assessment requires a standardized framework to ensure transparency and consistency among projects of similar typology. The intention is to provide guidance to all applicable stakeholders including policy makers, consultants, designers, contractors and operating organizations. The framework should consider the following in order to ensure a well-rounded and thorough assessment (Johnson, Jowitt, Grenfell, & Moir, 2012).

- Be applicable to all building typologies and set consistent boundaries according to the specific greenhouse gases contributors across projects of a similar type.
- Build on already established greenhouse gas emissions and life cycle analysis assessment approaches.

- Be applicable to all stages of project development including design, construction and feasibility, operation, in-use and decommissioning.
- Compare alternative material and process options in terms of whole life carbon emissions.
- Take account of upstream and downstream emissions of the project.
- Use regionally appropriate emission factors and update periodically as a result of changes in the fossil/ non-fossil mix of energy supply and changes in efficiency in relation to material processing, equipment manufacturer and operational activities.
- Record the source and date the emission factors, along with the range of uncertainty.
- Include non-costed aspects that further influence the total life cycle emissions such as land-use costs and change of land allocation.
- Determine a common unit of reporting of carbon intensity such as CO_2eq per area or per user, to enable comparison between projects and establish baselines by project typology.
- Recognize estimations and assumptions when made.

By understanding and recognizing the need for a standardized framework for carbon accounting in the construction industry, life cycle assessment tools are used to quantify and validate the total life-cycle carbon accumulated over the lifetime of a project be it a building, infrastructure or civil project. Currently available life cycle assessment tools are not regulated or required to address all items in the above assessment criterion, meaning the tools output differing results given the assumptions and inputs available.

2.7 Existing Life Cycle Assessment Tools

Table 2 summarizes the capabilities of five readily available life-cycle assessment tools and their general characteristics that set them apart from one another. Information presented in the table is primarily gathered from the program website, with the exception of *Tally*, *Athena Impact Estimator* and *One-Click LCA* where communications with the company confirmed information.

Although ThinkStep GaBi and SimaPro have been used for whole building assessments, they are not designed specifically for that purpose. They are primarily used in product based life cycle assessment and life cycle inventory creation and are therefore less relevant to whole building life cycle assessment.

Table 2: Comparison of General Characteristics of Five Leading LCA Tools

	Athena Impact Estimator	**Tally**	**One Click LCA**	**ThinkStep GaBi**	**SimaPro**
Company Ownership	Athena Sustainable Material Institute	KT Innovations, ThinkStep, AutoDesk	BioNova Ltd.	ThinkStep	PRe Consultants
Life Cycle Capabilities	Whole-Building	Whole-Building	Whole-Building	Product Based – Not Building Specific	Product Based – Not Building Specific
Material Data Collection Source	Athena LCI Database	GaBi LCI, NREL LCA, Quartz Project, ASTM	All Verified EPD's	GaBi Database	EcoInvent, USLCI, ELCD
Program Integration	Stand Alone Program	AutoDesk Revit Integrated	BIM Integrated/ Online Access	Stand Alone Program	Stand Alone Program
Software Update Frequency	Bi-Annual	Periodically	On request within 24 hours	Annually	Periodically
Iso 14040 & 14044 Compliant	Yes	Yes	Yes	Yes	Yes
System Boundaries	Cradle-to-Grave	Cradle-to-Grave	Cradle-to-Grave	Cradle-To-Grave	Cradle-To-Grave
Country of Origin	Canada	USA	Finland	Germany	Netherlands
Geographic Variability	North America Only	Yes- US Only	Yes	Yes	European Based
Canadian Applicability	Yes	Weak Canadian Material Database	Yes	Yes	Yes
Models M&E	No	No	Yes	No	No
Leed V4 Verified	Yes	Yes	Yes	Yes	Yes
Material Lifespan Modifications	Embedded in Program	Embedded in Program	Auto-Populates, can be modified	Yes	Yes

End-of-Life Outputs	Deconstruction, demolition, disposal, waste processing & transport	Does not include transportation	Deconstruction and waste	Unknown	Unknown
Mode of Transportation and distance	Auto-populated to nearest NA city	Auto-Populates, can be modified (mode and distance)	Auto-Populates, can be modified (mode and distance)	Yes	Yes
Operational & Construction Waste	Waste factor included in material quantities	No	No	Yes	Yes
Skill Level Requirement	Moderate	High Revit Skill Required	Moderate	Advanced	Advanced
Transparency	Undisclosed "back-end calculations"	Outputs project specific report with detailed information. Some undisclosed "back-end" calculations	Undisclosed "back-end calculations"	High transparency of "back-end" calculations	High transparency of "back-end" calculations

2.7.1 Athena Impact Estimator

The *Athena Impact Estimator* for Buildings is a whole-building life-cycle assessment tool that reports footprint data for the following impact categories: acidification, global warming potential, human health risk, respiratory effect potential, ozone depletion, smog potential, eutrophication and total fossil energy. The program pulls LCA and LCI data from the Athena Database and other North American databases. Electricity gird mixes, transportation modes and distances, and product manufacturing technologies are all regionally specific to the geographical location of the project.

Athena Impact Estimator operates by either inputting a project's bill of materials or by building the project in the program itself, the latter of which calculates the bill of materials within the program. *Athena Impact Estimator* is not a user intensive program as outputs are primarily dictated by back end research and averages, rather than site/project specific data.

2.7.2 Tally

Tally, developed by KieranTimberlake in the United States and released in 2013, is a building integrated modelling (BIM) plug-in that determines quantity take-offs directly from AutoDesk Revit. *Tally* is a whole building life cycle assessment tool that gathers materials information from the GaBi LCI database, and all data is from the U.S., with the intention to develop worldwide in the future. *Tally* allows user input specific to the project for transportation distances from product manufacturer to site, annual operational energy, and construction process energy and water. *Tally* reports the following impact categories: acidification, eutrophication, global warming potential, ozone depletion potential, smog formation and primary energy demand.

2.7.3 One-Click LCA

One-Click LCA, developed by BioNova Limited in Finland is a web-based program that gathers a project bill of materials from any BIM program, including but not limited to AutoDesk Revit. The *One-Click LCA* material database accepts any EPD worldwide, so long as it is third-party verified, meaning the database includes only specific materials and products by specific manufacturers, not generic materials. The *One-Click LCA* team inputs new EPDs within 24 hours of their confirmation of verification.

Unique to *One-Click LCA*, the program is compliant with over 50 rating systems, assessment measures and standards worldwide, meaning the program has numerous impact categories available for assessment and comparison, depending on the needs of the user.

3 Literature Review

Life cycle assessment is conducted in research and literature extensively using either hand calculations or assessment tools in three primary ways: to report total greenhouse gas emissions in a particular case study building, to quantify the percent carbon savings from building retrofits over new builds, and to compare materials or methods to determine the difference in life cycle carbon emissions. Little research has been done in comparing assessment tools and the variability in outputs, creating the basis for the research conducted.

Life cycle assessment tools are readily used in research to report and analyze the effects a project has on the environment over its life span. One study, conducted by Kylili et al. published in Resources, Conservation and Recycling publication, analyzed a passive house certified building within the sub-tropical climatic zone, using EcoHestia assessment tool to optimize the benefits of lowering operational energy over the life time of the building by adding material and in hand, increasing embodied energy. The parametric analysis conducted concluded that the significant operational energy savings from thick mineral wool envelope assemblies effected the total embodied carbon of the building in a minor way in proportion to the percent savings in operational energy over the life time of the building (Kylili, Ilic, & Fokaides, 2017).

Paleari et al. conducted a study on a net-zero site energy residential building in Italy to underline the difference between and energy only approach to energy efficiency and an environmental approach considering a building's life cycle. In the particular case study, 54% of the total impacts are from the product stage and the use phase accounts for 41%. The research proved that as buildings are becoming more efficient and using significantly less operational energy over its life time, embodied energy plays a greater role. (Paleari, Lavagna, & Campioli, 2016)

Another typical use for whole building life cycle assessment in research is to compare a baseline building and an improved or upgraded building to demonstrate the percent embodied energy or carbon savings the projected is projected to save in compared to a typical new build. The Athena Sustainable Materials Institute has completed a number of studies like this, such as the UBC

Biological Sciences Complex Renew project, which proved that the building avoided the consumption of 4 million liters of water, 24,000 gigajoules of fossil fuels, and 13,000 tonnes of materials by renovating rather than demolishing and building new (Athena Sustainable Materials Institute, 2011). Similarly, research was conducted using *Tally* by Overland Architects in San Antonio, Texas on the Hughes Warehouse that determined that the adaptive reuse project reduced the total embodied energy on the adaptive reuse building by 48% in compared to a new build (The American Institute of Architects, 2017).

A study conducted at RMIT University in Melbourne, Australia presents an integrated life cycle framework that parametrically optimized eight heritage retrofit buildings to both minimize embodied and operational energy. The research was conducted using *SimaPro* for the embodied energy assessment and *AccuRate* for the operational energy simulation. Being designated heritage buildings, certain restrictions were placed on the allowable new construction. Each building was analyzed in its existing condition and then in various configurations by adding insulation, high performance windows and sealants to determine which had the greatest impact on reducing operational energy without significantly impacting embodied energy (Pow Chew Wong & Iyer-Raniga, 2011).

Life cycle assessment is commonly used to quantify and compare the environmental impacts associated with alternative building designs and material selection. One study, conducted by the University of British Columbia, compared the cradle-to-gate environmental impacts of a typical cast-in-place reinforced concrete frame to a laminated timber hybrid design. Results from the mid-ride office case study building indicated that the laminated timber hybrid design scored lower in 10 of 11 assessment categories including embodied carbon (Robertson, Lam, & Cole, 2012).

Another relevant study was conducted that looks further into the embodied energy and carbon of glazing systems- particularly of interest for this study as minimal glazing and curtain wall systems – product specific or generic – are included in life cycle assessment tool databases. The study compares the impacts of a transparent composite façade system to a glass curtain wall system. The study was performed at the University of North Carolina and concluded that the glass curtain wall system had 89% higher total emissions that then transparent composite façade system. The use phase in both systems proved to be dominant, given the short life span of glazing systems requiring repair, replacement, refurbishment and maintenance over the life time of the building (Kim, 2011).

The Oak Ridge National Laboratory conducted a study comparing four insulation materials which achieve the same thermal resistance value to determine the difference in primary energy consumption and global warming potential. *SimaPro* LCA software was used to compare polyisocyanurate (PIR) foam insulation, expanded (EPS) and extruded (XPS) polystyrene foam insulation and aerogel where results showed that XPS has the greatest embodied carbon and aerogel has the greatest embodied energy using the same functional unit across all analysis (Biswas, Shrestha, Bhandari, & Desjarlais, 2015).

There are a limited number of published studies comparing different whole building life cycle assessment tools and the implications the differences in tools have on reported results. Herrmann et al. conducted a comparison of *SimaPro* and *GaBi ThinkStep*, two life-cycle assessment tools for products and systems, to determine whether results yield identical, similar or different outputs given the same product and inputs. The study concluded that the programs yield differences so large that they could influence the reported assessment (Herrmann & Moltesen, 2014). This study is however less relevant to whole building life cycle assessment as it is in reference to specific materials and system flows, but demonstrates the importance of consistency among programs to better ensure reporting accuracy.

Another study, conducted by Haapio et al. from the Helsinki University of Technology in Finland compared 16 different European and North American based life cycle assessment tools to analyze and characterize the existing tools into groups based on their common features and purpose (Haapio & Viitaniemi, 2008). Tools are categorized in two ways; The Athena Classification System and the IEA Annex 31 Classification System. The Athena Classification System categorizes tools into three levels: level 1 are product comparison tools and information sources, level 2 are whole building design and decision support tools, and level 3 are whole building assessment frameworks or systems. The IEA Annex 31 Classification System categorizes tools into a directory of 5 categories; (1) energy modelling software, (2) environmental LCA tools for buildings and building stock, (3) environmental assessment framework and rating systems, (4) environmental guidelines or checklists for design and management of buildings and (5) environmental product declarations, catalogues, reference information, certifications and labels. Tools within the same level can be compared side-by-side. The *Athena Impact Estimator* is classified as a level 2 in both the Athena Classification System and IEA Annex 31 classification system. The Athena Impact Estimator is compared against 7 other tools based on its capabilities, for example whether it can model existing buildings, new building refurbishments, and what building typologies can be modelled. The study also shows which life cycle phases each tool can model and the source of the material databases (Haapio & Viitaniemi, 2008). The purpose of the study is to highlight the variability in tool functionality and ability to help users select the most appropriate LCA tool when conducting analysis.

Al-Ghamdi et al. of The University of Pittsburgh conducted a whole building life cycle assessment tool comparison of *SimaPro* and *Athena Impact Estimator* that aimed to identify the significant differences between the tools based on user experience, transparency of results and assumptions, geographical area, building system modelling and program integration. The research found there is a tradeoff between simplicity and transparency, where the *Athena Impact Estimator* can be conducted by a wider range of practitioners and consultant's due to its straight forward inputs, *SimaPro* provides more detailed results and explanations of assumptions and back-end operations (Al-Ghamdi & Bilec, 2017). The study found a difference in reporting results greater than 10% based on a case study building located in Pittsburgh, Pennsylvania. The conclusion of the research paper identifies the need to refine life-cycle assessment methods and to obtain more robust data sets. The need for future research is pivotal to overcome the challenges in data quality and uncertainty (Al-Ghamdi & Bilec, 2017).

Extensive research has been conducted by the Athena Sustainable Materials Institute on life cycle assessment reporting of materials, products, systems and whole buildings, where very little research has been conducted on *Tally* and *One-Click LCA* as the programs are young and therefore new to both research and industry. Given the literature reviewed for the creation of this research paper, a lack in understanding of the major differences and discrepancies between the three selected whole building life cycle assessment tools has been identified. In order to ensure quality and comparable reporting between programs, a better understanding of the differences in programs in required, creating the need for the research presented here. The research will seek to determine whether the research done to date by Al-Ghamdi et al. is in agreeance or contradictory to that completed here with different life cycle assessment tools.

4 Research Objectives

4.1 Summary of Research Problem

Following the release of the Ontario Climate Change Action Plan in June 2016, the Ontario Government has put out a call for action to the construction sector to create a consistent, accurate and readily available carbon accounting tool that is applicable to all new and existing building and infrastructure projects in Ontario. In response to the call for action, EllisDon Corporation, a Canadian general contractor, has requested an in-depth research study on the existing life cycle assessment tools on the market and available in Canada to determine their applicability to the call for action. EllisDon Corporation's end goal is to create a tool that provides real-time carbon accounting information on all active and completed projects in both the public and private sector in order to be able to report the company's total carbon emissions on all projects at any time. This research aims to contribute to the current understanding of carbon accounting and educate the construction industry on the selection of one tool over another when conducting whole building life cycle assessments, or provide recommendations for the creation of a new tool should the current programs not provide sufficient tracking for their purposes.

This research seeks to investigate the current and fast-changing discussion around carbon accounting and how life-cycle assessment tools are used to quantify and report the environmental impacts of buildings by evaluating the strengths and weaknesses of the three most commonly used tools in North America. The purpose of conducting the three life cycle assessment models is to understand the extent to which the user has control over the inputs and to identify the most significant discrepancies between models.

While there are numerous whole building life cycle assessment tools worldwide, the three selected have been identified by the newly released Canadian Green Building Council's Zero Carbon Building Framework, and therefore are likely to see an influx of users in the Canadian context upon the release of the framework in September 2017.

4.2 Research Questions

This research aims to address the following research questions:

1. What are the major similarities and differences between three readily available life-cycle assessment tools for Canadian construction projects?

    1a. How much input flexibility is inherent in three readily available life-cycle assessment tools and identify the effect in output variability and accuracy?

    1b. Which programs or strategies offer the most effective carbon accounting mechanism for the Canadian construction market?

4.3 Scope of Work

This research project seeks to examine and compare three life cycle assessment tools; *Athena Impact Estimator*, *Tally* and *One-Click LCA*. The scope of work includes a review of the inputs and outputs of the three programs to understand the applicability and strengths of one program over another. The three programs conduct full life-cycle assessments from project design to end-of-life, meaning the boundary conditions of each program remains identical, however each program permits different inputs and performs different "back-end" calculation methods impacting output consistency.

In order to perform a comparison between programs, a case study was performed where the Evergreen Brickworks Kilns Building 16 was modelled in the three programs and results outputted for comparison. The same geographical boundary conditions were used on the three models as well as the same bill of materials, in order to allow side-by-side result comparisons. A 60-year building lifespan was used for the three models.

4.3.1 Inclusions

The three life cycle assessment models included all new envelope materials, curtain wall, floors, roof, windows and doors. Material quantities were determined using the AutoDesk Revit file bill of materials and materials selected to closest match to the Brickworks Kilns specification document. The life cycle assessment is conducted using the Phase 2 construction documents issued July 27, 2017 (Revision 8).

4.3.2 Exclusions

The three life cycle assessment models excluded all existing materials/components of the building, as the project only considers new construction in the embodied carbon quantification. In order to create a side-by-side comparison of the tools, an identical bill of materials is used across all three programs. Given the program restrictions and available databases, mechanical and electrical equipment, plumbing, conduit, landscaping, furniture, appliances, connection details and sealants are not included in the three models. As well, given that the Brickworks Kilns project is an adaptive reuse project, limited structural changes were made, having minimal impact to the overall outputs, therefore structural members are excluded. The life cycle assessment does not include the Phase 3 because at the time of this report creation in August 2017, works were in the design stage and documents not finalized.

5 Methodology

Three whole building life-cycle assessment tools were analyzed and compared based on their differences in program input, back-end calculations and assumptions, and reported outputs.
A thorough literature review and involvement on the Evergreen Brickworks Kiln design team showed insight into the largely undefined method of accounting for carbon and the need for a universally adopted framework that is applicable to all building and infrastructure projects in Canada.

Below is the method followed to answer the research questions presented:

1. Meet with EllisDon Corporation to discuss their needs for a carbon accounting tool and determine the purpose, long term vision and steps taking to-date on pilot projects to account for carbon
2. Attend Evergreen Brickworks Kilns project design team bi-weekly meetings and progress site team meeting
    a. Determine project timelines including phasing and funding limitations
    b. Determine the project scope of work
    c. Obtain floor plans, elevations, specifications and information regarding the history of the building, specifically repairs and renovations from the building owner and design team
    d. Understand design team's vision and goals for the project
3. Define scope of carbon neutrality in relation to the Brickworks Kilns project and method intended to achieve it
    a. Define Scope 1, 2 and 3 emissions and life cycle phase emissions specific to the Brickworks Kilns project
    b. Determine inclusions and exclusions from the carbon neutrality scope and reasoning for each decision
4. Review literature to determine how life cycle assessment tools have been used in research to date and their applicability and similarities to the Brickworks Kilns project
5. Research readily available whole building life cycle assessment tools available in Canada and determine three leading tools for comparison
6. Review literature on comparing life cycle assessment tools and whether *Tally*, *One-Click LCA* and *Athena Impact Estimator* have previously been compared to each other or other tools
7. Define research questions
    a. Define scope of research
    b. Determine inclusions and exclusions from scope

    c. Determine Brickworks Kilns project construction drawing set to be used in research (Phase 2)

8. Obtain preliminary Building Information Modelling (BIM) AutoDesk Revit file from internal design team
    a. Cross reference AutoDesk Revit file with floor plans, elevations and specifications and update file where needed to reflect Phase 2 works
9. Model three life cycle assessment tools in parallel. Individual program specific methodologies are mapped in Figure 4
10. Export outputs and results from the three life cycle assessment tools
11. Compare results by life-cycle phase and building component
12. Perform sensitivity analysis to justify program differences and discrepancies
13. Draw case study conclusions
14. Draw general conclusions with regards to program input variability, applicability to the Canadian construction industry and, similarities between programs

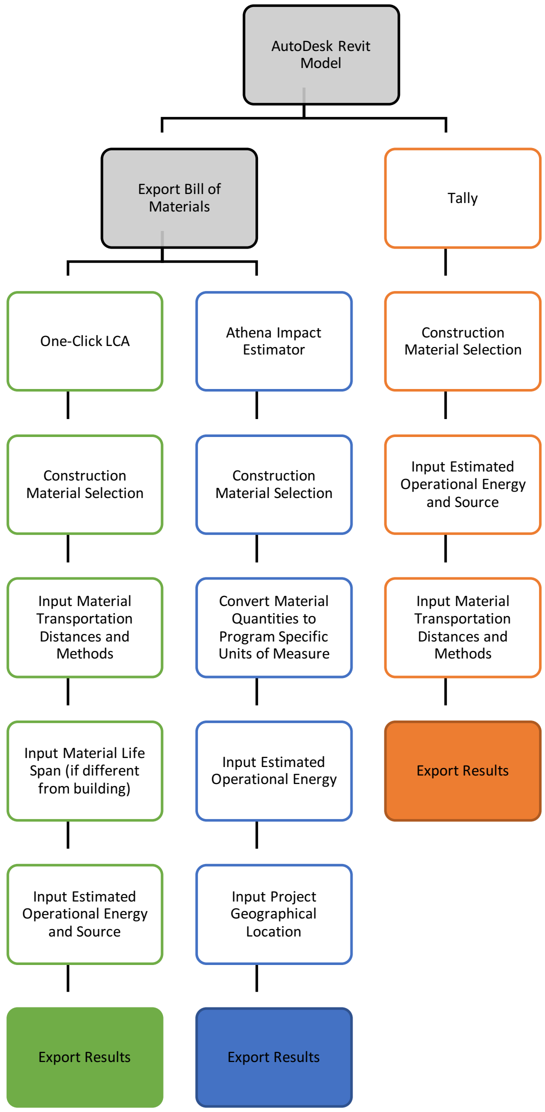

Figure 4: Life-Cycle Assessment Program-Specific Methodology

5.1 Life Cycle Assessment Tool Input Capabilities

Table 3: Summary of Life Cycle Assessment Program Input Capabilities

	Tally	**Athena IE**	**One-Click LCA**
Product Stage (A1-A3)			
Material Take-Off Method	AutoDesk Revit	BOM (excel or other) or built-in program	BOM (excel or other) or AutoDesk Revit
Material Database	GaBi LCA Database	Athena Sustainable Materials Institute LCA	All Third-Party Verified EPDs
Assembled Material Selection	Yes	No	Yes
Material Add-Ons	Yes	No	No
Specific or Generic Materials	Generic (some specific EPDs)	Generic	Specific EPDs (generic Canadian concrete)
Construction Stage (A4-A5)			
Transportation Distance Modification	Yes	No	Yes
Transportation Method Modification	4 options	No	30+ options
Construction Emissions Calculation	Requires manual input	Auto Generated	Auto Generated
Use (B1-B6)			
Operational Energy Input	Yes	Yes	Yes
Operational Energy Regional Source	Canada Wide	Closest Canadian City	Provincial
Material Life Span Modification	No	No	Yes
End-of-Life (C1-C4)			
No end-of-life inputs			

5.1.1 Product Stage (A1-A3)

5.1.1.1 Tally

Tally extracts the material quantities of a project directly from an AutoDesk Revit file where the material take-offs do not require user computation. *Tally* models a high level of detail in a simplified manner, where features can be selected based on the material purpose. For example, when gypsum wall board is selected, *Tally* prompts for a finish to be selected, or not. Similarly, foil facing can be selected, or not. Stud shapes, spacing, material type and insulation type can all be selected in a single layer. The model allows you to build up wall assemblies in detail and the program auto-generates material quantities.

The *Tally* material database is generated by the GaBi LCA database and includes primarily generic materials with the exception of some specific manufacturer's EPDs.

5.1.1.2 Athena Impact Estimator

The Athena Impact Estimator has two possible methods to determine material quantities- one from importing an excel spreadsheet bill of materials, and two by building up the model in the program by building component. Method one inputs units of measure specific to the program, requiring unit conversion from the bill of material format to the *Athena Impact Estimator* specific format. Method one is more practical when an AutoDesk Revit file or thorough bill of materials is provided to the designer. Method two, while simpler to quantify materials including framing spacing and number of doors, requires additional modelling and a thorough understanding of the construction documents in order to build up the model in the program. Method two is more practical when an AutoDesk Revit file or thorough bill of materials is not provided to the designer. The research presented here is conducted using method one.

The *Athena Impact Estimator* material database is populated using Athena Sustainable Materials Institute LCA database and is made up of generic North American materials.

5.1.1.3 One-Click LCA

One-Click LCA auto-populates the construction material take-offs either from the AutoDesk Revit file plug in or as an excel format bill of materials. In most cases, the material units of measure can either be selected by mass or volume. Should the program not recognize the material name or properties from the import, the program prompts for materials to be selected.

The *One-Click LCA* material database is populated using all third party verified EPDs worldwide. The program does not include generic materials, with the exception of Canadian concrete which is conducted using Canadian Ready Made Concrete Association (CRMCA) mix designs.

5.1.2 Construction Stage (A4-A5)

5.1.2.1 Tally

The four transportation methods supported by *Tally*; truck, rail, barge and shipping container and distances can be modified from the default values for each material specified. The number of vehicles, amount of fuel and travel time are estimated based on the volume or weight of materials.

Tally calculates project construction impacts in a similar manner to operational energy where total electricity, heating and water usage are inputted and the energy source selected. This method poses issues as construction impacts cannot be simply calculated and inputted as it is highly dependent on the building typology, materials specified and project complexity.

5.1.2.2 Athena Impact Estimator

Athena Impact Estimator does not allow user inputs for transportation distances or method of transportation. *Athena Impact Estimator* estimates transportation of material to site using regional data and the Athena Transport Database (Athena Sustainable Materials Institute, 2011).

Similarly, *Athena Impact Estimator* does not allow user inputs for construction impacts. *Athena Impact Estimator* estimates construction impacts using the Athena Construction Energy Database (Athena Sustainable Materials Institute, 2011).

5.1.2.3 One-Click LCA

One-Click LCA allows detailed inputs for calculating the emissions associated with transporting material to site, where the distance and method of transport for each material can be specified. A drop down of over 30 choices including delivery method (van, truck, mixer, plane, train, ship), vessel capacity and percent fill rate can all be selected in order to ensure the most accurate emissions factor can be applied. The number of vehicles, amount of fuel and travel time are estimated based on the volume or weight of materials.

One-Click LCA calculated the construction emissions based on material selection and quantities. The method in which values are determined is undisclosed.

5.1.3 Use (B1-B7)

5.1.3.1 Tally

The inclusion of operational energy inputs in *Tally* are optional, and should they be included, must be calculated using an external energy modelling program or other estimation method. The annual heating and electricity summing to the total annual site energy can be inputted into *Tally* and the energy source selected. *Tally*'s energy source selections are country-wide for all countries outside the United States, meaning specific grid mixes by geographical location are not recognized. Geographical limitations are discussed below.

Material life spans effecting the maintenance, repair, replacement and refurbishment of the building are integrated into the program and cannot be adjusted.

5.1.3.2 Athena Impact Estimator

Athena Impact Estimator allows for an optional input of the building's operating energy consumption of electricity, natural gas, LPG, heavy fuel, diesel and gasoline. The annual operational energy must be calculated in an external program and inputted into the *Athena Impact Estimator* as a single input. The energy source is based off the geographical location selected, where all major Canadian cities are listed.

Material life spans effecting the maintenance, repair, replacement and refurbishment of the building are integrated into the program and cannot be adjusted.

5.1.3.3 One-Click LCA

Depending on the license and purpose of analysis, *One-Click LCA* has operational energy inputs for consumption of grid electricity, fuel demands of stationary units such as generators, consumption of district heating and cooling, and exported energy such as on-site generation. The emissions factor applied to the grid electricity is specific to the geographical location. *One-Click LCA* specifies the grid mix by Canadian province.

The material life span of each individual material can be modified or changed from the program auto-populated values to reflect the true life span of materials based on climate, exposure, using and other factors. Typically, *One-Click LCA* auto-populates envelope and structural materials to match the life span of the building, assuming that components cannot be simply replaced or changed individually, and interior and exterior finishes, doors and windows have shorted life spans around 20-30 years versus the building lifespan of 60 years.

5.1.4 End-of-Life (C1-C4)

None of the three programs allow input variability that effects the end-of-life carbon impacts in whole building life cycle assessment. Recycling and waste facility selection, waste sorting methods and reuse potential of materials is not specified. In the case of all three programs, the end-of-life scenario is calculated based on the material LCA and EPD inputs, however the method and inputs are undisclosed.

5.2 Case Study: Evergreen Brickworks Kilns

Established in 1991, Evergreen is a not-for-profit organization committed to transforming public landscapes into thriving community spaces with environmental, social and economic benefits (ERA Architects Inc., 2016). Their flagship property, the Evergreen Brickworks, is a Toronto landmark located on the historic Don Valley brickworks site, which shut down in 1984. The site contains 16 heritage buildings which have overtime been converted into various public and private spaces serving as exceptional adaptive reuse examples.

Evergreen’s latest project is the transformation of Building 16, the expansive 53,000 square foot kilns facility originally built between 1956-57 for the firing and drying of bricks. The one-storey “Building 16” has the largest building foot print of all the buildings on the site. The building is undergoing extensive renovations to be converted into an all-season, multi-purpose event space. The all-electric building design is expected to use 1,010,000 kWh of electricity annually, according to Brookfield Global Integrated Solutions, the building mechanical engineer. Figure 5 is a schematic of the overall building renovation plan. The extent of work on the project include:

- introduction of radiant floor heating and a new concrete floor
- construction of a new elevated classroom and viewing deck raised above the existing ring kilns
- removal of a portion of drying kilns’ walls to create an interpretive gallery
- introduction of doors and glazing along the west elevation of Building 16
- introduction of new catering prep area
- construction of two new entrances integrated into the existing building
- construction of new washrooms integrated into the existing building (ERA Architects Inc., 2016)

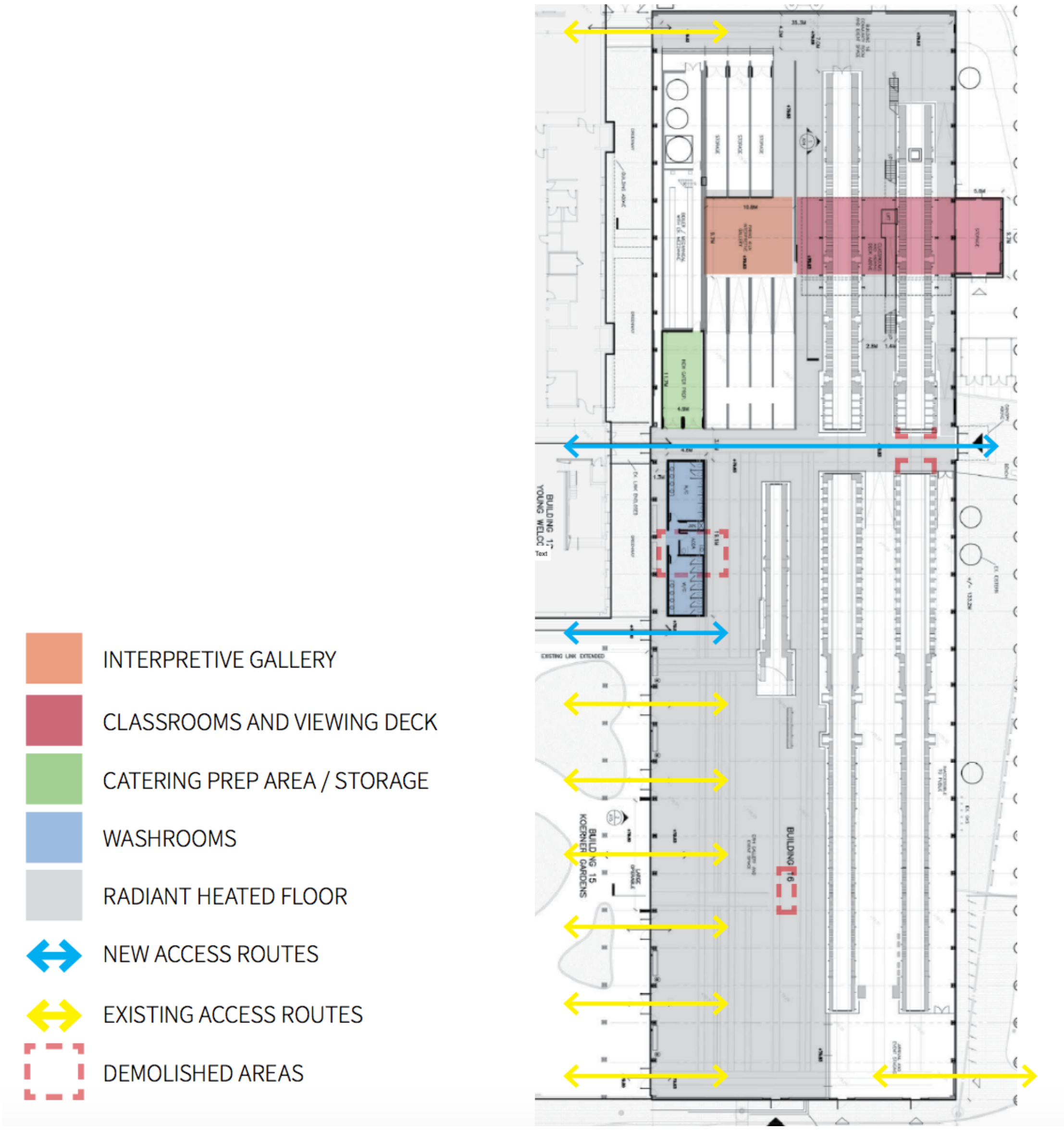

Figure 5: Building 16 Retrofit Overview (ERA Architects Inc., 2016)

5.2.1 Project Location and Site Restrictions

The Evergreen Brickworks is located at 550 Bayview Avenue on the West side of the Don Valley River in Toronto, Canada. Building 16 is located on the South-East end of the property, as highlighted in Figure 6.

The retrofit of the kiln building requires adherences to the Ontario Heritage Act (by-law 986-2002), as Building 16 was deemed an official heritage site based on its rich historical significance to the City of Toronto. In addition to its heritage status, this project presents special circumstances based on its setting. Located near Mud Creek and the Don River, the property sits on a flood plain and is prone to annual flooding over 3 feet, which requires a comprehensive storm water management plan (ERA Architects Inc., 2016).

Figure 6: Aerial View of the Evergreen Brickworks with Building 16 Highlighted (ERA Architects Inc., 2016)

5.2.2 Project Goals

The overarching goal of Building 16 is to create a "dynamic, year-round super hub that will ignite, accelerate and celebrate new innovations that shape our cities for the better" (Evergreen, 2017). The building integrates new building technologies into an existing heritage building, creating an exemplary adaptive reuse project demonstrating the value of heritage preservation and existing building reuse.

Unique to this building and the first in Canada, the Brickworks kilns project is targeting carbon neutrality. Selected as the first pilot project under EllisDon Corporation's Carbon Impact Initiative, the design team is committed to making the design choices necessary to drive down carbon dioxide emissions and offset the remaining carbon using various innovative offset or sequestration strategies. The definition of carbon neutral adhered to for this project is defined in Section 2.3 of this report, considering all life cycle phases from A1 to C4.

5.2.3 Project Timeline

Because of the fast-paced nature of the project which relies heavily on public and private funding and grants, the project is divided into three phases, where each phase is issued for tender as separate contracts. The design, permitting, pricing and construction of each phase is completed in sequence, but all three phases are at different stages at any one time.

As of August 2017, when this report was created, Phase 1 was complete, Phase 2 was under construction and Phase 3 was in the design and permitting phase. Phase 1 encompasses the removal of specified brickwork, removal of abandoned services, removal of existing electrical equipment, patching of existing brickworks, cleaning of debris, rubbish and demolished features, installation of the raised concrete floor with radiant in floor installed and installation of new structural members on the existing structure. Phase 2 encompasses the enclosure of the building including roof assembly installation, curtain wall installation, service room extension, window and door installation, internal partition wall installation, and washroom and catering kitchen appliance installation. Because the final design documents of Phase 3 have not been released, the research presented in this paper includes only the information from Phases 1 and 2. See Appendix for detailed construction drawings of Phases 1 and 2.

5.2.4 Integrated Design Team

The Evergreen team sought out a collaborative design team willing to work together at every stage of the project to achieve the difficult design goals and to design and build a project worth celebrating for its success as an industry leader. A bi-weekly design team meeting held by Evergreen ensures timely and up-do-date information sharing and helps mitigate problems from arising prior, during and post construction.

In order to achieve carbon neutrality, full design team participation is required as the life cycle assessment strategy requires input from all sectors of the project. This can pose problems when design changes occur, material substitutions are made and improper documentation is maintained. The continuous input from all partners is integral in creating an accurate and representative life cycle assessment.

Table 4: List of Brickworks Kilns Industry Partners and Roles

Industry Partner	Role
Evergreen Brickworks	Client
EllisDon Corporation	General Contractor
Brookfield Global Integrated Solutions	Mechanical Engineer
LGA Architects	Architect
ERA Architects	Heritage Consultation
ARUP	Structural Engineer
Ianuzziello & Associates	Electrical Engineer
CRH Canada	Manufacturing
SCS Consulting Group	Civil Engineer
Waverly Projects	Project Manager

5.2.5 Construction Details

A complete building material specification summary can be found in the Appendix including all specified material properties, manufacturers, products and thicknesses. Envelope assembly details and construction drawings provided by LGA architects are also found in the Appendix.

5.2.5.1 Exterior Walls

The existing double wythe brick walls on the first storey are denoted by the Ontario Heritage Act (Part IV (34)) as part of the existing structure that cannot be removed or altered. The south facing gable above the existing exterior wall features opaque, insulated metal panels. The total exterior wall area is 1,438m^2.

5.2.1.2 Curtain Wall

The west facing exterior façade, currently open to the elements, is being enclosed with an insulated glazing unit curtain wall system that is tempered and has a low-e coating. A portion of the west facing curtain wall is operable, sliding on a top and bottom rolling system. The north facing gable above the existing exterior wall features a similar curtain wall system that is inoperable. The total curtain wall area is 262m^2.

5.2.1.3 Service Room Addition

The service room addition on the east side of the building features an exterior brick veneer to match the existing to the same elevation as the existing service room and composite metal paneling above, with an extruded polystyrene layer, an air barrier membrane, sheathing, steel stud cavity filled with mineral wool batt insulation, a vapour barrier and cement board on the interior. The total area of wall with this assembly is $117m^2$.

5.2.1.4 Interior Partitions and Ceilings

Details of the interior partitions and ceilings can be found in the Appendix. Grout filled concrete masonry units (CMU) made up the structure of all interior partitions with various finishes dependent on location.

5.2.1.5 Typical Flooring

The new concrete slab is designed to top the existing slab adding height to the floors to mitigate flood risk on the interior space. In order to minimize material, plastic, air-filled dome forms are used to create large air-voids in the concrete, requiring significantly less material than a typical concrete slab. The system is topped with insulated concrete and a polished concrete top with radiant tubing and wire mesh.

5.2.1.6 Typical Roof

A corrugated metal roofing system is designed to top the existing metal roof to add thermal resistance and extend the lifetime of the roof. The new roofing assembly includes a 24-gauge ribbed metal roof, vapour barrier and polyisocyanurate insulation.

5.2.6 Building Integrated Modelling (BIM)

Arup Engineering provided a preliminary AutoDesk Revit model for the use of this research including the location and dimensions of the exterior walls, roof, floors, interior partitions and service room addition. The model included the shell for the existing conditions, Phase 1 and

Phase 2. The Revit model provided by Arup Engineering did not include the designation of materials, differences in assemblies or the completed structural components. The Revit model was then modified to include the materials and assembly allocations to ensure accurate material take-offs used in the bill of materials. Table 5 summarizes the bill of materials area quantity take-offs extracted from the AutoDesk Revit model.

Table 5: Bill of Material Quantity Take-Off per the Brickworks Kilns AutoDesk Revit Model

Assembly	**Area (m^2)**
Exterior Walls	1,565.51
Partitioning Walls	383.69
Roof	5,356.69
Ceiling	191.97
Floor	2,776.73
Curtain Wall	523.90
Windows	18.06
Doors	121.84

5.2.7 Greenhouse Gas Emissions Sources

Given the known parameters of the case study, Table 6 summarizes the greenhouse gas emissions source scope that the Evergreen Brickworks design team intends to include in the life cycle assessment used to quantify the amount of carbon over the life time of the building. The total sum of carbon emissions accumulated over the lifetime of the building must then be sequestered or off-set to achieve carbon neutrality.

Because the project is an adaptive reuse project where the building footprint remains the same and existing materials are used, the building does not experience emissions due to land use changes and site works. The design team also decided not to include the emissions associated with human travel (business travel by employees, site team travel to site, travel to and from site by visitors and staff) and the emissions used by the design team during the design process (office lighting, heating, water use). The emissions used by the construction team on site are included (lighting, heating, water used in the site trailer).

Table 6: Emissions by Project Phase of Evergreen Brickworks Kilns Case Study

LCA Phase		Emission Source	Emission Scope [as defined in Table 1]
Product Stage	A1 - Raw Material Extraction	Raw material extraction of all new material	Scope 3
	A2 - Interim Transportation	Transportation of raw material and recycled material to manufacturing plant	Scope 3
		Transportation between plant facilities	Scope 3
	A3 - Manufacturing	Off-site material manufacturing and assembly	Scope 3
Construction Stage	A4 - Transportation to Site	Material and machinery transportation to site	Scope 3
	A5 - Construction Processes	On-site building component assembly	Scope 2
		Site team trailer utilities (water, electricity, heating)	Scope 2
		Removal and disposal of construction material waste	Scope 3
		On-site machinery operation	Scope 2
Use	B1 - Use	*N/A*	
	B2 - Maintenance	Mechanical and electrical equipment maintenance	Scope 3
		General building maintenance	Scope 3
	B3 - Repair	Mechanical and electrical equipment repair	Scope 3
		Construction material repair	Scope 3
	B4 - Replacement	Mechanical and electrical equipment replacement	Scope 3
		Construction material replacement	Scope 3
	B5 - Refurbishment	Mechanical and electrical equipment replacement	Scope 3
		Construction material refurbishment	Scope 3
	B6 - Operational Energy	Electricity used for radiant in-floor heating	Scope 2

		Electricity used for lighting	Scope 2
		Electricity used to operate pumps and plumbing	Scope 2
		Electricity used to operate catering kitchen appliances	Scope 2
		Electricity to operate hot water heater	Scope 2
	B7 - Operational Water	Water used in plumbing and drainage system	Scope 2
		Water used in catering kitchen	Scope 2
End-of-Life	C1 - Deconstruction/Demolition	On-site machinery operation for deconstruction	Scope 2
		Demolition activity utility use (water, electricity, natural gas)	Scope 2
	C2 - Transportation off Site	Transportation from site to waste processing plant	Scope 3
	C3 - Waste Processing	Off-gassing from waste processing	Scope 3
		Waste processing utilities use (water, electricity, natural gas)	Scope 3
	C4 - Disposal	Disposal utilities use (water, electricity, natural gas)	Scope 3

5.2.8 Data Collection

Obtaining detailed data for the Evergreen Brickworks Kilns project prior to construction completion proved to be difficult as Phase 2 of the project only went to Tender in July 2017, meaning the specific materials have not been selected and therefore the EPDs are not readily available. While much of the data will be eventually obtained, a significant number of assumptions and averages were necessary to obtain results at the current stage of the project. Additionally, because the project is in-progress, design changes and as-built conditions are not reflected in the models.

5.3 Case Study Inputs

5.3.1 Product Stage (A1-A3)

Table 7 summarizes the material inputs into each LCA tool, given the project specification and contract document. A complete list by assembly type and specification section can be found in the Appendix. As identified in the table, some major discrepancies between available materials in the program databases consequently mean some materials cannot be fairly compared side-by-side.

While the Brickworks project has specified in all subcontractor's Schedule A that EPDs are required for all materials installed on site, this process is ongoing and no EPDs have been submitted to date. For this reason, the specific material and manufacturer's EPD are not reflected in the LCA models. Materials were selected in all cases to match the project specification to the closest degree given the material database available in each program.

Because *One-Click LCA* relies entirely on EPDs and does not have any generic material inputs with the exception of concrete which are generic from the Canadian Ready Mix Concrete Association (CRMCA), only products that have been third-party verified are included in the database. Therefore, the *One-Click LCA* Brickworks Kilns model does not have an input for the specifies air barrier self-adhering membrane as there are no EPDs listed for the specified product or similar.

Finishes such as paints, drywall tape, screws, nuts and bolts were excluded from the models as quantifying these materials cannot be simply estimated by a specified unit of measure as they are not included of the Brickworks Kilns AutoDesk Revit model.

The implications of inconsistent construction material inputs have a significant impact on the reported carbon in each model. As seen in Table 7, the material differences in some cases are so great that products in reality should not be compared. Resulting differences from product selection are discussed in detail in the case study results.

Table 7: Summary of Project Specified Materials vs. LCA Tool Inputs

Specified Material			**One Click**	**Tally**	**Athena**
Material Name	**Approved Manufacturer**	**Product Name**	**Product**	**Product**	**Product**
			Walls		
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA		Self-adhering 40mil membrane	Air Barrier
Brick, to match existing	Mortar Type N, exterior non-load bearing		Concrete Masonry Unit, 7 7/8inx7 5/8inx15 5/8in, HW Regular	Brick, grouted with mortar type N	Concrete Brick
Cement Board	CGC Inc.	Durock Cement Board Next Gen	Medium density fibreboard, 0.75in	Cement bonded particle board	Fiber Cement
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			Concrete Masonry Unit	Hollow core CMU, grouted, 6x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	6" Normal Weight Concrete Block
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	Gypsum Board Type X, 5/8", 2.25 psf	Fibreglass mat gypsum sheathing	1/2" Moisture Resistant Gypsum Board
Furring Channels		0.5 mm base steel thickness, galvanized. 70 mm wide x 22 mm deep hat shaped channel	Steel Framing Systems	Steel, furring channels, galvanized 7/8" 25 Ga.	Galvanized Studs
Insulated Metal Panel	AWIPanels/VicWest	F40 "Flat Wall"	Insulated metal panel, 1 3/4in-4in x 36in x 6in-48ft	Spandrel, aluminum, insulated (2" core)	3" Insulated Metal Panel

Specified Material			One Click	Tally	Athena
Material Name	**Approved Manufacturer**	**Product Name**	**Product**	**Product**	**Product**
Mineral Wool Batt Insulation	Roxul	ComfortBatt	Mineral wool insulation batt, R30, EcoBatt Insulation with Ecose Technology	Mineral wool (rockwool) rigid insulation board, low density	MW Batt R30
Patterned Back Painted Glass			Pressed glass partition, 0.236 in	Glazing, monolithic sheet	Glazing Panel
Pre-finished composite metal panels	Flynn Canada Ltd/ Vicwest Canada/ Exterior Technologies Group	Accumet PE/ ACM Panels/ Alpolic Panels	Roll formed steel panels, 24 gauge, 5.9 kg/m2	Aluminum, sheet	Metal Wall Cladding - Commercial (26Ga)
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	Steel Framing System	Galvanized Steel “Z” Channel	Galvanized Studs
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	XPS Insulation (extruded polystyrene)	Extruded Polystyrene, XPS	Extruded Polystyrene
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	Steel Framing System	Steel, C-stud metal framing, galvanized with insulation, 1 way spacing 405mm o.c.	Galvanized Studs
Tile finish			Bio-based Floor Tile	Ceramic Tile, unglazed, inclusive of mortar	Clay Tile
Vapour Barrier		Polyethylene film 6mil	Vapor Barrier, 0.06in	Polyethylene sheet vapor barrier (HDPE)	VR Protection Sheet

Specified Material			One Click	Tally	Athena
Material Name	**Approved Manufacturer**	**Product Name**	**Product**	**Product**	**Product**
Windows					
Type 1: FGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Float Glass, low-e coating	Traditional Curtain Wall, 1.5mx 1.6m and Clearwall curtain wall system	Glazing, double pane IGU, 2 layers of 4mm thick glass, air filled, low-e	Double Glazed Hard Coated Air
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating	Traditional Curtain Wall, 1.5mx 1.6m and Clearwall curtain wall system	Glazing, double pane IGU, 2 layers of 4mm thick glass, air filled, low-e	Double Glazed Hard Coated Air
Roof					
2 Lb Spray Insulation	BASF/ Demilec Inc.	Walltite Eco v.3/ Heatlok Soya	Spray foam insulation, 1.02in	Open cell spray foam applied polyurethane foam	FG LF Open Blow R31-40
24 Ga. Ribbed Metal Roof	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	Steel roof and floor deck, 22-16 gauge	Steel, roof decking, cold-formed galvanized	MBS Metal Roof Cladding - Commercial (24 Ga)
2-Ply Modified Bitumen Roofing System	Henry Company Canada Inc./ Siplast/ Soprema Waterproofing Inc.	2 Sheet Styrene-Butadiene-Styrene (SBS) Membrane	Fluid Applied Rubber Asphalt roofing	Self-adhering sheet waterproofing, modified bituminous sheet	Modified Bitumen Membrane
Cement Board	CGC Inc.	Durock Cement Board Next Gen	Medium density fibreboard, 0.75in	Cement bonded particle board	Fiber Board
Corrugated Metal Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	Composite Metal Decking, 30 mil	Steel, form deck, cold-galvanized	Galvanized Decking
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	Gypsum Board Type X, 5/8", 2.25 psf	Fibreglass mat gypsum sheathing	1/2" Moisture Resistant Gypsum Board

Specified Material			One Click	Tally	Athena
Material Name	**Approved Manufacturer**	**Product Name**	**Product**	**Product**	**Product**
Rigid Poly Iso Insulation	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	Polyisocyanurate (PIR) board	Polyiso foam board
Vapour Permeable Self Adhering Membrane		Polyethylene film 6mil	Vapor Barrier, 0.06in	Polyethylene sheet vapor barrier (HDPE)	VR Protection Sheet
Ceiling					
Gypsum Wall Board	Certainteed Gypsum Canada, CGC Inc./ Georgia-Pacific Canada LP	Furnish Board	Gypsum Wall Board, Regular, 0.5in	Wall board, gypsum, interior acrylic latex paint	1/2" Regular Gypsum Board
Metal Stud	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	Steel Framing System	Steel, C-stud metal framing, galvanized with insulation, 1 way spacing 405mm o.c.	Galvanized Studs
Mineral Wool Acoustical Batts	Roxul	ComfortBatt	Mineral wool insulation batt, R30, EcoBatt Insulation with Ecose Technology	Mineral wool, low density	MW Batt R30
Reinforced Concrete			Ready-mix concrete, 25 MPa GU cement with air entrained 0-14%, with rebar, hot rolled	Reinforced slab 3000 psi, exclusive of deck	Concrete Benchmark 2500psi, with rebar, rod, light sections
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	Steel Framing System	Galvanized Steel "Z" Channel	Galvanized Studs
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	Steel roof and floor deck, 22-16 gauge	Steel, roof decking, cold-formed galvanized	Galvanized Decking

Specified Material			One Click	Tally	Athena
Material Name	**Approved Manufacturer**	**Product Name**	**Product**	**Product**	**Product**
Floors					
Concrete Finish			Ready-mix concrete, 25 MPa GU with air entrained 0-14%	Structural, unreinforced, 3000psi/20MPa	Concrete Benchmark 3000psi
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete	Ready-mix concrete, 25 MPa GU with air entrained 0-14%	Air-Entrained Structural concrete, unreinforced	Concrete Benchmark 4000psi
Polished Concrete with radiant and wire mesh			Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	Structural, unreinforced, 3000psi/20MPa	Concrete Benchmark 3000psi
Raised Structural Cavity floor	Cupolex	Cupolex Modular Vaulted Sub-slab Forms, 25 MPa	Ready-mix concrete, 25 MPa GU with air entrained 0-14%	Air-Entrained Structural concrete, unreinforced	Concrete Benchmark 4000psi
Reinforced Concrete on Steel Deck			Steel roof and floor deck, 22-16 gauge	Steel, cold formed galvanized deck	Galvanized Decking
Reinforced Concrete Slab			Ready-mix concrete, 25 MPa GU with air entrained 0-14%, with rebar hot rolled	Cast-in-place concrete, slab on grade with reinforcing steel inclusive	Concrete Benchmark 4000psi with rebar, rod light sections

5.3.2 Construction Stage (A4-A5)

The Brickworks Kilns design team has requested all subcontractors document the vehicle activity to and from the site, including distances from material manufacturer to site, method of transportation and number of trips taken. This information is not utilized in this analysis because the project is still underway and the requested information has not been provided to-date.

On-site sub-metering is not being done on the Brickworks Kilns project, meaning construction process energy and associated carbon cannot be accurately measured. However, machinery use patterns, hours operated and purpose of use are being documented for further research to develop a better understanding of the energy and carbon implications associated with construction processes.

5.3.2.1 Tally

Default values were used where all materials are transported by truck at varying auto-populated distances generated from the US database. All materials are transported by ground transportation implying all material are local within North America.

Because construction process energy is highly variable and dependent on the project, an assumed value cannot be simply inputted into *Tally*. For this reason, the construction processes input is not considered in the model.

5.3.2.2 Athena Impact Estimator

As noted, both transportation and construction process energy cannot be modified in *Athena Impact Estimator*.

5.3.2.3 One-Click LCA

Default values are used for the calculation where the material transportation method selection for all materials is "trailer combination, 40 tonne capacity, 50% fill rate" and for concrete is "concrete mixer truck, average, 100% fill rate". Default transportation distances are not disclosed.

The *One-Click LCA* trial version does not include construction impacts (A5) and therefore is not considered in the model.

5.3.3 Use (B1-B7)

5.3.3.1 Tally

The 1,100,000 kWh/year electricity usage on the Brickworks Kilns project was inputted into *Tally* with an energy source selection of "Average grid mix – Canada". The lifespan of each material is integrated into the program and cannot be modified.

5.3.3.2 Athena Impact Estimator

The 1,100,000 kWh/year electricity usage on the Brickworks Kilns project was inputted into *Athena Impact Estimator* with a project location of Toronto. The lifespan of each material is integrated into the program and cannot be modified.

5.3.3.3 One-Click LCA

The 1,100,000 kWh/year electricity usage on the Brickworks Kilns project was inputted into *One-Click LCA* with an energy source selection of "Electricity, Canada, Ontario" from Statistics Canada 2015.

Default material life spans are used where all envelope and structural components have a life span the same as the building of 60 years, and all interior and exterior finishes, doors, windows and curtain wall have shorted life spans between 20 and 30 years.

5.3.4 End-of-Life (C1-C4)

The material inputs selected and back-end program calculations dictate the end-of-life scenario for each project.

6 Case Study Results

The three life cycle assessment tools outputted significantly different results based on the materials selected, detail of materials such as finishes and hardware, program assumptions and averages, and default inputs. While all programs are run using identical material take-offs, each program computes the embodied emissions at each life cycle phase differently.

6.1 Comparison by Building Element

Figure 7 compares the three whole building life cycle assessment tools by material category where each category is the sum of the embodied carbon of each material including all life cycle phases. Understandably, the roof and floors are the largest contributors of carbon dioxide given their percent volume of material compared to the walls, curtain wall, windows and doors. The three models show significant discrepancies between model outputs where the *Athena Impact Estimator* model and *Tally* model reported a difference of 41% in carbon emissions in the roof alone. Similarly, the *Tally* model reported 32% higher carbon emissions in the floors than both the *One-Click LCA* and *Athena Impact Estimator* models. In order to further understand the substantial differences in program outputs, a sensitivity analysis was performed on the two largest contributing material categories, the roof and the floors.

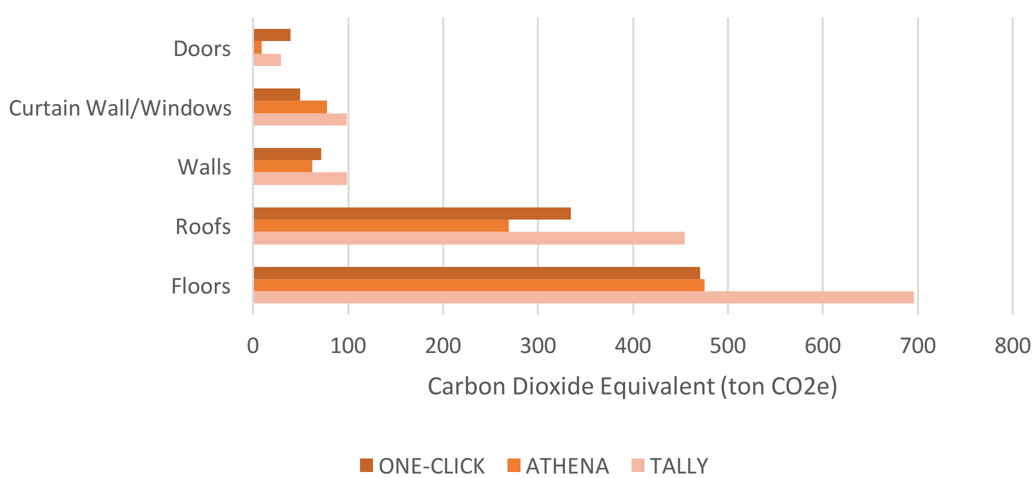

Figure 7: Comparison of the Three Life-Cycle Assessment Tools Total Carbon Dioxide Equivalents by Material Category

The slab on grade concrete floors consists of air-entrained, 25 MPa concrete with reinforcing. The floors are of varying thicknesses based on the existing floor height and sloped floor design. The volume of concrete was determined in accordance with construction drawings *A-100A and A-100B Ground Floor Plans* and *A-002 Assemblies*. The volume of concrete and mass of reinforcing was extracted from the Autodesk Revit file in order to ensure material take offs were identical among all models. While the volume of concrete is the same, the mass is different depending on the concrete composition and associated density selected.

The 4000 psi concrete selected in the *Athena Impact Estimator* outputs a carbon impact of 470,000 kg CO_2eq for the 2,902,000 kg of concrete. Therefore, the emissions factor utilized by the *Athena Impact Estimator* is 0.16 kg CO_2eq/kg concrete. The air-entrained structural concrete selected in the *Tally* model outputs a carbon impact of 695,682 kg CO_2eq for the 2,509,113 kg concrete. Therefore, the emissions factor utilized by *Tally* is 0.28 kg CO_2eq/kg concrete- nearly double that of the *Athena Impact Estimator* for the same volume of material. The results from the *Athena Impact Estimator* and *One-Click LCA* are similar, which can be confirmed and justified given that the concrete EPD used selected in *One-Click LCA* was conducted by Athena Sustainable Materials Institute. Mix design #1, 25GU with air entrainment 0-14% FA/SC has an emissions factor of 327.33 kg CO_2eq/ m^3 concrete (Canadian Ready Mix Concrete Associated, 2017). *Tally*'s U.S. material database with an emissions factor nearly double that of the other tools report substantially different results from *One-Click LCA* and *Athena Impact Estimator*'s similar Canadian values.

The rigid poly iso insulation specified on the Brickworks Kilns project is the greatest contributor of carbon in the roof assembly. Upon further investigation, it is uncovered that the life span of materials in each model is represented in the outputs differently. In the *Tally* model, the Polyisocyanurate (PIR) board has a lifespan of 30 years, meaning the material requires replacement once over the 60-year lifespan of the building. *Tally* encompasses the replacement of materials in accordance with the expected service life including the cradle-to-gate manufacturing of the replacement product. For this reason, the embodied carbon of poly iso is doubled. In the *One-Click LCA*, the poly iso foam board has the same life span of the building and has an emissions factor significantly lower than the *Tally* model of 2.08 kg CO_2/kg poly iso as opposed to 4.18 kg CO_2/kg poly iso.

6.2 Results by Life-Cycle Phase

Table 8 and Figure 8 summarize the life cycle assessment tool outputs by life cycle phase. Each tool classifies the outputs slightly differently, however all in the EN 15978 annotation format and nomenclature.

As noted in Table 8, phase A4 is not included in the *Tally* and *One-Click LCA* models, where the emissions due to construction are embedded in the *Athena Impact Estimator* back-end calculator, therefore results vary significantly and the scope of included phases are not consistent. As well, as noted above, phase B4 is handled in a very different manner model-to-model where *Tally*'s embedded material life spans influence the material replacement emissions and material lifespans cannot be altered by the user, increasing both the product life phase and replacement phase. Additionally, the three models treat the end-of-life phase differently where *Tally* takes the "avoided burden" approach where the building receives credit for material recyclability, where *Athena Impact Estimator* and *One-Click LCA* consider end-of-life material recyclability to be the benefit of the recycled content buyer, so to not double count emissions savings.

Table 8: Summary of Life Cycle Assessment Tool Outputs by Phase in ton CO_2eq

	Tally	Athena	One-Click
Product Life (A1-A3)	**1102.38**	**732.41**	**723.48**
Raw Material Extraction (A1)			
Transportation (A2)		0.45	
Manufacturing (A3)		731.95	
Construction Process (A4-A5)	**17.97**	**48.38**	**48.83**
Construction Processes (A4)	0.00	26.56	0.00
Transportation (A5)	17.97	21.81	48.83
Use (B1-B6)	**17,046.19**	**14,228.62**	**8,649.6**
Use (B1)	0.00	0.00	0.00
Maintenance (B2)			
Repair (B3)			
Replacement (B4)	257.19	76.61	158.60
Refurbishment (B5)			

Operational Energy and Water (B6)	*16,789*	*14,152*	*8,491*
End of Life (C1-C4)	**-0.37**	**35.66**	**34.22**
Deconstruction/Demolition (C1)		25.60	
Transport (C2)		10.05	
Waste Processing (C3)			34.22
Disposal (C4)			
TOTAL (ton CO2 eq)	**18,166.17**	**15,044.45**	**9,456.16**

Figure 8 is a visual representation of Table 8, where given the scope of inclusions and exclusions considered for this research, the operational carbon over the lifespan of the building far surpasses the embodied carbon, where the operational carbon accounts for 92% of the *Tally* model, 94% of the *Athena Impact Estimator* model and 90% of the *One-Click LCA* model. This result suggests that the Brickworks Kilns adaptive reuse project benefits from material reuse, avoiding the environmental burden of new materials.

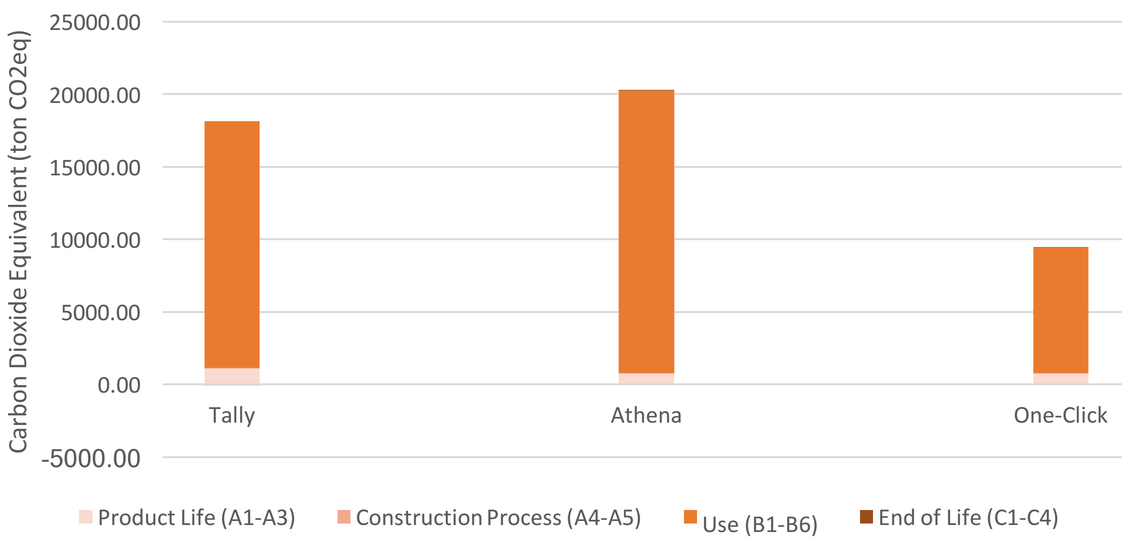

Figure 8: Comparison of the Three Life-Cycle Assessment Tools Total Carbon Dioxide Equivalents by Life-Cycle Phase

Figure 9 compares the building's embodied carbon, identical to Figure 8 without the operational phase (B6) showing the distribution of material embodied emissions over the life span of the building. In all cases, the product stage dominates where over 80% of the embodied emissions are accumulated during the raw material extraction and product manufacturing stage.

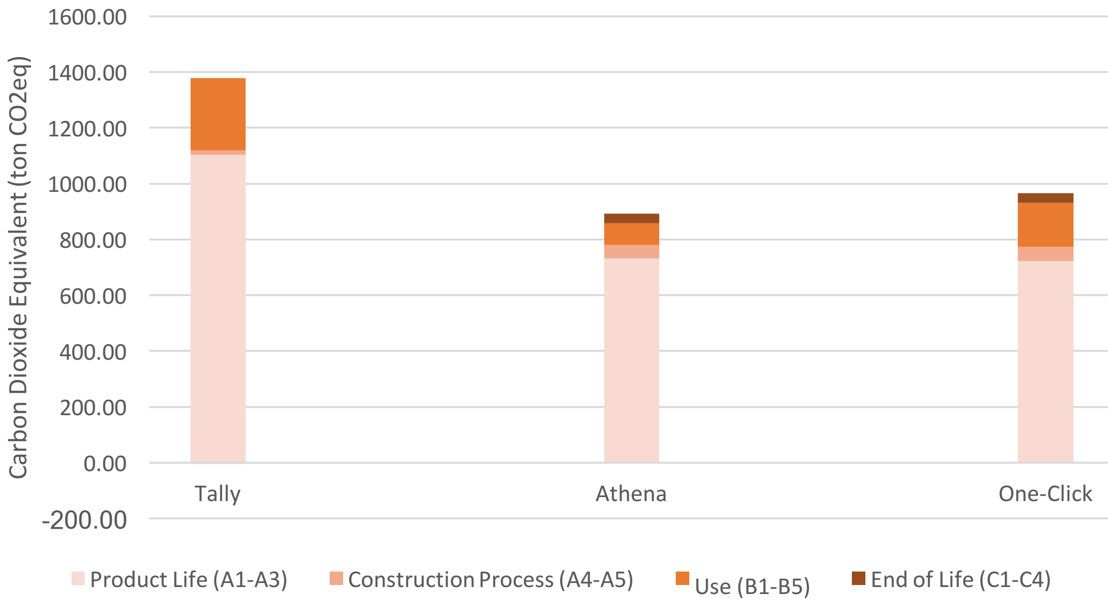

Figure 9: Comparison of the Three Life-Cycle Assessment Tools Total Carbon Dioxide Equivalents by Life-Cycle Phase (Excluding Operational Energy – B6)

Figure 10 and Figure 11 are the identical graphs to Figure 8 and Figure 9 however expressed in total primary energy demand in mega joules as opposed to carbon dioxide equivalents. When comparing Figure 8 and Figure 10, it can be concluded that the carbon emissions factor applied to *One-Click LCA* is substantially lower than those used in the other two programs, where *One-Click LCA* has the highest energy use but the lowest carbon equivalents. Alternatively, the energy demand and carbon equivalents of *Tally* and *Athena Impact Estimator* have a similar ratio when expressed in both metrics, where results vary in both metrics by under 10%.

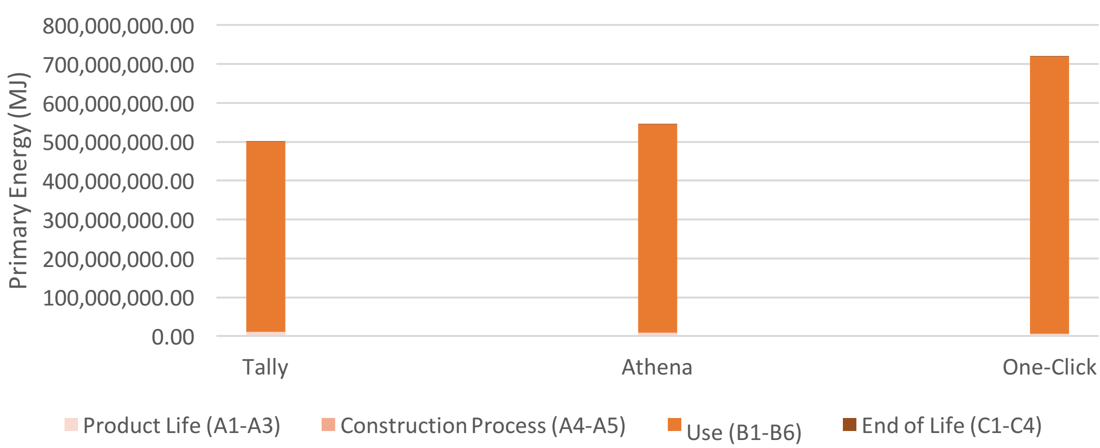

Figure 10: Comparison of the Three Life-Cycle Assessment Tools Total Primary Energy by Life-Cycle Phase

Figure 11 further concludes that there is significant variability between the embodied emissions output of the three programs where when expressed in primary energy demand, *Tally* remains the highest emitter, while *Athena Impact Estimator* and *One-Click LCA* reverse. By graphing the life cycle phases in terms of total primary energy demand, it can be concluded that both the carbon conversion and the analysis used to determine the energy metrics are inconsistent.

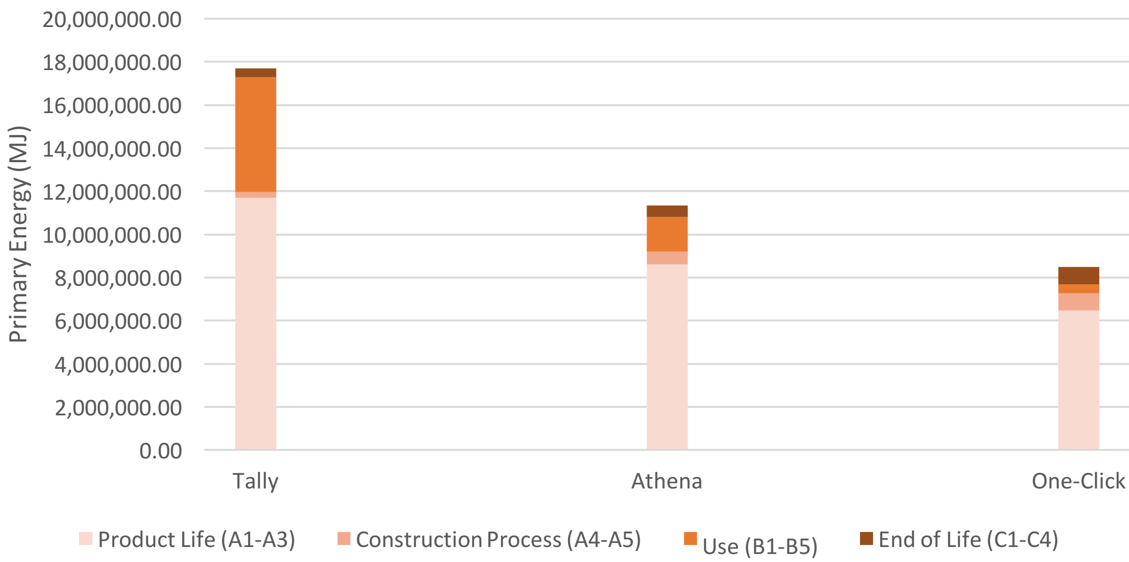

Figure 11: Comparison of the Three Life-Cycle Assessment Tools Total Primary Energy by Life-Cycle Phase (Excluding Operational Energy – B6)

6.2.1 Product Life (A1-A3)

One-Click LCA extrapolates the product life phase data directly from the EPDs conducted by third party verifiers based on the area, volume or weight of material in the bill of materials. EPDs encompass the full product stage including raw material extraction (A1), intermediate transportation (A2) and manufacturing and assembly (A3). Similarly, *Tally*'s reported product life values include phases A1-A3. *Athena Impact Estimator* reports product LCA based on the Athena LCI Database of generic material, not specific to a single manufacturer or product. Transportation estimations are regionally specific.

As discussed, *Tally*'s US material database have significantly different emissions factors associated with each material, which is reflected in the 33% increase in carbon emissions in the Product Life phase compared to *Athena Impact Estimator* and *One-Click LCA*.

6.2.2 Construction Process (A4-A5)

While *One-Click LCA* does have the capability to calculate emissions from construction processes typically, the trial license does not include this phase and therefore outputs zero emissions. It is unknown whether *One-Click LCA* considered construction waste in the A4 calculation. Given the transportation distances inputted from manufacturer to site and the area, volume or weight of material, *One-Click LCA* applies the appropriate emissions factor based on an estimated number of vehicles and fuel type.

The *Athena Impact Estimator* model reports an estimated construction process emissions value based on the Athena Construction Emissions Database, an undisclosed database used in all *Athena Impact Estimator* modelling. The *Athena Impact Estimator* applies a construction waste factor to all material in the bill of materials, however whether the construction waste processing emissions are considered in the construction phase is undisclosed. Transportation distances applied based on regional data and are applied based on the nearest city in the *Athena Impact Estimator* database.

The on-site construction emissions in the *Tally* model is determined based on a single input of total energy used on site during construction. The value is required to be calculated external from the *Tally* program either as an estimated value or a reported sub-metered total. In the case of the Brickworks project, the energy consumed during construction is unknown, therefore the input is left blank and does not contribute to the analysis. Given the transportation distances inputted from manufacturer to site and the area, volume or eight of material, *Tally* applies a U.S. average emissions factor based on an estimated number of vehicles and fuel type.

6.2.3 Use (B1-B6)

One-Click LCA typically has material life spans the same as the building for all envelope and structural materials, and shorter life spans for interior and exterior finishes, windows and doors. The program assumes that envelope and structural materials cannot be simply removed and replaced without removing and replacing the surrounding materials. Alternatively, *Tally* has pre-determined product lifespans that cannot be altered for all materials, assuming an internal component could be replaced without damaging surrounding materials. This method works in theory and is a more conservative report of the required replacement of materials, however not practical given how buildings are constructed and operated.

In the *Tally* model, maintenance and replacement considers the service life of each material, where the end of life emissions from the existing product are included, as well as the cradle-to-gate, transportation to site and construction process emissions of the replacement product, assuming the identical product is installed.

The *Athena Impact Estimator* does not indicate where the maintenance, repair, replacement and refurbishment outputs are gathered from. All three programs provide one all-encompassing value, rather than split into each life cycle phase (B2-B5).

6.2.3.1 Operational Energy

The operational electrical carbon emissions outputted from *Tally* uses the Canadian average electricity carbon emissions for final consumers, including transmission and distribution losses and electricity imports for neighboring countries as taking from the International Energy Agency statistics for the corresponding reference year of 2010. Given an inputted annual electricity usage of 1,010,000 kWh over the 60-year lifespan of the building and the total carbon emissions reported, the emissions factor is determined to be 0.28 kg CO_2/kWh.

Athena Impact Estimator's electrical emissions factor is regionally customized, where appropriate electricity grids are reflected in the emissions factor, according to the Athena Sustainable Materials Institute (Athena Sustainable Materials Institute, 2011). Given an inputted annual electricity usage of 1,010,000 kWh over the 60-year lifespan of the building and the total carbon emissions reported, the emissions factor is determined to be 0.32 kg CO_2/kWh.

The operational electrical energy outputted from *One-Click LCA* is determined using Statistics Canada 2015 data, and reflects the Ontario power grid according to Bionova Ltd. Given an inputted annual electricity usage of 1,010,000 kWh over the 60-year lifespan of the building and the total carbon emissions reported, the emissions factor is determined to be 0.14 kg CO_2/kWh.

In relation to latest Environment Canada National Inventories from 2011 which reports an electricity grid emissions factor in Ontario of 0.11 kg CO_2eq/kWh (Environment Canada, 2011), the emissions reported from the three programs are significantly greater- more than double in the case of the *Athena Impact Estimator*. Figure 12 graphically demonstrated the differences in outputted operational energy carbon emissions from each program with reference to the Environment Canada Inventories Report emissions factor from 2011, totaling 6,606 ton CO_2eq over the 60-year building operation period.

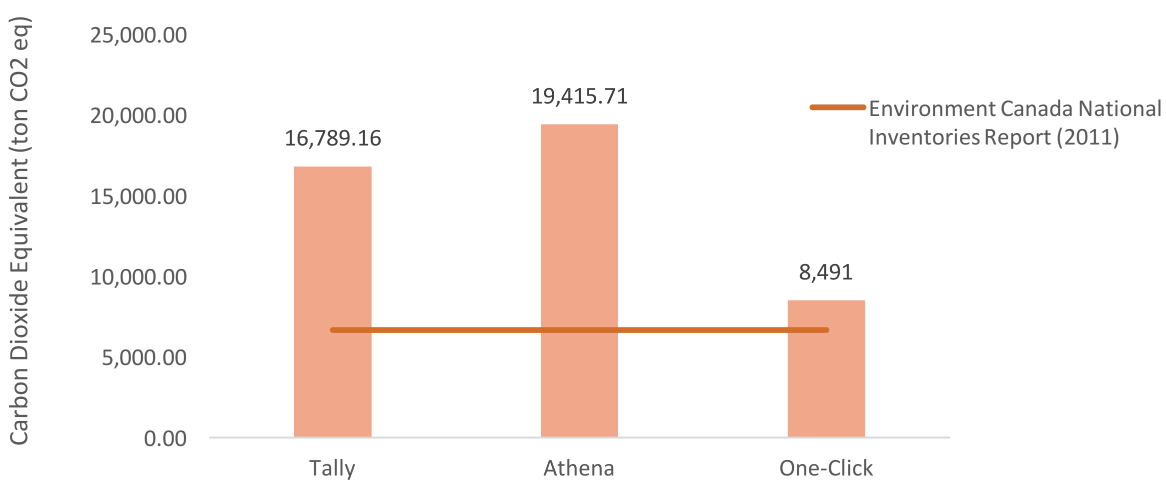

Figure 12: Comparison of Operational Energy (B6) Carbon Dioxide Emissions over the 60-Year Building Life Span

6.2.4 End-of-Life (C1-C4)

Tally's end-of-life reporting is based on average US construction and demolition waste treatment methods and rates including relevant material collection for recycling, incineration and landfilling rates. Recycling is modeled using an "avoided burden" approach where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recoverable material. For example, the aluminum sheet installed on site has a 95% recovery rate and 5% landfilled. The brick installed has a 50% recycling rate, 50% landfilling. The cement bonded particle board is 100% disposed in landfill. The rates reported assume the incoming project respects the recycling potential of each material. The Brickworks Kilns project outputted a negative emission value in the end-of-life phase, implying that the emissions saved by product recyclability outweighs the emissions to deconstruct, demolish, transport and dispose of all materials on site. Transportation off-site is excluded in *Tally* modelling.

One-Click LCA determines the end-of-life emissions as specified on the EPD of each material based on the recycling potential of each material. Details such as waste and recycling facility efficiency, transportation distances and deconstruction processes and their associated emissions are undisclosed in *One-Click LCA*.

The *Athena Impact Estimator* calculates the end-of-life effects on the "producer pay" principle where credit is not given based on future reuse of recovered material on future projects as it assumes the future project attains the "savings" from selecting recycled or recovered materials, so to not double count the sequestration or emissions savings on both the current and future projects. The end-of-life emissions account for the environmental burden of demolishing the building and transporting material to landfill (Athena Sustainable Materials Institute, 2011).

7 Discussion

The three life cycle assessment tools were evaluated and compared to determine which program offers the most opportunity in the Canadian construction market to report accurate carbon accumulation over the life time of a building or infrastructure project. While each program offers a unique approach and reporting system to whole building life cycle assessment, no one tool is superior in all respects. Upon conducting three whole building life-cycle assessments on the case study building using the three tools in question, Table 9 qualitatively compares the three tools based on their geographical applicability to Canadian projects, program user experience, material databases quality, scope inclusions and exclusions, and program restrictions using the Harvey Balls method.

Table 9: Observed Comparison of the Three LCA Tools

	Tally	Athena Impact Estimator	One-Click LCA
Regionally Specific Data	◔	◕	◕
User Experience	◕	◑	◕
Material Database Quality & Availability	◔	◑	◑
Robustness of Scope	◔	◔	◕
Program Restrictions	◑	◑	◕

7.1 Regionally Specific Data

Regional specificity has a significant impact on carbon emissions reporting at all life cycle phases, as seen in the high variability in the case study results presented. The *Tally* databases are predominantly from the U.S., meaning all back-end calculations and assumptions are based on American inputs and averages. Material and product life cycle assessments are based on American manufacturing plants, auto-populated transportation distances and methods are based off American averages and end-of-life calculations are based off American methods. Additionally, the program only includes one Canadian electricity grid mix option, meaning the grid mix reported generalizes the entirely of Canada rather than the cleaner Ontario grid.

The *Athena Impact Estimator* computes back-end calculations based on the project location's regional averages and assumptions of the closest city in the database. All major Canadian cities are listed, as well as some major U.S. cities. This data affects the back-end calculations of transportation distances and methods, electricity grid mixes and associated emissions factors and, end-of-life scenarios. Some issues arise from this method however, as should a project be located a significant distance away from the nearest city, transportation emissions are expected to be far greater than the averages reported by the *Athena Impact Estimator*. The North American material database and associated LCA data reflects generic products available in Canada, meaning major greenhouse gas emitting materials such as concrete and steel are represented accurately.

One-Click LCA utilizes specific product EPDs, meaning the emissions associated with specific materials are specific to the region in which they are produced and have been third-party verified confirming their accuracy. This method is superior when products with EPDs are specified, however does not have the same level of accuracy when substituted for similar products. Issues with an EPD-only database are discussed in detail below in section 7.2.3. The electricity grid mix selection in the *One-Click LCA* database is specific by Canadian provinces and values are taken from 2015 Statistics Canada data.

7.2 User Experience

User experience has significant implications on whether programs are adopted into industry practice and widely used across sectors. Input simplicity and consistency, transparency of program capabilities and output clarity ensure users are able to accurately and confidently report a project's emissions over its life time.

Being integrated into AutoDesk Revit, *Tally*'s modelling interface offers an exceptional user experience where material take-offs, quantities and weights are auto-generated based on the Revit model and selected materials' associated densities. One disadvantageous feature in *Tally* is the on-site construction impact input requirements, where the program accepts a single input for electricity, heating and water rather than being a program estimation based on material quantities and building typology like the other two programs. While this method is more accurate for post-construction reporting if the site is sub-metered during construction, it is less valuable during the design phase without a baseline or auto-generated input. *Tally* generates a thorough life cycle assessment report for every design iteration that identifies where all back-end calculation values are extracted from and separates outputs into various categories such as life cycle phase, building component and by specific material.

The *Athena Impact Estimator* bill of materials method poses some difficulty to users as the program only accepts specific units of measure based on material, meaning the input requirements are more intensive with a larger chance of error. For example, the weight of steel framing, the volume of paint on walls and the thickness of insulation must be inputted in 25mm steps. The *Athena Impact Estimator* has limited transparency of where back-end calculation values are extracted from, the methodology undertaken and the date last updated. As well, when performing a whole building life cycle assessment in the *Athena Impact Estimator,* results are exported in only two ways; by life cycle phase and by building component. The program does not allow individual material analysis, or life cycle impacts by material. In order to gather this data, a separate model must be created that analyses one material at a time.

Similar to the *Athena Impact Estimator*, the *One-Click LCA* model is generated from a bill of materials which can be either uploaded as an excel file, inputted manually or generated directly from AutoDesk Revit. The same challenges occur with material take-offs where the bill of materials exported from the AutoDesk Revit file is by volume rather than weight, meaning all steel quantities needed to be converted into weight to be inputted into *One-Click LCA*. Back-end calculation data sources are not readily available and do not describe the scope of inclusions and exclusions of each life cycle stage. Results can be exported by life cycle phase, building component and individual material, making data analysis straight forward and extensive.

7.3 Material Database Quality and Availability

As discussed, the U.S. material database embedded in *Tally* is populated using the GaBi LCA database. While the LCI of the generic materials is similar across borders, the LCIA varies significantly based on manufacturers, plant efficiency, raw material extraction methods, interim transportation distances and average recycled content of materials.

The *Athena Impact Estimator* material database has a limited selection and variability of materials, where the program inputs individual materials rather than pre-assembled materials such as doors, door hardware and stud wall systems. As well, non-standard concrete mix designs are not captured- the program only categorizes concrete by their strength, no additional properties such as air-entrainment, mix design number or percent recycled content. The database has limited glazing selection, innovative insulations or membranes, and mechanical and electrical equipment or conduit.

While *One-Click LCA*'s EPD driven database is set up to offer an extensive material database covering all building components, the usefulness of the program relies on industry adoption of EPDs by product manufacturers. BioNova Ltd. does not perform and populate the product LCA data like the other programs- it only inputs data from other publicly available information from third party verifiers. In the current version of *One-Click LCA*, the database has some major holes and missing information for example the lack of air barrier systems. In order for *One-Click LCA* to be used to its full potential, project specifications must only specify product that have EPDs. Until EPDs are more widely adopted by manufacturers*, One-Click LCA's* EPD driven database and reported whole building life cycle carbon emissions do not reflect the true as-built condition.

7.4 Robustness of Scope

Each life cycle assessment tools follow the ISO 14040 and 14044 principle and framework for LCA accounting, however the scope of included emissions vary program by program. Table 10 compares the building component modelling capabilities of each LCA tool. *Athena Impact Estimator* is predominantly used to model structure and envelope materials with limited ability to model all building components including mechanical equipment, piping and finishes. *Tally* does not support mechanical and electrical equipment or site work and landscaping. *One-Click LCA* is set up to support all material types, building systems and surrounding site work or landscaping, however limited to materials which have EPDs.

Table 10: Life Cycle Assessment Tool Modelling Capabilities

	Tally	**Athena Impact Estimator**	**One-Click LCA**
Load Bearing Members	Yes	Yes	Yes
Stairs	Yes	By component	Yes
Doors	Yes	By component	Yes
Site Work and Landscaping	No	No	Yes
Mechanical	No	No	Yes
Electrical	No	No	Yes
Sealants, Primers, Coatings	Yes	Limited	Yes
Nuts, bolts, Screws	Yes	Yes	Yes
Finishes (Paint, Tile)	Yes	Limited	Yes

7.5 Program Restrictions

The *Athena Impact Estimator* is a free downloadable program that can be performed by industry professionals of all training levels if provided a detailed bill of materials from a project design team. Minimal additional training is required to operate the program. *Tally* has an annual free of $695 US per floating license and requires a high skill level in AutoDesk Revit to operate and navigate fluently. *One-Click LCA* has an annual fee of $1,500 US per floating license, but can be operated by professionals of all skill levels if provided a detailed bill of materials from a project design team. *One-Click LCA* also provides thorough training to all license holders to ensure consistent user understanding and training.

8 Conclusions

The conducted research project seeks to examine and compare three life cycle assessment tools; *Athena Impact Estimator*, *Tally* and *One-Click LCA* to relate the input variability to the program outputs of the three programs. By conducting three whole building life-cycle assessments using a case study building's identical bill of materials, the research seeks to understand the applicability and strengths of one program over another and answer the presented research questions.

The research confirmed that the three programs output significantly different results given their variability of allowable program inputs, and back-end calculations and assumptions where the outputted whole building life cycle carbon equivalents of *One-Click LCA* is less than half than of *Tally*. However, the ratio of embodied emissions to operational emissions is similar across all three programs where the embodied emissions account for less than 10% of the total, and the material production stage account for over 80% of the embodied emissions. When compared to the total primary energy, it can be further concluded that not only are the carbon emissions factors variable, but the method of calculating the total energy from one programs to another varies as well.

Given that each of the three programs apply different back-end calculation LCI and LCIA methods that are not streamlined across the reporting process, the programs cannot be simply compared side-by-side. Better transparency, in particular in *One-Click LCA* and *Athena Impact Estimator* would greatly improve the ability to determine the accuracy of one program over another. Life cycle assessment tool generated "black-box" back-end calculations are approached with caution. While this may be beneficial from an industry user perspective by simplifying and outputting results quickly, this is disadvantageous to research personnel, as it takes away from the value of understanding and uncovering environmental "hot spots" through life cycle assessment interpretation.

Given the limitations placed on the Brickworks Kilns project to date including missing EPDs and vehicle transportation methods and distances, a high amount of uncertainty and assumptions were made to conduct the life cycle assessments, adding additional variability in results. In order to make the results more accurate and representative of the true works on site at the Brickworks Kilns projects, it is recommended to complete a whole building life cycle assessment upon completion of the project when all EPDs have been submitted and changes finalized. As well, for the purpose of this research and to simplify the project model, the Cupolex plastic air-voids in the concrete were not modelled. In order to accurately model the true material volumes on the Brickworks Kilns project, it is recommended to model the true material volume, or complete a volume to mass ratio and estimate the true mass of concrete on the site.

The research conducted compliments the current research and understand of whole building life cycle assessment tool comparisons where as noted in the research conducted by Al-Ghamdi & Bilec, the high variability it inputs has a significant effect on the outputted results, creating inaccuracy and inconsistency among reporting. As whole building life cycle assessment becomes more widely used in industry, better accuracy and transparency is required in order for designers to confidently market and report carbon neutrality in buildings.

8.1 Research Questions

1. *What are the major similarities and differences between three readily available life-cycle assessment tools for Canadian construction projects?*

The three whole building life cycle assessment tools analyzed perform cradle-to-grave assessments following the ISO 14040 and 14044 standard framework. The three programs calculate differing impact categories, but all have the capability of calculating greenhouse gas emissions in mass of equivalent carbon dioxide.

The three programs execute the life cycle assessment in significantly different ways influencing the outputted results. Different material databases, associated emissions factors, input variability and back end calculations effectively means side-by-side comparisons cannot be made. Additionally, the program reporting formats vary, therefore many of the results cannot be simply exported from the three programs and compared.

1a. *How much input flexibility is inherent in three readily available life-cycle assessment tools and identify the effect in output variability and accuracy?*

The three programs offer different input flexibility having a significant effect on output variability and program accuracy. Depending on the level of detail known about the building under investigation, program selection will influence the output accuracy. In cases where the project is in the design phase where materials have not been specified, transportation methods and distances unknown and construction methods not determined, a simplified and generic model is favorable. To date, whole building life cycle assessment is used as a decision-making tool- selecting one material over another and making a decision whether to refurbish or build new. However, as industry requests accuracy in carbon reporting to achieve carbon reduction target and carbon neutral projects, accurate modelling that is accessible to industry is required.

1b. *Which programs or strategies offer the most effective carbon accounting mechanism for the Canadian construction market?*

In most respects, *One-Click LCA* proves to be the life cycle assessment tool that addresses the Ontario Governments' call for action to create a consistent and accurate carbon accounting tool that is applicable to all new and existing building and infrastructure projects. *One-Click LCA* inputs regionally specific emissions factors, permits high flexibility in inputs, is straight forward for users and, has a committed, international team who are responsive and are consistently update and upgrading the program. On projects like the Brickworks Kilns project, *One-Click LCA* is a superior life cycle assessment tool as it reflects the true products and materials installed on site because EPDs are enforced for all materials installed on site. Until EPDs are required and the supply chain is cleaned up such that transportation distances are known and required to be reported by sub trades, or when generic materials are added to the database, *One-Click LCA* does not hold much value on Canadian projects. On projects where EPDs are not enforced, or the projects is in the design phase where products are yet to be determined and project details are not finalized, the *Athena Impact Estimator* is preferred as it uses a generic material database and estimates details that are typically unknown during the design phase. As determined through this research, *Tally* does not prove to be an ideal life cycle assessment tool to be used in Canada until the material database is updated and emissions factors are regionally specific, as seen by the skewed results throughout.

8.2 Future Research

In completing this research, a number of future research areas have been identified that would strengthens the body of knowledge around whole building life cycle assessment. One major area is to delve further into how emissions are calculated in the construction phase in particular to better define a method to account for emissions for a specific project, rather than the current estimation method based on material quantities only. A framework or methodology is needed to specify machinery inventory and quantities, and temporary materials needed that is specific to the building. The framework should consider building typology and size, construction duration, location and site accessibility. The research conducted essentially ignores construction emissions as *Tally* and *One-Click LCA* do not auto-populate the emissions and therefore cannot be simply estimated. A better understanding of the percent emissions due to the construction phase would be valuable information to determine whether extensive research and detail is needed, or if the percent emissions is negligible.

In addition, extending the research to look at a broader range of projects including new builds and other refurbishment projects would further validate the research conclusions and determine whether results are consistent between a new build project and a refurbishment project. A new build project would also offer a different perspective in understanding the percent embodied carbon to operational carbon of a new build compared to a refurbishment and the differences in each program's resulting outputs.

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11 Appendix

Tally - Walls

SPECIFIED MATERIAL						TALLY					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
W2											
Insulated Metal Panel	AWIPanels/VicWest	F40 "Flat Wall"	07 40 63	75	mm	Spandrel, aluminum, insulated (2" core)	Generic	140	m2	50.8	mm
W3											
Brick, to match existing	Mortar Type N, exterior non-load bearing		04 20 00			Brick, grouted with mortat type N	Generic	97.79	m2	45	mm
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	Extruded Polystyrene, XPS	Generic	97.79	m2	50	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00			Self adhering 40mil membrane	Generic	97.79	m2	0	mm
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Fibreglass mat gypsum sheathing	Generic	97.79	m2	12.7	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Steel, C-stud metal framing, galvanized with insulation, 1 way spacing 405mm o.c.	Generic	97.79	m2	90	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	Mineral wool, low density	Generic	97.79	m2	90	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	Polyethelene sheet vapor barrier (HDPE)	Generic	97.79	mm	0.3	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Cement bonded particle board	Generic	97.79	m2	12.7	mm
W4											
Pre-finished composite metal panels	Flynn Canada Ltd/ Vicwest Canada/ Exterior Technologies Group	Accumet PE/ ACM Panels/ Alpolic Panels	07 42 40			Aluminum, sheet	Generic	19.32	m2	4	mm
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	Extruded Polystyrene, XPS	Generic	19.32	m2	50	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00			Self adhering 40mil membrane	Generic	19.32	m2	0	mm
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Fibreglass mat gypsum sheathing	Generic	19.32	m2	12.7	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Steel, C-stud metal framing, galvanized with insulation, 1 way spacing 405mm o.c.	Generic	19.32	m2	90	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	Mineral wool, low density	Generic	19.32	m2	90	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	Polyethelene sheet vapor barrier (HDPE)	Generic	19.32	m2	0.3	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Cement bonded particle board	Generic	19.32	m2	12.7	mm
P1											
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			04 20 00	140	mm	Hollow core CMU, grouted, 6x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	Generic	95.4	m2	140	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool (rockwool) rigid insulation board, low density	Generic	95.4	m2	38	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Steel "Z" Channel	Generic	95.4	m2	0	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Cement bonded particle board	Generic	95.4	m2	12.5	mm
Tile finish						Ceramic Tile, unglazed, inclusive of mortar	Generic	95.4	m2	10	mm
P2											
Paint Finish						Exterior acrylic latex	Generic	89.12	m2	0	mm
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			04 20 00	140	mm	Hollow core CMU, grouted, 6x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	Generic	89.12	m2	140	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool (rockwool) rigid insulation board, low density	Generic	89.12	m2	38	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Steel "Z" Channel	Generic	89.12	m2	0	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Cement bonded particle board	Generic	89.12	m2	12.5	mm
P3											
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			04 20 00	190	mm	Hollow core CMU, grouted, 8x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	Generic	68.02	m2	190	mm
P4											
Patterned Back Painted Glass				6	mm	Glazing, monolithic sheet	Generic	171.3	m2	6	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Cement bonded particle board	Generic	171.3	m2	12.7	mm
Furring Channels		0.5 mm base steel thickness, galvanized. 70 mm wide x 22 mm deep hat shaped channel	09 21 16	22	mm	Steel, furring channels, galvanized 7/8" 25 ga.	Generic	171.3	m2	22	mm
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			04 20 00	140	mm	Hollow core CMU, grouted, 6x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	Generic	171.3	m2	140	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool (rockwool) rigid insulation board, low density	Generic	171.3	m2	38	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Steel "Z" Channel	Generic	171.3	m2	0	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Cement bonded particle board	Generic	171.3	m2	12.7	mm
Tile finish						Ceramic Tile, unglazed, inclusive of mortar	Generic	171.3	m2	10	mm
P5											
Tile finish						Ceramic Tile, unglazed, inclusive of mortar	Generic	149.1	m2	10	mm
CMU Filled with Grout, mortar type S, reinforced with hot dipped galvanized			04 20 00	100	mm	Hollow core CMU, grouted, 4x8x16, Mortar type S, reinforcing steel rod @ 48" o.c.	Generic	149.1	m2	100	mm
Tile finish						Ceramic Tile, unglazed, inclusive of mortar	Generic	149.1	m2	10	mm

Tally - Curtain Wall/Windows

SPECIFIED MATERIAL						TALLY					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
CW1											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating	08 80 00	25	mm	Glazing, double pane IGU, 2 layers of 4mm thick glass, air filled, low-e	Generic	383.815	m2		
CW3											
Type 1: FGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Float Glass, low-e coating	08 80 00	25	mm	Glazing, double pane IGU, 2 layers of 4mm thick glass, air filled, low-e	Generic	140.085	m2		
Windows											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating				Glazing, double pane IGU, 2 layers of 4mm thick glass, air filled, low-e	Generic	18.061	m2		

Tally - Roof

SPECIFIED MATERIAL						TALLY					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
R1											
24 Ga. Ribbed Metal Roof	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel, roof decking, cold-formed galvanized	Generic	5276	m2	5	mm
Vapour Permeable Self Adhering Membrance		Polyethylene film 6mil	07 26 00	0.15	mm	Polyethelene sheet vapor barrier (HDPE)	Generic	5276	m2	0.3	mm
Rigid Poly Iso Insulation	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	76	mm	Polyisocyanurate (PIR) board	Generic	5276	m2	76	mm
R2											
2-Ply Modified Bitumen Roofing System	Henry Company Canada Inc./ Siplast/ Soprema Waterproofing Inc.	2 Sheet Styrene-Butadiene-Styrene (SBS) Membrane	07 52 00			Self-adhering sheet waterproofing, modified bituminous sheet	Generic	80.69	m2	5	mm
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Fibreglass mat gypsum sheathing	Generic	80.69	m2	12.7	mm
Corrigated Metal Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel, form deck, cold-galvanized	Generic	80.69	m2	40	mm
2 Lb Spray Insulation	BASF/ Demilec Inc.	Walltite Eco v.3/ Heatlok Soya	07 21 19			Open cell spray foam applied polyurethane foam	Generic	80.69	m2	80	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Cement bonded particle board	Generic	80.69	m2	12.7	mm

Tally - Ceiling

SPECIFIED MATERIAL						TALLY					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
C2											
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel, roof decking, cold-formed galvanized	Generic	129.8	m2	5	mm
Metal Stud	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	89	mm	Steel, C-stud metal framing, galvanized with insulation, 1 way spacing 405mm o.c.	Generic	129.8	m2	89	mm
Mineral Wool Acoustical Batts	Roxul	ComfortBatt	07 21 00	89	mm	Mineral wool, low density	Generic	129.8	m2	89	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Hot rolled steel channel C3x3.5	Generic	129.8	m2	0	mm
Gypsum Wall Board	Certainteed Gypsum Canada, CGC Inc./ Georgia-Pacific Canada LP	Furnish Board	09 21 16	12.5	mm	Wall board, gypsum, interior acrylic latx paint	Generic	129.8	m2	12.5	mm
C3											
Reinforced Concrete						Reinforced slab 3000 psi, exclusive of deck	Generic	62.17	m2	20	mm
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel, roof decking, cold-formed galvanized	Generic	62.17	m2	5	mm

Tally - Floors

SPECIFIED MATERIAL						TALLY					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
F1											
Polished Concrete with radiant and wire mesh				75	mm	Structural, unreinforced, 3000psi/20MPa	Generic	2407.5	m2	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete		127	mm	Air-Entrained Structural concrete, unreinforced	Generic	2407.5	m2	127	mm
Raised Structural Cavity floor	Cupolex	Cupolex Modular Vaulted Sub-slab Forms, 25 Mpa		Varies		Air-Entrained Structural concrete, unreinforced	Generic	2407.5	m2	250	mm
F2											
Polished Concrete with radiant and wire mesh				75	mm	Structural, unreinforced, 3000psi/20MPa	Generic	208.07	m2	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete		Varies		Air-Entrained Structural concrete, unreinforced	Generic	208.07	m2	375	mm
F6											
Concrete Finish						Structural, unreinforced, 3000psi/20MPa	Generic	86.07	m2	89	mm
Reinforced Concrete on Steel Deck						Steel, cold formed galvanized deck	Generic	86.07	m2	0.76	mm
F8											
Reinforced Concrete Slab				150	mm	Cast-in-place concrete, slab on grade with reinforcing steel inclusive	Generic	75.09	m2	150	mm

Tally - Doors

SPECIFIED MATERIAL						ONE-CLICK LCA			
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM
			D101						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D102						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D103						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D104						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D105						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D106						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D107						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D108						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.947	m2
			D109a						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	2.127	m2
			D109b						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door, exterior, aluminum, anodized	Generic	4.229	m2
			D110						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D111						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D112						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D113						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D114						

Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D115						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D116						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D117						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D118						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D119						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D120						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D121						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D122						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D123						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D124						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D125						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D126						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D127						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D128						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D129						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Door, interior, steel, anodized	Generic	1.85	m2
			D130						

Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	1.85 m2
			D131				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	1.85 m2
			D132				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	1.85 m2
			D133				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	1.85 m2
			D134				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	3.53 m2
			D139a				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	2.524 m2
			D139b				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	5.047 m2
			D142				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	3.578 m2
			D143a				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	2.524 m2
			D143b				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	5.047 m2
			D144				
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Door, interior, steel, anodized	Generic	1.859 m2
			D145a				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	2.524 m2
			D145b				
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door, exterior, aluminum, anodized	Generic	5.047 m2

Athena Impact Estimator - Walls

SPECIFIED MATERIAL						ATHENA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
				W2							
Insulated Metal Panel	AWIPanels/VicWest	F40 "Flat Wall"	07 40 63	75	mm	3" Insulated Metal Panel	Generic	139.33	m2	76	mm
				W3							
Brick, to match existing	Mortar Type N, exterior non-load bearing		04 20 00			Concrete Brick	Generic	97.79	m2		
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	Extruded Polystyrene	Generic	195.58	m2 (25mm)	50	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00			Air Barrier	Generic	97.79	m2		
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	1/2" Moisture Resistant Gypsum Board	Generic	97.79	m2	15.8	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Galvanized steel	Generic	456.3	kg	90	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	MW Batt R30	Generic	97.79	m2	89	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	VR Protection Sheet	Generic	97.79	m2	0.15	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Fiber Cement	Generic	97.79	m2	12.7	mm
				W4							
Pre-finished composite metal panels	Flynn Canada Ltd/ Vicwest Canada/ Exterior Technologies Group	Accumet PE/ ACM Panels/ Alpolic Panels	07 42 40			Metal Wall Cladding - Commercial (26Ga)	Generic	19.271	m2		
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	Extruded Polystyrene	Generic	38.542	m2 (25mm)	50.8	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00			Air Barrier	Generic	19.271	m2		
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	1/2" Moisture Resistant Gypsum Board	Generic	19.271	m2	15.8	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Galvanized Studs	Generic	90.18	kg	90	mm
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	MW Batt R30	Generic	19.271	m2	89	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	VR Protection Sheet	Generic	19.271	m2	0.15	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Fiber Cement	Generic	19.271	m2	12.7	mm
				P1							
CMU Filled with Grout, mortar type S			04 20 00	140	mm	6" Normal Weight Concrete Block	Generic	1286	blocks		
Reinforced with hot dipped galvanized steel						Rebar, rod, light sections	Generic	77.78	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	MW Batt R30	Generic	95.398	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Studs	Generic	9.68	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Fiber Cement	Generic	95.398	m2	12.7	mm
Tile finish						Clay Tile	Generic	95.398	m2		
				P2							
Paint Finish											
CMU Filled with Grout, mortar type S			04 20 00	140	mm	6" Normal Weight Concrete Block	Generic	1202	blocks		
Reinforced with hot dipped galvanized steel						Rebar, rod, light sections	Generic	72.66	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	MW Batt R30	Generic	89.117	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Studs	Generic	9.56	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Fiber Cement	Generic	89.117	m2	12.7	mm
				P3							
CMU Filled with Grout, mortar type S			04 20 00	190	mm	4" Normal Weight Concrete Block	Generic	917	blocks		
Reinforced with hot dipped galvanized steel						Rebar, rod, light sections	Generic	55.46	kg		
				P4							
Patterned Back Painted Glass				6	mm	Glazing Panel	Generic	1.75	tonnes	6	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Fiber Cement	Generic	171.349	m2	12.7	mm
Furring Channels		0.5 mm base steel thickness, galvanized. 70 mm wide x 22 mm deep hat shaped channel	09 21 16	22	mm	Galvanized Studs	Generic	17.89	kg		
CMU Filled with Grout, mortar type S			04 20 00	140	mm	6" Normal Weight Concrete Block	Generic	2312	blocks		
Reinforced with hot dipped galvanized steel						Rebar, rod, light sections	Generic	139.7	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	MW Batt R30	Generic	171.349	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized Studs	Generic	14.22	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Fiber Cement	Generic	171.349	m2	12.7	mm
Tile finish						Clay Tile	Generic	171.349	m2		
				P5							
Tile finish						Clay Tile	Generic	149.1	m2		
CMU Filled with Grout, mortar type S			04 20 00	100	mm	4" Normal Weight Concrete Block	Generic	2011	blocks		
Reinforced with hot dipped galvanized steel						Rebar, rod, light sections	Generic	121.6	kg		
Tile finish						Clay Tile	Generic	149.1	m2		

Athena Impact Estimator - Curtain Wall/Windows

SPECIFIED MATERIAL						ATHENA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
CW1											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating	08 80 00	25	mm	Double Glazed Hard Coated Air	Generic	383.815	m2		
Aluminum Mullions						Aluminum Window Frame	Generic	861.5	kg		
CW3											
Type 1: FGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Float Glass, low-e coating	08 80 00	25	mm	Double Glazed Hard Coated Air	Generic	140.085	m2		
Aluminum Mullions						Aluminum Window Frame	Generic				
Windows											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating				Double Glazed Hard Coated Air	Generic	18.061	m2		
Aluminum Mullions						Aluminum Window Frame	Generic	48.74	m2		

Athena Impact Estimator - Roof

SPECIFIED MATERIAL						ATHENA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
R1											
24 Ga. Ribbed Metal Roof	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			MBS Metal Roof Cladding - Commercial (24 Ga)	Generic	5276.176	m2		
Vapour Permeable Self Adhering Membrance		Polyethylene film 6mil	07 26 00	0.15	mm	VR Protection Sheet	Generic	5276.176	m2	0.15	mm
Rigid Poly Iso Insulation	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	76	mm	Polyiso foam board	Generic	15828.528	m2 (25mm)	76	mm
R2											
2-Ply Modified Bitumen Roofing System	Henry Company Canada Inc./ Siplast/ Soprema Waterproofing Inc.	2 Sheet Styrene-Butadiene-Styrene (SBS) Membrane	07 52 00			Modified Bitumen Membrane	Generic	4.03	kg		
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	1/2" Moisture Resistant Gypsum Board	Generic	80.69	m2	12.7	mm
Corrigated Metal Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Galvanized Decking	Generic	0.41	tonnes		
2 Lb Spray Insulation	BASF/ Demilec Inc.	Walltite Eco v.3/ Heatlok Soya	07 21 19			FG LF Open Blow R31-40	Generic	80.69	m2		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Fiber Board	Generic	80.69	m2		

Athena Impact Estimator - Ceiling

SPECIFIED MATERIAL						ATHENA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
C2											
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Galvanized Decking	Generic	0.67	tonnes		
Metal Stud	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	89	mm	Galvanized studs	Generic	176	kg		
Mineral Wool Acoustical Batts	Roxul	ComfortBatt	07 21 00	89	mm	MW Batt R30	Generic	519.362	m2 (25mm)	88	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Galvanized studs	Generic	14.45	kg		
Gypsum Wall Board	Certainteed Gypsum Canada, CGC Inc./ Georgia-Pacific Canada LP	Furnish Board	09 21 16	12.5	mm	1/2" Regular Gypsum Board	Generic	129.84	m2	12.7	mm
C3											
Reinforced Concrete						Concrete Benchmark 2500psi	Generic	9.325	m3		
Reinforcing						Rebar, rod, light sections	Generic	54.24	kg		
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Galvanized Decking	Generic	0.32	tonnes		

Athena Impact Estimator - Floors

SPECIFIED MATERIAL						ATHENA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
F1											
Polished Concrete with radiant and wire mesh				75	mm	Concrete Benchmark 3000psi	Generic	180.5625	m3	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete		127	mm	Concrete Benchmark 4000psi	Generic	305.7525	m3	127	mm
Raised Structural Cavity floor	Cupolex	Cupolex Modular Vaulted Sub-slab Forms, 25 Mpa		Varies		Concrete Benchmark 4000psi	Generic	601.87	m3	250	mm
F2											
Polished Concrete with radiant and wire mesh				75	mm	Concrete Benchmark 3000psi	Generic	15.60525	m3	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete		Varies		Concrete Benchmark 4000psi	Generic	78.03	m3	375	mm
F6											
Concrete Finish						Concrete Benchmark 3000psi	Generic	7.66	m3	89	mm
Reinforced Concrete on Steel Deck						Galvanized Decking	Generic	443.2	kg		
F8											
Reinforced Concrete Slab				150	mm	Concrete Benchmark 4000psi	Generic	11.26	m3	150	mm
Steel reinforcing rod						Rebar, rod, light sections	Generic	982.7	kg		

Athena Impact Estimator - Doors

SPECIFIED MATERIAL						ATHENA			
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM
			D101						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D102						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D103						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D104						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D105						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D106						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D107						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D108						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		53.19	kg
						Steel		6.838	kg
			D109a						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		38.4	kg
						Steel		4.935	kg
			D109b						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		76.32	kg
						Steel		9.811	kg
			D110-134						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Galvanized Steel		801.8	kg
						Stainless Steel		186.4	kg
			D139a						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Aluminum		45.55	kg

					Steel	5.855 kg
D139b						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Aluminum	91.01 kg
					Steel	11.71 kg
D142						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Galvanized Steel	61.73 kg
					Stainless Steel	6.441 kg
D143a & D145a						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Aluminum	91.09 kg
					Steel	11.71 kg
D143b & D145b						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Aluminum	182.13 kg
					Steel	23.43 kg
D144						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Galvanized Steel	32.07 kg
					Stainless Steel	3.347 kg

One-Click LCA - Walls

SPECIFIED MATERIAL						ONE-CLICK LCA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
W2											
Insulated Metal Panel	AWIPanels/VicWest	F40 "Flat Wall"	07 40 63	75	mm	Insulated metal panel, 1 3/4in-4in x 36in x 6in-48ft	Versapanel (Centria)	10.45	m3		
W3											
Brick, to match existing	Mortar Type N, exterior non-load bearing		04 20 00			Concrete Masonry Unit, 7 7/8inx7 5/8inx15 5/8in, HW Regular	Mid West Block and Brick	8.8	m3		
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	XPS Insulation (extruded polystyrene)	Quartz	97.79	m2	50.8	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00								
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Gypsum Board Type X, 5/8", 2.25 psf	CertainTweed	97.79	m2	15.8	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Steel framing systems	Studrite	456.3	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	97.79	m2	89	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	Vapor Barrier, 0.06in	Quartz	97.79	m2	0.15	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	97.79	m2	12.7	mm
W4											
Pre-finished composite metal panels	Flynn Canada Ltd/ Vicwest Canada/ Exterior Technologies Group	Accumet PE/ ACM Panels/ Alpolic Panels	07 42 40			Roll formed steel panels, 24 gauge, 5.9 kg/m2	CSSBI	19.271	m2		
Rigid Insulation XPS Horizontal	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	50	mm	XPS Insulation (extruded polystyrene)	Quartz	19.271	m2	50.8	mm
Air Barrier Self-Adhering Membrane	Cosella-Dorken/ Henry Company Canada Inc./ Vaproshield	Delta-Vent SA/ Blueskin VP160/ WrapShield SA	07 27 00								
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Gypsum Board Type X, 5/8", 2.25 psf	CertainTweed	19.271	m2	15.8	mm
Steel Stud, 405mm o.c.	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	90	mm	Steel framing systems	Studrite	90.18	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	90	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	19.271	m2	89	mm
Vapour Barrier		Polyethylene film 6mil	07 26 00	0.15	mm	Vapor Barrier, 0.06in	Quartz	19.271	m2	0.15	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	19.271	m2	12.7	mm
P1											
CMU Filled with Grout, mortar type S			04 20 00	140	mm	Concrete Masonry Unit	Quartz	13.356	m3		
Reinforced withhot dipped galvanized						Rebar, hot rolled	Knoxville Steel Mill	77.78	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	95.398	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Steel framing systems	Studrite	9.68	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	95.398	m2	12.7	mm
Tile finish						Bio-based floor tile	Armstrong	95.398	m2		
P2											
Paint Finish											
CMU Filled with Grout, mortar type S			04 20 00	140	mm	Concrete Masonry Unit	Quartz	12.48	m3		
Reinforced withhot dipped galvanized						Rebar, hot rolled	Knoxville Steel Mill	72.66	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	89.117	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Steel framing systems	Studrite	9.56	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	89.117	m2	12.7	mm
P3											
CMU Filled with Grout, mortar type S			04 20 00	190	mm	Concrete Masonry Unit	Quartz	12.922	m3		
Reinforced withhot dipped galvanized						Rebar, hot rolled	Knoxville Steel Mill	55.46	kg		
P4											
Patterned Back Painted Glass				6	mm	Pressed glass partition, 0.236 in	Infinite Glass	171.349	m2	6	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	171.349	m2	12.7	mm
Furring Channels		0.5 mm base steel thickness, galvanized. 70 mm wide x 22 mm deep hat shaped channel	09 21 16	22	mm	Steel framing systems	Studrite	17.89	kg		
CMU Filled with Grout, mortar type S			04 20 00	140	mm	Concrete Masonry Unit	Quartz	23.99	m3		
Reinforced withhot dipped galvanized						Rebar, hot rolled	Knoxville Steel Mill	139.7	kg		
Mineral Wool Batt Insulation	Roxul	ComfortBatt	07 21 00	38	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	171.349	m2	38.1	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Steel framing systems	Studrite	14.22	kg		
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.5	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	171.349	m2	12.7	mm
Tile finish						Bio-based floor tile	Armstrong	171.349	m2		
P5											
Tile finish						Bio-based floor tile	Armstrong	149.1	m2		
CMU Filled with Grout, mortar type S			04 20 00	100	mm	Concrete Masonry Unit	Quartz	14.91	m3		
Reinforced withhot dipped galvanized						Rebar, hot rolled	Knoxville Steel Mill	121.6	kg		
Tile finish						Bio-based floor tile	Armstrong	149.1	m2		

One-Click LCA - Curtain Wall/Windows

SPECIFIED MATERIAL						ONE-CLICK LCA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
CW1											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating	08 80 00	25	mm	Traditional Curtain Wall, 1.5mx 1.6m and clearwall curtain wall system	Kawneer	383.815	m2		
CW3											
Type 1: FGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Float Glass, low-e coating	08 80 00	25	mm	Traditional Curtain Wall, 1.5mx 1.6m and clearwall curtainl wall system	Kawneer	140.085	m2		
Windows											
Type 2: TGL	AGC Flat Glass/ Cardinal Glass Industries/ Guardian Industries/ Oldcastle Glass Inc/ PPG Industries Ltd./ Viracon Inc.	Double Pane, Tempered, low-e coating				Aluminum window, fixed and ribbon	Kawneer	18.061	m2		

One-Click LCA - Roof

SPECIFIED MATERIAL						ONE-CLICK LCA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
R1											
24 Ga. Ribbed Metal Roof	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel roof and floor deck, 22-16 gauge	Steel Deck Institute	63314	kg		
Vapour Permeable Self Adhering Membrance		Polyethylene film 6mil	07 26 00	0.15	mm	Vapor Barrier, 0.06in	Quartz	5276	m2	0.15	mm
Rigid Poly Iso Insulation	Dow Cornings Canada/ Owens Cornings Canada	Styrofoam SM/ Foamular C-300	07 21 00	76	mm	ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	Dow Cornings	5276	m2	76	mm
R2											
2-Ply Modified Bitumen Roofing System	Henry Company Canada Inc./ Siplast/ Soprema Waterproofing Inc.	2 Sheet Styrene-Butadiene-Styrene (SBS) Membrane	07 52 00			Fluid Applied Rubber Asphalt roofing	Quartz	80.69	m2	4.5	mm
Exterior Sheathing	CertainTeed Gypsum Canada/ CGC Inc/ Georgia-Pacific Canada LP	GlasRoc Brand Sheathing/ Securock Glass-Mat Sheathing/ Dens-Glass Gold	05 41 00	12.7	mm	Gypsum Board Type X, 5/8", 2.25 psf	CertainTweed	80.69	m2	15.8	mm
Corrigated Metal Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Composite Metal Decking, 30 mil	Quartz	80.69	m2	0.76	mm
2 Lb Spray Insulation	BASF/ Demilec Inc.	Walltite Eco v.3/ Heatlok Soya	07 21 19			Spray foam insulation, 1.02in	Dow Cornings	80.69	m2	25	mm
Cement Board	CGC Inc.	Durock Cement Board Next Gen	09 21 16	12.7	mm	Medium density fibreboard, 0.75in	Canadian Wool Council	80.69	m2	12.7	mm

One-Click LCA - Ceiling

SPECIFIED MATERIAL						ONE-CLICK LCA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
C2											
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel roof and floor deck, 22-16 gauge	Steel Deck Institute	668	kg		
Metal Stud	Bailey Metal Products/ Sanders Steel Inc./ Steelform Building Products	CSA S136, Grade A to D steel with Z275 zinc coating designation in accordance with ASTM A653/A653M	05 41 00	89	mm	Steel framing systems	Studrite	176	kg		
Mineral Wool Acoustical Batts	Roxul	ComfortBatt	07 21 00	89	mm	Mineral wool insulation batt, R11, EcoBatt Insulation with Ecose Technology	Knauf Insulation	129.84	m2	88	mm
Resilient Channel		0.5 mm thick galvanized metal, 57 mm wide x 12 mm deep	09 21 16	12.5	mm	Steel framing systems	Studrite	14.45	kg		
Gypsum Wall Board	Certainteed Gypsum Canada, CGC Inc./ Georgia-Pacific Canada LP	Furnish Board	09 21 16	12.5	mm	Gypsum Wall Board, Regular, 0.5in	Generic (NREL)	129.84	m2	12.7	mm
C3											
Reinforced Concrete						Ready-mix concrete, 25 Mpa GU cement with air entrained 0-14%	CRMCA	9.325	m3		
Reinforcing steel						Rebar, hot rolled	Knoxville Steel Mill	54.24	kg		
Steel Deck	Agway Metals Inc./ Roll From Group/ VicWest Steel	Z275, Galvanized steel	07 61 00			Steel roof and floor deck, 22-16 gauge	Steel Deck Institute	320	kg		

One-Click LCA - Floors

SPECIFIED MATERIAL						ONE-CLICK LCA					
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM	Thickness	UOM
F1											
Polished Concrete with radiant and wire mesh					75 mm	Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	2407.5	m2	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete			127 mm	Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	2407.5	m2	127	mm
Raised Structural Cavity floor	Cupolex	Cupolex Modular Vaulted Sub-slab Forms, 25 Mpa		Varies		Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	2407.5	m2	250	mm
F2											
Polished Concrete with radiant and wire mesh					75 mm	Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	208.07	m2	75	mm
Insulated Concrete (R10)	Foamcrete	Dufferin Concrete		Varies		Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	208.07	m2	375	mm
F6											
Concrete Finish						Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	86.07	m2	89	mm
Reinforced Concrete on Steel Deck						Steel roof and floor deck, 22-16gauge	SDI	443.2	kg		
F8											
Reinforced Concrete Slab					150 mm	Ready-mix concrete, 25 Mpa GU with air entrained 0-14%	CRCMA	11.26	m3	150	mm
						Rebar, hot rolled	Knoxville Steel Mill	982.7	kg		

One-Click LCA - Doors

SPECIFIED MATERIAL						ONE-CLICK LCA			
Material Name	Approved Manufacturer	Product Name	Specification Section	Thickness	UOM	Material Name	Manufacturer	Quantity Take Off	UOM
			D101						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.813625	m2
			D102						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D103						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D104						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D105						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D106						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D107						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D108						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	5.62725	m2
			D109a						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.23077	m2
			D109b						
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50	mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.23077	m2
			D110						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D111						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D112						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D113						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D114						

Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D115						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D116						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D117						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D118						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D119						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D120						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D121						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D122						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D123						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D124						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D125						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D126						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D127						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D128						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D129						
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45	mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D130						

Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D131					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.759725	m2
			D132					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D133					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	1.951695	m2
			D134					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	3.90339	m2
			D13a					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.23077	m2
			D139b					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	4.46154	m2
			D142					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	3.90339	m2
			D143a					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.23077	m2
			D143b					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	4.46154	m2
			D144					
Frame: Hollow Metal, finish paint; Door:Hollow Metal, finish paint	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	44.45 mm	Steel door, interior, 1 3/4in x 4x8ft	Total Door Systems	3.90339	m2
			D145a					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	2.23077	m2
			D145b					
Frame: Aluminum, finish bronze anodized; Door:Aluminum, finish bronze anodized	Fleming Doors Products/ Daybar Industries Limited/ Steel-Craft Door Products Ltd.	Steel: ASTM A568/A568M, Class 1; Commercial grade steel, hot dip galvanized to ASTM A653/A653M, ZF120 galvanized coating.	08 11 13	50 mm	Door exterior, honeycomb core, 1 3/4in, 14-18 gauge	Ceco Door	4.46154	m2

Tally Results by Life Cycle Phase

Row Labels	Sum of Global Warming Potential Total (kgCO2eq)
End of Life	-374.30
Maintenance and Replacement	257,193.97
Manufacturing	1,102,383.13
Operational Energy	16,789,158.68
Transportation	17,972.48
Grand Total	**18,166,333.96**

Tally Results by Material

Row Labels	Sum of Global Warming Potential Total (kgCO2eq)
03 - Concrete	**695,682.15**
Air-entrained structural concrete; unreinforced	582,103.84
Cast-in-place concrete; slab on grade	7,131.35
Concrete; unreinforced; generic; 3000 psi (20MPa)	105,730.88
Reinforced slab; exclusive of deck	716.09
04 - Masonry	**37,977.68**
Brick; generic; grouted	5,996.03
Hollow-core CMU; grouted	31,981.65
05 - Metals	**123,535.14**
Aluminum; sheet	923.56
Steel; C-stud metal framing with insulation	4,065.17
Steel; form deck	3,358.03
Steel; furring channel	119.62
Steel; roof decking	115,068.76
06 - Wood/Plastics/Composites	**11,542.03**
Cement bonded particle board	10,933.86
Fiberglass mat gypsum sheathing	608.17
07 - Thermal and Moisture Protection	**335,834.41**
Expanded polystyrene (EPS); board	121.40
Extruded polystyrene (XPS); board	881.74
Mineral wool; board; generic	2,509.94
Open cell; polyurethane foam; spray-applied	488.22
Polyethelene sheet vapor barrier (HDPE)	8,524.99
Polyisocyanurate (PIR); board	322,538.82
Self adhering membrane	431.53
Self-adhering sheet waterproofing; modified bituminous sheet	337.78
08 - Openings and Glazing	**134,359.46**
Aluminum mullion; anodized	14,140.75
Door; exterior; aluminum	23,649.35

Door; interior; steel	5,858.57
Glazing; double pane IGU	38,768.03
Glazing; monolithic sheet	6,474.23
Spandrel; aluminum; insulated	45,131.65
Window frame; aluminum	336.88
09 - Finishes	**38,244.40**
Ceramic tile; unglazed	36,701.35
Fiberglass mat gypsum sheathing	419.05
Wall board; gypsum	1,124.00
Operational Electricity	**16,789,158.68**
Operational Electricity	16,789,158.68
Operational Heating	**0.00**
Operational Heating	0.00
Grand Total	**18,166,333.96**

Athena Impact Estimator - Results by Building Component

LCA Measures	Unit	Walls	Roofs	Floors	Project Extra Materials	Total
Global Warming Potential	kg CO2 eq	6.19E+04	2.69E+05	4.75E+05	8.70E+04	**8.93E+05**

Athena Impact Estimator - Results by Life Cycle Phase

		PRODUCT (A1 to A3)			**CONSTRUCTION PROCESS (A4 & A5)**			**USE (B2, B4 & B6)**				**END OF LIFE (C1 to C4)**			**BEYOND BUILDING LIFE (D)**			**TOTAL EFFECTS**	
LCA Measures	**Unit**	Manufacturing	Transport	**Total**	Construction-Installation Process	Transport	**Total**	Replacement Manufacturing	Replacement Transport	Operational Energy Use Total	**Total**	De-construction, Demolition, Disposal & Waste Processing	Transport	**Total**	BBL Material	BBL Transport	**Total**	**A to C**	**A to D**
Global Warming Potential	kg CO2 eq	7.32E+05	4.59E+02	**7.32E+05**	2.66E+04	2.18E+04	**4.84E+04**	7.52E+04	1.46E+03	1.94E+07	**1.95E+07**	2.56E+04	1.01E+04	**3.57E+04**	-1.66E+05	0.00E+00	**-1.66E+05**	**2.03E+07**	**2.01E+07**

One-Click LCA Results - Construction Materials

Resource	User input	Global warming kg CO2e	Comments
External wall			
Concrete masonry unit (CMU), 7 7/8inx7 5/8inx15 5/8in, HW Re...	8.8 m3	3,185.60	W3
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	90.18 kg	217.33	W4
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	456.3 kg	1,099.68	W3
Insulated metal panel, 1 3/4in-4inx36inx6-48ft, Versapanel (...	10.45 m3	9,048.82	W2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	19.27 m2	1.88	W4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	97.79 m2	9.53	W3
XPS insulation (extruded polystyrene), 1.02in	19.27 m2	622.25	W4
XPS insulation (extruded polystyrene), 1.02in	97.79 m2	3,157.56	W3
Roll formed steel panels, 24 gauge, 5.9 kg/m2 (CSSBI)	19.27 m2	288.03	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	19.27 m2	60.16	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	97.79 m2	305.26	W3
Vapor barrier, 0.06in	19.27 m2	14.39	W4
Vapor barrier, 0.06in	97.79 m2	73.01	W3
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	19.27 m2	96.31	W4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	97.79 m2	488.74	W3
Partition Wall			
Concrete masonry unit	12.48 m3	5,447.57	P2
Concrete masonry unit	12.92 m3	5,640.51	P3
Concrete masonry unit	13.36 m3	5,829.95	P1
Concrete masonry unit	14.91 m3	6,508.28	P5

Concrete masonry unit	23.99 m3	10,471.73	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	95.4 m2	437.88	P1
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	171.35 m2	786.49	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	298.2 m2	1,368.74	P5
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.56 kg	23.04	P2 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.68 kg	23.33	P1 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.22 kg	34.27	P3 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	17.89 kg	43.11	P3 Furring channel
Pressed glass partition, 0.236in, 152.3 lbs/ft3, InfinteGlas...	171.35 m2	6.56	P4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	89.12 m2	3.72	P2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	95.4 m2	3.98	P1
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	171.35 m2	7.16	P4
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	55.46 kg	36.73	P3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	72.66 kg	48.12	P2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	77.78 kg	51.51	P1
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	121.6 kg	80.52	P5
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	139.7 kg	92.51	P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	89.12 m2	445.39	P2
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	95.4 m2	476.78	P1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	856.37	P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	856.37	P4

Floor and roof

Fluid-applied rubber asphalt roofing, 0.17in	80.69 m2	276.12	R2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	7.6 m3	2,487.71	F6
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	9.32 m3	3,052.35	C3
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	11.25 m3	3,682.46	F8
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	15.6 m3	5,106.35	F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	78 m3	25,531.74	F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	180.53 m3	59,092.88	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	305.69 m3	100,061.51	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	601.75 m3	196,970.83	F1
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.45 kg	34.82	C2 resilient channels
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	176 kg	424.16	C2
Gypsum board, wallboard, regular, 0.5 inch (12.7 mm)	129.84 m2	326.24	C2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	129.84 m2	12.65	C2
ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	5,276 m2	72,610.09	R1
Spray foam insulation, 1.02in	80.69 m2	7,787.05	R2
Composite metal decking, 30 mil	80.69 m2	1,254.91	R2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	54.24 kg	35.92	C3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	982.7 kg	650.74	F8
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	320 kg	758.4	C3
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	443.2 kg	1,050.38	F6

Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	668 kg	1,583.16	C2
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	63,314 kg	150,054.18	R1
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	80.69 m2	251.88	R2
Vapor barrier, 0.06in	5,276 m2	3,938.88	R1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	80.69 m2	403.27	R2

Windows and doors

Aluminum window, fixed and ribbon, 1.2m x 1.5m, 24.8 kg/piec...	18.06 m2	7,730.11	
Steel door, interior, 1 3/4in x 4x8 ft (Total Door Systems)	55.1 m2	6,842.94	
Door, exterior, Honeycomb core, 1 3/4in, 14-18 gauge, 48.42x...	66.74 m2	2,814.16	
Traditional curtain wall, 1.5m x 1.6m, 35.6 kg/piece, 1600 1...	523.9 m2	10,404.65	

One-Click LCA Results - Transportation Phase

Resource	User input	Global warming kg CO2e	Comments
External wall			
Concrete masonry unit (CMU), 7 7/8inx7 5/8inx15 5/8in, HW Re...	8.8 m3	99.85	W3
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	90.18 kg	3.58	W4
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	456.3 kg	18.1	W3
Insulated metal panel, 1 3/4in-4inx36inx6-48ft, Versapanel (...	10.45 m3	34.96	W2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	19.27 m2	0.85	W4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	97.79 m2	4.33	W3
XPS insulation (extruded polystyrene), 1.02in	19.27 m2	0.39	W4
XPS insulation (extruded polystyrene), 1.02in	97.79 m2	1.98	W3
Roll formed steel panels, 24 gauge, 5.9 kg/m2 (CSSBI)	19.27 m2	1.53	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	19.27 m2	1.67	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	97.79 m2	8.48	W3
Vapor barrier, 0.06in	19.27 m2	0.15	W4
Vapor barrier, 0.06in	97.79 m2	0.78	W3
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	19.27 m2	1.28	W4

Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	97.79 m2	6.51	W3

Parition

Concrete masonry unit	12.48 m3	141.58	P2
Concrete masonry unit	12.92 m3	146.59	P3
Concrete masonry unit	13.36 m3	151.52	P1
Concrete masonry unit	14.91 m3	169.14	P5
Concrete masonry unit	23.99 m3	272.15	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	95.4 m2	5.22	P1
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	171.35 m2	9.38	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	298.2 m2	16.33	P5
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.56 kg	0.38	P2 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.68 kg	0.38	P1 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.22 kg	0.56	P3 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	17.89 kg	0.71	P3 Furring channel
Pressed glass partition, 0.236in, 152.3 lbs/ft3, InfinteGlas...	171.35 m2	192.11	P4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	89.12 m2	1.69	P2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	95.4 m2	1.81	P1
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	171.35 m2	3.25	P4

Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	55.46 kg	2.2	P3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	72.66 kg	2.88	P2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	77.78 kg	3.08	P1
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	121.6 kg	4.82	P5
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	139.7 kg	5.54	P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	89.12 m2	5.93	P2
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	95.4 m2	6.35	P1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	11.41	P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	11.41	P4

Floors and roof

Fluid-applied rubber asphalt roofing, 0.17in	80.69 m2	18.21	R2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	7.6 m3	276.96	F6
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	9.32 m3	339.82	C3
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	11.25 m3	409.97	F8
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	15.6 m3	568.49	F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	78 m3	2,842.44	F2

Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	180.53 m3	6,578.80	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	305.69 m3	11,139.83	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	601.75 m3	21,928.73	F1
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.45 kg	0.57	C2 resilient channels
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	176 kg	6.98	C2
Gypsum board, wallboard, regular, 0.5 inch (12.7 mm)	129.84 m2	7.73	C2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	129.84 m2	5.75	C2
ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	5,276 m2	200.44	R1
Spray foam insulation, 1.02in	80.69 m2	39.39	R2
Composite metal decking, 30 mil	80.69 m2	18.71	R2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	54.24 kg	2.15	C3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	982.7 kg	38.97	F8
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	320 kg	12.69	C3
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	443.2 kg	17.58	F6
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	668 kg	26.49	C2
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	63,314 kg	2,511	R1

Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	80.69 m2	7	R2
Vapor barrier, 0.06in	5,276 m2	42.16	R1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	80.69 m2	5.37	R2

Windows and doors

Aluminum window, fixed and ribbon, 1.2m x 1.5m, 24.8 kg/piec...	18.06 m2	1.25	
Steel door, interior, 1 3/4in x 4x8 ft (Total Door Systems)	55.1 m2	282.83	
Door, exterior, Honeycomb core, 1 3/4in, 14-18 gauge, 48.42x...	66.74 m2	115.81	
Traditional curtain wall, 1.5m x 1.6m, 35.6 kg/piece, 1600 1...	523.9 m2	36.36	

One-Click LCA Results - Replacement and Refurbishment Phase

Resource	User input	Global warming kg CO2e	Comments
External Wall			
Concrete masonry unit (CMU), 7 7/8inx7 5/8inx15 5/8in, HW Re...	8.8 m3		W3
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	90.18 kg		W4
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	456.3 kg		W3
Insulated metal panel, 1 3/4in-4inx36inx6-48ft, Versapanel (...	10.45 m3		W2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	19.27 m2	1.88	W4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	97.79 m2	9.53	W3
XPS insulation (extruded polystyrene), 1.02in	19.27 m2	622.25	W4
XPS insulation (extruded polystyrene), 1.02in	97.79 m2	3,157.56	W3
Roll formed steel panels, 24 gauge, 5.9 kg/m2 (CSSBI)	19.27 m2		W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	19.27 m2		W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	97.79 m2		W3
Vapor barrier, 0.06in	19.27 m2	14.39	W4
Vapor barrier, 0.06in	97.79 m2	73.01	W3

Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	19.27 m2		W4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	97.79 m2		W3

Partition

Concrete masonry unit	12.48 m3		P2
Concrete masonry unit	12.92 m3		P3
Concrete masonry unit	13.36 m3		P1
Concrete masonry unit	14.91 m3		P5
Concrete masonry unit	23.99 m3		P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	95.4 m2	1,313.63	P1
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	171.35 m2	2,359.48	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	298.2 m2	4,106.21	P5
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.56 kg		P2 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.68 kg		P1 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.22 kg		P3 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	17.89 kg		P3 Furring channel
Pressed glass partition, 0.236in, 152.3 lbs/ft3, InfinteGlas...	171.35 m2	6.56	P4

Mineral wool insulation batt, R11, EcoBatt Insulation with E...	89.12 m2	3.72	P2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	95.4 m2	3.98	P1
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	171.35 m2	7.16	P4
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	55.46 kg		P3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	72.66 kg		P2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	77.78 kg		P1
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	121.6 kg		P5
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	139.7 kg		P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	89.12 m2		P2
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	95.4 m2		P1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2		P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2		P4

Floors and roof

Fluid-applied rubber asphalt roofing, 0.17in	80.69 m2	1,104.48	R2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	7.6 m3		F6
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	9.32 m3		C3
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	11.25 m3		F8
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	15.6 m3		F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	78 m3		F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	180.53 m3		F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	305.69 m3		F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	601.75 m3		F1
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.45 kg		C2 resilient channels
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	176 kg		C2
Gypsum board, wallboard, regular, 0.5 inch (12.7 mm)	129.84 m2	326.24	C2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	129.84 m2	12.65	C2
ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	5,276 m2	72,610.09	R1

Spray foam insulation, 1.02in	80.69 m2	7,787.05	R2
Composite metal decking, 30 mil	80.69 m2	1,254.91	R2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	54.24 kg		C3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	982.7 kg		F8
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	320 kg		C3
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	443.2 kg		F6
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	668 kg		C2
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	63,314 kg		R1
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	80.69 m2		R2
Vapor barrier, 0.06in	5,276 m2	3,938.88	R1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	80.69 m2		R2

Windows and doors

Aluminum window, fixed and ribbon, 1.2m x 1.5m, 24.8 kg/piec...	18.06 m2	30,920.43	
Steel door, interior, 1 3/4in x 4x8 ft (Total Door Systems)	55.1 m2	20,528.82	

Door, exterior, Honeycomb core, 1 3/4in, 14-18 gauge, 48.42x...	66.74 m2	8,442.47	
Traditional curtain wall, 1.5m x 1.6m, 35.6 kg/piece, 1600 1...	523.9 m2		

One-Click LCA Results - Deconstruction and Waste Phase

Resource	User input	Global warming kg CO2e	Comments
External Wall			
Concrete masonry unit (CMU), 7 7/8inx7 5/8inx15 5/8in, HW Re...	8.8 m3	195.07	W3
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	90.18 kg	0.7	W4
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	456.3 kg	3.54	W3
Insulated metal panel, 1 3/4in-4inx36inx6-48ft, Versapanel (...	10.45 m3	17.39	W2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	19.27 m2	2.55	W4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	97.79 m2	12.94	W3
XPS insulation (extruded polystyrene), 1.02in	19.27 m2	1.17	W4
XPS insulation (extruded polystyrene), 1.02in	97.79 m2	5.92	W3
Roll formed steel panels, 24 gauge, 5.9 kg/m2 (CSSBI)	19.27 m2	0.3	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	19.27 m2	9.98	W4
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	97.79 m2	50.62	W3

Vapor barrier, 0.06in	19.27 m2	0	W4
Vapor barrier, 0.06in	97.79 m2	0	W3
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	19.27 m2	1.49	W4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	97.79 m2	7.56	W3

Partiton wall

Concrete masonry unit	12.48 m3	0	P2
Concrete masonry unit	12.92 m3	0	P3
Concrete masonry unit	13.36 m3	0	P1
Concrete masonry unit	14.91 m3	0	P5
Concrete masonry unit	23.99 m3	0	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	95.4 m2	31.19	P1
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	171.35 m2	56.03	P4
Bio-based tile flooring, 12x12, 12x24in, 0.125 in, 1.44 lbs/...	298.2 m2	97.5	P5
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.56 kg	0.07	P2 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	9.68 kg	0.08	P1 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.22 kg	0.11	P3 resilient channel
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	17.89 kg	0.14	P3 Furring channel

Pressed glass partition, 0.236in, 152.3 lbs/ft3, InfinteGlas...	171.35 m2	71.97	P4
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	89.12 m2	5.05	P2
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	95.4 m2	5.41	P1
Mineral wool insulation batt, R11, EcoBatt Insulation with E...	171.35 m2	9.72	P4
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	55.46 kg	0.43	P3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	72.66 kg	0.56	P2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	77.78 kg	0.6	P1
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	121.6 kg	0.94	P5
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	139.7 kg	1.08	P4
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	89.12 m2	6.89	P2
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	95.4 m2	7.37	P1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	13.24	P4

Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	171.35 m2	13.24	P4

Floors and roof

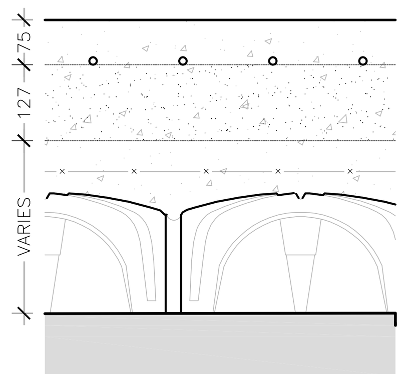
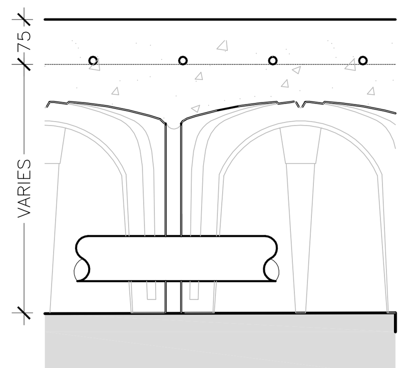
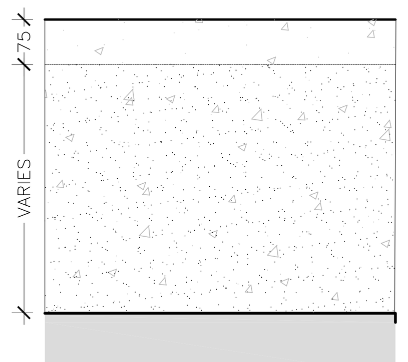
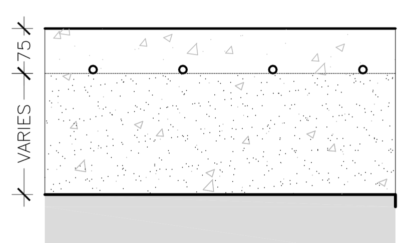
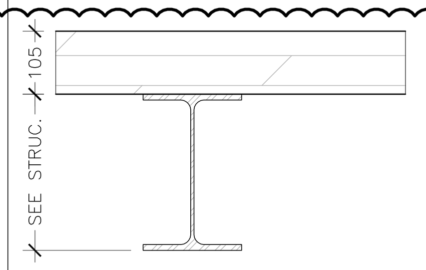
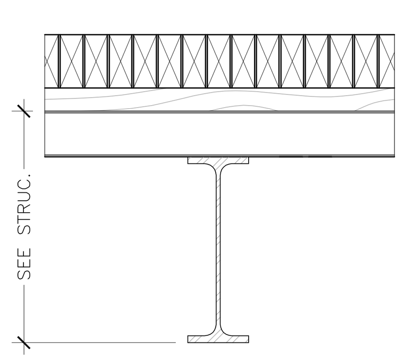
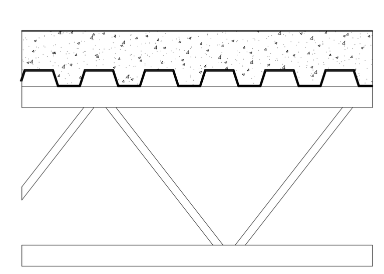
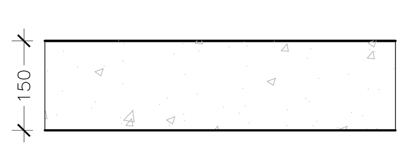
Fluid-applied rubber asphalt roofing, 0.17in	80.69 m2	20.61	R2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	7.6 m3	201.89	F6
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	9.32 m3	247.71	C3
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	11.25 m3	298.84	F8
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	15.6 m3	414.4	F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	78 m3	2,071.99	F2
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	180.53 m3	4,795.59	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	305.69 m3	8,120.34	F1
Ready-mix concrete, 25MPa GU cem. cem. with air entr. 0-14% ...	601.75 m3	15,984.87	F1
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	14.45 kg	0.11	C2 resilient channels
Steel framing systems, Studrite, Joistrite, Framerite, Viper...	176 kg	1.36	C2
Gypsum board, wallboard, regular, 0.5 inch (12.7 mm)	129.84 m2	46.14	C2

Mineral wool insulation batt, R11, EcoBatt Insulation with E...	129.84 m2	17.18	C2
ISO foam insulation, 0.5-2in, Tuff-R Insulation (Dow)	5,276 m2	598.35	R1
Spray foam insulation, 1.02in	80.69 m2	117.59	R2
Composite metal decking, 30 mil	80.69 m2	0	R2
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	54.24 kg	0.42	C3
Rebar, hot-rolled, Knoxville mill, 490 lbs/ft3 (Gerdau)	982.7 kg	7.62	F8
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	320 kg	2.48	C3
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	443.2 kg	3.43	F6
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	668 kg	5.18	C2
Steel roof and floor deck, 22-16 gauge (Steel Deck Institute...	63,314 kg	490.68	R1
Gypsum Board Type X, 5/8", 2.25 psf (CertainTeed Toronto Fac...	80.69 m2	41.77	R2
Vapor barrier, 0.06in	5,276 m2	0	R1
Medium density fiberboard (MDF), 0.75in (Canadian Wood Counc...	80.69 m2	6.23	R2

Windows and doors

Aluminum window, fixed and ribbon, 1.2m x 1.5m, 24.8 kg/piec...	18.06 m2	0.28	
Steel door, interior, 1 3/4in x 4x8 ft (Total Door Systems)	55.1 m2	63.16	
Door, exterior, Honeycomb core, 1 3/4in, 14-18 gauge, 48.42x...	66.74 m2	25.86	
Traditional curtain wall, 1.5m x 1.6m, 35.6 kg/piece, 1600 1...	523.9 m2	8.12	

FLOOR ASSEMBLIES

TYPE	FIRE RATING (MIN.)	INSUL. R-VALUE	DIAGRAM	DESCRIPTION
F1	N/A	R10		FLOOR, TYP. 75mm POLISHED CONCRETE TOPPING WITH RADIANT & WIRE MESH 127mm INSULATED CONCRETE (R10) RAISED STRUCTURAL CAVITY FLOOR EXISTING FLOOR. UNEVEN. VARIES In-floor radiant heating system; refer to mechanical 127mm insulated concrete mix Cupolex modular, vaulted sub-slab forms (varies per plans) with concrete Existing floor slab Note 1: Reinforcement - cupolex, concrete or otherwise per structural Note 2: Control Joints - assume 7'-6" x 7'-6" grid throughout Note 3: Embed metal where indicated on plans for heritage interpretation of existing rails. Assume 3/8"" D x 1/2" wide, flush with su
F1-B	N/A			FLOOR, EVENT PREP ROOM. 75mm POLISHED CONCRETE TOPPING WITH RADIANT & WIRE MESH. RAISED STRUCTURAL CAVITY FLOOR. FOR MECHANICAL. SEE MECHANICAL. EXISTING FLOOR. UNEVEN. VARIES
F2	N/A			FLOOR, INSULATED 75mm POLISHED CONCRETE TOPPING WITH RADIANT & WIRE MESH. INSULATED CONCRETE. EXISTING FLOOR. UNEVEN. VARIES
F3	N/A	R10		FLOOR, INSULATED 75mm POLISHED CONCRETE TOPPING WITH RADIANT & WIRE MESH. WITH SLOPE PER PLANS. R10 INSULATED CONCRETE. EMBEDDED DRAIN LINE. SEE MECHANICAL. EXISTING FLOOR, UNEVEN, VARIES.
F4 (PHASE 3)	N/A PER OBC 3.1.4.7(4) & 3.1.4.6			PHASE 3 HEAVY TIMBER FLOOR CLEAR STAIN TYP. 105mm THICK SOLID CROSS LAMINATED TIMBER FLOOR WITH NO CONTINUOUS LINES OF END JOINTS DARK STAINED BOTTOM INTUMESCENT PAINTED STEEL STRUCTURE CONFORMING TO ULC Z369 WITH PAINT FINISH NOTE: RM. 202 WITH CARPET TILE
F5	N/A			EXTERIOR RAISED WALKWAY 38 mm x 89 mm CEDAR WOOD DECKING LAID ON EDGE CONTINUOUS WOOD NAILER AS REQ. WITH COUNTERSUNK THROUGH BOLTS AND WASHERS GALVANIZED DOUBLE CHANNEL GALVANIZED STRUCTURE
F6	N/A			SERVICE ROOM SECOND FLOOR CONCRETE FINISH, AS NOTED IN FINISHES PLAN REINFORCED CONCRETE ON STEEL DECK - SEE STRUCTURAL 300mm STEEL STRUCTURE - SEE STRUCT.
F7	N/A			BOILER RM. MEZZANINE INFILL 50mm GALV. METAL GRATE TO MATCH EXISTING.
F8	N/A			SERVICE ROOM ADDITION FLOOR 150mm REINFORCED CONCRETE SLAB, REFER TO STRUCT.

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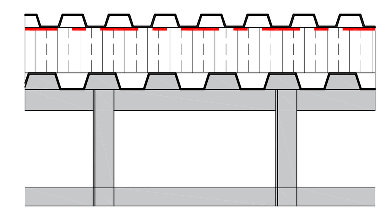
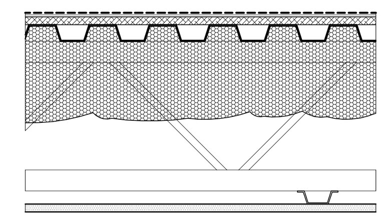
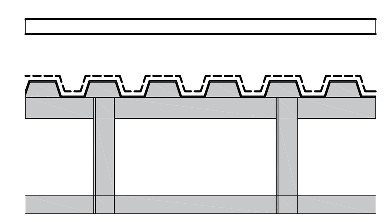
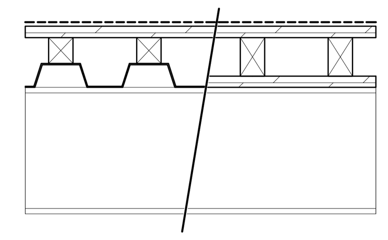
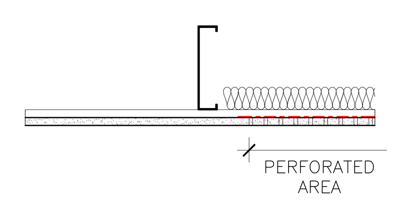
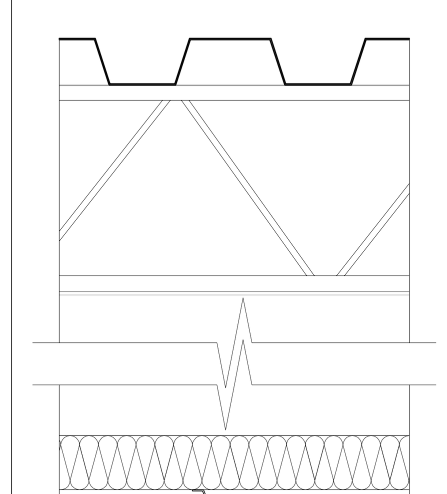
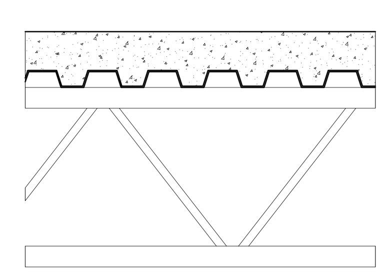
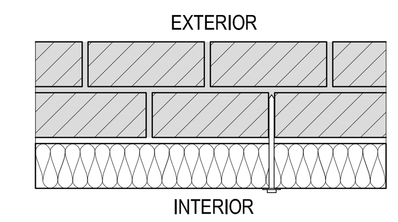
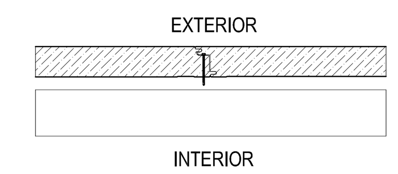
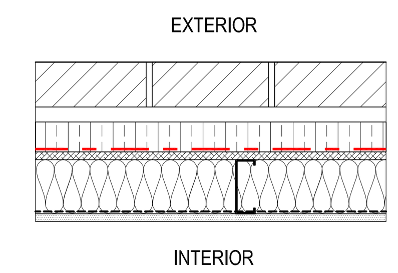
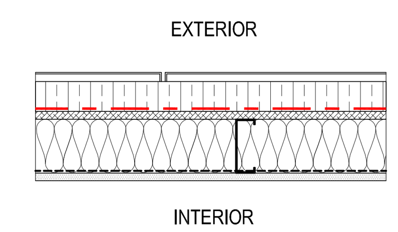
ROOF ASSEMBLIES

TYPE	FIRE RATING (MIN.)	INSUL. R-VALUE	DIAGRAM	DESCRIPTION
R1	N/A	R15		BUILT-UP CORRUGATED METAL ROOF ON EXISTING ROOF DECKING 24 ga. RIBBED METAL ROOF VAPOUR PERMEABLE SELF-ADHERING MEMBRANE 76 mm RIGID POLY ISO INSULATION INTERMITTENT Z-GIRTS NOTCHED TO FIT EX. ROOF, FIXED WITH NEW FASTENERS TO REPLACE EXISTING ROOF FASTENERS. BUTYL TAPE CAULKING - 2 LINES EX. CORRUGATED METAL ROOF ON PURLIN STRUCTURE
R2	N/A	R35		ROOF AT MECHANICAL ROOM 2-PLY MODIFIED BITUMEN ROOFING SYSTEM DENSDECK SHEATHING CORRUGATED METAL DECK - SEE STRUCTURAL METAL FRAMING - SEE STRUCTURAL 2LB SPRAY INSULATION TO R-35 FURRING AS REQUIRED 12.7mm CEMENT BOARD WITH MECHANICAL FASTENERS
R3	N/A	R0		ROOF AT SOLAR PANEL ARRAY SOLAR PANEL - SEE MECH. AIR SPACE AND SUPPORTS AS REQUIRED METALIZED LIQUID APPLIED ELASTOMETRIC WATER PROTECTION MEMBRANE EX. CORRUGATED METAL ROOF ON PURLIN STRUCTURE
R4	N/A			NEW AND EXISTING CANOPY ROOF 2 PLY MODIFIED BITUMEN ROOFING NEW: ¾ INCH PLYWOOD ON BLOCKING SLOPED TO DRAIN ON NEW STEEL STRUCTURE EXISTING: ¾ INCH PLYWOOD ON BLOCKING SLOPED TO DRAIN ON EXISTING WOOD DECK

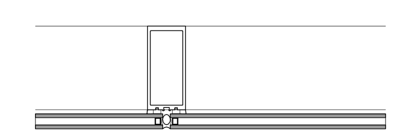
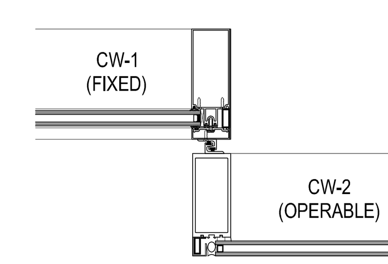
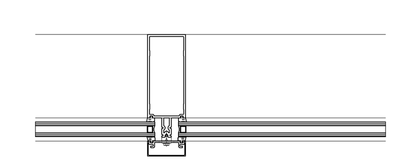
CEILING ASSEMBLIES

TYPE	FIRE RATING (MIN.)	SOUND RATING (STC & NRC)	DIAGRAM	DESCRIPTION
C1	N/A			GWB CEILING 12.5mm GWB, TAPED & PAINTED - 30% AREA = GWB - 70% AREA = PERFORATED GWB @ PERFORATED AREAS PROVIDE BLACK BUILDING PAPER & 38mm MINERAL WOOL ACOUSTICAL BATTS 12.5mm RELISIENT CHANNEL METAL STUD FRAMING, 2 x 6 METAL STUDS @ 450 O.C. OR AS REQ'D METAL STUD KICKERS AS REQ'D FASTENERS AS REQ'D TO FASTEN TO EXISTING METAL ROOF FRAMING
C2	N/A			CEILING AT WASHROOM CORRIDOR STEEL DECK - SEE STRUCT. 350mm STEEL STRUCTURE - SEE STRUCT. SPACE FOR MECHANICAL 89mm METAL STUD 89mm MINERAL WOOL ACOUSTICAL BATTS 12.5mm RESILIENT CHANNEL BLACK BUILDING PAPER 12.5mm PERFORATED GWB
C3	N/A			CEILING IN MECH ROOM CONCRETE FINISH, AS NOTED IN FINISHES PLAN REINFORCED CONCRETE ON STEEL DECK - SEE STRUCTURAL 300mm STEEL STRUCTURE - SEE STRUCT.

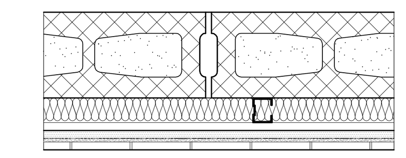
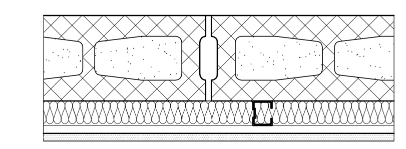
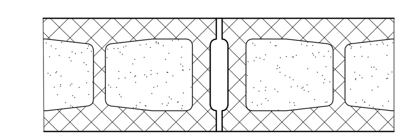
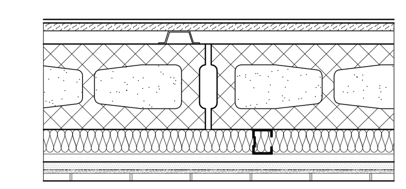
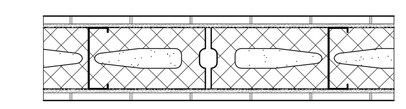
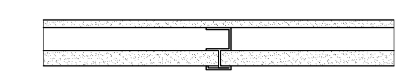
EXTERIOR WALLS

TYPE	FIRE RATING (MIN.)	INSUL. R-VALUE	DIAGRAM	DESCRIPTION
W1	N/A	R12		EX. INSULATED EXTERIOR WALL EXISTING MULTI-WYTHE MASONRY WALL 75mm RIGID MINERAL WOOL BOARD (R12) FASTEN WITH WASHER, ON GROUT ONLY
W2	N/A	R15		SOUTH GABLE INSULATED METAL PANEL 75mm INSULATED METAL PANEL ORIENTED VERTICALLY - F40 "FLAT WALL" BY AWIP / VICWEST - STANDARD PANEL WIDTH (40" = 1016mm) WITH SMOOTH EXTERIOR FACE HORIZONTAL METAL Z-BAR OR ANGLE SUBGIRT AS REQ'D BY ENGINEERED SYSTEM EXISTING VERTICAL METAL FRAMING
W3	N/A	R24		SERVICE ROOM ADDITION BRICK TO MATCH EXISTING 12.7mm AIR SPACE 50mm RIGID INSULATION XPS HORIZONTAL Z-GIRT SUPPORTS AIR BARRIER MEMBRANE 12.7mm DENSGLAS SHEATHING 90mm STEEL STUD @ 405mm O/C WITH MINERAL WOOL BATT INSULATION VAPOUR BARRIER CEMENT BOARD
W4	N/A	R24		PRE-FINISHED METAL COMPOSITE PANEL 12.7mm AIR SPACE 50mm RIGID INSULATION XPS Z-GIRT SUPPORTS AIR BARRIER MEMBRANE 12.7mm DENSGLAS SHEATHING 90mm STEEL STUD @ 405mm O/C WITH MINERAL WOOL BATT INSULATION VAPOUR BARRIER CEMENT BOARD

CURTAIN WALL ASSEMBLIES

TYPE	FIRE RATING (MIN.)	SOUND RATING (STC & NRC)	DIAGRAM	DESCRIPTION
CW-1				CURTAIN WALL SYSTEM @ GRADE - THERMALLY BROKEN MULLIONS, DARK BRONZE ANODIZED - INSULATED GLAZING UNIT, TEMPERED, LOW-E - STRUCTURAL SILICONE SEALANT @ VERTICAL MULLIONS PROVIDE STRUCTURE W/IN MULLIONS AS REQ'D AT LARGE OPENINGS LAMINATED WHERE INDICATED IN DRAWINGS
CW-2				OPERABLE CURTAIN WALL CURTAIN WALL SYSTEM TO MATCH CW-1 - HARDWARE TO PROVIDE HORIZONTAL SLIDING ACTION: ENGINEERED TOP/BOTTOM TRACKS, BOTTOM ROLLER SYSTEM, ETC - COORDINATE INTERFACE W/ CW-1 TO PROVIDE SILLS, SEALANTS, ETC FOR WEATHER TIGHT SEAL PROVIDE STRUCTURE W/IN MULLIONS AS REQ'D LAMINATED WHERE INDICATED IN DRAWINGS
CW-3				CURTAIN WALL @ NORTH GABLE CLEAR ANODIZED ALUMINUM CURTAIN WALL - INSULATED GLAZING UNIT, LOW-E - FACE CAP @ MULLIONS - PROVIDE STRUCTURE W/IN MULLIONS AS REQ'D AT LARGE OPENINGS

INTERIOR PARTITIONS

TYPE	FIRE RATING (MIN.)	SOUND RATING (STC)	DIAGRAM	DESCRIPTION
P1	N/A	–		CATERING ROOM WALL - TILE FINISH 140mm CMU FILLED WITH GROUT TO 80.51 ELEV. 38mm METAL STRAPPING 38mm MINERAL WOOL BATT INSULATION 12.5mm RESILIENT CHANNEL 12.5mm CEMENT BOARD TILE FINISH ACOUSTIC SEALANT AT JOINTS WITH COVE BASE
P2	N/A	–		SERVICE ROOM PARTITION PAINT FINISH 140mm CMU FILLED WITH GROUT TO 80.51 ELEV. 38mmMETAL STRAPPING 38mm MINERAL WOOL BATT INSULATION 12.5mm RESILIENT CHANNEL 12.5mm CEMENT BOARD
P3	2 HR. BASED ON ULC U905	32		SERVICE ROOM FIRE WALL 190mm CMU RATED FOR ULC 2H, FILLED WITH GROUT TO 80.51 ELEV.
P4	N/A	57		WASHROOM PERIMETER WALL 6mm PATTERNED BACK-PAINTED GLASS, LAMINATED AND TEMPERED 12.7mm CEMENT BOARD FURRING CHANNELS 140 mm CMU FILLED WITH GROUT TO 80.51 ELEV.38mm 38mmMETAL STRAPPING OR FURRED OUT (REFER TO PLANS) 38mm MINERAL WOOL BATT INSULATION 12.5mm RESILIENT CHANNEL 12.5mm CEMENT BOARD TILE FINISH ACOUSTIC SEALANT AT JOINTS
P5	N/A			TOILET ENCLOSURE WALLS TILE FINISH 100mm CMU FILLED WITH GROUT TO 80.51 ELEV., 100mm METAL STUD ABOVE 80.51 ELEV. TILE FINISH
P6	N/A	STC 39		SHAFT WALL 15.9mm TYPEX GYPSUM - PAINT FINISH 64mm C-H STUDS 25 GAUGE 610mm O/C 25.4mm SHEETROCK GYPSUM LINER PANEL

NOTE ON 1HR BLOCK WALL CALCULATIONS:

140mm CONCRETE BLOCK WITH EQUIVALENT THICKNESS OF AT LEAST 73mm. HOLLOW CONCRETE MASONRY UNITS MADE WITH TYPE S OR N CONCRETE MUST HAVE A MINIMUM SPECIFIED COMPRESSIVE STRENGTH OF 15MPA, DETERMINED IN ACCORDANCE WITH CSA A165.1

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ISSUE DATE:

NO.	DATE	DESCRIPTION
1	2017-04-12	ISSUED FOR COSTING
2	2017-06-01	PERMIT PHASE 2
3	2017-06-14	PLANNING REVIEW
4	2017-06-20	ISSUED FOR COORDINATION
5	2017-06-26	ISSUED FOR COORDINATION
6	2017-07-05	ISSUED FOR ENVELOPE TENDER
7	2017-07-11	PERMIT PHASE 2 RE-ISSUE
8	2017-07-27	PERMIT PHASE 2 REVISION

PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

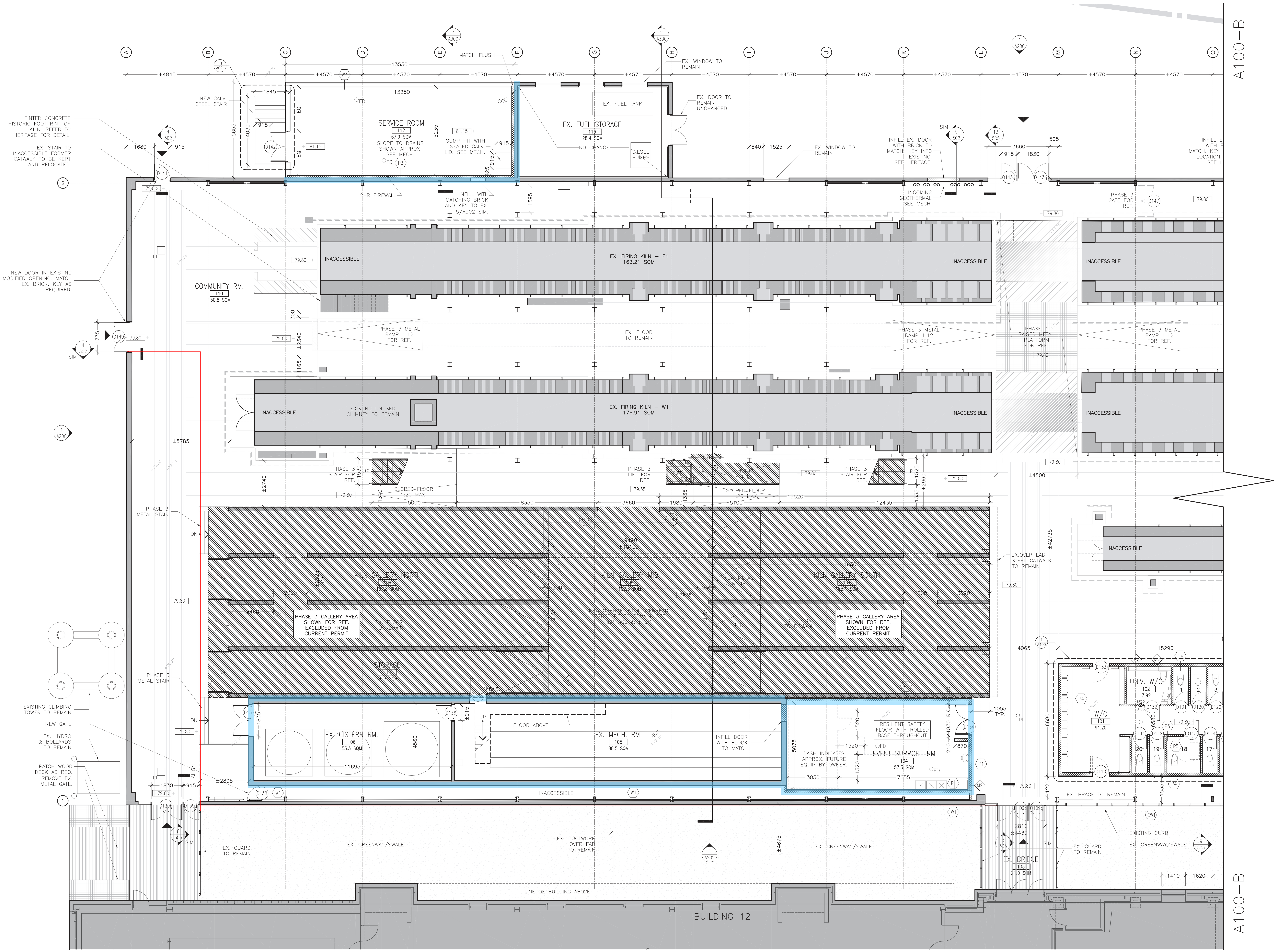
DRAWING TITLE:

ASSEMBLIES

PROJECT NO: 16376
SCALE:
DRAWN BY: MC
REVIEWED BY: DA

DRAWING NO:

A002



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EXISTING TO REMAIN
TINTED CONCRETE
METAL
EMBEDDED HAZARD STRIP
EXIT
CONVENIENCE
+79.80 NEW ELEVATION
+79.31 EXISTING ELEVATION
CMU
NEW WALL

TORONTO Building
PERMIT REVIEWED FOR COMPLIANCE WITH THE ONTARIO BUILDING CODE
17 173993 BLD 00

ZONING	Cuming, Sebastian	29/Aug/2017
O.B.C.	Hussain, Saleha	29/Aug/2017
FIRE SERVICES		
O.B.C.(S)		

GENERAL NOTE:
1. [1] INDICATES NEW PHASE 1 FLOOR HATCHES

a. REFER TO PHASE I FLOOR REPAIR PERMIT. # 17 115797 BLD
b. ALL NOTED PHASE III WORK IS EXCLUDED FROM CURRENT PERMIT AND SHOWN FOR REFERENCE ONLY

ONTARIO ASSOCIATION OF ARCHITECTS
DEAN GOODMAN
LICENCE
4394

ISSUE DATE:

NO.	DATE	DESCRIPTION
1	2017-03-14	PLANNING REVIEW
2	2017-05-12	ISSUED FOR COSTING
3	2017-06-01	PERMIT PHASE 2
4	2017-06-20	ISSUED FOR COORDINATION
5	2017-07-05	ISSUED FOR ENVELOPE TENDER
6	2017-07-11	PERMIT PHASE 2 RE-ISSUE

PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

DRAWING TITLE:

PROPOSED
GROUND FLOOR PLAN - NORTH

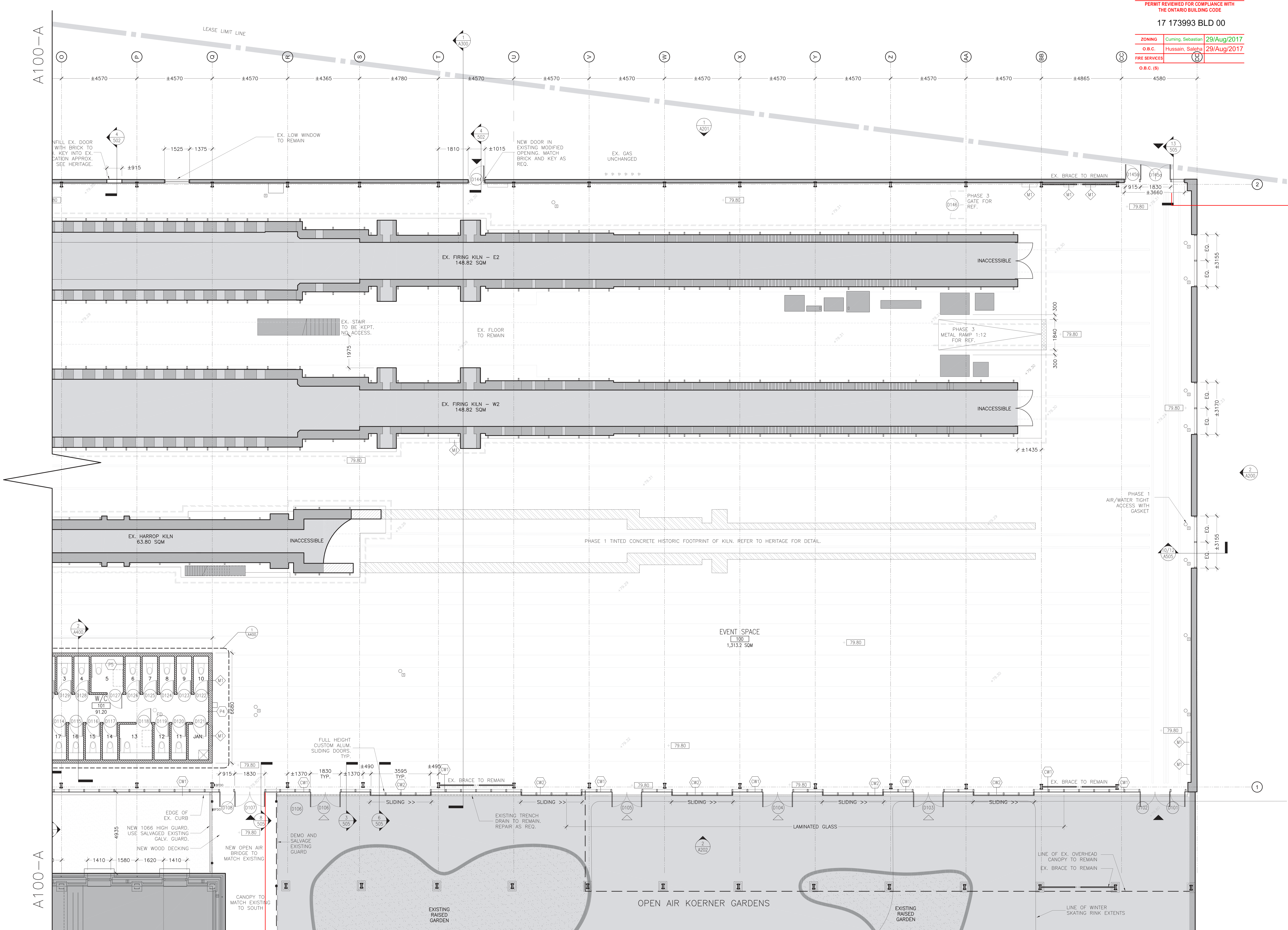
PROJECT NO: 16376
SCALE: 1:100
DRAWN BY: MC/JL
REVIEWED BY: DA

DRAWING NO:

A100-A

TORONTO Building
PERMIT REVIEWED FOR COMPLIANCE WITH THE ONTARIO BUILDING CODE
17 173993 BLD 00

ZONING	Cuming, Sebastian	29/Aug/2017
O.B.C.	Hussain, Saleha	29/Aug/2017
FIRE SERVICES		
O.B.C. (S)		



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1	2017-03-14	PLANNING REVIEW
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5	2017-07-05	ISSUED FOR ENVELOPE TENDER
6	2017-07-11	PERMIT PHASE 2 RE-ISSUE

PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

DRAWING TITLE:

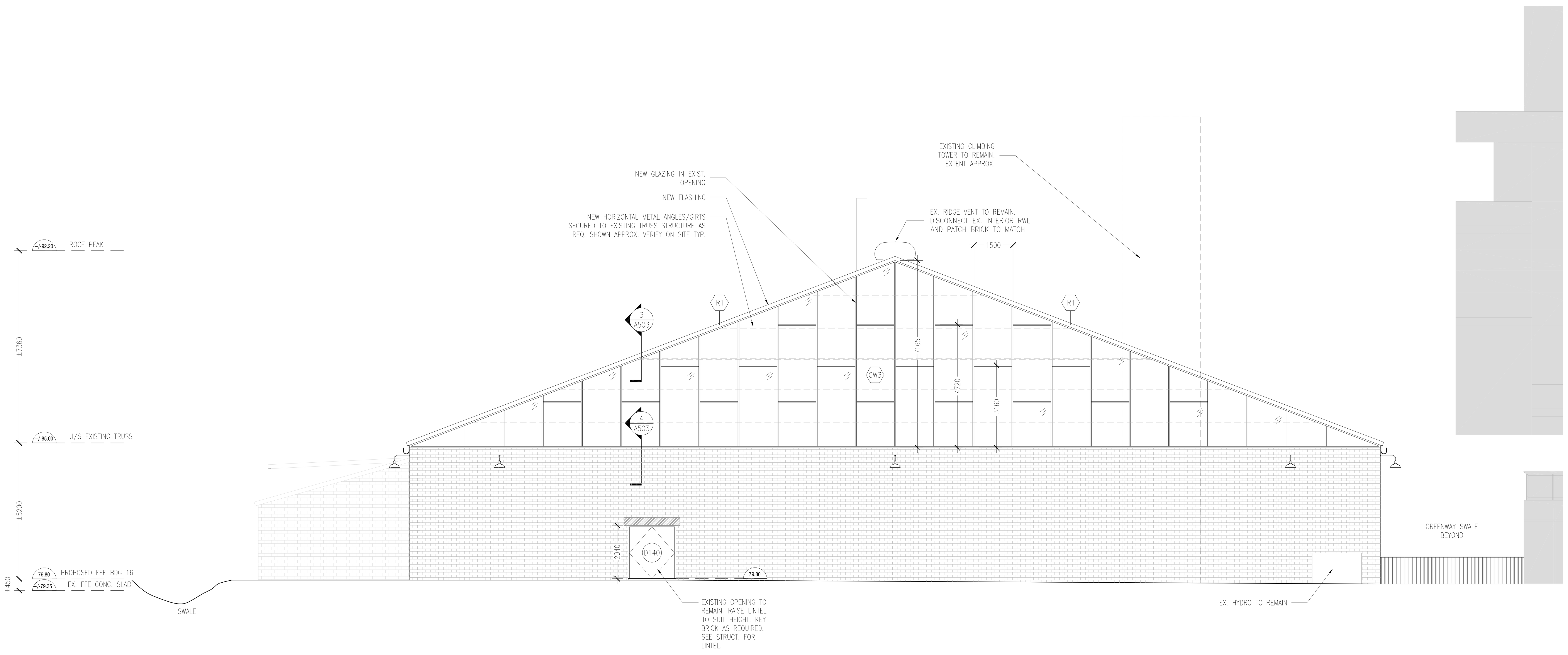
PROPOSED
GROUND FLOOR PLAN - SOUTH

PROJECT NO: 16376
SCALE: 1:100
DRAWN BY: MC/JL
REVIEWED BY: DA

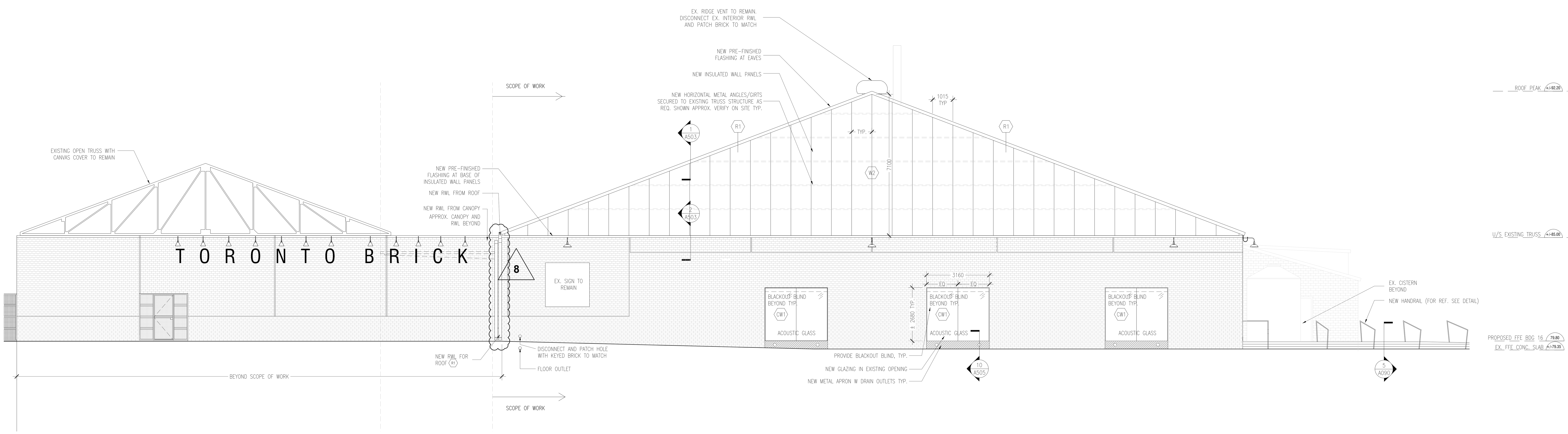
DRAWING NO:

A100-B

TORONTO City Planning
Heritage Preservation Services
29/Aug/2017



1 A200 NORTH ELEVATION
1:100



2 A200 SOUTH ELEVATION
1:100

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ELEVATION NOTES:
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4. CONFIRM RAIN WATER LEADER LOCATIONS WITH PLANS.

GLAZING NOTES:

1. TEMPERED 3 FT AND LOWER
2. ACOUSTIC GLASS ON SOUTH END OPENINGS
3. LAMINATED WEST SECTION PER PLANS
4. BIRD FRIENDLY FRIT FOR ALL

ONTARIO ASSOCIATION OF ARCHITECTS
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6	2017-07-05	ISSUED FOR ENVELOPE TENDER
7	2017-07-11	PERMIT PHASE 2 RE-ISSUE
8	2017-07-13	AMENDMENT 1 TO TENDER

PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

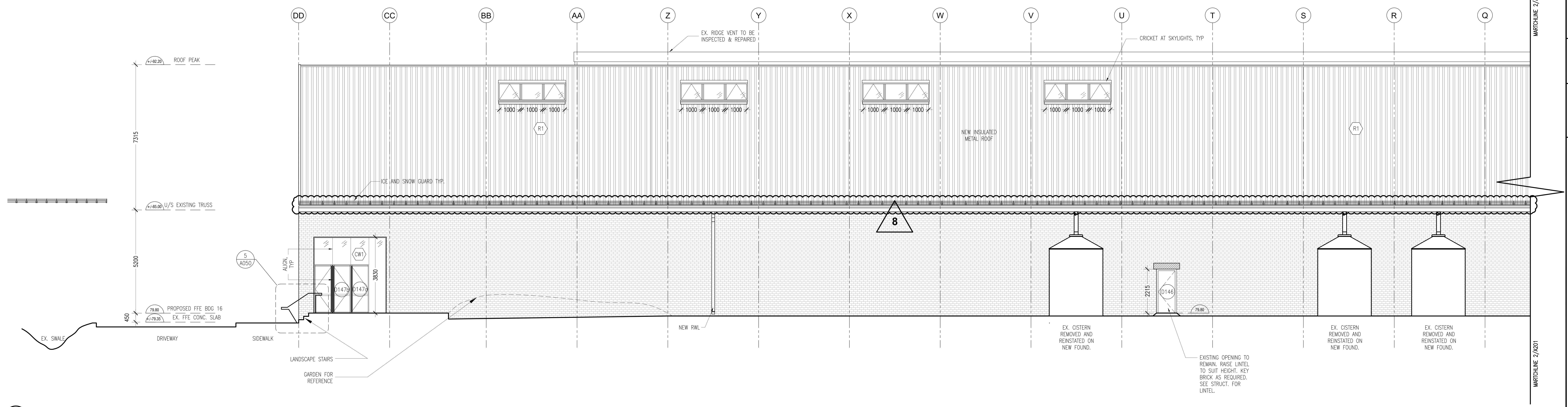
DRAWING TITLE:

PROPOSED
ELEVATION - NORTH & SOUTH

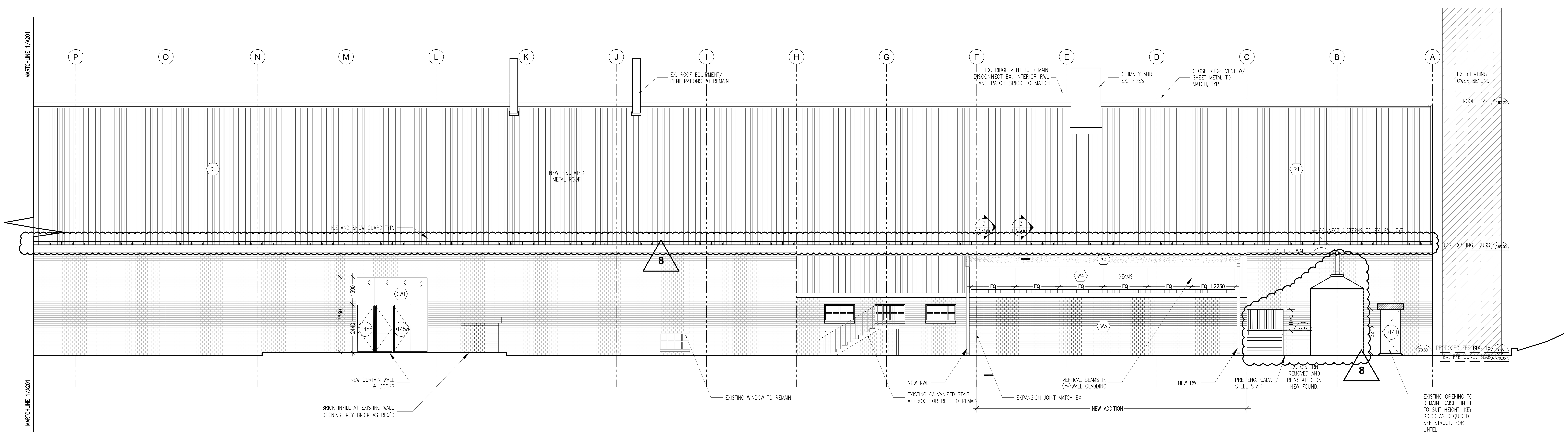
PROJECT NO: 16376
SCALE: 1:100
DRAWN BY: MC/JL
REVIEWED BY: DA

DRAWING NO:

A200



1 A201 EAST ELEVATION
1:100



2 A201 EAST ELEVATION
1:100

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PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

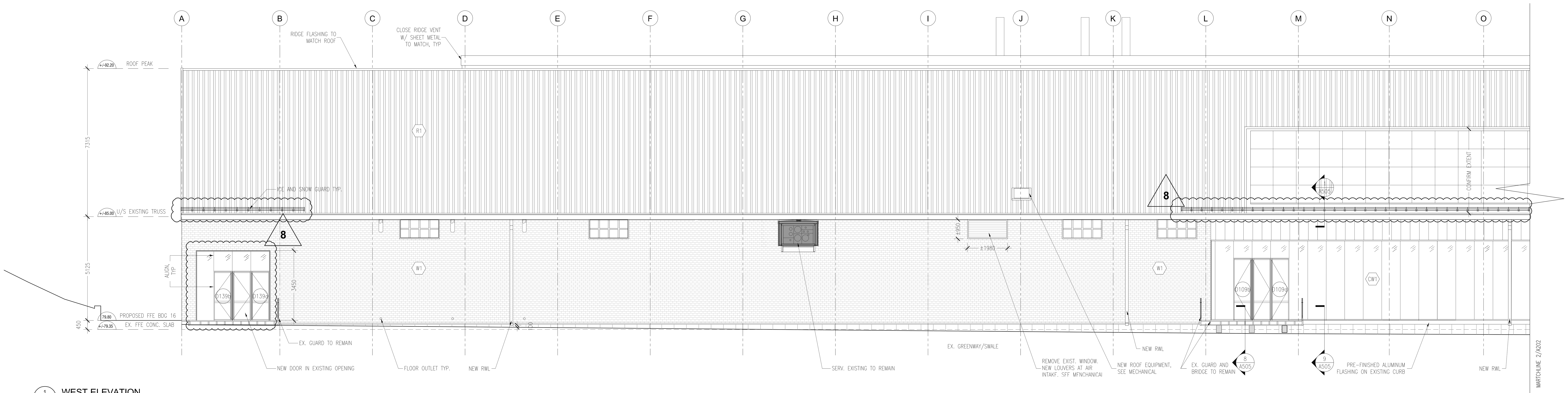
DRAWING TITLE:

PROPOSED
ELEVATION EAST

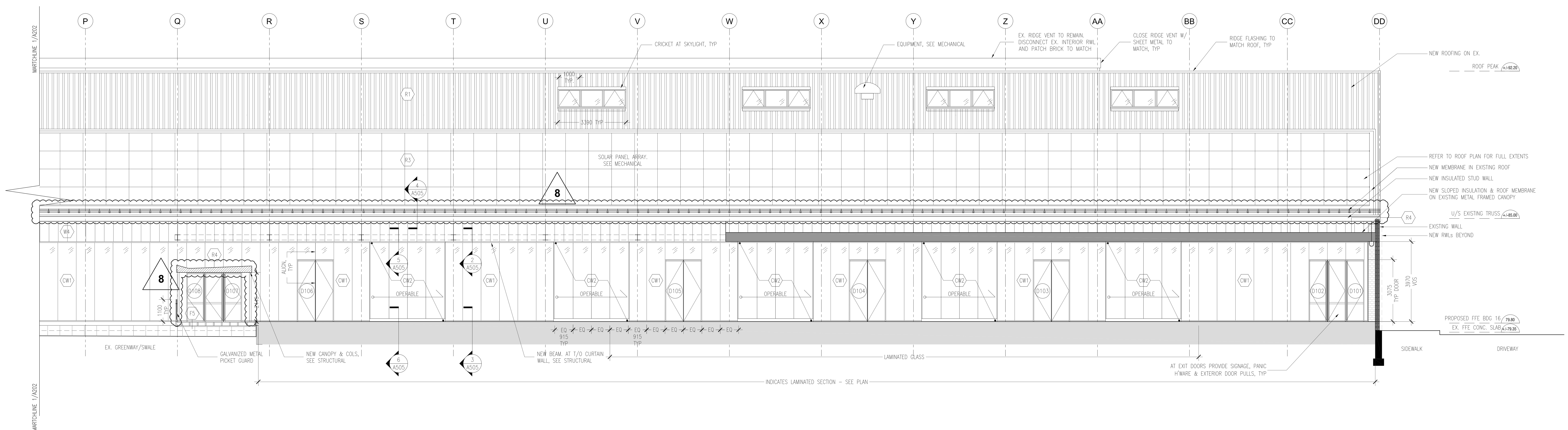
PROJECT NO: 16376
SCALE: 1:100
DRAWN BY: MC/JL
REVIEWED BY: DA

DRAWING NO:

A201



1 A202 WEST ELEVATION
1:100



2 A202 WEST ELEVATION
1:100

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PROJECT:

EVERGREEN BRICK WORKS
BUILDING 16 RENOVATIONS

PHASE 2

550 BAYVIEW AVE
TORONTO, ON

DRAWING TITLE:

PROPOSED
ELEVATION - WEST

PROJECT NO: 16376
SCALE: 1:100
DRAWN BY: MC/JL
REVIEWED BY: DA

DRAWING NO:

A202

EllisDon
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Concrete Pour Report - PDF Format: New Report (Ref. # -)

70256 Evergreen Brick Works Bldg 16

Report date: 2017-Aug-23 at 12:35 **Generated by:** Hayley Cormick

Description:

Date	Concrete Pour Type	Location	Concrete Type	Strength		Qty		Ticket #	# of Cylinders
03/08/2017	Other	Bathroom Footing	Air Entrained Concrete	32.00	MPa	10.00	Cubic Metres		3
03/13/2017	Slab	First phase slab GL DD-Q	Air Entrained Concrete	25.00	MPa	157.00	Cubic Metres		6
03/15/2017	Slab	First phase slab (2nd layer) GL DD-Q	Other	0.00	MPa	240.00	Cubic Metres		6
03/24/2017	Slab	First phase slab (third layer) GL DD-Q	Normal Concrete	30.00	MPa	120.00	Cubic Metres		6
06/06/2017	Other	Relocated washroom wall footing.	Air Entrained Concrete	32.00	MPa	3.00	Cubic Metres		3
06/19/2017	Grade Beam	Grade Beams	Air Entrained Concrete	32.00	MPa	76.00	Cubic Metres		3
06/26/2017	Slab	Cupolex slab layer, north and east, GL A-E & A-K along GL 2	Normal Concrete	25.00	MPa	59.00	Cubic Metres		3
06/29/2017	Slab	Foamcrete slab layer, pour area 2	Low Weight Concrete	0.00	MPa	56.00	Cubic Metres		3
07/19/2017	Column	Slab topping layer, pour area 2	Air Entrained Concrete	25.00	MPa	40.00	Cubic Metres		3
07/20/2017	Column	Cupolex layer, pour area 3.	Air Entrained Concrete	25.00	MPa	108.00	Cubic Metres		3
07/24/2017	Column	Foamcrete layer, pour area 3a.	Air Entrained Concrete	0.00	MPa	56.00	Cubic Metres		3
07/27/2017	Slab	Foamcrete layer, pour area 3b.	Low Weight Concrete	0.00	MPa	49.00	Cubic Metres		3
08/08/2017	Column	Slab topping layer, pour area 3a.	Air Entrained Concrete	25.00	MPa	56.00	Cubic Metres		3
08/14/2017	Slab	Slab topping layer, pour area 3b.	Normal Concrete	25.00	MPa	48.00	Cubic Metres		3