PANELIZED DEEP RETROFITS OF MUNICIPAL BUILDINGS

New Glasgow Municipal Operations Building

Case Study Report

Issue Date: September 30, 2023

New Glasgow flourish

Natural Resources Canada | Ressources naturelles Canada

ReCover

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Project Team

Timon Bruulsema, P.E. (CA)	**Energy Consultant, RDH Building Science**
Stanley Francispillai, PEng	**WUFI Modeling**
Mark Gardin, PQS(F), MRICS	**Cost Consultant, Qsolv Incorporated,**
Liam Kidson, PEng	**Electrical Consultant, M&R Engineering**
Hayley Knowles, EIT	**Mechanical Consultant, M&R Engineering**
Aidan McCracken, EIT	**Structural Consultant, DesignPoint Engineering**
Amanda McNeil, PEng	**Project Management, ReCover**
Jim Nostedt, PEng	**TCBO Analysis, SEEFAR Building Analytics**
Fatma Osman	**Embodied Carbon Accounting**
Andrea Pietila, PEng CPHD	**Energy Consultant, RDH Building Science**
Lorrie Rand, BEDS CPHD	**Architecture, Habit Studio**
Nick Rudnicki	**Project Lead, RSI Projects**
Aaron Smith, PEng	**Mechanical Consultant, M&R Engineering**
Evan Teasdale, PEng	**Structural Consultant, DesignPoint Engineering**

This research project was led by The ReCover Initiative, a Nova Scotia based non-profit organization working to accelerate deep retrofits in Canada.

New Glasgow Municipal Operations Building

Executive Summary

Who is ReCover

ReCover is a Nova Scotia-based non-profit focused on revolutionizing Canada's buildings to combat climate change. Through innovative research, technology, and partnerships, they lead in scalable deep retrofit solutions. Their efforts in Canada lower energy costs and enhance well-being by collaborating with communities, building owners, and financial institutions.

What is the Project

This project examines six cases of municipally owned buildings, inspired by the successful Energiesprong approach from the Netherlands, which streamlines retrofits. Despite challenges adapting to Canada's diverse buildings and climates, some projects have successfully implemented some Energiesprong-inspired retrofits. The ReCover Initiative found cost-effective benefits in panelized retrofits for multi-unit dwellings, aiming for Net Zero Energy. The study seeks to apply effective residential retrofit strategies to support municipal decarbonization.

Project Objectives

The project objectives are to make deep retrofits in Canada more feasible, showcase a panelized retrofit approach, and enhance confidence in retrofits. It aims for a 50% reduction in EUI, a NZER scenario with potential for NZE through solar PV, minimal disruption to occupants, low embodied carbon solutions, cost-effectiveness, and a payback period of 20 years or less.

Methods Used

The project progressed through several phases : building selection based on criteria and evaluation, data collection including utility info and drawings, baseline energy modeling, designing retrofit scenarios with energy conservation measures, and cost analysis involving Class D cost estimation and TCBO modeling.

Building Performance Improvements

EUI

77% improvement
Existing : 249 kWh/m^2
Recommend : 56 kWh/m^2

GHG

69% improvement
Existing : 554,390 kg/yr
Recommend : 171,930 kg/yr

Lifetime Utility Costs

75% improvement
Existing : $58.3 M
Recommend : $14.8 M

Lifetime Savings

$13.3 Million
Existing : $83.3 M
Recommend : $70.0 M

ROI

51 Years
When whole building cost of doing nothing exceeds whole building cost of recommended retrofit.

Retrofit Measures

2x4 ReCover wall panels
2x4 ReCover inverted roof panels
High performance windows and doors
Updated Boiler
New high performance ventilation system

Acronyms and Definitions

ACH	**A**ir **C**hanges per **H**our, measured with a blower door test
CO_2e	**C**arbon di**O**xide **E**quivalent
Deep Retrofit	A project involving multiple energy efficiency and/or renewable energy measures in an existing building, designed to achieve major reductions in energy use. A deep retrofit usually includes reducing energy demand and switching from fossil fuels to electricity for space and water heating – to achieve 70% energy savings and 80% to 100% GHG emissions reductions.
Energiesprong	A retrofit methodology developed in the Netherlands to implement Net-Zero retrofits using prefabricated envelope panels and compact exterior mechanical pods. Energiesprong retrofits are financed by the cost savings from future energy consumption and required maintenance. Translation: Energy Leap.
EUI	**E**nergy **U**se **I**ntensity
FCA	**F**acility **C**ondition **A**ssessment: a comprehensive evaluation of a building's physical condition.
GHG	**G**reen**H**ouse **G**as
GWP	**G**lobal **W**arming **P**otential: a measure of how much energy the emissions of 1 ton of gas will absorb over a given time, relative to the emissions of 1 ton of carbon dioxide.
NZE	**N**et-**Z**ero **E**nergy building: a building in which on-site renewable energy generated equals the annual energy consumption of the building
NZER	**N**et-**Z**ero **E**nergy **R**eady building: a building whose annual energy consumption is low enough that it could be Net-Zero Energy with the addition of a source of renewable energy
PV	Solar **P**hoto**V**oltaic array
TCBO	**T**otal **C**ost of **B**uilding **O**wnership: building life cycle cost analysis that includes all major operating costs over the useful life of the building.
WRB	**W**ater-**R**esistive **B**arrier: a synthetic membrane installed outside of the building's sheathing to protect it from the impacts of bulk water.
ZCB	**Z**ero **C**arbon **B**uilding:

Introduction

Over one-third of Canada's planned greenhouse gas (GHG) emissions reductions will come from energy efficiency measures.[1] Increasing the pace and scale of deep retrofits is imperative to achieving net-zero emissions, as most buildings standing today will still exist in 2050.

Municipalities across Canada are working to implement climate action plans to reduce their GHGs and to protect people and infrastructure from the impacts of climate change. Deep retrofits support both efforts.

The Panelized Deep Retrofits of Municipal Buildings project includes six deep retrofit case studies of municipally owned buildings in Canada. The buildings studied are representative of buildings in municipalities throughout the country. Their uses include community centres, administration, transit, and maintenance facilities in three Canadian climate zones.

Conventional retrofit practices are not scalable. They require large budgets, custom design, and invasive construction. The only retrofit initiative to be successfully scaled to date is the Dutch approach, Energiesprong, which involves prefabricated panelized envelope over-cladding and systematic mechanical upgrades. This approach reduces time on site and project complexity compared with common retrofit practices and permits buildings to continue to be used during the work.

Energiesprong has succeeded in part because of the Netherlands' homogenous building stock. The diversity of buildings and range of climate conditions in Canada pose challenges in adapting the approach to this country, yet several Energiesprong-inspired projects have been completed or are under way. These include Ottawa Community Housing's four-unit townhouse retrofit completed in 2021, Sundance Housing Cooperative in Edmonton, which is mid-way through retrofits on their 59 townhouses, and three single family homes in Alberta.

Measures that focus on simple payback and short-term return on investment can be counterproductive with assets as long lasting as buildings. Economic evaluation through Total Cost of Building Ownership (TCBO) analysis is more appropriate for complex retrofit projects that make changes to multiple interrelated building systems.

The ReCover Initiative has studied the potential for prefabricated panelized deep retrofits in lo-rise multi-unit dwellings in two previous case studies[2]. These studies found the lowest TCBO over the anticipated life of the building was achieved through Net Zero Energy retrofits where the targets were met with an Energy Use Intensity (EUI) reduction of at least 75% before adding solar PV.

This study of Panelized Deep Retrofits of Municipal Buildings was undertaken to develop deep retrofit strategies to support municipal decarbonization efforts.

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[1] IEA (2022), *Canada 2022*, IEA, Paris https://www.iea.org/reports/canada-2022 , License: CC BY 4.0

[2] ReCover Initiative (2020) *ReCover Phase One Case Study Report* and ReCover Initiative (2022) *Scarlettwood Court Deep Retrofit Case Study Repor*t, https://www.recoverinitiative.ca/about-us/our-results/report-request

Project Objectives

The objectives of this study were to de-risk investment in deep retrofits in Canada, to provide evidence on the effectiveness and scalability of a panelized deep retrofit approach and to build confidence and experience in deep retrofits among Canadian municipalities and industry stakeholders.

The goals for the Deep Retrofits explored included:

1. Develop a scenario that achieves an Energy Use Intensity (EUI) reduction of 50%.
2. Develop a Net Zero Energy Ready (NZER) scenario that can achieve Net Zero Energy (NZE) with the addition of solar PV.
3. All solutions minimize occupant disruption during construction.
4. All solutions target minimal embodied carbon.
5. Identify the retrofit pathway to the lowest Total Cost of Building Ownership.
6. Demonstrate a calculated payback of 20 years or better.

Methodology

The project was completed in the following phases:

1) Building selection.
   a) Definition of selection criteria.
   b) Building evaluation and selection.
2) Data and document collection, including:
   a) Utility data
   b) Building drawings
   c) Facility Condition Assessment, ideally no more than five years old
   d) Field Review
3) Baseline energy modeling (hourly analysis).
   a) Determination of model inputs
   b) Energy Model Calibration
   c) Baseline energy model results
4) Design Energy Conservation Measures (ECMs) for retrofit scenarios, including:
   a) u-values, window, and door performance specifications
   b) mechanical and electrical systems upgrades
   c) panel design, including:
      i) structural design and fastening details.
      ii) panel dimensions and layouts.
      iii) hygrothermal modeling with WUFI Pro to assess moisture risk.
      iv) embodied carbon accounting.
      v) aesthetic upgrades.
5) Cost Analysis.
   a) Class D cost estimate.
   b) TCBO modeling.

Building Selection

A short-list of buildings was proposed for study by the Town of New Glasgow. Criteria for consideration included the following:

- high EUI
- potential to eliminate fossil fuel-based building systems.
- high maintenance deficit
- simple form
- ample space to stage a panelized construction project.
- solar potential

Several factors led to the selection of the Municipal Operations Building for this study by the Town of New Glasgow and the ReCover team. As one of New Glasgow's most energy intensive buildings, with annual energy costs above $100,000, it is a priority to retrofit, however operations must continue throughout any work to the building. A panelized retrofit may be the best solution to limit disruptions for the town.

It's geometry and generous space on the site make it a good candidate for a panelized retrofit, and it has a large and unshaded roof with strong solar potential.

Data and Document Collection

The Town of New Glasgow provided the following data and supporting documents pertaining to the Municipal Operations Building:

- 1987 floor plan of the space (Appendix A)
- Fuel oil consumption records April 2019 – April 2022 (Appendix F)
- Electrical consumption records January 2018 – April 2022 (Appendix F)
- 2017 SNC Lavalin condition assessment report.

Typically, a minimum of two years of consumption records for all utilities serving a building is required. As the time frame for this project included reduced building occupancy during the pandemic, at least one year preceding the beginning of the pandemic was included in the analysis.

Comprehensive building drawings were not available. Smarter Spaces was engaged to complete **LiDAR** (Light Detection and Ranging) imaging to capture the external building geometry. The 3D point cloud generated from the scan was interpreted to produce CAD and BIM drawing files for use by the design team (Appendix A).

A site visit was conducted by design team members to verify structural, mechanical, and electrical details from the resources provided and to understand building conditions. The team also engaged with Town of New Glasgow staff to understand building usage patterns, baseline operational settings for mechanical systems and for information on occupant comfort and building deficiencies.

A new **Facility Condition Assessment** (FCA) was obtained from Capital Management Engineering Limited (Appendix B).

Building Description

The New Glasgow Municipal Operations Building is a one-storey steel structure with a gross floor area of 7,430m^2 (80,000 sq. ft). The space is divided into two areas, a 5,670 m^2 retail space at the front of the building, which is presently unoccupied, and a 1,760m^2 space at the back used by the New Glasgow Public Works and Engineering Department. The facility is used as a maintenance shop for storage and servicing of New Glasgow's fleet of trucks, snowplows, and other heavy machinery. It also contains office space, storage rooms, washrooms, and service spaces. The north wall of the building is partially shared with an adjacent movie theatre.

Prior to the start of this study the town of New Glasgow had initiated a preliminary plan to retrofit the building to address necessary upgrades and to convert a portion of the unused space to administrative use.

Figure 1 Municipal Operations Building

Context

The Municipal Operations Building is located at 624 E River Road, New Glasgow, in Pictou County, Nova Scotia. The building was originally built as a K-Mart box store in 1976. It is in a commercial area of New Glasgow with nearby forested areas. The building has been used by the Department of Engineering and Public works since 2012. The retail area of the building was used as a weekend Flea Market prior to the COVID-19 pandemic.

New Glasgow is in Canadian building code climate zone 6. The weather is humid and changeable in all seasons, with year-round potential for significant precipitation. Average temperatures in Nova Scotia are increasing and are predicted to continue to rise, with the

incidence and severity of storms also accelerating.[3] High winds and driving rain are key building science concerns in New Glasgow.

In 2022 the Town of New Glasgow implemented their community climate action plan[4] which targets 50% reduction in community GHG emissions and 30% reduction in Municipal GHG emissions below 2018 levels by 2030. Acting on emissions from buildings is one of five focus areas in the plan.

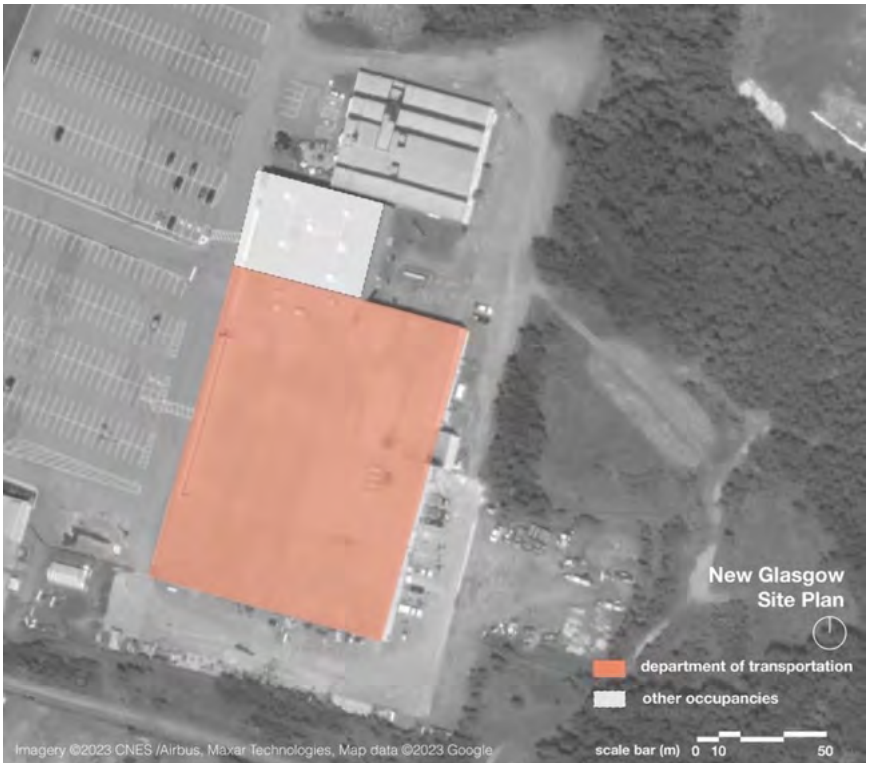


Figure 2 Site Plan

[3] Nova Scotia Department of Environment and Climate Change (2022) *Weathering What's Ahead: Climate Change Risk and Nova Scotia's Well-being*, https://climatechange.novascotia.ca/sites/default/files/uploads/climate-change-risk-report.pdf

[4] McIntosh, E. and Mitchell, R. (2022) *Community Climate Action Plan & Greenhouse Gas Emissions Reduction Target 2022-2030,* Town of New Glasgow https://www.newglasgow.ca/departments/climate-change/482-new-glasgow-community-climate-action-plan-2022/file.html

Building Code Considerations

A preliminary building code review has been completed to determine building code implications of a panelized retrofit to the Municipal Operations Building, based on its present occupancy.[5] The primary focus of the review was to determine if panels made with combustible materials can be installed on the existing structure.

The construction type, cladding and fire rating requirements for each exterior wall of a building are based on the area of the wall and its proximity to the property boundaries. Due to the repair garage activities the building is classified as **NBCC Group F2 - Medium Hazard Industrial Occupancy.** At 7,430 m^2, the one storey, sprinklered, structure can be of either combustible or noncombustible construction. All structural elements are required to have a 45-minute fire resistance rating (FRR). The steel structure is not currently fire rated, so this work must be completed as part of a retrofit.

The south and east walls of the building are far from property lines and can be of either combustible or non-combustible construction. The west wall is 4m from the west property line and therefore requires a 2-hour FRR and noncombustible cladding. This means noncombustible panels can be installed on the south, east and west elevations.

Approximately half of the north wall of the building is a party wall shared with the adjacent building and the remainder sits on the north property line. As such, the entire north wall is required to be of noncombustible construction. The existing concrete block walls meet this requirement; however, the masonry is in poor condition and needs repairs to ensure continuity. The party wall section of the north wall must have a 4-hour FRR. This is requirement is not currently met and will need to be implemented as part of a retrofit.

Combustible panels are not permitted on the north wall. This wall is required to have a 2-hour FRR and must be of non-combustible construction. An alternate retrofit solution for the north wall is required to integrate with a panelized retrofit to provide continuous airtightness and thermal performance.

Cellulose insulation has a Class 1 fire rating, which is the best fire rating for materials with the lowest level of risk. It is treated with borate which acts as both a fire retardant and pest repellant.

[5] The code requirements of proposed future occupancies are outside the scope of this study and have not been considered.

Building Enclosures

The walls of the Municipal Operations Building consist of 200mm (8”) concrete block. On the south, west elevations and exposed portion of the north wall, the wall has 25mm (1”) rigid insulation and brick cladding. There is interior drywall finish in some areas and exposed concrete block elsewhere. The east (rear) wall has no finishes or insulation.

The roof is an uninsulated corrugated metal roof deck with a modified bitumen roof system. The concrete slab-on-grade floor and cast in place concrete foundations are also uninsulated. Windows are single glazed aluminum storefront units and are concentrated on the west wall.

Table 1 Existing Building Enclosure Performance

	Effective USI $W/m^2 \cdot K$ ($Btu/h \cdot ft^2 \cdot °F$	Effective RSI $m^2 \cdot K/W$ ($ft^2 \cdot °F \cdot h/BTU$)
weighted average walls	USI-1.49 (U-0.26)	RSI-0.67 (R-3.8)
weighted average roofs	USI-8.1 (U-1.42)	RSI-0.12 (R-0.7)
weighted average slab	USI-4.1 (U-0.7)	RSI-0.24 (R-1.36)
overhead doors	USI-2.8 (U-0.5)	RSI-0.35 (R-2)
windows	USI-3.8 (U-0.67)	RSI-0.26 (R-1.5)

Existing Structure

The building consists of **structural steel** columns and beams that support an open web steel joist (OWSJ) and corrugated steel deck roof system. Details on the steel strength and weld connections is unavailable, and analysis was based historic steel strengths and the construction date.

Modeling indicates that most of the primary steel structure can support the post-retrofit loads but reinforcement of some columns and beams may be necessary. The OWSJs can’t support added loading. Verification of the steel strength and connection details must be done prior to construction.

The **exterior walls** of the building are 200 mm (8”) thick concrete block. These serve as part of the lateral load resisting system (LLRS) and do not support the roof. Various penetrations have been made in the masonry over the years and there are cracks in the walls and at openings. There is no visible grout or reinforcing in the blocks.

Further details on existing structure are given in Appendix C.

Existing Mechanical Systems

The building has a flat roof, sloped to internal **rainwater drains** and numerous mechanical penetrations which must be carefully detailed in a panelized retrofit.

The building is sprinklered.

Hot water is supplied by five electric water heaters are located near the points of use. Each tank has a nominal capacity of 40 gallons.

Space heating is provided by a single oil-fired hot water boiler with a two-stage burner. Heat is distributed from the boiler by two main heating loops. The first loop is connected to a built-up air handling unit with a hydronic heating coil which supplies air to the retail space at the front of the building. Its setpoint is 7°C but the space generally remains at 9°C or higher throughout the winter, so it remains off. The air handling unit also has a DX **cooling** coil served by four 34-ton rooftop condensing units. The unit has not operated since the summer of 2020.

The second heating loop feeds multiple unit heaters distributed throughout the maintenance shop area at the back of the building, storage rooms at the side of the building and a unit heater in the retail entrance. The unit heaters receive water directly from the boiler. The shop area is maintained at around 18°C. A mini split and electric baseboards have been installed in the office area and a mini split has also been installed in the back storage room.

Ventilation is provided to the retail space when the air handling unit is running. The maintenance shop does not have a continually operating ventilation system. Two inline exhaust fans are connected to flexible hoses in the space and can be operated in certain shop areas when there is an increased risk of pollutants due to welding and automotive fumes. Makeup air is provided by motorized dampers and a louver that are triggered by a CO sensor or manual operation along with two wall mounted exhaust fans. Destratification fans have also been installed in the back storage area for improved air movement.

The HVAC systems were not designed for the current building use. Consequently, ventilation is inadequate in occupied areas, particularly in the winter when the garage doors are not open. Areas of high heat loads (i.e., server room) were noted by the staff to frequently get very hot.

Appendix D provides further details of the existing mechanical system.

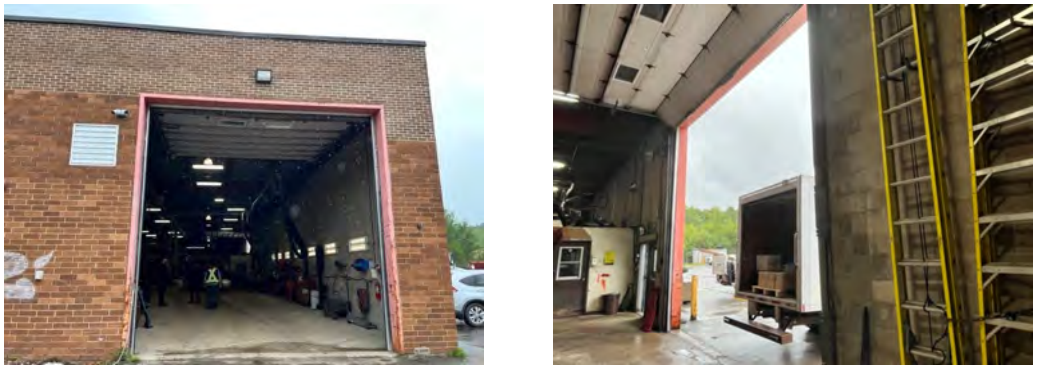


Figure 3 Natural ventilation

Existing Electrical Systems

The incoming power service consists of two, 4” conduits servicing a pad mount transformer on the east side of the building. The secondary service entrance enters in the main electrical room.

All **main distribution equipment** is original to the building and has surpassed its reasonable life expectancy, with some equipment showing signs of rust.

Most of the **interior lighting** is provided by fluorescent fixtures, however approximately 15 fixtures have been replaced with LED lamps. Lighting throughout the building is past its reasonable life expectancy and many fixtures require service. Emergency lighting, exit signage and the building fire alarm panel are battery operated.

The building lacks an automatic **lighting control system** and relies on manual control. This could lead to energy waste if lights are left on in unoccupied areas of the building for extended periods of time (overnight).

Appendix E gives further details of the existing electrical system.

Energy Consumption

Energy analysis was based on electrical records spanning January 2018 to April 2022 and fuel oil records from April 2019 to March 2022 (Appendix F). During this time span the Municipal Operations Building used an average of 63,347 L of fuel oil (680,342 ekWh) and 258,000 kWh of electricity annually. Energy use decreased slighting after June of 2021 when the Flea Market stopped operating out of the space.

Annual energy costs for the building exceed $100,000. The combined annual emissions measure nearly 400tCO2e, representing 13% of New Glasgow’s total GHG emissions.

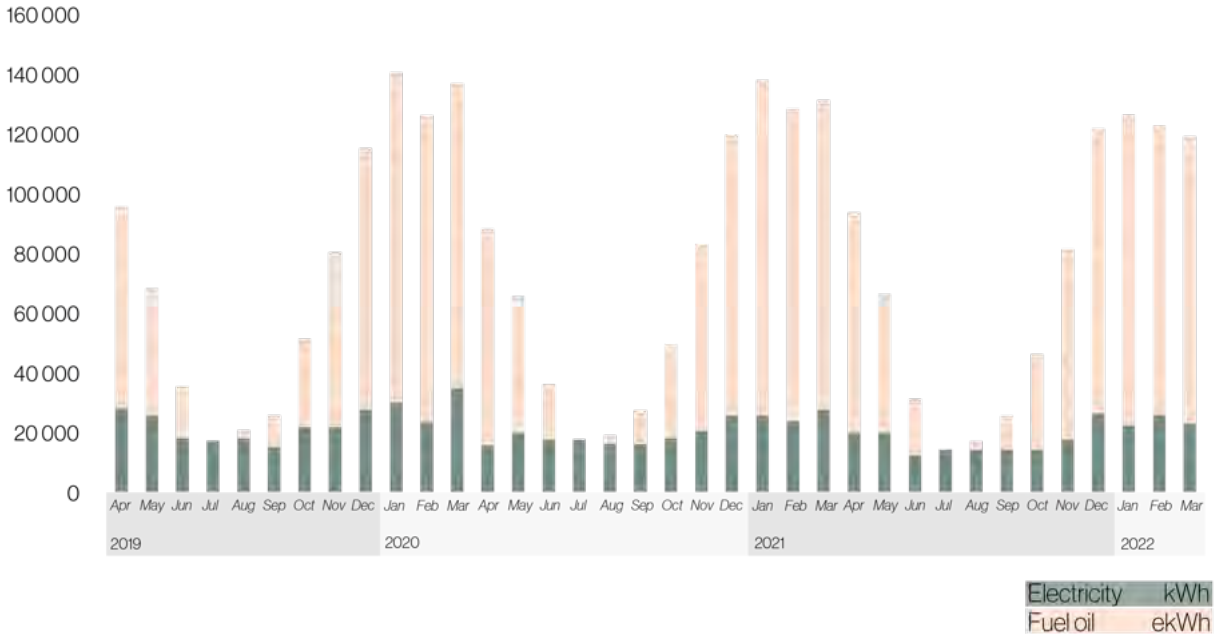


Figure 4 Historical Energy Use:

Baseline Energy Model and Calibration

Whole building energy modeling with eQUEST was conducted to understand existing building performance and to inform the development and optimization of retrofit scenarios. Energy model inputs (Appendix G) were based on documentation described earlier in this report and in consultation with Town of New Glasgow staff on occupancy patterns and operational set points of the mechanical and electrical equipment.

The energy model was calibrated with historical utility data to closely reflect the current building performance. Initial model calibration results deviated substantially from the documented performance. It is possible that the building is gaining heat from the adjacent movie theatre through its party wall. Additionally, under certain winter conditions, heat losses through a highly conductive building envelope can be reduced due to heat recovery through infiltration. As the Municipal Operations Building is an uninsulated steel building, it is believed to be experiencing this condition.

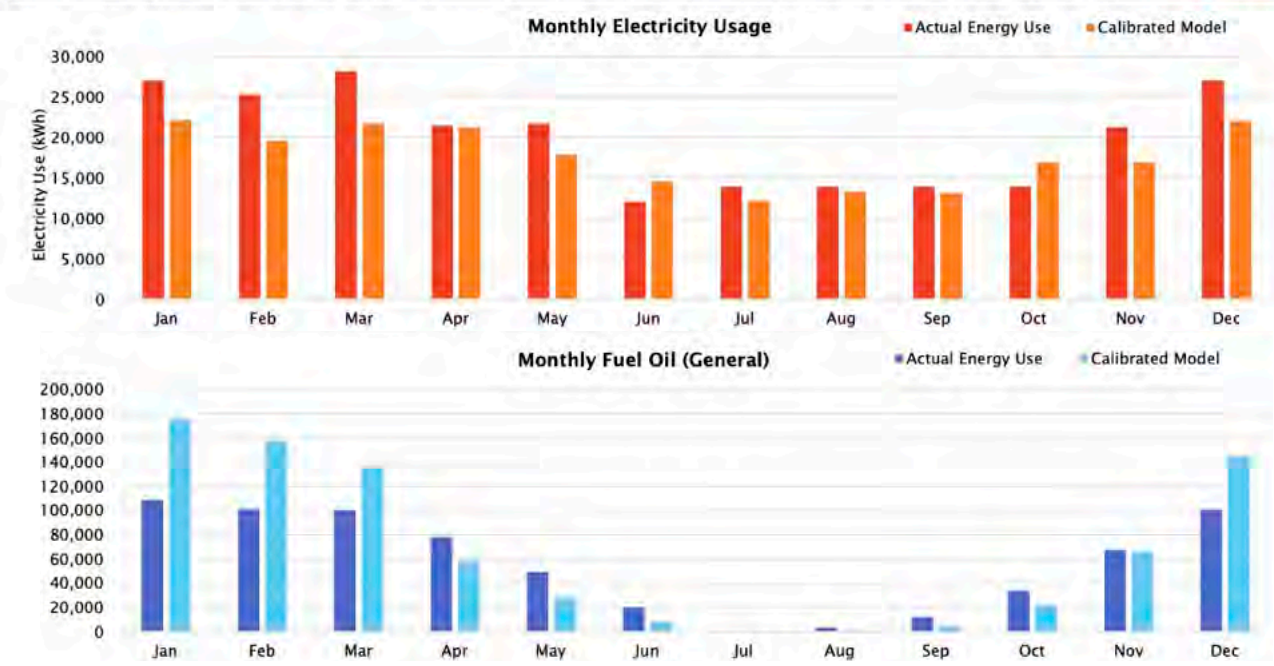


Figure 5 Calibrated Energy Use.

Correction factors were applied in the energy model to calibrate the model more closely. The air infiltration rate was reduced from 2.3 l/s/m^2 to 1.5 l/s/m^2 and the roof assembly was increased from R-0.7 to R-4 in the baseline energy model. In the final model electrical consumption deviates from existing use by 11.8% and fuel oil deviates from existing use by 18.7%.

The retail area of the Municipal Operations Building, approximately 75% of the floor area of the building, is maintained with heating systems set at 7°C. It is implausible that it will continue to be operated at such a low temperature post-retrofit. Performance comparisons between a 7°C baseline and a 20°C post retrofit are not useful, so the model was calibrated for both the actual 7°C baseline and for a theoretical 20°C baseline

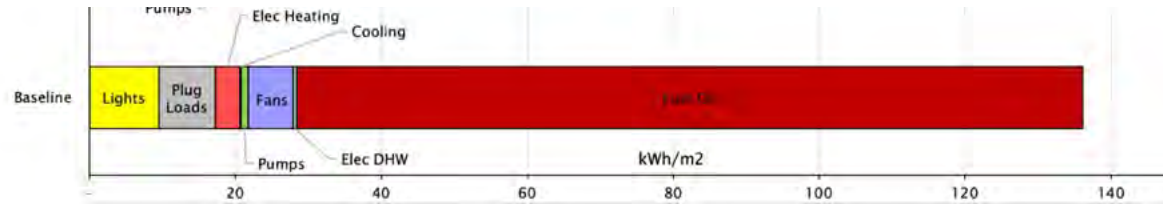


Figure 6 Total Energy Use Intensity (kWh/m^2/yr)

The Total Energy Use Intensity (TEUI) for the building at current operating conditions is 136 kWh/m^{2}a. In the theoretical scenario where it is maintained at 20°C it is 248.5 kWh/m^{2}a (Figure 8). Over 80% of the heat losses are through the uninsulated steel roof as shown in the Thermal Energy Demand Intensity graph (Figure 7).

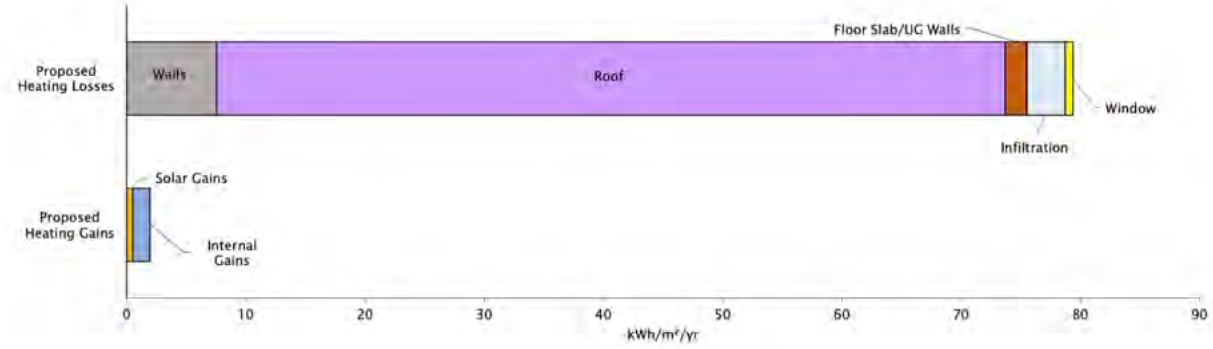


Figure 7 Thermal Energy Demand Intensity (kWh/m^2/yr)

Results

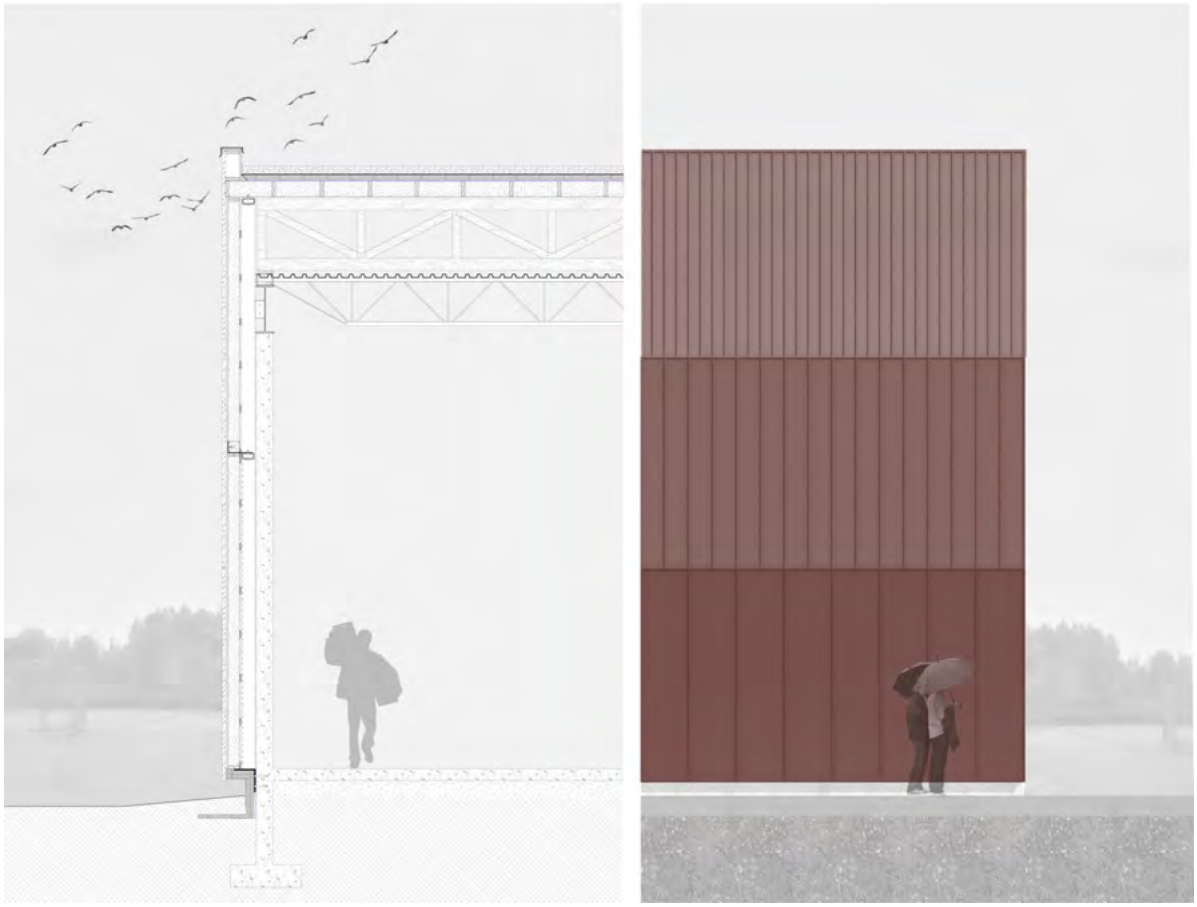


Figure 8 Partial section-elevation

The design team worked collaboratively to develop retrofit scenarios targeting the project objectives. The analysis assumes a 'like for like' retrofit where space usage, occupancy schedules, internal geometry, volume of conditioned space, and window and door dimensions and locations are consistent with existing conditions.

The strategy for building enclosure upgrades includes prefabricated ReCover panels installed on both the walls and roof.

Energy Conservation Measures

Energy conservation measures for the following four scenarios were developed:

1. **Minimum Upgrade** Scenario targeting a 50% reduction in TEUI from the baseline.
2. **NZER – ASHP** targeting a 75% reduction in TEUI from the baseline.
3. **NZER - GSHP** targeting a 75% reduction in TEUI from the baseline.
4. Net Zero Energy (**NZE**).

Building enclosure upgrades were developed for each scenario with post-retrofit airtightness targeting 0.5 L/s·m^2, an estimated 83% reduction from the existing air infiltration. All scenarios propose upgrading to high performance windows.

Mechanical and electrical retrofits were developed based on ease of integration with existing systems and installation cost. Building systems upgrades for the Minimum Upgrade scenario maintain fuel-oil as achieving 50% EUI savings with 100% electrification is cost prohibitive given its age and condition. The NZER scenarios include full electrification of the HVAC and domestic hot water (DHW) systems.

Air source heat pumps (ASHP) and ground source heat pumps (GSHP) were evaluated in the NZER scenario, to learn which option has the lowest TCBO. A GSHP is more energy efficient than an ASHP, but the cost to install a GSHP system are typically significantly higher, so the best investment depends on specific building conditions. The NZE scenario is based on the GSHP option which was found to have the lowest TCBO.

Details of the retrofit scenarios are summarized in Table 2.

Table 2 Retrofit Scenarios EUI Reductions

	Target TEUI	TEUI kWh/m^2	TEUI reduction from 7C	TEUI reduction from 20°C
Existing 7°C	-	136.1	-	-
Existing 20°C	-	248.5	-	-
Min. Upgrade	50% savings	85.1	38%	66%
NZER – ASHP	75% savings	36.4	75%	86%
NZER – GSHP	75% savings	32.6	75%	86%
NZE	100% savings			

Table 2 Retrofit Scenarios Summary				
	Existing Building	**Minimum Upgrade**	**NZE – ASHP [1]**	**NZE – GSHP[1]**
Effective Wall R-value	RSI-0.7 (R-3.8)	2x4 ReCover panel RSI-2.46 (R-14)	2x6 ReCover panel RSI-3.52 (R-20)	2x6 ReCover panel RSI-3.52 (R-20)
Effective Roof R-value	RSI-0.12 (R-0.7)	2x6 ReCover panel And rigid XPS RSI-3.17 (R-18)	2x8 ReCover panel And rigid XPS RSI-3.17 (R-18)	2x8 ReCover panel And rigid XPS RSI-3.17 (R-18)
windows	Vinyl, single glazed RSI-0.44 (R-2.5)	triple pane RSI-1.02 (R-5.56)	triple pane RSI-1.02 (R-5.56)	triple pane RSI-1.02 (R-5.56)
Air Tightness at 75Pa	3.0 L/s·m2	0.5 L/s·m2	0.5 L/s·m2	0.5 L/s·m2
Central Heating Eq.	Oil-fired boiler with two stage burner	Oil-fired boiler with modulating burner	ASHP	GSHP
Heating System	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils
Air Conditioning	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils
DHW Equip.	Electric Water Heater	Electric Water Heater	Heat pump Water Heater	Heat pump Water Heater
Ventilation Equipment	Maintenance: Exhaust fan Retail: Air handling unit Office: None	Maintenance: 90% SRE ERV [6] Retail: Air handling unit Office: 90% SRE ERV [6]	Maintenance: 90% SRE ERV [6] Retail: 90% SRE ERV [6] Office: 90% SRE ERV [6]	Maintenance: 90% SRE ERV [6] Retail: 90% SRE ERV [6] Office: 90% SRE ERV [6]
Lighting		LED retrofit kit	All new LED	All new LED
Solar PV	none	none	230 kW (DC)	230 kW (DC)

1 Net Zero Energy Ready systems are identical with exclusion of renewables.
2 Installed with heat coil and DX cooling coil served by rooftop condensers.
3 Located in storage room.
4 Located in server room.
5 Controlled through CO sensors.
6 SRE ERV: Sensible heat-recovery efficiency energy/enthalpy recovery ventilator (Tempeff Dualcore or similar).

Design

The New Glasgow Municipal Operations Building is a former big box store, a building type that is ubiquitous and forgettable. There are thousands of pre-engineered steel buildings across Canada that must be retrofit to achieve a net-zero emissions future. These retrofits present an opportunity for placemaking and to instill character in a building archetype that is a blank slate.

The design concept for the New Glasgow Municipal Operations Building is a nod to the mining heritage of the community. Three courses of rust toned metal with varied vertical rib spacings represent stratified layers of earth. The colour will stand out against its backdrop of trees in all seasons. Metal is cladding is recommended as while it has high up-front carbon emissions, it is a good investment for its durability and longevity, and it can be later recycled or repurposed at its end of life.

The proposed cladding update to the Municipal Operations Building is distinctive and elevates the building's presence on the site.

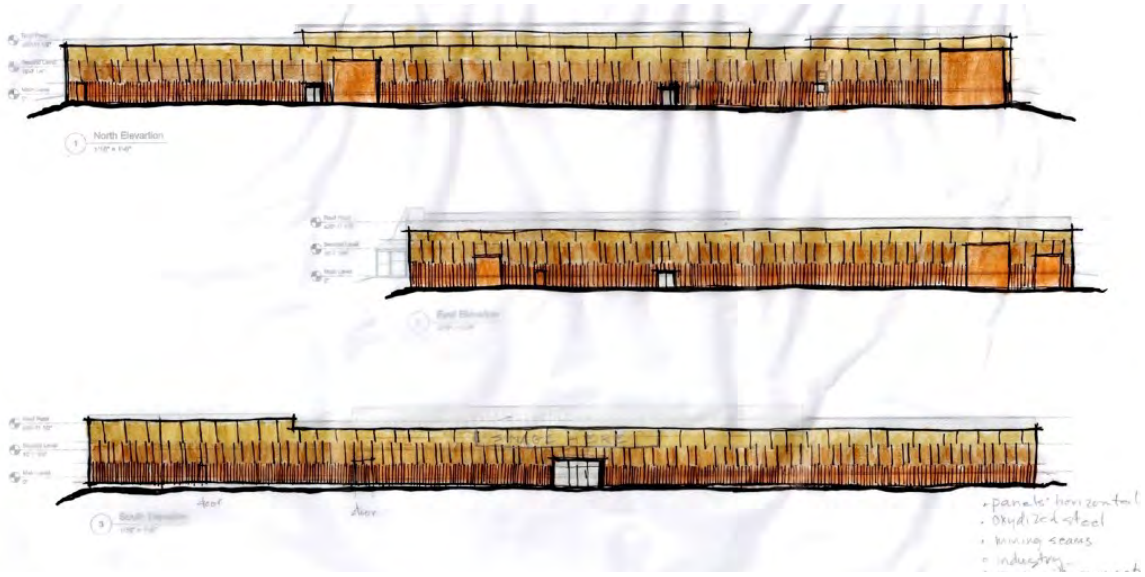


Figure 9 Concept Sketch

Panelized Wall Details

The prototype ReCover panel is a wood framed box which holds carbon storing cellulose insulation. The depth of the frame is flexible depending on the needed performance.

The panel components were specified to minimize moisture risks by shedding precipitation on the outside and to promote any moisture movement that occurs from the interior to dry to the exterior.

Strapping on the interior of the panel permits fitting adjustments against the existing walls and provides an internal air cavity that serves as a moisture buffer space for vapour diffusion from the inside to pass out through the panels. The frame backing layer is a "smart" vapour control

membrane which varies in permeability depending on the relative humidity of its environment. If moisture is present between the panel and the existing walls the membrane fibers open to let moisture escape. Wood panel framing, plywood sheathing and cellulose insulation are all hygroscopic materials, meaning their fibers transport moisture from areas of higher humidity to those of lower humidity. A vapour-open water-resistive barrier (WRB) protects the outer plywood sheathing and provides a drainage plane behind the rainscreen cavity and metal siding.

Panel schematics and connection details for each scenario are in Appendix H.

NZER Scenario Wall Panel effective RSI-2.46 (R-14)

1. metal cladding[6]
2. 19mm strapping/rain screen cavity
3. WRB membrane
4. Plywood sheathing
5. Dense-pack cellulose insulation
6. Framing: 2x6 wood studs 24”o.c.[7]
7. variable permeability vapour control membrane
8. strapping

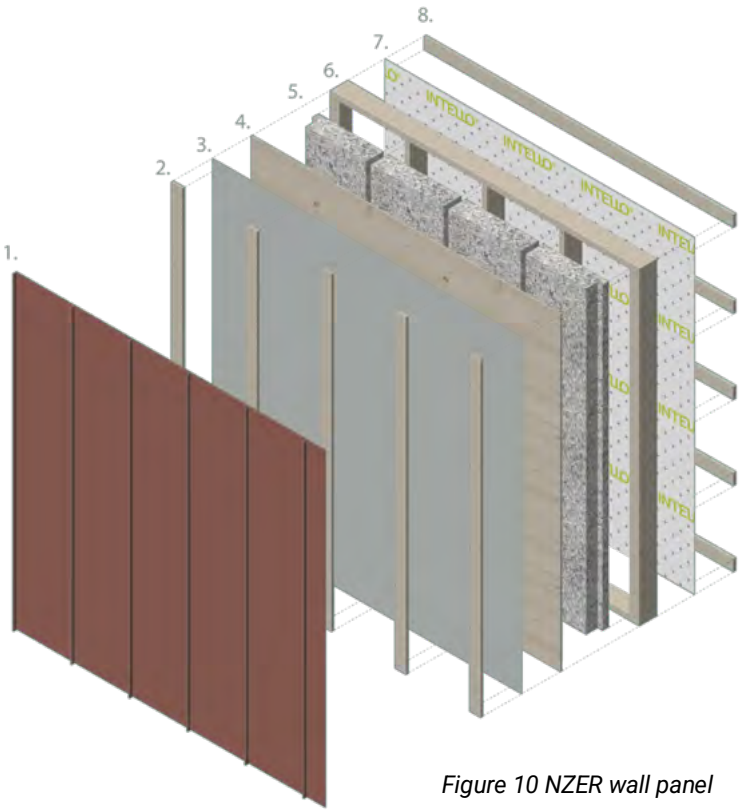


Figure 10 NZER wall panel

The new wall assembly will be two panels high, each approximately 12’-6” in height, running from the foundation and beyond roof to make a new parapet. The panel widths vary based on optimized spacing around the building with a standard width of 2.4m (8’) with modifications to suit the building geometry and window and door positions. The design includes prefabricated corner panels, to simplify installation in the field. These are 0.6m (2’) wide in each direction. Panel schematics and connection details for the Municipal Operations Building are provided in Appendix H and the proposed panel layout is provided in Appendix I.

[6] Panels will be assembled remotely; however, the cladding will be installed on site.

[7] Wall panel framing is based on 2x4s in the Minimum Upgrade scenario.

Panelized Roof Details

A flat roof insulated with dense packed cellulose insulation is risky from a hygrothermal perspective. This risk can be mitigated by adding a sufficient depth of rigid foam insulation outboard of the sheathing to keep it warm and thereby prevent condensation. Hygrothermal analysis of the roof panel showed a high risk of moisture and condensation on the sheathing if the panels were installed as part of a conventional flat roof assembly; consequently, the proposed roof is an inverted or protected membrane roof (PMR).

A protected membrane roof has roofing membrane installed on the sheathing surface with insulation above it and ballast on top. The only suitable rigid foam for this application is extruded polystyrene (XPS), which has high embodied carbon. Sopra-XPS has been specified for this assembly, as it is made with 70% recycled XPS and has a much lower embodied carbon than similar XPS products. Gypsum based sheathing is used to prevent any risk from moisture on the sheathing layer. The roof panel is designed to dry to the interior through variable permeability vapour control membrane or 'smart membrane' installed at the warm side of the panel to release any moisture that migrates through the panel.

Proposed NZER Scenario Roof effective RSI-2.8 (R-16)

1. Ballast
2. Sopra XPS
3. Roof membrane
4. DensElement sheathing
5. Dense-packed cellulose
6. Framing: 2x8 joists 24"o.c.[8]
7. variable permeability vapour control membrane
8. strapping

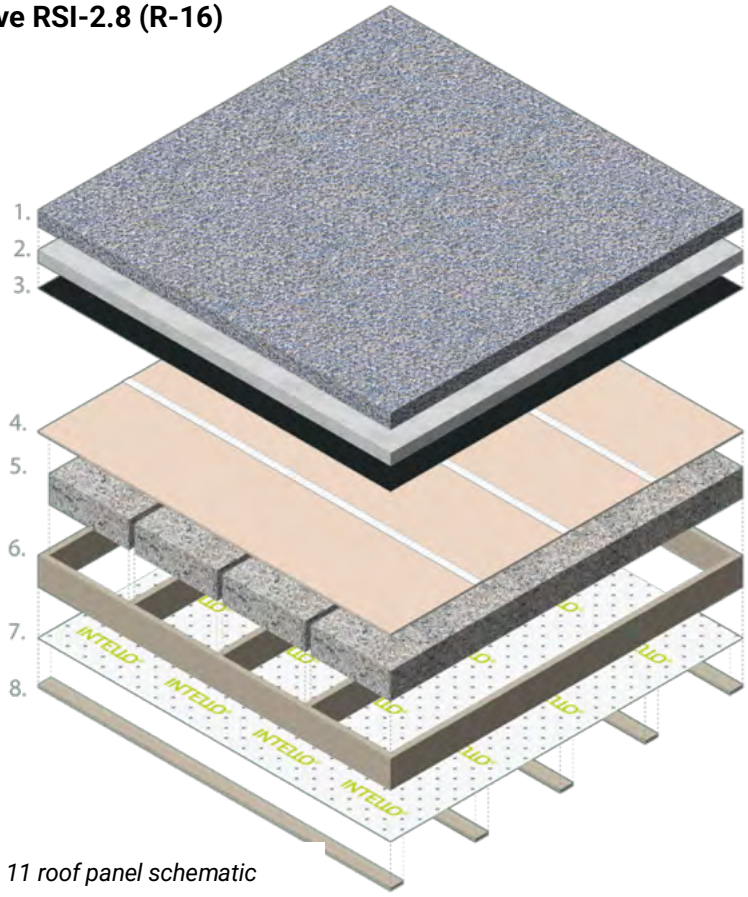


Figure 11 roof panel schematic

[8] Panel framing is based on 2x6 joists in the Minimum Upgrade scenario.

Structural Design

A new structural system is proposed to attach ReCover panels to the existing steel structure. To avoid loading the existing OWSJs, a system of new pre-engineered wood trusses will span between existing structural steel beams, an overall span of approximately 50’. These trusses will distribute the load of ReCover roof panels to the existing steel superstructure.

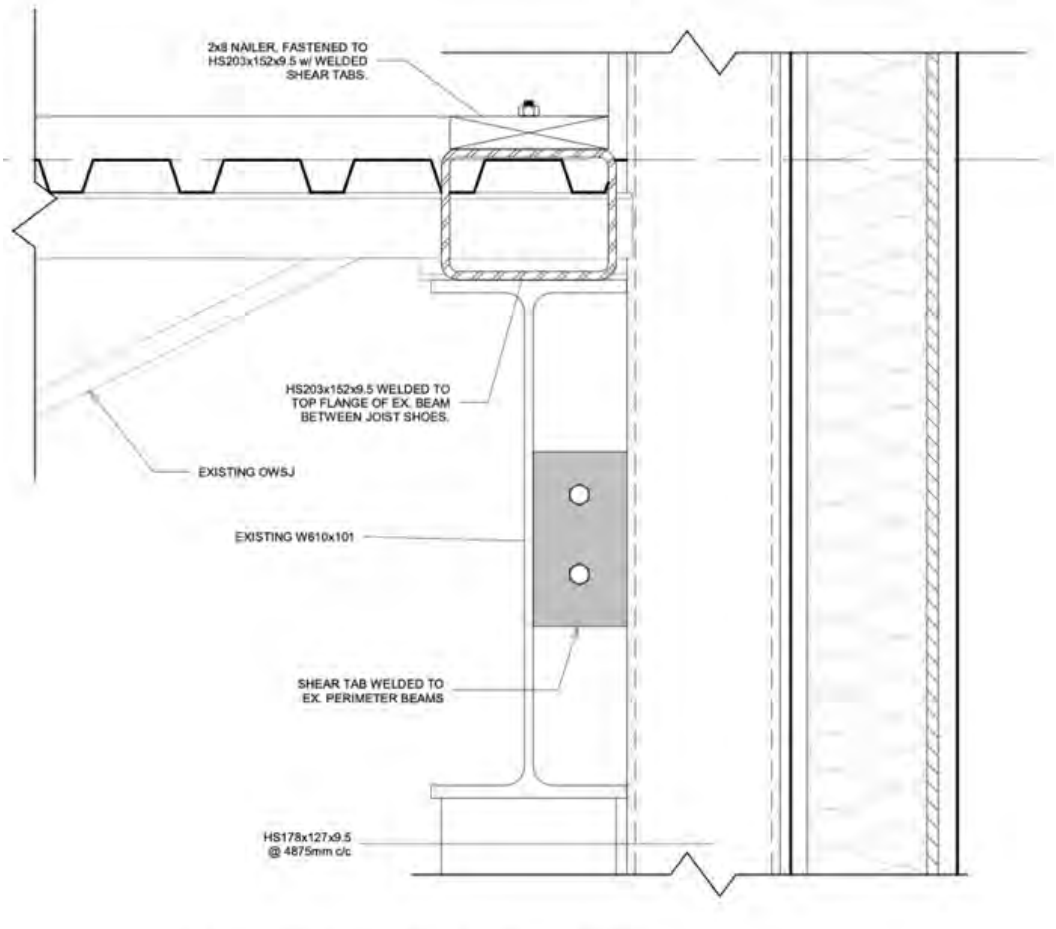


Figure 12 Partial Structural Section

The new roof trusses connect to the existing steel structure with steel HSS blocking installed between the existing OWSJ shoes, fastened with a 2x8 nailer at the top.

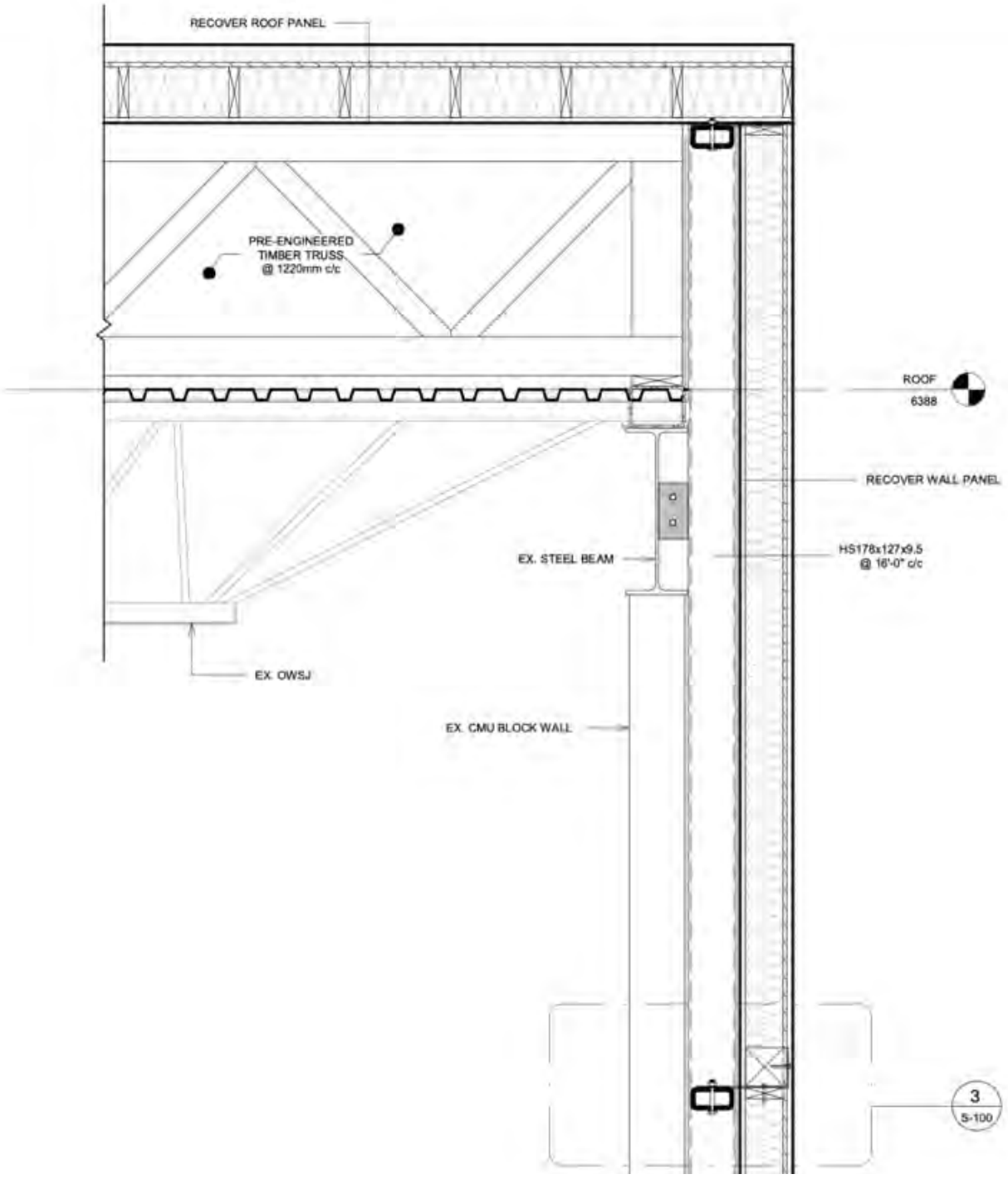


Figure 13 panel to truss connection

The new wall assembly is two panels high. A steel exoskeleton transfers mid-height wall panel loads to the existing roof diaphragm and foundation.

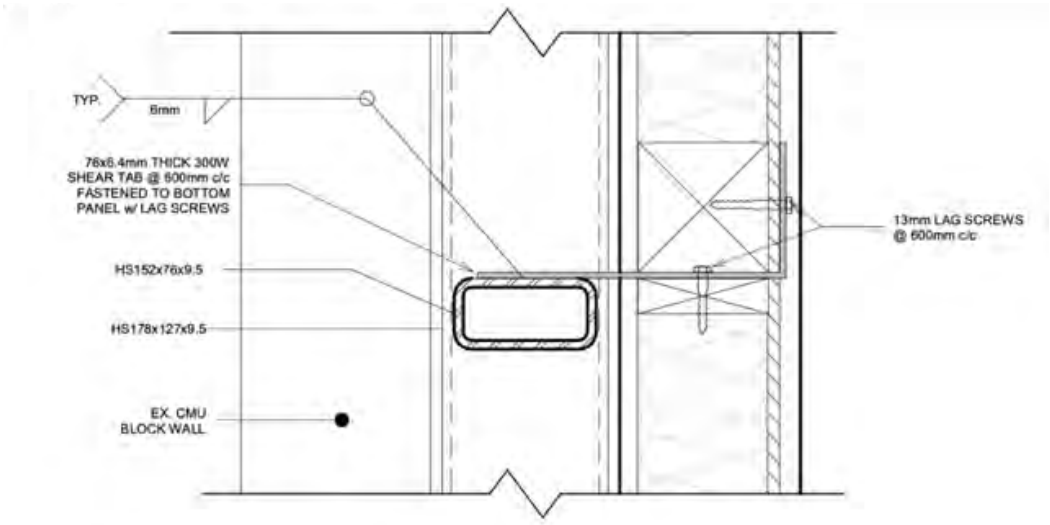


Figure 14 mid-height wall panel connection

A steel lintel supports the steel wall structure and wall panels at the base.
The lintel fastens to the existing concrete foundation walls using post-installed epoxy anchors.

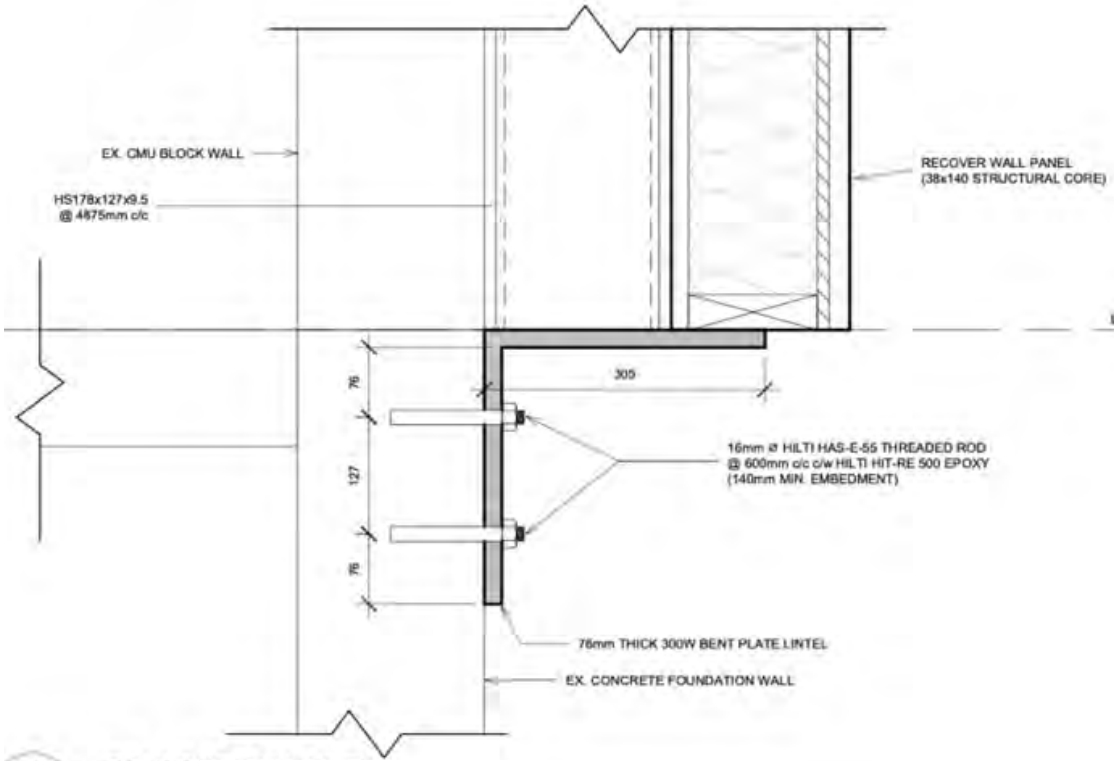


Figure 15 foundation lintel

Foundation Insulation

The angled steel panel support at the foundation is a linear thermal bridge and should be fully covered by 100mm (4”) of expanded polystyrene or mineral wool insulation to reduce heat losses and prevent localized condensation on the steel.

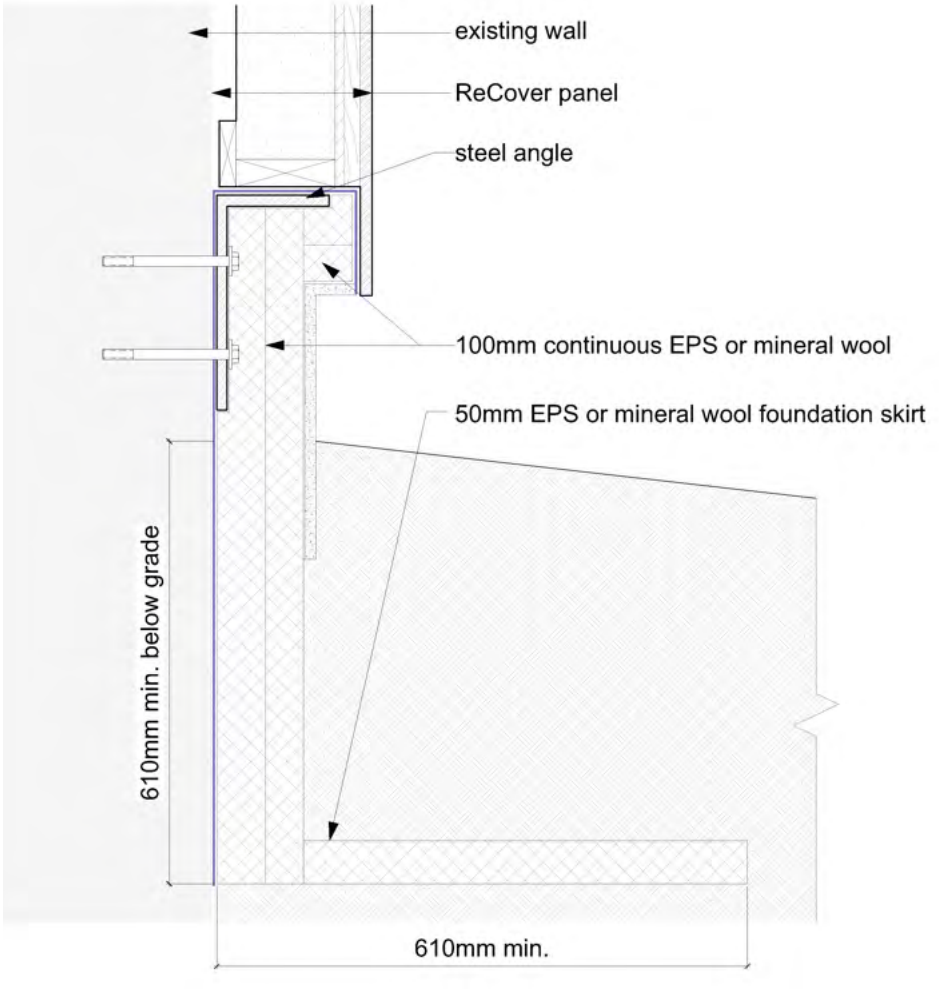


Figure 16 foundation insulation

Hygrothermal Modeling

The analysis of moisture and temperature over time is called hygrothermal analysis. Adding new materials to the exterior of a building can slow or block moisture from passing through, and prolonged exposure to moisture in the building assemblies can lead to durability issues including mold growth and decay.

Hygrothermal simulations were conducted on the New Glasgow Municipal Operations Building NZER wall and roof assemblies using WUFI® Pro (Appendix J). The analysis focused on the plywood sheathing and cellulose insulation in the assemblies, as biogenic materials are most susceptible to moisture damage. When moisture content of wood exceeds 20% for prolonged periods it can decay.

Hygrothermal performance is dependent on the material characteristics of each component of a building assembly. Assumptions were made regarding the materials in the existing walls and roof. Confirmation of the assumptions is required prior to finalizing the retrofit designs.

Simulations were run for each orientation of each assembly for a 10-year period post-retrofit. All simulations use the post-retrofit 20°C temperature as the 7°C scenario presented unacceptable moisture risk.

Most materials tested were shown to undergo cyclical seasonal moisture fluctuations consistent with expectations for buildings in the Nova Scotia climate. Specifically, the moisture content peaks in winter, with the greatest peak occurring in the first year post-retrofit, and with spikes that decrease over the subsequent years. A moisture spike that exceeds 20% in one winter does not typically damage the building so long as drying occurs in the warm season. Spikes above 20% that persist for several years indicate a potential for mould and eventual decay.

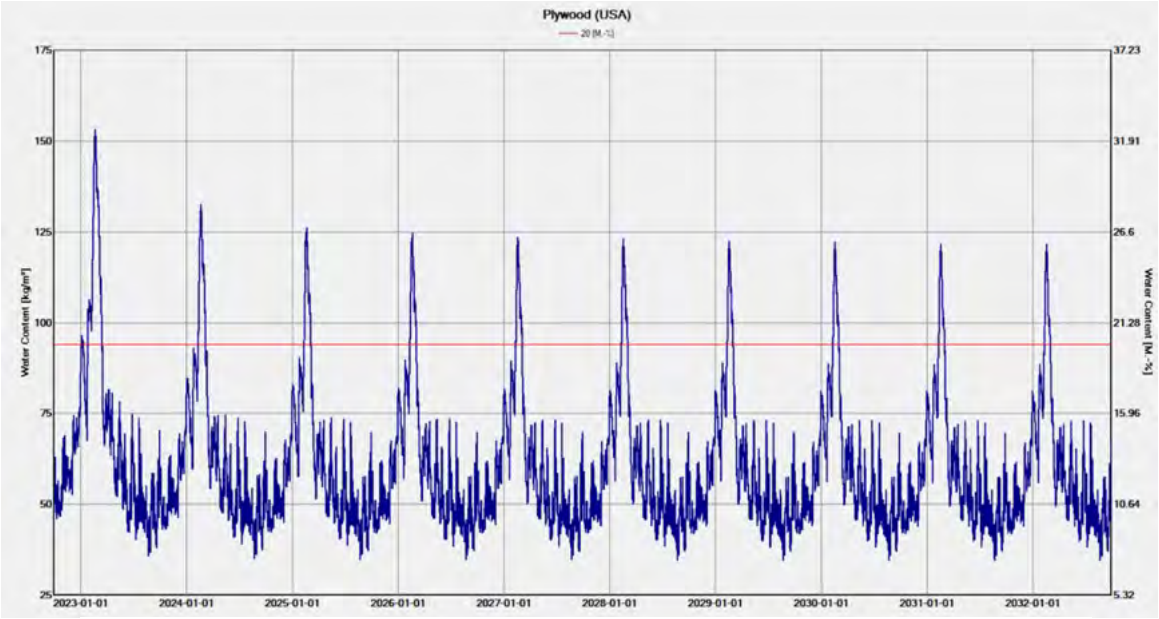


Figure 17 WUFI output: south wall (outer plywood layer)

In the new wall assemblies, all orientations simulated show moisture content spikes above 20% occur in the plywood with varying magnitude and duration of these spikes depending on material and orientation. The modeling indicates potential moisture risks in walls in both the south and east walls (eg Figure 18). As multiple assumptions were made regarding specific material properties of the existing assemblies, additional modeling should be done after confirming the actual materials.

Modeling also indicated a risk of mould growth on the east wall panel sheathing. An alternate moisture and mould resistant sheathing, such as gypsum based sheathing board, is recommended if further analysis continues to indicate risk.

The post-retrofit roof also demonstrates a necessity for a sheathing substitution as the moisture content several of the plywood layers experience recurring annual spikes above 20% (Figure 19), as well as high mold growth indices. As the materials that make up the proposed roof are all known, the proposed roof assembly includes gypsum based sheathing board in place of plywood. The cellulose layer of the proposed roof did not indicate risk.

Hygrothermal monitoring of selected assemblies of the post retrofit building could offer valuable data on the real-world performance of assemblies that contain biogenic materials such as wood and cellulose.

If the retrofit proceeds, is recommended that hygrothermal monitoring be implemented on selected assemblies to verify actual performance against modeling.

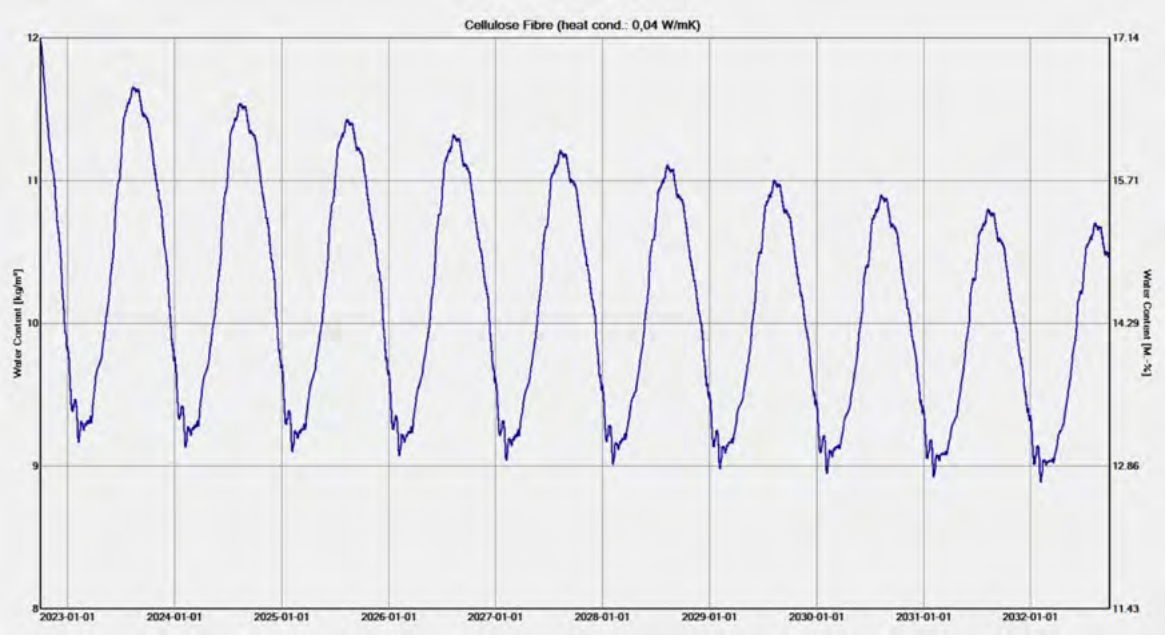


Figure 18 WUFI output – roof assembly (cellulose layer)

Embodied Carbon

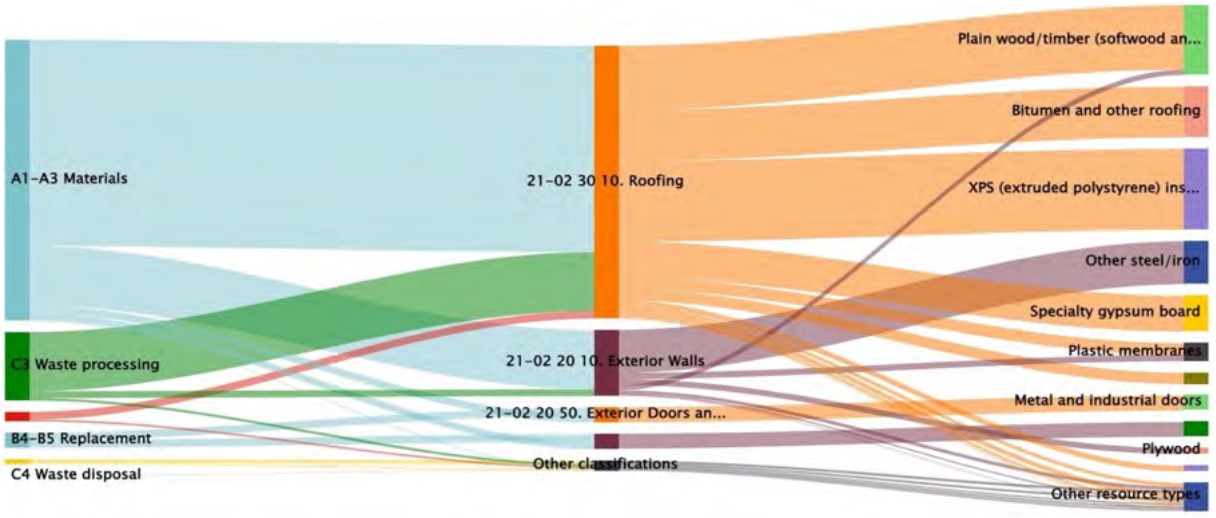


Figure 19 Retrofit Global Warming by Stage and Material

With the short time remaining to limit the impacts of climate change, it is not responsible to complete retrofits that reduce long-term operational emissions while emitting high up-front embodied carbon. Materials used in retrofits must emit the lowest possible carbon or the construction emissions may offset the intended GHGs saved through the retrofit.

Carbon accounting is complex and imperfect. This is frequently used as justification for not factoring embodied carbon into decision making. The objective of including it in this study is not to deliver a definitive value for embodied carbon in the building, rather it is to contribute to the necessary discourse in the building industry, so that the impacts of embodied carbon on GHG emissions are more widely understood.

Embodied Carbon was modeled for this project in One Click LCA (Appendix K). Materials modeled were based on the most representative materials available to the Canadian market with Environmental Product Declarations (EPDs) available in the One Click LCA database. The analysis was limited to embodied carbon of assembly materials being added to the building including panel additions to above-grade walls, roofs, below-grade components, and windows and doors. HVAC and electrical components were excluded from the analysis.

The results include a whole life cycle assessment of the building in six impact categories: Global Warming, Ozone Depletion, Acidification, Eutrophication, Formation of tropospheric ozone, Depletion of nonrenewable energy, and Biogenic carbon storage.

Table 3 Total Global Warming Potential

gross floor area m^2	A1-A3 $KgCO2e/m^2$	A1-C4 KgCO2e/m2	Biogenic carbon KgCO2e/m2
7,478	**37.91**	**51.13**	**79.4**

The major contributors to the GWP in this design are the wood trusses, the roof membranes, the XPS foam insulation in the roof, and the steel wall cladding. The A1-A3 Materials stage contributed 74% of the total carbon emissions associated with the building as illustrated in Figure 20 & 21.

The biogenic carbon storage of this building design surpasses that of the A1-C4 emissions by 36%, making a surplus in carbon storage capacity. This storage is attributed to the wood products (75%) and cellulose insulation (25%) used in the assemblies (Figure 22).

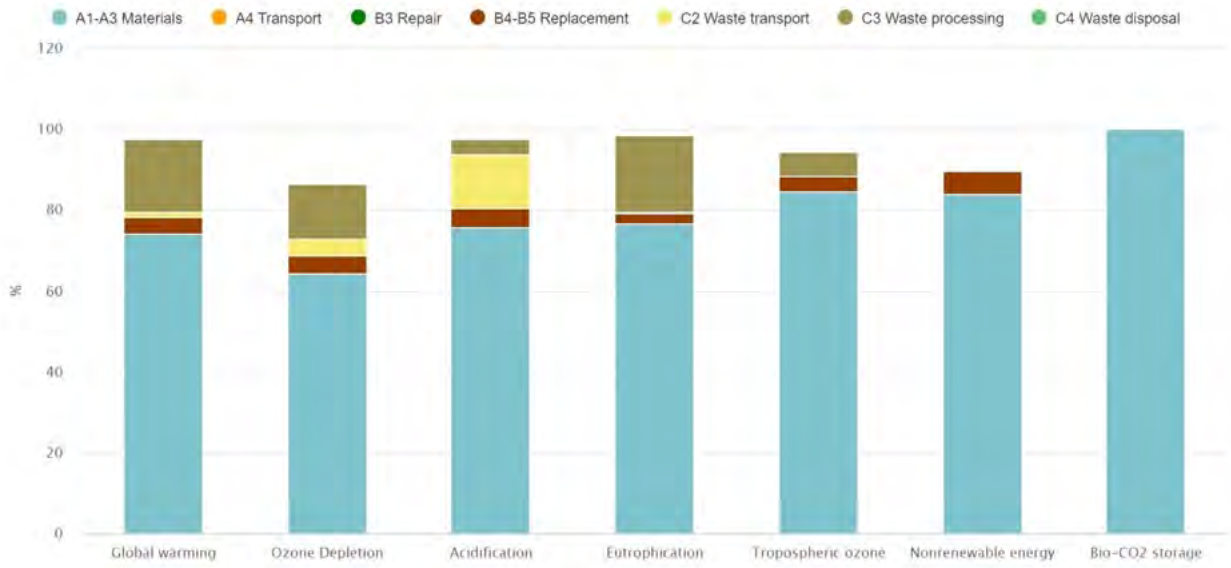


Figure 20 Life Cycle Impacts by Stage (%)

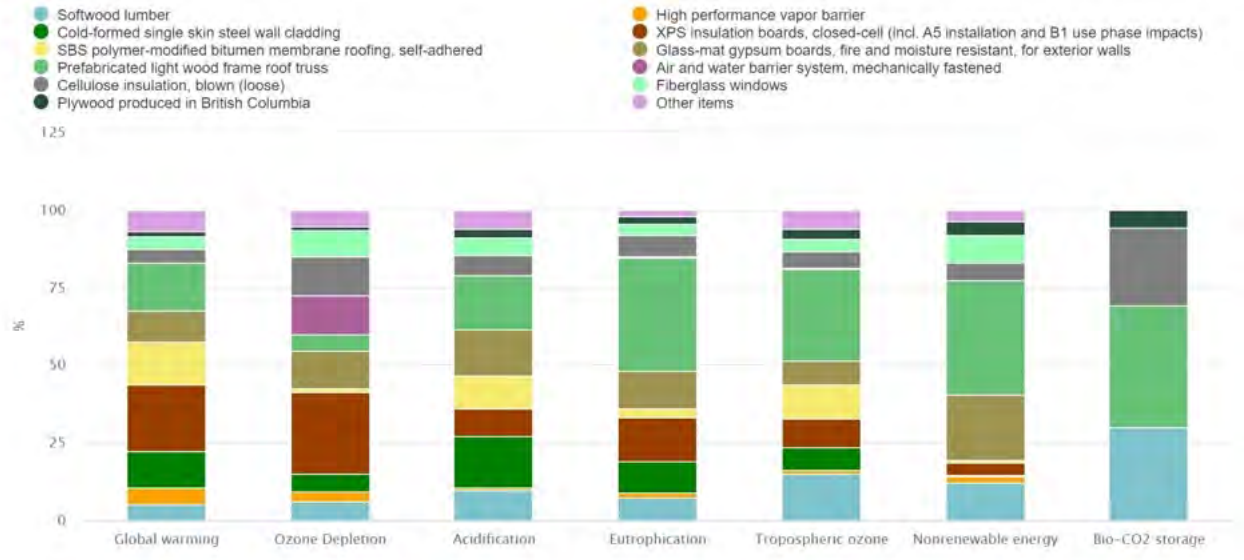


Figure 21 Life Cycle Impacts by Material (%)

Proposed Mechanical Systems

All scenarios:

- Rainwater drains and plumbing vents that penetrate the roof are to be insulated from ceiling to floor with 3” pipe insulation to prevent thermal bridging.
- Two energy recovery ventilators (ERVs) will be added in the offices in the maintenance office. They will be dual core type with approximately 90% heat recovery efficiency.
- All existing building controls will remain, with NOx and CO sensors to control the maintenance ventilation and a programmable time clock added for all other ERVs.
- Direct exhaust will remain in the engine and welding area.

1. Minimum Upgrade Scenario:
    - Heating will be provided by the existing unit heaters served by a new 480 kW cast iron oil-fired boiler, existing mini split heat pumps and baseboard heaters. Heating loads in the building remain high enough that a high temperature boiler is required to avoid replacement of the entire distribution system.
    - Cooling for the maintenance area will continue to be with existing mini split units.
    - Cooling in the retail area will continue to be with existing rooftop and air handling units.
    - Domestic hot water will continue to be served by the five existing electric water heaters.
    - Ventilation in the retail area will continue to be through the existing air handling unit.

2. NZER – ASHP:
    - Heating provided by three 24-ton cold climate air to water heat pumps. This includes upgrading the distribution system. The ASHP system is sized to meet 60% of the peak design heating load.
    - 120 kW electric boiler sized for 40% of the load.
    - Cooling in the maintenance office and retail areas provided by chilled water from the ASHP. The maintenance area will continue to be cooled with existing mini split units.
    - Heating and ventilation systems will be decoupled.
    - Domestic water provided by a new 80-gallon heat pump water heater (HPWH).
    - New ERV, dual core type with approximately 90% heat recovery efficiency, serving the retail area.
    - Direct digital control system to operate heat pumps and circulation pumps.

3. NZER – GSHP:
    - Heating and cooling provided by a 20-ton GSHP system. This includes upgrading the distribution system. The ASHP system is sized to meet 60% of the peak heating load.
    - 110 kW electric boiler sized for the remaining 40% of the load.
    - Domestic water provided by a new 80-gallon heat pump water heater (HPWH).
    - New ERV, dual core type with approximately 90% heat recovery efficiency, serving the retail area.
    - Direct digital control system to operate heat pumps and circulation pumps.
    - Direct exhaust system with makeup air unit serving the maintenance area.

Proposed Electrical Systems

All Scenarios: Existing service to remain.

1. Minimum Upgrade Scenario:
    - Lighting upgrade with LED lighting kits.
    - Existing lighting controls remain.

2. NZER Scenarios
    - Lighting upgraded to LED fixtures throughout.
    - The lighting control system will be updated to include automatic lighting control.
    - New 800A switchboard.

3. Net Zero Energy: 230kW (DC) solar pv array

Nova Scotia Power Net Metering Program

The current Nova Scotia Power net metering agreement has expired. An update to the program is under review by the Nova Scotia Utility Review Board and Nova Scotia Power. Under the old agreement only 100kW of solar could be installed on any building. Under the new net metering agreement, it is proposed to allow up to 1MW of solar to be installed on any building that incurs a demand charge. There will be two new classifications of net metered systems in the new program, a class 1 system which is under 100kW and a class 2 system which is under 1MW.

In the net metering program, 100% of the excess energy generated from the solar array goes back onto the NSPI grid, and the customer gets a credit for the energy generated. Under the new proposal, the credit will be a percentage of the customers electricity rate for class 2 systems and will be equal to the customers electricity rate for class 1 systems. The credits automatically come off the power bill, further reducing the cost, the more solar that is installed. Being involved in a net-metering program is an essential part of achieving net-zero as it allows any excess energy generated to flow back onto the grid.

It is possible to install photovoltaics and not enroll in the net metering program. In this scenario, the building would draw power from the solar array as it is needed (up to the arrays maximum capacity). Any excess energy that is generated by the array is clipped (wasted) and no credit is given by the utility for that power. This scenario is only feasible if the customer routinely uses the approximate amount of power the array would generate. To optimize this, a short load study would be performed on the building to determine approximately how much energy is used at any given time of the day/ year, and an array of the average size could be constructed to offset that consumption. This scenario isn't truly considered net-zero since to use 100% of the energy generated, the solar array must overproduce.

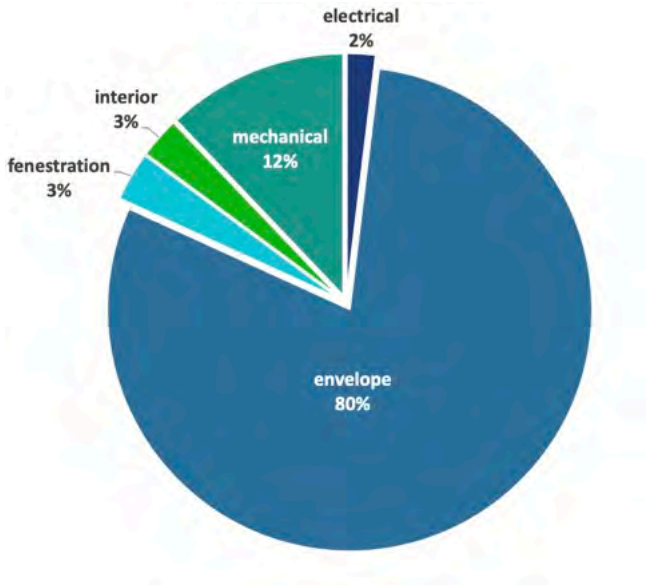
The net-metered option is recommended to ensure that a net-zero system can be achieved. As the conditions for the net-metering program are changing day to day, further consultation with Nova Scotia Power will be needed to ensure all requirements are met prior to construction.

Construction Costs

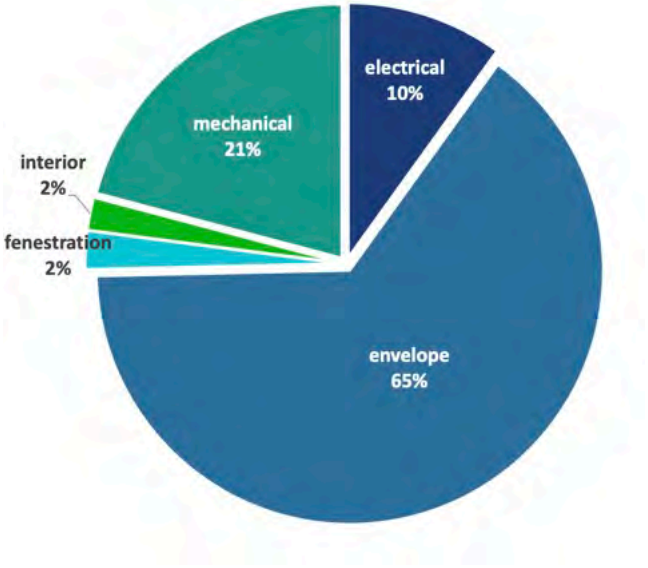
Class D – Feasibility Cost Estimates (Appendix M) were obtained for the Minimum Upgrade, the two Net Zero Energy Ready scenarios and Net Zero Energy retrofit scenarios. The costs include all materials, labour, equipment, overheads, general conditions, plus markups and contractor's profit for the retrofit options. Pricing reflects competitive bids for every element of the work for a project of this type procured under an open market stipulated lump sum bid contract in Debert, Nova Scotia.

A Class D estimate is an indicative estimate of the final project costs and is expected to be within ±25% of actual costs.

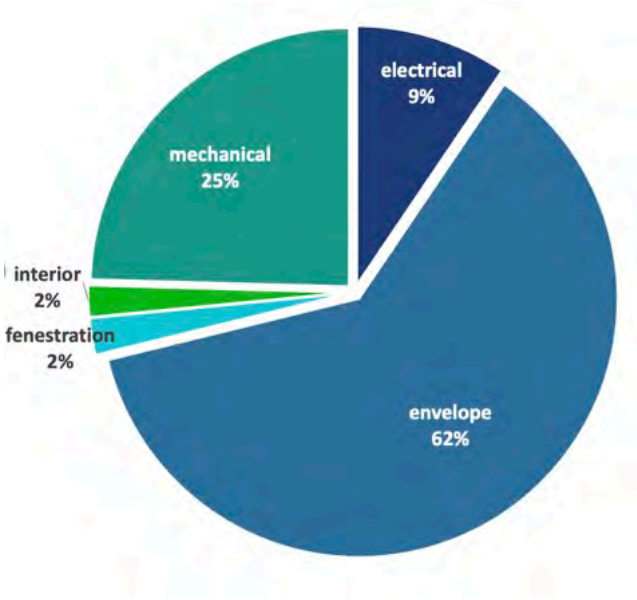
Minimum Upgrade	
Envelope	$10,865,224
Fenestration	$451,607
Interiors	$375,749
Mechanical	$1,647,125
Electrical	$262,293
total	**$13,601,998**



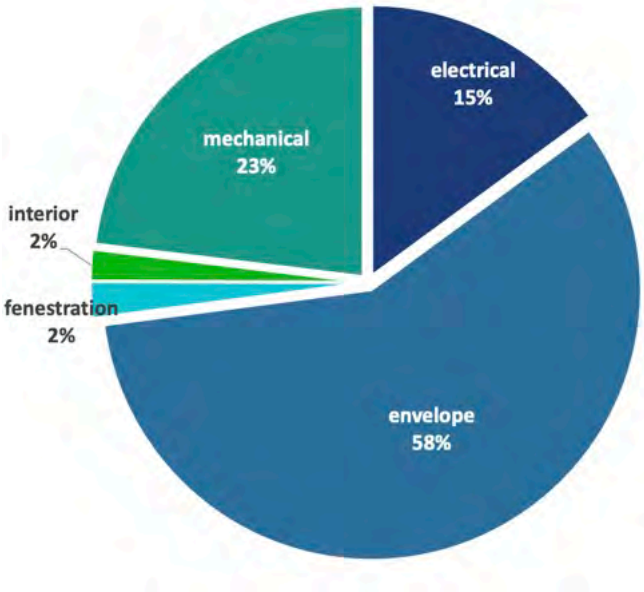
NZER –ASHP	
Envelope	$12,165,733
Fenestration	$451,608
Interiors	$388,291
Mechanical	$3,928,074
Electrical	$1,869,293
total	**$18,803,000**



NZER – GSHP	
Envelope	$12,165,506
Fenestration	$451,600
Interiors	$388,284
Mechanical	$4,842,353
Electrical	$1,869,258
total	**$19,717,000**



NZE – GSHP	
Envelope	$12,165,859
Fenestration	$451,613
Interiors	$388,295
Mechanical	$4,842,493
Electrical	$3,136,740
total	**$20,985,000**



Total Cost of Building Ownership

Total Cost of Building Ownership (TCBO) analysis was conducted using the Sustainable Energy Efficient Facility Asset Renewal (SEEFAR)-Valuation© program. Calculations include costs for utilities, insurance, carbon tax, maintenance, maintenance capital (replacing major components as they age out), interest, and escalation of these costs over time. TCBO analysis typically includes property taxes, however the building is not subject to property tax. The input parameters for the SEEFAR-Valuation© are given in Appendix N.

The following tables present a comparative analysis of the existing **base case** TCBO and each of the retrofit scenarios explored by the design team. A base case TCBO was evaluated based on the current condition of the building and the maintenance and renewal that would be required for the next 60 years for all components of the building, including interior elements. The TCBO for each retrofit scenario was modeled based on the design details, modeled energy performance and construction cost estimates for the retrofit scenarios outlined in this report.

Table 5 TCBO Summary

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE
GHG emissions (kg) (60 Years)	33,263,379	10,315,774	10,890,984	9,750,148	0
EUI (kWh/m2/year)	248.6	56.0	36.4	32.6	0.0
TCBO at 60 years	**$83,302,000**	**$70,019,000**	**$88,623,000**	**$82,166,000**	**$73,947,000**
TCBO Savings at 60 years	$0	$13,283,000	-$5,321,000	$1,136,000	$9,355,000
% diff. from Base Case	-	16%	-6%	1%	11%

Key TCBO Results:

- The base case TCBO is $83M, about seven times the estimated Cost Replacement Value (CRV) of $12.3M.
- The minimum upgrade scenario uses 77% less energy than the base case and saves 16% in lifetime operating costs.
- The NZER– ASHP option uses 85% less energy than the base case but costs 6% more than the base case.
- The NZER –GSHP option uses 85% less energy than the base case but costs virtually the same over the remaining life of the building.
- A NZE retrofit provides 100% energy savings, and a $9.3M reduction in lifetime operating costs over a NZER retrofit.
- The lowest TCBO is the Minimum Upgrade with a 16% reduction in TCBO and a savings of $13.3M. However, this analysis does not include the costs associated with eventual electrification of the Minimum Upgrade between now and 2050.

Table 6 Operating Cost Summary					
	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE
Utilities (including carbon tax)					
Cost	$ 58,279,000	$ 14,812,000	$ 11,743,000	$ 10,565,000	$ 493,000
Diff. from Base Case	$ -	$ (43,467,000)	$ (46,536,000)	$ (47,714,000)	$ (57,786,000)
% diff from Base Case	0%	-75%	-80%	-82%	-99%
Energy Cost ($/ft2)	$ 728.49	$ 185.15	$ 146.79	$ 132.06	$ 6.16
					Maintenance
Cost	$ 279,000	$ 302,000	$ 407,000	$ 407,000	$ 1,165,000
Diff. from Base Case	$ -	$ 23,000	$ 128,000	$ 128,000	$ 886,000
% diff from Base Case	0%	8%	46%	46%	318%
Cost ($/ft2)	$ 3.49	$ 3.78	$ 5.09	$ 5.09	$ 14.56
					Insurance & Taxes
Costs	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000
Diff. from Base Case	$ -	$ -	$ -	$ -	$ -
% diff from Base Case	0%	0%	0%	0%	0%
					First Year Annual Maintenance
Cost	$ 2,400	$ 2,600	$ 3,500	$ 3,500	$ 10,011
Diff. from Base Case	$ -	$ 200	$ 1,100	$ 1,100	$ 7,611
% diff from Base Case	0%	8%	46%	46%	317%
Cost ($/ft2)	$ 0.03	$ 0.03	$ 0.04	$ 0.04	$ 0.13

- The 60-year utility costs for the Base Case are 4.75 times the CRV of the building.
- The NZR options reduce the 60-year utility costs by 80%.
- A NZE retrofit reduces the energy costs by 99% to $42,000, which is the meter charge or minimum charge for the electrical service.
- The maintenance costs for all scenarios have increased due to added mechanical and solar equipment.
- Insurance costs are the same for all options.

Parameters:

- The analysis start year is 2024. Utility, construction, and maintenance costs have been escalated to 2024. Construction costs have been escalated by 20% for 2022-23, and by 10% from 2023-24, or 32% over the two years.
- NS Power rates will increase by 7.1% in 2023 and 7.0% in 2024.
- Carbon tax for fuel oil came into effect in NS in 2023, it is calculated separately in the SEEFAR model and is not included in the fuel oil price.
- Carbon tax has been applied to electricity as it is expected to be passed on to the customer by NS Power.
- Solar panel maintenance is based on $28/kWdc/year.

Table 7 Capital Cost Summary					
	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE
Initial Retrofit / HPB CostYear 1					
Initial Cost	$ 1,616,000	$ 15,947,000	$ 21,487,000	$ 22,461,000	$ 23,289,000
Diff. from Base Case	$ -	$ 14,331,000	$ 19,871,000	$ 20,845,000	$ 21,673,000
% diff from Base Case	0%	887%	1230%	1290%	1341%
Cost ($/ft2)	$ 20	$ 199	$ 269	$ 281	$ 291
Maintenance Capital Costs 60 Years					
Cost	$ 21,806,000	$ 30,976,000	$ 44,427,000	$ 37,722,000	$ 37,604,000
Diff. from Base Case	$ -	$ 9,170,000	$ 22,621,000	$ 15,916,000	$ 15,798,000
% diff from Base Case	0%	42%	104%	73%	72%
Cost ($/ft2)	$ 273	$ 387	$ 555	$ 472	$ 470
Retrofit / HPB + Maintenance Capital Costs 60 Years					
Total Costs	$ (23,422,000)	$ (46,923,000)	$ (65,914,000)	$ (60,183,000)	$ (60,893,000)
Diff. from Base Case	$ -	$ (23,501,000)	$ (42,492,000)	$ (36,761,000)	$ (37,471,000)
% diff from Base Case	0%	-100%	-181%	-157%	-160%

The Capital Cost Summary compares the first-year capital investment in maintaining the existing building with the construction costs for the retrofit scenarios. The capital costs for the retrofits have been escalated to 2024 values from the construction cost estimate. The retrofits costs are high because of the extensive work on the building enclosure and due to new mechanical systems and solar panels in the NZER and NZE scenarios. The costs of all retrofit scenarios are more than the CRV of the building.

Maintenance capital is the cost of replacing major building components as they wear or age out. For example, the boiler needs to be replaced every 25 years.

This analysis assumes that solar panels will not be replaced in the 60-year time frame of the analysis, but that they will undergo regular renewal through annual maintenance.

	Units	Table 8 Annual Energy Consumption				
		Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE
Water	m3	902.00	902.00	902.00	902.00	902.00
Sewer Discharge	m3	902.00	902.00	902.00	902.00	902.00
Electric	kWh	235,673.00	164,078.00	270,920.00	242,541.00	242,541.00
Gas	m3	-	-	-	-	-
Heating Oil	Litres	148,888.00	23,281.00	-	-	-
GHG emissions	kg CO2 eq	554,389.65	171,929.56	181,516.40	162,502.47	-
Solar PV generated	kWh	-	-	-	-	242,541.00
Total	ekWh	#########	416,288.83	270,920.00	242,541.00	-
Total	GJ	6,655.05	1,498.64	975.31	873.15	-
EUI	kWh/m2/yr	**248.64**	**55.99**	**36.44**	**32.62**	-

Key Results:

- Total energy consumption is decreased in all retrofit scenarios the Net Zero Energy scenario has zero consumption.
- Annual electrical consumption increases in the NZER and NZ scenarios due to the electrification of mechanical equipment.
- GHG emissions and EUI are reduced across all retrofit scenarios.
- The minimum upgrade reduces GHGs and EUI by 77%.
- The NZR options reduce GHGs and EUI by 86% and the Net Zero Energy retrofits reduce GHGs by 100%.
- A new NS Power net metering policy is proposed to be adopted later in 2023. The building could be net-positive if policy permits.
- Water consumption is the same in all options, as this water use was not a focus of the study. There may be an opportunity for savings through plumbing upgrades.

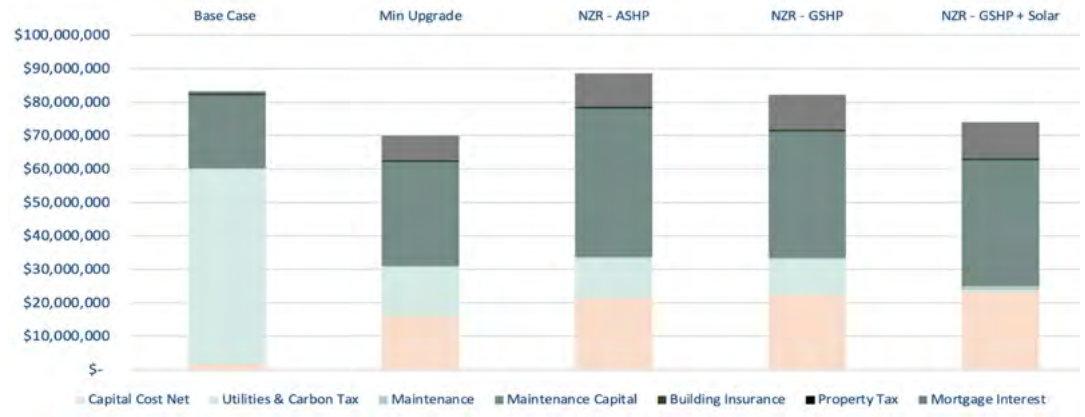


Figure 22 TCBO Comparison

Cumulative TCBO

The existing building has the lowest TCBO for the first 51 years, but the Minimum Upgrade has lower costs for the remaining life of the building.

The Minimum Upgrade retrofit is the best investment for this building, resulting in a 77% reduction in GHG emissions and 16% operational savings compared with the existing base case.

This scenario maintains fuel oil-based heating, and the building must be electrified by 2050.

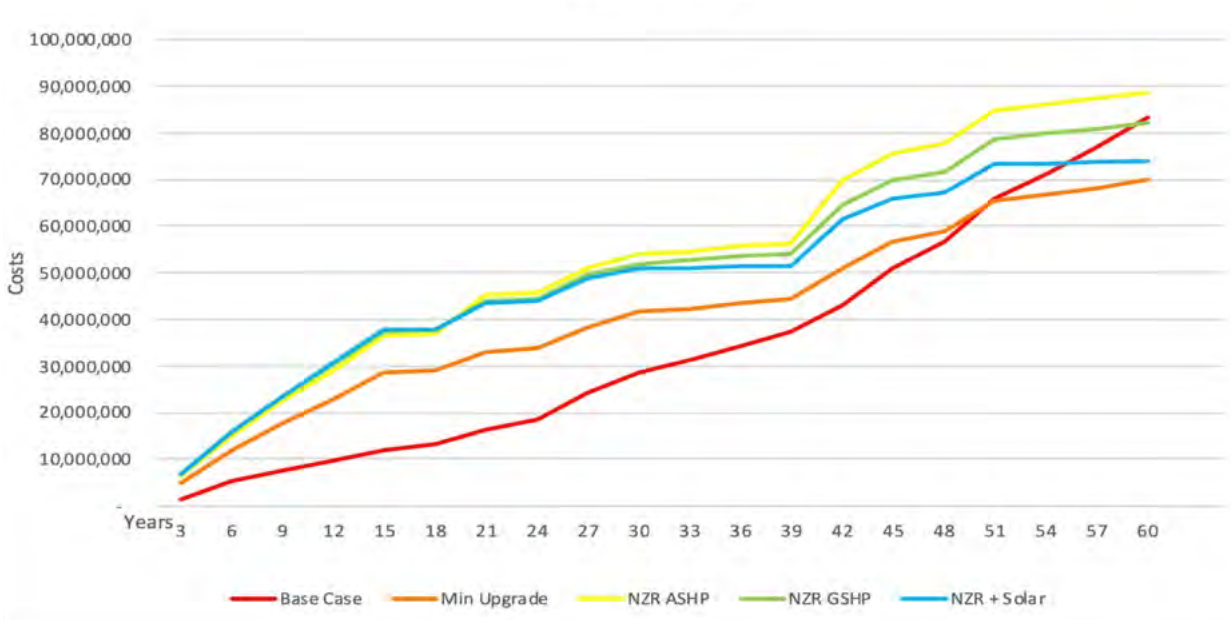


Figure 23 Cumulative TCBO

Discussion

The Town of New Glasgow has a population of approximately 10,000 people. Their operating budget for 2022-2023 is just over $22 million dollars. The least expensive retrofit considered, the Minimum Upgrade, costs more than their annual capital budget of $13.1M.

The high cost to retrofit this building will inevitably raise the question of demolishing and building new or pulling up stakes entirely and finding a new location for the Municipal Operations. A new building would have the advantage of being purpose built for the municipality's needs and could more easily attain high performance targets.

Yet, this building exists now. A deep retrofit today means it can last another 60 years or more. A panelized deep retrofit means that it can continue to be operational with only minimal disruption to essential town services. Demolishing it and building new means additional expense in relocation, a much longer wait to be in the finished building and preventable emissions in the form of embodied carbon will be released in construction.

The embodied carbon in the retrofit is 51.13 kgCO2e. One 15m steel beam in the existing building has an embodied carbon of 12,56 kgCO_2e[9]. This highlights the importance of being thoughtful about demolition in evaluating decarbonization options.

Money is a barrier to retrofit acceleration. But it only one resource among many that challenge efforts to reduce GHGs. There is also insufficient time, personnel and raw material to rebuild every building in the country that is too inconvenient, too technically challenging, or too costly to retrofit.

The $13M Minimum Upgrade scenario achieves a 66% reduction in EUI and saves 382,460 kgCO^2e from being emitted annually and has the best TCBO at 16% lower than the base case. Of the options considered it is the best investment for the Town of New Glasgow. Yet moving forward with this scenario will lock in its oil-fired systems for years to come. The TCBO analysis for this option does not capture the costs of the necessary electrification of the building at some point between now and 2050. That future cost is likely to offset the difference between the Minimum and NZER options today.

Should New Glasgow spend their entire capital budget to retrofit one building? It is not their only building, and not their only building with a very high EUI. This situation demonstrates the magnitude of the problem facing Canada's municipalities. Small and large they are under-resourced for the work ahead.

The Net Zero Energy option is an 11% TCBO savings and prevents 554,390 kgCO^2e from being emitted per year and costs more than $20M. It is not the easy option, but it is the right one.

[9] Calculated using Building Emissions Accounting for Materials (BEAM) calculator, by Builders for Climate Action.

Conclusions

This study of Panelized Deep Retrofits of Municipal Buildings was undertaken to develop deep retrofit strategies to support municipal decarbonization efforts by adapting the Energiesprong approach to the Canadian context.

The project goals were to develop deep retrofit scenarios that can achieve 50% or more EUI savings and a scenario that can achieve Net Zero Energy (NZE) with the addition of solar PV. The solutions needed to minimize occupant disruption and embodied carbon. The recommended retrofit pathway would be the option with the lowest Total Cost of Building Ownership. Finally, the recommended solution should demonstrate a calculated payback of 20 years or better.

The technical details of the retrofit scenarios were straightforward. The economic targets were challenging and in the case of the 20-year payback, not one of the six proposed retrofits can be shown to achieve it.

The ReCover Initiative has studied the potential for prefabricated panelized deep retrofits in lo-rise multi-unit dwellings in two previous case studies[10]. These studies found the lowest TCBO over the anticipated life of the building was achieved through Net Zero Energy retrofits where the targets were met with an Energy Use Intensity (EUI) reduction of at least 75% before adding solar PV. This was not the result in the Panelized Retrofits to Municipal Buildings study.

While the results of this project were not expected, they do serve the objectives to de-risk investment in deep retrofits in Canada, to provide evidence on the effectiveness and scalability of a panelized deep retrofit approach and to build confidence and experience in deep retrofits among Canadian municipalities and industry stakeholders.

This study shows that the technical challenges are secondary to the overwhelming barrier of cost. It also showed that if investment in deep retrofits doesn't start now robust building upgrades now, municipalities will pay exponentially more down the road.

The New Glasgow Municipal Operations Building is one of the town's most energy intensive buildings, with annual GHGs measuring close to 400tCO2e. Investment in an innovative deep retrofit solution for this building will result in $9.3M in savings for the Town of New Glasgow, enable densification of an underused resource and increase the lifespan of the asset.

Investment in the project is an opportunity to begin to create a deep retrofit recipe for a building type that is incredibly energy inefficient and ubiquitous.

[10] ReCover Initiative (2020) *ReCover Phase One Case Study Report* and ReCover Initiative (2022) *Scarlettwood Court Deep Retrofit Case Study Repor*t, https://www.recoverinitiative.ca/about-us/our-results/report-request

Appendix A

Pre-retrofit Drawings

- **Existing Drawings**
- **LiDAR Drawings**

DRAWING REFERENCE

DRWG. No.	DESCRIPTION
KF-520	TYPICAL SERVICE DESK DRAWING SHOWING OUTLETS AND SERVICES REQUIRED.
KF-1473	INTERIOR SIGN AND DECOR DRWG.
KF-1433	CORNICE REQUIREMENTS.
KA-1	SHOWING ADDITIONS & ALTERATIONS TO EXISTING KMART.
KA-484	PROPOSED BARGAIN HAROLDS STORE REQUIREMENTS.
PRINCE	DRWG No. N-25990 SHOWING DECOR AND REQUIREMENTS @ CAFETERIA.
DATA BOOK	SHOWING FIXTURE REQUIREMENTS, DETAILS ETC. & GENERAL INFORMATION.
K.D.	CHECK LIST ON FORM 1056.
KF-1478	SERVICE DESK REQUIREMENTS.

ALSO REFER TO FINAL KF-1 & MERCHANDISE LAYOUT

APPROVED BY

APPROVED BY K. T. BOYLE

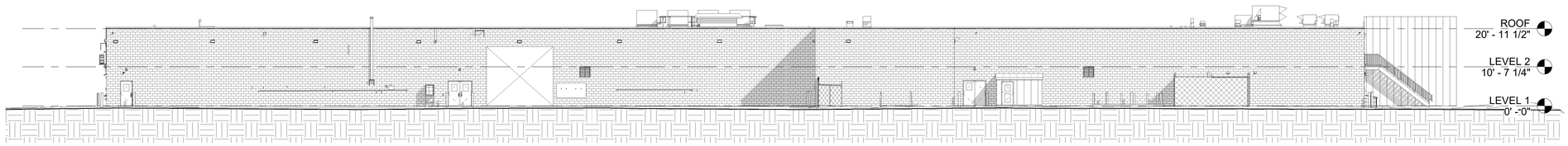
TITLE
CORNICE REQUIREMENTS DETAIL

K MART No. 5475

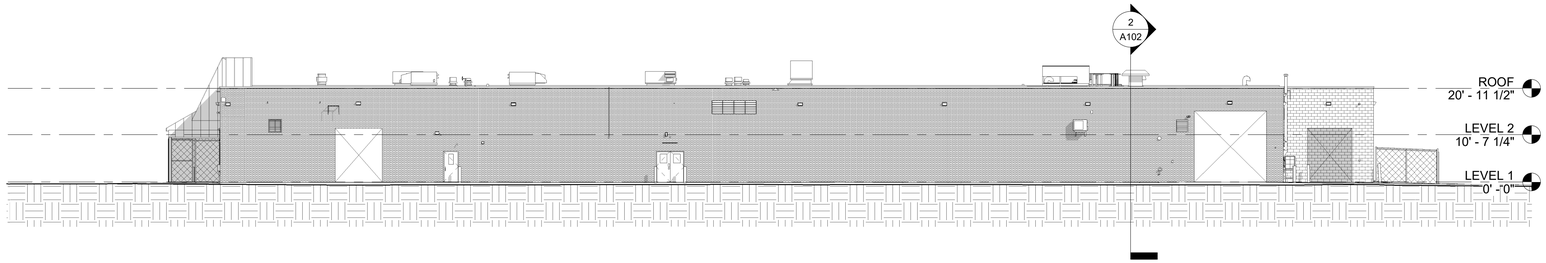
K MART CANADA LTD.
STORE PLANNING DEPARTMENT
BRAMPTON ONTARIO

DRAWN BY: [illegible]
DATE: JUNE 15 1983
SCALE
CHECKED BY
DRAWING No. KF-1433

Kmart

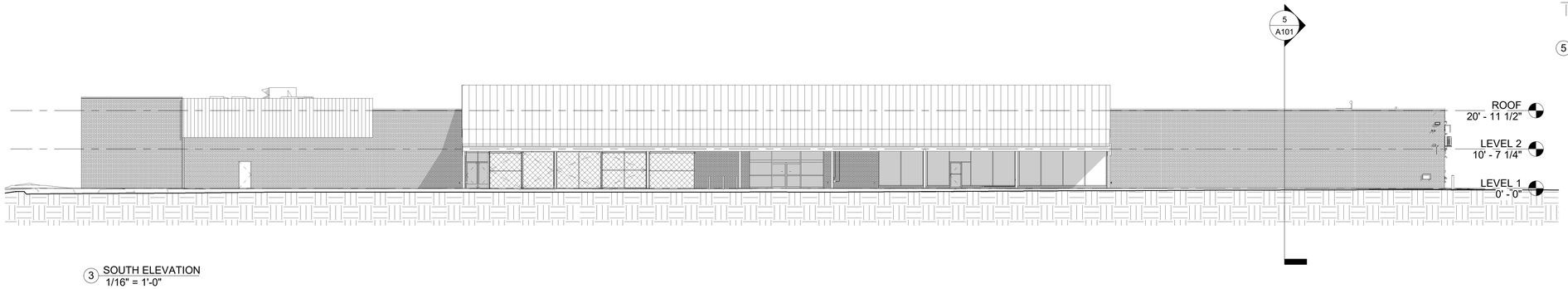


1 NORTH ELEVATION
1/16" = 1'-0"



2 EAST ELEVATION
1/16" = 1'-0"

5 SECTION 2
1/8" = 1'-0"



3 SOUTH ELEVATION
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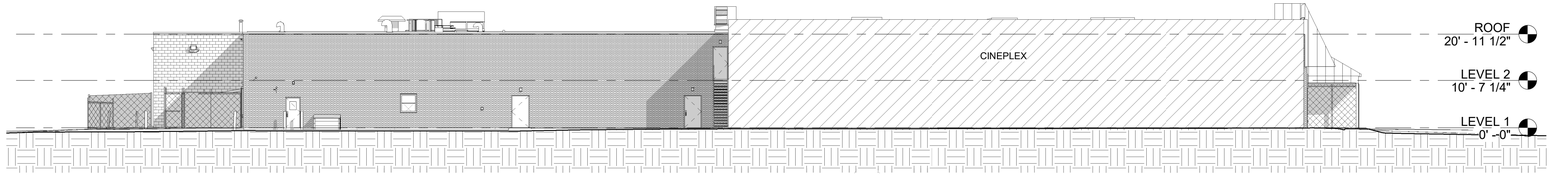

4 WEST ELEVATION
1/16" = 1'-0"

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NEW GLASGOW KMART - EXISTING CONDITIONS

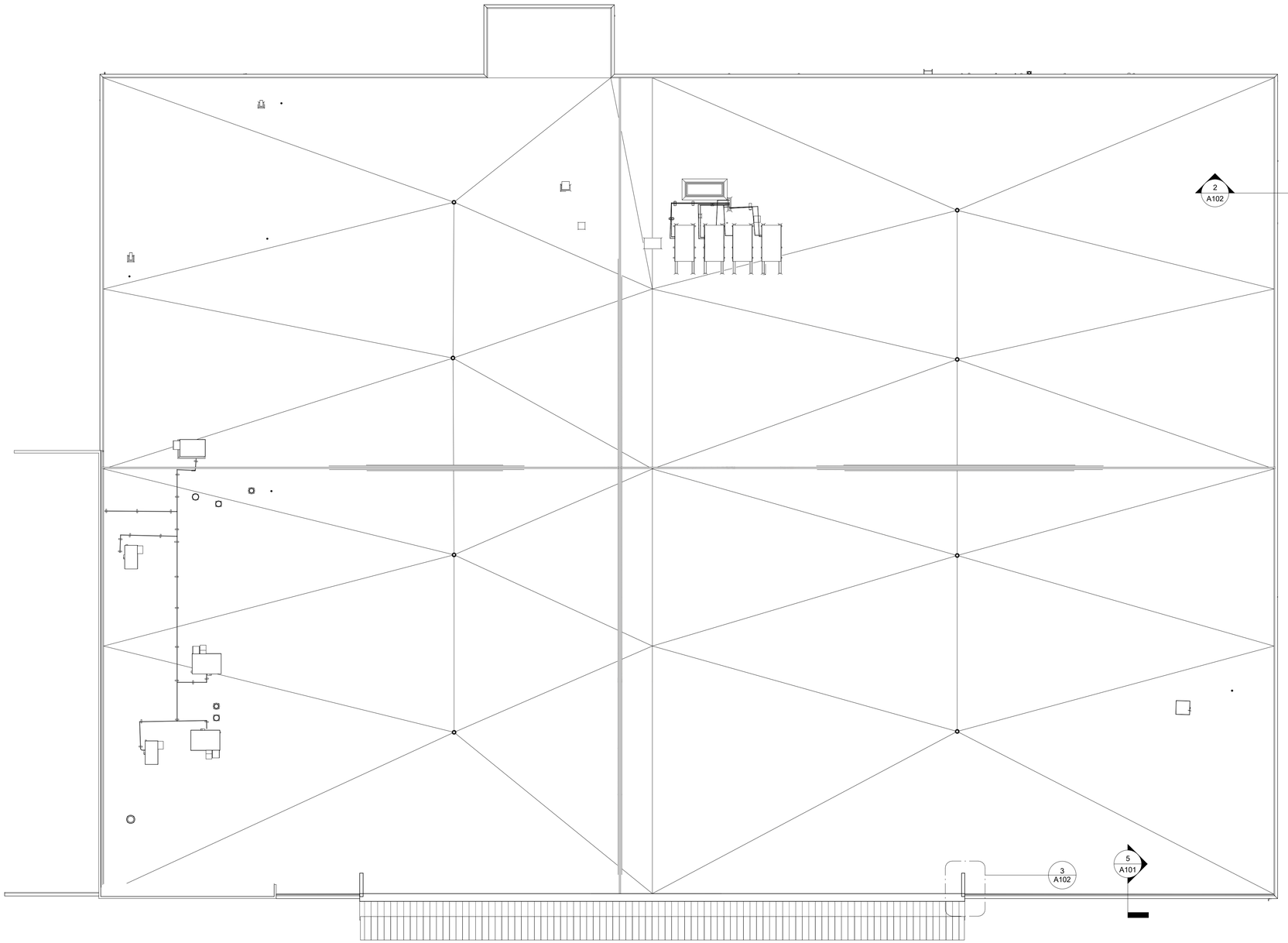
612 EAST RIVER RD

PROJECT NUMBER:	310-1629
FIELD WORK:	BS/JB
DRAWN:	KM
AUDIT:	GH
SUBMISSION:	2022-07-14

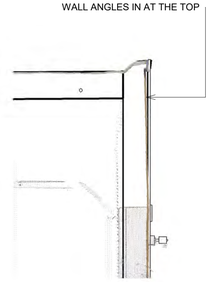
ELEVATIONS

SCALE: As indicated

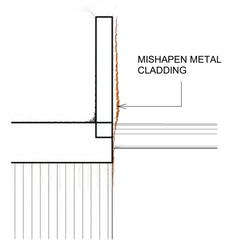
A101



1 ROOF PLAN
1/16" = 1'-0"



2 SECTION 1
3/8" = 1'-0"



3 ROOF PLAN - CALLOUT 1
1/4" = 1'-0"

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NEW GLASGOW KMART - EXISTING CONDITIONS

612 EAST RIVER RD

PROJECT NUMBER:	310-1629
FIELD WORK:	BS/JB
DRAWN:	KM
AUDIT:	GH
SUBMISSION:	2022-07-14

ROOF PLAN

SCALE: As indicated

A102

Appendix B

Facility Condition Assessment

General Building Information Worksheet

Building Name	Dept. of Transportation, New Glasgow
Civic Address	624 East River Rd
Municipality, City	New Glasgow
Primary Use / Building Type	Municipal Services Bldg
Primary Units	Square Foot
Building Area Square Foot	82,000
Replacement Cost per Square Foot	$ 150
Building Replacement Cost	$ 12,300,000
Year of Construction or Major Renovation	1974
Start Year	2022
Current Year	2022
Target FCI	8%
Soft Costs (%)	25%
Interest Rate	2.50%
Inflation Rate	8.00%

Asset Definition Columns	
1	Site Work
2	Structure
3	Roof
4	Exterior Envelope
5	Building Interior
6	Mechanical
7	Electrical
8	Life Safety / Fire Suppression
9	Vertical Con. & Specialty Systems

Building Component Summary Worksheet

Dept. of Transportation, New Glasgow

									Decision Parameters										
Component	Uniformat Code	Recapitalization Detail	Year of Installation or Repair	Expected Useful Life (EUL)	Current Age	Theoretical Remaining Useful Life (RUL)	Useful Life Corrected For Observations	Year of Replacement	Life Safety	O&M Impact	Impact to Business	Utility	Vision	Total	Type of event (Cyclic/Single)	Unit	Quantity	Unit Cost	Total Cost
Site Work																			
Asphalt Parking, South & East Side, adjacent to the building	G2020 - Parking Lots	Replace asphalt at end of useful life	2020	20	2	18	10	2032	No	Yes	Yes	High	No	3	Cyclical	ft²	39,000	$ 5.50	$ 214,500
Chain Link Fence	B2030 - Chain Link Fence	Replace at end of useful life	2000	40	22	18	18	2040	No	Yes	No	Low	No	0	Cyclical	ft	1,100	$ 22.00	$ 24,200
Chain Link Fence - Repair allowance	B2030 - Chain Link Fence	Repair allowance every five years for equivalent to 150 ft	2000	5	22	-17	18	2040	No	No	Yes	Normal	No	1	Cyclical	ft	150	$ 22.00	$ 3,300
Gravel Parking Lot, Equipment laydown area, east side	G2020 - Parking Lots	Add gravel and re-grade as needed as part of operations and maintenance	2000	80	22	58	50	2072	No	Yes	No	High	No	2	Single	ft²	25,000	$ -	$ -
Concrete sidewalk, Front of building	G2030 - Pedestrian Paving	Replace concrete sidewalk at end of useful life	1974	40	48	-8	25	2047	No	No	Yes	Low	Yes	1	Cyclical	ft	325	$ 45.00	$ 14,625
Structure																			
Concrete Foundation	A1010 - Standard Foundations	Allowance for minor repairs, 1% of floor plate	1974	75	48	27	15	2037	No	No	Yes	Low	No	0	Single	ft²	835	$ 56.00	$ 46,760
Slab on Grade: Repair rear overhead door area	B1010 - Floor Construction	Concrete slab appears to be degrading. Aggregate is showing and concrete topping has worn.	1974	40	48	-8	0	2022	No	No	Yes	High	No	2	Single	ft²	3,000	$ 12.85	$ 38,550
Slab on Grade	B1010 - Floor Construction	Repair slab on grade- Allowance 2.5% of floor plate to address slab issues	1974	75	48	27	15	2037	Yes	Yes	Yes	High	No	4	Single	ft²	2,050	$ 56.35	$ 115,518
Steel columns and joists (assessment)	B1020 - Roof Construction	Complete structural assessment to ensure original design meets current snow load requirement	1974	75	48	27	0	2022	Yes	Yes	Yes	Normal	No	3	Single	Ea	1	$ 5,500.00	$ 5,500
Steel Superstructure	B1020 - Roof Construction	Replace structure at end of useful life	1974	75	48	27	50	2072	Yes	Yes	Yes	Normal	No	3	Cyclical	ft	83,500	$ 25.00	$ 2,087,500
Roof																			
Modified Bitumen Roof - Southeast quadrant	B3010 - Roof Coverings	Replace membrane at end of useful life	2010	20	12	8	5	2027	No	Yes	Yes	High	No	3	Cyclical	ft²	17,000	$ 22.00	$ 374,000
Modified Bitumen Roof - Southwest quadrant	B3010 - Roof Coverings	Replace membrane at end of useful life	2010	20	12	8	5	2027	No	Yes	Yes	High	No	3	Cyclical	ft²	17,000	$ 22.00	$ 374,000
Modified Bitumen Roof - Northwest quadrant	B3010 - Roof Coverings	Replace membrane at end of useful life	2010	20	12	8	8	2030	No	Yes	Yes	High	No	3	Cyclical	ft²	17,000	$ 22.00	$ 374,000
Modified Bitumen Roof - Northeast quadrant	B3010 - Roof Coverings	Replace membrane at end of useful life	2010	20	12	8	5	2027	No	Yes	Yes	High	No	3	Cyclical	ft²	17,000	$ 22.00	$ 374,000
Exterior Envelope																			
Prefinished Metal Awning - maintenance	B3010 - Roof Coverings	Clean and paint underside of awning	2010	35	12	23	1	2023	No	No	No	Normal	Yes	1	Cyclical	ft²	2,700	$ 2.50	$ 6,750
Prefinished Metal Awning - replacement	B3010 - Roof Coverings	Replace metal awning at end of useful life, minor corrosion noted on under side.	2010	35	12	23	23	2045	No	No	No	Normal	Yes	1	Cyclical	ft²	2,700	$ 25.00	$ 67,500
Brick Exterior Walls - repointing	B2010 - Exterior Walls	Cyclic repointing to maintain brick	1974	5	48	-43	5	2027	No	Yes	Yes	Normal	Yes	3	Cyclical	ft²	1,750	$ 25.00	$ 43,750
Brick Exterior Walls - replace	B2010 - Exterior Walls	Replace brick at end of useful life	1974	75	48	27	50	2072	No	Yes	Yes	Normal	Yes	3	Cyclical	ft²	11,500	$ 52.50	$ 603,750
Concrete block walls - repointing	B2010 - Exterior Walls	Repoint concrete masonry units. Budget allowance. Localized step cracking noted from interior	1974	75	48	27	5	2027	No	Yes	No	Normal	No	1	Single	ft²	1,250	$ 25.00	$ 31,250
Overhead Door - East side (oversized door)	B2030 - Exterior Doors	Replace door at end of useful life	2010	15	12	3	5	2027	No	Yes	Yes	High	No	3	Cyclical	Ea	1	$ 10,000.00	$ 10,000
Overhead Door - Heavy Equipment maintenance bay SE Corner	B2030 - Exterior Doors	Replace door at end of useful life	2010	15	12	3	5	2027	No	Yes	Yes	High	No	3	Cyclical	Ea	1	$ 7,500.00	$ 7,500
Overhead Door - Sidewalk vehicle storage	B2030 - Exterior Doors	Replace door at end of useful life	2010	15	12	3	5	2027	No	Yes	Yes	High	No	3	Cyclical	Ea	1	$ 5,500.00	$ 5,500
Front entrance Door, Automatic sliding double doors	B2030 - Exterior Doors	Doors were not functional during the site visit. Replacement is anticipated.	2000	35	22	13	0	2022	No	Yes	Yes	Low	Yes	2	Cyclical	Ea	1	$ 7,500.00	$ 7,500
Curtain Glass Glazing, front elevation	B2020 - Exterior Windows	Replace glazing at end of useful life	2000	35	22	13	10	2032	No	Yes	Yes	Normal	No	2	Cyclical	ft²	1,024	$ 110.00	$ 112,640
Aluminium framed entrance door inset into curtain wall	B2030 - Exterior Doors	Replace door at end of useful life	2000	35	22	13	13	2035	No	Yes	No	Low	No	0	Cyclical	Ea	1	$ 2,500.00	$ 2,500
Double Steel Entrance - East Side	B2030 - Exterior Doors	Double steel doors with minor corrosion and minor impact damage, replacement required at end of life.	2005	25	17	8	8	2030	Yes	Yes	No	Normal	No	2	Cyclical	Ea	1	$ 2,500.00	$ 2,500
Double Steel Entrance - South Side	B2030 - Exterior Doors	Double steel doors with corrosion and minor impact damage, replacement required at end of life.	1995	25	27	-2	2	2024	No	Yes	No	Normal	No	1	Cyclical	Ea	1	$ 2,500.00	$ 2,500
Single Steel entrance door east side	B2030 - Exterior Doors	Door was observed to be in good condition	2015	25	7	18	18	2040	Yes	Yes	No	Normal	No	2	Cyclical	Ea	1	$ 1,000.00	$ 1,000
Single Steel entrance door south side	B2030 - Exterior Doors	Door was observed to be in good condition	2015	25	7	18	18	2040	Yes	Yes	No	Normal	No	2	Cyclical	Ea	1	$ 1,000.00	$ 1,000
Windows - vinyl framed	B2020 - Exterior Windows	Windows were in good condition, new window in staff room, Windows can be replaced as pat of regular operation and maintenance	2018	35	4	31	31	2053	No	Yes	No	Normal	No	1	Cyclical	LS	0	$ -	$ -
Building Interior																			
VCT Flooring, retail area	C3020 - Floor Finishes	Floor has reached the end of its life and needs to be replaced	1990	25	32	-7	0	2022	No	Yes	No	Normal	No	1	Cyclical	ft²	46,000	$ 9.86	$ 453,611
Office flooring	C3010 - Floor Finishes	Office flooring varies in finishes. The majority of the flooring is at or near end of life and will need to be replaced in the short term	1995	25	27	-2	5	2027	Yes	Yes	Yes	High	Yes	5	Cyclical	ft²	29,700	$ 9.86	$ 292,842
Washroom Flooring	C3020 - Floor Finishes	Currently a combination of unfinished exposed concrete and hard tile. Allowance for hard tile finish	1974	50	48	2	0	2022	No	Yes	No	Low	No	0	Cyclical	ft²	500	$ 14.50	$ 7,250
Gypsum Board Walls	C3010 - Wall Finishes	Gypsum wall board in fair condition, Repair as part of operations and maintenance activities	1974	60	48	12	20	2042	No	No	No	Normal	No	0	Cyclical	LS	0	$ -	$ -
Suspended Tile Ceiling - Retail area	C3030 - Ceiling Finishes	Tiles are at end of life with damage and bowing noted, replacement anticipated	1995	20	27	-7	0	2022	No	Yes	Yes	Normal	No	2	Cyclical	ft²	46,000	$ 6.91	$ 317,860
Interior Doors	C1020 - Interior Doors	Interior doors varied in condition but were generally in good condition, Individual door replacement can be done through operation and maintenance activities.	1974	60	48	12	20	2042	No	No	No	Low	No	-1	Cyclical	Ea	0	$ -	$ -
Washroom Ceilings - splined tiles	C3030 - Ceiling Finishes	Replacement anticipated in long term.	1995	20	27	-7	7	2029	No	No	No	Normal	No	0	Cyclical	ft²	500	$ 6.91	$ 3,455
Washroom Vanities	E2010 - Fixed Furnishings	Replace at end of useful life. Preformed laminate counter top in good condition	2012	20	10	10	10	2032	No	No	No	High	No	1	Cyclical	Lft	24	$ 250.00	$ 6,000

Washroom Partitions	C1010 - Partitions	Partition were in fair condition, replacement is anticipated in the short term	1995	30	27	3	3	2025	No	No	No	High	No	1	Cyclical	Ea	7	$ 1,250.00	$ 8,750
Mechanical																			
Plumbing Service	D2020 - Domestic Water Distribution	No reported issues with incoming water service, no major repair or replacement anticipated	1974	40	48	-8	15	2037	No	Yes	Yes	Normal	No	2	Cyclical	LS	1	$ -	$ -
Back flow preventer	D2020 - Domestic Water Distribution	No backflow preventer was identified, in its absence a back flow preventer should be installed	1974	40	48	-8	0	2022	Yes	No	Yes	Normal	No	2	Cyclical	LS	1	$ 1,500.00	$ 1,500
Domestic Hot Water Tank- Giant 2018	D2020 - Domestic Water Distribution	Replace hot water tank at end of useful life	2018	15	4	11	11	2033	No	No	No	Normal	No	0	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Domestic Hot Water Tank- Giant 2017	D2020 - Domestic Water Distribution	Replace hot water tank at end of useful life	2017	15	5	10	10	2032	No	No	No	Normal	No	0	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Domestic Hot Water Tank- Bradford and White	D2020 - Domestic Water Distribution	Replace hot water tank at end of useful life	2020	15	2	13	10	2032	No	No	No	Normal	No	0	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Copper Piping Distribution - repair allowance	D2020 - Domestic Water Distribution	Distribution reported to be in good condition with no leaks reported. Maintenance allowance every five years anticipated to be required for selective replacement.	2022	5	0	5	0	2022	No	Yes	Yes	Low	No	1	Cyclical	LS	1	$ 7,500.00	$ 7,500
Plumbing Fixtures, sinks, urinal, toilets	D2010 - Plumbing Fixtures	Replacement anticipated at end of useful life,	1995	35	27	8	8	2030	No	Yes	Yes	Normal	No	2	Cyclical	Ea	18	$ 1,000.00	$ 18,000
Fuel Oil Tank 20000 l estimated	D3010 - Energy Supply	Fuel Tank was not observed. It is assumed to be a dual walled 20,000 l tank. To be confirmed by site contact.	2000	30	22	8	8	2030	Yes	Yes	Yes	Normal	Yes	4	Cyclical	Ea	1	$ 10,000.00	$ 10,000
Volcano Boiler 100 hp rating	D3020 - Heat Generating Systems	Replace boiler.	1974	40	48	-8	0	2022	Yes	Yes	Yes	High	No	4	Cyclical	Ea	1	$ 61,100.00	$ 61,100
Air Handling Unit- coil	D3040 - Distribution Systems	Heating coil repair / replacement allowance	2007	30	15	15	14	2036	No	Yes	Yes	High	No	3	Cyclical	Ea	1	$ 16,450.00	$ 16,450
Air Handling Unit	D3040 - Distribution Systems	Air handling unit consists of three rooms, return, fan room and supply. 25 hp motor and fan. Louvre and coil reported separately. Partial replacement allowance.	1974	40	48	-8	5	2027	No	Yes	Yes	High	No	3	Cyclical	Ea	1	$ 14,650.00	$ 14,650
Fan Coil Units (FCU)	D3040 - Distribution Systems	Varies in age, due to low cost of individual units, replacement is usually completed as part of operations and maintenance		15	2022	-2007		2022	No	Yes	Yes	High	Yes	4	Cyclical				$ -
Electrical																			
Main Disconnect Square D, 800A 600V	D5010 - Electrical Service and Distribution	Replace at end of useful life	1974	40	48	-8	0	2022	Yes	Yes	Yes	Normal	No	3	Cyclical	Ea	1	$ 24,150.00	$ 24,150
Transformers	B2020 - Exterior Windows	Replacement is not anticipated to be required	1974	40	48	-8	20	2042	Yes	Yes	Yes	High	Yes	5	Cyclical	LS	0	$ -	$ -
Secondary disconnects	D5010 - Electrical Service and Distribution	Replacement anticipated to be required due to age and lack of replacement parts	1974	40	48	-8	0	2022	Yes	Yes	Yes	Normal	No	3	Cyclical	LS	1	$ 25,000.00	$ 25,000
Branch Wiring and secondary panels	D5020 - Lighting and Branch Wiring	Allowance for selective replacement on a cyclic basis	2022	5	0	5	0	2022	Yes	Yes	Yes	Normal	No	3	Cyclical	LS	1	$ 5,000.00	$ 5,000
Lighting - Retail and office areas	D5020 - Lighting and Branch Wiring	The lighting generally consists of florescent type fixtures with LED tubes. Fixtures are at end of life, complete relamping is anticipated.	1995	20	27	-7	0	2022	No	Yes	Yes	Normal	No	2	Cyclical	ft²	49,000	$ 9.74	$ 477,260
Lighting, Metal Halide Pendant	D5020 - Lighting and Branch Wiring	Replacement is not anticipated,	1995	20	27	-7	15	2037						0	Cyclical	LS	1	$ -	$ -
Life Safety / Fire Suppression																			
Exit Signs and battery backup emergency lighting	D4030 - Fire Protection	Replacement is typically completed as needed as part of operation and maintenance	1974	40	48	-8	10	2032	Yes	No	No	Low	Yes	1	Cyclical	Ea	0	$ -	$ -
Sprinkler system	D4010 - Sprinklers	Replacement is not anticipated. Localized repair and replacement is completed as part of operations and maintenance. Last inspected by Fire Stop Enterprises 2022/12/03	1974	40	48	-8	0	2022	Yes	Yes	Yes	Low	No	2	Cyclical	LS	1	$ -	$ -

Dept. of Transportation, New Glasgow
Cash Flow Analysis Output Sheet

Component	Recapitalization Detail	Year of Replacement	Expected Useful Life (EUL)	Total Cost	Year 1 2022	Year 2 2023	Year 3 2024	Year 4 2025	Year 5 2026	Year 6 2027	Year 7 2028	Year 8 2029	Year 9 2030	Year 10 2031	Year 11 2032	Year 12 2033	Year 13 2034	Year 14 2035	Year 15 2036	Year 16 2037	Year 17 2038	Year 18 2039	Year 19 2040	Year 20 2041	Year 21 2042	Year 22 2043	Year 23 2044	Year 24 2045	Year 25 2046
Site Work																													
Asphalt Parking, South & East Side, adjacent to the building	Replace asphalt at end of useful life	20	2032	$ 214,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$214,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Chain Link Fence	Replace at end of useful life	40	2040	$ 24,200	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 24,200	$ -	$ -	$ -	$ -	$ -	$ -
Chain Link Fence - Repair allowance	Repair allowance every five years for equivalent to 150 ft	5	2040	$ 3,300	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,300	$ -	$ -	$ -	$ -	$ 3,300	$ -
Gravel Parking Lot, Equipment laydown area, east side	Add gravel and re-grade as needed as part of operations and maintenance	80	2072	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Concrete sidewalk, Front of building	Replace concrete sidewalk at end of useful life	40	2047	$ 14,625	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Site Work Summary					**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$214,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 27,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 3,300**	**$ -**
Structure																													
Concrete Foundation	Allowance for minor repairs, 1% of floor plate	75	2037	$ 46,760	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 46,760	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Slab on Grade: Repair rear overehad door area	Concrete slab appears to be degrading, Aggrgate is showing and concrete topping has wom.	40	2022	$ 38,550	$ 38,550	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Slab on Grade	Repair slab on grade- Allowance 2.5% of floor plate to address slab issues	75	2037	$ 115,518	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$115,518	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Steel coumns and joists (assessment)	Complete structural assessment to ensure original design meets current snow load requirement	75	2022	$ 5,500	$ 5,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Steel Superstructure	Replace structure at end of useful life	75	2072	$ 2,087,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Structure Summary					**$ 44,050**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$162,278**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Roof																													
Modified Bitument Roof - Southeast quadrant	Replace membrane at end of useful life	20	2027	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Modified Bitument Roof - Southwest quadrant	Replace membrane at end of useful life	20	2027	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Modified Bitument Roof - Northwest quadrant	Replace membrane at end of useful life	20	2030	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$374,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Modified Bitument Roof - Northeast quadrant	Replace membrane at end of useful life	20	2027	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ 374,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Roof Summary					**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 1,122,000**	**$ -**	**$ -**	**$374,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
Exterior Envelope																													
Prefinished Metal Awning - maintenance	Clean and paint underside of awning	35	2023	$ 6,750	$ -	$ 6,750	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Prefinished Metal Awning - replacement	Replace metal awning at ed of useful life, minor corrosion noted on under side.	35	2045	$ 67,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 67,500	$ -
Brick Exterior Walls - repointing	Cyclic repointing to maintain brick	5	2027	$ 43,750	$ -	$ -	$ -	$ -	$ -	$ 43,750	$ -	$ -	$ -	$ -	$ 43,750	$ -	$ -	$ -	$ -	$ 43,750	$ -	$ -	$ -	$ -	$ 43,750	$ -	$ -	$ -	$ -
Brick Exterior Walls - replace	Replace brick at end of useful life	75	2072	$ 603,750	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Concrete block walls - repointing	Repoint concrete masonry units. Budget allowance. Localized step cracking noted from interior	75	2027	$ 31,250	$ -	$ -	$ -	$ -	$ -	$ 31,250	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Overhead Door - East side (oversized door)	Replace door at end of useful life	15	2027	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 10,000	$ -	$ -	$ -	$ -	$ -
Overhead Door - Heavy Equipment maintenance bay SE Corner	Replace door at end of useful life	15	2027	$ 7,500	$ -	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ -
Overhead Door - Sidewalk vehicle storage	Replace door at end of useful life	15	2027	$ 5,500	$ -	$ -	$ -	$ -	$ -	$ 5,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 5,500	$ -	$ -	$ -	$ -	$ -
Front entrance Door, Automatic sliding double doors	Doors were not functional during the site visit. Replacement is anticipated.	35	2022	$ 7,500	$ 7,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Curtain Glass Glazng, front elevation	Replace glazing at end of useful life	35	2032	$ 112,640	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$112,640	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Aluminium framed entrance door inset into curtain wall	Replace door at end of useful life	35	2035	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Double Steel Entrance - East Side	Double steel doors with minor corrosion and minor impact damage, replacement required at end of life.	25	2030	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Double Steel Entrance - South Side	Double steel doors with corrosion and minor impact damage, replacement required at end of life.	25	2024	$ 2,500	$ -	$ -	$ 2,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Single Steel entrance door east side	Door was observed to be in good condition	25	2040	$ 1,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Single Steel entrance door south side	Door was observed to be in good condition	25	2040	$ 1,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Windows - vinyl framed	Windows were in good condition, new window in staff room, Windows can be replaced as pat of regular operation and maintenance	35	2053	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Exterior Envelope Summary					**$ 7,500**	**$ 6,750**	**$ 2,500**	**$ -**	**$ -**	**$ 98,000**	**$ -**	**$ -**	**$ 2,500**	**$ -**	**$156,390**	**$ -**	**$ -**	**$ -**	**$ 2,500**	**$ -**	**$ 43,750**	**$ -**	**$ -**	**$ 2,000**	**$ -**	**$ 66,750**	**$ -**	**$ -**	**$ 67,500**	**$ -**
Building Interior																													
VCT Flooring, retail area	Floor has reached the end of its life and needs to be replaced	25	2022	$ 453,611	$ 453,611	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Office flooring	Office flooring varies in finishes. The majority of the flooring is at or near end of life and will need to be replaced in the short term	25	2027	$ 292,842	$ -	$ -	$ -	$ -	$ -	$ 292,842	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Washroom Flooring	Currently a combination of unfinished exposed concrete and hard tile. Allowance for hard tile finish	50	2022	$ 7,250	$ 7,250	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -

Gypsum Board Walls	Gypsum wall board in fair condition, Repair as part of operations and maintenance activities	60	2042	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Suspended Tile Ceiling - Retail area	Tiles are at end of life with damage and bowing noted, replacement anticipated	20	2022	$ 317,860	$ 317,860	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$317,860	$ -	$ -	$ -	$ -
Interior Doors	Interior doors varied in condition but were generally in good condition, Individual door replacement can be done through operation and maintenance activities.	60	2042	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Washroom Ceilings - splined tiles	Replacement anticipated in long term.	20	2029	$ 3,455	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 3,455	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Washroom Vanities	Replace at end of useful life. Preformed laminate counter top in good condition	20	2032	$ 6,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 6,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Washroom Partitions	Partition were in fair condition, replacement is anticipated in the short term	30	2025	$ 8,750	$ -	$ -	$ -	$ 8,750	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Building Interior Summary					**$ 778,721**	**$ -**	**$ -**	**$ 8,750**	**$ -**	**$ 292,842**	**$ -**	**$ 3,455**	**$ -**	**$ -**	**$ 6,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$317,860**	**$ -**	**$ -**	**$ -**	**$ -**
Mechanical																													
Plumbing Service	No reported issues with incoming water service, no major repair or replacement anticipated	40	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Back flow preventer	No backflow preventer was identified, in its absence a back flow preventer should be installed	40	2022	$ 1,500	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Domestic Hot Water Tank- Giant 2018	Replace hot water tank at end of useful life	15	2033	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Domestic Hot Water Tank- Giant 2017	Replace hot water tank at end of useful life	15	2032	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Domestic Hot Water Tank- Bradford and White	Replace hot water tank at end of useful life	15	2032	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 1,500	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Copper Piping Distribution - repair allowance	Distribution reported to be in good condition with no leaks reported. Maintenance allowance every five years anticipated to be required for selective replacement.	5	2022	$ 7,500	$ 7,500	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -	$ 7,500	$ -	$ -	$ -	$ -
Plumbing Fixtures, sinks, urinal, toilets	Replacement anticipated at end of useful life,	35	2030	$ 18,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 18,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fuel Oil Tank 20000 l estimated	Fuel Tank was not observed. It is assumed to be a dual walled 20,000 l tank. To be confirmed by site contact.	30	2030	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 10,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Volcano Boiler 100 hp rating	Replace boiler.	40	2022	$ 61,100	$ 61,100	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Air Handling Unit- coil	Heating coil repair / replacement allowance	30	2036	$ 16,450	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 16,450	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Air Handling Unit	Air handling unit consists of three rooms, return, fan room and supply. 25 hp motor and fan. Louvre and coil reported separately. Partial replacement allowance.	40	2027	$ 14,650	$ -	$ -	$ -	$ -	$ -	$ 14,650	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Fan Coil Units (FCU)	Varies in age, due to low cost of individual units, replacement is usually completed as part of operations and maintenance	15	2022	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Mechanical Summary					**$ 70,100**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 22,150**	**$ -**	**$ -**	**$ 28,000**	**$ -**	**$ 10,500**	**$ 1,500**	**$ -**	**$ -**	**$ 16,450**	**$ 7,500**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 7,500**	**$ -**	**$ -**	**$ -**	**$ -**
Electrical																													
Main Disconnect Square D, 800A 600V	Replace at end of useful life	40	2022	$ 24,150	$ 24,150	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Transformers	Replacement is not anticipated to be required	40	2042	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Secondary disconnects	Replacement anticipated to be required due to age and lack of replacement parts	40	2022	$ 25,000	$ 25,000	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Branch Wiring and secondary panels	Allowance for selective replacement on a cyclic basis	5	2022	$ 5,000	$ 5,000	$ -	$ -	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -	$ 5,000	$ -	$ -	$ -	$ -
Lighting - Retail and office areas	The lighting generally consists of florescent type fixtures with LED tubes. Fixtures are at end of life, complete relamping is anticipated.	20	2022	$ 477,260	$ 477,260	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$477,260	$ -	$ -	$ -	$ -
Lighting, Metal Halide Pendant	Replacement is not anticipated.	20	2037	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -
Electrical Summary					**$ 531,410**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 5,000**	**$ -**	**$ -**	**$ -**	**$ -**	**$482,260**	**$ -**	**$ -**	**$ -**	**$ -**
Life Safety / Fire Suppression																													
Exit Signs and battery backup emergency lighting	Replacement is typically completed as needed as part of operation and maintenance	40	2032																										
Sprinkler system	Replacement is not anticipated. Localized repair and replacement is completed as part of operations and maintenance. Last inspected by Fire Stop Enterprises 2022/12/03	40	2022																										
Life Safety / Fire Suppression Summary					**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**	**$ -**
			Totals	**Year**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2037**	**2038**	**2039**	**2040**	**2041**	**2042**	**2043**	**2044**	**2045**	**2046**
			$		**$ 1,431,781**	**$ 6,750**	**$ 2,500**	**$ 8,750**	**$ -**	**$ 1,539,992**	**$ -**	**$ 3,455**	**$404,500**	**$ -**	**$392,390**	**$ 1,500**	**$ -**	**$ 2,500**	**$ 16,450**	**$218,528**	**$ -**	**$ -**	**$ 29,500**	**$ -**	**$874,370**	**$ -**	**$ -**	**$ 70,800**	**$ -**

Total 25 year expenditure $ 5,003,765

Total square footage **82,000**

25 year recap rate: $/sq ft / year $ **2.44**

Appendix C

Structural Outline Specification

NEW GLASGOW – TRANSPORTATION DEPARTMENT FACILITY

Building Use and Occupancy

The Town of New Glasgow's Transportation Department Facility is a single-storey structure, housed in a building repurposed from retail use located at 624 East River Road. The structure is owned and operated by the Town of New Glasgow and consists of two distinct interior uses:

- Storage, housed in the former retail area;
- Maintenance garage for the Town's Transportation Department.

A photo of the building exterior is shown in Figure 1.

Figure 1: New Glasgow Transportation Department Facility front elevation.

Structural Assessment

In general, the building consists of structural steel framing (columns and beams) supporting an open web steel joist (OWSJ) and corrugated metal roof system. Walls are comprised of concrete block that have been assumed to serve as part of the lateral load resisting system (LLRS). No evidence of steel bracing was seen, although a majority of the structure was hidden by interior and exterior finishes. A photo of the visible structure in the maintenance garage is shown in Figure 2.

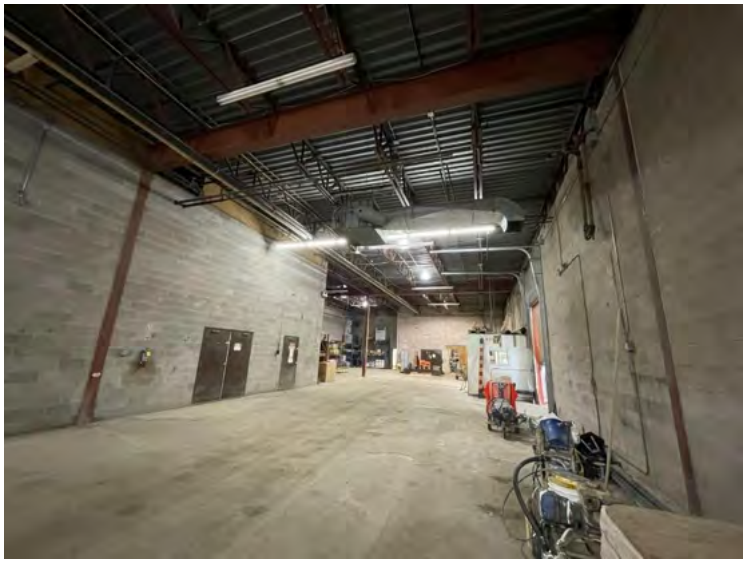


Figure 2: Exposed structure in maintenance garage.

Based on review of available past drawings, it is estimated that the building was constructed in 1975. While this date alone does not fully define the mechanical properties of the material used, it does allow for assumptions to be made about the strength of the steel used in the beams and columns.

Clause 5.2.2 of CSA S16-14 states that the yield strength and ultimate strength of unidentifiable structural steel shall be taken as 210 MPa and 380 MPa, respectively. However, knowing the construction date of the building

allows for a reasonable assumption to be made for the steel strength. Historic Listing of Selected Structural Steel, published by the Canadian Institute of Steel Construction (CISC) is shown below in Figure 3.

CSA Standards

Designation	Date Published	Yield Strength		Tensile Strength (F_u)	
		ksi	MPa	ksi	MPa
A16	1924	½ F_u	½ F_u	55 - 65	380 - 450
S39	1935	30	210	55 - 65	380 - 450
S40	1935	33	230	60 - 72	410 - 500
G40.4	1950	33	230	60 - 72	410 - 500
G40.5	1950	33	230	60 - 72	410 - 500
G40.6	1950	45 [1]	310	80 - 95	550 - 650
G40.8	1960	40 [3]	280	65 - 85	450 - 590
G40.12	1964 *	44 [2]	300	65	450
G40.21	1973 **	Replaced all previous Standards, see CISC Handbook			

* Introduced in May 1962 by the Algoma Steel Corporation as "Algoma 44"
** In May 1997, grade 350W became the only grade for W and HP shapes produced by Algoma Steel Inc.
[1] Silicon steel
[2] Yield reduces when thickness exceeds 1½ inches (40 mm).
[3] Yield reduces when thickness exceeds ⅝ inches (16 mm).

Figure 3: Historic Listing of Selected Structural Steel (CISC).

Based on a construction date of 1975, we have assumed that the structural steel used in the W-section columns and beams is ASTM A992, Grade 50 steel with a yield strength of 50 ksi (345 MPa)

Rooftop unit (RTU) condensers and ceiling mounted air handling units (AHU) are currently supported by the roof system. However, specifics such as size and overall weight were not available at the time of this report. It is also expected these units would be upgraded during the retrofit; as such, their impact and location would need to be reviewed during detailed design once this information is finalized.

It is not possible to deem the structure satisfactory based on past performance as per NBCC Structural Commentary L since it cannot be argued that loading would not increase as a result of the retrofit. There is currently no known insulation on the roof and limited snow has been accumulating on the roof as a result. Increasing insulation would certainly increase the snow load on the roof compared to the snow load that it has satisfactorily resisted in the past.

Applied Loading

Live, Wind, and Snow Loading was calculated as per the National Building Code of Canada, 2015 Edition (NBCC2015). Based on known assemblies a dead load of 0.62 kPa was used for analysis, including a 0.25 kPa allowance for suspended services. A breakdown of the existing and proposed roof dead loads is shown in Table 1.

Table 1: Existing and proposed dead loads.

	Component	Dead Load (kPa)
Existing	18ga Steel Deck	0.15
	30" Deep OWSJ @ 6' c/c	0.22
	Suspended Service Allowance	0.25
Proposed	Recover Roof Panel	0.50
	PV Panel Allowance	0.15
	Optional Ballast	1.00
	TOTAL EXISTING	**0.62**
	TOTAL PROPOSED	**1.27**
	TOTAL PROPOSED (INCL. ROOF BALLAST)	**2.27**

It is understood that a ballast of approximately 1.00 kPa is proposed on top of the rigid insulation in the ReCover roof panels. In an effort to minimize additional loading, we propose connecting the rigid insulation to the plywood substrate with foam fasteners. Accordingly, for this report, we have assumed a proposed dead load of 1.27 kPa for analysis.

Open Web Steel Joists

The open web steel joists (OWSJ) were fabricated by Truscon (as identified by a tag located on an OWSJ). No specifics on member sizes, material strength and/or weld details were able to be provided since record drawings were not available and access was limited to take detailed measurements. DesignPoint conducted preliminary modelling using assumed member sizes (based on visual observations) for a typical 50' long, 30" deep OWSJ with a tributary width of 6'. Several deficiencies were observed when considering current dead and snow loading in accordance with the National Building Code of Canada (NBCC, 2015).

Figure 4: Typical roof structure.

It should be noted that OWSJ evaluation/rehabilitation is recommended to be undertaken by the joist manufacturer only as each OWSJ is a proprietary fabricated truss. Although it is possible to evaluate individual members within the truss (if site measurements are taken), it is difficult, if not impossible, to document the capacity of existing welds at all panels points. These trusses are typically optimized based on design loads and as such, rarely have additional (reserve) capacity to accommodate future increases in load. Accordingly, in the absence of design documentation and/or a detailed measure-up and structural analysis, DesignPoint does not recommend increasing the load on the existing OWSJs.

Roof Decking

The roof system is a corrugated steel deck of unknown gauge and depth. As such, it is not possible to evaluate the decking based on current/future loading unless site measurements are obtained to confirm. It is also likely that the OWSJ are puddle welded to the deck to form a diaphragm and it would not be economical nor practical to reuse the existing roof deck if the OWSJ are replaced.

Figure 5: Open Web Steel Joist.

However, for preliminary purposes, DesignPoint reviewed capacities for an 18 gauge 1-1/2" deck (manufactured by Canam Group) which is typical for similar applications. Based on a 6' joist spacing, a deck of similar material and section properties would be sufficient to support the current factored and service loads on the roof if arranged in a double/triple span configuration which is not uncommon for this type of application. It is also possible that the deck has an increased thickness which would allow for a single span configuration; alternatively, the deck could have been designed for reduced loading (based on requirements in previous versions of the NBCC).

Roof Beams

Roof beams were taken to be W610x101 as per hoist drawings completed in 2015 and measurements obtained on site. Based on available drawings, the beam spans vary from approximately 20'-0" to 38'-10" and support the roof system above (OWSJ + deck). Review of site photos (of a select, visible area of the building) show roof beams that appear to be fully continuous over columns. No shear tabs connections were documented during the site visit.

Figure 6: Typical roof beam.

For the purposes of this study, the beam along Gridline 7 was modelled as fully continuous over column supports between Gridlines A and D and between Gridline F and I. From the site visit, it was not clear if the beams are moment connected to the exterior columns; thus, a pin connection was assumed at this location only. The maximum tributary width for the beam was taken to be 50'.

Table 2 and 3 display the approximated utilization ratios under existing and proposed loading, respectively, assuming a girder section of W610x101 throughout and a steel yield strength of 345 MPa.

Table 2: Existing girder utilization.

Beam Span	M_f (kN-m)	M_r (kN-m) [F_y = 345 MPa]	Utilization Ratio	V_f (kN)	V_r (kN) [F_y = 345 MPa]	Utilization Ratio
Grid A – D	665	900	73%	427	1300	33%
Grid F – I	878	900	97%	481	1300	37%

Table 3: Proposed girder utilization.

Beam Span	M_f (kN-m)	M_r (kN-m) [F_y = 345 MPa]	Utilization Ratio	V_f (kN)	V_r (kN) [F_y = 345 MPa]	Utilization Ratio
Grid A – D	784	900	82%	504	1300	39%
Grid F – I	1035	900	115%	567	1300	44%

As seen in Table 3, there is a potential overload in the beam between Grid F and Grid J based on an assumed size of W610x101. This area was not visible during the initial inspection and shall be confirmed during detailed design. The connection details at the columns will also need to be verified to determine which the continuous length of each member. As the distance between Gridline H and I is longer than the typical girder length, it is also possible that a larger section was used for these spans, in which case reinforcing may not be required.

It should also be noted that a 2000 lbs hoist (+ 500 lbs dead load) was added to the maintenance garage area in 2015 between GL B and C. If the hoist is to remain, its maximum capacity should be reviewed based on final details of the panels. Moreover, connection details would need to be verified to confirm beam capacities throughout the entire structure.

Columns

Building columns generally consist of W200x46 sections. Exterior columns are spaced at approximately 49'-9' (building long direction) and 28'-3" (building short direction). Interior columns are located at gridlines and support the roof beams. Columns have a typical height of approximately 18' (5.4 m) from the floor slab to the underside of the beams. The portion of the column below the slab on grade was not visible, meaning that base plates and anchors rods were also concealed from view and not able to be assessed as part of this study.

Figure 7: Typical column.

Connection eccentricity at the interior roof beams was not considered as beams were identified from site photos to be continuous over supports. The connection detail at exterior columns should be site verified and checked for eccentricity, if required.

Assuming pinned end conditions and an unbraced length of 5500mm, the capacity of a W200x46 column in pure axial compression if 705kN.

Table 4: Existing column utilization.

Column ID	Tributary Area (m^2)	C_f (kN)	C_r (kN-m) [F_y = 345 MPa]	Utilization Ratio
Typ. Col.	131	623	705	88%
Grid D	145	689	705	97%
Grid H	155	737	705	105%

Table 5: Proposed column utilization (without ballast)

Column ID	Tributary Area (m^2)	C_f (kN)	C_r (kN-m) [F_y = 345 MPa]	Utilization Ratio
Typ. Col.	131	700	705	99%
Grid D	145	775	705	110%
Grid H	155	828	705	117%

As seen above, interior columns along Grid D and Grid H are overloaded in compression under proposed panel loading. This is based on the assumption that all columns in the building consist of W200x46 sections, as seen on Grids A, B, and C. Select invasive investigation will be required to confirm the cross section of the columns along all grids. It should be noted that the column capacity is limited by weak-axis bucking. Reinforcing the 12

overloaded columns could be accomplished by welding new structural steel to the existing columns along the entire heigh to increase the weak-axis buckling capacity.

Masonry Walls

The exterior walls of the building are constructed of 300 mm (12") thick concrete block laid in running bond and are intended to serve as the part of the lateral load resisting system (LLRS) of the building and do not appear to support any roof loading, which is supported by the structural steel roof beams/columns. Various penetrations have been made in the masonry walls over the years. Grout and reinforcing were not visible in the blocks above these openings as shown in Figure 8.

Figure 8: Opening in masonry wall.

Review of site photos, as well as observations during the site inspections revealed several door openings that appear to have been post-installed in exterior walls. Lintels above these openings were not grouted and cracking was visible at the corners of these openings. SNC Lavalin's condition assessment report (2017) also noted the presence of vertical cracks in some walls, which could be attributed to overstress due to lateral wind pressures on unreinforced masonry block walls. Some walls were covered in brick veneer and as such, could not be visually evaluated.

Recommendations

As discussed, the existing OWSJs are assumed to be overloaded under modern code prescriptions and shall not be relied on to support additional weight caused by panel dead load and increased snow load due to insulating the roof. Primary structural steel members, excluding the open web steel joists, *may* be adequate, depending on the grade of steel. Based on an assumed yield strength of 345 MPa, consistent with historic steel strengths and the building's construction date, the majority of the existing structure can support existing and proposed loading. Coupon testing of the existing steel is recommended to verify its yield strength and confirm the suitability of the beams and columns for reuse under increased loading.

A detailed structural analysis is required to analyze both the capacity of the building as a whole, and the walls as part of a LLRS. In order to complete this investigation, it is anticipated that destructive testing would be required in order to attain enough material information and confirm the lack of grout. Since several openings have been post installed, it is not possible to deem the walls satisfactory based on past performance. It is possible that the shear walls for the building have been compromised with these openings, which is why deficiencies, such as cracking at the corners of openings, has been observed. These deficiencies are evident under current conditions and as such, the repairs of these structural elements are beyond the scope of this report.

Based on these findings, we have proposed a new structural system to attach ReCover panels to the existing steel structure. In order to avoid loading the existing OWSJs, we recommend installing a system of new pre-engineered trusses designed to span between existing structural steel beams, an overall span of approximately 50'. These trusses will be designed to support the ReCover roof panels and distribute load to the existing steel superstructure.

Based on wall panel design constraints, it is understood that the new wall assembly will be two panels high, each approximately 12'-6" in height. Based on the condition of the existing masonry and assumed lack of grout

and reinforcing, it is not feasible to introduce a linear load at mid-height of the existing CMU walls. In order to avoid this point load, a steel exoskeleton has been designed to transfer mid-height wall panel loads under wind loading to the existing roof diaphragm and existing foundation.

A partial diagram of the proposed assembly is shown in Figure 9.

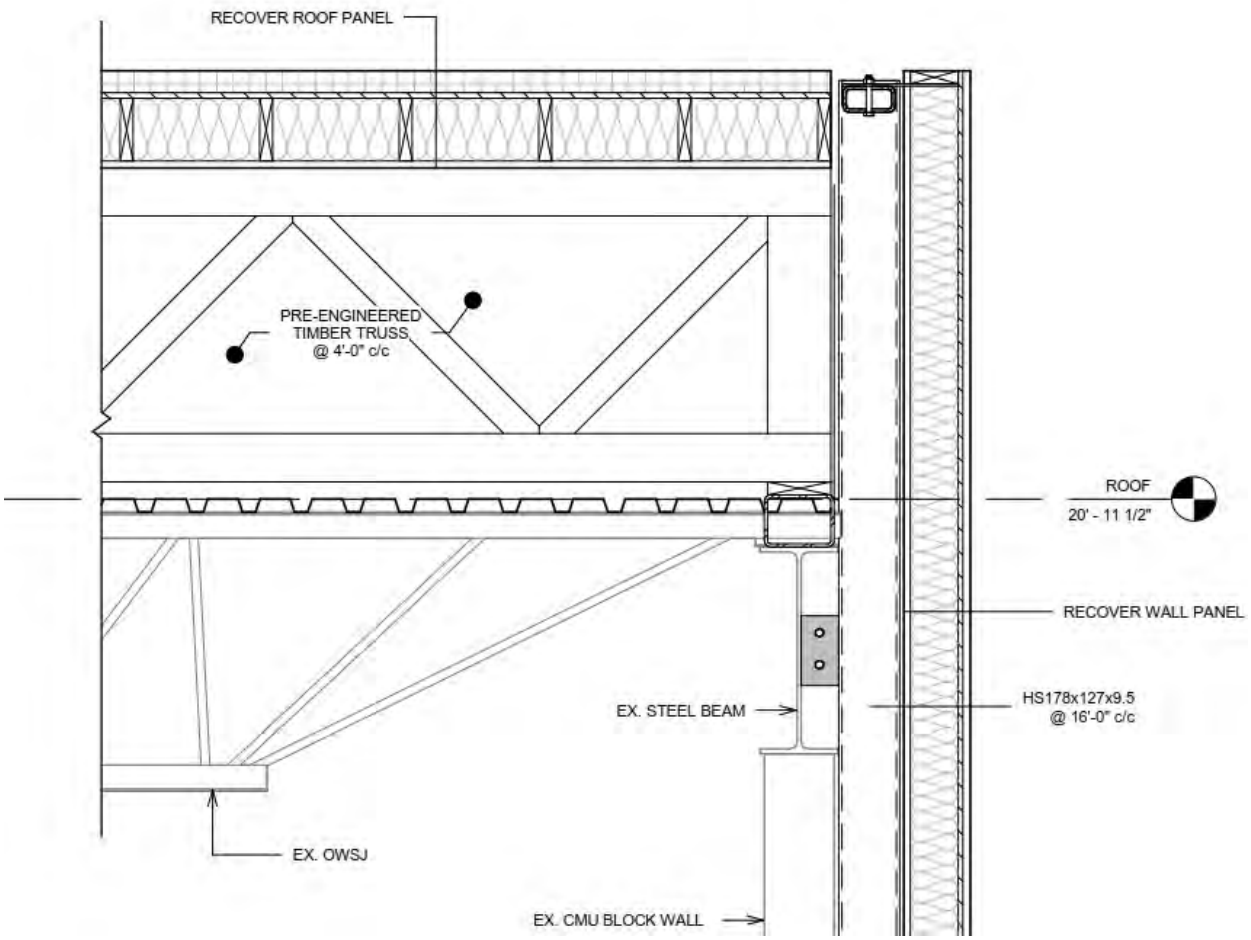


Figure 9: Proposed ReCover panel schematic.

Based on the current assembly, blocking will be required in order to connect the new trusses to the existing steel structure. DesignPoint has proposed steel HSS blocking installed between existing OWSJ shoes with a 2x8 nailer fastened to the top to attach the new trusses. A detail of this proposed connection is shown in Figure 10.

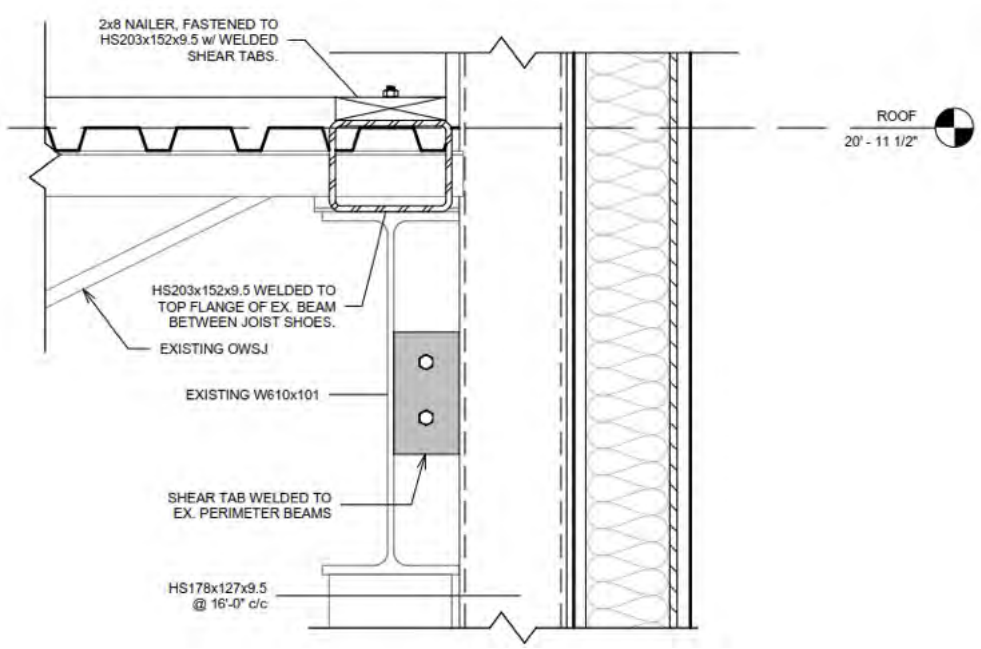


Figure 10: Panel connection details at roof.

A steel lintel is proposed to support the proposed steel wall structure and wall panels at the base. The proposed lintel would be fastened to the existing concrete foundation walls using post-installed epoxy anchors. A schematic of this proposed connection is shown in Figure 11.

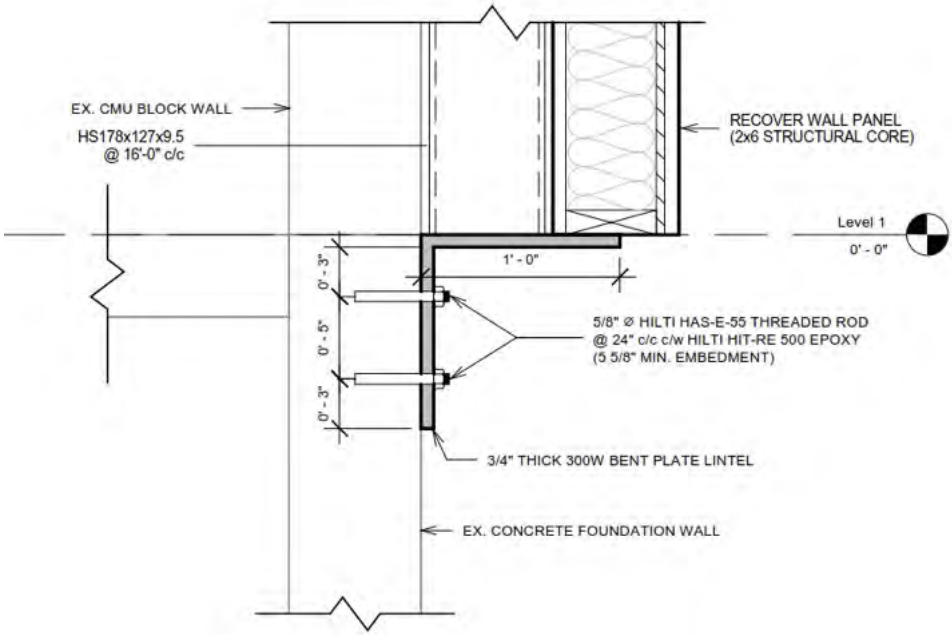


Figure 11: Panel connection at foundation.

Structural details and panel assemblies are available in Appendix A.

Appendix D

Mechanical Outline Specification

PURPOSE

The purpose of this Design Summary is to document the existing and propose new mechanical systems for the energy retrofit of 610 E River Road in New Glasgow, Nova Scotia. The intent is to summarize the major features and design parameters for the Plumbing and HVAC disciplines.

The building was originally built in 1976 as a K-Mart commercial facility. In the 1990's the building was then sold to Central Supplies and operated as a building supplies retail space for around 20 years. Subsequently, Crombie REIT bought the building in 2012 and currently leases it to New Glasgow Engineering and Public Works.

Since 2012 the building has primarily operated as a maintenance shop in the back storage area and a weekly flea market in the old K-Mart retail space. However, the flea market has not occupied the space since June 2021. Currently, the building functions as a mechanics and maintenance shop and the front retail space is empty. There are preliminary discussions regarding the future use of the building.

EXISTING SYSTEMS

Site Services

The existing water service and sanitary systems are connected to municipal service.

Plumbing Services

Rainwater
The building has a flat roof, sloped to roof drains.

Domestic Water Service
Hot water is supplied by five electric water heaters are located near the points of use. Each tank has a nominal capacity of 40 gallons.

Figure 1 Electric Hot Water Tank

Plumbing Fixtures

The facility consists of a men's and women's washroom in the office area. The washroom facility contains seven toilets, three urinals, and seven wash sinks. No flow rate was available on the fixtures, but most appear to be original to the building. The sinks were noted to not have touchless faucets. The back breakroom contained an oven, fridge, sink, and microwave. The building originally had a commercial kitchen which has since been removed. Should water efficiency measures be installed, it is recommended that fixtures be upgraded to low flow units.

Figure 2 Typical Bathroom Fixture in Facility

Figure 3 Back breakroom

HVAC System

Heating and Cooling

The building is heated by a single oil-fired hot water boiler with a two-stage burner, estimated output capacity of 1100 kW, and 80% efficiency. The boiler supply water temperature setpoint is between 165°F - 185°F. A 13,600L fuel oil tank is stored outside the building.

Figure 4 Boiler located in Boiler Room

Figure 5 Fuel Oil Storage Tank

Heat is distributed from the boiler by two main heating loops. The first loop is connected to a built-up air handling unit (see Figure 6) with a hydronic heating coil which supplies air to the retail space in the front of the building. The air handling unit also has a DX cooling coil served by four 34-ton rooftop condensing units, see Figure 7. The unit has not operated since the space was unoccupied last summer. The circulation pump for this loop is rated at 5 HP.

Figure 6 Built-up Air Handling Unit

Figure 7 Condensing Units on Roof

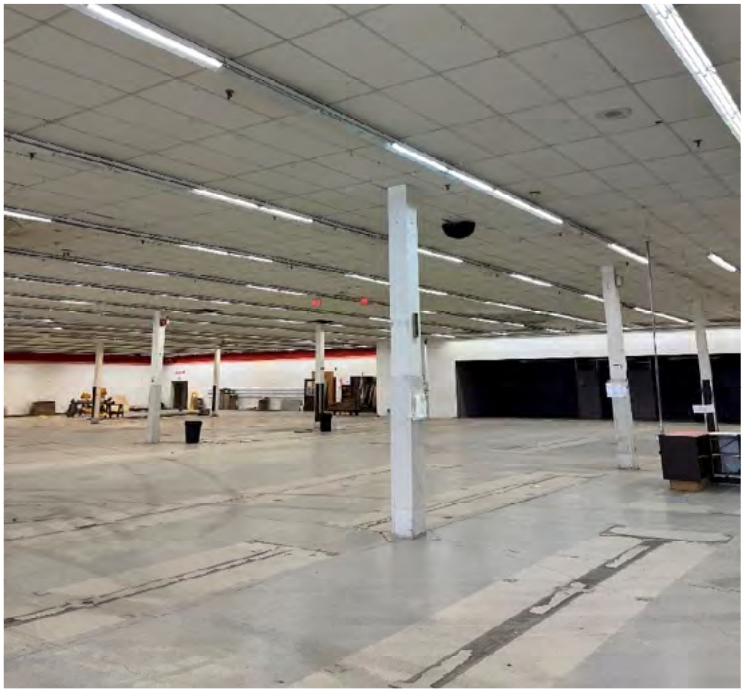


Figure 8 Unoccupied Retail Space

The second heating loop feeds multiple unit heaters distributed throughout the shop area located in the back of the building, some storage rooms at the side of the building as well as a unit heater in the retail entrance, refer to Figures 8, 10 and 11. The unit heaters receive water directly from the boiler as there is no control valve in the second heating loop. The shop area is maintained around 18°C. In the office area, a mini split and electric baseboards have been installed, refer to Figures 12 and 13. A mini split has also been installed in the back storage room, refer to Figures 14 and 15. The retail space is heated by the built-up air handling unit; its setpoint is 7°C but the space generally remains at 9°C or higher throughout the winter so it remains off. The circulation pump for this loop is rated at 1.5 HP.

Figure 9 Unit Heater Connection

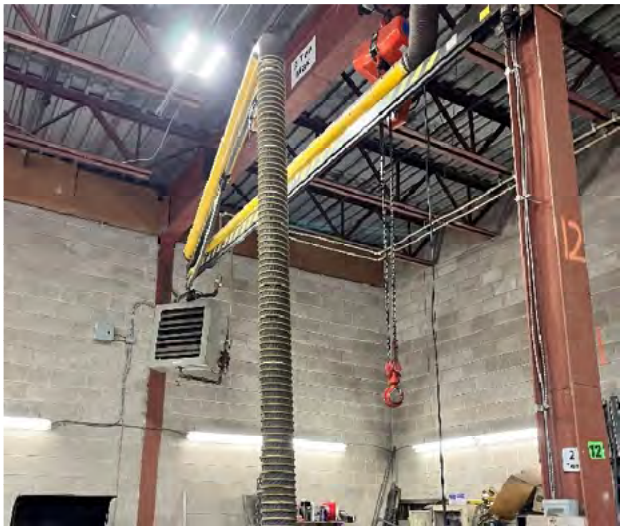


Figure 10 Unit Heater in back of Facility

Figure 11 Electric Baseboard in Breakroom

Figure 12 Indoor Unit in Office Area

Figure 13 Outdoor Unit of Office Area

Figure 14 Indoor Uni tin Storage Area

Figure 15 Storage Area Entrance

Ventilation

Ventilation is provided to the retail space when the air handling unit is running. The air handling unit includes a hot water heating coil and DX cooling coil served by four 34-ton rooftop condensers. There appear to be actuated dampers to control the outdoor air supply allowing the unit to provide ventilation in addition to heating and cooling, however it was not confirmed whether they are functional.

Two inline exhaust fans are connected to flexible hoses in the space and can be operated in certain shop areas when there is an increased risk of pollutants due to welding and automotive fumes. The shop does not have a continually operating ventilation system, makeup air is provided by motorized dampers and a louver that are triggered by a CO sensor or hand operation along with two wall mounted exhaust fans. Destratification fans have also been installed in the back storage area for improved air movement, refer to Figure 20.

Figure 16 Side door providing natural ventilation

Figure 17 Back door providing natural ventilation

Figure 18 Exhaust Fan System

Figure 19 Exhaust Fan Control

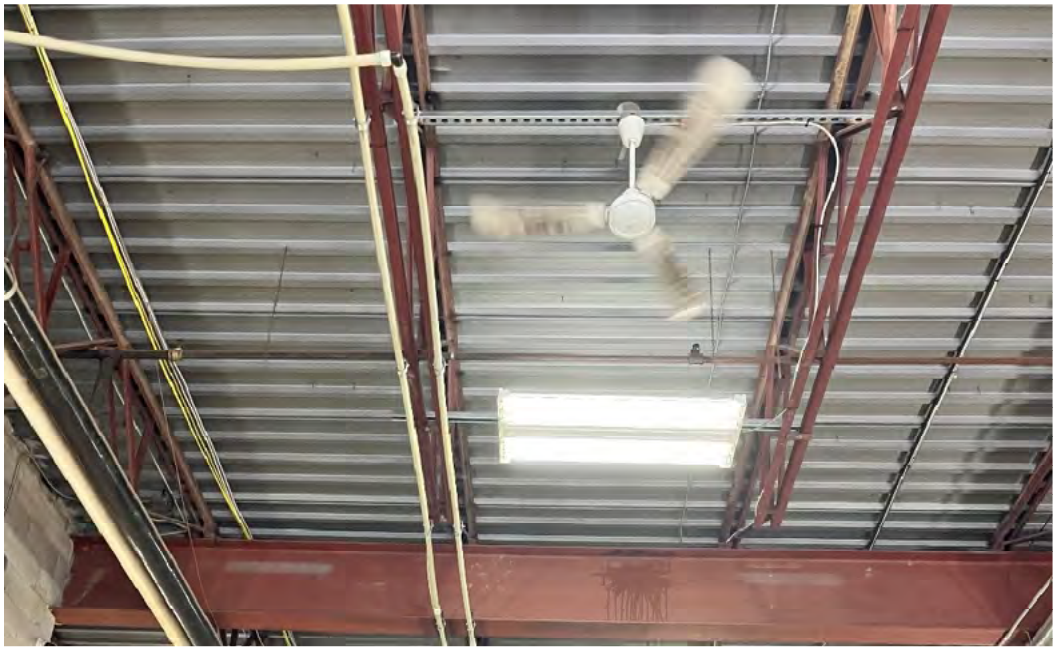


Figure 20 Destratification Fan in Back Shop

HVAC Equipment Summary

Figure 21 below identifies the HVAC equipment locations in the building.

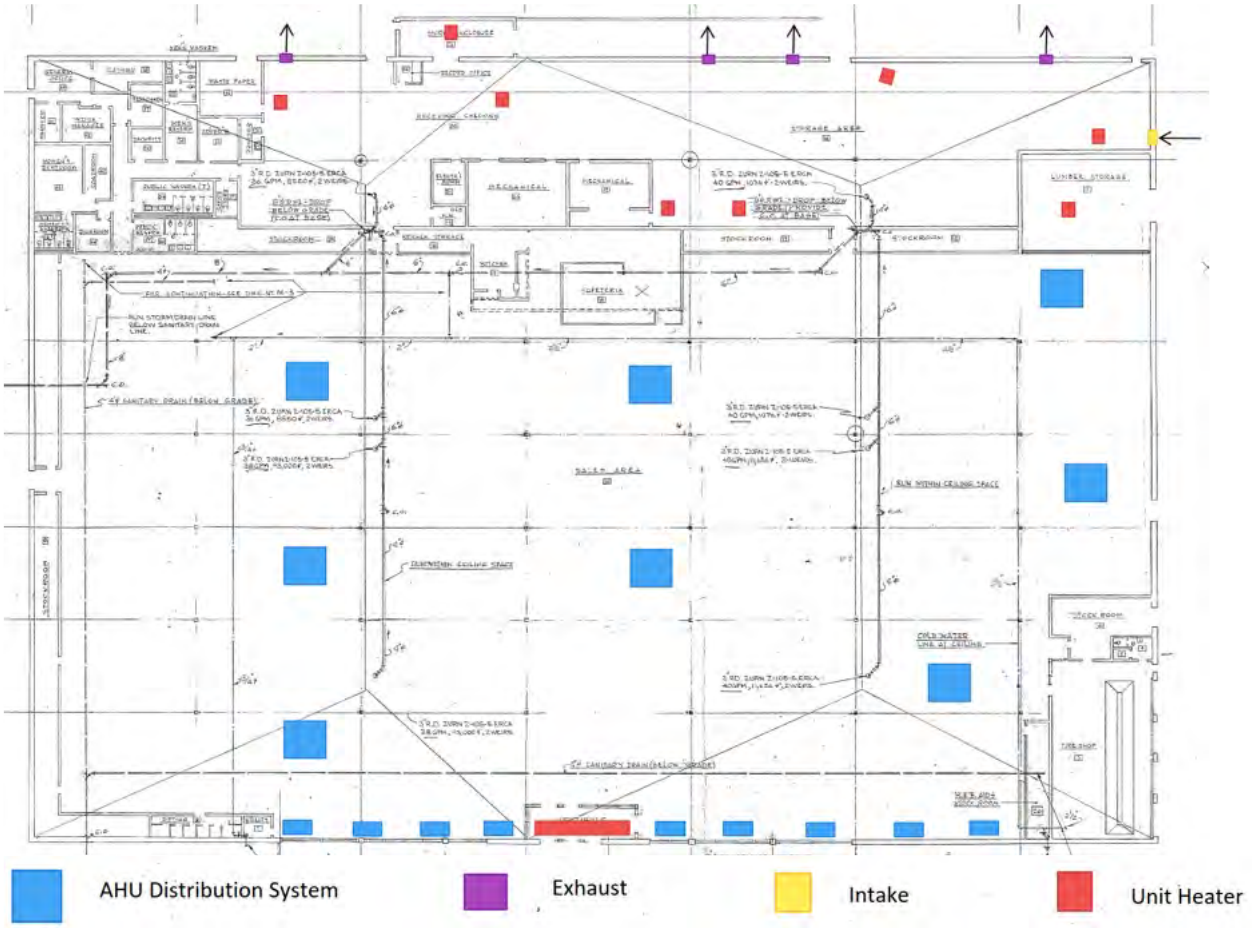


Figure 21 HVAC Equipment Layout

COMMENTS

It was noted by building maintenance that the Victaulic joints in the heating system leak during start up and shut down. Building staff are currently maintaining the leak with a bucket for water collection.

Figure 22 Ceiling water damage in retail space from leaking Victaulic joints

The building is currently not being used for what the HVAC system was designed for. Consequently, there is not adequate ventilation in occupied areas (particularly in the winter when the garage doors are not open) and areas of high heat loads (i.e., server room) were noted by the staff to frequently get very hot.

PROPOSED SYSTEMS

Systems have been proposed as per the minimally acceptable, net zero ready, and net zero scenarios. The details of each system are provided below. For the purpose of this study, it has been assumed that the occupancy schedules and space usage are consistent with existing conditions.

In all scenarios, it is recommended that insulation be added to internal rainwater leaders and plumbing vents to prevent condensation and thermal bridging. Typically, insulation to prevent condensate is a minimum of 1/2" (~R-3); however, it is recommended that the insulation be increased to 3" (~R-20) to prevent thermal bridging. The insulation should be run down to the slab which may require access inside walls. To fully minimize thermal bridging, roof drain retrofits should be prioritized to be external of the enclosure.

The temperatures used for designing the HVAC systems are as follows, based on the 2.5% design temperatures for New Glasgow from the NECB:

Outdoor Design Conditions:
- Summer: 27°C [81°F] DB, 21 °C [70°F] WB
- Winter: -19°C [-2°F] DB

Indoor Design Conditions:
- Summer: 75°F [24°C] DB (Office and Retail areas)
- Winter: 70°F [21°C] DB (Office and Retail areas)
  59°F [15°C] DB (Maintenance)

1. Minimum Acceptable Scenario

Heating and Cooling

Heating will be provided by a combination of the existing unit heaters served by a new cast iron oil-fired boiler, existing mini split heat pumps, and existing electric baseboard heaters. The boiler is being replaced due to its age. As this scenario does not reduce the heating loads sufficiently to use a low temperature system, the use of a high temperature boiler avoids the replacement of the existing high temperature distribution system. Cooling for the maintenance area will be provided by the destratification fans and mini split heat pumps. The Retail (former K-Mart) area will continue to be cooled by the existing rooftop condensing units and air handling unit.

Domestic hot water would continue to be served by the five electric water heaters.

A summary of this system is included in the table below.

Space	Heating	Cooling	DHW
Office	Existing Electric Baseboard	Existing Mini Split Units	Existing Electric Water Heaters
Maintenance	Existing Unit Heater served by new Oil-Fired Boiler		
Retail	New Oil-Fired Boiler	Existing Rooftop Unit	

Ventilation

The minimum acceptable scenario includes replacing the existing office air handler and maintenance exhaust fans and louvers with two energy recovery ventilators (ERVs). ERVs would be

dual core type with approximately 90% heat recovery efficiency similar to Tempeff Dualcore (pictured below). ERV ducting would be galvanized steel. Outdoor air and exhaust air ductwork will be insulated between the outside wall and ERV. The Retail area would continue to be ventilated with the existing air handling unit.

Direct exhaust would remain for engine and welding exhaust. Currently, the engine and welding exhaust operating schedules are low; however, should the demand significantly increase, new systems should be considered.

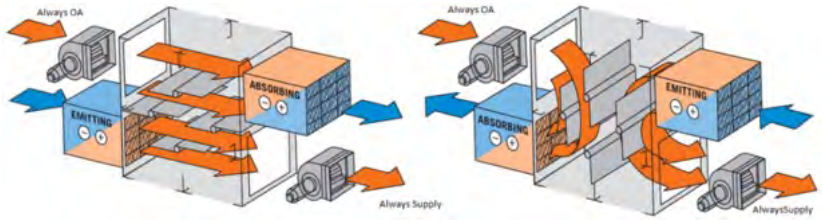


Figure 23 Tempeff Dual Core ERV System

Controls

All existing building controls will remain with the addition of NOx and CO sensors to control the Maintenance ERV and a programmable time clock for the office ERV.

Equipment List

- (1) 480 kW [1638 MBH] oil-fired boiler with modulating burner
- (1) 150 L/s [320cfm] ERV with ECM motors and dual cores
- (1) 12,000 L/s [25,500cfm] ERV with ECM motors and duale cores

2. Net Zero Carbon Energy Ready Scenario

The net zero carbon energy ready system includes full electrification of the HVAC and DHW systems. Two scenarios have been proposed: Air source heat pumps and Ground Source heat pumps.

a. Air Source Heat Pump (ASHP) Option

Heating and Cooling

The oil-fired boiler and rooftop units will be replaced with cold climate air to water heat pumps to heat the entire building, refer to Figure 26. The heat pumps will have a circulation pump on the condenser side and speed will be controlled based on the compressor operation.

The two existing circulation loops will remain; however, distribution systems will need to be altered to allow for the full utilization of the heat pumps. In the maintenance area, the existing high temperature unit heaters can remain assuming the building loads are reduced such that the capacity can be met with the low temperature system. In the office space, electric baseboard heaters would be replaced with four pipe fan coils to allow for heating and cooling to be provided from the heat pumps. Four pipe fan coils would be installed in the Retail area at locations similar to that depicted in Figure 21 to decouple the ventilation from heating and cooling. Accessories to the hot water piping systems include make-up water source, expansion tank, air venting, circulation pumps, and isolation valves.

The air source heat pump has been sized according to so that it meets 60% of the peak design heating load at a reduced outdoor air temperature of -4°F. The electric boiler is sized for the remaining 40% of the load. As peak demands rarely occur throughout the year, it is much more economical for the electric boiler to provide heating during peak demand periods. Reducing the heat pump capacity to 60% of peak load typically results in the electric boiler only providing 5 – 15% of annual heating.

The air source heat pump would be mounted outdoors on a stand outside of the mechanical room (shown in the figure below). Ideally, the heat pumps would be installed on the south side of the building to maximize winter performance due to higher outdoor air temperatures.

Figure 24 Location of Air Source Heat Pump

Cooling in the office and retail area will be provided by chilled water from the air source heat pump. The four pipe fan coils installed for heating would also function as the cooling distribution system for these two areas. The maintenance area would continue to be cooled with the existing mini split heat pumps.

Domestic water would be provided by a packaged heat pump water heater (HPWH). As the building currently has a low domestic hot water load, a packaged unit provides economical savings by negating the need for a backup heating source. The HPWH has been sized according to existing tank capacity, refer to Figure 27.

Figure 25 Air to Water Cold Climate Heat Pump

Figure 26 Packaged Heat Pump Water Heater

Ventilation
The existing built-up air handling unit would be removed and three ERVs would be installed for the office, maintenance, and retail areas. Airflows are consistent with the minimum accepted scenario with the addition of a 1700L/s [3600cfm] ERV for the retail space.

Direct exhaust would remain for engine and welding exhaust. Currently, the engine and welding exhaust operating schedules are low; however, should the demand significantly increase, new systems should be considered.

Controls
The ASHP would require a direct digital control system to operate circulation pumps and heat pumps. All existing building controls will remain with the addition of NOx and CO sensors to control the Maintenance ERV and a programmable time of day schedule for the office and retail ERVs.

System Overview
A list of required equipment and system schematic have been included below.

Equipment List

- (3) Nominal 24-ton air to water heat pumps
- (1) 120 kW Electric Boiler
- (10) 5-ton four pipe fan coils for the retail areas
- (3) 1-ton four pipe fan coils for the office area
- Heating loop pumps (includes standby pumps)
    - (2) HP-HX Circulation pumps, approximately 200 gpm each with ECM motors
    - (2) HX-Buffer Tank Circulation pumps, approximately 200 gpm each with ECM motors
    - (2) Retail area Circulation Pumps, approximately 150 gpm each with VFD
    - (2) Maintenance Circulation Pumps, approximately 50 gpm each with ECM motors
    - (1) Electric Boiler Pump, approximately 80 gpm with ECM motor
- Cooling loop pumps (includes standby pumps)

  - (2) HP-HX Pumps, 200 gpm with ECM motors
  - (2) HX-Buffer Tank Pumps, 200 gpm with ECM motors
  - (2) Building Circulation pumps, approximately 200 gpm each with VFD
- (2) Buffer tanks
- (4) Air separators
- (4) Expansion tanks
- (1) 200 gpm heat exchanger for heating loop
- (1) 200 gpm heat exchanger for cooling loop
- (1) 150 L/s [320cfm] ERV with ECM motors and dual cores
- (1) 12,000 L/s ERV [25,500cfm] with ECM motors and dual cores
- (1) 1700 L/s [3600cfm] ERV with ECM motors and dual cores
- (5) 80 gallon packaged heat pump water heater

System Schematic

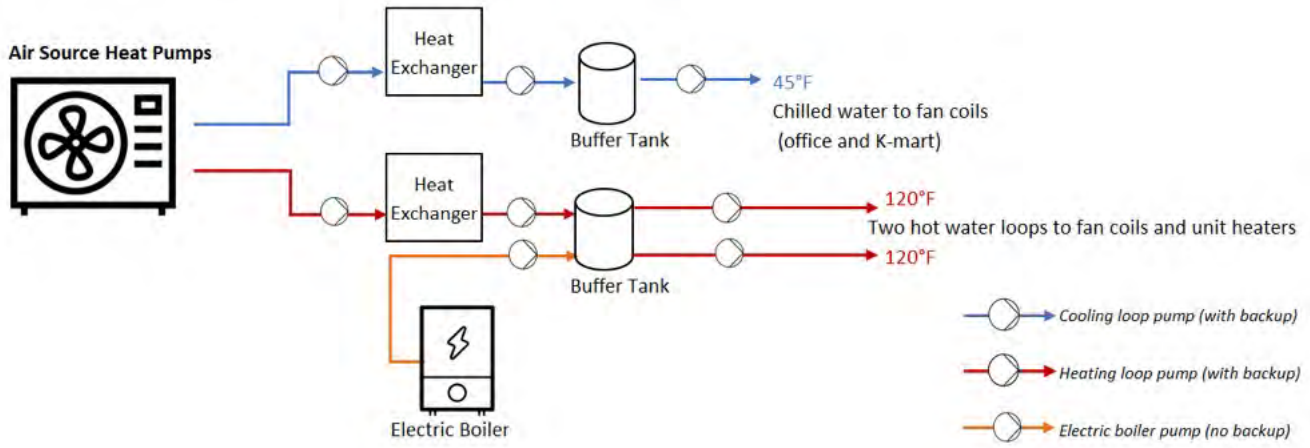


Figure 27 ASHP System Schematic

a. Ground Source Heat Pump (GSHP) Option

This option is the equivalent to the ASHP scenario except heating would be generated by a water to water, or ground source, heat pump. A series of water to water heat pumps will be connected to closed-loop vertical borehole ground heat exchangers providing hot water to buffer tanks. The vertical loop heat exchanger system will consist of long lengths of 1-1/4" diameter HDPE or PEX tubing placed in boreholes drilled to a depth of approximately 150m below the surface level and filled with thermally enhanced grout. Length of pipe, diameter of pipe, and the spacing of wells will depend on the final building heating and cooling loads during detailed design. An estimated 17 boreholes will be required for the building.[1] Similar to the ASHP, the GSHP system has also been sized for 60% of the peak design load.

[1] *Assumes 150m boreholes with capacity of 50 ft per kW*

Accessories to the GSHP piping system would include glycol fill tank, expansion tank, air venting, circulation pumps and isolation valves. Each heat pump will have a circulation pump on the evaporator and condenser side and be controlled by the heat pump when the compressor is engaged.

The boreholes would most likely be located on the southeast side of the property as to minimize disruption to site operations, refer to Figure 28. However, further analysis must be conducted to confirm the system design. The GSHPs would be located in the mechanical room.

Figure 28 Proposed Borehole Location

Cooling would be provided by the GSHP including the maintenance area which was previously cooled by the existing mini split units

The GSHP option would utilize the same distribution system outlined in the ASHP option. Accessories to the hot water piping systems include make-up water source, expansion tank, air venting, circulation pumps, and isolation valves.

Domestic water would be provided by a packaged heat pump water heater (HPWH). As the building has a low domestic hot water load, a packaged unit provides economical savings by negating the need for a backup heating source. The HPWH has been sized according to existing tank capacity.
A summary of the heating and cooling systems has been included in the table below.

Ventilation

The ventilation systems will be equivalent to the ASHP systems. Three ERVs would be installed for the office, maintenance, and retail areas. Additionally, the maintenance facility would have a direct exhaust system with make-up air dampers.

Controls

The ASHP would require a direct digital control system to operate circulation pumps and heat pumps. All existing building controls will remain with the addition of NOx and CO sensors to control the Maintenance ERV and a programmable time of day schedule for the office and retail ERVs.

System Overview

A list of required equipment and system schematic have been included below.

Equipment List

- (2) Nominal 20 ton ground source heat pumps
- (1) 110 kW Electric Boiler
- (5) 10 ton four pipe fan coils for Retail areas
- (3) 1 ton four pipe fan coils for office area
- Heating Loop Pumps (includes standby pumps)
    - (2) Ground loop circulation pumps, approximately 120 gpm each with VFD
    - (2) HP – HX Pumps, approximately 200 gpm each with ECM motors
    - (2) HX – Buffer Tank Pumps, approximately 200 gpm each with ECM motors
    - (2) Retail area Circulation Pumps, approximately 140 gpm each with VFD
    - (2) Maintenance Circulation Pumps, approximately 80 gpm each with ECM motors
    - (1) Electric Boiler Pump, approximately 90 gpm each with ECM motors
- Cooling Loop Pumps (includes standby pumps)
    - (2) HP – HX Pumps, approximately 140 gpm each with ECM motors
    - (2) HX – Buffer Tank Pumps, approximately 140 gpm each with ECM motors
    - (2) Buffer to Building Pumps, approximately 140 gpm each with ECM motors
- (1) 200 gpm heat exchanger for heating loop
- (1) 140 gpm heat exchanger for cooling loop
- (4) Air separators
- (4) Expansion tanks
- (1) 150 L/s ERV [320cfm] with ECM motors and polypropylene cores
- (1) 12,000 L/s [25,500cfm] ERV with ECM motors and dual cores
- (1) 1700 L/s 3600cfm] ERV with ECM motors and dual cores
- (5) 80 gallon packaged heat pump water heaters

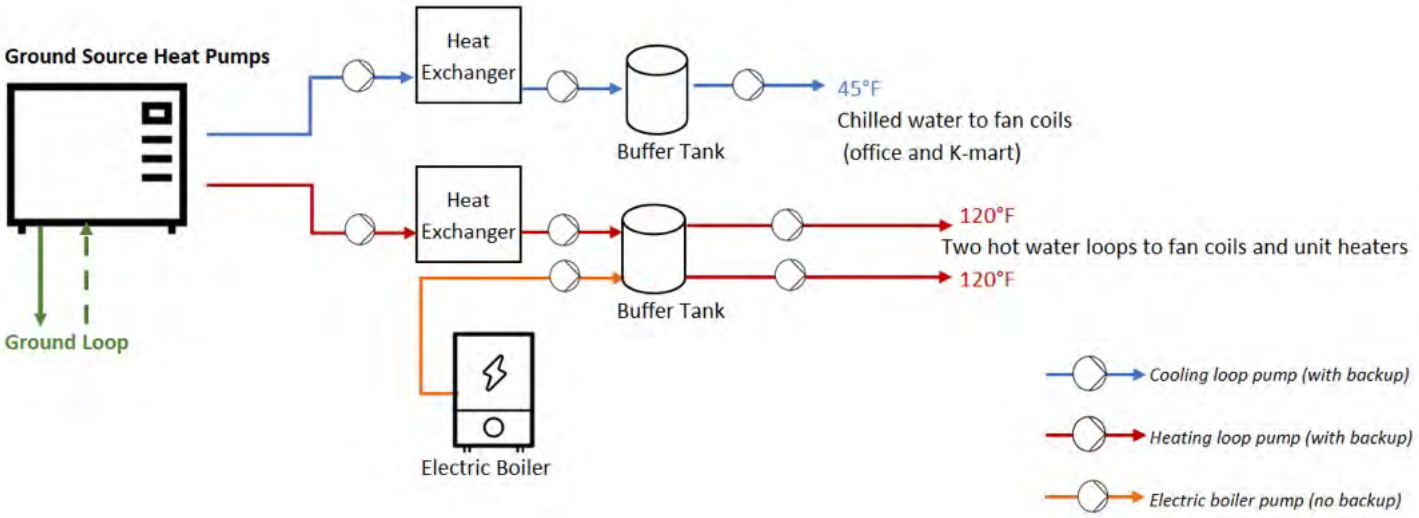


Figure 29 GSHP System Schematic

3. Net Zero Scenario

The net zero scenario is identical to the net zero ready scenario with the addition of a PV system.

Scenario System Summary

Item	Existing Building	Minimum Acceptable	ASHP Net Zero Energy[1]	GSHP Net Zero Energy [1]
Effective Wall R-value	R-3.8	R-10	R-20	R-20
Effective Roof R-value	R-0.7	R-10	R-40	R-40
Air Tightness (L/s·m^2 at 75Pa)	3.0 L/s·m2	0.5 L/s·m2	0.5 L/s·m2	0.5 L/s·m2
Central Heating Equipment	Oil-fired boiler with two-stage burner	Oil-fired boiler with modulating burner	ASHP	GSHP
Heating System	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Air handling unit [2] Office: Electric baseboards	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Unit heaters Retail: Four pipe fan coils Office: Four pipe fan coils
Air Conditioning	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Air handling unit [2] Office: Mini split [4]	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils	Maintenance: Mini split [3] Retail: Four pipe fan coils Office: Four pipe fan coils
DHW Equipment	Electric Water Heater	Electric Water Heater	HP Water Heater	HP Water Heater
Ventilation Equipment	Maintenance: Exhaust fan Retail: Air handling unit Office: None	Maintenance: 90% SRE ERV[5] Retail: Air handling unit Office: 90% SRE ERV	Maintenance: 90% SRE ERV[5] Retail: 90% SRE ERV Office: 90% SRE ERV	Maintenance: 90% SRE ERV[5] Retail: 90% SRE ERV Office: 90% SRE ERV

[1] Net Zero Energy Ready systems are identical with exclusion of renewables
[2] Installed with heat coil and DX cooling coil served by rooftop condensers
[3] Located in storage room
[4] Located in server room
[5] Demand controlled through CO sensors

Appendix E

Electrical Outline Specification

PURPOSE

The purpose of this Design Summary is to document the existing and propose new electrical systems for the energy retrofit of 610 E River Road in New Glasgow, Nova Scotia. The intent is to summarize the major features and design parameters for the Lighting and Power Distribution systems.

The building was originally built in 1976 as a K-Mart commercial facility. In the 1990's the building was then sold to Central Supplies and operated as a building supplies retail space for around 20 years. Subsequently, Crombie REIT bought the building in 2012 and currently leases it to New Glasgow Engineering and Public Works.

Since 2012 the building has primarily operated as a maintenance shop in the back storage area and a weekly flea market in the old K-Mart retail space. However, the flea market has not occupied the space since June 2021. Currently, the building functions as a mechanics and maintenance shop and the front retail space is empty. There are preliminary discussions regarding the future use of the building.

EXISTING SYSTEMS

Site Services

The existing incoming power service consists of two, 4" conduits on the primary side servicing the existing pad mount transformer. The pad mount transformer is 500kVA. The existing main incoming secondary service is sized at 800A, 600V, 3P within two conduit runs. Due to the lack of an existing single line diagram the size of the buildings secondary feeders is unknown. The secondary service entrance enters the building in the main electrical room and terminates onto the buildings main switch which is a 80% rated fusible disconnect. The disconnect then terminates onto the buildings main splitter which feeds all other distribution within the building.

Figure 1: Utility Transformer

Figure 2: Utility Transformer Tag

Figure 3: Main Disconnect Switch

Electrical Power Distribution Services

Main Distribution Equipment

The existing main distribution is original to the building and consists of a main disconnect, a main splitter and multiple branch circuit panelboards. All main distribution equipment has surpassed its reasonable life expectancy and some equipment is showing signs of rust. No maintenance logs are available to determine if any work has been completed done throughout the years.

The main building disconnect is a 80% rated 800A fusible disconnect switch. All other disconnects for panels, motors etc. are fusible disconnects. Visually the disconnects appear to be in okay condition. Where all existing main distribution equipment is loose disconnects and panels off a main splitter, there is not much room left in the main electrical room to add future distribution.

Figure 4: Main Building Splitter

Existing Branch Circuit Panelboards

Several 120-208V and 347-600V branch circuit panelboards exist throughout the building servicing various areas. All panelboards appear to be original to the building and range from very poor to good condition. Some panelboards have been completely filled with breakers and as a result, mini-breakers have been installed to expand capacity past what they were originally designed for. Some panels do appear to include breakers that are no longer in use, which could be removed to allow room for new distribution and branch circuits.

No logging data on power demand of the existing panelboards is available , more information would be needed to determine if the panels have adequate capacity to allow for additional load in the future. This could either be a calculated estimation, or the panels could be logged with a power meter to determine demand load.

No single line diagram is available for the building which makes it challenging to determine what panels feed what equipment. In general panel directories are present although they do not appear to be accurate in many instances. If any existing distribution is to be re-used, we recommend circuit tracing be performed on all distribution equipment and panel directories and a single line be updated.

Figure 5: Existing Distribution

Figure 6: Existing Distribution

Figure 7: Existing Distribution

Figure 8: Existing Distribution

Figure 9: Existing Distribution

Referencing table A-8.4.3.2.2, Division B of the 2017 National Energy Code the basic plug load for each section of the building is as follows.

Occupancy Type	Demand Load	Area
Manufacturing Facility	10 W/m^2	1730 m^2
Office	7.5 W/m^2	220 m^2
Retail	2.5 W/m^2	4550 m^2

Emergency Power Distribution
No emergency power distribution was present on site. Emergency lighting, exit signage and the building fire alarm panel are battery operated.

Lighting and Lighting Control System

Interior Lighting
In the warehouse section of the building, most of the fixtures are T8, 2 lamp fluorescent fixtures, surface and pendant mounted. There are many fixtures that require service. The warehouse offices and washrooms consist of T8, 4 lamp fluorescent fixtures. The approximately 15 high bay HID fixtures appear to have been replaced with LED lamps. Lighting throughout the warehouse is past its reasonable life expectancy. Replacement of lighting is recommended over retrofit to LED. Continued replacement of existing T8 ballasts is not recommended. The existing lighting power density of the building is estimated to be 24W/m^2.

Figure 7: Warehouse Lighting

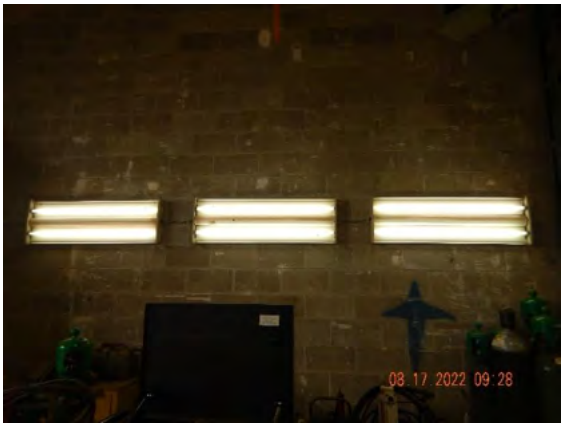


Figure 8: Warehouse Lighting

The K-Mart side of the building consists entirely of T8, 2 lamp fluorescent fixtures which are surface mounted. Approximately 50% of the lamps in this area of the building appear to be burnt out and no-longer working. Similar to the warehouse side, the existing light fixtures are original to the building and are past their reasonable life expectancy.

Figure 102: K-Mart Lighting

Figure 139: K-mart Lighting

Lighting Control System
Currently, the building lacks an automatic lighting control system relying entirely on manual control for the building. This could lead to energy waste if lights are left on in unoccupied areas of the building for extended periods of time (overnight). Addition of an automatic lighting control system is recommended.

PROPOSED SYSTEMS

Systems have been proposed as per the minimum acceptable, net zero ready and net zero scenarios. The details of each system are provided below. For the purpose of this study, it has been assumed that the occupancy schedules and space usage are consistent with existing conditions.

In all scenarios, it is recommended that at a minimum, existing lighting be upgraded to LED. Retrofit kits are an option but not recommended due to the age of the existing lighting.

In some scenarios, the existing building electrical service may need to up upgraded to allow for the electrification of heating and cooling equipment. The necessity of these upgrades entirely depends on how much new equipment is being added onto the existing system.

1. Minimum Acceptable Scenario

Lighting
At a minimum, all lighting throughout the building should be upgraded to LED using LED lighting retrofit kits. These kits come complete with LED replacement lamps and ballasts so the existing fixtures throughout the building can be internally re-wired to work with LED lamps. This will allow the existing building lighting to remain in the same areas and will fix the issue of frequent burnt out fixtures throughout the building. High bay retrofit kits will be provided for all the existing T8HO lamps and regular retrofit kits will be provided for the remaining fixtures.

Figure 11

Figure 12

Although retrofit kits are a great cost-effective option to retrofit a building to LED. In this scenario we would still recommend upgrading the building with new LED fixtures due to the age of the existing light fixtures. For a list of example upgrade fixtures see the "net-zero ready scenario". If replacement of the existing lighting fixtures is cost-prohibitive, LED retrofit kits would be acceptable in the minimum acceptance scenario.

Lighting Control
The minimum acceptable scenario does not change any of the existing lighting controls. Controls will remain manual on/off with no automatic control.

Power Distribution
The minimum acceptable scenario has few changes to the electrical distribution system due to the lack of electrification of mechanical equipment. The existing building service will remain as-is. A small load study will be performed to see which panel is suitable to handle additional load to connect two new ERV units c/w ECM motors and a new oil-fired 375kW boiler unit. Since this equipment does not introduce much load onto the electrical system, the existing panelboards can be used to energize this equipment. In total this scenario will add an additional 17kW of electrical load onto the existing electrical distribution.

No photovoltaics will be added as part of the minimum acceptable scenario.

Minimum Acceptance Scenario Electrical Loads	Qty	kW	Total Load
375kW Oil-fired Boiler	1	5	5
150 L/s ERV with ECM motors and polypropylene cores	1	2	2
12000 L/s ERV with ECM motors and polypropylene cores	2	5	10
Total Added Load			17

2. Net Zero Ready Scenario

The net zero scenario systems include full electrification of the HVAC and DHW systems. Two options have been proposed: air source heat pumps and ground source heat pumps.

Lighting

In the net zero ready scenario, existing fluorescent fixtures will be replaced with equivalent LED fixtures. This upgrade will also act as a lifecycle upgrade to the aging existing light fixtures. Additional light fixtures will be provided in areas where existing lighting is lacking. Light fixtures will be replaced like-for-like matching colour temperature and lumen output. In this scenario, the lighting power density will reduce to an estimated 10W/m^2. See replacement fixture schedule below:

Existing Fixture	Existing Wattage (total lamps)	Example Replacement Fixture Product Number	Replacement Fixture Wattage
Linear Highbays	160W (2 lamps)	Lithonia: IBG 80LM SEF AFL GND MVOLT	48W
Retail Linears	120W (2 lamps)	Lithonia: ZL1D L48 SMR 7000LM	58W
Round Highbays	160W (1 lamp)	Lithonia: JEBL 12000LM FRGL MVOLT	90W

Additional light fixture alternatives will be provided as needed so all lighting is LED.

Lighting Control System

The lighting control system will be updated throughout the building to include automatic lighting control. This upgrade will help reduce unnecessary energy waste by automatically controlling the lighting to only be used while spaces are occupied. Automatic control will be provided in accordance with the national energy code. The two zones used will be warehouse and retail space. Daylight sensors will be provided in all areas with natural light and vacancy sensors will be provided in all areas as required by the National Energy Code. All new lighting control will be low voltage 0-10V or wireless.

Electrical Power Distribution System

In the net zero ready scenario, a significant amount of mechanical equipment will be electrified, greatly increasing the load on the distribution system. Using the billing information from the past 4 years, 2018-2022 we can determine that a service upgrade will not be necessary for the mechanical equipment alone, although one may be needed depending on the size of the solar array installed. The building demand load between 2018-2022 is consistently below 100kW where the current building service size is approximately 830kW. The net zero ready scenario should account for a PV installation when considering upgrading the buildings service size. The current energy model predicts a peak PV potential of 760kW AC, although to achieve net-zero, only 230kW of PV will need to be installed. Even though the existing switchboard would be capable of accommodating this load with some modification to the main breaker, a new switchboard is strongly recommended as a lifecycle upgrade due to the age of the existing equipment. The new switchboard would the same size as the existing splitter, 800A and the new main breakers size will depend on the amount of photovoltaics being added on the roof.

In both mechanical options, new electrical distribution will be added off the main distribution to allow for connection to mechanical equipment. A new 208V, 3P panelboard will be added to serve all new pumps, ERVs and heat pumps etc. Two new buckets will be provided for the new distribution equipment inside the new main switchboard.

Air Source Heat Pump (ASHP) Option

Net-Zero Ready (ASHP)	Qty	kW	Total Load (kw)
Nominal 24ton air to water heat pump	3	50	150
120kW Electric Boiler	1	120	120
5-Ton Electric Heating Coils	10	3	30
1-Ton Electric Heating Coils	1	1	1
HP-HX Circ Pumps	2	1.5	3
HX-Buffer Tank Circ Pumps	2	1.38	2.76
K-Mart Circ Pumps	2	2.2	4.4
Maintenance Circ Pumps	2	0.764	1.528
Electric Boiler Pump	1	0.608	0.608
HP-HX Buffer Tank Circ	2	1.5	3
HX-Buffer Tank Pumps	2	1.38	2.76
Building Circ Pumps	2	2.2	4.4
150L/s ERV with ECM Motors	1	2	2
12000 L/s ERV with ECM Motors	1	5	5
1700L/S ERV with ECM Motors	1	2	2
80 Gallon Heat Pump Water Heater	5	5	5
Total Added Load			338

Ground Source Heat Pump (GSHP) Option

Net-Zero Ready (ASHP)	Qty	kW	Total Load (kw)
Nomial 20ton ground source heat pump	2	40	80
110kW Electric Boiler	1	110	110
10 ton electric fan coil unit	5	7	35
1 ton fan coil unit	1	1	1
Ground Loop Circulation Pump	2	2.2	4.4
HP-HX Pumps	2	1.38	2.75
HX-Buffer Tank Pumps	2	1.38	2.75
K-Mart Circulation Pumps	2	1.5	3
Maintenance Circulation Pumps	2	1.38	2.75
Electric Boiler Pump	1	0.61	0.61
HP-HX Pumps	2	0.61	1.22
HX-Buffer Tank Pumps	2	0.61	1.22
Buffer to Building Pumps	2	1.38	2.75
150L/s ERV with ECM Motors	1	2	2

12000 L/s ERV with ECM Motors	1	5	5
1700L/S ERV with ECM Motors	1	2	2
80 Gallon Heat Pump Water Heater	1	5	5
Total Added Load			262

The previous 4 years of billing information suggests the current building demand load is under 100kW, meaning there is approximately 563kW of demand load available using the existing electrical equipment. In both mechanical scenarios, air-source or ground source, there is substantial room available in the demand calculation for the addition of photovoltaics on the roof. One strategy commonly used to increase the amount of solar available to be installed is to reduce the size of the main breaker to limit how much energy can be pulled from the grid all at once. This allows you to install more solar onto the main board as it reduces the risk of the board's busbar being overloaded, taking into account both sources of power. For example, an 800A switchboard with a 600A main breaker would allow for 415kW of solar to be installed rather than only 205kW with a 800A main breaker. In order to allow for the installation of the full PV system, the new main switchboard will be installed at 800A with a 600A main breaker.

A letter will be sent to the utility (Nova Scotia Power) to inform them of added load onto the buildings existing electrical service. A new padmount transformer may be provided by the utility if they feel it is necessary to account for the added load. The letter will include an updated load calculation showing what the existing load is on the building (obtained from the year-old demand load study) and what the new load will be. The cost of replacement of the existing pad mount transformer is covered by the utility if it is required.

3. Net Zero Scenario

The net zero scenario is identical to the net zero ready scenario with the addition of a PV system. Since the PV system already accounts for in the net-zero ready scenario, there is no changes needed to the electrical distribution system.

The current Nova Scotia Power net metering agreement has expired. An update to the program is currently being reviewed by the Nova Scotia Utility Review Board and Nova Scotia Power. Under the old agreement only 100kW of solar could be installed on any building. Under the new net metering agreement, it is proposed to allow up to 1MW of solar to be installed on any building that incurs a demand charge. There will be two new classifications of net metered systems in the new program, a class 1 system which is under 100kW and a class 2 system which is under 1MW. In the net metering program, 100% of the excess energy generated from the solar array goes back onto the NSPI grid, and the customer gets a credit for the energy generated. Under the new proposal, the credit will be a percentage of the customers electricity rate for class 2 systems and will be equal to the customers electricity rate for class 1 systems. The credits automatically come off the power bill, further reducing the cost, the more solar that is installed. Being involved in a net-metering program is an essential part of achieving net-zero as it allows any excess energy generated to flow back onto the grid.

It is possible to install photovoltaics and not enroll in the net metering program. In this scenario, the building would draw power from the solar array as it is needed (up to the arrays maximum capacity). Any excess energy that is generated by the array is clipped (wasted) and no credit is given by the utility for that power. This scenario is only feasible if the customer routinely uses the approximate amount of power the array would generate. To optimize this, a short load study would

be performed on the building to determine approximately how much energy is used at any given time of the day/ year, and an array of the average size could be constructed to offset that consumption. This scenario isn't truly considered net-zero since in order to use 100% of the energy generated, the solar array must overproduce.

Air Source Heat Pump (ASHP) Option

Maximum Allowable PV Array Size (AC)	PV Array Size (DC) DC:AC Ratio of 1.7:1	Introduced Demand Load (Mechanical)	Total New Demand Load	Switchboard Size	Main Breaker Size	Net Metering Eligible
135kW	230kW	338kW (326A)	438kW (422A)	800A	600A (80% rated)	Yes (with new agreement)

Ground Source Heat Pump (GSHP) Option

Maximum Allowable PV Array Size (AC)	PV Array Size (DC) DC:AC Ratio of 1.7:1	Introduced Demand Load (Mechanical)	Total New Demand Load	New Switchboard Size	New Main Breaker Size	Net Metering Eligible
135kW	230kW	262kW (252A)	362kW (350A)	800A	600A (80% rated)	Yes (with new agreement)

Note a DC:AC ratio of 1.7:1 is used as recommended ratio of array size to inverter size. Final Ratio to be confirmed by system designer. Replacement of the main switchgear is recommended in all scenarios.

Out of the two different methods of metering, the net-metered option is recommended to ensure that a net-zero system can be achieved. As the current conditions for the net-metering program are changing day to day, further consultation with Nova Scotia Power will be needed to ensure all requirements are met prior to construction.

Appendix F

Pre-retrofit Utility Records

New Glasgow
Energy Use As Reported by Client

Summarized by Monthly Consumption

As calculated by RDH

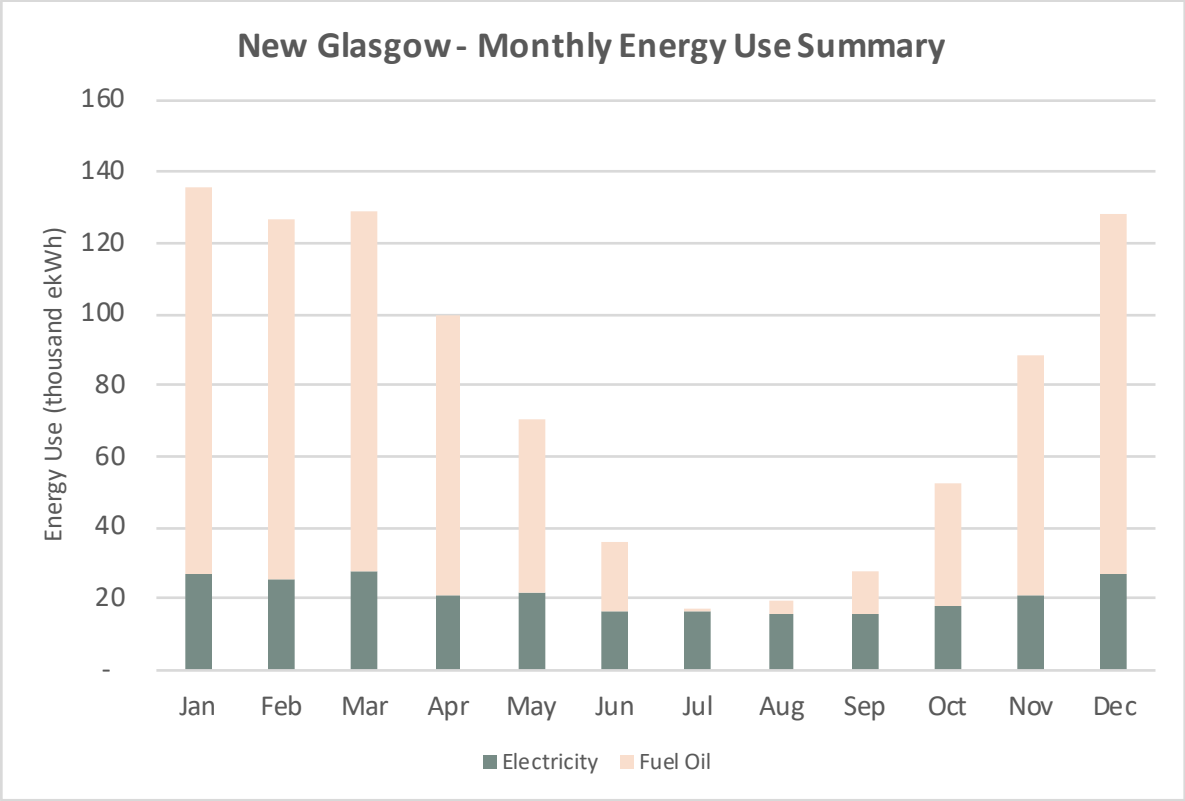
Electrical Consumption (kWh)

	2018	2019	2020	2021	2022	Average	
Jan	32,640	24,960	29,760	25,440	22,080	26,976	Jan
Feb	26,400	27,840	23,040	23,520	25,526	25,265	Feb
Mar	28,320	27,840	34,560	27,360	22,680	28,152	Mar
Apr	24,000	27,840	15,360	19,680	20,246	21,425	Apr
May	22,080	25,440	19,680	19,680	-	21,720	May
Jun	18,240	17,760	17,280	12,000	-	16,320	Jun
Jul	18,720	16,800	17,280	13,920	-	16,680	Jul
Aug	17,280	17,760	15,840	13,920	-	16,200	Aug
Sep	18,720	14,880	15,840	13,920	-	15,840	Sep
Oct	20,160	21,600	17,760	13,920	-	18,360	Oct
Nov	25,920	21,600	20,160	17,280	-	21,240	Nov
Dec	29,280	27,360	25,440	25,920	-	27,000	Dec

Fuel Oil Consumption (L)

	2019	2020	2021	2022	Average (L)	ekWh	
Jan	-	10,262	10,426	9,666	10,118	108,798	Jan
Feb	-	9,562	9,715	9,007	9,428	101,379	Feb
Mar	-	9,484	9,636	8,934	9,351	100,550	Mar
Apr	8,163	6,735	6,842	-	7,247	77,922	Apr
May	5,133	4,235	4,303	-	4,557	48,999	May
Jun	2,092	1,726	1,753	-	1,857	19,969	Jun
Jul	21	17	18	-	19	200	Jul
Aug	330	273	277	-	293	3,154	Aug
Sep	1,264	1,043	1,060	-	1,122	12,069	Sep
Oct	3,555	2,933	2,980	-	3,156	33,937	Oct
Nov	7,066	5,829	5,923	-	6,273	67,450	Nov
Dec	10,584	8,732	8,872	-	9,396	101,033	Dec

ekWh converstion factor used	10.75

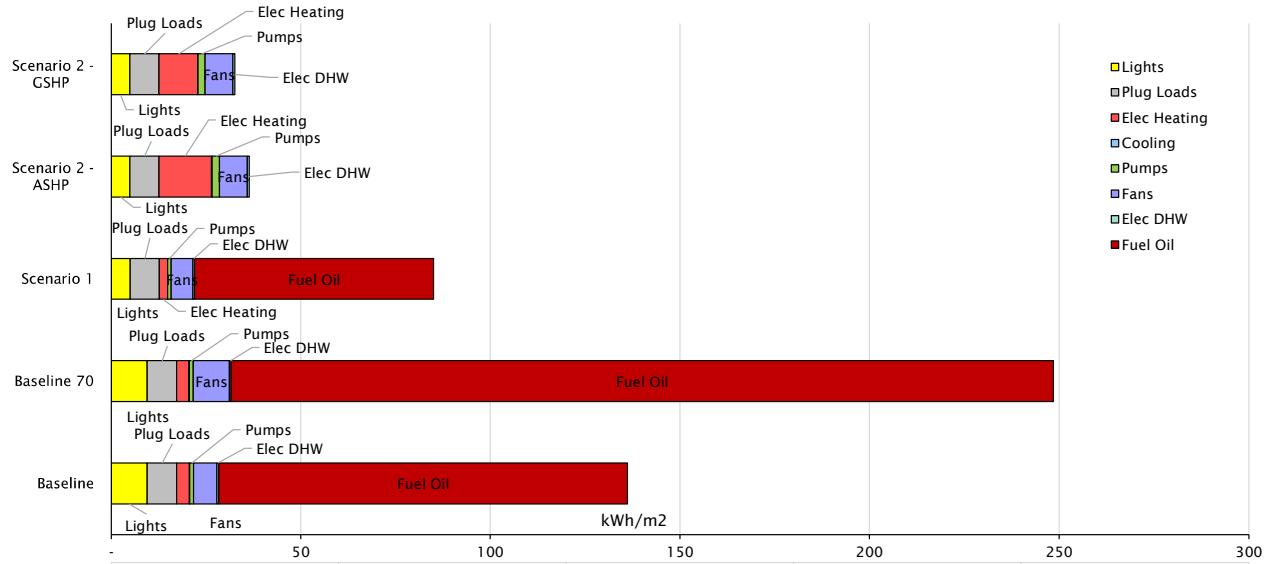

New Glasgow - Monthly Energy Use Summary
Energy Use (thousand ekWh)
160
140
120
100
80
60
40
20
-
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Electricity
Fuel Oil

Appendix G

Energy Model Reports

New Glasgow

Total Energy Use Intensity TEUI (kWh/m²/yr):

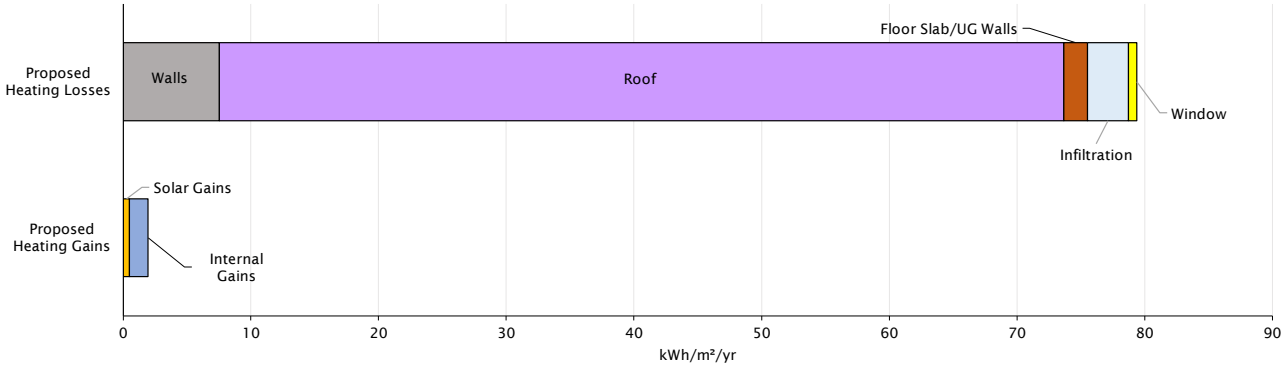


	Baseline	Baseline 70	Scenario 1	Scenario 2 - ASHP	Scenario 2 - GSHP
Lights	9.55	9.55	5.04	4.93	4.93
Plug Loads	7.70	7.70	7.70	7.70	7.70
Elec Heating	3.40	3.26	2.14	13.83	10.20
Cooling	0.11	0.11	0.04	0.19	0.09
Pumps	1.00	1.04	0.89	1.96	1.88
Fans	6.17	9.54	5.77	7.35	7.35
Elec DHW	0.47	0.45	0.45	0.45	0.45
Fuel Oil	107.75	216.82	63.04	-	-

Note: The values presented above represent the relative proportion of each component of total energy use

	TEUI:	Total
Baseline:	136.1 kWh/m²	1012897 kWh
Baseline 70F:	248.5 kWh/m²	1848636 kWh
Scenario 1:	85.1 kWh/m²	632956 kWh
Scenario 2 (ASHP):	36.4 kWh/m²	270920 kWh
Scenario 2 (GSHP):	32.6 kWh/m²	242541 kWh

Thermal Energy Demand Intensity TEDI (kWh/m²/yr)



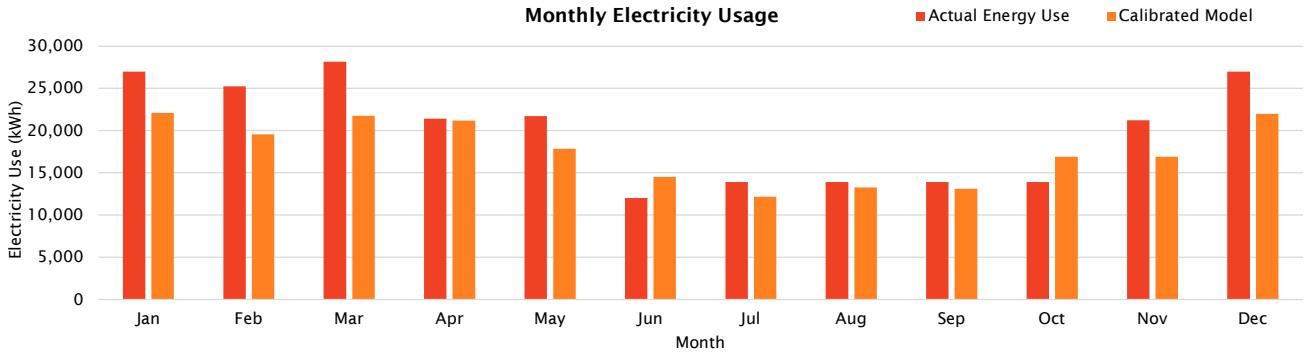
Note: The values presented above, represent the relative proportion of each component of the thermal energy demand intensity. These values include adjustments that account for internal gains from lights/plug loads/solar

New Glasgow

Project #, Building Name:		26522.000 ReCover Initiative
Calibrated Model Filename:		2023-02-03 New Glasgow Warehouse-cineplex.inp
Weather File		CAN_NS_CARIBOU-POINT-(AUT)_8200774_CWEC.BIN
Total Energy, kWh	9.15E+05	**Notes on Calibration:**
		See attached Inputs Document
Meter EUI, kWh/m2	123	
Model EUI, kWh/m2	136	

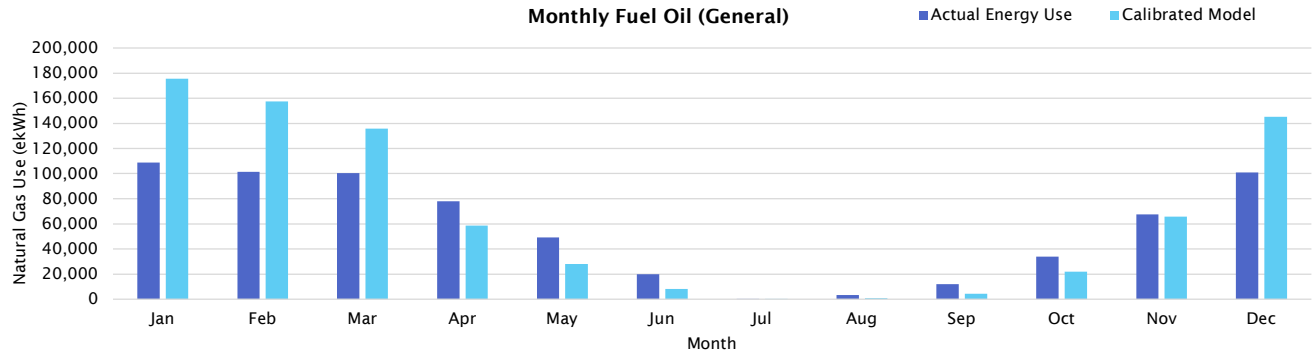
Monthly Electricity Usage (kWh)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Actual Energy Use	26,976	25,265	28,152	21,425	21,720	12,000	13,920	13,920	13,920	13,920	21,240	27,000	239,458
Calibrated Model	22,118	19,552	21,744	21,192	17,866	14,503	12,147	13,264	13,116	16,907	16,899	22,005	211,313
Difference	-4,858	-5,713	-6,408	-233	-3,854	2,503	-1,773	-656	-804	2,987	-4,341	-4,995	-28,145
% Difference	-18.0%	-22.6%	-22.8%	-1.1%	-17.7%	20.9%	-12.7%	-4.7%	-5.8%	21.5%	-20.4%	-18.5%	-11.8%



Monthly Fuel Oil Usage (ekWh)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Actual Energy Use	108,798	101,379	100,550	77,922	48,999	19,969	200	3,154	12,069	33,937	67,450	101,033	675,461
Calibrated Model	175,550	157,410	135,849	58,586	28,142	8,212	70	899	4,235	21,843	65,624	145,126	801,546
Difference	66,752	56,031	35,299	-19,336	-20,857	-11,757	-130	-2,255	-7,834	-12,094	-1,826	44,093	126,085
% Difference	61.4%	55.3%	35.1%	-24.8%	-42.6%	-58.9%	-64.9%	-71.5%	-64.9%	-35.6%	-2.7%	43.6%	18.7%



GENERAL

Building	New Glasgow Public Works Building
Archetype	Existing Warehouse
Site Location	New Glasgow, Nova Scotia

Building Summary	New Glasgow Baseline	Minimum Acceptable (50%) Reduction	Net Zero Carbon Ready Air to Water Heat Pump	Net Zero Carbon Ready Ground Source Heat Pump	Units	Reference/Description
Breakdown of Space Types					-	Based on drawings
Conditioned Floor Area (SQF)	**7,430 (80,000)**	"	"	"	**m² (ft²)**	
Storage/Stock Room/Receiving	1,210 (13,000)	"	"	"	m² (ft²)	
Office	220 (2,400)	"	"	"	m² (ft²)	
Vestibule	30 (300)	"	"	"	m² (ft²)	
Kmart	5,670 (61,000)	"	"	"	m² (ft²)	
Misc. (janitor, mech rooms...)	200 (2,100)	"	"	"	m² (ft²)	
Washroom	110 (1,200)	"	"	"	m² (ft²)	
Opaque Enclosure Performance						
Above Grade Wall R-value (North and South)	4" brick (exterior), 1" Rigid Insulation, Minimal air gap, 8" Concrete Block (R-4.9)	Panelized Walls to meet effective R-14	Panelized Walls to meet effective R-20	Panelized Walls to meet effective R-20	(ft²-hr-°F/Btu) effective	Assembly info from PW Building Assessment Report Existing R-value estimates provided by ARCH Note that roof was calibrated to R-4 to account for heat recovery through infiltration from high conductivity of assembly
Above Grade Wall R-value (West)	4" brick (exterior), 1" Rigid Insulation, Minimal air gap, 8" Concrete Block 1/2" Gypsum board (R-5.3)	Panelized Walls to meet effective R-14	Panelized Walls to meet effective R-20	Panelized Walls to meet effective R-20	(ft²-hr-°F/Btu) effective	
Above Grade Wall R-value (East)	8" Concrete Block (exterior) (R-1)	Panelized Walls to meet effective R-14	Panelized Walls to meet effective R-20	Panelized Walls to meet effective R-20	(ft²-hr-°F/Btu) effective	
Main Roof R-value	1/4" Mod Bit (exterior) 1/4" Fibreboard 1.5" Steel deck (R-0.7) (R-4 calibrated)	Panelized Roof to meet effective R-18	Panelized Roof to meet effective R-45	Panelized Roof to meet effective R-45	(ft²-hr-°F/Btu) effective	
Slab on Grade R-value	No Insulation	No Insulation	No Insulation	No Insulation	(ft²-hr-°F/Btu) effective	
Exposed Floor R-value	No Insulation	No Insulation	No Insulation	No Insulation	(ft²-hr-°F/Btu) effective	
Fenestration						
Overhead Door R-value	Assumed R-2 (Clearfield) Overhead doors are 5.6% of wall area	Assumed R-10 (Clearfield) Overhead doors are 5.6% of wall area	Assumed R-10 (Clearfield) Overhead doors are 5.6% of wall area	Assumed R-10 (Clearfield) Overhead doors are 5.6% of wall area	(ft²-hr-°F/Btu) effective	per Arch
Window-to-Wall Ratio (WWR)	4.5%	4.5%	4.5%	4.5%	%	per Drawings
Windows Installed Overall U-value	Single Glazed Storefront Assumed USI-3.8 (U-0.67)	Triple-Glazed Windows Assumed U-0.18	Triple-Glazed Windows Assumed U-0.18	Triple-Glazed Windows Assumed U-0.18	(Btu/ft²-hr-°F)	per Arch
Window Overall SHGC	0.87	0.32	0.32	0.32	-	per Arch, based on PHI info for single gazing
Infiltration						
Infiltration Rate	1.5 L/s/m² exterior vertical enclosure and roof area @ 75Pa (Modelled as 0.25 L/s/m² @ 5Pa, assumed operating pressure)	Reduction to 0.75L/s/m² exterior enclosure area	Reduction to 0.75L/s/m² exterior enclosure area	Reduction to 0.75L/s/m² exterior enclosure area	L/s/m² exterior vertical enclosure and roof area @ 5Pa	Based on ASHRAE Fundamentals, Leaky Building (2009); infiltration rate per m^2 of exterior envelope. Assumed for now. Calibrated to 50% to account for heat recovery through infiltration from high conductivity of assembly

MECHANICAL	New Glasgow Baseline	Minimum Acceptable (50%) Reduction	Net Zero Carbon Ready Air to Water Heat Pump	Net Zero Carbon Ready Ground Source Heat Pump	Units	Reference/Description
Ventilation System Description	Maintenance area = basic ventilation (exhaust fan + intake connected to a CO sensor), but do not run consistently. Rely on natural ventilation (open overhead doors) in the summer.	Maintenance area = ERV controlled with CO & Nox sensors Office area = ERV with time clock	Maintenance area = ERV controlled with CO & Nox sensors Office area = ERV with time clock	Maintenance area = ERV controlled with CO & Nox sensors Office area = ERV with time clock	-	RDH Site Notes from call w/ M&R
Heating/Cooling System Description	Oil-fired boilers serve hydronic heated unit heaters. Two mini-split units cool office/storage room. Rooftop unit with DX cooling & hydronic heating serves K-mart	New Oil-fired boilers serve existing hydronic unit heaters. Existing mini-split units cooling office/storage room.	Air-to-water heat pump providing heating and cooling to 4-pipe FCUs. Backup electric boiler.	Air-to-water heat pump providing heating and cooling to 4-pipe FCUs. Backup electric boiler.	-	
Heating Plant						
System Description	100 bhp Central Oil-Fired Boiler	480 kW Oil-Fired Boiler	Air-to-water heat pump with 120 kW Electric Boiler Back-up	Ground source heat pump with 110 kW Electric Boiler Back-up	-	New Glasgow PW Building Assessment Report Note: RDH modelled a much lower boiler capacity to calibrate the Fuel Oil consumption (~10x smaller than available capacity)
Heat Capacity	100 bhp	480 kW				
Plant Efficiency	78.0	86.6% - Modulating	AWHP: COP = 3 Boiler = 100%	AWHP: COP = 3 Boiler = 100%	%	per M&R
Hot Water Supply/Return Temperature	Assume Supply 185F Return 165F	Assume Supply 185F Return 165F	Supply = 120˚F Return = 100˚F (assumed)	Supply = 120˚F Return = 100˚F (assumed)	˚C (˚F)	per M&R system scematics
Cooling Plant						
System Description	n/a	n/a	Air-to-water heat pump	Air-to-water heat pump	-	RDH Site Notes from call w/ M&R and PW Building Assessment
Plant Efficiency	n/a	n/a	EER = 11	EER = 11	-	per M&R
Cold Water Supply/Return Temperature			45˚F	45˚F	˚C (˚F)	PW Building Assessment
Pumps						
Pump Type	1.50	1.5 - assumed same	Circ = (2)1.5, (2)2.2, (2)0.764, (2)2.2 kW Buffer Tanks = (2)1.377, (4)0.608 kW Elec Boiler = (1) 0.608 kW	Circ = (2)1.5, (2)1.377, (2)1.377 (8)2.2 kW Ground Loop = (2)2.0 kW Elec Boiler = (1) 0.608 kW	HP	Per M&R equipment specs
Pump Control	Constant	Constant - assumed same	VFD	VFD		
MECHANICAL	**New Glasgow Baseline**	**Minimum Acceptable (50%) Reduction**	**Net Zero Carbon Ready Air to Water Heat Pump**	**Net Zero Carbon Ready Ground Source Heat Pump**	**Units**	**Reference/Description**
Airside System Description						

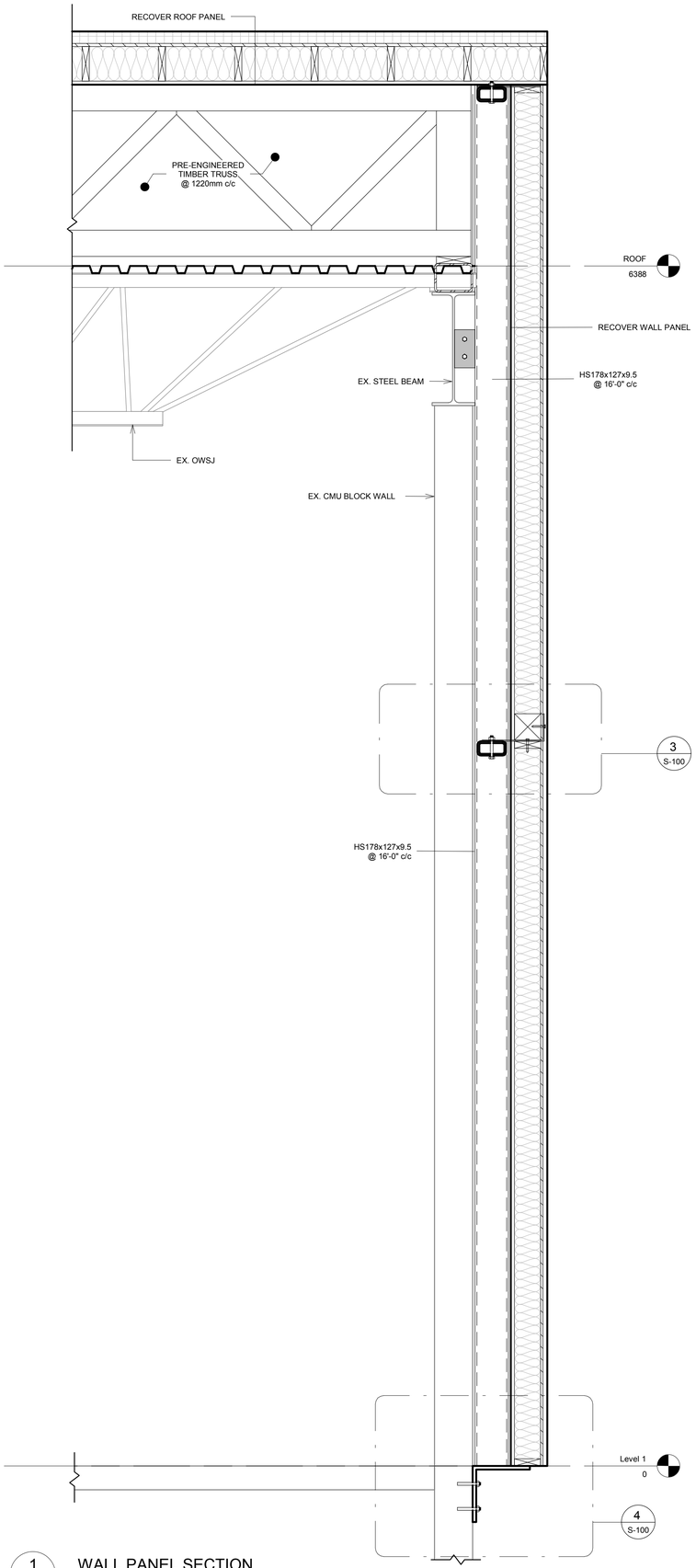
System Description	Kmart = AHU with DX cooling & hydronic heating Maintenance area = Unit heaters Office = Mini-split + electric baseboards	Kmart = AHU with DX cooling & hydronic heating Maintenance area = Unit heaters Office = Mini-split + electric baseboards	4-pipe FCUs in K-mart and office area to cycle on/off to meet heating and cooling loads.	4-pipe FCUs in K-mart and office area to cycle on/off to meet heating and cooling loads.	-	RDH Site Notes from call w/ M&R
Total Supply Air Flow Rate	Estimated capacity 35,000 cfm (Kmart) - runs when there is a call for heating (setpoint temperature is 7˚C)	Estimated capacity 35,000 cfm (Kmart) - runs when there is a call for heating (setpoint temperature is 7˚C)	Autosized.	Autosized.	L/s (cfm)	New Glasgow PW Building Assessment
Total System Fan Power	0.25	0.25	0.25	0.25	W/cfm	New Glasgow PW Building Assessment
Minimum Outdoor Air Flow Rate	0	Provided by ERVs ducting directly into spaces, see below for performance	Provided by ERVs ducting directly into spaces, see below for performance	Provided by ERVs ducting directly into spaces, see below for performance	L/s (cfm)	per M&R
Economizer	None	None	None	None	-	
Heating Type	AHU & Unit Heaters = Hydronic Office = Electric baseboards	AHU & Unit Heaters = Hydronic Office = Electric baseboards	Hydronic	Hydronic	-	
Cooling Type	4x30 ton DX Units (Kmart space only - not used) Two mini-splits (COP=3.8), assumed 3 tons total (office)	4x30 ton DX Units (Kmart space only - not used) Two mini-splits (COP=3.8), assumed 3 tons total (office)	Hydronic	Hydronic	-	New Glasgow PW Building Assessment
Fan Type						
ERVs						
Air Flow	0.00	320 cfm (Office) 25,500 cfm (Warehouse)	320 cfm (Office) 25,500 cfm (Warehouse) 3600 cfm (Kmart)	320 cfm (Office) 25,500 cfm (Warehouse) 3600 cfm (Kmart)	W/cfm	New Glasgow PW Building Assessment
Fan Schedule	Off	Office - runs during building occupied hours Warehouse- controlled with CO & NOx sensors	Office & Kmart - runs during building occupied hours Warehouse- controlled with CO & NOx sensors	Office & Kmart - runs during building occupied hours Warehouse- controlled with CO & NOx sensors		Estimate of 2 hours per day for sensor controlled warehouse ERV
Energy Recovery	n/a	Sensible = 90% Latent = 70%	Sensible = 90% Latent = 70%	Sensible = 90% Latent = 70%	-	
Energy Exchanger By-pass	n/a	Dual Core	Dual Core	Dual Core	-	
West Office Electric Baseboards						
Heat Capacity	-15000	-15000	no baseboards	no baseboards	BTUH	New Glasgow PW Building Assessment
Domestic Hot Water						
Heating Source	5 Electric Water Heaters 40 gal ea.	5 Electric Water Heaters 40 gal ea.	Heat Pump Water Heater	Heat Pump Water Heater	-	Mechanical - New Glasgow Existing Outline Specification.pdf
Thermal Efficiency	100%	100%	4.0 UEF	4.0 UEF	%	M&R to confirm heat pump water heater efficiency
Peak DHW Load	Office: 90 Warehouse: 66	Office: 90 Warehouse: 66	Office: 90 Warehouse: 66	Office: 90 Warehouse: 66	W/person	NECB 2020 Table A-8.4.3.2.(2)-B Default Loads by Space Type NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Schedule	Fractional	Fractional	Fractional	Fractional	-	
DHW HW Supply Temp	60	60	60	60	˚C	
Storage tank capacity					Liters	

OPERATION	New Glasgow Baseline	Minimum Acceptable (50%) Reduction	Net Zero Carbon Ready Air to Water Heat Pump	Net Zero Carbon Ready Ground Source Heat Pump	Units	Reference/Description
Lighting						
Type	HID (exterior, and interior) T12 Fluorescent (bays)	LED retrofit kits	LED	LED		New Glasgow: RDH Site Notes from call w/ M&R
Lighting Power Density	Office/Warehouse Combined = 20W/m² KMART = 5.4 W/m²	Office/Warehouse Combined = 11W/m² KMART = 6.8 W/m²	Office/Warehouse Combined = 10 W/m² KMART = 6.2 W/m²	Office/Warehouse Combined = 10 W/m² KMART = 6.2 W/m²	W/m²	ASHRAE 90.1-1989 Kmart space LPD reduced by 50% for broken fixtures and run at a 5% schedule
Schedule	Fractional	Fractional	Fractional	Fractional	-	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Process Loads						
Plug Loads	Office: 7.5 Warehouse/Maintenance Area: 10 Kmart Area: 1	Office: 7.5 Warehouse/Maintenance Area: 10 Kmart Area: 1	Office: 7.5 Warehouse/Maintenance Area: 10 Kmart Area: 1	Office: 7.5 Warehouse/Maintenance Area: 10 Kmart Area: 1	W/m²	Office NECB 2020 Table A-8.4.3.2.(2)-B Default Loads by Space Type Warehouse - Increased to 10W/m2 for calibration
Schedule	Fractional	Fractional	Fractional	Fractional	-	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Process Loads	See pictures of kitchen equipment	See pictures of kitchen equipment	See pictures of kitchen equipment	See pictures of kitchen equipment	W/m²	Kitchen equipment is in use per M&R
Schedule	6am-4pm	6am-4pm	6am-4pm	6am-4pm	-	
Occupancy						
Occupant Density	Office: 48m²/occupant (4-6 occupants) Warehouse: 100 m²/occupant (~12 occupants) Assumed zero occupancy in previous Kmart area	Office: 48m²/occupant (4-6 occupants) Warehouse: 100 m²/occupant (~12 occupants) Assumed zero occupancy in previous Kmart area	Office: 48m²/occupant (4-6 occupants) Warehouse: 100 m²/occupant (~12 occupants) Assumed zero occupancy in previous Kmart area	Office: 48m²/occupant (4-6 occupants) Warehouse: 100 m²/occupant (~12 occupants) Assumed zero occupancy in previous Kmart area	m²/occupant	Office per M&R NECB 2020 Table A-8.4.3.2.(2)-B Default Loads by Space Type
Occupant Schedule	Fractional	Fractional	Fractional	Fractional	-	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Setpoints						
Heating Setpoint/Setback	Adjustable thermostats - assumed Setpoint 18°C/ Setback 18°C KMART - Minimum 7°C, maintained w/ Unit Heaters	Adjustable thermostats - assumed Setpoint 18°C/ Setback 18°C KMART - Minimum 7°C, maintained w/ Unit Heaters	Adjustable thermostats - assumed Setpoint 18°C/ Setback 18°C KMART - Minimum 7°C, maintained w/ Unit Heaters	Adjustable thermostats - assumed Setpoint 18°C/ Setback 18°C KMART - Minimum 7°C, maintained w/ Unit Heaters	°C	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A Office/Warehouse setpoint modified per feedback from M&R
Cooling Setpoint/Setback	Adjustable thermostats - assumed Setpoint 24°C/ Setback 29°C	Adjustable thermostats - assumed Setpoint 24°C/ Setback 29°C	Adjustable thermostats - assumed Setpoint 24°C/ Setback 29°C	Adjustable thermostats - assumed Setpoint 24°C/ Setback 29°C	°C	

Appendix H

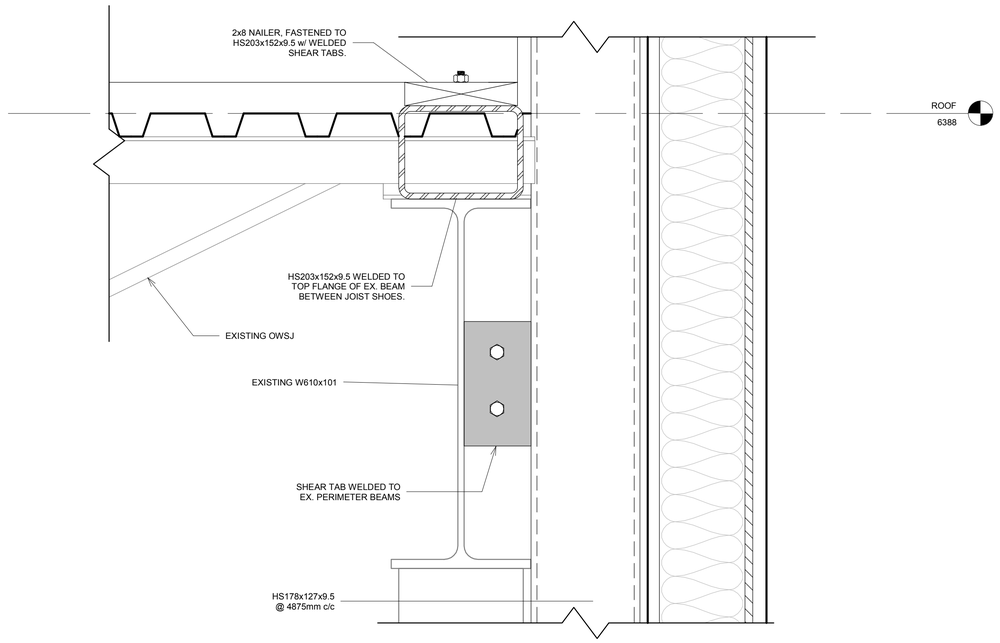
Panel Schematics

- **Panel Schematics**
- **Panel Connection Details**



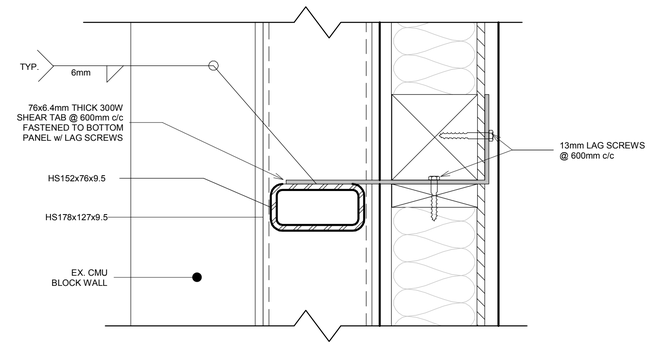
1 S-100 WALL PANEL SECTION

1 : 15



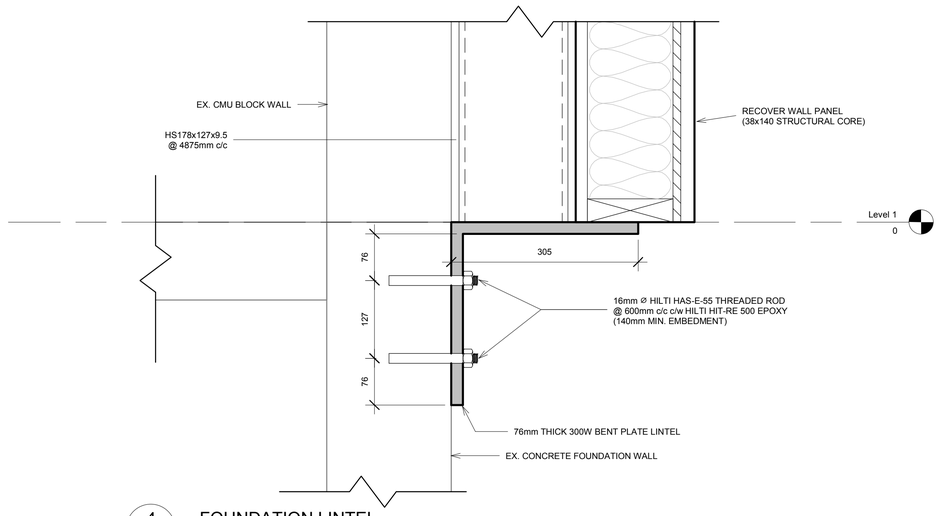
2 S-100 WALL AND ROOF PANEL JOINTS

1 : 5



3 S-100 MID-HEIGHT WALL PANEL CONNNECTION

1 : 5



4 S-100 FOUNDATION LINTEL

1 : 5

PRELIMINARY

ISSUE	DATE	DESCRIPTION
2	10/02/2023	REVISED CONNECTION DETAILS
1	01/02/2023	ISSUED FOR REVIEW

CONSULTANT

DESIGNPOINT
engineering • surveying • solutions
902.832.5597
designpoint.ca

CLIENT

RECOVER INITIATIVE

PROJECT DESCRIPTION

NEW GLASGOW PUBLIC WORKS RETROFIT

NEW GLASGOW, NOVA SCOTIA

SHEET DESCRIPTION

PRELIMINARY PANEL CONNECTION DETAILS

Drawn	Engineer	Project No.	Drawing No.
A. MCCRACKEN	E. TEASDALE	22-316	S-100
Scale: As indicated	Filename: 22-316_NG.rvt		1 or 1

P:\2022\22-316 RSI - NRCan Retrofit\01 - Drawings\Eng Design\22-316_Panel.rvt

Roof Panel Schematics

Cellulose Inverted Roof - R18 - 2x4 - DensGlass

ReCover Initiative

ReCover

Version Date
February 27, 2023

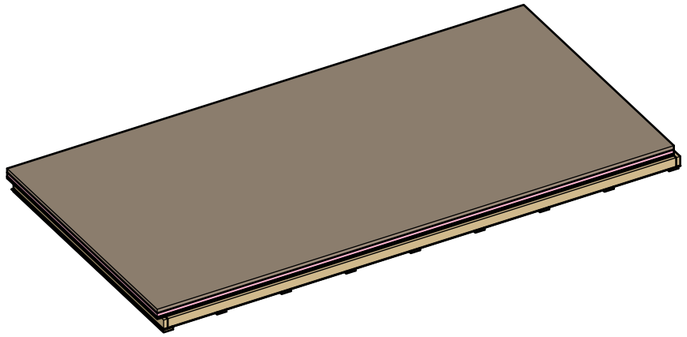
PROJECT
2x4 R18 Cellulose XPS
Inverted Roof Panel

Drawn By
Nick Rudnicki

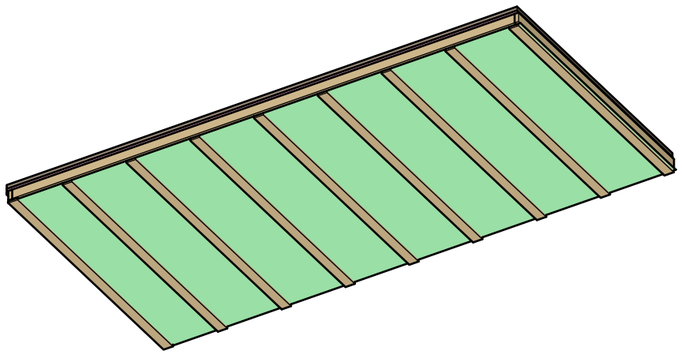
01

Installed and Finished Panel

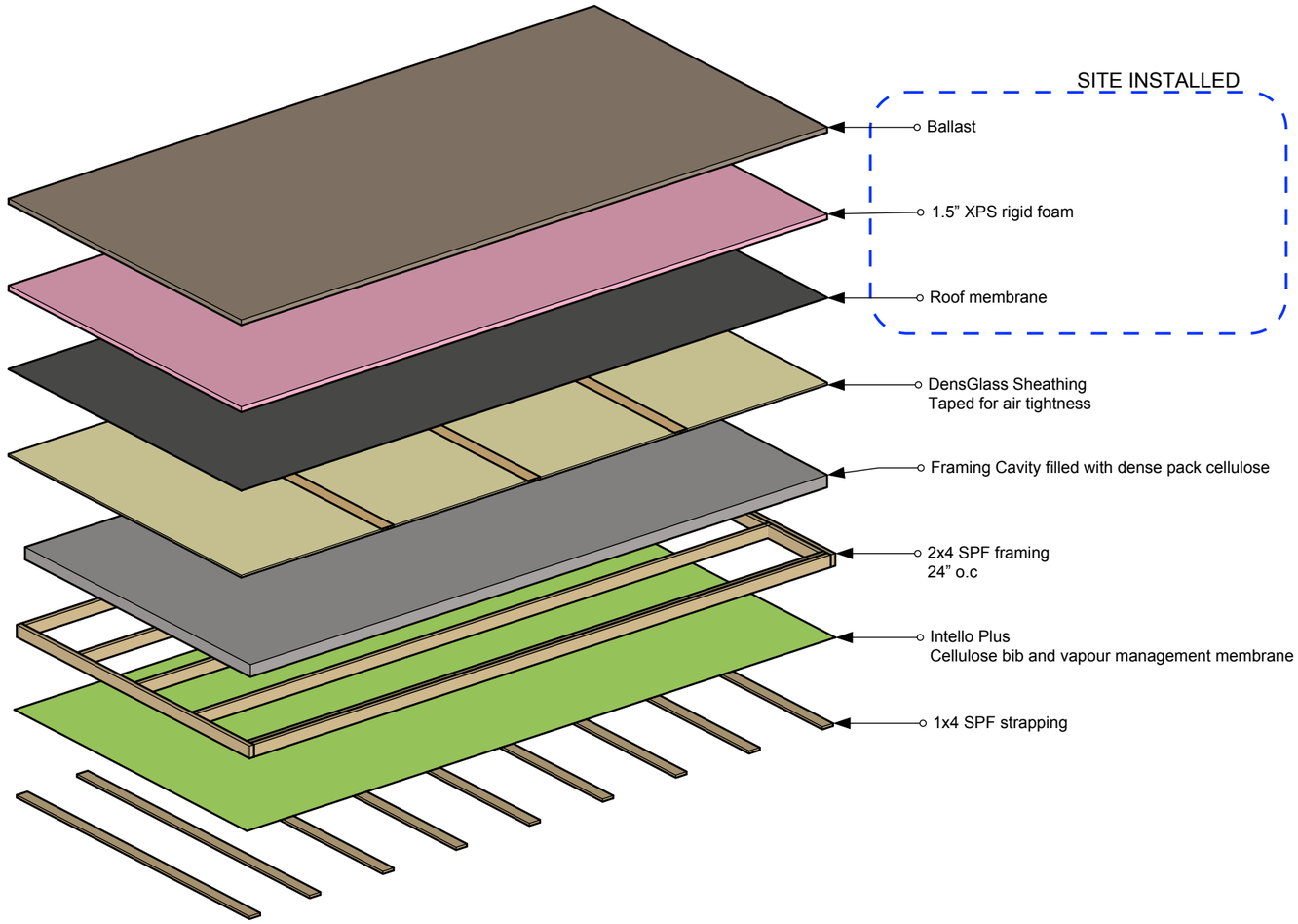
Overview of panel and site-installed XPS and roofing



Top View



Bottom View



Exploded View

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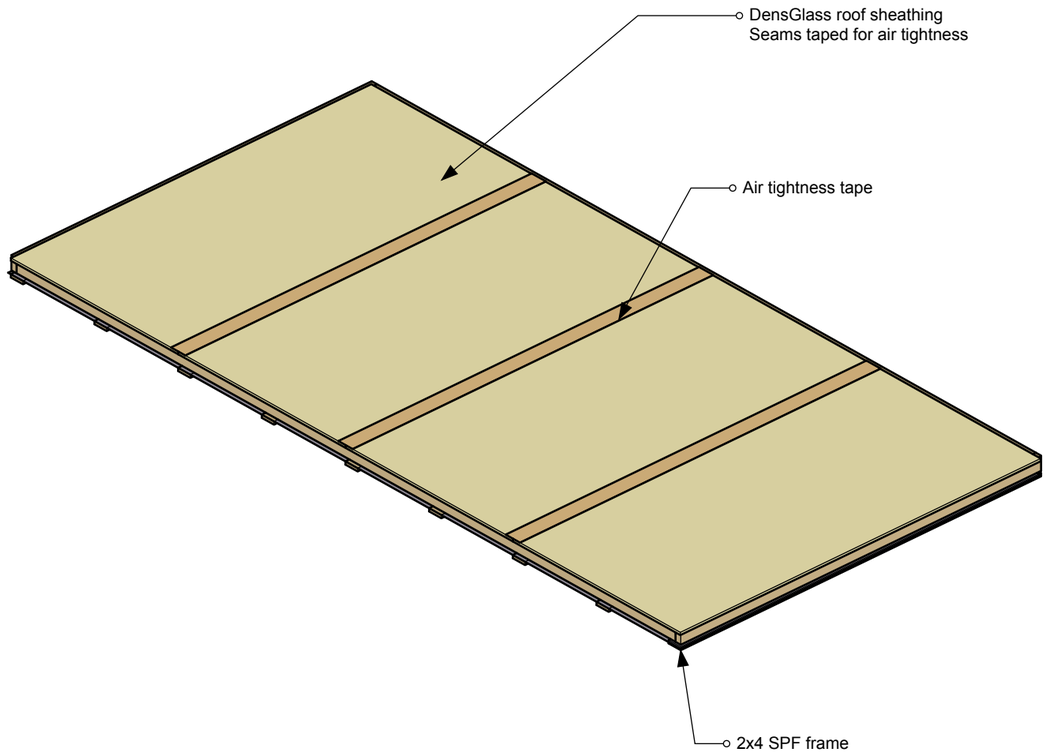
Version Date
February 27, 2023

PROJECT
2x4 R18 Cellulose XPS
Inverted Roof Panel

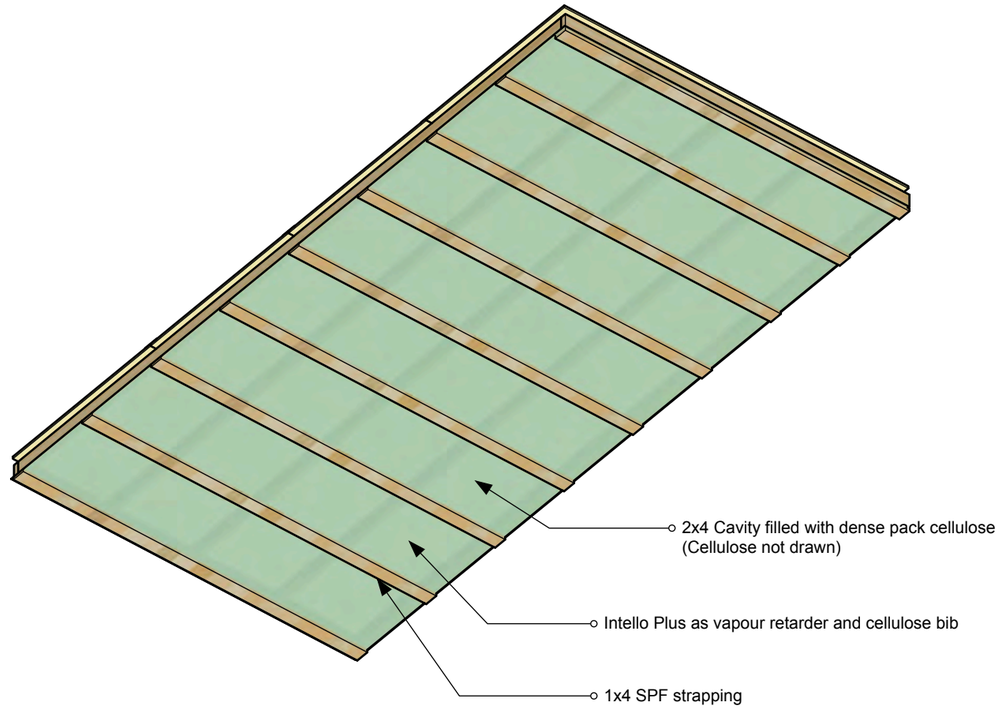
Drawn By
Nick Rudnicki

02

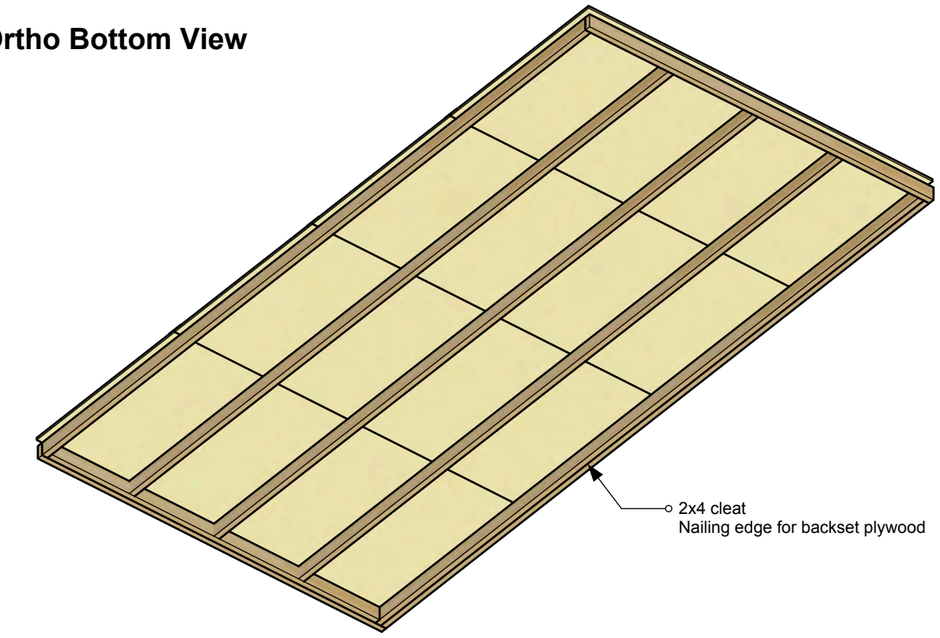
Just the Panel Overview



Top View



Ortho Bottom View



ReCover

Version Date
February 27, 2023

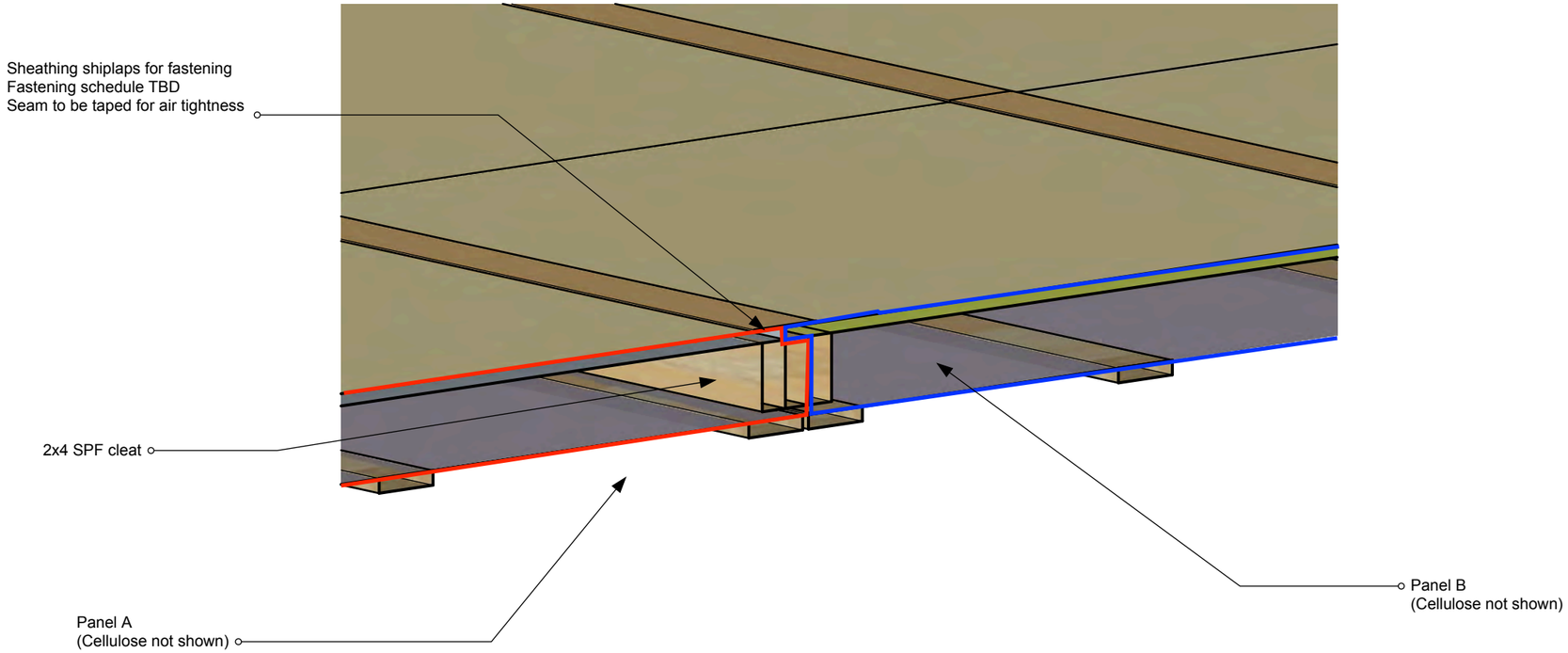
PROJECT
2x4 R18 Cellulose XPS
Inverted Roof Panel

Drawn By
Nick Rudnicki

03

Seam Joining Detail

How Panels Join Together on Site



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Version Date
February 27, 2023

PROJECT
2x4 R18 Cellulose XPS
Inverted Roof Panel

Drawn By
Nick Rudnicki

04

Wall Panel Schematics

Cellulose - R11 - 2x4 - 1/2” Plywood

ReCover Initiative

ReCover

DRAWN BY
Nick Rudnicki

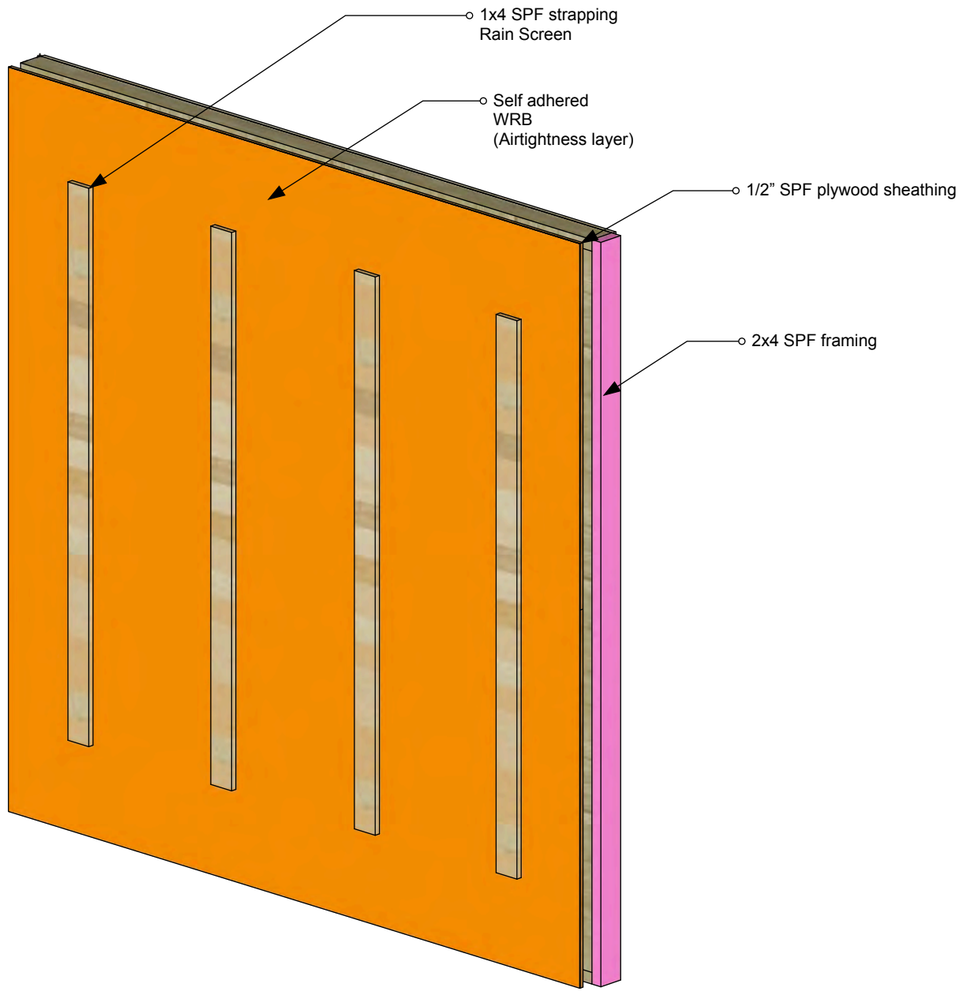
PROJECT
2x4 R11 Cellulose
Panel Schematics

Version Date
February 27, 2023

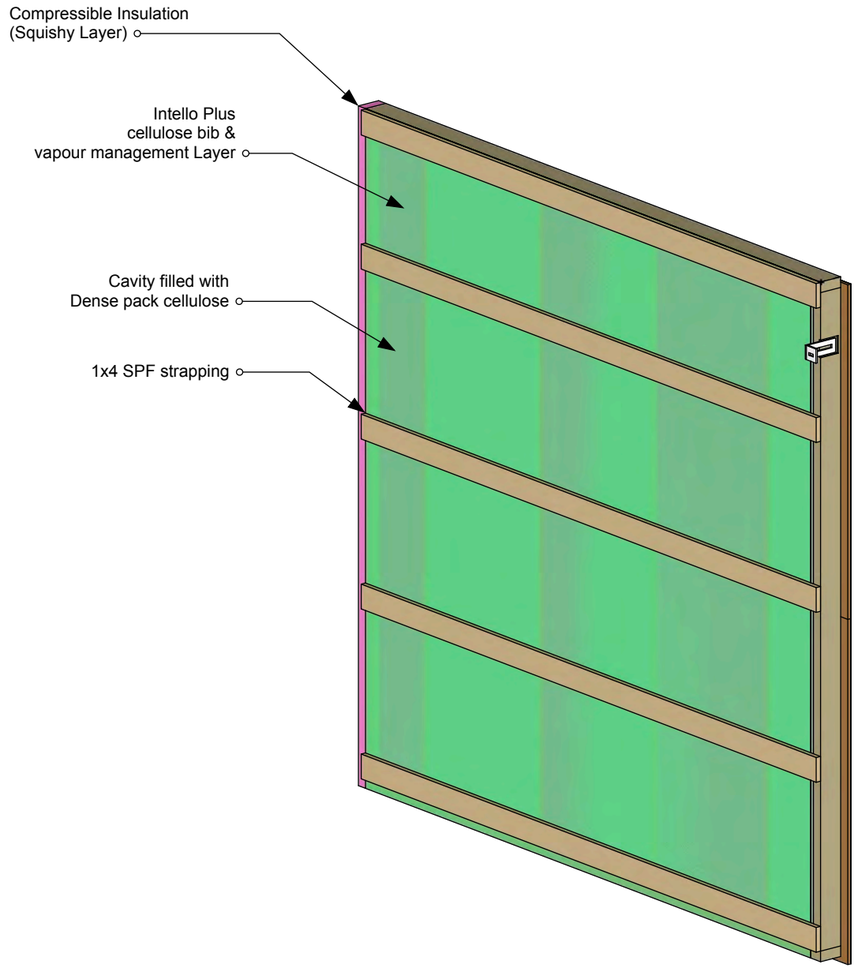
01

Panel - Overview

Panel schematic with all membranes in place



EXTERIOR VIEW



INTERIOR VIEW

ReCover

Version Date
February 27, 2023

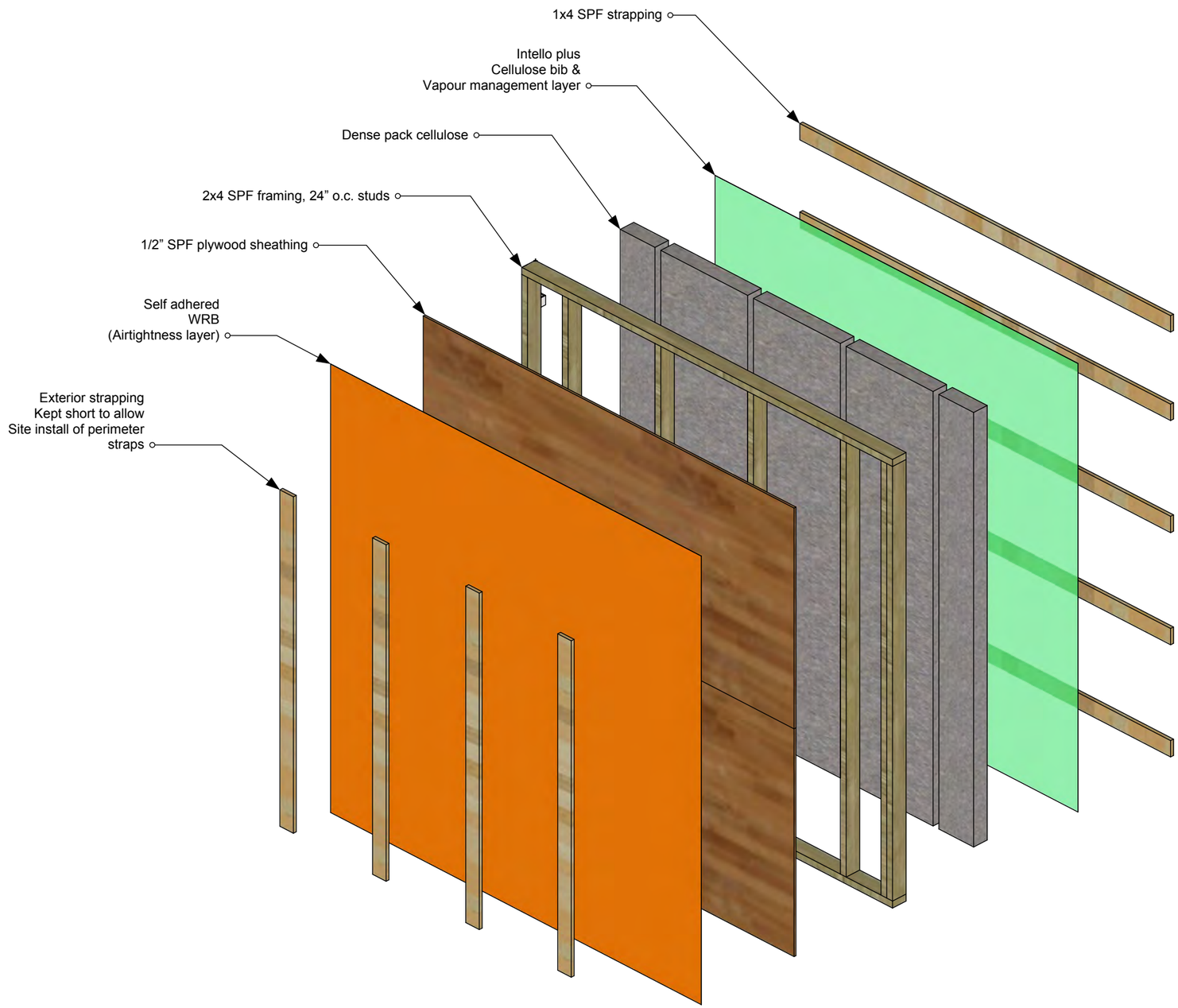
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

02

Panel - Exploded View

Panel schematic with all membranes in place



ReCover

Version Date
February 27, 2023

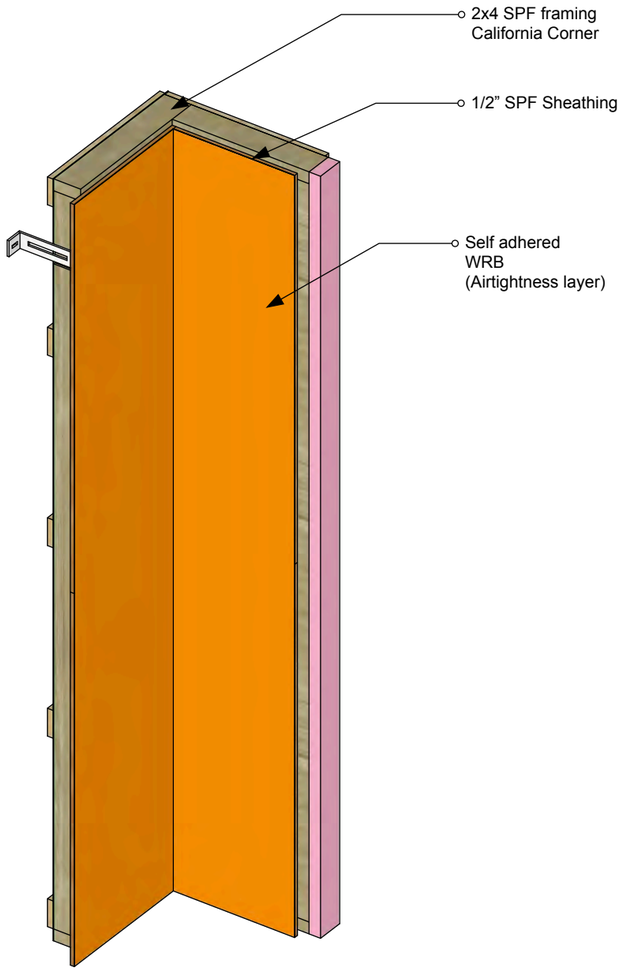
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

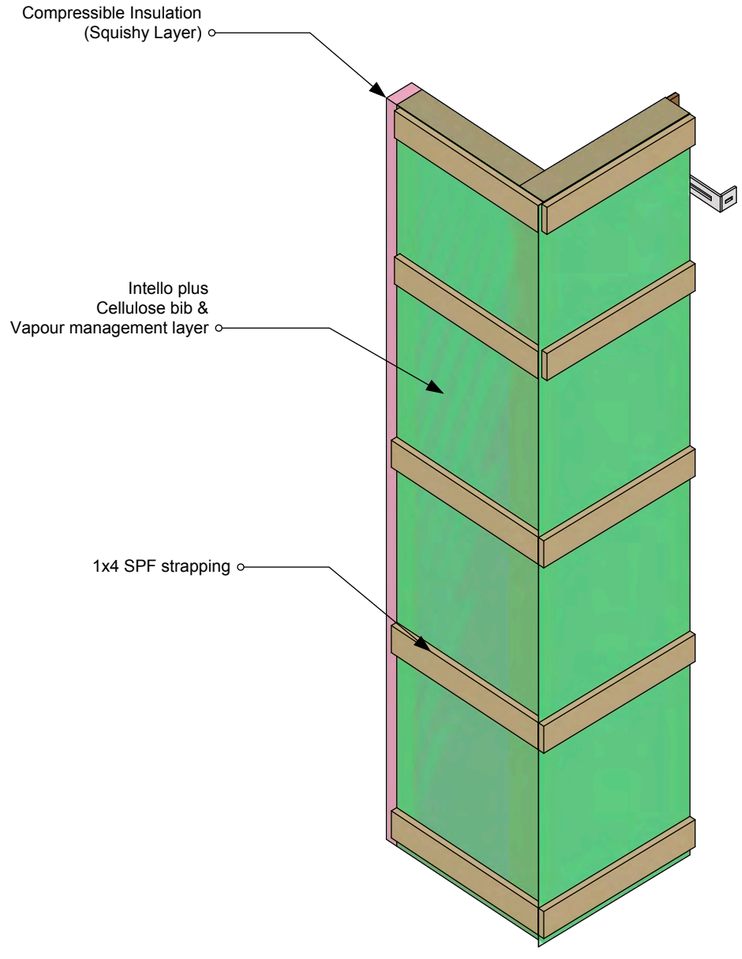
03

Panel - Inside Corner

Panel schematic with all membranes in place



EXTERIOR VIEW



INTERIOR VIEW

RSI projects

ReCc

Version Date
February 27, 2023

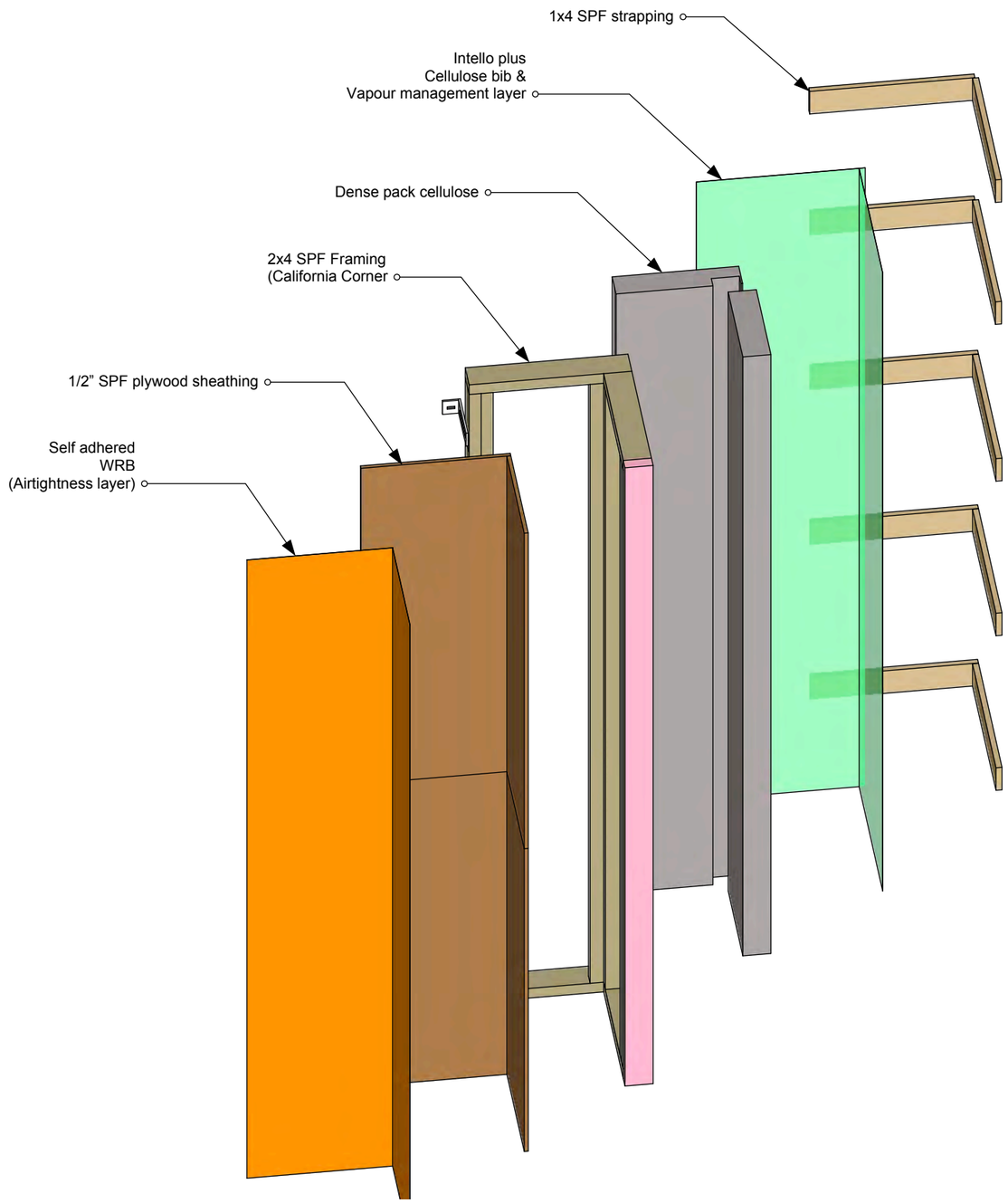
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

04

Panel - Inside Corner - Exploded

Panel schematic with all membranes in place



ReCover

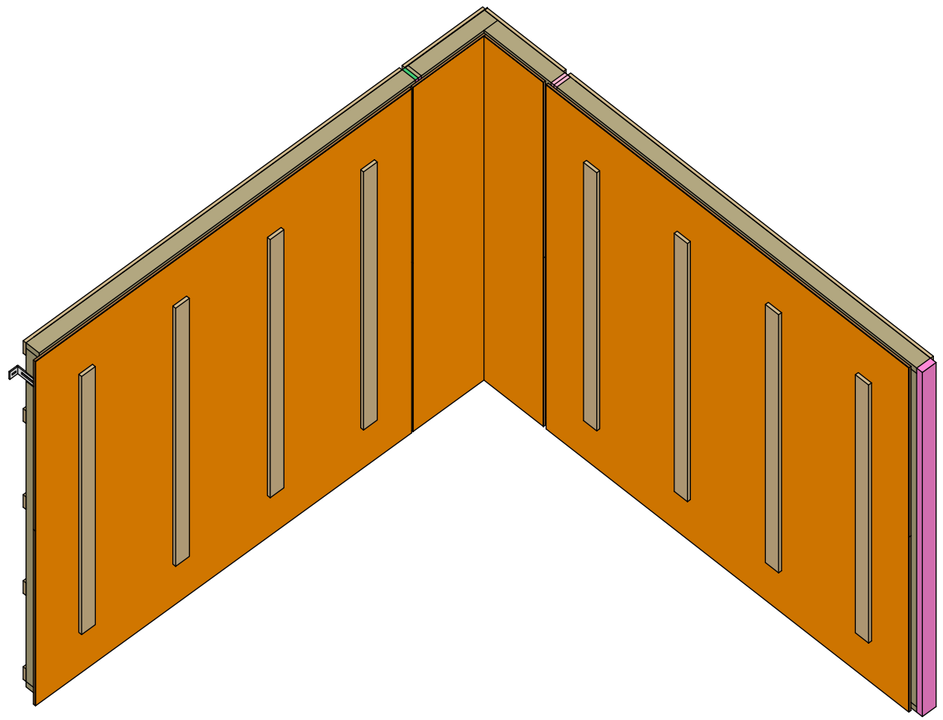
Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

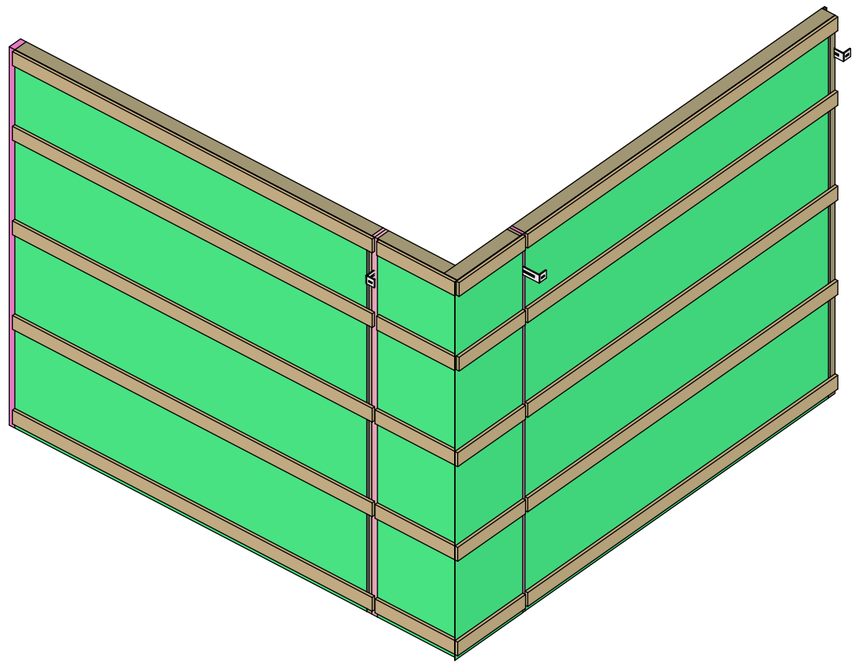
DRAWN BY
Nick Rudnicki

05

Inside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

ReCover

Version Date
February 27, 2023

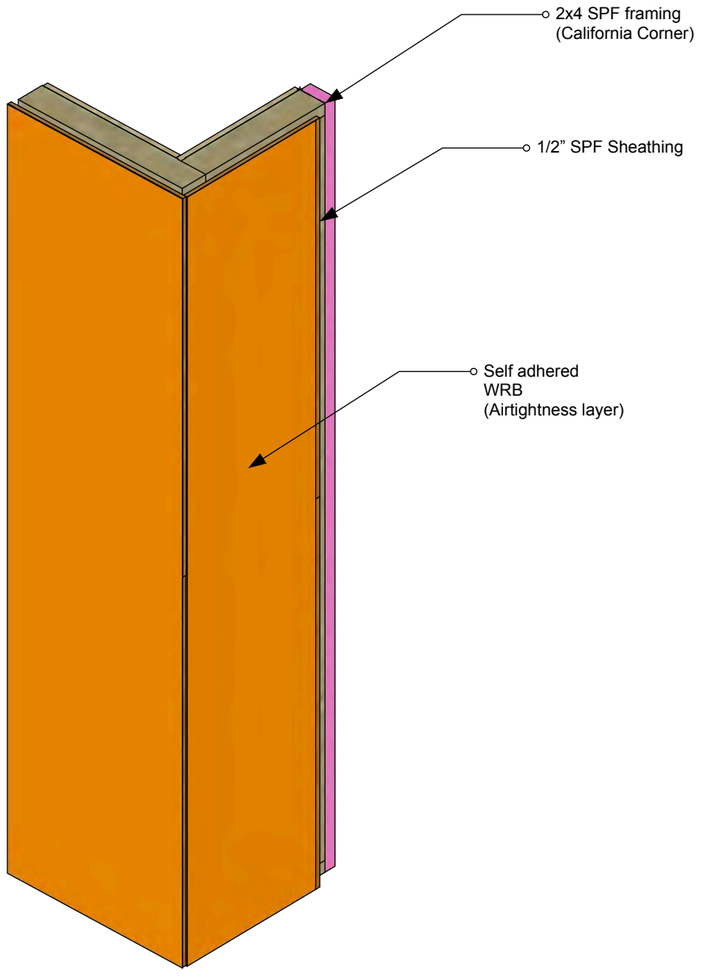
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

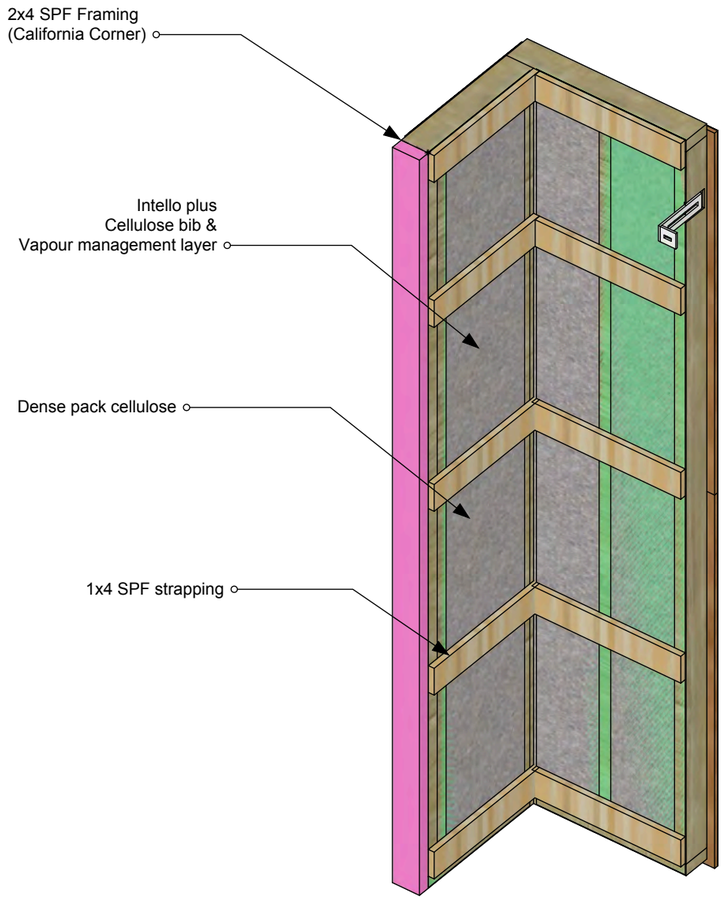
06

Panel - Outside Corner

Panel schematic with all membranes in place



EXTERIOR VIEW



INTERIOR VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

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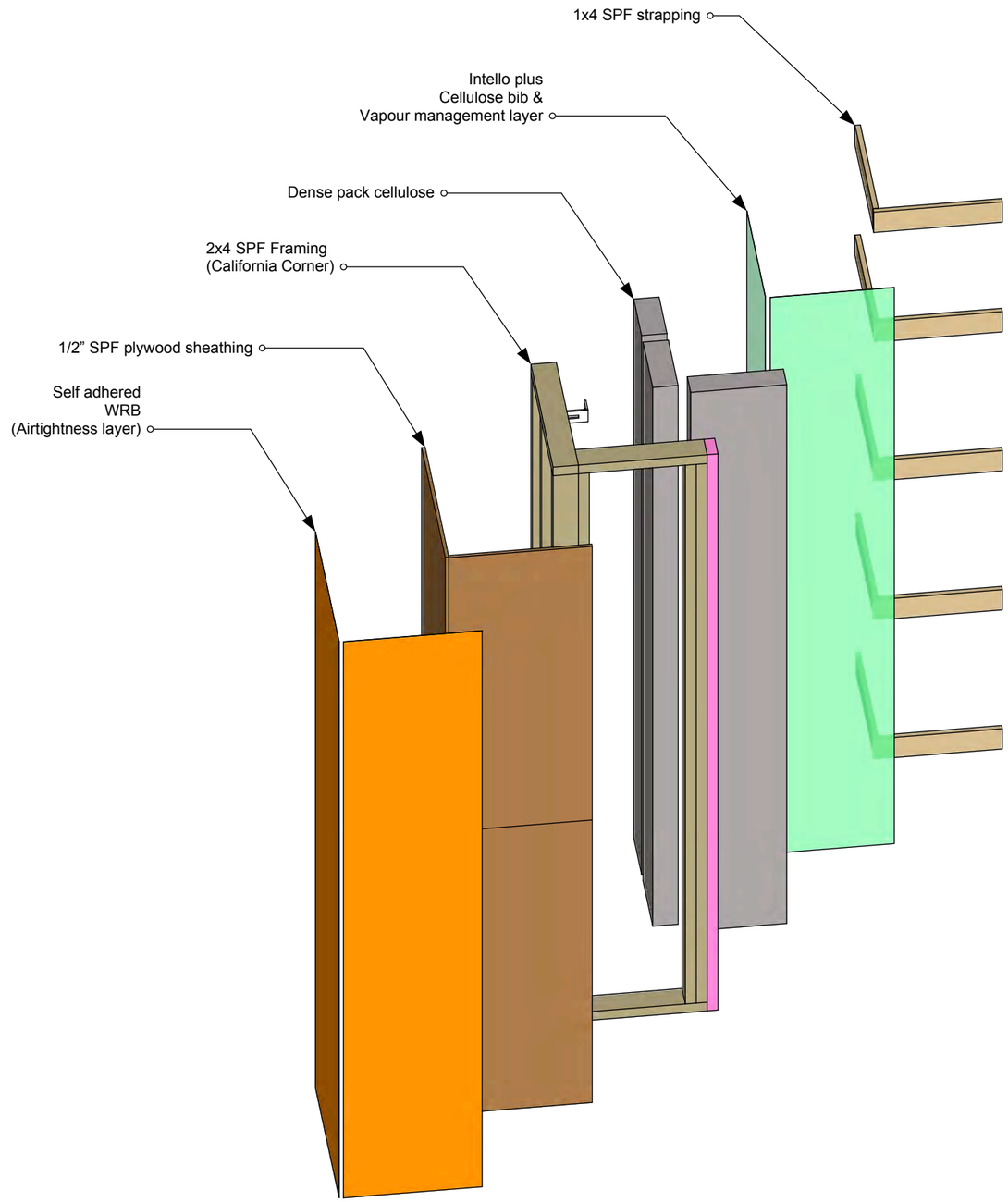
Nick Rudnicki

07

Panel - Outside Corner - Exploded

Panel schematic with all membranes in place



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Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

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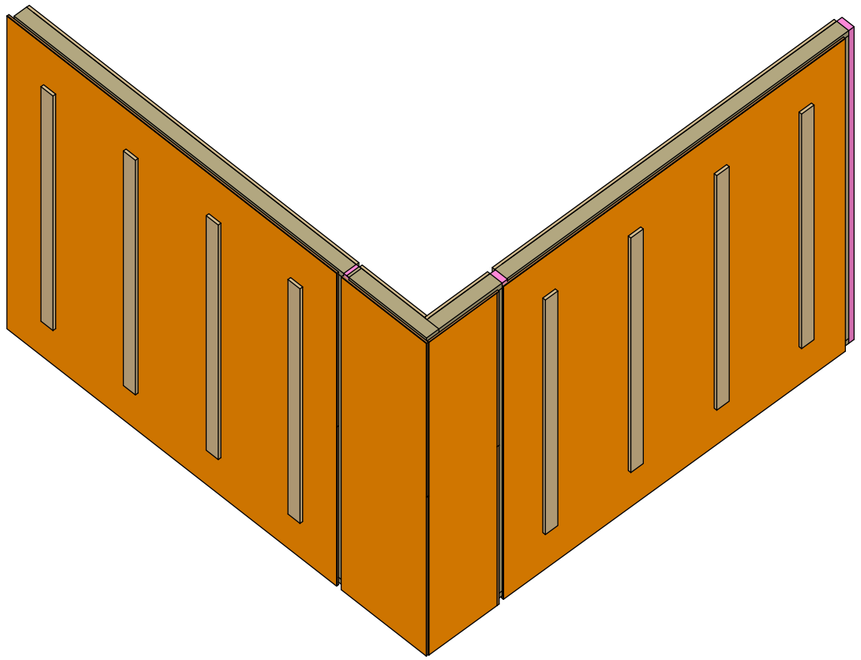
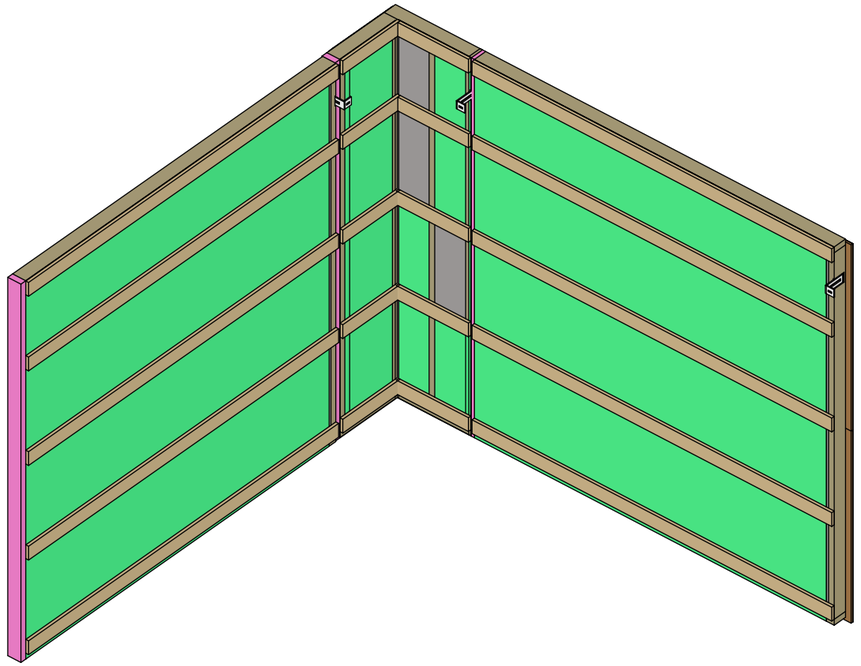
Nick Rudnicki

08

Outside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

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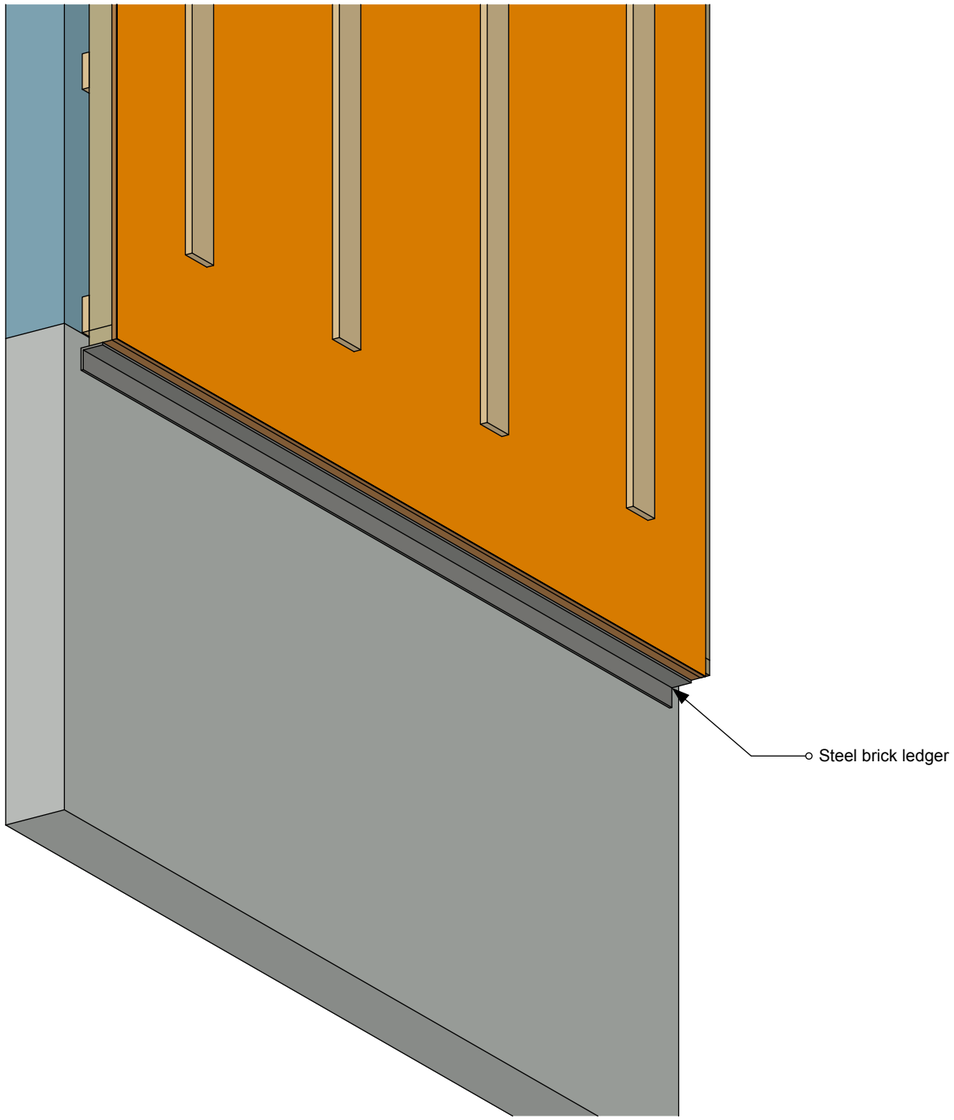
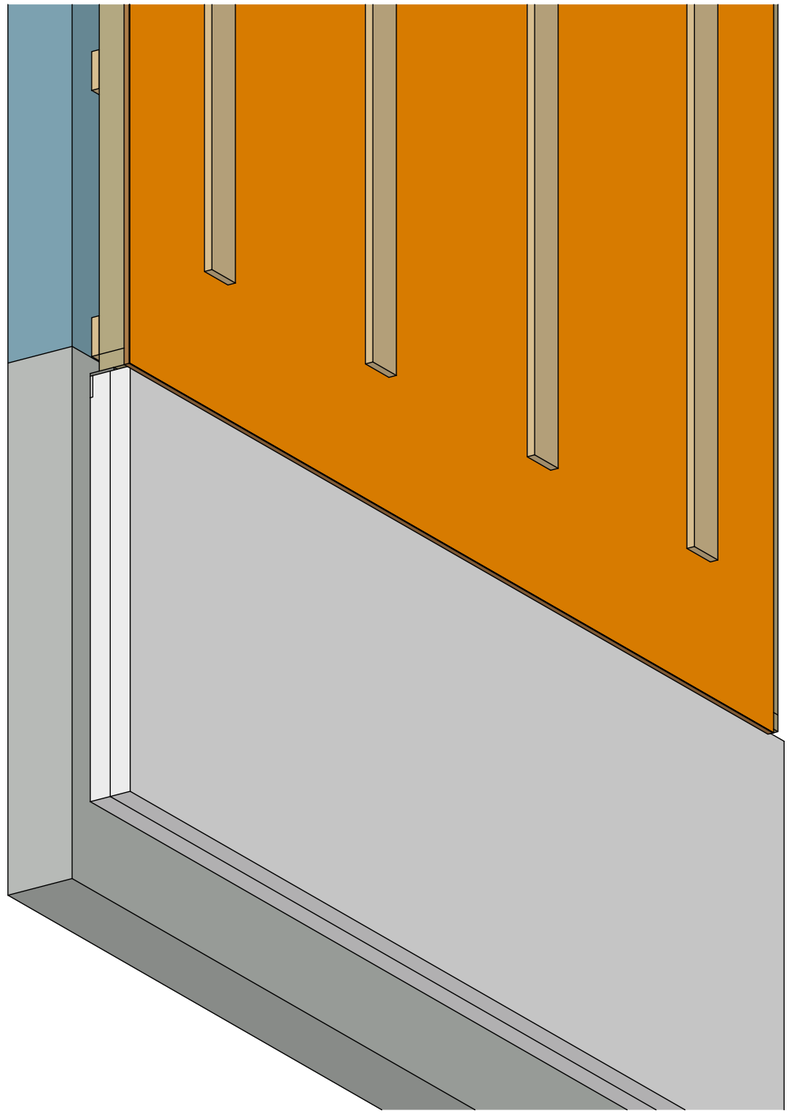
09

Foundation Attachment - Ledger

"Brick Ledger" style continuous ledger for panel support



BEFORE SITE INSULATION



AFTER SITE INSULATION

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
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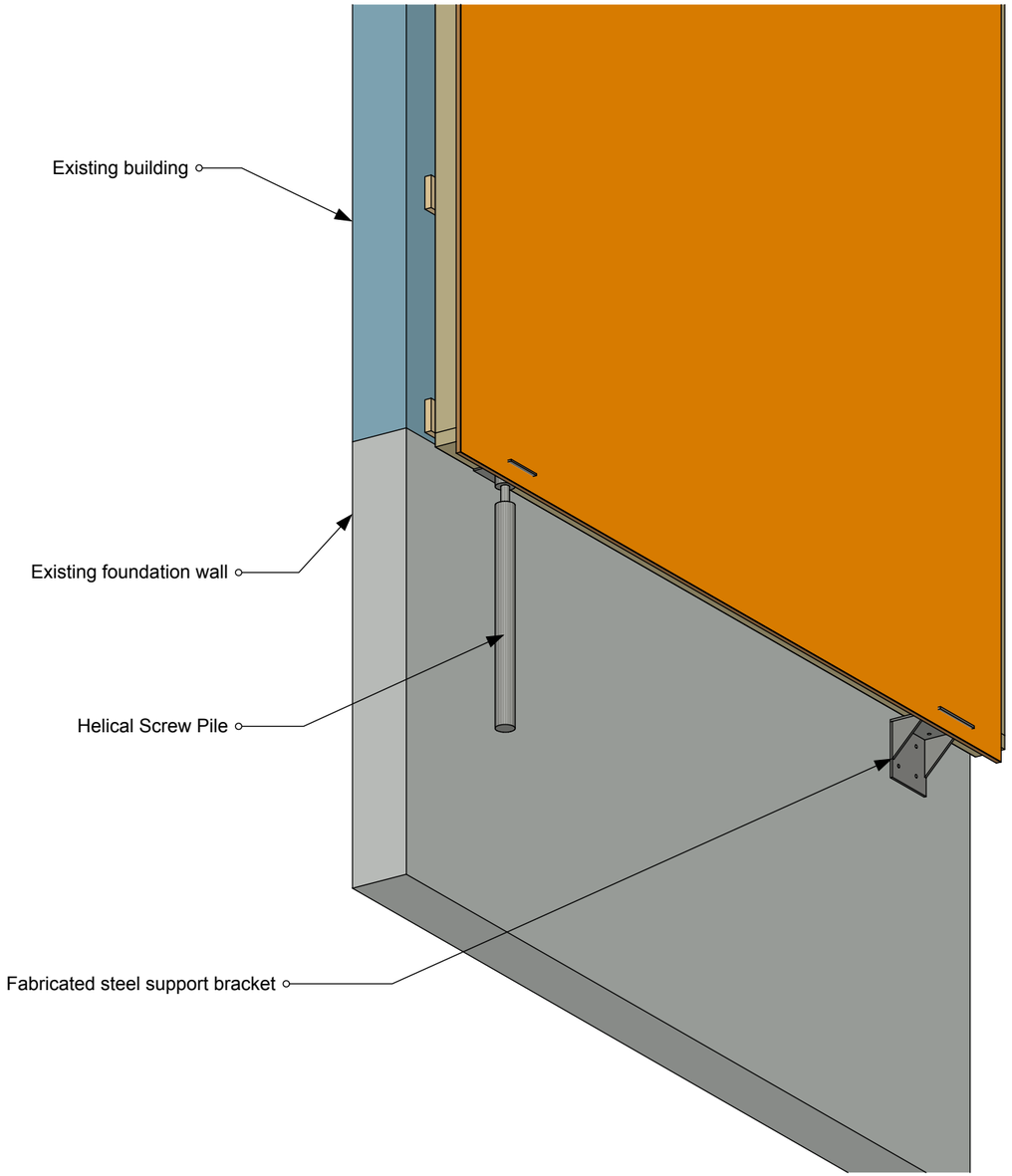
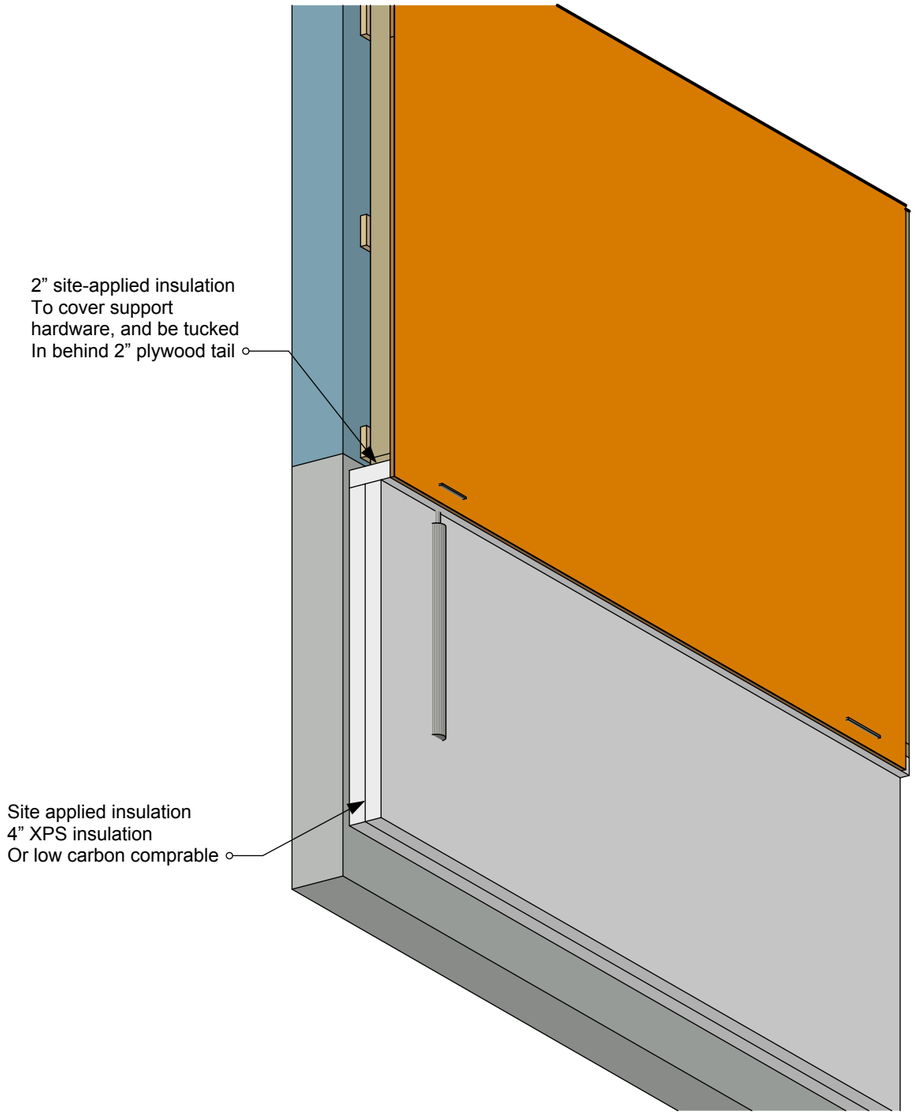
Foundation Attachment - Pile or Bracket

First options for attaching the panels to the foundation



BEFORE SITE INSULATION



AFTER SITE INSULATION

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

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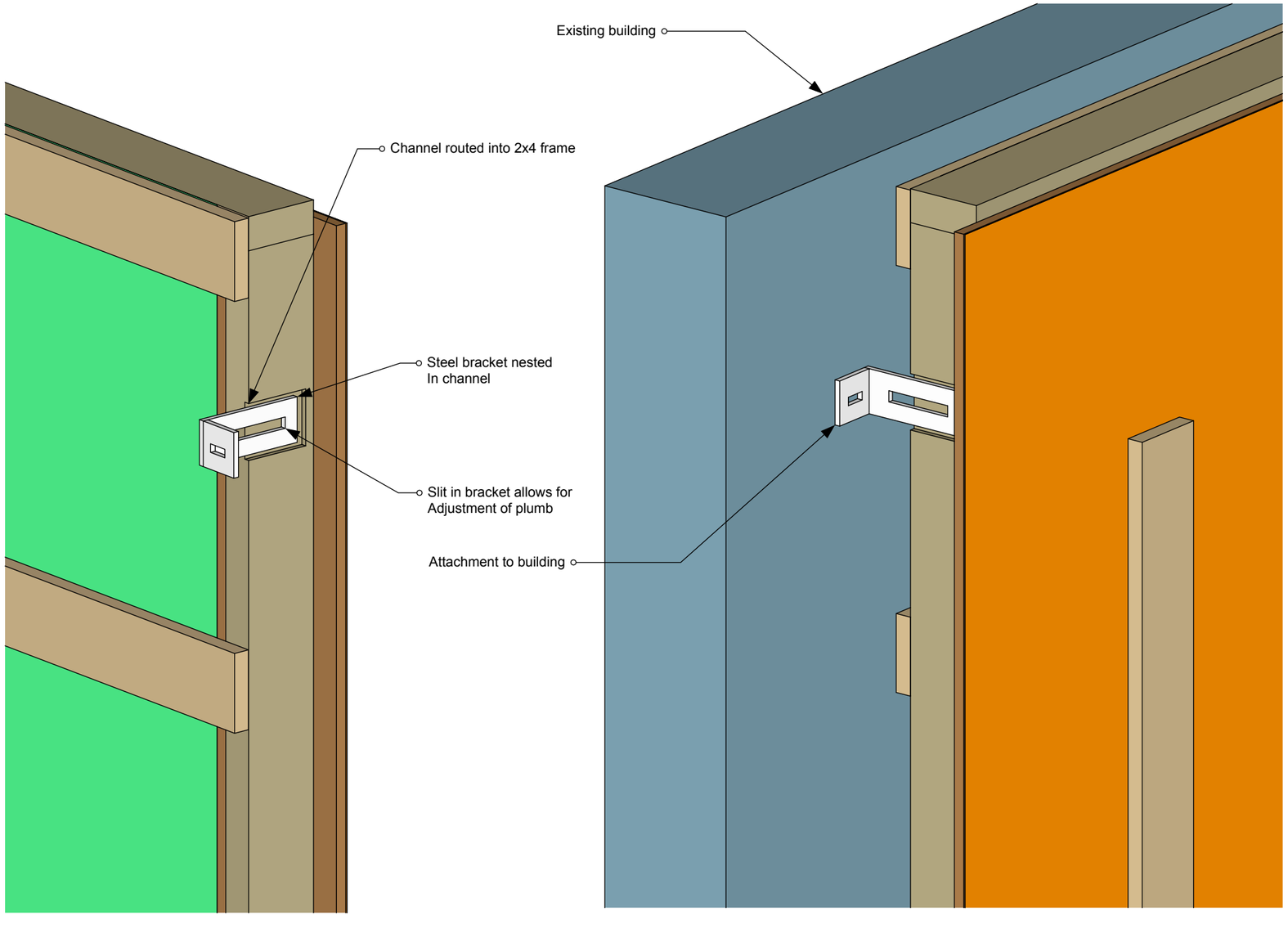
Nick Rudnicki

Attach to Existing

Bracket to attach individual panels to existing



INTERIOR VIEW

EXTERIOR VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

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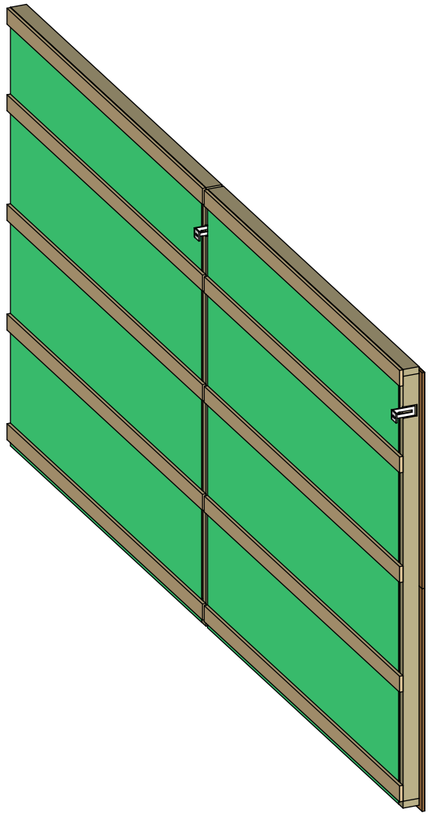
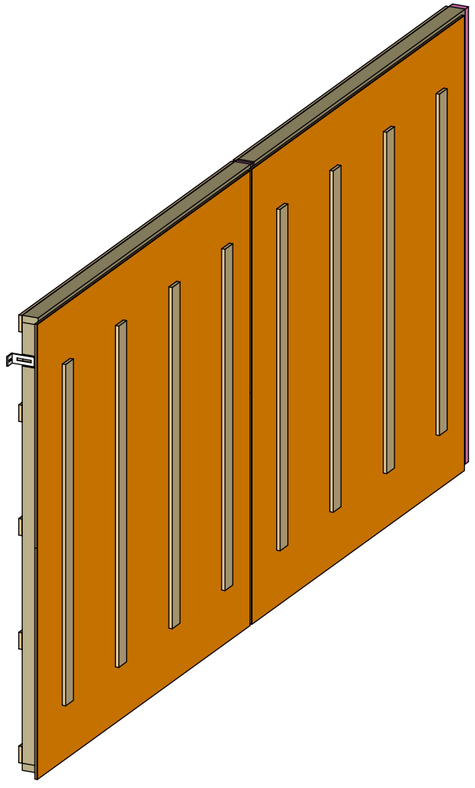
Nick Rudnicki

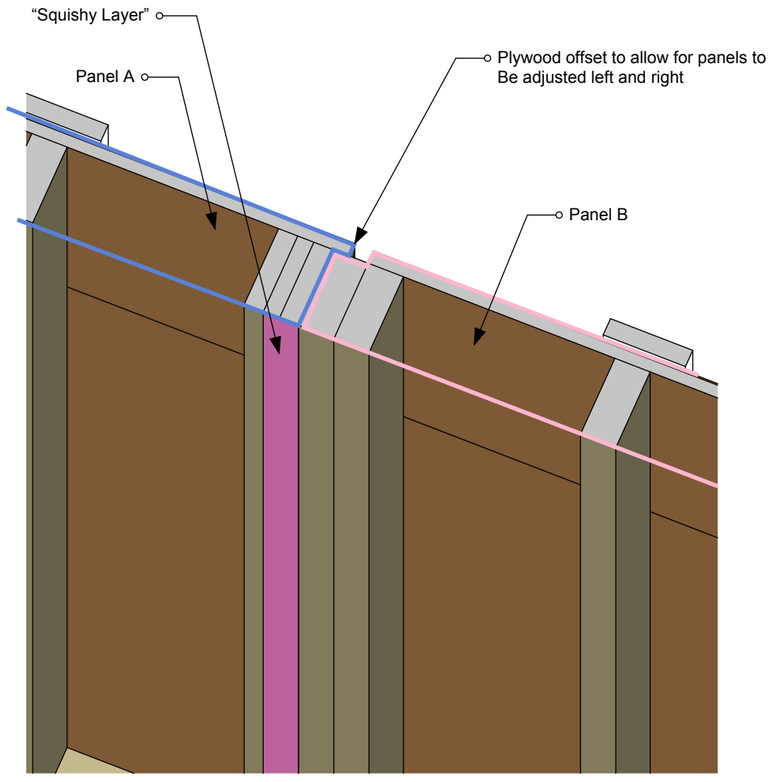
Vertical Wall Joins



INTERIOR VIEW



EXTERIOR VIEW



SECTION VIEW

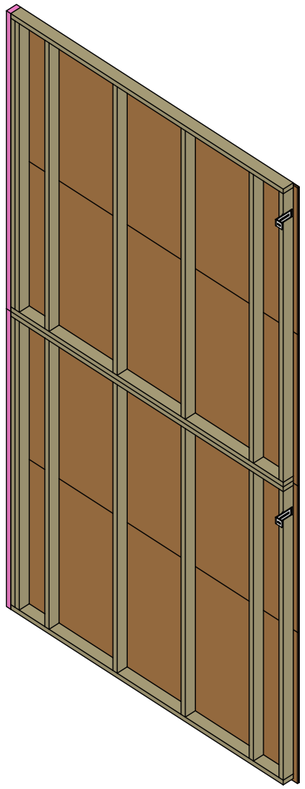
ReCover

Version Date
February 27, 2023

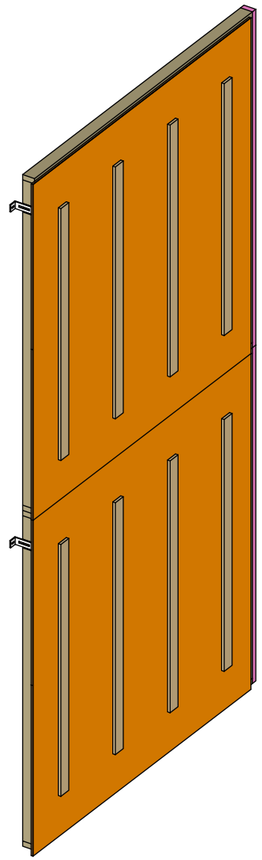
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

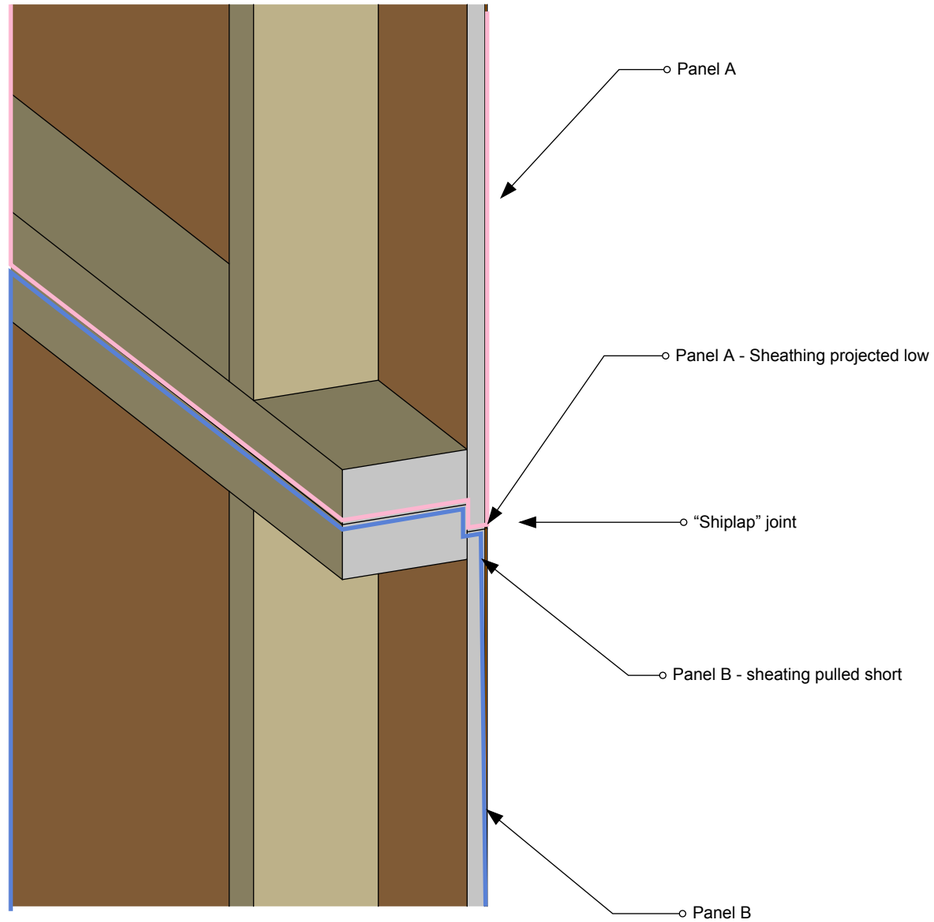
Horizontal Wall Joins



INTERIOR VIEW



EXTERIOR VIEW



SECTION VIEW

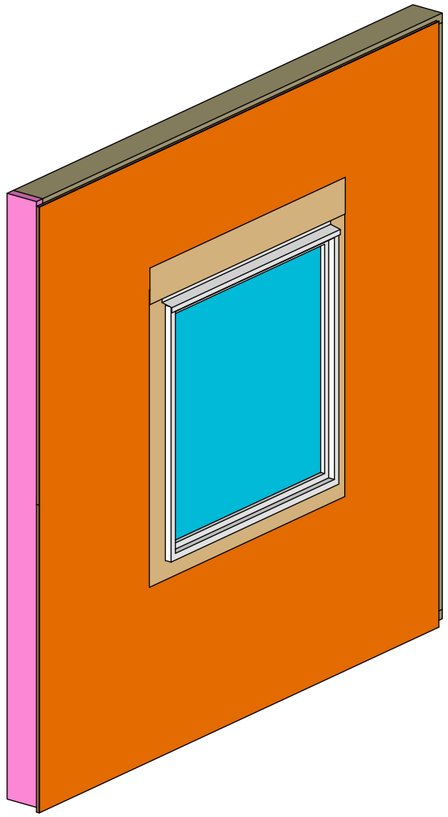
ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

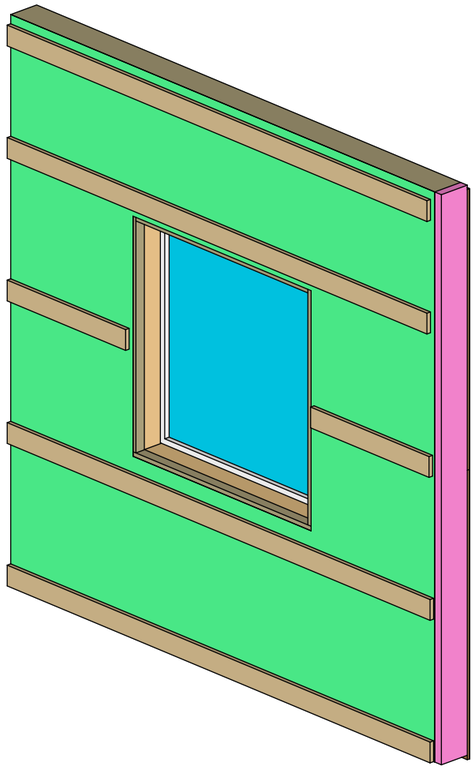
DRAWN BY
Nick Rudnicki

Window Panel

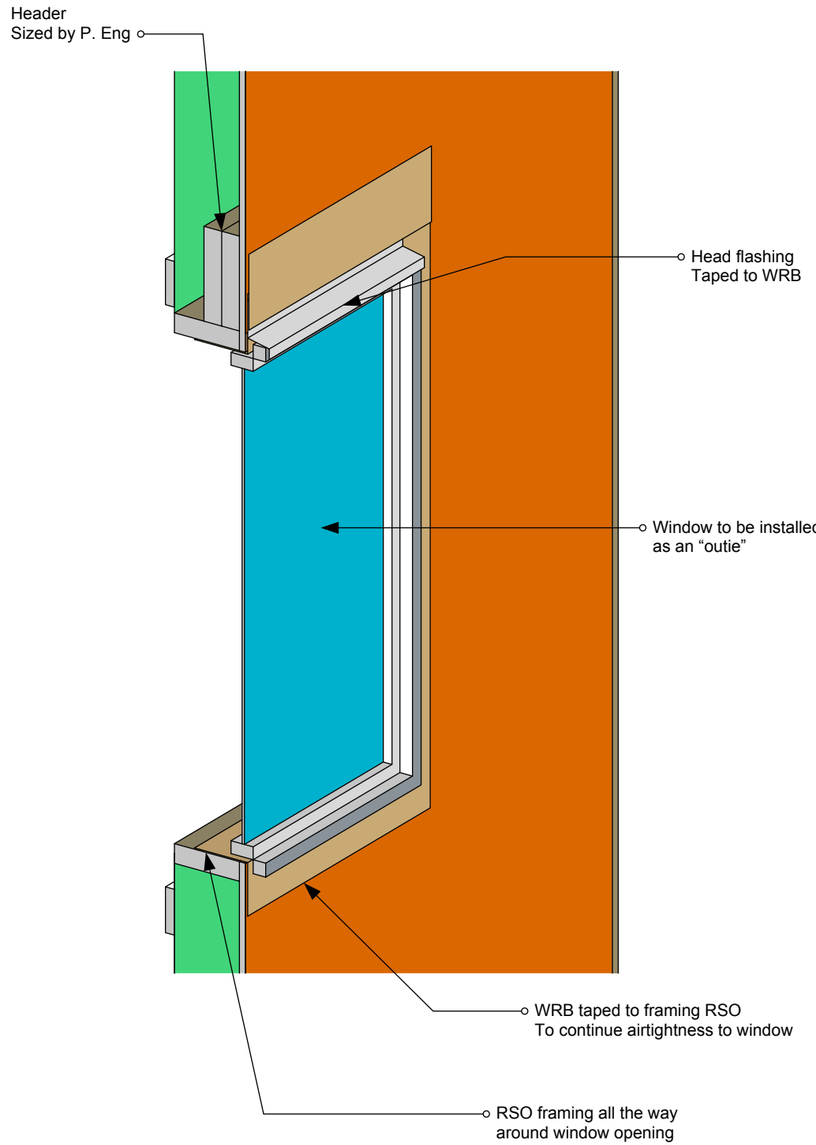


PANEL
EXTERIOR VIEW

Window installed in factory
Window installed as an “outie” to minimize how much window sill there is exposed to the rain



PANEL
EXTERIOR VIEW



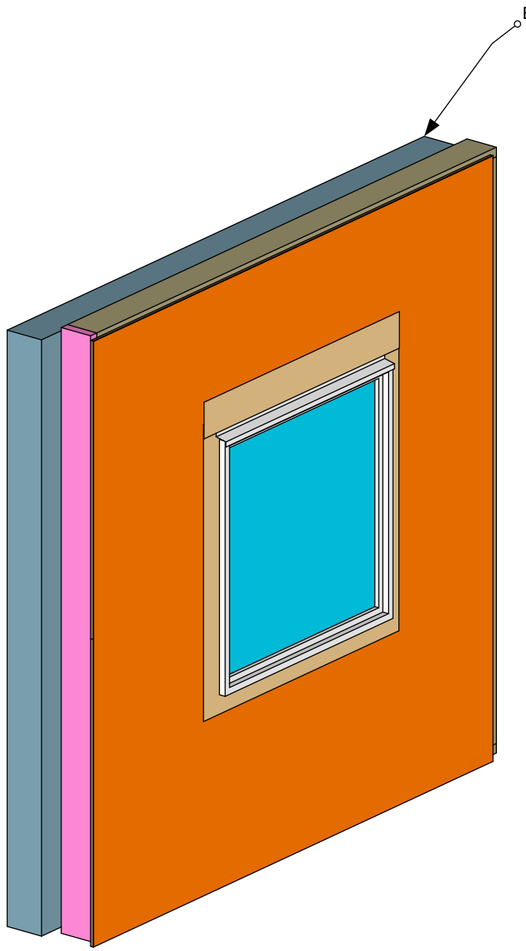
ReCover

Version Date
February 27, 2023

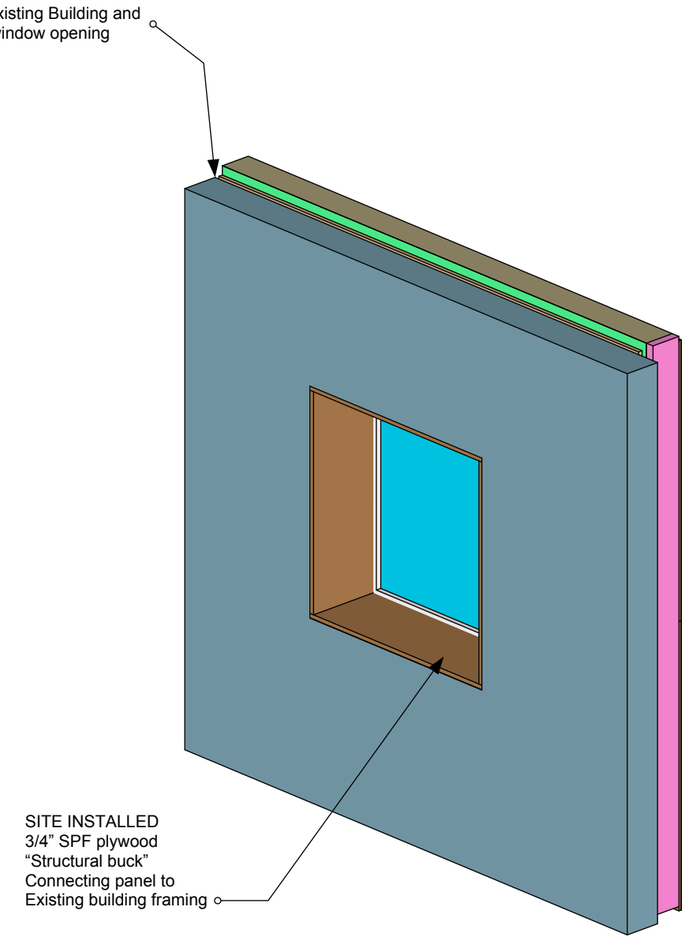
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

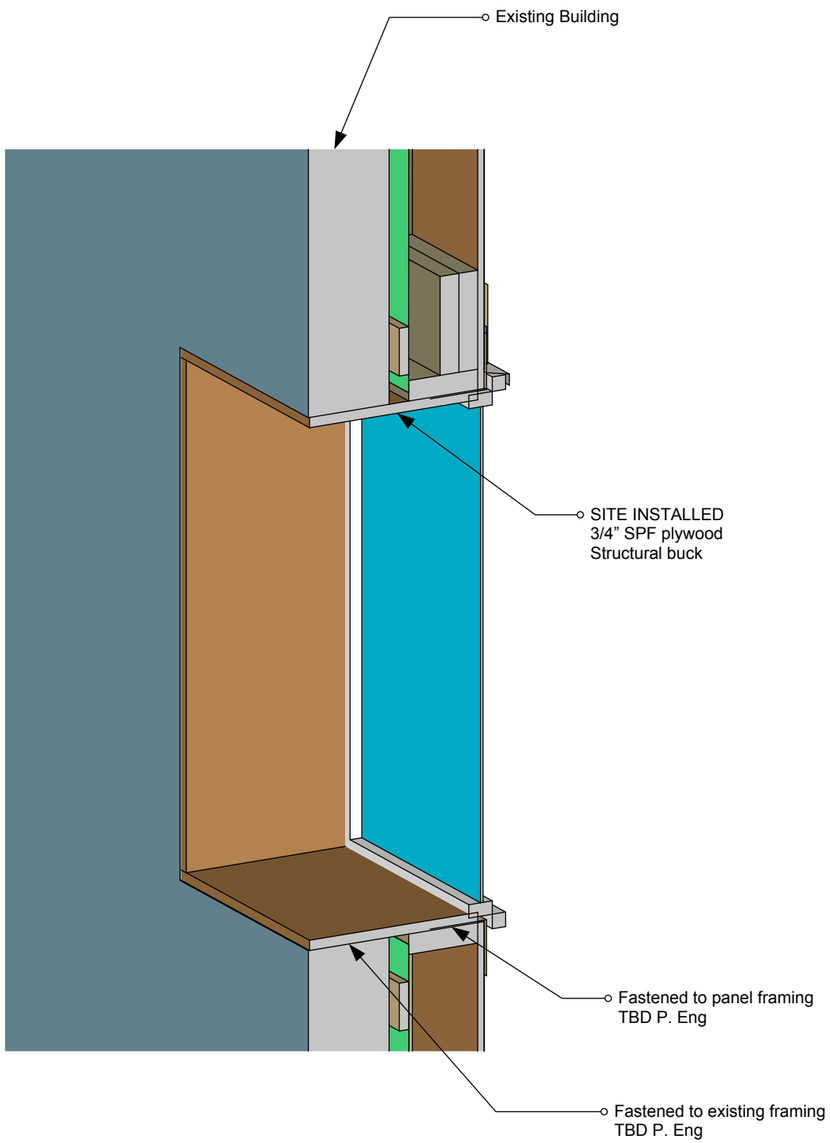
Window Penetration



EXTERIOR VIEW



INTERIOR VIEW



SECTION VIEW

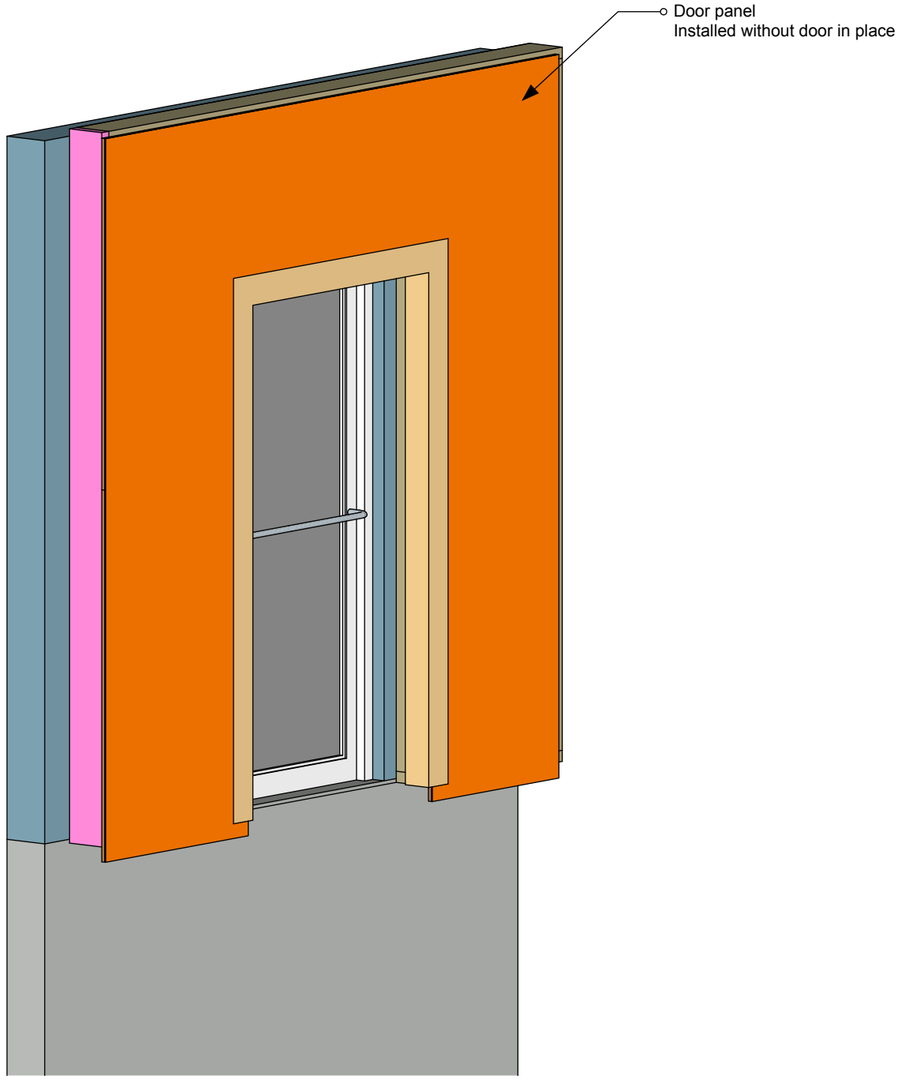
ReCover

Version Date
February 27, 2023

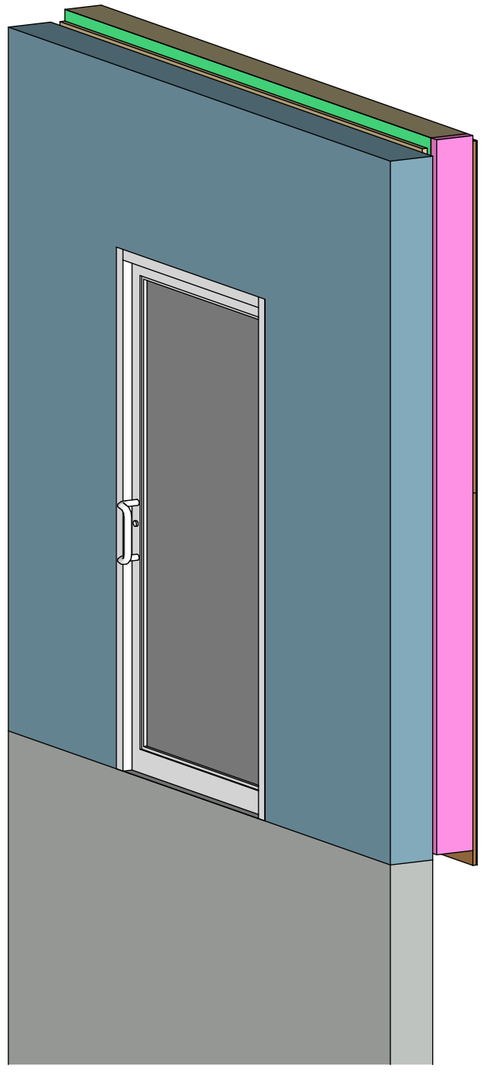
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

Door Penetration Panel



EXTERIOR VIEW



INTERIOR VIEW

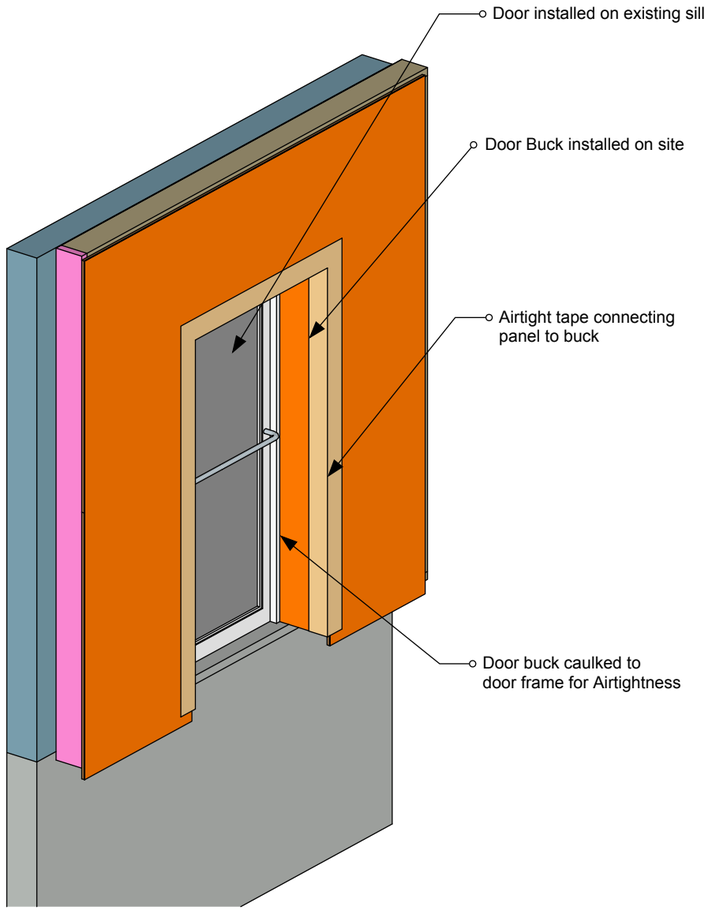
ReCover

Version Date
February 27, 2023

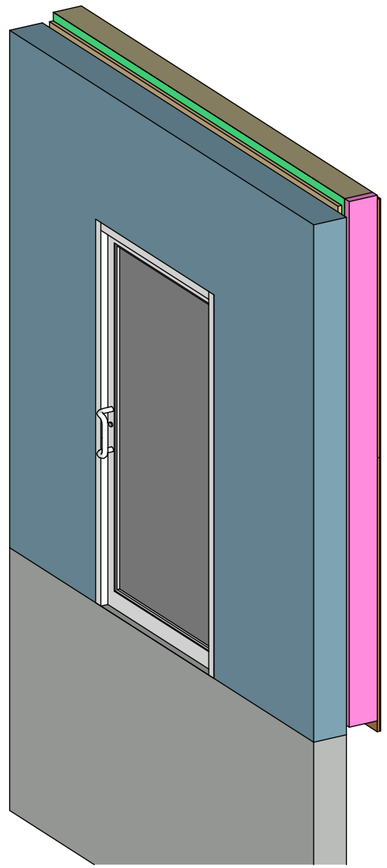
PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

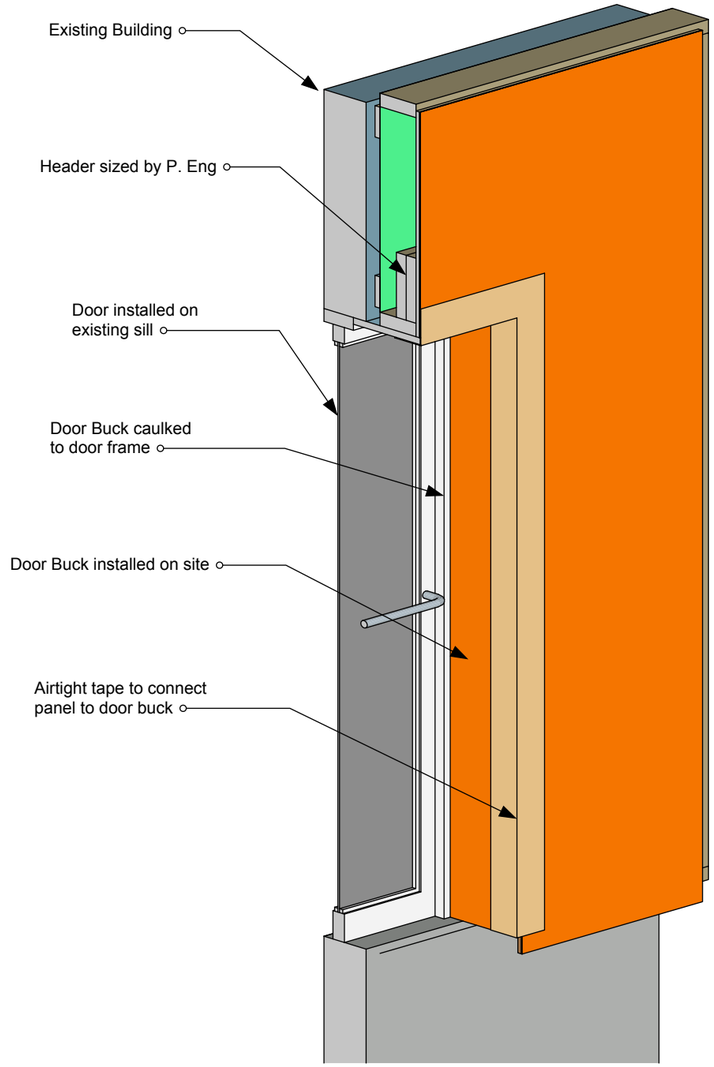
Door Penetration Panel Installed



EXTERIOR VIEW



INTERIOR VIEW



SECTION VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x4 R11 Cellulose
Panel Schematics

DRAWN BY
Nick Rudnicki

Wall Panel Schematics

Cellulose - R16 - 2x6 - 1/2" Plywood

ReCover Initiative

ReCover

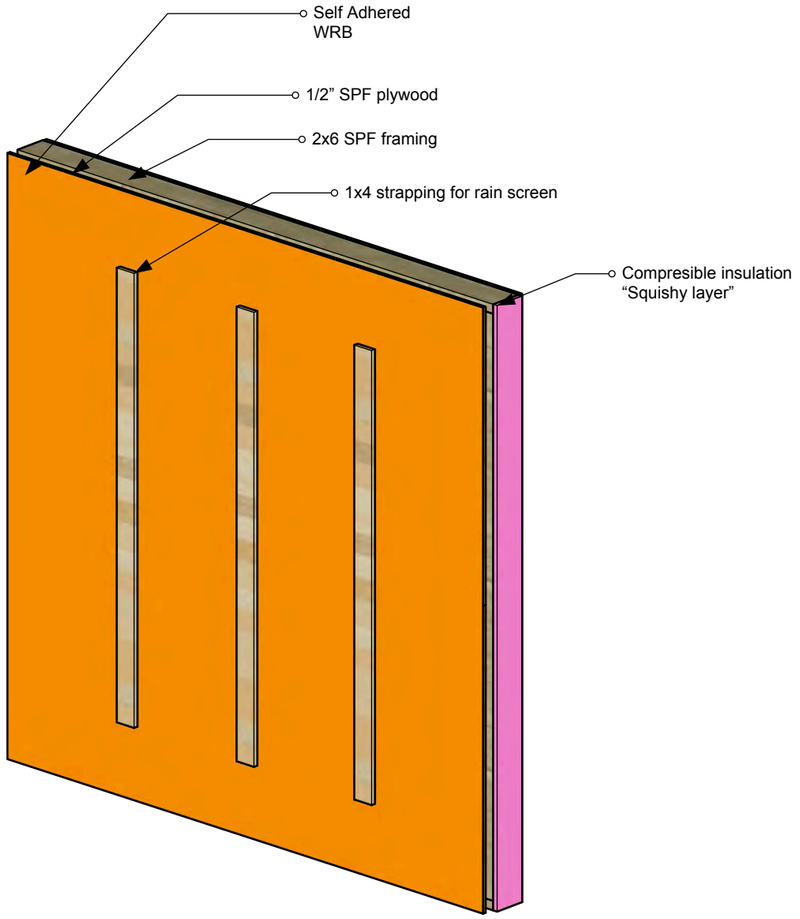
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

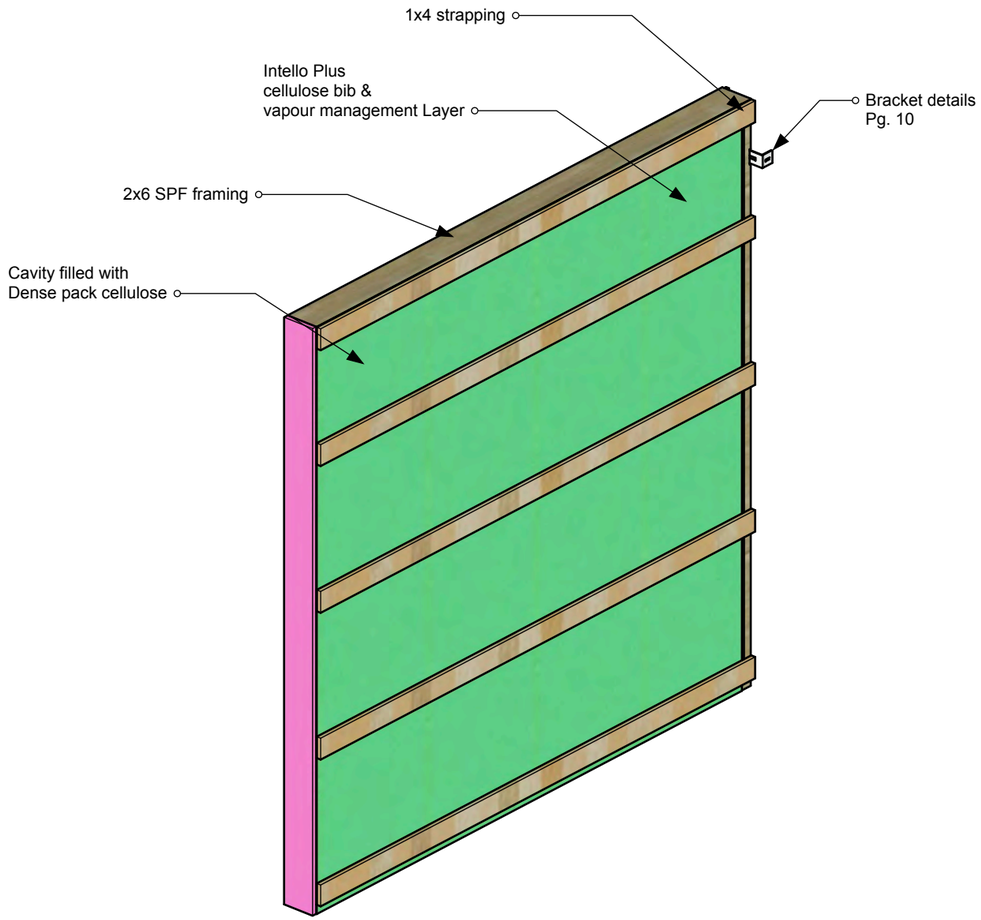
Drawn By
Nick Rudnicki

01

Basic Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

ReCover

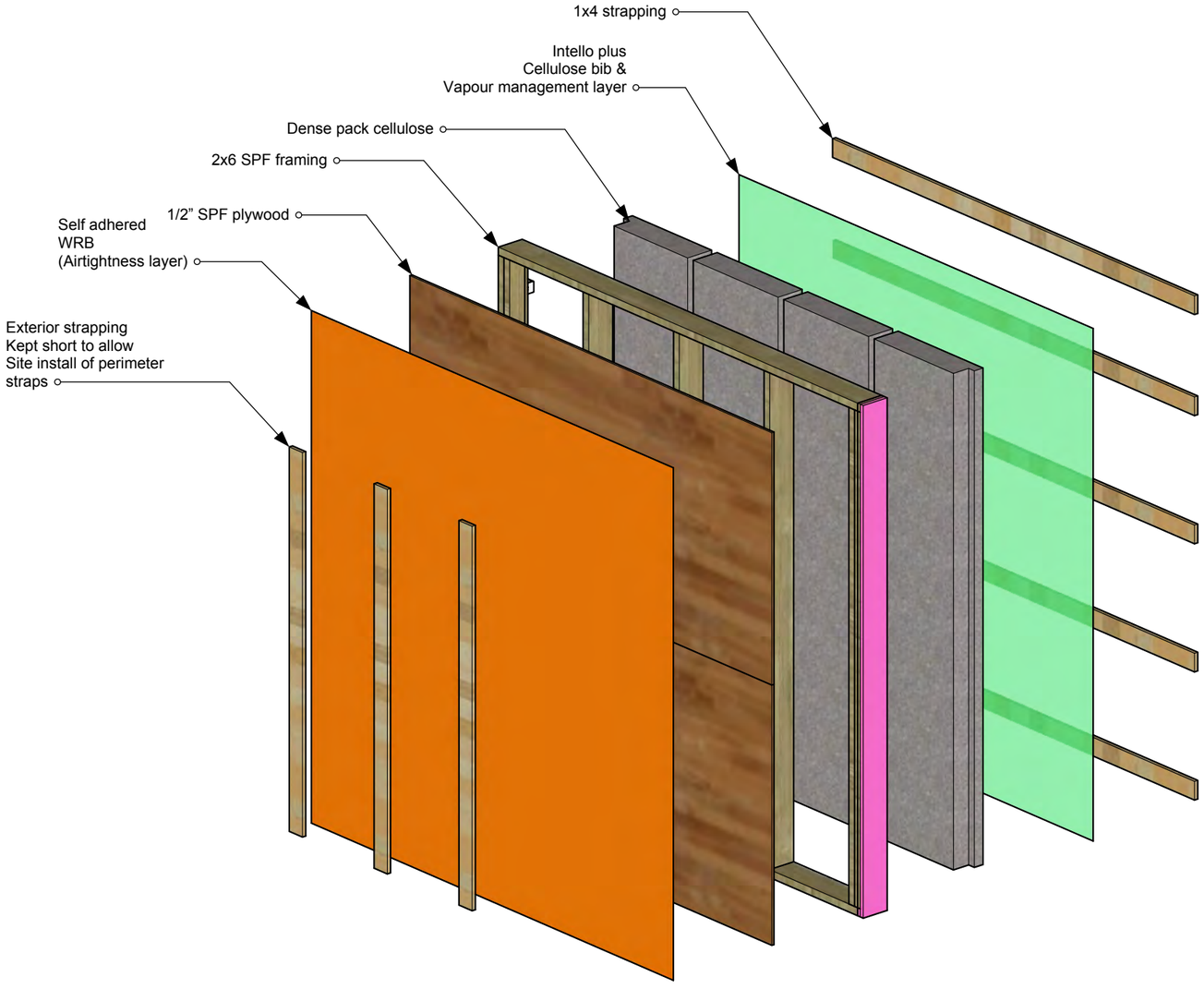
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

02

Basic Panel - Exploded View



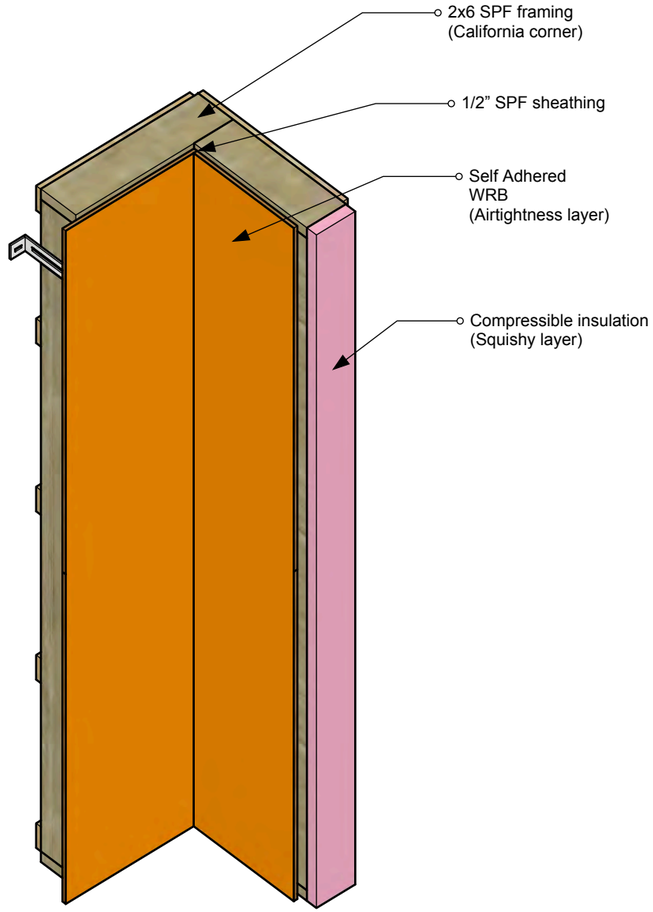
ReCover

Version Date
February 27, 2023

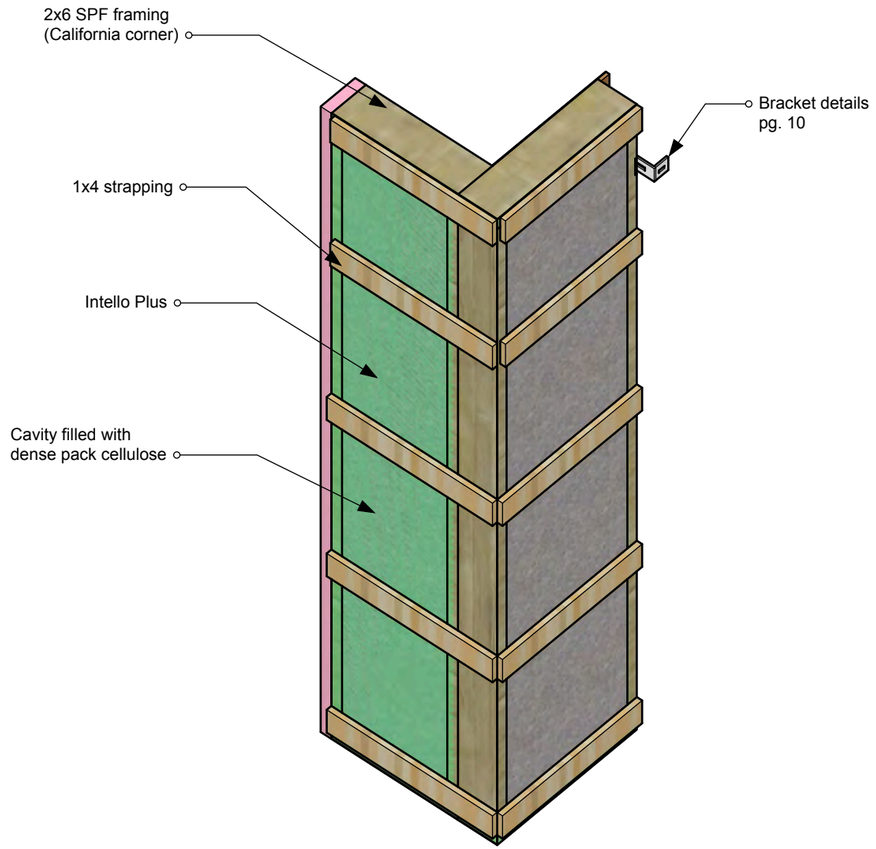
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

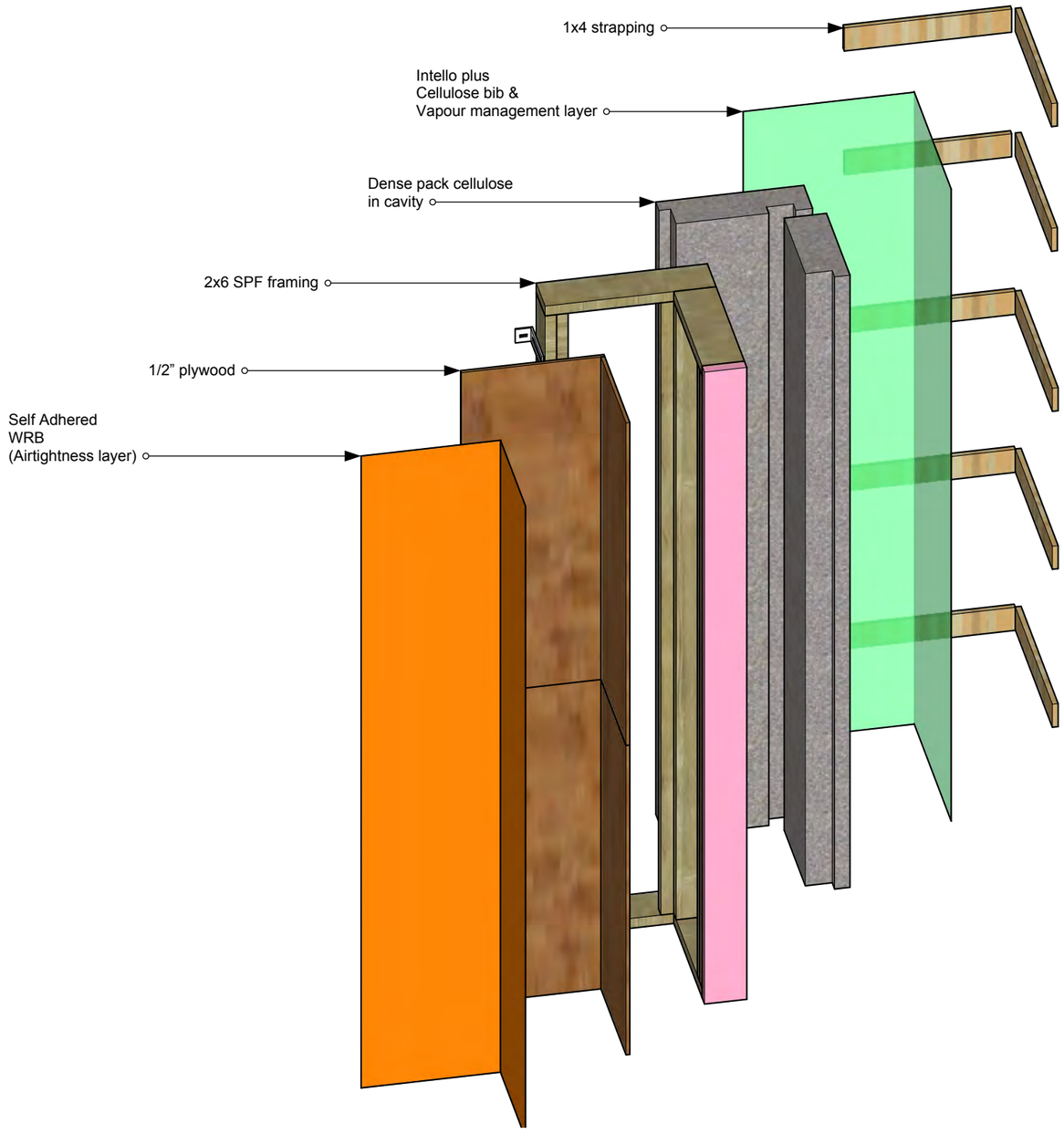
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Panel - Exploded View



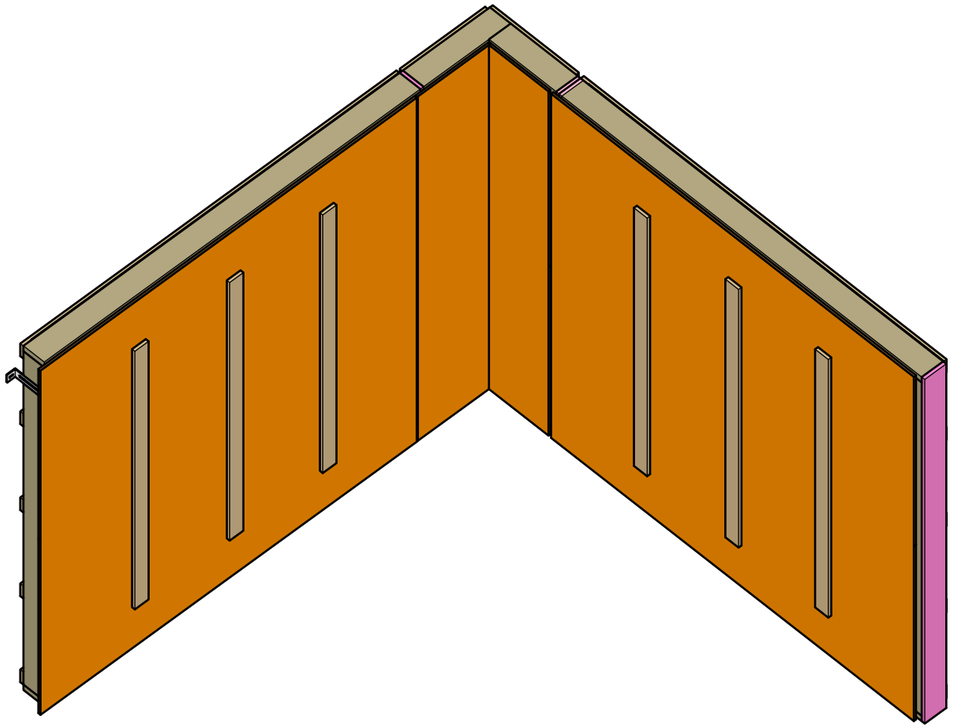
ReCover

Version Date
February 27, 2023

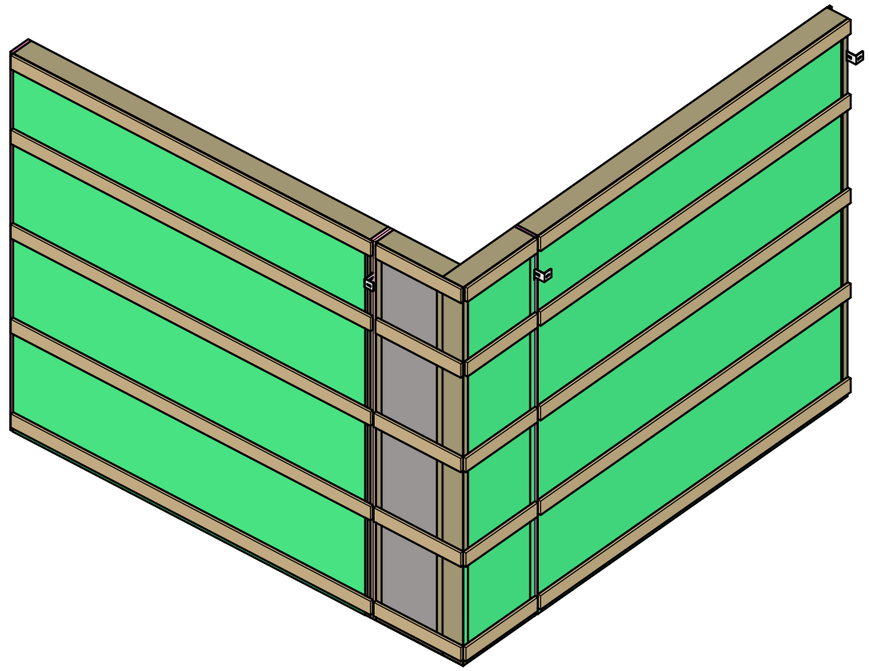
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

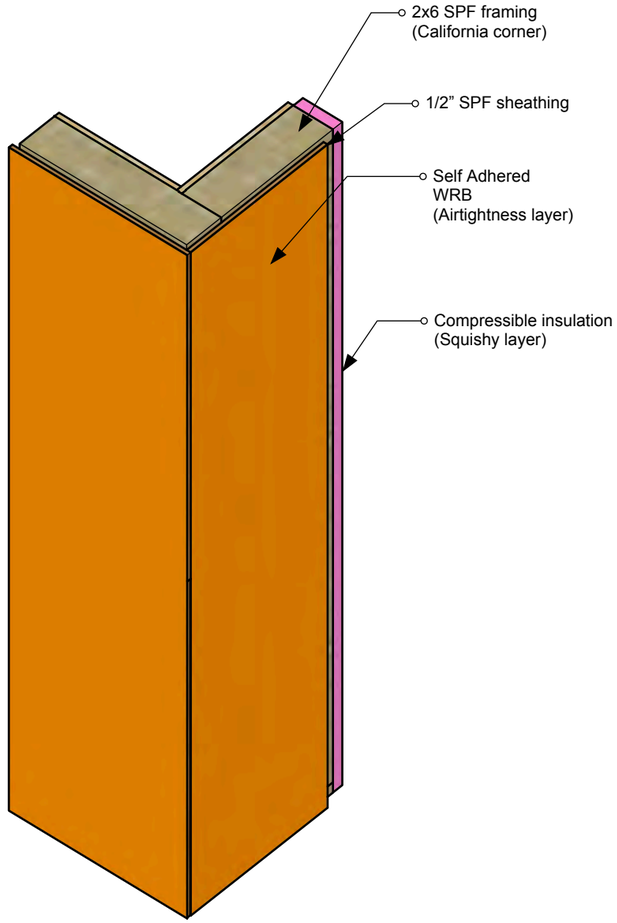
ReCover

Version Date
February 27, 2023

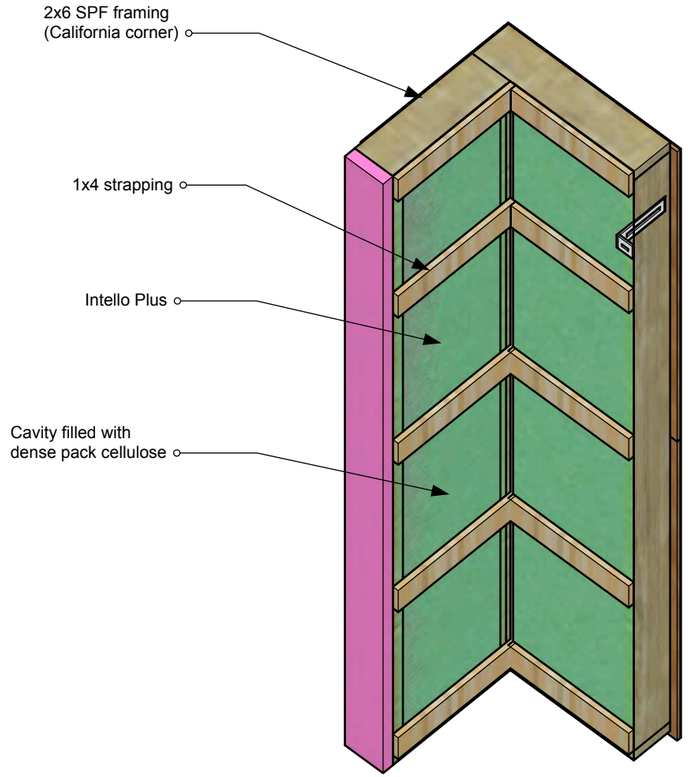
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Outside Corner Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

ReCover

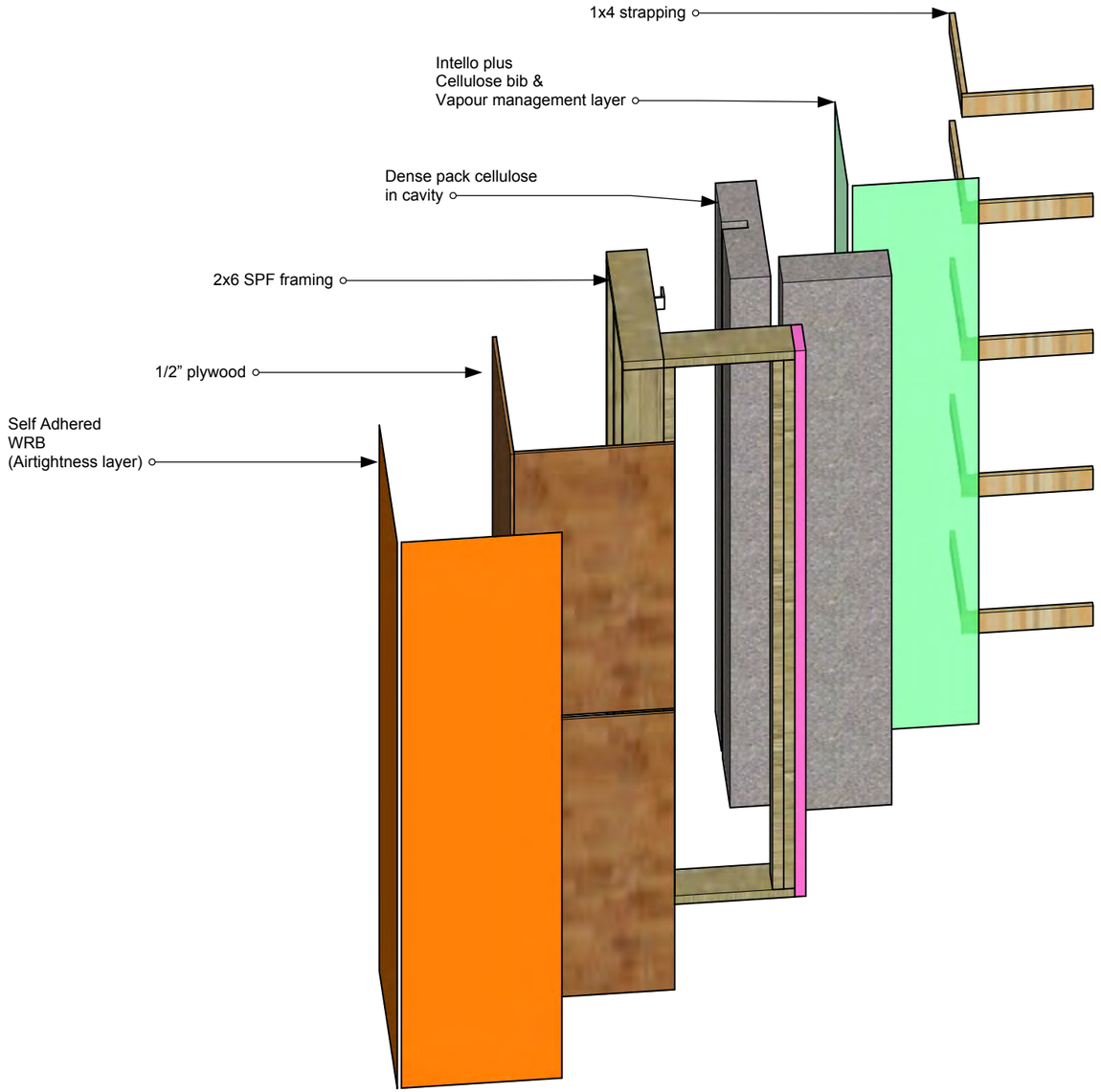
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

07

Outside Corner Panel - Exploded View



ReCover

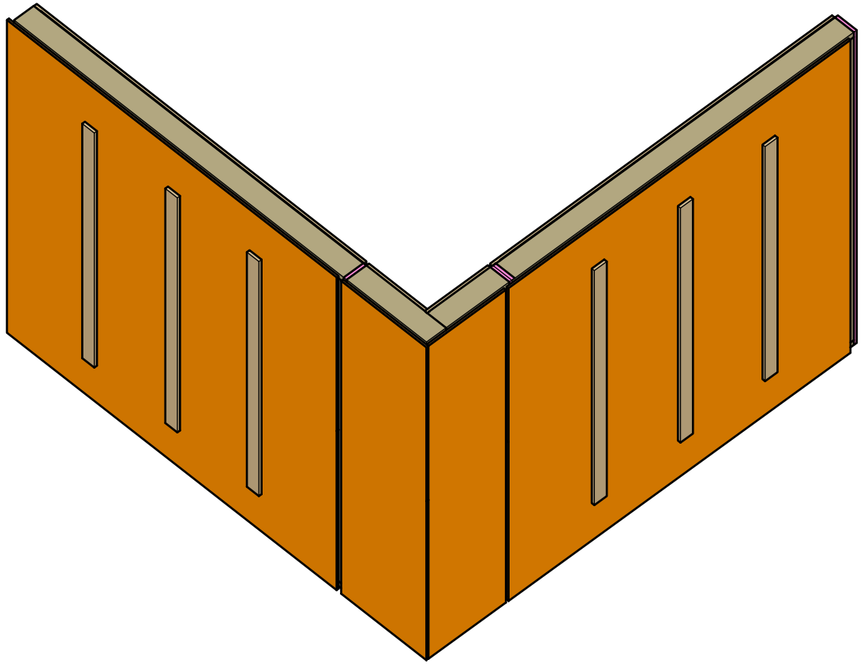
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

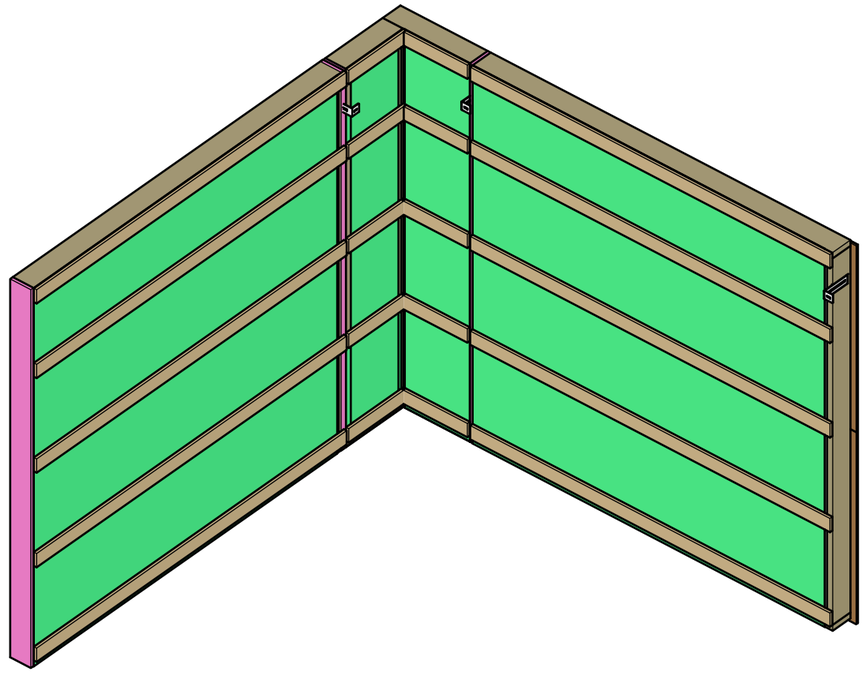
Drawn By
Nick Rudnicki

08

Outside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

ReCover

Version Date
February 27, 2023

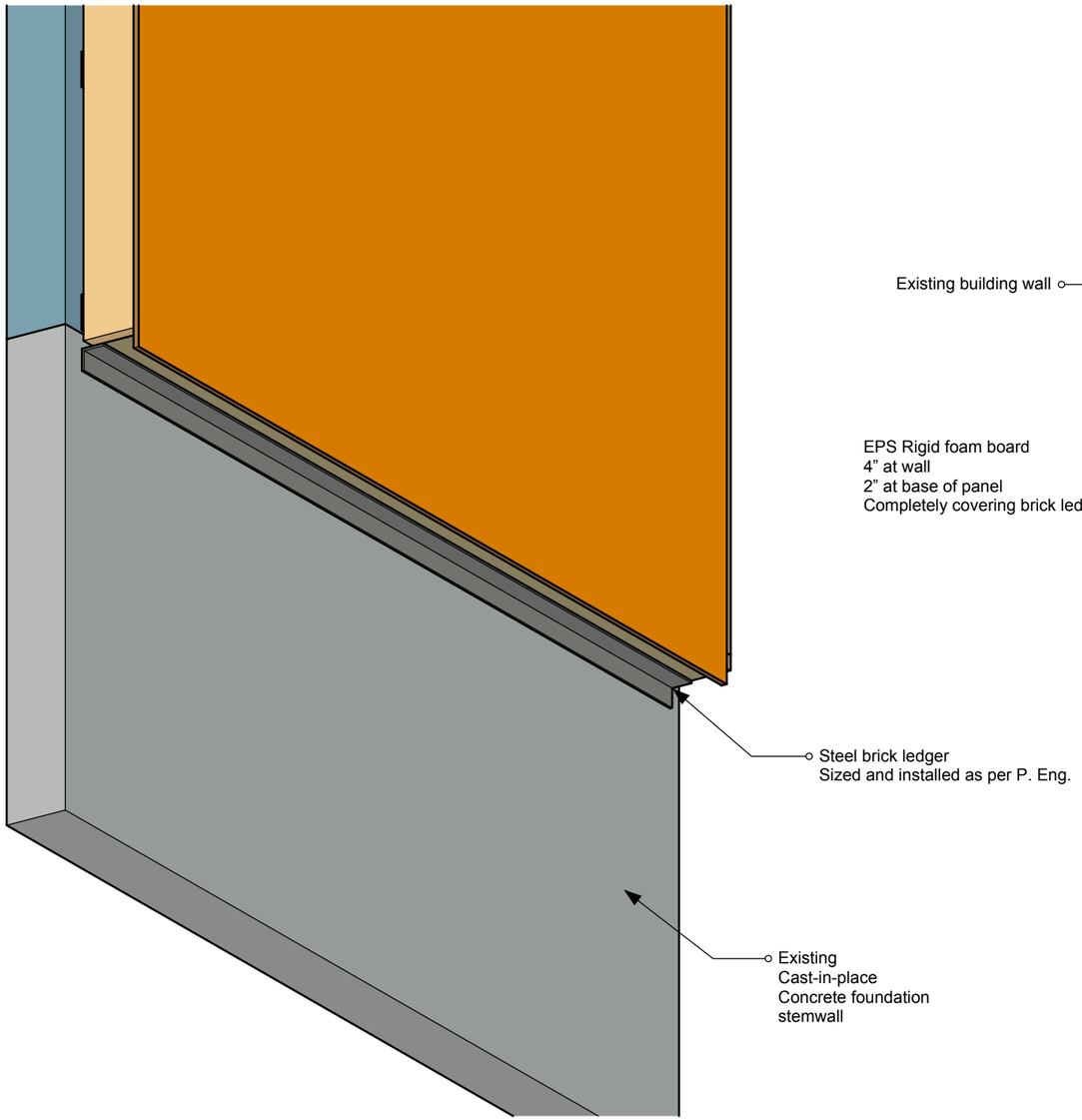
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

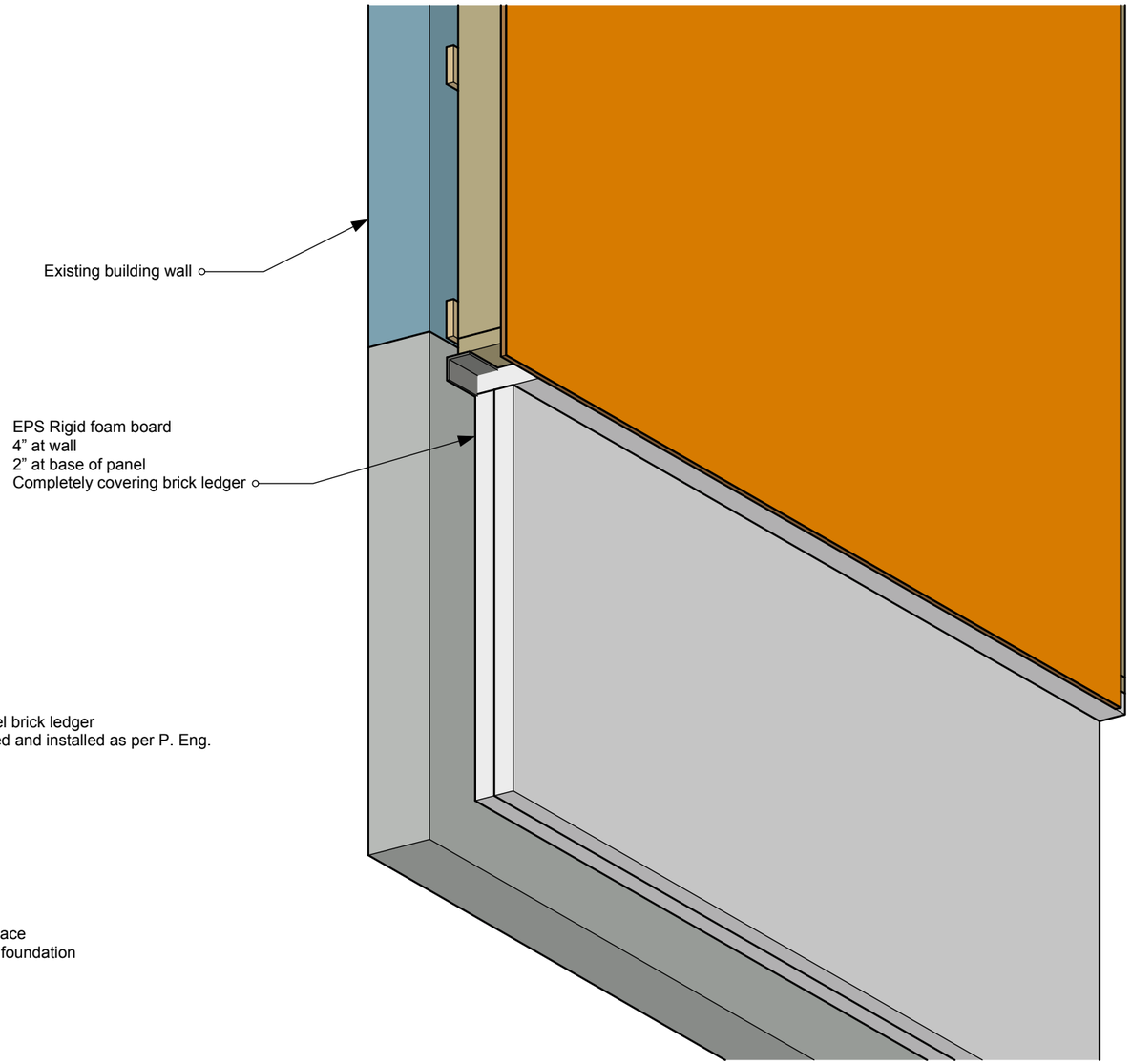
09

Foundation Attachment - Brick Ledger

"Brick Ledger" style continuous ledger for panel support



BEFORE SITE INSULATION



AFTER SITE INSULATION

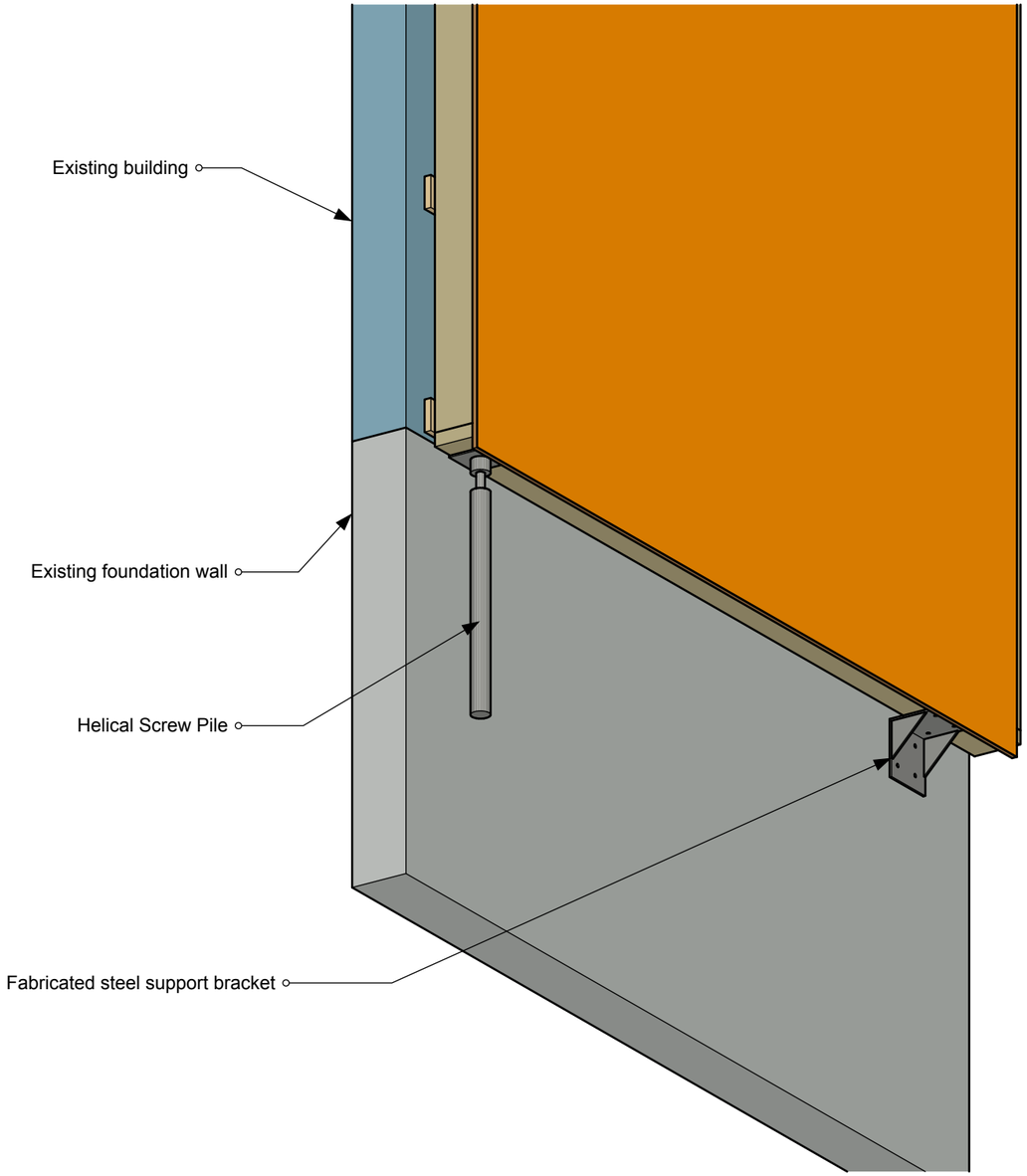
ReCover

Version Date
February 27, 2023

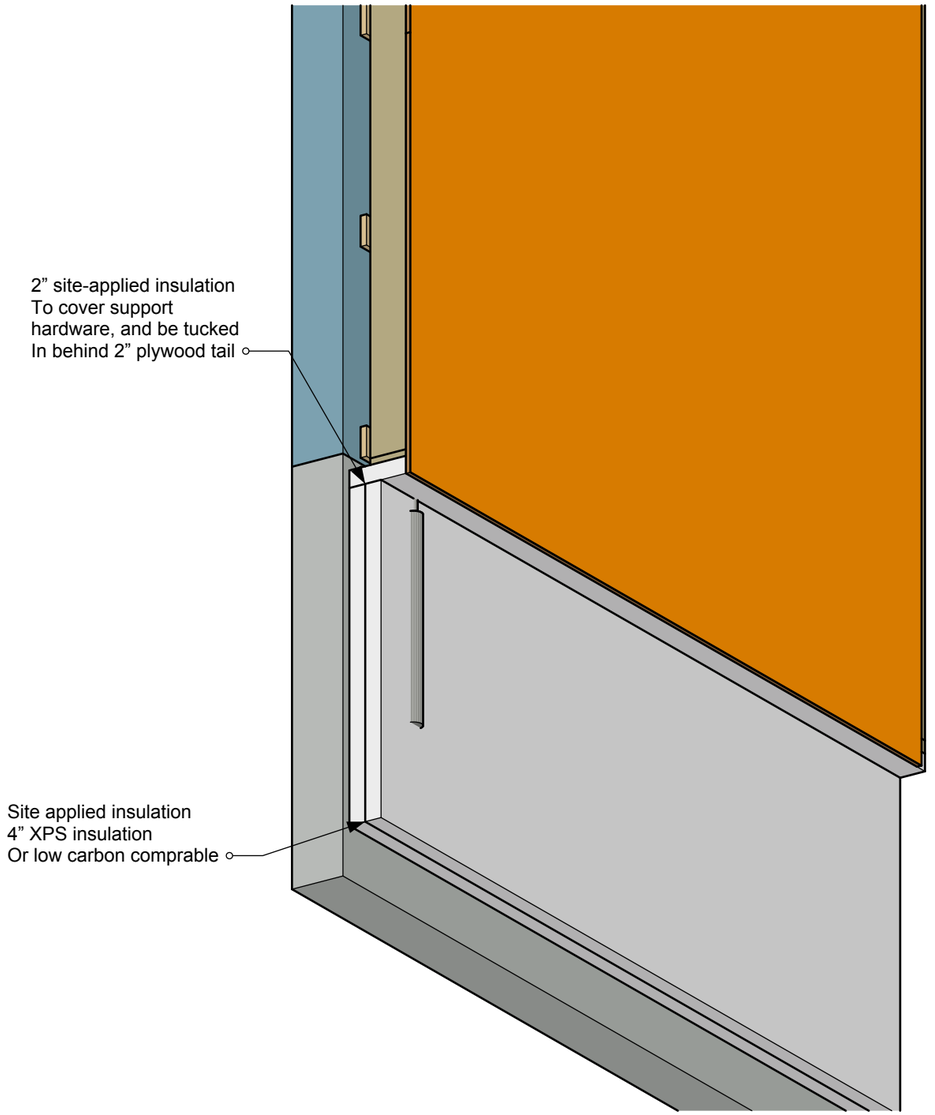
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Alternate Foundation Attachment - Pile or Bracket



BEFORE SITE INSTALLATION



AFTER SITE INSULATION

ReCover

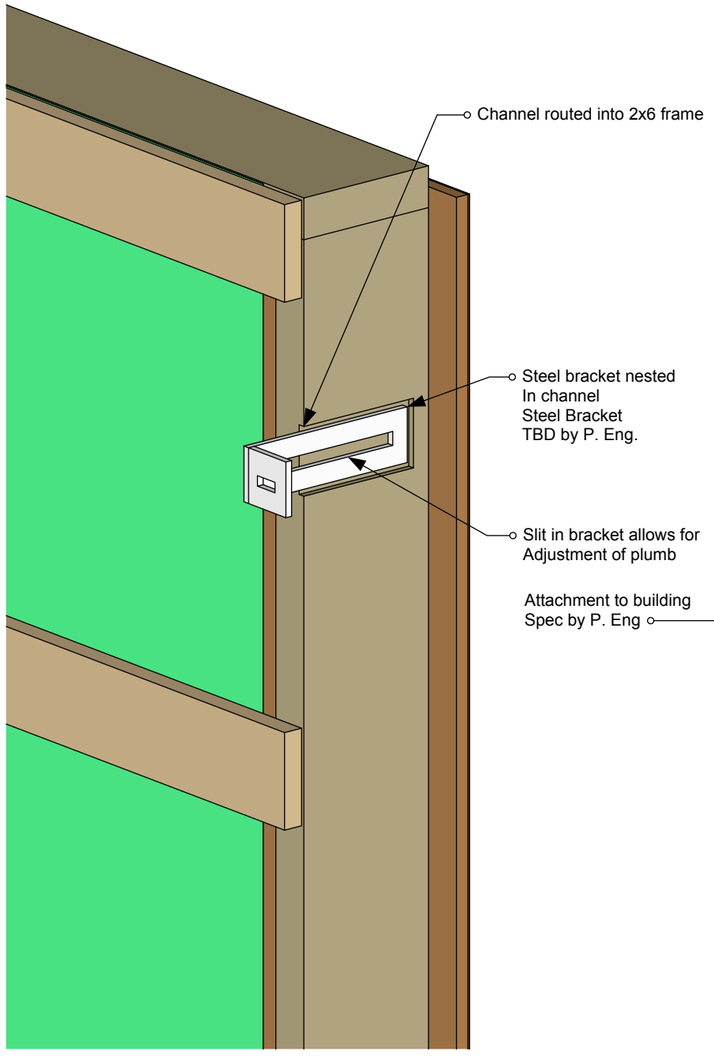
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

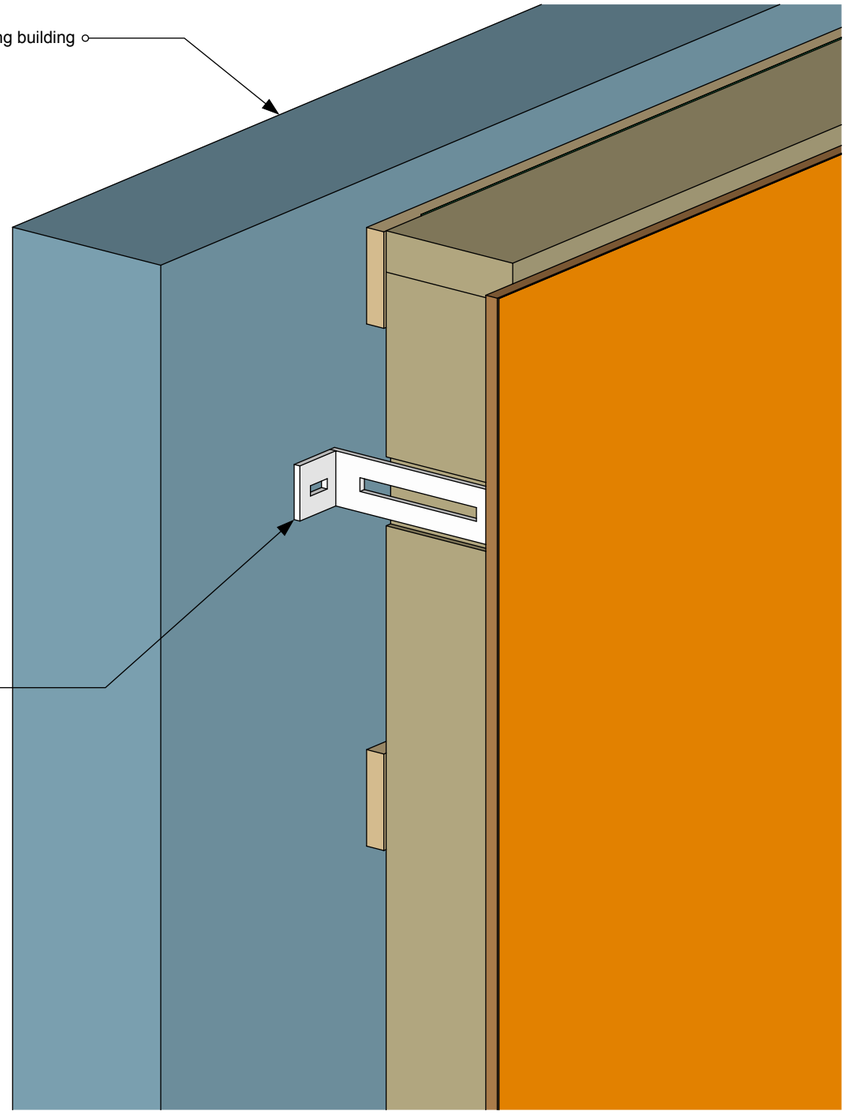
Drawn By
Nick Rudnicki

Attach to Existing Building

Bracket to attach individual panels to existing



INTERIOR VIEW



EXTERIOR VIEW

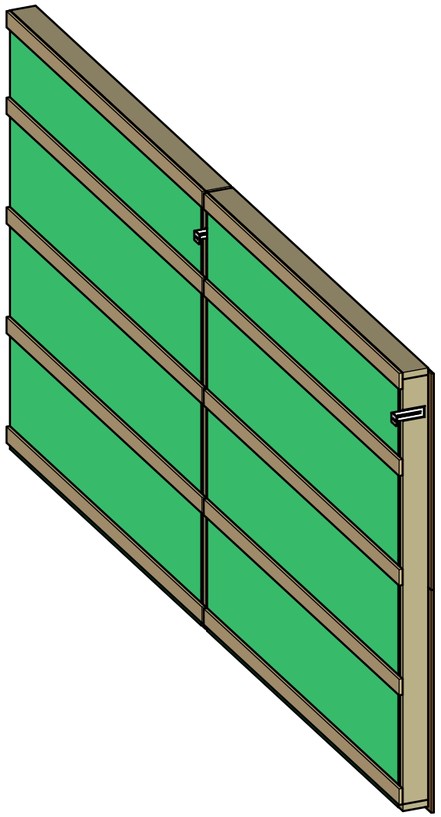
ReCover

Version Date
February 27, 2023

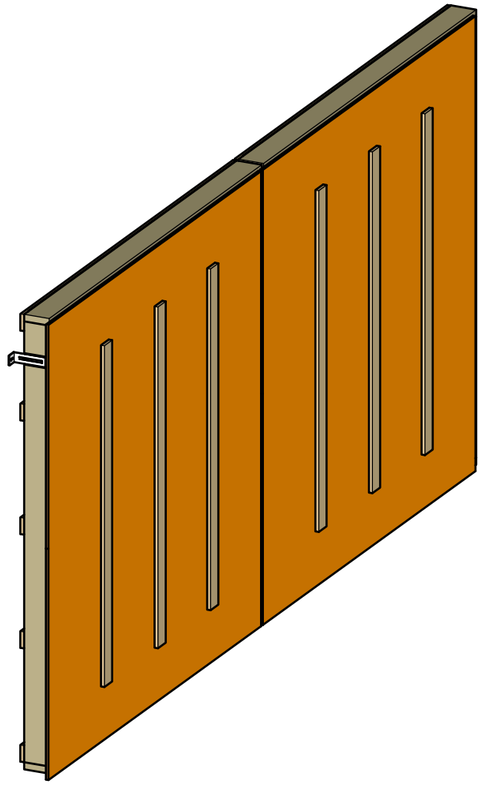
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

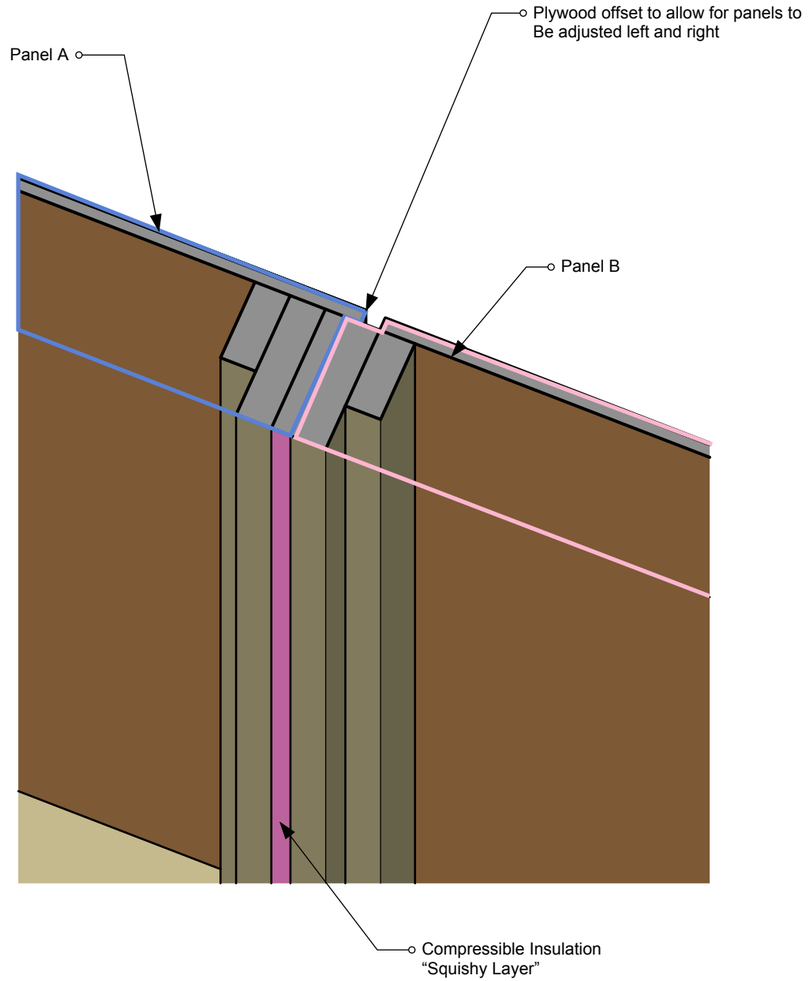
Vertical Wall Joints



INTERIOR VIEW



EXTERIOR VIEW



SECTION VIEW

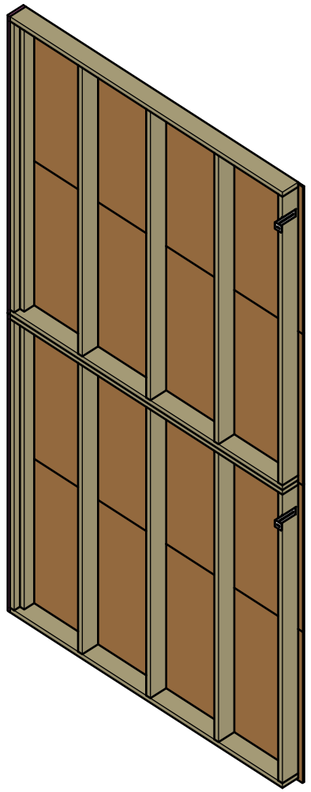
ReCover

Version Date
February 27, 2023

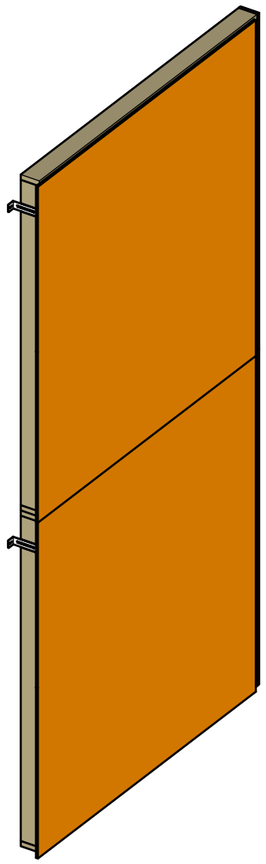
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

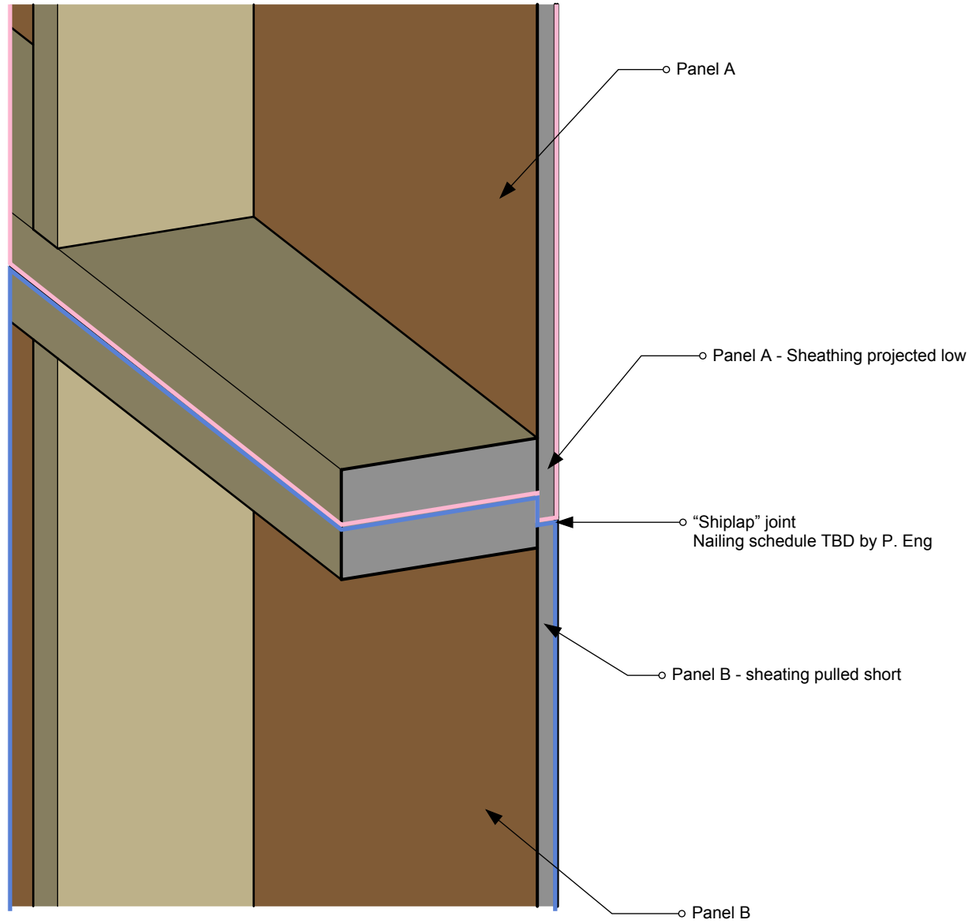
Horizontal Wall Joins



INTERIOR VIEW



EXTERIOR VIEW



SECTION VIEW

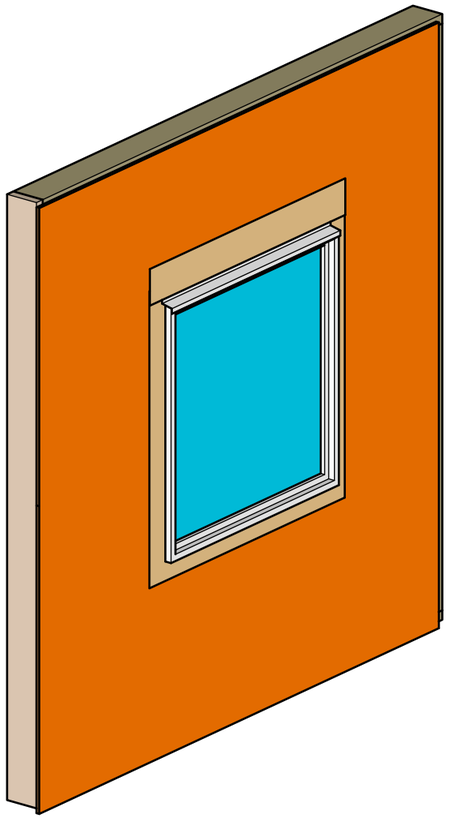
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

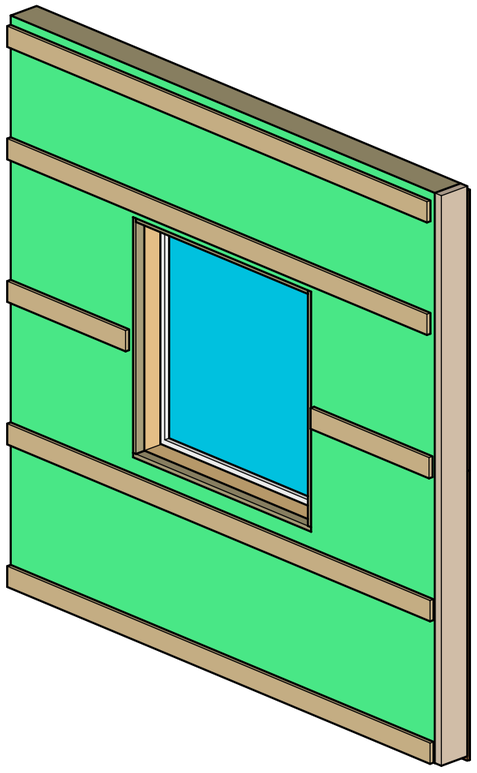
Drawn By
Nick Rudnicki

Window Panel

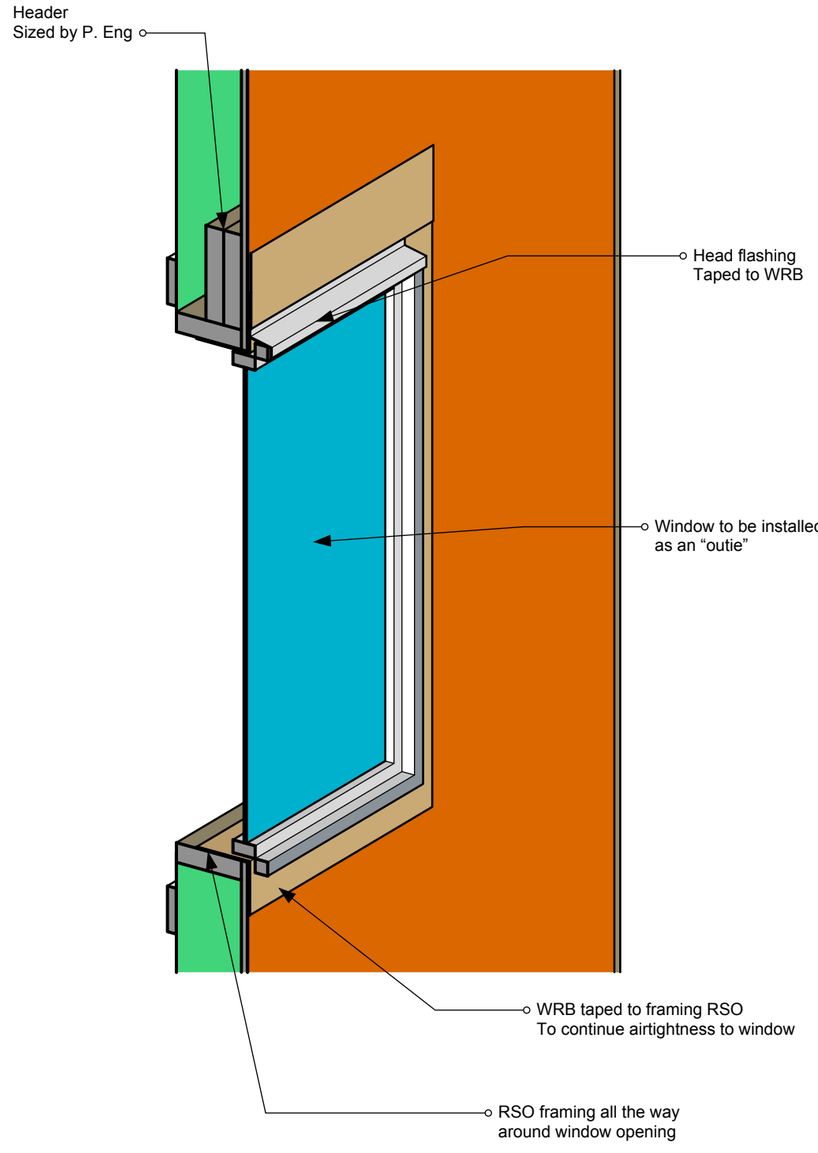


PANEL
EXTERIOR VIEW

Window installed in factory
Window installed as an "outie" to minimize how much window sill there is exposed to the rain



PANEL
EXTERIOR VIEW



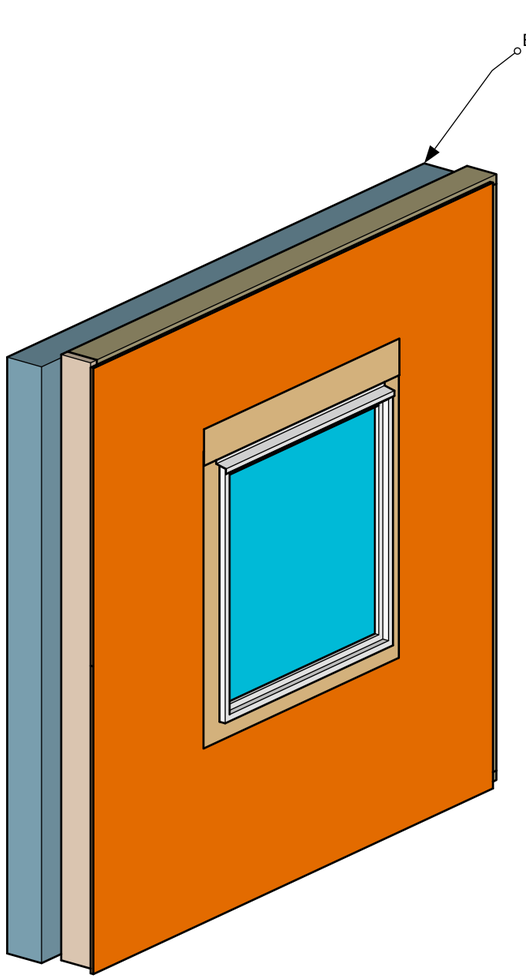
ReCover

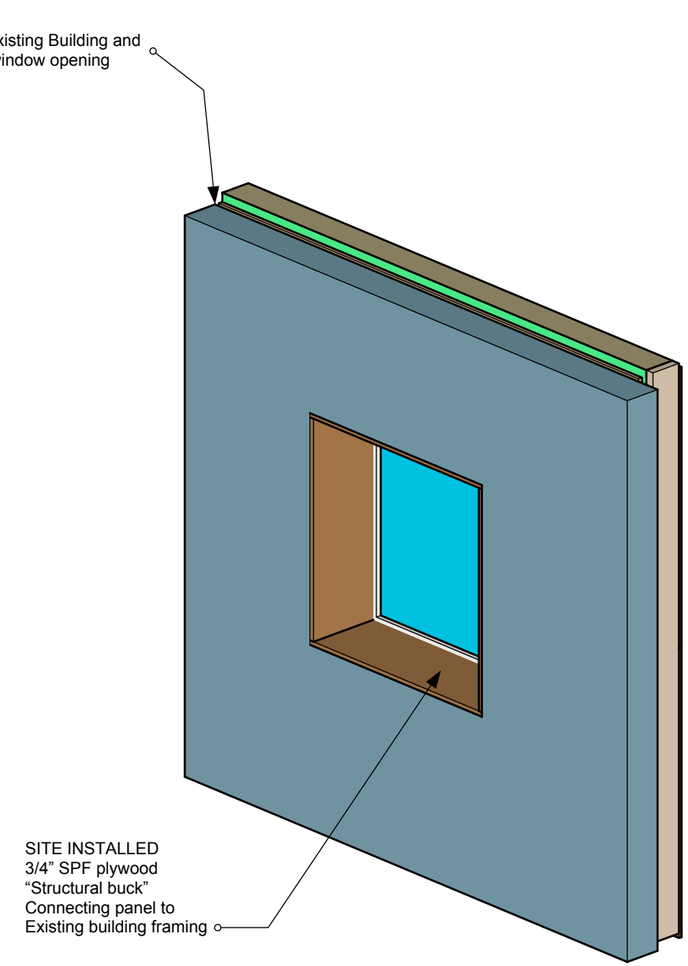
Version Date
February 27, 2023

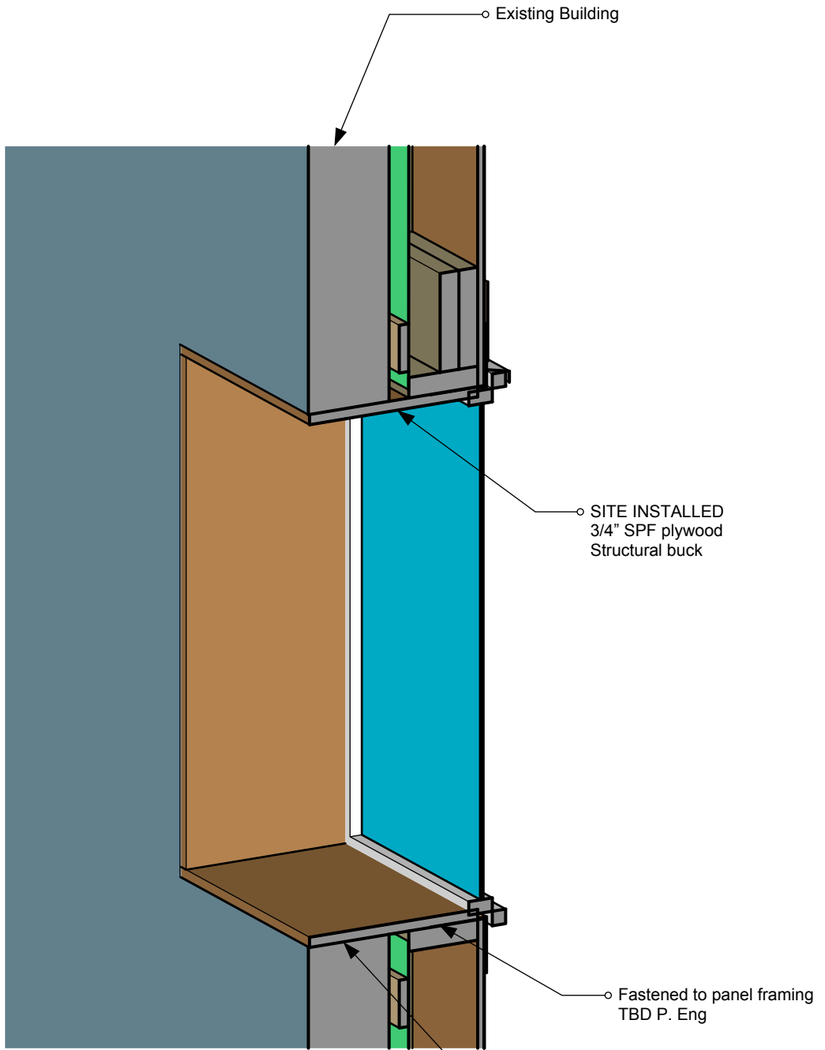
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Window Panel Install







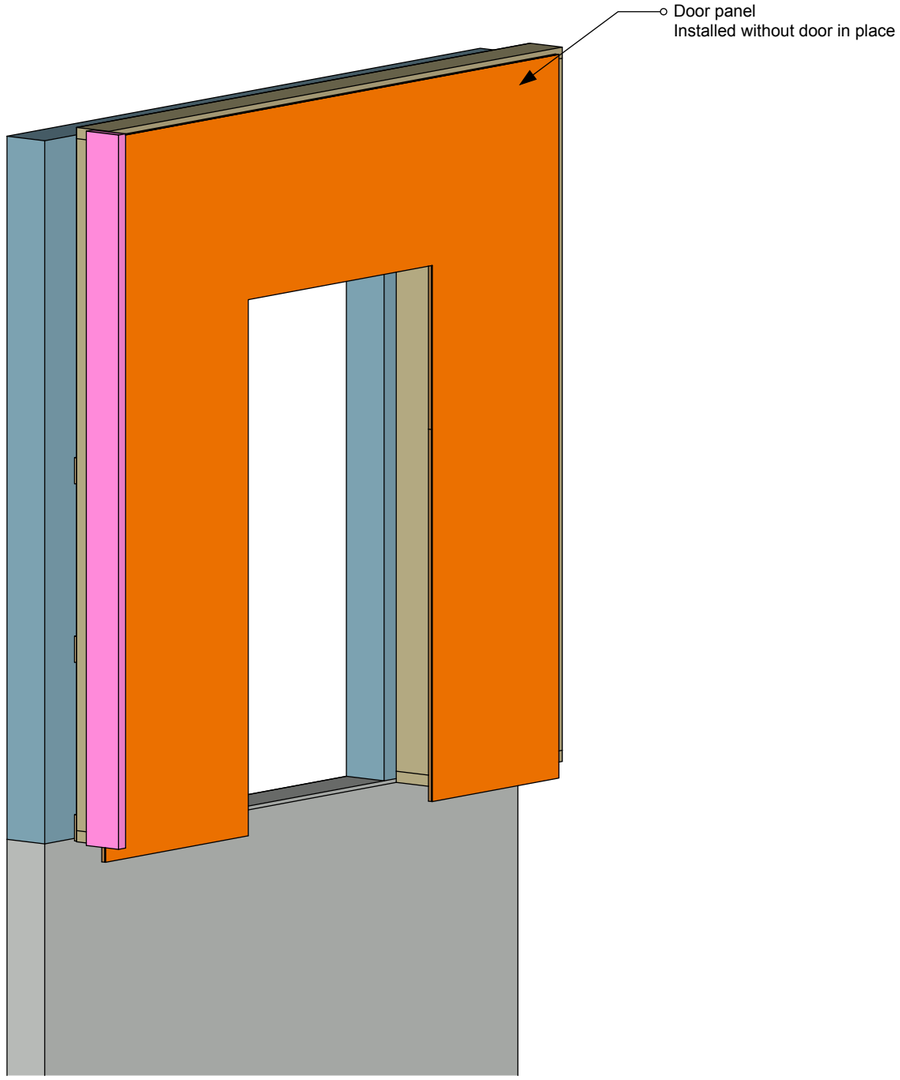
ReCover

Version Date
February 27, 2023

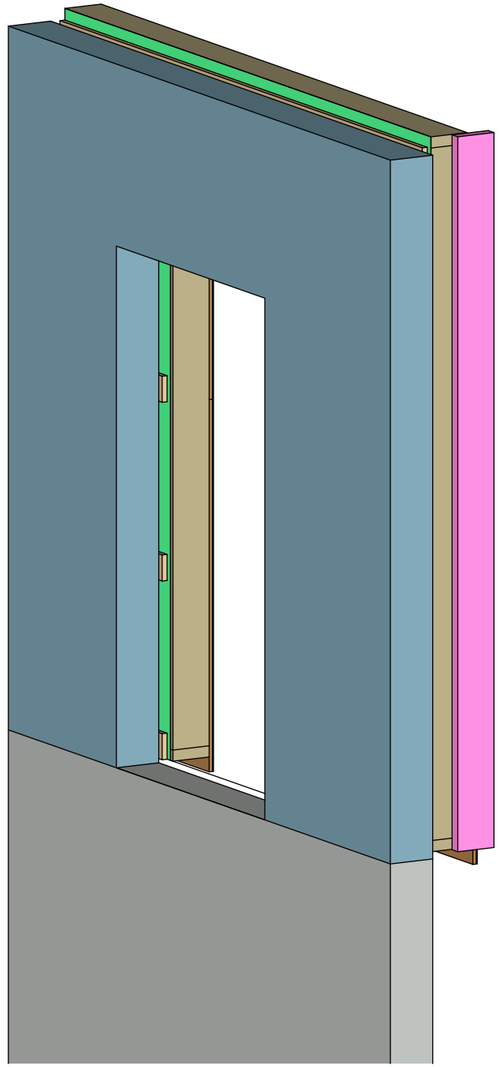
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Door Penetration Panel



EXTERIOR VIEW



INTERIOR VIEW

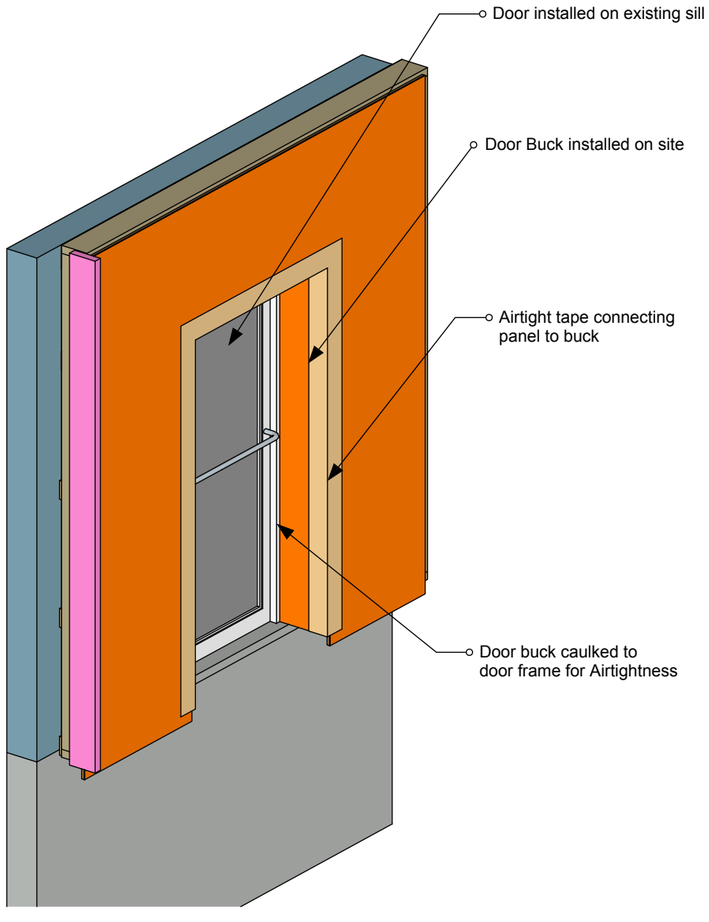
ReCover

Version Date
February 27, 2023

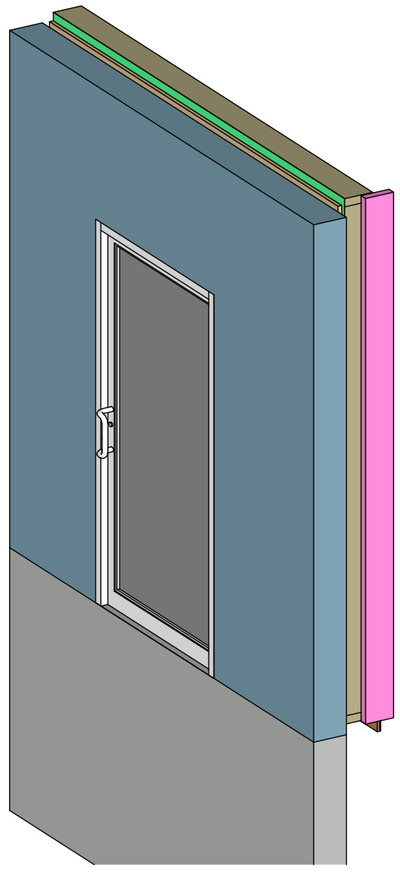
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

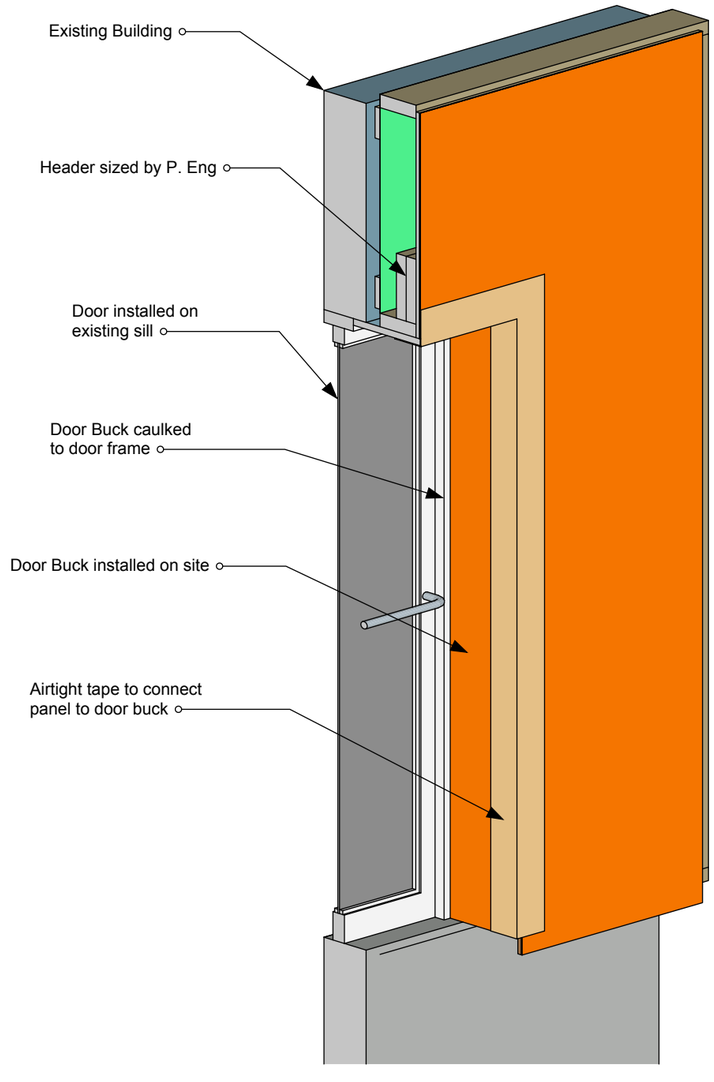
Door Penetration Panel Installed



EXTERIOR VIEW



INTERIOR VIEW



SECTION VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Roof Panel Schematics

Cellulose Inverted Roof - R38 - 2x8 - DensGlass

ReCover Initiative

ReCover

DRAWN BY
Nick Rudnicki

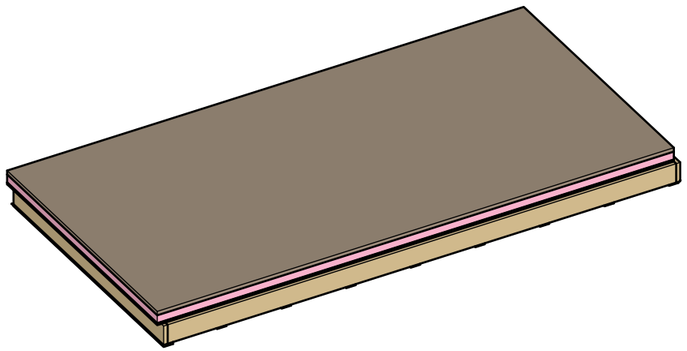
PROJECT
2x8 R38 Cellulose XPS
Inverted Roof Panel

Version Date
February 27, 2023

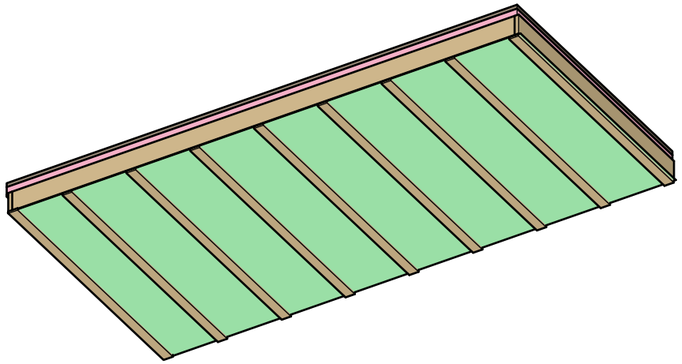
01

Installed and Finished Panel

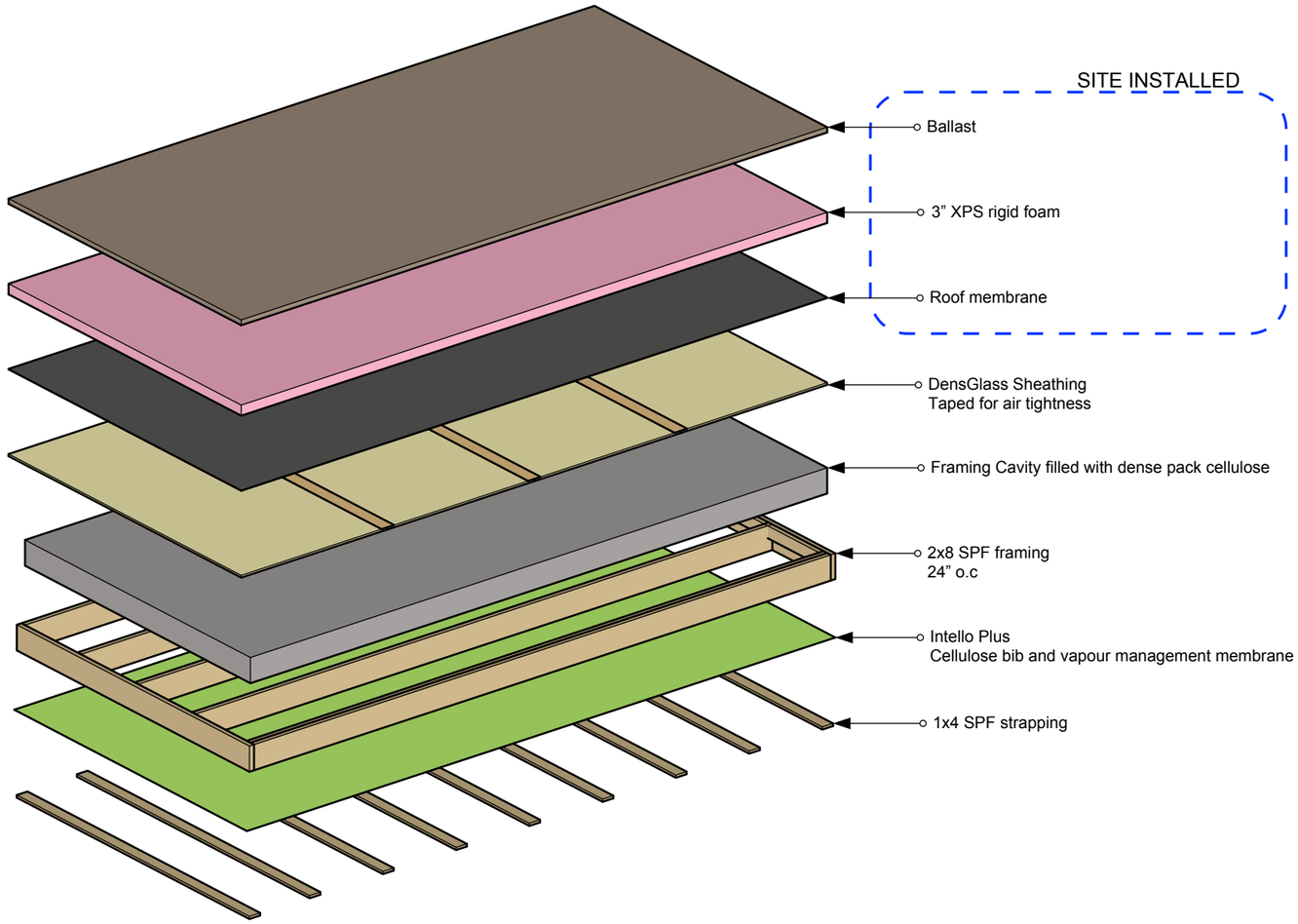
Overview of panel and site-installed XPS and roofing



Top View



Bottom View



Exploded View

ReCover

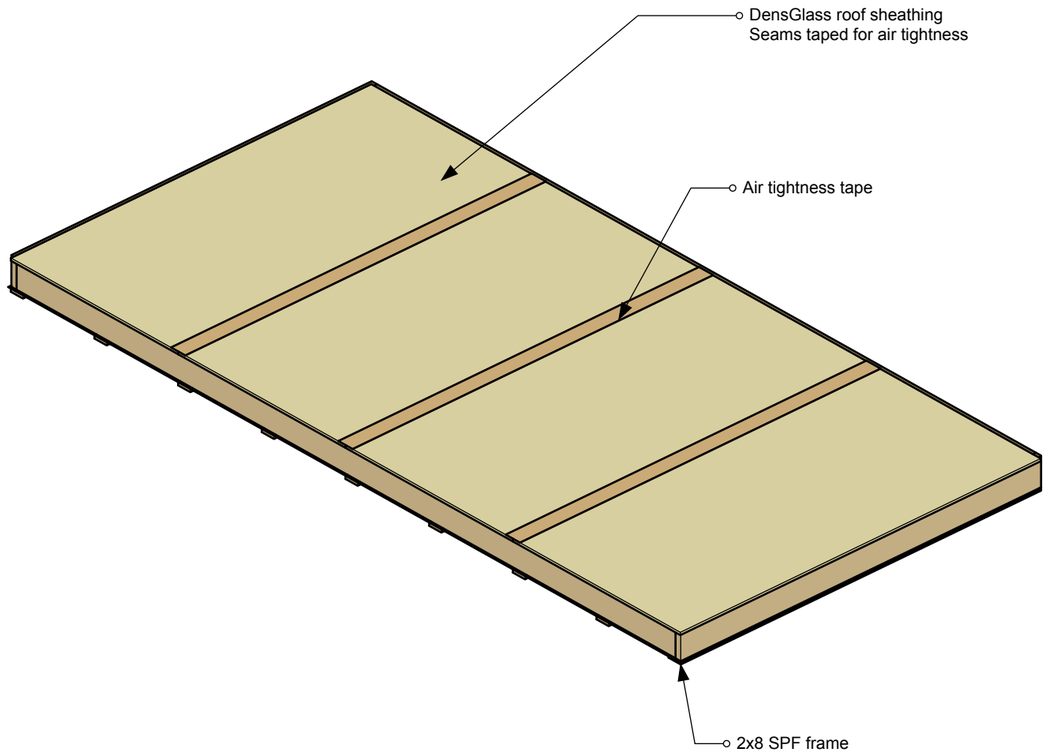
Version Date
February 27, 2023

PROJECT
2x8 R38 Cellulose XPS
Inverted Roof Panel

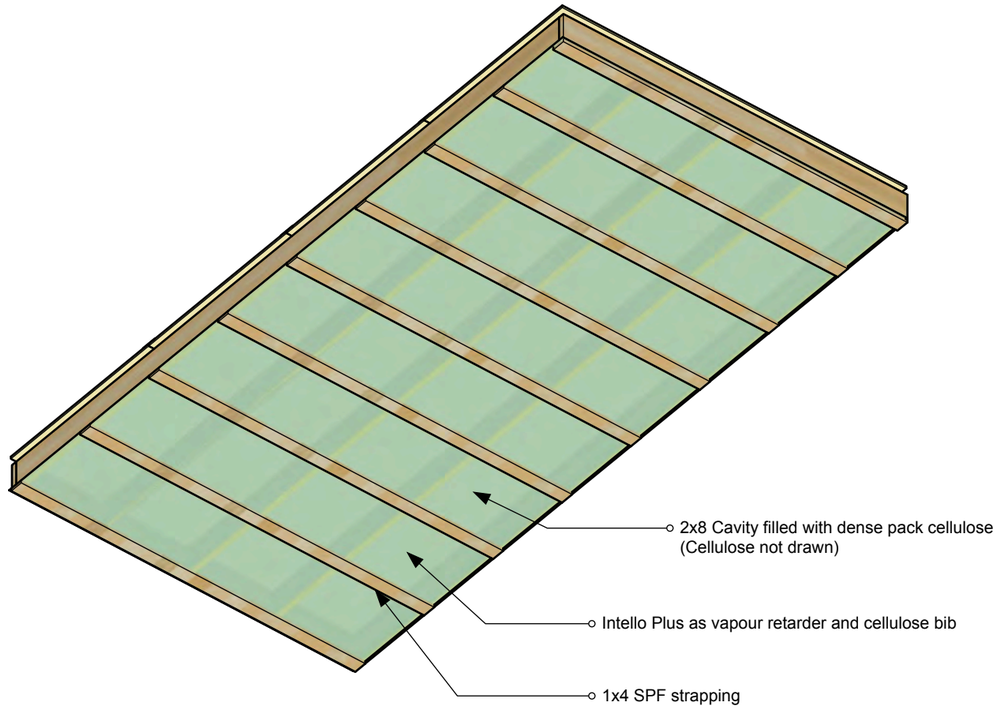
DRAWN BY
Nick Rudnicki

02

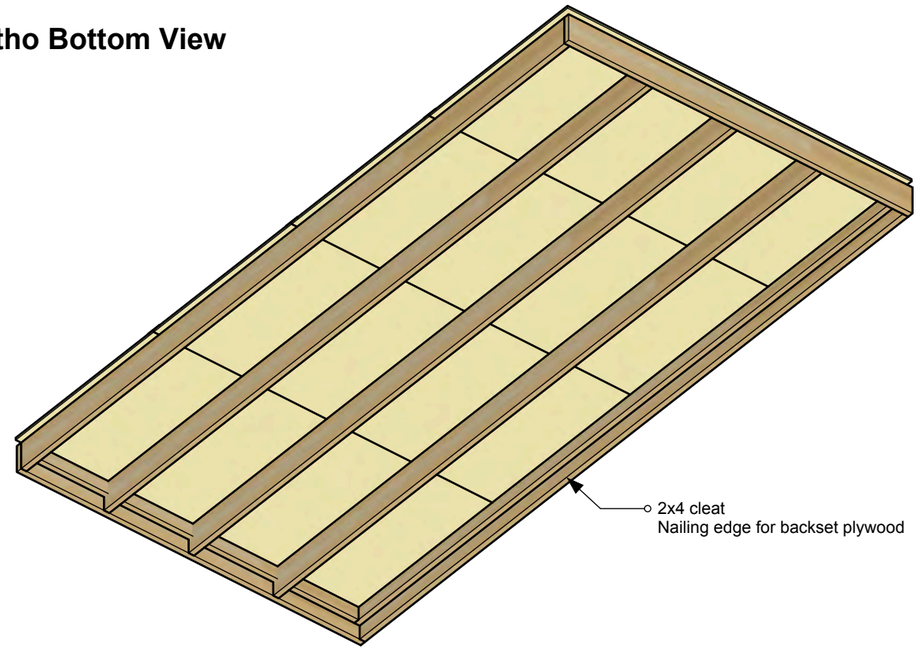
Just the Panel Overview



Top View



Ortho Bottom View



ReCover

Version Date
February 27, 2023

PROJECT
2x8 R38 Cellulose XPS Inverted Roof Panel

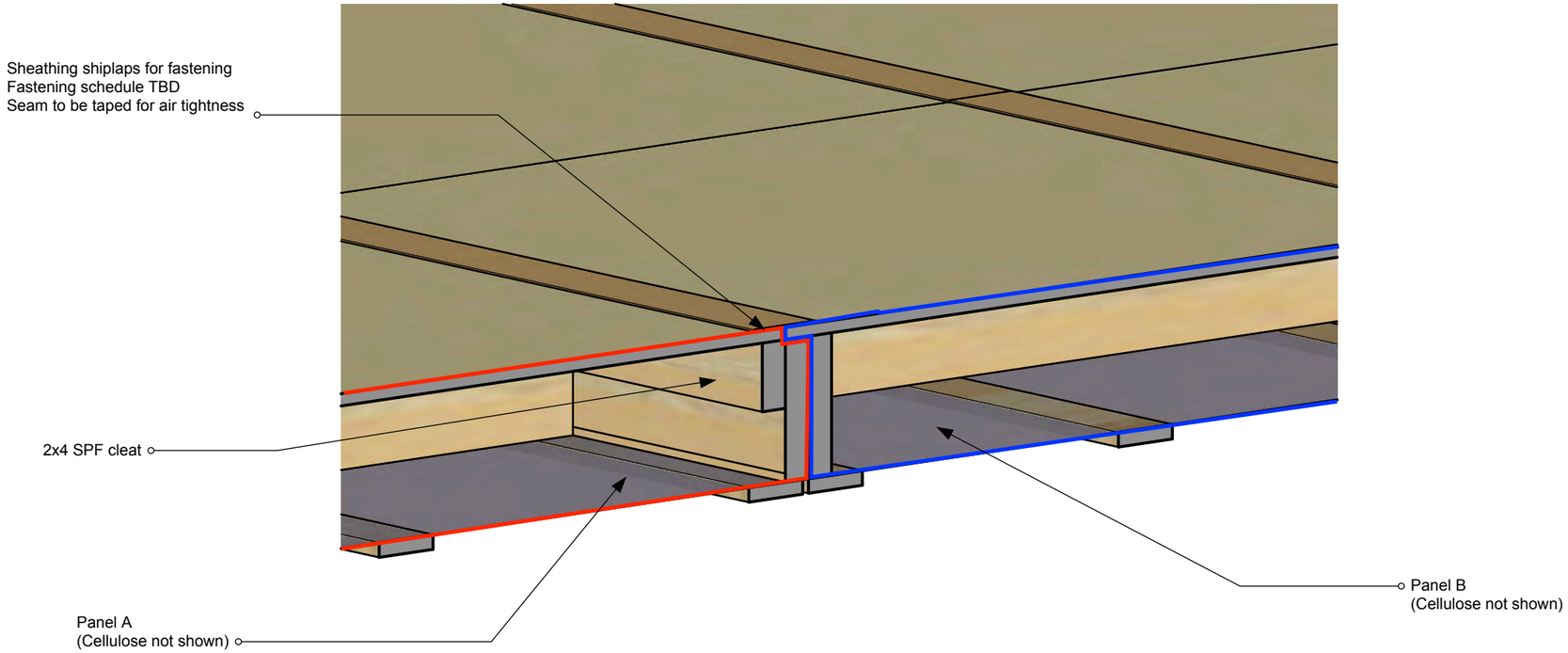
DESCRIPTION
Sheet Description

DRAWN BY
Nick Rudnicki

03

Seam Joining Detail

How Panels Join Together on Site



ReCover

Version Date
February 27, 2023

PROJECT
2x8 R38 Cellulose XPS Inverted Roof Panel

DESCRIPTION
Sheet Description

DRAWN BY
Nick Rudnicki

04

Appendix I

Panel Layouts

Municipal Operations Building Panelized Retrofit

Town of New Glasgow

ReCover

CLIENT
Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

Project Address
612 East River Road
New Glasgow
Nova Scotia

PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

01

Existing Building

ReCover

CLIENT
Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

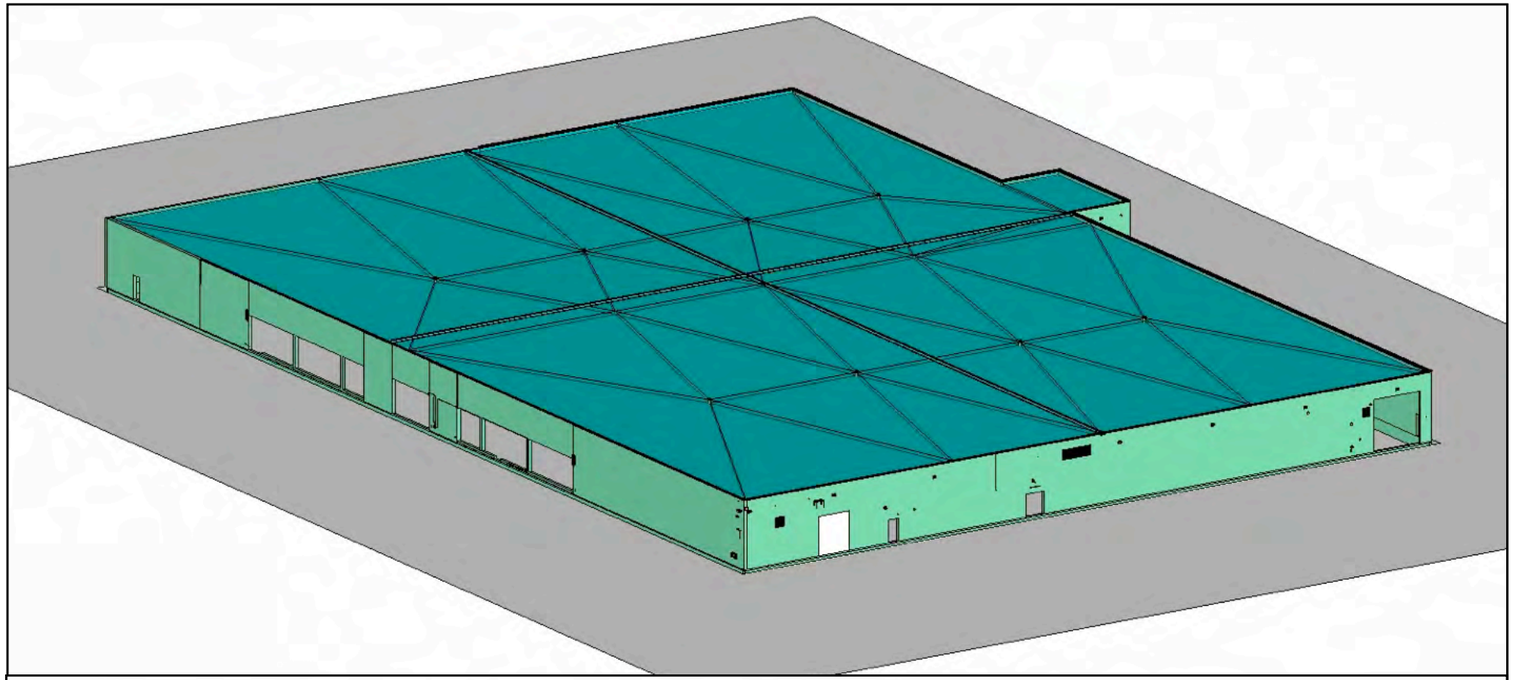
Project Address
612 East River Road
New Glasgow
Nova Scotia

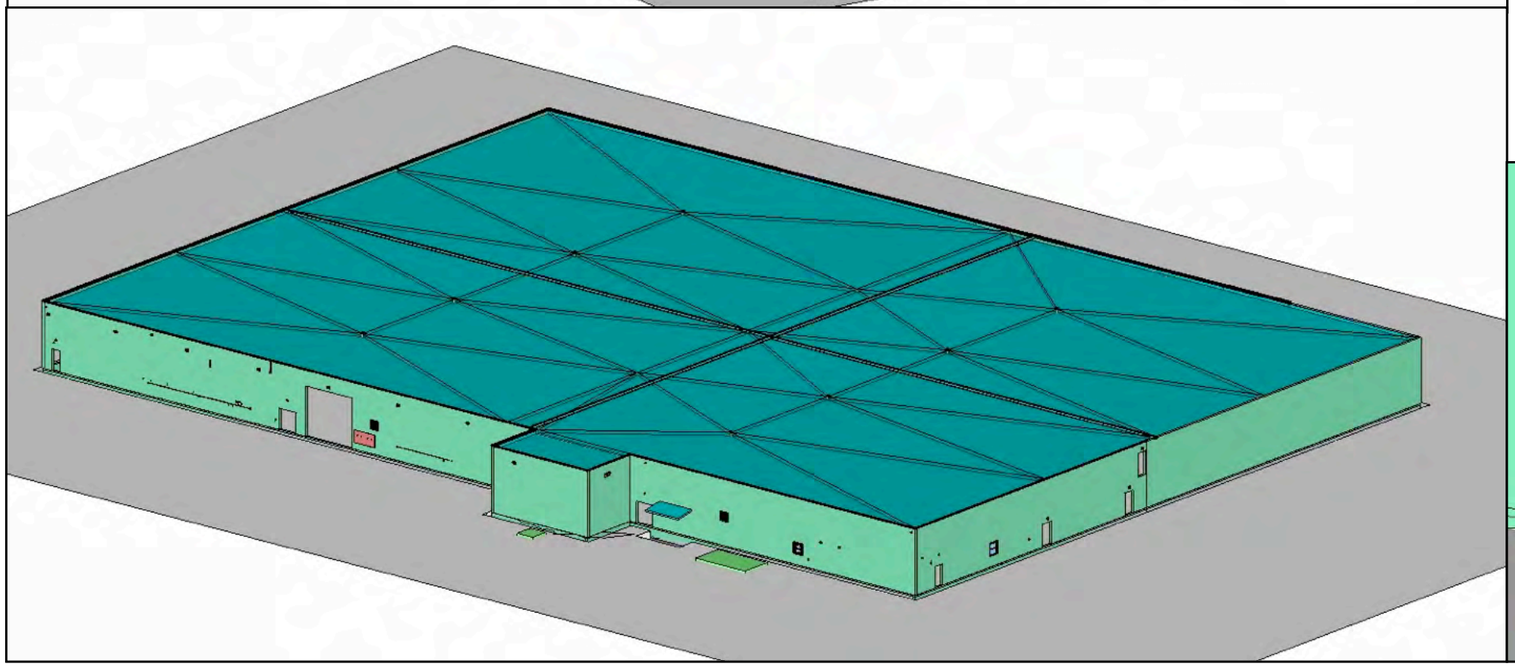
PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

02

Demolition Plan



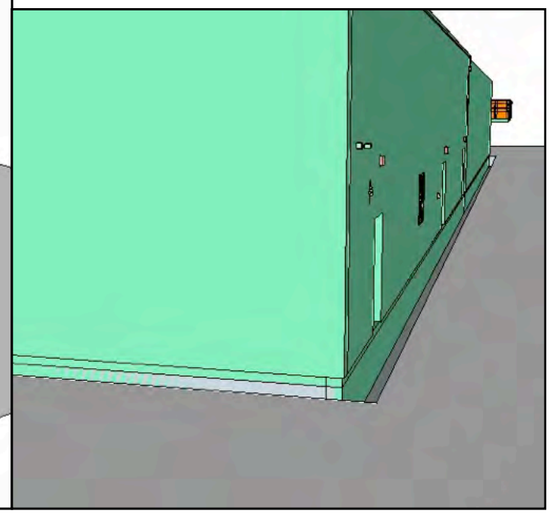


Scope of Demolition

- all windows and doors as part of envelope upgrade
- entryway awning
- mechanical components from roof
- bollards

Scope of Excavation

- trench around the perimeter



ReCover

CLIENT
Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

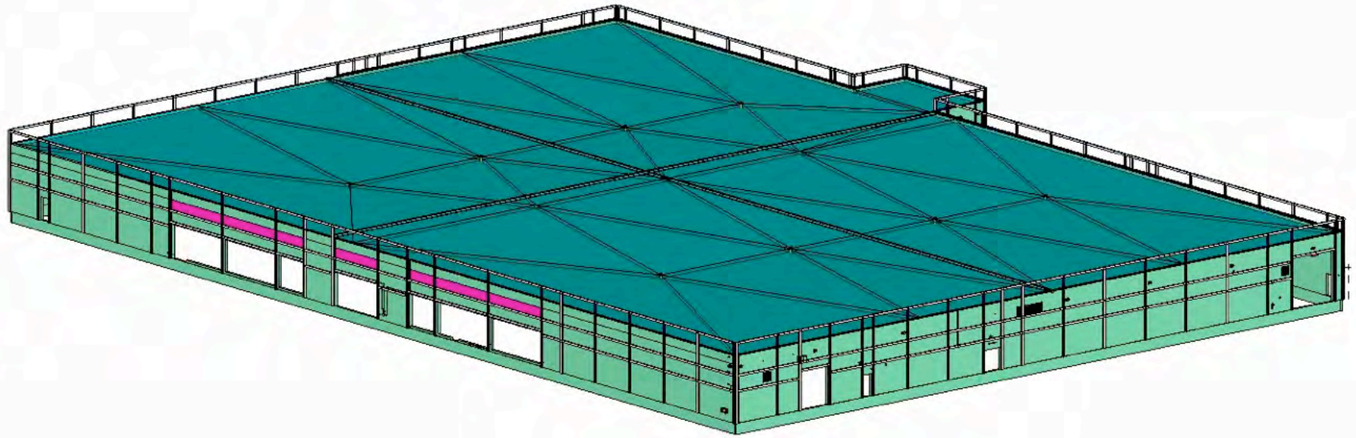
Project Address
612 East River Road
New Glasgow
Nova Scotia

PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

03

Wall Support Steel Install

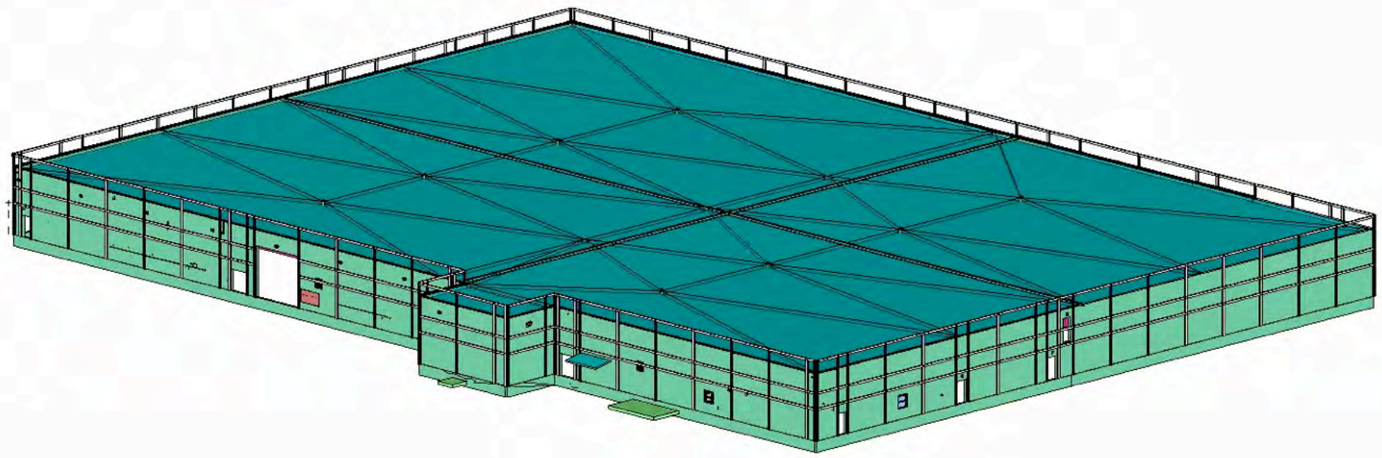


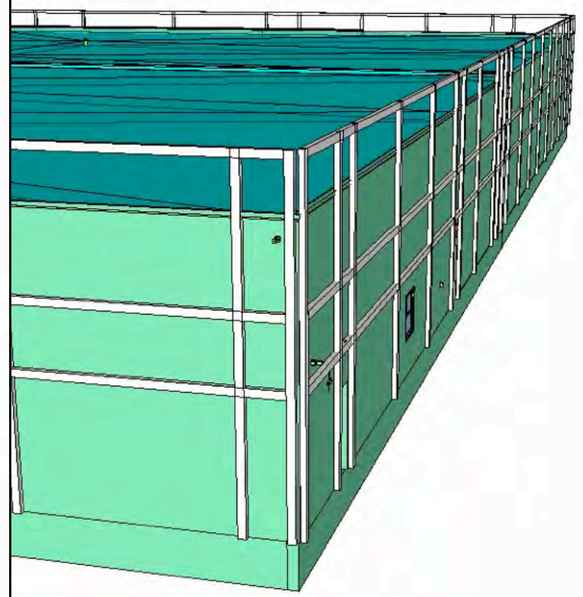
Existing Walls

Existing walls are not strong enough to support wall panels.

New Steel Supports

Installed as per P. Eng. specifications, this system of externally supported steel beams will carry the weight and lateral loads of the wall panels. Spaced vertically every 4880mm (16’), horizontally at the horizontal seams of the panels, and intentionally overshooting the roofline to accommodate the roof trusses.





ReCover

CLIENT
Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

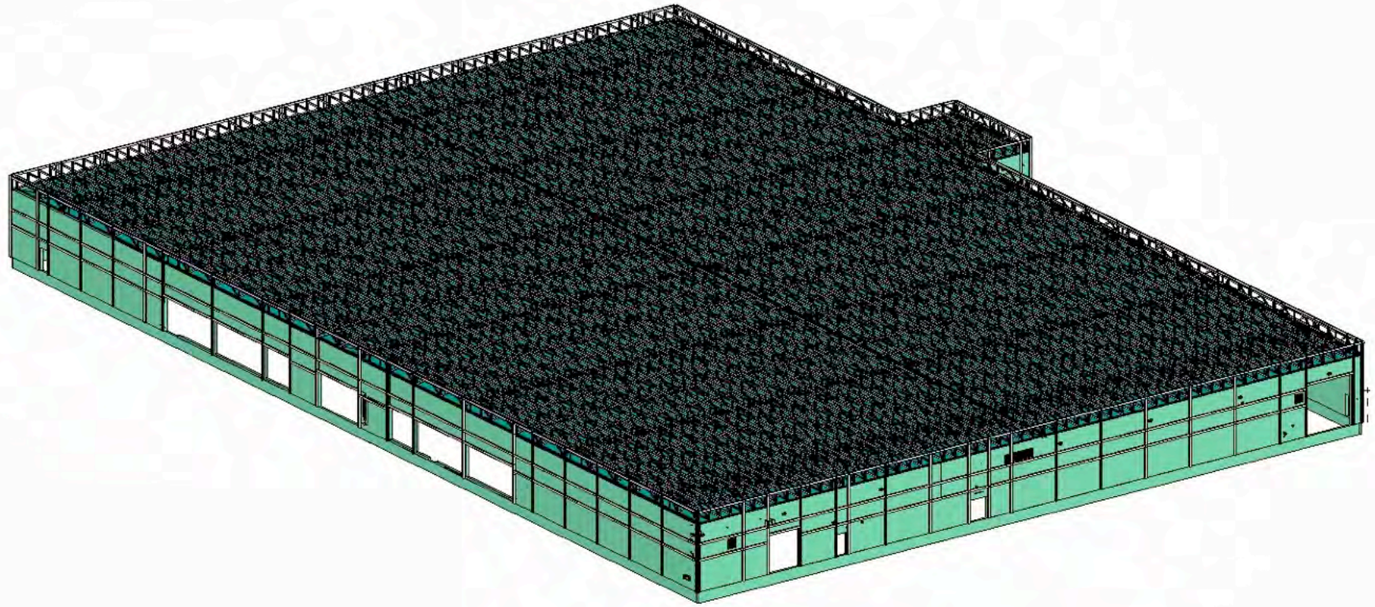
Project Address
612 East River Road
New Glasgow
Nova Scotia

PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

04

Roof Reinforcement

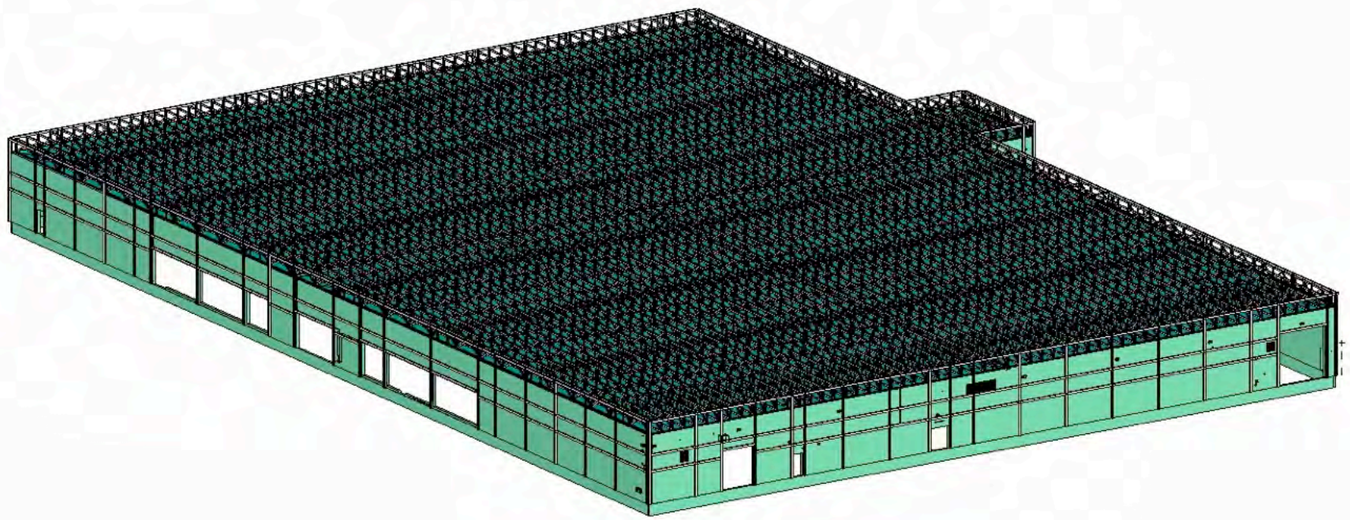


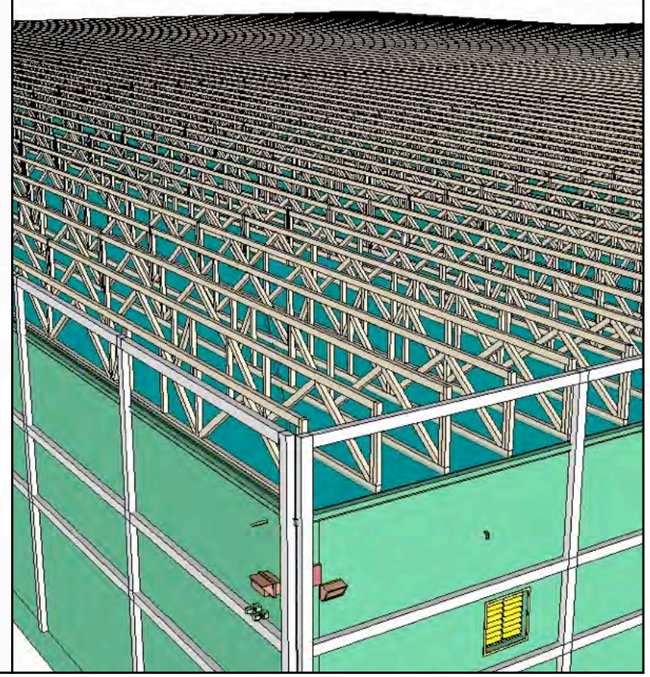
Existing Roof Beams

Original roof beams are spaced too far apart for panels to span them.

Modification

Roof will have to be retrofit with 15,240mm (50') long, 1,371mm (54") tall trusses to span the gaps of existing roof beams and allow for standard sized panels to be installed on top of them.





ReCover

CLIENT
Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

Project Address
612 East River Road
New Glasgow
Nova Scotia

PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

05

Wall Panel Layout

ReCover

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Town of New Glasgow
111 Provost St
New Glasgow
NS, B2H 5E1

Version Date
February 27, 2023

Project Address
612 East River Road
New Glasgow
Nova Scotia

PROJECT
Panelized Retrofit
of Municipal
Operations Building

DRAWN BY
Nick Rudnicki

06

Roof Panel Layout

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111 Provost St
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Project Address
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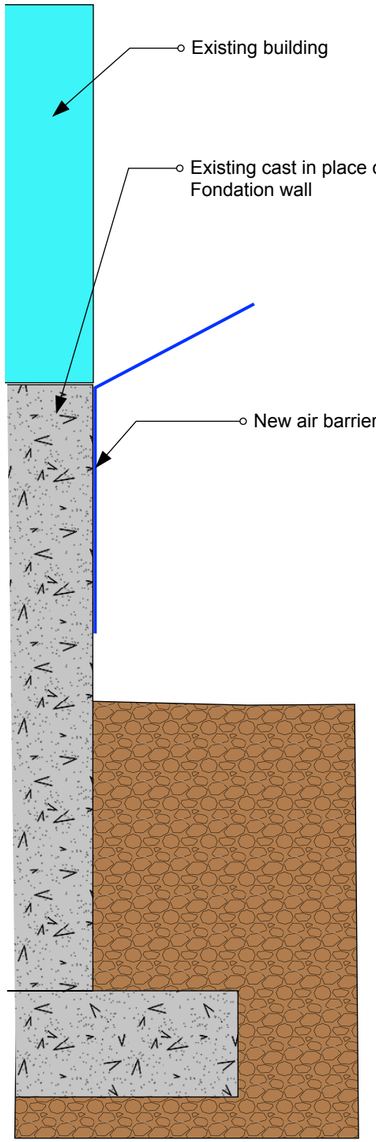
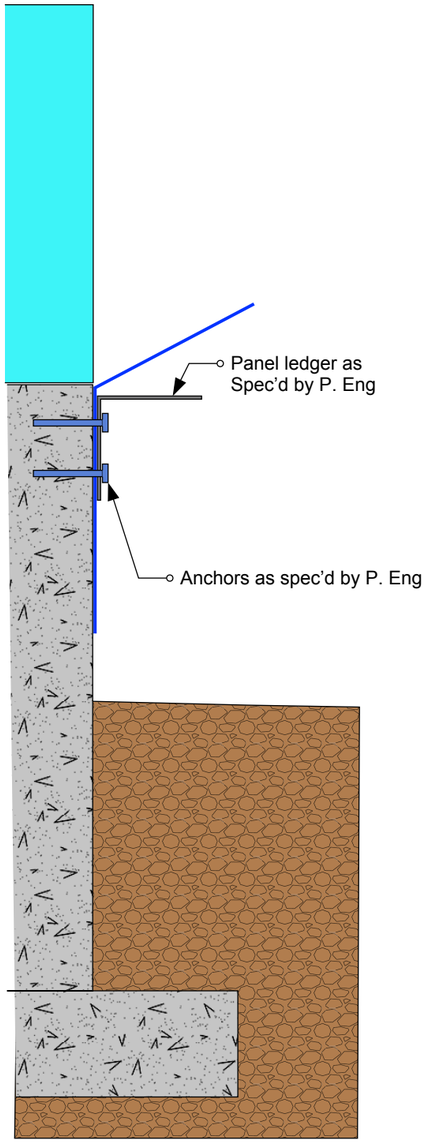
Nick Rudnicki

Foundation Insulation and Panel Base

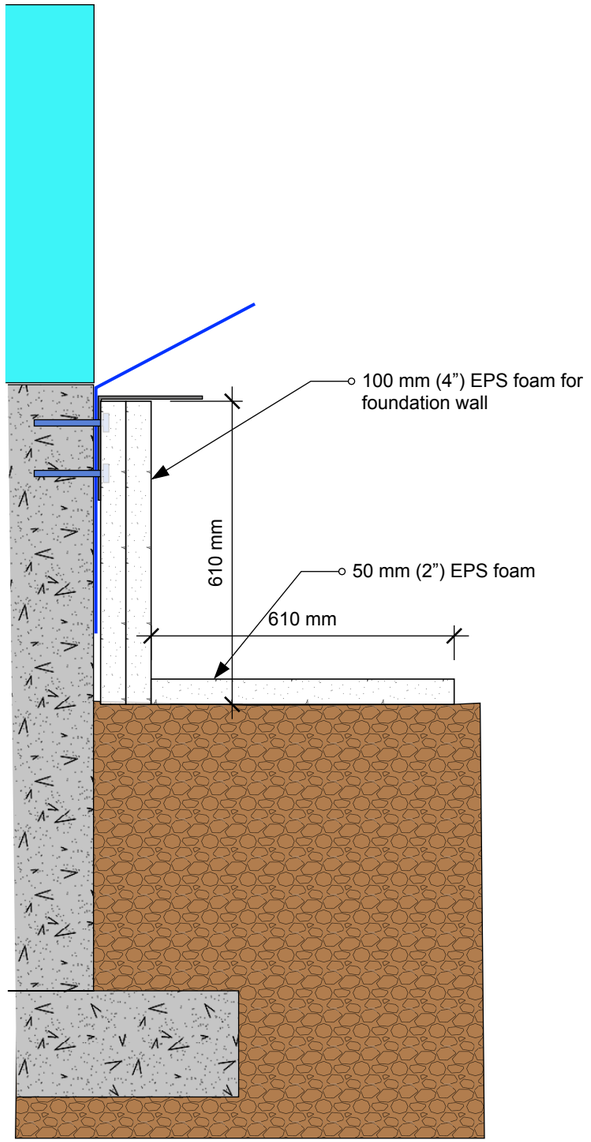


STEP 1
Install the Air barrier



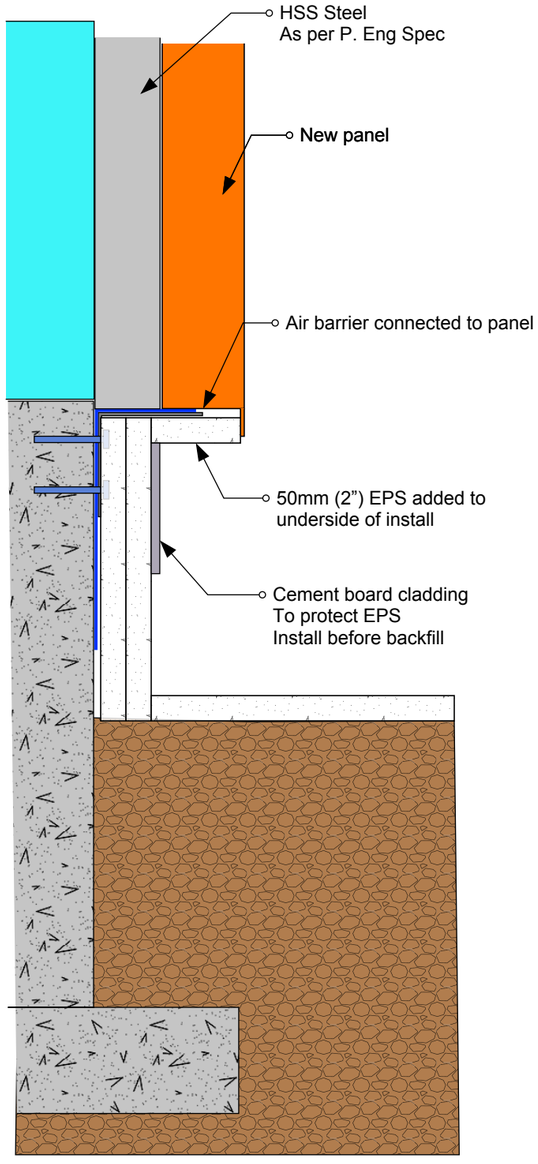
STEP 2
Install panel ledger overtop of air barrier.

Allow flap of air barrier to come out over the top of the ledger.



STEP 3
Install 100mm (4") of EPS to foundation wall to a depth of 610mm (24")

Install a 50mm (2") thick and 610mm (24") wide fin of EPS at a depth of 610mm (24") below grade



STEP 4
Install Panel on top of ledge

Tie air barrier to panel

Attach cement board to portion of foundation wall EPS that will be exposed after backfill

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Nick Rudnicki

08

Appendix J

Hygrothermal Report

- **Report**

RE: Preliminary WUFI® Pro Results – PRELIMINARY DRAFT, FOR FINAL REVIEW

Location: 624 E River Road, Town of New Glasgow, Nova Scotia

Date: 2023-02-09

The services of Stanley Francispillai, P. Eng. (Quebec, Nova Scotia), were retained by Habit Studio Incorporated for the ReCover Initiative: Panelized Deep Energy Retrofits of Municipal Buildings project. These services were limited to the presentation of results for the hygrothermal modelling of the post-retrofit above-grade wall and roof assemblies of six municipal buildings using the ReCover Initiative team's panel designs. The present feasibility report serves as a summary of the WUFI® Pro results obtained for the Municipal Maintenance Facility building located at 624 E River Road in the Town of New Glasgow, Nova Scotia.

INTRODUCTION

It is understood that the Municipal Maintenance Facility, built in 1976, is located at the eastern edge of a large parking area shared with other retail and restaurant spaces. The length of the building runs North North-East to South South-West, with the western side exposed to the parking lot, while the eastern façade faces a wooded area approximately 75-m away; approximately half of the northern side of the building is connected to a movie theater to the north-west, while the southern side of the maintenance facility faces Johnny Miles Memorial Trail (see **Figure 1**).

Figure 1 – Plan view location and orientation of 624 E River Road (shaded red), New Glasgow (Google, 2022)

PRELIMINARY

It is understood that the building's primary use is to serve as a maintenance shop in one portion of the building, while a flea market is hosted in what was previously the K-Mart space of the building. However, it is understood that only the maintenance shop has been in service in the past several years.

PRELIMINARY

SCOPE OF WORK

The scope of work for this project includes the presentation of results associated with the hygrothermal modelling of the post-retrofit exterior wall and roof assemblies of the Municipal Maintenance Facility over a 10-year period using the software WUFI® Pro. The simulations use preliminary assumptions based on discussions made with the ReCover team, as well as the PHIUS+ protocol *Moisture Risk Analysis & Assessment using WUFI v1.1* (G. Wright, P. Ferreira, R. Richman, 2021).

The hygrothermal modelling includes all exterior walls except the northern portion of wall shared with the adjacent cinema building – it is understood that this portion of wall will not be retrofitted, and therefore falls outside the scope of work for this project. The flat roof of the building was also simulated in this feasibility study. The retrofit designs used in the hygrothermal models were provided by the ReCover team.

It is of note that no design was conducted by Stanley Francispillai, P. Eng. Existing assemblies were obtained from available documents, and retrofit assemblies were defined by the ReCover team for simulation in WUFI® Pro, the results of which are presented in this feasibility report.

PRELIMINARY

INPUTS & ASSUMPTIONS

Prior to completing the preliminary simulations in WUFI®, the inputs and assumptions guiding the simulations were chosen with the ReCover team. These inputs and assumptions were made based on information received from the Town of New Glasgow, including photos, a hand-drawn floor plan (*624 ERR Building Envelop info.pdf*, received on 2022-08-19), and a SNC-Lavalin report (*New Glasgow PW Building Assessment.pdf*, dated 2017-09-17). No site-visit was conducted by the author of this report; thus, the inputs and assumptions of the hygrothermal simulations are based solely on this received information, as well as input from ReCover. Reference documents are included in **APPENDIX D**.

OUTDOOR CLIMATE: The outdoor climate was modelled using the closest location to the Town of New Glasgow with data available to the author of this report – this was Halifax, Nova Scotia (Halifax CWEC data, 1995 with monthly rain allocated on an hourly basis via Canadian Climate Normals). It is to be noted that this climate file is for typical weather patterns and does not consider extreme weather events – a specific New Glasgow (or Nova Scotia) climate file is not available in the WUFI database.

INDOOR CLIMATE: The non-residential indoor climate was modelled using sinusoidal functions. Two separate indoor temperature setpoints were simulated, including 7°C and 21°C. The 7°C setpoint represents the current setpoint for the commercial area (K-Mart section of the building), while the 21°C setpoint was assumed to represent normal occupancy conditions. Given that the 7°C setpoint may remain in place post-retrofit until normal tenancy is resumed, it was assumed that this temperature setpoint should be modelled in the hygrothermal simulations. For both temperature setpoints, a relative humidity setpoint of 50% was assumed. As it is unclear as to what current and future tenancy patterns and moisture loads will be present, the following assumptions were made regarding the indoor climate:

Table 1 – Setpoints and assumptions used in WUFI simulations for interior climate of building

Interior Setpoints	Average	Amplitude	Range	Date of Maximum Value
Temperature 1	7°C	1°C	6°C – 8°C	July 15th
Temperature 2	21°C	1°C	20°C – 22°C	July 15th
Relative Humidity	50%	10%	40% – 60%	July 15th

Note: it is assumed that the temperature and relative humidity setpoints are applied to the entire building

ASSEMBLY MATERIALS: Based on the information obtained, the primary existing wall and roof assemblies shown in **Table 2** were modelled for the maintenance facility (detailed material properties included in **APPENDIX A** and **APPENDIX B**). The retrofit assemblies proposed for the retrofit were originally sourced from the project document *22 11 08 – Assembly Details.pdf*, received on 2022-11-08 from RSI Projects. However, final designs and assemblies were conveyed by the ReCover team via phone and video calls.

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Table 2 – Assemblies and material components used in WUFI simulations

Assembly	Materials (Interior to Exterior)	Thickness, m (inch)
North & South Walls *(wind-dependent exterior resistance film)*	Concrete Block (painted, unpainted)	0.203 (8.0)
	Rigid Insulation	0.025 (1.0)
	Brick	0.102 (4.0)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.51)
	Plywood	0.013 (0.51)
	Weather Resistive Barrier (WRB)	0.001 (0.04)
	Air Space	0.010 (0.39)
	Metal Cladding	0.001 (0.04)
East Wall *(wind-dependent exterior resistance film)*	Concrete Block (painted, unpainted)	0.203 (8.0)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.51)
	Plywood	0.013 (0.51)
	Weather Resistive Barrier (WRB)	0.001 (0.04)
	Air Space	0.010 (0.39)
	Metal Cladding	0.001 (0.04)
West Wall *(wind-dependent exterior resistance film)*	Gypsum Board*	0.013 (0.49)
	Concrete Block	0.203 (8.0)
	Rigid Insulation	0.025 (1.0)
	Brick	0.102 (4.0)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.51)
	Plywood	0.013 (0.51)
	Weather Resistive Barrier (WRB)	0.001 (0.04)
	Air Space	0.010 (0.39)
	Metal Cladding	0.001 (0.04)
Roof *(shaded/unshaded conditions)*	Steel Deck	0.001 (0.03)
	Fibreboard	0.006 (0.24)
	Modified Bitumen Cap & Base Sheets	0.004 (0.16)
	Air Space	1.35 (53.2)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.184 (7.25)
	Plywood/DensElement	0.016 (0.63)
	Roof Membrane	0.001 (0.04)
	Extruded Polystyrene Insulation	0.075 (3.0)

**West wall was simulated with/without painted gypsum board – without gypsum board scenarios included painted/unpainted concrete block*

PRELIMINARY

MOISTURE & AIR SOURCES: To determine how the retrofit walls perform under certain environmental stresses, a 1% driving rain moisture source was placed on the exterior face of the wall's WRB in the form of a fictitious 1-mm layer of brick, as per the PHIUS+ protocol. Moreover, the vented cladding was given a default ventilation rate of 25 air changes per hour (ACH) and was placed within the 10 mm "*Air layer 10mm; metallic*" material which is pre-defined by WUFI® for use adjacent to metal surfaces.

ORIENTATIONS: Given that the wall assemblies differ in the four cardinal directions, the North, South, East, and West orientations were all simulated in WUFI®; these were set to 90° inclinations from the horizontal. The roof assembly was inclined at 0° from the horizontal.

RAIN LOAD: In terms of rain loading, the ASHRAE Standard 160 rain load calculation method was utilized. For the wall assemblies, the rain exposure factor was based on the building's height of less than 10-m, while the rain exposure category was assumed to be medium, as the building is located approximately 12-km from the northern coast of Nova Scotia. The rain deposition factor was automatically defined based on the overhead presence of a low-slope roof. These same assumptions were used for the roof assembly, with the only difference being the rain deposition factor requiring a higher value due to increased bulk water contact from rainwater runoff.

BOUNDARY CONDITIONS: For the post-retrofit condition studied, it was assumed that the proposed exterior metal wall cladding would be painted, while the interior side of the various walls were simulated for both painted and unpainted finishes as site-visit photographs shared from the Town of New Glasgow seem to indicate both cases throughout the building. These paints would affect the surface transfer (sd) coefficients of the hygrothermal models. Other sd-coefficients considered in the models are included in **APPENDIX B**.

INITIAL CONDITIONS: Finally, as per ASHRAE 160, initial material conditions were set to EMC80 (equilibrium moisture content at 80% relative humidity), while concrete-based materials were set to EMC90; for all materials, the starting temperature was set to 20°C. The simulations were defined to begin on October 1st, 2022, which is the default starting day for WUFI®, and continue for a period of 10-years.

Other inputs of the WUFI simulations can be found in the software's auto-generated results report, included in **APPENDIX B**.

PRELIMINARY

RESULTS

The PHIUS+ protocol's post-processing and evaluation procedure was sourced for describing the results of the post-retrofit hygrothermal simulations conducted.

POST-RETROFIT WALL – 7°C Temperature Setpoint

The post-retrofit wall assemblies simulated with a 7°C interior temperature setpoint demonstrated certain numerical anomalies for all orientations. Although no convergence failures were reported, the differences between balances of change in total water content and the sum of the moisture fluxes were significant.

The assemblies also demonstrated increasing water content over time rather than drying out from the 80% RH initial condition imposed. **For these reasons, and per the PHIUS+ protocol, it is understood that the 7°C setpoint does not allow for proper moisture management of the wall assemblies post-retrofit based on the information available and the assumptions presented in this report. This setpoint will no longer be discussed in this report.**

POST-RETROFIT WALL – 21°C Temperature Setpoint

The post-retrofit wall assembly simulated with a 21°C interior temperature setpoint did not demonstrate any numerical errors for all orientations and conditions tested – no convergence failures occurred, and the differences between balances of change in total water content and the sum of the moisture fluxes were very small.

As recommended by the protocol, the plywood layer was subdivided into three adjacent layers for near-surface condition assessment, with the outermost and innermost layers being 1/8-inch thick, respectively. The three plywood layers were focused upon for this feasibility report given their susceptibility to decay and mold. To estimate decay risk, the time periods during which the mass percentage of water content (MC) remains above 20% were studied.

In all orientations, at least one of the three plywood layers experiences spikes in MC above 20%. However, the occurrence and duration of these spikes vary from orientation to orientation. In general, the primary spike occurs in the first year, after which the MC decreases annually. However, the output of the East post-retrofit wall assemblies demonstrates significant MC levels in the plywood layers. The outermost layer experiences significant MC spikes above 20% for approximately five years with an annual decrease in duration; the primary spike in the first year lasts from approximately mid-December 2022 to mid-March 2023. After the first five years, the fluctuations in yearly MC are more stable (**Figure 2**). Meanwhile, the center layer experiences a MC spike above 20% from approximately late December 2022 to early May 2023 (**Figure 3**), and the inner layer experiences MC spikes above 20% from approximately early November 2022 to early May 2023, as well as January 2024 to mid-February 2024 (**Figure 4**). These results are similar for both the painted and unpainted interior finish simulations in the East orientation. It is also worth noting

PRELIMINARY

that the South orientation (painted and unpainted simulations) shows recurring MC spikes above 20% in the outermost plywood layer – however, after the first year, the duration of these spikes is approximately one month long and occurs in February-March (**Figure 6**). (Note: all orientations' MC graphs are available in **APPENDIX C**)

For mold-related durability, a VTT simulation was conducted using the WUFI® Pro plug-in which examines the mold growth index at the specified locations. The plywood layers and the outermost element of the cellulose layer were simulated using VTT. The plywood layers were defined with a sensitivity class of "Sensitive" (second-highest risk category) and a material class experiencing "Almost no decline". The cellulose layer was simulated in VTT as a proxy for the structural wood members (not modelled) located within the cavity. Based on discussions with ReCover, it was assumed that the chemical properties of the cellulose insulation may impart greater mold resistance to the cavity wood members – for this reason, a sensitivity class of "Medium resistant" was used to simulate the wood members within the cellulose cavity.

The mold growth index ranges from 0 to 6 and is coupled with a traffic light scheme in the WUFI® plug-in, ranging from green (uncritical) to yellow to red (inacceptable) – within the yellow range, there is potential risk for mold growth, however more information would be required about the specific material used to decide whether the risk is deemed acceptable or inacceptable.

The North, South, and West orientations experience acceptable VTT results according to WUFI, with the green VTT light being presented. However, the East orientation's simulation outputs a yellow VTT light for the mold growth index for the center and inner plywood layers. In the center plywood, the mold growth index remains below 1.1, while the inner plywood's index remains below 1.4. In all orientations, the cellulose cavity's "Medium resistant" sensitivity class allows for a green VTT light. These results are similar for both the painted and unpainted interior finish simulations in the East orientation. Results of the VTT simulations for the layers simulated in the East post-retrofit wall assembly (painted interior) are presented in **Figure 7**.

For these reasons, and per the PHIUS+ protocol, it is understood that the proposed post-retrofit wall assembly may manage moisture adequately based on the information available and the assumptions presented in this report. However, this is dependent on whether the plywood can be subject to certain periods of high moisture content, as well as all wood layers' mold resistance properties.

It should be noted that a sheathing substitution from the originally defined plywood material may create a more suitable panelized retrofit strategy for this building in terms of mold and decay resistance based on the information available and the assumptions presented in this report – this should be explored further.

PRELIMINARY

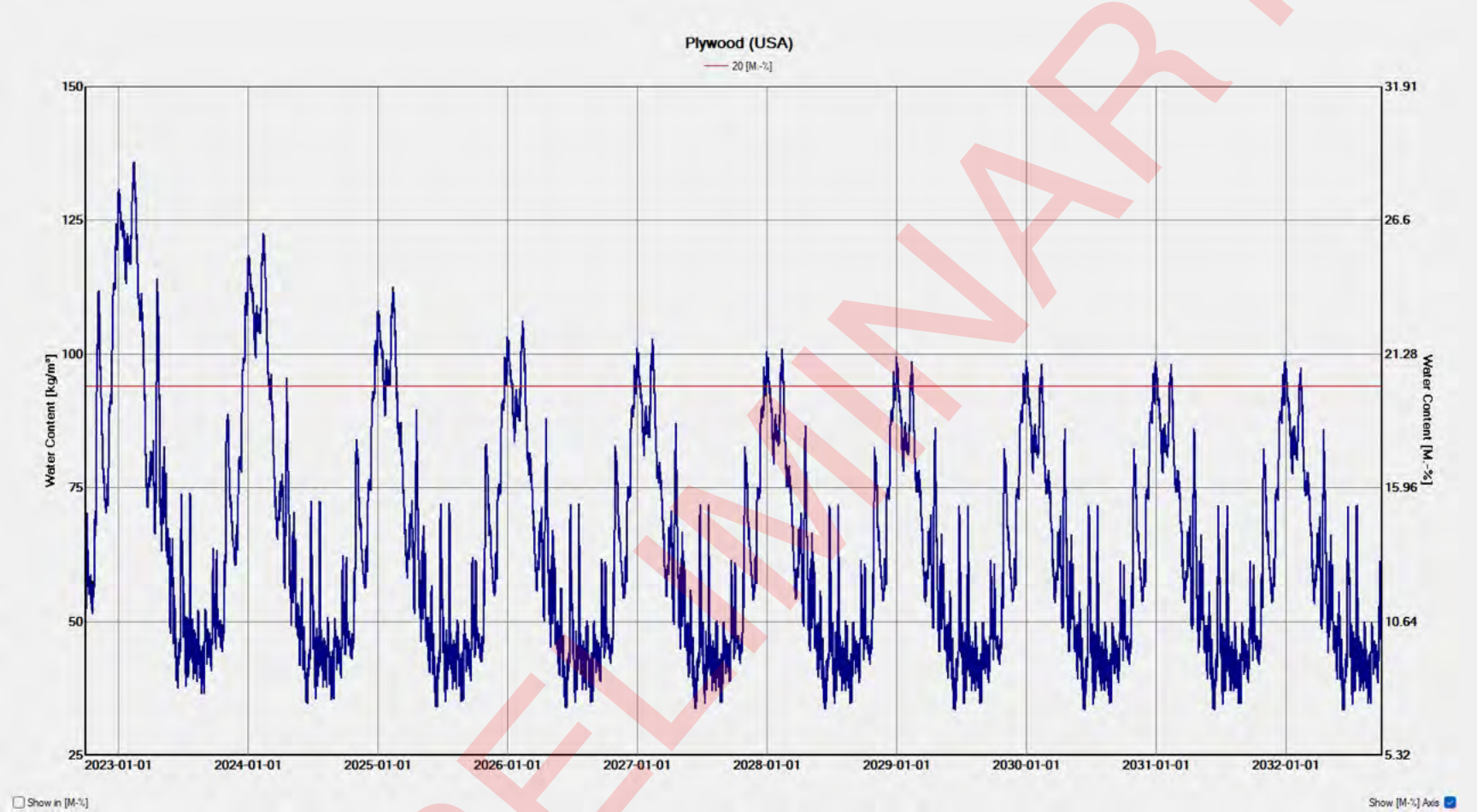

Figure 2 – WUFI® output for wall assembly (painted interior): water content (kg/m^3, %) over 10-year period studied for post-retrofit East wall assembly's outer 1/8-inch plywood layer

PRELIMINARY

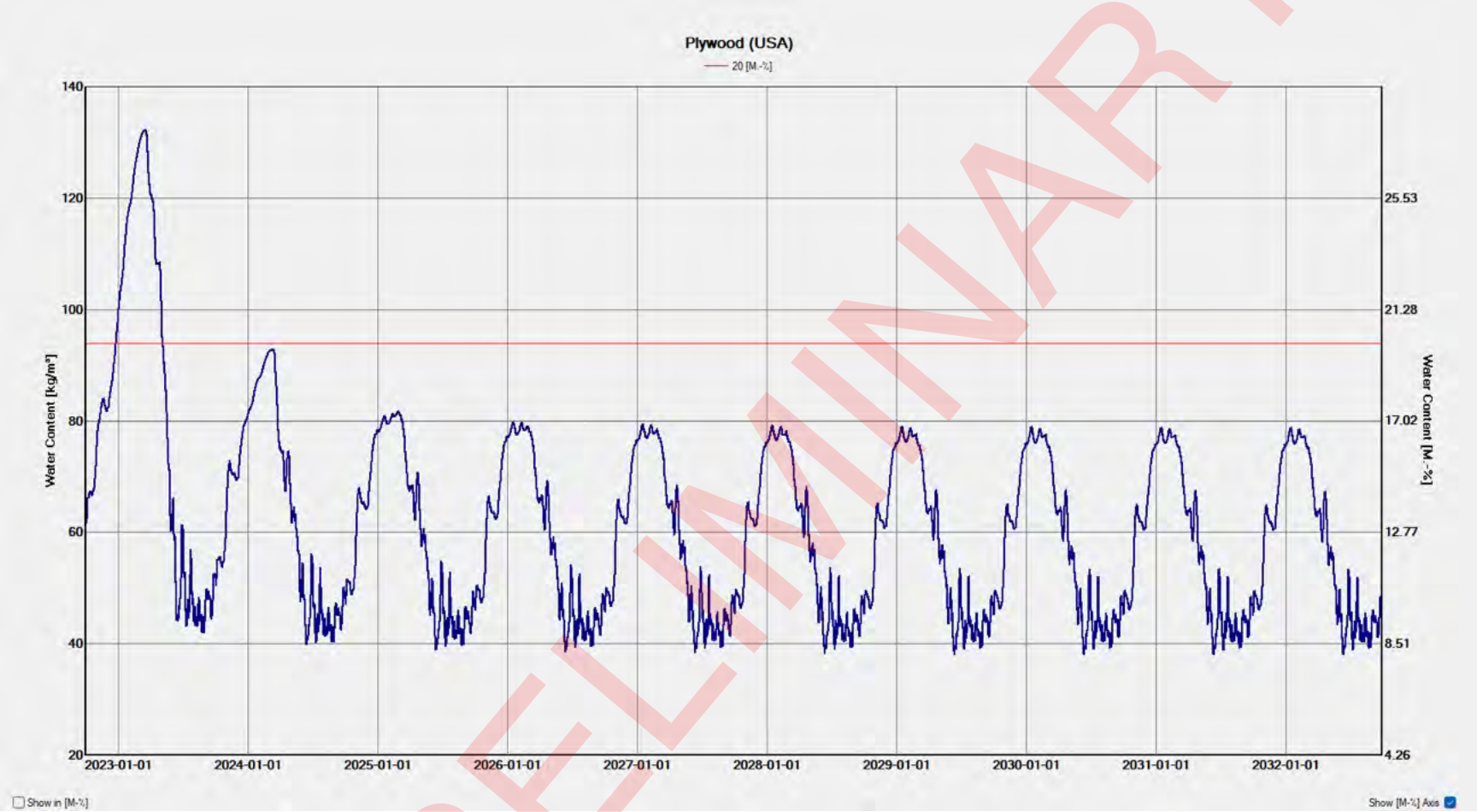

Figure 3 – WUFI® output for wall assembly (painted interior): water content (kg/m³, %) over 10-year period studied for post-retrofit East wall assembly's center 1/4-inch plywood layer

PRELIMINARY

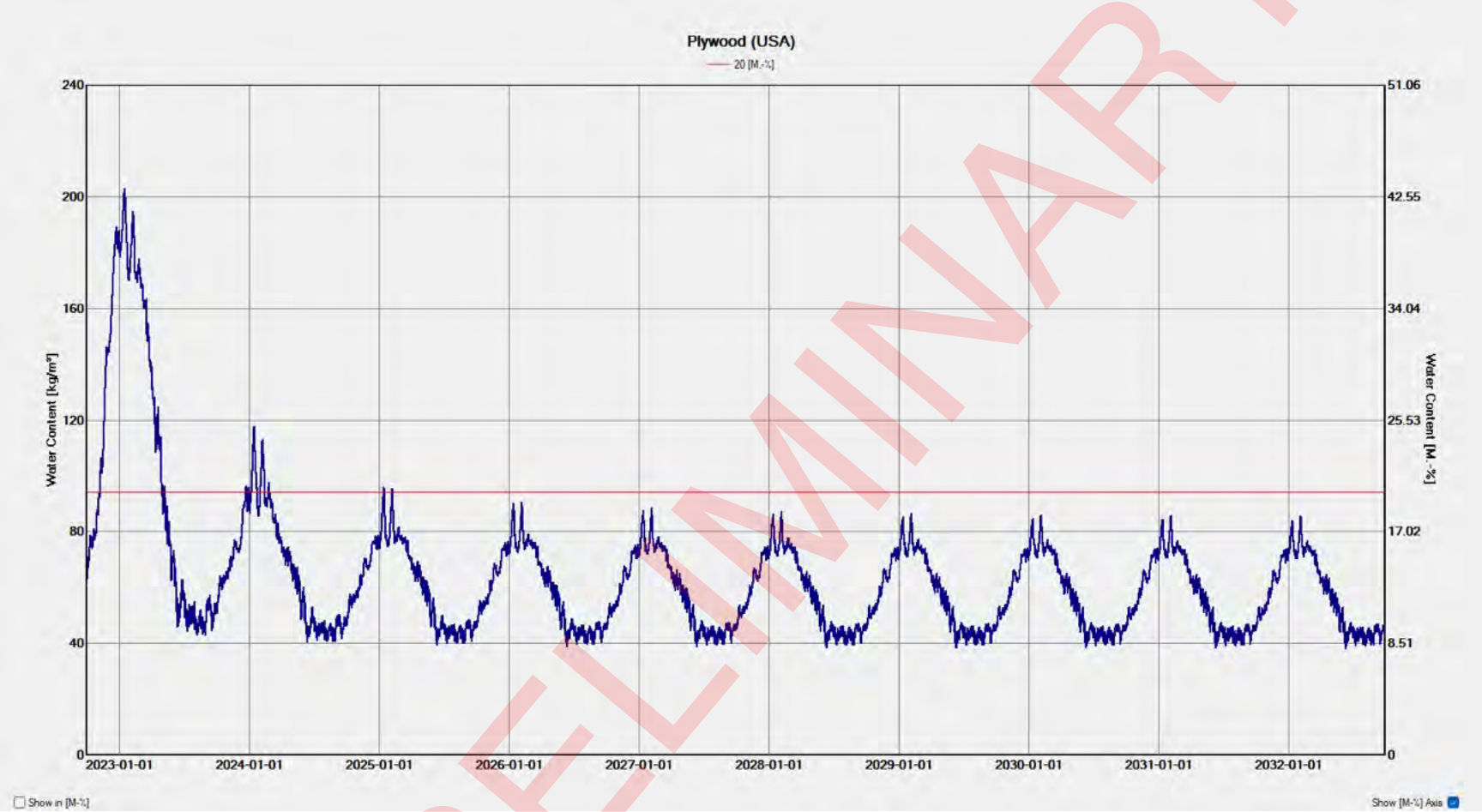

Figure 4 – WUFI® output for wall assembly (painted interior): water content (kg/m^3, %) over 10-year period studied for post-retrofit East wall assembly's inner 1/8-inch plywood layer

PRELIMINARY

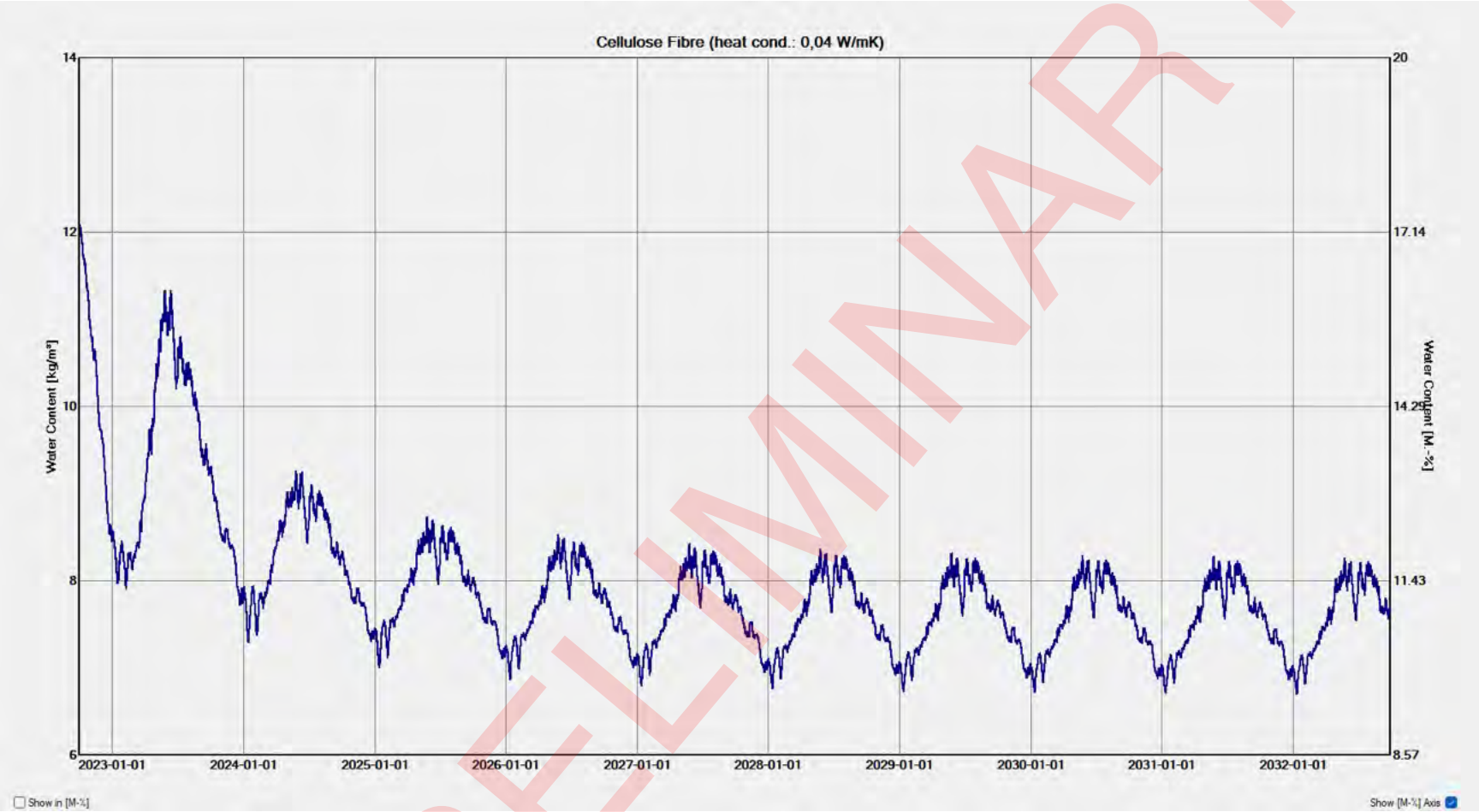

Figure 5 – WUFI® output for wall assembly (painted interior): water content (kg/m³, %) over 10-year period studied for post-retrofit East wall assembly's cellulose layer

PRELIMINARY

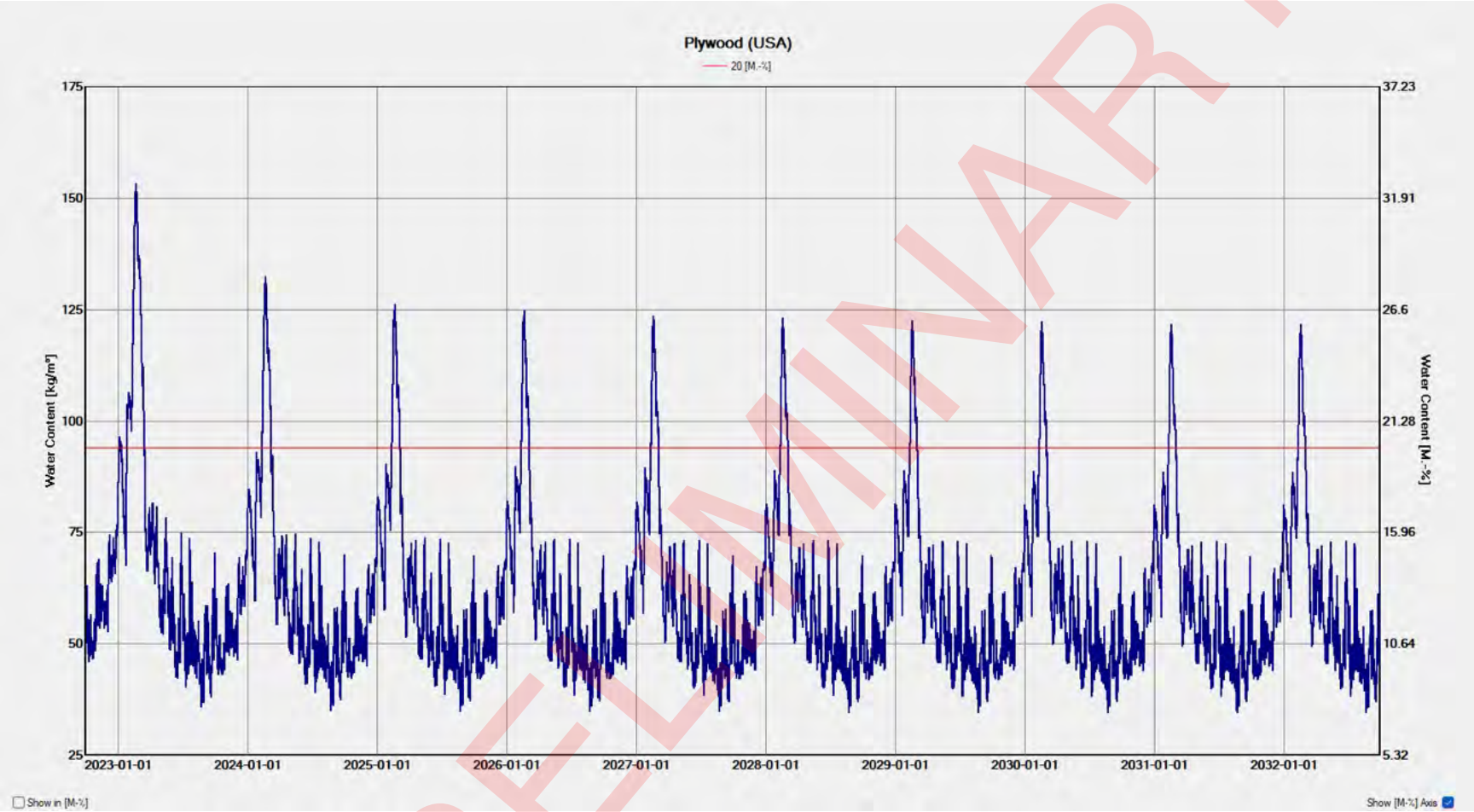

Figure 6 – WUFI® output for wall assembly (painted interior): water content (kg/m³, %) over 10-year period studied for post-retrofit South wall assembly's outer 1/8-inch plywood laye

PRELIMINARY

Figure 7 – WUFI® output for wall assembly: VTT mold growth index simulation over 10-year period studied for post-retrofit East wall assembly's plywood and cellulose layers
(blue: outer plywood; green: center plywood; light blue: inner plywood; red: outermost cellulose element; black: other cellulose element)

PRELIMINARY

POST-RETROFIT WALL (PANEL-ONLY ASSEMBLY AT ROOF LEVEL) – 21°C Temperature Setpoint

A second post-retrofit wall assembly set of simulations was conducted consisting solely of the panel with no existing wall – this represents the condition of the walls at the roof level, wherein a 1.35 m (54") airspace exists between the existing roof and the overlain roof panels. This wall assembly, simulated with a 21°C interior temperature setpoint (conditions of airspace were assumed to be the same as the interior of the building, per ReCover), did not demonstrate any numerical errors for all orientations and conditions tested – no convergence failures occurred, and the differences between balances of change in total water content and the sum of the moisture fluxes were very small.

Once again, the plywood layer was subdivided into three adjacent layers per the PHIUS+ protocol. In all orientations, at least one of the three plywood layers experiences spikes in MC above 20%. However, the occurrence and duration of these spikes vary from orientation to orientation. In general, the primary spike occurs in the first year, after which the MC decreases annually. For instance, in the East orientation, the outermost layer experiences a few significant MC spikes above 20% in the first year of analysis, occurring from approximately early November 2022 to mid-November 2022, as well as mid-December 2022 to mid-March 2023. After the first year of simulation, smaller spikes with shorter durations occur annually (see **Figure 8**). Meanwhile, the East orientation's center layer experiences a MC spike above 20% from approximately mid-January 2023 to late-March 2023 (**Figure 9**), and the inner layer experiences a MC spike above 20% from approximately mid-November 2022 to mid-March 2023 (**Figure 10**). It is also worth noting that the South orientation shows recurring MC spikes above 20% in the outermost plywood layer – however, after the first year, the duration of these spikes is approximately one month long and occurs from mid to late-February (**Figure 12**). (Note: all orientations' MC graphs are available in **APPENDIX C**)

Following the same assumptions regarding the plywood and cellulose layers for VTT analysis, all orientations achieved a green VTT light in terms of mold growth index.

For these reasons, and per the PHIUS+ protocol, it is understood that the proposed post-retrofit wall assembly may manage moisture adequately based on the information available and the assumptions presented in this report. However, this is dependent on whether the plywood can be subject to certain periods of high moisture content, as well as all wood layers' mold resistance properties.

It should be noted that a sheathing substitution from the originally defined plywood material may create a more suitable panelized retrofit strategy for this building in terms of mold and decay resistance based on the information available and the assumptions presented in this report – this should be explored further.

PRELIMINARY

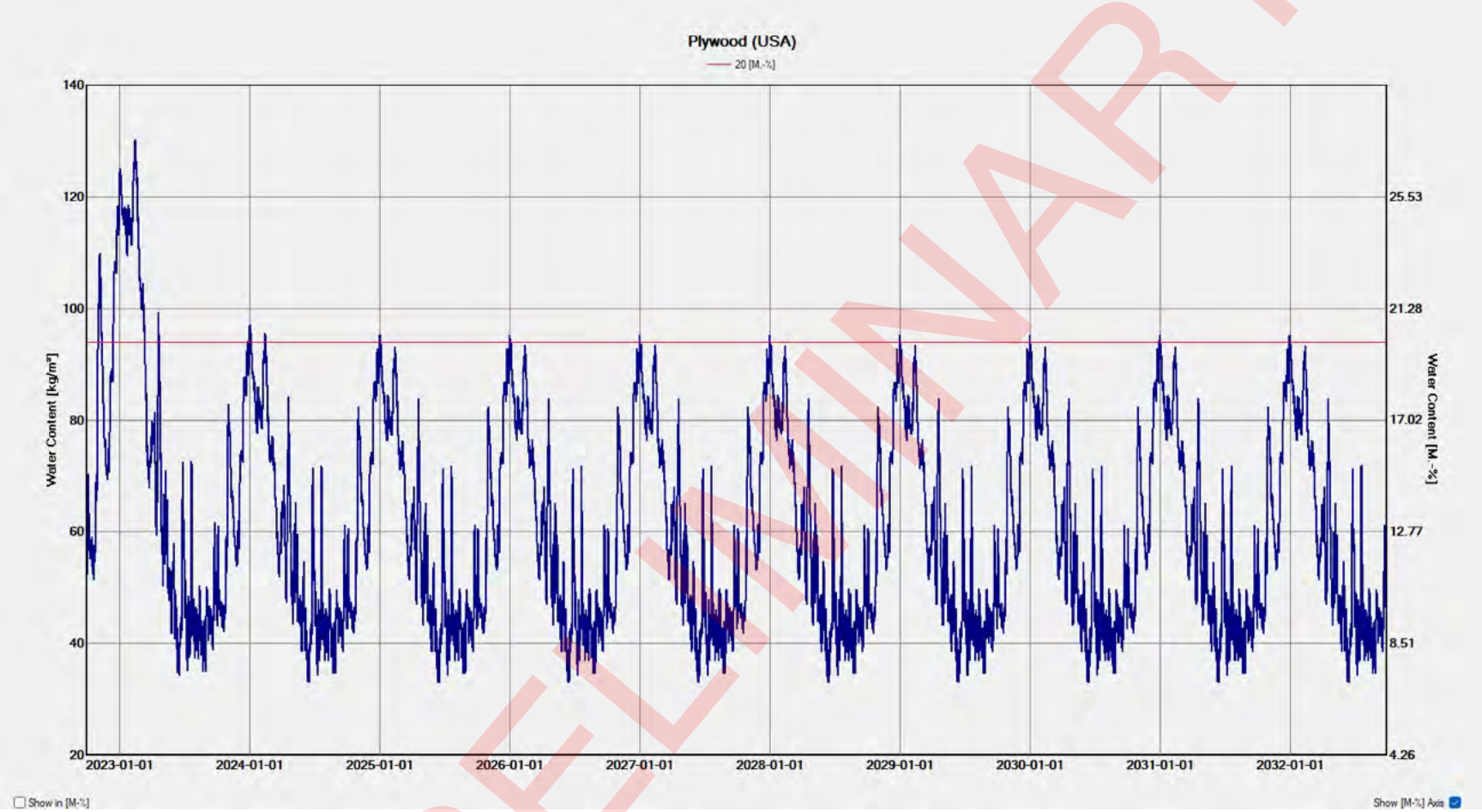

Figure 8 – WUFI® output for wall assembly (at roof level): water content (kg/m³, %) over 10-year period studied for post-retrofit roof-level East wall assembly's outer 1/8-inch plywood layer

PRELIMINARY

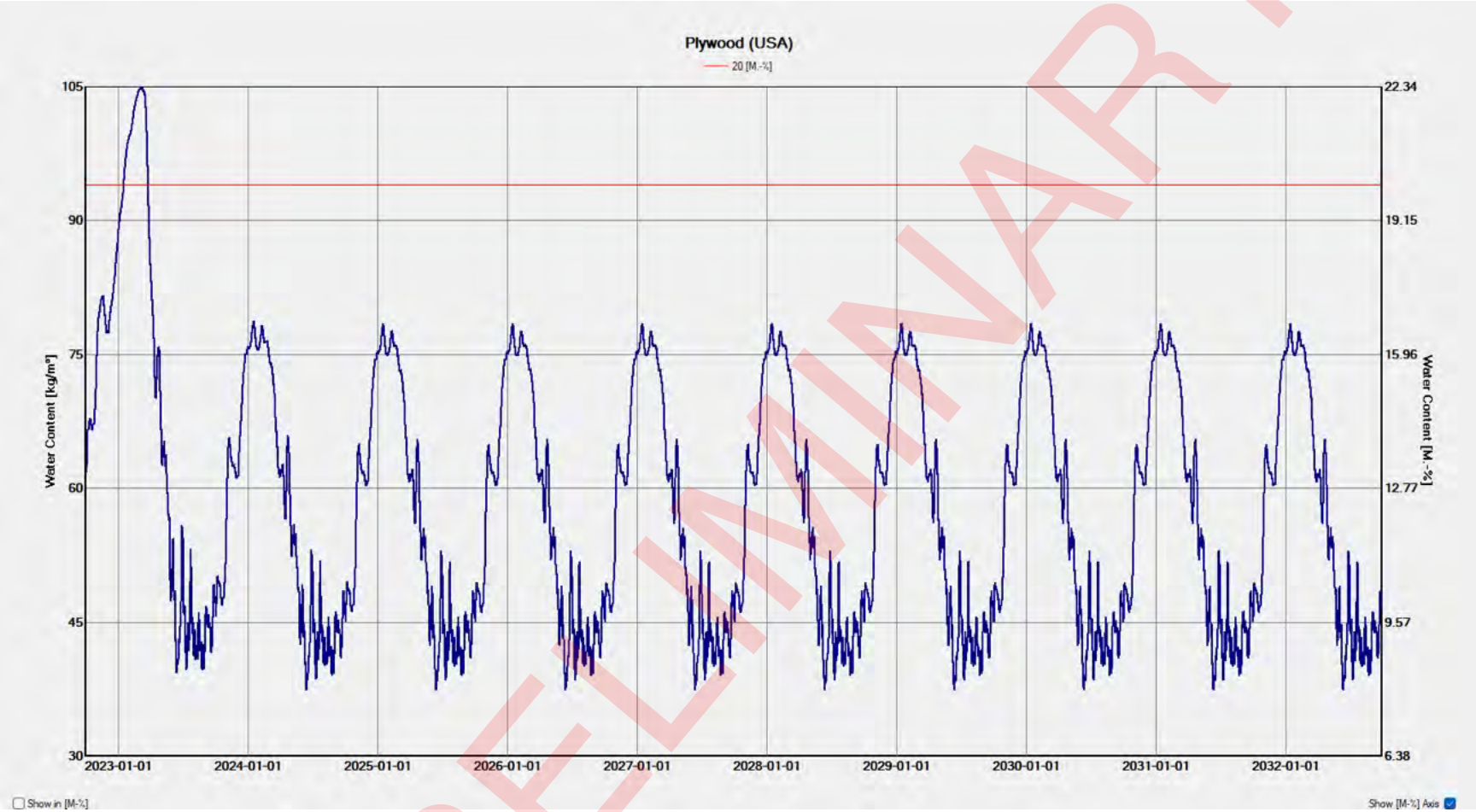

Figure 9 – WUFI® output for wall assembly (at roof level): water content (kg/m³, %) over 10-year period studied for post-retrofit roof level East wall assembly's center plywood layer

PRELIMINARY

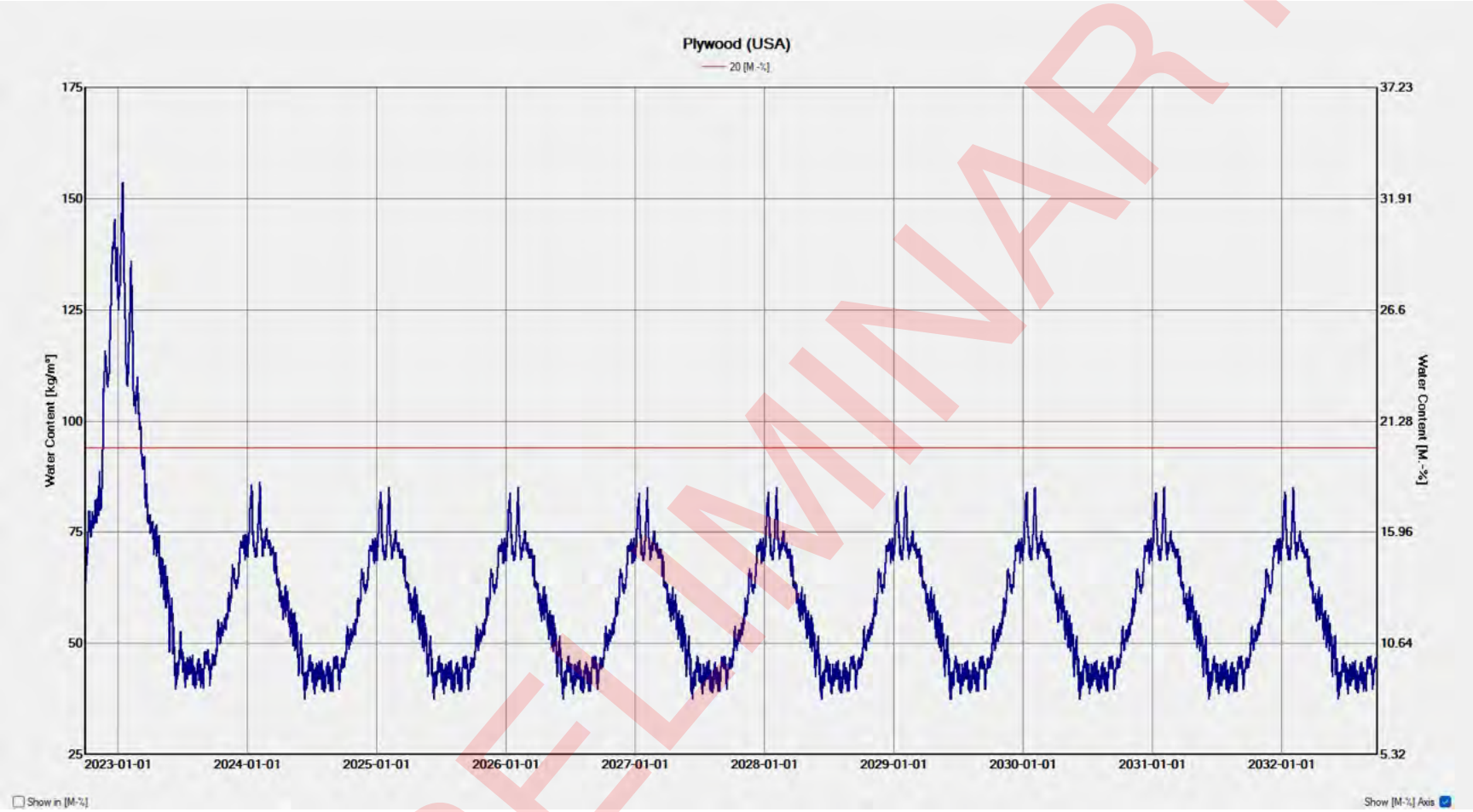

Figure 10 – WUFI® output for wall assembly (at roof level): water content (kg/m^3, %) over 10-year period studied for post-retrofit roof level East wall assembly's inner 1/8-inch plywood layer

PRELIMINARY

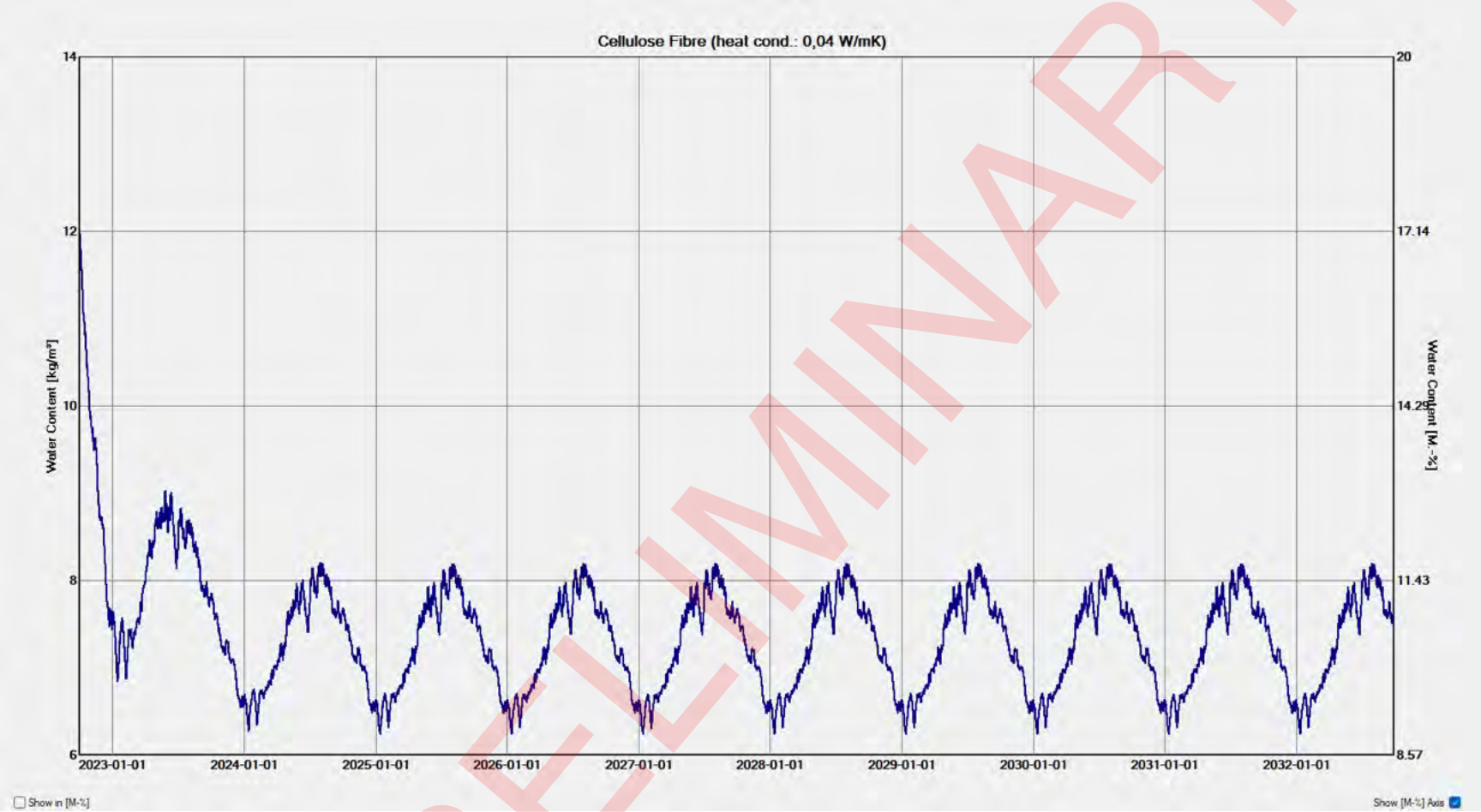

Figure 11 – WUFI® output for wall assembly (at roof level): water content (kg/m³, %) over 10-year period studied for post-retrofit roof level East wall assembly's cellulose layer

PRELIMINARY

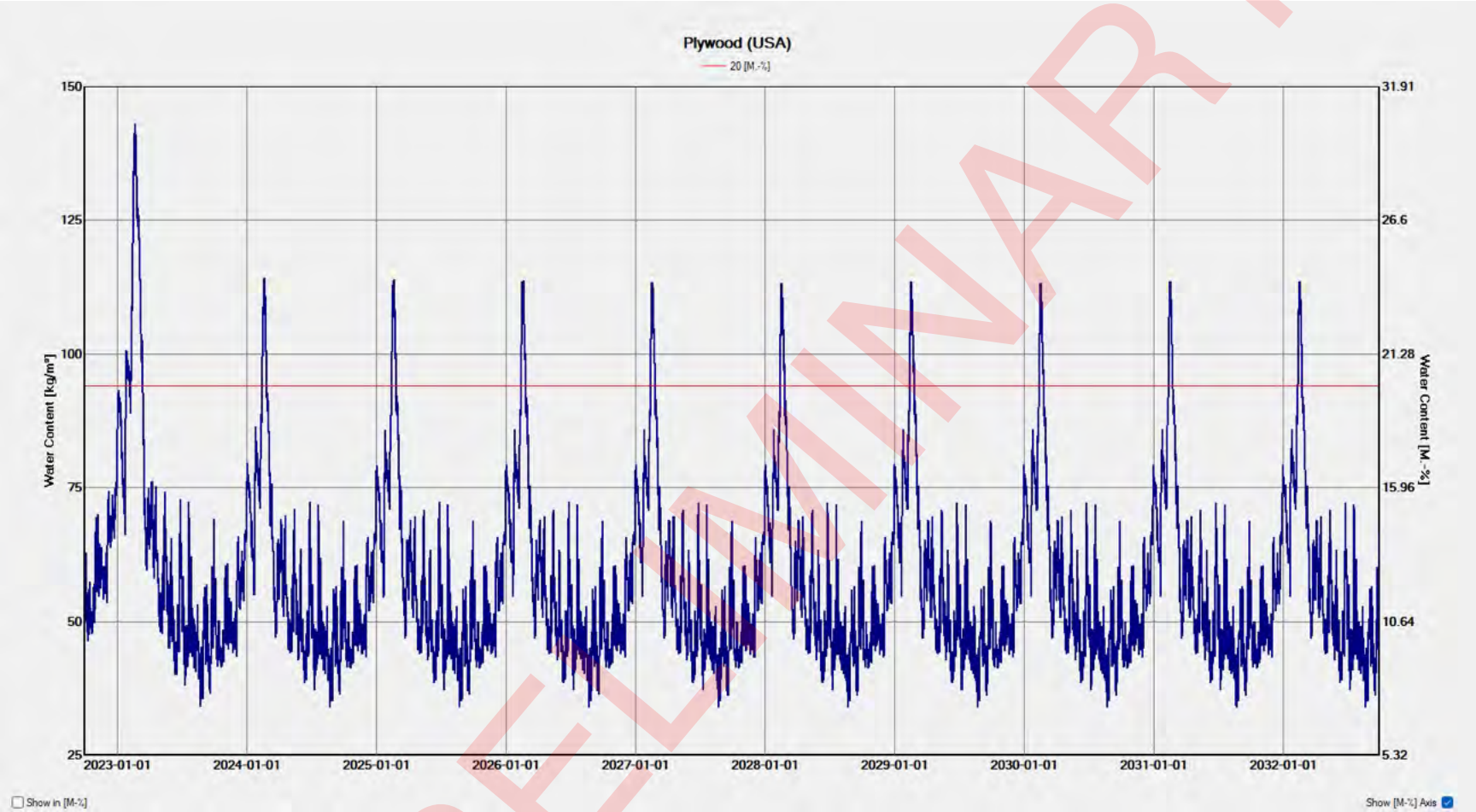

Figure 12 – WUFI® output for wall assembly (at roof level): water content (kg/m³, %) over 10-year period studied for post-retrofit roof-level South wall assembly's outer 1/8-inch plywood layer

PRELIMINARY

POST-RETROFIT ROOF – 7°C Temperature Setpoint

Numerous iterations of the post-retrofit roof were conducted based on the changes in design provided by the ReCover team. However, given the results obtained for the post-retrofit wall simulations with 7°C interior temperature setpoint, which demonstrated numerical errors for the conditions tested, no further simulations were run using the 7°C setpoint, including simulations of the final roof design which includes a 54" airspace.

POST-RETROFIT ROOF – 21° Temperature Setpoint (Plywood Sheathing)

The post-retrofit roof assembly simulated with a 21°C interior temperature setpoint did not demonstrate any numerical errors for all orientations and conditions tested – no convergence failures occurred, and the differences between balances of change in total water content and the sum of the moisture fluxes were very small.

Again, as recommended by the protocol, the plywood layer was subdivided into three adjacent layers, with the outermost and innermost layers being 1/8-inch thick, respectively. All plywood layers experienced spikes in MC above 20%. However, the occurrence and duration of these spikes vary based on the layer in question. The outermost and innermost layers experience significant MC spikes above 20% almost every year simulated with an annual decrease in maximum MC and duration (**Figure 13**, **Figure 15**). Meanwhile, the center layer experiences a very small MC spike above 20% in only the first year of simulation (**Figure 14**). These results are similar for both the shaded and unshaded simulations modelled (the shaded results, which present the more problematic case, are presented).

For mold-related durability, a VTT simulation was conducted to simulate the mold growth index at the specified locations within the plywood layers and the outermost element of the cellulose layer. Using the same assumptions as per the wall assemblies' simulations, the results of the shaded roof assembly VTT simulation indicate a yellow VTT traffic light for the outermost (<3.0), center (<2.8), and innermost (<2.5) plywood layers. Green VTT lights are obtained for the wood members within the cellulose layer when considering a medium resistance sensitivity class (**Figure 17**).

For these reasons, and per the PHIUS+ protocol, it is understood that the proposed post-retrofit roof assembly may <u>not</u> manage moisture adequately based on the information available and the assumptions presented in this report.

PRELIMINARY

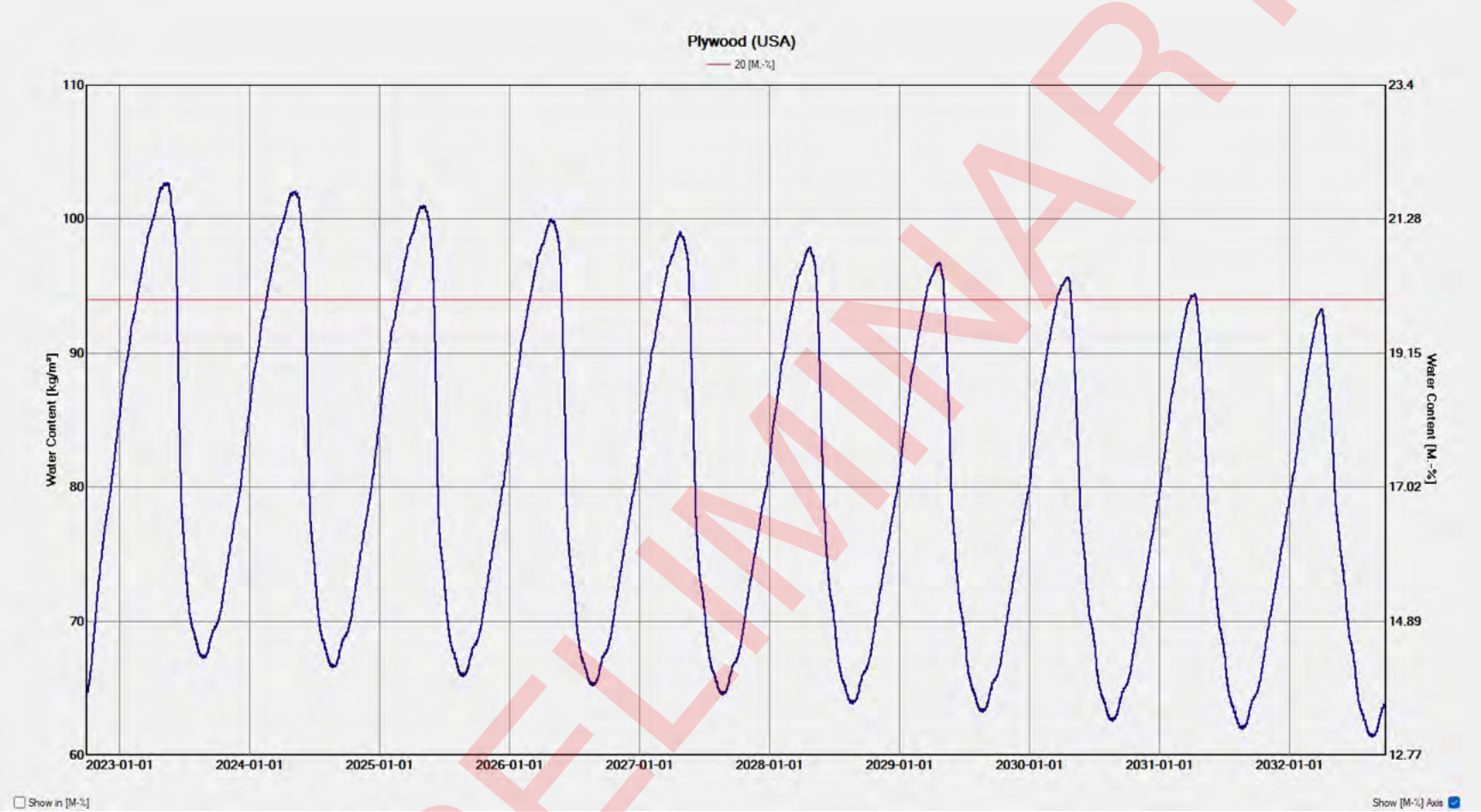

Figure 13 – WUFI® output for plywood roof assembly (shaded): water content (kg/m³, %) over 10-year period studied for post-retrofit roof assembly's outer 1/8-inch plywood layer

PRELIMINARY

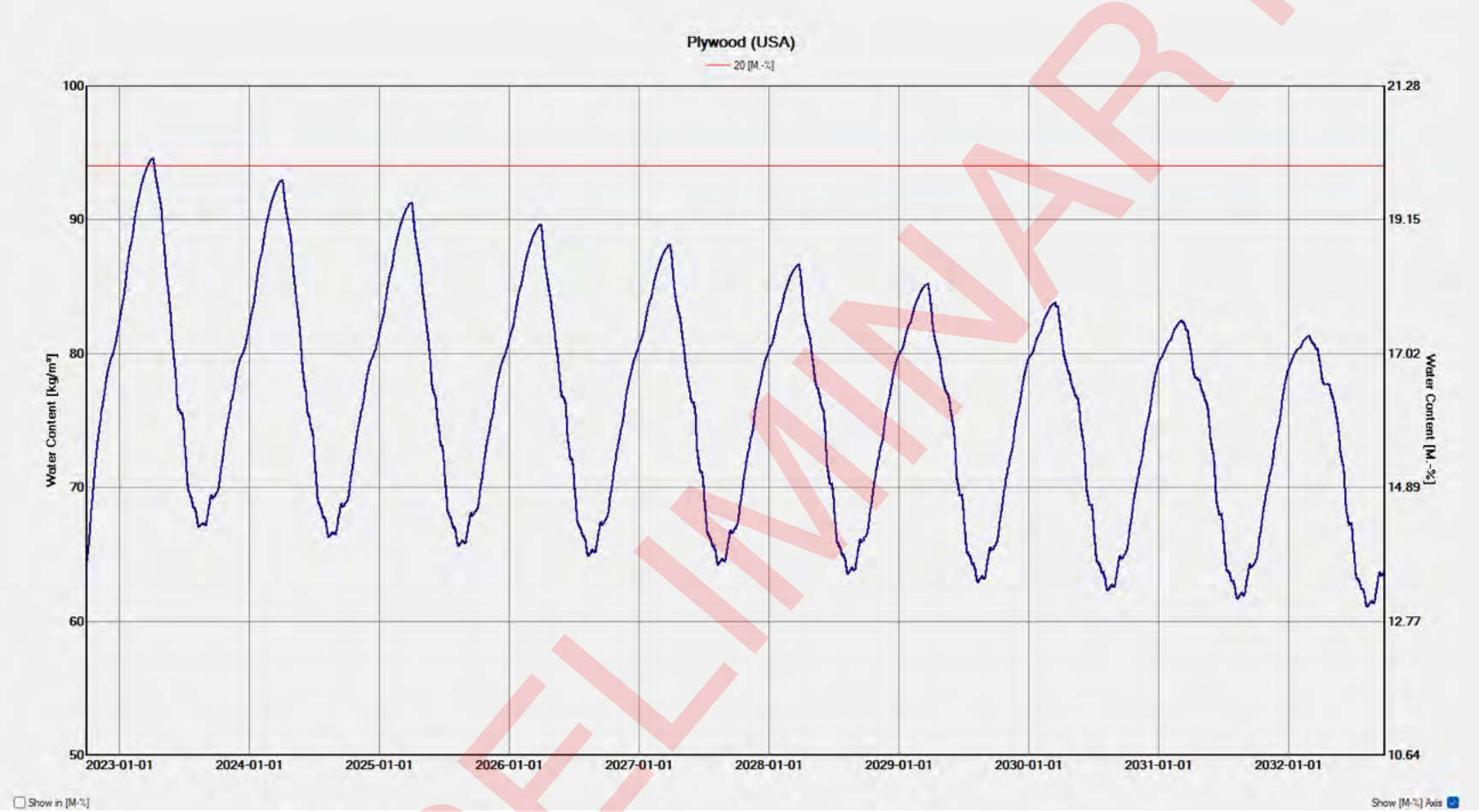

Figure 14 – WUFI® output for plywood roof assembly (shaded): water content (kg/m^3, %) over 10-year period studied for post-retrofit roof assembly's center 1/8-inch plywood layer

PRELIMINARY

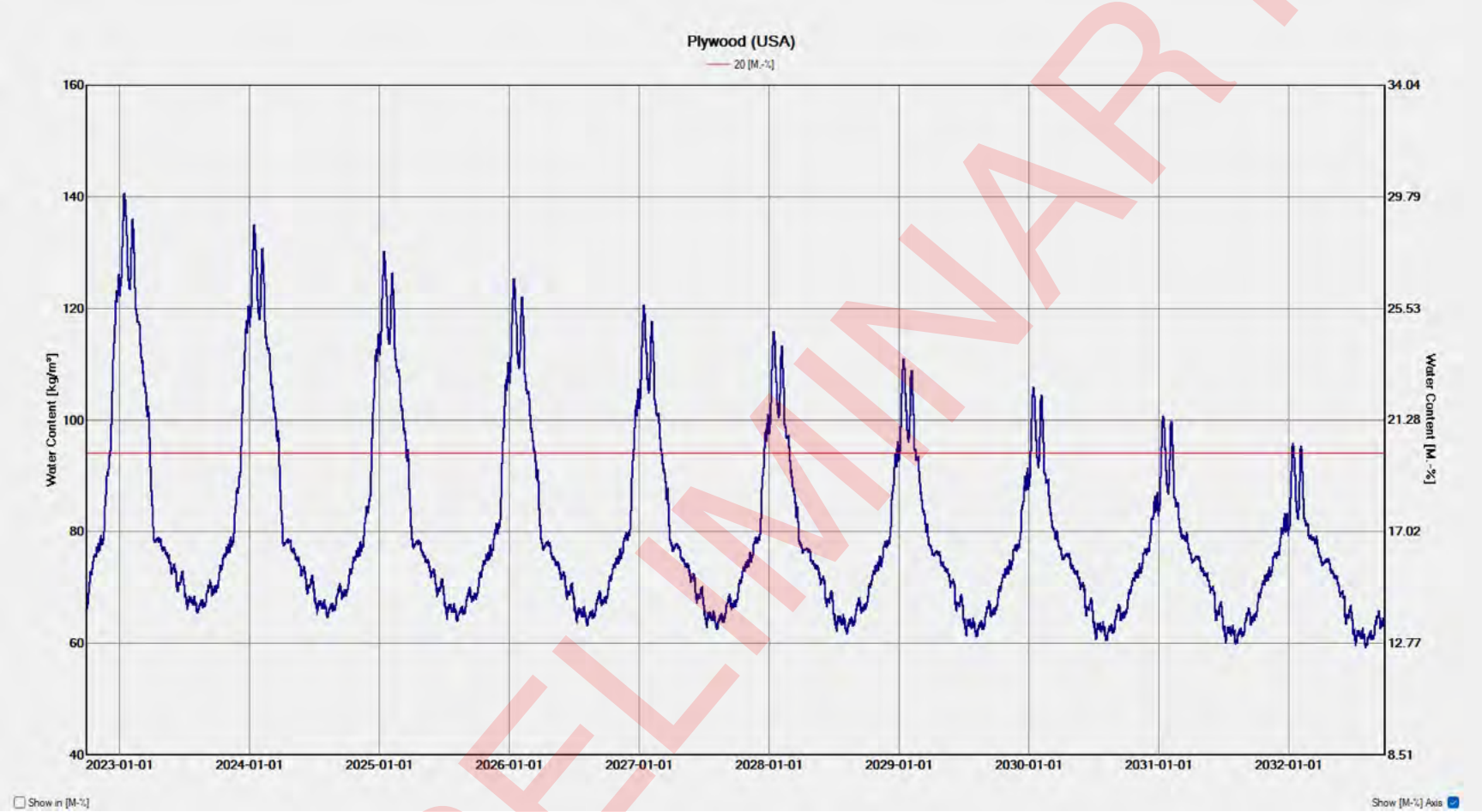

Figure 15 – WUFI® output for plywood roof assembly (shaded): water content (kg/m³, %) over 10-year period studied for post-retrofit roof assembly's inner 1/8-inch plywood layer

PRELIMINARY

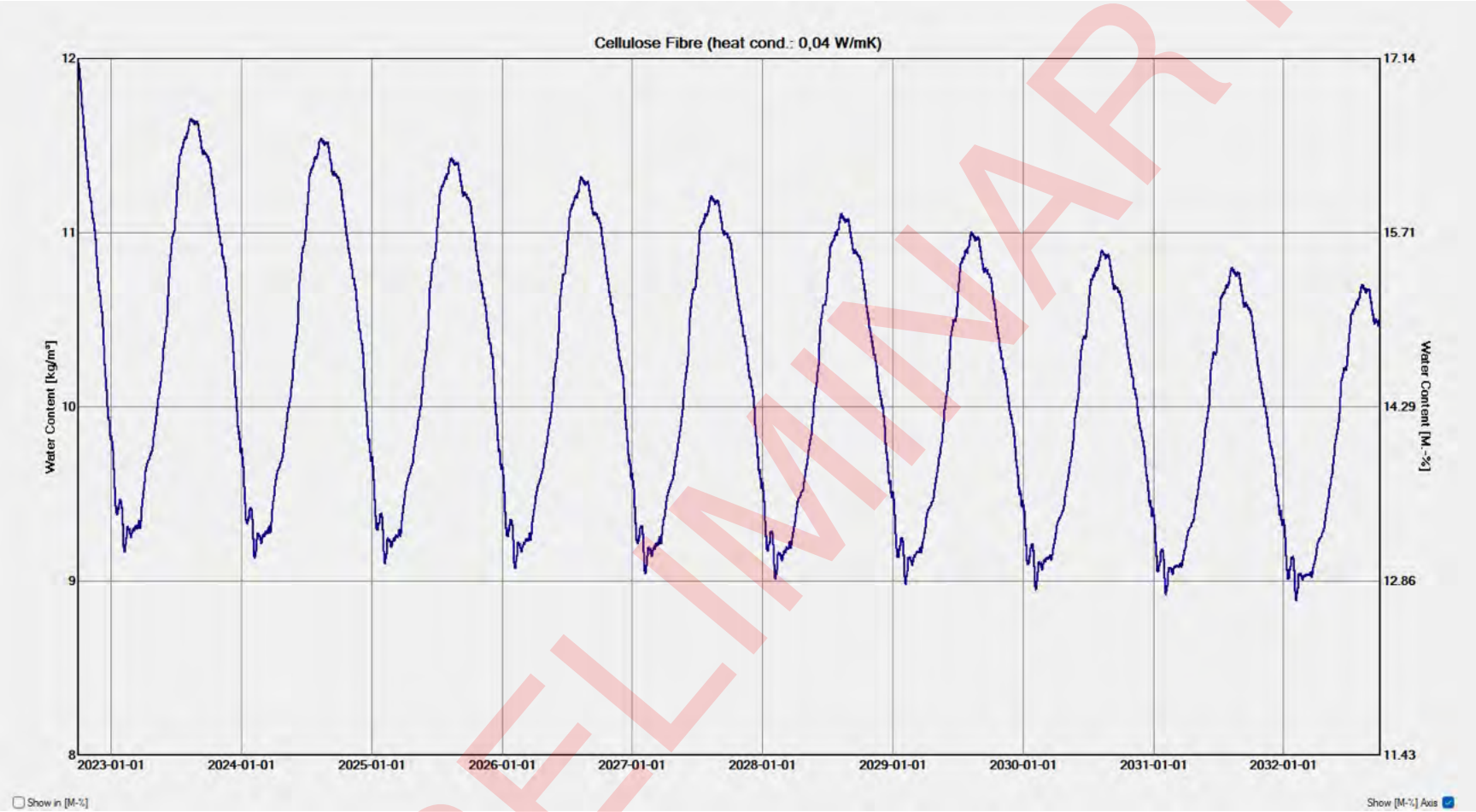

Figure 16 – WUFI® output for plywood roof assembly (shaded): water content (kg/m³, %) over 10-year period studied for post-retrofit roof cellulose layer

PRELIMINARY

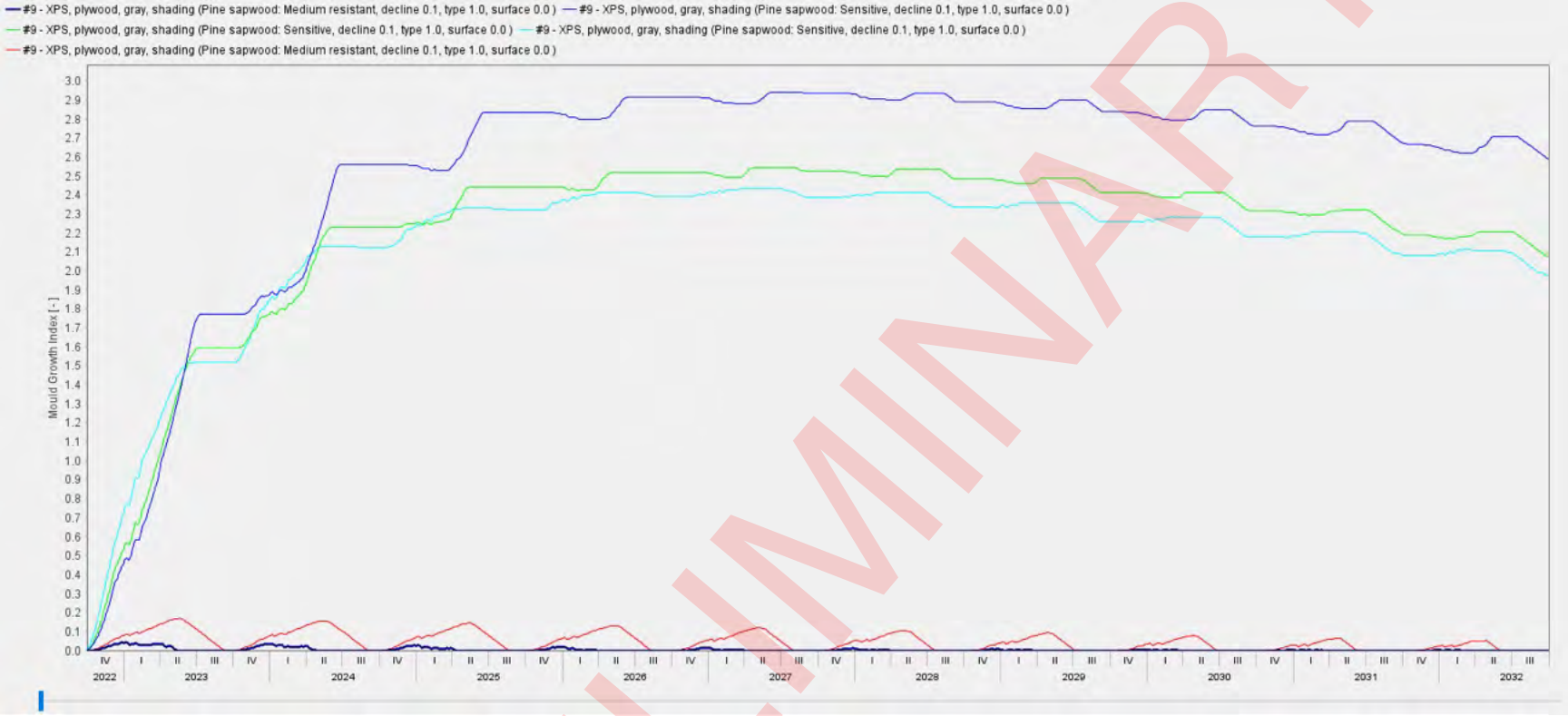

Figure 17 – WUFI® output for plywood roof assembly (shaded): VTT mold growth index simulation over 10-year period studied for post-retrofit roof assembly's plywood and cellulose layers
(blue: outer plywood; green: center plywood; light blue: inner plywood; red: outermost cellulose element; black: other cellulose element)

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POST-RETROFIT ROOF – 21° Temperature Setpoint (DensElement Sheathing)

A simulation using DensElement sheathing was created per ReCover's request for an alternate sheathing option. The pre-defined DensElement™ Barrier System material was used in WUFI®.

The post-retrofit roof assembly simulated with a 21°C interior temperature setpoint did not demonstrate any numerical errors for all orientations and conditions tested – no convergence failures occurred, and the differences between balances of change in total water content and the sum of the moisture fluxes were very small.

It is understood that the DensElement material provides improved decay and mold growth resistance versus traditional plywood sheathing. Therefore, the 20% MC threshold was not studied for this material, although the MC over time within the cellulose layer is presented in **Figure 18** for comparison with the plywood sheathing roof's cellulose layer simulation results (**Figure 16**).

For mold-related durability, a VTT simulation was conducted to simulate the mold growth index at the outermost element of the cellulose layer. Using the "Medium resistant" sensitivity class and "Almost no decline" inputs, the VTT simulation indicates a green VTT traffic light (<0.7) for the wood members (approximated using the cellulose layer) within the cellulose cavity (**Figure 19**, shaded roof results). It is worth noting, however, that if medium resistance mold resistance is not imparted to the wood members within the cellulose cavity and the "Sensitive" sensitivity class is used, a mold growth index of approximately 3.4 (red) is obtained.

For these reasons, and per the PHIUS+ protocol, it is understood that the proposed post-retrofit roof assembly may manage moisture adequately based on the information available and the assumptions presented in this report. However, this is dependent on the wood members' mold resistance properties.

PRELIMINARY

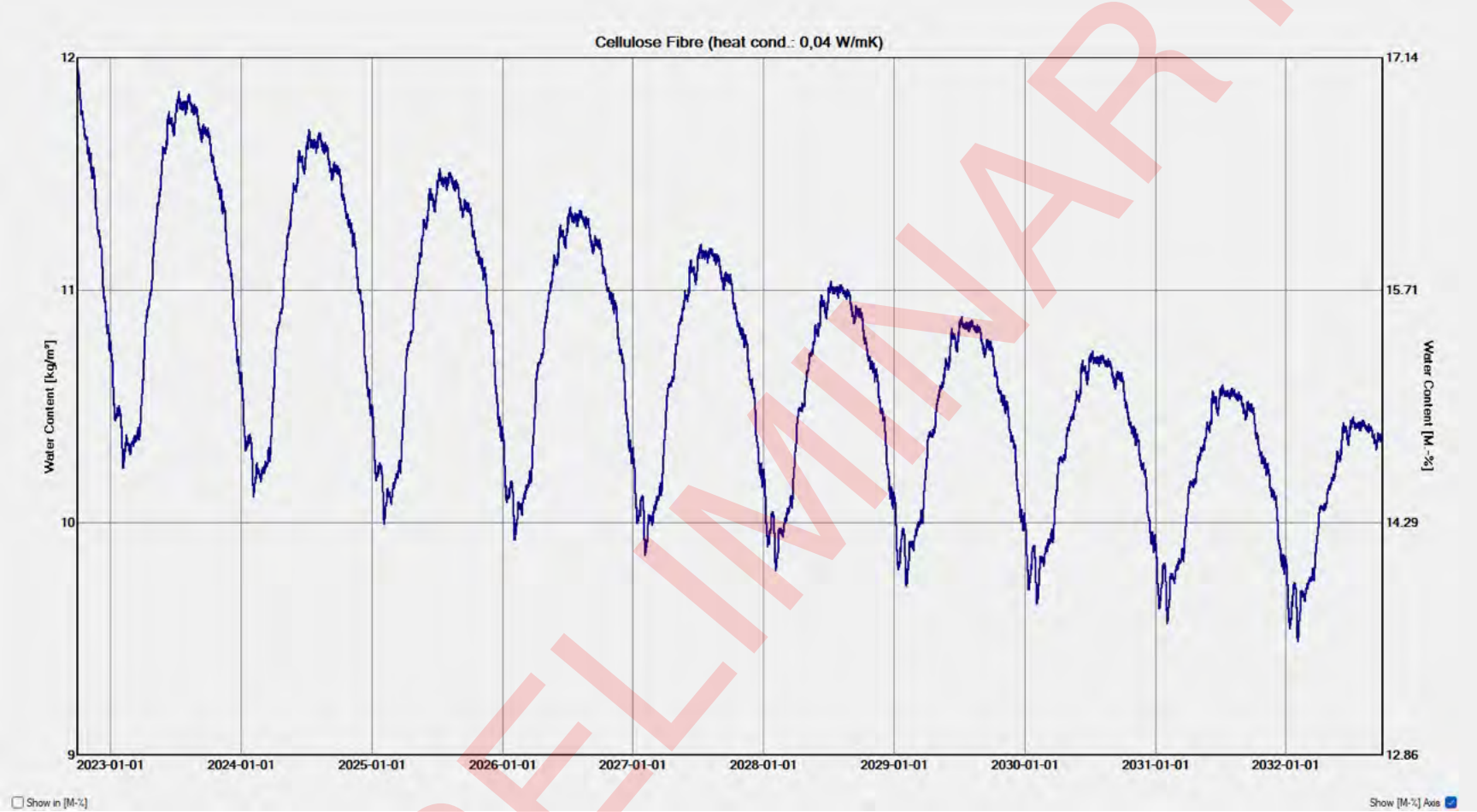

Figure 18 – WUFI® output for DensElement roof assembly (shaded): water content (kg/m^3, %) over 10-year period studied for post-retrofit roof cellulose layer

PRELIMINARY

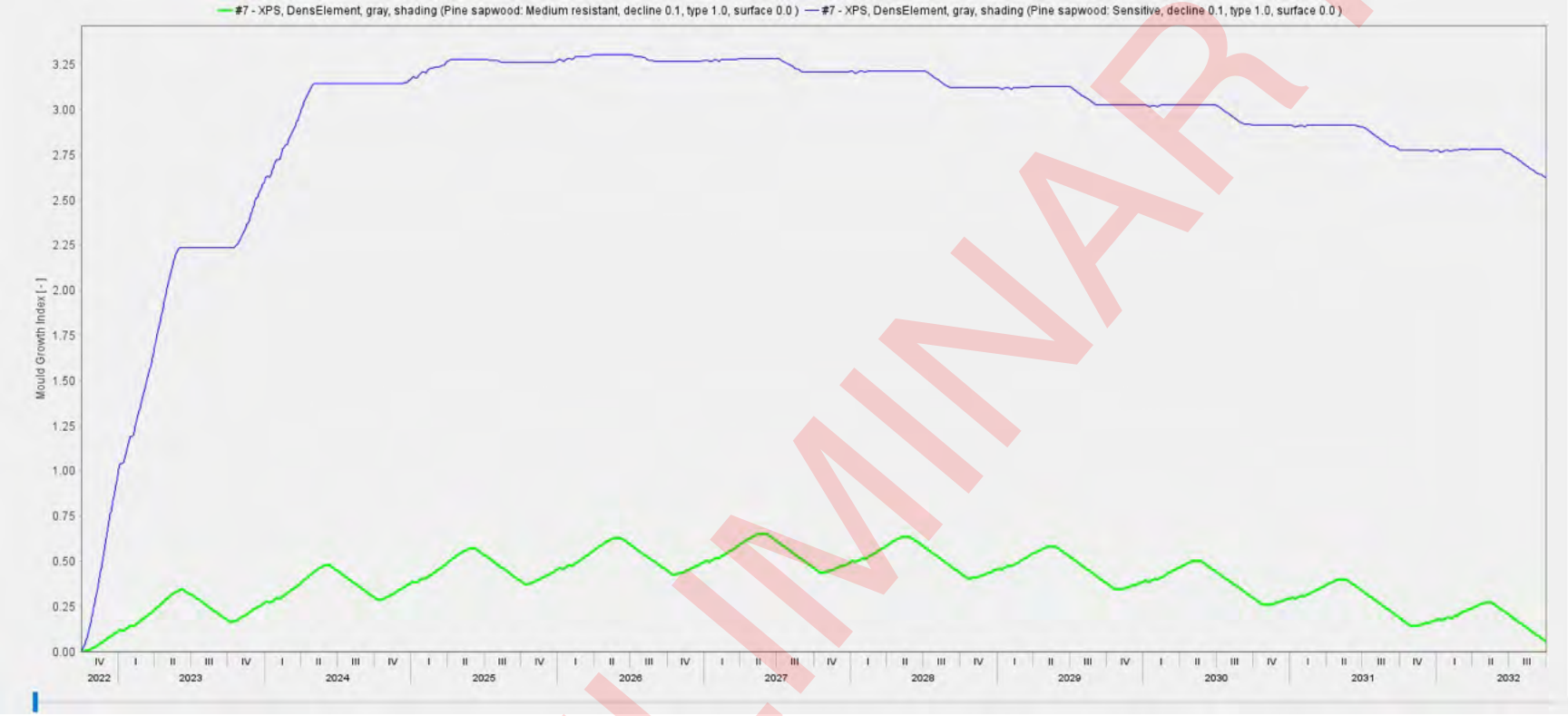

Figure 19 – WUFI® output for DensElement roof assembly (shaded): VTT mold growth index simulation over 10-year period studied for post-retrofit roof assembly's cellulose layer (outermost cellulose element simulated)
(green: "medium resistance" sensitivity class; blue: "sensitive" sensitivity class)

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LIMITATIONS OF STUDY

The results presented in this report are subject to certain limitations, including the following:

- Wall and roof assembly materials and thicknesses were assumed based on information obtained from the Town of New Glasgow and the ReCover team, as well as available predefined WUFI materials;
- The 54" airspace simulated in the post-retrofit New Glasgow roof was assumed to experience the same temperature and relative humidity conditions as the interior environment of the post-retrofit building (with no air exchanges from the surrounding environments). This assumption was used for the panel-only wall simulations;
- It was assumed the ballast would be a well-draining material and was not included in the post-retrofit roof simulations;
- The SNC-Lavalin report (*New Glasgow PW Building Assessment.pdf*, dated 2017-09-17) indicates that the existing concrete is painted on the East side – however, this was not modelled, as the presence, type, and condition of this paint must be validated;
- All material properties, including but not limited to thermal conductivity and permeability, were assumed based on WUFI® Pro default values as well as the ReCover team's approximations. The specific vulnerability of the existing and proposed materials to mold growth is approximated;
- Damage functions indicated in the report were the only ones studied – rot/decay of the wood elements (excluding sheathing), corrosion of any metal elements, bulk water leaks, and any other damage functions were not simulated due to limitations of the one-dimensional WUFI® Pro software, information available, and scope of work;
- Mold growth index simulation using VTT requires estimation of the properties of each material layer studied. The assumptions used in this feasibility study should be validated with specialists in this field. The mold growth risks involved could be higher if the materials specified for the project are more vulnerable to mold growth than the approximated materials modelled in WUFI®;
- VTT results can vary from one element to another within a given material layer – the results presented in this report are dependent on the elements chosen for simulation;
- The climate file used for the simulations approximates the typical weather experienced by the building under simulation (no extreme weather events), and also cannot adequately model the micro-climate experienced by the building in its specific location;
- All interfaces, connections, and details (e.g., interface between wall and roof assemblies) were not modelled in WUFI® Pro and should be validated by others;
- This report assumes that any issues with the existing envelope will be addressed prior to conducting the retrofit, including but not limited to cracking of the masonry, unsealed penetrations, etc.;
- WUFI® Pro is a one-dimensional software that cannot quantify all real-world hygrothermal phenomena. For instance, WUFI® 2-D could better approximate a complex

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two-dimensional phenomenon that WUFI® Pro could not – certain software is therefore better served in certain situations;

- WUFI® Pro is a software and is limited by the quality of data inputted into each case studied – given the nature of the study in question, the information available for the assemblies' components, the unknown properties of each material, and the approximated indoor/outdoor conditions, great care must be taken when considering the WUFI® Pro results presented in this feasibility report.

If the ReCover team's retrofit design should move forward to construction, it is imperative that a more thorough investigation of the wall and roof assemblies in question be conducted so that more accurate predictions of the assemblies' hygrothermal performance can be made. Further information of the building is necessary, including but not limited to validation of the wall and roof assemblies, determination of material thicknesses and properties, etc. Therefore, the results of the WUFI® Pro models presented in this report can only be used as a first step towards understanding the post-retrofit hygrothermal performance of the wall and roof assemblies in question. **This feasibility report can be used as a preliminary assessment of retrofitting the building but cannot be used for construction purposes.** Once further investigation of the actual conditions is completed (e.g., wall and roof openings) and the design of the panels are reviewed and approved by the appropriate parties, the hygrothermal models will need to be simulated again with the validated inputs, a specific location-based climate file, etc. This will create a more accurate WUFI® model of the building envelope in question and allow for a better understanding of the assemblies' hygrothermal performance post-retrofit.

It is hoped that this report is to your satisfaction. If you have any questions, please do not hesitate to contact Stanley Francispillai.

Stanley Francispillai, P. Eng. (QC, NS)
WUFI® Pro Software Modeller
(438) 872-5524

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APPENDIX A

Assembly Notes

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Assembly Notes

Project: New Glasgow NRCan Pilot Project
Case: NorthNE & SouthSW walls (modelled as North and South)
Reference Files: *"New Glasgow - Existing Building Assemblies (2022-08-29).pdf"* (Google Drive)
"22 11 08 - Assembly Details.pdf" (2022-11-08 email, Nick Rudnicki)
"23 01 16 - NG retrofit drawings" (Google Drive)
Phone & video calls with ReCover Team

Assembly (Exterior to Interior)	**Modelled Material (WUFI)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Metal cladding	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol
3/4" air gap	Air Layer 10 mm; metallic (Generic Materials)	Specific air layer behind metallic surfaces	PHIUS+ protocol
High Perm WRB (Assume PERM 50, Tech specs available)	Spun Bonded Polyolefin Membrane (SBP) (North America Database)	-	Assumption
1/2" SPF Plywood	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
5.5" of dense pack cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer Database)	-	Past ReCover project assumption
Cellulose Bib Super high PERM	INTELLO PLUS (ETA) (N.A. Database)	-	ReCover Team
1/2" air gap (from 1x4 SPF strapping)	Air Layer 20 mm; without additional moisture capacity (Generic Materials)	-	For strapping + existing wall abnormalities
4" Brick	Red Matt Clay Brick	-	PHIUS+ protocol
1" Rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
Minimal air space	-	Not modeled - based on SNC Lavalin observations, presence and thickness uncertain	
8" Concrete block	Concrete Brick (N.A. Database)	-	

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Assembly Notes			
Project:	New Glasgow NRCan Pilot Project		
Case:	WestNW wall (modelled as West)		
Reference File:	*"New Glasgow - Existing Building Assemblies (2022-08-29).pdf"* (Google Drive) *"22 11 08 - Assembly Details.pdf"* (2022-11-08 email, Nick Rudnicki) *"23 01 16 - NG retrofit drawings"* (Google Drive) *Phone & video calls with ReCover Team*		
Assembly (Exterior to Interior)	**Modelled Material (WUFI)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Metal cladding	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol
3/4" air gap	Air Layer 10 mm; metallic (Generic Materials)	Specific air layer behind metallic surfaces	PHIUS+ protocol
High Perm WRB (Assume PERM 50, Tech specs available)	Spun Bonded Polyolefin Membrane (SBP) (North America Database)	-	Assumption
1/2" SPF Plywood	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
5.5" of dense pack cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer Database)	-	Past ReCover project assumption
Cellulose Bib Super high PERM	INTELLO PLUS (ETA) (N.A. Database)	-	ReCover Team
1/2" air gap (from 1x4 SPF strapping)	Air Layer 20 mm; without additional moisture capacity (Generic Materials)	-	For strapping + existing wall abnormalities
4" Brick	Red Matt Clay Brick	-	PHIUS+ protocol
1" Rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
Minimal air space	-	Not modeled - based on SNC Lavalin observations, presence and thickness uncertain	
8" Concrete block	Concrete Brick (N.A. Database)	-	
1/2" Gypsum board	Gypsum Board (USA) (N.A. Database)	-	

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Assembly Notes			
Project:	New Glasgow NRCan Pilot Project		
Case:	EastSE wall (modelled as East)		
Reference File:	*"New Glasgow - Existing Building Assemblies (2022-08-29).pdf"* (Google Drive) *"22 11 08 - Assembly Details.pdf"* (2022-11-08 email, Nick Rudnicki) *"23 01 16 - NG retrofit drawings"* (Google Drive) *Phone & video calls with ReCover Team*		
Assembly (Exterior to Interior)	**Modelled Material (WUFI)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Metal cladding	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol
3/4" air gap	Air Layer 10 mm; metallic (Generic Materials)	Specific air layer behind metallic surfaces	PHIUS+ protocol
High Perm WRB (Assume PERM 50, Tech specs available)	Spun Bonded Polyolefin Membrane (SBP) (North America Database)	-	Assumption
1/2" SPF Plywood	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
5.5" of dense pack cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer Database)	-	Past ReCover project assumption
Cellulose Bib Super high PERM	INTELLO PLUS (ETA) (N.A. Database)	-	ReCover Team
1/2" air gap (from 1x4 SPF strapping)	Air Layer 20 mm; without additional moisture capacity (Generic Materials)	-	For strapping + existing wall abnormalities
8" Concrete block	Concrete Brick (N.A. Database)	-	Exterior paint not considered as presence/type/condition must be validated

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Assembly Notes			
Project:	New Glasgow NRCan Pilot Project		
Case:	Roof		
Reference File:	*"New Glasgow - Existing Building Assemblies (2022-08-29).pdf"* (Google Drive) *"22 11 08 - Assembly Details.pdf"* (2022-11-08 email, Nick Rudnicki) *"23 01 16 - NG retrofit drawings"* (Google Drive) *Phone & video calls with ReCover Team*		
Assembly (Exterior to Interior)	**Modelled Material (WUFI)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Extruded Polystyrene Insulation	Extruded Polystyrene Insulation (North America Database)	-	
Roof Membrane	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol ReCover Team
5/8" plywood or DensElement	Plywood (USA) (N.A. Database) *DensElement™ Barrier System (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol ReCover Team
7.25" I-Joist Cavity Filled with dense pack cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer Database)	-	Past ReCover project assumption
Cellulose Bib Super high PERM	INTELLO PLUS (ETA) (N.A. Database)	-	ReCover Team
54" Air Space	9 x (Air Layer 150 mm; without additional moisture capacity) (Generic Materials)	-	ReCover Team
1/4" Modified Bitumen Cap & Base Sheets	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol ReCover Team
1/4" Fibreboard	Fiberboard (N.A. Database)	-	
1.5" Steel Deck (0.05" thick)	Metal Deck, unperforated (N.A. Database)	-	

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APPENDIX B

WUFI® Pro-Generated Reports

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NRCan | Recover FEED Studies

New Glasgow Retrofit Building Embodied Carbon Assessment

Fatma Osman, BA, Toronto Metropolitan University

INTRODUCTION

This report presents an embodied carbon analysis of the New Glasgow retrofit project proposed by the Recover Initiative as part of the NRCan FEED studies. Understanding the embodied carbon in the construction industry can help reduce the overall carbon footprint of buildings, which is one of the main goals the Recover initiative works to achieve. This report emphasizes the importance of embodied carbon analysis and the environmental impacts attributed to material selection.

SCOPE OF WORK

The scope of work includes conducting an embodied carbon analysis of the retrofit project; all materials that are proposed to be added to the existing building. This analysis is limited to embodied carbon of assembly materials and does not include other systems, such as the HVAC systems. Specifically, the analysis looks at additions to above-grade walls, roofs, below-grade components, and windows and doors. The results include a whole life cycle assessment of the building in six impact categories: Global Warming, Ozone Depletion, Acidification, Eutrophication, Formation of tropospheric ozone, Depletion of nonrenewable energy, and Biogenic carbon storage.

INPUTS AND ASSUMPTIONS

- The materials used in the analysis were chosen based on the most representative materials available to the Canadian market that has Environmental Product Declarations (EPDs) available in the One Click LCA software database.
- Materials were chosen based on their environmental performance; averages were prioritized (unless low-carbon materials were specified by the Recover design team).
- The service life used in the analysis is 60 years as per LEED v4 minimum requirement for whole building LCAs.
- Materials within assembly panels were assumed to have a 60 years service life as the building; all other materials were left to default service lives as per the One Click software.

THIS REPORT CONTAINS

- Summary of Results.
- Summary of Global Warming Potential (GWP) per building floor area.
- Graphs that summarize the detailed tables.
- Detailed data on assembly materials and specific products used in the assessment (in Appendix).
- Detailed data on embodied carbon of the different life stages of the buildings in the form of tables (in Appendix).

New Glasgow Retrofit Project LCA results summary

Table 1: Total Global Warming Potential

New Glasgow building gross floor area m2	A1-A3 KgCO2e/m2	A1-C4 KgCO2e/m2	Biogenic Carbon KgCO2e/m2
7,477.97	37.91	51.13	79.4

The major contributors to the GWP in this design are the wood used for building the truss, the roof membranes, the XPS foam insulation in the roof, and the steel wall cladding. The A1-A3 Materials stage contributed 74% of the total carbon emissions associated with this building as illustrated in Figure 1 & 2. Table 1 above shows that the biogenic carbon storage of this building design surpasses that of the A1-C4 emissions 36%, making the building have a surplus in carbon storage capacity. This storage is attributed to the wood products (75%) and cellulose insulation (25%) used in the assembly as shown in Figure 3. The results graphs below show the breakdowns of life cycle stages and impact categories associated with the materials.

Results Graphs

New Glasgow Retrofit Global Warming by Stage and Material

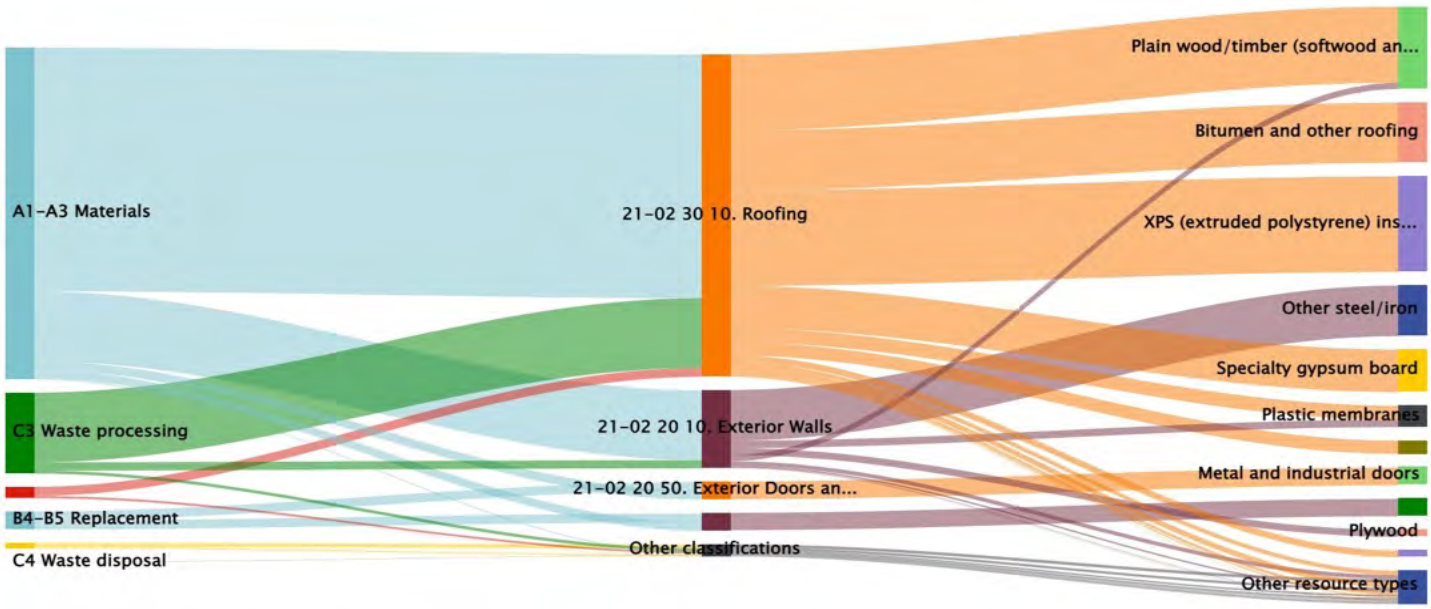


Figure 1: New Glasgow retrofit design breakdown of the life cycle stages and the associated materials

New Glasgow Retrofit Life-Cycle Impacts by Stage (%)

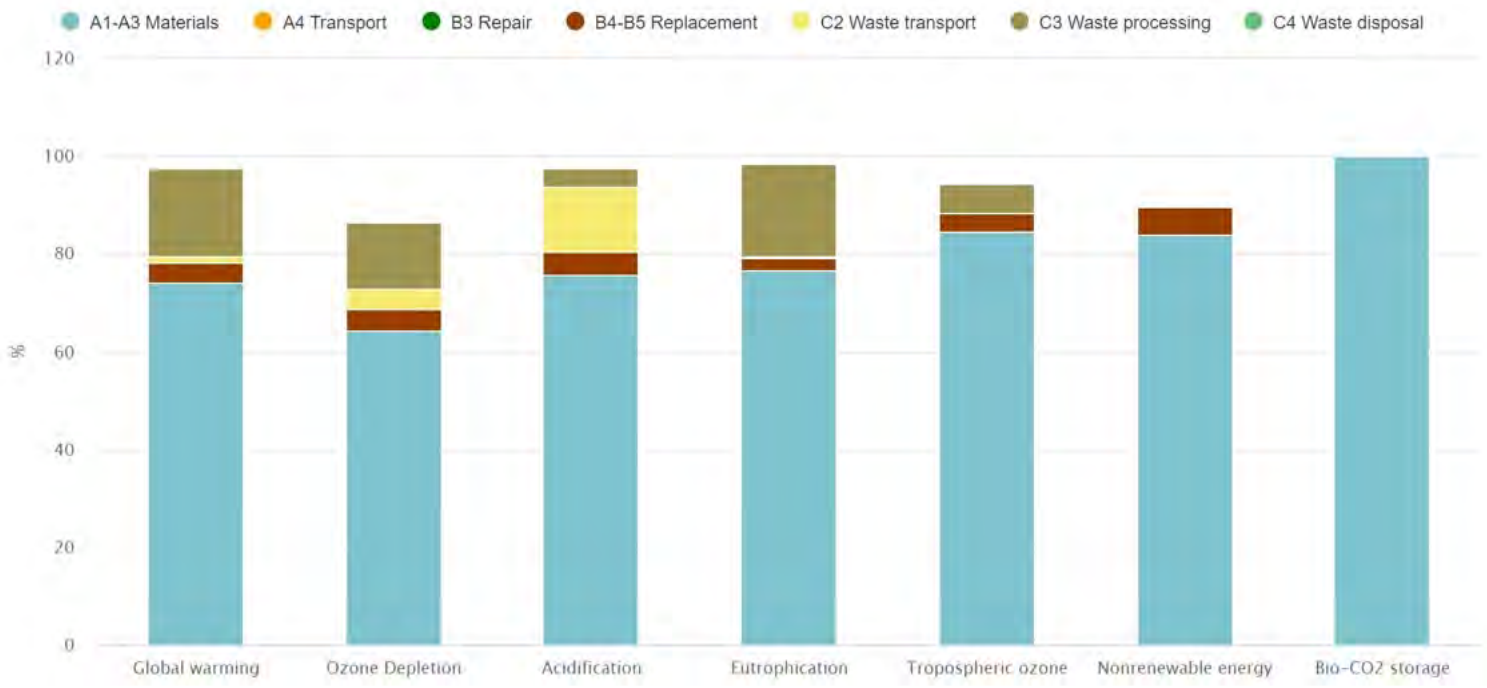


Figure 2: New Glasgow retrofit design breakdown of the life cycle impact categories and the associated life cycle stag

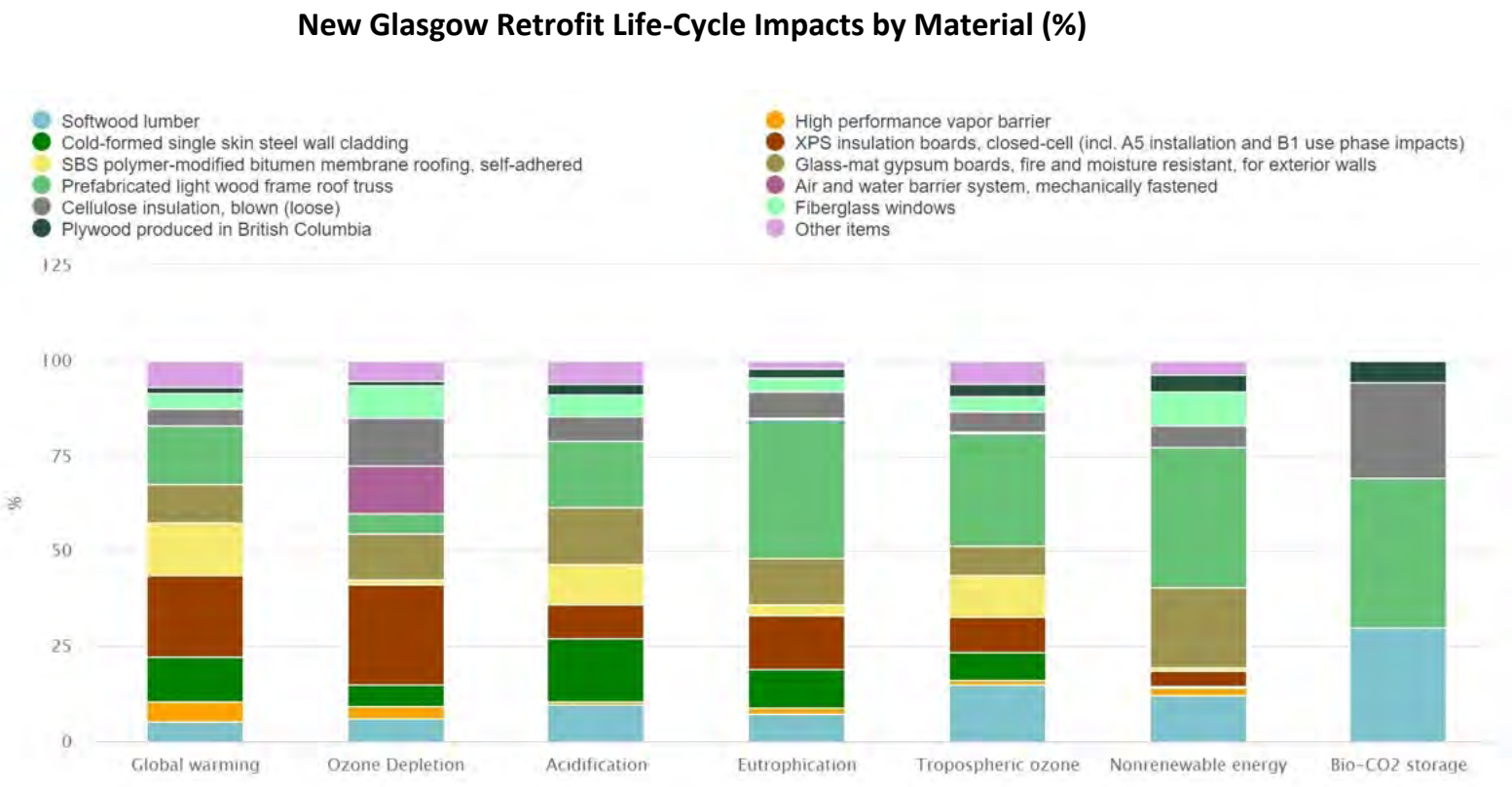


Figure 3: New Glasgow retrofit design breakdown of the life cycle impact categories and the associated material

Appendix

Proposed Retrofit Assemblies and Environmental Impact calculations

New Glasgow

Wall Panel Assembly (R16)

Material (ReCover specification)	Description (from EPD)	Thickness (mm)	Volume of material (m3)	Carbon emissions (A1-A3) (KgCO2E)	% of total
Self Adhered WRB	Air and water barrier system, mechanically fastened, 0.0225 lbs/ft2, 0.11 kg/m2, Tyvek (DuPont)		*	307.4	0.5%
1/2" SPF plywood sheathing	Plywood produced in British Columbia, 477.33 kg/m3 (Forestry Innovation Investment)	13	44.596	5900	9.8%
2x6 SPF framing	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		61.907	4600	7.6%
Compressible insulation	Loose fill fiberglass insulation, blown, Rsi=1 m2K/W, 19.84 mm, 0.46 kg/m2, 23.2 kg/m3, (Johns Manville)	21	4.152	120	0.2%
Exterior strapping (#3)	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		3.658	270	0.4%
Dense pack cellulose (5.5")	Cellulose insulation, blown (loose), L = 0.039 W/mK, R = 2.56 m2K/W (15 ft2°Fh/BTU), 50 kg/m3 (3.12lbs/ft3), (applicable for densities: 40-90 kg/m3 (2.5-5.62 lbs/ft3)),	140	398.445	3500	5.8%
Intello plus	High performance vapor barrier, 0.021 in (0.5 mm), 0.76 kg/m2, Florprufe® 120 (GCP Applied Technologies)		*	1100	1.8%
1x4 strapping	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		8.129	600	1.0%
Metal siding (cladding)	**Cold-formed single skin steel wall cladding, 0.36-1.27 mm, 4.17 kg/m2 (Metal Building Manufacturers Association)**		*****	**43000**	**71.3%**
4" EPS wall insulation	EPS insulation (generic)	101.6	58	670	1.1%
2" thick below grade fin		50.8			
Cement board	Cement board, 1/2 in (12.7 mm), 11.8 kg/m2, PLUS (PermaBASE Building Products)	6.35	0.60325	260	0.4%
Total				**60327.4**	100.0%
* Software calculates the impact based on the area provided			**Per m2**	**8.1**	**kg CO2/m2**

Roof Panel Assembly (R38)

Material (ReCover specification)	Description (from EPD)	Thickness (mm)	Volume of material (m3)	Carbon emissions (A1-A3) (KgCO2E)	% of total
Ballast	Crushed gravel (One Click LCA)	0.1	*	5,700	2.8%
3" XPS rigid foam	XPS insulation boards, closed-cell, (SOPREMA)	0.1	574.1	36,000	17.4%
Roof membrane	SBS polymer-modified bitumen membrane roofing, self-adhered, 6.69 kg/m2 (Certain Teed, Henry, IKO, Malarkey Roofing Products, Siplast, Soprema)		*	51,000	24.7%
DenseGlass sheathing (taped)	Glass-mat gypsum boards, fire and moisture resistant, for exterior walls, 12.7 mm (1/2 inch), 9.75 kg/m2 (1.997 lb/ft2), 768 kg/m3, 1/2 DensGlass, 1/2 DensElementTM (Georgia-Pacific Gypsum LLC)	0	119.6	36,000	17.4%
Dense pack cellulose in cavity	Cellulose insulation, blown (loose), L = 0.039 W/mK, R = 2.56 m2K/W (15 ft2°Fh/BTU), 50 kg/m3 (3.12lbs/ft3), (applicable for densities: 40-90 kg/m3 (2.5-5.62 lbs/ft3))	0.2	1297.4	11,000	5.3%
2x8 SPF framing 24" oc	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		137.7	10,000	4.8%
Intello Plus	High performance vapor barrier, 0.021 in (0.5 mm), 0.76 kg/m2, Florprufe® 120 (GCP Applied Technologies)		*	2,300	1.1%
1x4 SPF strapping	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		15.7	1,200	0.6%
Truss	**Prefabricated light wood frame roof truss, 417 kg/m3, 99.6% softwood lumber, < 0.1% LVL, < 0.1% OSB, 0.4% metal connector plates (Quebec Wood Export Bureau (2020))**		**306**	**53,611.2**	**25.9%**
Total				**206,811.20**	100.0%
* Software calculates the impact based on the area provided			**Per m2**	**27.7**	**kg CO2/m2**

Doors and Windows

Material (ReCover specification)	Description (from EPD)	Thickness (mm)	Volume of material (m3)	Carbon emissions (A1-A3) (KgCO2E)	% of total

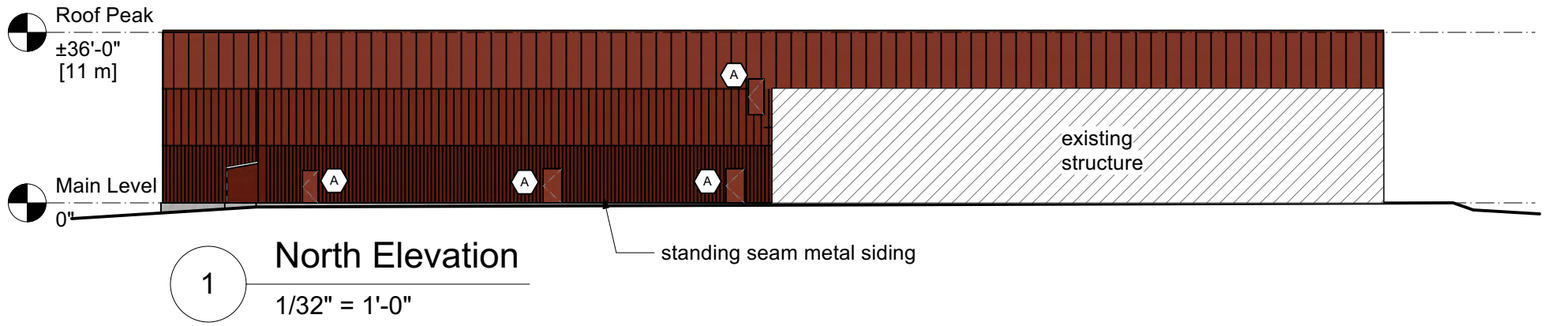
Insulated core steel doors	Galvanized steel door with polyurethane core, 44.5 mm (1.75 inch), 42.5 kg/unit, 490 kg/m3 (DE LA FONTAINE)	*	*	1,700	11.6%
High performance overhead doors	Overhead sectional door, 3600x3600mm, TX42 (Alsta)	*	*	5,800	39.5%
High performance triple pane windows	Fiberglass windows, 1.5m x 1.3 m, 40 mm frame thickness,1.42 m2 glazing area, 60.50 kg/m2, 300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series (Inline)	*	*	7,200	49.0%
Total				**14,700**	100.0%
* Quantity is calculated in software based on area and/or number of units			**Per m2**	**1.0**	**kg CO2/m2**

Environmental Emissions

New Glasgow Project		**A1 to C4**	**A1-A3**	**A4-A5**	**B1-B5**	**C1-C4**	**A1-A3**
Result category	**Units**	**Total**	**Construction Materials**	**Transportation to site & construction**	**Material replacement & refurbishment**	**Deconstruction**	**A1-A3 % of total**
Global warming	kg CO2e	382,372.50	283471.8	9616.37	15305.16	73979.17	74.1%
Ozone Depletion	kg CFC11e	0.02	0.012	0.0025	0.00088	0.0035	63.6%
Acidification	kg SO_2e	2,283.11	1729.44	54.64	106.52	392.51	75.7%
Eutrophication	kg Ne	514.86	394.82	7.67	12.53	99.84	76.7%
Formation of tropospheric ozone	kg O3e	29,343.50	24819.69	1549.71	1129.6	1844.5	84.6%
Depletion of nonrenewable energy	MJ	2,851,971.97	2396135	273703.3	156013.9	26119.77	84.0%
Biogenic carbon storage	kg CO2e	594,075.30	594075.3	0	0	0	

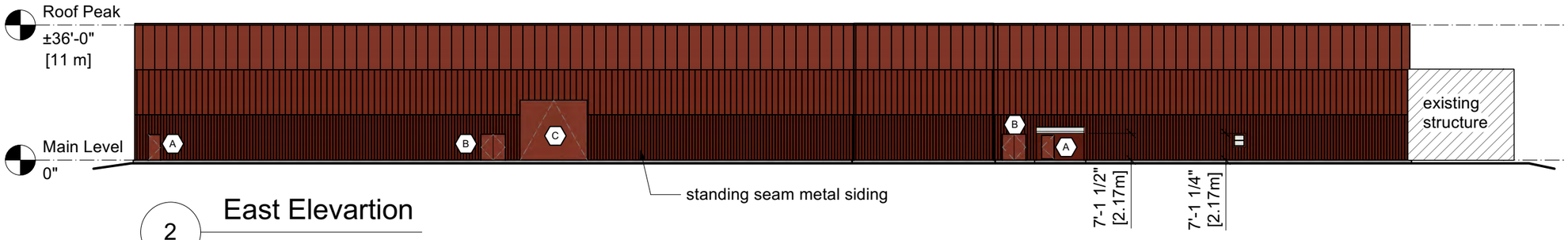
Appendix L

Architectural Elevation Drawings



1 North Elevation

1/32" = 1'-0"



2 East Elevartion

1/32" = 1'-0"

0 12 24 36 48 60FT

graphic scale:

north arrow:

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ReCover

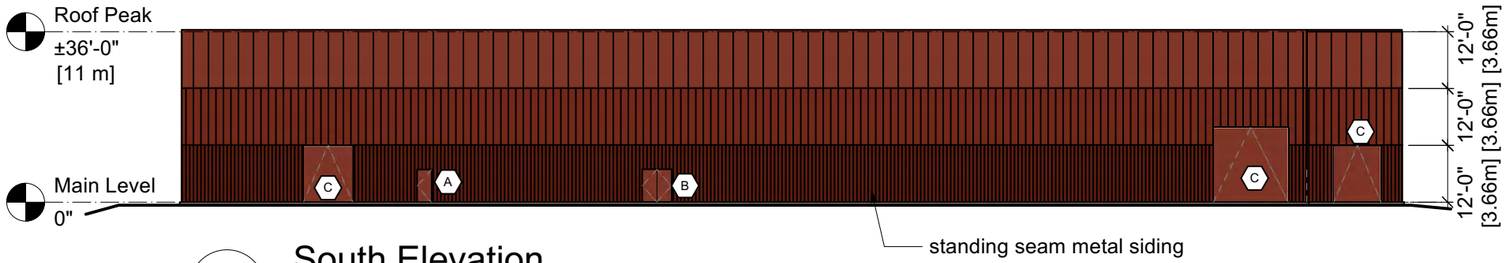
Municipal Operations Bldg

Town of New Glasgow, NS

ReCover Initiative Panelized Deep Retrofit Study

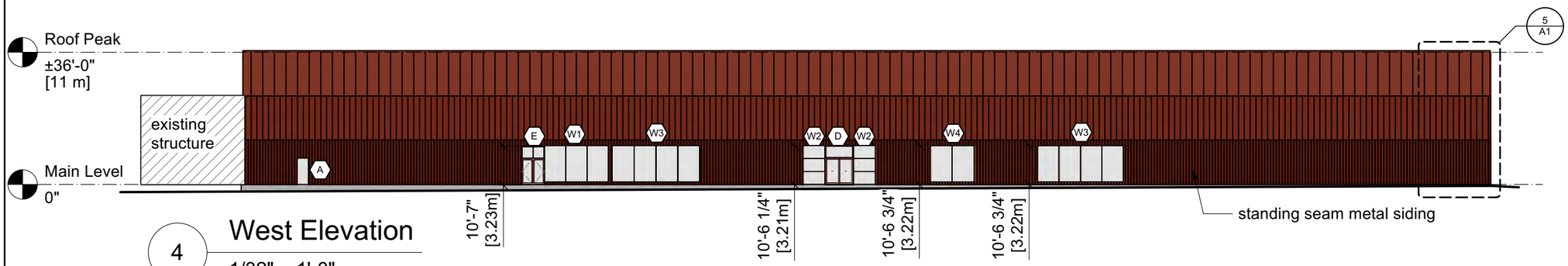
New Glasgow_CURRENT.vwx

drawing title: Proposed North & East Elevations		
phase: concept		sheet size: 17x11
drawn by: IG	checked by: LR	drawing number: A1
date: 2023-08-15	scale: as noted	



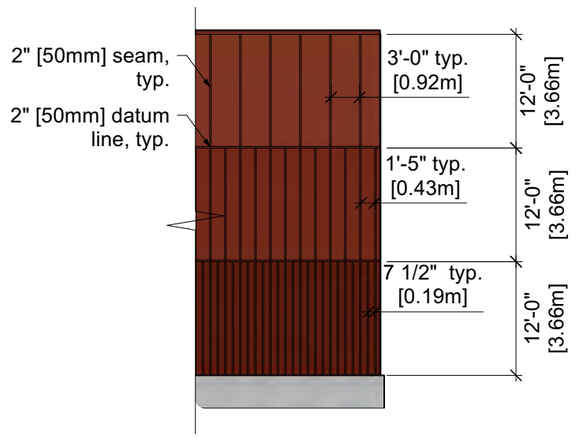
3 South Elevation

1/32" = 1'-0"



4 West Elevation

1/32" = 1'-0"



5 Siding detail

1/16" = 1'-0"

0 12 24 36 48 60FT

graphic scale:

north arrow:

habit studio

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ReCover

Municipal Operations Bldg

Town of New Glasgow, NS

ReCover Initiative Panelized Deep Retrofit Study

New Glasgow_CURRENT.vwx

drawing title: Proposed South & West Elevations		
phase: concept		sheet size: 17x11
drawn by: IG	checked by: LR	drawing number: A2
date: 2023-08-15	scale: as noted	

APPLICABLE CODES AND STANDARDS

Building Code:	2020 Nova Scotia Building Code Regulations (NSBC) 2015 National Building Code of Canada (NBCC)
Fire Code:	2015 National Fire Code of Canada
Accessibility:	2020 Nova Scotia Building Code Regulations (NSBC) 2015 National Building Code of Canada (NBCC)

BUILDING DESCRIPTION

New Glasgow Municipal Operations Building

		NSBC Reference
Building Area (Footprint):	7 430 m²	
Gross Floor Area:	7 430 m²	
Building Height:	1 Storey	1.4.1.2
Major Occupancy, Proposed:	Group F2 - Medium Hazard Industrial Occupancy - Repair Garage	3.1.2.1.

CONSTRUCTION REQUIREMENTS

		NSBC Reference
Construction Governed by:	NSBC Part 3	1.3.3.2.
Building Area:	< 9 600 m²	3.2.2.77.(1)(c)(i)
Building Height:	1 Storey	3.2.2.77.(1)(c)(i)
Streets to Face:	None	
Construction Type:	Combustible or Nomcombustible	3.2.2.77.(2)
Fire Resistance Ratings:		
Upper Floors (n/a):	45 Minute	3.2.2.77.(2)(b)
Loadbearing Elements supporting an assembly required to have a fire-resistance rating	45-minute FRR or noncombustible	3.2.2.77.(2)(c)
Roof, Occupied (n/a):	N/A	
Loadbearing Elements supporting a fire separation	45-minute	3.2.2.77.(2)(d)
Sprinkler:	Required	3.2.2.77.(1)(a)
Standpipe:	Required	3.2.5.8.(1)(c)
Fire Alarm:	Required	3.2.4.1.(1)
Portable Fire Extinguisher:	Required within 22.9 m of travel from all points within	NFC 2.1.5.1. / NFPA 10
Fire Hydrant:	Required within 45 m of fire department connection of sprinkler or standpipe system.	3.2.5.15.

SPATIAL SEPARATIONS

The type of construction, cladding and fire-resistance rating of the exposed building faces is summarized below.
NSBC References: Article 3.2.3.1. and NSBC Table 3.2.3.1.-E

Facing	Limiting Distance (m)	Wall Area (m²)	H:L Ratio	Unprotected Openings		Exposing Building Face		
				Permitted	Proposed	FRR	Construction	Cladding
North (party wal	0.0		1:0	0.0%	0.0%	4 hour*	Noncombustible	
North	0.0	112.0	1:3.1	0.0%	0.0%	2 hour	Noncombustible	Noncombustible
East	45.0	675.0	1:16.3	100.0%	0.1%	-	Comb. or Noncomb.	Comb. or Noncomb.
South	25.0	471.0	1:12.3	100.0%	0.0%	-	Comb. or Noncomb.	Comb. or Noncomb.
West	4.0	660.0	1:16.3	14.0%	10.0%	2 hour	Comb. or Noncomb.	Noncomb.

graphic scale: | north arrow:

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ReCover

Municipal Operations Bldg

Town of New Glasgow, NS

ReCover Initiative Panelized Deep Retrofit Study

New Glasgow_CURRENT.vwx

drawing title: Code review

phase: concept | sheet size: 17x11

drawn by: IG | checked by: LR | drawing number: A3

date: 2023-08-15 | scale: as noted

Appendix M

Cost Estimate

Retrofit 610 East River Road

New Glasgow, Nova Scotia

ELEMENTAL COST PLAN
CLASS D - FEASIBILITY ESTIMATE
JULY 20, 2023

163 Village Road, Herring Cove, Nova Scotia, Canada, B3V 1H2
www.qsolv.ca

Preamble

INTRODUCTION

The Class D - Feasibility Estimate enclosed represents the construction costs for the proposed energy retrofit options to the existing retail store building located at 610 East River Road in New Glasgow, Nova Scotia as design by RSI Projects Inc.

Four scenario cost options are presented in this report as follows:

Scenario One 50% Improvements generally includes the replacement of the masonry facade with new metal siding on prefab insulated panels, roof replacement on pre-eng roof and insulated panels, replacement of windows and doors, upgrade of existing boiler, addition of ERVs, and upgrade lighting with LED retrofit kits.

Scenario Two Net Zero Ready - ASHP generally includes the replacement of the masonry facade with metal siding on prefab insulated panels, insulation on foundation walls, replacement of windows and doors, roof replacement on pre-eng roof and insulated panels, change HVAC to an air source heat pump system and ERVs, upgrade switchboard, replacement of lighting with LED fixtures, and add heat pump hot water heaters.

Scenario Three Net Zero Ready - GSHP generally includes the replacement of the masonry facade with metal siding on prefab insulated panels, insulation on foundation walls, replacement of windows and doors, roof replacement on pre-eng roof and insulated panels, change HVAC to a ground source heat pump system and ERVs, upgrade of switchboard, replacement of lighting with LED fixtures, and add heat pump hot water heaters.

Scenario Four Net Zero generally includes all scope items from Scenario Three plus adds photovoltaics.

APPROACH

The construction costs for this report include all materials, labour, equipment, overheads, general conditions, plus markups and contractor's profit, for the retrofit options as presented in the project documents.

Preamble

APPROACH

The estimated **Construction Value** per Scenario is as follows:

Scenario One Minimum Code	$13,602,000.00
Scenario Two Net Zero Ready - ASHP	$18,803,000.00
Scenario Three Net Zero Ready - GSHP	$19,717,000.00
Scenario Four Net Zero	$20,985,000.00

Quantities were measured based on the Canadian Institute of Quantity Surveyors (CIQS) standards for Method of Measurement and presented in elemental format.

Pricing reflects competitive bids for every element of the work for a project of this type procured under an open market stipulated lump sum bid contract in New Glasgow, Nova Scotia. Unit costs are developed and expressed as typical sub-contractor pricing and are inclusive of subcontractor's overheads and profits.

This estimate is an indication of the probable construction costs and is intended to represent fair market value of the construction costs. This estimate should not be considered a prediction of the lowest bid.

SPACE MEASUREMENT

The Gross Floor Area (GFA) was measured at 81,928 square feet (sf) based on the Canadian Institute of Quantity Surveyors (CIQS) Method of Measurement and the International Construction Measurement Standards (ICMS).

COST BASE

All costs are expressed in third quarter 2023 Canadian dollars (3Q2023).

All costs are shown exclusive of the 13% Harmonized Sales Tax (HST).

Preamble

ESCALATION

An Escalation Allowance is excluded from this report as no project schedule was provided.

Nova Scotia is experiencing significant construction escalation currently with no signs of easing moving forward. It is recommended the Owner carry a Construction Escalation allowance of 10% per annum to the mid point of construction and should be monitored and reviewed continuously during the remaining design phase.

CONTINGENCIES

A Design Development Contingency Allowance of 10% is included in this report to allow for scope and budget adjustments during the remaining design phase.

A Construction Contingency Allowance of 10% is included in this report to allow for scope changes and possible change orders during the construction phase.

EXCLUSIONS

The following have been excluded from this cost report:

Premium for single source materials or equipment unless noted otherwise
Third party commissioning
Professional and design fees
Project management fees
Interim financing
Legal fees and surveys
Owners risk allowance
Moving costs or swing space
Furniture and equipment unless noted otherwise
Hazardous materials abatement
Rock excavation
Accelerated schedule premiums
Shift premiums or after-hours work

Preamble

EXCLUSIONS

Cash allowances
Testing and inspections
Cost premiums due to new tariffs placed on material and equipment
Cost premiums due to changes in COVID-19 protocols
Allowances for rebates

DOCUMENTATION

This Class D estimate is based on the following documentation:

Drawings/Specifications/Reports	Dated:
A101	July 14, 2022
A102	July 14, 2022
Mechanical Outline Specification	January 3, 2023
Electrical Outline Specification	February 10, 2023
Structural Plan S-100	February 10, 2023
Retrofit Scenarios Details	No Date
Wall Panel Schematics	February 27, 2023

PROJECT COST SUMMARY

PROJECT: RETROFIT 610 EAST RIVER ROAD
LOCATION: NEW GLASGOW, NS
CLIENT:
DESIGNER: RSI PROJECTS

Class D Estimate

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13453

	DESCRIPTION	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	NOTES
1	SCENARIO 1 50% IMPROVEMENT	81928	sf	$ 166.00	$ 13,602,000	
2	SCENARIO 2 NET ZERO READY, ASHP	81928	sf	$ 230.00	$ 18,803,000	
3	SCENARIO 3 NET ZERO READY, GSHP	81928	sf	$ 241.00	$ 19,717,000	
4	SCENARIO 4 NET ZERO	81928	sf	$ 256.00	$ 20,985,000	

ELEMENTAL COST SUMMARY

PROJECT: RETROFIT 610 EAST RIVER ROAD
LOCATION: NEW GLASGOW, NS
CLIENT:
DESIGNER: RSI PROJECTS

Scenario 1 50% Improvement

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13453
GFA:sf 81928

GROSS FLOOR AREA 81928 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL						$ 90	$ 7,393,288	54.35
A1 SUBSTRUCTURE						$ -	$ -	0.00
A11 Foundations	1.000	81928	sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	81928	sf	$ -	$ -	$ -		0.00
A2 STRUCTURE						$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE						$ 90	$ 7,393,288	54.35
A31 Walls Below Grade	1.000	81928	sf	$ -	$ -	$ -		0.00
A32 Walls Above Grade	0.275	22502	sf	$ 106.83	$ 2,403,845	$ 29		17.67
A33 Windows and Entrances	0.030	2423	sf	$ 121.78	$ 295,035	$ 4		2.17
A34 Roof Coverings	1.000	81928	sf	$ 57.30	$ 4,694,407	$ 57		34.51
A35 Projections	1.000	81928	sf	$ -	$ -	$ -		0.00
B INTERIORS						$ 3	$ 245,477	1.80
B1 PARTITIONS AND DOORS						$ -	$ -	0.00
B11 Partitions	1.000	81928	sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	81928	sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES						$ 3	$ 245,477	1.80
B21 Floor Finishes	1.000	81928	sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	81928	sf	$ 2.50	$ 204,820	$ 3		1.51
B23 Wall Finishes	1.000	81928	sf	$ 0.50	$ 40,657	$ 0		0.30
B3 FITTINGS AND EQUIPMENT						$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	81928	sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	81928	sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	81928	sf	$ -	$ -	$ -		0.00
SERVICES						$ 15	$ 1,247,423	9.17
C1 MECHANICAL						$ 13	$ 1,076,067	7.91
C11 Plumbing and Drainage	1.000	81928	sf	$ -	$ -	$ -		0.00
C12 Fire Protection	1.000	81928	sf	$ 6.00	$ 491,567	$ 6		3.61
C13 HVAC	1.000	81928	sf	$ 6.59	$ 539,500	$ 7		3.97
C14 Controls	1.000	81928	sf	$ 0.55	$ 45,000	$ 1		0.33
C2 ELECTRICAL						$ 2	$ 171,356	1.26
C21 Services and Distribution	1.000	81928	sf	$ -	$ -	$ -		0.00
C22 Lighting, Devices and Heating	1.000	81928	sf	$ 2.09	$ 171,356	$ 2		1.26
C23 Systems and Ancillaries	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE						$ 108	$ 8,886,188	65.33
D SITE & ANCILLARY WORK						$ -	$ -	0.00
D1 SITEWORK						$ -	$ -	0.00
D11 Site Development	1.000	81928	sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK						$ -	$ -	0.00
D21 Demolition	1.000	81928	sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE						$ 108	$ 8,886,188	65.33
Z GENERAL REQUIREMENTS AND ALLOWANCES						$ 58	$ 4,715,456	34.67
Z1 GENERAL REQUIREMENTS AND FEES						$ 29	$ 2,354,840	17.31
Z11 General Requirements and Overheads		15%			$ 1,332,928	$ 16		9.80
Z12 Contractors Profit		10%			$ 1,021,912	$ 12		7.51
Z2 ALLOWANCES						$ 29	$ 2,360,616	17.35
Z21 Design Allowance		10%			$ 1,124,103	$ 14		8.26
Z22 Escalation Allowance TBD		0%			$ -	$ -		0.00
Z23 Construction Allowance		10%			$ 1,236,513	$ 15		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)				$166 per sf			$ 13,602,000	100.00

QSolv

Element	Quantities		Unit Rates	Sub-totals
EXTERIOR ENCLOSURE				
A32 Walls Above Grade				
▪ remove masonry façade	22502	sf	$ 6.00	$ 135,013
▪ structural upgrades including base angle and mid girts	183000	lbs	$ 4.00	$ 732,000
▪ supply and install r11 prefab insulated wall panels	20163	sf	$ 26.00	$ 524,235
▪ supply and install prefinished metal siding	22502	sf	$ 45.00	$ 1,012,598
A32 Walls Above Grade Total	**22502**	**sf**	**$ 106.83**	**$ 2,403,845**
A33 Windows and Entrances				
▪ replace overhead doors with R10 overhead doors	4	no	$ 12,000.00	$ 48,000
▪ replace storefront windows with triple pane	1363	sf	$ 145.00	$ 197,635
▪ replace insulated metal exits	13	no	$ 3,800.00	$ 49,400
A33 Windows and Entrances Total	**2423**	**sf**	**$ 121.78**	**$ 295,035**
A34 Roof Coverings				
▪ remove existing roof finish	81928	sf	$ 2.50	$ 204,820
▪ pre-eng wood trusses with nailers	81928	sf	$ 8.00	$ 655,423
▪ new mod bit roof finish with R18 Recover panels	81928	sf	$ 41.00	$ 3,359,043
▪ allowance for removing, reinstalling mechanical	1	sum	$ 45,000.00	$ 45,000
▪ spray fireproof underside of beams, deck	81928	sf	$ 4.00	$ 327,712
▪ fire rated gwb cladding to columns	81928	sf	$ 1.25	$ 102,410
A34 Roof Coverings Total	**81928**	**sf**	**$ 57.30**	**$ 4,694,407**
A35 Projections				
▪ canopies - no change	1	sum	$ -	$ -
A35 Projections Total	**81928**	**sf**	**$ -**	**$ -**
FINISHES				
B22 Ceiling Finishes				
▪ cut and patch ceilings for new mechanical/electrical	40964	sf	$ 5.00	$ 204,820
B22 Ceiling Finishes Total	**81928**	**sf**	**$ 2.50**	**$ 204,820**
B23 Wall Finishes				
▪ cut and patch walls for new mechanical/electrical	81928	sf	$ 0.10	$ 8,193
▪ patch existing party wall	3246	sf	$ 10.00	$ 32,465
B23 Wall Finishes Total	**81928**	**sf**	**$ 0.50**	**$ 40,657**
MECHANICAL				
C12 Fire Protection				
▪ expand wet pipe sprinkler system to include roof cavity	81928	sf	$ 6.00	$ 491,567
C12 Fire Protection Total	**81928**	**sf**	**$ 6.00**	**$ 491,567**
C13 Heating, Ventilation, Air Conditioning				
▪ new 480kW boiler connected to existing system	1	sum	$ 120,000.00	$ 120,000

Element	Quantities		Unit Rates	Sub-totals
▪ ERV 320cfm	1	sum	$ 3,500.00	$ 3,500
▪ ERV 25500cfm	1	sum	$ 380,000.00	$ 380,000
▪ new ERV ductwork connected to existing	2000	lbs	$ 18.00	$ 36,000
C13 Heating, Ventilation, Air Conditioning Total	**81928**	**sf**	**$ 6.59**	**$ 539,500**
C14 Controls				
▪ building automated controls - connect to existing system	1	sum	$ 45,000.00	$ 45,000
C14 Controls Total	**81928**	**sf**	**$ 0.55**	**$ 45,000**
ELECTRICAL				
C22 Lighting, Devices and Heating				
▪ install LED retrofit kits to all existing lights	81928	sf	$ 2.00	$ 163,856
▪ upgrade selective mechanical connections	1	sum	$ 7,500.00	$ 7,500
C22 Lighting and Heating Total	**81928**	**sf**	**$ 2.09**	**$ 171,356**
GENERAL REQUIREMENTS AND FEES				
Z11 General Requirements and Overheads				
▪ contractor's overheads			15.00%	$ 1,332,928
Z11 General Requirements and Overheads Total	**81928**	**sf**	**$ 16.27**	**$ 1,332,928**
Z12 Contractor's Profit				
▪ contractor's profit			10.00%	$ 1,021,912
Z12 Contractor's Profit Total	**81928**	**sf**	**$ 12.47**	**$ 1,021,912**
ALLOWANCES				
Z21 Design Allowance				
▪ design development contingency			10.00%	$ 1,124,103
Z21 Design Allowance Total	**81928**	**sf**	**$ 13.72**	**$ 1,124,103**
Z23 Construction Contingency				
▪ construction contingency			10.00%	$ 1,236,513
Z23 Construction Contingency	**81928**	**sf**	**$ 15.09**	**$ 1,236,513**

ELEMENTAL COST SUMMARY

PROJECT: RETROFIT 610 EAST RIVER ROAD
LOCATION: NEW GLASGOW, NS
CLIENT:
DESIGNER: RSI PROJECTS

Scenario 2 Net Zero Ready - ASHP

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13453
GFA:sf 81928

GROSS FLOOR AREA 81928 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL						$ 101	$ 8,242,893	43.84
A1 SUBSTRUCTURE						$ -	$ -	0.00
A11 Foundations	1.000	81928	sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	81928	sf	$ -	$ -	$ -		0.00
A2 STRUCTURE						$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE						$ 101	$ 8,242,893	43.84
A31 Walls Below Grade	0.026	2136	sf	$ 318.66	$ 680,750	$ 8		3.62
A32 Walls Above Grade	0.275	22502	sf	$ 106.83	$ 2,403,845	$ 29		12.78
A33 Windows and Entrances	0.030	2423	sf	$ 121.78	$ 295,035	$ 4		1.57
A34 Roof Coverings	1.000	81928	sf	$ 59.36	$ 4,863,263	$ 59		25.86
A35 Projections	1.000	81928	sf	$ -	$ -	$ -		0.00
B INTERIORS						$ 3	$ 253,670	1.35
B1 PARTITIONS AND DOORS						$ -	$ -	0.00
B11 Partitions	1.000	81928	sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	81928	sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES						$ 3	$ 253,670	1.35
B21 Floor Finishes	1.000	81928	sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	81928	sf	$ 2.50	$ 204,820	$ 3		1.09
B23 Wall Finishes	1.000	81928	sf	$ 0.60	$ 48,850	$ 1		0.26
B3 FITTINGS AND EQUIPMENT						$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	81928	sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	81928	sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	81928	sf	$ -	$ -	$ -		0.00
SERVICES						$ 46	$ 3,787,413	20.14
C1 MECHANICAL						$ 31	$ 2,566,207	13.65
C11 Plumbing and Drainage	1.000	81928	sf	$ 0.27	$ 22,500	$ 0		0.12
C12 Fire Protection	1.000	81928	sf	$ 6.00	$ 491,567	$ 6		2.61
C13 HVAC	1.000	81928	sf	$ 20.05	$ 1,642,500	$ 20		8.74
C14 Controls	1.000	81928	sf	$ 5.00	$ 409,639	$ 5		2.18
C2 ELECTRICAL						$ 15	$ 1,221,207	6.49
C21 Services and Distribution	1.000	81928	sf	$ 3.91	$ 320,000	$ 4		1.70
C22 Lighting, Devices and Heating	1.000	81928	sf	$ 11.00	$ 901,207	$ 11		4.79
C23 Systems and Ancillaries	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE						$ 150	$ 12,283,976	65.33
D SITE & ANCILLARY WORK						$ -	$ -	0.00
D1 SITEWORK						$ -	$ -	0.00
D11 Site Development	1.000	81928	sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK						$ -	$ -	0.00
D21 Demolition	1.000	81928	sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE						$ 150	$ 12,283,976	65.33
Z GENERAL REQUIREMENTS AND ALLOWANCES						$ 80	$ 6,518,492	34.67
Z1 GENERAL REQUIREMENTS AND FEES						$ 40	$ 3,255,254	17.31
Z11 General Requirements and Overheads		15%			$ 1,842,596	$ 22		9.80
Z12 Contractors Profit		10%			$ 1,412,657	$ 17		7.51
Z2 ALLOWANCES						$ 40	$ 3,263,238	17.35
Z21 Design Allowance		10%			$ 1,553,923	$ 19		8.26
Z22 Escalation Allowance TBD		0%			$ -	$ -		0.00
Z23 Construction Allowance		10%			$ 1,709,315	$ 21		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)				$230 per sf			$ 18,803,000	100.00

Element	Quantities		Unit Rates	Sub-totals
EXTERIOR ENCLOSURE				
A31 Walls Below Grade				
▪ remove concrete sidewalk and dispose	11274	sf	$ 3.50	$ 39,460
▪ remove asphalt paving and dispose	21743	sf	$ 3.50	$ 76,102
▪ excavate to 2 feet below grade	237	cyd	$ 40.00	$ 9,485
▪ new 2" EPS insulation	2136	sf	$ 3.50	$ 7,477
▪ cement board	1457	sf	$ 5.00	$ 7,283
▪ backfill to subgrade	237	cyd	$ 50.00	$ 11,856
▪ reinstate concrete sidewalks	11274	sf	$ 18.00	$ 202,935
▪ reinstate asphalt paving	21743	sf	$ 15.00	$ 326,151
A31 Walls Below Grade Total	**2136**	**sf**	**$ 318.66**	**$ 680,750**
A32 Walls Above Grade				
▪ remove masonry façade	22502	sf	$ 6.00	$ 135,013
▪ structural upgrades including base angle and mid girts	183000	lbs	$ 4.00	$ 732,000
▪ supply and install r11 prefab insulated wall panels	20163	sf	$ 26.00	$ 524,235
▪ supply and install prefinished metal siding	22502	sf	$ 45.00	$ 1,012,598
A32 Walls Above Grade Total	**22502**	**sf**	**$ 106.83**	**$ 2,403,845**
A33 Windows and Entrances				
▪ replace overhead doors with R10 overhead doors	4	no	$ 12,000.00	$ 48,000
▪ replace storefront windows with triple pane	1363	sf	$ 145.00	$ 197,635
▪ replace insulated metal exits	13	no	$ 3,800.00	$ 49,400
A33 Windows and Entrances Total	**2423**	**sf**	**$ 121.78**	**$ 295,035**
A34 Roof Coverings				
▪ remove existing roof finish	81928	sf	$ 2.50	$ 204,820
▪ pre-eng wood trusses with nailers	81928	sf	$ 8.00	$ 655,423
▪ new mod bit roof finish with R38 Recover panels	81928	sf	$ 43.00	$ 3,522,899
▪ allowance for removing, reinstalling mechanical	1	sum	$ 50,000.00	$ 50,000
▪ spray fireproof underside of beams, deck	81928	sf	$ 4.00	$ 327,712
▪ fire rated gwb cladding to columns	81928	sf	$ 1.25	$ 102,410
A34 Roof Coverings Total	**81928**	**sf**	**$ 59.36**	**$ 4,863,263**
A35 Projections				
▪ canopies - no change	1	sum	$ -	$ -
A35 Projections Total	**81928**	**sf**	**$ -**	**$ -**
FINISHES				
B22 Ceiling Finishes				
▪ cut and patch ceilings for new mechanical/electrical	40964	sf	$ 5.00	$ 204,820
B22 Ceiling Finishes Total	**81928**	**sf**	**$ 2.50**	**$ 204,820**
B23 Wall Finishes				
▪ cut and patch walls for new mechanical/electrical	81928	sf	$ 0.20	$ 16,386

Element	Quantities		Unit Rates	Sub-totals
▪ patch existing party wall	3246	sf	$ 10.00	$ 32,465
B23 Wall Finishes Total	**81928**	**sf**	**$ 0.60**	**$ 48,850**
MECHANICAL				
C11 Plumbing and Drainage				
▪ new 80gal HPWH hot water tanks	5	no	$ 4,500.00	$ 22,500
C11 Plumbing and Drainage Total	**81928**	**sf**	**$ 0.27**	**$ 22,500**
C12 Fire Protection				
▪ expand wet pipe sprinkler system to include roof cavity	81928	sf	$ 6.00	$ 491,567
C12 Fire Protection Total	**81928**	**sf**	**$ 6.00**	**$ 491,567**
C13 Heating, Ventilation, Air Conditioning				
▪ ASHP-24 tons	3	no	$ 60,000.00	$ 180,000
▪ electric boiler - 120kW	1	no	$ 30,000.00	$ 30,000
▪ HP HX pumps	4	no	$ 12,000.00	$ 48,000
▪ HP BT pumps	4	no	$ 12,000.00	$ 48,000
▪ circulation pumps	4	no	$ 11,000.00	$ 44,000
▪ maintenance circulation pumps	2	no	$ 5,500.00	$ 11,000
▪ electric boiler pump	1	no	$ 6,500.00	$ 6,500
▪ buffer tanks	2	no	$ 15,000.00	$ 30,000
▪ air separators	4	no	$ 3,500.00	$ 14,000
▪ expansion tanks	4	no	$ 2,500.00	$ 10,000
▪ heat exchangers	2	no	$ 15,000.00	$ 30,000
▪ distribution piping	3000	lf	$ 100.00	$ 300,000
▪ fancoils - 4 pipe 5 ton	5	no	$ 7,500.00	$ 37,500
▪ fancoils - 4 pipe 1 ton	5	no	$ 4,000.00	$ 20,000
▪ ERV 25500cfm	1	no	$ 380,000.00	$ 380,000
▪ ERV 3600cfm	1	no	$ 90,000.00	$ 90,000
▪ ERV 320cfm	1	no	$ 3,500.00	$ 3,500
▪ new ERV ductwork	20000	lbs	$ 18.00	$ 360,000
C13 Heating, Ventilation, Air Conditioning Total	**81928**	**sf**	**$ 20.05**	**$ 1,642,500**
C14 Controls				
▪ building automated controls - connect to existing system	81928	sf	$ 5.00	$ 409,639
C14 Controls Total	**81928**	**sf**	**$ 5.00**	**$ 409,639**
ELECTRICAL				
C21 Services and Distribution				
▪ replace main entrance, 800A switchgear	1	sum	$ 150,000.00	$ 150,000
▪ new feeders	1	sum	$ 90,000.00	$ 90,000
▪ new panel, transformer for HVAC	1	sum	$ 50,000.00	$ 50,000
▪ new disconnects, mechanical connections	1	sum	$ 30,000.00	$ 30,000
C21 Services and Distribution Total	**81928**	**sf**	**$ 3.91**	**$ 320,000**
C22 Lighting, Devices and Heating				

Element	Quantities		Unit Rates	Sub-totals
▪ new interior lighting - LED type	81928	sf	$ 8.00	$ 655,423
▪ lighting controls	81928	sf	$ 3.00	$ 245,784
C22 Lighting and Heating Total	**81928**	**sf**	**$ 11.00**	**$ 901,207**
GENERAL REQUIREMENTS AND FEES				
Z11 General Requirements and Overheads				
▪ contractor's overheads			15.00%	$ 1,842,596
Z11 General Requirements and Overheads Total	**81928**	**sf**	**$ 22.49**	**$ 1,842,596**
Z12 Contractor's Profit				
▪ contractor's profit			10.00%	$ 1,412,657
Z12 Contractor's Profit Total	**81928**	**sf**	**$ 17.24**	**$ 1,412,657**
ALLOWANCES				
Z21 Design Allowance				
▪ design development contingency			10.00%	$ 1,553,923
Z21 Design Allowance Total	**81928**	**sf**	**$ 18.97**	**$ 1,553,923**
Z23 Construction Contingency				
▪ construction contingency			10.00%	$ 1,709,315
Z23 Construction Contingency	**81928**	**sf**	**$ 20.86**	**$ 1,709,315**

ELEMENTAL COST SUMMARY

PROJECT: RETROFIT 610 EAST RIVER ROAD
LOCATION: NEW GLASGOW, NS
CLIENT:
DESIGNER: RSI PROJECTS

Scenario 3 Net Zero Ready - GSHP

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13453
GFA:sf 81928

GROSS FLOOR AREA 81928 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL						$ 101	$ 8,242,893	41.81
A1 SUBSTRUCTURE						$ -	$ -	0.00
A11 Foundations	1.000	81928	sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	81928	sf	$ -	$ -	$ -		0.00
A2 STRUCTURE						$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE						$ 101	$ 8,242,893	41.81
A31 Walls Below Grade	0.026	2136	sf	$ 318.66	$ 680,750	$ 8		3.45
A32 Walls Above Grade	0.275	22502	sf	$ 106.83	$ 2,403,845	$ 29		12.19
A33 Windows and Entrances	0.030	2423	sf	$ 121.78	$ 295,035	$ 4		1.50
A34 Roof Coverings	1.000	81928	sf	$ 59.36	$ 4,863,263	$ 59		24.67
A35 Projections	1.000	81928	sf	$ -	$ -	$ -		0.00
B INTERIORS						$ 3	$ 253,670	1.29
B1 PARTITIONS AND DOORS						$ -	$ -	0.00
B11 Partitions	1.000	81928	sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	81928	sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES						$ 3	$ 253,670	1.29
B21 Floor Finishes	1.000	81928	sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	81928	sf	$ 2.50	$ 204,820	$ 3		1.04
B23 Wall Finishes	1.000	81928	sf	$ 0.60	$ 48,850	$ 1		0.25
B3 FITTINGS AND EQUIPMENT						$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	81928	sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	81928	sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	81928	sf	$ -	$ -	$ -		0.00
SERVICES						$ 54	$ 4,384,769	22.24
C1 MECHANICAL						$ 39	$ 3,163,562	16.04
C11 Plumbing and Drainage	1.000	81928	sf	$ 0.27	$ 22,500	$ 0		0.11
C12 Fire Protection	1.000	81928	sf	$ 6.00	$ 491,567	$ 6		2.49
C13 HVAC	1.000	81928	sf	$ 25.34	$ 2,076,000	$ 25		10.53
C14 Controls	1.000	81928	sf	$ 7.00	$ 573,495	$ 7		2.91
C2 ELECTRICAL						$ 15	$ 1,221,207	6.19
C21 Services and Distribution	1.000	81928	sf	$ 3.91	$ 320,000	$ 4		1.62
C22 Lighting, Devices and Heating	1.000	81928	sf	$ 11.00	$ 901,207	$ 11		4.57
C23 Systems and Ancillaries	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE						$ 157	$ 12,881,332	65.33
D SITE & ANCILLARY WORK						$ -	$ -	0.00
D1 SITEWORK						$ -	$ -	0.00
D11 Site Development	1.000	81928	sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK						$ -	$ -	0.00
D21 Demolition	1.000	81928	sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE						$ 157	$ 12,881,332	65.33
Z GENERAL REQUIREMENTS AND ALLOWANCES						$ 83	$ 6,835,479	34.67
Z1 GENERAL REQUIREMENTS AND FEES						$ 42	$ 3,413,553	17.31
Z11 General Requirements and Overheads		15%			$ 1,932,200	$ 24		9.80
Z12 Contractors Profit		10%			$ 1,481,353	$ 18		7.51
Z2 ALLOWANCES						$ 42	$ 3,421,926	17.36
Z21 Design Allowance		10%			$ 1,629,488	$ 20		8.26
Z22 Escalation Allowance TBD		0%			$ -	$ -		0.00
Z23 Construction Allowance		10%			$ 1,792,437	$ 22		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)				$241 per sf			$ 19,717,000	100.00

QSolv

Element	Quantities		Unit Rates	Sub-totals
EXTERIOR ENCLOSURE				
A31 Walls Below Grade				
▪ remove concrete sidewalk and dispose	11274	sf	$ 3.50	$ 39,460
▪ remove asphalt paving and dispose	21743	sf	$ 3.50	$ 76,102
▪ excavate to 2 feet below grade	237	cyd	$ 40.00	$ 9,485
▪ new 2" EPS insulation	2136	sf	$ 3.50	$ 7,477
▪ cement board	1457	sf	$ 5.00	$ 7,283
▪ backfill to subgrade	237	cyd	$ 50.00	$ 11,856
▪ reinstate concrete sidewalks	11274	sf	$ 18.00	$ 202,935
▪ reinstate asphalt paving	21743	sf	$ 15.00	$ 326,151
A31 Walls Below Grade Total	**2136**	**sf**	**$ 318.66**	**$ 680,750**
A32 Walls Above Grade				
▪ remove masonry façade	22502	sf	$ 6.00	$ 135,013
▪ structural upgrades including base angle and mid girts	183000	lbs	$ 4.00	$ 732,000
▪ supply and install r11 prefab insulated wall panels	20163	sf	$ 26.00	$ 524,235
▪ supply and install prefinished metal siding	22502	sf	$ 45.00	$ 1,012,598
A32 Walls Above Grade Total	**22502**	**sf**	**$ 106.83**	**$ 2,403,845**
A33 Windows and Entrances				
▪ replace overhead doors with R10 overhead doors	4	no	$ 12,000.00	$ 48,000
▪ replace storefront windows with triple pane	1363	sf	$ 145.00	$ 197,635
▪ replace insulated metal exits	13	no	$ 3,800.00	$ 49,400
A33 Windows and Entrances Total	**2423**	**sf**	**$ 121.78**	**$ 295,035**
A34 Roof Coverings				
▪ remove existing roof finish	81928	sf	$ 2.50	$ 204,820
▪ pre-eng wood trusses with nailers	81928	sf	$ 8.00	$ 655,423
▪ new mod bit roof finish with R38 Recover panels	81928	sf	$ 43.00	$ 3,522,899
▪ allowance for removing, reinstalling mechanical	1	sum	$ 50,000.00	$ 50,000
▪ spray fireproof underside of beams, deck	81928	sf	$ 4.00	$ 327,712
▪ fire rated gwb cladding to columns	81928	sf	$ 1.25	$ 102,410
A34 Roof Coverings Total	**81928**	**sf**	**$ 59.36**	**$ 4,863,263**
A35 Projections				
▪ canopies - no change	1	sum	$ -	$ -
A35 Projections Total	**81928**	**sf**	**$ -**	**$ -**
FINISHES				
B22 Ceiling Finishes				
▪ cut and patch ceilings for new mechanical/electrical	40964	sf	$ 5.00	$ 204,820
B22 Ceiling Finishes Total	**81928**	**sf**	**$ 2.50**	**$ 204,820**
B23 Wall Finishes				
▪ cut and patch walls for new mechanical/electrical	81928	sf	$ 0.20	$ 16,386

Element	Quantities		Unit Rates	Sub-totals
▪ patch existing party wall	3246	sf	$ 10.00	$ 32,465
B23 Wall Finishes Total	**81928**	**sf**	**$ 0.60**	**$ 48,850**
MECHANICAL				
C11 Plumbing and Drainage				
▪ new 80gal HPWH hot water tanks	5	no	$ 4,500.00	$ 22,500
C11 Plumbing and Drainage Total	**81928**	**sf**	**$ 0.27**	**$ 22,500**
C12 Fire Protection				
▪ expand wet pipe sprinkler system to include roof cavity	81928	sf	$ 6.00	$ 491,567
C12 Fire Protection Total	**81928**	**sf**	**$ 6.00**	**$ 491,567**
C13 Heating, Ventilation, Air Conditioning				
▪ geothermal wells, testing	17	no	$ 22,000.00	$ 374,000
▪ gshp exterior piping, trenching, backfill, reinstatement	1	sum	$ 45,000.00	$ 45,000
▪ gshp interior piping	1	sum	$ 30,000.00	$ 30,000
▪ gshp-20 tons	2	no	$ 75,000.00	$ 150,000
▪ electric boiler - 110kW	1	no	$ 30,000.00	$ 30,000
▪ HP HX pumps	4	no	$ 12,000.00	$ 48,000
▪ HP BT pumps	4	no	$ 12,000.00	$ 48,000
▪ circulation pumps	4	no	$ 11,000.00	$ 44,000
▪ maintenance circulation pumps	2	no	$ 5,500.00	$ 11,000
▪ electric boiler pump	1	no	$ 6,500.00	$ 6,500
▪ buffer tanks	2	no	$ 15,000.00	$ 30,000
▪ air separators	4	no	$ 3,500.00	$ 14,000
▪ expansion tanks	4	no	$ 2,500.00	$ 10,000
▪ heat exchangers	2	no	$ 15,000.00	$ 30,000
▪ distribution piping	3000	lf	$ 100.00	$ 300,000
▪ fancoils - 4 pipe 10 ton	5	no	$ 12,000.00	$ 60,000
▪ fancoils - 4 pipe 1 ton	3	no	$ 4,000.00	$ 12,000
▪ ERV 25500cfm	1	no	$ 380,000.00	$ 380,000
▪ ERV 3600cfm	1	no	$ 90,000.00	$ 90,000
▪ ERV 320cfm	1	no	$ 3,500.00	$ 3,500
▪ new ERV ductwork	20000	lbs	$ 18.00	$ 360,000
C13 Heating, Ventilation, Air Conditioning Total	**81928**	**sf**	**$ 25.34**	**$ 2,076,000**
C14 Controls				
▪ building automated controls - connect to existing system	81928	sf	$ 7.00	$ 573,495
C14 Controls Total	**81928**	**sf**	**$ 7.00**	**$ 573,495**
ELECTRICAL				
C21 Services and Distribution				
▪ replace main entrance, 800A switchgear	1	sum	$ 150,000.00	$ 150,000
▪ new feeders	1	sum	$ 90,000.00	$ 90,000
▪ new panel, transformer for HVAC	1	sum	$ 50,000.00	$ 50,000
▪ new disconnects, mechanical connections	1	sum	$ 30,000.00	$ 30,000

Element	Quantities		Unit Rates		Sub-totals
C21 Services and Distribution Total	**81928**	**sf**	**$ 3.91**	**$**	**320,000**
C22 Lighting, Devices and Heating					
▪ new interior lighting - LED type	81928	sf	$ 8.00	$	655,423
▪ lighting controls	81928	sf	$ 3.00	$	245,784
C22 Lighting and Heating Total	**81928**	**sf**	**$ 11.00**	**$**	**901,207**
GENERAL REQUIREMENTS AND FEES					
Z11 General Requirements and Overheads					
▪ contractor's overheads			15.00%	$	1,932,200
Z11 General Requirements and Overheads Total	**81928**	**sf**	**$ 23.58**	**$**	**1,932,200**
Z12 Contractor's Profit					
▪ contractor's profit			10.00%	$	1,481,353
Z12 Contractor's Profit Total	**81928**	**sf**	**$ 18.08**	**$**	**1,481,353**
ALLOWANCES					
Z21 Design Allowance					
▪ design development contingency			10.00%	$	1,629,488
Z21 Design Allowance Total	**81928**	**sf**	**$ 19.89**	**$**	**1,629,488**
Z23 Construction Contingency					
▪ construction contingency			10.00%	$	1,792,437
Z23 Construction Contingency	**81928**	**sf**	**$ 21.88**	**$**	**1,792,437**

ELEMENTAL COST SUMMARY

PROJECT: RETROFIT 610 EAST RIVER ROAD
LOCATION: NEW GLASGOW, NS
CLIENT:
DESIGNER: RSI PROJECTS

Scenario 4 Net Zero

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13453
GFA:sf 81928

GROSS FLOOR AREA 81928 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL						$ 101	$ 8,242,893	39.28
A1 SUBSTRUCTURE						$ -	$ -	0.00
A11 Foundations	1.000	81928	sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	81928	sf	$ -	$ -	$ -		0.00
A2 STRUCTURE						$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	81928	sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE						$ 101	$ 8,242,893	39.28
A31 Walls Below Grade	0.026	2136	sf	$ 318.66	$ 680,750	$ 8		3.24
A32 Walls Above Grade	0.275	22502	sf	$ 106.83	$ 2,403,845	$ 29		11.46
A33 Windows and Entrances	0.030	2423	sf	$ 121.78	$ 295,035	$ 4		1.41
A34 Roof Coverings	1.000	81928	sf	$ 59.36	$ 4,863,263	$ 59		23.17
A35 Projections	1.000	81928	sf	$ -	$ -	$ -		0.00
B INTERIORS						$ 3	$ 253,670	1.21
B1 PARTITIONS AND DOORS						$ -	$ -	0.00
B11 Partitions	1.000	81928	sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	81928	sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES						$ 3	$ 253,670	1.21
B21 Floor Finishes	1.000	81928	sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	81928	sf	$ 2.50	$ 204,820	$ 3		0.98
B23 Wall Finishes	1.000	81928	sf	$ 0.60	$ 48,850	$ 1		0.23
B3 FITTINGS AND EQUIPMENT						$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	81928	sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	81928	sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	81928	sf	$ -	$ -	$ -		0.00
SERVICES						$ 64	$ 5,212,769	24.84
C1 MECHANICAL						$ 39	$ 3,163,562	15.08
C11 Plumbing and Drainage	1.000	81928	sf	$ 0.27	$ 22,500	$ 0		0.11
C12 Fire Protection	1.000	81928	sf	$ 6.00	$ 491,567	$ 6		2.34
C13 HVAC	1.000	81928	sf	$ 25.34	$ 2,076,000	$ 25		9.89
C14 Controls	1.000	81928	sf	$ 7.00	$ 573,495	$ 7		2.73
C2 ELECTRICAL						$ 25	$ 2,049,207	9.77
C21 Services and Distribution	1.000	81928	sf	$ 14.01	$ 1,148,000	$ 14		5.47
C22 Lighting, Devices and Heating	1.000	81928	sf	$ 11.00	$ 901,207	$ 11		4.29
C23 Systems and Ancillaries	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE						$ 167	$ 13,709,332	65.33
D SITE & ANCILLARY WORK						$ -	$ -	0.00
D1 SITEWORK						$ -	$ -	0.00
D11 Site Development	1.000	81928	sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	81928	sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK						$ -	$ -	0.00
D21 Demolition	1.000	81928	sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	81928	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE						$ 167	$ 13,709,332	65.33
Z GENERAL REQUIREMENTS AND ALLOWANCES						$ 89	$ 7,274,857	34.67
Z1 GENERAL REQUIREMENTS AND FEES						$ 44	$ 3,632,973	17.31
Z11 General Requirements and Overheads		15%			$ 2,056,400	$ 25		9.80
Z12 Contractors Profit		10%			$ 1,576,573	$ 19		7.51
Z2 ALLOWANCES						$ 44	$ 3,641,884	17.35
Z21 Design Allowance		10%			$ 1,734,230	$ 21		8.26
Z22 Escalation Allowance TBD		0%			$ -	$ -		0.00
Z23 Construction Allowance		10%			$ 1,907,654	$ 23		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)				$256 per sf			$ 20,985,000	100.00

QSolv

Element	Quantities		Unit Rates	Sub-totals
EXTERIOR ENCLOSURE				
A31 Walls Below Grade				
▪ remove concrete sidewalk and dispose	11274	sf	$ 3.50	$ 39,460
▪ remove asphalt paving and dispose	21743	sf	$ 3.50	$ 76,102
▪ excavate to 2 feet below grade	237	cyd	$ 40.00	$ 9,485
▪ new 2" EPS insulation	2136	sf	$ 3.50	$ 7,477
▪ cement board	1457	sf	$ 5.00	$ 7,283
▪ backfill to subgrade	237	cyd	$ 50.00	$ 11,856
▪ reinstate concrete sidewalks	11274	sf	$ 18.00	$ 202,935
▪ reinstate asphalt paving	21743	sf	$ 15.00	$ 326,151
A31 Walls Below Grade Total	**2136**	**sf**	**$ 318.66**	**$ 680,750**
A32 Walls Above Grade				
▪ remove masonry façade	22502	sf	$ 6.00	$ 135,013
▪ structural upgrades including base angle and mid girts	183000	lbs	$ 4.00	$ 732,000
▪ supply and install r11 prefab insulated wall panels	20163	sf	$ 26.00	$ 524,235
▪ supply and install prefinished metal siding	22502	sf	$ 45.00	$ 1,012,598
A32 Walls Above Grade Total	**22502**	**sf**	**$ 106.83**	**$ 2,403,845**
A33 Windows and Entrances				
▪ replace overhead doors with R10 overhead doors	4	no	$ 12,000.00	$ 48,000
▪ replace storefront windows with triple pane	1363	sf	$ 145.00	$ 197,635
▪ replace insulated metal exits	13	no	$ 3,800.00	$ 49,400
A33 Windows and Entrances Total	**2423**	**sf**	**$ 121.78**	**$ 295,035**
A34 Roof Coverings				
▪ remove existing roof finish	81928	sf	$ 2.50	$ 204,820
▪ pre-eng wood trusses with nailers	81928	sf	$ 8.00	$ 655,423
▪ new mod bit roof finish with R38 Recover panels	81928	sf	$ 43.00	$ 3,522,899
▪ allowance for removing, reinstalling mechanical	1	sum	$ 50,000.00	$ 50,000
▪ spray fireproof underside of beams, deck	81928	sf	$ 4.00	$ 327,712
▪ fire rated gwb cladding to columns	81928	sf	$ 1.25	$ 102,410
A34 Roof Coverings Total	**81928**	**sf**	**$ 59.36**	**$ 4,863,263**
A35 Projections				
▪ canopies - no change	1	sum	$ -	$ -
A35 Projections Total	**81928**	**sf**	**$ -**	**$ -**
FINISHES				
B22 Ceiling Finishes				
▪ cut and patch ceilings for new mechanical/electrical	40964	sf	$ 5.00	$ 204,820
B22 Ceiling Finishes Total	**81928**	**sf**	**$ 2.50**	**$ 204,820**
B23 Wall Finishes				
▪ cut and patch walls for new mechanical/electrical	81928	sf	$ 0.20	$ 16,386

Element	Quantities		Unit Rates	Sub-totals
▪ patch existing party wall	3246	sf	$ 10.00	$ 32,465
B23 Wall Finishes Total	**81928**	**sf**	**$ 0.60**	**$ 48,850**
MECHANICAL				
C11 Plumbing and Drainage				
▪ new 80gal HPWH hot water tanks	5	no	$ 4,500.00	$ 22,500
C11 Plumbing and Drainage Total	**81928**	**sf**	**$ 0.27**	**$ 22,500**
C12 Fire Protection				
▪ expand wet pipe sprinkler system to include roof cavity	81928	sf	$ 6.00	$ 491,567
C12 Fire Protection Total	**81928**	**sf**	**$ 6.00**	**$ 491,567**
C13 Heating, Ventilation, Air Conditioning				
▪ geothermal wells, testing	17	no	$ 22,000.00	$ 374,000
▪ gshp exterior piping, trenching, backfill, reinstatement	1	sum	$ 45,000.00	$ 45,000
▪ gshp interior piping	1	sum	$ 30,000.00	$ 30,000
▪ gshp-20 tons	2	no	$ 75,000.00	$ 150,000
▪ electric boiler - 110kW	1	no	$ 30,000.00	$ 30,000
▪ HP HX pumps	4	no	$ 12,000.00	$ 48,000
▪ HP BT pumps	4	no	$ 12,000.00	$ 48,000
▪ circulation pumps	4	no	$ 11,000.00	$ 44,000
▪ maintenance circulation pumps	2	no	$ 5,500.00	$ 11,000
▪ electric boiler pump	1	no	$ 6,500.00	$ 6,500
▪ buffer tanks	2	no	$ 15,000.00	$ 30,000
▪ air separators	4	no	$ 3,500.00	$ 14,000
▪ expansion tanks	4	no	$ 2,500.00	$ 10,000
▪ heat exchangers	2	no	$ 15,000.00	$ 30,000
▪ distribution piping	3000	lf	$ 100.00	$ 300,000
▪ fancoils - 4 pipe 10 ton	5	no	$ 12,000.00	$ 60,000
▪ fancoils - 4 pipe 1 ton	3	no	$ 4,000.00	$ 12,000
▪ ERV 25500cfm	1	no	$ 380,000.00	$ 380,000
▪ ERV 3600cfm	1	no	$ 90,000.00	$ 90,000
▪ ERV 320cfm	1	no	$ 3,500.00	$ 3,500
▪ new ERV ductwork	20000	lbs	$ 18.00	$ 360,000
C13 Heating, Ventilation, Air Conditioning Total	**81928**	**sf**	**$ 25.34**	**$ 2,076,000**
C14 Controls				
▪ building automated controls - connect to existing system	81928	sf	$ 7.00	$ 573,495
C14 Controls Total	**81928**	**sf**	**$ 7.00**	**$ 573,495**
ELECTRICAL				
C21 Services and Distribution				
▪ replace main entrance, 800A switchgear	1	sum	$ 150,000.00	$ 150,000
▪ new feeders	1	sum	$ 90,000.00	$ 90,000
▪ new panel, transformer for HVAC	1	sum	$ 50,000.00	$ 50,000
▪ new disconnects, mechanical connections	1	sum	$ 30,000.00	$ 30,000
▪ photovoltaic system complete with racking, inverters	230	kW	$ 3,600.00	$ 828,000

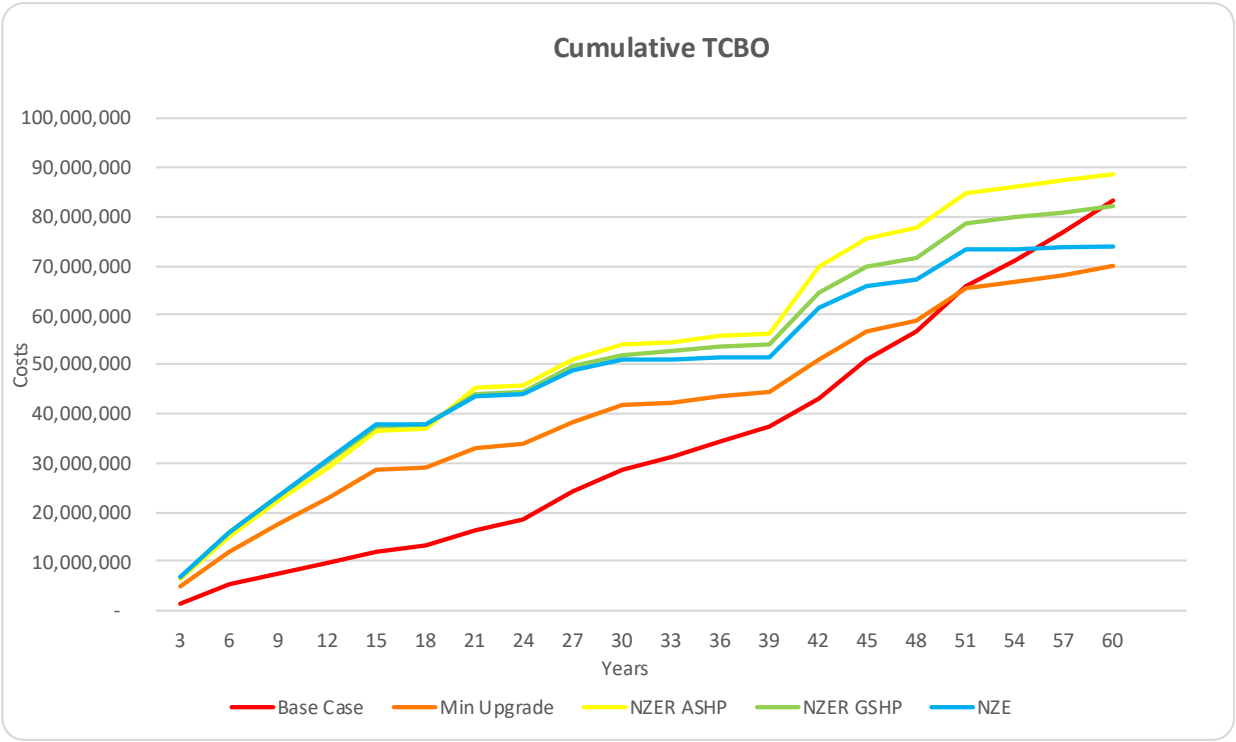
Element	Quantities		Unit Rates		Sub-totals
C21 Services and Distribution Total	**81928**	**sf**	**$ 14.01**	**$**	**1,148,000**
C22 Lighting, Devices and Heating					
▪ new interior lighting - LED type	81928	sf	$ 8.00	$	655,423
▪ lighting controls	81928	sf	$ 3.00	$	245,784
C22 Lighting and Heating Total	**81928**	**sf**	**$ 11.00**	**$**	**901,207**
GENERAL REQUIREMENTS AND FEES					
Z11 General Requirements and Overheads					
▪ contractor's overheads			15.00%	$	2,056,400
Z11 General Requirements and Overheads Total	**81928**	**sf**	**$ 25.10**	**$**	**2,056,400**
Z12 Contractor's Profit					
▪ contractor's profit			10.00%	$	1,576,573
Z12 Contractor's Profit Total	**81928**	**sf**	**$ 19.24**	**$**	**1,576,573**
ALLOWANCES					
Z21 Design Allowance					
▪ design development contingency			10.00%	$	1,734,230
Z21 Design Allowance Total	**81928**	**sf**	**$ 21.17**	**$**	**1,734,230**
Z23 Construction Contingency					
▪ construction contingency			10.00%	$	1,907,654
Z23 Construction Contingency	**81928**	**sf**	**$ 23.28**	**$**	**1,907,654**

Appendix N

Total Cost of Building Ownership

NS Municipal Building - Deep Retrofit

	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
GHG emissions (kg) (60 Years)	33,263,379	10,315,774	10,890,984	9,750,148	0
EUI (kWh/m2/year)	248.6	56.0	36.4	32.6	0.0
TCBO at 60 years	**$83,302,000**	**$70,019,000**	**$88,623,000**	**$82,166,000**	**$73,947,000**
TCBO Savings at 60 years	$0	$13,283,000	-$5,321,000	$1,136,000	$9,355,000
60 Year TCBO savings compared to Base Case		**16%**	**-6%**	**1%**	**11%**



Total Cost of Building Ownership (TCBO)

	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
GHG emissions (kg) (60 Years)	33,263,379	10,315,774	10,890,984	9,750,148	-
EUI (kWh/m2/year)	249	56	36	33	0
TCBO at 12 Years	$ 9,643,000	$ 23,034,000	$ 29,263,000	$ 30,320,000	$ 30,654,000
TCBO at 25 Years	$ 22,835,000	$ 38,054,000	$ 50,674,000	$ 49,202,000	$ 48,623,000
TCBO at 60 years	$ 83,302,000	$ 70,019,000	$ 88,623,000	$ 82,166,000	$ 73,947,000
TCBO Savings at 60 years		$ 13,283,000	$ (5,321,000)	$ 1,136,000	$ 9,355,000
60 Year TCBO savings compared to Base Case		16%	-6%	1%	11%
TCBO/Year/m2	$ 187	$ 157	$ 199	$ 184	$ 166
TCBO/Year/ft2	$ 17	$ 15	$ 18	$ 17	$ 15
60-Year TCBO/m2	$ 11,204	$ 9,418	$ 11,920	$ 11,051	$ 9,946
60-YearTCBO/ft2	$ 1,041	$ 875	$ 1,108	$ 1,027	$ 924
60 Year Energy Cost / m2	$ 5,405	$ 1,194	$ 740	$ 663	$ 3

CAPITAL COST SUMMARY

	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
Initial Retrofit / HPB CostYear 1					
Initial Cost	$ 1,616,000	$15,947,000	$21,487,000	$22,461,000	$23,289,000
Difference from Base Case		$14,331,000	$19,871,000	$20,845,000	$21,673,000
% Over Base Case		887%	1230%	1290%	1341%
Cost ($/ft2)	$ 20.20	$ 199.34	$ 268.59	$ 280.76	$ 291.11
Maintenance Capital Costs 60 Years					
Cost	$21,806,000	$30,976,000	$44,427,000	$37,722,000	$37,604,000
Difference from Base Case		$ 9,170,000	$22,621,000	$15,916,000	$15,798,000
% Over Base Case		42.05%	103.74%	72.99%	72.45%
Cost ($/ft2)	$ 272.58	$ 387.20	$ 555.34	$ 471.53	$ 470.05
Retrofit / HPB + Maintenance Capital Costs 60 Years					
Total Costs	$23,422,000	$46,923,000	$65,914,000	$60,183,000	$60,893,000
Difference from Base Case		$23,501,000	$42,492,000	$36,761,000	$37,471,000
% Over Base Case		100.34%	181.42%	156.95%	159.98%

OPERATING COST SUMMARY

	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
Utilities (including carbon tax)					
Cost	$ 58,279,000	$ 14,812,000	$ 11,743,000	$ 10,565,000	$ 493,000
Difference from Base Case		$(43,467,000)	$(46,536,000)	$(47,714,000)	$(57,786,000)
% Over Base Case		-75%	-80%	-82%	-99%
Energy Cost ($/ft2)	$ 728.49	$ 185.15	$ 146.79	$ 132.06	$ 6.16
Maintenance					
Cost	$ 279,000	$ 302,000	$ 407,000	$ 407,000	$ 1,165,000
Difference from Base Case		$ 23,000	$ 128,000	$ 128,000	$ 886,000
% Over Base Case		8%	46%	46%	318%
Maintenance Cost ($/ft2)	$ 3.49	$ 3.78	$ 5.09	$ 5.09	$ 14.56
Insurance & Taxes					
Costs	$ 570,000	$ 570,000	$ 570,000	$ 570,000	$ 570,000
Difference from Base Case		$ -	$ -	$ -	$ -
% Over Base Case		0%	0%	0%	0%
First Year Annual Maintenance					
Cost	$ 2,400	$ 2,600	$ 3,500	$ 3,500	$ 10,011
Difference from Base Case		$ 200	$ 1,100	$ 1,100	$ 7,611
% Over Base Case		8%	46%	46%	317%
First Year Maintenance Cost ($/ft2)	$ 0.03	$ 0.03	$ 0.04	$ 0.04	$ 0.13

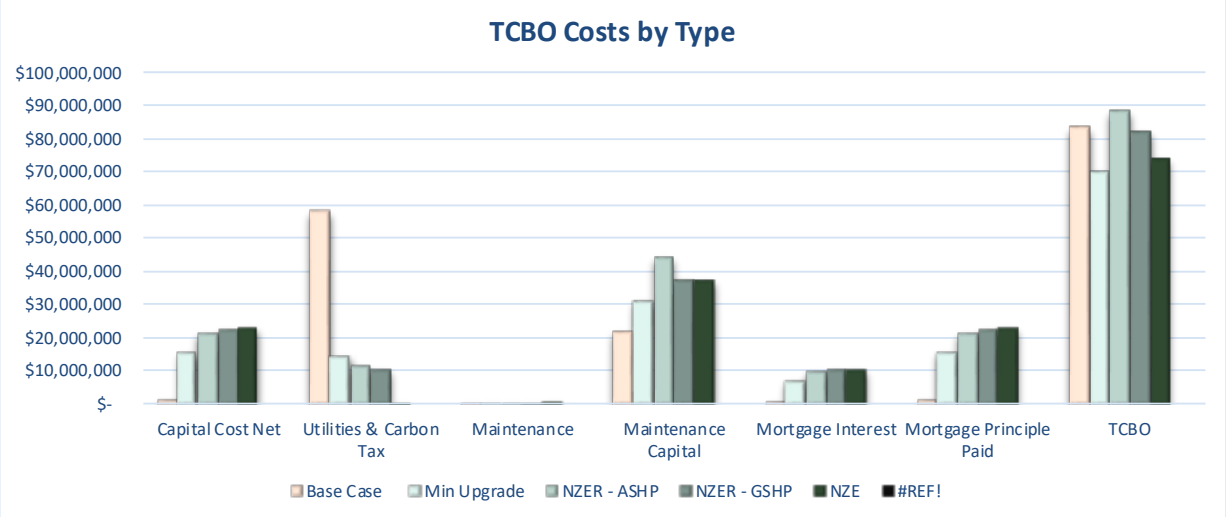
Annual Energy Consumption and GHG Emissions

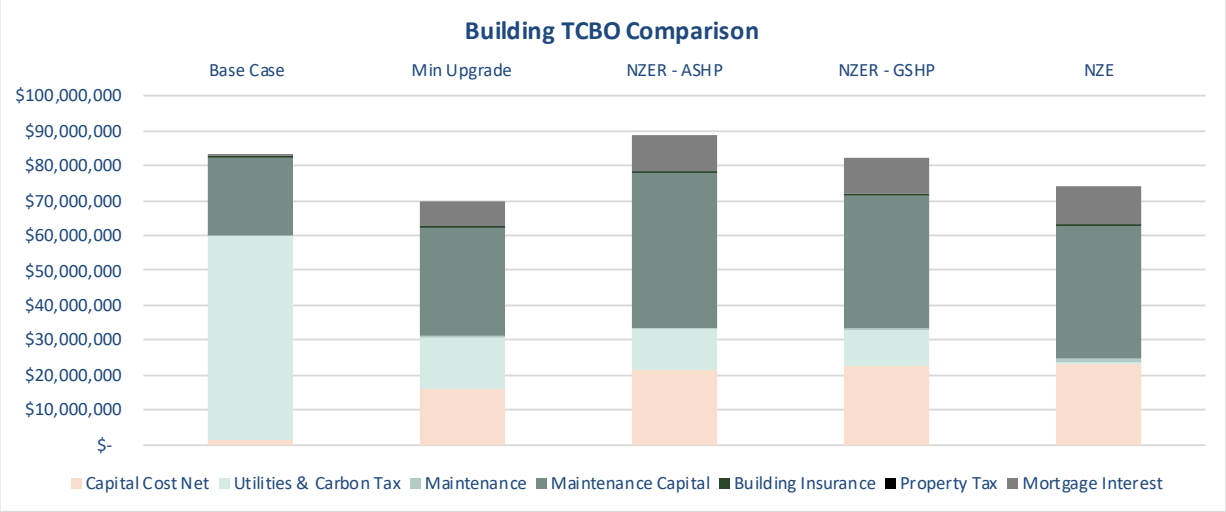
	Units	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
Annual Water Consumption	m3	902	902	902	902	902
Annual Sewer Discharge	m3	902	902	902	902	902
Annual Electric Consumption	kWh	235,673	164,078	270,920	242,541	242,541
Annual Gas Consumption	m3	-	-	-	-	-
Annual Heating Oil Consumption	Litres	148,888	23,281	-	-	-
GHG emissions	kg CO2 eq	554,390	171,930	181,516	162,502	-
Annual Solar PV generated	kWh	-	-	-	-	242,541
Total Annual Energy Consumption	ekWh	1,848,626	416,289	270,920	242,541	-
Total Annual Energy Consumption	GJ	6,655	1,499	975	873	-
EUI	kWh/m2/yr	249	56	36	33	-

60 Year Cost of Ownership Comparison

	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
Capital Cost	$ 1,616,262	$ 15,946,649	$ 21,487,252	$ 22,461,330	$ 23,289,330
Utility Subsidy	$ -	$ -	$ -	$ -	$ -
Capital Cost Net	$ 1,616,262	$ 15,946,649	$ 21,487,252	$ 22,461,330	$ 23,289,330
Utilities & Carbon Tax	$ 58,278,621	$ 14,811,776	$ 11,742,967	$ 10,564,522	$ 492,944
Maintenance	$ 279,198	$ 302,465	$ 407,164	$ 407,164	$ 1,164,615
Maintenance Capital	$ 21,806,278	$ 30,975,641	$ 44,427,242	$ 37,721,931	$ 37,603,745
Building Insurance	$ 570,258	$ 570,258	$ 570,258	$ 570,258	$ 570,258
Property Tax	$ -	$ -	$ -	$ -	$ -
Mortgage Interest	$ 751,297	$ 7,412,586	$ 9,988,061	$ 10,440,847	$ 10,825,732
Mortgage Principle Paid	$ 1,616,262	$ 15,946,649	$ 21,487,252	$ 22,461,330	$ 23,289,330
Mortgage Principal Received	$ (1,616,262)	$ (15,946,649)	$ (21,487,252)	$ (22,461,330)	$ (23,289,330)
TCBO	$ 83,301,913	$ 70,019,374	$ 88,622,943	$ 82,166,052	$ 73,946,624

	Cost as a Percentage of TCBO				
Capital Cost Net	1.9%	22.8%	24.2%	27.3%	31.5%
Utilities & Carbon Tax	70.0%	21.2%	13.3%	12.9%	0.7%
Maintenance	0.3%	0.4%	0.5%	0.5%	1.6%
Maintenance Capital	26.2%	44.2%	50.1%	45.9%	50.9%
Building Insurance	0.7%	0.8%	0.6%	0.7%	0.8%
Property Tax	0.0%	0.0%	0.0%	0.0%	0.0%
Mortgage Interest	0.9%	10.6%	11.3%	12.7%	14.6%
TCBO	100.0%	100.0%	100.0%	100.0%	100.0%





INPUTS : General

	Units	Base Case	Min Upgrade	NZER - ASHP	NZER - GSHP	NZE
Utility Costs						
Water						
unit water cost	$/m3	1.46	1.46	1.46	1.46	1.46
annual water escalation rate	%	3%	3%	3%	3%	3%
include annual "Basic Charge Water" for active service, else 0	$/year	236.92	236.92	236.92	236.92	236.92
"Basic Charge Water" escalation rate	%	4%	4%	4%	4%	4%
annual consumption	m3	902	902	902	902	902
refrofit reduction	%	0%	0%	0%	0%	0%
Sewer						
unit sewer cost	$/m3	1.34	1.34	1.34	1.34	1.34
annual sewer escalation rate	%	3%	3%	3%	3%	3%
include annual "Basic Charge Sewer" for active service, else 0	$/year					
"Basic Charge Sewer" escalation rate	%	3%	3%	3%	3%	3%
annual consumption	m3	902	902	902	902	902
refrofit reduction	%	0				
Electricity						
unit cost	$/kWh	$ 0.12	$ 0.12	$ 0.12	$ 0.12	$ 0.12
annual escalation rate	%	3%	3%	3%	3%	3%
include annual "Basic Charge" for active service, else 0	$/year	151.8	151.8	151.8	151.8	151.8
"Basic Charge" escalation rate	%	3%	3%	3%	3%	3%
GHG emission factor	kg/kWh	0.67	0.67	0.67	0.67	0.67
Is Carbon Tax ADDED TO energy cost?	No = 0 or Yes = 1	1	1	1	1	1
annual consumption	kWh	235673	164078	270920	242541	242541
refrofit reduction (only use this when TCPO calculation)	%	0%	0%	0%	0%	0%

Natural Gas						
unit cost	$/m3					
annual escalation rate	%					
include annual "Basic Charge" for active service, else 0	$/year					
"Basic Charge" escalation rate	%					
GHG emission factor	kg/m3	1.902355	1.902355	1.902355	1.902355	1.902355
Is Carbon Tax ADDED TO energy cost?	No = 0 or Yes = 1	1	1	1	1	1
annual consumption	m3					
refrofit reduction	%	0%	100%	100%	100%	100%

No 2 Heating Oil						
unit cost	$/Litre	$ 1.46	$ 1.46			
annual escalation rate	%	3%	3%	3%	3%	3%
include annual "Basic Charge" for active service, else 0	$/year					
"Basic Charge" escalation rate	%	3%	3%	3%	3%	3%
GHG emission factor	kg/L	2.663	2.663	2.663	2.663	2.663
Is Carbon Tax ADDED TO energy cost?	No = 0 or Yes = 1	1				
annual consumption	Litres	148888	23281			
refrofit reduction	%	0				

GHG Emissions

Carbon Tax escalation rate - after carbon tax finishes	%	4%	4%	4%	4%	4%
Carbon Tax Year		2020	2030	2040	2050	2060	2070
GHG unit cost ($/tonne)		$ 30.00	$ 170.00	$ 251.64	$ 372.49	$ 551.38	$ 816.17
Carbon Tax for Project Year		$ 80.00	$ 198.88	$ 294.38	$ 435.76	$ 645.03	$ 954.81

Mortgage Financing of New Investment						
1st Year New Investment Capital Amount	$	No input here - See Value Tab Calculation				
Percent of 1st Year Capital Investment Financed with Mortgage	%	100%	100%	100%	100%	100%
Mortgage Financing of New Investment		No input here - See Value Tab Calculation				
Interest Rate	%	5.50%	5.50%	5.50%	5.50%	5.50%
Amortization in Years	#	15	15	15	15	15
Start Date (yyyy-mm-dd)		2023-12-31	2023-12-31	2023-12-31	2023-12-31	2023-12-31

Property Tax						
property tax lump sum OR	$					
property tax rate (% of building value) (e.g. .43%)	%					
property tax escalation rate	%	1.50%	1.50%	1.50%	1.50%	1.50%

Insurance						
property insurance annual cost lump sum OR	$	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
property insurance rate (% of building value) (e.g. .27%)	%					
property insurance escalation rate	%	2.00%	2.00%	2.00%	2.00%	2.00%

Property Market Value Forecast by Decade:						
0-10 years	%	4.00%	4.00%	4.00%	4.00%	4.00%
11-20 years	%	4.00%	4.00%	4.00%	4.00%	4.00%
21-30 years	%	4.00%	4.00%	4.00%	4.00%	4.00%
31-40 years	%	4.00%	4.00%	4.00%	4.00%	4.00%
41-50 years	%	4.00%	4.00%	4.00%	4.00%	4.00%
51-60 years	%	4.00%	4.00%	4.00%	4.00%	4.00%

Market Value Inputs						
Project Type - Either Retrofit or New Build only	Input	Retrofit	Retrofit	Retrofit	Retrofit	Retrofit
Current Building Value (normally existing building at current status (before new capital investment) or New Code Built Building). Include Comments on the source of Market Value Information.		replacement cost $150/ft2				
Market Value Base Case For Retrofits only (else Zero)	Input $	$ 12,300,000.00				
New Investment Project Cost - A thru F		No input here - See Value Tab Calculation				
New Investment over Current Market Value		No input here - See Value Tab Calculation				
Rate of Inclusion of New Investment for Mkt Val Calc.	Input %	75.00%	75.00%	75.00%	75.00%	75.00%
Market Value Estimate Upon Completion of the Project		No input here - See Value Tab Calculation				
Net Present Value Rate (NPV) for Discounting Results		0.0242				
Annual Service Cost Escalation Rate		2.00%	2.00%	2.00%	2.00%	2.00%
Annual Capital Cost Escalation Rate		2.00%	2.00%	2.00%	2.00%	2.00%

Total Cost of Portfolio Ownership						
Is this a TCPO calculation	No = 0 or Yes = 1	0	0	0	0	0
Year 1 Retrofit Capital Unit Cost	$/ft2	Base Case				
Year 1 Retrofit Capital Total Cost	$	See Value Tab				
Maintenance Capital Cost Reduction for Retrofit	%	0%				

Solar PV Array						
Array Unit Cost	$/kWdc					$ 3,600.00
Array Size	kWdc	-	-	-	-	230
Total System Cost	$					$828,000.00
System Annual Maintenance Cost (1)	$/kWdc/year					$ 28.31
Total System Annual Maintenance Cost	$/year					$ 6,511.08
Annual Solar Energy Output Degradation	%					0
Unit cost of solar energy displacing utility energy	$/kWac	$ 0.12	$ 0.12	$ 0.12	$ 0.12	$ 0.12
Annual Solar Energy Produced, Displacing Utility Energy	kWh/year					242,541
Unit cost of solar energy generated back to the grid	$/kWhac					
Annual Solar Energy Generated Back to the Grid	kWh/year					

Input : Base Case

BASE CASE

Line No.	Building Components Subject to M&R	Include in Option	Cost	Useful Life (years)	Current Age	Annual Service Cost	Annual Service Cost Escalation Rate	Annual Capital Cost Escalation Rate
	Units	0=no or 1=yes	$	Years	Years	$	2.00%	2.00%
1	Concrete Foundation	0	$ 46,760	61	0		2.00%	2.00%
2	Slab on Grade: Repair rear overhead door area	1	$ 38,550	40	40		2.00%	2.00%
3	Slab on Grade	0	$ 115,518	61	0		2.00%	2.00%
4	Steel columns and joists (assessment)	1	$ 5,500	61	0		2.00%	2.00%
5	Steel Superstructure	0	$ 2,087,500	61	0		2.00%	2.00%
6	Modified Bitumen Roof - Southeast quadrant	1	$ 374,000	20	15	$ 500	2.00%	2.00%
7	Modified Bitumen Roof - Southwest quadrant	1	$ 374,000	20	15		2.00%	2.00%
8	Modified Bitumen Roof - Northwest quadrant	1	$ 374,000	20	12		2.00%	2.00%
9	Modified Bitumen Roof - Northeast quadrant	1	$ 374,000	20	15		2.00%	2.00%
10	Prefinished Metal Awning - maintenance	1	$ 6,750	35	34		2.00%	2.00%
11	Prefinished Metal Awning - replacement	1	$ 67,500	35	12		2.00%	2.00%
12	Brick Exterior Walls - repointing	1	$ 43,750	5	5		2.00%	2.00%
13	Brick Exterior Walls - replace	1	$ 603,750	75	25		2.00%	2.00%
14	Concrete block walls - repointing	1	$ 31,250	75	70		2.00%	2.00%
15	Overhead Door - East side (oversized door)	1	$ 10,000	15	10		2.00%	2.00%
16	Overhead Door - Heavy Equipment maintenance bay SE Corner	1	$ 7,500	15	10		2.00%	2.00%
17	Overhead Door - Sidewalk vehicle storage	1	$ 5,500	15	10		2.00%	2.00%
18	Front entrance Door, Automatic sliding double doors	1	$ 7,500	35	35		2.00%	2.00%
19	Curtain Glass Glazing, front elevation	1	$ 112,640	35	25		2.00%	2.00%
20	Aluminium framed entrance door inset into curtain wall	1	$ 2,500	35	22		2.00%	2.00%
21	Double Steel Entrance - East Side	1	$ 2,500	25	17		2.00%	2.00%
22	Double Steel Entrance - South Side	1	$ 2,500	25	23		2.00%	2.00%
23	Single Steel entrance door east side	1	$ 1,000	25	7		2.00%	2.00%
24	Single Steel entrance door south side	1	$ 1,000	25	7		2.00%	2.00%
25	Windows - vinyl framed	1	$ -	35	4		2.00%	2.00%
26	VCT Flooring, retail area	1	$ 453,611	25	25		2.00%	2.00%
27	Office flooring	1	$ 292,842	25	20		2.00%	2.00%
28	Washroom Flooring	1	$ 7,250	50	50		2.00%	2.00%
29	Gypsum Board Walls	0	$ -	60	40		2.00%	2.00%
30	Suspended Tile Ceiling - Retail area	0	$ 317,860	20	20		2.00%	2.00%
31	Interior Doors	1	$ -	60	40		2.00%	2.00%
32	Washroom Ceilings - splined tiles	1	$ 3,455	20	13		2.00%	2.00%
33	Washroom Vanities	1	$ 6,000	20	10		2.00%	2.00%
34	Washroom Partitions	1	$ 8,750	30	27		2.00%	2.00%
35	Plumbing Service	1	$ -	40	25		2.00%	2.00%
36	Back flow preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
37	Domestic Hot Water Tank- Giant 2018	1	$ 1,500	10	4		2.00%	2.00%
38	Domestic Hot Water Tank- Giant 2017	1	$ 1,500	10	5		2.00%	2.00%
39	Domestic Hot Water Tank- Bradford and White	1	$ 1,500	10	5		2.00%	2.00%
40	Copper Piping Distribution - repair allowance	1	$ 7,500	5	5		2.00%	2.00%
41	Plumbing Fixtures, sinks, urinal, toilets	1	$ 18,000	35	27		2.00%	2.00%
42	Fuel Oil Tank 20000 l estimated	1	$ 10,000	30	22		2.00%	2.00%
43	Volcano Boiler 100 hp rating	1	$ 106,470	25	25	$ 500	2.00%	2.00%
44	Air Handling Unit- coil	1	$ 16,450	30	16	$ 100	2.00%	2.00%
45	Air Handling Unit	1	$ 14,650	35	35	$ 100	2.00%	2.00%

Line No.	Building Components Subject to M&R	Include in Option 0=no or 1=yes		Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
46	Fan Coil Units (FCU)	1	$	-	15	15		2.00%	2.00%
47	Main Disconnect Square D, 800A 600V	1	$	24,150	40	40		2.00%	2.00%
48	Transformers	1	$	-	40	20		2.00%	2.00%
49	Secondary disconnects	1	$	25,000	40	40		2.00%	2.00%
50	Branch Wiring and secondary panels	1	$	5,000	5	5		2.00%	2.00%
51	Lighting - Retail and office areas	1	$	477,260	20	20		2.00%	2.00%
52	Lighting, Metal Halide Pendant	1	$	-	20	5		2.00%	2.00%
53	Exit Signs and battery backup emergency lighting	1	$	-	40	30		2.00%	2.00%
54	Sprinkler system	1	$	-	40	40	$ 1,000	2.00%	2.00%

Input : Min Upgrade

BASE CASE

Line No.	Building Components Subject to M&R Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
1	Concrete Foundation	0	$ 46,760	61	0		2.00%	2.00%
2	Slab on Grade: Repair rear overhead door area	1	$ 38,550	40	40		2.00%	2.00%
3	Slab on Grade	0	$ 115,518	61	0		2.00%	2.00%
4	Steel columns and joists (assessment)	1	$ 5,500	61	0		2.00%	2.00%
5	Steel Superstructure	0	$ 2,087,500	61	0		2.00%	2.00%
6	Modified Bitumen Roof - Southeast quadrant	1	$ 374,000	20	15	$ 500	2.00%	2.00%
7	Modified Bitumen Roof - Southwest quadrant	1	$ 374,000	20	15		2.00%	2.00%
8	Modified Bitumen Roof - Northwest quadrant	1	$ 374,000	20	12		2.00%	2.00%
9	Modified Bitumen Roof - Northeast quadrant	1	$ 374,000	20	15		2.00%	2.00%
10	Prefinished Metal Awning - maintenance	1	$ 6,750	35	34		2.00%	2.00%
11	Prefinished Metal Awning - replacement	1	$ 67,500	35	12		2.00%	2.00%
12	Brick Exterior Walls - repointing	1	$ 43,750	5	5		2.00%	2.00%
13	Brick Exterior Walls - replace	1	$ 603,750	75	25		2.00%	2.00%
14	Concrete block walls - repointing	1	$ 31,250	75	70		2.00%	2.00%
15	Overhead Door - East side (oversized door)	1	$ 10,000	15	10		2.00%	2.00%
16	Overhead Door - Heavy Equipment maintenance bay SE Corner	1	$ 7,500	15	10		2.00%	2.00%
17	Overhead Door - Sidewalk vehicle storage	1	$ 5,500	15	10		2.00%	2.00%
18	Front entrance Door, Automatic sliding double doors	1	$ 7,500	35	35		2.00%	2.00%
19	Curtain Glass Glazing, front elevation	1	$ 112,640	35	25		2.00%	2.00%
20	Aluminium framed entrance door inset into curtain wall	1	$ 2,500	35	22		2.00%	2.00%
21	Double Steel Entrance - East Side	1	$ 2,500	25	17		2.00%	2.00%
22	Double Steel Entrance - South Side	1	$ 2,500	25	23		2.00%	2.00%
23	Single Steel entrance door east side	1	$ 1,000	25	7		2.00%	2.00%
24	Single Steel entrance door south side	1	$ 1,000	25	7		2.00%	2.00%
25	Windows - vinyl framed	1	$ -	35	4		2.00%	2.00%
26	VCT Flooring, retail area	1	$ 453,611	25	25		2.00%	2.00%
27	Office flooring	1	$ 292,842	25	20		2.00%	2.00%
28	Washroom Flooring	1	$ 7,250	50	50		2.00%	2.00%
29	Gypsum Board Walls	1	$ -	60	40		2.00%	2.00%
30	Suspended Tile Ceiling - Retail area	0	$ 317,860	20	20		2.00%	2.00%
31	Interior Doors	1	$ -	60	40		2.00%	2.00%
32	Washroom Ceilings - splined tiles	1	$ 3,455	20	13		2.00%	2.00%
33	Washroom Vanities	1	$ 6,000	20	10		2.00%	2.00%
34	Washroom Partitions	1	$ 8,750	30	27		2.00%	2.00%
35	Plumbing Service	1	$ -	40	25		2.00%	2.00%
36	Back flow preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
37	Domestic Hot Water Tank- Giant 2018	1	$ 1,500	10	4		2.00%	2.00%
38	Domestic Hot Water Tank- Giant 2017	1	$ 1,500	10	5		2.00%	2.00%
39	Domestic Hot Water Tank- Bradford and White	1	$ 1,500	10	5		2.00%	2.00%
40	Copper Piping Distribution - repair allowance	1	$ 7,500	5	5		2.00%	2.00%
41	Plumbing Fixtures, sinks, urinal, toilets	1	$ 18,000	35	27		2.00%	2.00%
42	Fuel Oil Tank 20000 l estimated	1	$ 10,000	30	22		2.00%	2.00%
43	Volcano Boiler 100 hp rating	0	$ 106,470	40	40		2.00%	2.00%
44	Air Handling Unit- coil	1	$ 16,450	30	16		2.00%	2.00%
45	Air Handling Unit	1	$ 14,650	40	35		2.00%	2.00%
46	Fan Coil Units (FCU)	1	$ -	15	15		2.00%	2.00%

	Line No.	Building Components Subject to M&R Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
	47	Main Disconnect Square D, 800A 600V	1	$ 24,150	40	40		2.00%	2.00%
	48	Transformers	1	$ -	40	20		2.00%	2.00%
	49	Secondary disconnects	1	$ 25,000	40	40		2.00%	2.00%
	50	Branch Wiring and secondary panels	1	$ 5,000	5	5		2.00%	2.00%
	51	Lighting - Retail and office areas	1	$ 477,260	20	20		2.00%	2.00%
	52	Lighting, Metal Halide Pendant	1	$ -	20	5		2.00%	2.00%
	53	Exit Signs and battery backup emergency lighting	1	$ -	40	30		2.00%	2.00%
	54	Sprinkler system	1	$ -	40	40	$ 1,000	2.00%	2.00%
RETROFIT	109	A32 Walls Above Grade	1					2.00%	2.00%
	110	remove masonry façade	1	$ 135,013	61	0		2.00%	2.00%
	111	structural upgrades including base angle and mid girts	1	$ 732,000	61	0		2.00%	2.00%
	112	supply and install r11 prefab insulated wall panels	1	$ 524,235	61	0		2.00%	2.00%
	113	supply and install prefinished metal siding	1	$ 1,012,598	61	0		2.00%	2.00%
	114	A33 Windows and Entrances	1					2.00%	2.00%
	115	replace overhead doors with R10 overhead doors	1	$ 48,000	20	0	$ 500	2.00%	2.00%
	116	replace storefront windows with triple pane	1	$ 197,635	30	0		2.00%	2.00%
	117	replace insulated metal exits	1	$ 49,400	25	0		2.00%	2.00%
	118	A34 Roof Coverings	1					2.00%	2.00%
	119	remove existing roof finish	1	$ 204,820	61	0		2.00%	2.00%
	120	pre-eng wood trusses with nailers	1	$ 655,423	61	0		2.00%	2.00%
	121	new mod bit roof finish with R38 Recover panels	1	$ 3,359,043	20	0		2.00%	2.00%
	122	allowance for removing, reinstalling mechanical	1	$ 45,000	61	0		2.00%	2.00%
	123	spray fireproof underside of beams, deck	1	$ 327,712	61	0		2.00%	2.00%
	124	fire rated gwb cladding to columns	1	$ 102,410	61	0		2.00%	2.00%
	125	A35 Projections	1					2.00%	2.00%
	126	canopies - no change	1					2.00%	2.00%
	127	B22 Ceiling Finishes	1					2.00%	2.00%
	128	cut and patch ceilings for new mechanical/electrical	1	$ 204,820	61	0		2.00%	2.00%
	129	B23 Wall Finishes	1					2.00%	2.00%
	130	cut and patch walls for new mechanical/electrical	1	$ 8,193	61	0		2.00%	2.00%
	131	patch existing party wall	1	$ 32,465	61	0		2.00%	2.00%
	132	C11 Plumbing	1					2.00%	2.00%
	133		1					2.00%	2.00%
	134	C12 Fire Protection	1					2.00%	2.00%
	135	expand wet pipe sprinkler system to include roof cavity	1	$ 491,567	61	0		2.00%	2.00%
	136	C13 HVAC	1					2.00%	2.00%
	137	new 480kW boiler connected to existing system	1	$ 120,000	30	0	$ 100	2.00%	2.00%
	153		1					2.00%	2.00%
	154	ERV 25500cfm	1	$ 380,000	25	0	$ 100	2.00%	2.00%
	155		1					2.00%	2.00%
	156	ERV 320cfm	1	$ 3,500	25	0	$ 100	2.00%	2.00%
	157	new ERV ductwork	1	$ 36,000	61	0		2.00%	2.00%
	158	C14 Controls	1					2.00%	2.00%
	159	building automated controls - connect to existing system	1	$ 45,000	20	0	$ 100	2.00%	2.00%
	160	C21 Services and Dostribution	1					2.00%	2.00%
	161		1					2.00%	2.00%
	166	C22 Lighting, Devices and Heating	1					2.00%	2.00%
	167	install LED retrofit kits to all existing lights	1	$ 163,856	15	0	$ -	2.00%	2.00%
	168	upgrade selective mechanical connections	1	$ 7,500	40	0	$ -	2.00%	2.00%

Line No.	Building Components Subject to M&R	Include in Option	Cost	Useful Life (years)	Current Age	Annual Service Cost	Annual Service Cost Escalation Rate	Annual Capital Cost Escalation Rate
	Units	0=no or 1=yes	$	Years	Years	$	2.00%	2.00%
169	Z11 General Requirements and Overheads	1					2.00%	2.00%
170	contractor's overheads	1	$ 1,332,929	61	0		2.00%	2.00%
171	Z12 Contractor's Profit	1					2.00%	2.00%
172	contractor's profit	1	$ 1,021,912	61	0		2.00%	2.00%
173	Z21 Design Allowance	1					2.00%	2.00%
174	design development contingency	1	$ 1,124,103	61	0		2.00%	2.00%
175	Z23 Construction Contingency	1					2.00%	2.00%
176	construction contingency	1	$ 1,236,513	61	0		2.00%	2.00%
177		1					2.00%	2.00%
180	construction escalation for 2024	1	$ 888,619	61	0		2.00%	2.00%

Input : NZER - ASHP

BASE CASE

Line No.	Building Components Subject to M&R	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
1	Concrete Foundation	0	$ 46,760	61	0	$ -	2.00%	2.00%
2	Slab on Grade: Repair rear overhead door area	1	$ 38,550	40	40	$ -	2.00%	2.00%
3	Slab on Grade	0	$ 115,518	61	0	$ -	2.00%	2.00%
4	Steel columns and joists (assessment)	1	$ 5,500	61	0	$ -	2.00%	2.00%
5	Steel Superstructure	0	$ 2,087,500	61	0	$ -	2.00%	2.00%
6	Modified Bitumen Roof - Southeast quadrant	1	$ 374,000	20	15	$ 500	2.00%	2.00%
7	Modified Bitumen Roof - Southwest quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
8	Modified Bitumen Roof - Northwest quadrant	1	$ 374,000	20	12	$ -	2.00%	2.00%
9	Modified Bitumen Roof - Northeast quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
10	Prefinished Metal Awning - maintenance	1	$ 6,750	35	34	$ -	2.00%	2.00%
11	Prefinished Metal Awning - replacement	1	$ 67,500	35	12	$ -	2.00%	2.00%
12	Brick Exterior Walls - repointing	1	$ 43,750	5	5	$ -	2.00%	2.00%
13	Brick Exterior Walls - replace	1	$ 603,750	75	25	$ -	2.00%	2.00%
14	Concrete block walls - repointing	1	$ 31,250	75	70	$ -	2.00%	2.00%
15	Overhead Door - East side (oversized door)	1	$ 10,000	15	10	$ -	2.00%	2.00%
16	Overhead Door - Heavy Equipment maintenance bay SE Corner	1	$ 7,500	15	10	$ -	2.00%	2.00%
17	Overhead Door - Sidewalk vehicle storage	1	$ 5,500	15	10	$ -	2.00%	2.00%
18	Front entrance Door, Automatic sliding double doors	1	$ 7,500	35	35	$ -	2.00%	2.00%
19	Curtain Glass Glazing, front elevation	1	$ 112,640	35	25	$ -	2.00%	2.00%
20	Aluminium framed entrance door inset into curtain wall	1	$ 2,500	35	22	$ -	2.00%	2.00%
21	Double Steel Entrance - East Side	1	$ 2,500	25	17	$ -	2.00%	2.00%
22	Double Steel Entrance - South Side	1	$ 2,500	25	23	$ -	2.00%	2.00%
23	Single Steel entrance door east side	1	$ 1,000	25	7	$ -	2.00%	2.00%
24	Single Steel entrance door south side	1	$ 1,000	25	7	$ -	2.00%	2.00%
25	Windows - vinyl framed	1	$ -	35	4	$ -	2.00%	2.00%
26	VCT Flooring, retail area	1	$ 453,611	25	25	$ -	2.00%	2.00%
27	Office flooring	1	$ 292,842	25	20	$ -	2.00%	2.00%
28	Washroom Flooring	1	$ 7,250	50	50	$ -	2.00%	2.00%
29	Gypsum Board Walls	1	$ -	60	40	$ -	2.00%	2.00%
30	Suspended Tile Ceiling - Retail area	0	$ 317,860	20	20	$ -	2.00%	2.00%
31	Interior Doors	1	$ -	60	40	$ -	2.00%	2.00%
32	Washroom Ceilings - splined tiles	1	$ 3,455	20	13	$ -	2.00%	2.00%
33	Washroom Vanities	1	$ 6,000	20	10	$ -	2.00%	2.00%
34	Washroom Partitions	1	$ 8,750	30	27	$ -	2.00%	2.00%
35	Plumbing Service	1	$ -	40	25	$ -	2.00%	2.00%
36	Back flow preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
37	Domestic Hot Water Tank- Giant 2018	1	$ 1,500	10	4	$ -	2.00%	2.00%
38	Domestic Hot Water Tank- Giant 2017	1	$ 1,500	10	5	$ -	2.00%	2.00%
39	Domestic Hot Water Tank- Bradford and White	1	$ 1,500	10	5	$ -	2.00%	2.00%
40	Copper Piping Distribution - repair allowance	1	$ 7,500	5	5	$ -	2.00%	2.00%
41	Plumbing Fixtures, sinks, urinal, toilets	1	$ 18,000	35	27	$ -	2.00%	2.00%
42	Fuel Oil Tank 20000 l estimated	1	$ 10,000	30	22	$ -	2.00%	2.00%
43	Volcano Boiler 100 hp rating	0	$ 106,470	40	40	$ -	2.00%	2.00%
44	Air Handling Unit- coil	1	$ 16,450	30	16	$ -	2.00%	2.00%
45	Air Handling Unit	1	$ 14,650	40	35	$ -	2.00%	2.00%

	Line No.	Building Components Subject to M&R Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
	46	Fan Coil Units (FCU)	1	$ -	15	15	$ -	2.00%	2.00%
	47	Main Disconnect Square D, 800A 600V	1	$ 24,150	40	40	$ -	2.00%	2.00%
	48	Transformers	1	$ -	40	20	$ -	2.00%	2.00%
	49	Secondary disconnects	1	$ 25,000	40	40	$ -	2.00%	2.00%
	50	Branch Wiring and secondary panels	1	$ 5,000	5	5	$ -	2.00%	2.00%
	51	Lighting - Retail and office areas	1	$ 477,260	20	20	$ -	2.00%	2.00%
	52	Lighting, Metal Halide Pendant	1	$ -	20	5	$ -	2.00%	2.00%
	53	Exit Signs and battery backup emergency lighting	1	$ -	40	30	$ -	2.00%	2.00%
	54	Sprinkler system	1	$ -	40	40	$ 1,000	2.00%	2.00%
	99		1					2.00%	2.00%
	100	A31 Walls Below Grade	1					2.00%	2.00%
	101	remove concrete sidewalk and dispose	1	$ 39,460	61	0		2.00%	2.00%
	102	remove asphalt paving and dispose	1	$ 76,102	61	0		2.00%	2.00%
	103	excavate to 2 feet below grade	1	$ 9,485	61	0		2.00%	2.00%
	104	new 2" EPS insulation	1	$ 7,477	61	0		2.00%	2.00%
	105	cement board	1	$ 7,283	61	0		2.00%	2.00%
	106	backfill to subgrade	1	$ 11,856	61	0		2.00%	2.00%
	107	reinstate concrete sidewalks	1	$ 202,935	61	0		2.00%	2.00%
	108	reinstate asphalt paving	1	$ 326,151	61	0		2.00%	2.00%
	109	A32 Walls Above Grade	1					2.00%	2.00%
	110	remove masonry façade	1	$ 135,013	61	0		2.00%	2.00%
	111	structural upgrades including base angle and mid girts	1	$ 732,000	61	0		2.00%	2.00%
	112	supply and install r11 prefab insulated wall panels	1	$ 524,235	61	0		2.00%	2.00%
	113	supply and install prefinished metal siding	1	$ 1,012,598	61	0		2.00%	2.00%
	114	A33 Windows and Entrances	1					2.00%	2.00%
	115	replace overhead doors with R10 overhead doors	1	$ 48,000	20	0	$ 500	2.00%	2.00%
	116	replace storefront windows with triple pane	1	$ 197,635	30	0	$ -	2.00%	2.00%
	117	replace insulated metal exits	1	$ 49,400	25	0	$ -	2.00%	2.00%
	118	A34 Roof Coverings	1					2.00%	2.00%
	119	remove existing roof finish	1	$ 204,820	61	0	$ -	2.00%	2.00%
	120	pre-eng wood trusses with nailers	1	$ 655,423	61	0	$ -	2.00%	2.00%
	121	new mod bit roof finish with R38 Recover panels	1	$ 3,522,899	20	0	$ -	2.00%	2.00%
	122	allowance for removing, reinstalling mechanical	1	$ 50,000	61	0	$ -	2.00%	2.00%
	123	spray fireproof underside of beams, deck	1	$ 327,712	61	0	$ -	2.00%	2.00%
	124	fire rated gwb cladding to columns	1	$ 102,410	61	0	$ -	2.00%	2.00%
	125	A35 Projections	1		0	0	$ -	2.00%	2.00%
	126	canopies - no change	1		0	0	$ -	2.00%	2.00%
	127	B22 Ceiling Finishes	1		0	0	$ -	2.00%	2.00%
	128	cut and patch ceilings for new mechanical/electrical	1	$ 204,820	61	0	$ -	2.00%	2.00%
	129	B23 Wall Finishes	1		0	0	$ -	2.00%	2.00%
	130	cut and patch walls for new mechanical/electrical	1	$ 16,386	61	0	$ -	2.00%	2.00%
	131	patch existing party wall	1	$ 32,465	61	0	$ -	2.00%	2.00%
	132	C11 Plumbing	1					2.00%	2.00%
	133	new 80gal HPWH hot water tanks	1	$ 22,500	14	0	$ -	2.00%	2.00%
	134	C12 Fire Protection	1					2.00%	2.00%
RETROFIT	135	expand wet pipe sprinkler system to include roof cavity	1	$ 491,567	61	0		2.00%	2.00%
	136	C13 HVAC	1					2.00%	2.00%
	137	ASHP-24 tons	1	$ 180,000	15	0	$ 100	2.00%	2.00%
	138	electric boiler - 120kW	1	$ 30,000	30	0	$ 100	2.00%	2.00%
	139	HP HX pumps	1	$ 48,000	15	0	$ 50	2.00%	2.00%
	140	HP BT pumps	1	$ 48,000	15	0	$ 50	2.00%	2.00%
	141		1					2.00%	2.00%

Line No.	Building Components Subject to M&R	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
142		1					2.00%	2.00%
143		1					2.00%	2.00%
144	circulation pumps	1	$ 44,000	25	0		2.00%	2.00%
145	maintenance circulation pumps	1	$ 11,000	25	0		2.00%	2.00%
146	electric boiler pump	1	$ 6,500	25	0		2.00%	2.00%
147	buffer tanks	1	$ 30,000	25	0		2.00%	2.00%
148	air separators	1	$ 14,000	25	0		2.00%	2.00%
149	expansion tanks	1	$ 10,000	25	0		2.00%	2.00%
150	heat exchangers	1	$ 30,000	25	0		2.00%	2.00%
151	distribution piping	1	$ 300,000	61	0		2.00%	2.00%
152	fancoils - 4 pipe 5 ton	1	$ 37,500	25	0		2.00%	2.00%
153	fancoils - 4 pipe 1 ton	1	$ 20,000	25	0		2.00%	2.00%
154	ERV 25500cfm	1	$ 380,000	25	0	$ 300	2.00%	2.00%
155	ERV 3600cfm	1	$ 90,000	25	0	$ 100	2.00%	2.00%
156	ERV 320cfm	1	$ 3,500	25	0	$ 100	2.00%	2.00%
157	new ERV ductwork	1	$ 360,000	61	0		2.00%	2.00%
158	C14 Controls	1					2.00%	2.00%
159	building automated controls - connect to existing system	1	$ 409,639	20	0	$ 500	2.00%	2.00%
160	C21 Services and Dostribution	1					2.00%	2.00%
161	replace main entrance, 800A switchgear	1	$ 150,000	40	0		2.00%	2.00%
162	new feeders	1	$ 90,000	61	0		2.00%	2.00%
163	new panel, transformer for HVAC	1	$ 50,000	61	0		2.00%	2.00%
164	new disconnects, mechanical connections	1	$ 30,000	40	0		2.00%	2.00%
165	0	1					2.00%	2.00%
166	C22 Lighting, Devices and Heating	1					2.00%	2.00%
167	new interior lighting - LED type	1	$ 655,423	20	0	$ -	2.00%	2.00%
168	lighting controls	1	$ 245,784	20	0	$ -	2.00%	2.00%
169	Z11 General Requirements and Overheads	1		0	0	$ -	2.00%	2.00%
170	contractor's overheads	1	$ 1,842,597	61	0	$ -	2.00%	2.00%
171	Z12 Contractor's Profit	1		0	0	$ -	2.00%	2.00%
172	contractor's profit	1	$ 1,412,657	61	0	$ -	2.00%	2.00%
173	Z21 Design Allowance	1		0	0	$ -	2.00%	2.00%
174	design development contingency	1	$ 1,553,923	61	0	$ -	2.00%	2.00%
175	Z23 Construction Contingency	1		0	0	$ -	2.00%	2.00%
176	construction contingency	1	$ 1,709,316	61	0	$ -	2.00%	2.00%
177		1		0	0	$ -	2.00%	2.00%
178		1		0	0	$ -	2.00%	2.00%
179		1		0	0	$ -	2.00%	2.00%
180	construction escalation for 2024	1	$ 1,228,398	61	0	$ -	2.00%	2.00%
181		1					2.00%	2.00%

Input : NZER - GSHP

BASE CASE

Line No.	Building Components Subject to M&R	Include in Option	Cost	Useful Life (years)	Current Age	Annual Service Cost	Annual Service Cost Escalation Rate	Annual Capital Cost Escalation Rate
	Units	0=no or 1=yes	$	Years	Years	$	2.00%	2.00%
1	Concrete Foundation	0	$ 46,760	61	0	$ -	2.00%	2.00%
2	Slab on Grade: Repair rear overhead door area	1	$ 38,550	40	40	$ -	2.00%	2.00%
3	Slab on Grade	0	$ 115,518	61	0	$ -	2.00%	2.00%
4	Steel columns and joists (assessment)	1	$ 5,500	61	0	$ -	2.00%	2.00%
5	Steel Superstructure	0	$ 2,087,500	61	0	$ -	2.00%	2.00%
6	Modified Bitumen Roof - Southeast quadrant	1	$ 374,000	20	15	$ 500	2.00%	2.00%
7	Modified Bitumen Roof - Southwest quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
8	Modified Bitumen Roof - Northwest quadrant	1	$ 374,000	20	12	$ -	2.00%	2.00%
9	Modified Bitumen Roof - Northeast quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
10	Prefinished Metal Awning - maintenance	1	$ 6,750	35	34	$ -	2.00%	2.00%
11	Prefinished Metal Awning - replacement	1	$ 67,500	35	12	$ -	2.00%	2.00%
12	Brick Exterior Walls - repointing	1	$ 43,750	5	5	$ -	2.00%	2.00%
13	Brick Exterior Walls - replace	1	$ 603,750	75	25	$ -	2.00%	2.00%
14	Concrete block walls - repointing	1	$ 31,250	75	70	$ -	2.00%	2.00%
15	Overhead Door - East side (oversized door)	1	$ 10,000	15	10	$ -	2.00%	2.00%
16	Overhead Door - Heavy Equipment maintenance bay SE Corner	1	$ 7,500	15	10	$ -	2.00%	2.00%
17	Overhead Door - Sidewalk vehicle storage	1	$ 5,500	15	10	$ -	2.00%	2.00%
18	Front entrance Door, Automatic sliding double doors	1	$ 7,500	35	35	$ -	2.00%	2.00%
19	Curtain Glass Glazing, front elevation	1	$ 112,640	35	25	$ -	2.00%	2.00%
20	Aluminium framed entrance door inset into curtain wall	1	$ 2,500	35	22	$ -	2.00%	2.00%
21	Double Steel Entrance - East Side	1	$ 2,500	25	17	$ -	2.00%	2.00%
22	Double Steel Entrance - South Side	1	$ 2,500	25	23	$ -	2.00%	2.00%
23	Single Steel entrance door east side	1	$ 1,000	25	7	$ -	2.00%	2.00%
24	Single Steel entrance door south side	1	$ 1,000	25	7	$ -	2.00%	2.00%
25	Windows - vinyl framed	1	$ -	35	4	$ -	2.00%	2.00%
26	VCT Flooring, retail area	1	$ 453,611	25	25	$ -	2.00%	2.00%
27	Office flooring	1	$ 292,842	25	20	$ -	2.00%	2.00%
28	Washroom Flooring	1	$ 7,250	50	50	$ -	2.00%	2.00%
29	Gypsum Board Walls	1	$ -	60	40	$ -	2.00%	2.00%
30	Suspended Tile Ceiling - Retail area	0	$ 317,860	20	20	$ -	2.00%	2.00%
31	Interior Doors	1	$ -	60	40	$ -	2.00%	2.00%
32	Washroom Ceilings - splined tiles	1	$ 3,455	20	13	$ -	2.00%	2.00%
33	Washroom Vanities	1	$ 6,000	20	10	$ -	2.00%	2.00%
34	Washroom Partitions	1	$ 8,750	30	27	$ -	2.00%	2.00%
35	Plumbing Service	1	$ -	40	25	$ -	2.00%	2.00%
36	Back flow preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
37	Domestic Hot Water Tank- Giant 2018	1	$ 1,500	10	4	$ -	2.00%	2.00%
38	Domestic Hot Water Tank- Giant 2017	1	$ 1,500	10	5	$ -	2.00%	2.00%
39	Domestic Hot Water Tank- Bradford and White	1	$ 1,500	10	5	$ -	2.00%	2.00%
40	Copper Piping Distribution - repair allowance	1	$ 7,500	5	5	$ -	2.00%	2.00%
41	Plumbing Fixtures, sinks, urinal, toilets	1	$ 18,000	35	27	$ -	2.00%	2.00%
42	Fuel Oil Tank 20000 l estimated	1	$ 10,000	30	22	$ -	2.00%	2.00%
43	Volcano Boiler 100 hp rating	0	$ 106,470	40	40	$ -	2.00%	2.00%
44	Air Handling Unit- coil	1	$ 16,450	30	16	$ -	2.00%	2.00%
45	Air Handling Unit	1	$ 14,650	40	35	$ -	2.00%	2.00%

	Line No.	Building Components Subject to M&R Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
	46	Fan Coil Units (FCU)	1	$ -	15	15	$ -	2.00%	2.00%
	47	Main Disconnect Square D, 800A 600V	1	$ 24,150	40	40	$ -	2.00%	2.00%
	48	Transformers	1	$ -	40	20	$ -	2.00%	2.00%
	49	Secondary disconnects	1	$ 25,000	40	40	$ -	2.00%	2.00%
	50	Branch Wiring and secondary panels	1	$ 5,000	5	5	$ -	2.00%	2.00%
	51	Lighting - Retail and office areas	1	$ 477,260	20	20	$ -	2.00%	2.00%
	52	Lighting, Metal Halide Pendant	1	$ -	20	5	$ -	2.00%	2.00%
	53	Exit Signs and battery backup emergency lighting	1	$ -	40	30	$ -	2.00%	2.00%
	54	Sprinkler system	1	$ -	40	40	$ 1,000	2.00%	2.00%
	99		1					2.00%	2.00%
	100	A31 Walls Below Grade	1					2.00%	2.00%
	101	remove concrete sidewalk and dispose	1	$ 39,460	61	0	$ -	2.00%	2.00%
	102	remove asphalt paving and dispose	1	$ 76,102	61	0	$ -	2.00%	2.00%
	103	excavate to 2 feet below grade	1	$ 9,485	61	0	$ -	2.00%	2.00%
	104	new 2" EPS insulation	1	$ 7,477	61	0	$ -	2.00%	2.00%
	105	cement board	1	$ 7,283	61	0	$ -	2.00%	2.00%
	106	backfill to subgrade	1	$ 11,856	61	0	$ -	2.00%	2.00%
	107	reinstate concrete sidewalks	1	$ 202,935	61	0	$ -	2.00%	2.00%
	108	reinstate asphalt paving	1	$ 326,151	61	0	$ -	2.00%	2.00%
	109	A32 Walls Above Grade	1		0	0	$ -	2.00%	2.00%
	110	remove masonry façade	1	$ 135,013	61	0	$ -	2.00%	2.00%
	111	structural upgrades including base angle and mid girts	1	$ 732,000	61	0	$ -	2.00%	2.00%
	112	supply and install r11 prefab insulated wall panels	1	$ 524,235	61	0	$ -	2.00%	2.00%
	113	supply and install prefinished metal siding	1	$ 1,012,598	61	0	$ -	2.00%	2.00%
	114	A33 Windows and Entrances	1		0	0	$ -	2.00%	2.00%
	115	replace overhead doors with R10 overhead doors	1	$ 48,000	20	0	$ 500	2.00%	2.00%
	116	replace storefront windows with triple pane	1	$ 197,635	30	0	$ -	2.00%	2.00%
	117	replace insulated metal exits	1	$ 49,400	25	0	$ -	2.00%	2.00%
	118	A34 Roof Coverings	1		0	0	$ -	2.00%	2.00%
	119	remove existing roof finish	1	$ 204,820	61	0	$ -	2.00%	2.00%
	120	pre-eng wood trusses with nailers	1	$ 655,423	61	0	$ -	2.00%	2.00%
	121	new mod bit roof finish with R38 Recover panels	1	$ 3,522,899	20	0	$ -	2.00%	2.00%
	122	allowance for removing, reinstalling mechanical	1	$ 50,000	61	0	$ -	2.00%	2.00%
	123	spray fireproof underside of beams, deck	1	$ 327,712	61	0	$ -	2.00%	2.00%
	124	fire rated gwb cladding to columns	1	$ 102,410	61	0	$ -	2.00%	2.00%
	125	A35 Projections	1		0	0	$ -	2.00%	2.00%
	126	canopies - no change	1		0	0	$ -	2.00%	2.00%
	127	B22 Ceiling Finishes	1		0	0	$ -	2.00%	2.00%
	128	cut and patch ceilings for new mechanical/electrical	1	$ 204,820	61	0	$ -	2.00%	2.00%
	129	B23 Wall Finishes	1		0	0	$ -	2.00%	2.00%
	130	cut and patch walls for new mechanical/electrical	1	$ 16,386	61	0	$ -	2.00%	2.00%
	131	patch existing party wall	1	$ 32,465	61	0	$ -	2.00%	2.00%
	132	C11 Plumbing	1		0	0	$ -	2.00%	2.00%
	133	new 80gal HPWH hot water tanks	1	$ 22,500	14	0	$ -	2.00%	2.00%
	134	C12 Fire Protection	1	$ -				2.00%	2.00%
RETROFIT	135	expand wet pipe sprinkler system to include roof cavity	1	$ 491,567	61	0		2.00%	2.00%
	136	C13 HVAC	1					2.00%	2.00%
	137	geothermal wells, testing	1	$ 374,000	61	0		2.00%	2.00%
	138	gshp exterior piping, trenching, backfill, reinstatement	1	$ 45,000	61	0		2.00%	2.00%
	139	gshp interior piping	1	$ 30,000	61	0		2.00%	2.00%
	140	gshp-20 tons	1	$ 150,000	20	0	$ 100	2.00%	2.00%

Line No.	Building Components Subject to M&R	Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
141		electric boiler - 110kW	1	$ 30,000	30	0	$ 100	2.00%	2.00%
142		HP HX pumps	1	$ 48,000	20	0	$ 50	2.00%	2.00%
143		HP BT pumps	1	$ 48,000	20	0	$ 50	2.00%	2.00%
144		circulation pumps	1	$ 44,000	25	0		2.00%	2.00%
145		maintenance circulation pumps	1	$ 11,000	25	0		2.00%	2.00%
146		electric boiler pump	1	$ 6,500	25	0		2.00%	2.00%
147		buffer tanks	1	$ 30,000	25	0		2.00%	2.00%
148		air separators	1	$ 14,000	25	0		2.00%	2.00%
149		expansion tanks	1	$ 10,000	25	0		2.00%	2.00%
150		heat exchangers	1	$ 30,000	25	0		2.00%	2.00%
151		distribution piping	1	$ 300,000	61	0		2.00%	2.00%
152		fancoils - 4 pipe 10 ton	1	$ 60,000	25	0		2.00%	2.00%
153		fancoils - 4 pipe 1 ton	1	$ 12,000	25	0		2.00%	2.00%
154		ERV 25500cfm	1	$ 380,000	25	0	$ 300	2.00%	2.00%
155		ERV 3600cfm	1	$ 90,000	25	0	$ 100	2.00%	2.00%
156		ERV 320cfm	1	$ 3,500	25	0	$ 100	2.00%	2.00%
157		new ERV ductwork	1	$ 360,000	61	0		2.00%	2.00%
158	C14	Controls	1					2.00%	2.00%
159		building automated controls - connect to existing system	1	$ 573,495	20	0	$ 500	2.00%	2.00%
160	C21	Services and Dostribution	1		0	0	$ -	2.00%	2.00%
161		replace main entrance, 800A switchgear	1	$ 150,000	40	0	$ -	2.00%	2.00%
162		new feeders	1	$ 90,000	61	0	$ -	2.00%	2.00%
163		new panel, transformer for HVAC	1	$ 50,000	61	0	$ -	2.00%	2.00%
164		new disconnects, mechanical connections	1	$ 30,000	40	0	$ -	2.00%	2.00%
165			1		0	0	$ -	2.00%	2.00%
166	C22	Lighting, Devices and Heating	1		0	0	$ -	2.00%	2.00%
167		new interior lighting - LED type	1	$ 655,423	20	0	$ -	2.00%	2.00%
168		lighting controls	1	$ 245,784	40	0	$ -	2.00%	2.00%
169	Z11	General Requirements and Overheads	1		0	0	$ -	2.00%	2.00%
170		contractor's overheads	1	$ 1,932,200	61	0	$ -	2.00%	2.00%
171	Z12	Contractor's Profit	1		0	0	$ -	2.00%	2.00%
172		contractor's profit	1	$ 1,481,353	61	0	$ -	2.00%	2.00%
173	Z21	Design Allowance	1		0	0	$ -	2.00%	2.00%
174		design development contingency	1	$ 1,629,489	61	0	$ -	2.00%	2.00%
175	Z23	Construction Contingency	1		0	0	$ -	2.00%	2.00%
176		construction contingency	1	$ 1,792,438	61	0	$ -	2.00%	2.00%
179			1		0	0	$ -	2.00%	2.00%
180		construction escalation for 2024	1	$ 1,288,133	61	0	$ -	2.00%	2.00%
181			1					2.00%	2.00%
200		Array Size 0 kWdc	1	$ -			$ -	2.00%	2.00%

Input : NZE

Line No.	Building Components Subject to M&R	Include in Option	Cost	Useful Life (years)	Current Age	Annual Service Cost	Annual Service Cost Escalation Rate	Annual Capital Cost Escalation Rate
	Units	0=no or 1=yes	$	Years	Years	$	2.00%	2.00%
1	Concrete Foundation	0	$ 46,760	61	0	$ -	2.00%	2.00%
2	Slab on Grade: Repair rear overhead door area	1	$ 38,550	40	40	$ -	2.00%	2.00%
3	Slab on Grade	0	$ 115,518	61	0	$ -	2.00%	2.00%
4	Steel columns and joists (assessment)	1	$ 5,500	61	0	$ -	2.00%	2.00%
5	Steel Superstructure	0	$ 2,087,500	61	0	$ -	2.00%	2.00%
6	Modified Bitumen Roof - Southeast quadrant	1	$ 374,000	20	15	$ 500	2.00%	2.00%
7	Modified Bitumen Roof - Southwest quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
8	Modified Bitumen Roof - Northwest quadrant	1	$ 374,000	20	12	$ -	2.00%	2.00%
9	Modified Bitumen Roof - Northeast quadrant	1	$ 374,000	20	15	$ -	2.00%	2.00%
10	Prefinished Metal Awning - maintenance	1	$ 6,750	35	34	$ -	2.00%	2.00%
11	Prefinished Metal Awning - replacement	1	$ 67,500	35	12	$ -	2.00%	2.00%
12	Brick Exterior Walls - repointing	1	$ 43,750	5	5	$ -	2.00%	2.00%
13	Brick Exterior Walls - replace	1	$ 603,750	75	25	$ -	2.00%	2.00%
14	Concrete block walls - repointing	1	$ 31,250	75	70	$ -	2.00%	2.00%
15	Overhead Door - East side (oversized door)	1	$ 10,000	15	10	$ -	2.00%	2.00%
16	Overhead Door - Heavy Equipment maintenance bay SE Corner	1	$ 7,500	15	10	$ -	2.00%	2.00%
17	Overhead Door - Sidewalk vehicle storage	1	$ 5,500	15	10	$ -	2.00%	2.00%
18	Front entrance Door, Automatic sliding double doors	1	$ 7,500	35	35	$ -	2.00%	2.00%
19	Curtain Glass Glazing, front elevation	1	$ 112,640	35	25	$ -	2.00%	2.00%
20	Aluminium framed entrance door inset into curtain wall	1	$ 2,500	35	22	$ -	2.00%	2.00%
21	Double Steel Entrance - East Side	1	$ 2,500	25	17	$ -	2.00%	2.00%
22	Double Steel Entrance - South Side	1	$ 2,500	25	23	$ -	2.00%	2.00%
23	Single Steel entrance door east side	1	$ 1,000	25	7	$ -	2.00%	2.00%
24	Single Steel entrance door south side	1	$ 1,000	25	7	$ -	2.00%	2.00%
25	Windows - vinyl framed	1	$ -	35	4	$ -	2.00%	2.00%
26	VCT Flooring, retail area	1	$ 453,611	25	25	$ -	2.00%	2.00%
27	Office flooring	1	$ 292,842	25	20	$ -	2.00%	2.00%
28	Washroom Flooring	1	$ 7,250	50	50	$ -	2.00%	2.00%
29	Gypsum Board Walls	1	$ -	60	40	$ -	2.00%	2.00%
30	Suspended Tile Ceiling - Retail area	0	$ 317,860	20	20	$ -	2.00%	2.00%
31	Interior Doors	1	$ -	60	40	$ -	2.00%	2.00%
32	Washroom Ceilings - splined tiles	1	$ 3,455	20	13	$ -	2.00%	2.00%
33	Washroom Vanities	1	$ 6,000	20	10	$ -	2.00%	2.00%
34	Washroom Partitions	1	$ 8,750	30	27	$ -	2.00%	2.00%
35	Plumbing Service	1	$ -	40	25	$ -	2.00%	2.00%
36	Back flow preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
37	Domestic Hot Water Tank- Giant 2018	1	$ 1,500	10	4	$ -	2.00%	2.00%
38	Domestic Hot Water Tank- Giant 2017	1	$ 1,500	10	5	$ -	2.00%	2.00%
39	Domestic Hot Water Tank- Bradford and White	1	$ 1,500	10	5	$ -	2.00%	2.00%
40	Copper Piping Distribution - repair allowance	1	$ 7,500	5	5	$ -	2.00%	2.00%
41	Plumbing Fixtures, sinks, urinal, toilets	1	$ 18,000	35	27	$ -	2.00%	2.00%
42	Fuel Oil Tank 20000 l estimated	1	$ 10,000	30	22	$ -	2.00%	2.00%
43	Volcano Boiler 100 hp rating	0	$ 106,470	40	40	$ -	2.00%	2.00%
44	Air Handling Unit- coil	1	$ 16,450	30	16	$ -	2.00%	2.00%
45	Air Handling Unit	1	$ 14,650	40	35	$ -	2.00%	2.00%
46	Fan Coil Units (FCU)	1	$ -	15	15	$ -	2.00%	2.00%

BASE CASE

	Line No.	Building Components Subject to M&R Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
	47	Main Disconnect Square D, 800A 600V	1	$ 24,150	40	40	$ -	2.00%	2.00%
	48	Transformers	1	$ -	40	20	$ -	2.00%	2.00%
	49	Secondary disconnects	1	$ 25,000	40	40	$ -	2.00%	2.00%
	50	Branch Wiring and secondary panels	1	$ 5,000	5	5	$ -	2.00%	2.00%
	51	Lighting - Retail and office areas	1	$ 477,260	20	20	$ -	2.00%	2.00%
	52	Lighting, Metal Halide Pendant	1	$ -	20	5	$ -	2.00%	2.00%
	53	Exit Signs and battery backup emergency lighting	1	$ -	40	30	$ -	2.00%	2.00%
	54	Sprinkler system	1	$ -	40	40	$ 1,000	2.00%	2.00%
RETROFIT	99		1					2.00%	2.00%
RETROFIT	100	A31 Walls Below Grade	1					2.00%	2.00%
RETROFIT	101	remove concrete sidewalk and dispose	1	$ 39,460	61	0	$ -	2.00%	2.00%
RETROFIT	102	remove asphalt paving and dispose	1	$ 76,102	61	0	$ -	2.00%	2.00%
RETROFIT	103	excavate to 2 feet below grade	1	$ 9,485	61	0	$ -	2.00%	2.00%
RETROFIT	104	new 2" EPS insulation	1	$ 7,477	61	0	$ -	2.00%	2.00%
RETROFIT	105	cement board	1	$ 7,283	61	0	$ -	2.00%	2.00%
RETROFIT	106	backfill to subgrade	1	$ 11,856	61	0	$ -	2.00%	2.00%
RETROFIT	107	reinstate concrete sidewalks	1	$ 202,935	61	0	$ -	2.00%	2.00%
RETROFIT	108	reinstate asphalt paving	1	$ 326,151	61	0	$ -	2.00%	2.00%
RETROFIT	109	A32 Walls Above Grade	1		0	0	$ -	2.00%	2.00%
RETROFIT	110	remove masonry façade	1	$ 135,013	61	0	$ -	2.00%	2.00%
RETROFIT	111	structural upgrades including base angle and mid girts	1	$ 732,000	61	0	$ -	2.00%	2.00%
RETROFIT	112	supply and install r11 prefab insulated wall panels	1	$ 524,235	61	0	$ -	2.00%	2.00%
RETROFIT	113	supply and install prefinished metal siding	1	$ 1,012,598	61	0	$ -	2.00%	2.00%
RETROFIT	114	A33 Windows and Entrances	1		0	0	$ -	2.00%	2.00%
RETROFIT	115	replace overhead doors with R10 overhead doors	1	$ 48,000	20	0	$ 500	2.00%	2.00%
RETROFIT	116	replace storefront windows with triple pane	1	$ 197,635	30	0	$ -	2.00%	2.00%
RETROFIT	117	replace insulated metal exits	1	$ 49,400	25	0	$ -	2.00%	2.00%
RETROFIT	118	A34 Roof Coverings	1		0	0	$ -	2.00%	2.00%
RETROFIT	119	remove existing roof finish	1	$ 204,820	61	0	$ -	2.00%	2.00%
RETROFIT	120	pre-eng wood trusses with nailers	1	$ 655,423	61	0	$ -	2.00%	2.00%
RETROFIT	121	new mod bit roof finish with R38 Recover panels	1	$ 3,522,899	20	0	$ -	2.00%	2.00%
RETROFIT	122	allowance for removing, reinstalling mechanical	1	$ 50,000	61	0	$ -	2.00%	2.00%
RETROFIT	123	spray fireproof underside of beams, deck	1	$ 327,712	61	0	$ -	2.00%	2.00%
RETROFIT	124	fire rated gwb cladding to columns	1	$ 102,410	61	0	$ -	2.00%	2.00%
RETROFIT	125	A35 Projections	1		0	0	$ -	2.00%	2.00%
RETROFIT	126	canopies - no change	1		0	0	$ -	2.00%	2.00%
RETROFIT	127	B22 Ceiling Finishes	1		0	0	$ -	2.00%	2.00%
RETROFIT	128	cut and patch ceilings for new mechanical/electrical	1	$ 204,820	61	0	$ -	2.00%	2.00%
RETROFIT	129	B23 Wall Finishes	1		0	0	$ -	2.00%	2.00%
RETROFIT	130	cut and patch walls for new mechanical/electrical	1	$ 16,386	61	0	$ -	2.00%	2.00%
RETROFIT	131	patch existing party wall	1	$ 32,465	61	0	$ -	2.00%	2.00%
RETROFIT	132	C11 Plumbing	1		0	0	$ -	2.00%	2.00%
RETROFIT	133	new 80gal HPWH hot water tanks	1	$ 22,500				2.00%	2.00%
RETROFIT	134	C12 Fire Protection	1					2.00%	2.00%
RETROFIT	135	expand wet pipe sprinkler system to include roof cavity	1	$ 491,567	61	0	$ -	2.00%	2.00%
RETROFIT	136	C13 HVAC	1		0	0	$ -	2.00%	2.00%
RETROFIT	137	geothermal wells, testing	1	$ 374,000	61	0	$ -	2.00%	2.00%
RETROFIT	138	gshp exterior piping, trenching, backfill, reinstatement	1	$ 45,000	61	0	$ -	2.00%	2.00%
RETROFIT	139	gshp interior piping	1	$ 30,000	61	0	$ -	2.00%	2.00%
RETROFIT	140	gshp-20 tons	1	$ 150,000	20	0	$ 100	2.00%	2.00%
RETROFIT	141	electric boiler - 110kW	1	$ 30,000	30	0	$ 100	2.00%	2.00%

Line No.	Building Components Subject to M&R	Units	Include in Option 0=no or 1=yes	Cost $	Useful Life (years) Years	Current Age Years	Annual Service Cost $	Annual Service Cost Escalation Rate 2.00%	Annual Capital Cost Escalation Rate 2.00%
142		HP HX pumps	1	$ 48,000	20	0	$ 50	2.00%	2.00%
143		HP BT pumps	1	$ 48,000	20	0	$ 50	2.00%	2.00%
144		circulation pumps	1	$ 44,000	25	0	$ -	2.00%	2.00%
145		maintenance circulation pumps	1	$ 11,000	25	0	$ -	2.00%	2.00%
146		electric boiler pump	1	$ 6,500	25	0	$ -	2.00%	2.00%
147		buffer tanks	1	$ 30,000	25	0	$ -	2.00%	2.00%
148		air separators	1	$ 14,000	25	0	$ -	2.00%	2.00%
149		expansion tanks	1	$ 10,000	25	0	$ -	2.00%	2.00%
150		heat exchangers	1	$ 30,000	25	0	$ -	2.00%	2.00%
151		distribution piping	1	$ 300,000	61	0	$ -	2.00%	2.00%
152		fancoils - 4 pipe 10 ton	1	$ 60,000	25	0	$ -	2.00%	2.00%
153		fancoils - 4 pipe 1 ton	1	$ 12,000	25	0	$ -	2.00%	2.00%
154		ERV 25500cfm	1	$ 380,000	25	0	$ 300	2.00%	2.00%
155		ERV 3600cfm	1	$ 90,000	25	0	$ 100	2.00%	2.00%
156		ERV 320cfm	1	$ 3,500	25	0	$ 100	2.00%	2.00%
157		new ERV ductwork	1	$ 360,000	61	0	$ -	2.00%	2.00%
158	C14	Controls	1		0	0	$ -	2.00%	2.00%
159		building automated controls - connect to existing system	1	$ 573,495	20	0	$ 500	2.00%	2.00%
160	C21	Services and Dostribution	1		0	0	$ -	2.00%	2.00%
161		replace main entrance, 800A switchgear	1	$ 150,000	40	0	$ -	2.00%	2.00%
162		new feeders	1	$ 90,000	61	0	$ -	2.00%	2.00%
163		new panel, transformer for HVAC	1	$ 50,000	61	0	$ -	2.00%	2.00%
164		new disconnects, mechanical connections	1	$ 30,000	40	0	$ -	2.00%	2.00%
165		photovoltaic system complete with racking, inverters - 230kW	0		0	0	$ -	2.00%	2.00%
166	C22	Lighting, Devices and Heating	1		0	0	$ -	2.00%	2.00%
167		new interior lighting - LED type	1	$ 655,423	20	0	$ -	2.00%	2.00%
168		lighting controls	1	$ 245,784	40	0	$ -	2.00%	2.00%
169	Z11	General Requirements and Overheads	1		0	0	$ -	2.00%	2.00%
170		contractor's overheads	1	$ 1,932,200	61	0	$ -	2.00%	2.00%
171	Z12	Contractor's Profit	1		0	0	$ -	2.00%	2.00%
172		contractor's profit	1	$ 1,481,353	61	0	$ -	2.00%	2.00%
173	Z21	Design Allowance	1		0	0	$ -	2.00%	2.00%
174		design development contingency	1	$ 1,629,489	61	0	$ -	2.00%	2.00%
175	Z23	Construction Contingency	1		0	0	$ -	2.00%	2.00%
176		construction contingency	1	$ 1,792,438	61	0	$ -	2.00%	2.00%
180		construction escalation for 2024	1	$ 1,288,133	61	0	$ -	2.00%	2.00%
199			1					2.00%	2.00%
200		Array Size 230 kWdc	1	$ 828,000			$ 6,511	2.00%	2.00%