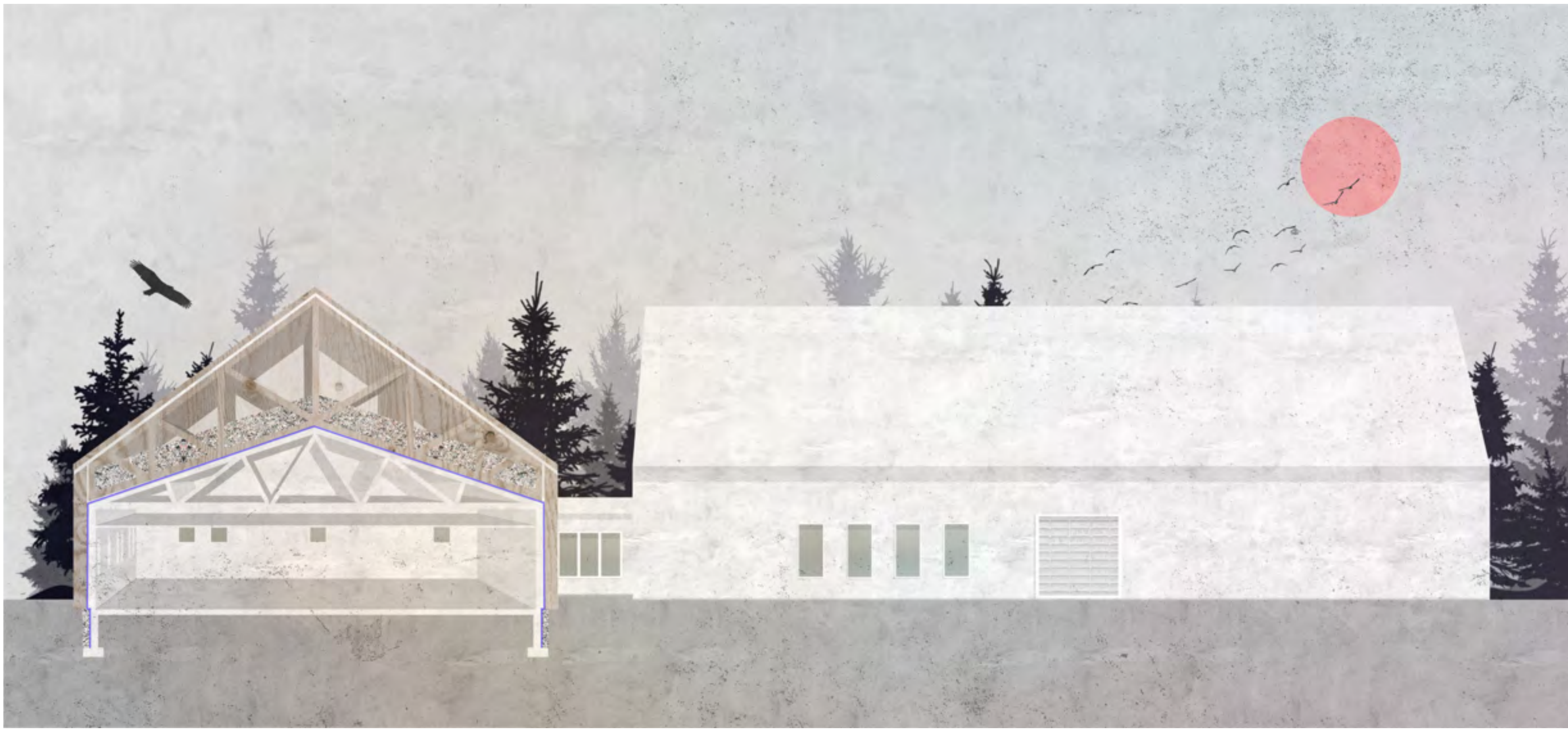


PANELIZED DEEP RETROFITS OF MUNICIPAL BUILDINGS

Debert Water Utility Building

Case Study Report

Issue Date: September 30, 2023

Colchester
Natural Resources Canada / Ressources naturelles Canada
ReCover

Table of Contents

List of Figures 3
Acknowledgements 4
Executive Summary 5
Acronyms and Definitions 6
Introduction 7
Project Objectives 8
Methodology 8
- Building Selection 9
- Data and Document Collection 9

Building Description 10
- Context 10
- Building Code Considerations 11
- Building Enclosures 12
- Existing Structure 15
- Existing Mechanical Systems 15
- Existing Electrical Systems 16

Energy Consumption 16
- Baseline Energy Model and Calibration 16

Results 19
- Energy Conservation Measures 20
- Design 23
  - Panelized Wall Details 23
  - Roof Details 25
  - Building A Structural Design 26
  - Building B Structural Design 27
  - Foundation Insulation 29
  - Hygrothermal Modeling 30
  - Embodied Carbon 32
  - Proposed Mechanical Systems 34
  - Proposed Electrical Systems 35
  - Nova Scotia Power Net Metering Program 35
- Construction Costs 36
- Total Cost of Building Ownership 38
  - Cumulative TCBO 42

Discussion 43
Conclusions 44

Appendices

Appendix A Pre-retrofit Drawings
Appendix B Facility Condition Assessment
Appendix C Structural Outline Specification
Appendix D Mechanical Outline Specification
Appendix E Electrical Outline Specification
Appendix F Pre-retrofit Utility Records
Appendix G Energy Model Reports
Appendix H Panel Schematics
Appendix I Panel Layouts
Appendix J Hygrothermal Report
Appendix K Embodied Carbon
Appendix L Architectural Elevation Drawings
Appendix M Cost Estimate
Appendix N Total Cost of Building Ownership

List of Figures

Figure 1 Debert Water Facility 10
Figure 2 Site Plan 11
Figure 3 Building A exterior wall section. 13
Figure 4 Building B exterior wall section 14
Figure 5 Energy Use 16
Figure 6 Calibrated Energy Usage 17
Figure 7 Thermal Energy Demand Intensity (TEDI) 18
Figure 8 Total Energy Use Intensity (TEUI) 18
Figure 9 Building B retrofit cross section. 19
Figure 10 Debert Water Utility Building Retrofit Scenarios Total Energy Use Intensity (TEUI). 22
Figure 11 Concept south view 23
Figure 12 Wall Panel Assembly 24
Figure 13 Roof Assembly 25
Figure 14 Building A panel connections at roof and foundation 26
Figure 15 Building B panel connection at roof 27
Figure 16 panel axonometric drawing 28
Figure 17 Foundation Insulation 29
Figure 18 WUFI Pro output - Building A north wall (inner plywood layer) 30
Figure 19 WUFI Pro output - Building B south roof (inner plywood) 31
Figure 20 Global Warming by Stage and Material 32
Figure 21 Life Cycle Impacts by Stage (%) 33
Figure 22 Life Cycle Impacts by Material (%) 33
Figure 23 TCBO Comparison 41
Figure 24 Cumulative TCBO 42

Acknowledgements

The authors thank the Green Infrastructure – Energy Efficient Buildings Program from Natural Resources Canada for providing funding to this project.

We would also like to acknowledge our project partners Efficiency Canada, Efficiency ONE, Habit Studio, Passive Buildings Canada, and QUEST Canada.

Finally, thank you to the following funding partners for their contributions to the project:

The Atmospheric Fund

Nova Scotia Department of Natural Resources and Renewables

City of Burlington

Municipality of Colchester

Halifax Regional Municipality

Town of New Glasgow

Town of Oakville

City of Saskatoon

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.

PANELIZED DEEP RETROFITS OF MUNICIPAL BUILDINGS

Debert Water Utility 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

69% improvement

Existing : 216 kWh/m^2
Recommend : 68 kWh/m^2

GHG

79% improvement

Existing : 57,283 kg/yr
Recommend : 12,233 kg/yr

Lifetime Utility Costs

75% improvement

Existing : $6.0 M
Recommend : $1.5 M

ROI

51 Years

When whole building cost of doing nothing exceeds whole building cost of deep retrofit.

Retrofit Measures

Existing walls
Existing roof
High performance windows and doors
New ventilation system
42 kW Solar PV 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 low-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.

---

[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 Report*, 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 Municipality of Colchester. 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 Debert Water Utility Facility for this study by the Municipality of Colchester and the ReCover team. The building incurs relatively high energy costs and has an inefficient fuel-oil heating system. It is also in need of a new siding, which presents an opportune time to consider upgrading the building envelope.

The form of the building is more articulated than is ideal for a panelized retrofit, however each of its two parts are simple in isolation. Additionally, as the two parts represent different construction types, the project is an opportunity to simultaneously explore the potential for a panelized retrofit on both a wood framed structure and a masonry structure.

Data and Document Collection

The Municipality of Colchester provided the following data and supporting documents pertaining to the Debert Water Utility Facility:

- 1979 construction drawings (Appendix A)
- Fuel oil consumption records March 2020 to March 2022 (Appendix F)
- Electrical consumption records March 2020 to March 2022 (Appendix F)

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 requested, however older records were not available.

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 staff of the municipality 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 as one did not exist for the property (Appendix B).

Building Description

The Debert Water Utility Building is a one-storey structure with a gross floor area of 718m^2 (7,728 sq. ft) consisting of two wings connected by an enclosed walkway.

Building A is a 181m^2 (1,948 sq.ft.) office space which is rented out to an engineering company. Building B is a 537m^2 (5,780 sq.ft.) maintenance facility used for servicing and storage of equipment and contains an office area.

Figure 1 Debert Water Facility

Context

The Debert Water Utility Building is located at 251 Lancaster Crescent, Debert, Nova Scotia. Debert is a rural, predominantly agricultural community in Colchester County, NS. The Water Utility Building is in an industrial area surrounded by woodland. It was built in 1979 as a Tree Breeding Centre for the Nova Scotia Department of Lands and Forests.

Debert is in Canadian building code climate zone 6. Its weather is humid and changeable in all seasons, with year-round potential for significant precipitation. The site is approximately 10 km inland from the waters of the Minas Basin. 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 Nova Scotia.

---

[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

Figure 2 Site Plan

In 2021 the Municipality of Colchester implemented Carbon-Free Colchester[4], their Community Energy and Emissions Plan which targets net-zero Greenhouse Gas (GHG) emissions by 2050. Energy conservation through building upgrades, including retrofits, and building electrification are key pillars of the plan. Colchester has set a goal for deep retrofits to 80% of their existing buildings by 2040, and net-zero retrofits to all municipally owned buildings by 2035.

Building Code Considerations

A preliminary National Building Code of Canada (NBCC) review has been completed to determine if prefabricated envelope panels made with combustible materials can be installed on the Debert Water Utility Building (Appendix L).

The construction type, cladding and fire rating requirements for each exterior wall of a building are based on the area of the wall, its proximity to the property boundaries and the building's occupancy classification. The Debert Water Utility Building has two major occupancies. Building A is classified under the National Building Code of Canada (NBCC) as **Group D Business Occupancy** and Building B is classified as **Group F2 Medium-hazard Industrial Occupancy** due to its function as a repair garage.

[4] Municipality of Colchester. (2021) *Carbon-Free Colchester*. https://www.colchester.ca/community-1/3522-carbon-free-colchester-community-energy-emissions-plan/file

Both buildings are permitted to be of combustible or non-combustible construction. The structural elements of Building B are required to have a 45-minute fire-resistance rating or to be of non-combustible construction. A fire separation is not required between the occupancies. Both parts of the building are believed to be currently in compliance with these requirements.

Side setbacks have been reviewed based on a scaled site plan and it was determined that walls of the building may be constructed of either combustible or non-combustible elements. Based on this a panelized retrofit made with combustible elements and metal cladding complies with NBCC requirements.

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.

Building Enclosures

Building A is a timber structure insulated with fiberglass batt in both the exterior walls and roof. It has 2" of continuous sub-slab rigid insulation and 2" of rigid insulation installed on the interior perimeter of the frost walls to a depth of 48". Figure 3 shows the Building A existing wall section taken from the original 1979 drawings.

Building B has concrete block walls insulated with 2 ½" of rigid insulation on the exterior. The drawings specify a protected membrane roof assembly with 4" of rigid insulation, however the current roof is a conventional modified bitumen roof system. It is believed that the current roof has 4" of rigid insulation. The perimeter frost walls are insulated with 3" of rigid insulation. In all instances of rigid insulation in this building the material is assumed to be extruded polystyrene. Figure 4 shows the Building B existing wall section taken from the original 1979 drawings.

Table 1 Existing Thermal Performance

	Effective USI W/m^2·K (Btu/h·ft^2·°F	Effective RSI m^2·K/W (ft^2·°F·h/BTU)
weighted average walls	USI-0.44 (U-0.077)	RSI-2.27 (R-12.9)
weighted average roofs	USI-0.37 (U-0.065)	RSI-2.71 (R-15.4)
weighted average slab	USI-4.1 (U-0.7)	RSI-0.24 (R-1.36)
overhead door	USI-1.13 (U-0.2)	RSI-0.88 (R-5)
windows	USI-1.98 (U-0.35)	RSI-0.5 (R-2.86)

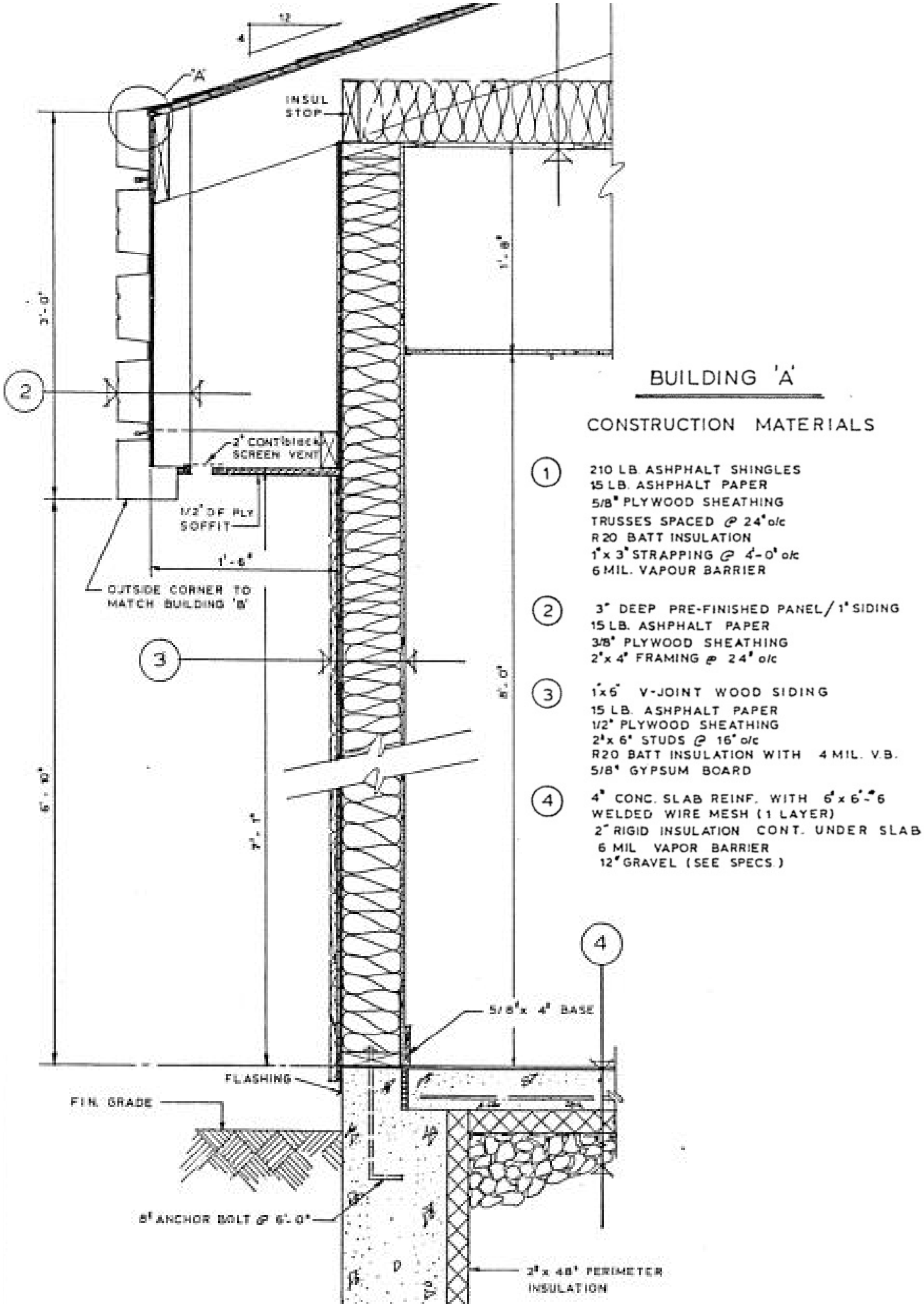


Figure 3 Building A exterior wall section.

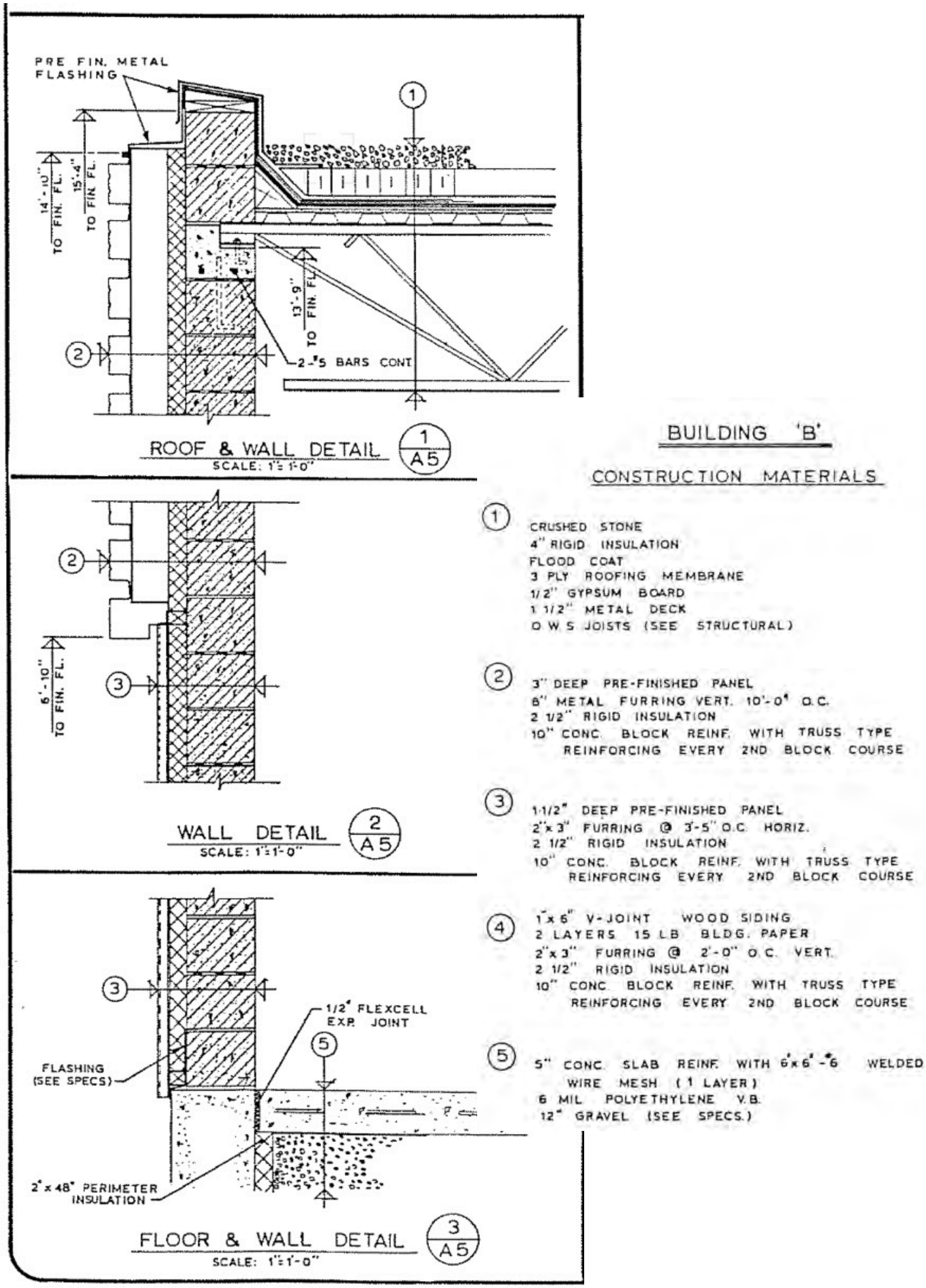


Figure 4 Building B exterior wall section

Existing Structure

Building A & B are connected via a ±7' wide timber framed walkway. Both buildings, and the walkway, are founded on **concrete slab-on-grades**, with perimeter **frost walls and interior strip footings** to support load bearing walls.

Building A is **wood framed** with 2x6 studs at 16" on centre and pre-engineered timber roof trusses. The wall and roof assemblies are shown in Figure 3. The walkway between Building A and B is also wood framed with a 2" x 8" central ridge board and 2" x 6" rafters and ceiling joists at 24". The rafters are structurally deficient based on current loading.

Building B is constructed with 10" **reinforced concrete block** walls and an **open web steel joist** (OWSJ) and corrugated metal deck roof. The existing masonry walls in Building B extend beyond the existing roof to form a parapet wall. Details are shown in Figure 4.

The walls of both buildings can support additional loading. A panelized roof solution is not structurally viable for Building A. Adding roof panels to Building B is possible, however reinforcing of the existing roof structure would be required. The recommended retrofit for both sides of the building is for new structure to bear on the existing load-bearing walls.

Existing Mechanical Systems

Hot water is supplied by an electric water heater located in the mechanical room.

Space heating in all parts of the building is by hot water baseboard heaters or unit heaters. Hot water is provided by one oil-fired boiler which is in good condition and still has some remaining useful life. Baseboard heaters are installed in all parts of the building except for the office area of the maintenance facility which has an electric baseboard heater. Supplemental hot water unit heaters have also been installed in the work area on the south side of the building and outside the mechanical room.

A 2.5-ton heat pump was installed in the Building A in June 2022 to provide heating and cooling. The office area was previously cooled with a ducted air conditioner. The maintenance garage has two window unit air conditioning units installed in the offices but does not have cooling anywhere else.

The facility is inadequately ventilated for occupation. The only **ventilation** provided is bathroom exhaust fans.

The building does not have a building automation system. Standalone pneumatic thermostats control baseboard heater control valves and electronic thermostats control force flow heater fans.

Appendix D provides details of the existing mechanical system and Mechanical Outline Specification.

Existing Electrical Systems

The electrical system is in acceptable condition, however many of the components have near end of life or no longer comply with current codes. The incoming **power service** is supplied via a pad mount transformer. The main incoming secondary service is sized at 800A which is not compliant with current electrical codes.

The **main switchboard** is original to the building, and while it has been well maintained, it has reached its end of life. Several **branch circuit panelboards** throughout the building serve various areas. Their overall condition is good, and while some are original to the building, circuit capacity has been expanded over time.

The **interior lighting** in Building A was upgraded in the past 20 years to 2x2 and 2x4 fixtures complete with T8 lamps. Building B is lit with original fluorescent lighting with high output fixtures in the warehouse areas. Approximately 40% of the Building B fixtures are not functional. The mechanical room lacks lighting entirely.

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

Appendix E provides details of the existing electrical system and Electrical Outline Specification.

Energy Consumption

Energy analysis was based on electrical and fuel oil consumption spanning March 2020 to March 2022 (Appendix F). During the documented time span the building used an average of 10,167 L of fuel oil (105,232 ekWh) and 44,400 kWh of electricity annually.

The time span of the consumption records includes times of reduced occupation due to the COVID-19 pandemic. Typical energy use is believed to be higher than modeling suggests.

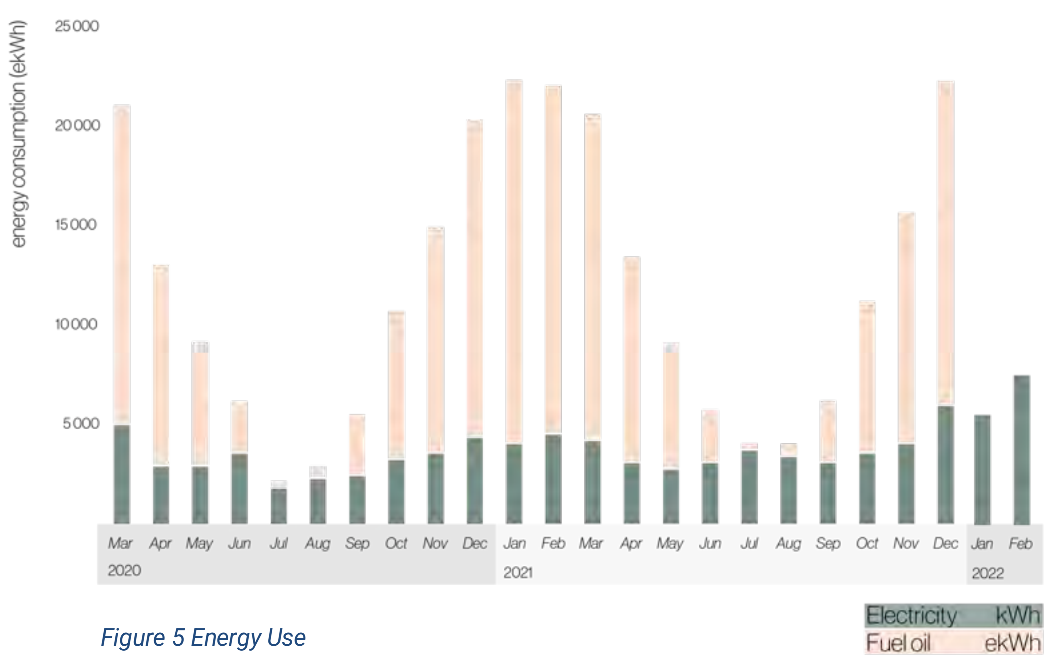


Figure 5 Energy Use

Baseline Energy Model and Calibration

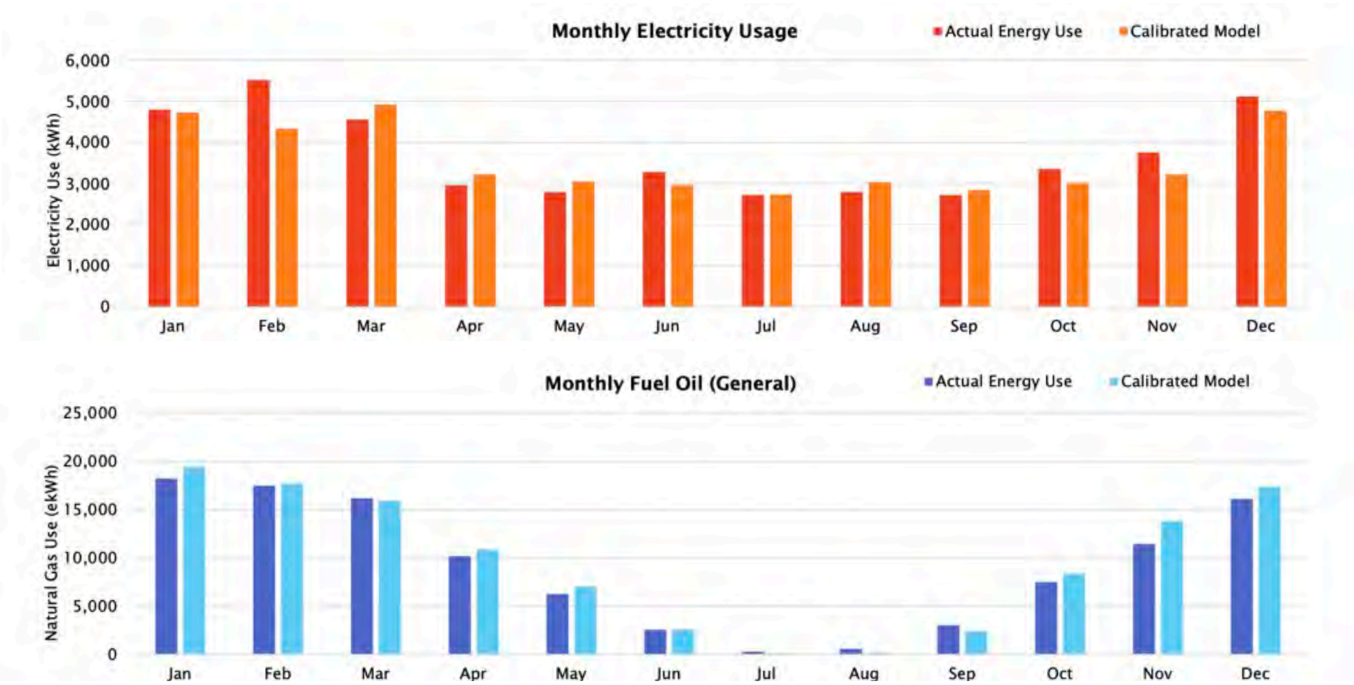


Figure 6 Calibrated Energy Usage

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

The energy model was calibrated with the historical utility data to closely reflect the current building performance. Fuel oil deliveries to the building are irregular and occurred only once in 2020 and four times in 2021. As such, consumption rates could not be tied to a regular billing cycle and monthly usage was estimated based on climate data.

The building is heated primarily with fuel oil and supplemented with electric heat. Accurately apportioning the ratio of fuel oil to electricity presented challenges in model calibration. To facilitate calibration, the heating impacts from the air source heat pump serving Building A were excluded from the baseline model. The modeled electrical consumption deviates from the existing usage by 3.5% and modeled fuel oil deviates by 5.5%.

The Total Energy Use Intensity (TEUI) for the existing building is 220.6 kWh/m^2/yr. More than 75% of its energy use is for space heating (Figure 8). The building is currently unventilated, consequently ventilation heat losses represent less than 1% of the total heat losses in the building. Adding a mechanical ventilation system will be an essential part of any retrofit to this building, however even a highly efficient heat recovery ventilator will increase heat loss through ventilation and the EUI.

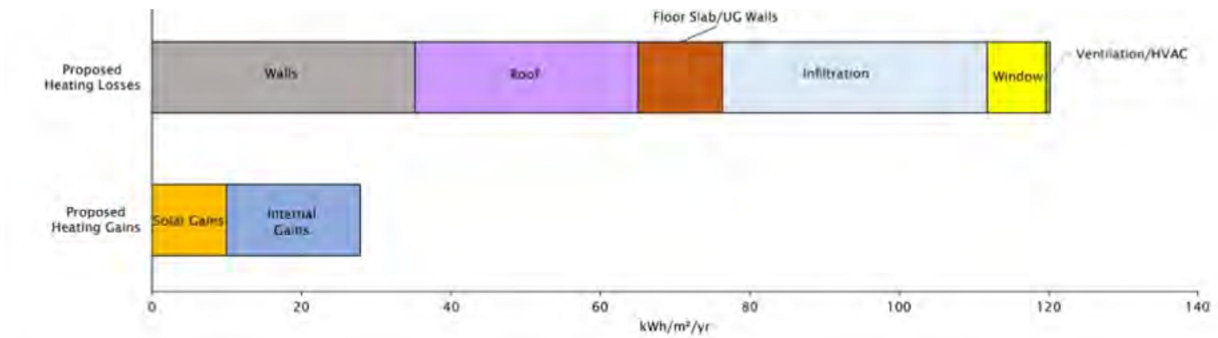


Figure 7 Thermal Energy Demand Intensity (TEDI)

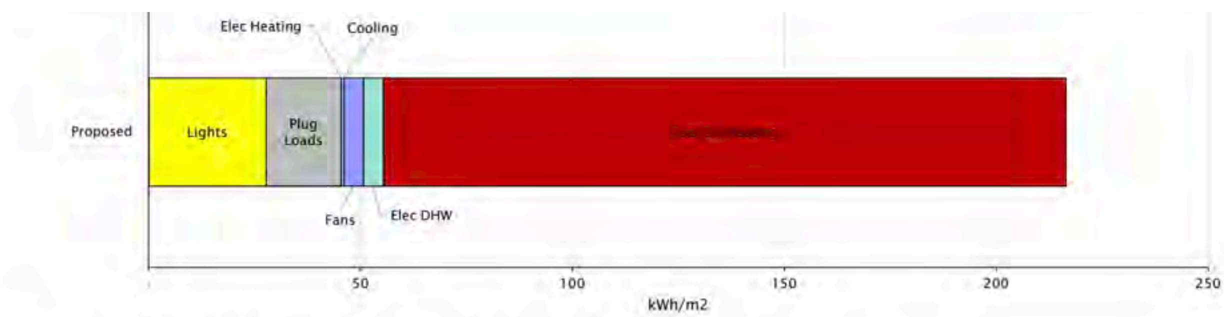


Figure 8 Total Energy Use Intensity (TEUI)

Results

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 is to retrofit the walls with prefabricated ReCover panels and to install new pre-engineered timber roof systems over the existing roofs, supported on the existing exterior bearing walls.

A panelized roof retrofit is not recommended for Building A and although it is technically possible for Building B, it would cost more in up front and lifetime costs. A new flat roof would require costly reinforcing of the existing steel OWSJ system to support the weight of the new roof panels. It will also result in higher snow loads than the current roof, since improved thermal performance will increase snow accumulation. Flat roofs typically require more ongoing maintenance than sloped roofs, representing higher costs over the life of the building. For these reasons a truss roof is a recommended as a better investment for this retrofit.

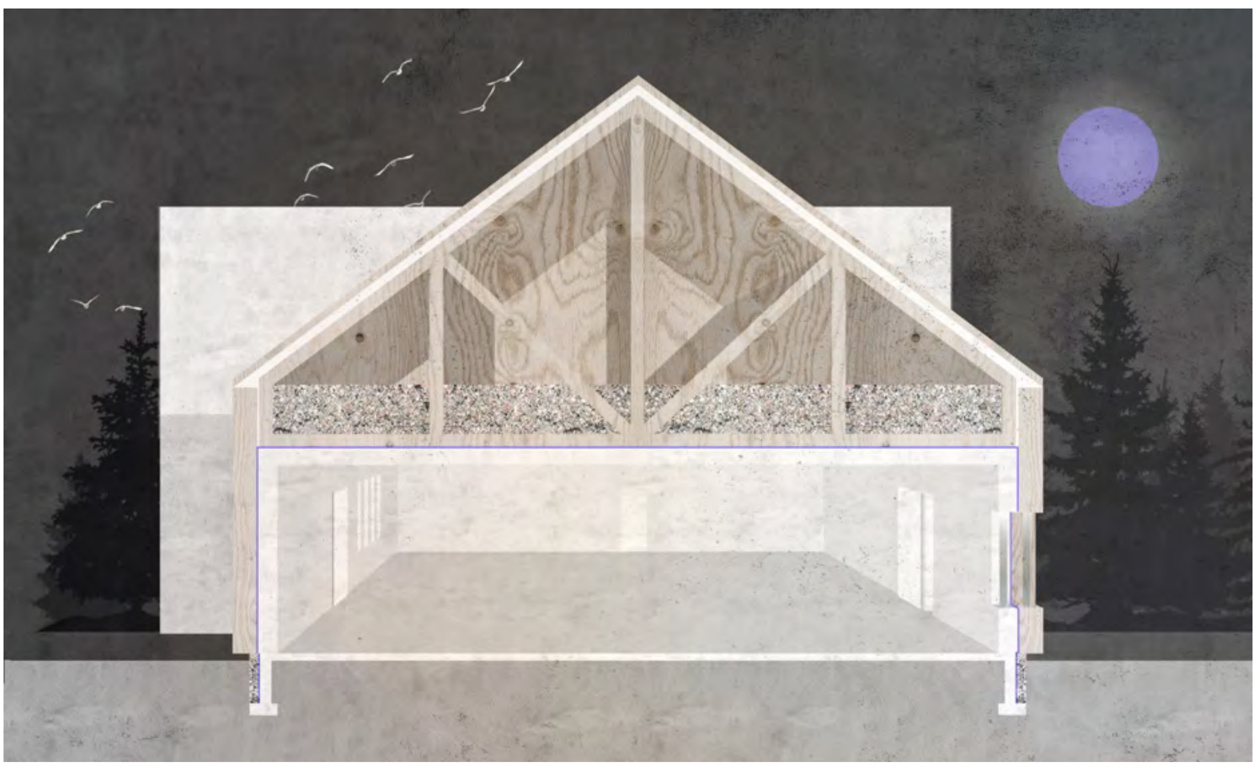


Figure 9 Building B retrofit cross section.

Energy Conservation Measures

Energy conservation measures (ECMs) 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 0.75 $L/s \cdot m^2$, an estimated 67% reduction from the existing air infiltration. All scenarios propose upgrading to high performance, triple pane windows.

Mechanical and electrical retrofits were developed based on ease of integration with existing systems and installation cost. Both air source heat pumps (ASHP) and ground source heat pumps (GSHP) were considered in the analysis to learn which option offers the lowest TCBO. A GSHP is more energy efficient than an ASHP, however the cost to install a GSHP are typically significantly higher. The best heat pump investment depends on specific building conditions. For this project the Net Zero Energy scenario was based on the ASHP option as it has the lowest TCBO.

The primary difference between the Minimum Upgrade and the NZER scenarios is the existing oil-fired boiler is retained in the Minimum Upgrade. If fossil fuels are not removed now another retrofit will be necessary before 2035 (Colchester's deadline for their corporate buildings to be net-zero).

Details of the retrofit scenarios are summarized in Table 2.

Table 2 Retrofit Scenarios Summary

	Existing Building	Minimum Upgrade	NZE – ASHP[1]	NZE – GSHP[1]
Effective Wall R-value	RSI-2.11 (R-12)	RSI-4.4 (R-25) existing +ReCover panels)	RSI-4.4 (R-25) existing +ReCover panels)	RSI-4.4 (R-25) existing +ReCover panels)
Effective Roof R-value	RSI 2.71 (R-15.4)	RSI-7.04 (R-40) existing + new cellulose)	RSI-7.04 (R-40) existing + new cellulose)	RSI-7.04 (R-40) existing + new cellulose)
Air Tightness (at 75Pa)	2.3 L/s·m2	0.75 L/s·m2	0.75 L/s·m2	0.75 L/s·m2
Central Heating Equipment	Oil-fired boiler with single stage burner	Oil-fired boiler with single stage burner	ASHP	GSHP
Heating System	Bldg A: Hydronic baseboards Bldg B: Hydronic baseboards & unit heaters	Bldg A: Hydronic baseboards Bldg B: Hydronic baseboards & unit heaters	Bldg A: Hydronic baseboard Bldg B: Hydronic baseboards & unit heaters	Bldg A: Hydronic baseboard Bldg B: Hydronic baseboards &unit heaters
Air Conditioning[2]	Bldg A: Existing ASHP Bldg B: Packaged air conditioning units	Bldg A: Existing ASHP Bldg B: Mini split units	Bldg A: Existing ASHP Bldg B: Mini split units	Bldg A: Existing ASHP Bldg B: Water to Air consoles
DHW Equip	Electric Water Heater	Electric Water Heater	HP Water Heater	HP Water Heater
Ventilation Equipment	Extract (bathrooms only)	Bldg A: 90% SRE[3] ERV Bldg B: 90% SRE[3] ERV	Bldg A: 90% SRE[3] ERV Bldg B: 90% SRE[3] ERV	Bldg A: 90% SRE[3] ERV Bldg B: 90% SRE[3] ERV
Solar PV	none	none	45 kW (DC)	45 kW (DC)

[1] Net Zero Energy Ready systems are identical with exclusion of renewables.
[2] Building B only provides cooling in north and south offices.
[3] SRE ERV: Sensible heat-recovery efficiency energy/enthalpy recovery ventilator (Tempeff Dualcore or similar).

Table 3 Retrofit Scenarios Results			
	Target TEUI	**TEUI kWh/m^2**	**TEUI reduction**
Existing	-	220.6	-
Minimum Upgrade	50% savings	125.7	43%
NZER – ASHP	75% savings	55.3	75%
NZER – GSHP	75% savings	55.3	75%
NZE	100% savings	0	100%

The modeled performance of the Minimum Upgrade does not meet the 50% EUI reduction target. This is primarily due to the impact of adding code compliant mechanical ventilation in the retrofits, which offsets part of the energy savings from the energy conservation measures. The design team explored options to further reduce the EUI in the Minimum Upgrade scenario, however achieving greater savings were not cost effective.

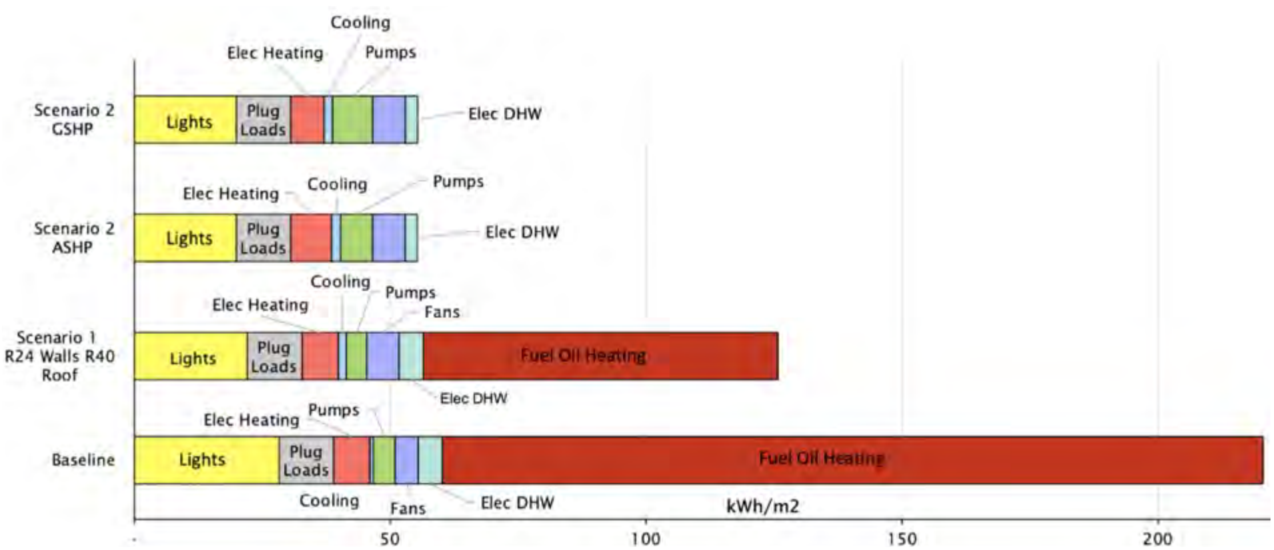


Figure 10 Debert Water Utility Building Retrofit Scenarios Total Energy Use Intensity (TEUI).

Figure 11 Concept south view

Design

Cosmetic upgrades are a significant driver of building retrofits, and it is important to demonstrate that deep retrofits can play a role in building beautification.

The new roof trusses will have an 8:12 pitch. A higher roofline will shed snow more effectively and gives the building more presence. The overall proportions of the two buildings in the proposed design are more in keeping with the vernacular agricultural buildings in the community of Debert.

Most buildings will require attention in the coming decades, so design strategies must reduce the maintenance burden for municipalities. Metal cladding is recommended on both the walls and roof for long term resilience and durability and for the lowest TCBO. A muted shade of green is suggested to be harmonious in the wooded setting. Wood accents add warmth at the entrance and a complementary wood-look finish highlights the overhead doors.

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. All retrofit scenarios proposed for the Debert Water Utility Building use panels with 2x6 stud framing.

The panel components were specified to minimize moisture risks by shedding precipitation on the outside and by promoting drying activity to the exterior through the panel assembly. This is important as the existing assemblies include vapour retarding materials, including polyethylene vapour barrier and rigid foam insulation, which will inhibit drying to the interior of the building. These materials will also inhibit outward vapour drive, from the interior into the panels, however given the age and condition of the building it is highly unlikely that these materials comprise a continuous vapour barrier. The panels are be designed to promote any moisture movement that occurs from the interior to dry to the exterior.

Strapping on the interior side 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 are found in Appendix H.

Proposed NZER Scenario ReCover Panel effective RSI-2.8 (R-16)

1. metal cladding [5]
2. 19mm strapping/rainscreen cavity.
3. WRB membrane
4. plywood sheathing
5. dense-pack cellulose
6. panel framing: 2x6 studs 24”o.c.
7. variable permeability vapour control membrane
8. interior strapping

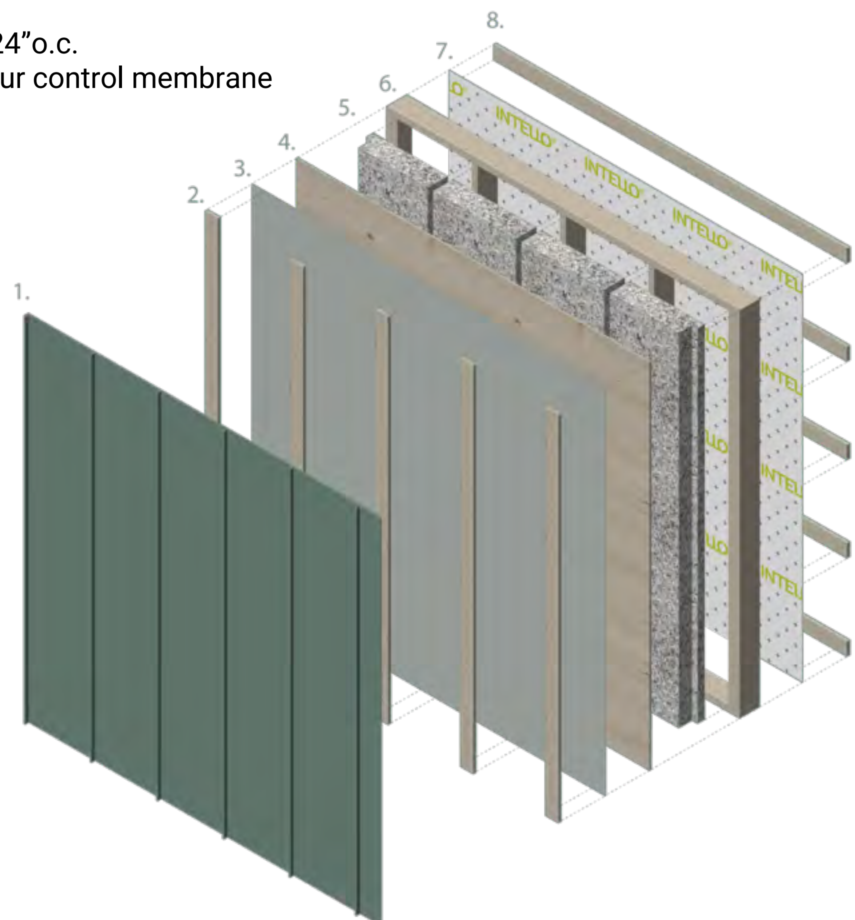


Figure 12 Wall Panel Assembly

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

The wall panels span from foundation to roof, a height of approximately 4.25m (14') when they are extended to the underside of the new roof overhangs. 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.

The proposed panel layout for the Debert Water Utility Building is provided in Appendix I.

Roof Details

The proposed roof assemblies are conventional truss roofs. The new Building A roof will have scissor trusses with a 4:12 bottom chord that fits above the existing roof slope and an 8:12 top chord. The pitch of Building B will have a flat bottom and an 8:12 to match Building A. Hygrothermal modeling shows that the roofs should be well ventilated for optimal longevity.

Building B Roof Assembly effective RSI-7.04 (R-40)[6]

1. metal roofing
2. strapping
3. WRB membrane
4. plywood sheathing
5. pre-engineered roof trusses
6. new cellulose insulation
7. WRB membrane

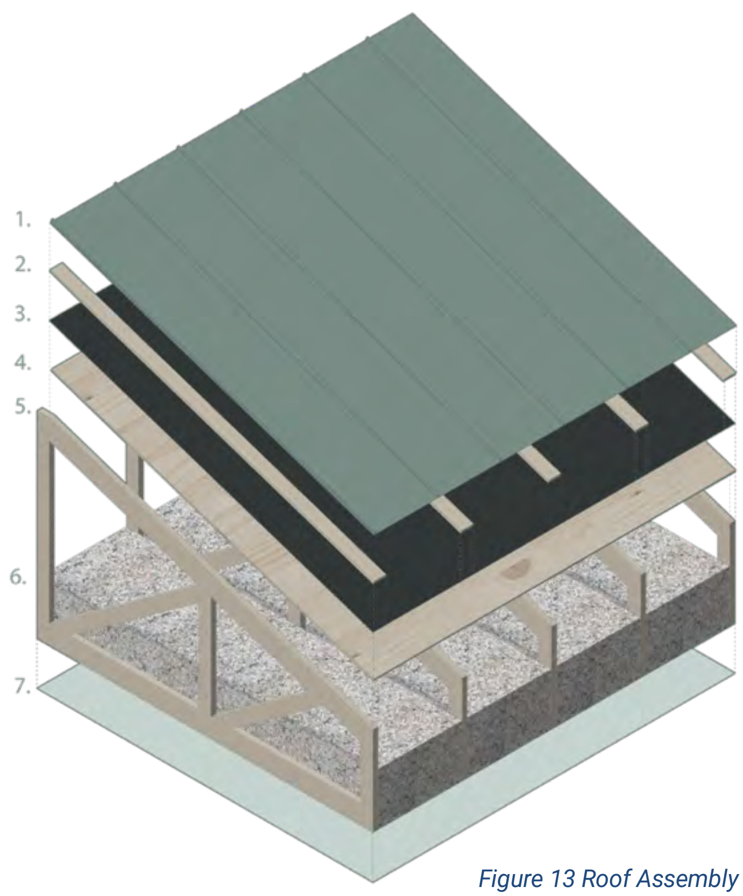


Figure 13 Roof Assembly

---

[6] Building A roof assembly is identical to Building B, except for its scissor truss bottom chord.

Building A Structural Design

- new roof trusses connect to solid blocking fastened to existing two-ply top plates.
- top of the ReCover panel fastens to the roof with Simpson Strong-Tie tie plates.
- panels span from foundation to roof.
- supported at the concrete foundation with a steel bent plate lintel.

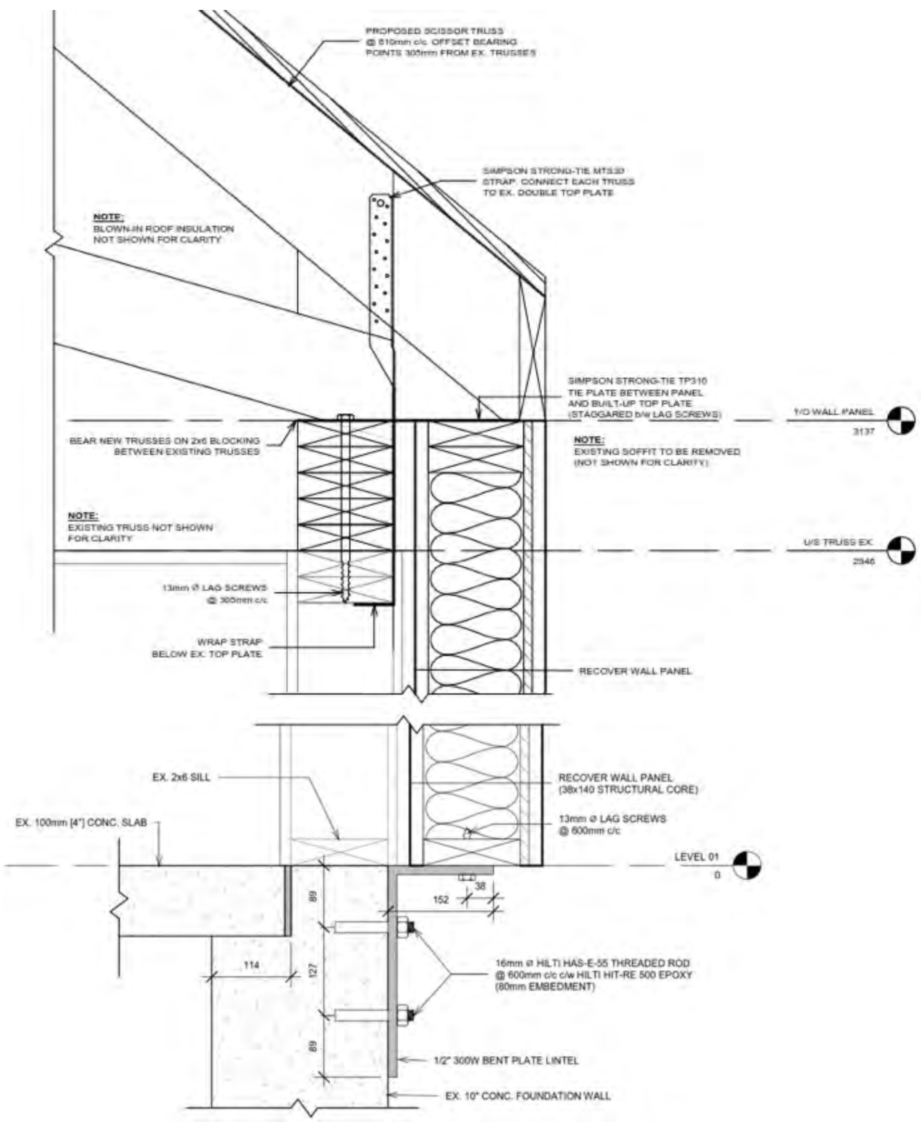


Figure 14 Building A panel connections at roof and foundation

Building B Structural Design

- roof trusses are supported on the existing masonry parapet wall.
- top of the ReCover panel fastens to the roof with Simpson Strong-Tie tie plates.
- panels span from foundation to roof.
- supported at the foundation with a steel bent plate lintel like Figure 15.

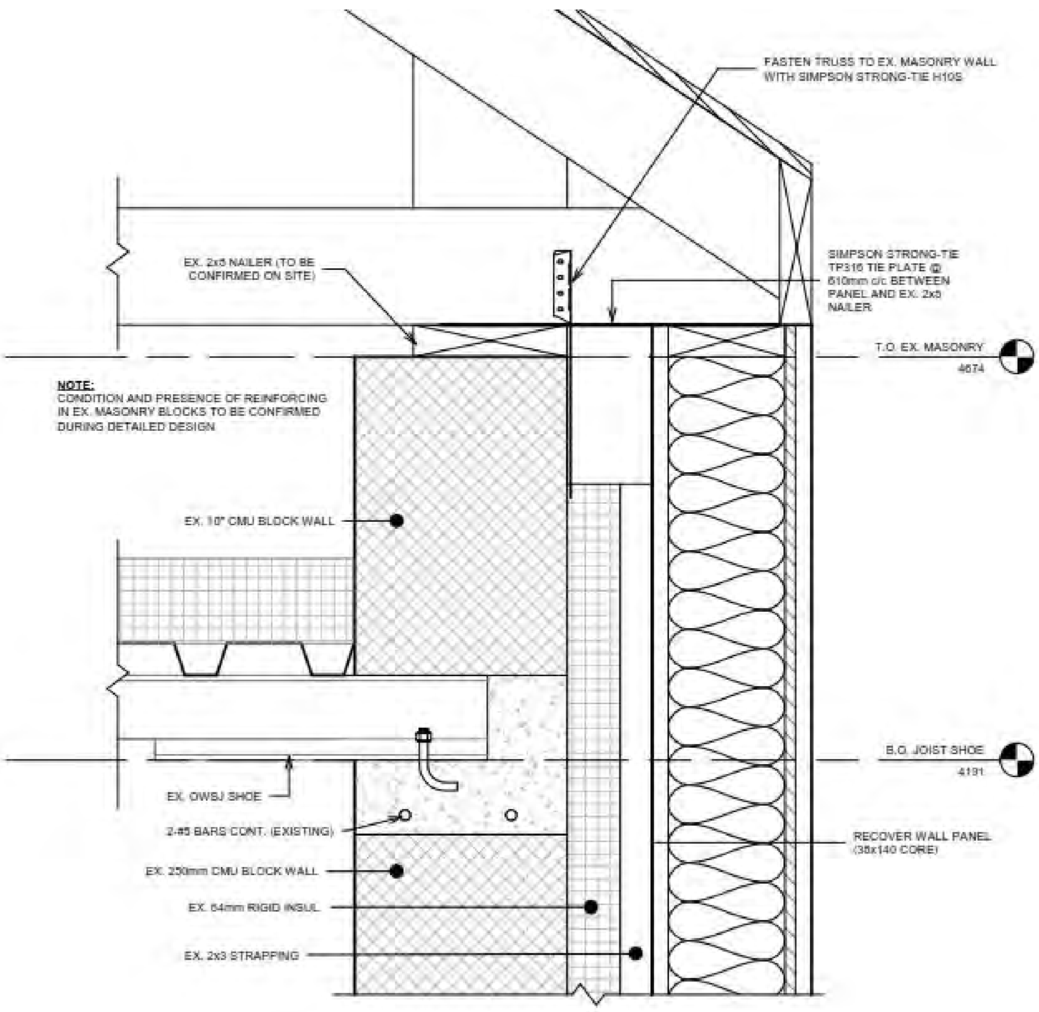


Figure 15 Building B panel connection at roof

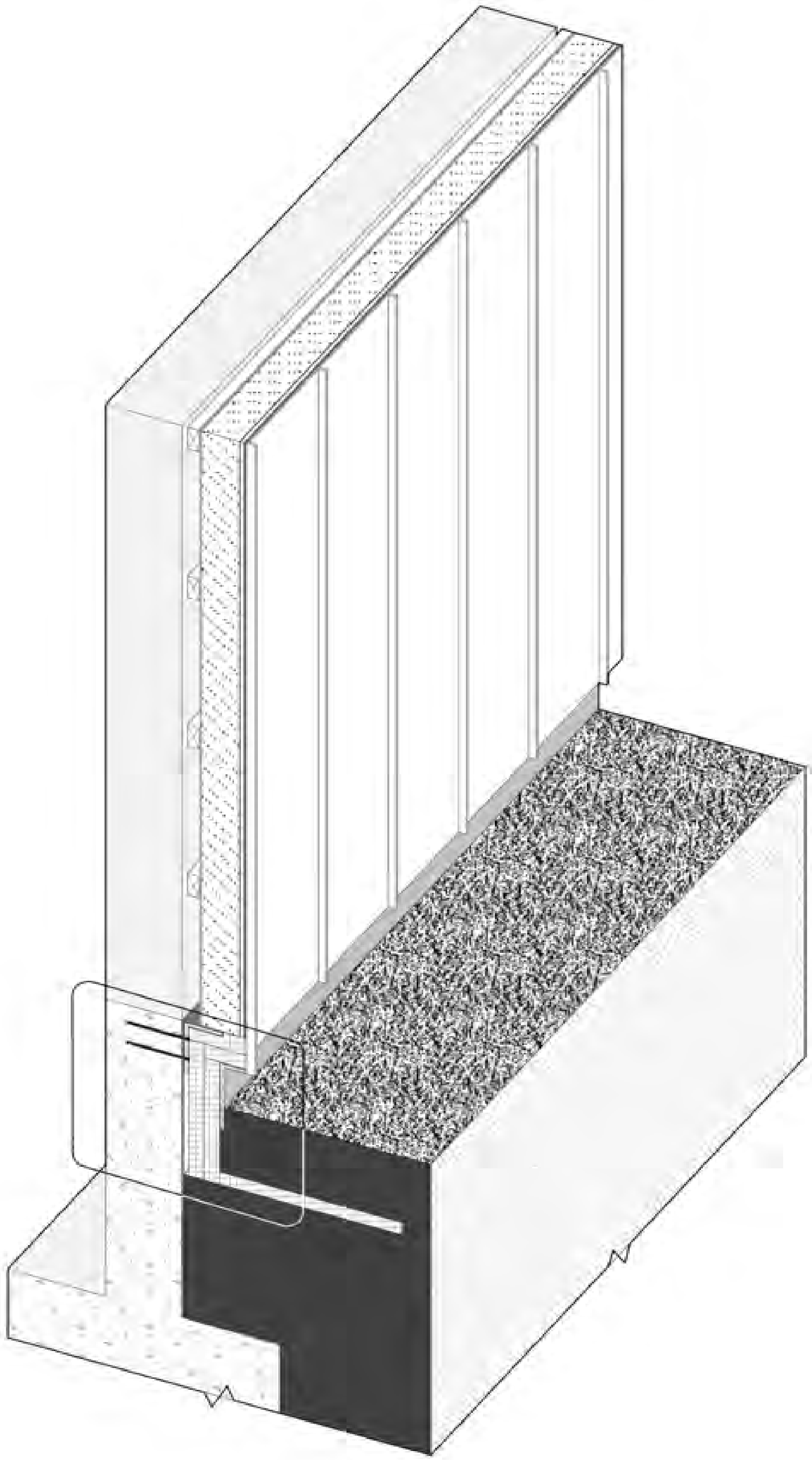


Figure 16 panel axonometric drawing

Foundation Insulation

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

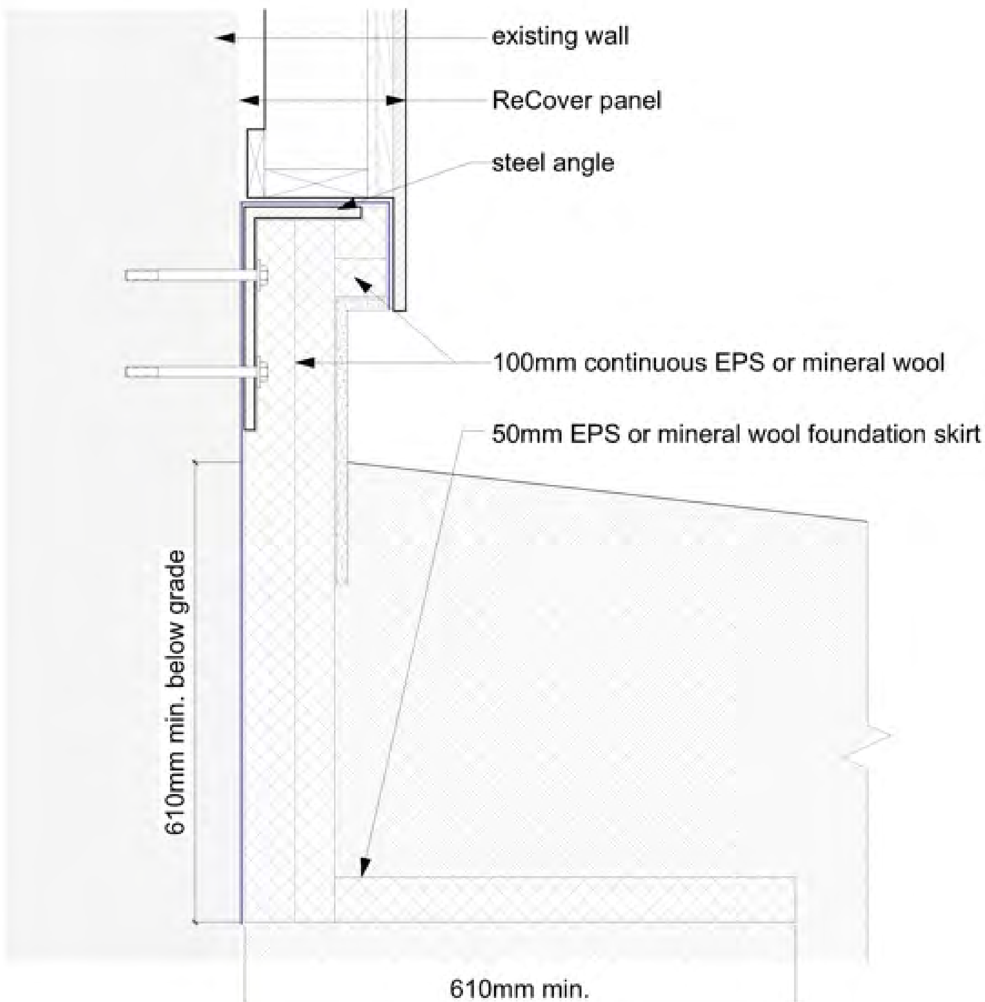


Figure 17 Foundation Insulation

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 Debert Water Utility Building NZER wall and roof assemblies with WUFI® Pro (Appendix J). The analysis focused on 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 these 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 assemblies were found 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.

The materials tested in all walls of the building follow a pattern like that shown in the graph in Figure 18, with a moisture content spike above 20% in the first winter and smaller spikes in subsequent years. This is an indication of good drying potential. The wall materials tested also demonstrate a low risk of mould.

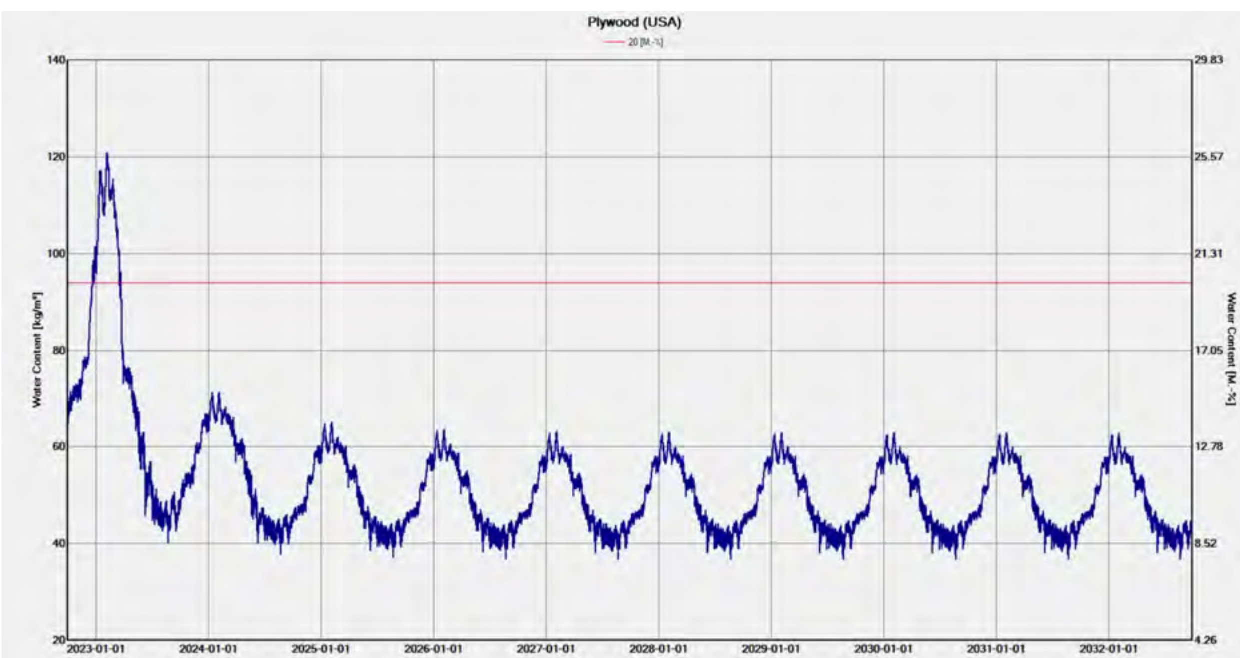


Figure 18 WUFI Pro output - Building A north wall (inner plywood layer)

The materials tested in the post-retrofit roof materials of both buildings follow a pattern like the one shown in Figure 19. The first year moisture spike in the plywood layer tested does not reach 20% moisture content, however the annual peak moisture is consistent from year to year. This is an indication that the material is undergoing seasonal moisture fluctuations but that it may not dry sufficiently over time. Analysis in both roofs showed that relative humidity inside the ventilated attics reach nearly 100% in the plywood and at the surface of the cellulose layers in summer. These findings indicate that while the assembly may be a low risk for mould or decay, the design should prioritize generous air flow in the ventilated attics.

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

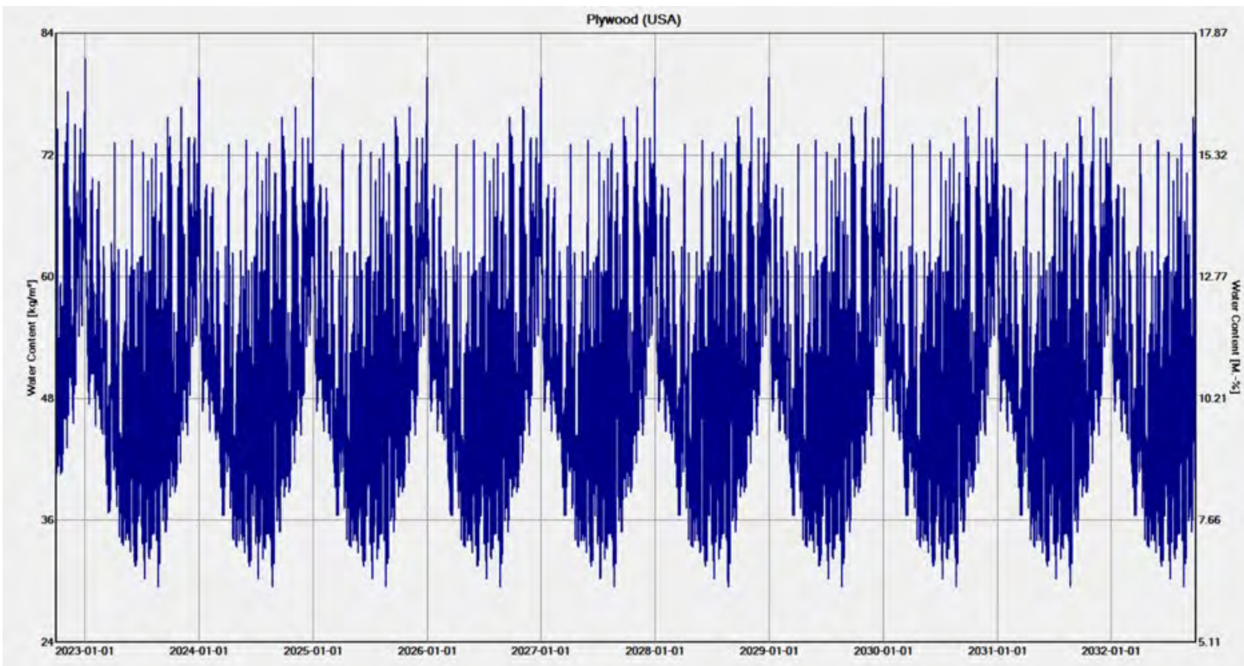


Figure 19 WUFI Pro output - Building B south roof (inner plywood)

Embodied Carbon

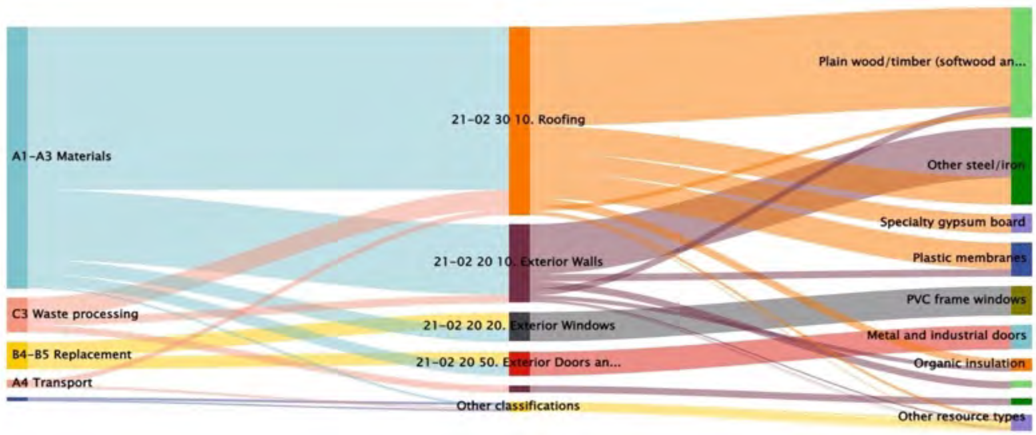


Figure 20 Global Warming by Stage and Material

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.

Table 4 Total Global Warming Potential			
gross floor area m^2	A1-A3 KgCO2e/m^2	A1-C4 KgCO2e/m2	Biogenic carbon KgCO2e/m2
720	**69.47**	**89.28**	**156.5**

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.

The major contributors to the global warming potential (GWP) in this design are the wood trusses and the steel cladding. The A1-A3 Materials stage contributed 78% of the total carbon emissions associated with this building as illustrated in Figure 20 & 21.

The biogenic carbon storage surpasses that of the A1-C4 emissions by 43%, making a surplus in carbon storage capacity as shown in Table 4. This storage is attributed to the wood products (92.7%) and cellulose insulation (7.3%) used in the assemblies (Figure 22).

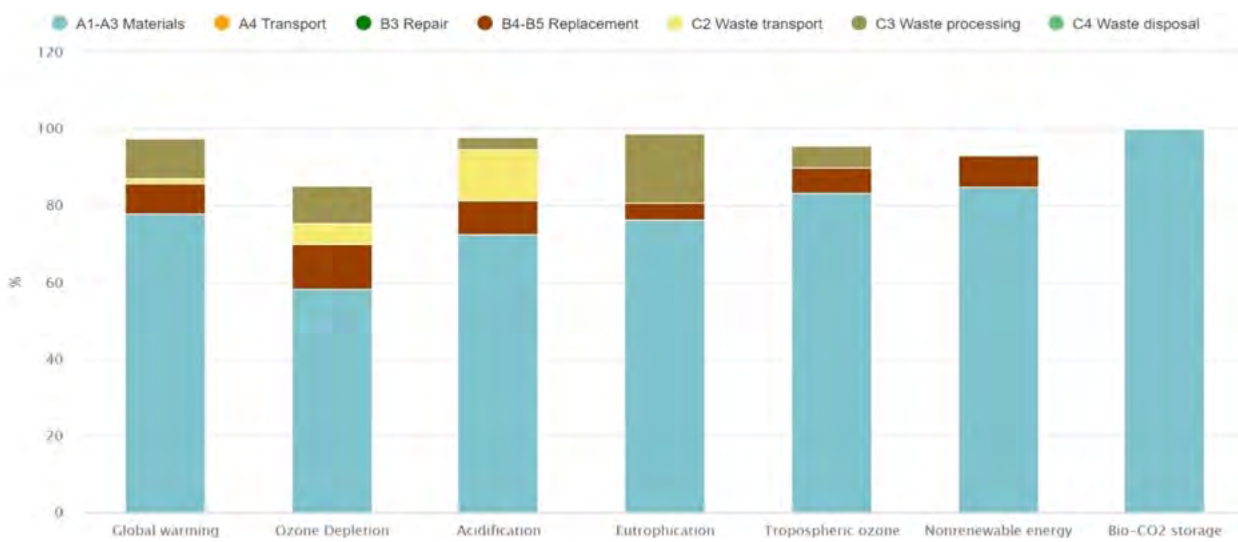


Figure 21 Life Cycle Impacts by Stage (%)

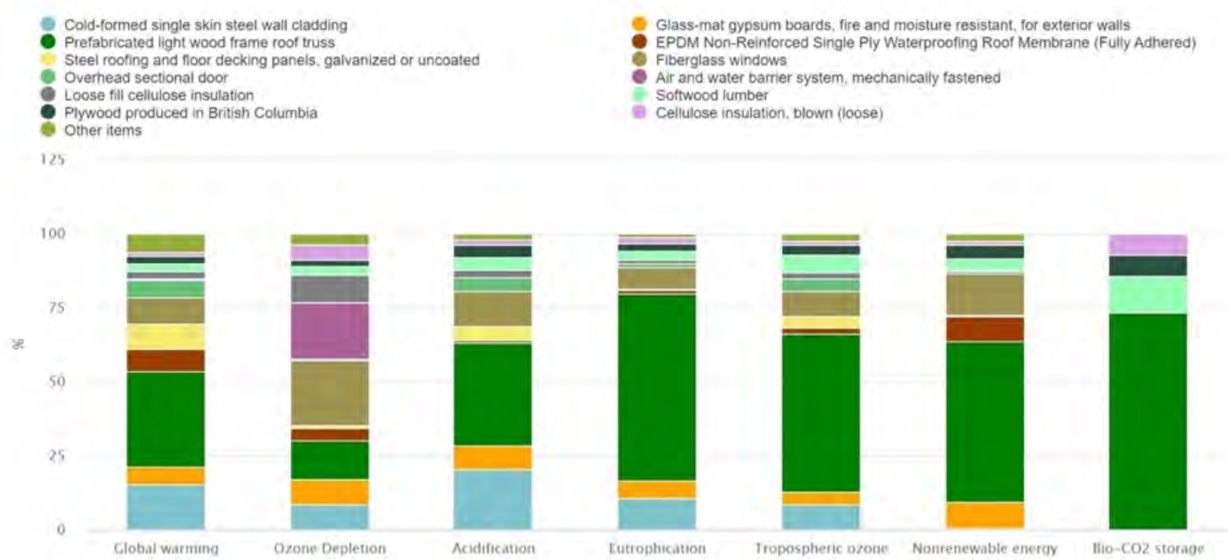


Figure 22 Life Cycle Impacts by Material (%)

Proposed Mechanical Systems

All scenarios:

- Two energy recovery ventilators (ERVs) will be added in Building A and Building B. They will be dual core type with approximately 90% heat recovery efficiency. Programmable time of day controls would run the ERVs.
- Cooling will be provided only to spaces that already have existing cooling.
- Cooling in Building A will continue to be provided by existing ASHPs.
- Plumbing vents that penetrate the roof are to be insulated from ceiling to floor with 3" pipe insulation to prevent thermal bridging.

1. Minimum Upgrade Scenario:

- Heating will continue to be provided by the existing combination of the oil-fired boiler and electric baseboard heaters. As the existing boiler still has some remaining useful life this avoids the replacement of the distribution system. The system still needs to be replaced by 2035 in this scenario.
- Building B: office spaces upgrade to new two 0.75-ton mini split units
- Domestic hot water will be supplied by the existing electric water heaters.
- Existing building controls will remain with new time clocks to control the ERVs.
- In the south office, an auxiliary heat relay system will control both the mini split unit and hydronic baseboards to ensure simultaneous heating and cooling does not occur.

2. NZER – ASHP:

- Two 9-ton, cold climate air source heat pumps sized for 60% of the peak heating load.
- 15 kW electric boiler sized for the remaining 40% of the load. Reducing the heat pump capacity to 60% of peak load typically results in the boiler providing 5 – 15% of heating.
- Building B: office spaces upgrade to new mini split units.
- Domestic water provided by a new 80-gallon heat pump water heater (HPWH)
- The ASHP control system to operate circulation pumps and heat pumps.
- In the south office, an auxiliary heat relay system will control the mini split unit and hydronic baseboards to ensure simultaneous heating and cooling does not occur.

3. NZER – GSHP:

- 24-ton GSHP system, which has also been sized for 60% capacity. The GSHP option will use the existing hydronic baseboard heaters as the distribution method. Hydronic baseboard heaters will be installed in the north office.
- 20 kW electric boiler, sized for the remaining 40% of the load.
- Two water-to-air console heat pumps will be installed in the Building B offices to provide cooling.
- Domestic hot water provided by a new 80-gallon heat pump water heater (HPWH).

Proposed Electrical Systems

1. Minimum Upgrade Scenario:
    - Existing electrical service to remain.
    - LED lighting upgrade with LED retrofit kits in all parts of the building.

2. NZER Scenarios
    - Service upgrade to power the existing loads plus added loads from newly electrified mechanical equipment and for solar photovoltaics.
    - New switchboard and distribution system upgrade.
    - Lighting replacement with LED fixtures throughout the building, with additional fixtures provided to under-illuminated areas.
    - Lighting control system upgrade to automatic lighting controls, complete with daylight sensors and vacancy sensors.

3. Net Zero Energy
    - 42 kW (DC) solar pv array

Nova Scotia Power Net Metering Program

The current NS 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 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. This building would be a class 1 building.

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.

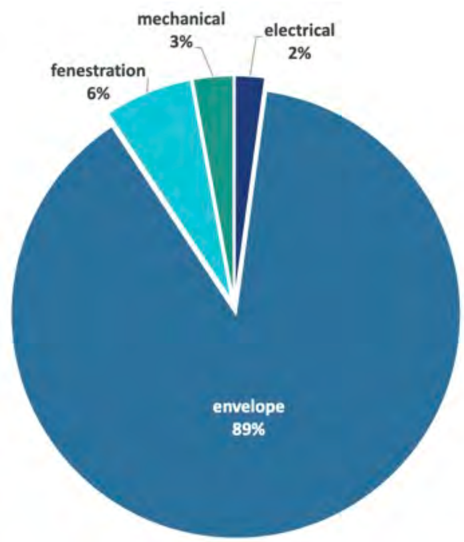
Construction Costs

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.

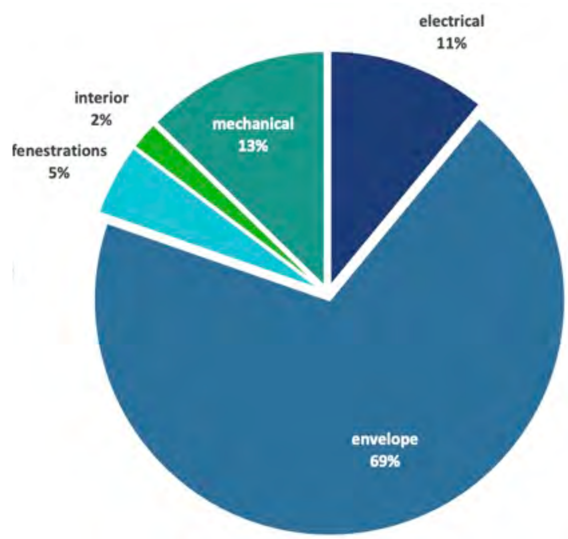
A Class D estimate is an indicative estimate of the final project costs and is expected to be within ±25% of actual costs.

A cost estimate for a fifth scenario, the Minimum Upgrade + Solar PV was extrapolated from data in the Class D estimates.

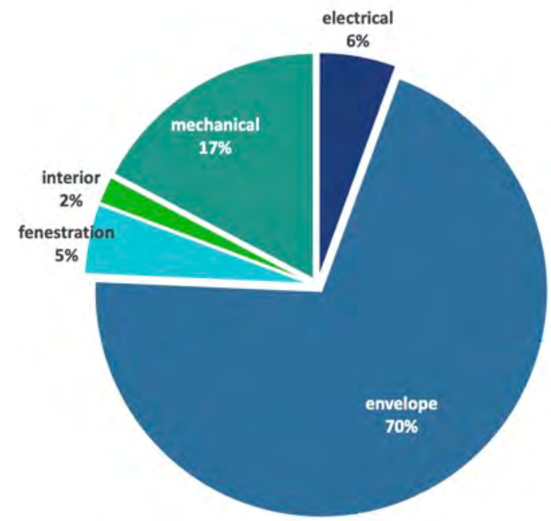
Minimum Upgrade	
Envelope	$1,737,399
Fenestration	$124,708
Mechanical	$57,427
Electrical	$42,466
total	**$1,962,000**



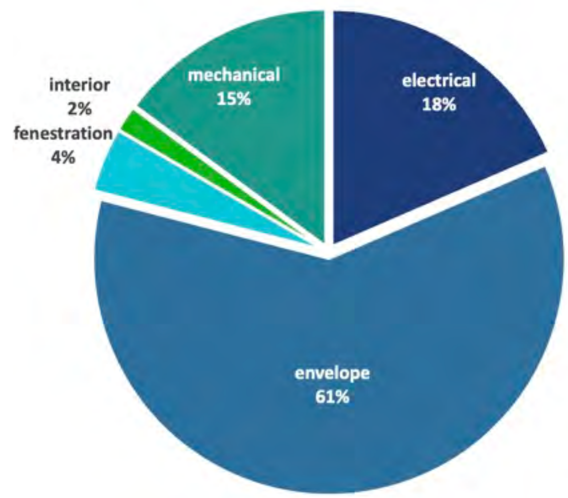
NZER –ASHP	
Envelope	$1,737,200
Fenestration	$124,694
Interiors	$49,563
Mechanical	$318,433
Electrical	$274,110
total	**$2,504,000**



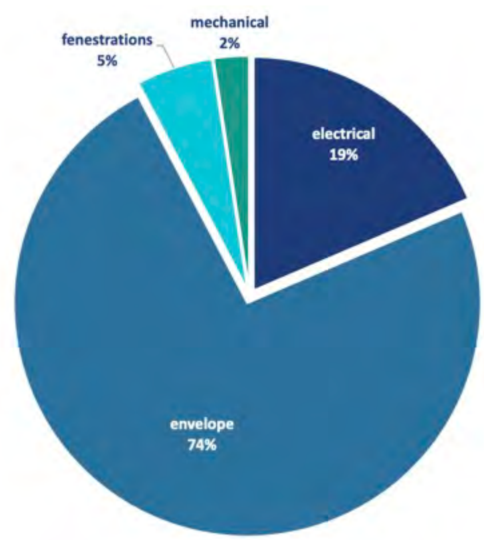
NZER – GSHP	
Envelope	$1,736,879
Fenestration	$124,671
Interiors	$49,554
Mechanical	$427,837
Electrical	$137,785
total	**$2,476,725**



NZE	
Envelope	$1,736,759
Fenestration	$124,662
Interiors	$49,550
Mechanical	$427,807
Electrical	$531,220
total	**$2,869,998**



Min. + PV	
Envelope	$1,737,399
Fenestration	$124,708
Mechanical	$57,427
Electrical	$437,567
total	**$2,357,101**



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, carbon tax, maintenance, maintenance capital (replacing major components as they age out), insurance, interest, and escalation of these costs over time. TCBO analysis typically includes property taxes, however the building is not subject to property tax. Inputs 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. The base case TCBO is 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.

A retrofit scenario was analysed in the TCBO that was not considered in the earlier engineering analysis; the Minimum Upgrade scenario plus solar. This was considered as construction costs for the NZER and NZE scenarios were high - more than the building's estimated Cost Replacement Value (CRV) of $2.37M. The Minimum Upgrade + solar scenario results in the best TCBO for the building and the only scenario that saves money over the life of the building.

Table 5 TCBO Summary

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
GHG emissions (kg) (60 Years)	3,437,029	2,299,297	1,659,416	1,660,662	0	734029.32
EUI (kWh/m2/year)	220.6	123.5	57.5	57.5	0.0	69.3
TCBO at 60 years	**$9,076,000**	**$9,814,000**	**$10,363,000**	**$10,351,000**	**$10,408,000**	**$7,820,000**
TCBO Savings at 60 years	$0	-$738,000	-$1,287,000	-$1,275,000	-$1,332,000	$1,256,000
% diff. from Base Case	-	-8%	-14%	-14%	-15%	14%

Key Results:

- The base case TCBO is $9M, three times the building's CRV of $2.37M.
- The minimum upgrade scenario uses 43% less energy than the base case but adds 8% to the TCBO.[7]
- The NZER options use 75% less energy than the base case but cost 14% more in lifetime operating costs.
- The NZE retrofit provides 100% energy savings yet increases the TCBO by 15%.
- The lowest TCBO is the Minimum Upgrade plus PV which delivers a 68% reduction in EUI for a 14% TCBO savings of $1.25M.

[7] Minor discrepancies are noted between TCBO energy results and the TEUI results given earlier in this report due to differences in protocols for building area take-offs, with SEEFAR using exterior building dimensions and energy modeling based on interior dimensions.

Table 6 Operating Cost Summary	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Utilities (including carbon tax)						
Cost	$ 5,978,000	$ 3,782,000	$ 2,436,000	$ 2,438,000	$ 42,000	$ 1,523,000
Diff. from Base Case	$ -	$ (2,196,000)	$ (3,542,000)	$ (3,540,000)	$ (5,936,000)	$ (4,455,000)
% diff from Base Case	0%	-37%	-59%	-59%	-99%	-75%
Energy Cost ($/ft2)	$ 773.78	$ 489.54	$ 315.31	$ 315.57	$ 5.44	$ 197.13
Maintenance						
Cost	$ 279,000	$ 174,000	$ 122,000	$ 122,000	$ 270,000	$ 313,000
Diff. from Base Case	$ -	$ (105,000)	$ (157,000)	$ (157,000)	$ (9,000)	$ 34,000
% diff from Base Case	0%	-38%	-56%	-56%	-3%	12%
Cost ($/ft2)	$ 36.11	$ 22.52	$ 15.79	$ 15.79	$ 34.95	$ 40.51
Insurance & Taxes						
Costs	$ 465,000	$ 465,000	$ 465,000	$ 465,000	$ 465,000	$ 465,000
Diff. from Base Case	$ -	$ -	$ -	$ -	$ -	$ -
% diff from Base Case	0%	0%	0%	0%	0%	0%
First Year Annual Maintenance						
Cost	$ 2,400	$ 1,500	$ 1,150	$ 1,050	$ 2,324	$ 2,689
Diff. from Base Case	$ -	$ (900)	$ (1,250)	$ (1,350)	$ (76)	$ 289
% diff from Base Case	0%	-38%	-52%	-56%	-3%	12%
Cost ($/ft2)	$ 0.31	$ 0.19	$ 0.15	$ 0.14	$ 0.30	$ 0.35

- The 60-year utility costs for the Base Case are 2.5 times the CRV of the building.
- The NZR options reduce the 60-year utility costs by 59%.
- 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 cost less than the base case because of the reduced maintenance for a metal roof and siding compared with asphalt shingles and wood siding. Eliminating the boiler also represents significant maintenance savings.
- 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	Min Solar
Initial Retrofit / HPB CostYear 1						
Initial Cost	$ 95,000	$ 2,110,000	$ 2,687,000	$ 2,804,000	$ 3,720,000	$ 2,278,000
Diff. from Base Case	$ -	$ 2,015,000	$ 2,592,000	$ 2,709,000	$ 3,625,000	$ 2,183,000
% diff from Base Case	0%	2121%	2728%	2852%	3816%	2298%
Cost ($/ft2)	$ 12	$ 273	$ 348	$ 363	$ 482	$ 295
Maintenance Capital Costs 60 Years						
Cost	$ 2,181,000	$ 1,530,000	$ 2,419,000	$ 2,192,000	$ 2,819,000	$ 1,349,000
Diff. from Base Case	$ -	$ (651,000)	$ 238,000	$ 11,000	$ 638,000	$ (832,000)
% diff from Base Case	0%	-30%	11%	1%	29%	-38%
Cost ($/ft2)	$ 282	$ 198	$ 313	$ 284	$ 365	$ 175
Retrofit / HPB + Maintenance Capital Costs 60 Years						
Total Costs	$ (2,276,000)	$ (3,640,000)	$ (5,106,000)	$ (4,996,000)	$ (6,539,000)	$ (3,627,000)
Diff. from Base Case	$ -	$ (1,364,000)	$ (2,830,000)	$ (2,720,000)	$ (4,263,000)	$ (1,351,000)
% diff from Base Case	0%	-60%	-124%	-120%	-187%	-59%

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 new mechanical systems and solar panels. The NZE scenario costing $1M 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. The costs to maintain the building in all scenarios is similar, at around $1M.

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.

Table 8 Annual Energy Consumption

	Units	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Water	m3	-	-	-	-	-	-
Sewer Discharge	m3	-	-	-	-	-	-
Electric	kWh	43,240.00	38,937.00	41,279.00	41,310.00	41,279.00	38,973.00
Gas	m3	-	-	-	-	-	-
Heating Oil	Litres	10,632.00	4,594.00	-	-	-	4,594.00
GHG emissions	kg CO2 eq	57,283.82	38,321.61	27,656.93	27,677.70	-	12,233.82
Solar PV generated	kWh	-	-	-	-	41,279.00	38,973.00
Total	ekWh	158,420.00	88,705.33	41,279.00	41,310.00	-	49,768.33
Total	GJ	570.31	319.34	148.60	148.72	-	179.17
EUI	kWh/m2/yr	**220.64**	**123.55**	**57.49**	**57.53**	-	69.32

Key Results:

- Electricity consumption, GHGs and EUI are decreased in all retrofit scenarios.
- Water consumption and sewer discharge were not measured. There may be an opportunity for savings by replacing plumbing fixtures, but that was not undertaken in this study.
- The Minimum Upgrade plus solar reduces GHG emissions by 78% and EUI by 68%
- Fuel oil is used in the Base Case, Minimum Upgrade and Minimum Upgrade + solar scenarios. Fossil fuel must be eliminated by 2035 to meet the Municipality of Colchester's emissions targets, and by 2050 to meet Canada's.

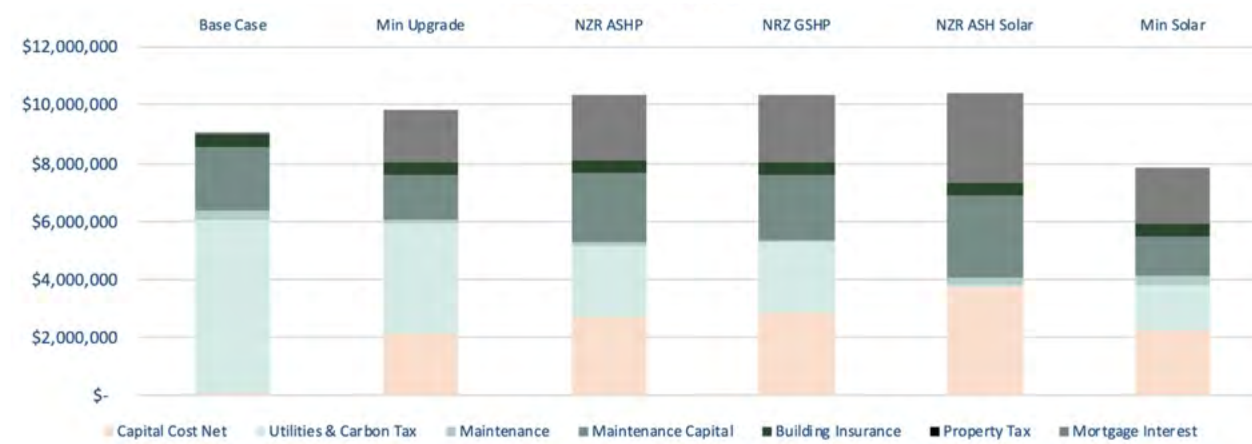


Figure 23 TCBO Comparison

Cumulative TCBO

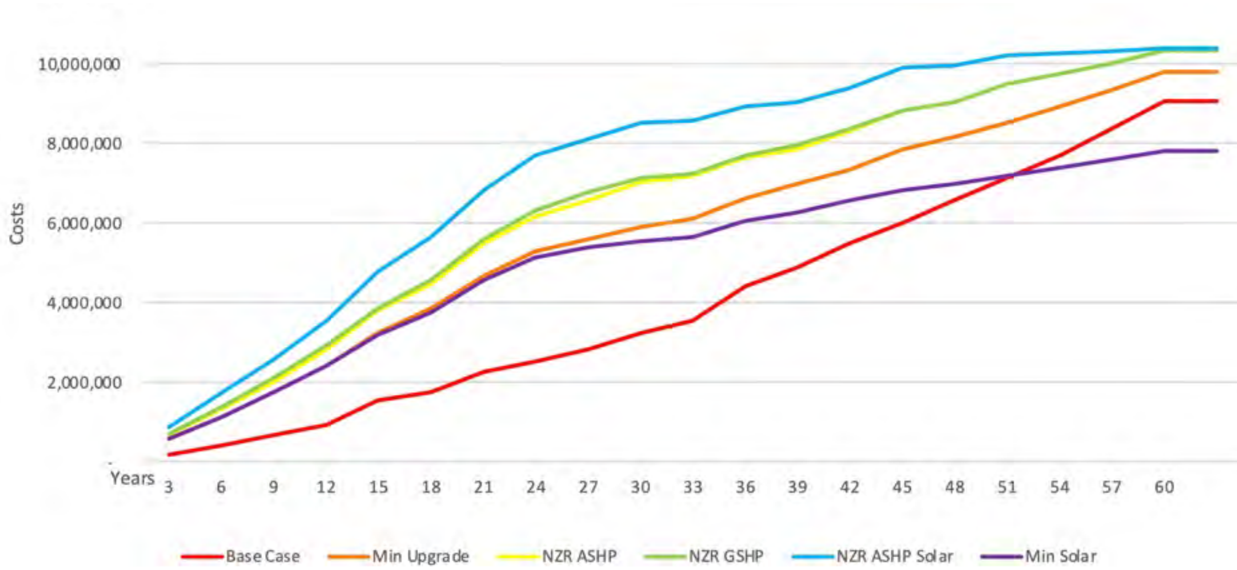


Figure 24 Cumulative TCBO

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

Discussion

There are two key issues we are trying to address in this study, reducing GHG emissions and minimizing the lifetime Total Cost of Building Ownership.

This results for this project are perhaps the most surprising out of the six buildings studied. All the retrofit scenarios initially developed represent a higher TCBO than the existing building. Adding solar panels to the Minimum Upgrade was the only way to achieve a positive TCBO. This indicates that the proposed retrofits and their capital costs need to be examined to find more savings.

The cost of the retrofits designed in this study are much higher than anticipated. It is impractical to invest over $400/ft^2 to upgrade a building when a new facility could be built for similar money, however stopping emissions is about more than energy used for heating and cooling. The Municipality of Colchester has committed to decarbonizing their corporate buildings by 2035 and replacing all existing buildings with high EUIs with new buildings is also impractical.

The embodied carbon emissions from the retrofit are 89 $kgCO_2e$. Embodied carbon data is not readily available for commercial buildings of this type, but this building is small enough that it can be evaluated at the scale of a large house. If the Debert Water Utility Facility were to be replaced by a new build with moderate carbon materials, its embodied carbon would be 108,000 $kgCO_2e$ based on a value of 150 $kgCO_2e$ per m^2. [8] This number doesn't include the embodied carbon content of the existing structure which would be sent to landfill, which contains significant amounts of concrete and steel. If our goal is to stop emissions today, evaluating every retrofit through the lens of embodied carbon is valuable.

The recommended retrofit is the Minimum Upgrade + solar with its 14% TCBO savings over the next 60 years. This retrofit maintains fuel-oil based heating equipment in the building, which must be removed by 2050 to meet Canada's net-zero goals. The costs to retrofit the heating system at that future date are not captured in the TCBO and may well offset the 14% savings achieved. For this reason, this scenario is no more viable than the options with negative TCBOs.

Further work is needed to identify ways to reduce the cost to retrofit the Debert Water Utility Facility.

[8] Passive Buildings Canada and Builders for Climate Action (2022) Emissions of Materials Benchmark Assessment for Residential Construction Report. https://www.buildersforclimateaction.org/report---embarc-report.html

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 to achieve 50% or more EUI savings and at least one 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 retrofits to the six municipal buildings 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[9]. 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 did not meet expectations, 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.

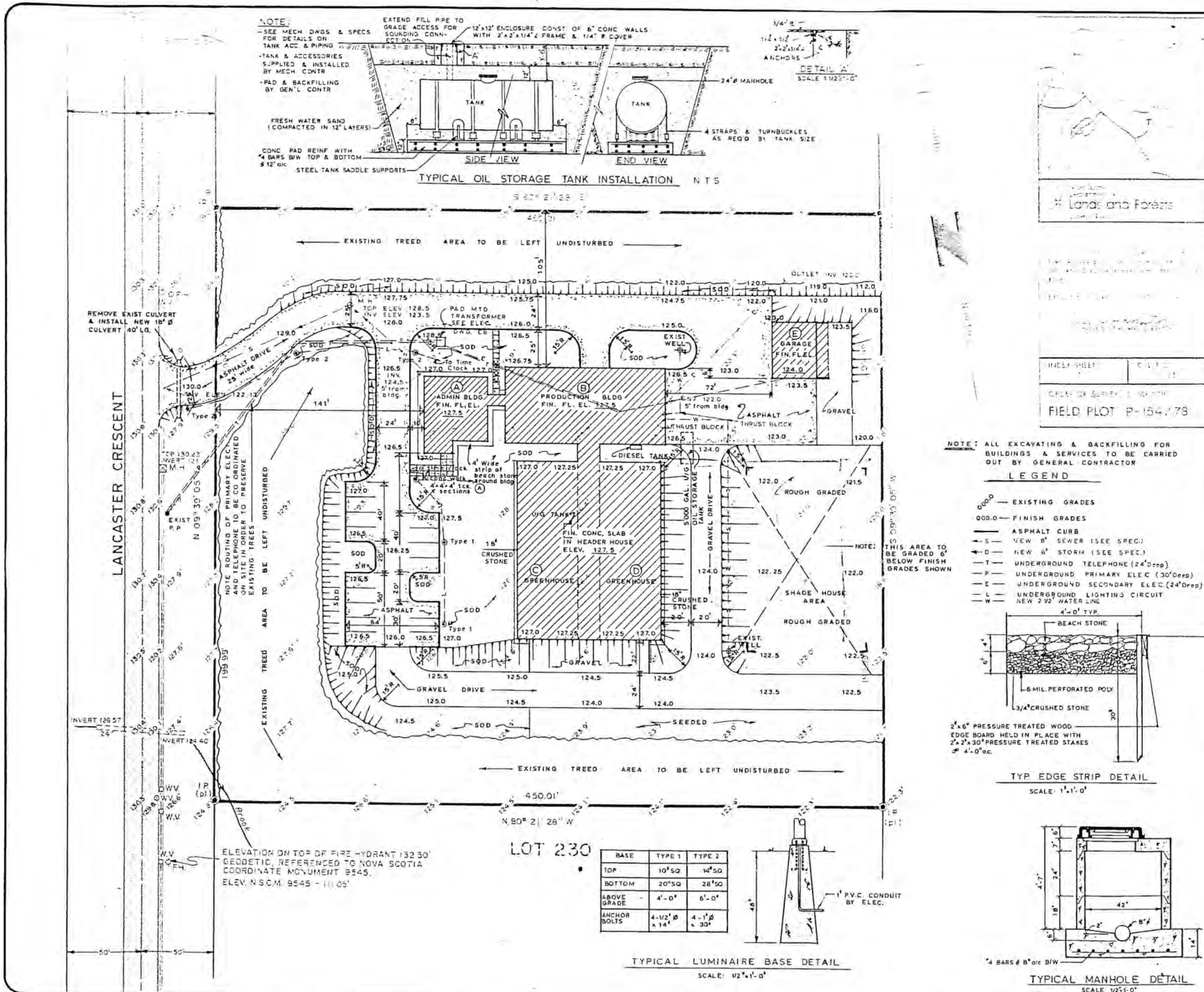
This study shows that the technical challenges are secondary to the overwhelming barrier of cost. It also showed that if investment in deep retrofits doesn't start now, municipalities will pay exponentially more down the road.

Deep GHG reductions are very achievable in municipal buildings. The Minimum Upgrade scenario with the addition of solar, is the only retrofit option considered for the Debert Water Utility Building that resulted in a positive TCBO. The retrofit will cost 2.36M, which is $10,000 less than the cost replacement value of the building. It results in a 69% reduction in EUI and 79% reduction in GHGs and saves $1.3M over the life of the building.

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

Appendix A

Pre-retrofit Drawings



BASE	TYPE 1	TYPE 2
TOP	10"SQ	14"SQ
BOTTOM	20"SQ	28"SQ
ABOVE GRADE	4'-0"	6'-0"
ANCHOR BOLTS	4-1/2"⌀ x 14"	4-1"⌀ x 30"

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS

OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS

DESCRIPTION	NO.	DATE

CONSULTANTS

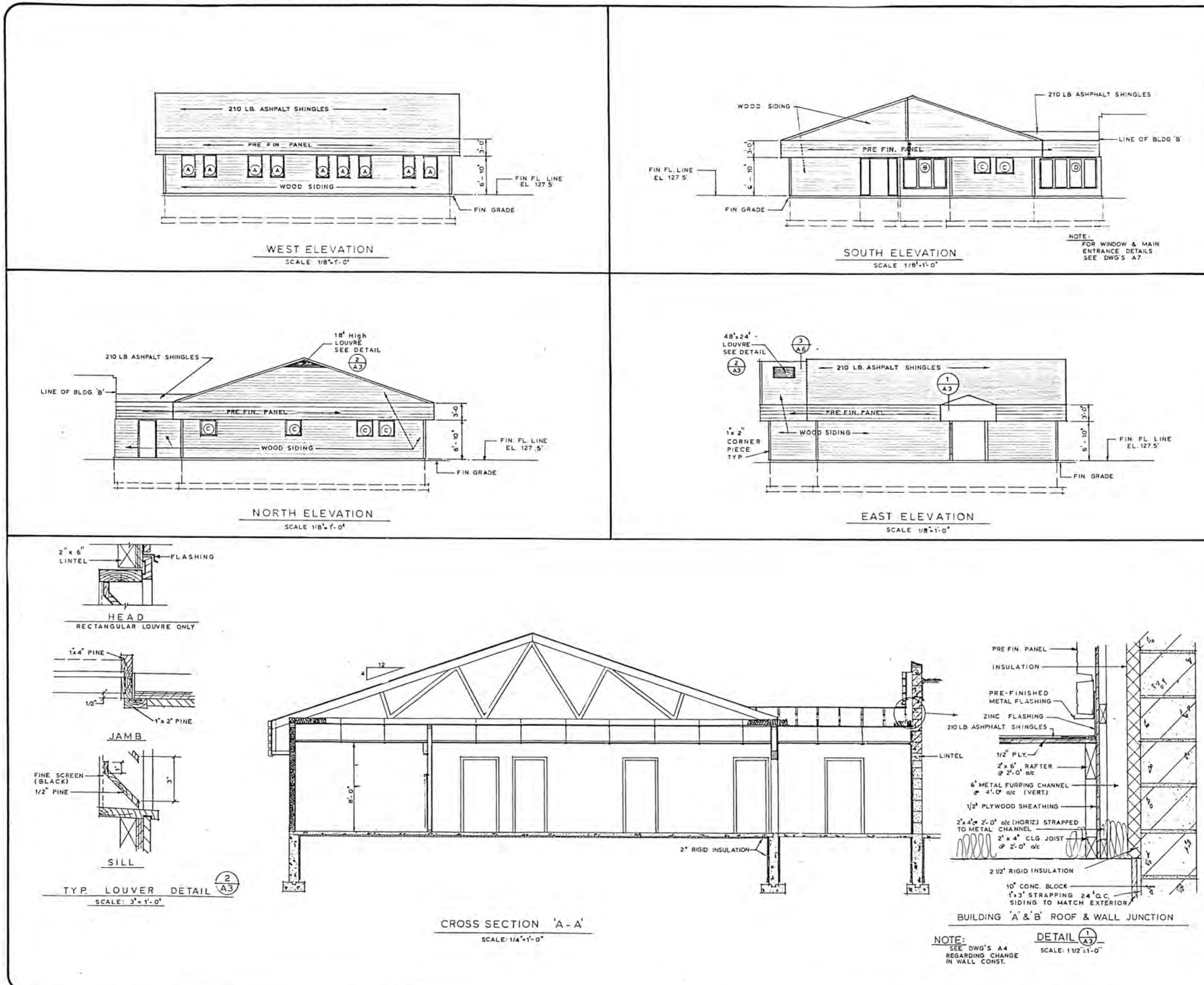
PROJECT: TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT - COLCHESTER COUNTY - N.S.

TITLE: EXISTING CONDITIONS & SITE PLAN

DRAWN: D. P. J.	MICRO NO.: B03-DO-01
CHECKED: D.J.M. & D.P.J.	P.M. NO.: 12/U
APPROVED	
DATE: 79-11-26	SCALE: 1" = 30'

SEAL

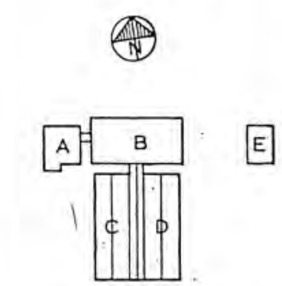
DWG. NO. A1



NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS DESCRIPTION	NO.	DATE

CONSULTANTS



KEY PLAN

PROJECT
TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT · COLCHESTER COUNTY · N.S.

TITLE
BUILDING A
ELEVATIONS & CROSS SECTION 'A-A'

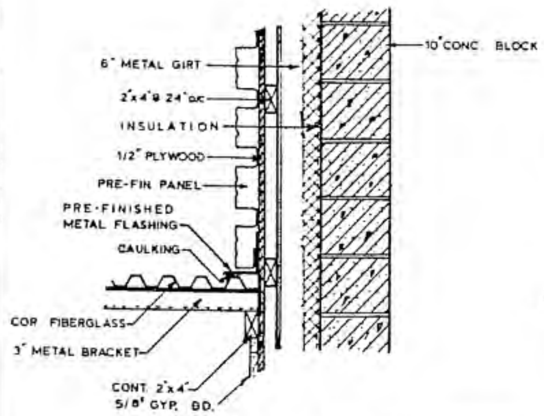
DRAWN	MICRO. NO.
A.J.D.	B03-DO-01
CHECKED D.J.M. & D.P.J.	P.H. NO. 12/U
APPROVED	
DATE 79·11·26	SCALE 1/8"=1'-0"

SEAL — REGISTERED MEMBER N.S. ASSOCIATION OF ARCHITECTS

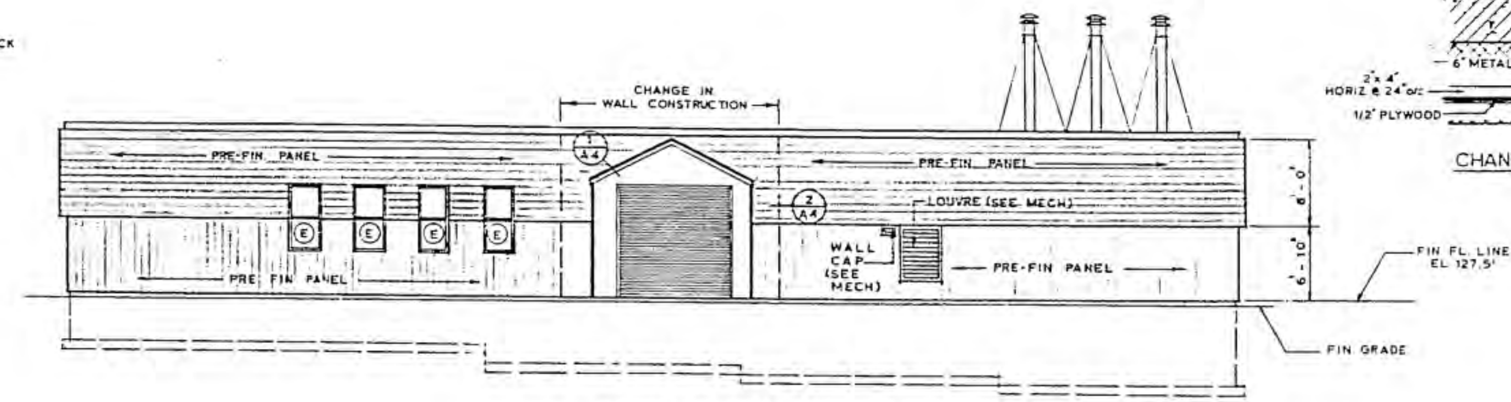
DWG. NO. A3

A3-1 A3-2 A3-3

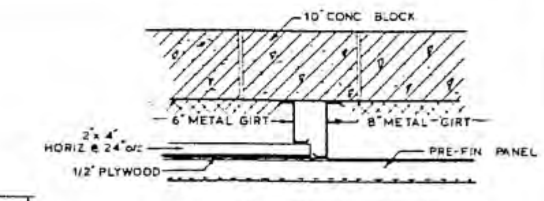
B



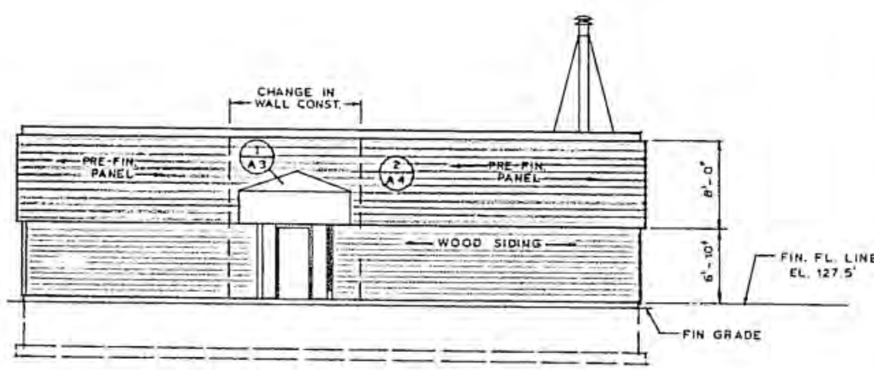
BLDGS. C & B; ROOF - WALL JUNCTION DETAIL (1/A4)
SCALE: 1':1'-0"



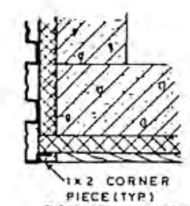
SOUTH ELEVATION
SCALE: 1/8" = 1'-0"



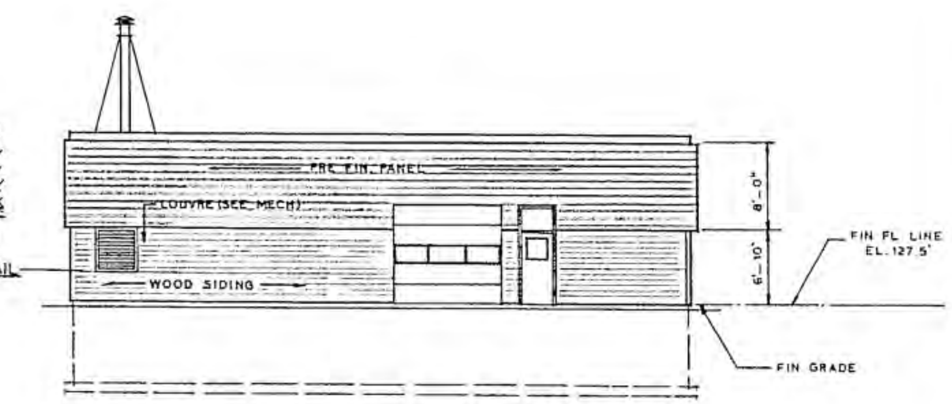
CHANGE IN WALL CONST DETAIL (2/A4)
SCALE: 1':1'-0"



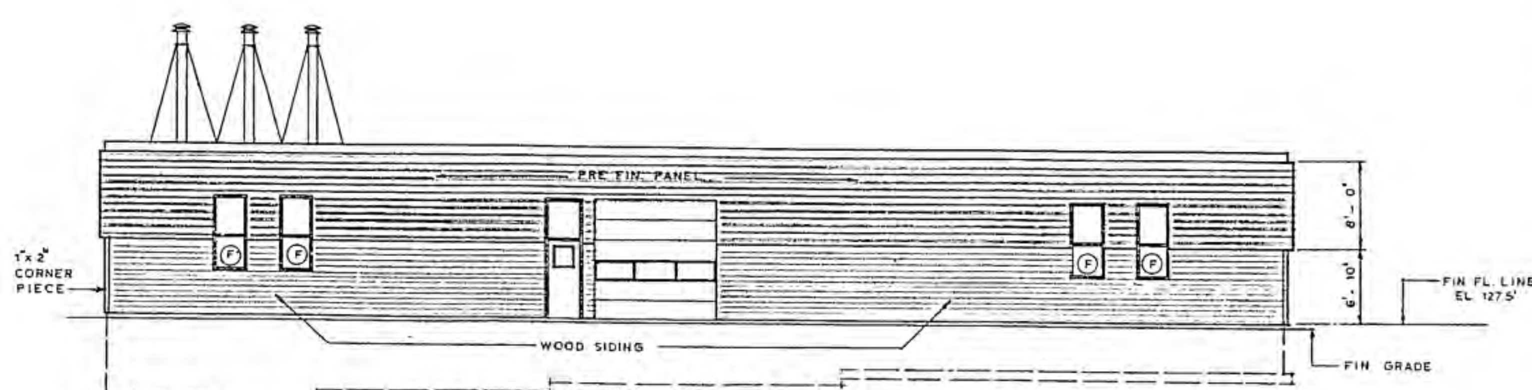
WEST ELEVATION
SCALE: 1/8"=1'-0"



CORNER DETAIL
SCALE: 1':1'-0"



EAST ELEVATION
SCALE: 1/8"=1'-0"



NORTH ELEVATION
SCALE: 1/8"=1'-0"

NOTE

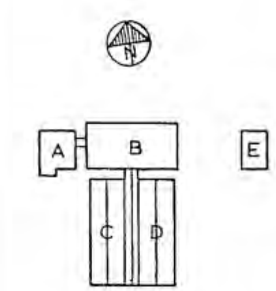
FOOTING MUST BE A MINIMUM OF 4'-6" BELOW EXISTING GRADES OR 4'-6" BELOW FINISH GRADES WHICHEVER IS GREATER, TO ENSURE MINIMUM BEARING CAPACITY OF SOIL @ 3,000 P.S.F.

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS

DESCRIPTION	NO.	DATE

CONSULTANTS



KEY PLAN

PROJECT
TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT · COLCHESTER COUNTY · N.S.

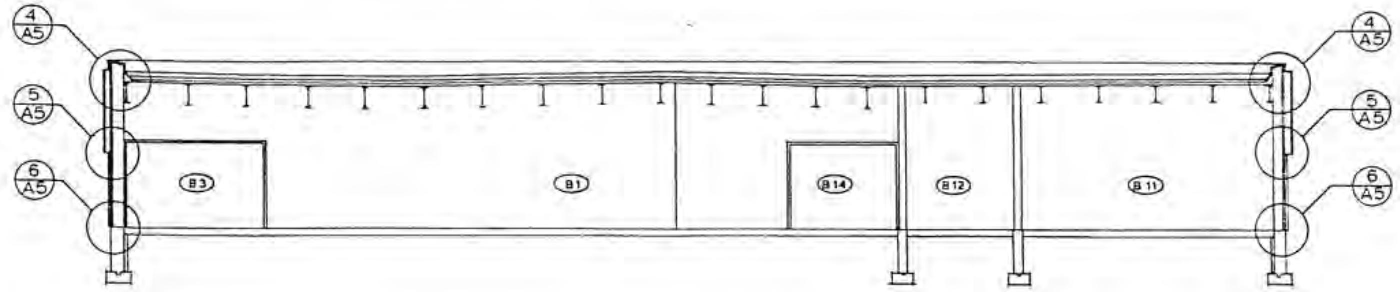
TITLE
BUILDING 'B' ELEVATIONS

DRAWN A.J.D.	MICRO. NO. B03-DO-01
CHECKED D.J.M. & D.P.J.	P.H. NO. 12/U
APPROVED	
DATE 79·11·26	SCALE 1/8" = 1'-0"

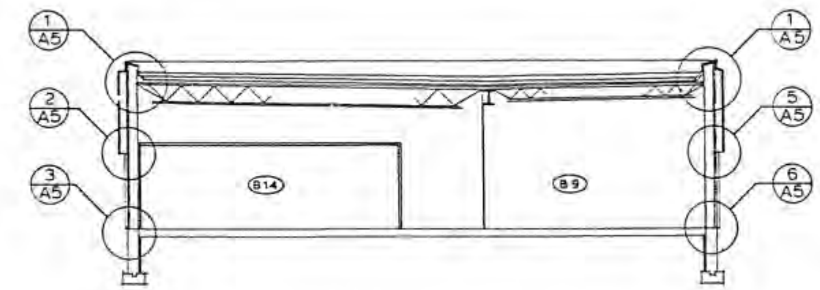
SEAL

DWG. NO. A4

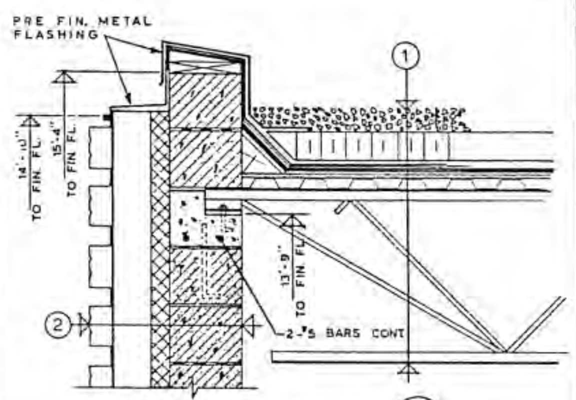
A4-1 | A4-2
A4-3
B



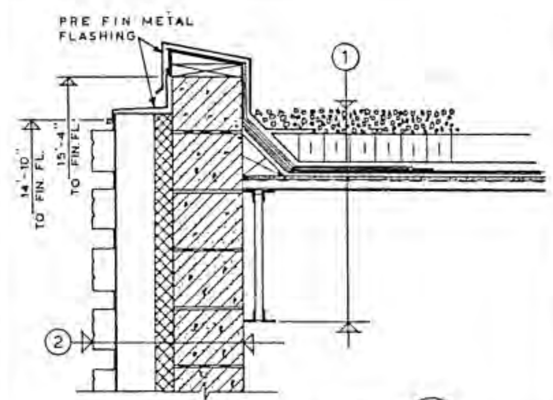
LONGITUDINAL SECTION 'B-B'
SCALE 1/8"=1'-0"



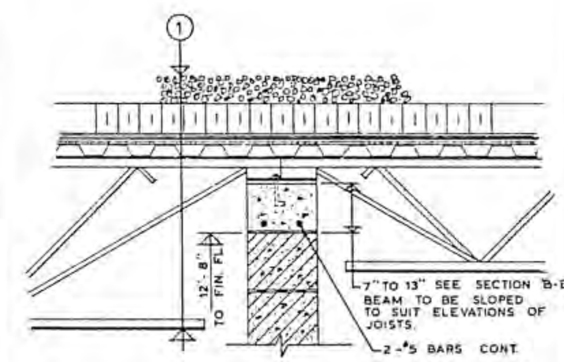
CROSS SECTION 'C-C'
SCALE 1/8"=1'-0"



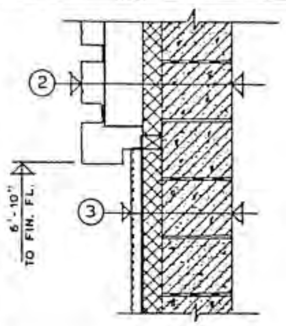
ROOF & WALL DETAIL (1/A5)
SCALE: 1"=1'-0"



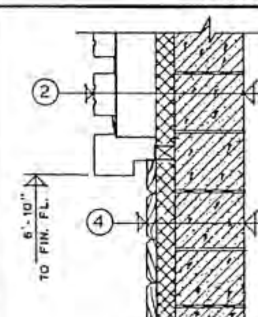
ROOF & WALL DETAIL (4/A5)
SCALE: 1"=1'-0"



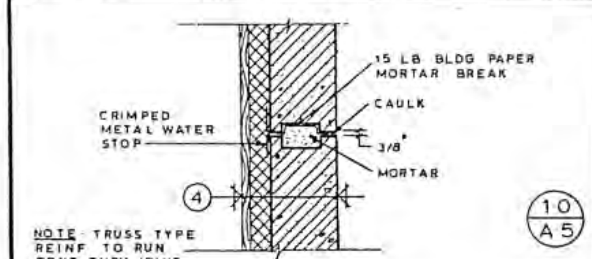
INT. BEARING PART. & ROOF DETAIL (7/A5)
SCALE: 1"=1'-0"



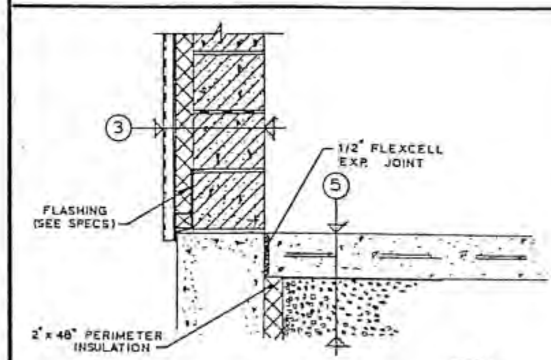
WALL DETAIL (2/A5)
SCALE: 1"=1'-0"



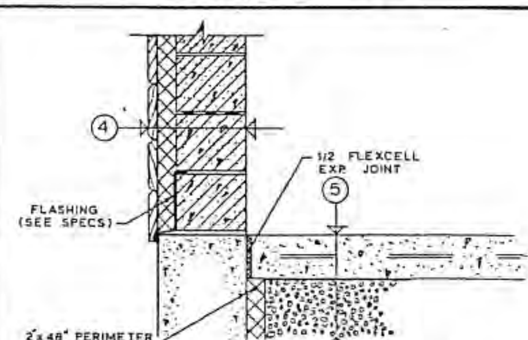
WALL DETAIL (5/A5)
SCALE: 1"=1'-0"



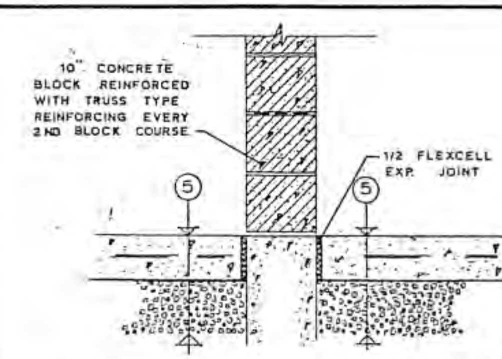
TYPICAL WALL CONTROL JOINT DETAIL



FLOOR & WALL DETAIL (3/A5)
SCALE: 1"=1'-0"



FLOOR & WALL DETAIL (6/A5)
SCALE: 1"=1'-0"



INT. BEARING PART. & FLOOR DETAIL (9/A5)
SCALE: 1"=1'-0"

BUILDING 'B'

CONSTRUCTION MATERIALS

(1)
CRUSHED STONE
4" RIGID INSULATION
FLOOD COAT
3 PLY ROOFING MEMBRANE
1/2" GYPSUM BOARD
1 1/2" METAL DECK
O.W.S. JOISTS (SEE STRUCTURAL)

(2)
3" DEEP PRE-FINISHED PANEL
8" METAL FURRING VERT. 10'-0" O.C.
2 1/2" RIGID INSULATION
10" CONC. BLOCK REINF. WITH TRUSS TYPE REINFORCING EVERY 2ND BLOCK COURSE

(3)
1-1/2" DEEP PRE-FINISHED PANEL
2"x3" FURRING @ 3'-5" O.C. HORIZ.
2 1/2" RIGID INSULATION
10" CONC. BLOCK REINF. WITH TRUSS TYPE REINFORCING EVERY 2ND BLOCK COURSE

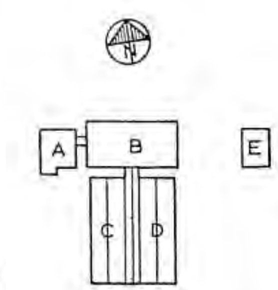
(4)
1"x6" V-JOINT WOOD SIDING
2 LAYERS 15 LB BLDG. PAPER
2"x3" FURRING @ 2'-0" O.C. VERT.
2 1/2" RIGID INSULATION
10" CONC. BLOCK REINF. WITH TRUSS TYPE REINFORCING EVERY 2ND BLOCK COURSE

(5)
5" CONC. SLAB REINF. WITH 6x6-6 WELDED WIRE MESH (1 LAYER)
6 MIL POLYETHYLENE V.B.
12" GRAVEL (SEE SPECS.)

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS		
DESCRIPTION	NO.	DATE

CONSULTANTS



KEY PLAN

PROJECT: TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT · COLCHESTER COUNTY · N.S.

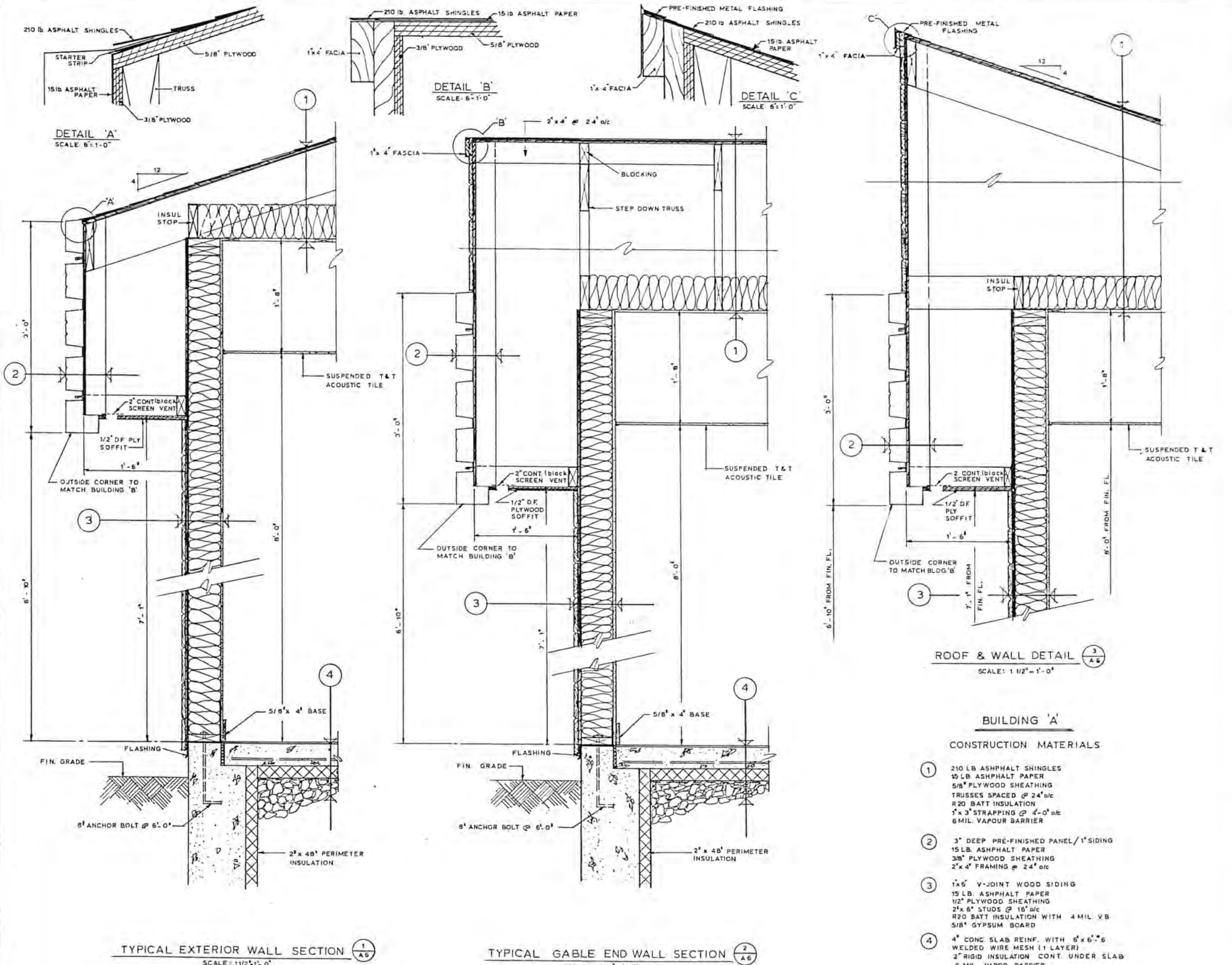
TITLE: BUILDING 'B'
SECTIONS & DETAILS

DRAWN: S.A.H.	MICRO. NO.: B03-DO-01
CHECKED: D.J.M. & D.P.J.	P.H. NO.: 12/U
APPROVED:	
DATE: 79-11-26	SCALE: 1" & 1/8"= 1'-0"

SEAL: REGISTERED MEMBER

DWG. NO. A5

A5-1 A5-2
B



BUILDING 'A'

CONSTRUCTION MATERIALS

1. 210 LB ASPHALT SHINGLES
15 LB. ASPHALT PAPER
5/8" PLYWOOD SHEATHING
TRUSSES SPACED @ 24" o/c
R20 BATT INSULATION
1"x 3" STRAPPING @ 2'-0" o/c
6 MIL. VAPOUR BARRIER

2. 3" DEEP PRE-FINISHED PANEL / 1" SIDING
15 LB. ASPHALT PAPER
3/8" PLYWOOD SHEATHING
2"x 4" FRAMING @ 24" o/c

3. 1"x 6" V-JOINT WOOD SIDING
15 LB. ASPHALT PAPER
1/2" PLYWOOD SHEATHING
2"x 6" STUDS @ 16" o/c
R20 BATT INSULATION WITH 4 MIL. VB
5/8" GYPSUM BOARD

4. 4" CONC. SLAB REINF. WITH 6"x 6" - 6 WELDED WIRE MESH (1 LAYER)
2" RIGID INSULATION CONT. UNDER SLAB
6 MIL VAPOR BARRIER
12" GRAVEL (SEE SPECS.)

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS		
DESCRIPTION	NO.	DATE

CONSULTANTS

KEY PLAN

A B C D E

PROJECT: TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT - COLCHESTER COUNTY - N.S.

TITLE: BUILDING 'A' WALL SECTIONS

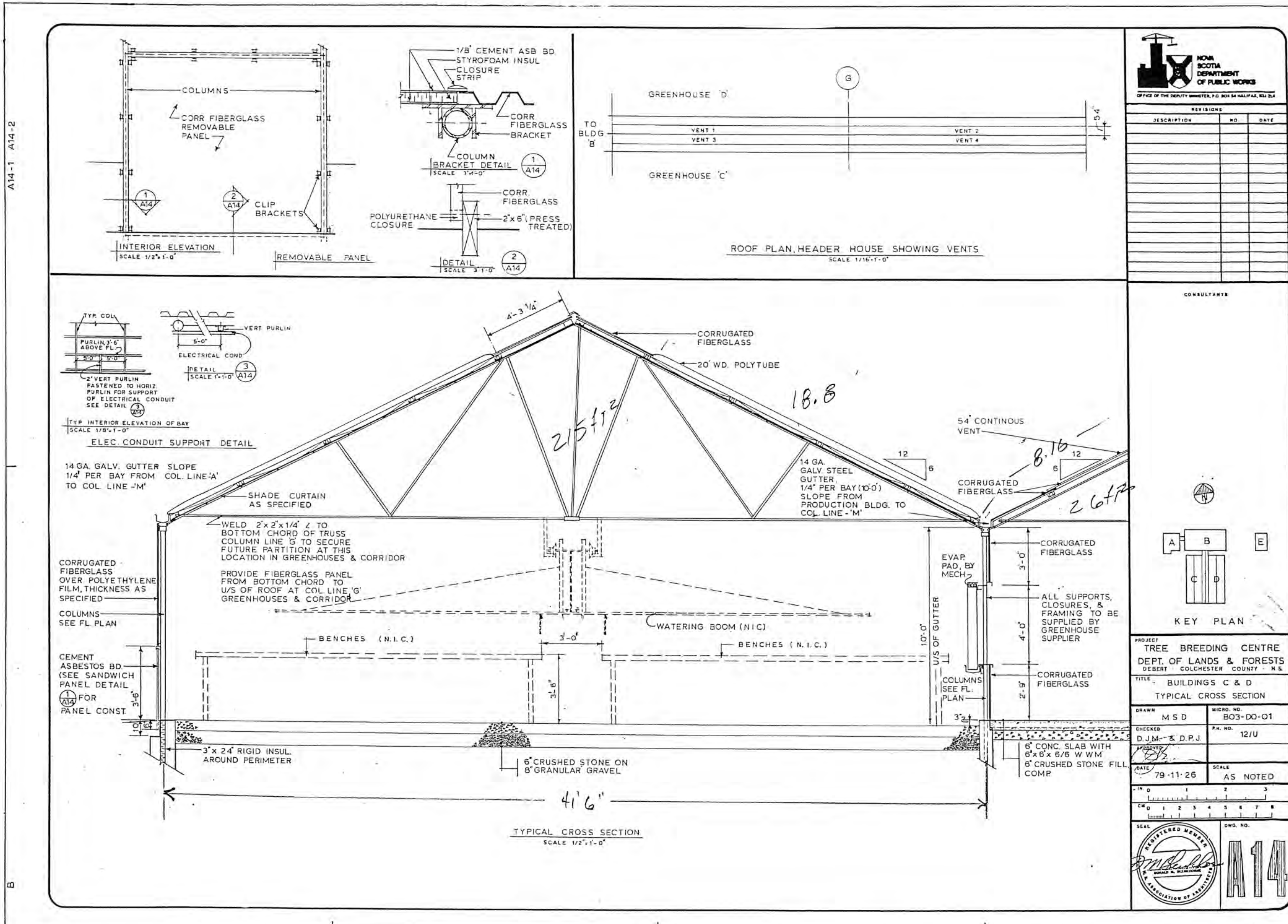
DRAWN: A.J.D.
MICRO. NO.: BO3-DO-01
CHECKED: D.J.M. & D.P.J.
F.H. NO.: 12/U
APPROVED:
DATE: 79-11-26
SCALE: 1 1/2" = 1'-0"

SEAL: REGISTERED MEMBER N.S. ASSOCIATION OF ARCHITECTS — DONALD M. BLENKHORNE

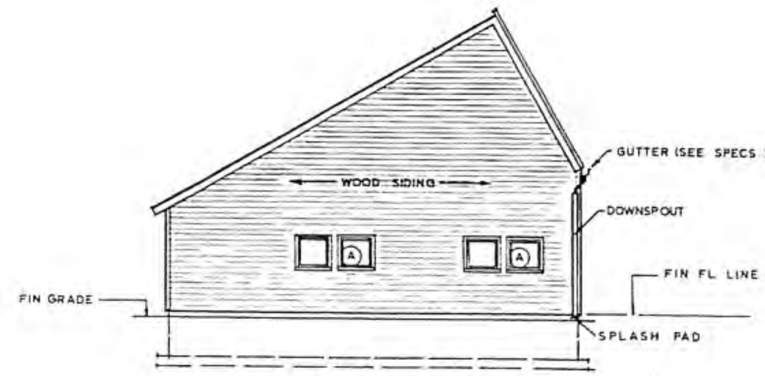
DWG. NO. A6

A6-1 A6-2

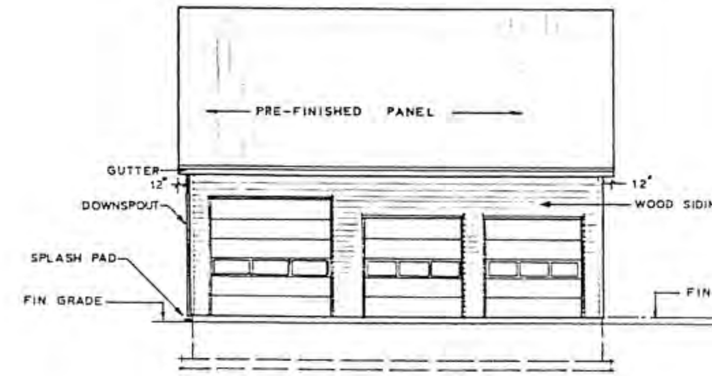
B


A14-1 A14-2
COLUMNS
CORR FIBERGLASS REMOVABLE PANEL
CLIP BRACKETS
INTERIOR ELEVATION
SCALE 1/2"=1'-0"
REMOVABLE PANEL
1/8" CEMENT ASB BD.
STYROFOAM INSUL.
CLOSURE STRIP
CORR FIBERGLASS
BRACKET
COLUMN
BRACKET DETAIL
SCALE 3"=1'-0"
CORR. FIBERGLASS
POLYURETHANE CLOSURE
2"x6" (PRESS TREATED)
DETAIL
SCALE 3"=1'-0"
GREENHOUSE 'D'
TO BLDG 'B'
VENT 1
VENT 2
VENT 3
VENT 4
54"
GREENHOUSE 'C'
ROOF PLAN, HEADER HOUSE SHOWING VENTS
SCALE 1/16"=1'-0"
NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
REVISIONS
DESCRIPTION
NO.
DATE
CONSULTANTS
TYP. COL.
PURLIN 3'-6" ABOVE FL.
5'-0"
VERT. PURLIN
ELECTRICAL COND.
DETAIL
SCALE 1"=1'-0"
2" VERT PURLIN FASTENED TO HORIZ. PURLIN FOR SUPPORT OF ELECTRICAL CONDUIT SEE DETAIL
TYP. INTERIOR ELEVATION OF BAY
SCALE 1/8"=1'-0"
ELEC. CONDUIT SUPPORT DETAIL
14 GA. GALV. GUTTER SLOPE 1/4" PER BAY FROM COL. LINE 'A' TO COL. LINE 'M'
4'-3 1/4"
CORRUGATED FIBERGLASS
20" WD. POLYTUBE
18.8
21.5ft²
54" CONTINOUS VENT
8.16
26ft²
12
6
14 GA. GALV. STEEL GUTTER, 1/4" PER BAY (10'-0") SLOPE FROM PRODUCTION BLDG. TO COL. LINE 'M'
SHADE CURTAIN AS SPECIFIED
WELD 2"x2"x1/4" ∠ TO BOTTOM CHORD OF TRUSS COLUMN LINE 'G' TO SECURE FUTURE PARTITION AT THIS LOCATION IN GREENHOUSES & CORRIDOR
PROVIDE FIBERGLASS PANEL FROM BOTTOM CHORD TO U/S OF ROOF AT COL. LINE 'G' GREENHOUSES & CORRIDOR
CORRUGATED FIBERGLASS OVER POLYETHYLENE FILM, THICKNESS AS SPECIFIED
COLUMNS SEE FL. PLAN
WATERING BOOM (N.I.C)
BENCHES (N.I.C.)
3'-0"
3'-6"
CEMENT ASBESTOS BD. (SEE SANDWICH PANEL DETAIL 1/A14 FOR PANEL CONST.
EVAP. PAD, BY MECH.
10'-0" U/S OF GUTTER
COLUMNS SEE FL. PLAN
ALL SUPPORTS, CLOSURES, & FRAMING TO BE SUPPLIED BY GREENHOUSE SUPPLIER
4'-0"
2'-9"
3"
3" x 24" RIGID INSUL. AROUND PERIMETER
6" CRUSHED STONE ON 8" GRANULAR GRAVEL
6" CONC. SLAB WITH 6"x6"x 6/6 W W M
6" CRUSHED STONE FILL, COMP.
41'6"
TYPICAL CROSS SECTION
SCALE 1/2"=1'-0"
KEY PLAN
A B E C D
PROJECT TREE BREEDING CENTRE DEPT. OF LANDS & FORESTS DEBERT · COLCHESTER COUNTY · N.S.
TITLE BUILDINGS C & D TYPICAL CROSS SECTION
DRAWN M S D
MICRO. NO. B03-DO-01
CHECKED D.J.M. & D.P.J.
P.H. NO. 12/U
APPROVED
DATE 79-11-26
SCALE AS NOTED
DWG. NO. A14
REGISTERED MEMBER N.S. ASSOCIATION OF ARCHITECTS
B

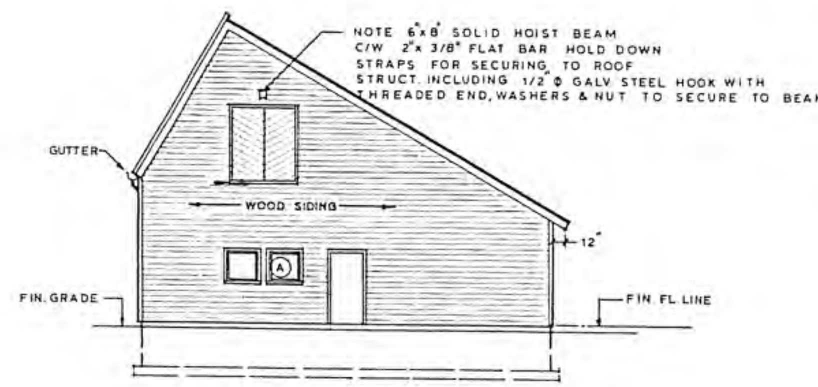
A16-1 A16-2 A16-3



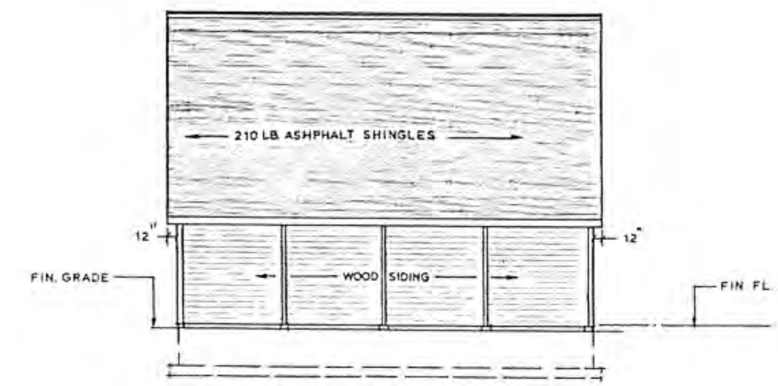
NORTH ELEVATION
SCALE 1/8"=1'-0"



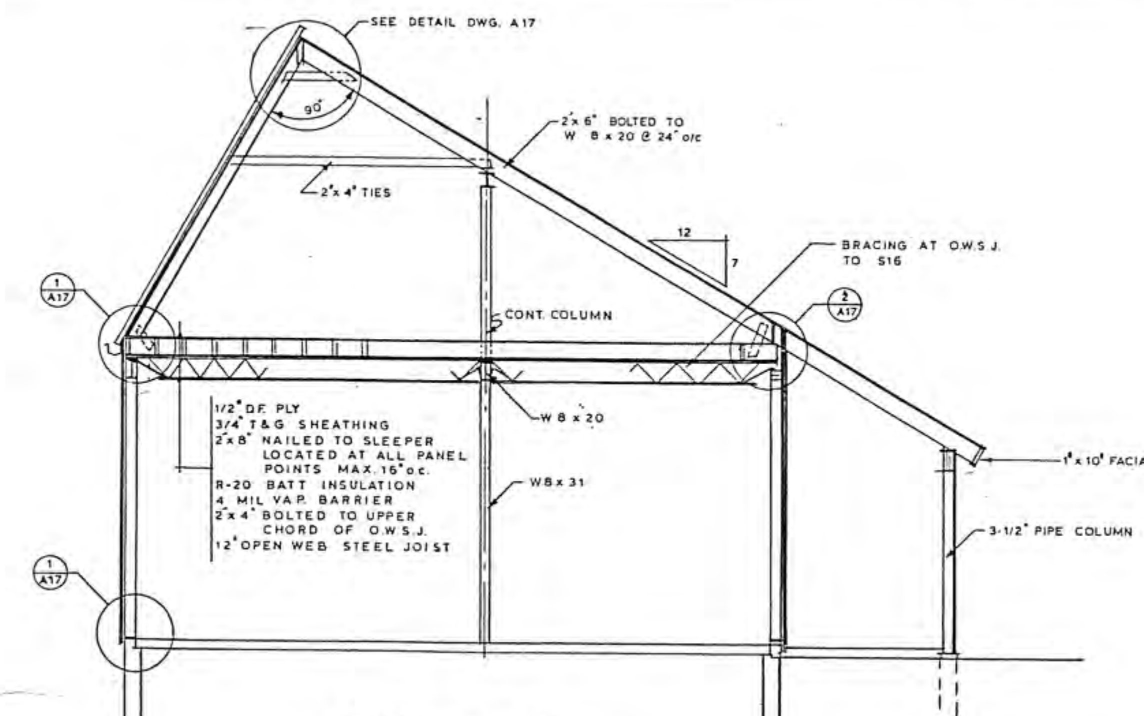
WEST ELEVATION
SCALE 1/8"=1'-0"



SOUTH ELEVATION
SCALE 1/8"=1'-0"



EAST ELEVATION
SCALE 1/8"=1'-0"



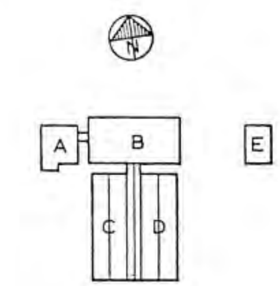
TYPICAL SECTION
SCALE: 1/4"=1'-0"

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L6

REVISIONS

DESCRIPTION	NO.	DATE

CONSULTANTS



KEY PLAN

PROJECT
TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT · COLCHESTER COUNTY · N.S.

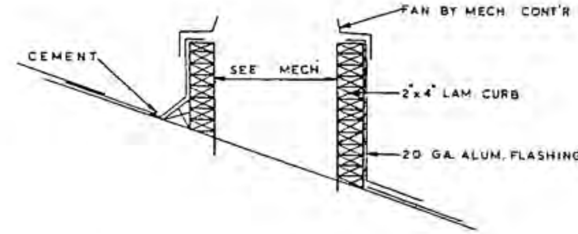
TITLE
BUILDING 'E'
ELEVATIONS & CROSS SECTION

DRAWN A.J.D.
MICRO. NO. B03-D0-01
CHECKED D.J.M. & D.P.J.
P.H. NO. 12/U
APPROVED
DATE 79-11-26
SCALE

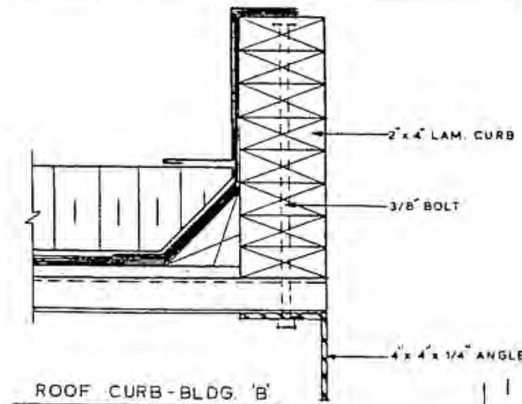
SEAL
REGISTERED MEMBER
DWG. NO. A16

B

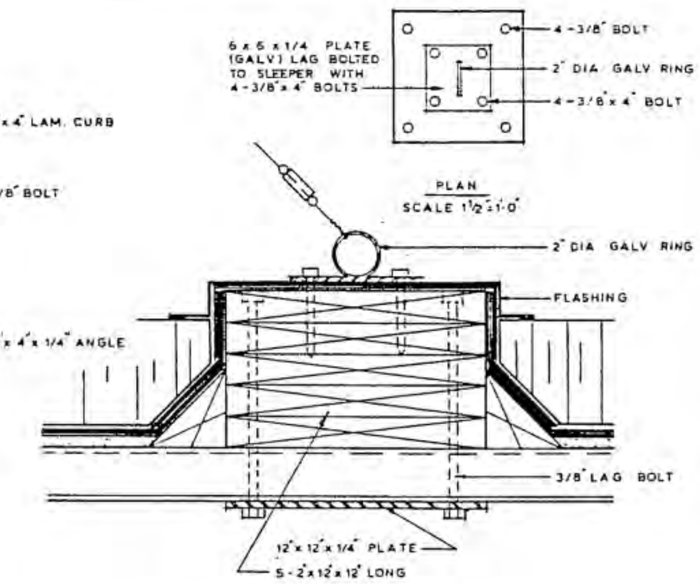
A19-1



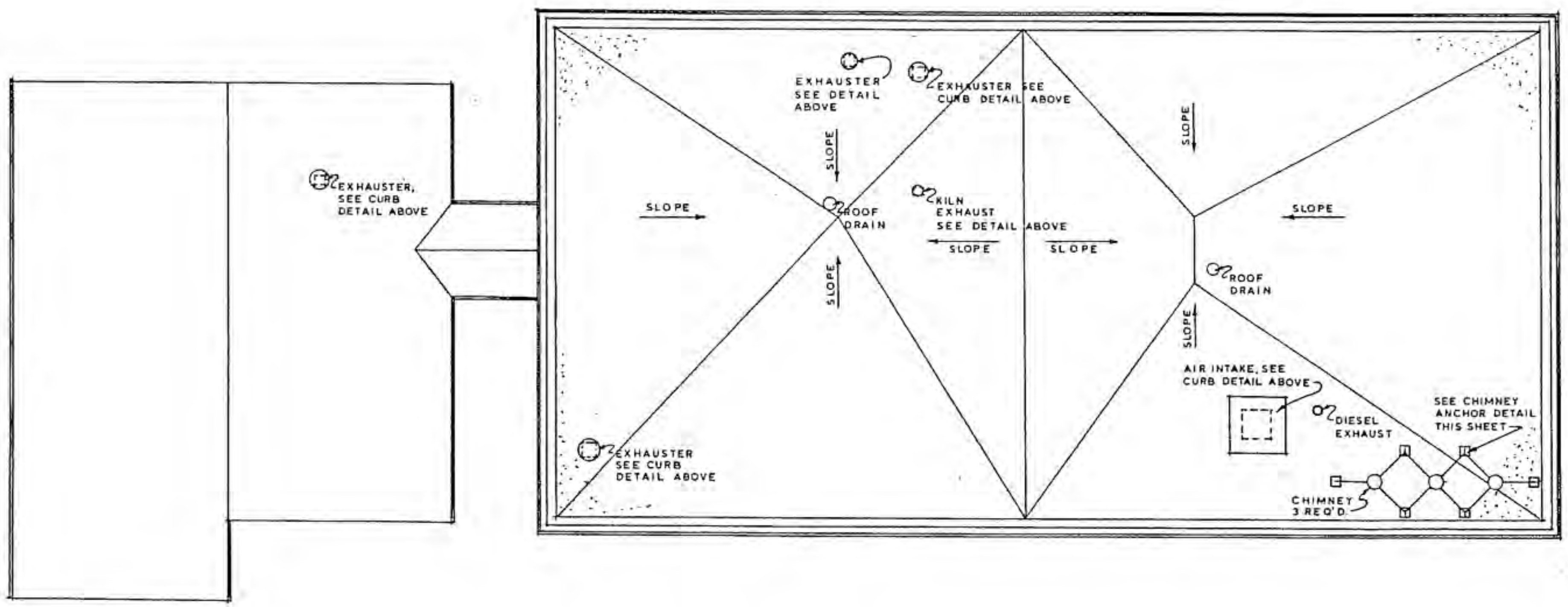
ROOF CURB DETAIL - BLDG. 'A'
SCALE 1"=1'-0"



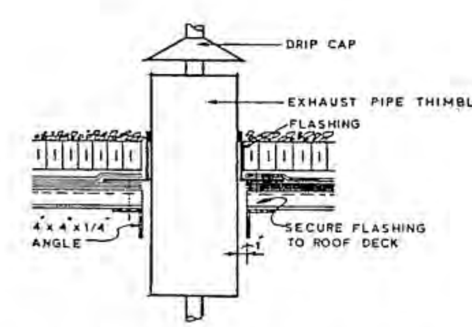
ROOF CURB - BLDG. 'B'
SCALE 3"=1'-0"



CHIMNEY ANCHOR DETAILS



ROOF PLAN BUILDING 'A' & 'B'
SCALE 1/8"=1'-0"



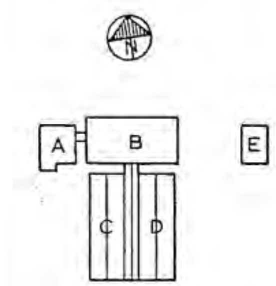
DIESEL EXHAUST FLASHING DETAIL
SCALE 1"=1'-0"

NOVA SCOTIA DEPARTMENT OF PUBLIC WORKS
OFFICE OF THE DEPUTY MINISTER, P.O. BOX 54 HALIFAX, B3J 2L4

REVISIONS

DESCRIPTION	NO	DATE

CONSULTANTS



KEY PLAN

PROJECT
TREE BREEDING CENTRE
DEPT. OF LANDS & FORESTS
DEBERT - COLCHESTER COUNTY - N.S.

TITLE
BLDG. 'A' & 'B'
ROOF PLAN

DRAWN M S D	MICRO. NO. B03-DO-01
CHECKED D.J.M. & D.P.J.	P.H. NO. 12/U
APPROVED	
DATE 79-11-26	SCALE AS NOTED

SEAL

DWG. NO. A19

B

Appendix B

Facility Condition Assessment

- **Building Component Summary Worksheet**
- **Building component photo log**
- **Building Component Cash Flow**

Building Component Summary Worksheet
Debert Water Utility Building

									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 Drive	G2010 - Roadways	Areas of cracking. Replace at end of useful life	1995	20	27	-7	8	2030	No	Yes	No	Normal	No	1	Cyclical	ft²	15,060	$ 5.50	$ 82,830
Asphalt Parking	G2020 - Parking Lots	Areas of cracking. Replace at end of useful life	1995	20	27	-7	8	2030	No	Yes	No	Normal	No	1	Cyclical	ft²	7,720	$ 5.50	$ 42,460
Asphalt Curbing	G2010 - Roadways	Areas of visible impact damage. Replace at end of useful life	1995	20	27	-7	15	2037	No	No	No	Low	No	-1	Cyclical	ft	920	$ 5.50	$ 5,060
Asphalt Paving - Repair Allowance	G2010 - Roadways	Allowance to repair 5% of asphalt to extend the useful life.	2022	5	0	5	3	2025	No	No	No	High	No	1	Single	ft²	1,139	$ 5.50	$ 6,265
Concrete Pavers	G2030 - Pedestrian Paving	Replace as required through O&M.	1995	20	27	-7	50	2072	No	Yes	No	Normal	No	1	Single	ft²	300	$ -	$ -
Pole Mounted Halogen Lighting	G4020 - Site Lighting	Replace at end of useful life	2010	25	12	13	13	2035	Yes	Yes	No	Low	Yes	2	Cyclical	Ea	3	$ 3,500.00	$ 10,500
Structure																			
Concrete Foundation	A1010 - Standard Foundations	Concrete foundation and strip footings. Allowance for minor repairs at 1% of floor plate	1980	75	42	33	33	2055	No	Yes	Yes	Low	No	1	Cyclical	ft²	80	$ 56.00	$ 4,480
Slab on Grade	A1030 - Slab on Grade	Allowance for minor repairs, 2.5% of floor plate	1980	75	42	33	33	2055	No	Yes	Yes	Low	No	1	Cyclical	ft²	200	$ 56.35	$ 11,270
Concrete Block Superstructure	B1020 - Roof Construction	Minor repair for localized step cracking, repairs as part of O&M	1980	75	42	33	48	2070	No	No	No	Low	No	-1	Cyclical	ft²	0	$ -	$ -
Metal Deck on Steel Joists	B1020 - Roof Construction	replacement not anticipated	1980	75	42	33	33	2055	No	Yes	Yes	Normal	No	2	Cyclical	ft²	0	$ -	$ -
Wood Roof Structure	B1020 - Roof Construction	Repair allowance at end of useful life	1980	75	42	33	33	2055	Yes	Yes	Yes	Normal	No	3	Cyclical	ft²	2,480	$ 2.50	$ 6,200
Roof																			
Modified Bitumen	B3010 - Roof Coverings	Replace at end of life	2017	20	5	15	15	2037	No	Yes	Yes	High	No	3	Cyclical	ft²	5,480	$ 22.00	$ 120,560
Asphalt Shingles	B3010 - Roof Coverings	Replace at end of life	2000	25	22	3	5	2027	No	Yes	Yes	High	No	3	Cyclical	ft²	2,480	$ 5.50	$ 13,640
Exterior Envelope																			
Prefinished Metal Siding	B2010 - Exterior Walls	Replace at end of useful life	1980	35	42	-7	15	2037	No	Yes	Yes	Normal	Yes	3	Cyclical	ft²	3,055	$ 8.16	$ 24,929
Prefinished Metal Siding - Maintenance	B2010 - Exterior Walls	Allowance for refinishing Metal Siding	1980	10	42	-32	1	2023	No	Yes	Yes	Normal	Yes	3	Single	ft²	3,055	$ 2.80	$ 8,554
Painted Wood Clapboard Siding	B2010 - Exterior Walls	Replace at end of useful life, minor immediate repairs to be completed as part of O&M	2000	30	22	8	8	2030	No	Yes	Yes	Normal	Yes	3	Cyclical	ft²	3,885	$ 10.92	$ 42,424
Wood Framed Glazing Units	B2020 - Exterior Windows	Replace at end of useful life	2000	30	22	8	5	2027	No	Yes	Yes	Normal	No	2	Cyclical	ft²	175	$ 60.00	$ 10,500
Vinyl Glazing Units	B2020 - Exterior Windows	Replace at end of useful life	2000	30	22	8	10	2032	No	Yes	Yes	Normal	No	2	Cyclical	ft²	30	$ 60.00	$ 1,800
Aluminum Framed Glazing Units	B2020 - Exterior Windows	Replace at end of useful life	1980	40	42	-2	10	2032	No	Yes	Yes	Normal	No	2	Cyclical	ft²	170	$ 85.00	$ 14,450
Overhead Door - East Elevation, South Elevation	B2030 - Exterior Doors	Replace at end of useful life	2000	15	22	-7	8	2030	No	Yes	Yes	Normal	No	2	Cyclical	Ea	2	$ 5,000.00	$ 10,000
Front Entrance Door, Framed With Glazing	B2030 - Exterior Doors	Replace at end of useful life	2000	30	22	8	5	2027	No	Yes	Yes	Normal	No	2	Cyclical	Ea	1	$ 3,500.00	$ 3,500
Metal Door With Glazing - East & North Elevations	B2030 - Exterior Doors	Replace at end of useful life	2000	25	22	3	3	2025	No	Yes	Yes	Low	No	1	Cyclical	Ea	2	$ 1,500.00	$ 3,000
Metal Service Door	B2030 - Exterior Doors	Replace at end of useful life	2000	25	22	3	3	2025	No	Yes	Yes	Low	No	1	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Building Interior																			
VCT Flooring	C3020 - Floor Finishes	Replace at end of useful life	1980	25	42	-17	10	2032	No	Yes	No	Low	No	0	Cyclical	ft²	7,900	$ 8.35	$ 65,965
VCT Flooring - Maintenance Bay	C3020 - Floor Finishes	Replace at end of useful life	1980	25	42	-17	0	2022	No	Yes	No	High	No	2	Single	ft²	800	$ 8.35	$ 6,680
VCT Flooring - Repair Allowance	C3020 - Floor Finishes	Local Repairs are anticipated to be completed through O&M	2022	4	0	4	4	2026	No	Yes	No	Normal	No	1	Cyclical	ft²	7,900	$ -	$ -
Gypsum Board Walls	C3010 - Wall Finishes	Local Repairs are anticipated to be completed through O&M,	1980	65	42	23	50	2072	No	Yes	No	Normal	No	1	Cyclical	LS	1	$ -	$ -
Painted Concrete Block Walls	C3010 - Wall Finishes	Cyclical painting is anticipated to be complete through O&M	1980	75	42	33	50	2072	No	Yes	No	Normal	No	1	Cyclical	LS		$ -	$ -
Suspended Ceiling	C3030 - Ceiling Finishes	Local accoustic tile replacement anticipated to be completed through O&M. Replace ceiling structure at end of useful life	1980	20	42	-22	15	2037	Yes	No	No	Normal	Yes	2	Cyclical	ft²	2,400	$ 5.63	$ 13,512
Solid Wood Core Doors	C1020 - Interior Doors	Replacement is not anticipated	1980	60	42	18	40	2062	Yes	No	Yes	Normal	No	2	Cyclical	Ea	0	$ 900.00	$ -
Kitchenette Millwork	C3010 - Wall Finishes	Replace at end of life	2010	25	12	13	13	2035	No	No	No	Normal	No	0	Cyclical	Lft	10	$ 225.00	$ 2,250
Mechanical																			
Plumbing Service & Distribution	D2020 - Domestic Water Distribution	No major replacement is anticipated	1980	50	42	8	15	2037	No	Yes	Yes	Normal	No	2	Cyclical	ft²	7,900	$ 10.25	$ 80,975
Back Flow Preventer	D2020 - Domestic Water Distribution	install a back flow preventer	2022	20	0	20	0	2022	Yes	No	Yes	Low	Yes	2	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Domestic Hot Water Tank, 48 Gallon Electric	D2020 - Domestic Water Distribution	Replace at end of useful life	2019	15	3	12	12	2034	No	Yes	Yes	Low	No	1	Cyclical	Ea	1	$ 2,500.00	$ 2,500
Water Pumps (2 hp)	D2090 - Other Plumbing Systems	Replace / rebuild at end of useful life	1980	35	42	-7	5	2027	No	Yes	Yes	Normal	No	2	Cyclical	Ea	2	$ 2,500.00	$ 5,000
Plumbing fixtures	D2010 - Plumbing Fixtures	Replace at end of useful life,	1980	35	42	-7	8	2030	No	Yes	No	Normal	No	1	Cyclical	Ea	12	$ 1,050.00	$ 12,600
Shower	D2010 - Plumbing Fixtures	Replace at end of useful life	2000	30	22	8	8	2030	No	Yes	No	Low	No	0	Cyclical	Ea	2	$ 3,000.00	$ 6,000
Boiler	D3020 - Heat Generating Systems	Replace at end of useful life	2005	30	17	13	13	2035	No	Yes	Yes	Normal	Yes	3	Cyclical	Ea	1	$ 12,500.00	$ 12,500
Expansion Tank	D3020 - Heat Generating System	Replace at end of useful life	2020	30	2	28	28	2050	No	No	Yes	Normal	No	1	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Baseboard Radiators	D3020 - Heat Generating System	Replace at end of usful life. Minor repairs as part of O&M budgets	1980	40	42	-2	20	2042	No	Yes	Yes	Normal	No	2	Cyclical	ft²	7,900	$ 9.15	$ 72,285
Lennox Heat Pump	D3020 - Heat Generating System	Replace at end of useful life	2022	20	0	20	20	2042	No	Yes	Yes	Normal	Yes	3	Cyclical	Ton	3	$ 3,000.00	$ 7,500
Diesel Fuel Storage Tank	G3060 - Fuel Distribution	Replace at end of life	1995	25	27	-2	5	2027	No	No	No	Low	No	-1	Cyclical	Ea	1.0	$ 12,500.00	$ 12,500
Diesel Generator	D3010 - Energy Supply	Replace at end of useful life	1979	35	43	-8	2	2024	No	No	Yes	Low	No	0	Cyclical	Ea	1	$ 18,000.00	$ 18,000
Day Tank	D3010 - Energy Supply	Day tank label not accesible. Replacement anticipated to be at end of life	1980	20	42	-22	2	2024	No	Yes	Yes	Low	No	1	Cyclical	Ea	1	$ 1,500.00	$ 1,500
Electrical																			
Main Distribution (800A, 120V)	D5010 - Electrical Service and Distribution	Replace main panel at end of useful life.	1980	40	42	-2	4	2026	No	Yes	Yes	Normal	No	2	Cyclical	LS	1	$ 5,000.00	$ 5,000
Electrical Panels & Branch Wiring	D5010 - Electrical Service and Distribution	Allowance for 10% repairs every 10 years	1980	40	42	-2	8	2030	No	Yes	Yes	Normal	No	2	Cyclical	ft²	790	$ 13.31	$ 10,515
Lighting Fixtures	D5020 - Lighting and Branch Wiring	T12 light fixtures. Replace bulbs as part of O&M. Replace fixture at end of useful life	2000	25	22	3	5	2027	Yes	Yes	Yes	High	No	4	Cyclical	ft²	7,900	$ 3.70	$ 29,230
Life Safety / Fire Suppression																			
Exit Signage	D4030 - Fire Protection	Anticipated to be inspected annually. Replace through O&M at end of useful life	2000	20	22	-2	15	2037	Yes	Yes	No	Normal	Yes	3	Cyclical	LS	1	$ -	$ -
Smoke Alarm	D4030 - Fire Protection	Anticipated to be inspected annually. Replace through O&M at end of useful life	2000	15	22	-7	10	2032	Yes	No	Yes	Low	No	1	Cyclical	LS	1	$ -	$ -
Fire Extinguisher	D4030 - Fire Protection	Anticipated to be inspected annually. Replace through O&M at end of useful life	2000	15	22	-7	0	2022	Yes	Yes	Yes	Low	Yes	3	Cyclical	LS	1	$ -	$ -

Projected Cash Flow

Debert Water Utility Building

Component	Recapitalization Detail	Year of Replacement	Expected Useful Life (EUL)	Total Cost
Site Work				
Asphalt Drive	Areas of cracking. Replace at end of useful life	2030	20	$ 82,830
Asphalt Parking	Areas of cracking. Replace at end of useful life	2030	20	$ 42,460
Asphalt Curbing	Areas of visible impact damage. Replace at end of useful life	2037	20	$ 5,060
Asphalt Paving - Repair Allowance	Allowance to repair 5% of asphalt to extend the useful life.	2025	5	$ 6,265
Concrete Pavers	Replace as required through O&M.	2072	20	$ -
Pole Mounted Halogen Lighting	Replace at end of useful life	2035	25	$ 10,500
Structure				
Concrete Foundation	Concrete foundation and strip footings. Allowance for minor repairs at 1% of floor plate	2055	75	$ 4,480
Slab on Grade	Allowance for minor repairs, 2.5% of floor plate	2055	75	$ 11,270
Concrete Block Superstructure	Minor repair for localized step cracking, repairs as part of O&M	2070	75	$ -
Metal Deck on Steel Joists	replacement not anticipated	2055	75	$ -
Wood Roof Structure	Repair allowance at end of useful life	2055	75	$ 6,200
Roof				
Modified Bitumen	Replace at end of life	2037	20	$ 120,560
Asphalt Shingles	Replace at end of life	2027	25	$ 13,640
Exterior Envelope				
Prefinished Metal Siding	Replace at end of useful life	2037	35	$ 24,929
Prefinished Metal Siding - Maintenance	Allowance for refinishing Metal Siding	2023	10	$ 8,554
Painted Wood Clapboard Siding	Replace at end of useful life, minor immediate repairs to be completed as part of O&M	2030	30	$ 42,424
Wood Framed Glazing Units	Replace at end of useful life	2027	30	$ 10,500
Vinyl Glazing Units	Replace at end of useful life	2032	30	$ 1,800
Aluminum Framed Glazing Units	Replace at end of useful life	2032	40	$ 14,450
Overhead Door - East Elevation, South Elevation	Replace at end of useful life	2030	15	$ 10,000
Front Entrance Door, Framed With Glazing	Replace at end of useful life	2027	30	$ 3,500
Metal Door With Glazing - East & North Elevations	Replace at end of useful life	2025	25	$ 3,000
Metal Service Door	Replace at end of useful life	2025	25	$ 1,500
Building Interior				
VCT Flooring	Replace at end of useful life	2032	25	$ 65,965
VCT Flooring - Maintenance Bay	Replace at end of useful life	2022	25	$ 6,680
VCT Flooring - Repair Allowance	Local Repairs are anticipated to be completed through O&M	2026	4	$ -
Gypsum Board Walls	Local Repairs are anticipated to be completed through O&M,	2072	65	$ -
Painted Concrete Block Walls	Cyclical painting is anticipated to be complete through O&M	2072	75	$ -
Suspended Ceiling	Local accoustic tile replacement anticipated to be completed through O&M. Replace ceiling structure at end of useful life	2037	20	$ 13,512
Solid Wood Core Doors	Replacement is not anticipated	2062	60	$ -
Kitchenette Millwork	Replace at end of life	2035	25	$ 2,250
Mechanical				
Plumbing Service & Distribution	No major replacement is anticipated	2037	50	$ 80,975
Back Flow Preventer	install a back flow preventer	2022	20	$ 1,500
Domestic Hot Water Tank, 48 Gallon Electric	Replace at end of useful life	2034	15	$ 2,500
Water Pumps (2 hp)	Replace / rebuild at end of useful life	2027	35	$ 5,000
Plumbing fixtures	Replace at end of useful life,	2030	35	$ 12,600
Shower	Replace at end of useful life	2030	30	$ 6,000
Boiler	Replace at end of useful life	2035	30	$ 12,500
Expansion Tank	Replace at end of useful life	2050	30	$ 1,500
Baseboard Radiators	Replace at end of usful life. Minor repairs as part of O&M budgets	2042	40	$ 72,285
Lennox Heat Pump	Replace at end of useful life	2042	20	$ 7,500
Diesel Fuel Storage Tank	Replace at end of life	2027	25	$ 12,500
Diesel Generator	Replace at end of useful life	2024	35	$ 18,000
Day Tank	Day tank label not accesible. Replacement anticipated to be at end of life	2024	20	$ 1,500
Electrical				
Main Distribution (800A, 120V)	Replace main panel at end of useful life.	2026	40	$ 5,000
Electrical Panels & Branch Wiring	Allowance for 10% repairs every 10 years	2030	40	$ 10,515
Lighting Fixtures	T12 light fixtures. Replace bulbs as part of O&M. Replace fixture at end of useful life	2027	25	$ 29,230
Life Safety / Fire Suppression				
Exit Signage	Anticipated to be inspected annually. Replace through O&M at end of useful life	2037	20	$ -
Smoke Alarm	Anticipated to be inspected annually. Replace through O&M at end of useful life	2032	15	$ -
Fire Extinguisher	Anticipated to be inspected annually. Replace through O&M at end of useful life	2022	15	$ -

Component	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 Drive									$ 82,830																
Asphalt Parking									$ 42,460																
Asphalt Curbing																$ 5,060									
Asphalt Paving - Repair Allowance				$ 6,265																					
Concrete Pavers																									
Pole Mounted Halogen Lighting														$ 10,500											
Structure																									
Concrete Foundation																									
Slab on Grade																									
Concrete Block Superstructure																									
Metal Deck on Steel Joists																									
Wood Roof Structure																									
Roof																									
Modified Bitumen																$ 120,560									
Asphalt Shingles						$ 13,640																			
Exterior Envelope																									
Prefinished Metal Siding																$ 24,929									
Prefinished Metal Siding - Maintenance		$ 8,554										$ 8,554										$ 8,554			
Painted Wood Clapboard Siding									$ 42,424																
Wood Framed Glazing Units						$ 10,500																			
Vinyl Glazing Units											$ 1,800														
Aluminum Framed Glazing Units											$ 14,450														
Overhead Door - East Elevation, South Elevation									$ 10,000																
Front Entrance Door, Framed With Glazing						$ 3,500																			
Metal Door With Glazing - East & North Elevations				$ 3,000																					
Metal Service Door				$ 1,500																					
Building Interior																									
VCT Flooring											$ 65,965														
VCT Flooring - Maintenance Bay	$ 6,680																								
VCT Flooring - Repair Allowance																									
Gypsum Board Walls																									
Painted Concrete Block Walls																									
Suspended Ceiling																$ 13,512									
Solid Wood Core Doors																									
Kitchenette Millwork														$ 2,250											
Mechanical																									
Plumbing Service & Distribution																$ 80,975									
Back Flow Preventer	$ 1,500																								
Domestic Hot Water Tank, 48 Gallon Electric													$ 2,500												
Water Pumps (2 hp)						$ 5,000																			
Plumbing fixtures									$ 6,000																
Shower									$ 6,000																
Boiler														$ 12,500											
Expansion Tank																									
Baseboard Radiators																									
Lennox Heat Pump																					$ 7,500				
Diesel Fuel Storage Tank						$ 12,500																			
Diesel Generator			$ 18,000																						
Day Tank			$ 1,500																				$ 1,500		
Electrical																									
Main Distribution (800A, 120V)					5000																				
Electrical Panels & Branch Wiring									$ 10,515																
Lighting Fixtures						$ 29,230																			
Life Safety / Fire Suppression																									
Exit Signage																									
Smoke Alarm																									
Fire Extinguisher																									

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**
	$	**$ 8,180**	**$ 8,554**	**$ 19,500**	**$ 10,765**	**$ 5,000**	**$ 74,370**	**$ -**	**$ -**	**$ 200,229**	**$ -**	**$ 82,215**	**$ 8,554**	**$ 2,500**	**$ 25,250**	**$ -**	**$ 245,036**	**$ -**	**$ -**	**$ -**	**$ -**	**$ 7,500**	**$ 8,554**	**$ 1,500**	**$ -**	**$ -**

Appendix C

Structural Outline Specification

Debert Water Utility Building - Colchester

Structural Analysis

The Colchester site consists of 5 buildings, labelled A through E. The usage of the buildings is currently unknown to DesignPoint; however, it appears as though Building A & B are the primary buildings, while Building E is a garage and Buildings C & D are greenhouses which appear to be no longer be present based on recent Google Earth imagery. It is understood that only Building A and Building B will be considered for the purposes of this feasibility study. A site plan with each building is shown below in Figure 1.

Figure 1: Existing Debert Water Utility buildings.

Based on review of available past drawings and the estimated age of the structure, ASTM A36 steel was assumed (yield strength of 250 MPa and ultimate tensile strength of 400 MPa) and SPF No.1/No.2 was assumed for the timber components.

The structural framing for the buildings greatly (in both overall geometry and materials) and will be discussed in subsequent sections. It should be noted that DesignPoint did not complete a site visit at this site as per the terms of our proposal and as such, has completed this assessment based only on available drawings from 1979, as well as select photos from mechanical/electrical site visits.

Building A & B

Building A & B are connected via a small, ±7' wide timber framed walkway. Both buildings, as well as the walkway, are founded on concrete slab on grades, with exterior frost walls and interior strip footings to support load bearing walls.

Building A

Building A is approximately 44' x 52' (including bump out at front of building) and appears to be fully timber framed with walls consisting of 2x6 studs at 16" on centre and pre-engineered timber roof trusses. The roof system consists of timber trusses (4 types, labelled A through D). Unfortunately, the trusses were designed by the manufacturer and as such, no member sizes were provided, and shop drawings are not available. It is therefore not possible to evaluate the roof trusses and their connections without conducting a site visit to take detailed measurements of all members and connector plates. Roof details were also not provided on the drawings for Building A. Based on the age of the structure and changes in the code over the decades, it is expected that the roof structure would be found to be deficient if analyzed under current NBCC-prescribed loading. A partial section of the Building A wall and roof structure is shown in Figure 2.

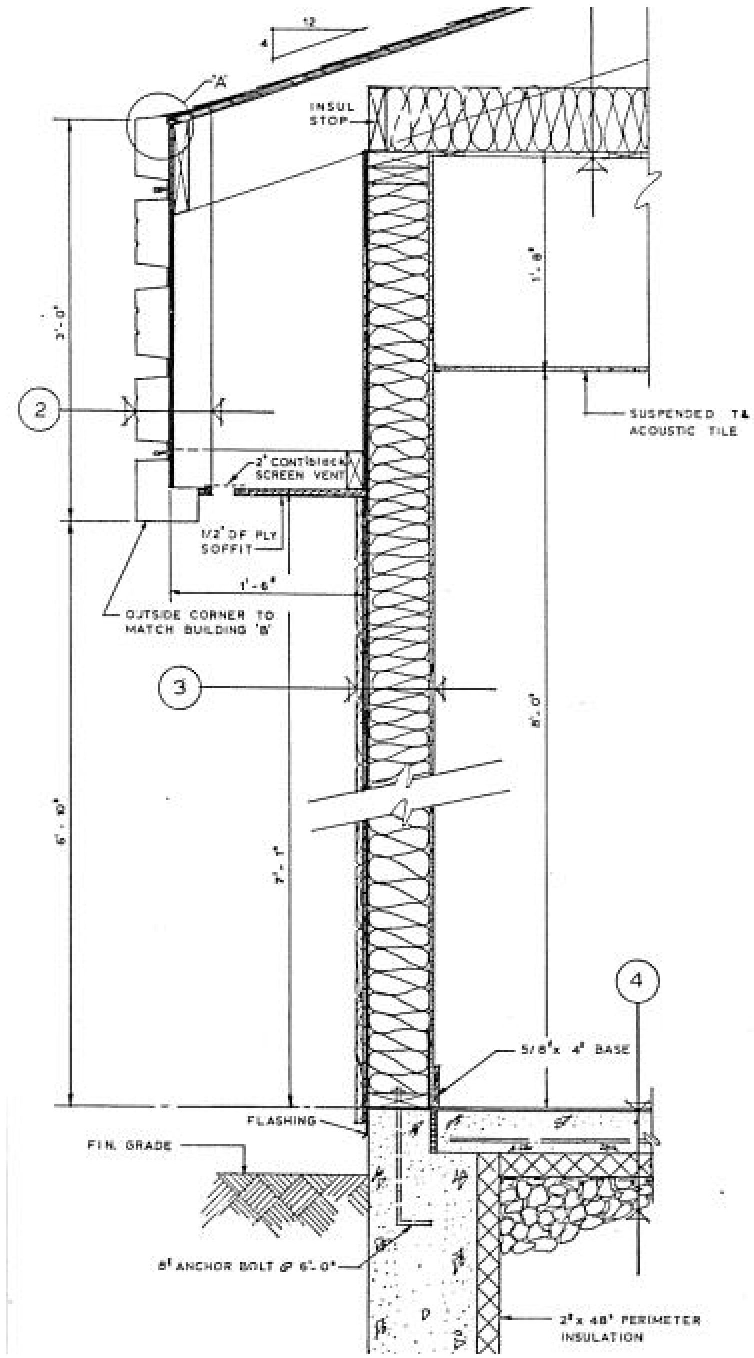


Figure 2: Building A exterior wall section.

Walkway Between Building A & B

The walkway between Building A and B is timber framed with a 2” x 8” central ridge board and 2” x 6” rafters and ceiling joists at 24”. The roof pitch was taken to be 4/12 based on scaled drawings. Snow drifting was considered due to the proximity of higher, adjacent buildings which rendered the rafters deficient in both moment and shear based on current loading.

Building B

Building B is approximately 54’ x 107’ and consists of 10” thick concrete block walls. Based on the drawings, it appears as though lintels (either steel or precast concrete) were designed to span over all openings. Block walls were also reinforced at 16” on center and detailed with ties every second block course. Minor increases in dead and/or snow load could be accommodated by the walls and it is not anticipated that the wind load area will increase as a result of the retrofit. As such, an analysis of the lateral load resisting system (LLRS) is not required as it can be deemed satisfactory based on past performance in accordance with NBCC Structural Commentary L. It should be site confirmed that no additional openings (beyond those detailed on the drawings) have been post-installed which could compromise the capacity of the LLRS. An overall condition assessment of the walls should be completed as well to ensure no deficiencies are present if the intent is to support/anchor the new panelized coverings on the walls.

The roof system for Building B consists of open web steel joist (OWSJ) and corrugated metal deck (22 gauge, 1-1/2” deep). Based on sheet A5 of the provided design drawings, it appears as though the original roof assembly also included crushed stone, 100mm [4”] thick rigid insulation, a 3-ply roofing membrane and 13mm [½”] thick gypsum board. During a site visit, it was noted that Building B now has a membrane on the exterior face of the roof assembly. It is not clear whether a full roof assembly replacement has been completed throughout the service life of the structure, or if this membrane was added on top of existing ballast materials. For the purposes of this study, the original construction materials were assumed for the roof analysis. The yield and tensile strengths of the deck are not known but based on currently available products of similar gauge and thickness, the roof deck would be sufficient for current dead and snow loading. If the OWSJ are to be replaced (see discussion below), it would be both economical and practical to also replace the decking as the two are likely puddle welded to form a diaphragm. Local snow drifting effects near the chimneys have not been considered at this stage of the project. A section of the existing wall and roof assembly is shown in Figure 3.

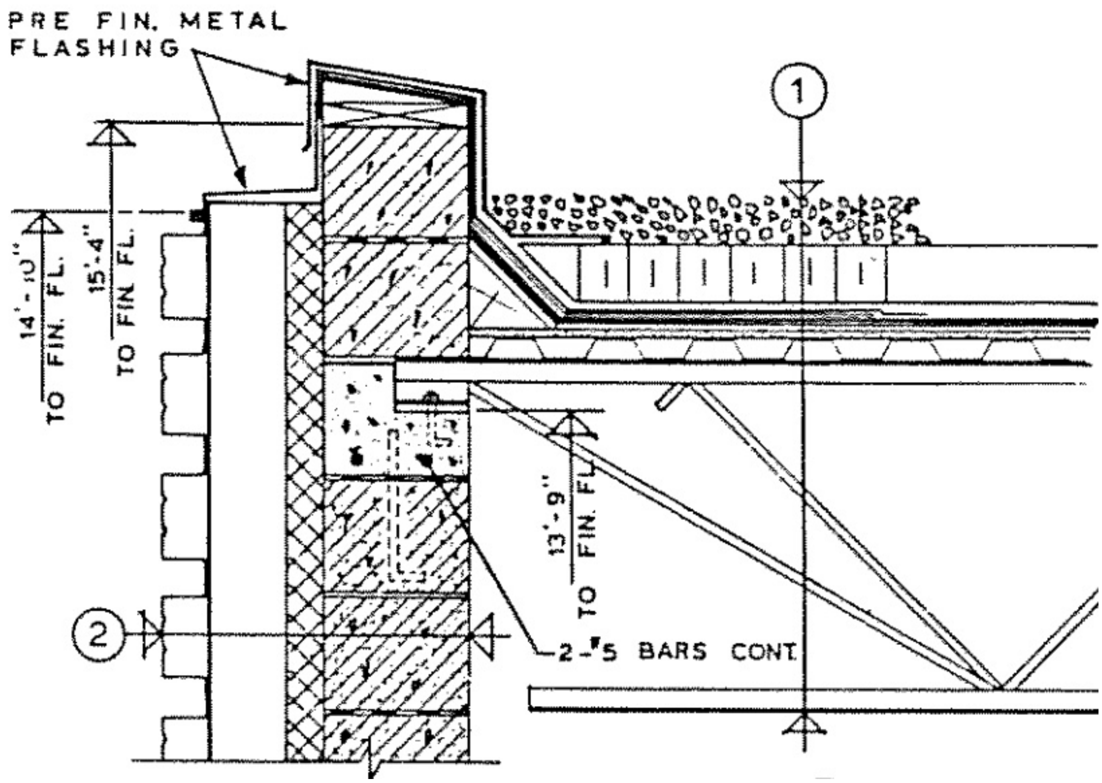


Figure 3: Building B exterior wall at roof section.

The OWSJ were not able to be evaluated based on unknown member sizes and connection details. From available site photos, it appears as though the web members are solid round bar, with back-to-back angles for the top and bottom chords. 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. We would therefore recommend that the OWSJ be reinforced or replaced to accommodate additional dead/snow loading that may result from the panelized coverings or increased insulation. Alternatively, a new roof structure could be constructed above the existing OWSJs to transfer all roof loading to the existing bearing walls.

Recommendations

As discussed, although a site visit was not conducted to verify the member sizes and condition of the building roof framing, it is anticipated that the existing roof framing is likely overloaded when analyzed under current code-prescribed loading and is thus unsuitable to support additional loading during a retrofit. In lieu of detailed inspections, measurements, and reinforcing design for the existing pre-engineered timber trusses of Building A, and the existing OWSJ roof structure of Building B, we recommend a system of panelized roof coverings that spans between the existing bearing walls to avoid adding additional load to the existing roof structure.

Based on our assessment, it has been determined that the existing bearing walls (2x6 studs in Building A, 10" CMU blocks in Building B) have reserve capacity and may be used to support the new roof panel structure. As a result, we have proposed a system of new panelized roof structures for each building consisting of pre-engineered timber trusses bearing on the existing exterior bearing walls. Wall panels have been designed to span between the existing building foundations and roof diaphragms. We have proposed a steel bent plate lintel fastened to the existing foundation wall to support the proposed ReCover wall panels. A preliminary detail is shown in Figure 4.

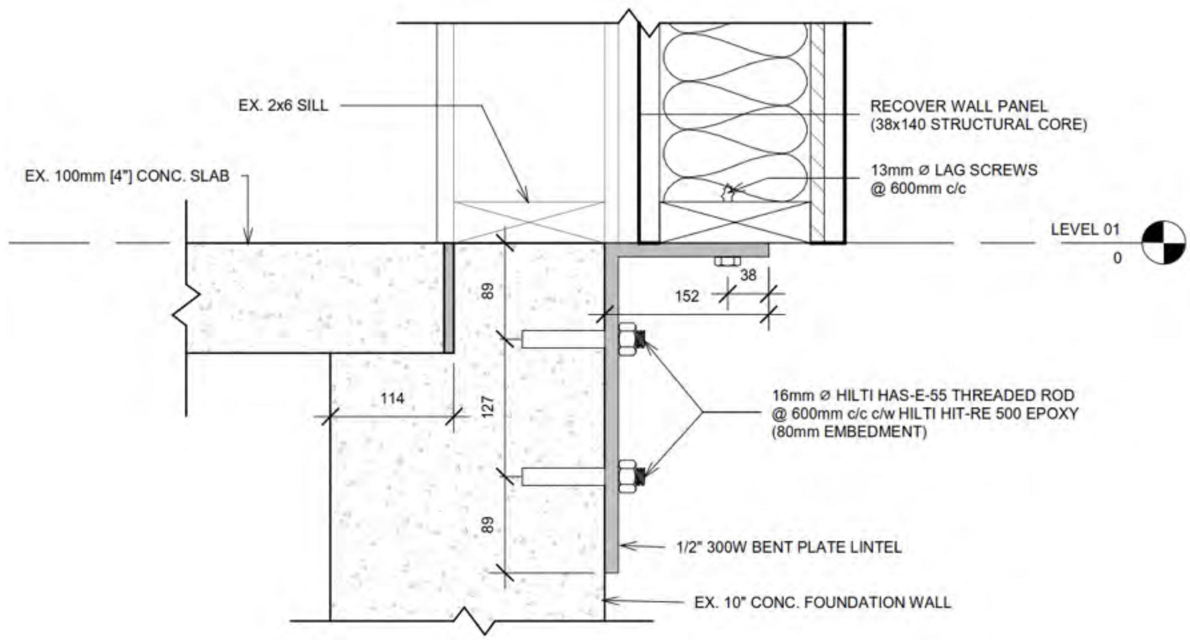


Figure 4: Proposed foundation lintel connection.

At building A, we propose attaching new roof trusses to solid blocking fastened to the existing two-ply top plates. Additionally, the top of the ReCover panels shall be tied to the roof structure using Simpson Strong-Tie tie plates. A detail of this connection is shown in Figure 5, with full drawings available in Appendix A.

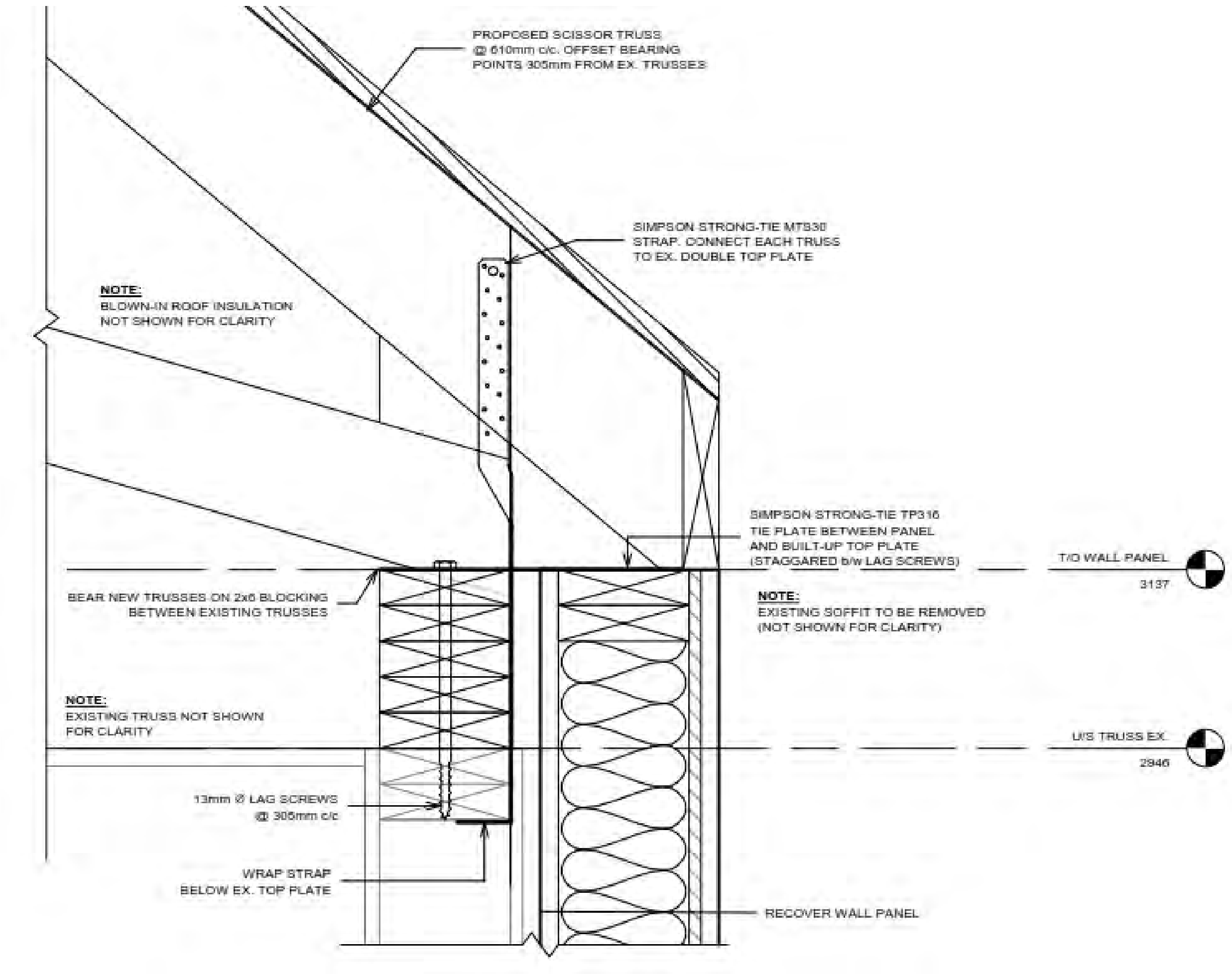


Figure 5: Proposed connections at Building A roof.

As shown in Figure 3, the existing masonry walls extend beyond the existing roof to form a small parapet wall. We propose bearing the new roof trusses on this masonry parapet. It should be noted that the condition and presence of reinforcing in the parapet shall be confirmed prior to finalizing the connection details. A photo of the proposed panel connection at Building B is shown in Figure 6.

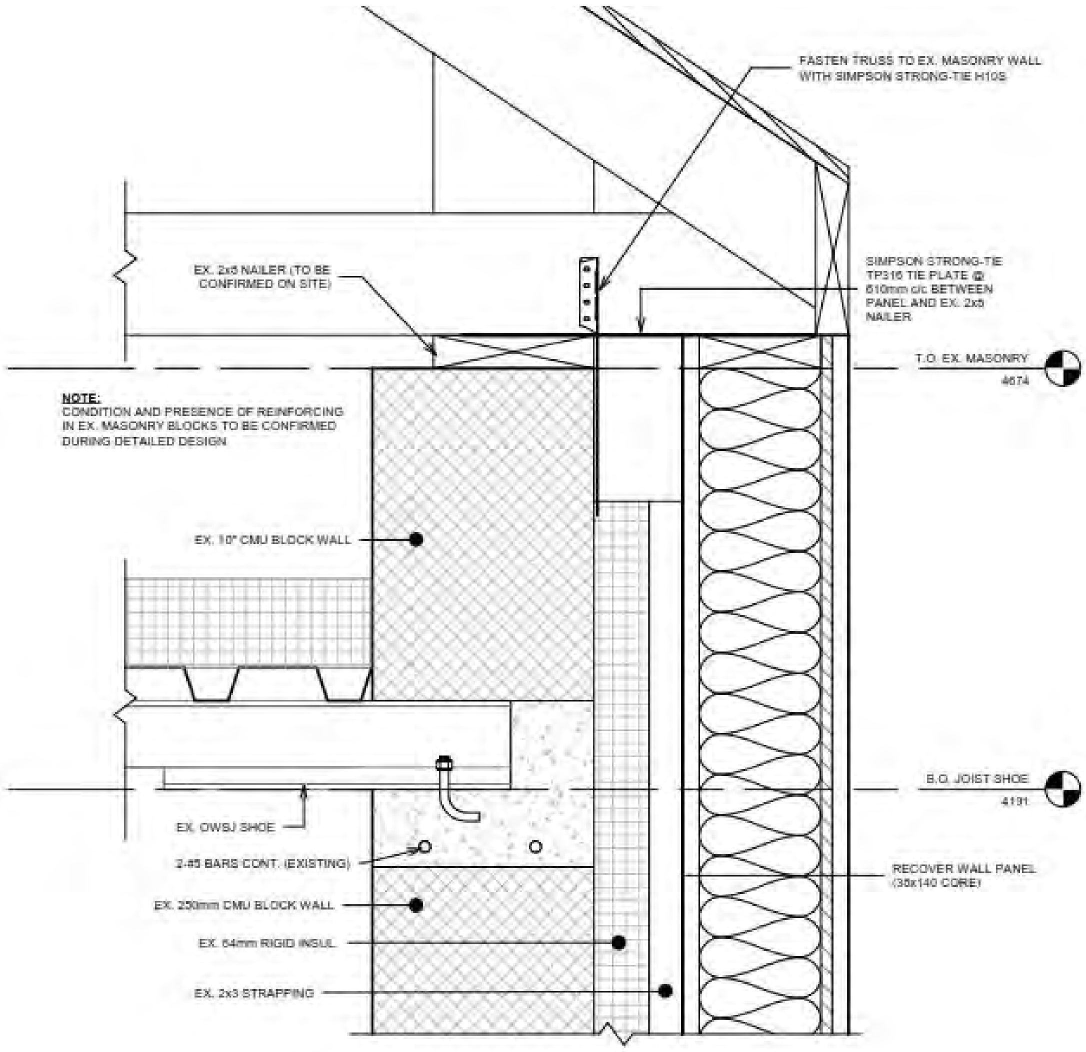


Figure 6: Proposed connections at Building B roof.

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 251 Lancaster Crescent in Debert, Nova Scotia. The intent is to summarize the major features and design parameters for the Plumbing and HVAC disciplines.

The building was built in 1979 as a Tree Breeding Centre for the Department of Lands and Forests. The facility originally included three primary areas: admin, production, and a greenhouse. It is estimated that the greenhouse was removed from the structure 15 years ago. Currently, the front admin area is being rented out as business space and the back production area is now a maintenance facility.

EXISTING SYSTEMS

Site Services

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

Plumbing Services

Rainwater
Above the office section, a sloped, asphalt, shingle roof drains rainwater. The back service section consists of a modified bitumen flat roof sloped to internal roof drains, refer to Figure 1.

Figure 1 Roof drains over service area of building

Domestic Water Service
Hot water is supplied by an electric water heater located in the mechanical room. The tank has a nominal capacity of 48 gallons and maximum allowable load rating of 11kW, shown in Figure 2. It was noted that there is no backflow preventor installed on the incoming water service.

Figure 2 Electric domestic hot water heater

Plumbing Fixtures

The facility consists of two washrooms, each with a toilet, sink, and shower – we were unable to gather information on flow rates but they appear to be reasonably new. A top-loading washer and dryer set were also located in one of the washrooms – they could be replaced with new higher efficiency products. The building owner noted that the shower and washer/dryer use is limited to once a year and once a month, respectively. Figures 3 through 8 detail these fixtures.

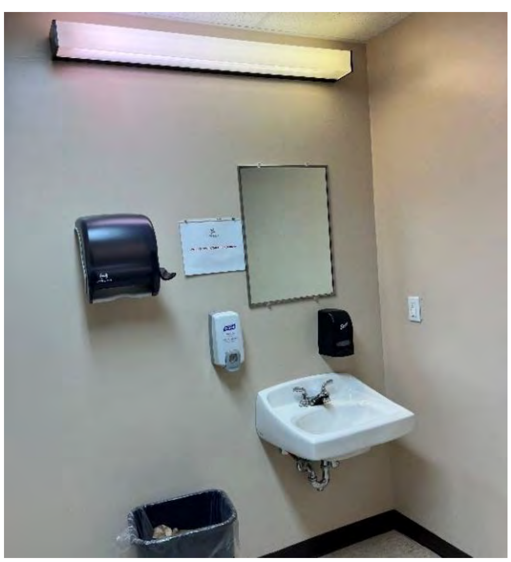


Figure 3 Typical sink fixtures

Figure 4 Typical toilets

Figure 5 Washer and Dryer in Washroom

Figure 6 Typical Shower in Washroom

The facility also contains two staff breakrooms: one in the office area and one in the back maintenance facility. Both breakrooms include a fridge, microwave, and sink.

Figure 7 Office Breakroom

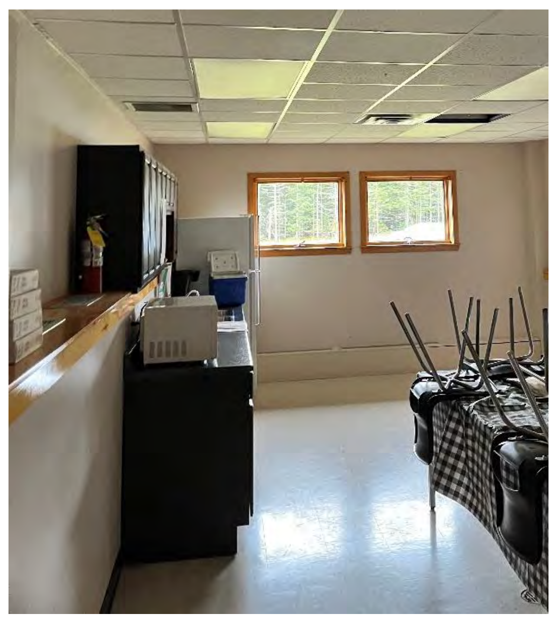


Figure 8 Maintenance area breakroom

HVAC System

Heating and Cooling

All spaces in the existing building are heated using hot water baseboard heaters or unit heaters. Hot water is provided by one 483 MBH output oil-fired boiler with a single stage burner, as shown in Figure 9. The boiler cuts in at 170°F and cuts out at 200°F. Previous records indicate that there were originally three boilers installed, however the heating equipment was likely reduced when the greenhouse was removed. Figure 11 depicts the 6,000 gallon exterior double walled storage tank stores the heating oil on site.

The boiler has a single speed circulation pump and two single speed pumps (P12/P13) operate as duty/standby circulating heat around the building. We were unable to gather information on the building circulators, but the original design called for ½ HP pumps operating at 28gpm and 20ft head. Pumps P1 through P10 are no longer in operation as the greenhouse was removed from the building. P11, P14, and P15 are no longer in operation as the DHWT is provided by an electric water heater. Heating piping is generally insulated but some piping is uninsulated in the boiler room and at some unit heaters.

An air compressor is located in the boiler room with dual 3 HP motors. It feeds both tools in the shop and pneumatic heating controls.

Figure 9 Oil-fired boiler

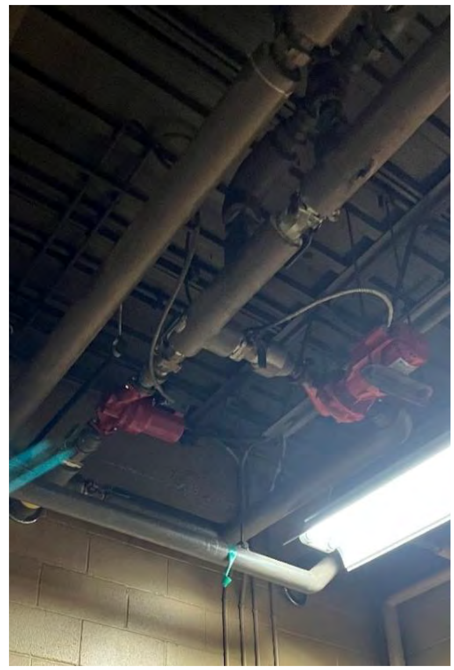


Figure 10 Hot water recirculation loop

Figure 11 On-site oil storage tank

Baseboard heaters are installed in all areas of the building except for the north office area of the maintenance facility which has an electric baseboard heater (depicted in Figures 12 and 13).

Supplemental hot water unit heaters have also been installed in the work area on the south side of the building and outside the mechanical room.

Figure 12 Baseboard heater in meeting room

Figure 13 Baseboard heater in north office

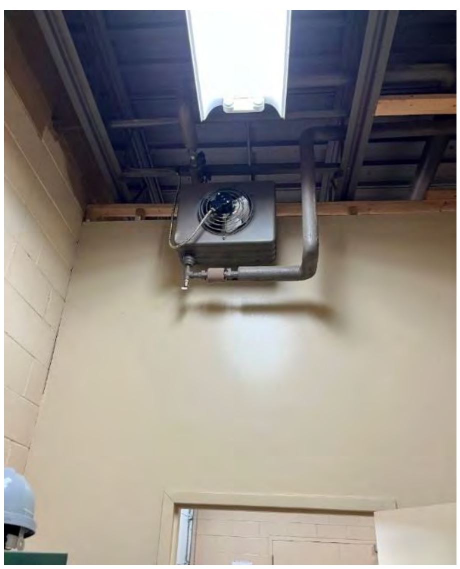


Figure 14 Unit heater outside mechanical room

Figure 15 Unit heater in work area

A 2.5-ton heat pump has also been installed in the office area to provide heating and cooling. The unit was only installed in June 2022. The office area was previously cooled with a ducted air conditioner. The indoor and outdoor heat pump units are shown in Figures 16 and 17.

Figure 16 Indoor heat pump unit

Figure 17 Outdoor heat pump unit

The maintenance area does not have any cooling aside from two window unit air conditioning units installed in the north and south offices, shown in Figures 18 and 19.

Figure 18 North office air conditioning unit

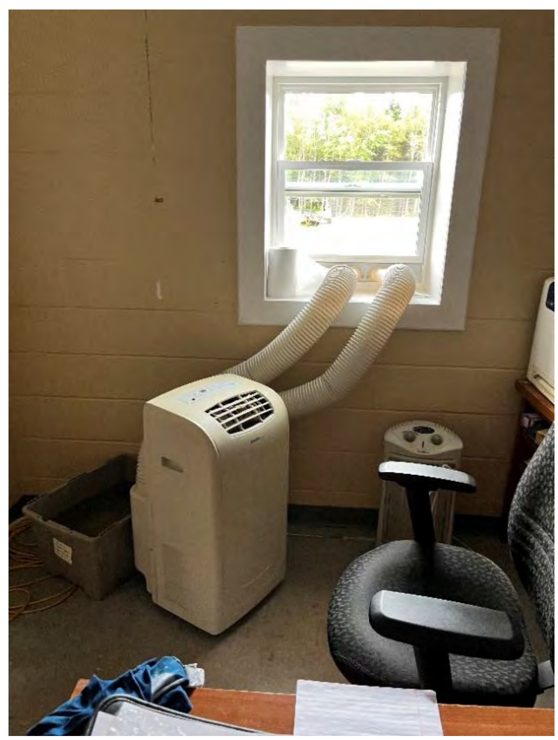


Figure 19 South office air conditioning unit

Ventilation

The only ventilation installed in the facility includes bathroom exhaust fans.

Figure 20 Bathroom exhaust inlet

Figure 21 Bathroom exhaust outlet

Schedule of Equipment:

Boiler	Fuel Type	Oil-fired
	Temperature Range	170°F - 200°F
	Output	483 MBH
	Efficiency	82%
Burner	Type	Single stage
	HP	1/3 HP
Circulation Pumps	Tag ID	P12 and P13
	HP	1/2 HP*
Heat Pump – Indoor Unit	Nominal Tonnage	2.5 tons
	Blower Motor Output	1/2 HP
Heat Pump – Outdoor Unit	SEER	14.0
	HSPF	9.0
	Condenser HP	1/6 HP
Storage Tank	Type	Double walled
	Capacity	6,000 gallons
**Assumed from drawings as information was not available on site*		

Controls

The building does not have a central building automation system. Standalone pneumatic thermostats control baseboard heater control valves and electronic thermostats control force flow heater fans.

COMMENTS

Currently, the facility is inadequately ventilated for occupation. No other occupant complaints were reported.

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 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 Debert from the NECB:

Outdoor Design Conditions:

Summer: 27°C [81°F] DB, 21 °C [70°F] WB

Winter: -21°C [-6°F] DB

Indoor Design Conditions:

Summer: 75°F [24°C] DB

Winter: 72°F [22°C]

1. Minimum Acceptable Scenario

Heating and Cooling

Heating will continue to be provided by a combination of the existing unit heaters and hydronic baseboard heaters served by the existing oil-fired boiler, and existing electric baseboard heaters. The existing boiler still has some remaining useful life so this scenario avoids the replacement of the existing high temperature distribution system.

Cooling will only be provided to areas that have already had systems installed. These areas include the north/south offices in Building A and the leased office area in Building B. The existing air source heat pump (ASHP) in Building A would continue to be used as it was installed this year. In the Building B offices, the existing Packaged Terminal Air Conditioner (PTAC) and portable air conditioning units would be replaced with mini split units.

Domestic hot water will continue to be supplied by the existing electric water heaters.

A summary of the heating and cooling systems for each area of the building is included below.

Building	Space	Heating	Cooling	DHW
Building A	Leased Office	Hydronic baseboard heaters with existing oil-fired boiler	Existing ASHP	Existing electric water heater
Building B	Maintenance		-	
	Lunchroom		-	
	South Office		New mini-split unit	
	North Office	Existing electric baseboard heaters	New mini-split unit	

Ventilation

The minimum acceptable scenario includes adding two energy recovery ventilators (ERVs) for Building A and Building B. The ERVs would be dual core type with approximately 90% heat recovery efficiency similar to Tempeff Dualcore (pictured below). New ERV ducting would be galvanized steel. Outdoor air and exhaust air ductwork will be insulated between the outside wall and ERV.

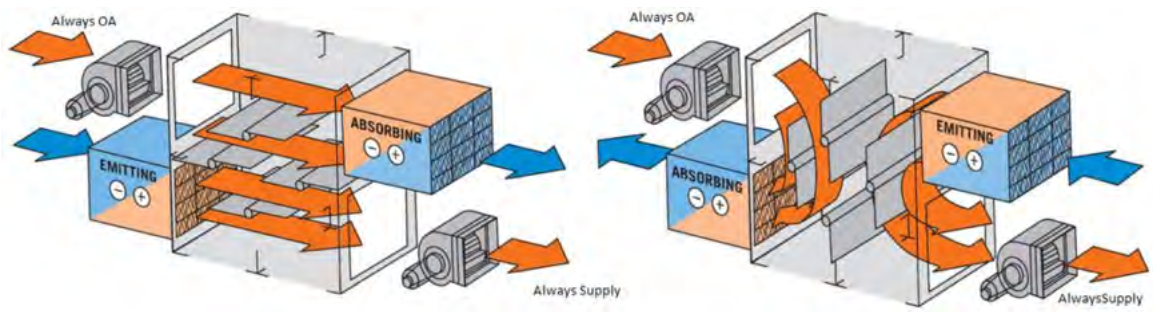


Figure 22 Tempeff Dual Core ERV System

Controls

All existing building controls will remain with the addition of time clocks to control the ERVs. In the south office, an auxiliary heat relay system would control both the mini split unit and hydronic baseboards to ensure simultaneous heating and cooling does not occur.

Equipment List

- (1) 90 L/s [190cfm] ERV with ECM motors and dual cores
- (1) 250 L/s [530cfm] ERV with ECM motors and dual cores
- (2) 0.75 ton mini split heat pumps

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.

a. Air Source Heat Pump (ASHP) Option

Heating and Cooling

Heating will be generated by a cold climate air source heat pump (refer to Figure 24) in place of the oil-fired boiler. The heat pumps will have a circulation pump on the condenser side and speed will be controlled based on the compressor operation. Heating will be distributed by the existing hydronic baseboard heaters and thermal zones. A mini split heat pump will provide heating to the north office as the electric baseboards would be removed. 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 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 Figure 23 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 23 ASHP Outdoor Unit Location

In Building A, cooling will be provided by the existing ASHP. Two mini split units will provide cooling in the north and south offices in Building B.

Domestic water would be provided by a packaged heat pump water heater (HPWH), as shown in Figure 25. 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.

Figure 24 Split Air to Water Cold Climate Heat Pump

Figure 25 Packaged Heat Pump Water Heater

Ventilation
Similar to the Minimum Acceptable Scenario, two ERVs would be used for the space: one in Building A and one in Building B. As ventilation loads are occupant dependant, the airflows are consistent with the minimum accepted scenario.

Controls
The ASHP would require a direct digital control system to operate circulation pumps and heat pumps. Programmable time of day controls would run the ERVs. In the south office, an auxiliary

heat relay system would control both the mini split unit and hydronic baseboards to ensure simultaneous heating and cooling does not occur.

System Overview

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

Equipment List

- (2) Nominal 9-ton air to water heat pump
- (1) 15 kW Electric Boiler
- Heating loop pumps (includes standby pumps)
    - (2) HX – Buffer Tank circulation pumps, approximately 60 gpm with ECM motors
    - (2) Buffer Tank – Building circulation pumps, approximately 60 gpm with ECM motors
    - (1) Electric Boiler Pump, approximately 20 gpm with ECM motor
- (1) 150 gallon buffer tank
- (2) Air separators
- (2) Expansion tanks
- (1) 90 L/s [190cfm] ERV with ECM motors and dual cores
- (1) 333 L/s [705cfm] ERV with ECM motors and dual cores
- (2) 0.75 ton mini split heat pumps
- (1) 80 gallon packaged heat pump water heater

System Schematic

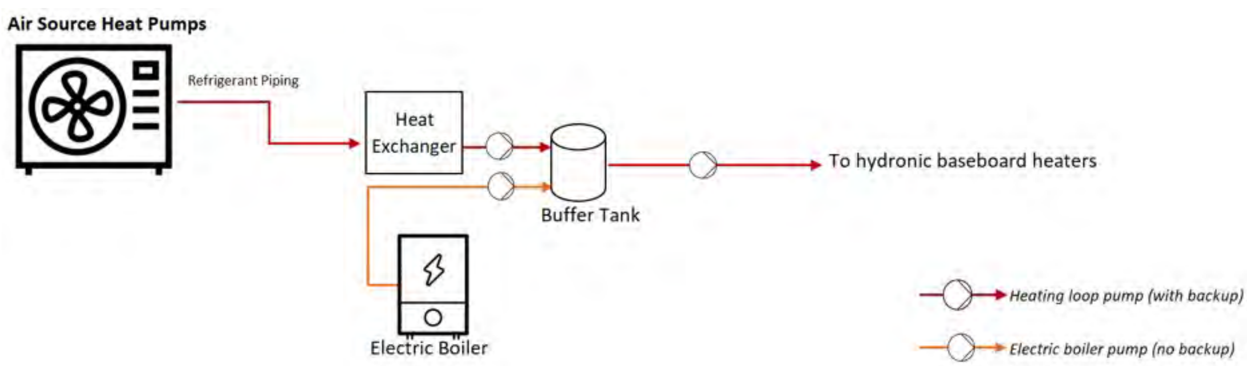


Figure 26 ASHP Schematic

a. *Ground Source Heat Pump (GSHP) Option*

Heating and Cooling

This option is the equivalent to the ASHP option except the heating will be generated by a water to water, or ground source, heat pump (as shown in Figure 27). 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 three boreholes will be required to provide both space heating and domestic hot water for the building.[1] Similar to the ASHP, the GSHP system has also been sized for 60% capacity.

Figure 27 Ground Source Heat Pump

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 south side of the property on the site of the old greenhouse (refer to Figure 28); however, further geotechnical analysis must be conducted to confirm. Boreholes are typically spaced 4.8 – 6 meters apart. The GSHPs would be located in the mechanical room in Building B.

Figure 28 Proposed Borehole Location

The GSHP option would utilize the existing hydronic baseboard heaters as the distribution method. Hydronic baseboard heaters would be installed in the north office. Accessories to the hot water piping systems include make-up water source, expansion tank, air venting, circulation pumps, and isolation valves.

As per the ASHP option, cooling in Building A will be provided by the existing ASHP. Two water to air console heat pumps would be installed in the two offices to provide cooling. At later dates, additional units may be installed in other areas of the building that currently do not have cooling.

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

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.

Ventilation
Similar to the Minimum Acceptable Scenario, two ERVs would be used for the space: one in Building A and one in Building B. As ventilation loads are occupancy dependant, the airflows are consistent with the minimum accepted scenario.

Controls
The GSHP plants will require direct digital control systems to operate circulation pumps and heat pumps with input from buffer tanks. Programmable time of day controls will run the ERVs.

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

Equipment List

- (2) Nominal 4 ton ground source heat pump
- (1) 20 kW Electric Boiler
- Heating Loop Pumps (includes standby pumps)
    - (2) Ground loop circulation pumps, approximately 30 gpm with VFD
    - (2) HP circulation pumps, approximately 30 gpm with ECM motors
    - (2) Building circulation pumps, approximately 60 gpm with ECM motors
    - (1) Electric Boiler pump, approximately 25 gpm with ECM motors
- (3) Air separators
- (3) Expansion tanks
- (1) 90 L/s [190cfm] ERV with ECM motors and dual cores
- (1) 333 L/s [705cfm] ERV with ECM motors and dual cores
- (2) 0.75 ton water to air consoles
- (1) 80 gallon packaged heat pump water heater

System Schematic

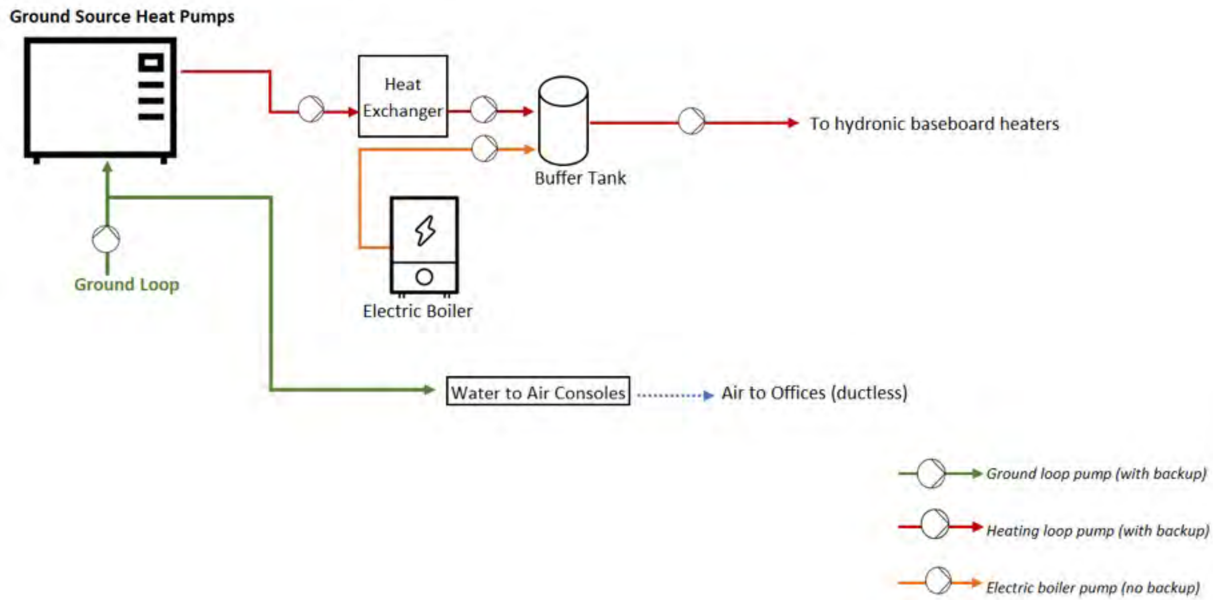


Figure 29 GSHP Schematic

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-12.9	R-24	R-24	R-24
Effective Roof R-value	R-15.4	R-40	R-40	R-40
Air Tightness (L/s·m² at 75Pa)	2.3 L/s·m2	0.75 L/s·m2	0.75 L/s·m2	0.75 L/s·m2
Central Heating Equipment	Oil-fired boiler with single stage burner	Oil-fired boiler with single stage burner	ASHP	GSHP
Heating System	Bldg A: Hydronic baseboards Bldg B: Hydronic baseboards and unit heaters	Bldg A: Hydronic baseboards Bldg B: Hydronic baseboards and unit heaters	Bldg A: Hydronic baseboard Bldg B: Hydronic baseboards and unit heaters	Bldg A: Hydronic baseboard Bldg B: Hydronic baseboards and unit heaters
Air Conditioning[2]	Bldg A: Existing ASHP Bldg B: Packaged air conditioning units	Bldg A: Existing ASHP Bldg B: Mini split units	Bldg A: Existing ASHP Bldg B: Mini split units	Bldg A: Existing ASHP Bldg B: Water to Air consoles
DHW Equipment	Electric Water Heater	Electric Water Heater	HP Water Heater	HP Water Heater
Ventilation Equipment	Bldg A: None (Exhaust Fans) Bldg B: None (Exhaust Fans)	Bldg A: 90% SRE ERV Bldg B: 90% SRE ERV	Bldg A: 90% SRE ERV Bldg B: 90% SRE ERV	Bldg A: 90% SRE ERV Bldg B: 90% SRE ERV
Renewables	-	-	TBD	TBD

[1] Net Zero Energy Ready systems are identical with exclusion of renewables
[2] Building B only provides cooling in north and south offices

Appendix E

Electrical Outline Specification

PURPOSE

The purpose of this Design Summary is to document the existing and propose new mechanical systems for the energy retrofit of 251 Lancaster Crescent in Debert, Nova Scotia. The intent is to summarize the major features and design parameters for the electrical power distribution and lighting systems.

The building was built in 1979 as a Tree Breeding Centre for the Department of Lands and Forests. The facility originally included three primary areas: admin, production, and a greenhouse. It is estimated that the greenhouse was removed from the structure 15 years ago. Currently, the front admin area is being rented out as business space and the back production area is now a maintenance facility.

EXISTING SYSTEMS

Site Services

Existing incoming power service consists of two, 4” conduits on the primary side servicing the existing pad mount transformer on site. The pad mount transformer is 150kVA. The existing main incoming secondary service is sized at 800A and consists of two, 3-1/2” conduits containing 4#500MCM RW90 cables each. By today’s code standards these cables would no longer be suitable for 800A service. The secondary service entrance enters the building in the main electrical room and terminates onto the main switchboard. The building’s main disconnect is an 80% rated main breaker in the main switchboard.

Figure 1

Figure 2

Electrical Power Distribution Services

Main Switchboard

The existing main switchboard is original to the building. It appears to be well maintained but has reached its end of life. No maintenance logs are available to determine work done throughout the years.

The main building disconnect is an 80% rated 800A main breaker. All other disconnects for panels, motors etc. are fusible disconnects. Visually the disconnects appear to be in good condition. Although cubicles 1 and 3 are full, there is spare room in cubicle 2 for the addition of future buckets to expand the existing distribution. Several spare fusible disconnects exist in cubicle 3 that are currently not in use. There is a 400A emergency distribution panel installed inside the main switchboards second cubicle. The condition of the main switchboard is okay.

Figure 3

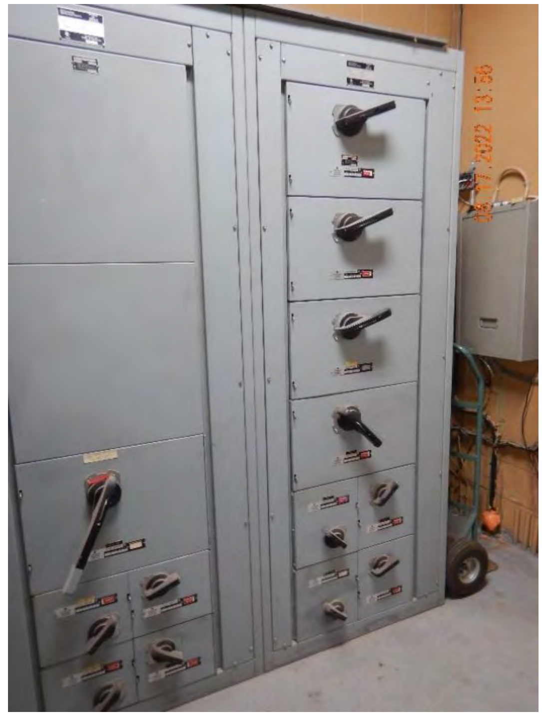


Figure 4

Existing Branch Circuit Panelboards

Several 120-208V branch circuit panelboards exist throughout the building servicing various areas. Over the years, some of these panels have had work done and the existing panel schedules are consequently out of date. 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.

We do not have any logging data on power demand of the existing panelboards, 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.

The overall condition of the branch circuit panelboards is good, while some are original to the building, it appears some have been added through the years to expand circuit capacity.

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
Washrooms	1 W/m^2	30 m^2
Office	7.5 W/m^2	186 m^2
Storage	1 W/m^2	502 m^2


Figure 5


Figure 6

Emergency Power Distribution

A 150kW 208V, 3P emergency generator and distribution exists on site but is reportedly no longer in use. The existing emergency distribution is always powered by the "normal" side and is essentially just used as normal power. It was discussed on-site that on-site emergency power generation is no longer needed.

Figure 7

Lighting and Lighting Control System

Interior Lighting

There was a general lack of lighting throughout the building used by Colchester County. Around 40% of the existing fixtures on this side of the building were burnt out or not functional. The lighting in the Rural Roots side of the building was replaced in the past 20 years and is significantly more well-lit. The mechanical room specifically on the Colchester side lacks lighting which presents a safety concern for people working in this room. The existing lighting power density for the building is estimated to be 22W/m^2 which assumes all fixtures in working condition.

The side of the building occupied by Colchester County is primarily original lighting, consisting of mostly T12 fluorescent lamps. The warehouse areas of the building consist mainly of high output fixtures. The estimated lighting power density for this section of the building is 25W/m^2.

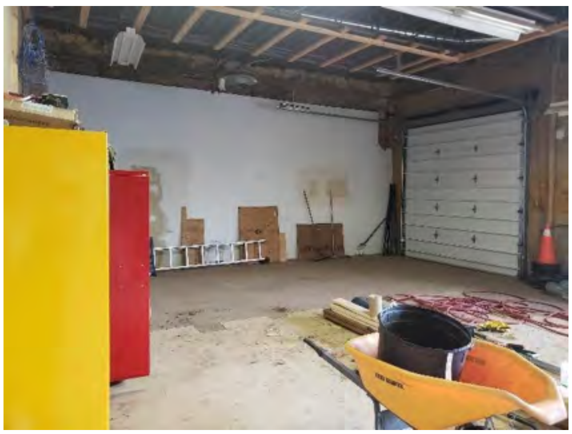


Figure 8

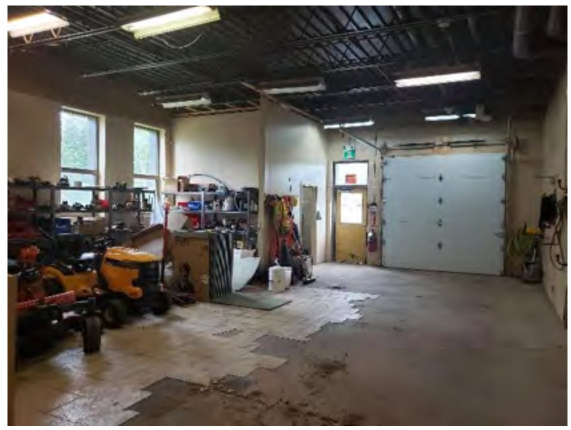


Figure 9

The Rural Roots side of the building has been upgraded to 2x2 and 2x4 fixtures complete with T8 lamps. This area has a drop T-bar ceiling with recessed fixtures; however, it appears that the old highbay warehouse lighting remains in the plenum space above the T-bar. It is recommended this lighting is removed in the future, to prevent accidentally turning it on. The estimated lighting power density for this section of the building is 15W/m^2.

Figure 10

Figure 11

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 using LED lighting retrofit kits. These kits a relatively inexpensive and will help dramatically reduce energy consumption from 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 depend on how much new equipment is being added onto the existing system and what the existing system can support.

1. Minimum Acceptable Scenario

Lighting
In the minimum acceptable scenario, 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. In this scenario, the lighting power density will reduce to an estimated 10W/m^2.

Figure 12

Figure 13

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 two new 0.75 ton mini split heat pumps. 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 14kW of electrical load onto the existing electrical distribution.

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

Minimum Acceptance Scenario Electrical Loads	Qty	kW	Total Load
90 L/s ERV with ECM motors and polypropylene cores	1	2	2
250 L/s ERV with ECM motors and polypropylene cores	1	2	2
0.75 ton mini split heat pumps	2	5	10
Total Added Load			14

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 9W/m^2. See replacement fixture schedule below:

Existing Fixture	**Existing Wattage (total lamps)**	**Example Replacement Fixture Product Number**	**Replacement Fixture Wattage**
Warehouse Linear Highbays	160W (2 lamps)	Lithonia: IBG 80LM SEF AFL GND MVOLT	48W
Office 2x4s	160W (4 lamps)	Lithonia: 2BLT4 40LHE MVOLT	35W
Office 2x2s	80W (2 lamps)	Lithonia: 2BLT2 33LHE MVOLT	25W
Warehouse Round Highbays	160W (1 lamp)	Lithonia: JEBL 12000LM FRGL MVOLT	90W

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 office space. Daylight sensors will be provided in all areas with natural light and vacancy sensors will be provided in all areas. 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. Due to the added load of the electrified mechanical equipment, a new building service upgrade and switchboard is strongly recommended, as the existing switchboard has reached its end of life. Without any demand billing data prior to 2020, it is unknown what the existing building demand load is and therefore, it is unknown what new service size will be required to accommodate the changes to the buildings electrical system. To determine what the existing building load is, existing power bills will have to be logged to get more information on the monthly demand load. This will give an idea of what the existing load on the system is and how large the new building service should be to accommodate. Based off the information we have access to, it is unlikely that the buildings demand is reaching near the existing service size, therefore it is likely that the existing switchboard will be replaced 1:1 with a new 800A switchboard and main breaker. The net zero ready scenario should account for a PV installation when considering upgrading the buildings service size. The current energy model predicts a 45kW AC PV system will be required to achieve a net-zero system. Assuming the most likely scenario of a new 800A switchboard, this system can easily be accommodated.

In both mechanical options, new electrical distribution will be added off the new main switchboard to allow for connection to mechanical equipment. A new 208V, 3P panelboard, fed from the new main switchboard, will be added to service all new pumps, ERVs and heat pumps.

Air Source Heat Pump (ASHP) Option

Net-Zero Ready (ASHP)	Qty	kW	Total Load (kw)
9-ton air to water heat pump	**2**	10.26	20.52
26kW Electric Boiler	1	26	26
HX -Buffer Circ	**2**	0.333	0.666
Buffer tank	**2**	0.608	1.216
Electric Boiler Pump	1	**0.153**	**0.153**
90 L/s ERV with ECM motors and polypropylene cores	1	2	2
250 L/s ERV with ECM motors and polypropylene cores	1	5	**2**
0.75 ton mini split heat pumps	2	5	**10**
80 Gallon packaged heat pump water heats	1	5	5
Total Added Load			67.555

Ground Source Heat Pump (GSHP) Option

Net-Zero Ready (ASHP)	Qty	kW	Total Load (kw)
Nomial 24ton ground source heat pump	**3**	15	45
23kW Electric Boiler	1	23	23
Ground Loop Circ Pumps	3	2.2	6.6
HP Circ Pumps	2	0.185	0.37
Building Circ Pumps	2	1.377	2.754
Electric Boiler Pump	1	0.153	0.153
90 L/s ERV with ECM motors and polypropylene cores	1	2	2
250 L/s ERV with ECM motors and polypropylene cores	1	2	2
0.75 ton mini split heat pumps	2	5	10
80 Gallon packaged heat pump water heats	1	5	5
Total Added Load			96.877

The new building service upgrade will be sized to accommodate the existing electrical load, as well as the new added mechanical load. The exact size of the new equipment will depend on the existing building electrical demand load determined by logging the existing billing information. To determine the new service size, the existing electrical load will be added onto the mechanical load outlined in the chosen option above. Replacing the buildings service entrance would include replacing the existing main switchboard, the existing main breaker and the existing secondary service conductors.

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)	Estimated New Switchboard Size	Estimated New Main Breaker	Net Metering Eligible
26.5kW	45kW	68kW (189A)	800A	800A (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)	Estimated New Switchboard Size	Estimated New Main Breaker	Net Metering Eligible
26.5kW	45kW	97kW (269A)	800A	800A (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

Colchseter
Energy Use As Reported by Client

Summarized by Monthly Consumption

As calculated by RDH

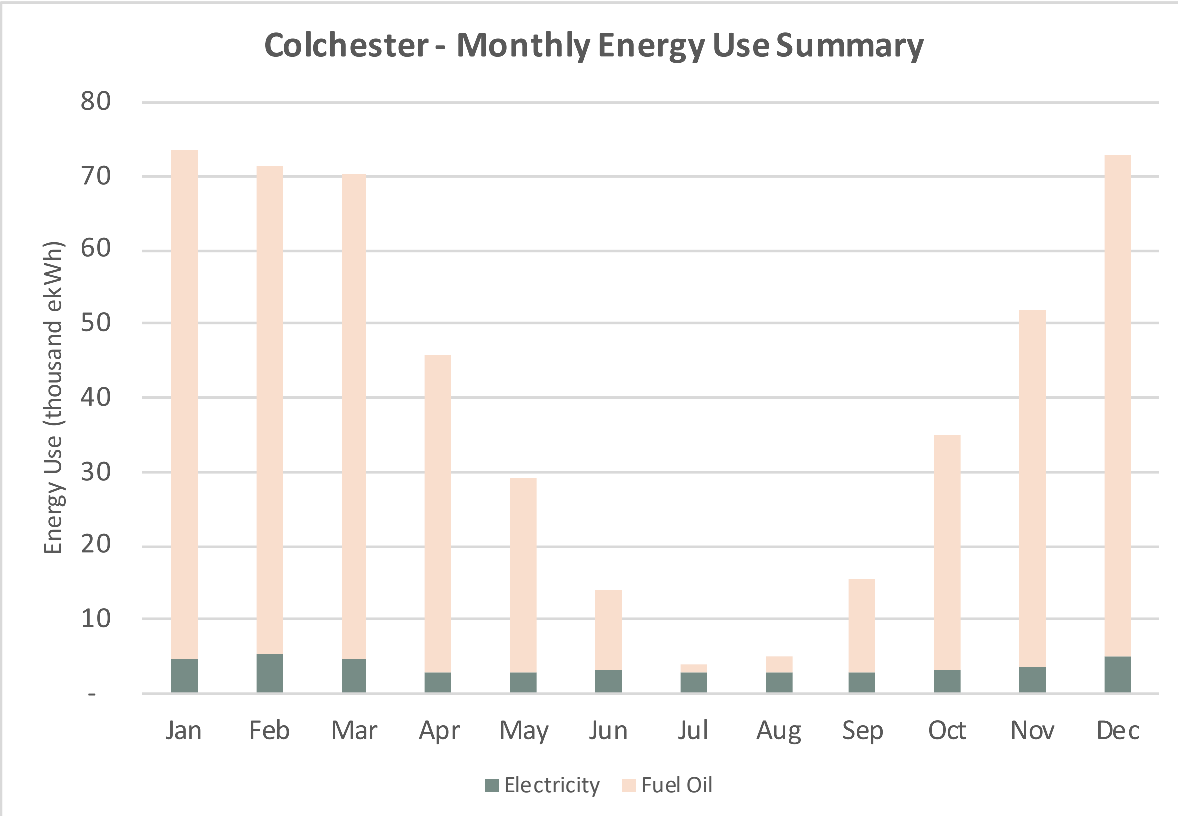
Electrical Consumption (kWh)

	2020	2021	2022	Average	
Jan		4,000	5,600	4,800	Jan
Feb		4,480	6,560	5,520	Feb
Mar	4,960	4,160		4,560	Mar
Apr	2,880	3,040		2,960	Apr
May	2,880	2,720		2,800	May
Jun	3,520	3,040		3,280	Jun
Jul	1,760	3,680		2,720	Jul
Aug	2,240	3,360		2,800	Aug
Sep	2,400	3,040		2,720	Sep
Oct	3,200	3,520		3,360	Oct
Nov	3,520	4,000		3,760	Nov
Dec	4,320	5,920		5,120	Dec

Fuel Oil (L)

	2020	2021	2022	Avg. (M^3)	ekWh	
Jan		6,435	6,333	6,384	68,649	Jan
Feb		6,166	6,068	6,117	65,779	Feb
Mar	6,915	5,771	5,679	6,122	65,825	Mar
Apr	4,350	3,630		3,990	42,905	Apr
May	2,674	2,232		2,453	26,375	May
Jun	1,097	915		1,006	10,818	Jun
Jul	121	101		111	1,191	Jul
Aug	243	203		223	2,397	Aug
Sep	1,297	1,083		1,190	12,797	Sep
Oct	3,201	2,672		2,936	31,575	Oct
Nov	4,894	4,084		4,489	48,270	Nov
Dec	6,888	5,748		6,318	67,939	Dec

ekWh converstion factor used	10.75

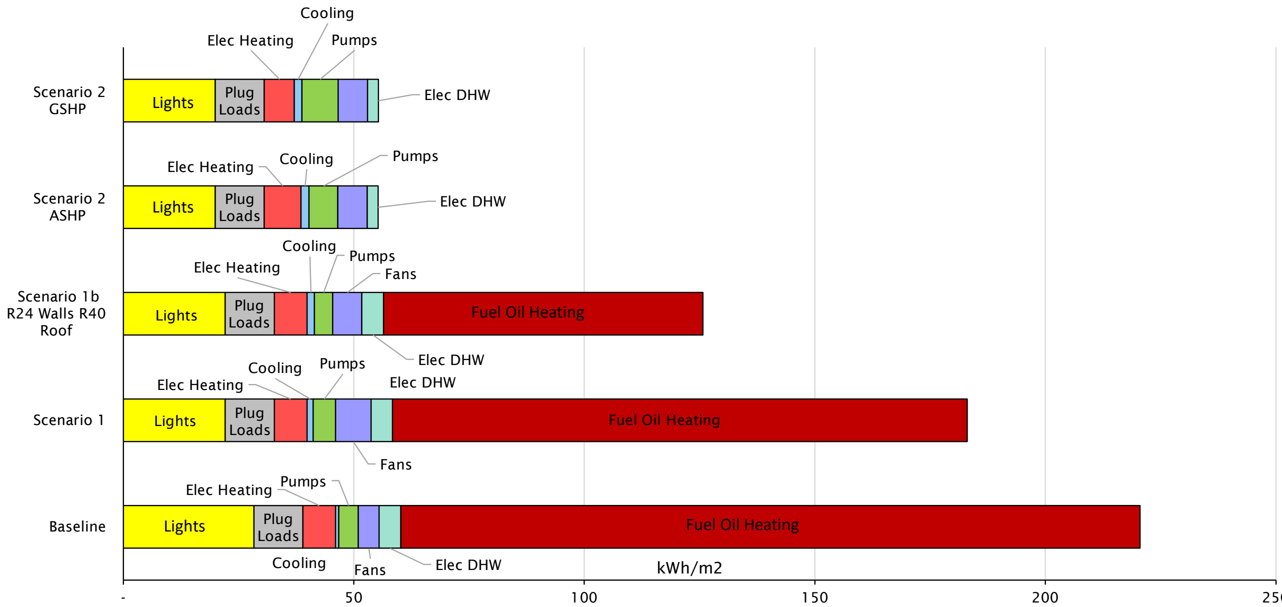

Colchester - Monthly Energy Use Summary
80
70
60
50
40
30
20
10
-
Energy Use (thousand ekWh)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Electricity
Fuel Oil

Appendix G

Energy Model Reports

Colchester

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

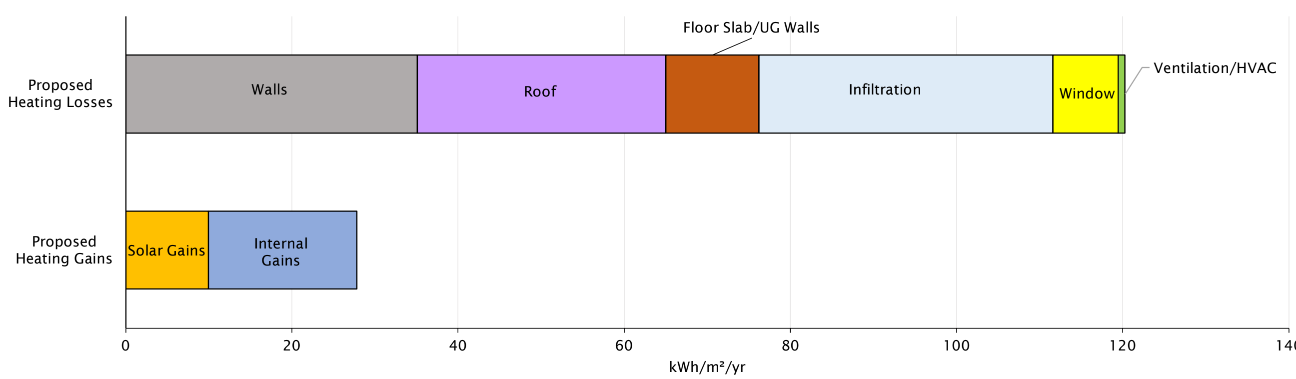


	Baseline	Scenario 1	Scenario 1b R24 Walls R40 Roof	Scenario 2 ASHP	Scenario 2 GSHP
Lights	28.30	22.11	22.11	19.90	19.90
Plug Loads	10.66	10.66	10.66	10.66	10.66
Elec Heating	7.06	7.06	7.06	7.97	6.51
Cooling	0.70	1.35	1.64	1.78	1.68
Pumps	4.20	4.83	3.93	6.25	7.85
Fans	4.57	7.72	6.36	6.37	6.37
Elec DHW	4.68	4.68	4.67	2.33	2.33
Fuel Oil Heating	160.39	124.67	69.29	-	-

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

	TEUI:	Total:
Baseline:	220.6 kWh/m²	158,423 kWh
Scenario 1:	183.1 kWh/m²	131,492 kWh
Scenario 1b:	125.7 kWh/m²	90,293 kWh
Scenario 2 ASHP:	55.3 kWh/m²	39,691 kWh
Scenario 2 GSHP:	55.3 kWh/m²	39,722 kWh

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



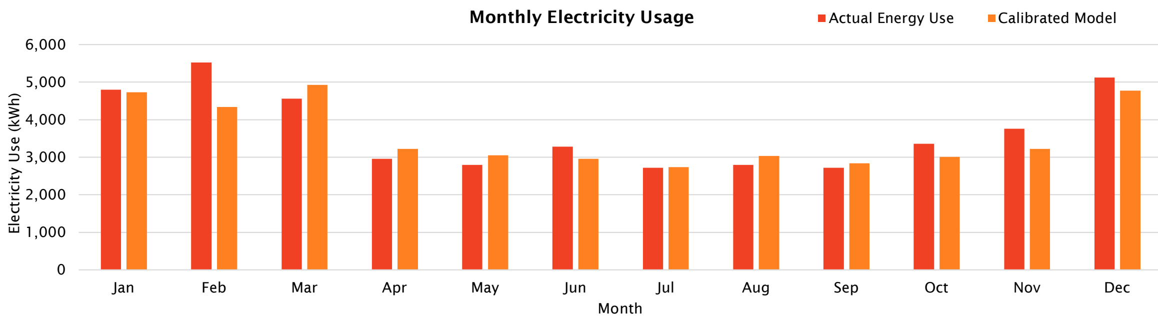
Note: The values presented above, represent the relative proportion of each component of the thermal energy demand intensity. These values include adjustments that account for internal gains from lights/plug loads/solar

Colchester

Project #, Building Name: Calibrated Model Filename: Weather File	26522.000 ReCover NRCAN Deep Energy Retrofit Feasability Study 2022-09-15 Colchester Warehouse.inp CAN_NS_DEBERT_8201390_CWEC.BIN
Total Energy, kWh 1.54E+05 **Meter EUI, kWh/m2** 215 **Model EUI, kWh/m2** 221	**Notes on Calibrations:** See attached Inputs Document

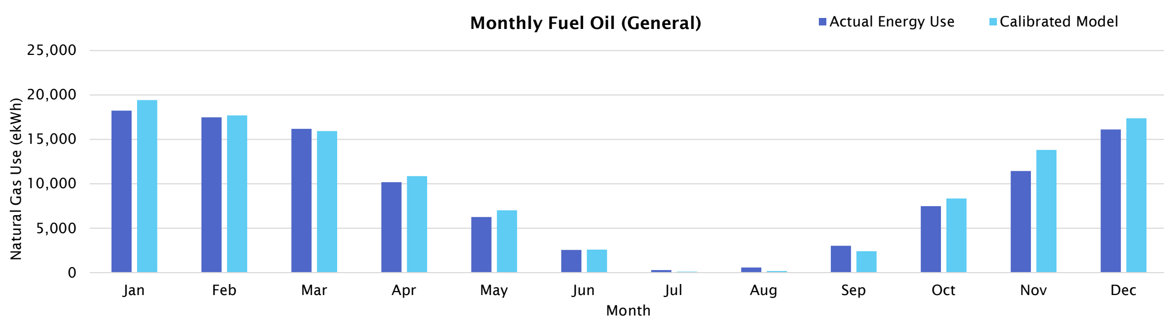
Monthly Electricity Usage (kWh)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Actual Energy Use	4,800	5,520	4,560	2,960	2,800	3,280	2,720	2,800	2,720	3,360	3,760	5,120	44,400
Calibrated Model	4,728	4,335	4,928	3,225	3,054	2,954	2,736	3,037	2,836	3,009	3,219	4,773	42,834
Difference	-72	-1,185	368	265	254	-326	16	237	116	-351	-541	-347	-1,566
% Difference	-1.5%	-21.5%	8.1%	8.9%	9.1%	-9.9%	0.6%	8.4%	4.3%	-10.5%	-14.4%	-6.8%	-3.5%



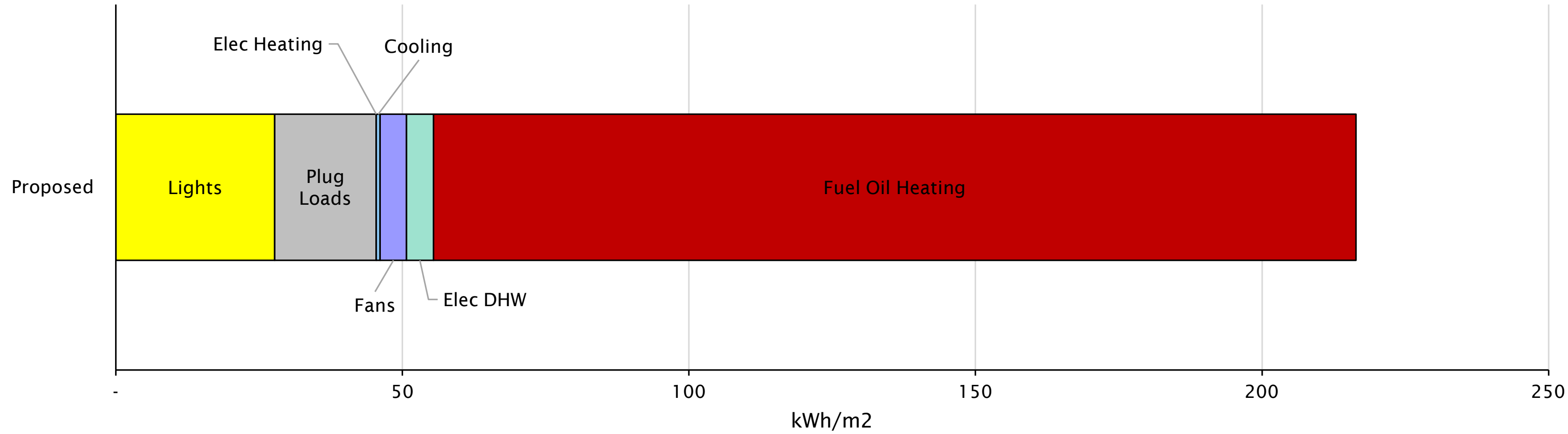
Monthly Fuel Oil Usage (ekWh)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Actual Energy Use	18,219	17,457	16,161	10,166	6,249	2,563	282	568	3,032	7,481	11,437	16,098	109,715
Calibrated Model	19,402	17,669	15,924	10,858	7,013	2,590	116	188	2,416	8,353	13,807	17,363	115,699
Difference	1,183	211	-237	692	764	26	-166	-380	-616	871	2,370	1,266	5,984
% Difference	6.5%	1.2%	-1.5%	6.8%	12.2%	1.0%	-58.8%	-66.8%	-20.3%	11.6%	20.7%	7.9%	5.5%



Colchester

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



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

GENERAL

Building	Colchester - Water Utility Building
Archetype	Existing Warehouse or Low-Rise Office
Site Location	Debert, Colchester County, Nova Scotia

Building Summary	**Colchester Baseline**	**Units**	**Reference/Description**
Number of Storeys	1	-	Based on drawings
Conditioned Floor Area Bldg. A (Total)	**181 (1,950)**	**m² (ft²)**	
Office Bldg. A	151 (1,630)	m² (ft²)	
Washrooms Bldg. A	30 (320)	m² (ft²)	
Conditioned Floor Area Bldg. B (Total)	**537 (5,778)**	**m² (ft²)**	
Office Bldg. B	35 (380)	m² (ft²)	
Storage/mech/ Bldg. B	502 (5,398)	m² (ft²)	
Opaque Enclosure Performance			
Bldg. A Wall 3	1" Wood Siding 1/2" Plywood Sheathing 2"x6" Studs @ 16" O.C. w/ R20 Batt 5/8" Gypsum Board (R-18.6)	m^2-K/W (ft²-hr-˚F/Btu) effective	Colchester: All Assembly data from Water Utility Building Structural -251 Lancaster.pdf Architectural drawings Existing R-value estimates provided by ARCH
Bldg. A Roof	Asphalt Shingles 5/8" Plywood Sheathing Framing at 24" O.C. w/ R20 Batt (ceiling level) (R-18.6)	m^2-K/W (ft²-hr-˚F/Btu) effective	
Bldg. A Slab on Grade	2" Rigid underslab (R-7)	m^2-K/W (ft²-hr-˚F/Btu) effective	
Bldg. B Wall 3	1.5" Deep Pre-Finished Panel 2"x3" Furring @ 3'-5" O.C. horiz. w/ 2.5" rigid insulation 10" Concrete block reinforced w/ truss type reinforcing every 2nd block (R-9.1)	m^2-K/W (ft²-hr-˚F/Btu) effective	
Bldg. B Wall 4	1"x6" V-joint Wood Siding 2"x3" Furring @ 2'-0" O.C. vert. w/ 2.5" rigid insulation 10" Concrete block reinforced w/ truss type reinforcing every 2nd block (R-9.7)	m^2-K/W (ft²-hr-˚F/Btu) effective	

Bldg. B Roof	Crushed Stone 4" Rigid Insulation 1/2" Gypsum Board 1.5" Metal Deck (R-14.3)	m^2-K/W (ft²-hr-°F/Btu) effective	Colchester: All Assembly data from Water Utility Building Structural -251 Lancaster.pdf Architectural drawings Existing R-value estimates provided by ARCH
Bldg. B Slab on Grade	Uninsulated (Perimeter 2" insulation on the interior of footing extending 4' down)	m^2-K/W (ft²-hr-°F/Btu) effective	
Fenestration			
Bldg. B Overhead Door	New, Assume R-5 (Clearfield)		Per Arch
Window-to-Wall Ratio (WWR)	5.3%	%	Per Arch
Windows Installed Overall U-value	Double Glazed Windows wood and vinyl framed (U-0.35)	W/m^2-K (Btu/ft²-hr-°F)	
Window Overall SHGC	0.77	-	Per Arch
Infiltration			
Infiltration Rate	2.3 L/s/m² exterior vertical enclosure and roof area @ 75Pa (Modelled as 0.40 L/s/m² @ 5Pa, assumed operating pressure)		Reduced to midway between ASHRAE Fundamentals, Leaky Building (2009) and ASHRAE Fundamentals, Average Building (2009) per discussion w/ the team; Infiltration rate per m^2 of exterior envelope.
Infiltration Schedule		-	

MECHANICAL	Colchester Baseline	Units	Reference/Description
Ventilation System Description	No Ventilation	-	
Heating/Cooling System Description	Hydronic baseboards served by an oil-fired boiler. Mini-split cooling in Bldg. A.	-	
Heating Plant			
System Description	Oil-Fired Boiler (circa 2005) 483 MBH output	-	Colchester: Site Notes Interior photos side A
Plant Efficiency	0.80	%	per M&R Mechanical
Hot Water Supply/Return Temperature	Assume Supply 180F Return 160F	˚C (˚F)	
Cooling Plant			
System Description	n/a	-	Colchester: Site Notes
Plant Efficiency	n/a	-	
Cold Water Supply/Return Temperature	n/a	˚C (˚F)	
Pumps			
Pump Type	2 pumps 1/2 HP ea	HP	Water UtltyBldng Struc-251Lancaster.pdf mech drawings P12 and P13 on sheet M8
Pump Operation	Continuous		
Zone Heating/Cooling System			
System Description	Fin-tube baseboards w/ hydronic piping. And hydronic unit heaters in warehouse area. Now have a heat pump but this would not be included in utility data to calibrate. Exhaust Fan in Bldg. A	-	Colchester: Site Notes

MECHANICAL	Colchester Baseline	Units	Reference/Description
Airside System Description			
System Description	New ducted seasonal heat pump to supplement heating and provide cooling in the office area. Previously there was a mini-split for cooling serving the office.	-	Colchester: Site Notes - NOT MODELLED FOR BASELINE
Outdoor Air Fraction	Bathroom fan	-	Colchester: Site Notes
Outdoor Air Flow Rate	47	L/s (cfm)	Bathroom exhaust fan per Mechanical- Colchester Existing Outline Specification. Assumed to be running 8 hours per work day for calibration
Total Supply Air Flow Rate	n/a	L/s (cfm)	
Economizer	n/a	-	
Heating Type	Hydronic from central oil-fired boiler Bldg. A: Baseboards Bldg. B: Baseboards and Unit Heaters	-	Mechanical- Colchester Existing Outline Specification
Zone Heat Capacity: Electric baseboards	Bldg. A: 1500W Bldg. B 2000W		Electric baseboards Bldg. B per Electrical ESAR1 file Electric space heating in Bldg. A per M&R site photos
Cooling Type	1/2 Ton Mini-split (Bldg. A)	-	1/2 ton assumed to calibrate to utility bills
Cooling Efficiency	Mini-split COP-2.5	-	Assumed
Fan Type	n/a		
Fan Power	n/a	W/cfm	
Fan Schedule	n/a		
Energy Recovery	n/a	-	
Energy Exchanger By-pass	n/a	-	

Domestic Hot Water			
Heating Source	Electric Water Heater (Make: GSW)	-	2201080 Debert Photolog
Thermal Efficiency	100%	%	
Peak DHW Load	Office: 90 Warehouse: 65	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	-	
DHW HW Supply Temp	60	˚C	
Storage tank capacity		Liters	
OPERATION	**Colchester Baseline**	**Units**	**Reference/Description**
Lighting			
Type	T12 Fluorescents		Colchester: Site Notes
Lighting Power Density	Bldg. A: 9 W/m^2 Bldg. B: 10 W/m^2	W/m²	Electrical ESAR1 file notes that some rooms in the Bldg. A office have no working lights. M&R site visit photos show many lights not working in Bldg. A and Bldg. B
Schedule		-	
Process Loads			
Plug Loads & Schedule	Office: 7.5 Warehouse: 1	W/m²	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
Process Loads & Schedule	Washer/dryer - once a month Compressor 5HP - 2 hrs per day? Kitchen (fridge, microwave) - Fractional schedule	-	Colchester: Site Notes - Not modeled, calibrated with NECB plug loads
Occupancy			
Occupant Density	Office: 10 people Warehouse: 5 people	m²/occupant	per Arch
Occupant Schedule	Fractional	-	
Setpoints			
Heating Setpoint/Setback	22/18	°C	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Cooling Setpoint/Setback	24/29	°C	

GENERAL

Building	Colchester - Water Utility Building
Archetype	Existing Warehouse or Low-Rise Office
Site Location	Debert, Colchester County, Nova Scotia

Building Summary	**Colchester Baseline**	**Scenario 1: Minimum Acceptable (50%) Reduction**	**Scenario 2: Net Zero Ready ASHP**	**Scenario 2: Net Zero Ready GSHP**	**Units**	**Reference/Description**
Number of Storeys	1				-	
Conditioned Floor Area Bldg. A (Total)	**181 (1,950)**				**m^2 (ft^2)**	
Office Bldg. A	151 (1,630)				m^2 (ft^2)	
Washrooms Bldg. A	30 (320)				m^2 (ft^2)	Based on drawings
Conditioned Floor Area Bldg. B (Total)	**537 (5,778)**				**m^2 (ft^2)**	
Office Bldg. B	35 (380)				m^2 (ft^2)	
Storage/mech/ Bldg. B	502 (5,398)				m^2 (ft^2)	
Opaque Enclosure Performance						
Bldg. A Wall 3	1" Wood Siding 1/2" Plywood Sheathing 2"x6" Studs @ 16" O.C. w/ R20 Batt 5/8" Gypsum Board (R-18.6)	Existing assembly (Scenario 1b: R-24)	R24	R24	m^2-K/W (ft^2-hr-˚F/Btu) effective	
Bldg. A Roof	Asphalt Shingles 5/8" Plywood Sheathing Framing at 24" O.C. w/ R20 Batt (ceiling level) (R-18.6)	Existing assembly (Scenario 1b: R-40)	R40	R40	m^2-K/W (ft^2-hr-˚F/Btu) effective	
Bldg. A Slab on Grade	2" Rigid underslab (R-7)				m^2-K/W (ft^2-hr-˚F/Btu) effective	Colchester: All Assembly data from Water Utility Building Structural -251 Lancaster.pdf Architectural drawings Existing R-value estimates provided by ARCH
Bldg. B Wall 3	1.5" Deep Pre-Finished Panel 2"x3" Furring @ 3'-5" O.C. horiz. w/ 2.5" rigid insulation 10" Concrete block reinforced w/ truss type reinforcing every 2nd block (R-9.1)	Existing assembly (Scenario 1b: R-24)	R24	R24	m^2-K/W (ft^2-hr-˚F/Btu) effective	
Bldg. B Wall 4	1"x6" V-joint Wood Siding 2"x3" Furring @ 2'-0" O.C. vert. w/ 2.5" rigid insulation 10" Concrete block reinforced w/ truss type reinforcing every 2nd block (R-9.7)	Existing assembly (Scenario 1b: R-24)	R24	R24	m^2-K/W (ft^2-hr-˚F/Btu) effective	
Bldg. B Roof	Crushed Stone 4" Rigid Insulation 1/2" Gypsum Board 1.5" Metal Deck (R-14.3)	Existing assembly (Scenario 1b: R-40)	R40	R40	m^2-K/W (ft^2-hr-˚F/Btu) effective	Colchester: All Assembly data from Water Utility Building Structural -251 Lancaster.pdf Architectural drawings Existing R-value estimates provided by ARCH
Bldg. B Slab on Grade	Uninsulated (Perimeter 2" insulation on the interior of footing extending 4' down)	Uninsulated (Perimeter 2" insulation on the interior of footing extending 4' down)	Uninsulated (Perimeter 2" insulation on the interior of footing extending 4' down)	Uninsulated (Perimeter 2" insulation on the interior of footing extending 4' down)	m^2-K/W (ft^2-hr-˚F/Btu) effective	
Fenestration						
Bldg. B Overhead Door	New, Assume R-5 (Clearfield)	R-10 (Clearfield)	R-10 (Clearfield)	R-10 (Clearfield)		Per Arch
Window-to-Wall Ratio (WWR)	5.3%	5.3%	5.3%	5.3%	%	Per Arch
Windows Installed Overall U-value	Double Glazed Windows wood and vinyl framed (U-0.35)	U-0.18	U-0.18	U-0.18	W/m^2-K (Btu/ft^2-hr-˚F)	
Window Overall SHGC	0.77	0.32	0.32	0.32	-	Per Arch
Infiltration						
Infiltration Rate	2.3 L/s/m^2 exterior vertical enclosure and roof area @ 75Pa (Modelled as 0.40 L/s/m^2 @ 5Pa, assumed operating pressure)	Reduction to 0.75L/s/m^2 exterior enclosure area	Reduction to 0.75L/s/m^2 exterior enclosure area	Reduction to 0.75L/s/m^2 exterior enclosure area		Reduced to midway between ASHRAE Fundamentals, Leaky Building (2009) and ASHRAE Fundamentals, Average Building (2009) per discussion w/ the team; Infiltration rate per m^2 of exterior envelope.
Infiltration Schedule					-	

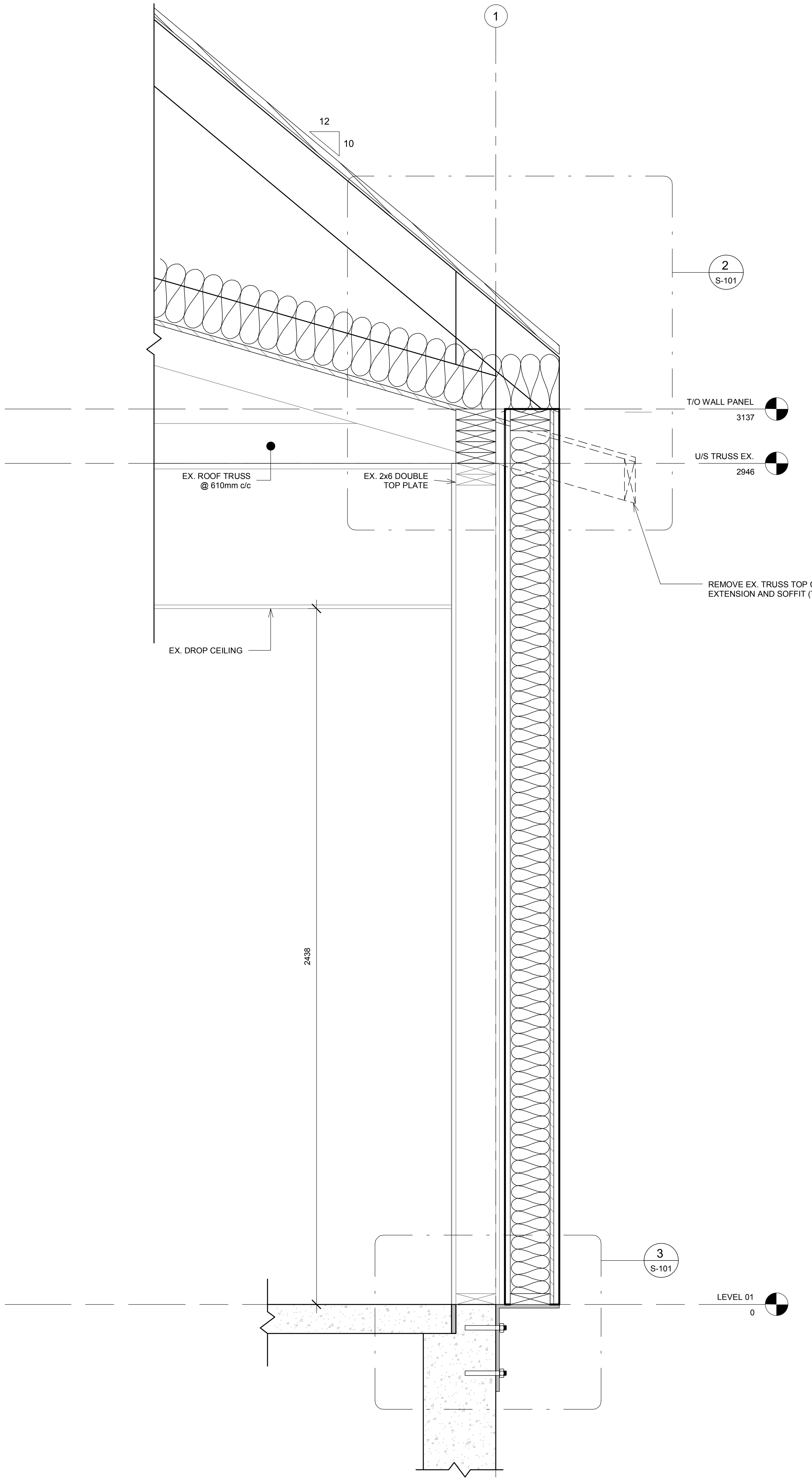
MECHANICAL	Colchester Baseline	Scenario 1: Minimum Acceptable (50%) Reduction	Scenario 2: Net Zero Ready ASHP	Scenario 2: Net Zero Ready GSHP	Units	Reference/Description
Ventilation System Description	No Ventilation	Existing mechanical with 2 new mini-splits in building B cooling only. Building A ASHP cooling only	Heating: Cold climate Air source heat pump (ASHP) serving hydronic baseboards and unit heaters Cooling: Building A - Existing ASHP Building B 2 new mini splits	Ground source heat pump (GSHP) serving hydronic baseboards and unit heaters. Cooling: Building A - ASHP Building B - Water to air consoles fed by ground loop	-	
Heating/Cooling System Description	Hydronic baseboards served by an oil-fired boiler. Mini-split cooling in Bldg. A.				-	
Heating Plant						
System Description	Oil-Fired Boiler (circa 2005) 483 MBH output	Oil-Fired Boiler (circa 2005) 483 MBH output	Cold climate Air source heat pump (ASHP) 2x9 ton 15 kW backup electric boiler	Cold climate Air source heat pump (GSHP) 2x4 ton 20 kW backup electric boiler	-	Colchester: Site Notes Interior photos side A
Plant Efficiency	0.80	0.80	COP 3.10 Nominal	COP 2.85	%	per M&R Mechanical
Heat-pump Cut-off Temperature			-22 F	n/a	˚C (˚F)	
Hot Water Supply/Return Temperature	Assume Supply 180F Return 160F	Assume Supply 180F Return 160F			˚C (˚F)	
Cooling Plant						
System Description	n/a	n/a	n/a	n/a	-	Colchester: Site Notes
Plant Efficiency	n/a				-	
Cold Water Supply/Return Temperature	n/a				˚C (˚F)	
Pumps						
Pump Type	2 pumps 1/2 HP ea	2 pumps 1/2 HP ea	HX Buffer Circ: 0.33*2 = 0.66 kW Buffer Tank: 0.608*2 = 1.216 kW Elec Boiler Pump = 0.153 kW	Ground Loop: 2*2HP*0.75 = 3 kW HP Circ Pumps: 0.185*2 = 0.37 kW Building Circ Pumps: 1.377*2 = 2.754 kW	HP	Water UtltyBldng Struc-251Lancaster.pdf mech drawings P12 and P13 on sheet M8 All HP pumps are 1 standby
Pump Operation	Continuous	Continuous				
Zone Heating/Cooling System						
System Description	Fin-tube baseboards w/ hydronic piping. And hydronic unit heaters in warehouse area. Now have a heat pump but this would not be included in utility data to calibrate. Exhaust Fan in Bldg. A				-	Colchester: Site Notes
MECHANICAL	**Colchester Baseline**	**Scenario 1: Minimum Acceptable (50%) Reduction**	**Scenario 2: Net Zero Ready ASHP**	**Scenario 2: Net Zero Ready GSHP**	**Units**	**Reference/Description**
Airside System Description						
System Description	New ducted seasonal heat pump to supplement heating and provide cooling in the office area. Previously there was a mini-split for cooling serving the office.	New ducted seasonal heat pump to supplement heating and provide cooling in the office area.	New ducted seasonal heat pump to supplement heating and provide cooling in the office area.	New ducted seasonal heat pump to supplement heating and provide cooling in the office area.	-	Colchester: Site Notes - NOT MODELLED FOR BASELINE
Outdoor Air	Bathroom fan	Supplied by ERVs	Supplied by ERVs	Supplied by ERVs	-	Colchester: Site Notes
Outdoor Air Flow Rate	47	See ERVs	See ERVs	See ERVs	L/s (cfm)	Bathroom exhaust fan per Mechanical- Colchester Existing Outline Specification. Assumed to be running 8 hours per work day for calibration
Total Supply Air Flow Rate	n/a	Autosize	Autosize	Autosize	L/s (cfm)	
Economizer	n/a				-	
Heating Type	Hydronic from central oil-fired boiler Bldg. A: Baseboards Bldg. B: Baseboards and Unit Heaters	Hydronic from central oil-fired boiler Bldg. A: Baseboards Bldg. B: Baseboards and Unit Heaters	Hydronic from AWHP Bldg. A: Hydronic Baseboards Bldg B: Hydronic baseboards; North office 3/4 ton mini split for heating	Hydronic from GSHP Bldg. A: Hydronic Baseboards Bldg B: Hydronic baseboards	-	Mechanical- Colchester Existing Outline Specification
Zone Heat Capacity: Electric baseboards	Bldg. A: 1500W Bldg. B 2000W	Bldg. A: 1500W Bldg. B 2000W	No electric baseboards	No electric baseboards		Electric baseboards Bldg. B per Electrical ESAR1 file Electric space heating in Bldg. A per M&R site photos
Cooling Type	1/2 Ton Mini-split (Bldg. A)	Building A: ASHP 2.5 ton Building B: (2) 3/4 ton minisplits	Building A: ASHP 2.5 ton Building B: (2) 3/4 ton minisplits	Building A: ASHP 2.5 ton Building B: Water to air heat pump fed by the GSHP (2) 0.75 units	-	1/2 ton assumed to calibrate to utility bills
Cooling Efficiency	Mini-split COP-2.5	ASHP COP: 3.45 Mini-split COP-3.6	ASHP COP: 3.45 Mini-split COP-3.6	ASHP COP: 3.45 Distributed GSHP (Water-to-air console): 2.85	-	Assumed
Fan Type	n/a					

ERVs						
Air Flow	n/a	190 cfm Office 530 cfm Warehouse	190 cfm Office 530 cfm Warehouse	190 cfm Office 530 cfm Warehouse	W/cfm	
Fan Schedule	n/a	time clock control - occupancy	time clock control - occupancy	time clock control - occupancy		MNECB Fan Schedule A
Energy Recovery	n/a	yes	yes	yes	-	
Energy Exchanger By-pass	n/a	Dual Core	Dual Core	Dual Core	-	
Domestic Hot Water						
Heating Source	Electric Water Heater (Make: GSW)	Electric Water Heater (Make: GSW)	Packaged HP Water Heater (ASHP) UEF = 3.75	Packaged HP Water Heater (ASHP) UEF = 3.75	-	2201080 Debert Photolog
Thermal Efficiency	100%	100%			%	
Peak DHW Load	Office: 90 Warehouse: 65	Office: 90 Warehouse: 65	Office: 90 Warehouse: 65	Office: 90 Warehouse: 65	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	**Colchester Baseline**	**Scenario 1: Minimum Acceptable (50%) Reduction**	**Scenario 2: Net Zero Ready ASHP**	**Scenario 2: Net Zero Ready GSHP**	**Units**	**Reference/Description**
Lighting						
Type	T12 Fluorescents					Colchester: Site Notes
Lighting Power Density	Bldg. A: 12.8 W/m ^{2} Bldg. B: 12.8 W/m ^{2}	Bldg. A: 9 W/m ^{2} Bldg. B: 9 W/m ^{2}	Bldg. A: 10 W/m ^{2} Bldg. B: 10 W/m ^{2}	Bldg. A: 10 W/m ^{2} Bldg. B: 10 W/m ^{2}	W/m²	Electrical ESAR1 file notes that some rooms in the Bldg. A office have no working lights. M&R site visit photos show many lights not working in Bldg. A and Bldg. B - Lighting schedule reduced by 25% from NECB
Schedule					-	
Process Loads						
Plug Loads & Schedule	Office: 7.5 Warehouse: 1				W/m²	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
Process Loads & Schedule	NECB plug loads	NECB plug loads	NECB plug loads	NECB plug loads	-	Colchester: Site Notes - Not modeled, calibrated with NECB plug loads
Occupancy						
Occupant Density	Office: 10 people Warehouse: 5 people				m²/occupant	per Arch
Occupant Schedule	Fractional				-	
Setpoints						
Office Heating Setpoint/Setback	22/18	22/18	22/18	22/18	°C	NECB 2020 Table A-8.4.3.2(2)-A Operating Schedule A
Warehouse Heating Setpoint/Setback	18	18	18	18	°C	
Office Cooling Setpoint/Setback	24/29	24/29	24/29	24/29	°C	

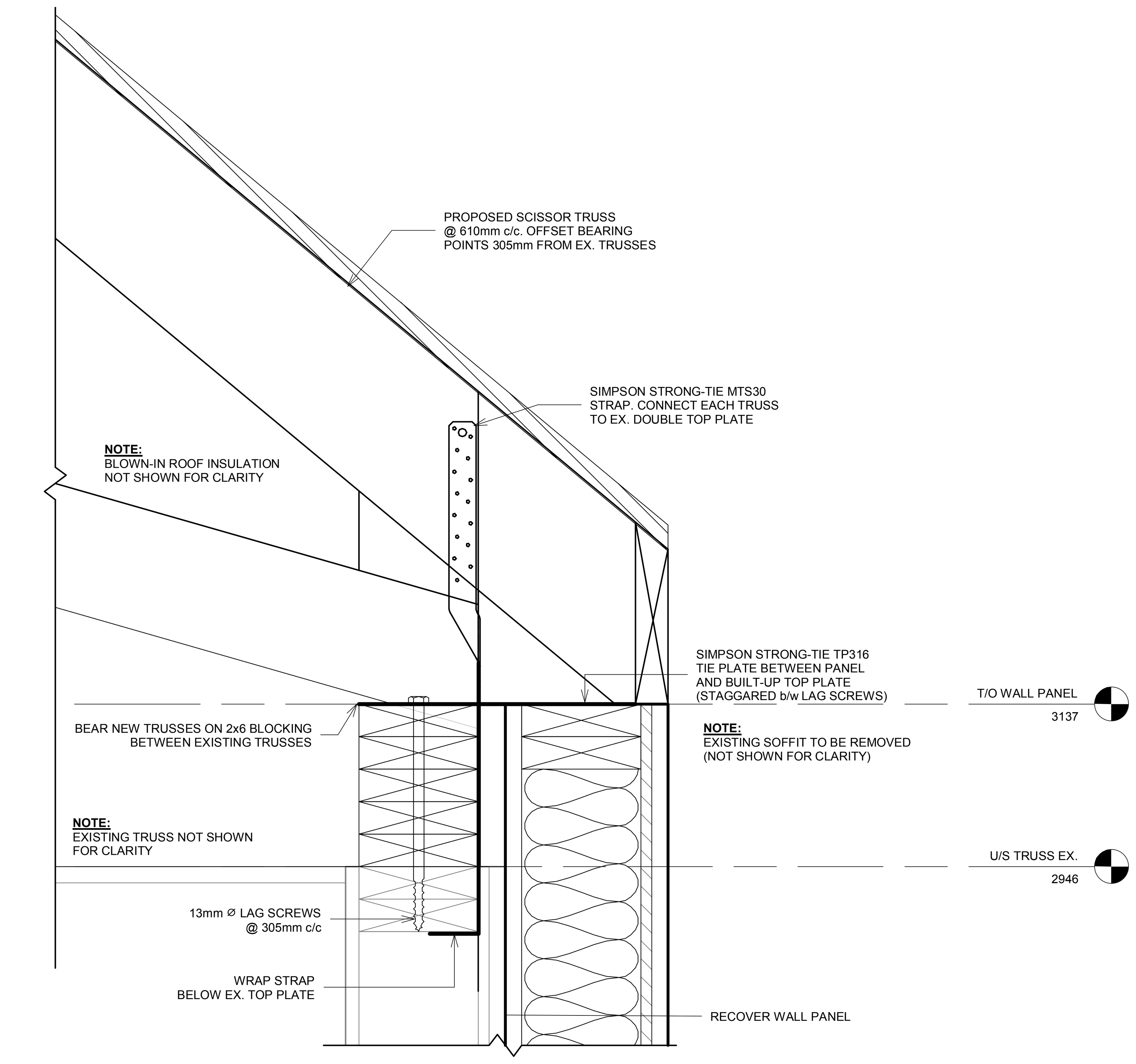
Appendix H

Panel Schematics

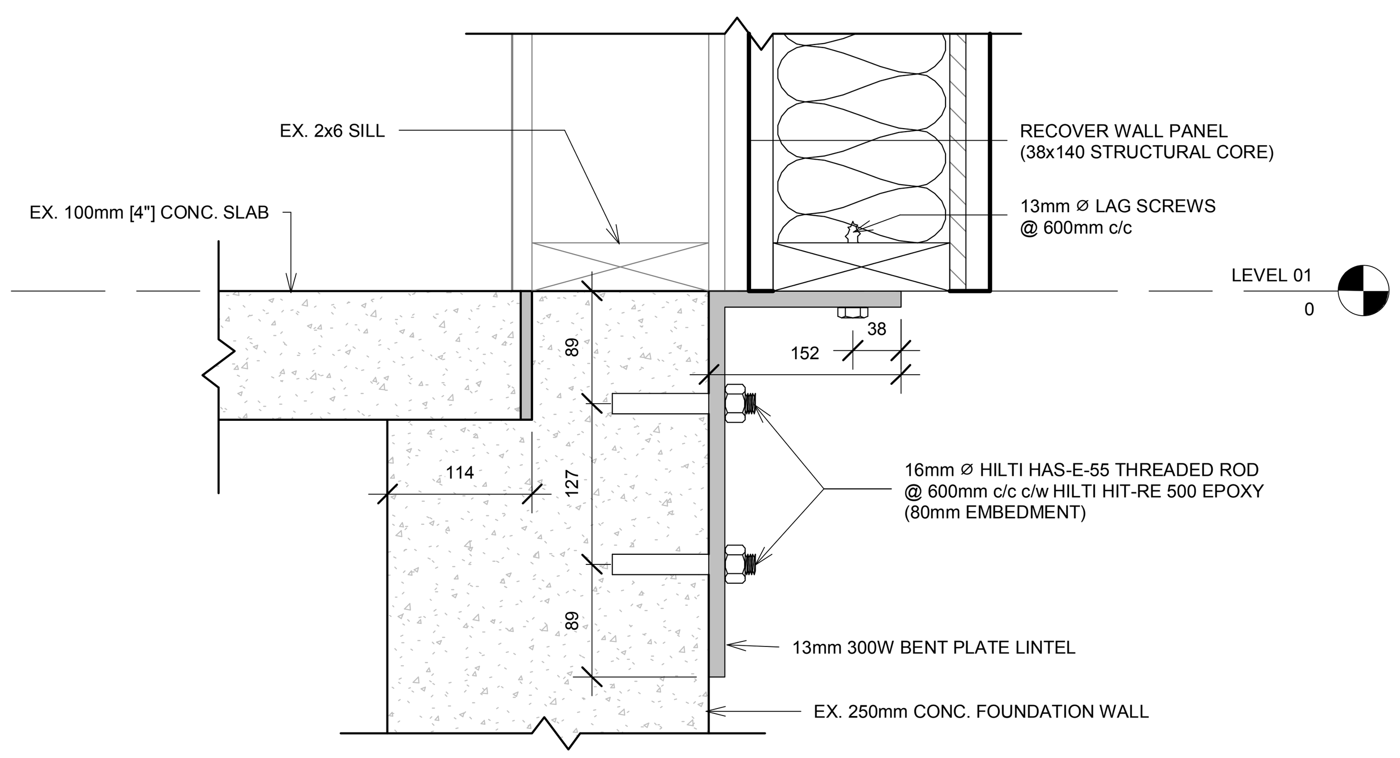
- **Panel Schematics**
- **Panel Connection Details**



1 S-101 BUILDING A WALL SECTION
1 : 10



2 S-101 PANEL CONNECTION AT ROOF
1 : 5



3 S-101 FOUNDATION LINTEL
1 : 5

PRELIMINARY

ISSUE	DATE	DESCRIPTION
2	13/02/2023	REVISED CONNECTION DETAILS
1	08/02/2023	ISSUED FOR REVIEW

CONSULTANT

DESIGNPOINT
engineering • surveying • solutions
902.832.5597 designpoint.ca

CLIENT

RECOVER INITIATIVE

PROJECT DESCRIPTION

DEBERT WATER UTILITY BUILDING

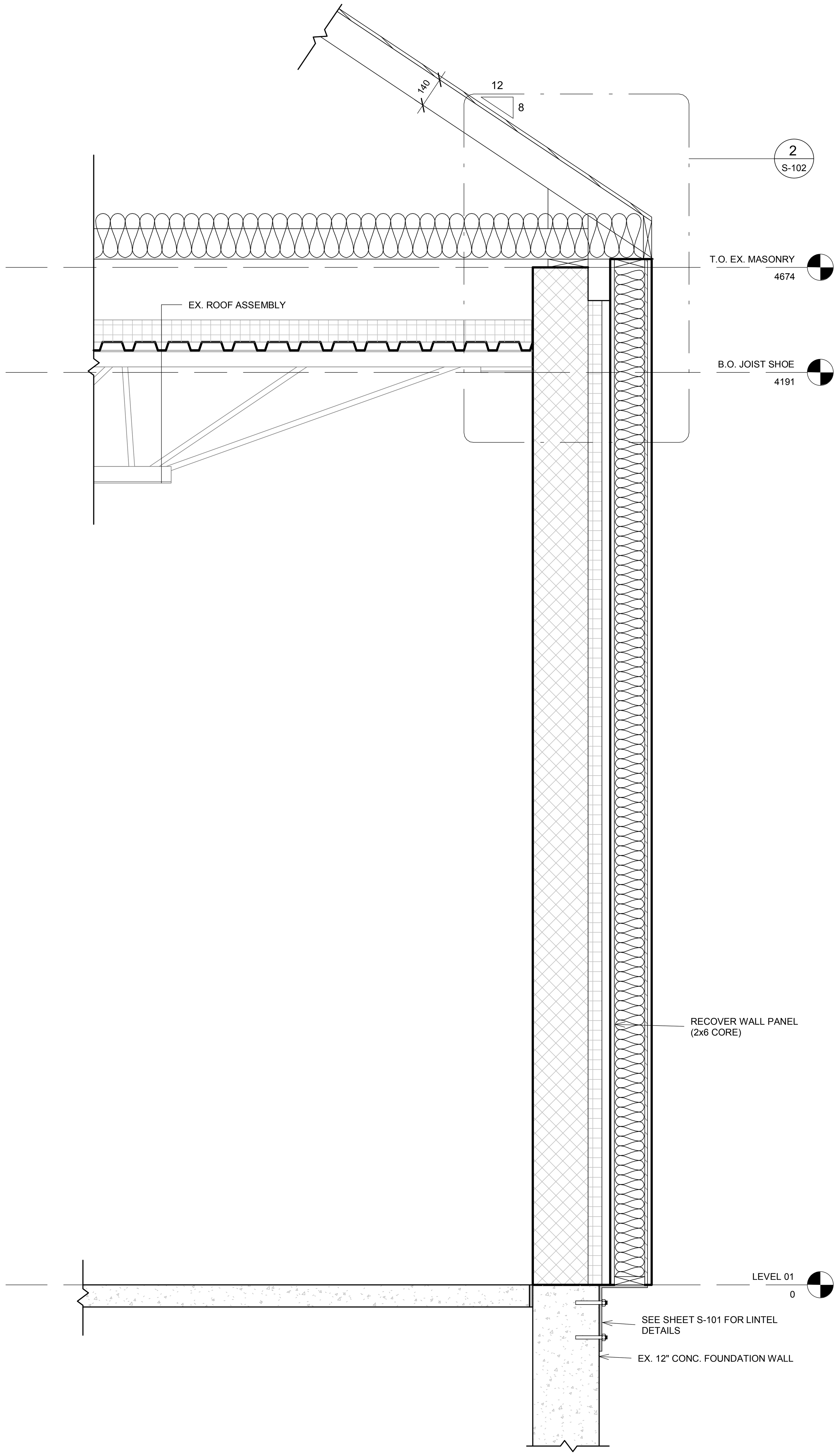
DEBERT, NOVA SCOTIA

SHEET DESCRIPTION

BUILDING A PANEL DETAILS

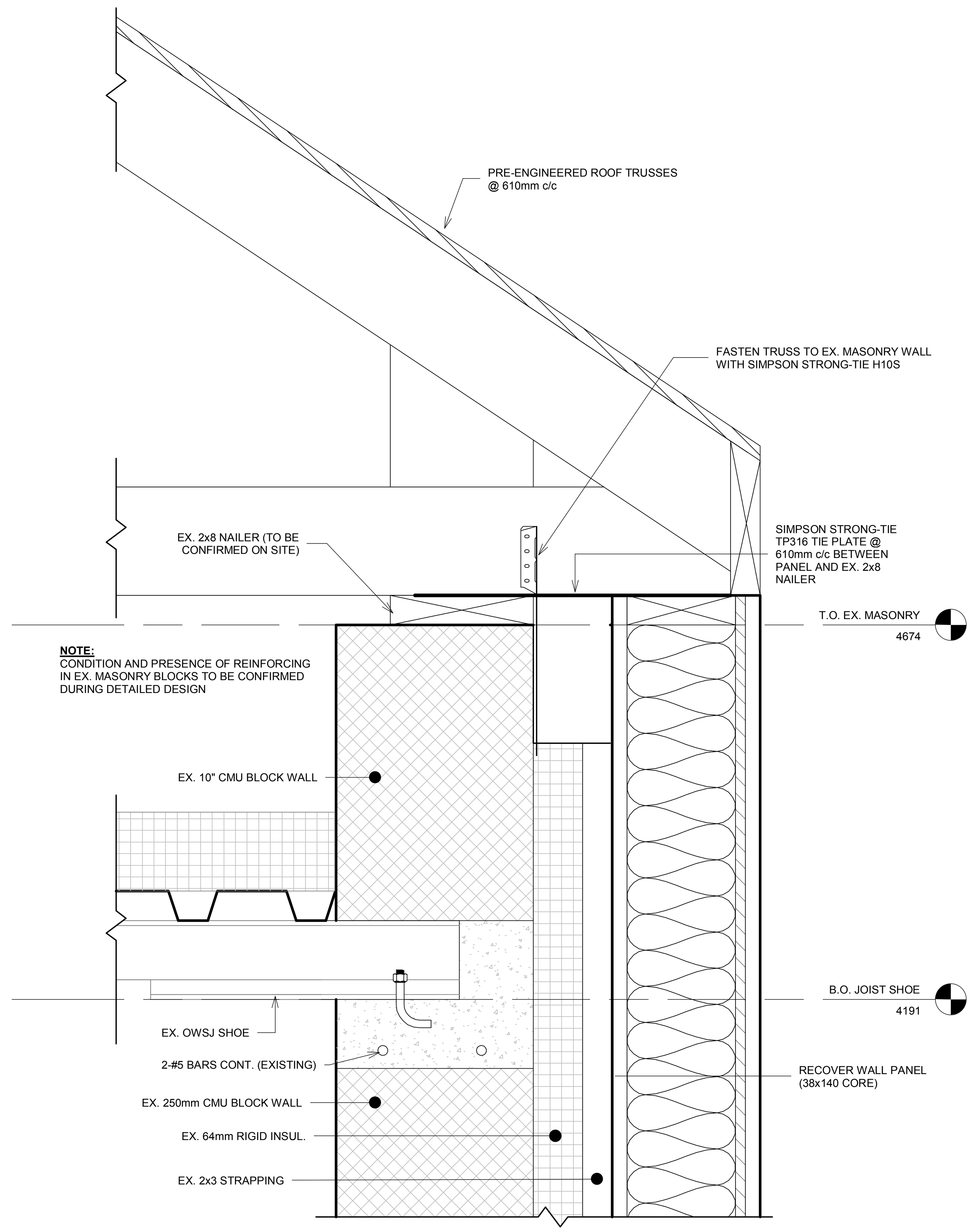
Drawn	Engineer	Project No.	Drawing No.
A. MCCRACKEN	E. TEASDALE	22-316	S-101
Scale: As indicated	Filename: 22-316_Colchester.rvt		1 of 2

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



1 S-102 BUILDING B WALL SECTION

1 : 15



2 S-102 PANEL CONNECTION AT ROOF B

1 : 5

PRELIMINARY

ISSUE	DATE	DESCRIPTION
2	13/02/2023	REVISED CONNECTION DETAILS
1	08/02/2023	ISSUED FOR REVIEW

CONSULTANT

DESIGNPOINT engineering • surveying • solutions

902.832.5597 designpoint.ca

CLIENT

RECOVER INITIATIVE

PROJECT DESCRIPTION

DEBERT WATER UTILITY BUILDING

DEBERT, NOVA SCOTIA

SHEET DESCRIPTION

BUILDING B CONNECTION DETAILS

Drawn	Engineer	Project No.	Drawing No.
A. MCCRACKEN	E. TEASDALE	22-316	S-102
Scale	Filename		2 of 2
As indicated	22-316_Colchester.rvt		

Wall Panel Schematics

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

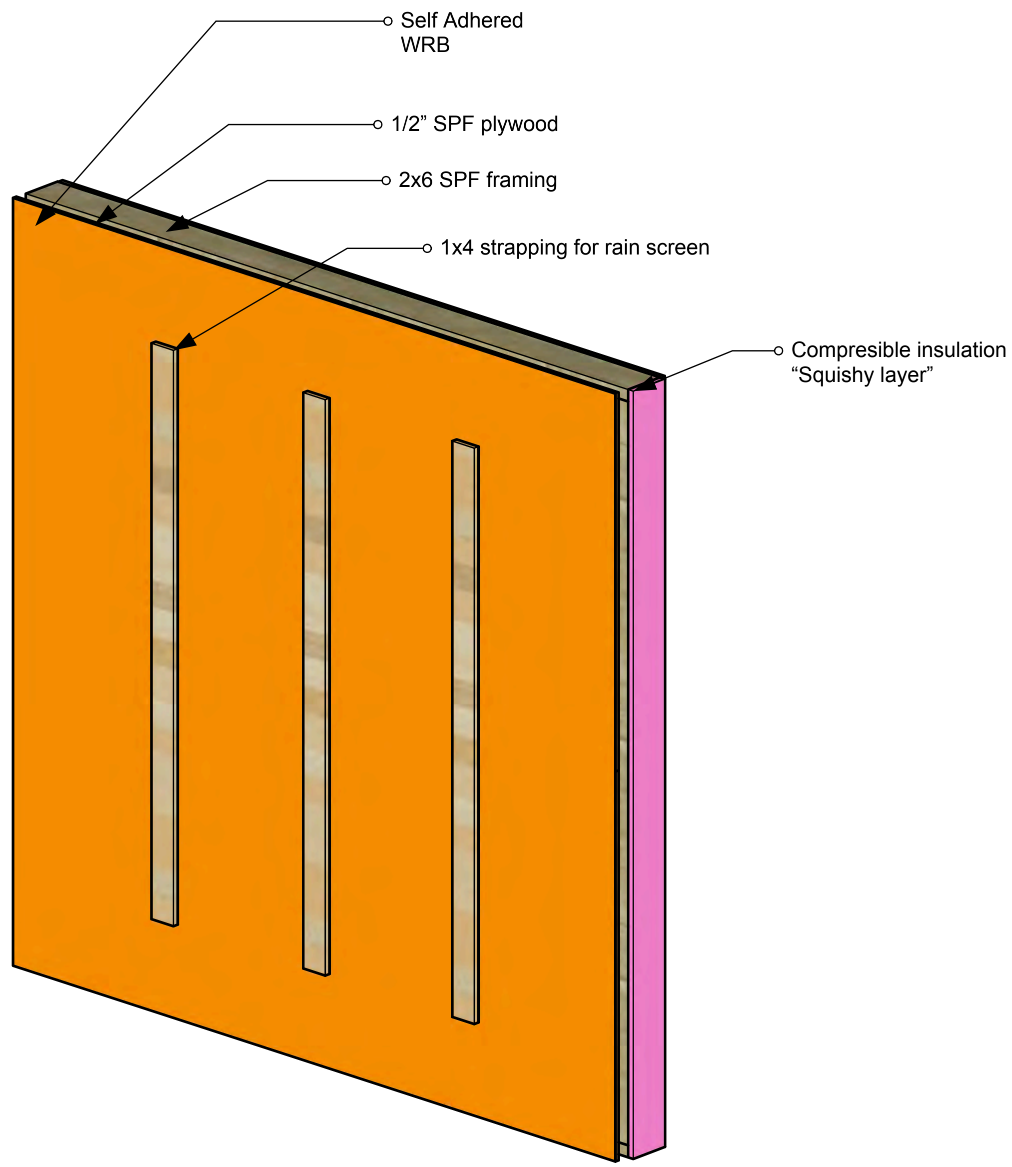
ReCover Initiative

Version Date
February 27, 2023

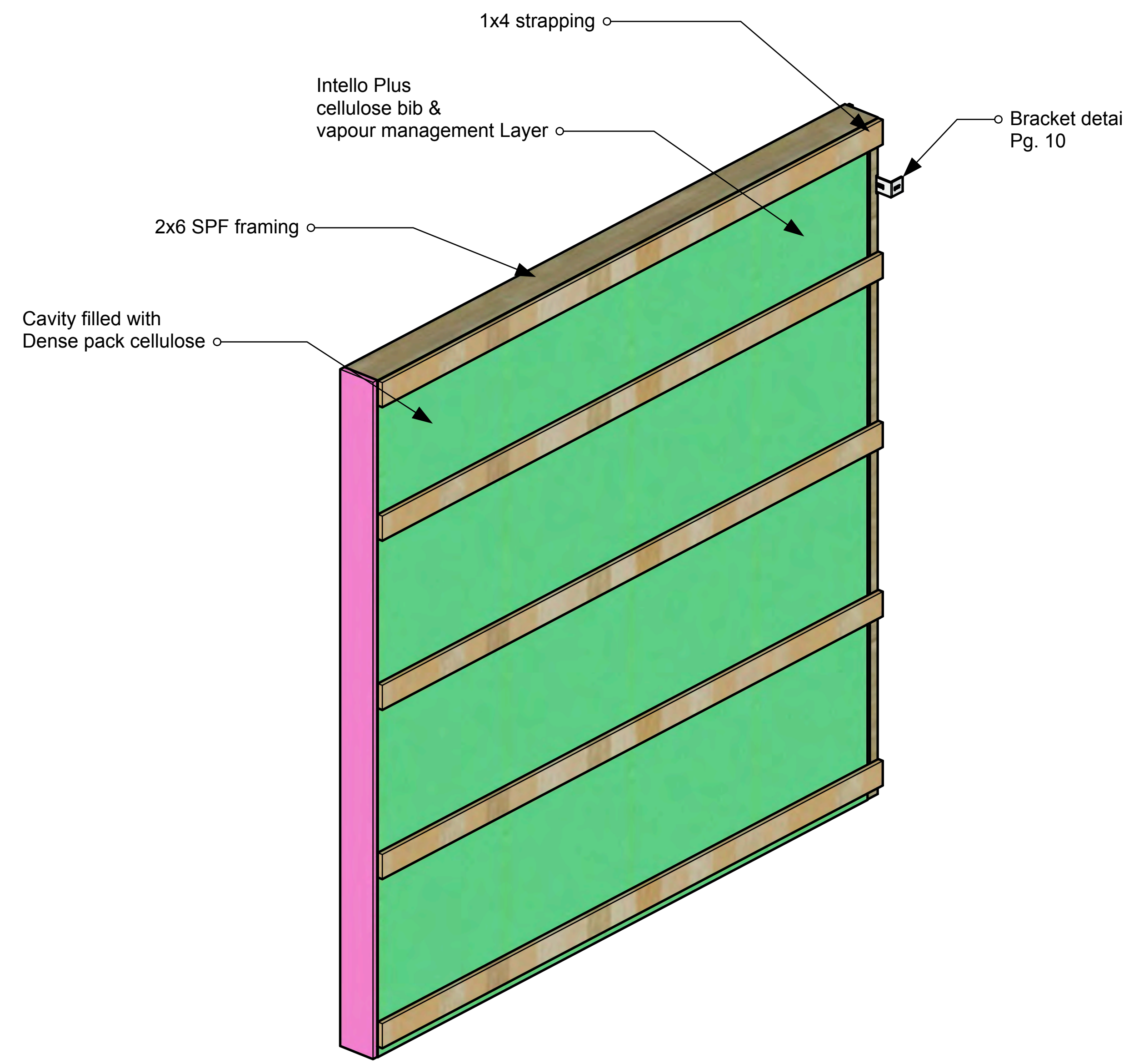
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Basic Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

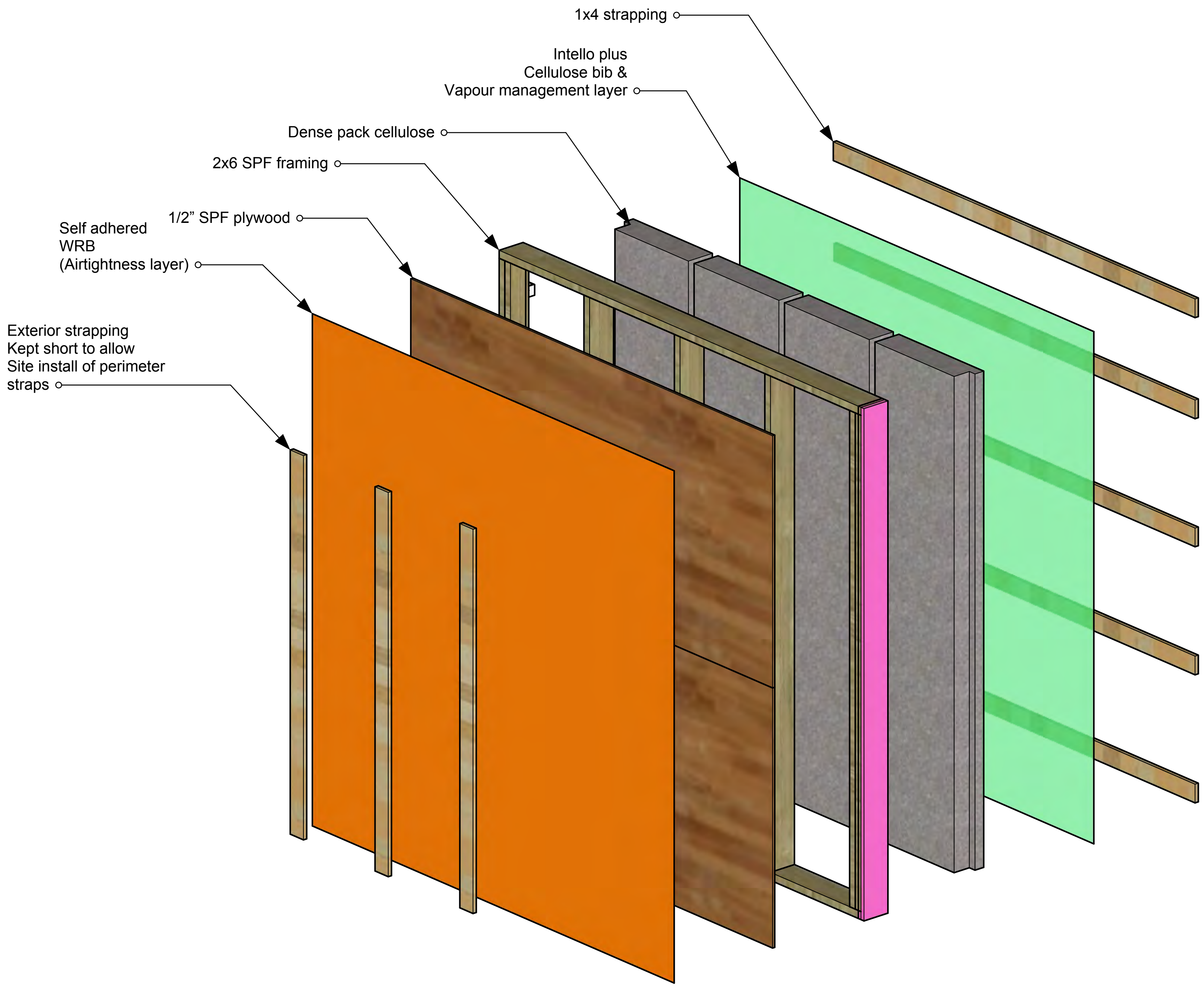
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Basic Panel - Exploded View



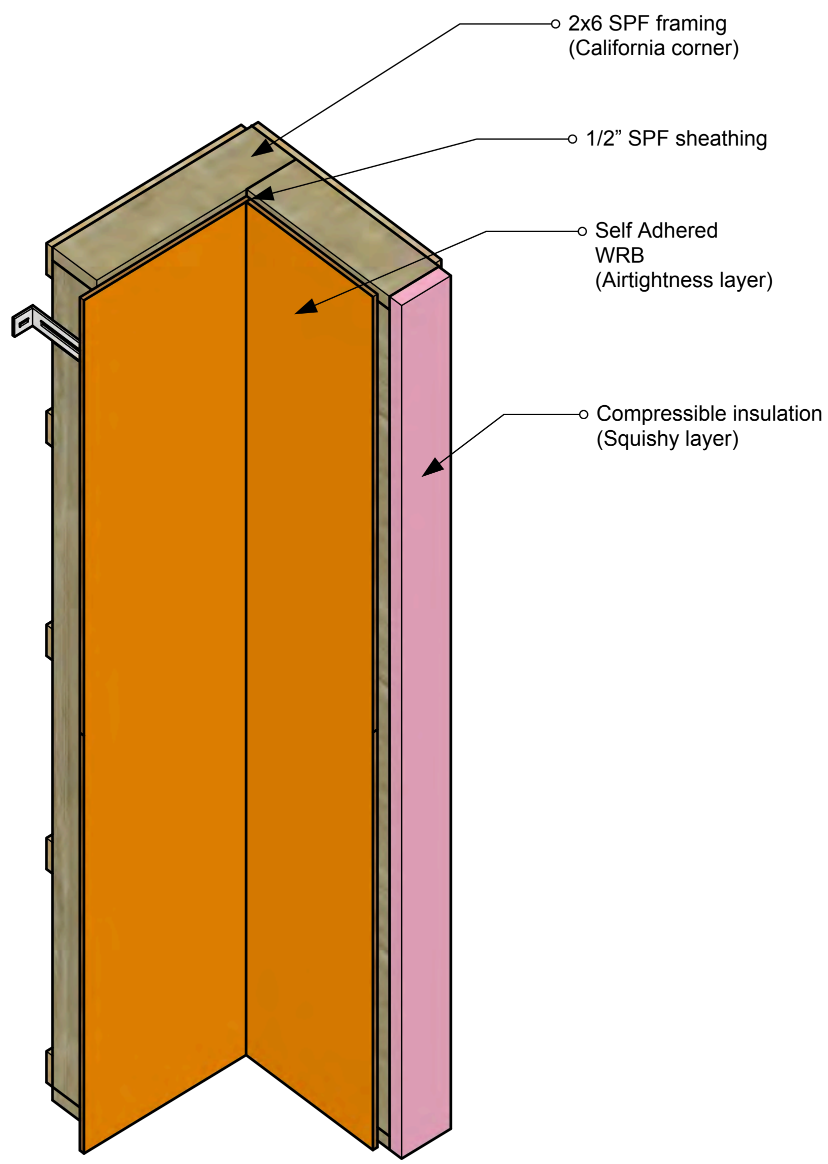
ReCover

Version Date
February 27, 2023

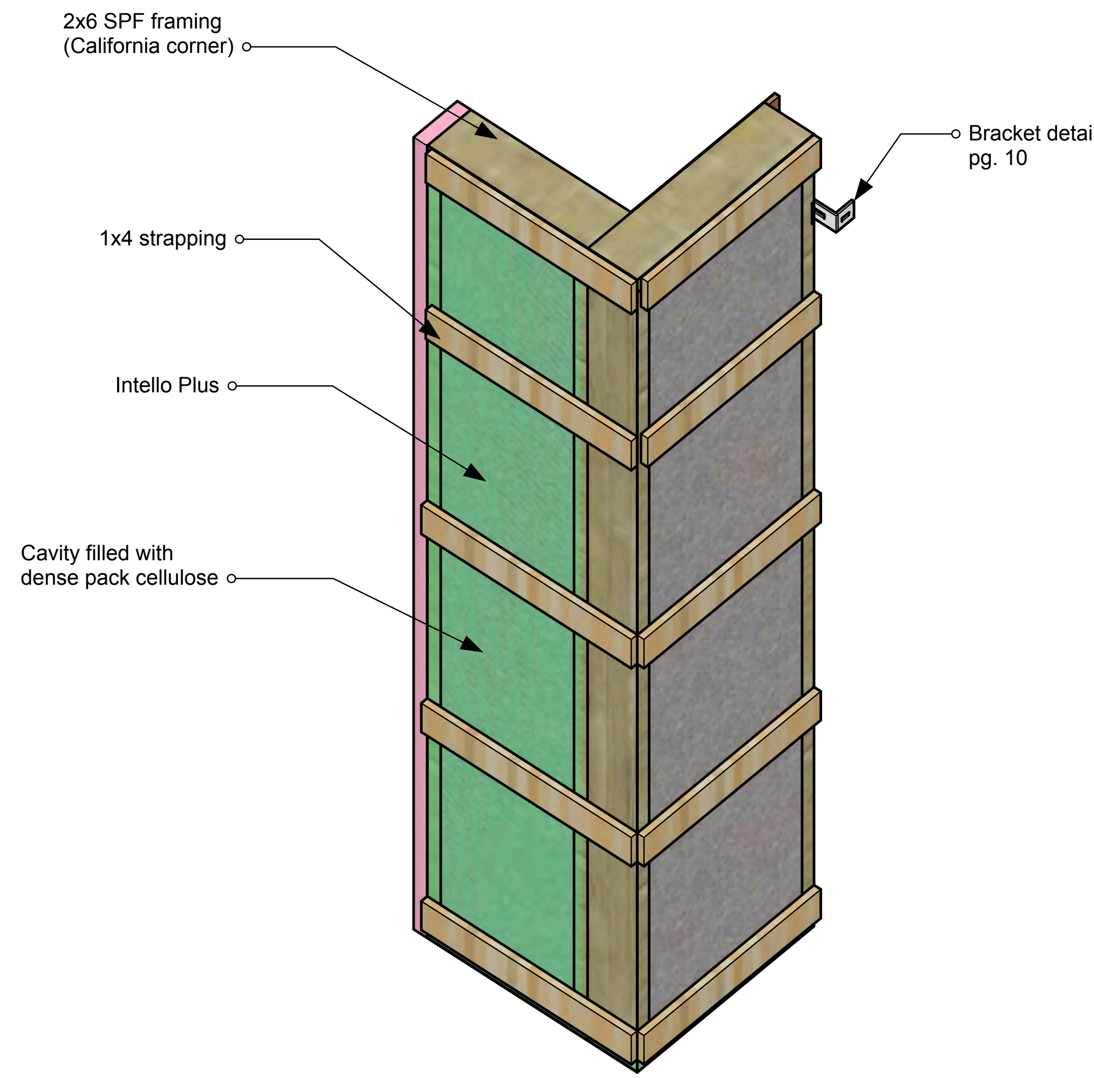
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

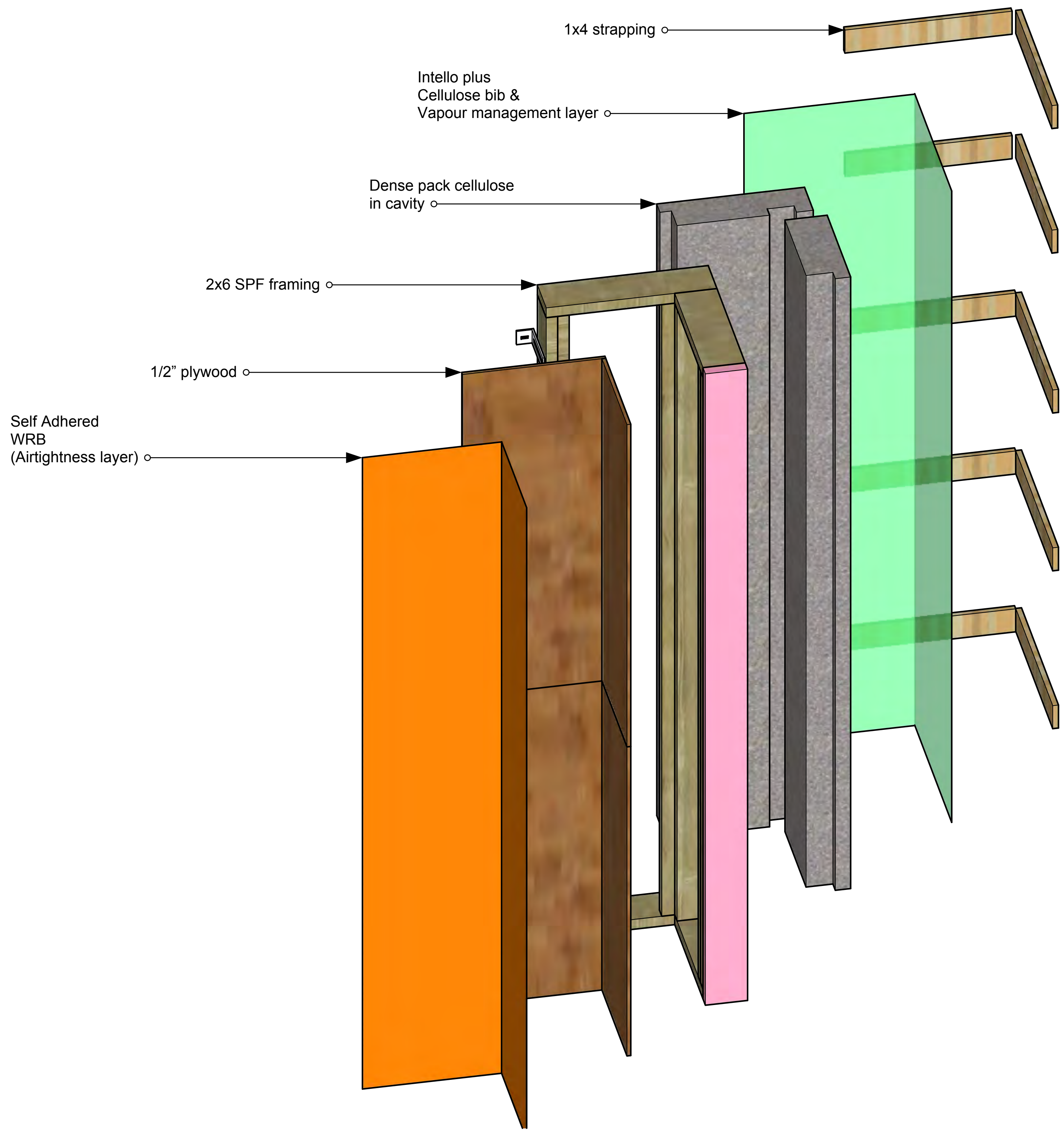
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Panel - Exploded View



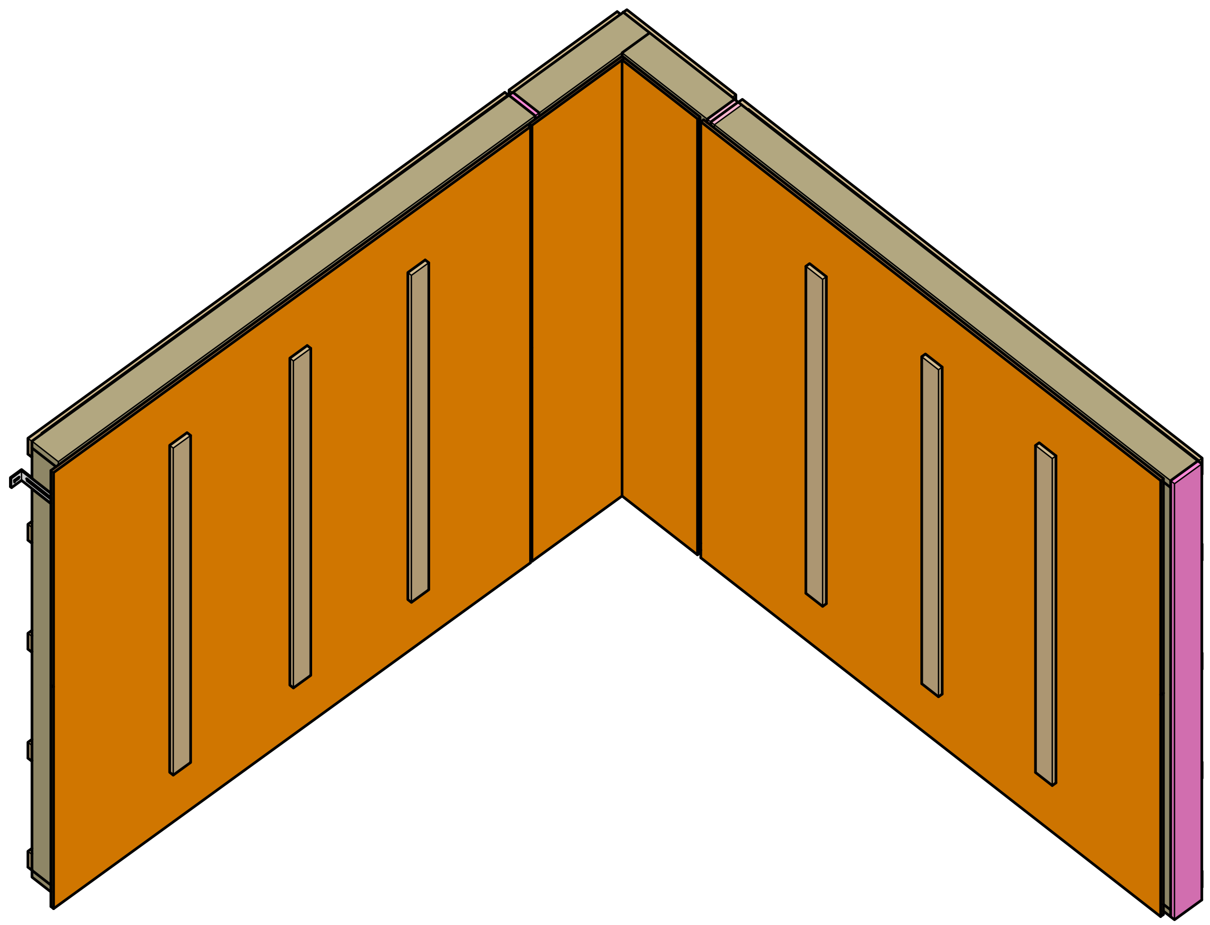
ReCover

Version Date
February 27, 2023

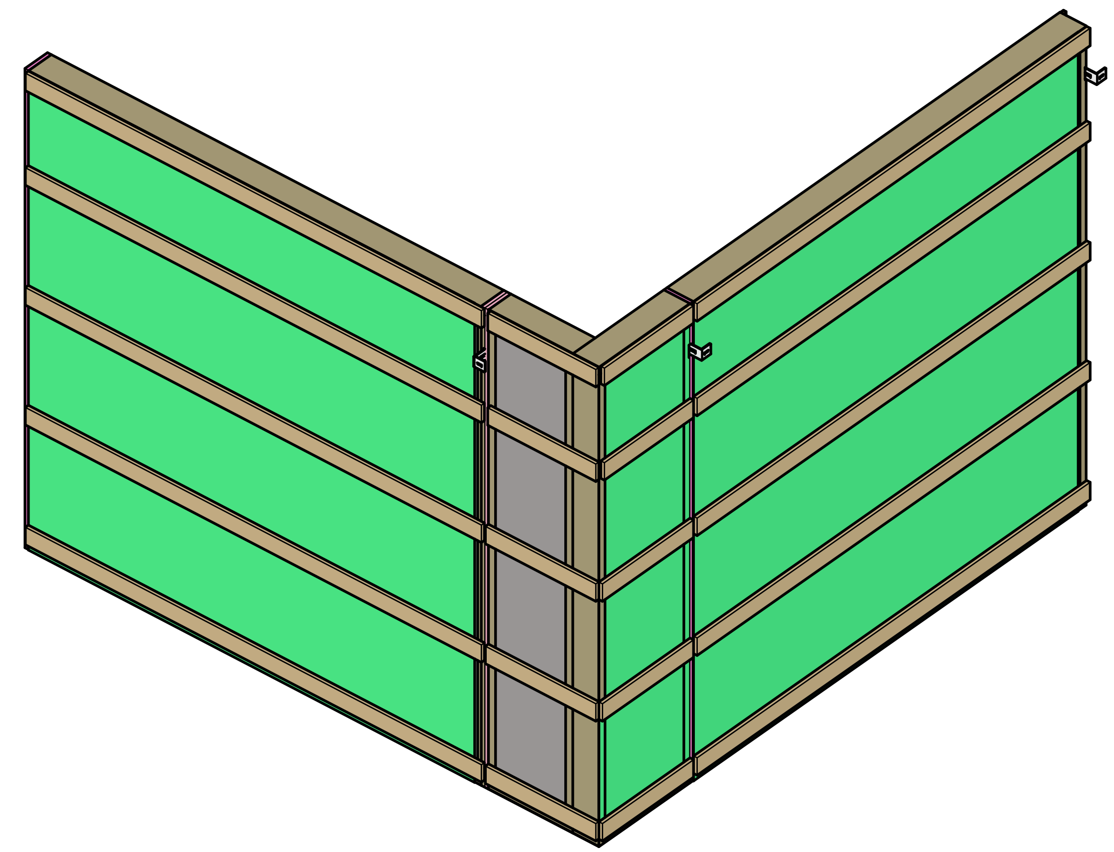
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Inside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

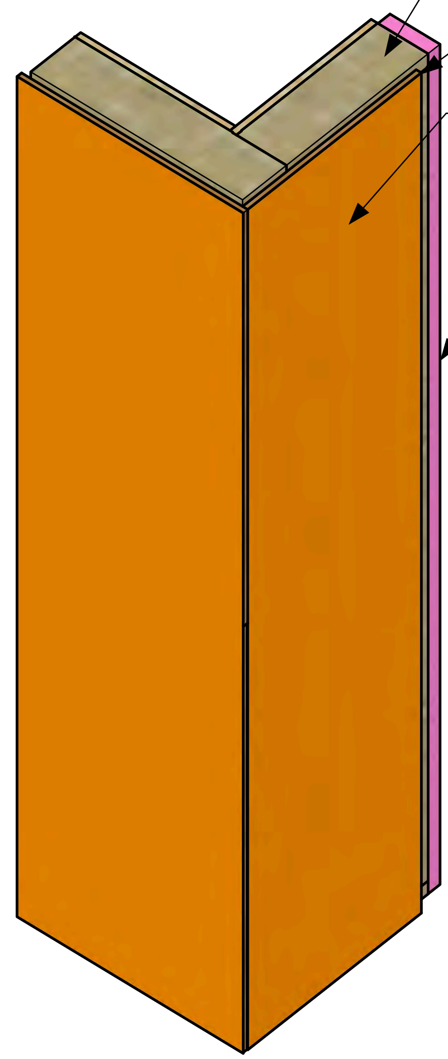
ReCover

Version Date
February 27, 2023

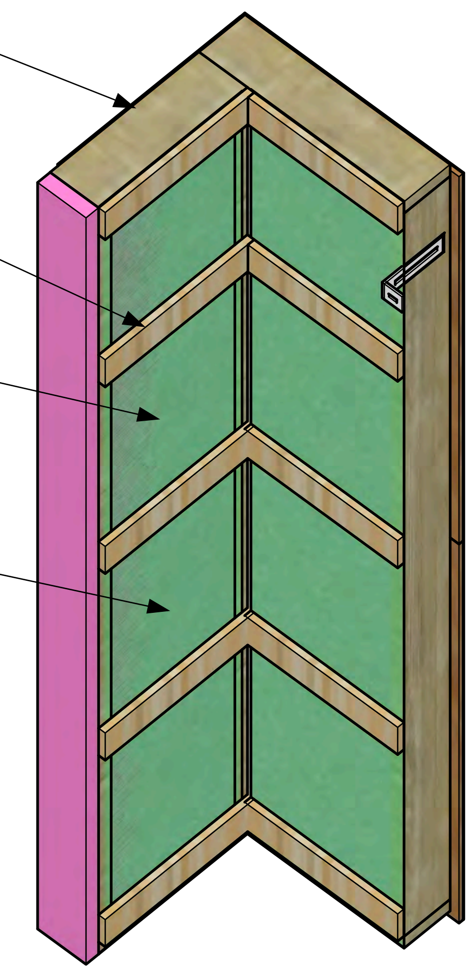
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Outside Corner Panel - Overview



EXTERIOR VIEW



INTERIOR VIEW

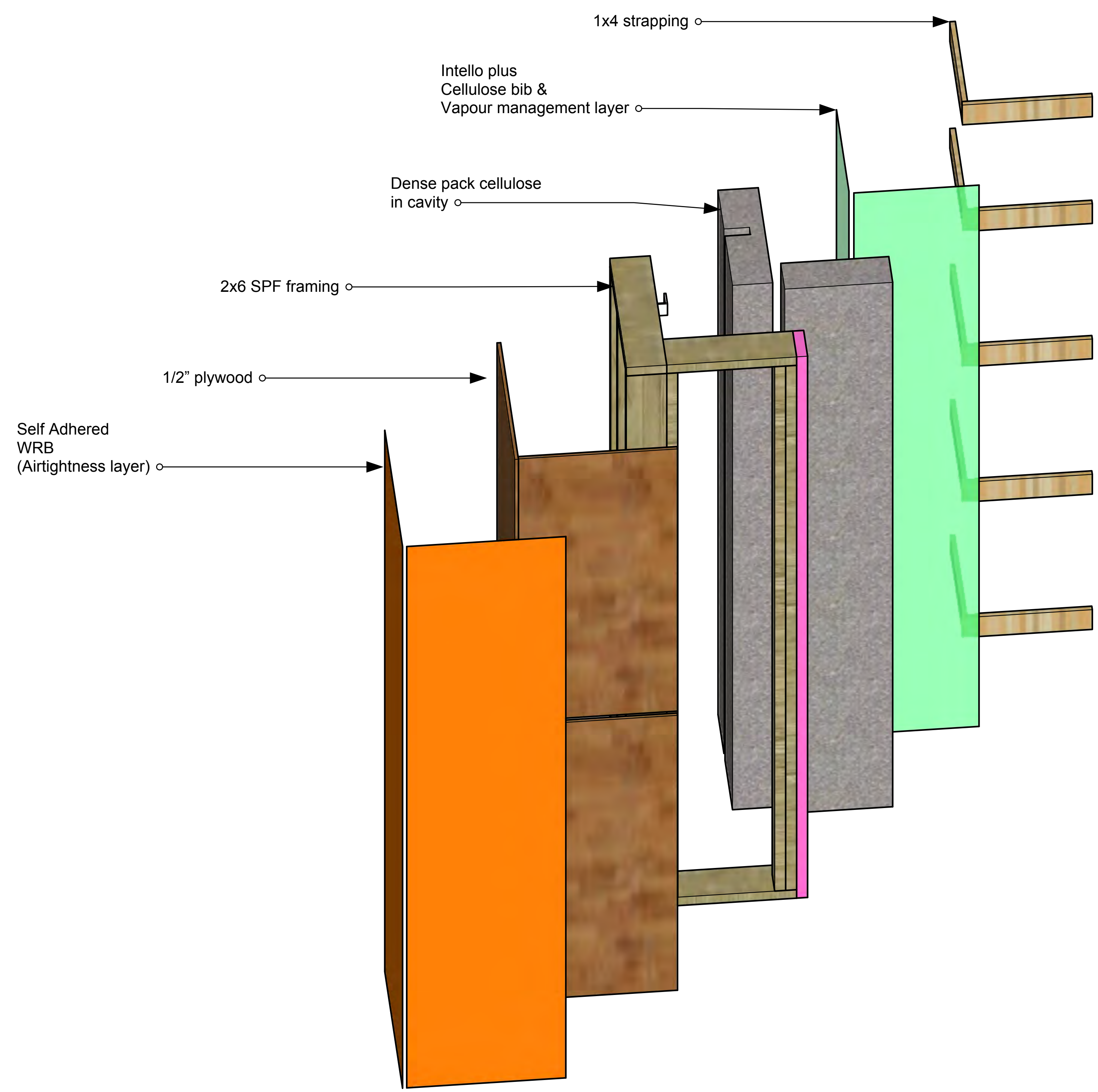
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Outside Corner Panel - Exploded View



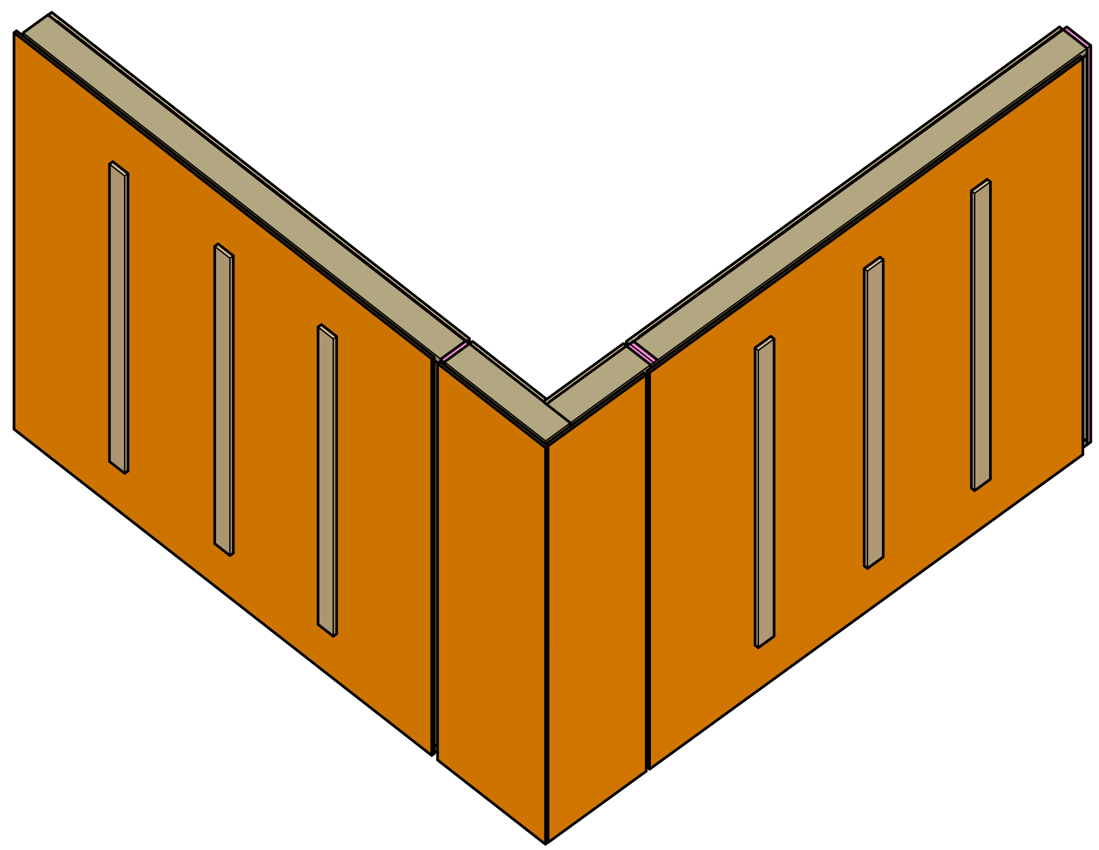
ReCover

Version Date
February 27, 2023

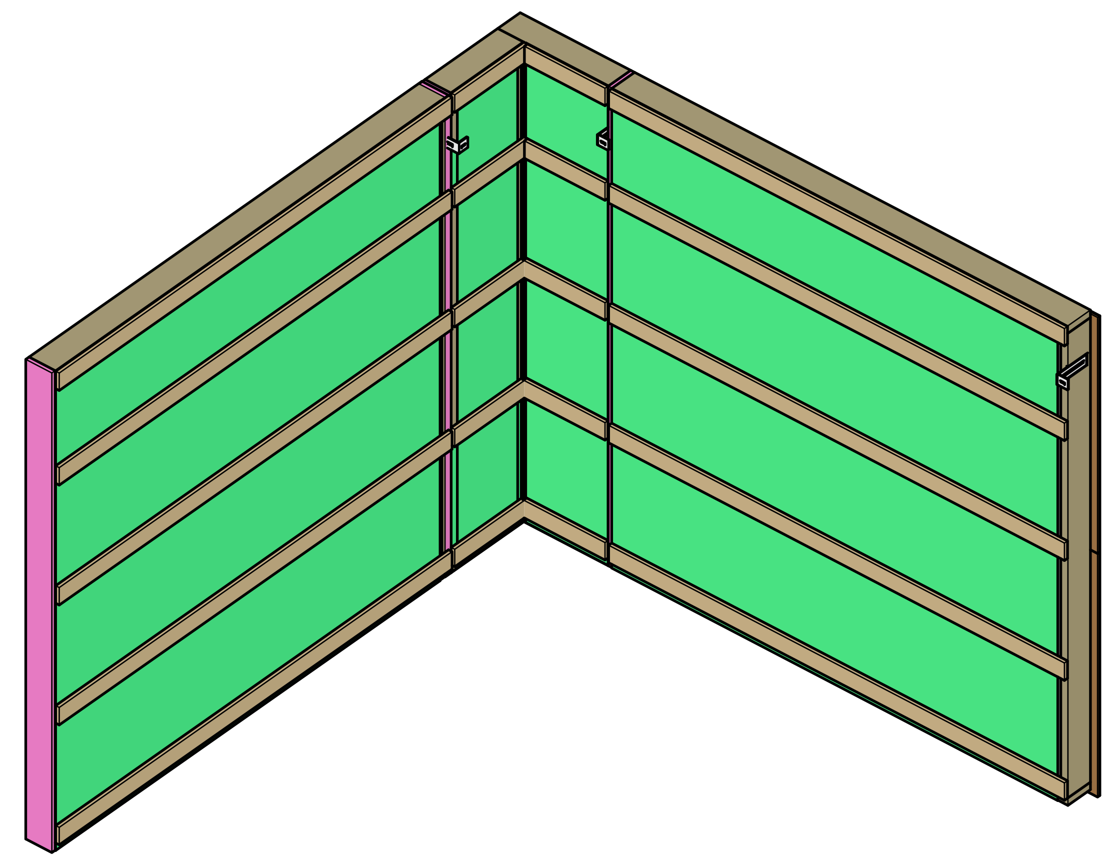
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Outside Corner Installed



EXTERIOR VIEW



INTERIOR VIEW

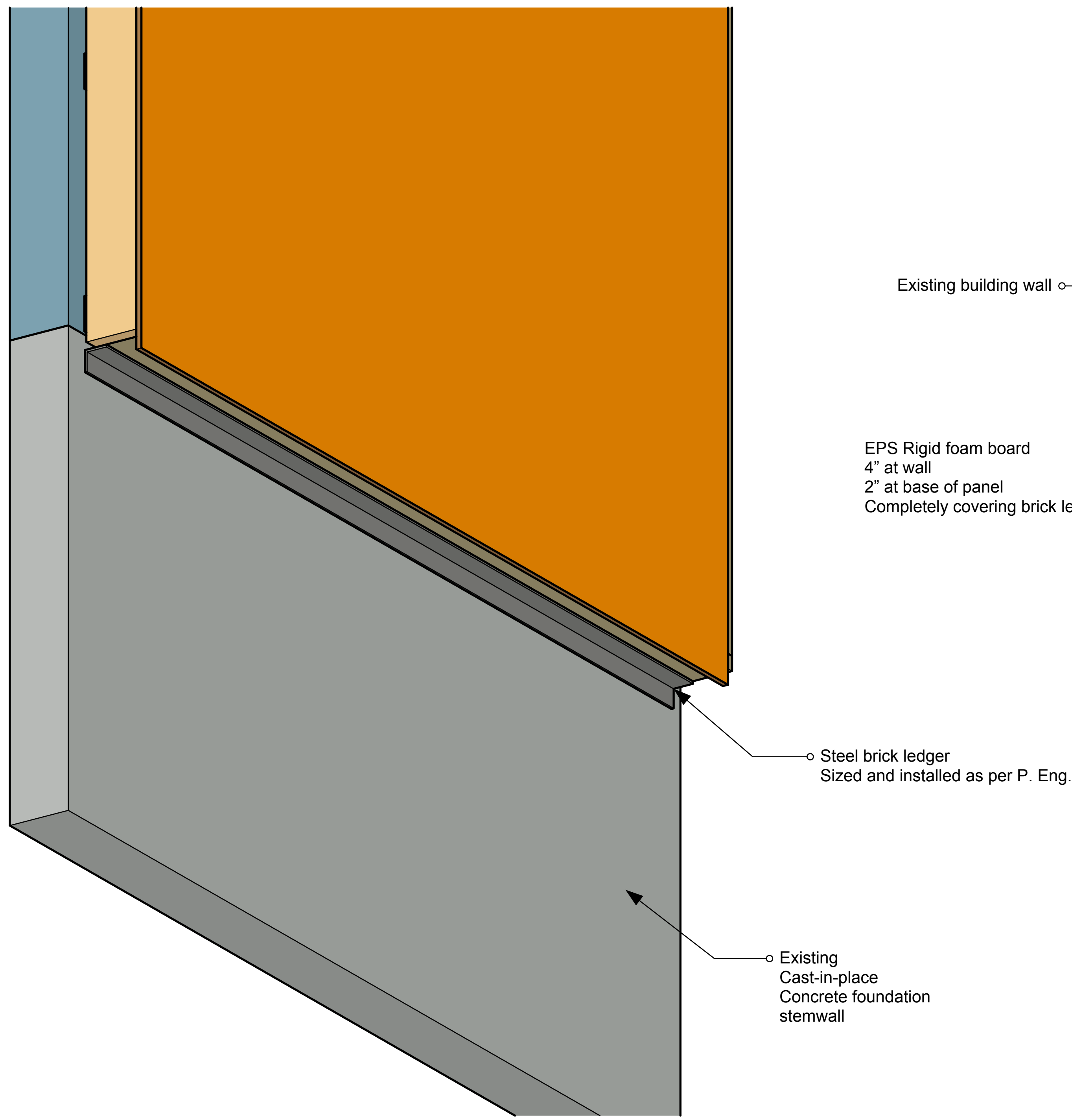
Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

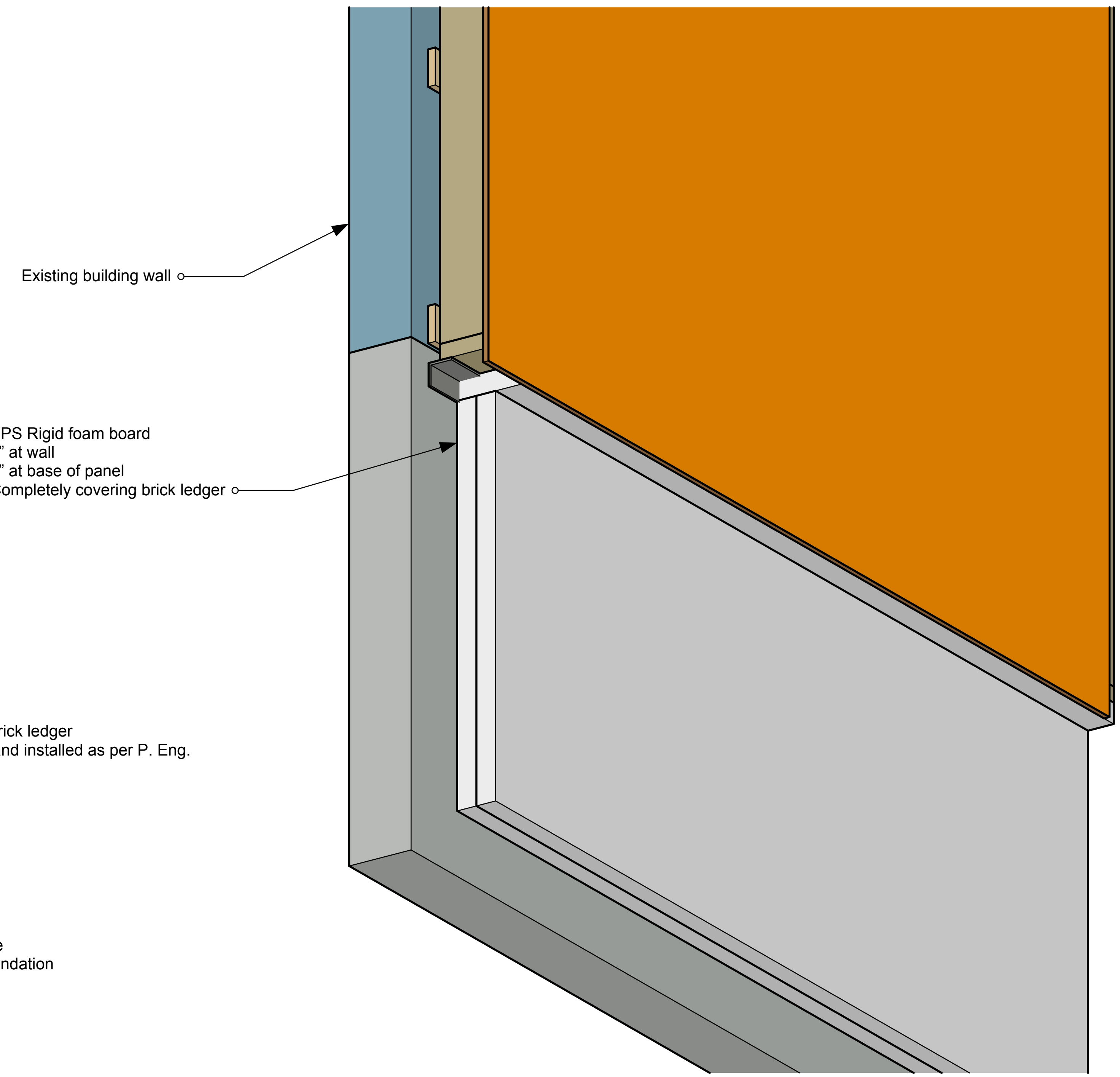
Drawn By
Nick Rudnicki

Foundation Attachment - Brick Ledger

"Brick Ledger" style continuous ledger for panel support

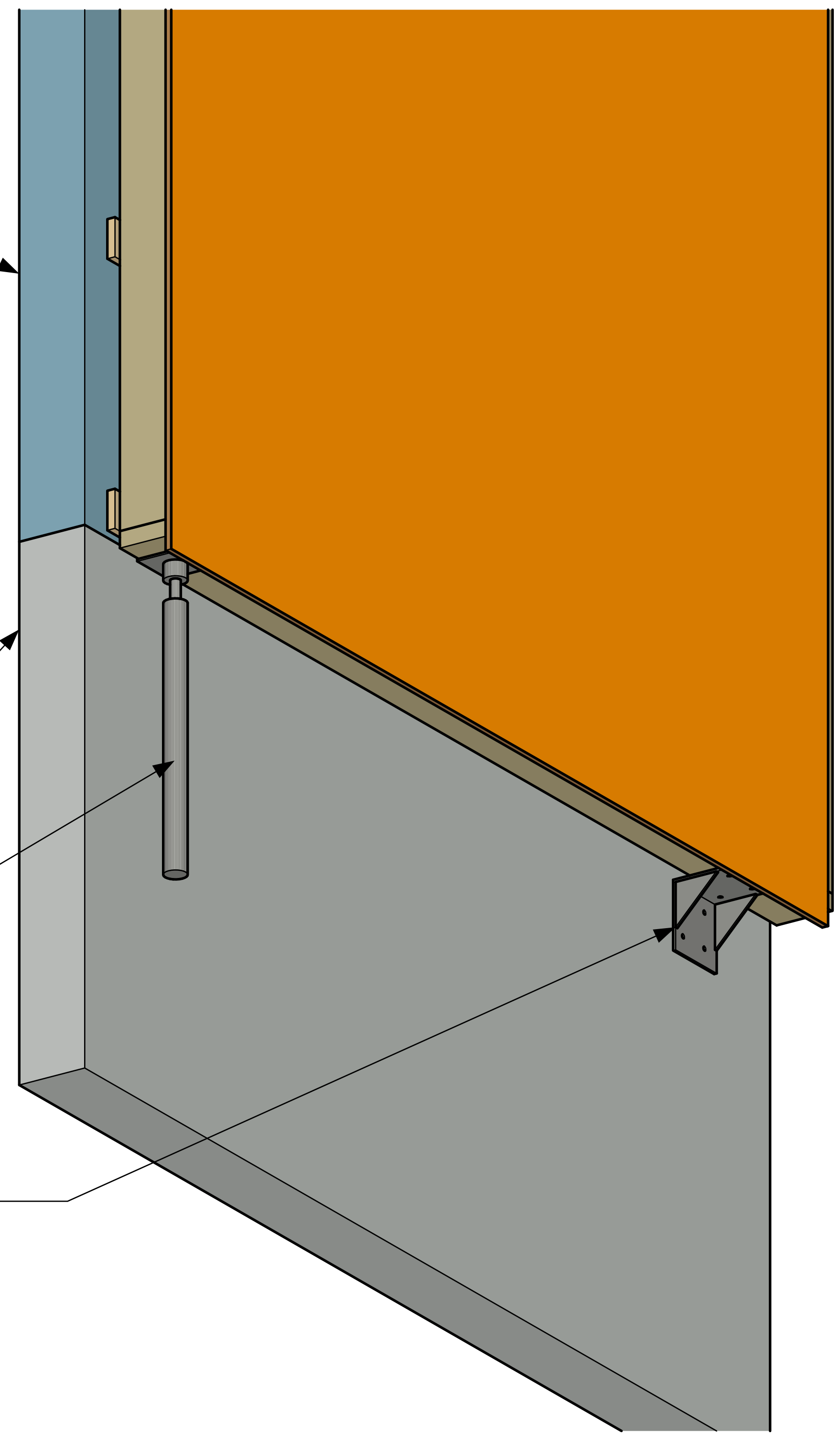


BEFORE SITE INSULATION

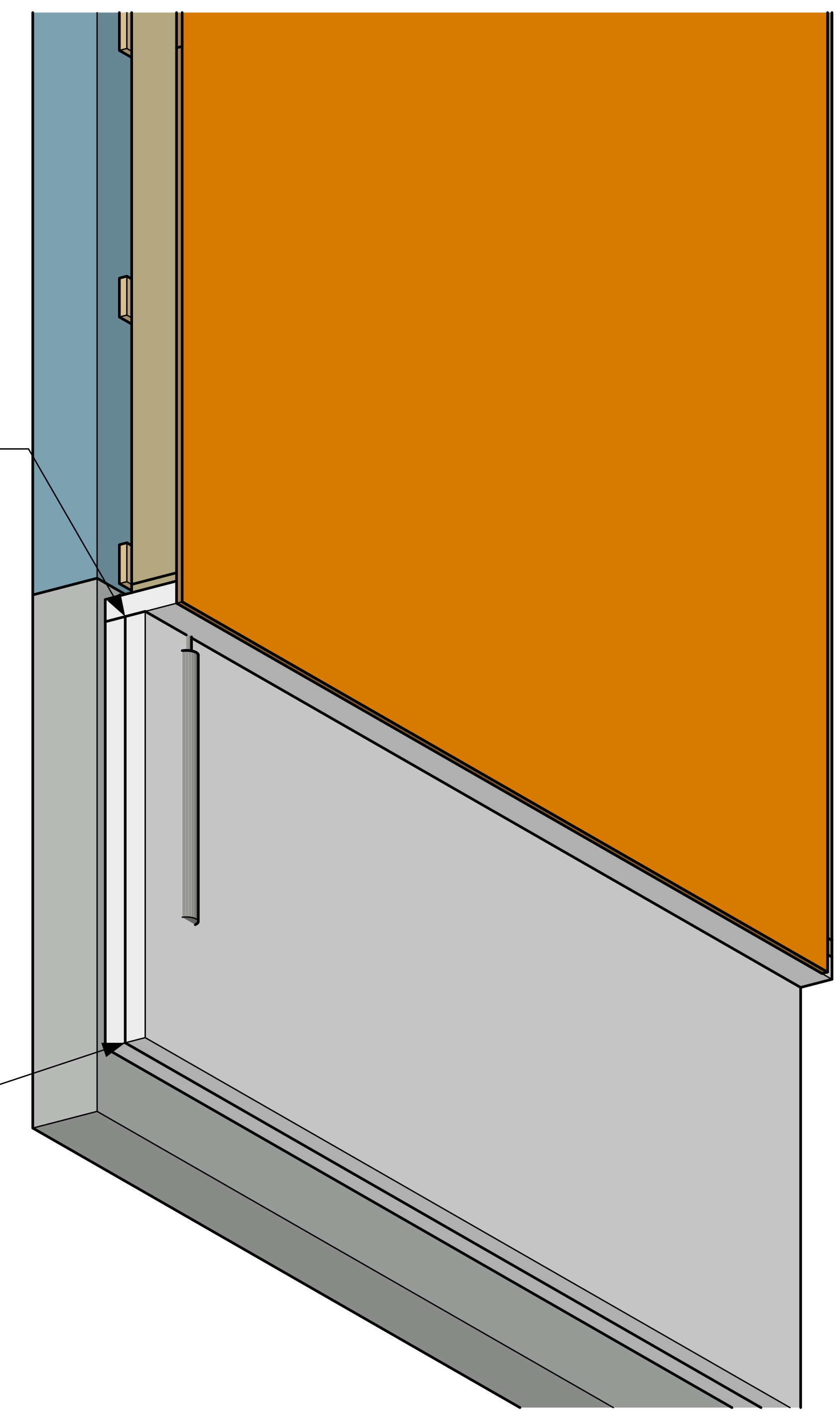


AFTER SITE INSULATION

Alternate Foundation Attachment - Pile or Bracket



BEFORE SITE INSULATION



AFTER SITE INSULATION

ReCover

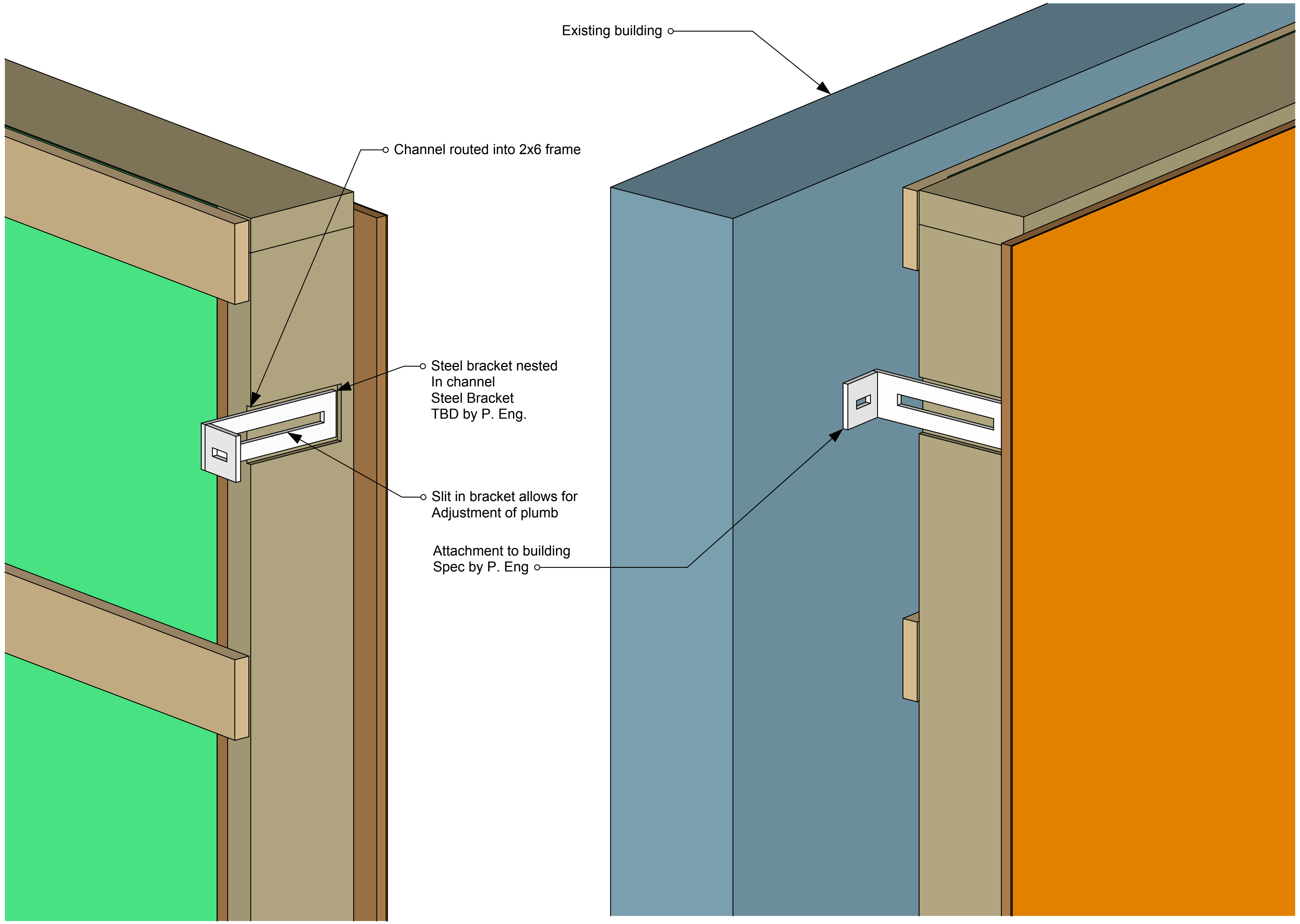
Version Date
February 27, 2023

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**

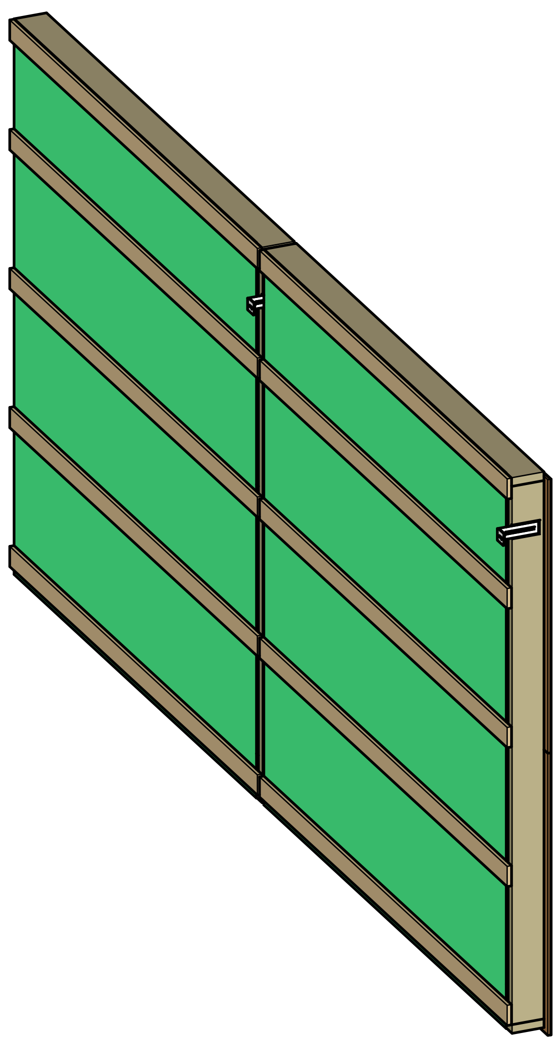
ReCover

Version Date
February 27, 2023

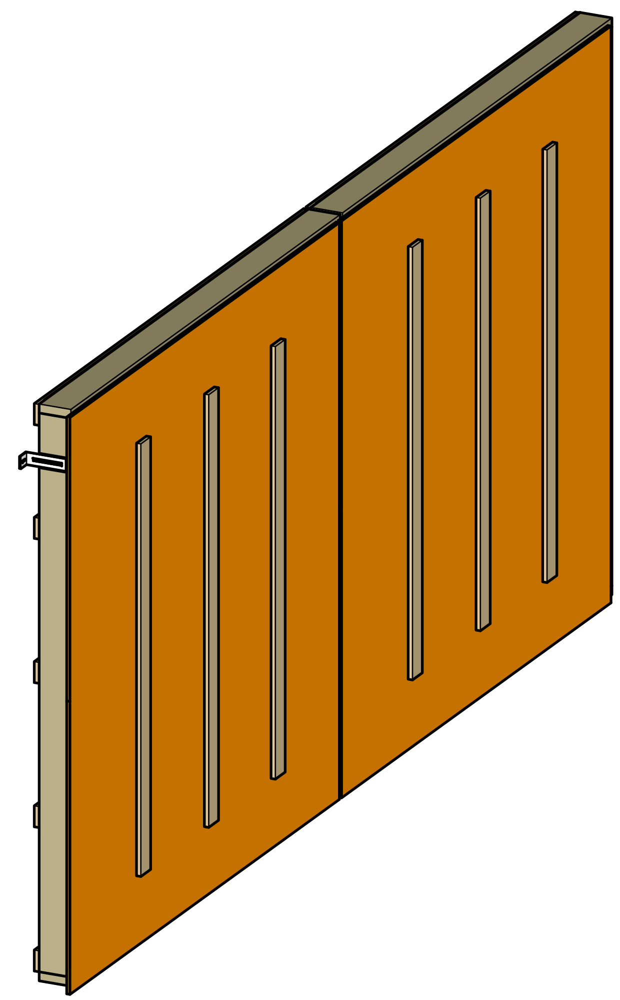
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

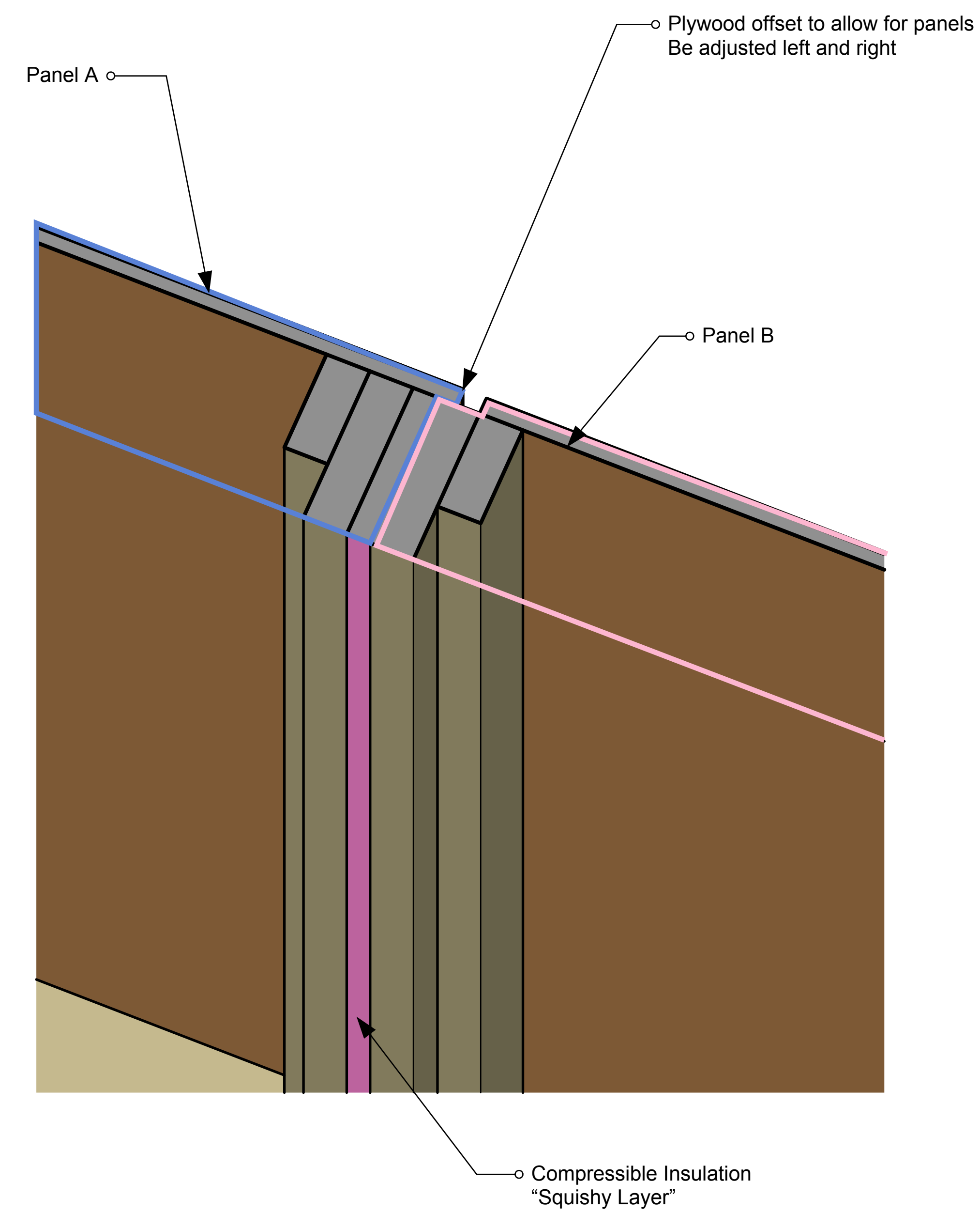
Vertical Wall Joints



INTERIOR VIEW



EXTERIOR VIEW



SECTION VIEW

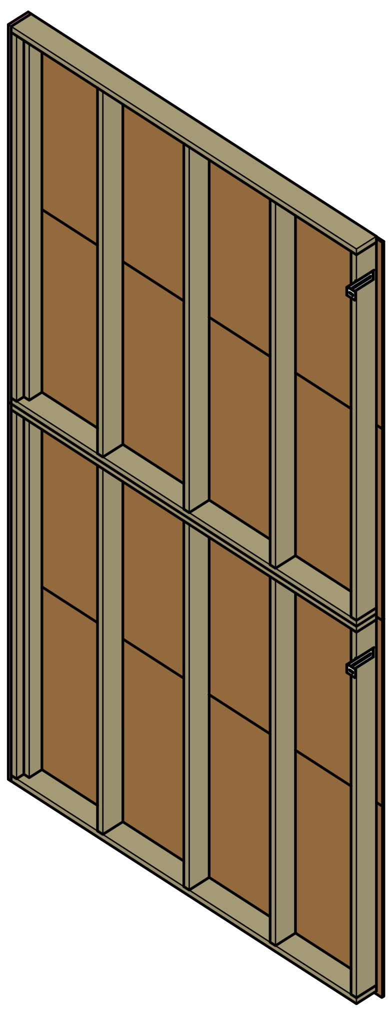
ReCover

Version Date
February 27, 2023

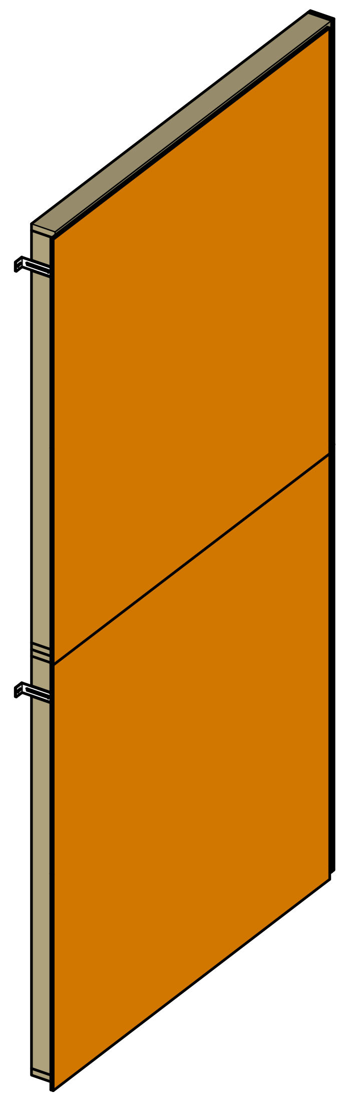
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

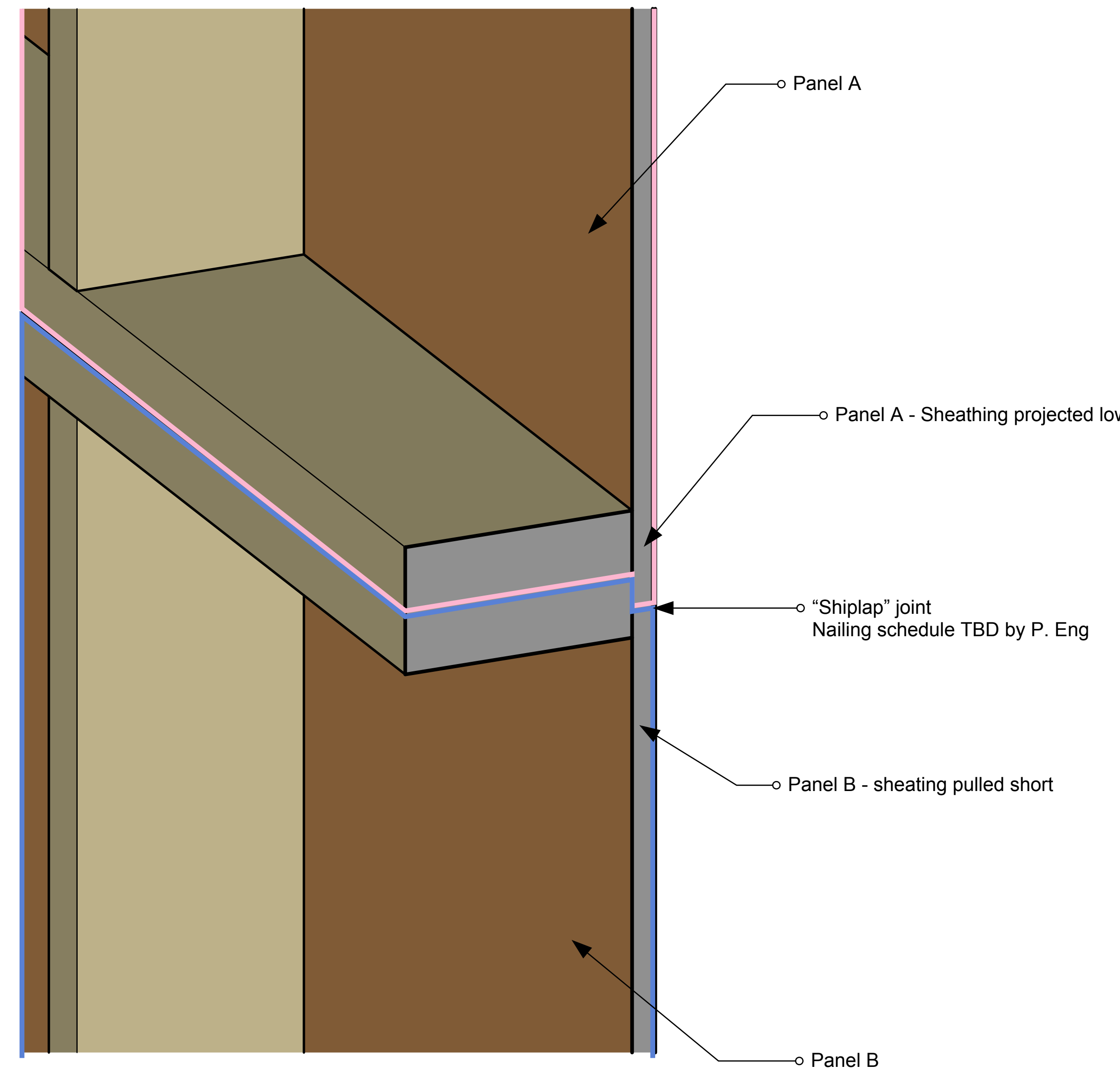
Horizontal Wall Joins



INTERIOR VIEW



EXTERIOR VIEW



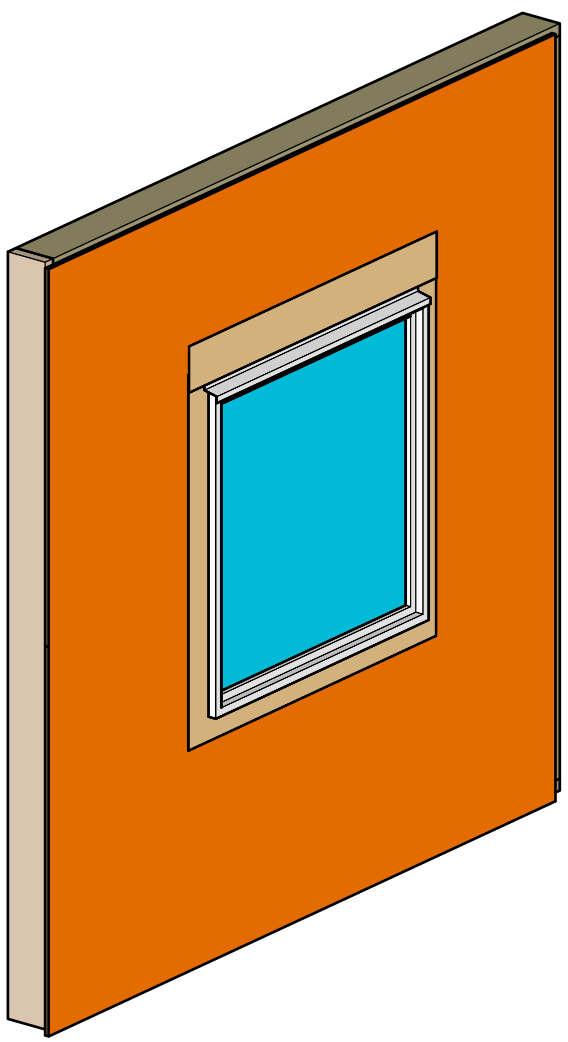
SECTION VIEW

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

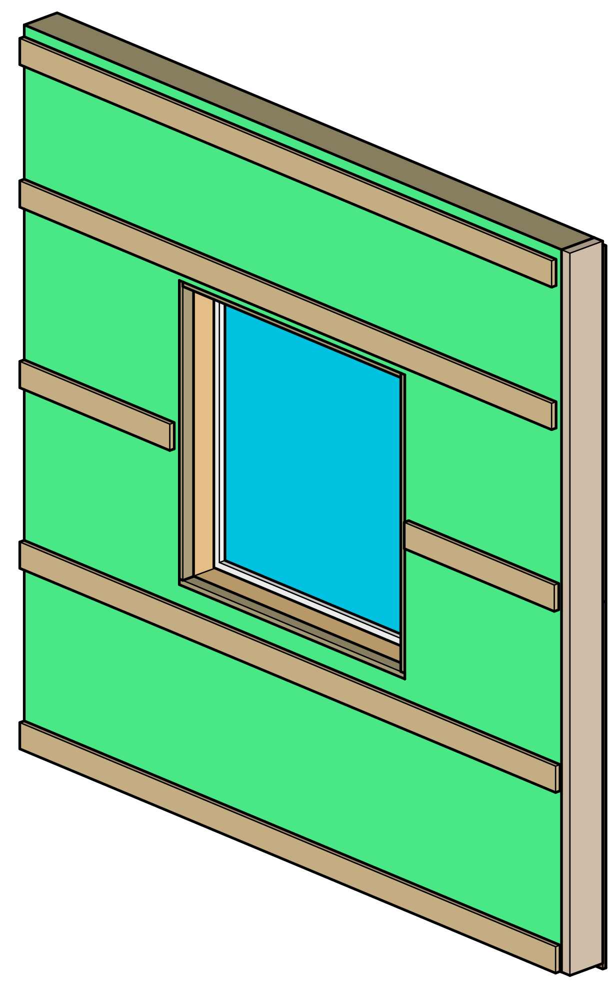
Drawn By
Nick Rudnicki

Window Panel

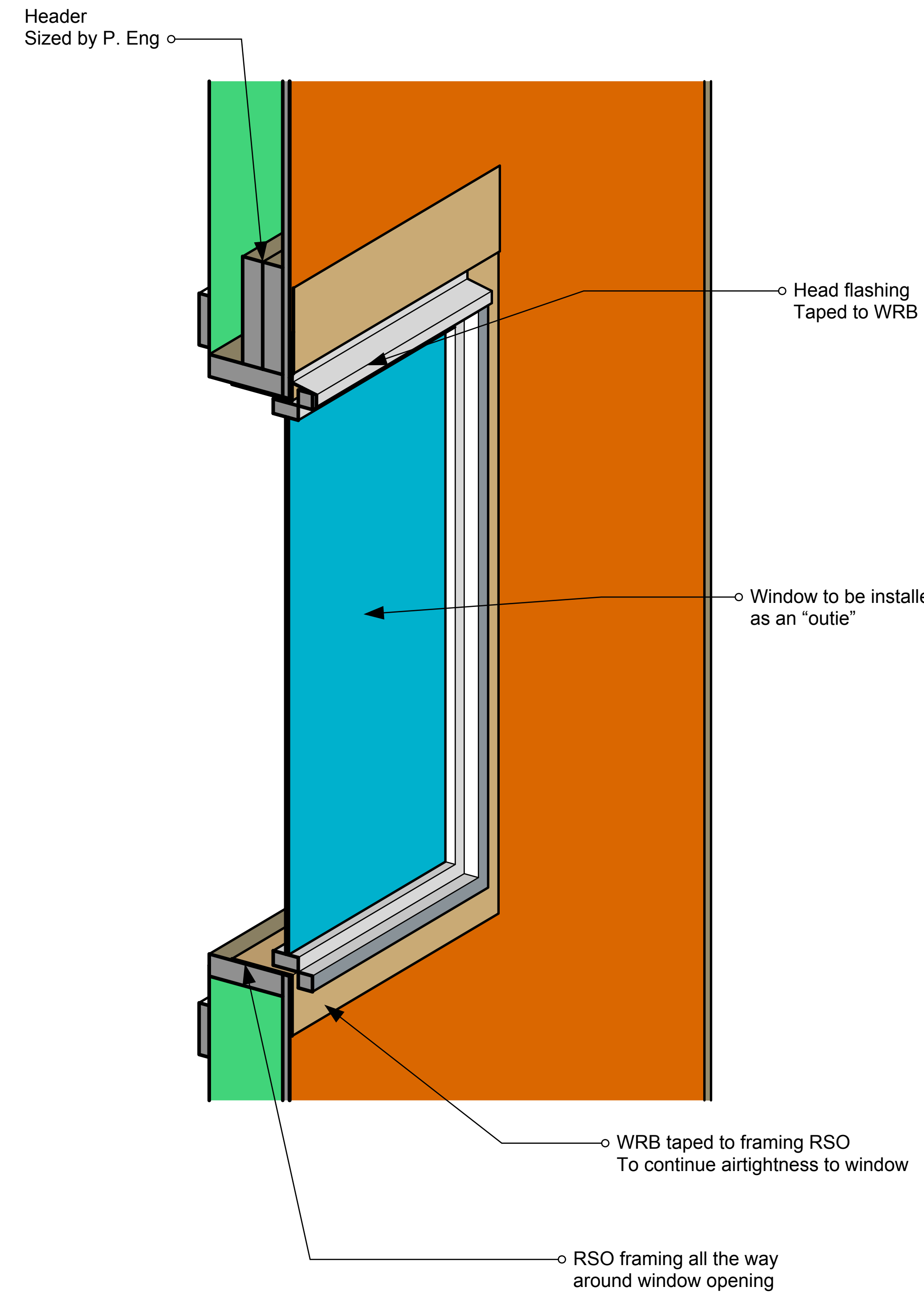


PANEL
EXTERIOR VIEW

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



PANEL
EXTERIOR VIEW



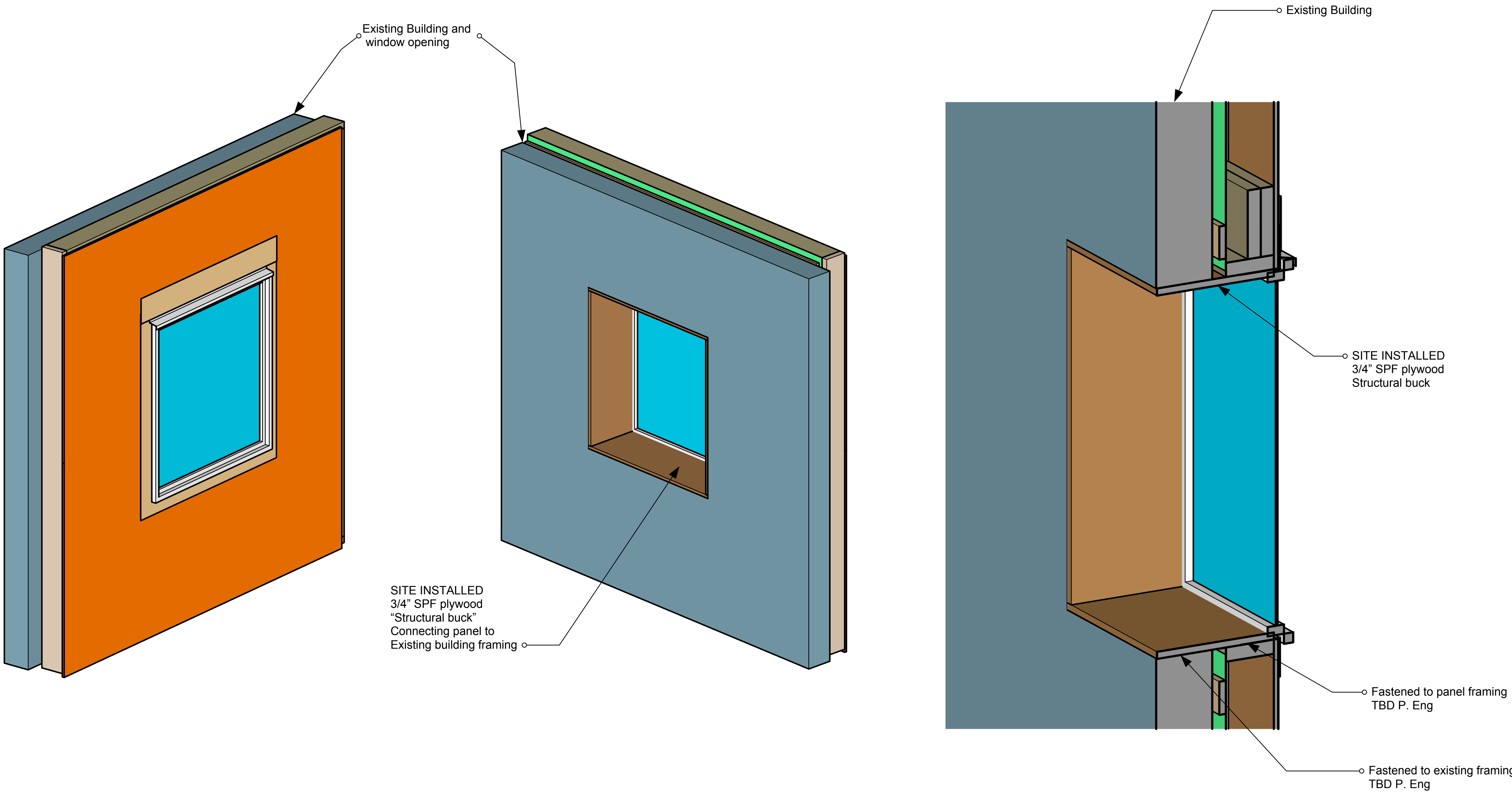
ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Window Panel Install

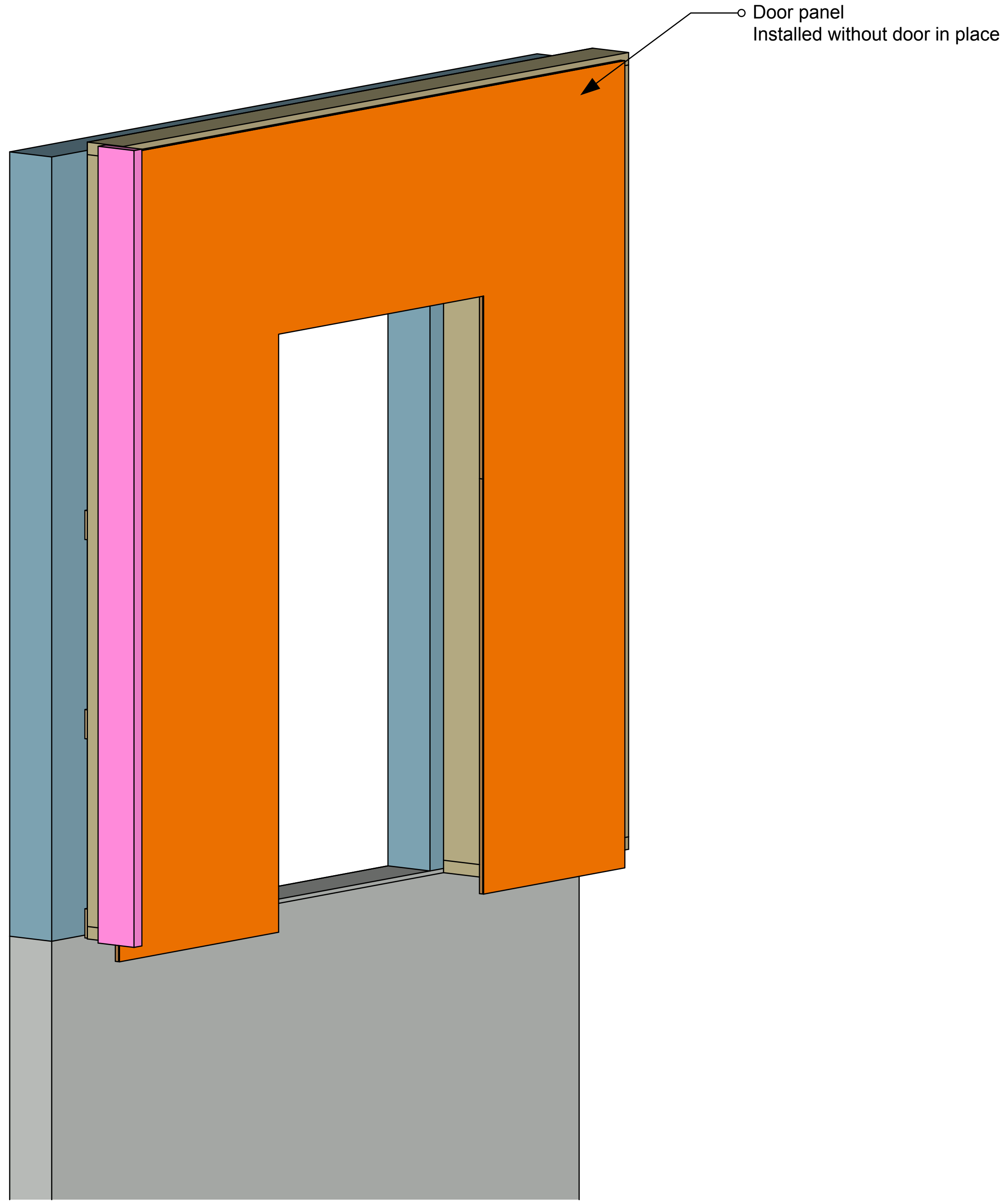


Version Date
February 27, 2023

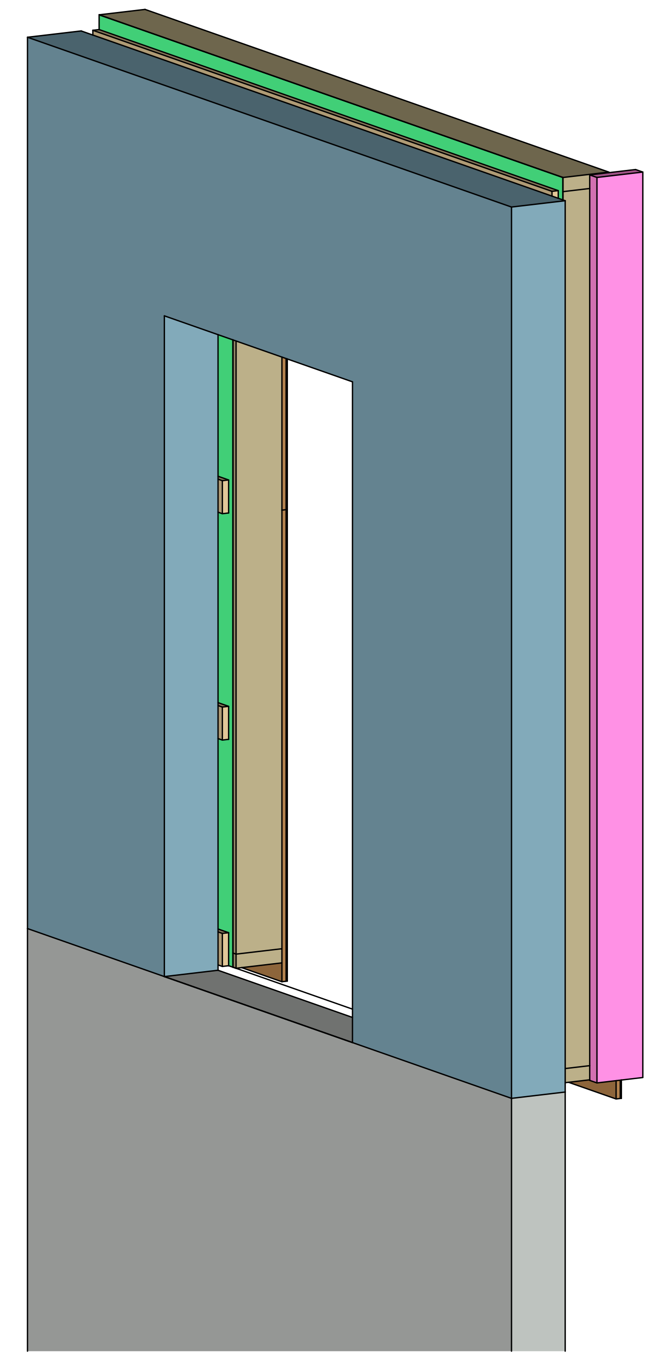
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Door Penetration Panel



EXTERIOR VIEW



INTERIOR VIEW

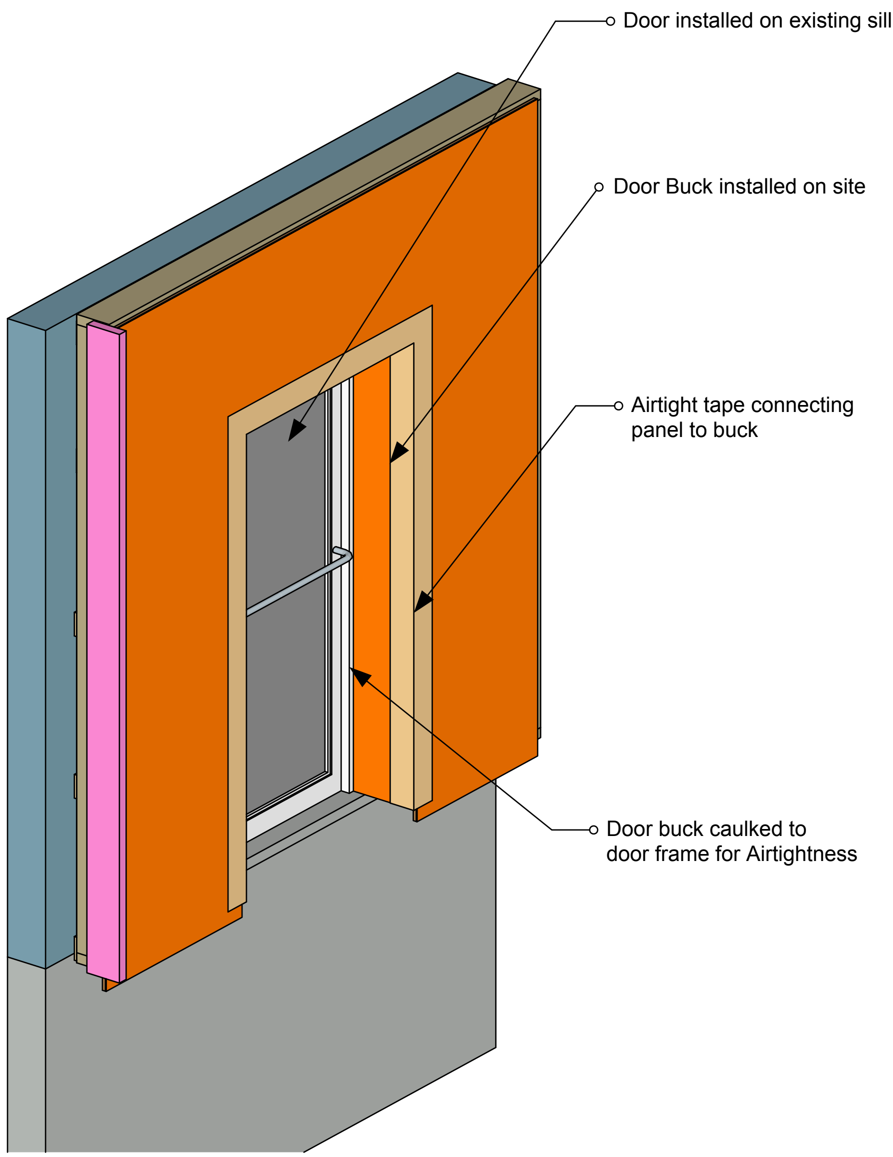
ReCover

Version Date
February 27, 2023

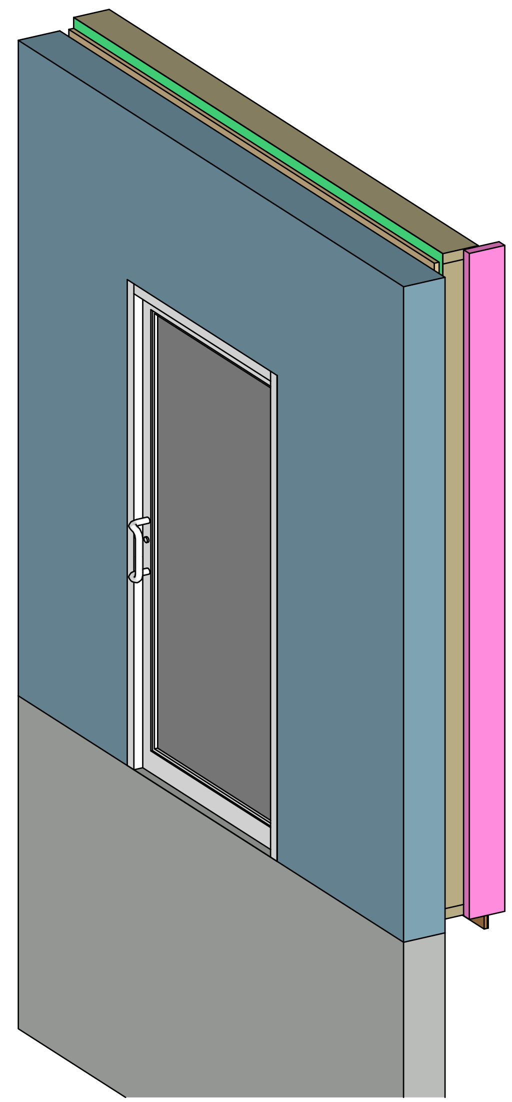
PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

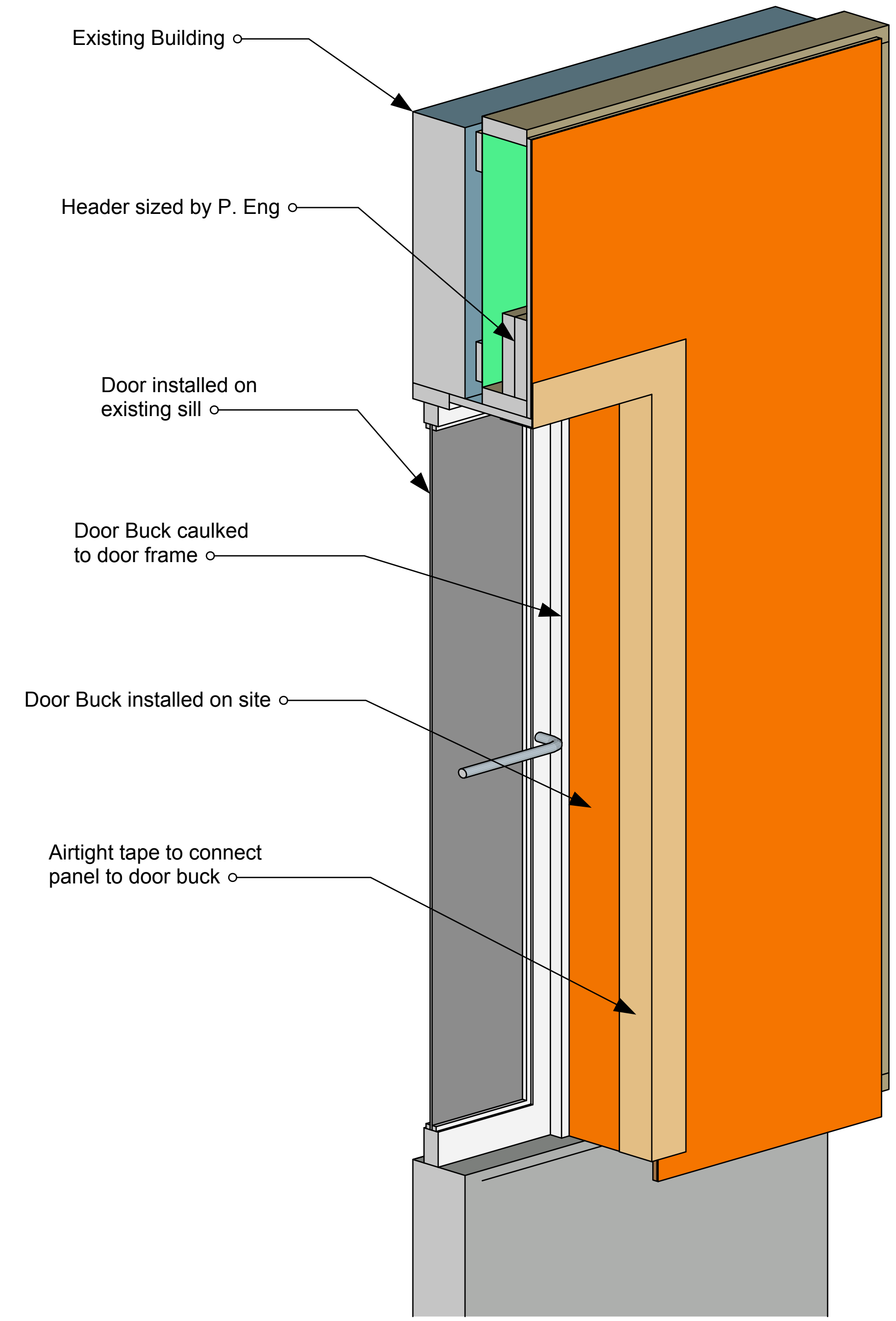
Door Penetration Panel Installed



EXTERIOR VIEW



INTERIOR VIEW



SECTION VIEW

ReCover

Version Date
February 27, 2023

PROJECT
2x6 R 16 Cellulose
Panel Schematics

Drawn By
Nick Rudnicki

Appendix I

Panel Layouts

Colchester Panelized Retrofit

Construction Plan

County of Colchester

RSI projects

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

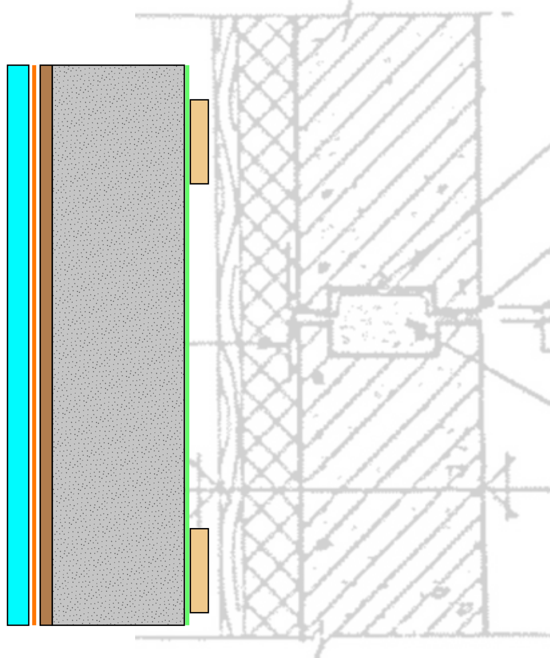
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki
DESCRIPTION
Sheet Description

Hygrothermal Schematic



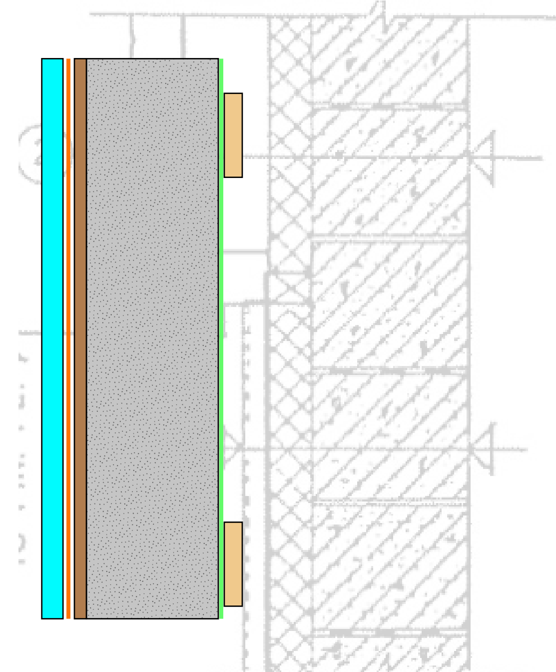
Building B - Wall 4
Exterior Wall Panels

Interior Space

(Existing)
10" concrete block
2.5" rigid insulation
2x3" furring
2 layers of #15 bldg paper
1x6" v-joint wood siding
(End existing)

(New panel)
1x4" SPF strapping
Cellulose Bib
5.5" dense pack cellulose
1/2" SPF plywood sheathing
High Perm WRB
7/8" corrugated metal siding (vented)
(End new panel)

Exterior Air



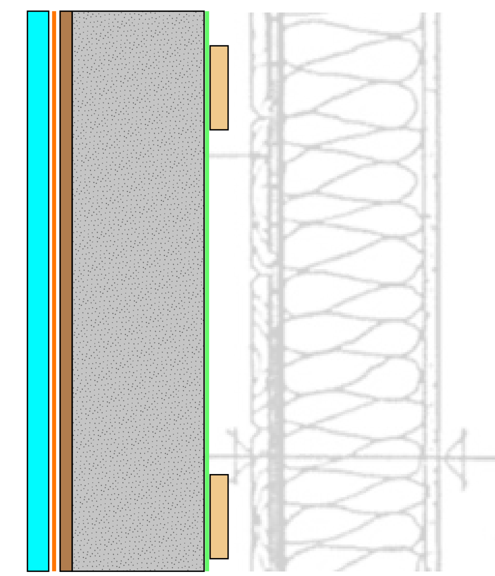
Building B - Wall 2 or 3
Exterior Wall Panels

Interior Space

(Existing)
10" concrete block
2.5" rigid insulation
2x3" furring
Corrugated metal panel
(End existing)

(New panel)
1x4" SPF strapping
Cellulose Bib
5.5" dense pack cellulose
1/2" SPF plywood sheathing
High Perm WRB
7/8" corrugated metal siding (vented)
(End new panel)

Exterior Air



Building A - Wall 3
Exterior Wall Panels

Interior Space

(Existing)
5/8" drywall
R20 Batt Insulation
2x6 SPF stud @ 16" o.c.
1/2 SPF plywood sheathing
#15 tar paper
1x6 v-joint wood siding
(End existing)

(New panel)
1x4" SPF strapping
Cellulose Bib
5.5" dense pack cellulose
1/2" SPF plywood sheathing
High Perm WRB
7/8" corrugated metal siding (vented)
(End new panel)

Exterior Air

RSI projects

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

ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki
DESCRIPTION
Sheet Description

Hygrothermal Schematic

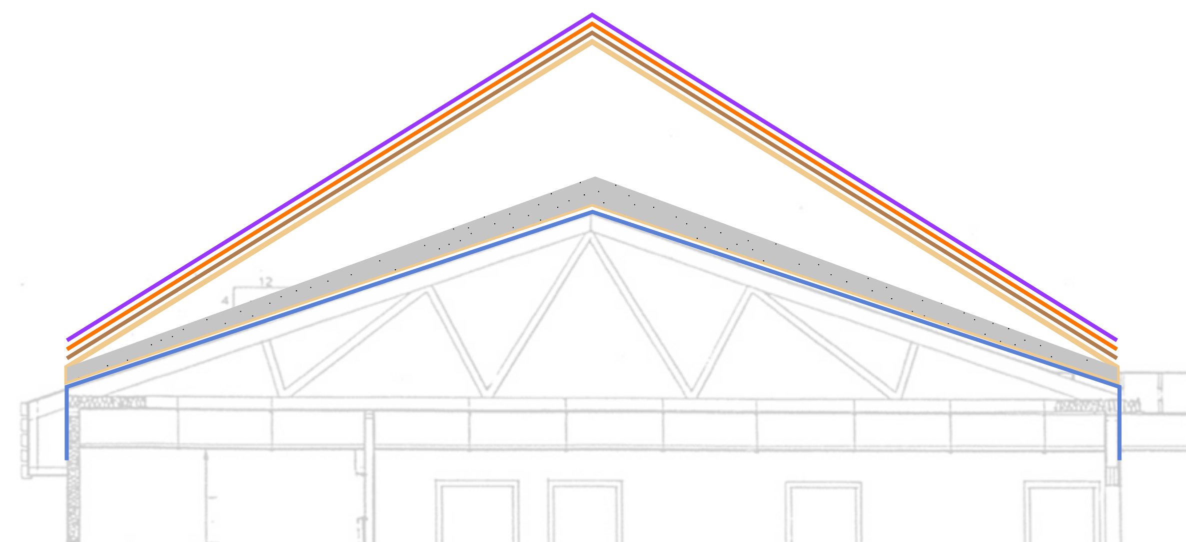
Existing Sloped Roof

Interior Space

(Existing)
6 mil vapour barrier
1x3” SPF strapping
R20 Batt Insulation
Trusses @ 24” o.c.
unvented air space
5/8” SPF plywood sheathing
15# Asphault Paper
210 lbs Asphalt Shingles
(End existing)

(New panel)
6mil vapour barrier taped for air tightness
8” loose fill cellulose
Scissor truss 24” o.c. (10/12 pitch)
Vented air space
5/8” sheathing
Low perm roof membrane
Corrugated metal roofing
(End new panel)

Exterior Air



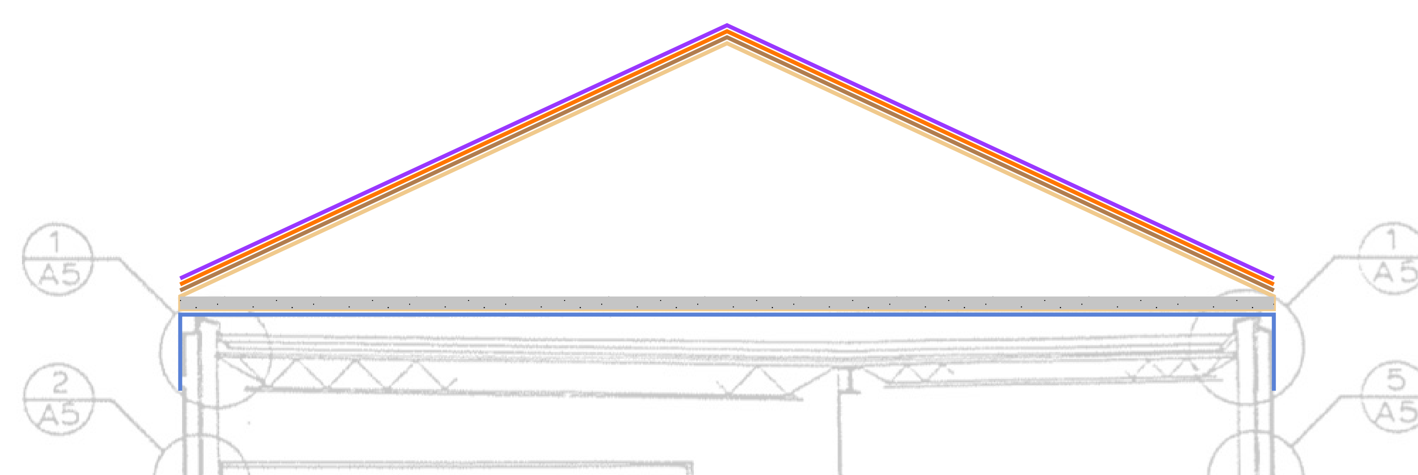
Existing Flat Roof

Interior Space

(Existing)
1.5” metal roof deck
1/2” gypsum board
3 ply roofing membrane
Flood coat
4” Rigid Insulation
Torch on Membrane
(End existing)

(New panel)
6mil vapour barrier taped
for air tightness
8” loose fill cellulose
Raised Heel truss 24” o.c.
(8/12 pitch)
Vented air space
5/8” sheathing
Low perm roof membrane
Corrugated metal roofing
(End new panel)

Exterior Air



RSI projects

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

ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

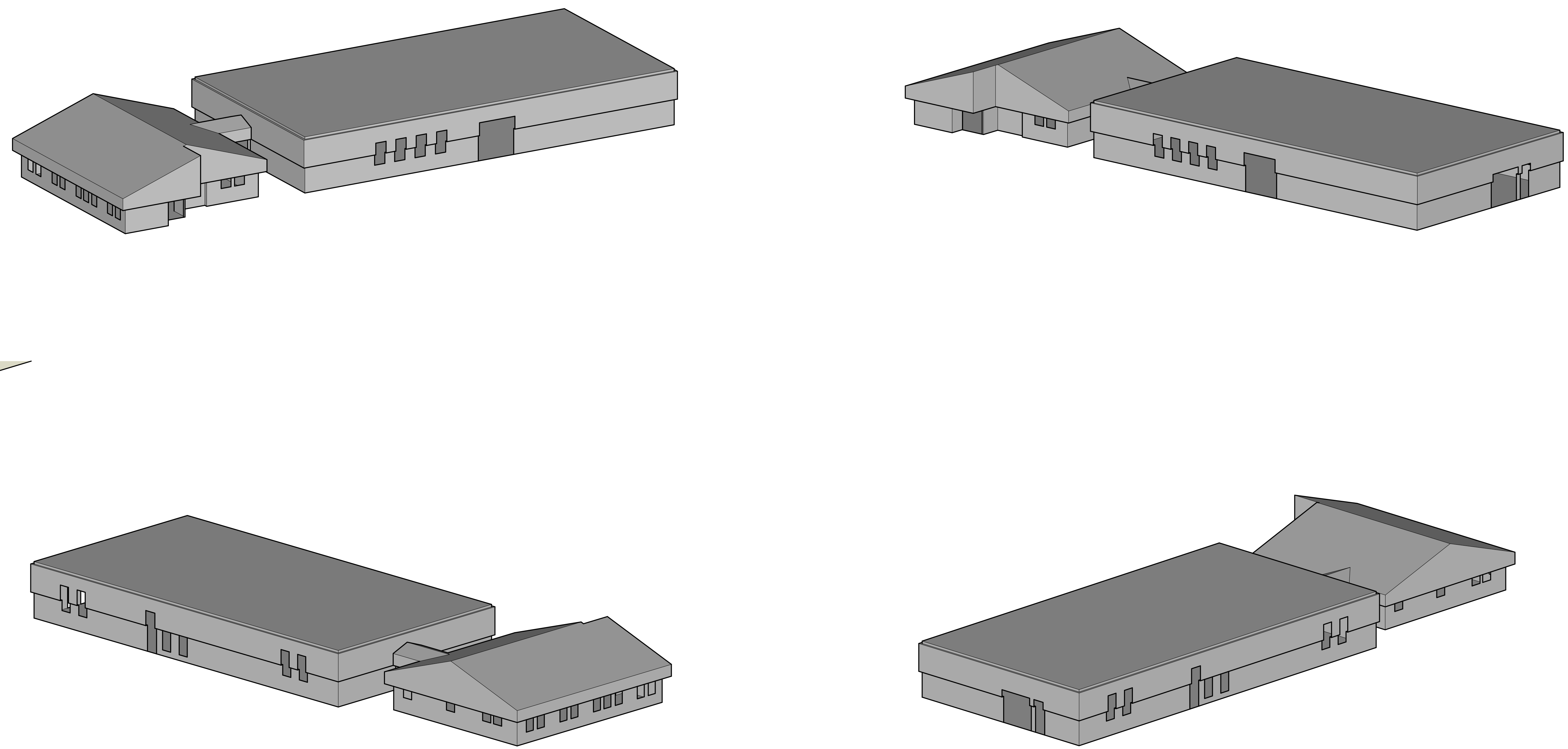
Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki
DESCRIPTION
Sheet Description

03

Existing Building



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

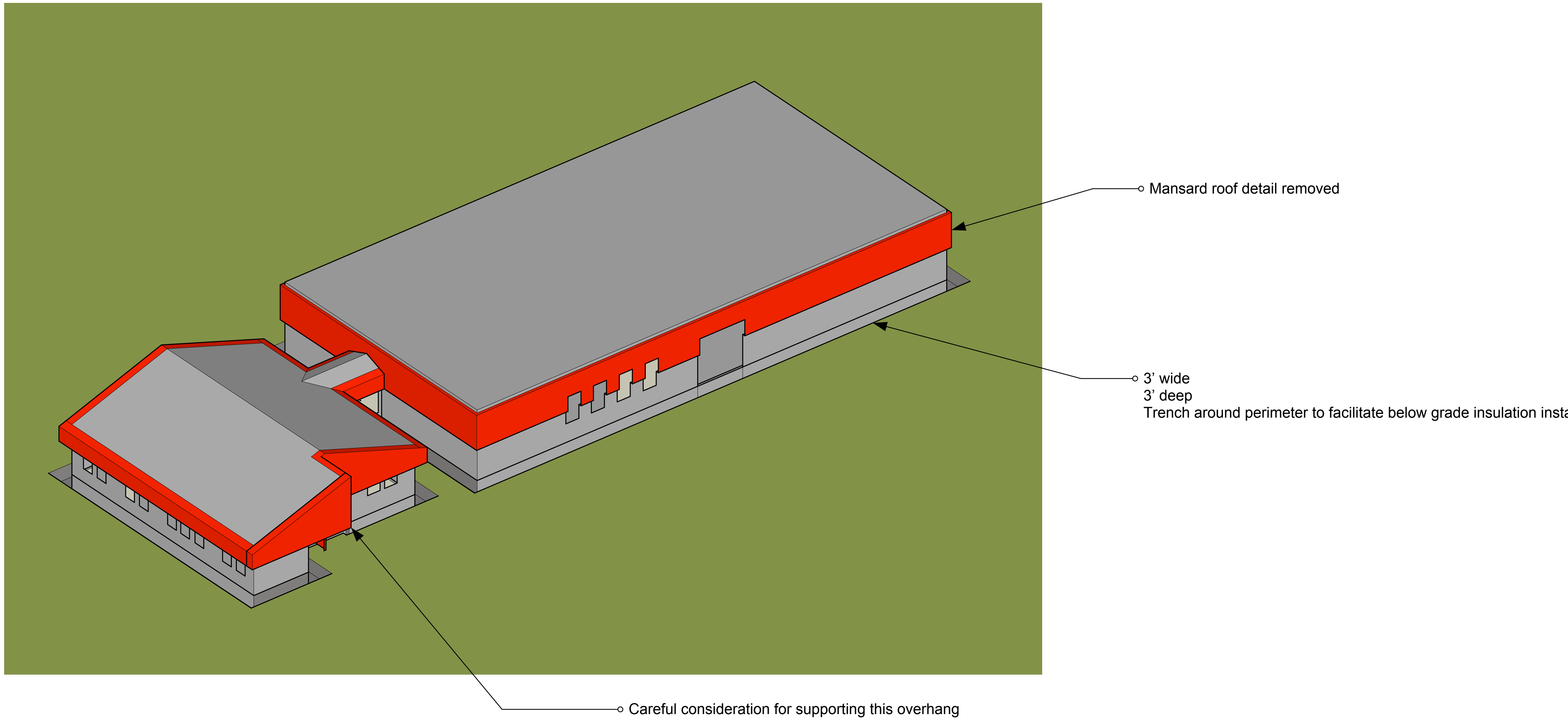
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Demolition and Excavation



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

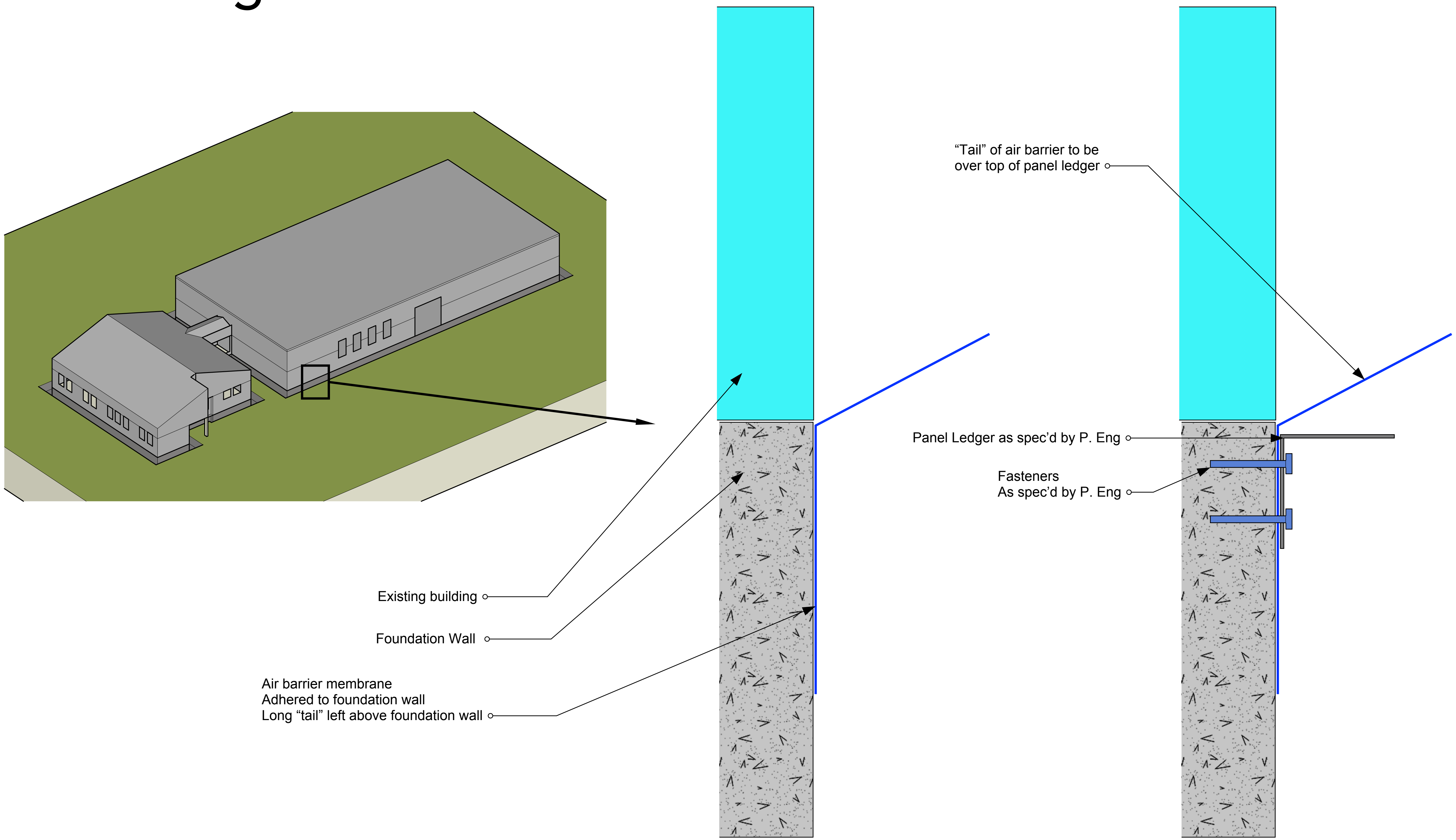
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Panel Ledger install



Step 1
Air Barrier

Step 2
Panel Ledger

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

ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

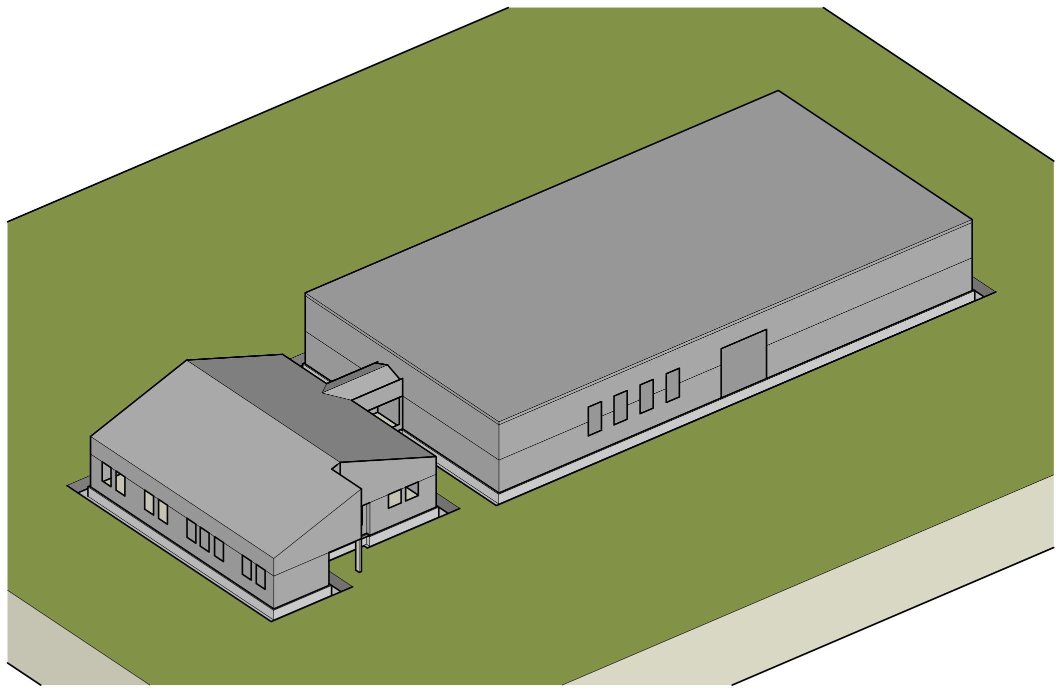
Project Address
251 Lancaster Crescent
Debert
Nova Scotia

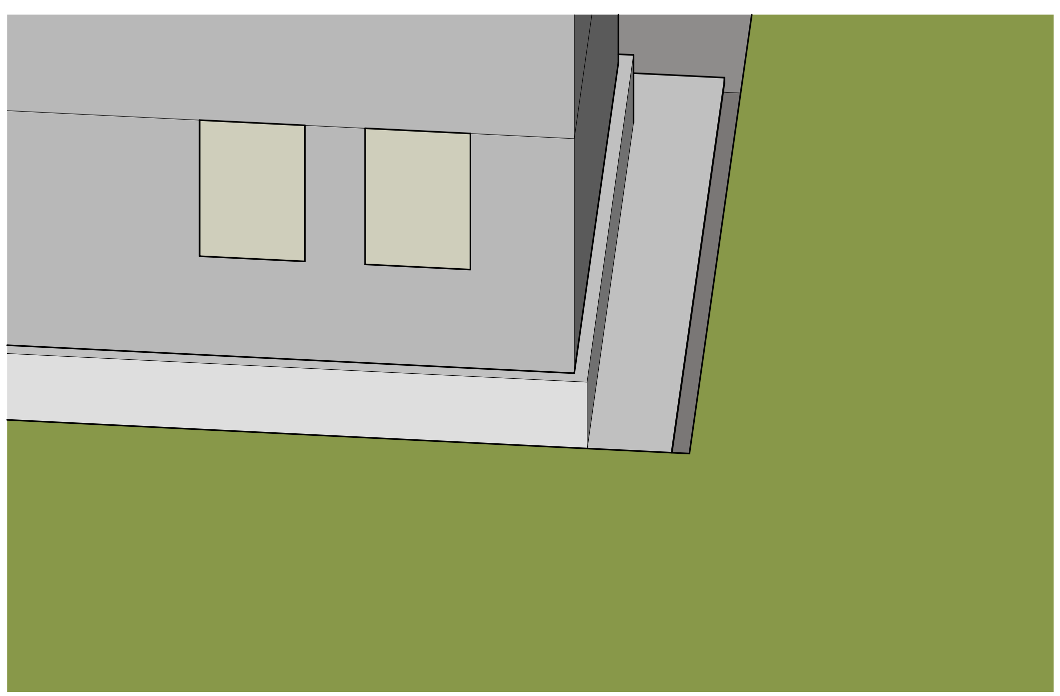
PROJECT
Panelized Retrofit

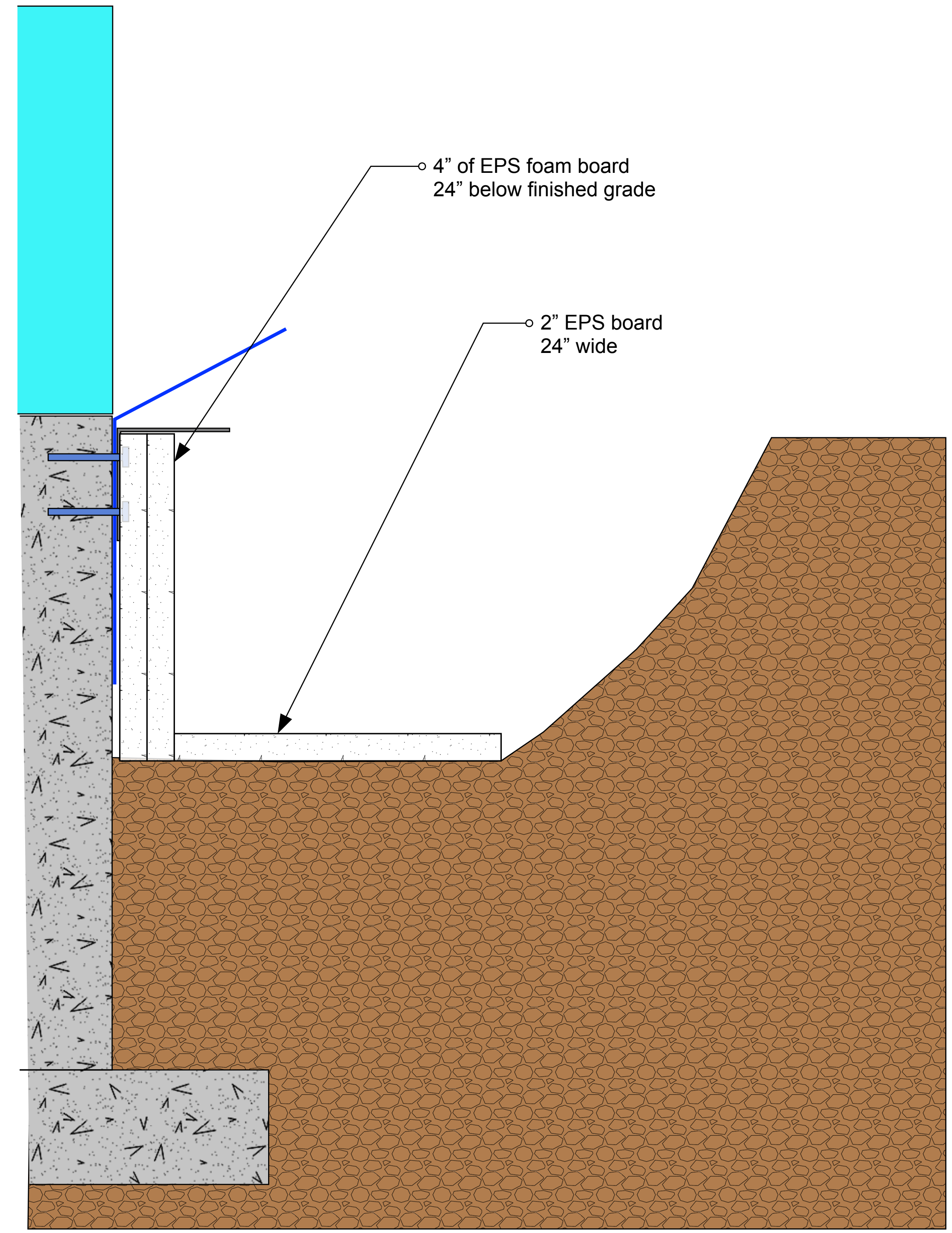
DRAWN BY
Nick Rudnicki

06

Foundation Insulation







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

ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

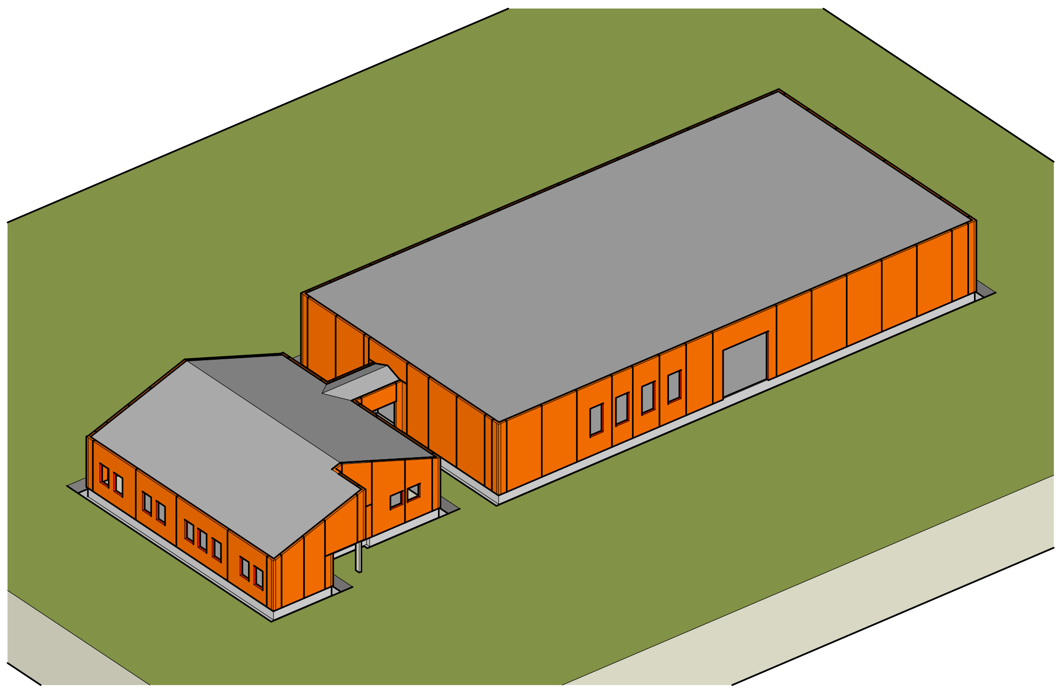
Project Address
251 Lancaster Crescent
Debert
Nova Scotia

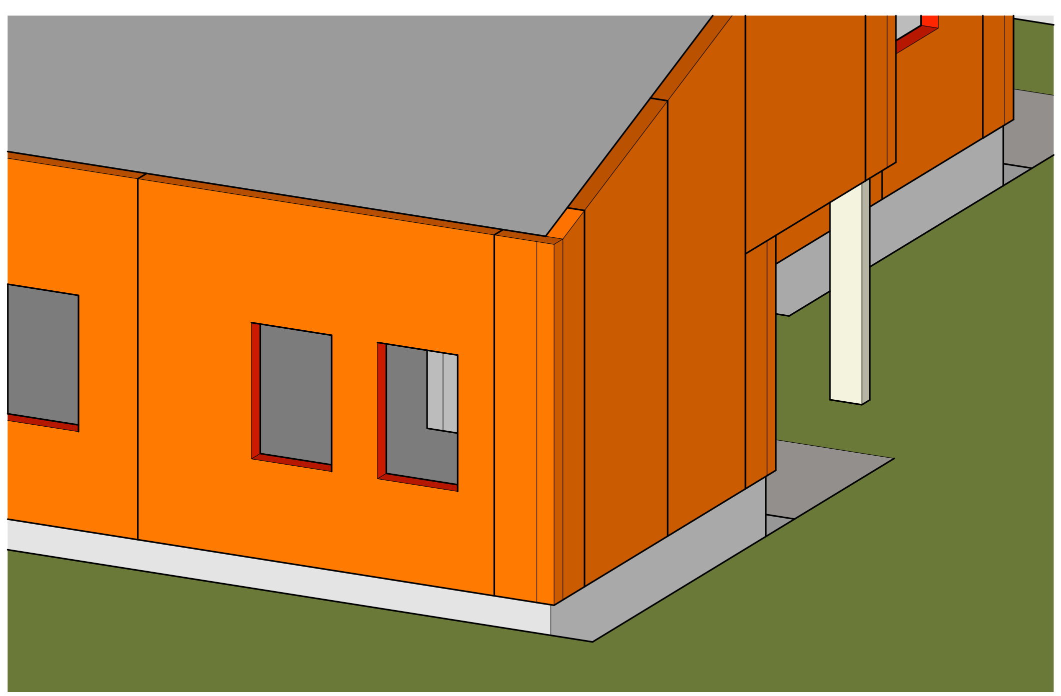
PROJECT
Panelized Retrofit

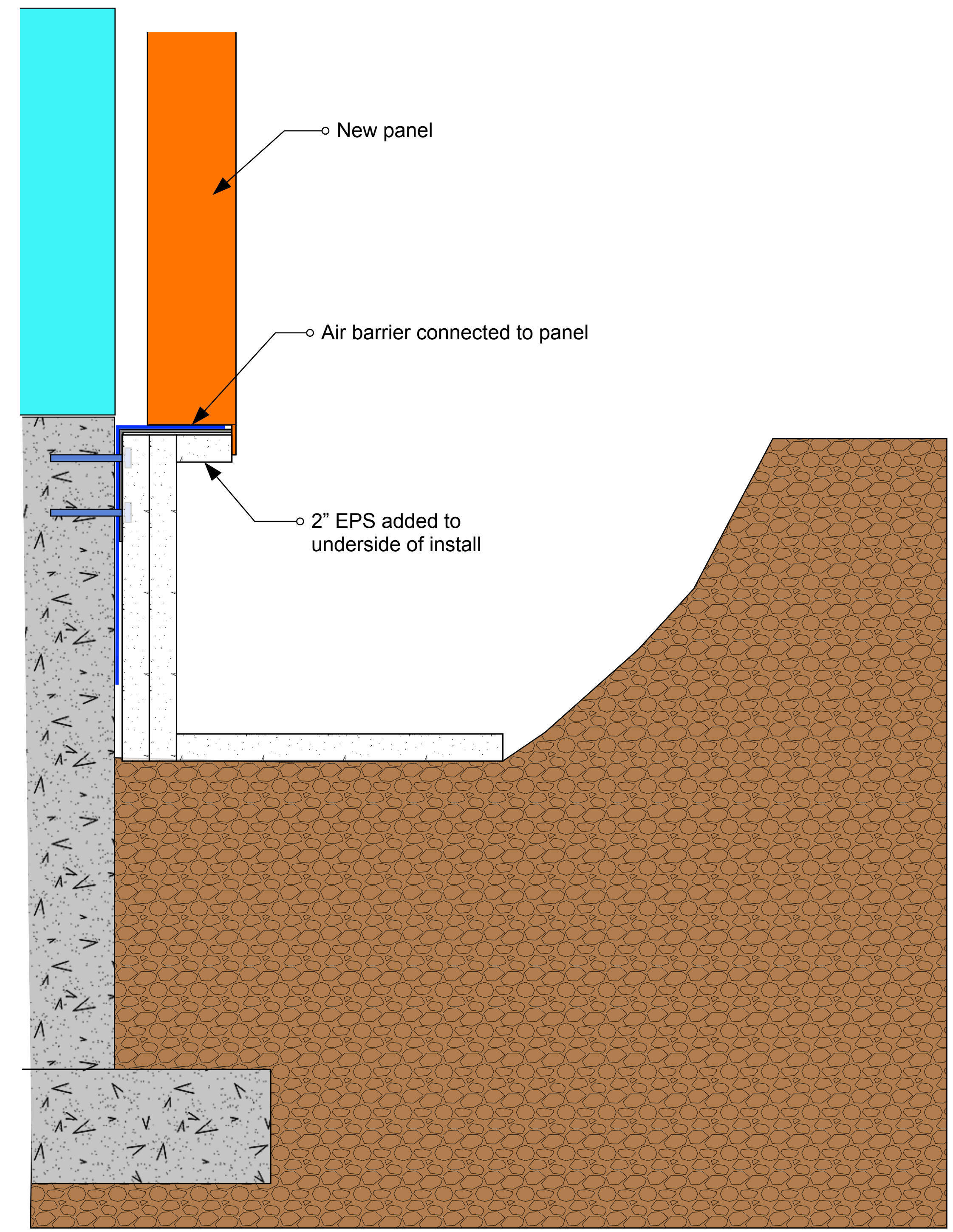
DRAWN BY
Nick Rudnicki

07

Wall Panel Install







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

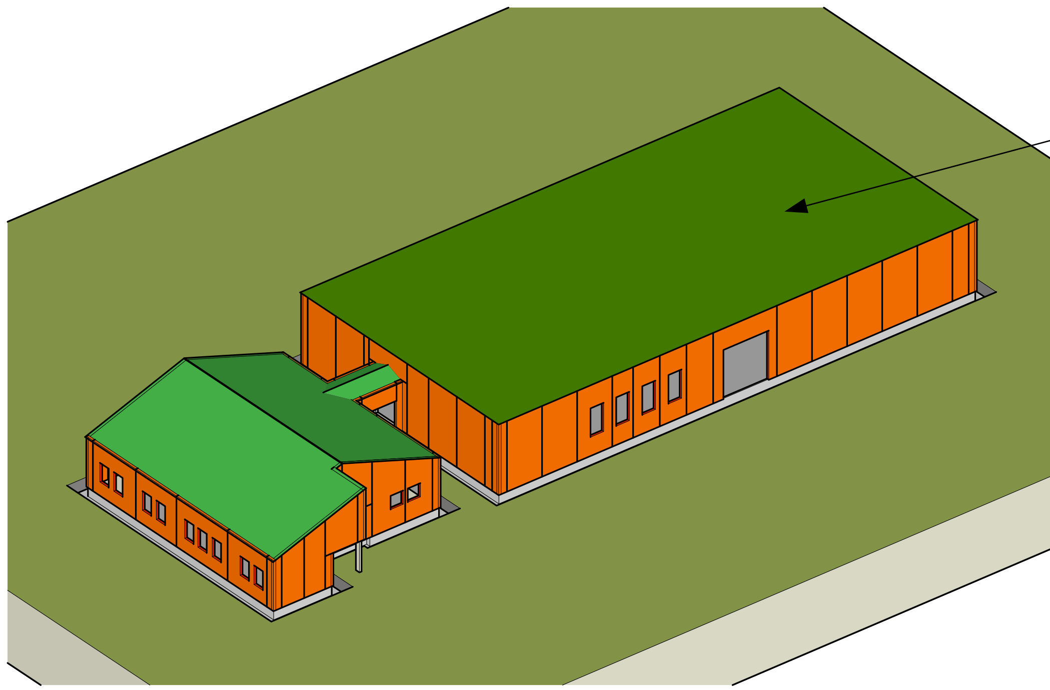
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

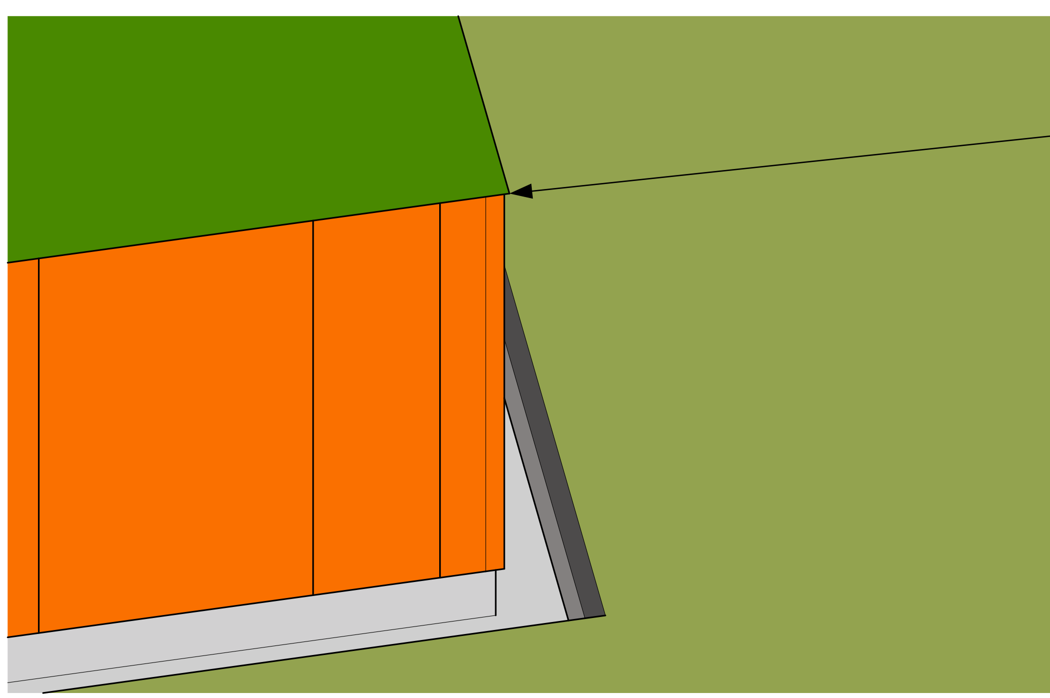
PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Roof Air Barrier



All existing roof is covered in continuous air barrier



Air barrier overlaps with installed panels and is connected to wall panel air barrier

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

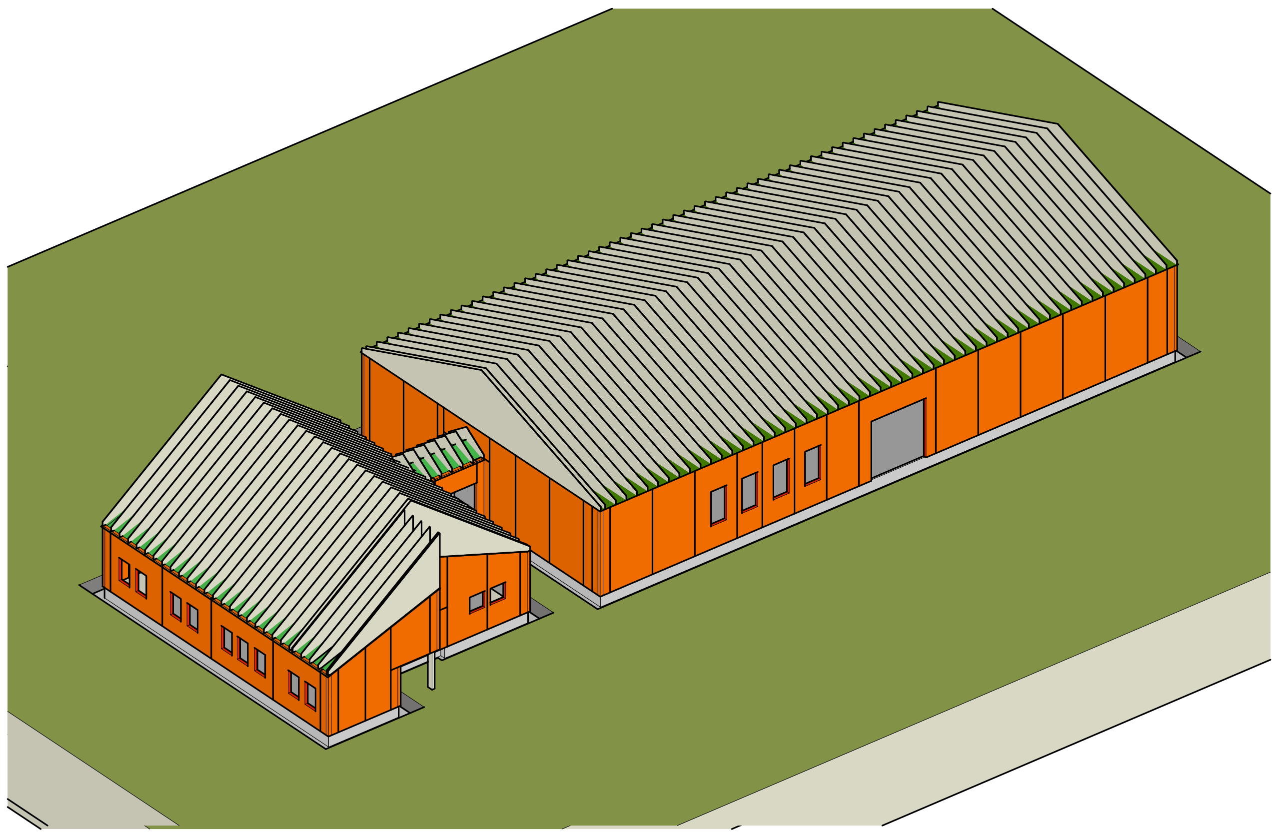
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

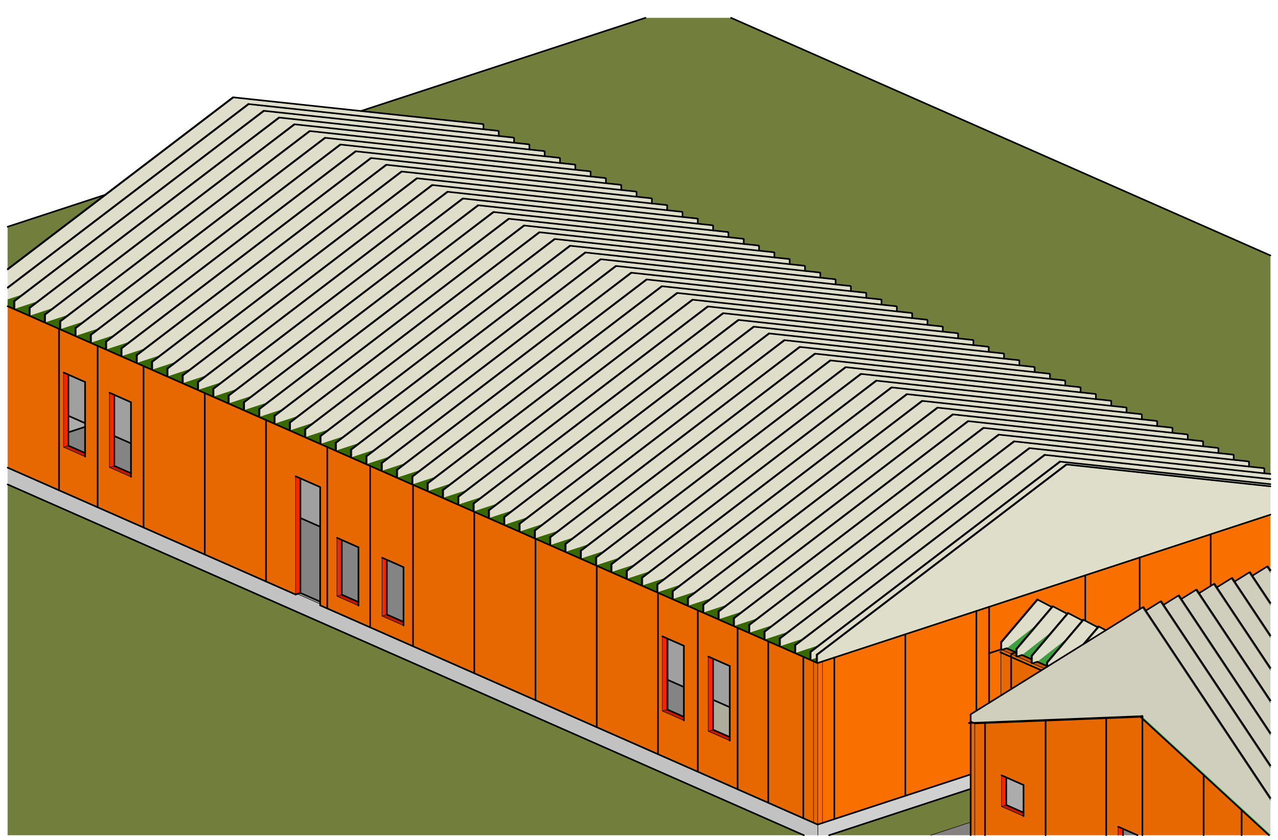
Project Address
251 Lancaster Crescent
Debert
Nova Scotia

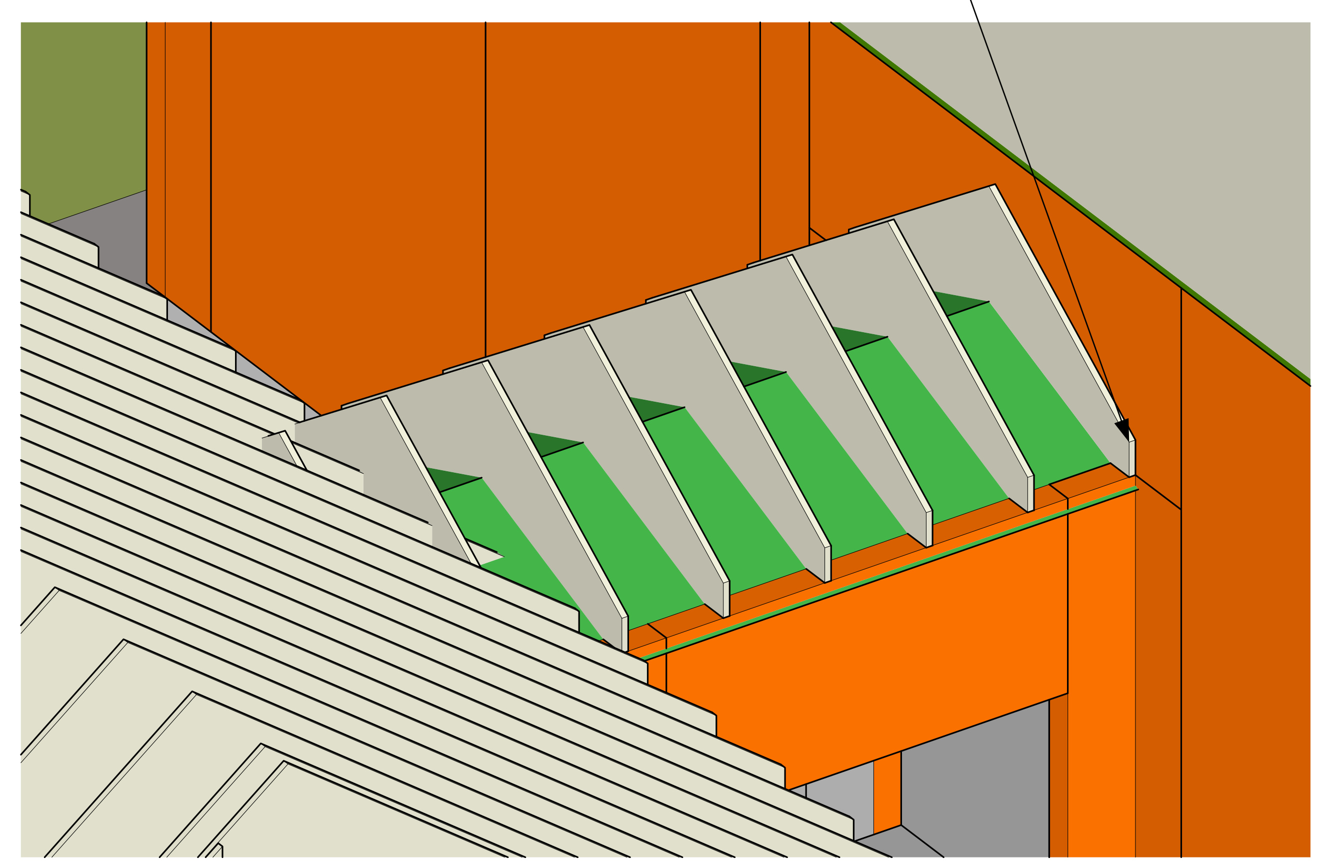
PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Install Roof Trusses







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

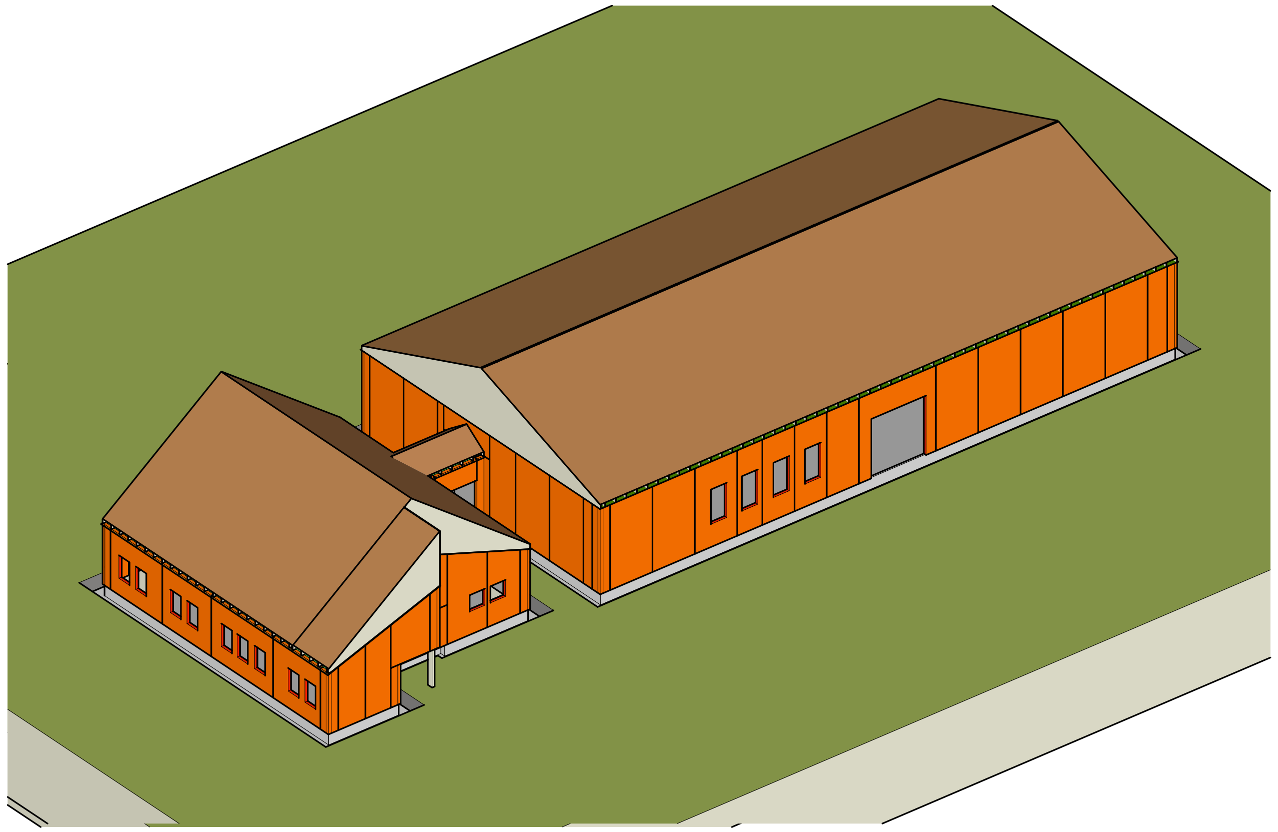
ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

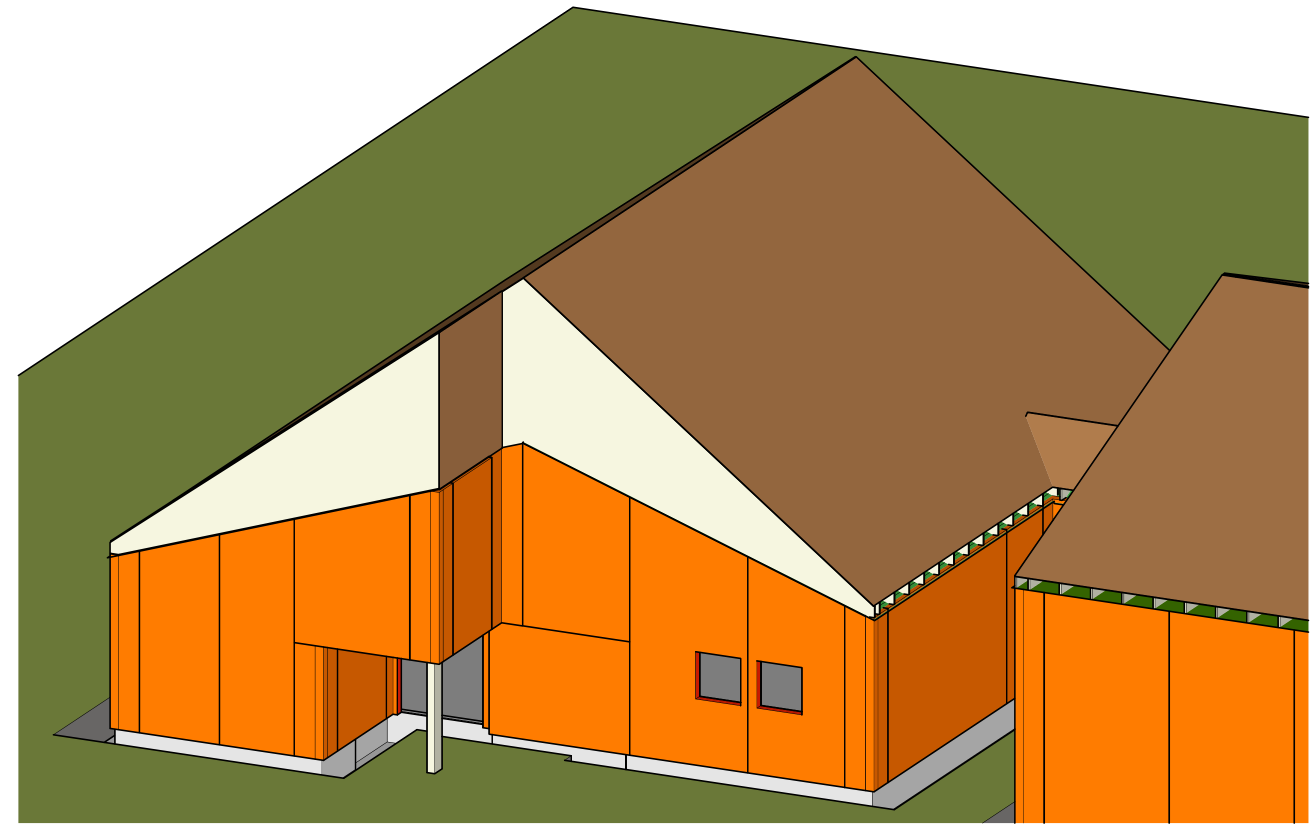
Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Roof Sheathing and Loose Pack Cellulose





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

ISSUE
MM.DD.YY
RE-ISSUE
MM.DD.YY

Project Address
251 Lancaster Crescent
Debert
Nova Scotia

PROJECT
Panelized Retrofit

DRAWN BY
Nick Rudnicki

Appendix J

Hygrothermal Report

- **Report**

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

Location: 251 Lancaster Crescent, Debert, Nova Scotia

Date: 2023-02-15

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 design. The present report serves as a summary of the WUFI® Pro results obtained for the Colchester Water Utility Administration buildings located at 251 Lancaster Crescent in Debert, Nova Scotia.

INTRODUCTION

It is understood that the Colchester Water Utility Administration facility, built in 1979, is located in a small clearing east of Lancaster Crescent and the Sobeys Debert Distribution Centre. The buildings in question, namely Building A and Building B, are oriented a few degrees east of due North. The buildings are partially sheltered from the treeline located approximately 20-m to the North. The eastern side of Building A faces the western side of Building B, and the two buildings are linked by a 3.5-m long stretch of enclosed corridor (see **Figure 1**).

Figure 1 – Plan view location and orientation of Building A (shaded red) and Building B (shaded blue) of the Colchester Water Utility Administration facility, Debert (Google, 2022)

It is understood that Building A is currently being used as business space, while Building B serves as a maintenance facility.

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 Building A and Building B of the Colchester Water Utility Administration 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 above-grade exterior walls and roof structures excluding the corridor portion located between Building A and Building B. 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 through WUFI® Pro. This report consists of the output of these simulations.

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 Municipality of Colchester, including photos and a set of drawings (*Water Utility Building Structural Plans – 251 Lancaster Cres.pdf*). 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 Municipality of Colchester 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 Colchester (or Nova Scotia) climate file is not available in the WUFI database.

INDOOR CLIMATE: The non-residential indoor climate was modelled using sinusoidal functions. The average indoor temperature and relative humidity setpoints of 21°C and 50% were used in these simulations. The range of temperatures simulated were based on RDH Building Science's energy model inputs for the Colchester project (*2022 08 31 COLCHESTER Model Inputs – RDH.pdf*). The relative humidity setpoint of 50% was assumed for regular occupancy. As it is unclear as to what future tenancy patterns and moisture loads will be present, the following assumptions were made regarding the indoor climate:

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

Interior Setpoints	Average	Amplitude	Range	Date of Maximum Value
Temperature	21°C	3°C	18°C – 24°C	July 15^{th} (assumed)
Relative Humidity	50%	10%	40% – 60%	July 15^{th} (assumed)

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

ASSEMBLY MATERIALS: Based on the information obtained, the primary existing wall and roof assemblies shown in **Table 2** and **Table 3** were modelled for Building A and Building B, respectively (detailed material properties are included in **APPENDIX A** and **APPENDIX B**). The assemblies proposed for the retrofit were originally sourced from the project document *22 11 23 – Colchester Build Plan.pdf*, received on 2022-11-23 from RSI Projects. However, final designs and assemblies were conveyed by the ReCover team via phone and video calls.

It should also be noted that assumptions were made regarding certain assemblies. For instance, the air spaces within the Building A post-retrofit roof were simulated at an average thickness of 0.6-m (new and existing spaces). Other modelling assumptions are included in notes below the following tables as well as in the Appendices. **Assembly material choices and assumptions should be reviewed for agreement with existing and proposed conditions.**

Table 2 – Building A assemblies and material components used in WUFI simulations

Assembly	Materials (Interior to Exterior)	Thickness, m (inch)
Lower Wall	Gypsum Board	0.016 (0.63)
	4 mil Vapour Retarder*	0.001 (0.04)
	Batt Insulation	0.140 (5.51)
	Plywood Sheathing	0.013 (0.51)
	15 LB Asphalt Paper	0.001 (0.03)
	Wood Siding	0.011 (0.41)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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)
Upper Wall	Gypsum Board	0.016 (0.63)
	4 mil Vapour Retarder*	0.001 (0.04)
	Batt Insulation	0.140 (5.51)
	Plywood Sheathing	0.013 (0.51)
	15 LB Asphalt Paper***	0.001 (0.03)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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	Polyethylene Membrane	0.001 (0.04)
	Batt Insulation	0.151 (5.94)
	Air Space	0.600 (23.62)
	Plywood Sheathing	0.016 (0.63)
	15 LB Asphalt Paper***	0.001 (0.03)
	Asphalt Shingle System	0.004 (0.16)
	Polyethylene Membrane	0.001 (0.04)
	Low-Density Cellulose Insulation	0.203 (8.00)
	Air Space	0.600 (23.62)
	Plywood	0.016 (0.63)
	PVC Membrane	0.002 (0.06)
	Metal Cladding**	0.001 (0.04)

*Vapour retarder (indicated in *Water Utility Building Structural Plans – 251 Lancaster Cres.pdf*) position assumed
Metal Cladding modelled using **Roof Membrane V13 from WUFI as per protocol

***15 LB Asphalt Paper assumed to exist in upper wall assembly (behind removed metal panel/outboard of plywood sheathing), modelled using **Bituminous Paper (#15 Felt)** from WUFI

Table 3 – Building B assemblies and material components used in WUFI simulations

Assembly	Materials (Interior to Exterior)	Thickness, m (inch)
North, East, West *Lower Wall*	Reinforced Concrete Block	0.254 (10.0)
	Rigid Insulation	0.064 (2.52)
	15 LB Building Paper (x2)	0.001 (0.03) each
	Wood Siding*	0.011 (0.41)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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)
North, East, West *Upper Wall*	Reinforced Concrete Block	0.254 (10.0)
	Rigid Insulation	0.064 (2.52)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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)
South *Lower Wall*	Reinforced Concrete Block	0.254 (10.0)
	Rigid Insulation	0.064 (2.52)
	15 LB Building Paper (x2)	0.001 (0.03) each
	Pre-finished Panel***	0.001 (0.03)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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)
South *Upper Wall*	Reinforced Concrete Block	0.254 (10.0)
	Rigid Insulation	0.064 (2.52)
	Air Space	0.020 (0.79)
	Cellulose Bib	0.001 (0.04)
	Dense-Pack Cellulose	0.140 (5.50)
	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	Metal Deck	0.001 (0.04)
	Gypsum Board	0.013 (0.50)
	TPO Membrane (x3)	0.002 (0.08) each
	Polyisocyanurate Board	0.102 (4.0)
	Polyiso. Board Glass-Matt Facer	0.001 (0.04)
	Vapour Barrier	0.001 (0.04)
	Low-Density Cellulose******	0.203 (8.0)
	Air Space	0.600 (23.6)
	Plywood	0.016 (0.63)
	PVC Membrane	0.002 (0.06)
	Metal Cladding**	0.001 (0.04)

*Wood Siding modelled using **Composite Wood Siding** material, but with higher permeance

Metal Cladding modelled using **Roof Membrane V13 from WUFI as per protocol

***1-1/2" pre-finished panel indicated in *Water Utility Building Structural Plans – 251 Lancaster Cres.pdf* was assumed to be metal and was modelled using WUFI's default **Metal Deck, Unperforated**, including its thickness of 0.0008-m

****Low-Density Cellulose modelled using **Cellulose Fibre (heat cond.: 0,04 W/mK)** WUFI material, but with higher conductivity and lower density

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 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.

For the roof assemblies, no information was provided concerning air exchange rates within the newly created attic spaces. For Building A, several scenarios were simulated for the new attic given the double-attic post-retrofit system present (existing attic was assumed to experience 10-ACH) – these are presented in the **RESULTS** section of this report. Building B, with the new single-attic post-retrofit system, was simulated solely with an assumed rate of 10-ACH.

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 Building A roof assembly is composed of two separate inclined roof systems, both new and existing. For this preliminary work, the slope of the existing 18° roof was utilized for simulations. Building B's new gable roof was designed to be inclined at 34°, **however WUFI®'s output Balances were not close enough to indicate trustworthy results. For this reason, a 29° inclination, whose Balances were more similar, was used.**

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 42-km from the northern coast of Nova Scotia. The wall assemblies' rain deposition factor was automatically defined based on the steep-slope roof structures involved. 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 cladding would be painted, while the interior side of the various walls were also simulated with painted finishes based on site-visit photographs shared from the municipality. Meanwhile, the roof's exterior metal finish was assumed to be painted, while the interior was not. 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.**

RESULTS

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

BUILDING A: POST-RETROFIT LOWER WALL

The post-retrofit Building A Lower Wall assembly simulated 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 layers (both new and existing) were subdivided into three adjacent layers for near-surface condition assessment, with the outermost and innermost layers being 1/8-inch thick. The various plywood layers and other biogenic materials 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, there is at least one spike in mass percentage of water content (MC) above 20% between December 2022 and April 2023 in the new plywood layers (existing plywood does not experience MC spikes above 20%). For instance, the innermost 1/8-inch layer of the new plywood of the North lower wall assembly experiences a MC above 20% between approximately 2022-12-20 and 2023-03-23, but then dries out below 20% in subsequent years (**Figure 2**Figure 2). Similar results were observed in all orientations.

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 and existing fiberglass batt layers were simulated in VTT as proxies for the structural wood members (not modelled) located within these cavities. 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. For the fiberglass batt layer, the "Sensitive" class was used.

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.

In all Building A Lower Wall assembly orientations, the elements chosen for VTT simulation within the plywood (new and existing), cellulose, and fiberglass batt layers demonstrated a green VTT traffic light, indicating low mold growth indices.

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.

Moreover, depending on the proximity of the two buildings in question and their respective new roof systems, the effects of shade should, in the future, be simulated for certain wall systems.

BUILDING A: POST-RETROFIT UPPER WALL

The post-retrofit Building A Upper Wall assembly simulated 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. As was the case in the Lower Wall of Building A, certain plywood layers (new only) experience periods of MC above 20% but remain below this threshold after the first year of simulation. For instance, the innermost (new) plywood 1/8-inch layer in the East orientation experiences a spike in MC above 20% between approximately 2022/12/20 and 2023/03/25, but then remains below 20% after this point (**Figure 3**).

Using the same assumptions previously stated for mold growth parameters, another VTT simulation was conducted for the Building A Upper Wall assemblies. In all orientations, the elements chosen for VTT simulation within the plywood (new and existing), cellulose, and fiberglass batt layers demonstrated a green VTT traffic light, indicating low mold growth indices.

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.

Moreover, depending on the proximity of the two buildings in question and their respective new roof systems, the effects of shade should, in the future, be simulated for certain wall systems.

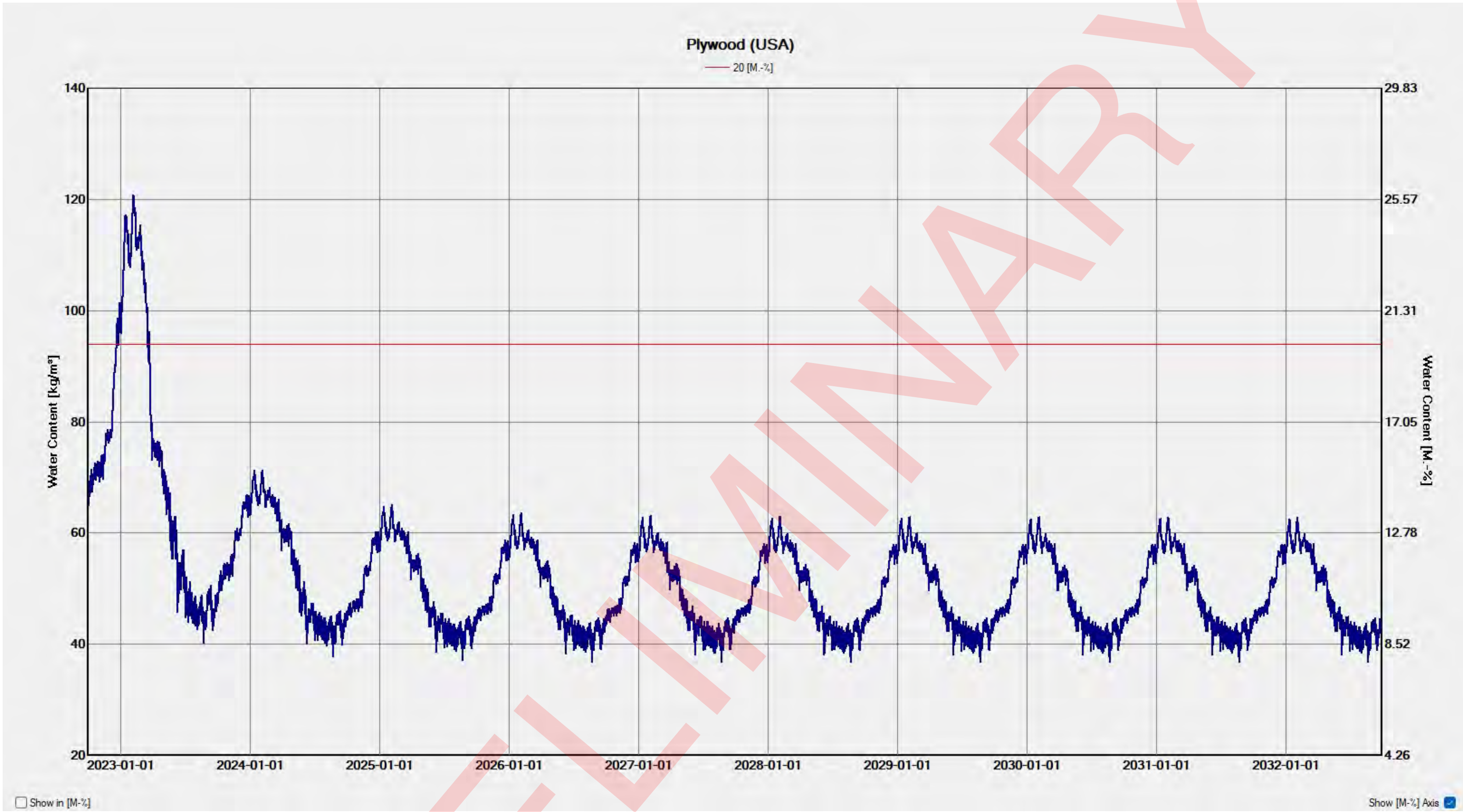


Figure 2 – WUFI® output for Building A Lower Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building A North Lower Wall assembly's [new] inner 1/8-inch plywood layer

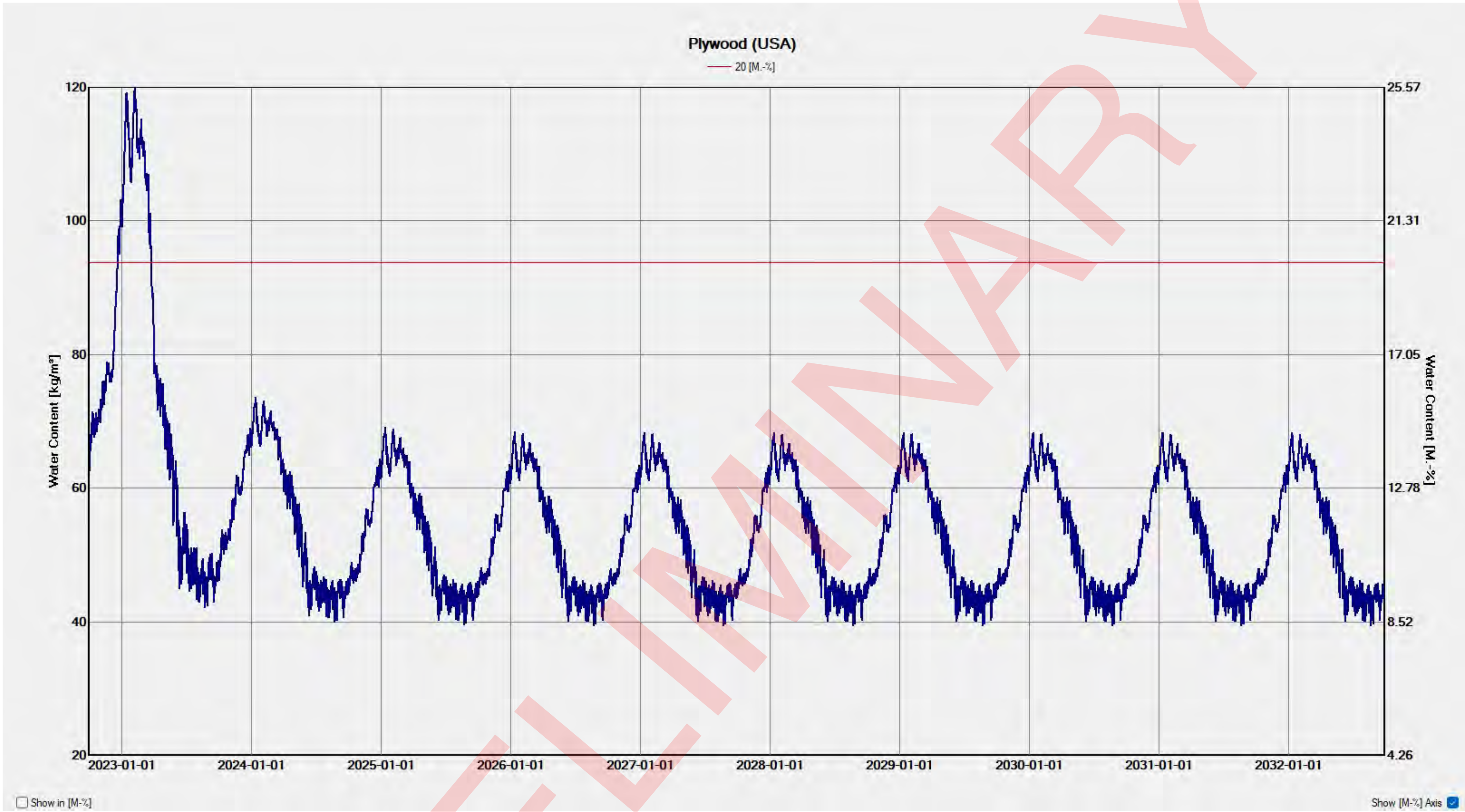


Figure 3 – WUFI® output for Building A Lower Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building A East Lower Wall assembly's inner 1/8-inch plywood layer

BUILDING A: POST-RETROFIT ROOF

The post-retrofit Building A Roof assembly simulated 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 generally small.

Again, the plywood layers were subdivided, respectively, into three adjacent layers per the PHIUS+ protocol. The plywood layers were the author's focus for the assembly observations. Due to lack of information regarding venting, attic space/height, etc., several scenarios were studied for the Building A post-retrofit double-attic roof. This included varying the air change rates in the two attic spaces – this includes the following scenarios:

Roof Orientation	Existing Attic Air Exchange	New Attic Air Exchange
West	0 ACH from interior	10 ACH
	10 ACH from interior	
	0.1 ACH from interior	
	0.01 ACH from interior	
	5 ACH from interior & exterior	
East	0 ACH from interior	10 ACH
	10 ACH from interior	
	0.1 ACH from interior	
	0.01 ACH from interior	
	5 ACH from interior & exterior	

In the roof assembly, the MC in all studied layers decreases or remains stable throughout the 10-year period studied, and the 20% MC threshold is not surpassed in any of these layers (**Figure 4**). However, per WUFI® film results, the relative humidity in the air space reaches almost 100% humidity behind the new plywood layer and above the new cellulose layer (**Figure 5**).

Moreover, using the same previously stated assumptions and inputs for the biogenic materials, the VTT simulation conducted indicated a green traffic light status for the plywood layers.

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 whether the plywood can be subject to certain periods of high moisture content, as well as all wood layers' mold resistance properties.

Moreover, further detail (venting, height, etc.) of the newly created attic space is required for future simulations if this project should proceed to construction as high RH levels may be expected.

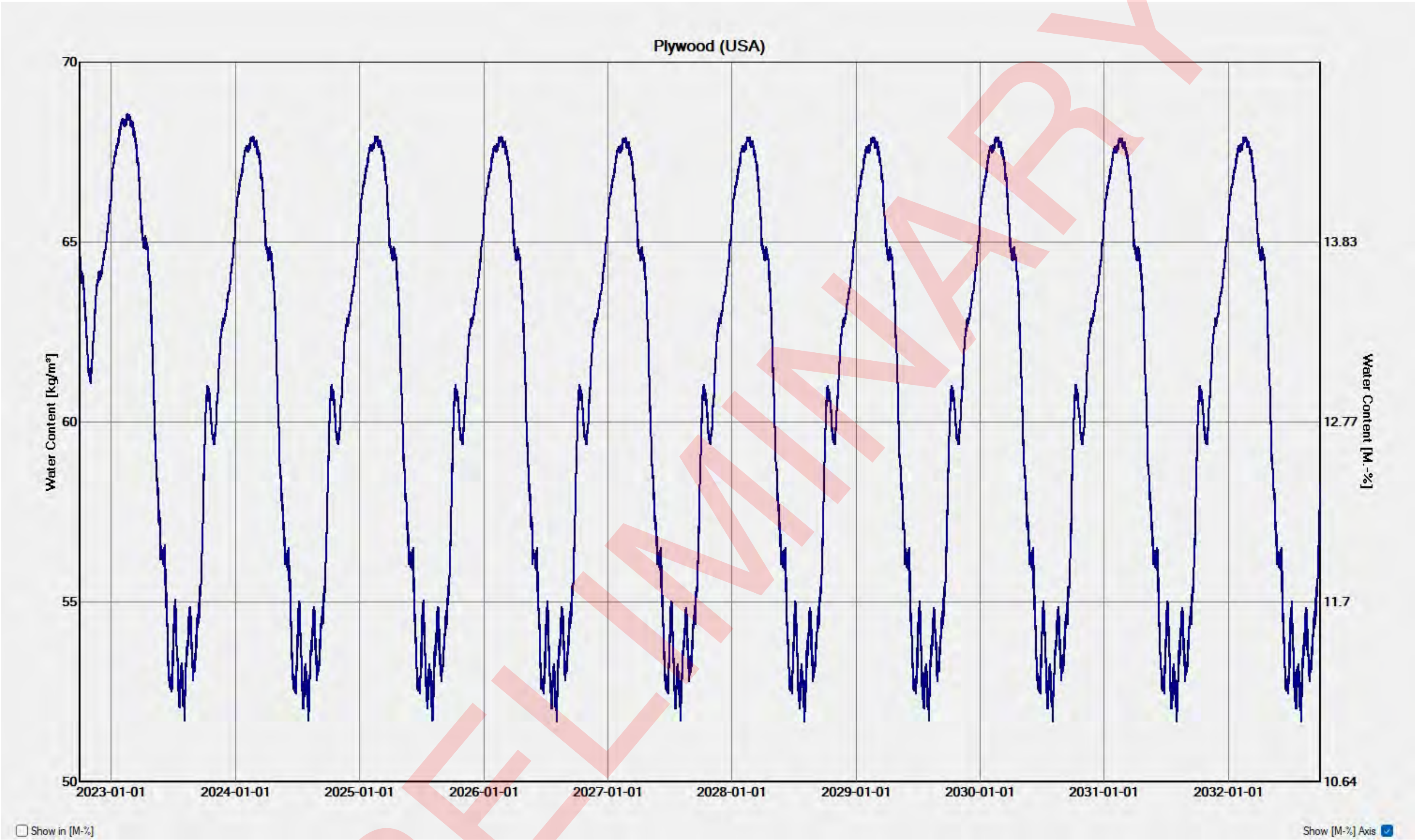


Figure 4 – WUFI® output for Building A Roof assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building A West Roof assembly's [new] outer 1/8-inch plywood layer (scenario with 0ACH existing attic, 10ACH new attic space

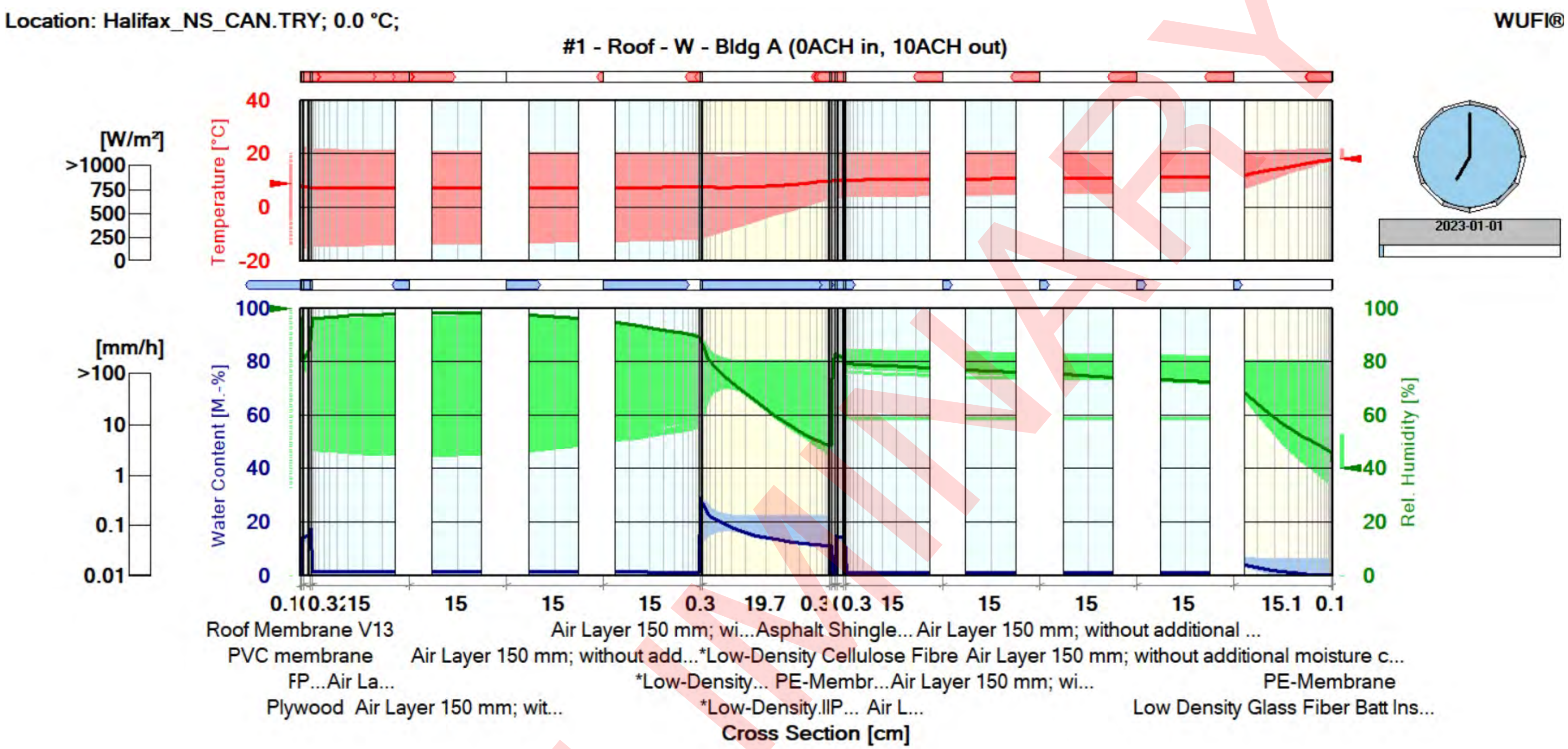


Figure 5 – WUFI® film output for Building A Roof assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building A West Roof assembly – high RH in new airspace (new attic space)

BUILDING B: POST-RETROFIT LOWER WALL (North, East, West)

The post-retrofit Building B Lower Wall North, East, and West assembly simulated 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 the innermost 1/8-inch layer of the new plywood of the North lower wall assembly, the mass percentage of water content (MC) remains above 20% between approximately mid-December 2022 and late April 2023, but then dries out below 20% in subsequent years (**Figure 6**). Plywood layers in the East and West orientations also experience MC spikes above 20% between December 2022 and April 2023, but remain below 20% after the first year of simulation. Moreover, all three orientations achieve green VTT traffic light status in the plywood layers as well as the outermost cellulose element.

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.

Moreover, depending on the proximity of the two buildings in question and their respective new roof systems, the effects of shade should, in the future, be simulated for certain wall systems.

BUILDING B: POST-RETROFIT UPPER WALL (North, East, West)

The post-retrofit Building B Upper Wall North, East, and West assembly simulated 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 was the case in the North, East, and West Lower Wall of Building B, certain plywood layers experience periods of MC above 20% in the first year of simulation but fall below 20% in subsequent years in the Upper Wall. For instance, the East orientation's outermost plywood layer only experiences MC above 20% from 2022-12-17 to 2023-01-15 and again from 2023-02-09 to 2023-02-16; the innermost plywood only experiences continued +20% MC between 2022-12-19 and 2023-03-25 (**Figure 7**). Moreover, all plywood layers as well as the outermost cellulose element in the three orientations achieve green VTT traffic light status.

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.

Moreover, depending on the proximity of the two buildings in question and their respective new roof systems, the effects of shade should, in the future, be simulated for certain wall systems.

BUILDING B: POST-RETROFIT LOWER WALL (South)

The post-retrofit Building B Lower Wall South assembly simulated did not demonstrate any numerical errors for the South orientation 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, the plywood layer was subdivided into three adjacent layers per the PHIUS+ protocol. In the Building B Lower Wall South assembly, the MC in all studied layers decreases or remains stable throughout the 10-year period studied, and only a 9-day spike in MC above 20% in the outermost plywood layer occurs in mid-February of the first year of study (**Figure 8**). Moreover, using the same previously stated assumptions and inputs for the biogenic materials, the VTT simulation conducted indicated a green traffic light status for the plywood layers and outermost cellulose element in the retrofit panel.

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.

Moreover, depending on the new roof system installed, the effects of shade should, in the future, be simulated for certain wall systems.

BUILDING B: POST-RETROFIT UPPER WALL (South)

The post-retrofit Building B Upper Wall South assembly simulated did not demonstrate any numerical errors for the South orientation 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, the plywood layer was subdivided into three adjacent layers per the PHIUS+ protocol. In the Building B Upper Wall South assembly, the MC in all studied layers decreases or remains stable throughout the 10-year period studied, and only a 10-day spike in MC above 20% in the outermost plywood layer occurs in mid-February of the first year of study (**Figure 9**). Moreover, using the same previously stated assumptions and inputs for the biogenic materials, the VTT simu lation conducted indicated a green traffic light status for the plywood layers and outermost cellulose element in the retrofit panel.

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.

Moreover, depending on the new roof system installed, the effects of shade should, in the future, be simulated for certain wall systems.

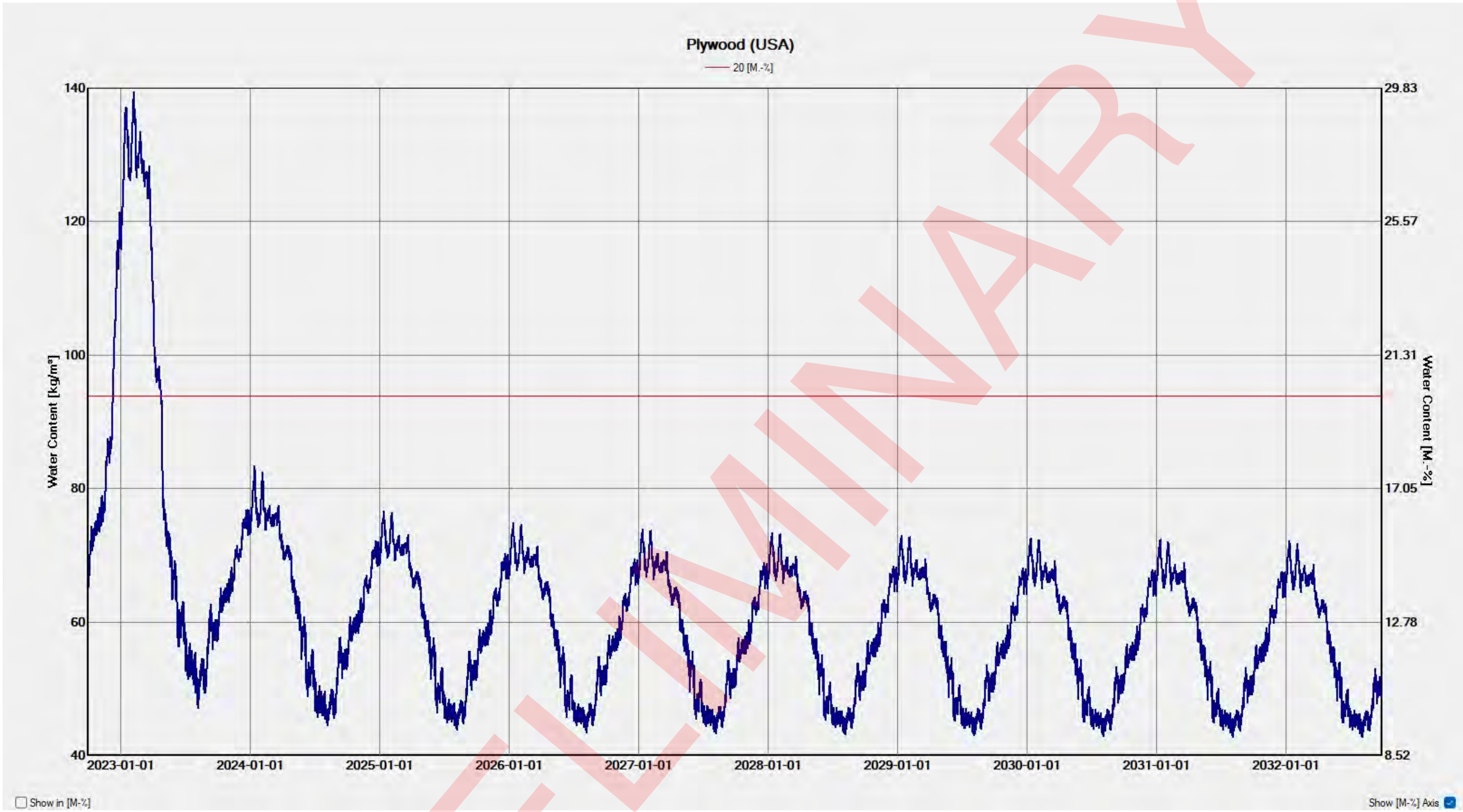


Figure 6 - WUFI® output for Building B Lower Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B North Lower Wall assembly's [new] inner 1/8-inch plywood layer

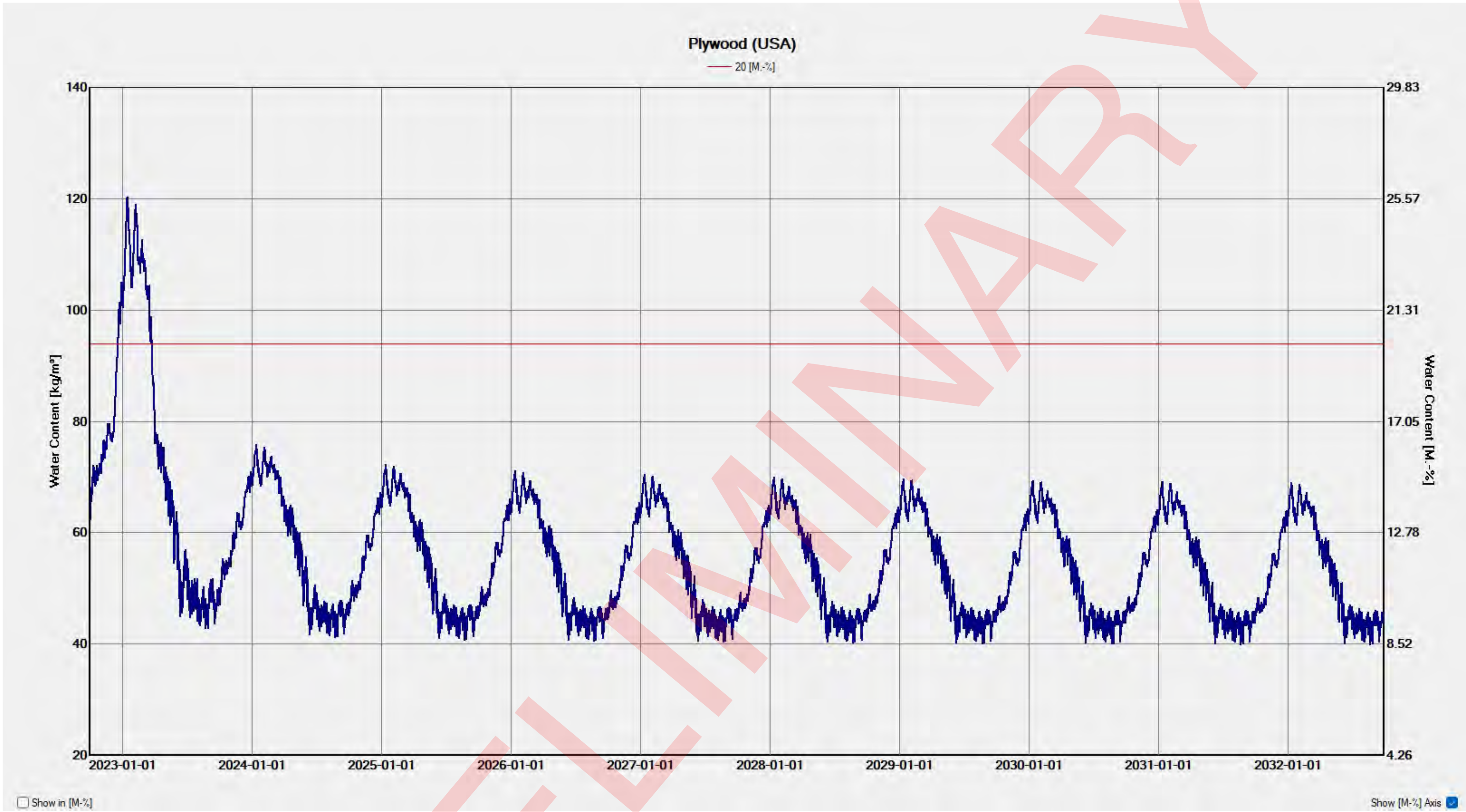


Figure 7 - WUFI® output for Building B Upper Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B East Upper Wall assembly's inner 1/8-inch plywood layer

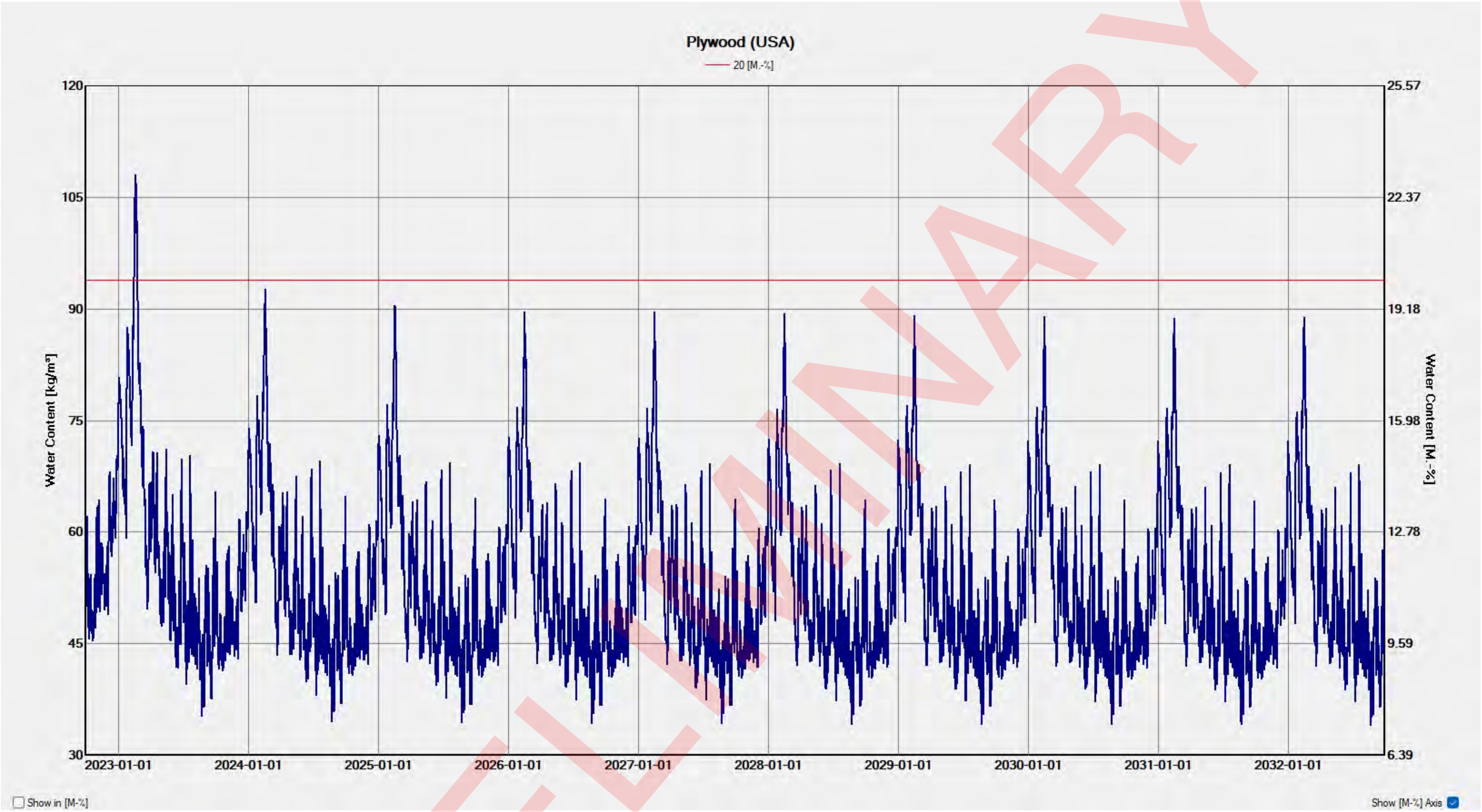


Figure 8 – WUFI® output for Building B Lower Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B South Lower Wall assembly's outer 1/8-inch plywood layer

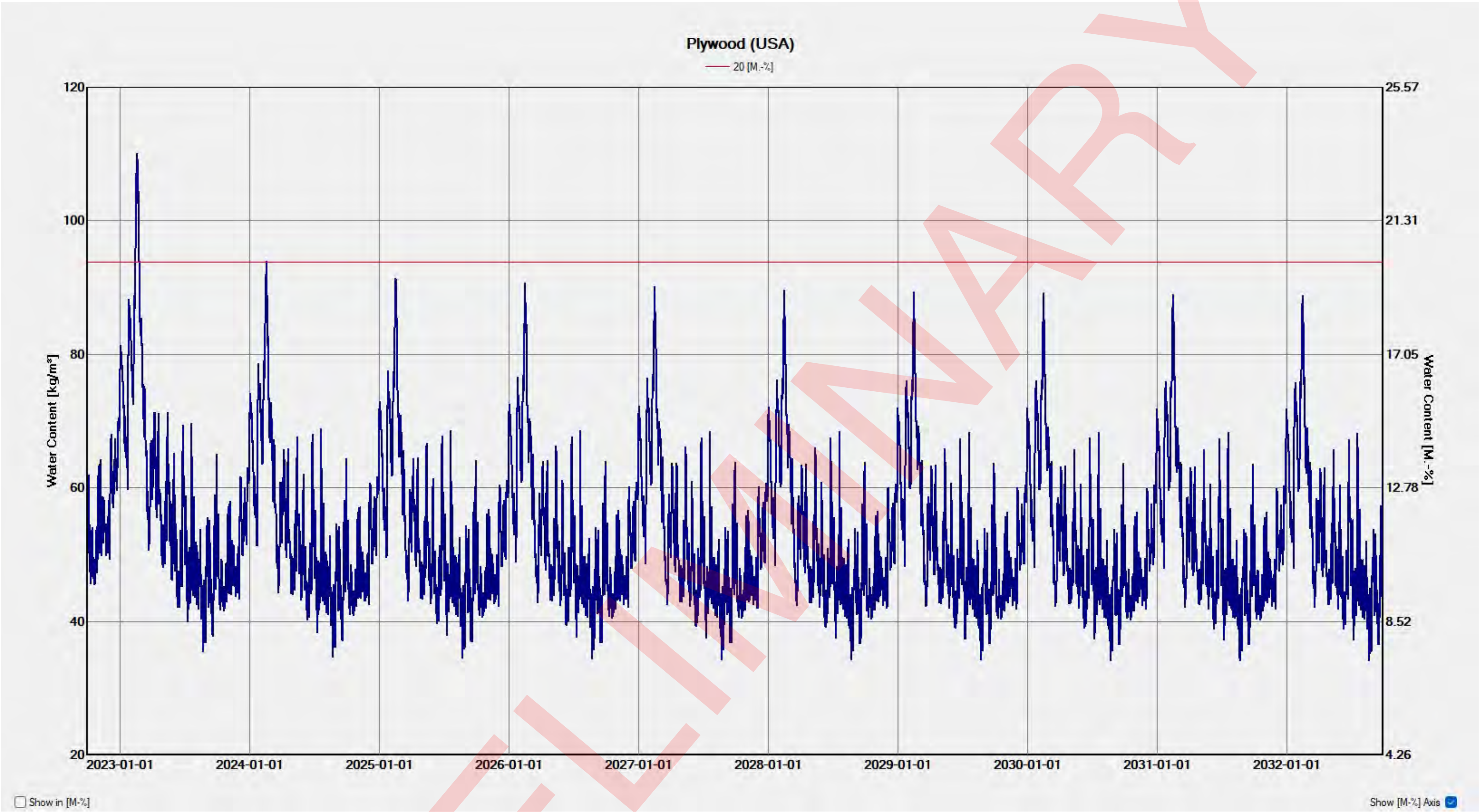


Figure 9 – WUFI® output for Building B Upper Wall assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B South Upper Wall assembly's outer 1/8-inch plywood layer

BUILDING B: POST-RETROFIT ROOF

The post-retrofit Building B roof assembly simulated did not demonstrate any numerical errors for the 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 generally small.

Again, the plywood layer was subdivided into three adjacent layers per the PHIUS+ protocol. In the roof assembly, the MC in all studied layers decreases or remains stable throughout the 10-year period studied, and the 20% MC threshold is not surpassed in any of these layers (see **Figure 10**, **Figure 11**). However, per WUFI®'s film results, the relative humidity in the air space reaches almost 100% humidity behind the new plywood layer and above the new cellulose layer (**Figure 12**). Further detail is required for the newly created attic space in terms of venting, height, etc.

Moreover, using the same previously stated assumptions and inputs for the biogenic materials, the VTT simulation conducted indicated a green traffic light status for the plywood layers. However, in the South orientation of the shaded simulation conducted, the mold growth index increases in magnitude over time within the innermost plywood layer (**Figure 13**). For this reason, a 20-year model was created solely for VTT simulation of the innermost plywood layer, the results of which seem to trend towards a gradual plateau of the mold growth index in the long-term (**Figure 14**).

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 whether the plywood can be subject to certain periods of high moisture content, as well as all wood layers' mold resistance properties. It is important that a study of the long-term mold-resistance of the plywood be studied prior to construction, as the present WUFI® results indicate an annual increase in mold growth index that may plateau in later years.

Finally, further detail (venting, height, etc.) of the newly created attic space is required for future simulations if this project should proceed to construction as high RH levels may be expected.

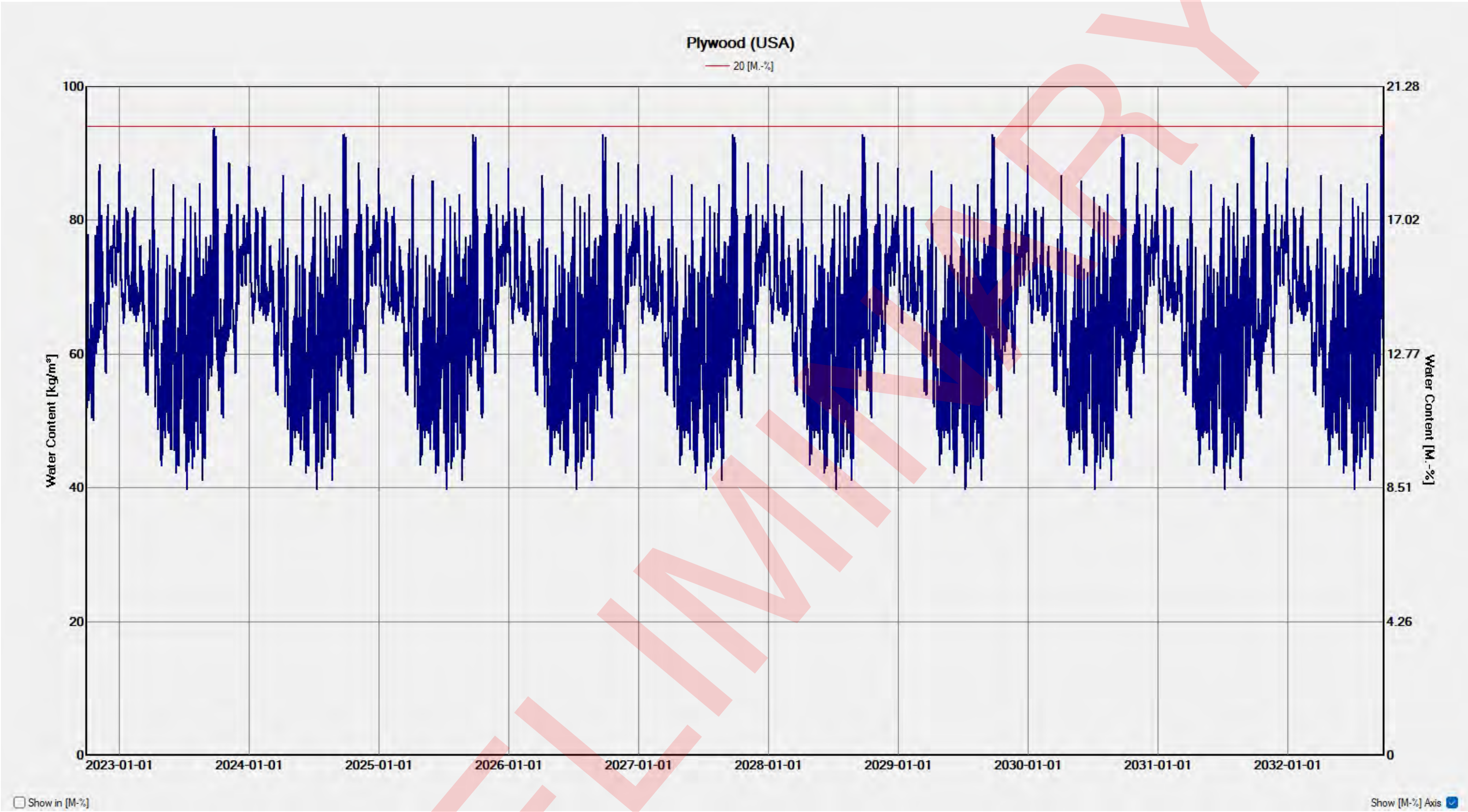


Figure 10 - - WUFI® output for Building B Roof assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B North Roof assembly's inner 1/8-inch plywood layer (shaded scenario)

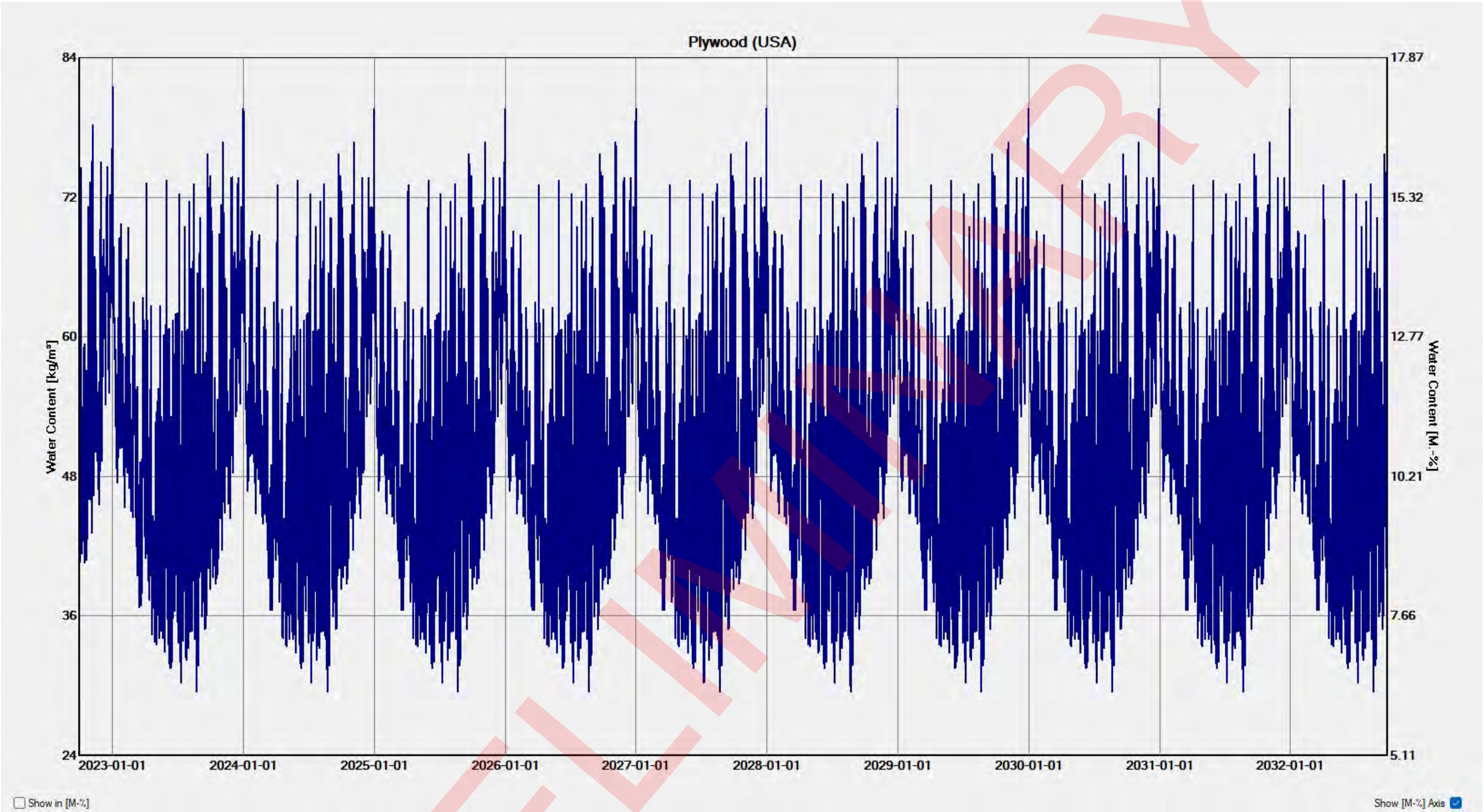


Figure 11 - WUFI® output for Building B Roof assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B South Roof assembly's inner 1/8-inch plywood layer (unshaded scenario)

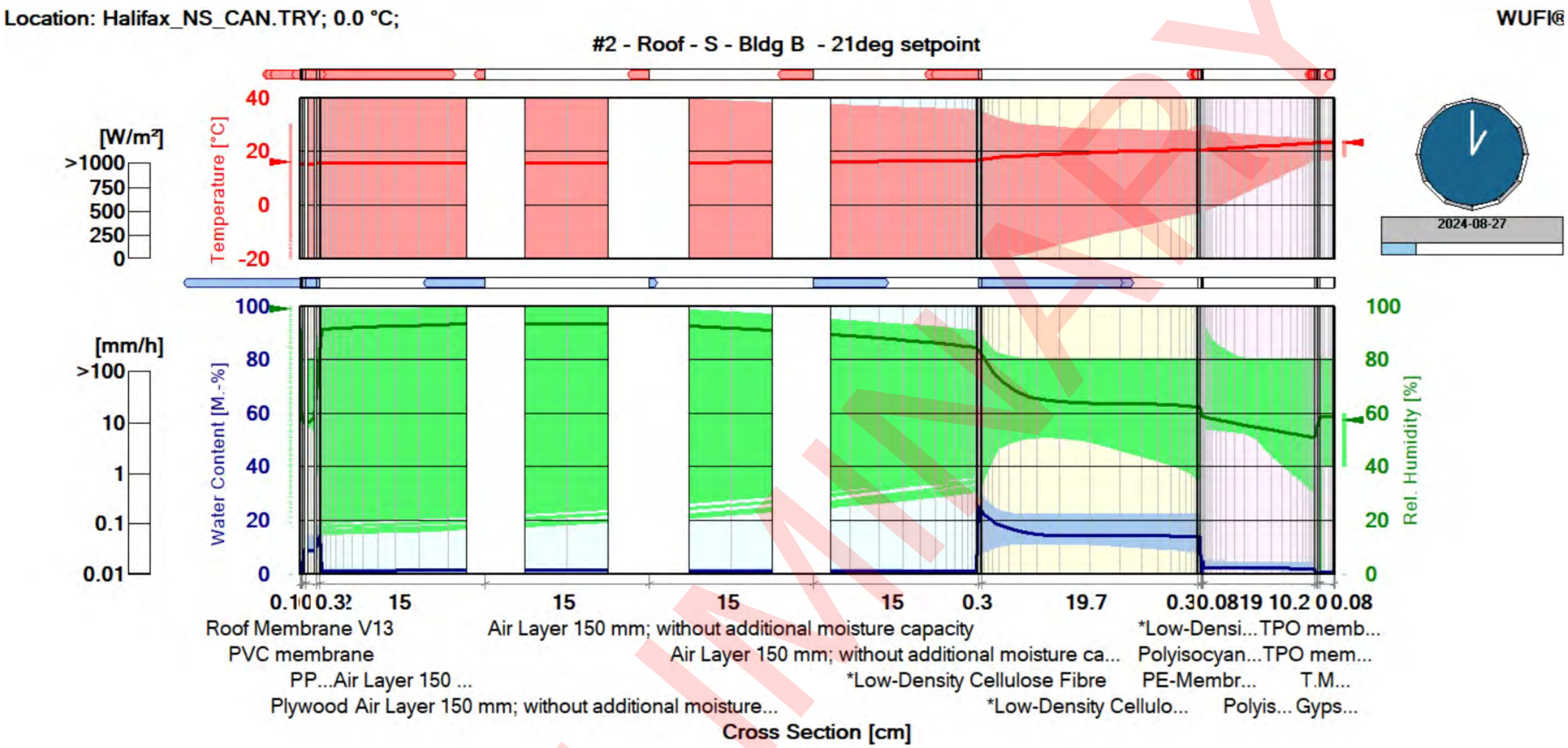


Figure 12 - WUFI® film output for Building B Roof assembly: water content (kg/m³, %) over 10-year period studied for post-retrofit Building B South Roof assembly – high RH in new airspace (new attic space, unshaded scenario)

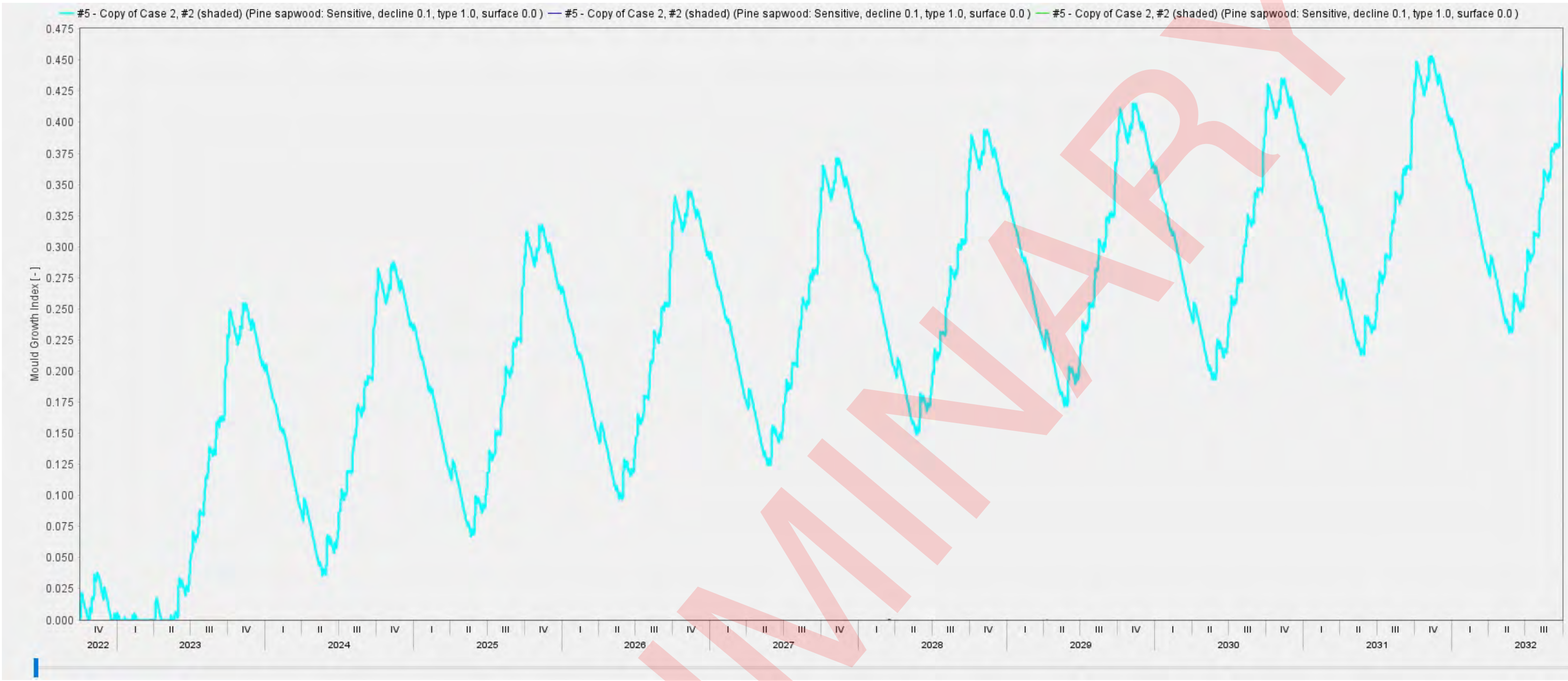


Figure 13 – WUFI® VTT output for Building B Roof assembly: mold growth index over 10-year period studied for post-retrofit Building B South Roof assembly's inner 1/8-inch plywood layer (shaded scenario)

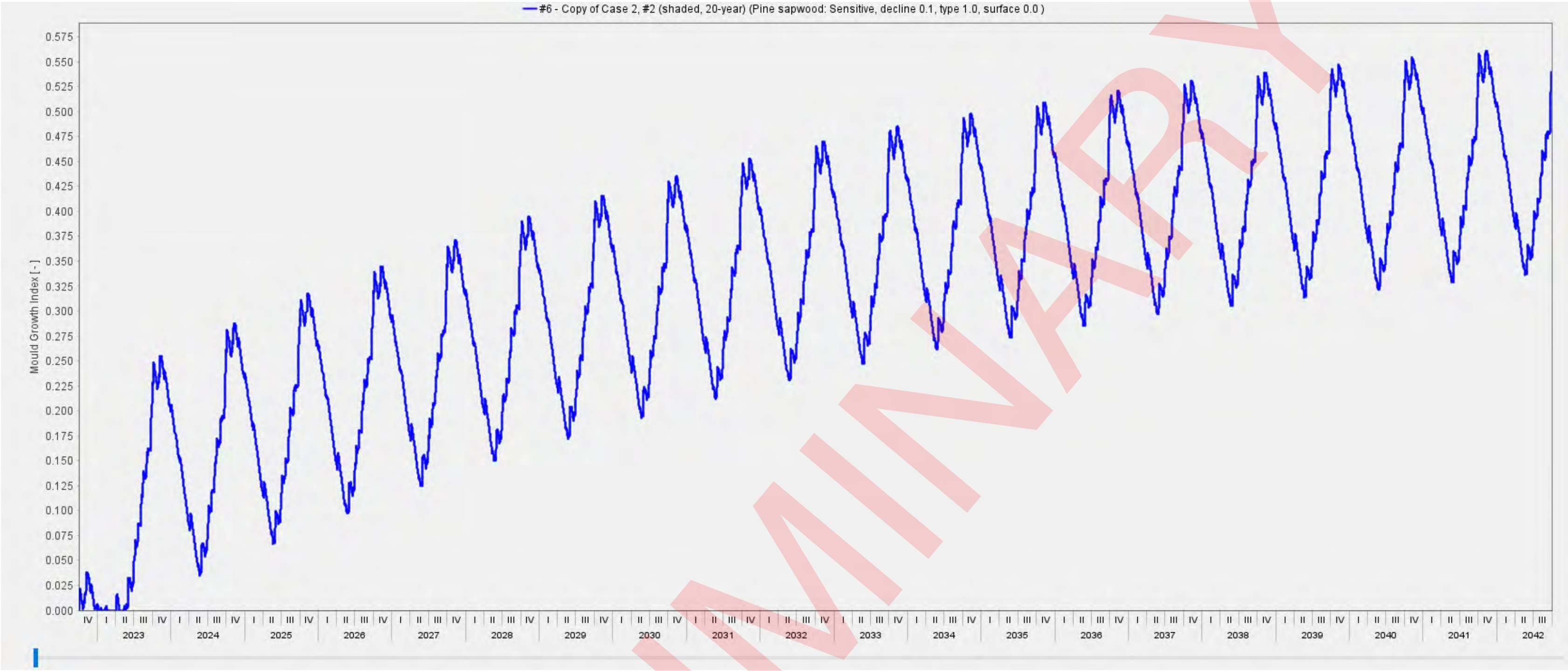


Figure 14 – WUFI® VTT output for Building B Roof assembly: mold growth index over 20-year period studied for post-retrofit Building B South Roof assembly's inner 1/8-inch plywood layer (shaded scenario)

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 Municipality of Colchester and the ReCover team, as well as available predefined WUFI® materials;
- The attic spaces simulated were of average estimated height;
- Both buildings in question have multi-roof systems with varying inclinations, respectively. This cannot be specifically modelled in WUFI® Pro, as one inclination must be chosen for the entire assembly under simulation. Moreover, the inclination of the Building B roof assembly was decreased to 29° as less trustworthy results were obtained using higher inclinations in WUFI®;
- 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 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 preliminary feasibility report 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, hygrothermal models will need to be simulated 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

APPENDIX A

Assembly Notes

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building A)		
Case:	LOWER Wall (Assembly 3, sheet A6)		
Reference Files:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
1"x6" V-Joint Wood Siding	Composite Wood Siding (N.A. Database)	Permeability at each RH level increased by 15% to achieve approximately 10 perms permeance under WET conditions as per Building Science Corp. Info-312	Assumption
15LB Asphalt Paper	Bituminous Paper (#15 Felt) (N.A. Database)	-	Assumption
1/2" Plywood Sheathing	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol

R20 Batt with 4mil V.B.	Low Density Glass Fiber Batt Insulation (N.A. Database) + PE-Membrane (Poly; 0.07 perm)	Altered PE permeability from 0.0026 perm-inch to 0.003937 perm-inch to increase permeability (assumed approx. 0.10 perms for 4 mil poly)	- + https://inspectapedia.com/interiors/Perm-Ratings-for-Materials.php
5/8" Gypsum Board	Gypsum Board (USA) (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building A)		
Case:	UPPER Wall (Assembly 3 without siding, sheet A6)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
15LB Asphalt Paper	Bituminous Paper (#15 Felt) (N.A. Database)	-	Assumption
1/2" Plywood Sheathing	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
R20 Batt with 4mil V.B.	Low Density Glass Fiber Batt Insulation (N.A. Database) + PE-Membrane (Poly; 0.07 perm)	Altered PE permeability from 0.0026 perm-inch to 0.003937 perm-inch to increase permeability (assumed approx. 0.10 perms for 4 mil poly)	- + https://inspectapedia.com/interiors/Perm-Ratings-for-Materials.php
5/8" Gypsum Board	Gypsum Board (USA) (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building A)		
Case:	Roof (Assembly 1, sheet A6)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Corrugated metal roofing	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol
Low perm roof membrane	PVC Membrane (N.A. Database)	-	Assumption
5/8" sheathing	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
Vented air space	Air Layer 150 mm; without additional moisture capacity (Generic Materials)	4 x material = 600 mm airspace Vented at 10ACH	Assumption
8" loose fill cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer-IBP)	Bulk density changed to 55 kg/m3; Thermal conductivity changed to 0,05 W/mK	Assumption; ReCover
6 mil vapour barrier taped for air tightness	PE-Membrane (Poly; 0.07 perm) (Fraunhofer-IBP)	-	Assumption
210 lbs Asphalt Shingles	Asphalt Shingle System (N.A. Database)	-	Assumption
15# Asphault Paper	Bituminous Paper (#15 Felt) (N.A. Database)	-	-
5/8" SPF plywood sheathing	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
Unvented air space	Air Layer 150 mm; without additional moisture capacity (Generic Materials)	4 x material = 600 mm airspace Vented at 0, 0.01, 0.1, 5, and 10ACH	Assumption

R20 Batt Insulation	Low Density Glass Fiber Batt Insulation (N.A. Database)	-	-
6 mil vapour barrier	PE-Membrane (Poly; 0.07 perm) (Fraunhofer-IBP)	-	Assumption

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building B)		
Case:	North, East, West LOWER Wall (Assembly 4, sheet A5)		
Reference Files:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
1"x6" V-Joint Wood Siding	Composite Wood Siding (N.A. Database)	Permeability at each RH level increased by 15% to achieve approximately 10 perms permeance under WET conditions as per Building Science Corp. Info-312	Assumption
2 LAYERS 15 LB BLDG. PAPER	Bituminous Paper (#15 Felt) (N.A. Database)	2 x material	Assumption
2.5" rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
10" concrete block	Concrete Brick (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building B)		
Case:	North, East, West UPPER Wall (Assembly 2, sheet A5)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
2.5" rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
10" concrete block	Concrete Brick (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building B)		
Case:	South LOWER Wall (Assembly 3, sheet A5)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
1-1/2" DEEP PRE-FINISHED PANEL	Metal Deck, unperforated (N.A. Database)	Default WUFI material thickness used (0.0008m)	-
2.5" rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
10" concrete block	Concrete Brick (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building B)		
Case:	South UPPER Wall (Assembly 2, sheet A5)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf*		
	21 11 22 - Colchester Build Plan.pdf		
	Colchester - Existing Building Assemblies (2022-08-29).pdf		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
7/8" corrugated metal siding (vented)	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)	-	-
1/2" SPF Plywood sheathing	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
2.5" rigid insulation	Extruded Polystyrene Insulation (N.A. Database)	-	Assumption
10" concrete block	Concrete Brick (N.A. Database)	-	-

Assembly Notes			
Project:	Colchester NRCan Pilot Project (Building B)		
Case:	Roof (Assembly 1, sheet A5)		
Reference File:	*Water Utility Building Structural Plans - 251 Lancaster Cres.pdf* *21 11 22 - Colchester Build Plan.pdf* *Colchester - Existing Building Assemblies (2022-08-29).pdf*		
Assembly (Exterior to Interior)	**Modeled Material (DB/Mat'l)**	**Alterations (If Applicable)**	**Supporting Docs. (If Applicable)**
Corrugated metal roofing	Roof Membrane V13 (Generic Materials)	-	PHIUS+ protocol
Low perm roof membrane	PVC Membrane (N.A. Database)	-	Assumption
5/8" sheathing	Plywood (USA) (N.A. Database)	Split into three layers, 1/8" inner and outer	PHIUS+ protocol
Vented air space	Air Layer 150 mm; without additional moisture capacity (Generic Materials)	4 x material = 600 mm airspace Vented at 10ACH	Assumption
8" loose fill cellulose	Cellulose Fibre (heat cond.: 0,04 W/mK) (Fraunhofer-IBP)	Bulk density changed to 55 kg/m3; Thermal conductivity changed to 0,05 W/mK	Assumption; ReCover
6 mil vapour barrier taped for air tightness	PE-Membrane (Poly; 0.07 perm) (Fraunhofer-IBP)	-	Assumption
Torch on Membrane	Polyisocyanurate Board, Glass-Matt Facer	-	Assumption
4" Rigid Insulation	Polyisocyanurate Board (N.A. Database)	-	Assumption
Flood coat (not modelled)	-	-	Assumed TPO Membrane sufficient for modelling
3 ply roofing membrane	TPO Membrane (N.A. Database)	3 x material	Assumption
1/2" gypsum board	Gypsum Board (USA) (N.A. Database)	-	-
1.5" metal roof deck	Metal Deck, unperforated (N.A. Database)	-	-

Appendix K

Embodied Carbon

NRCan | Recover FEED Studies

Colchester Retrofit Building Embodied Carbon Assessment

Fatma Osman, BA, Toronto Metropolitan University

INTRODUCTION

This report presents an embodied carbon analysis of the Colchester 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).

Colchester Retrofit Project LCA results summary

Table 1: Total Global Warming Potential

Colchester building gross floor area m2	A1-A3 KgCO2e/m2	A1-C4 KgCO2e/m2	Biogenic carbon
720	69.47	89.28	156.5

The major contributors to the GWP in this design are the wood used for building the truss, and the steel wall cladding. The A1-A3 Materials stage contributed 78% 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 by 43% , making the building have a surplus in carbon storage capacity. This storage is attributed to the wood products (92.7%) and cellulose insulation (7.3%) 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

Colchester Retrofit Global Warming by Stage and Material

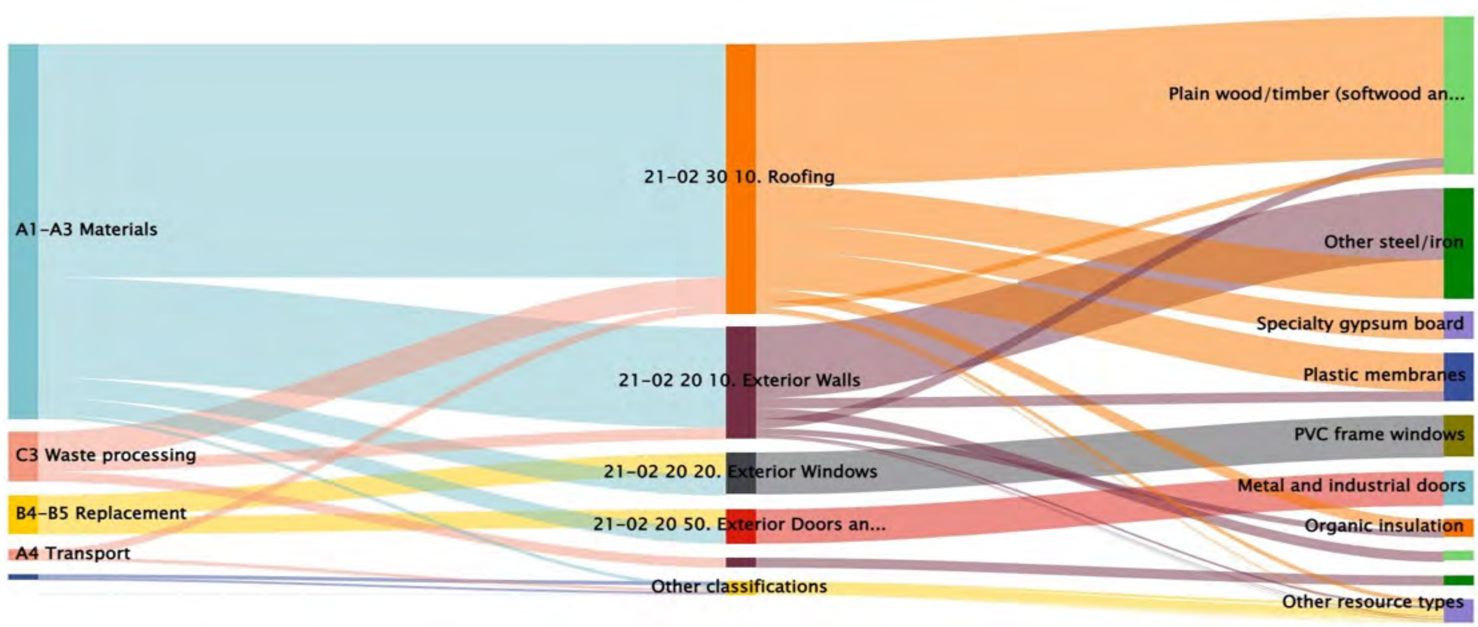


Figure 1: Colchester retrofit design breakdown of the life cycle stages and the associated materials

Colchester Retrofit Life-Cycle Impacts by Stage (%)

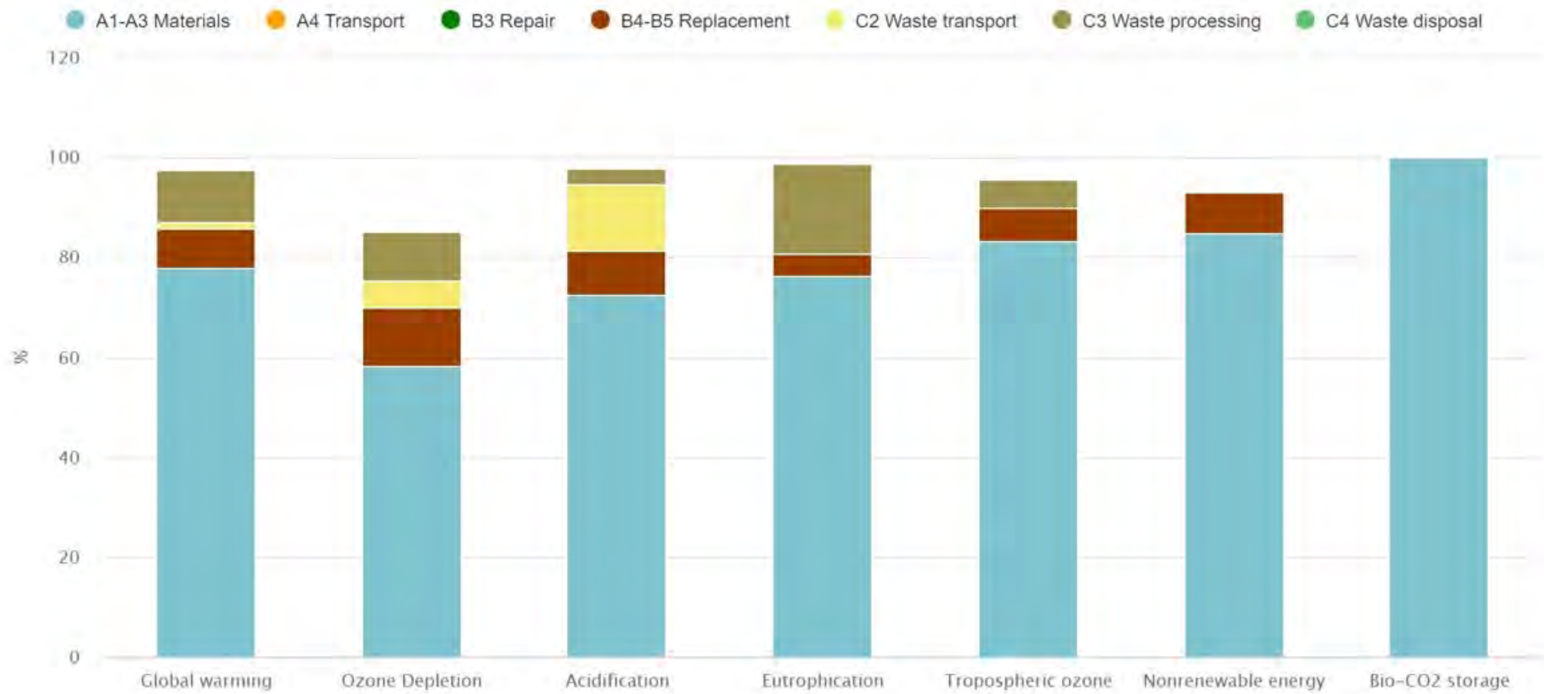


Figure 2: Colchester retrofit design breakdown of the life cycle impact categories and the associated life cycle stage

Colchester Retrofit Life-Cycle Impacts by Material (%)

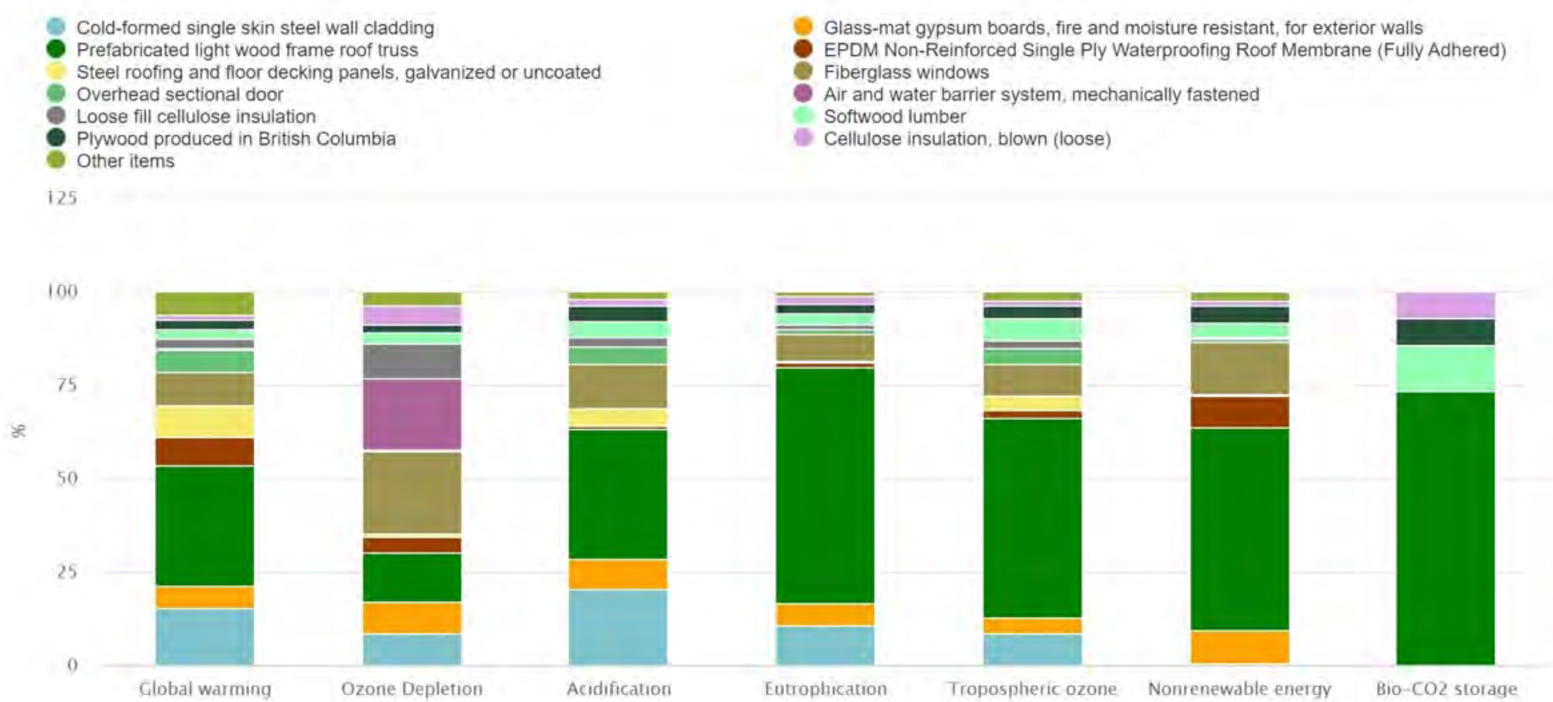


Figure 3: Colchester retrofit design breakdown of the life cycle impact categories and the associated materials

Appendix

Proposed Retrofit Assemblies and Environmental Impact calculations

Colchester

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)		*	67.8	0.5%
1/2" SPF plywood sheathing	Plywood produced in British Columbia, 477.33 kg/m3 (Forestry Innovation Investment)	13	10.488	1381.1	10.0%
2x6 SPF framing	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		14.559	1077.7	7.8%
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	0.976	27.1	0.2%
Exterior strapping (#3)	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		0.86	63.7	0.5%
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	93.704	822.9	5.9%
Intello plus	High performance vapor barrier, 0.021 in (0.5 mm), 0.76 kg/m2, Florprufe® 120 (GCP Applied Technologies)		*	237.3	1.7%
1x4 strapping	Softwood lumber, 405 kg/m3 (Canadian Wood Council)		1.912	141.5	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)**		*****	**9555.4**	**68.9%**
4" EPS wall insulation	EPS insulation (generic)	0.1016	30	347.4	2.5%
2" thick below grade fin		0.0508			
Cement board	Cement board, 1/2 in (12.7 mm), 11.8 kg/m2, PLUS (PermaBASE Building Products)	0.00635	0.3175	137.8	1.0%
Total				**13859.5**	100.0%
* Software calculates the impact based on the area provided			**Per m2**	**19.2**	**kg CO2/m2**

Roof Assembly

Material (ReCover specification)	Description (from EPD)	Thickness (mm)	Volume of material (m3)	Carbon emissions (A1-A3) (KgCO2E)	% of total
Trusses over existing	**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))**		108	**18,921.60**	**60.7%**
R25 loose fill cellulose	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)), Lambda=0.039 W/(m.K)	0.1761	131.6	1,582.45	5.1%
New sheathing (DenseGlass Sheathing)	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)	0.0159	11.9	3,610.86	11.6%
New roofing	Steel roofing and floor decking panels, galvanized or uncoated, tensile strength: 410-655 N/mm2, 7800 kg/m3 (Nucor)	0.000340	0.3	5,179.10	16.6%
WRB membrane	EPDM Non-Reinforced Single Ply Waterproofing Roof Membrane (Fully Adhered), 60 mils: 2.07 kg/m2 (Single Ply Roofing Industry)		*	1,861.93	6.0%
Total				**31,155.94**	100.0%
* Software calculates the impact based on the area provided			**Per m2**	**43.3**	**kg CO2/m2**

Windows and Doors

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)	*	*	333	6.7%
High performance overhead doors	Overhead sectional door, 3600x3600mm, TX42 (Alsta)	*	*	1,942	38.8%

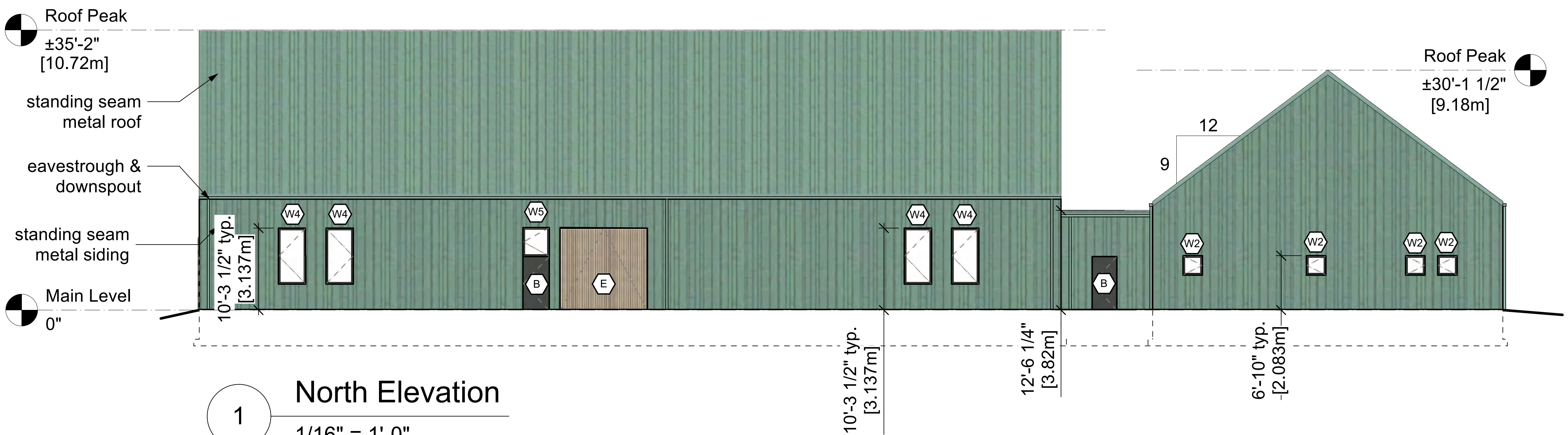
High performance triple pane windows	Fiberglass windows, 1.5m x 1.3 m, 40 mm frame thickness, 1.42 m2 glazing area, 60.50 kg/m2, 300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series (Inline)	*	*	2,725.20	54.5%
Total				**5,000.2**	100.0%
* Quantity is calculated in software based on area and/or number of units			**Per m2**	**3.8**	**kg CO2/m2**

Environmental Emissions

Colchester 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	64,281.28	50015.66	1536.46	5222	7507.16	77.8%
Ozone Depletion	kg CFC11e	0.00	0.0016	0.0004	0.00033	0.00043	58.0%
Acidification	kg SO_2e	414.30	300.77	8.75	36.73	68.05	72.6%
Eutrophication	kg Ne	105.60	80.61	1.23	4.52	19.24	76.3%
Formation of tropospheric ozone	kg O3e	5,696.40	4736.08	248.2	384.82	327.3	83.1%
Depletion of nonrenewable energy	MJ	676,424.23	573936.9	43688.2	54952.29	3846.84	84.8%
Biogenic carbon storage	kg CO2e	112,667.20	112667.2	0	0	0	100.0%

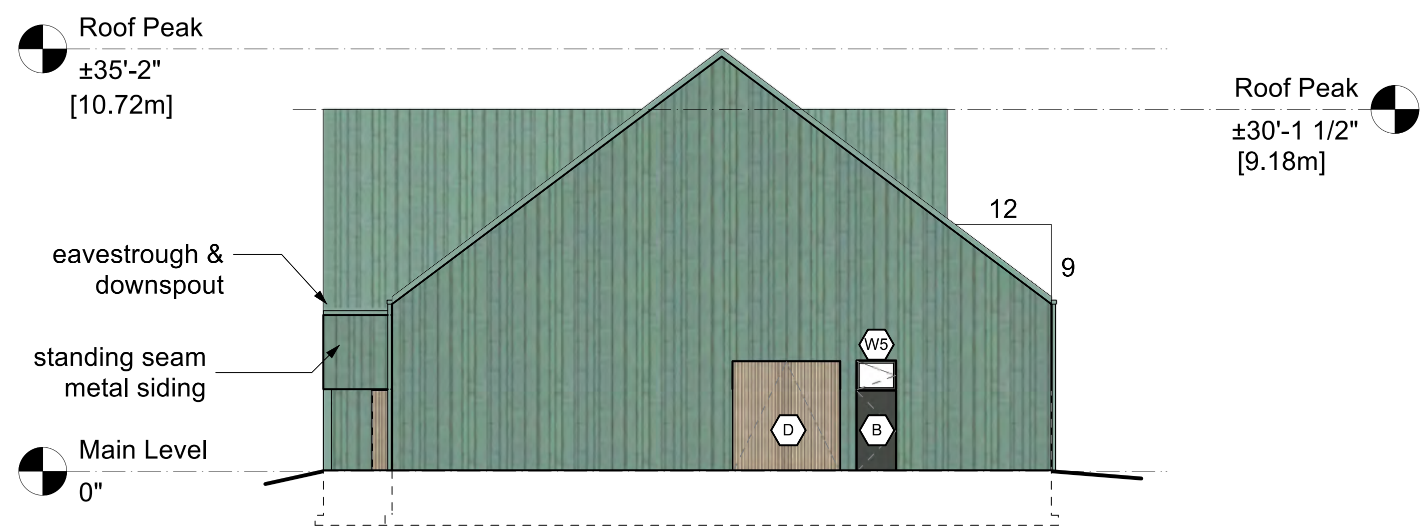
Appendix L

Architectural Elevation Drawings



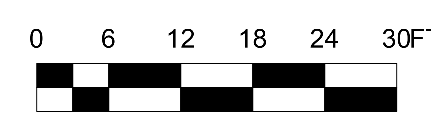
1 North Elevation

1/16" = 1'-0"



2 East Elevation

1/16" = 1'-0"



graphic scale:

north arrow:

habit studio

6437 Cork St, Halifax, NS
email: lorrie@habitstudio.ca | tel: 902.448.6873

ReCover

Debert Water Utility Building

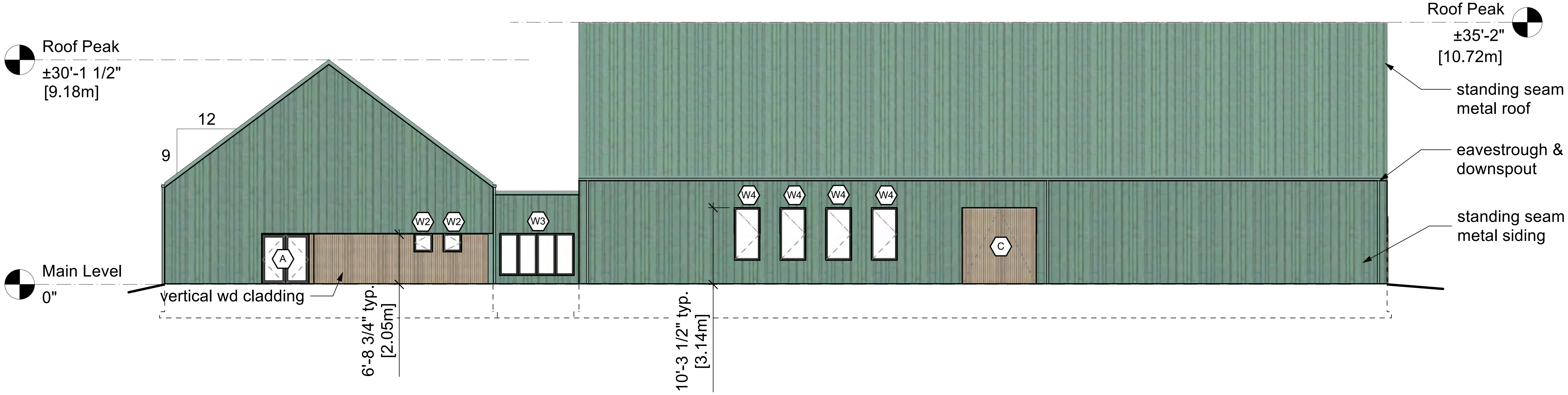
Municipality of Colchester, NS

ReCover Initiative Panelized Deep Retrofit Study

drawing title: Proposed North & East Elevations

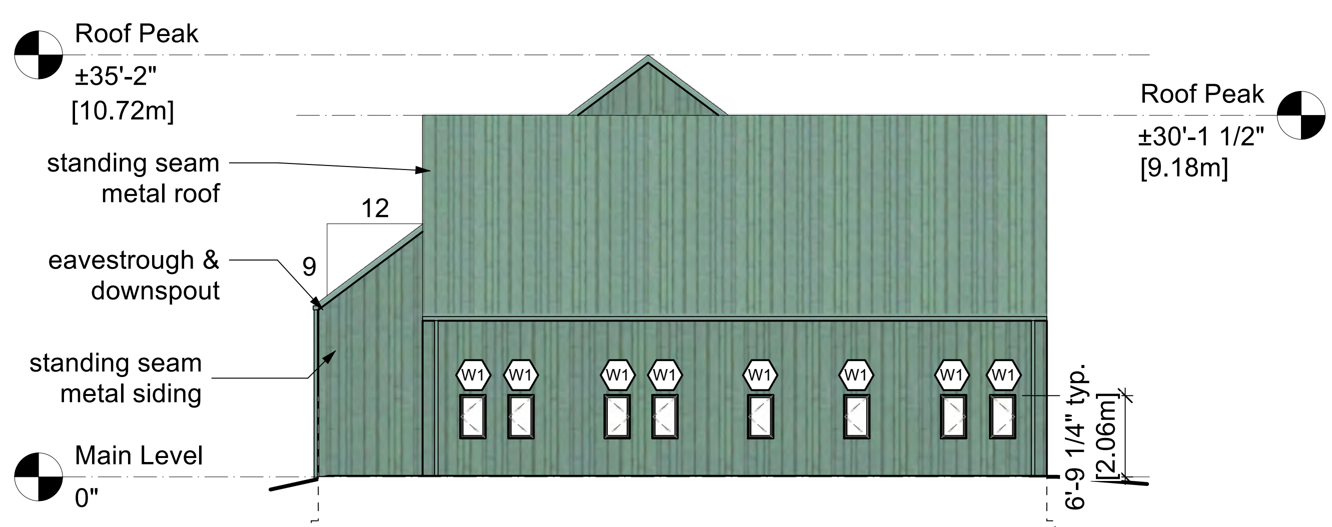
phase: concept		sheet size: 17x11
drawn by: IG	checked by: LR	drawing number: A1
date: 2023-08-15	scale: as noted	

Colchester_CURRENT.vwx



3 South Elevation

1/16" = 1'-0"



4 West Elevation

1/16" = 1'-0"

0 6 12 18 24 30FT

graphic scale: | north arrow:

habit studio

6437 Cork St, Halifax, NS

email: lorrie@habitstudio.ca | tel: 902.448.6873

ReCover

Debert Water Utility Building

Municipality of Colchester, NS

ReCover Initiative Panelized Deep Retrofit Study

Colchester_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

Colchester Municipal Operations Building

		NSBC Reference
Building A Area (Footprint):	181 m²	
Gross Floor Area:	181 m²	
Building Height:	1 Storey	1.4.1.2
Major Occupancy, Proposed:	Group D - Business	3.1.2.1.

CONSTRUCTION REQUIREMENTS

		NSBC Reference
Construction Governed by:	NSBC Part 9	1.3.3.3.
Building Area:	< 1,000 m²	3.2.2.62.(1)
Building Height:	1 Storey	3.2.2.62.(1)
Streets to Face:	None	
Construction Type:	Combustible or Nomcombustible	3.2.2.62.(2)
Fire Resistance Ratings:		
Upper Floors (n/a):	45 Minute	3.2.2.62.(2)(a)
Loadbearing Elements supporting an assembly required to have a fire-resistance rating	45-minute FRR or noncombustible	3.2.2.62.(2)(b)
Roof, Occupied (n/a):	N/A	
Loadbearing Elements supporting a fire separation	N/A	
Sprinkler:	not required	3.2.2.62.
Standpipe:	not required	3.2.5.8.(c)
Fire Alarm:	not required	3.2.4.1.
Portable Fire Extinguisher:	Required within 22.9 m of travel from all points within	NFC 2.1.5.1. / NFPA 10
Fire Hydrant:	not required	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:

habit studio

6437 Cork St, Halifax, NS
email: lorrie@habitstudio.ca | tel: 902.448.6873

ReCover

Debert Water Utility Building

Municipality of Colchester, NS

ReCover Initiative Panelized Deep Retrofit Study

Colchester_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 251 Lancaster Crescent

Debert, Nova Scotia

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

QSolv

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 buildings A and B located at 251 Lancaster Crescent in Debert, Nova Scotia as design by RSI Projects Inc.

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

Scenario One 50% Improvement generally includes the replacement of the existing facade with metal siding on prefab insulated panels, insulation on foundation walls, replacement of windows and overhead doors, roof replacement on new pre-eng scissor roof trusses with cellulose insulation, addition of ERVs, addition of mini split units, and upgrade lighting with LED retrofit kits.

Scenario Two Net Zero Ready - ASHP generally includes the replacement of the existing facade with metal siding on prefab insulated panels, insulation on foundation walls, replacement of windows and overhead doors, roof replacement on new pre-eng scissor roof trusses with cellulose insulation, change HVAC to an air source heat pump system and ERVs, upgrade service entrance, 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 existing with metal siding on prefab insulated panels, insulation on foundation walls, replacement of windows and overhead doors, roof replacement on new pre-eng scissor roof trusses with cellulose insulation, change HVAC to a ground source heat pump system and ERVs, upgrade service entrance, 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	$1,962,000.00
Scenario Two Net Zero Ready - ASHP	$2,504,000.00
Scenario Three Net Zero Ready - GSHP	$2,613,000.00
Scenario Four Net Zero	$2,870,000.00

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 Debert, 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 8,092 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:**
Existing Drawings (41 plans)	November 26, 1979
Mechanical Outline Specification	January 15, 2023
Electrical Outline Specification	February 14, 2023
Structural Analysis	No Date
Retrofit Scenarios Details	No Date
Wall Panel Schematics	February 27, 2023

PROJECT COST SUMMARY

PROJECT:	RETROFIT 251 LANCASTER CRESCENT	DATE:	JULY 20, 2023
LOCATION:	DEBERT, NS	CLASS:	D - FEASIBILITY
CLIENT:		FILE	13454
DESIGNER:	RSI PROJECTS		

Class D Estimate

DESCRIPTION		ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	NOTES
1	SCENARIO 1 CODE MINIMUM	8092	sf	$ 242.00	$ 1,962,000	
2	SCENARIO 2 NET ZERO READY, ASHP	8092	sf	$ 309.00	$ 2,504,000	
3	SCENARIO 3 NET ZERO READY, GSHP	8092	sf	$ 323.00	$ 2,613,000	
4	SCENARIO 4 NET ZERO	8092	sf	$ 355.00	$ 2,870,000	

ELEMENTAL COST SUMMARY

Scenario 1 50% Improvement

PROJECT: RETROFIT 251 LANCASTER CRESCENT
LOCATION: DEBERT, NS
CLIENT:
DESIGNER: RSI PROJECTS

DATE: JULY 20, 2023
CLASS: D - FEASIBILITY
FILE 13454
GFA:sf 8092

GROSS FLOOR AREA 8092 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY	ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL					$ 150	$ 1,215,951	61.98
A1 SUBSTRUCTURE					$ -	$ -	0.00
A11 Foundations	1.000	8092 sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	8092 sf	$ -	$ -	$ -		0.00
A2 STRUCTURE					$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE					$ 150	$ 1,215,951	61.98
A31 Walls Below Grade	1.000	8092 sf	$ 5.76	$ 46,576	$ 6		2.37
A32 Walls Above Grade	1.000	8092 sf	$ 78.22	$ 632,964	$ 78		32.26
A33 Windows and Entrances	0.085	687 sf	$ 118.57	$ 81,434	$ 10		4.15
A34 Roof Coverings	1.000	8092 sf	$ 56.23	$ 454,977	$ 56		23.19
A35 Projections	1.000	8092 sf	$ -	$ -	$ -		0.00
B INTERIORS					$ -	$ -	0.00
B1 PARTITIONS AND DOORS					$ -	$ -	0.00
B11 Partitions	1.000	8092 sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	8092 sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES					$ -	$ -	0.00
B21 Floor Finishes	1.000	8092 sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	8092 sf	$ -	$ -	$ -		0.00
B23 Wall Finishes	1.000	8092 sf	$ -	$ -	$ -		0.00
B3 FITTINGS AND EQUIPMENT					$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	8092 sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	8092 sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	8092 sf	$ -	$ -	$ -		0.00
SERVICES					$ 8	$ 65,230	3.32
C1 MECHANICAL					$ 5	$ 37,500	1.91
C11 Plumbing and Drainage	1.000	8092 sf	$ -	$ -	$ -		0.00
C12 Fire Protection	1.000	8092 sf	$ -	$ -	$ -		0.00
C13 HVAC	1.000	8092 sf	$ 4.02	$ 32,500	$ 4		1.66
C14 Controls	1.000	8092 sf	$ 0.62	$ 5,000	$ 1		0.25
C2 ELECTRICAL					$ 3	$ 27,730	1.41
C21 Services and Distribution	1.000	8092 sf	$ -	$ -	$ -		0.00
C22 Lighting, Devices and Heating	1.000	8092 sf	$ 3.43	$ 27,730	$ 3		1.41
C23 Systems and Ancillaries	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE					$ 158	$ 1,281,181	65.30
D SITE & ANCILLARY WORK					$ -	$ -	0.00
D1 SITEWORK					$ -	$ -	0.00
D11 Site Development	1.000	8092 sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK					$ -	$ -	0.00
D21 Demolition	1.000	8092 sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE					$ 158	$ 1,281,181	65.30
Z GENERAL REQUIREMENTS AND ALLOWANCES					$ 84	$ 679,859	34.65
Z1 GENERAL REQUIREMENTS AND FEES					$ 42	$ 339,513	17.30
Z11 General Requirements and Overheads		15%		$ 192,177	$ 24		9.79
Z12 Contractors Profit		10%		$ 147,336	$ 18		7.51
Z2 ALLOWANCES					$ 42	$ 340,346	17.35
Z21 Design Allowance		10%		$ 162,069	$ 20		8.26
Z22 Escalation Allowance TBD		0%		$ -	$ -		0.00
Z23 Construction Allowance		10%		$ 178,276	$ 22		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)			$242 per sf			$ 1,962,000	100.00

Element	Quantities			Unit Rates		Sub-totals
EXTERIOR ENCLOSURE						
A31 Walls Below Grade						
▪ remove grass landscaping	444	sf	$	3.50	$	1,554
▪ remove beach stone	854	sf	$	3.50	$	2,990
▪ remove asphalt paving and dispose	848	sf	$	3.50	$	2,969
▪ excavate to 2 feet below grade	119	cyd	$	40.00	$	4,766
▪ new 2" EPS insulation	1073	sf	$	3.50	$	3,757
▪ cement board	1073	sf	$	5.00	$	5,367
▪ backfill to subgrade	119	cyd	$	50.00	$	5,957
▪ reinstate grass landscaping	444	sf	$	5.00	$	2,220
▪ reinstate beach stone	854	sf	$	5.00	$	4,272
▪ reinstate asphalt paving	848	sf	$	15.00	$	12,725
A31 Walls Below Grade Total	8092	sf	$	5.76	$	46,576
A32 Walls Above Grade						
▪ remove existing façade	7687	sf	$	1.50	$	11,530
▪ structural upgrade including base angle	17000	lbs	$	4.00	$	68,000
▪ supply and install r16 prefab insulated wall panels	7687	sf	$	27.00	$	207,538
▪ supply and install prefinished metal siding	7687	sf	$	45.00	$	345,897
A32 Walls Above Grade Total	8092	sf	$	78.22	$	632,964
A33 Windows and Entrances						
▪ replace windows with triple pane	363	sf	$	125.00	$	45,434
▪ new R10 overhead door	3	no	$	12,000.00	$	36,000
A33 Windows and Entrances Total	687	sf	$	118.57	$	81,434
A34 Roof Coverings						
▪ remove existing asphalt shingle roof finish	2504	sf	$	1.00	$	2,504
▪ remove existing mod bit roof finish	5964	sf	$	2.00	$	11,927
▪ 3/4 T&G plywood sheathing	9110	sf	$	10.00	$	91,102
▪ install new pre-engineered roof trusses above existing	9110	sf	$	13.00	$	118,433
▪ new knee wall construction, hurricane clips	217	sf	$	15.00	$	3,254
▪ new R25 loose fill insulation	9110	sf	$	2.00	$	18,220
▪ new metal roof system	9110	sf	$	23.00	$	209,536
A34 Roof Coverings Total	8092	sf	$	56.23	$	454,977
MECHANICAL						
C13 Heating, Ventilation, Air Conditioning						
▪ new 3/4 ton mini split heat pump	2	no	$	5,500.00	$	11,000
▪ ERV 190cfm	1	sum	$	3,500.00	$	3,500
▪ ERV 530cfm	1	sum	$	9,000.00	$	9,000
▪ new ERV ductwork connected to existing	500	lbs	$	18.00	$	9,000
C13 Heating, Ventilation, Air Conditioning Total	8092	sf	$	4.02	$	32,500
C14 Controls						
▪ individual controls	1	sum	$	5,000.00	$	5,000

Element	Quantities			Unit Rates		Sub-totals
C14 Controls Total	8092	sf	$	0.62	$	5,000
ELECTRICAL						
C22 Lighting, Devices and Heating						
▪ install LED retrofit kits to all existing lights	8092	sf	$	2.50	$	20,230
▪ upgrade selective mechanical connections	1	sum	$	7,500.00	$	7,500
C22 Lighting and Heating Total	8092	sf	$	3.43	$	27,730
GENERAL REQUIREMENTS AND FEES						
Z11 General Requirements and Overheads						
▪ contractor's overheads				15.00%	$	192,177
Z11 General Requirements and Overheads Total	8092	sf	$	23.75	$	192,177
Z12 Contractor's Profit						
▪ contractor's profit				10.00%	$	147,336
Z12 Contractor's Profit Total	8092	sf	$	18.21	$	147,336
ALLOWANCES						
Z21 Design Allowance						
▪ design development contingency				10.00%	$	162,069
Z21 Design Allowance Total	8092	sf	$	20.03	$	162,069
Z23 Construction Contingency						
▪ construction contingency				10.00%	$	178,276
Z23 Construction Contingency	8092	sf	$	22.03	$	178,276

ELEMENTAL COST SUMMARY

PROJECT:	RETROFIT 251 LANCASTER CRESCENT	DATE:	JULY 20, 2023
LOCATION:	DEBERT, NS	CLASS:	D - FEASIBILITY
CLIENT:		FILE	13454
DESIGNER:	RSI PROJECTS	GFA:sf	8092

Scenario 2 NZR - ASHP

GROSS FLOOR AREA 8092 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY	ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL					$ 150	$ 1,215,951	48.56
A1 SUBSTRUCTURE					$ -	$ -	0.00
A11 Foundations	1.000	8092 sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	8092 sf	$ -	$ -	$ -		0.00
A2 STRUCTURE					$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE					$ 150	$ 1,215,951	48.56
A31 Walls Below Grade	0.133	1073 sf	$ 43.39	$ 46,576	$ 6		1.86
A32 Walls Above Grade	1.000	8092 sf	$ 78.22	$ 632,964	$ 78		25.28
A33 Windows and Entrances	0.085	687 sf	$ 118.57	$ 81,434	$ 10		3.25
A34 Roof Coverings	1.126	9110 sf	$ 49.94	$ 454,977	$ 56		18.17
A35 Projections	1.000	8092 sf	$ -	$ -	$ -		0.00
B INTERIORS					$ 4	$ 32,368	1.29
B1 PARTITIONS AND DOORS					$ -	$ -	0.00
B11 Partitions	1.000	8092 sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	8092 sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES					$ 4	$ 32,368	1.29
B21 Floor Finishes	1.000	8092 sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	8092 sf	$ 2.00	$ 16,184	$ 2		0.65
B23 Wall Finishes	1.000	8092 sf	$ 2.00	$ 16,184	$ 2		0.65
B3 FITTINGS AND EQUIPMENT					$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	8092 sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	8092 sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	8092 sf	$ -	$ -	$ -		0.00
SERVICES					$ 48	$ 386,973	15.45
C1 MECHANICAL					$ 26	$ 207,960	8.31
C11 Plumbing and Drainage	1.000	8092 sf	$ 0.56	$ 4,500	$ 1		0.18
C12 Fire Protection	1.000	8092 sf	$ -	$ -	$ -		0.00
C13 HVAC	1.000	8092 sf	$ 20.14	$ 163,000	$ 20		6.51
C14 Controls	1.000	8092 sf	$ 5.00	$ 40,460	$ 5		1.62
C2 ELECTRICAL					$ 22	$ 179,013	7.15
C21 Services and Distribution	1.000	8092 sf	$ 11.12	$ 90,000	$ 11		3.59
C22 Lighting, Devices and Heating	1.000	8092 sf	$ 11.00	$ 89,013	$ 11		3.55
C23 Systems and Ancillaries	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE					$ 202	$ 1,635,293	65.31
D SITE & ANCILLARY WORK					$ -	$ -	0.00
D1 SITEWORK					$ -	$ -	0.00
D11 Site Development	1.000	8092 sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK					$ -	$ -	0.00
D21 Demolition	1.000	8092 sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE					$ 202	$ 1,635,293	65.31
Z GENERAL REQUIREMENTS AND ALLOWANCES					$ 107	$ 867,768	34.66
Z1 GENERAL REQUIREMENTS AND FEES					$ 54	$ 433,353	17.31
Z11 General Requirements and Overheads		15%		$ 245,294	$ 30		9.80
Z12 Contractors Profit		10%		$ 188,059	$ 23		7.51
Z2 ALLOWANCES					$ 54	$ 434,416	17.35
Z21 Design Allowance		10%		$ 206,865	$ 26		8.26
Z22 Escalation Allowance TBD		0%		$ -	$ -		0.00
Z23 Construction Allowance		10%		$ 227,551	$ 28		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)			$309 per sf			$ 2,504,000	100.00

QSolv

Element	Quantities		Unit Rates		Sub-totals	
EXTERIOR ENCLOSURE						
A31 Walls Below Grade						
▪ remove grass landscaping	444	sf	$	3.50	$	1,554
▪ remove beach stone	854	sf	$	3.50	$	2,990
▪ remove asphalt paving and dispose	848	sf	$	3.50	$	2,969
▪ excavate to 2 feet below grade	119	cyd	$	40.00	$	4,766
▪ new 2" EPS insulation	1073	sf	$	3.50	$	3,757
▪ cement board	1073	sf	$	5.00	$	5,367
▪ backfill to subgrade	119	cyd	$	50.00	$	5,957
▪ reinstate grass landscaping	444	sf	$	5.00	$	2,220
▪ reinstate beach stone	854	sf	$	5.00	$	4,272
▪ reinstate asphalt paving	848	sf	$	15.00	$	12,725
A31 Walls Below Grade Total	1073	sf	$	43.39	$	46,576
A32 Walls Above Grade						
▪ remove existing façade	7687	sf	$	1.50	$	11,530
▪ structural upgrade including base angle	17000	lbs	$	4.00	$	68,000
▪ supply and install r16 prefab insulated wall panels	7687	sf	$	27.00	$	207,538
▪ supply and install prefinished metal siding	7687	sf	$	45.00	$	345,897
A32 Walls Above Grade Total	8092	sf	$	78.22	$	632,964
A33 Windows and Entrances						
▪ replace windows with triple pane	363	sf	$	125.00	$	45,434
▪ new R10 overhead door	3	no	$	12,000.00	$	36,000
A33 Windows and Entrances Total	687	sf	$	118.57	$	81,434
A34 Roof Coverings						
▪ remove existing asphalt shingle roof finish	2504	sf	$	1.00	$	2,504
▪ remove existing mod bit roof finish	5964	sf	$	2.00	$	11,927
▪ 3/4 T&G plywood sheathing	9110	sf	$	10.00	$	91,102
▪ install new pre-engineered roof trusses above existing	9110	sf	$	13.00	$	118,433
▪ new knee wall construction, hurricane clips	217	sf	$	15.00	$	3,254
▪ new R25 loose fill insulation	9110	sf	$	2.00	$	18,220
▪ new metal roof system	9110	sf	$	23.00	$	209,536
A34 Roof Coverings Total	9110	sf	$	49.94	$	454,977
FINISHES						
B22 Ceiling Finishes						
▪ cut and patch ceilings for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B22 Ceiling Finishes Total	8092	sf	$	2.00	$	16,184
B23 Wall Finishes						
▪ cut and patch walls for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B23 Wall Finishes Total	8092	sf	$	2.00	$	16,184
MECHANICAL						

Element	Quantities		Unit Rates		Sub-totals	
C11 Plumbing and Drainage						
▪ new 80gal HP dhwt	1	no	$	4,500.00	$	4,500
C11 Plumbing and Drainage Total	8092	sf	$	0.56	$	4,500
C13 Heating, Ventilation, Air Conditioning						
▪ ASHP-9 tons	2	no	$	25,000.00	$	50,000
▪ electric boiler - 15kW	1	no	$	5,000.00	$	5,000
▪ HP HX pumps	2	no	$	5,500.00	$	11,000
▪ HP BT pumps	2	no	$	5,500.00	$	11,000
▪ electric boiler pump	1	no	$	2,500.00	$	2,500
▪ buffer tanks	1	no	$	10,000.00	$	10,000
▪ air separators	2	no	$	3,500.00	$	7,000
▪ expansion tanks	2	no	$	2,500.00	$	5,000
▪ distribution piping	250	lf	$	100.00	$	25,000
▪ new 3/4 ton mini split heat pump	2	no	$	5,500.00	$	11,000
▪ ERV 190cfm	1	sum	$	3,500.00	$	3,500
▪ ERV 705cfm	1	sum	$	13,000.00	$	13,000
▪ new ERV ductwork connected to existing	500	lbs	$	18.00	$	9,000
C13 Heating, Ventilation, Air Conditioning Total	8092	sf	$	20.14	$	163,000
C14 Controls						
▪ new ddc control system	8092	sf	$	5.00	$	40,460
C14 Controls Total	8092	sf	$	5.00	$	40,460
ELECTRICAL						
C21 Services and Distribution						
▪ new 600A service entrance	1	sum	$	50,000.00	$	50,000
▪ new feeders	1	sum	$	20,000.00	$	20,000
▪ new panel, transformer for HVAC	1	sum	$	20,000.00	$	20,000
C21 Services and Distribution Total	8092	sf	$	11.12	$	90,000
C22 Lighting, Devices and Heating						
▪ replace lighting with LED fixtures	8092	sf	$	8.00	$	64,737
▪ lighting controls	8092	sf	$	3.00	$	24,276
C22 Lighting and Heating Total	8092	sf	$	11.00	$	89,013
GENERAL REQUIREMENTS AND FEES						
Z11 General Requirements and Overheads						
▪ contractor's overheads				15.00%	$	245,294
Z11 General Requirements and Overheads Total	8092	sf	$	30.31	$	245,294
Z12 Contractor's Profit						
▪ contractor's profit				10.00%	$	188,059
Z12 Contractor's Profit Total	8092	sf	$	23.24	$	188,059

Element	Quantities		Unit Rates		Sub-totals
ALLOWANCES					
Z21 Design Allowance					
▪ design development contingency			10.00%	$	206,865
Z21 Design Allowance Total	8092	sf	$ 25.56	$	206,865
Z23 Construction Contingency					
▪ construction contingency			10.00%	$	227,551
Z23 Construction Contingency	8092	sf	$ 28.12	$	227,551

ELEMENTAL COST SUMMARY

Scenario 3 NZR - GSHP

PROJECT:	RETROFIT 251 LANCASTER CRESCENT	DATE:	JULY 20, 2023
LOCATION:	DEBERT, NS	CLASS:	D - FEASIBILITY
CLIENT:		FILE	13454
DESIGNER:	RSI PROJECTS	GFA:sf	8092

GROSS FLOOR AREA 8092 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY		ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL						$ 150	$ 1,215,951	46.53
A1 SUBSTRUCTURE						$ -	$ -	0.00
A11 Foundations	1.000	8092	sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	8092	sf	$ -	$ -	$ -		0.00
A2 STRUCTURE						$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	8092	sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	8092	sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	8092	sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE						$ 150	$ 1,215,951	46.53
A31 Walls Below Grade	0.133	1073	sf	$ 43.39	$ 46,576	$ 6		1.78
A32 Walls Above Grade	1.000	8092	sf	$ 78.22	$ 632,964	$ 78		24.22
A33 Windows and Entrances	0.085	687	sf	$ 118.57	$ 81,434	$ 10		3.12
A34 Roof Coverings	1.126	9110	sf	$ 49.94	$ 454,977	$ 56		17.41
A35 Projections	1.000	8092	sf	$ -	$ -	$ -		0.00
B INTERIORS						$ 4	$ 32,368	1.24
B1 PARTITIONS AND DOORS						$ -	$ -	0.00
B11 Partitions	1.000	8092	sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	8092	sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES						$ 4	$ 32,368	1.24
B21 Floor Finishes	1.000	8092	sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	8092	sf	$ 2.00	$ 16,184	$ 2		0.62
B23 Wall Finishes	1.000	8092	sf	$ 2.00	$ 16,184	$ 2		0.62
B3 FITTINGS AND EQUIPMENT						$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	8092	sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	8092	sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	8092	sf	$ -	$ -	$ -		0.00
SERVICES						$ 57	$ 458,473	17.55
C1 MECHANICAL						$ 35	$ 279,460	10.70
C11 Plumbing and Drainage	1.000	8092	sf	$ 0.56	$ 4,500	$ 1		0.17
C12 Fire Protection	1.000	8092	sf	$ -	$ -	$ -		0.00
C13 HVAC	1.000	8092	sf	$ 28.98	$ 234,500	$ 29		8.97
C14 Controls	1.000	8092	sf	$ 5.00	$ 40,460	$ 5		1.55
C2 ELECTRICAL						$ 22	$ 179,013	6.85
C21 Services and Distribution	1.000	8092	sf	$ 11.12	$ 90,000	$ 11		3.44
C22 Lighting, Devices and Heating	1.000	8092	sf	$ 11.00	$ 89,013	$ 11		3.41
C23 Systems and Ancillaries	1.000	8092	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE						$ 211	$ 1,706,793	65.32
D SITE & ANCILLARY WORK						$ -	$ -	0.00
D1 SITEWORK						$ -	$ -	0.00
D11 Site Development	1.000	8092	sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	8092	sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	8092	sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK						$ -	$ -	0.00
D21 Demolition	1.000	8092	sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	8092	sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE						$ 211	$ 1,706,793	65.32
Z GENERAL REQUIREMENTS AND ALLOWANCES						$ 112	$ 905,710	34.66
Z1 GENERAL REQUIREMENTS AND FEES						$ 56	$ 452,300	17.31
Z11 General Requirements and Overheads		15%			$ 256,019	$ 32		9.80
Z12 Contractors Profit		10%			$ 196,281	$ 24		7.51
Z2 ALLOWANCES						$ 56	$ 453,410	17.35
Z21 Design Allowance		10%			$ 215,909	$ 27		8.26
Z22 Escalation Allowance TBD		0%			$ -	$ -		0.00
Z23 Construction Allowance		10%			$ 237,500	$ 29		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)				$323 per sf			$ 2,613,000	100.00

Element	Quantities		Unit Rates		Sub-totals	
EXTERIOR ENCLOSURE						
A31 Walls Below Grade						
▪ remove grass landscaping	444	sf	$	3.50	$	1,554
▪ remove beach stone	854	sf	$	3.50	$	2,990
▪ remove asphalt paving and dispose	848	sf	$	3.50	$	2,969
▪ excavate to 2 feet below grade	119	cyd	$	40.00	$	4,766
▪ new 2" EPS insulation	1073	sf	$	3.50	$	3,757
▪ cement board	1073	sf	$	5.00	$	5,367
▪ backfill to subgrade	119	cyd	$	50.00	$	5,957
▪ reinstate grass landscaping	444	sf	$	5.00	$	2,220
▪ reinstate beach stone	854	sf	$	5.00	$	4,272
▪ reinstate asphalt paving	848	sf	$	15.00	$	12,725
A31 Walls Below Grade Total	**1073**	**sf**	**$**	**43.39**	**$**	**46,576**
A32 Walls Above Grade						
▪ remove existing façade	7687	sf	$	1.50	$	11,530
▪ structural upgrade including base angle	17000	lbs	$	4.00	$	68,000
▪ supply and install r16 prefab insulated wall panels	7687	sf	$	27.00	$	207,538
▪ supply and install prefinished metal siding	7687	sf	$	45.00	$	345,897
A32 Walls Above Grade Total	**8092**	**sf**	**$**	**78.22**	**$**	**632,964**
A33 Windows and Entrances						
▪ replace windows with triple pane	363	sf	$	125.00	$	45,434
▪ new R10 overhead door	3	no	$	12,000.00	$	36,000
A33 Windows and Entrances Total	**687**	**sf**	**$**	**118.57**	**$**	**81,434**
A34 Roof Coverings						
▪ remove existing asphalt shingle roof finish	2504	sf	$	1.00	$	2,504
▪ remove existing mod bit roof finish	5964	sf	$	2.00	$	11,927
▪ 3/4 T&G plywood sheathing	9110	sf	$	10.00	$	91,102
▪ install new pre-engineered roof trusses above existing	9110	sf	$	13.00	$	118,433
▪ new knee wall construction, hurricane clips	217	sf	$	15.00	$	3,254
▪ new R25 loose fill insulation	9110	sf	$	2.00	$	18,220
▪ new metal roof system	9110	sf	$	23.00	$	209,536
A34 Roof Coverings Total	**9110**	**sf**	**$**	**49.94**	**$**	**454,977**
FINISHES						
B22 Ceiling Finishes						
▪ cut and patch ceilings for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B22 Ceiling Finishes Total	**8092**	**sf**	**$**	**2.00**	**$**	**16,184**
B23 Wall Finishes						
▪ cut and patch walls for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B23 Wall Finishes Total	**8092**	**sf**	**$**	**2.00**	**$**	**16,184**
MECHANICAL						

Element	Quantities		Unit Rates		Sub-totals	
C11 Plumbing and Drainage						
▪ new 80gal HP dhwt	1	no	$	4,500.00	$	4,500
C11 Plumbing and Drainage Total	8092	sf	$	0.56	$	4,500
C13 Heating, Ventilation, Air Conditioning						
▪ geothermal wells, testing	3	no	$	25,000.00	$	75,000
▪ gshp exterior piping, trenching, backfill, reinstatement	1	sum	$	20,000.00	$	20,000
▪ gshp interior piping	1	sum	$	10,000.00	$	10,000
▪ gshp-4 tons	2	no	$	10,000.00	$	20,000
▪ electric boiler 20kW	1	no	$	10,000.00	$	10,000
▪ circulation pumps	5	no	$	3,500.00	$	17,500
▪ electric boiler pump	1	no	$	2,500.00	$	2,500
▪ air separators	3	no	$	3,500.00	$	10,500
▪ expansion tanks	3	no	$	2,500.00	$	7,500
▪ distribution piping	250	lf	$	100.00	$	25,000
▪ indoor units - 3/4 ton	2	no	$	5,500.00	$	11,000
▪ ERV 190cfm	1	sum	$	3,500.00	$	3,500
▪ ERV 705cfm	1	sum	$	13,000.00	$	13,000
▪ new ERV ductwork connected to existing	500	lbs	$	18.00	$	9,000
C13 Heating, Ventilation, Air Conditioning Total	8092	sf	$	28.98	$	234,500
C14 Controls						
▪ new ddc control system	8092	sf	$	5.00	$	40,460
C14 Controls Total	8092	sf	$	5.00	$	40,460
ELECTRICAL						
C21 Services and Distribution						
▪ new 600A service entrance	1	sum	$	50,000.00	$	50,000
▪ new feeders	1	sum	$	20,000.00	$	20,000
▪ new panel, transformer for HVAC	1	sum	$	20,000.00	$	20,000
C21 Services and Distribution Total	8092	sf	$	11.12	$	90,000
C22 Lighting, Devices and Heating						
▪ replace lighting with LED fixtures	8092	sf	$	8.00	$	64,737
▪ lighting controls	8092	sf	$	3.00	$	24,276
C22 Lighting and Heating Total	8092	sf	$	11.00	$	89,013
GENERAL REQUIREMENTS AND FEES						
Z11 General Requirements and Overheads						
▪ contractor's overheads				15.00%	$	256,019
Z11 General Requirements and Overheads Total	8092	sf	$	31.64	$	256,019
Z12 Contractor's Profit						
▪ contractor's profit				10.00%	$	196,281

Element	Quantities		Unit Rates		Sub-totals	
Z12 Contractor's Profit Total	8092	sf	$	24.26	$	196,281
ALLOWANCES						
Z21 Design Allowance						
▪ design development contingency				10.00%	$	215,909
Z21 Design Allowance Total	8092	sf	$	26.68	$	215,909
Z23 Construction Contingency						
▪ construction contingency				10.00%	$	237,500
Z23 Construction Contingency	8092	sf	$	29.35	$	237,500

ELEMENTAL COST SUMMARY

Scenario 4 Net Zero

PROJECT:	RETROFIT 251 LANCASTER CRESCENT	DATE:	JULY 20, 2023
LOCATION:	DEBERT, NS	CLASS:	D - FEASIBILITY
CLIENT:		FILE	13454
DESIGNER:	RSI PROJECTS	GFA:sf	8092

GROSS FLOOR AREA 8092 sf

ELEMENT	RATIO TO GFA	ELEMENTAL QUANTITY	ELEMENTAL UNIT RATE	ELEMENTAL AMOUNT	RATE PER GFA	TOTAL AMOUNT	%
A SHELL					$ 150	$ 1,215,951	42.37
A1 SUBSTRUCTURE					$ -	$ -	0.00
A11 Foundations	1.000	8092 sf	$ -	$ -	$ -		0.00
A12 Basement Excavation	1.000	8092 sf	$ -	$ -	$ -		0.00
A2 STRUCTURE					$ -	$ -	0.00
A21 Lowest Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A22 Upper Floor Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A23 Roof Construction	1.000	8092 sf	$ -	$ -	$ -		0.00
A3 EXTERIOR ENCLOSURE					$ 150	$ 1,215,951	42.37
A31 Walls Below Grade	0.133	1073 sf	$ 43.39	$ 46,576	$ 6		1.62
A32 Walls Above Grade	1.000	8092 sf	$ 78.22	$ 632,964	$ 78		22.05
A33 Windows and Entrances	0.085	687 sf	$ 118.57	$ 81,434	$ 10		2.84
A34 Roof Coverings	1.126	9110 sf	$ 49.94	$ 454,977	$ 56		15.85
A35 Projections	1.000	8092 sf	$ -	$ -	$ -		0.00
B INTERIORS					$ 4	$ 32,368	1.13
B1 PARTITIONS AND DOORS					$ -	$ -	0.00
B11 Partitions	1.000	8092 sf	$ -	$ -	$ -		0.00
B12 Doors	1.000	8092 sf	$ -	$ -	$ -		0.00
B2 INTERIOR FINISHES					$ 4	$ 32,368	1.13
B21 Floor Finishes	1.000	8092 sf	$ -	$ -	$ -		0.00
B22 Ceiling Finishes	1.000	8092 sf	$ 2.00	$ 16,184	$ 2		0.56
B23 Wall Finishes	1.000	8092 sf	$ 2.00	$ 16,184	$ 2		0.56
B3 FITTINGS AND EQUIPMENT					$ -	$ -	0.00
B31 Fittings and Fixtures	1.000	8092 sf	$ -	$ -	$ -		0.00
B32 Equipment	1.000	8092 sf	$ -	$ -	$ -		0.00
B33 Conveying Systems	1.000	8092 sf	$ -	$ -	$ -		0.00
SERVICES					$ 77	$ 626,473	21.83
C1 MECHANICAL					$ 35	$ 279,460	9.74
C11 Plumbing and Drainage	1.000	8092 sf	$ 0.56	$ 4,500	$ 1		0.16
C12 Fire Protection	1.000	8092 sf	$ -	$ -	$ -		0.00
C13 HVAC	1.000	8092 sf	$ 28.98	$ 234,500	$ 29		8.17
C14 Controls	1.000	8092 sf	$ 5.00	$ 40,460	$ 5		1.41
C2 ELECTRICAL					$ 43	$ 347,013	12.09
C21 Services and Distribution	1.000	8092 sf	$ 31.88	$ 258,000	$ 32		8.99
C22 Lighting, Devices and Heating	1.000	8092 sf	$ 11.00	$ 89,013	$ 11		3.10
C23 Systems and Ancillaries	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - LESS SITE					$ 232	$ 1,874,793	65.32
D SITE & ANCILLARY WORK					$ -	$ -	0.00
D1 SITEWORK					$ -	$ -	0.00
D11 Site Development	1.000	8092 sf	$ -	$ -	$ -		0.00
D12 Mechanical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D13 Electrical Site Services	1.000	8092 sf	$ -	$ -	$ -		0.00
D2 ANCILLARY WORK					$ -	$ -	0.00
D21 Demolition	1.000	8092 sf	$ -	$ -	$ -		0.00
D22 Alterations	1.000	8092 sf	$ -	$ -	$ -		0.00
NET BUILDING SUBTOTAL - INCLUDING SITE					$ 232	$ 1,874,793	65.32
Z GENERAL REQUIREMENTS AND ALLOWANCES					$ 123	$ 994,859	34.66
Z1 GENERAL REQUIREMENTS AND FEES					$ 61	$ 496,820	17.31
Z11 General Requirements and Overheads		15%		$ 281,219	$ 35		9.80
Z12 Contractors Profit		10%		$ 215,601	$ 27		7.51
Z2 ALLOWANCES					$ 62	$ 498,039	17.35
Z21 Design Allowance		10%		$ 237,161	$ 29		8.26
Z22 Escalation Allowance TBD		0%		$ -	$ -		0.00
Z23 Construction Allowance		10%		$ 260,877	$ 32		9.09
TOTAL CONSTRUCTION COST (HST EXTRA)			$355 per sf			$ 2,870,000	100.00

QSolv

Element	Quantities		Unit Rates		Sub-totals	
EXTERIOR ENCLOSURE						
A31 Walls Below Grade						
▪ remove grass landscaping	444	sf	$	3.50	$	1,554
▪ remove beach stone	854	sf	$	3.50	$	2,990
▪ remove asphalt paving and dispose	848	sf	$	3.50	$	2,969
▪ excavate to 2 feet below grade	119	cyd	$	40.00	$	4,766
▪ new 2" EPS insulation	1073	sf	$	3.50	$	3,757
▪ cement board	1073	sf	$	5.00	$	5,367
▪ backfill to subgrade	119	cyd	$	50.00	$	5,957
▪ reinstate grass landscaping	444	sf	$	5.00	$	2,220
▪ reinstate beach stone	854	sf	$	5.00	$	4,272
▪ reinstate asphalt paving	848	sf	$	15.00	$	12,725
A31 Walls Below Grade Total	1073	sf	$	43.39	$	46,576
A32 Walls Above Grade						
▪ remove existing façade	7687	sf	$	1.50	$	11,530
▪ structural upgrade including base angle	17000	lbs	$	4.00	$	68,000
▪ supply and install r16 prefab insulated wall panels	7687	sf	$	27.00	$	207,538
▪ supply and install prefinished metal siding	7687	sf	$	45.00	$	345,897
A32 Walls Above Grade Total	8092	sf	$	78.22	$	632,964
A33 Windows and Entrances						
▪ replace windows with triple pane	363	sf	$	125.00	$	45,434
▪ new R10 overhead door	3	no	$	12,000.00	$	36,000
A33 Windows and Entrances Total	687	sf	$	118.57	$	81,434
A34 Roof Coverings						
▪ remove existing asphalt shingle roof finish	2504	sf	$	1.00	$	2,504
▪ remove existing mod bit roof finish	5964	sf	$	2.00	$	11,927
▪ 3/4 T&G plywood sheathing	9110	sf	$	10.00	$	91,102
▪ install new pre-engineered roof trusses above existing	9110	sf	$	13.00	$	118,433
▪ new knee wall construction, hurricane clips	217	sf	$	15.00	$	3,254
▪ new R25 loose fill insulation	9110	sf	$	2.00	$	18,220
▪ new metal roof system	9110	sf	$	23.00	$	209,536
A34 Roof Coverings Total	9110	sf	$	49.94	$	454,977
FINISHES						
B22 Ceiling Finishes						
▪ cut and patch ceilings for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B22 Ceiling Finishes Total	8092	sf	$	2.00	$	16,184
B23 Wall Finishes						
▪ cut and patch walls for new mechanical/electrical	8092	sf	$	2.00	$	16,184
B23 Wall Finishes Total	8092	sf	$	2.00	$	16,184
MECHANICAL						

Element		Quantities			Unit Rates		Sub-totals
C11	Plumbing and Drainage						
	▪ new 80gal HP dhwt	1	no	$	4,500.00	$	4,500
C11	Plumbing and Drainage Total	8092	sf	$	0.56	$	4,500
C13	Heating, Ventilation, Air Conditioning						
	▪ geothermal wells, testing	3	no	$	25,000.00	$	75,000
	▪ gshp exterior piping, trenching, backfill, reinstatement	1	sum	$	20,000.00	$	20,000
	▪ gshp interior piping	1	sum	$	10,000.00	$	10,000
	▪ gshp-4 tons	2	no	$	10,000.00	$	20,000
	▪ electric boiler 20kW	1	no	$	10,000.00	$	10,000
	▪ circulation pumps	5	no	$	3,500.00	$	17,500
	▪ electric boiler pump	1	no	$	2,500.00	$	2,500
	▪ air separators	3	no	$	3,500.00	$	10,500
	▪ expansion tanks	3	no	$	2,500.00	$	7,500
	▪ distribution piping	250	lf	$	100.00	$	25,000
	▪ indoor units - 3/4 ton	2	no	$	5,500.00	$	11,000
	▪ ERV 190cfm	1	sum	$	3,500.00	$	3,500
	▪ ERV 705cfm	1	sum	$	13,000.00	$	13,000
	▪ new ERV ductwork connected to existing	500	lbs	$	18.00	$	9,000
C13	Heating, Ventilation, Air Conditioning Total	8092	sf	$	28.98	$	234,500
C14	Controls						
	▪ new ddc control system	8092	sf	$	5.00	$	40,460
C14	Controls Total	8092	sf	$	5.00	$	40,460
ELECTRICAL							
C21	Services and Distribution						
	▪ new 600A service entrance	1	sum	$	50,000.00	$	50,000
	▪ new feeders	1	sum	$	20,000.00	$	20,000
	▪ new panel, transformer for HVAC	1	sum	$	20,000.00	$	20,000
	▪ photovoltaic system complete with racking, inverters	42	kW	$	4,000.00	$	168,000
C21	Services and Distribution Total	8092	sf	$	31.88	$	258,000
C22	Lighting, Devices and Heating						
	▪ replace lighting with LED fixtures	8092	sf	$	8.00	$	64,737
	▪ lighting controls	8092	sf	$	3.00	$	24,276
C22	Lighting and Heating Total	8092	sf	$	11.00	$	89,013
GENERAL REQUIREMENTS AND FEES							
Z11	General Requirements and Overheads						
	▪ contractor's overheads				15.00%	$	281,219
Z11	General Requirements and Overheads Total	8092	sf	$	34.75	$	281,219
Z12	Contractor's Profit						
	▪ contractor's profit				10.00%	$	215,601

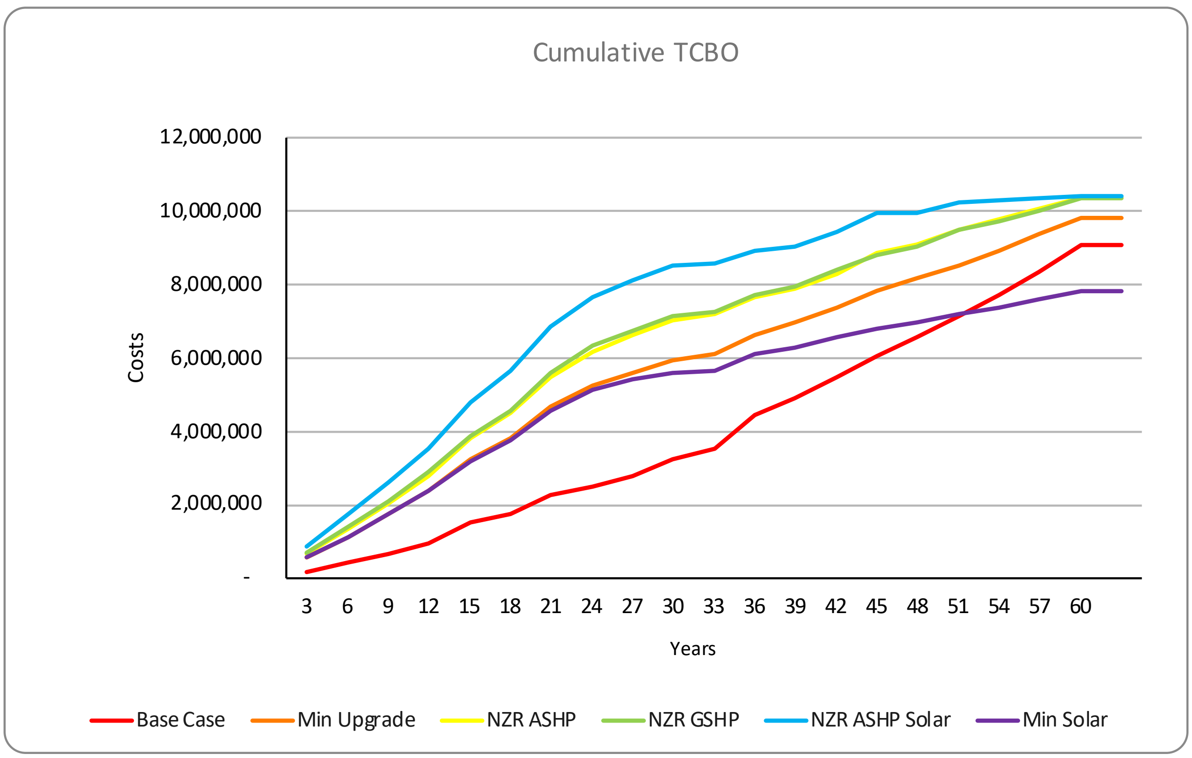
Element	Quantities		Unit Rates		Sub-totals
Z12 Contractor's Profit Total	8092	sf	$ 26.64	$	215,601
ALLOWANCES					
Z21 Design Allowance					
▪ design development contingency			10.00%	$	237,161
Z21 Design Allowance Total	8092	sf	$ 29.31	$	237,161
Z23 Construction Contingency					
▪ construction contingency			10.00%	$	260,877
Z23 Construction Contingency	8092	sf	$ 32.24	$	260,877

Appendix N

Total Cost of Building Ownership

NS Water Utility Building - Deep Retrofit

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
GHG emissions (kg) (60 Years)	3,437,029	2,299,297	1,659,416	1,660,662	0	734,029
EUI (kWh/m2/year)	220.6	123.5	57.5	57.5	0.0	69.3
TCBO at 60 years	**$9,076,000**	**$9,814,000**	**$10,363,000**	**$10,351,000**	**$10,408,000**	**$7,820,000**
TCBO Savings at 60 years	$0	-$738,000	-$1,287,000	-$1,275,000	-$1,332,000	$1,256,000
60 Year TCBO savings compared to Base Case		**-8%**	**-14%**	**-14%**	**-15%**	**14%**



Total Cost of Building Ownership (TCBO)

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
GHG emissions (kg) (60 Years)	3,437,029	2,299,297	1,659,416	1,660,662	-	734,029
EUI (kWh/m2/year)	221	124	57	58	0	69
TCBO at 12 Years	934000	2403000	2799000	2901000	3544000	2395000
TCBO at 25 Years	2620000	5497000	6523000	6685000	8075000	5346000
TCBO at 60 years	$ 9,076,000	$ 9,814,000	$ 10,363,000	$ 10,351,000	$ 10,408,000	$ 7,820,000
TCBO Savings at 60 years		$ (738,000)	$ (1,287,000)	$ (1,275,000)	$ (1,332,000)	$ 1,256,000
60 Year TCBO compared to Base Case		0	0	0	0	0
TCBO/Year/m2	$ 211	$ 228	$ 241	$ 240	$ 242	$ 182
TCBO/Year/ft2	$ 20	$ 21	$ 22	$ 22	$ 22	$ 17
60-Year TCBO/m2	$ 12,641	$ 13,669	$ 14,433	$ 14,416	$ 14,496	$ 10,891
60-YearTCBO/ft2	$ 1,175	$ 1,270	$ 1,341	$ 1,340	$ 1,347	$ 1,012
60 Year Energy Cost / m2	$ 5,789	$ 3,570	$ 2,169	$ 2,170	$ 58	$ 1,579

CAPITAL COST SUMMARY

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Initial Retrofit / HPB CostYear 1						
Initial Cost	$ 95,000	$ 2,110,000	$ 2,687,000	$ 2,804,000	$ 3,720,000	$ 2,278,000
Difference from Base Case		$ 2,015,000	$ 2,592,000	$ 2,709,000	$ 3,625,000	$ 2,183,000
% Over Base Case		2121%	2728%	2852%	3816%	2298%
Cost ($/ft2)	$ 12.30	$ 273.12	$ 347.80	$ 362.95	$ 481.51	$ 294.86

Maintenance Capital Costs 60 Years						
Cost	$ 2,181,000	$ 1,530,000	$ 2,419,000	$ 2,192,000	$ 2,819,000	$ 1,349,000
Difference from Base Case		$ (651,000)	$ 238,000	$ 11,000	$ 638,000	$ (832,000)
% Over Base Case		-29.85%	10.91%	0.50%	29.25%	-38.15%
Cost ($/ft2)	$ 282.31	$ 198.04	$ 313.11	$ 283.73	$ 364.89	$ 174.61

Retrofit / HPB + Maintenance Capital Costs 60 Years						
Total Costs	$ 2,276,000	$ 3,640,000	$ 5,106,000	$ 4,996,000	$ 6,539,000	$ 3,627,000
Difference from Base Case		$ 1,364,000	$ 2,830,000	$ 2,720,000	$ 4,263,000	$ 1,351,000
% Over Base Case		59.93%	124.34%	119.51%	187.30%	59.36%

OPERATING COST SUMMARY

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Utilities (including carbon tax)						
Cost	$ 5,978,000	$ 3,782,000	$ 2,436,000	$ 2,438,000	$ 42,000	$ 1,523,000
Difference from Base		$ (2,196,000)	$ (3,542,000)	$ (3,540,000)	$ (5,936,000)	$ (4,455,000)
% Over Base Case		-37%	-59%	-59%	-99%	-75%
Energy Cost ($/ft2)	$ 773.78	$ 489.54	$ 315.31	$ 315.57	$ 5.44	$ 197.13
Maintenance						
Cost	$ 279,000	$ 174,000	$ 122,000	$ 122,000	$ 270,000	$ 313,000
Difference from Base		$ (105,000)	$ (157,000)	$ (157,000)	$ (9,000)	$ 34,000
% Over Base Case		-38%	-56%	-56%	-3%	12%
Maintenance Cost ($/ft2)	$ 36.11	$ 22.52	$ 15.79	$ 15.79	$ 34.95	$ 40.51
Insurance & Taxes						
Costs	$ 465,000	$ 465,000	$ 465,000	$ 465,000	$ 465,000	$ 465,000
Difference from Base		$ -	$ -	$ -	$ -	$ -
% Over Base Case		0%	0%	0%	0%	0%
First Year Annual Maintenance						
Cost	$ 2,400	$ 1,500	$ 1,150	$ 1,050	$ 2,324	$ 2,689
Difference from Base		$ (900)	$ (1,250)	$ (1,350)	$ (76)	$ 289
% Over Base Case		-38%	-52%	-56%	-3%	12%
First Year Maintenance Cost ($/ft2)	$ 0.31	$ 0.19	$ 0.15	$ 0.14	$ 0.30	$ 0.35

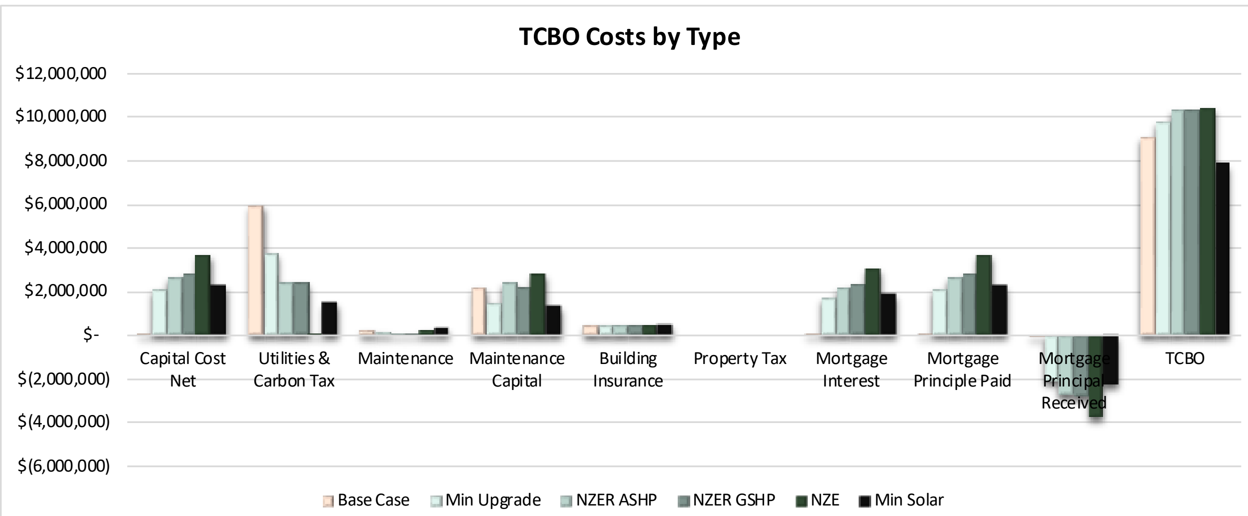
Annual Energy Consumption and GHG Emissions

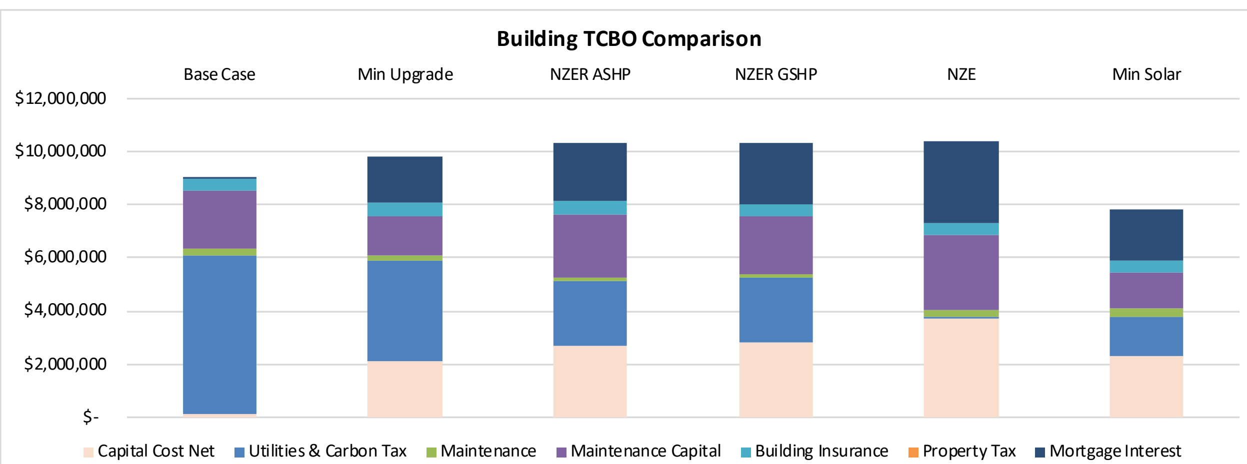
	Units	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Annual Water Consumption	m3	0.0	0.0	0.0	0.0	0.0	0.0
Annual Sewer Discharge	m3	0.0	0.0	0.0	0.0	0.0	0.0
Annual Electric Consumption	kWh	43,240.00	38,937.00	41,279.00	41,310.00	41,279.00	38,973.00
Annual Gas Consumption	m3	-	-	-	-	-	-
Annual Heating Oil Consumption	Litres	10,632.00	4,594.00	-	-	-	4,594.00
GHG emissions	kg CO2 eq	57,283.82	38,321.61	27,656.93	27,677.70	-	12,233.82
Annual Solar PV generated	kWh	-	-	-	-	41,279.00	38,973.00
Total Annual Energy Consumption	ekWh	158,420.00	88,705.33	41,279.00	41,310.00	-	49,768.33
Total Annual Energy Consumption	GJ	570.31	319.34	148.60	148.72	-	179.17
EUI	kWh/m2/yr	220.64	123.55	57.49	57.53	-	69.32

60 Year Cost of Ownership Comparison

	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Capital Cost	$ 94,702	$ 2,109,709	$ 2,687,140	$ 2,803,731	$ 3,720,401	$ 2,277,709
Utility Subsidy	$ -	$ -	$ -	$ -	$ -	$ -
Capital Cost Net	$ 94,702	$ 2,109,709	$ 2,687,140	$ 2,803,731	$ 3,720,401	$ 2,277,709
Utilities & Carbon Tax	$ 5,977,732	$ 3,781,539	$ 2,436,368	$ 2,438,167	$ 41,637	$ 1,522,675
Maintenance	$ 279,198	$ 174,499	$ 122,149	$ 122,149	$ 270,346	$ 312,816
Maintenance Capital	$ 2,181,379	$ 1,529,875	$ 2,419,470	$ 2,192,305	$ 2,819,127	$ 1,349,035
Building Insurance	$ 464,532	$ 464,532	$ 464,532	$ 464,532	$ 464,532	$ 464,532
Property Tax	$ -	$ -	$ -	$ -	$ -	$ -
Mortgage Interest	$ 78,713	$ 1,753,537	$ 2,233,483	$ 2,330,389	$ 3,092,303	$ 1,893,173
Mortgage Principle Paid	$ 94,702	$ 2,109,709	$ 2,687,140	$ 2,803,731	$ 3,720,401	$ 2,277,709
Mortgage Principal Received	$ (94,702)	$ (2,109,709)	$ (2,687,140)	$ (2,803,731)	$ (3,720,401)	$ (2,277,709)
TCBO	$ 9,076,256	$ 9,813,690	$ 10,363,141	$ 10,351,273	$ 10,408,347	$ 7,819,940

	Cost as a Percentage of TCBO					
Capital Cost Net	1.0%	21.5%	25.9%	27.1%	35.7%	29.1%
Utilities & Carbon Tax	65.9%	38.5%	23.5%	23.6%	0.4%	19.5%
Maintenance	3.1%	1.8%	1.2%	1.2%	2.6%	4.0%
Maintenance Capital	24.0%	15.6%	23.3%	21.2%	27.1%	17.3%
Building Insurance	5.1%	4.7%	4.5%	4.5%	4.5%	5.9%
Property Tax	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Mortgage Interest	0.9%	17.9%	21.6%	22.5%	29.7%	24.2%
TCBO	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%





INPUTS : General

	Units	Base Case	Min Upgrade	NZER ASHP	NZER GSHP	NZE	Min Solar
Utility Costs							
Water							
unit water cost	$/m3						
annual water escalation rate	%	3%	3%	3%	3%	3%	3%
include annual "Basic Charge Water" for active service, else 0	$/year						
"Basic Charge Water" escalation rate	%	4%	4%	4%	4%	4%	4%
annual consumption	m3						
refrofit reduction	%	0%	20%	20%	20%	20%	20%
Sewer							
unit sewer cost	$/m3						
annual sewer escalation rate	%	3%	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%	3%
annual consumption	m3						
refrofit reduction	%	0					
Electricity							
unit cost	$/kWh	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23
annual escalation rate	%	3%	3%	3%	3%	3%	3%
include annual "Basic Charge" for active service, else 0	$/year	255.36	255.36	255.36	255.36	255.36	255.36
"Basic Charge" escalation rate	%	3%	3%	3%	3%	3%	3%
GHG emission factor	kg/kWh	0.67	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	1
annual consumption	kWh	43240	38937	41279	41310	41279	38973
refrofit reduction (only use this when TCPO calculation)	%	0%	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	1.902355
Is Carbon Tax ADDED TO energy cost?	No = 0 or Yes = 1	1	1	1	1	1	1
annual consumption	m3						
refrofit reduction	%	0%	100%	100%	100%	100%	100%
No 2 Heating Oil							
unit cost	$/Litre	$ 1.46	$ 1.46				$ 1.46
annual escalation rate	%	3%	3%	3%	3%	3%	3%
include annual "Basic Charge" for active service, else 0	$/year						
"Basic Charge" escalation rate	%	3%	3%	3%	3%	3%	3%
GHG emission factor	kg/L	2.663	2.663	2.663	2.663	2.663	2.663
Is Carbon Tax ADDED TO energy cost?	No = 0 or Yes = 1	1	1				1
annual consumption	Litres	10632	4594				4594
refrofit reduction	%	0					

GHG Emissions							
Carbon Tax escalation rate - after carbon tax finishes	%	4%	4%	4%	4%	4%	4%
Carbon Tax Year	**2020**	**2030**	**2040**	**2050**	**2060**	**2070**	**2080**
GHG unit cost ($/tonne)	$ 30.00	$ 170.00	$ 251.64	$ 372.49	$ 551.38	$ 816.17	$ 1,208.14
Carbon Tax for Project Year	$ 80.00	$ 198.88	$ 294.38	$ 435.76	$ 645.03	$ 954.81	$ 1,413.35

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%	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%	5.50%
Amortization in Years	#	25	25	25	25	25	25

Start Date (yyyy-mm-dd)		2023-12-31	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%	1.50%

Insurance

property insurance annual cost lump sum OR	$	$ 4,073.00	$ 4,073.00	$ 4,073.00	$ 4,073.00	$ 4,073.00	$ 4,073.00
property insurance rate (% of building value) (e.g. .27%)	%						
property insurance escalation rate	%	2.00%	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%	4.00%
11-20 years	%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
21-30 years	%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
31-40 years	%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
41-50 years	%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
51-60 years	%	4.00%	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**	**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 $300/ft2
Market Value Base Case For Retrofits only (else Zero)	Input $	$ 2,370,000.00					
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%	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		2.42%					
Annual Service Cost Escalation Rate		2.00%	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%	2.00%

Total Cost of Portfolio Ownership

Is this a TCPO calculation	No = 0 or Yes = 1	0	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					$ 4,000.00	$ 4,000.00
Array Size	kWdc	0	0	0		45.0	42.0
Total System Cost	$					$180,000.00	$168,000.00
System Annual Maintenance Cost (1)	$/kWdc/year					$ 28.31	$ 28.31
Total System Annual Maintenance Cost	$/year					$ 1,273.91	$ 1,188.98
Annual Solar Energy Output Degradation	%					0	0
Unit cost of solar energy displacing utility energy	$/kWac	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23	$ 0.23
Annual Solar Energy Produced, Displacing Utility Energy	kWh/year					41279	38973
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 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					2.00%	2.00%
2	Slab on Grade	0					2.00%	2.00%
3	Concrete Block Superstructure	0					2.00%	2.00%
4	Metal Deck on Steel Joists	0					2.00%	2.00%
5	Wood Roof Structure	0					2.00%	2.00%
6	Modified Bitumen	1	$ 120,560	20	5	$ 500	2.00%	2.00%
7	Asphalt Shingles	1	$ 13,640	20	20	$ 200	2.00%	2.00%
8	Prefinished Metal Siding	0	$ 24,929	35	20		2.00%	2.00%
9	Prefinished Metal Siding - Maintenance	0	$ 8,554	10	9		2.00%	2.00%
10	Painted Wood Clapboard Siding	1	$ 42,424	20	20	$ 300	2.00%	2.00%
11	Wood Framed Glazing Units	1	$ 10,500	30	25		2.00%	2.00%
12	Min Upgrade	1	$ 1,800	20	Min Solar		2.00%	2.00%
13	Aluminum Framed Glazing Units	1	$ 14,450	40	10		2.00%	2.00%
14	Overhead Door - East Elevation, South Elevation	1	$ 10,000	15	7		2.00%	2.00%
15	Front Entrance Door, Framed With Glazing	1	$ 3,500	30	25		2.00%	2.00%
16	Metal Door With Glazing - East & North Elevations	1	$ 3,000	25	22		2.00%	2.00%
17	Metal Service Door	1	$ 1,500	25	22		2.00%	2.00%
18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
21	Gypsum Board Walls	0	$ -	65	15		2.00%	2.00%
22	Painted Concrete Block Walls	0	$ -	75	25		2.00%	2.00%
23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
24	Solid Wood Core Doors	0		60	20		2.00%	2.00%
25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
28	Domestic Hot Water Tank, 48 Gallon Electric	1	$ 2,500	10	3		2.00%	2.00%
29	Water Pumps (2 hp)	1	$ 5,000	35	30		2.00%	2.00%
30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
31	Shower	1	$ 6,000	30	22		2.00%	2.00%
32	Boiler	1	$ 12,500	30	17	$ 500	2.00%	2.00%
33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
39	Main Distribution (800A, 120V)	1	$ 5,000	40	36		2.00%	2.00%
40	Electrical Panels & Branch Wiring	1	$ 10,515	40	32		2.00%	2.00%
41	Lighting Fixtures	1	$ 29,230	25	20		2.00%	2.00%

Input : Min Upgrade

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					2.00%	2.00%
2	Slab on Grade	0					2.00%	2.00%
3	Concrete Block Superstructure	0					2.00%	2.00%
4	Metal Deck on Steel Joists	0					2.00%	2.00%
5	Wood Roof Structure	0					2.00%	2.00%
6	Modified Bitumen	0					2.00%	2.00%
7	Asphalt Shingles	0					2.00%	2.00%
8	Prefinished Metal Siding	0					2.00%	2.00%
9	Prefinished Metal Siding - Maintenance	0					2.00%	2.00%
10	Painted Wood Clapboard Siding	0					2.00%	2.00%
11	Wood Framed Glazing Units	0					2.00%	2.00%
12	Min Upgrade	0			Min Solar		2.00%	2.00%
13	Aluminum Framed Glazing Units	0					2.00%	2.00%
14	Overhead Door - East Elevation, South Elevation	0					2.00%	2.00%
15	Front Entrance Door, Framed With Glazing	0					2.00%	2.00%
16	Metal Door With Glazing - East & North Elevations	0					2.00%	2.00%
17	Metal Service Door	0					2.00%	2.00%
18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
21	Gypsum Board Walls	1	$ -	65	15		2.00%	2.00%
22	Painted Concrete Block Walls	1	$ -	75	25		2.00%	2.00%
23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
24	Solid Wood Core Doors	1	$ -	60	20		2.00%	2.00%
25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
28	Domestic Hot Water Tank, 48 Gallon Electric	1	$ 2,500	10	3		2.00%	2.00%
29	Water Pumps (2 hp)	0					2.00%	2.00%
30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
31	Shower	1	$ 6,000	30	22		2.00%	2.00%
32	Boiler - oil fired	1	$ 12,500	30	17	$ 500	2.00%	2.00%
33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
39	Main Distribution (800A, 120V)	0					2.00%	2.00%
40	Electrical Panels & Branch Wiring	0					2.00%	2.00%
41	Lighting Fixtures	0					2.00%	2.00%
42		1					2.00%	2.00%
100	A31 Walls Below Grade	1					2.00%	2.00%
101	remove grass landscaping	1	$ 1,554	61	0		2.00%	2.00%
102	remove beach stone	1	$ 2,990	61	0		2.00%	2.00%
103	remove asphalt paving and dispose	1	$ 2,969	61	0		2.00%	2.00%
104	excavate to 2 feet below grade	1	$ 4,766	61	0		2.00%	2.00%
105	new 2" EPS insulation	1	$ 3,757	61	0		2.00%	2.00%
106	cement board	1	$ 5,367	61	0		2.00%	2.00%
107	backfill to subgrade	1	$ 5,957	61	0		2.00%	2.00%
108	reinstate grass landscaping	1	$ 2,220	61	0		2.00%	2.00%
109	reinstate beach stone	1	$ 4,272	61	0		2.00%	2.00%
110	reinstate asphalt paving	1	$ 12,725	61	0		2.00%	2.00%

BASE CASE

RETROFIT

111	A32 Walls Above Grade	1					2.00%	2.00%
112	remove existing façade	1	$ 11,530	61	0		2.00%	2.00%
113	structural upgrade including base angle	1	$ 68,000	61	0		2.00%	2.00%
114	supply and install r16 prefab insulated wall panels	1	$ 207,538	61	0		2.00%	2.00%
115	supply and install prefinished metal siding	1	$ 345,897	61	0		2.00%	2.00%
116	A33 Windows and Entrances	1					2.00%	2.00%
117	replace windows with triple pane	1	$ 45,343	35	0		2.00%	2.00%
118	new R10 overhead door	1	$ 36,000	20	0		2.00%	2.00%
119	A34 Roof Coverings	1					2.00%	2.00%
120	remove existing asphalt shingle roof finish	1	$ 2,504	61	0		2.00%	2.00%
121	remove existing mod bit roof finish	1	$ 11,927	61	0		2.00%	2.00%
122	3/4 T&G plywood sheathing	1	$ 91,102	61	0		2.00%	2.00%
123	install new pre-engineered roof trusses above existing	1	$ 118,433	61	0		2.00%	2.00%
124	new knee wall construction, hurricane clips	1	$ 3,254	61	0		2.00%	2.00%
125	new R25 loose fill insulation	1	$ 18,220	61	0		2.00%	2.00%
126	new metal roof system	1	$ 209,536	61	0		2.00%	2.00%
127	B22 Ceiling Finishes	1					2.00%	2.00%
128		1					2.00%	2.00%
129	B23 Wall Finishes	1					2.00%	2.00%
130		1					2.00%	2.00%
131	C11 Plumbing and Drainage	1					2.00%	2.00%
132		1					2.00%	2.00%
133	C13 HVAC	1					2.00%	2.00%
134	new 3/4 ton mini split heat pump	1	$ 11,000	15	0	$ 50	2.00%	2.00%
144		1					2.00%	2.00%
145	ERV 190cfm	1	$ 3,500	15	0		2.00%	2.00%
146	ERV 530cfm	1	$ 9,000	15	0		2.00%	2.00%
147	new ERV ductwork connected to existing	1	$ 9,000	15	0		2.00%	2.00%
148	C14 Controls	1					2.00%	2.00%
149	new ddc control system	1	$ 5,000	20	0	$ 50	2.00%	2.00%
150	C21 Services and Distribution	1					2.00%	2.00%
151		1					2.00%	2.00%
155	install LED retrofit kits to all existing lights	1	$ 20,230	15	0	$ -	2.00%	2.00%
156	upgrade selective mechanical connections	1	$ 7,500	61	0	$ -	2.00%	2.00%
157	Z11 General Requirements and Overheads	1					2.00%	2.00%
158	contractor's overheads 15%	1	$ 192,164	61	0		2.00%	2.00%
159	Z12 Contractors Profit	1					2.00%	2.00%
160	contractor's profit 10%	1	$ 147,325	61	0		2.00%	2.00%
161	Z21 Design Allowance	1					2.00%	2.00%
162	design development contingency 10%	1	$ 162,058	61	0		2.00%	2.00%
163	Z23 Construction Allowance	1					2.00%	2.00%
164	construction contingency 10%	1	$ 178,264	61	0		2.00%	2.00%
169		1					2.00%	2.00%
170	construction escalation for 2024 - 10%	1	$ 128,109	61	0		2.00%	2.00%
171		1					2.00%	2.00%

Input : NZER ASHP

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					2.00%	2.00%
2	Slab on Grade	0					2.00%	2.00%
3	Concrete Block Superstructure	0					2.00%	2.00%
4	Metal Deck on Steel Joists	0					2.00%	2.00%
5	Wood Roof Structure	0					2.00%	2.00%
6	Modified Bitumen	0					2.00%	2.00%
7	Asphalt Shingles	0					2.00%	2.00%
8	Prefinished Metal Siding	0					2.00%	2.00%
9	Prefinished Metal Siding - Maintenance	0					2.00%	2.00%
10	Painted Wood Clapboard Siding	0					2.00%	2.00%
11	Wood Framed Glazing Units	0					2.00%	2.00%
12	Min Upgrade	0			Min Solar		2.00%	2.00%
13	Aluminum Framed Glazing Units	0					2.00%	2.00%
14	Overhead Door - East Elevation, South Elevation	0					2.00%	2.00%
15	Front Entrance Door, Framed With Glazing	0					2.00%	2.00%
16	Metal Door With Glazing - East & North Elevations	0					2.00%	2.00%
17	Metal Service Door	0					2.00%	2.00%
18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
21	Gypsum Board Walls	1	$ -	65	15		2.00%	2.00%
22	Painted Concrete Block Walls	1	$ -	75	25		2.00%	2.00%
23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
24	Solid Wood Core Doors	1	$ -	60	20		2.00%	2.00%
25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
28	Domestic Hot Water Tank, 48 Gallon Electric	0	$ 2,500	10	3		2.00%	2.00%
29	Water Pumps (2 hp)	0					2.00%	2.00%
30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
31	Shower	1	$ 6,000	30	22		2.00%	2.00%
32	Boiler - oil fired	0		30	17		2.00%	2.00%
33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
39	Main Distribution (800A, 120V)	0					2.00%	2.00%
40	Electrical Panels & Branch Wiring	0					2.00%	2.00%
41	Lighting Fixtures	0					2.00%	2.00%
99		1					2.00%	2.00%
100	A31 Walls Below Grade	1					2.00%	2.00%
101	remove grass landscaping	1	$ 1,554	61	0		2.00%	2.00%
102	remove beach stone	1	$ 2,990	61	0		2.00%	2.00%
103	remove asphalt paving and dispose	1	$ 2,969	61	0		2.00%	2.00%
104	excavate to 2 feet below grade	1	$ 4,766	61	0		2.00%	2.00%
105	new 2" EPS insulation	1	$ 3,757	61	0		2.00%	2.00%
106	cement board	1	$ 5,367	61	0		2.00%	2.00%
107	backfill to subgrade	1	$ 5,957	61	0		2.00%	2.00%
108	reinstate grass landscaping	1	$ 2,220	61	0		2.00%	2.00%
109	reinstate beach stone	1	$ 4,272	61	0		2.00%	2.00%
110	reinstate asphalt paving	1	$ 12,725	61	0		2.00%	2.00%
111	A32 Walls Above Grade	1					2.00%	2.00%
112	remove existing façade	1	$ 11,530	61	0		2.00%	2.00%

RETROFIT

113	structural upgrade including base angle	1	$ 68,000	61	0		2.00%	2.00%
114	supply and install r16 prefab insulated wall panels	1	$ 207,538	61	0		2.00%	2.00%
115	supply and install prefinished metal siding	1	$ 345,897	61	0		2.00%	2.00%
116	A33 Windows and Entrances	1					2.00%	2.00%
117	replace windows with triple pane	1	$ 45,343	35	0		2.00%	2.00%
118	new R10 overhead door	1	$ 36,000	20	0		2.00%	2.00%
119	A34 Roof Coverings	1					2.00%	2.00%
120	remove existing asphalt shingle roof finish	1	$ 2,504	61	0		2.00%	2.00%
121	remove existing mod bit roof finish	1	$ 11,927	61	0		2.00%	2.00%
122	3/4 T&G plywood sheathing	1	$ 91,102	61	0		2.00%	2.00%
123	install new pre-engineered roof trusses above existing	1	$ 118,433	61	0		2.00%	2.00%
124	new knee wall construction, hurricane clips	1	$ 3,254	61	0		2.00%	2.00%
125	new R25 loose fill insulation	1	$ 18,220	61	0		2.00%	2.00%
126	new metal roof system	1	$ 209,536	61	0		2.00%	2.00%
127	B22 Ceiling Finishes	1					2.00%	2.00%
128	cut and patch ceilings for new mechanical/electrical	1	$ 16,184	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	$ 16,184	61	0		2.00%	2.00%
131	C11 Plumbing and Drainage	1					2.00%	2.00%
132	new 80gal HP dhwt	1	$ 4,500	10	0		2.00%	2.00%
133	C13 HVAC	1					2.00%	2.00%
134	ASHP-9 tons	1	$ 50,000	15	0	$ 100	2.00%	2.00%
135	electric boiler - 15kW	1	$ 5,000	30	0	$ 50	2.00%	2.00%
136	HP HX pumps	1	$ 11,000	25	0		2.00%	2.00%
137	HP BT pumps	1	$ 11,000	25	0		2.00%	2.00%
138	electric boiler pump	1	$ 2,500	25	0		2.00%	2.00%
139	buffer tanks	1	$ 10,000	25	0		2.00%	2.00%
140		1					2.00%	2.00%
141	air separators	1	$ 7,000	25	0		2.00%	2.00%
142	expansion tanks	1	$ 5,000	25	0		2.00%	2.00%
143	distribution piping	1	$ 25,000	61	0		2.00%	2.00%
144	indoor units - 3/4 ton	1	$ 11,000	25	0		2.00%	2.00%
145	ERV 190cfm	1	$ 3,500	15	0		2.00%	2.00%
146	ERV 705cfm	1	$ 13,000	15	0		2.00%	2.00%
147	new ERV ductwork connected to existing	1	$ 9,000	61	0		2.00%	2.00%
148	C14 Controls	1					2.00%	2.00%
149	new ddc control system	1	$ 40,460	20	0	$ 100	2.00%	2.00%
150	C21 Services and Distribution	1					2.00%	2.00%
151	new 600A service entrance	1	$ 50,000	61	0		2.00%	2.00%
152	new feeders	1	$ 20,000	61	0		2.00%	2.00%
153	new panel, transformer for HVAC	1	$ 20,000	30	0		2.00%	2.00%
154		1					2.00%	2.00%
155	replace lighting with LED fixtures	1	$ 64,737	15	0		2.00%	2.00%
156	lighting controls	1	$ 24,276	20	0		2.00%	2.00%
157	Z11 General Requirements and Overheads	1					2.00%	2.00%
158	contractor's overheads	1	$ 245,280	61	0		2.00%	2.00%
159	Z12 Contractors Profit	1					2.00%	2.00%
160	contractor's profit	1	$ 188,048	61	0		2.00%	2.00%
161	Z21 Design Allowance	1					2.00%	2.00%
162	design development contingency	1	$ 206,853	61	0		2.00%	2.00%
163	Z23 Construction Allowance	1					2.00%	2.00%
164	construction contingency	1	$ 227,538	61	0		2.00%	2.00%
169		1					2.00%	2.00%
170	construction escalation for 2024 - 10%	1	$ 163,520	61	0		2.00%	2.00%

Input : NZER GSHP

	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%
BASE CASE	1	Concrete Foundation	0					2.00%	2.00%
	2	Slab on Grade	0					2.00%	2.00%
	3	Concrete Block Superstructure	0					2.00%	2.00%
	4	Metal Deck on Steel Joists	0					2.00%	2.00%
	5	Wood Roof Structure	0					2.00%	2.00%
	6	Modified Bitumen	0					2.00%	2.00%
	7	Asphalt Shingles	0					2.00%	2.00%
	8	Prefinished Metal Siding	0					2.00%	2.00%
	9	Prefinished Metal Siding - Maintenance	0					2.00%	2.00%
	10	Painted Wood Clapboard Siding	0					2.00%	2.00%
	11	Wood Framed Glazing Units	0					2.00%	2.00%
	12	Min Upgrade	0			Min Solar		2.00%	2.00%
	13	Aluminum Framed Glazing Units	0					2.00%	2.00%
	14	Overhead Door - East Elevation, South Elevation	0					2.00%	2.00%
	15	Front Entrance Door, Framed With Glazing	0					2.00%	2.00%
	16	Metal Door With Glazing - East & North Elevations	0					2.00%	2.00%
	17	Metal Service Door	0					2.00%	2.00%
	18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
	19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
	20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
	21	Gypsum Board Walls	1	$ -	65	15		2.00%	2.00%
	22	Painted Concrete Block Walls	1	$ -	75	25		2.00%	2.00%
	23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
	24	Solid Wood Core Doors	1	$ -	60	20		2.00%	2.00%
	25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
	26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
	27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
	28	Domestic Hot Water Tank, 48 Gallon Electric	0	$ 2,500	10	3		2.00%	2.00%
	29	Water Pumps (2 hp)	0					2.00%	2.00%
	30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
	31	Shower	1	$ 6,000	30	22		2.00%	2.00%
	32	Boiler	0		30	17		2.00%	2.00%
	33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
	34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
	35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
	36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
	37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
	38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
	39	Main Distribution (800A, 120V)	0					2.00%	2.00%
	40	Electrical Panels & Branch Wiring	0					2.00%	2.00%
	41	Lighting Fixtures	0					2.00%	2.00%
	99		1					2.00%	2.00%
RETROFIT	100	A31 Walls Below Grade	1					2.00%	2.00%
	101	remove grass landscaping	1	$ 1,554	61	0	$ -	2.00%	2.00%
	102	remove beach stone	1	$ 2,990	61	0	$ -	2.00%	2.00%
	103	remove asphalt paving and dispose	1	$ 2,969	61	0	$ -	2.00%	2.00%
	104	excavate to 2 feet below grade	1	$ 4,766	61	0	$ -	2.00%	2.00%
	105	new 2" EPS insulation	1	$ 3,757	61	0	$ -	2.00%	2.00%
	106	cement board	1	$ 5,367	61	0	$ -	2.00%	2.00%
	107	backfill to subgrade	1	$ 5,957	61	0	$ -	2.00%	2.00%
	108	reinstate grass landscaping	1	$ 2,220	61	0	$ -	2.00%	2.00%
	109	reinstate beach stone	1	$ 4,272	61	0	$ -	2.00%	2.00%
	110	reinstate asphalt paving	1	$ 12,725	61	0	$ -	2.00%	2.00%
	111	A32 Walls Above Grade	1		0	0	$ -	2.00%	2.00%
	112	remove existing façade	1	$ 11,530	61	0	$ -	2.00%	2.00%

113	structural upgrade including base angle	1	$	68,000	61	0	$	-	2.00%	2.00%
114	supply and install r16 prefab insulated wall panels	1	$	207,538	61	0	$	-	2.00%	2.00%
115	supply and install prefinished metal siding	1	$	345,897	61	0	$	-	2.00%	2.00%
116	A33 Windows and Entrances	1			0	0	$	-	2.00%	2.00%
117	replace windows with triple pane	1	$	45,343	35	0	$	-	2.00%	2.00%
118	new R10 overhead door	1	$	36,000	20	0	$	-	2.00%	2.00%
119	A34 Roof Coverings	1			0	0	$	-	2.00%	2.00%
120	remove existing asphalt shingle roof finish	1	$	2,504	61	0	$	-	2.00%	2.00%
121	remove existing mod bit roof finish	1	$	11,927	61	0	$	-	2.00%	2.00%
122	3/4 T&G plywood sheathing	1	$	91,102	61	0	$	-	2.00%	2.00%
123	install new pre-engineered roof trusses above existing	1	$	118,433	61	0	$	-	2.00%	2.00%
124	new knee wall construction, hurricane clips	1	$	3,254	61	0	$	-	2.00%	2.00%
125	new R25 loose fill insulation	1	$	18,220	61	0	$	-	2.00%	2.00%
126	new metal roof system	1	$	209,536	61	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	$	16,184	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	$	16,184	61	0	$	-	2.00%	2.00%
131	C11 Plumbing and Drainage	1			0	0	$	-	2.00%	2.00%
132	new 80gal HP dhwt	1	$	4,500	10	0	$	-	2.00%	2.00%
133	C13 HVAC	1			0	0	$	-	2.00%	2.00%
134	geothermal wells, testing	1	$	75,000	61	0			2.00%	2.00%
135	gshp exterior piping, trenching, backfill, reinstatement	1	$	20,000	61	0			2.00%	2.00%
136	gshp interior piping	1	$	10,000	61	0			2.00%	2.00%
137	gshp-4 tons	1	$	20,000	25	0	$	-	2.00%	2.00%
138	electric boiler 20kW	1	$	10,000	30	0	$	50	2.00%	2.00%
139	circulation pumps	1	$	17,500	25	0	$	-	2.00%	2.00%
140	electric boiler pump	1	$	2,500	0	0	$	-	2.00%	2.00%
141	air separators	1	$	10,500	25	0	$	-	2.00%	2.00%
142	expansion tanks	1	$	7,500	25	0	$	-	2.00%	2.00%
143	distribution piping	1	$	25,000	61	0	$	-	2.00%	2.00%
144	indoor units - 3/4 ton	1	$	11,000	25	0	$	-	2.00%	2.00%
145	ERV 190cfm	1	$	3,500	15	0	$	-	2.00%	2.00%
146	ERV 705cfm	1	$	13,000	15	0	$	-	2.00%	2.00%
147	new ERV ductwork connected to existing	1	$	9,000	61	0	$	-	2.00%	2.00%
148	C14 Controls	1			0	0	$	-	2.00%	2.00%
149	new ddc control system	1	$	40,460	20	0	$	100	2.00%	2.00%
150	C21 Services and Distribution	1			0	0	$	-	2.00%	2.00%
151	new 600A service entrance	1	$	50,000	61	0	$	-	2.00%	2.00%
152	new feeders	1	$	20,000	61	0	$	-	2.00%	2.00%
153	new panel, transformer for HVAC	1	$	20,000	30	0	$	-	2.00%	2.00%
154		1			0	0	$	-	2.00%	2.00%
155	replace lighting with LED fixtures	1	$	64,737	15	0	$	-	2.00%	2.00%
156	lighting controls	1	$	24,276	20	0	$	-	2.00%	2.00%
157	Z11 General Requirements and Overheads	1			0	0	$	-	2.00%	2.00%
158	contractor's overheads	1	$	256,005	61	0	$	-	2.00%	2.00%
159	Z12 Contractors Profit	1			0	0	$	-	2.00%	2.00%
160	contractor's profit	1	$	196,271	61	0	$	-	2.00%	2.00%
161	Z21 Design Allowance	1			0	0	$	-	2.00%	2.00%
162	design development contingency	1	$	215,898	61	0	$	-	2.00%	2.00%
163	Z23 Construction Allowance	1			0	0	$	-	2.00%	2.00%
164	construction contingency	1	$	237,488	61	0	$	-	2.00%	2.00%
169		1			0	0	$	-	2.00%	2.00%
170	construction escalation for 2024 - 10%	1	$	170,670	61	0	$	-	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					2.00%	2.00%
2	Slab on Grade	0					2.00%	2.00%
3	Concrete Block Superstructure	0					2.00%	2.00%
4	Metal Deck on Steel Joists	0					2.00%	2.00%
5	Wood Roof Structure	0					2.00%	2.00%
6	Modified Bitumen	0					2.00%	2.00%
7	Asphalt Shingles	0					2.00%	2.00%
8	Prefinished Metal Siding	0					2.00%	2.00%
9	Prefinished Metal Siding - Maintenance	0					2.00%	2.00%
10	Painted Wood Clapboard Siding	0					2.00%	2.00%
11	Wood Framed Glazing Units	0					2.00%	2.00%
12	Vinyl Glazing Units	0					2.00%	2.00%
13	Min Upgrade	0			Min Solar		2.00%	2.00%
14	Overhead Door - East Elevation, South Elevation	0					2.00%	2.00%
15	Front Entrance Door, Framed With Glazing	0					2.00%	2.00%
16	Metal Door With Glazing - East & North Elevations	0					2.00%	2.00%
17	Metal Service Door	0					2.00%	2.00%
18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
21	Gypsum Board Walls	1	$ -	65	15		2.00%	2.00%
22	Painted Concrete Block Walls	1	$ -	75	25		2.00%	2.00%
23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
24	Solid Wood Core Doors	1	$ -	60	20		2.00%	2.00%
25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
28	Domestic Hot Water Tank, 48 Gallon Electric	0	$ 2,500	10	3		2.00%	2.00%
29	Water Pumps (2 hp)	0		35	30		2.00%	2.00%
30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
31	Shower	1	$ 6,000	30	22		2.00%	2.00%
32	Boiler - oil fired	0		30	17		2.00%	2.00%
33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
39	Main Distribution (800A, 120V)	0					2.00%	2.00%
40	Electrical Panels & Branch Wiring	0					2.00%	2.00%
41	Lighting Fixtures	0					2.00%	2.00%
99		1					2.00%	2.00%
100	A31 Walls Below Grade	1					2.00%	2.00%
101	remove grass landscaping	1	$ 1,554	61	0	$ -	2.00%	2.00%
102	remove beach stone	1	$ 2,990	61	0	$ -	2.00%	2.00%
103	remove asphalt paving and dispose	1	$ 2,969	61	0	$ -	2.00%	2.00%
104	excavate to 2 feet below grade	1	$ 4,766	61	0	$ -	2.00%	2.00%
105	new 2" EPS insulation	1	$ 3,757	61	0	$ -	2.00%	2.00%
106	cement board	1	$ 5,367	61	0	$ -	2.00%	2.00%
107	backfill to subgrade	1	$ 5,957	61	0	$ -	2.00%	2.00%
108	reinstate grass landscaping	1	$ 2,220	61	0	$ -	2.00%	2.00%
109	reinstate beach stone	1	$ 4,272	61	0	$ -	2.00%	2.00%
110	reinstate asphalt paving	1	$ 12,725	61	0	$ -	2.00%	2.00%
111	A32 Walls Above Grade	1		0	0	$ -	2.00%	2.00%
112	remove existing façade	1	$ 11,530	61	0	$ -	2.00%	2.00%
113	structural upgrade including base angle	1	$ 68,000	61	0	$ -	2.00%	2.00%

BASE CASE

RETROFIT

114	supply and install r16 prefab insulated wall panels	1	$ 207,538	61	0	$ -	2.00%	2.00%
115	supply and install prefinished metal siding	1	$ 345,897	61	0	$ -	2.00%	2.00%
116	A33 Windows and Entrances	1		0	0	$ -	2.00%	2.00%
117	replace windows with triple pane	1	$ 45,343	35	0	$ -	2.00%	2.00%
118	new R10 overhead door	1	$ 36,000	20	0	$ -	2.00%	2.00%
119	A34 Roof Coverings	1		0	0	$ -	2.00%	2.00%
120	remove existing asphalt shingle roof finish	1	$ 2,504	61	0	$ -	2.00%	2.00%
121	remove existing mod bit roof finish	1	$ 11,927	61	0	$ -	2.00%	2.00%
122	3/4 T&G plywood sheathing	1	$ 91,102	61	0	$ -	2.00%	2.00%
123	install new pre-engineered roof trusses above existing	1	$ 118,433	61	0	$ -	2.00%	2.00%
124	new knee wall construction, hurricane clips	1	$ 3,254	61	0	$ -	2.00%	2.00%
125	new R25 loose fill insulation	1	$ 18,220	61	0	$ -	2.00%	2.00%
126	new metal roof system	1	$ 209,536	61	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	$ 16,184	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	$ 16,184	61	0	$ -	2.00%	2.00%
131	C11 Plumbing and Drainage	1		0	0	$ -	2.00%	2.00%
132	new 80gal HP dhwt	1	$ 4,500	10	0	$ -	2.00%	2.00%
133	C13 HVAC	1		0	0	$ -	2.00%	2.00%
134	ASHP-9 tons	1	$ 50,000	15	0	$ -	2.00%	2.00%
135	electric boiler - 15kW	1	$ 5,000	61	0	$ -	2.00%	2.00%
136	HP HX pumps	1	$ 11,000	61	0	$ -	2.00%	2.00%
137	HP BT pumps	1	$ 11,000	25	0	$ -	2.00%	2.00%
138	electric boiler pump	1	$ 2,500	30	0	$ 50	2.00%	2.00%
139	buffer tanks	1	$ 10,000	25	0	$ -	2.00%	2.00%
140	0	1	$ -	0	0	$ -	2.00%	2.00%
141	air separators	1	$ 7,000	25	0	$ -	2.00%	2.00%
142	expansion tanks	1	$ 5,000	25	0	$ -	2.00%	2.00%
143	distribution piping	1	$ 25,000	61	0	$ -	2.00%	2.00%
144	indoor units - 3/4 ton	1	$ 11,000	25	0	$ -	2.00%	2.00%
145	ERV 190cfm	1	$ 3,500	15	0	$ -	2.00%	2.00%
146	ERV 705cfm	1	$ 13,000	15	0	$ -	2.00%	2.00%
147	new ERV ductwork connected to existing	1	$ 9,000	61	0	$ -	2.00%	2.00%
148	C14 Controls	1		0	0	$ -	2.00%	2.00%
149	new ddc control system	1	$ 40,460	20	0	$ 100	2.00%	2.00%
150	C21 Services and Distribution	1		0	0	$ -	2.00%	2.00%
151	new 600A service entrance	1	$ 50,000	61	0	$ -	2.00%	2.00%
152	new feeders	1	$ 20,000	61	0	$ -	2.00%	2.00%
153	new panel, transformer for HVAC	1	$ 20,000	30	0	$ -	2.00%	2.00%
154	photovoltaic system complete with racking, inverters	1		0	0	$ -	2.00%	2.00%
155	replace lighting with LED fixtures	1	$ 64,737	15	0	$ -	2.00%	2.00%
156	lighting controls	1	$ 24,276	20	0	$ -	2.00%	2.00%
157	Z11 General Requirements and Overheads	1		0	0	$ -	2.00%	2.00%
158	contractor's overheads	1	$ 245,280	61	0	$ -	2.00%	2.00%
159	Z12 Contractors Profit	1		0	0	$ -	2.00%	2.00%
160	contractor's profit	1	$ 188,048	61	0	$ -	2.00%	2.00%
161	Z21 Design Allowance	1		0	0	$ -	2.00%	2.00%
162	design development contingency	1	$ 206,853	61	0	$ -	2.00%	2.00%
163	Z23 Construction Allowance	1		0	0	$ -	2.00%	2.00%
164	construction contingency	1	$ 227,538	61	0	$ -	2.00%	2.00%
165		1		0	0	$ -	2.00%	2.00%
170	construction escalation for 2024 - 10%	1	$ 163,520	61	0	$ -	2.00%	2.00%
199		1					2.00%	2.00%
200	Array Size 45 kWdc	1	$ 180,000			$ 1,274	2.00%	2.00%

Input : Min Solar

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					2.00%	2.00%
2	Slab on Grade	0					2.00%	2.00%
3	Concrete Block Superstructure	0					2.00%	2.00%
4	Metal Deck on Steel Joists	0					2.00%	2.00%
5	Wood Roof Structure	0					2.00%	2.00%
6	Modified Bitumen	0					2.00%	2.00%
7	Asphalt Shingles	0					2.00%	2.00%
8	Prefinished Metal Siding	0					2.00%	2.00%
9	Prefinished Metal Siding - Maintenance	0					2.00%	2.00%
10	Painted Wood Clapboard Siding	0					2.00%	2.00%
11	Wood Framed Glazing Units	0					2.00%	2.00%
12	Min Upgrade	0			Min Solar		2.00%	2.00%
13	Aluminum Framed Glazing Units	0					2.00%	2.00%
14	Overhead Door - East Elevation, South Elevation	0					2.00%	2.00%
15	Front Entrance Door, Framed With Glazing	0					2.00%	2.00%
16	Metal Door With Glazing - East & North Elevations	0					2.00%	2.00%
17	Metal Service Door	0					2.00%	2.00%
18	VCT Flooring	1	$ 65,965	25	15		2.00%	2.00%
19	VCT Flooring - Maintenance Bay	1	$ 6,680	25	25		2.00%	2.00%
20	VCT Flooring - Repair Allowance	1	$ -				2.00%	2.00%
21	Gypsum Board Walls	1	$ -	65	15		2.00%	2.00%
22	Painted Concrete Block Walls	1	$ -	75	25		2.00%	2.00%
23	Suspended Ceiling	1	$ 13,512	20	5		2.00%	2.00%
24	Solid Wood Core Doors	1	$ -	60	20		2.00%	2.00%
25	Kitchenette Millwork	1	$ 2,250	25	12		2.00%	2.00%
26	Plumbing Service & Distribution	1	$ 80,975	50	35		2.00%	2.00%
27	Back Flow Preventer	1	$ 1,500	30	30	$ 200	2.00%	2.00%
28	Domestic Hot Water Tank, 48 Gallon Electric	1	$ 2,500	10	3		2.00%	2.00%
29	Water Pumps (2 hp)	0		35	30		2.00%	2.00%
30	Plumbing fixtures	1	$ 12,600	35	27		2.00%	2.00%
31	Shower	1	$ 6,000	30	22		2.00%	2.00%
32	Boiler - oil fired	1	$ 12,500	30	17	$ 500	2.00%	2.00%
33	Expansion Tank	1	$ 1,500	30	2		2.00%	2.00%
34	Baseboard Radiators	1	$ 72,285	40	20		2.00%	2.00%
35	Lennox Heat Pump	1	$ 7,500	20	0	$ 200	2.00%	2.00%
36	Diesel Fuel Storage Tank	1	$ 12,500	25	20		2.00%	2.00%
37	Diesel Generator	1	$ 18,000	35	33	$ 500	2.00%	2.00%
38	Day Tank	1	$ 1,500	20	18		2.00%	2.00%
39	Main Distribution (800A, 120V)	0					2.00%	2.00%
40	Electrical Panels & Branch Wiring	0					2.00%	2.00%
41	Lighting Fixtures	0					2.00%	2.00%
99		1					2.00%	2.00%
100	A31 Walls Below Grade	1					2.00%	2.00%
101	remove grass landscaping	1	$ 1,554	61	0		2.00%	2.00%
102	remove beach stone	1	$ 2,990	61	0		2.00%	2.00%
103	remove asphalt paving and dispose	1	$ 2,969	61	0		2.00%	2.00%
104	excavate to 2 feet below grade	1	$ 4,766	61	0		2.00%	2.00%
105	new 2" EPS insulation	1	$ 3,757	61	0		2.00%	2.00%
106	cement board	1	$ 5,367	61	0		2.00%	2.00%
107	backfill to subgrade	1	$ 5,957	61	0		2.00%	2.00%
108	reinstate grass landscaping	1	$ 2,220	61	0		2.00%	2.00%
109	reinstate beach stone	1	$ 4,272	61	0		2.00%	2.00%
110	reinstate asphalt paving	1	$ 12,725	61	0		2.00%	2.00%
111	A32 Walls Above Grade	1					2.00%	2.00%
112	remove existing façade	1	$ 11,530	61	0		2.00%	2.00%

RETROFIT

113	structural upgrade including base angle	1	$ 68,000	61	0		2.00%	2.00%
114	supply and install r16 prefab insulated wall panels	1	$ 207,538	61	0		2.00%	2.00%
115	supply and install prefinished metal siding	1	$ 345,897	61	0		2.00%	2.00%
116	A33 Windows and Entrances	1					2.00%	2.00%
117	replace windows with triple pane	1	$ 45,343	35	0		2.00%	2.00%
118	new R10 overhead door	1	$ 36,000	20	0		2.00%	2.00%
119	A34 Roof Coverings	1					2.00%	2.00%
120	remove existing asphalt shingle roof finish	1	$ 2,504	61	0		2.00%	2.00%
121	remove existing mod bit roof finish	1	$ 11,927	61	0		2.00%	2.00%
122	3/4 T&G plywood sheathing	1	$ 91,102	61	0		2.00%	2.00%
123	install new pre-engineered roof trusses above existing	1	$ 118,433	61	0		2.00%	2.00%
124	new knee wall construction, hurricane clips	1	$ 3,254	61	0		2.00%	2.00%
125	new R25 loose fill insulation	1	$ 18,220	61	0		2.00%	2.00%
126	new metal roof system	1	$ 209,536	61	0		2.00%	2.00%
127	B22 Ceiling Finishes	1					2.00%	2.00%
128		1					2.00%	2.00%
129	B23 Wall Finishes	1					2.00%	2.00%
130		1					2.00%	2.00%
131	C11 Plumbing and Drainage	1					2.00%	2.00%
132		1					2.00%	2.00%
133	C13 HVAC	1					2.00%	2.00%
134	new 3/4 ton mini split heat pump	1	$ 11,000	20	0	$ 50	2.00%	2.00%
135		1					2.00%	2.00%
145	ERV 190cfm	1	$ 3,500	15	0		2.00%	2.00%
146	ERV 530cfm	1	$ 9,000	15	0		2.00%	2.00%
147	new ERV ductwork connected to existing	1	$ 9,000	61	0		2.00%	2.00%
148	C14 Controls	1					2.00%	2.00%
149	new ddc control system	1	$ 5,000	20	0	$ 50	2.00%	2.00%
150	C21 Services and Distribution	1					2.00%	2.00%
153		1					2.00%	2.00%
154	photovoltaic system complete with racking, inverters	1					2.00%	2.00%
155	install LED retrofit kits to all existing lights	1	$ 20,230				2.00%	2.00%
156	upgrade selective mechanical connections	1	$ 7,500				2.00%	2.00%
157	Z11 General Requirements and Overheads	1					2.00%	2.00%
158	contractor's overheads	1	$ 192,164				2.00%	2.00%
159	Z12 Contractors Profit	1					2.00%	2.00%
160	contractor's profit	1	$ 147,325				2.00%	2.00%
161	Z21 Design Allowance	1					2.00%	2.00%
162	design development contingency	1	$ 162,058				2.00%	2.00%
163	Z23 Construction Allowance	1					2.00%	2.00%
164	construction contingency	1	$ 178,264				2.00%	2.00%
169		1					2.00%	2.00%
170	construction escalation for 2024 - 10%	1	$ 128,109	61	0		2.00%	2.00%
199		1					2.00%	2.00%
200	Array Size 42 kWdc	1	$ 168,000			$ 1,189	2.00%	2.00%