OACETT Technology Report

Title: Sustainable Mechanical Design Solutions

From: Mackenzie Hunter, [redacted]

[redacted]

Discipline: Building

Date: [redacted]

Declaration of Sole Authorship

I, Mackenzie Hunter, confirm that this work submitted for assessment is my own and is expressed in my own words. Any uses made within it of the works of any other author, in any form (ideas, equations, figures, texts, tables, programs), are properly acknowledged at the point of use. A list of the references is included.

Signature:
Date: [redacted]

Proposal

From: Mackenzie Hunter

Date: [redacted]

Discipline: Building

Title: Sustainable Mechanical Design Solutions

Sustainability can be understood as responding to our current needs without compromising the ability for future generations to meet their needs. In today's society, there is a rising desire to make buildings in a more sustainable manner. Designers are responsible for coming up with design solutions that have a minimal impact on our environment. The operational mechanics of buildings in Ottawa can present many challenges due to the extreme climate changes we experience. The intent of this report is to examine sustainable mechanical design solutions that can be used in the construction of Algonquin College's addition to the existing H-Building.

The mechanical systems in a building play a critical role in sustainable design. Poorly designed mechanical systems can result in high energy and water consumption usage, increase the amount of pollution a building creates, and increase building operation costs. In order to avoid these issues, it is best to prioritize resource-efficient technologies in the building design.

There are many different resources-efficient technologies that can help achieve a greater sustainable mechanical design. In the design for the proposed addition to the existing H-Building, we will be focusing on just a few. The strategies that I will be looking to implement in the design include rainwater harvesting, solar water heating, and the utilization of high-performance HVAC equipment. Rainwater harvesting decreases the need for freshwater consumption, decreasing the need for public water supply. It also reduces the amount of stormwater runoff, which helps prevent flooding and channel erosion. Rainwater utilization has several applications that are coherent to minimizing fresh water supply to the completed building design. Employing the use of renewable energy sources like solar water heating can efficiently cover up to 80% of the building's hot water needs. The use of solar water heating limits the amount of electricity or gas used to heat water, in turn further reducing operation costs and pollution. In addition to the above technologies we will also review the use of high-performance HVAC systems. This solution is universal, meaning it can be used on almost any project type. HVAC systems account for approximately 40% of the energy used in commercial buildings, using high performance HVAC equipment can result in considerable energy, emission, and cost savings. Each HVAC discipline (heating, ventilating, air-conditioning and controls) has its own set of design requirements and standards. This means that each discipline has unique opportunities for energy savings.

The addition to the existing H-Building will benefit from utilizing simple mechanical design solutions including rainwater recycling, solar water heating, and the utilization of high-performance HVAC equipment. We can design a sustainable building that not only meets, but exceeds, the requirements of local building standards. Using these resource-efficient technologies does not diminish the quality of life we live; however, they can impart benefits on many levels.

OACETT

Dear Mackenzie Hunter, C.Tech.:

Your Technology Report Proposal has been ACCEPTED as SATISFACTORY and you have been assigned a one year deadline to submit the Technology Report- [redacted]

The Technology Report can be submitted through your OACETT portal account by selecting your C.E.T. application.

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If you have further inquiries regarding your certification, these can be sent to us at certify@oacett.org

Sincerely,

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Abstract

Today in many parts of the world buildings rely on mechanical systems. Mechanical systems play a critical role in creating a comfortable indoor environment for building occupants. With growing concerns of the footprint - we leave behind us; sustainability has become a significant aspect of building design. By installing sustainable mechanical systems in our buildings, we can have a large impact on the footprint our new buildings create overtime. This report gives an overview of three sustainable mechanical design principles; rainwater harvesting, solar water heating and high-performance HVAC equipment. We will examine how easily these systems can be integrated in our building design to improve the overall sustainability output of our building.

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1.0 Introduction

Sustainability can be understood as responding to our current needs without compromising the ability for future generations to meet their needs. In today's society, there is a rising desire to make buildings in a more sustainable manner. Designers are responsible for coming up with design solutions that have a minimal impact on our environment. The operational mechanics of buildings in Ottawa can present many challenges due to the extreme variation of climate changes we experience through-out the year. The intent of this report is to examine sustainable mechanical design solutions that can be used in the construction of Algonquin College's addition to the existing 'H' building. In this report we will look at the feasibility of installing a rainwater harvesting system, solar water heating and high-performance HVAC equipment.

2.0 Application / Installation of Rainwater Harvesting Systems

The re-use of water in a building system can be an effective way of creating a more environmentally friendly building. It reduces the demand for public water supply and reduces the amount of wastewater entering our storm / sewer systems. In short, rainwater harvesting is a process or technique that collects, filters, stores and reuses rainfall water. Collected rainwater has many applications dependant on the type of system you have installed. Rainwater can be potable, if properly treated, it can be used for drinking and cooking. "Rainwater can actually be very high-quality water for human consumption. It's relatively pure and doesn't contain any chlorine or other chemicals, which are often used to sanitize city tap water" [1]. If left untreated it can be used for bathing, laundry, flushing toilets, irrigation of lawns and green roofs and watering gardens and houseplants. Using collected rainwater for these applications come with a wide variety of benefits.

In Ottawa, older urban areas face issues with stormwater management. When rain falls on surfaces such as buildings, streets and parking lots it moves quickly into storm sewers. Storm sewers quickly drain directly into our surrounding streams and rivers, picking up pollutants along the way. This can cause several problems including poor water quality in surrounding bodies of water, increased risk of flooding and erosion, habitat degradation and beach closures. By implementing a rainwater harvesting system we are doing our part in taking a step towards a more sustainable building.

Installation of rainwater harvesting systems is possible in new and existing applications. However, installing a rainwater collection system is easiest with new construction. The installation of a rainwater harvesting system is quite simple. There are two main methods of harvesting rainwater. Rooftop harvesting is the most preferred method of rainwater collection. The basic components of this system include; catchment, gutter, down take pipes, a storage tank and the distribution system. An alternate method is surface run-off harvesting, this method involves catchment systems that catch the flow of water occurring on ground surface. Regardless of the system type, you will need a water cistern (storage tank) big enough to store the water you are collecting; in commercial applications it is most common to store water cisterns underground. The reasoning for this is because you will need a much larger storage tank than what would be required in a residential application. This is why installation is easier with new construction.

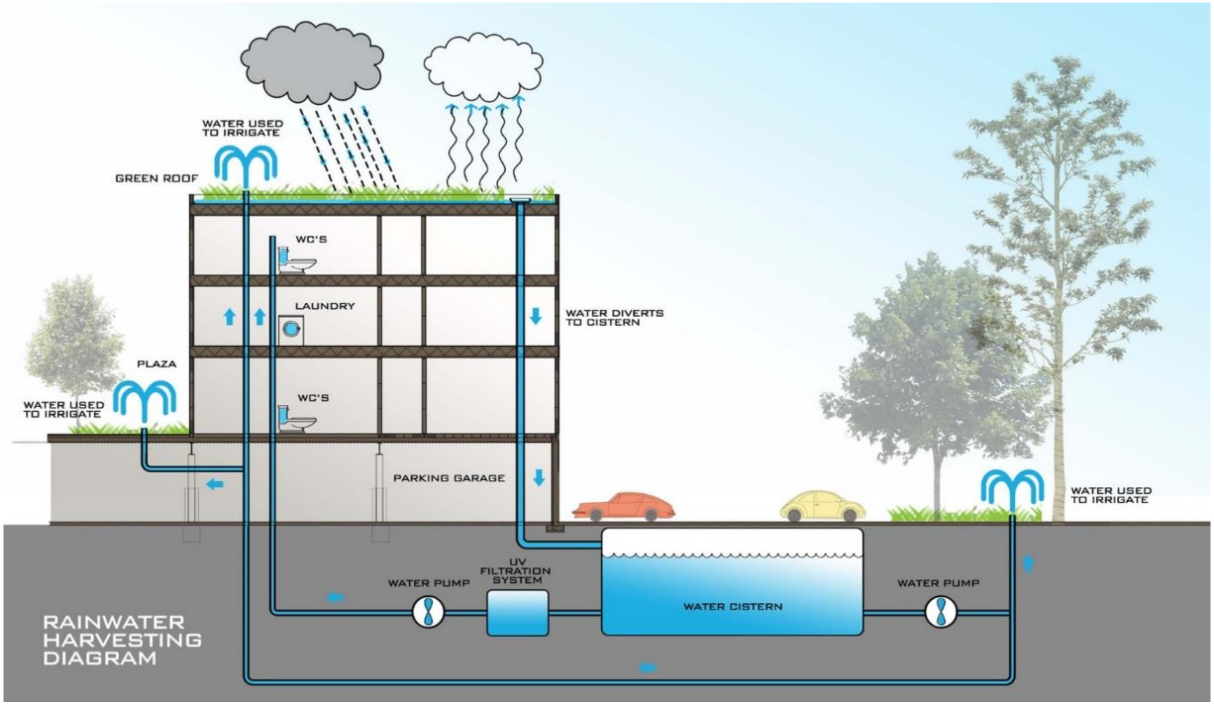

Figure 1 – Rainwater Harvesting Diagram [2].

The installation of a rainwater harvesting system on the addition to Algonquin College's 'H' building would be similar to the illustration in *Figure 1*. This illustration shows an example of the rooftop rainwater harvesting method being implemented. We would also be using the rooftop rainwater harvesting method in our new construction addition. The water would be collected through several catchment devices on the roof and transferred to a water cistern below grade using down take pipes. The water will then be stored for potable and non-potable use and pumped back into the building when needed. "Rainwater can be stored from anywhere between one week and indefinitely. The more consideration you put into your storage system – using the right materials, preventing algae and mosquitos – the longer your rainwater's shelf-life" [3]. It is best to properly store the water you are collecting to in order to maximize the economic benefits of our system.

Our building has several uses in which rainwater will be used. Our toilets and lavatories in our washrooms, drinking fountains and plumbing fixtures within our restaurant space will all be supplied with rainwater. In addition to the building applications mentioned above, we will also use the collected water to hydrate the plants in our indoor garden and to irrigate our green roof system. Using rainwater to water plants has many added benefits, it is a very high-quality water source. "There are several reasons rainwater is more suitable for plants than tap water, but the most important is chemistry. In tap water, chlorine is a necessary disinfectant and fluoride is added to prevent cavities" [4]. Any additional water collected can be used to irrigate and water the plants surrounding our building when needed.

2.1 Advantages / Disadvantages of Rainwater Harvesting Systems

We will start by discussing some of the possible disadvantages that may occur with a rainwater harvesting system. Rainfall can be unpredictable, this means that sometimes little, or no rainfall can limit the supply if rainwater being collected. This means rainwater harvesting systems are most suitable in areas that receive plenty of rainfall.

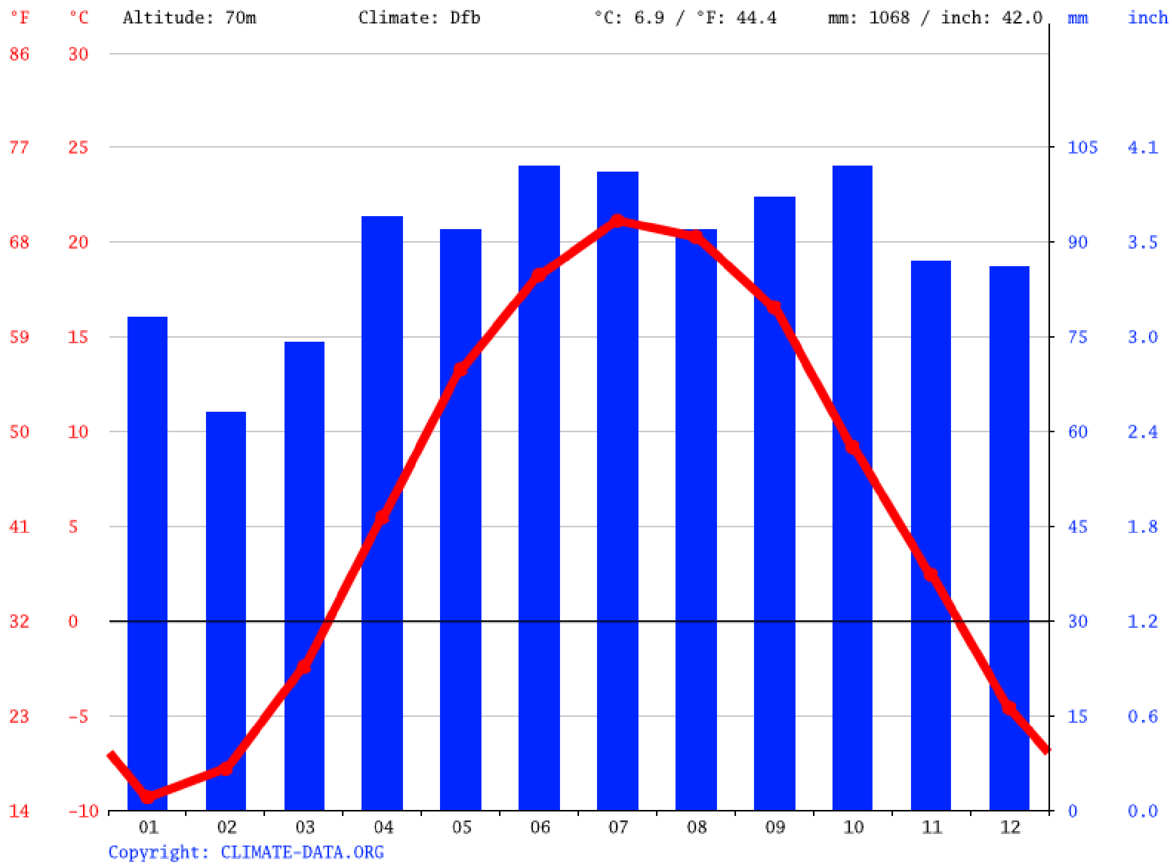

Figure 2 – Ottawa Climate Graph [5].

Ottawa has a significant amount of rain fall throughout the year. As illustrated in *Figure 2*, even in the driest month (February) Ottawa still receives plenty of rainfall. This makes Ottawa's weather a perfect candidate for a rainwater harvesting system.

Additional disadvantages to rainwater harvesting systems may include; the initial cost, the maintenance requirements and storage limitations. The initial cost of a rainwater harvesting systems has many variants, it can be quite costly at times. After using a cost estimation software, I have been able to determine the approximate cost of a rainwater harvesting system for the addition to Algonquin College's existing 'H' building. The cost of this system for its intended use would be approximately $48,028 (see Appendix A). "Like solar panels, the cost can be recovered in 10-15 years, which again depends on the amount of rainfall and sophistication of the system" [6]. Regular maintenance is a requirement for rainwater harvesting systems "Proper operation and maintenance of rainwater harvesting systems helps to protect water quality in several ways. Regular inspection and cleaning of catchment, gutters, filters and tanks reduce the likelihood of contamination. Water from other sources should not be mixed with that in the tank" [7]. Lastly, storage limitations can impose restrictions on how much rainwater is able to be used. If your system does not have enough storage capacity, you will no longer be taking full advantage of the system benefits. It is important to provide a tank that is large enough to collect enough to last through periods where rain supply may be limited.

The advantages of installing a rainwater harvesting system are plentiful. Although we mentioned maintenance in our disadvantages, the maintenance "requires little time and energy" [6]. Rainwater harvesting has several uses including drinking purposes and several nondrinking purposes. Untreated rainwater can be used for many common applications, some of these applications include bathing, laundry, flushing toilets, irrigation of lawns and green roofs and hydrating gardens and houseplants. The initial cost of rainwater harvesting systems can be expensive, however after the initial cost of the system has been surpassed you will start recovering the money spent. Having a rainwater collection system leads to a large reduction in water utility bill costs. With ever increasing utility cost this system will increase the amount you are saving overtime.

“With an increase in population, the demand for water is also continuously increasing” [6]. Collecting rainwater is a great way to reduce the need for public water supply. Water scarcity caused by the extraction of groundwater is an increasing issue. “Rainwater harvesting enables groundwater levels to be further sustained rather than depleted” [6]. Another sustainable advantage to collecting rainwater is stormwater management. When rain falls on surfaces such as buildings, streets and parking lots it moves quickly into storm sewers. Storm sewers quickly drain directly into our streams and rivers, picking up pollutants along the way. This can cause several problems including poor water quality in surrounding bodies of water, increased risk of flooding and erosion, habitat degradation and beach closures.

3.0 Application / Installation of Solar Water Heating

Solar water heating technology is the process in which energy from sunlight is converted into heat, which is then used to raise the temperature of water. Solar collectors for a water heating system come in an array of forms and have many different placement options; they can be mounted on a roof, on outside walls or on the ground. "Perhaps the most feasible investment in solar is for commercial applications. Unlike residential solar heating, commercial solar heating applications tend to have much larger demand that is steady in its requirements and the demand is usually 365 days per year." [6]

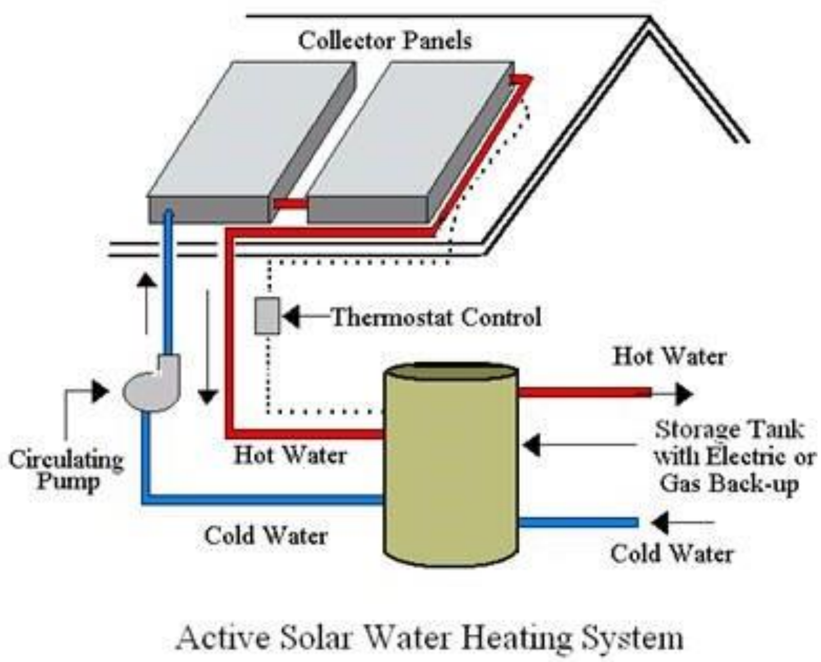

Figure 3 – Solar Water Heating System Diagram [7].

There are two main types of solar water heating systems, active and passive. Active solar water heating systems as illustrated in *Figure 3* use a pump to circulate water between the tank and collectors. “Inside the tank is a specialized pump that helps to circulate the water. The water is moved from the bottom of the tank through the collector to be reheated, and then back into the tank to create useable, hot water” [14]. We will be using an active solar water heating system with closed loop circulation in our addition to Algonquin College’s existing ‘H’ building. Closed loop circulation systems are best suited for climates in which the weather falls below zero. This is because closed loop systems “use an antifreeze solution that is circulated through the solar collectors and a heat exchanger at the solar storage tank” [8]. Due to our extreme winter conditions in Ottawa this is the best method to prevent our solar heating system from freezing.

The installation of solar heating systems requires proper design in order to function to their max capabilities. It is important to choose an area of installation that will receive high concentration of sunlight. Our new building is located on the north side of an existing building, this means our new build will adjoin to the existing building on its south side reducing the amount of light we have available to us. In addition to having a north facing building we have a green roof system covering the entirety of our roof. Most commercial buildings have flat roofs, this is ideal for the placement of solar collectors. Placing solar devices over our green roof however is not an option. Our solar collectors will be wall mounted to our third floor south facing wall. This position is ideal as it will receive the most amount of sunlight possible, it also doesn’t take up any valuable landscaping real estate.

3.1 Advantages / Disadvantages of Solar Water Heating

The disadvantages of solar water heating are known to be limited. The most obvious disadvantage being related to the systems dependence on sunlight. A solar water heating system doesn't require everyday to be sunny "however, you'll save more on your water heating bills if you live in a sunny area because you won't have to use the backup heating source as frequently" [9]. The sun's orientation correlates with our seasons. In Ottawa, during the summer season, daylight duration averages 15 hours. Whereas during the winter season it is closer to 8 hours. In spring and fall, on average we receive about 12 hours of daylight. Overall in Ottawa we receive a fair amount of sunlight, installing a solar water heating system is feasible for this reason. It is important however to verify your solar collectors will be installed in a position where they are maximizing their solar reception.

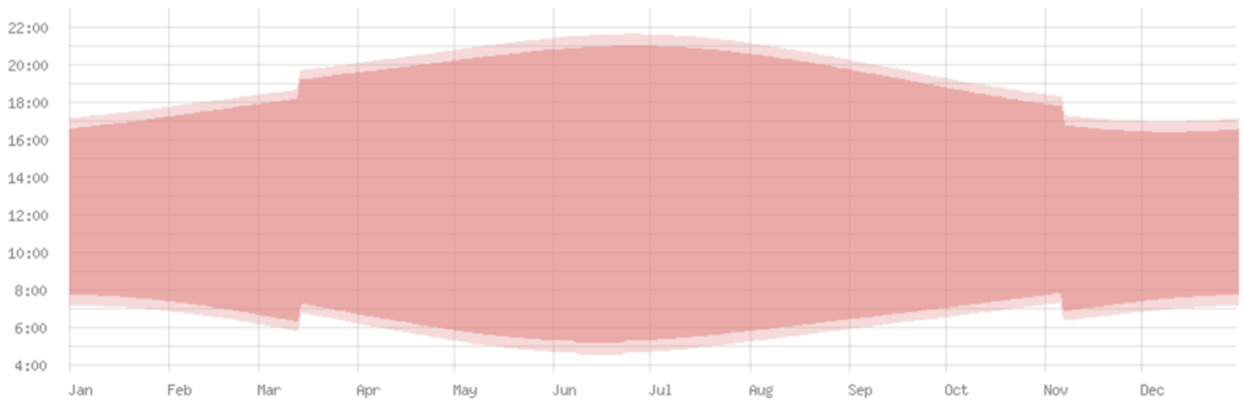

Figure 4 – Solar Water Heating System Diagram [10].

Another disadvantage of solar water heating is the large upfront installation cost. Unfortunately, I have been unable to find any accurate data for a cost estimation on this system. However, I have been able to find data from a project that is similar to the

Algonquin College ‘H’ building addition. It is estimated that it will take around 4 years to payback the initial costs of system installation (see Appendix B).

An advantage of solar water heating system is minimal maintenance, like many systems a solar water heating system will require regular maintenance. We have proposed the use of a closed loop system to be used in our addition to Algonquin Colleges’ existing ‘H’ building. Closed loop systems require the use of an antifreeze solution, this fluid will need to be checked occasionally to ensure it is still in good condition. In addition to maintaining the fluid in the collector panels, it is also important to maintain the cleanliness of the panels themselves, “dust and dirt can also hamper collector performance. In dry, dusty weather the panels may need periodic cleaning. Snow and ice usually melt off on their own but may need to be removed in the event of heavy accumulations, especially if the panels are mounted at a shallow angle” [11]. Maintenance for solar water heating systems is minimal, a well-maintained system has the ability to last more than 20 years.

Installing a solar water heating system will help save on energy bills. Solar energy is free and abundant, “solar hot water systems provide some amount of free hot water each day, and those savings add up over time” [9]. In Canada solar water heating is a great investment, there are several grants and credits available for companies that use solar water heating. “grants and tax credits can help to provide paybacks as low as 2-3 years. In Canada accelerated tax savings are offered to help companies invest in commercial solar water heaters” [12].

Solar water heating is great for our environment, using this system helps reduce our carbon footprint. Using alternative sources like natural gas and electricity to heat your water emits greenhouse gases that get released into our atmosphere. Heating water through the use of a solar system creates zero-emissions.

4.0 Overview of High-performance HVAC Equipment

“The term ‘HVAC’ refers to three disciplines of Heating, Ventilation and Air-conditioning. A fourth discipline, Controls, pervades the entire HVAC field. Controls determine how HVAC systems operate to meet the design goals of comfort, safety, and cost-effective operation” [15]. HVAC systems account for approximately 40% of the energy used in commercial buildings, using high performance HVAC equipment can result in considerable energy, emission, and cost savings. Each HVAC discipline (heating, ventilating, air-conditioning and controls) has its own set of design requirements and standards. This means that each discipline has unique opportunities for energy savings.

It is important to consider all aspects of your building design simultaneously. This way the building can incorporate effective design strategies to minimize the buildings overall heating and cooling loads. Sizing your HVAC systems in the proper manner will ensure efficient operation. Over sized HVAC equipment can result in increased costs because your system will not run efficiently. A small system can also run into problems because it must work much harder to do its job.

For our addition to Algonquin College’s existing ‘H’ building we have chosen equipment suppliers whose products use industry leading technologies. Using advanced equipment will help our building design meet and exceed building performance criteria. With careful HVAC design and equipment selection our building design will have a considerable reduction in energy, emissions and cost savings.

5.0 Conclusion

To conclude, there are many environmentally sustainable benefits provided by using rainwater harvesting, solar water heating systems and high-performance HVAC equipment. These systems can easily be added to new and existing buildings. Although, the initial cost of these systems may be expensive the costs are easily recuperated within in a short period of time, rainwater harvesting, solar water heating and high-performance HVAC equipment easily installed and operate at a high-efficiency rate in Canada's harsh climate.

In Ottawa we receive enough rain for a rainwater harvesting system, to collect a large supply of water. This supply of water can be used for multiple applications generating large cost savings. In addition to cost savings they generate many sustainable advantages.

A tried method of water heating, the implementation of solar water heating gives Algonquin College's addition to the 'H' building a secondary source of heating water throughout the year. "These very simple units are cost effective to install and are a great way to help reduce energy costs" [14].

Spending time on properly designing your HVAC system and selecting appropriate industry leading technologies will have a considerable reduction in energy, emissions and cost savings.

6.0 Recommendations

It is recommended that we shall install a rainwater harvesting system to provide water to service the plumbing fixtures in our building such as toilets and lavatories. Our rainwater harvesting system should also provide water to be used in our indoor garden space. In addition to providing an interior water supply, our rainwater harvesting system should provide water to be used for irrigation of our green roof system and the vegetation around the building. The best time to install this system will be during the early stages of construction. Underground parking is required for our addition to Algonquin College's existing 'H' building, this means a substantial amount of excavation will already be taking place. Water cisterns are best installed underground, installing our water cistern and piping at this time will reduce initial excavation costs.

Due to the need for installation in areas of high solar concentration, it is recommended that our solar collector panels be installed on the south face of our building. There they will receive maximum day light, due to limitations created by our existing building and our choice of roof type (green roof) placement opportunities are limited. Placement is typically most effective when a roof is able to be utilized, this will not be an option for our building. On the south facing side of our building, we have an existing connection that spans the height of two stories. Our addition is to be three stories in height; therefore, it is recommended that we install our solar collection panels in a wall mounted position on the third story of our new addition.

7.0 References

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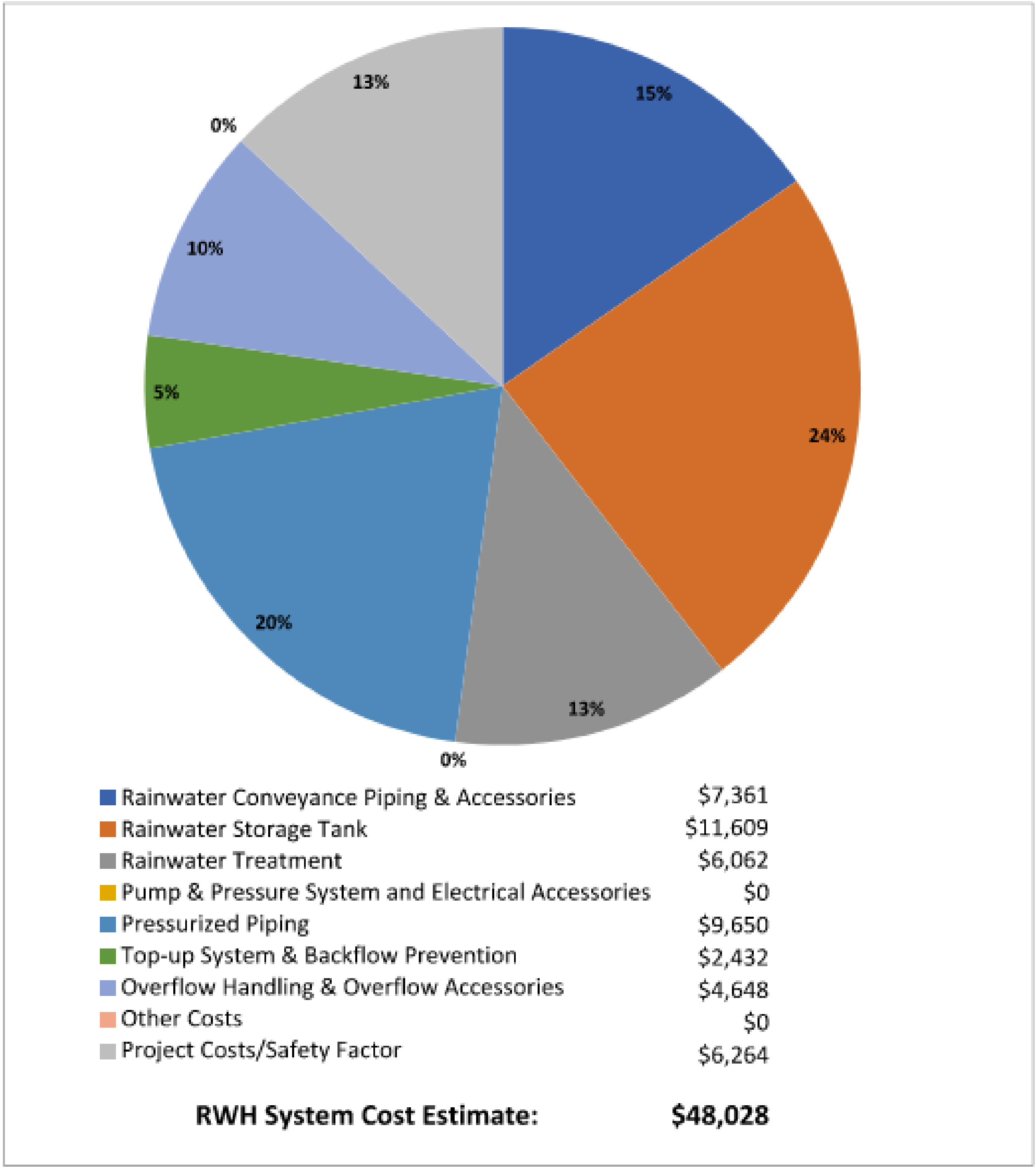
8.0 Appendices

Appendix A

Rainwater Harvesting System Cost Estimate

Rainwater Harvesting System Cost Estimate

Cost Overview



Rainwater Harvesting System Cost Estimate

Itemized Costs

Item	Size / Description	Quantity	Unit Cost	Total Cost
Rainwater Conveyance Piping & Accessories				
PVC SDR 35 (ext. installation)	200 mm [8 in.]	50.0 m	$59.27 /m	$2,963
Pipe Trenching	D: 1.2 m x W: 0.6 m	50.0 m	$15.82 /m	$791
Pipe Bedding	W: 0.6 m	50.0 m	$13.24 /m	$662
Backfill	Material Fill	37.5 m3	$2.82 /m3	$106
Manhole (Pre-cast concrete)	H: 1.2 m, 1.2 m ID	1.0 units	$2,839.41 /unit	$2,839
Extra Pipe from Cleanout(s) to Grade	200 mm [8 in.]	0.0 m	$59.27 /m	$0
			Sub-Total:	**$7,361**
Rainwater Storage Tank				
Precast Concrete (below-ground)		40000.0 Litres	$0.23 /Litre	$9,200
Tank Delivery/Freight		1.1 Tanks	$233.00 /Tank	$266
Standard Tank Access Riser	Appl. if buried	1.1 Tanks	$418.00 /Tank	$478
Installation/Craning	Appl. tanks >20,000 L	4.0 Hours	$155.00 /Hour	$620
Tank Excavation	D: up to 3m	71.8 m3	$10.47 /m3	$752
Tank Bedding	150 mm gravel fill	18.4 m2	$11.01 /m2	$203
Backfill	Material fill	31.8 m3	$2.82 /m3	$90
			Sub-Total:	**$11,609**
Rainwater Treatment				
Leaf Screen		0.0 units	$100.00 /unit	$0
Manhole (Pre-cast concrete)	Appl. area >1000 m2	0.0 units	$2,839.41 /unit	$0
UV Disinfection (ICI)		0.0 units	$119.89 /LPM	$0
				$0
Pump & Pressure System (ICI)	Approx. 2 hp	200.0 LPM	$28.69 /LPM	$5,737
Pump Float Switch	Approx. 2 hp	1.0 unit	$99.93 /unit	$100
Top-up Float Switch	Approx. 1/2 hp	1.0 unit	$54.16 /unit	$54
Pump Electrical Wiring	Approx. 8 gauge	32.0 m	$3.67 /m	$117
Top-up Electrical Wiring	Approx. 14 gauge	32.0 m	$1.67 /m	$53
			Sub-Total:	**$6,062**

Rainwater Harvesting System Cost Estimate

Itemized Costs

Item	Size / Description	Quantity	Unit Cost	Total Cost
Pressurized Piping				
Service pipe: Polyethylene (PE) C901	50 mm [2 in.]	43.0 m	$16.21 /m	$697
Supply Pipe: Copper Class K	40 mm [1 1/2 in.]	83.0 m	$91.72 /m	$7,613
Service Pipe: Pipe Trenching	D: 1.2 m x W: 0.6 m	43.0 m	$15.82 /m	$680
Service Pipe: Pipe Bedding	W: 0.6 m	43.0 m	$13.24 /m	$569
Service Pipe: Backfill	Material fill	32.3 m3	$2.82 /m3	$91
			Sub-Total:	**$9,650**
Top-up System & Backflow Prevention				
Solenoid Valve	40 mm [1 1/2 in.]	1.0 unit	$683.20 /unit	$683
Water Hammer Arrester	40 mm [1 1/2 in.]	1.0 unit	$153.67 /unit	$154
Water Meter	50 mm [2 in.]	1.0 unit	$552.19 /unit	$552
Reduced Press. Backflow Preventer	50 mm [2 in.]	1.0 unit	$1,043.42 /unit	$1,043
Top-up Pipe: ABS (ext. installation)	50 mm [2 in.]	0.0 m	$30.40 /m	$0
			Sub-Total:	**$2,432**
Overflow Handling & Overflow Accessories				
Overflow Pipe: PVC SDR 35 (ext. installation	200 mm [8 in.]	20.0 m	$59.27 /m	$1,185
Overflow Piping: Pipe Trenching	D: 1.2 m x W: 0.6 m	20.0 m	$15.82 /m	$316
Overflow Pipe: Pipe Bedding	W: 0.6 m	20.0 m	$13.24 /m	$265
Overflow Pipe: Backfill	Material fill	15.0 m3	$2.82 /m3	$42
Manhole (Pre-cast concrete)		1.0 units	$2,839.41 /unit	$2,839
Extra Pipe from Cleanout(s) to Grade	200 mm [8 in.]	0.0 m	$59.27 /m	$0
Soakaway Earthwork: Excavation	D: up to 3m	0.0 m3	$10.47 /m3	$0
Soakaway Earthwork: Sand Fill	D: 150 mm	0.0 m3	$40.36 /m3	$0
Soakaway Earthwork: Crushed Stone Fill	15-20 mm stone	0.0 m3	$96.77 /m3	$0
Soakaway Earthwork: Backfill	Material fill	0.0 m3	$2.82 /m3	$0
				$0
			Sub-Total:	**$4,648**
Other Costs				
				$0
				$0
				$0
			Sub-Total:	**$0**

Rainwater Harvesting System Cost Estimate

Itemized Costs

Item	Size / Description	Quantity	Unit Cost	Total Cost
Project Costs				
Engineering/Design Cost			4.0%	$1,671
Comissioning Cost			1.0%	$418
Contingency/Safety Factor			10.0%	$4,176
			Sub-Total:	**$6,264**

Summary:

Rainwater Conveyance Piping & Accessories	$7,361
Rainwater Storage Tank	$11,609
Rainwater Treatment	$6,062
Pump & Pressure System and Electrical Accessories	$0
Pressurized Piping	$9,650
Top-up System & Backflow Prevention	$2,432
Overflow Handling & Overflow Accessories	$4,648
Other Costs	$0
Project Costs/Safety Factor	$6,264

RWH System Cost Estimate	**$48,028**

Appendix B

Solar Water Heating Case Study

enerworks
Solar Heating and Cooling

Case Study:
Confederation Place Hotel
Kingston Waterfront

Application: Hotel, Motel, Conference Center, Institutional Residence

Features:

- Solar water-heating appliance provides **immediate savings** on natural gas costs
- **25-year lifetime** of the appliance
- Solar energy delivered for **\$10.46 per thousand ft³ (3¢/kWh, 33¢/m³)**
- **Expandable design** allows hotel to accommodate larger water loads in the future and further reduce energy costs
- **Retrofit design** plumbs into existing electric gas-fired hot-water tanks. Existing tanks act as back-up to ensure hot water is always available
- **Freeze protection** allows appliance to run year-round
- **Differential controller** turns pump on and off according to temperature differential across the collector array
- **System will have paid back after 4 years** nearly halving the simulated paypack of 7 years with an annual solar fraction of 26.5%, an average of 36% in summer, and 17% in winter

Site Specifications:

Name of Property:	Conference Place Hotel
Location:	Kingston, Ontario, Canada
Age of Building:	28 years—business, conference, tourism
Type of Property:	Hotel
Operation:	Year-round
Displaced Fuel:	Natural gas
Roof Type:	Flat roof
Solar Water Uses:	• Potable water • 94 guest rooms • Onsite laundry facilities • Kitchen • Seasonal pool

Application Configuration:

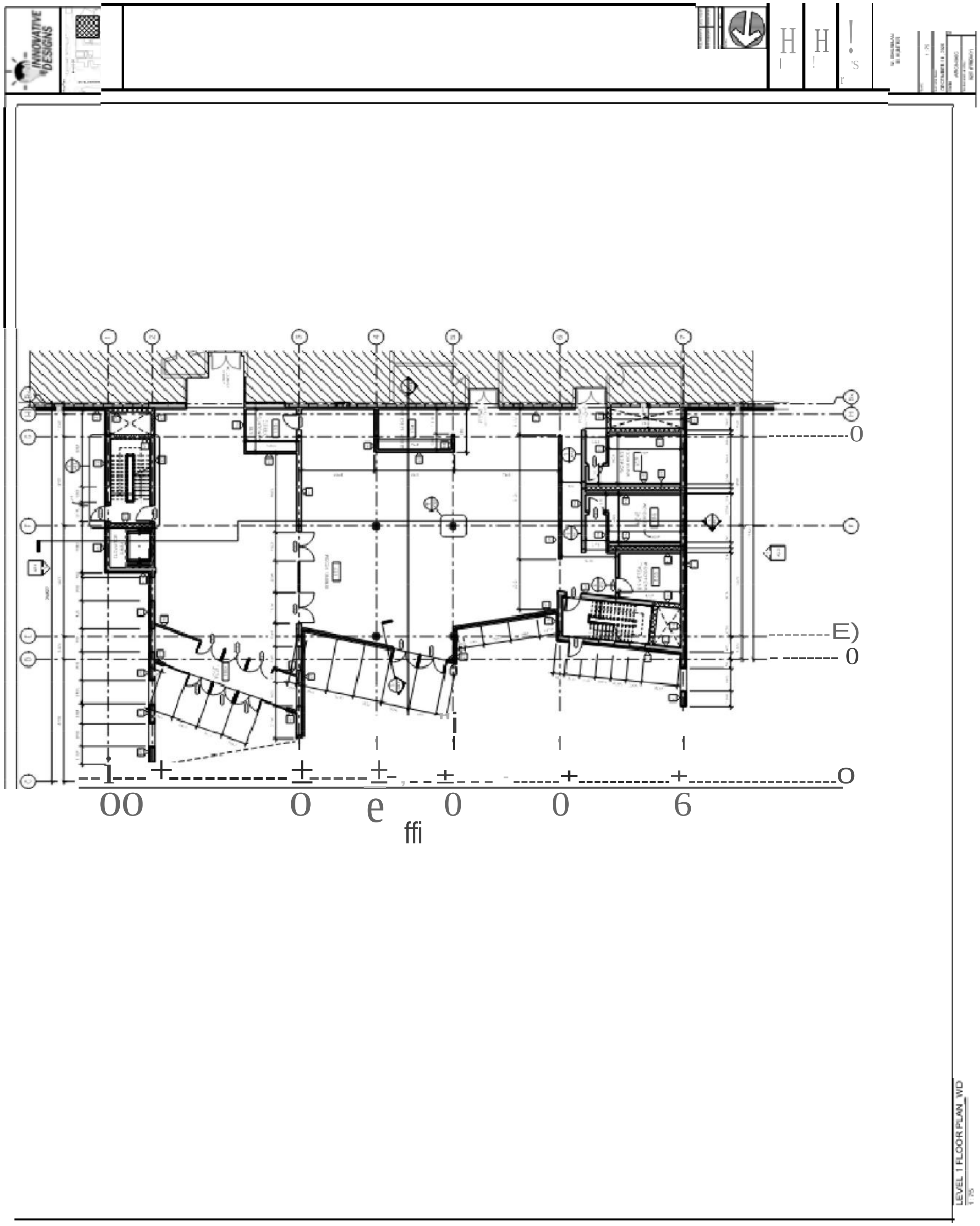
Solar Array:	2 modules of 10 Premier Efficiency Collectors each; expandable up to 4 modules
Racking:	C-channel racks at 45° angle
System Flow Rate:	Approximately 6.34 US gallon (24 L)/min.
Energy Terminal:	• 1" (25.4 mm) piping • Commercial brazed-plate copper primary heat exchanger • Differential controller • Secondary heat exchanger for pool heating

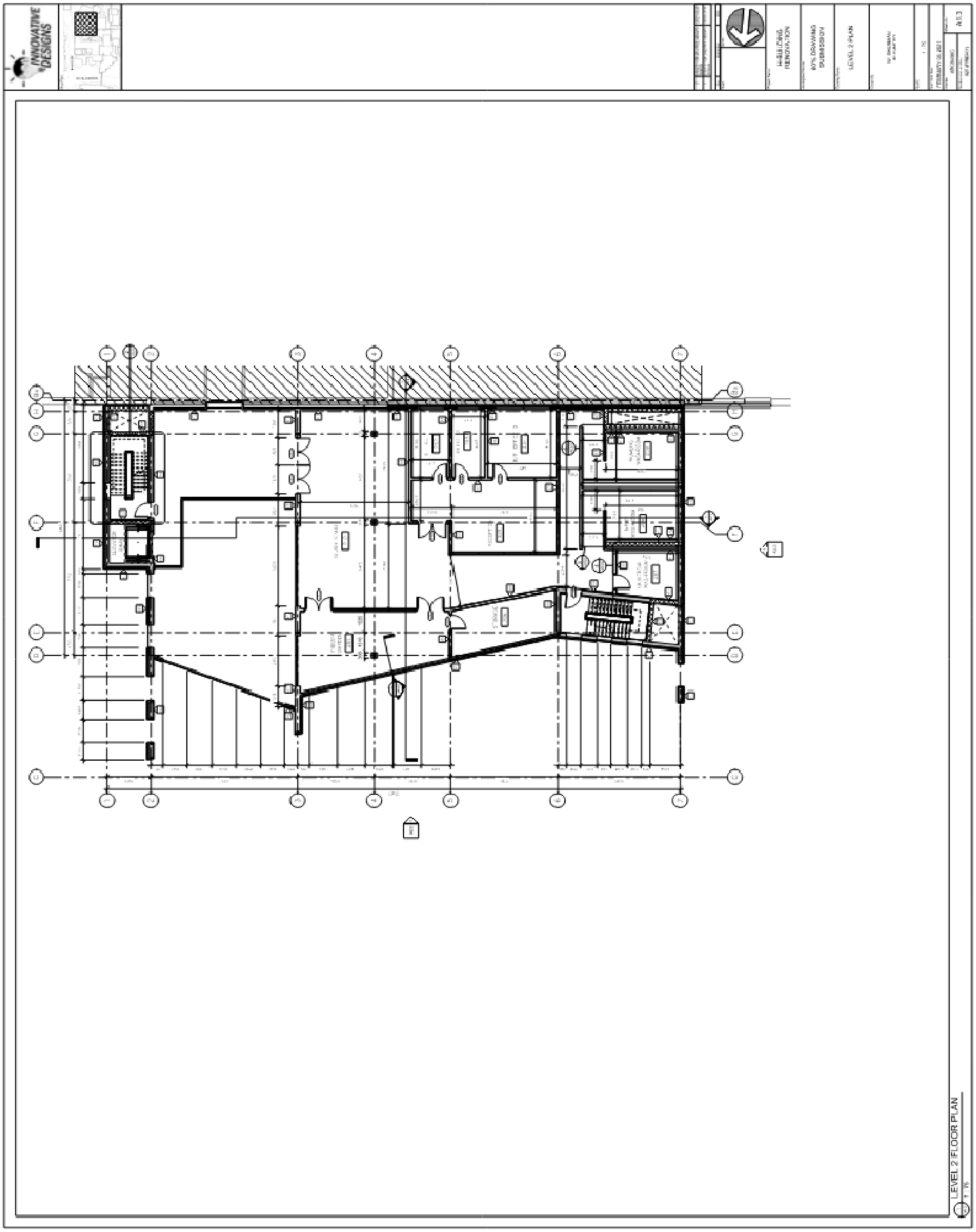
Assumptions for Simulation:

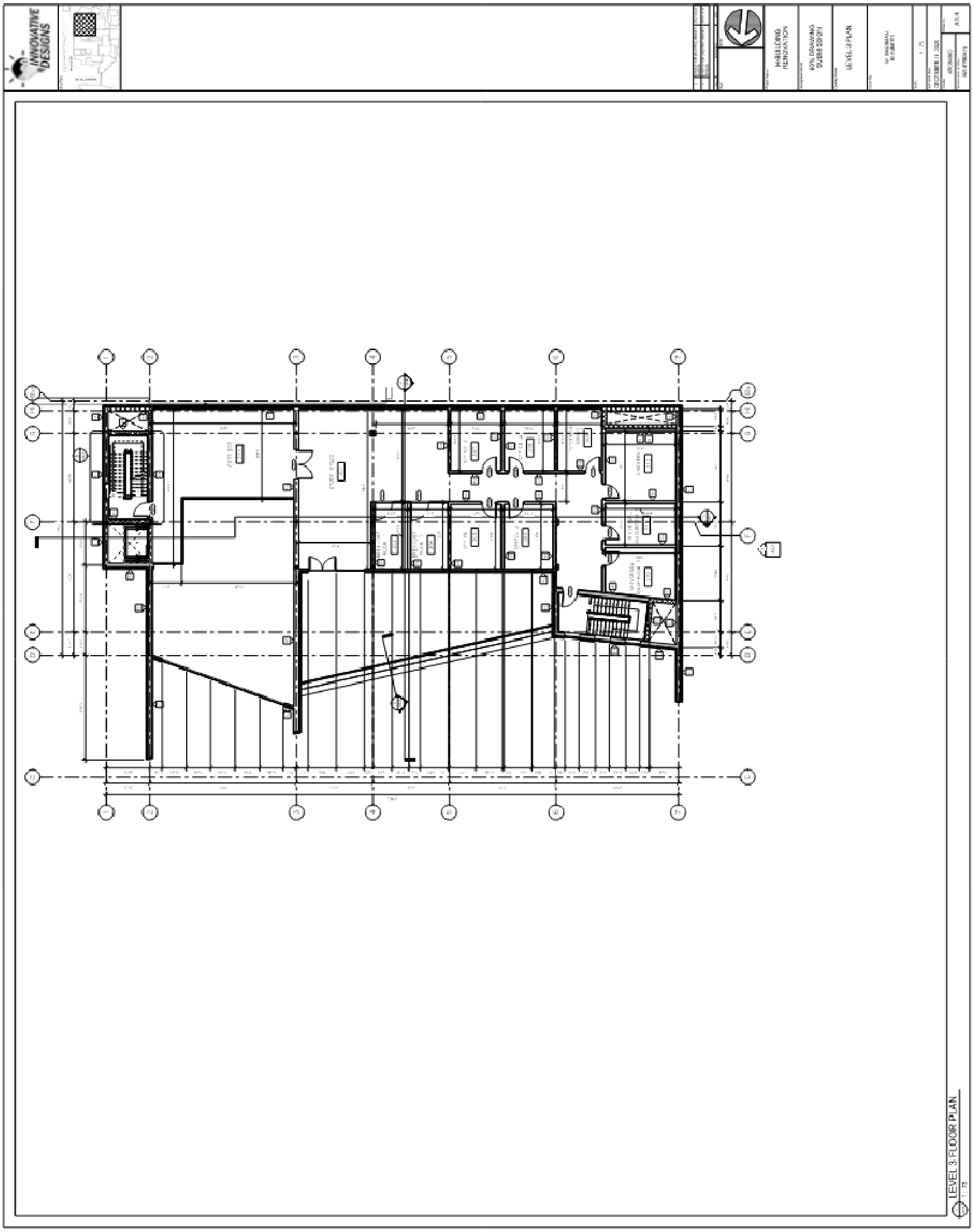
44 155 kWh/yr of solar energy
Natural gas energy content: 38.09 MJ/m³
Delivered natural gas rate: 50¢/m³
Natural gas inflation rate: 3%
Auxiliary tank efficiency: 58%
Lifetime of appliance: 25 years

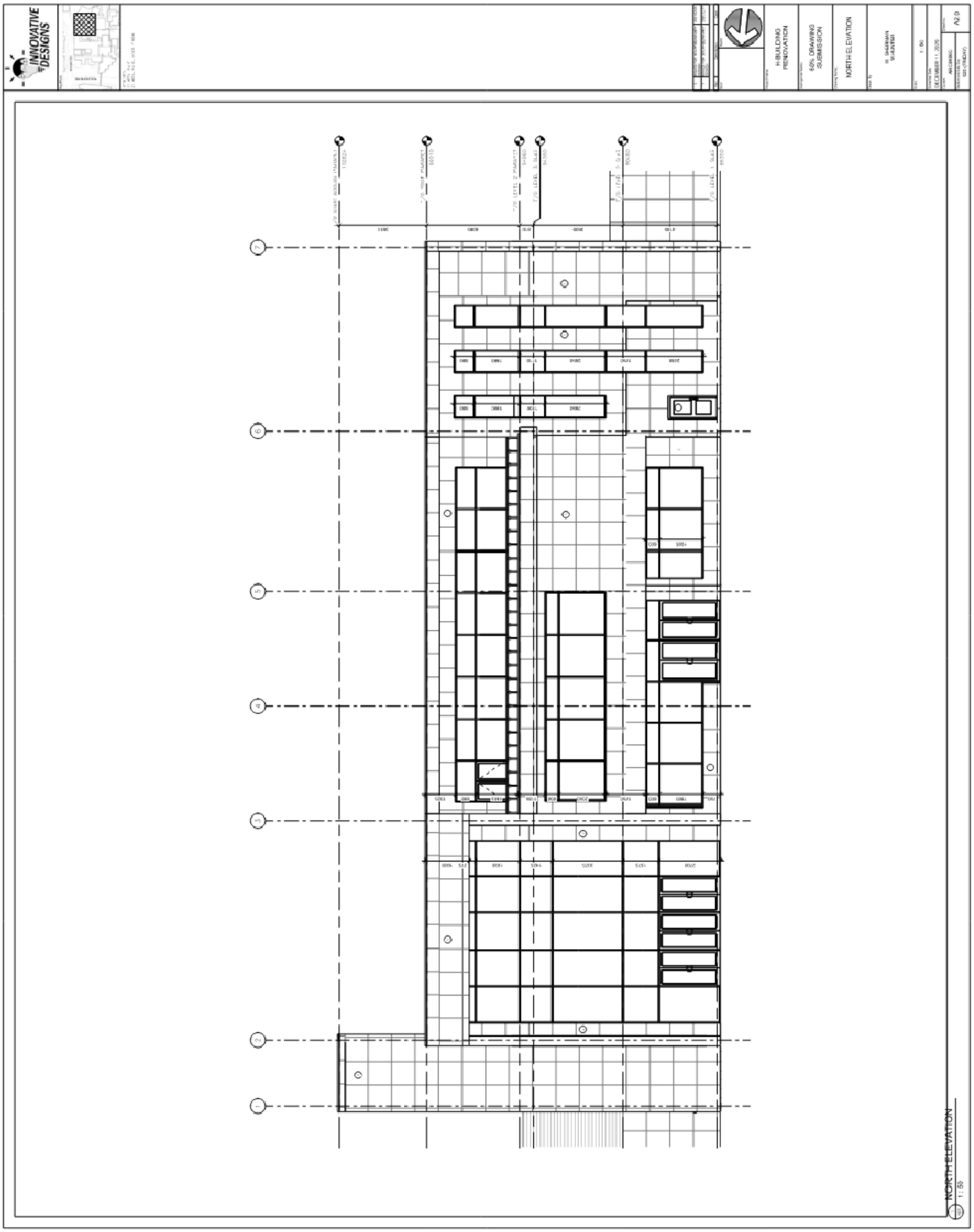
Appendix C

Working Drawings of Addition to 'H' Building

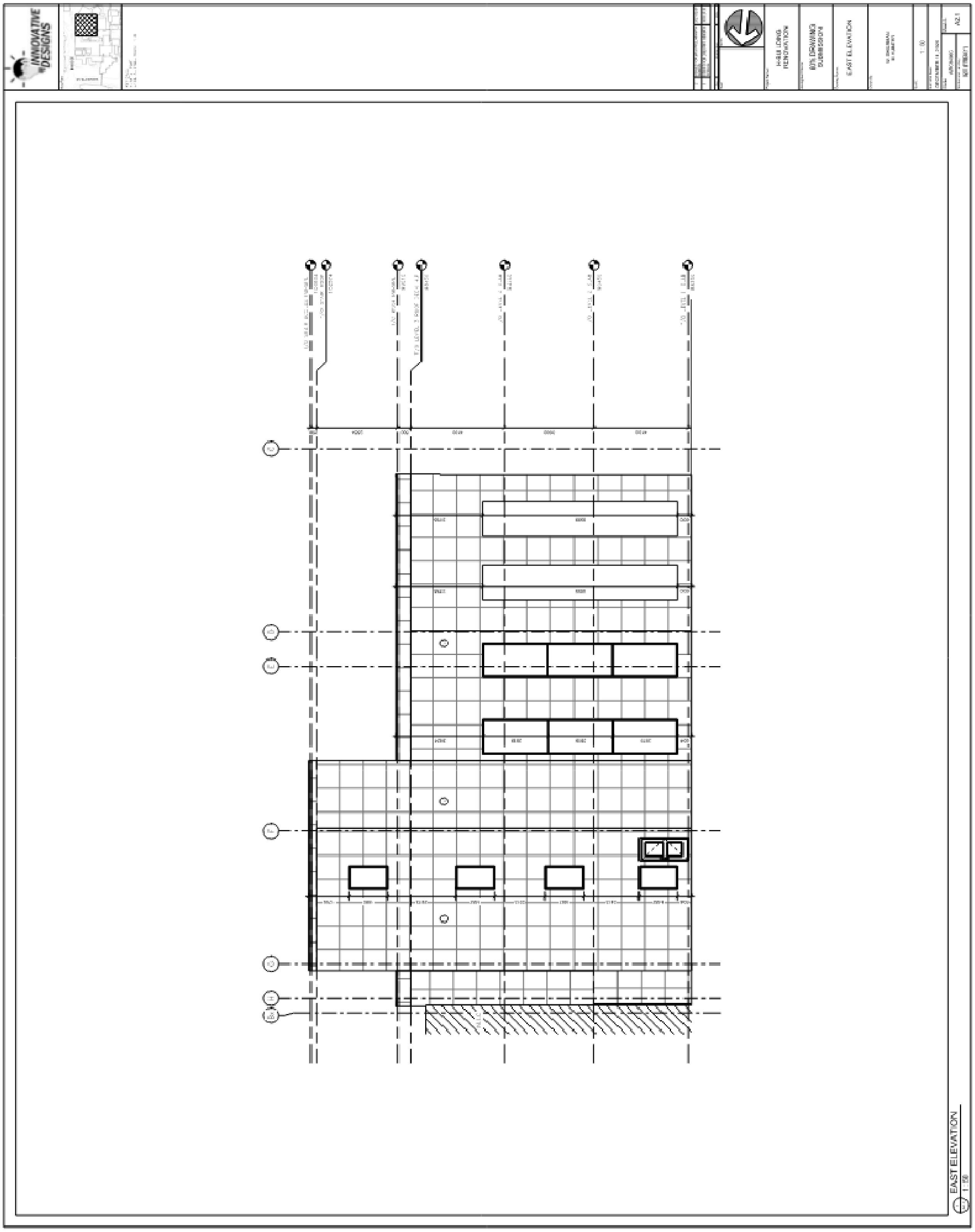

LEVEL 1 FLOOR PLAN_WD

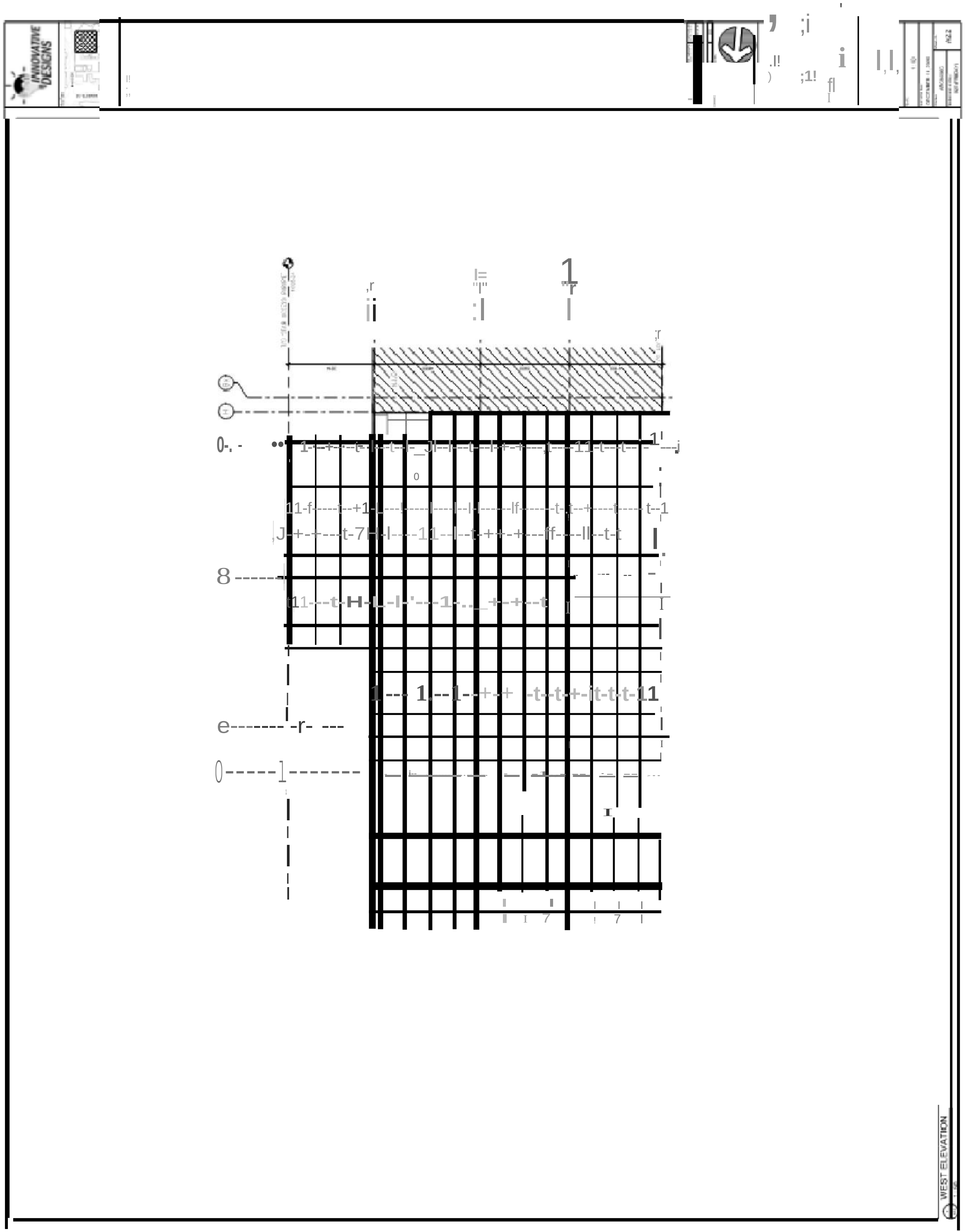

INNOVATIVE DESIGNS
LEVEL 2 FLOOR PLAN


INNOVATIVE DESIGNS
LEVEL 3 FLOOR PLAN
1 : 75



INNOVATIVE DESIGNS
H-BUILDING RENOVATION
60% DRAWING SUBMISSION
NORTH ELEVATION
1 : 50
NORTH ELEVATION
1 : 50


INNOVATIVE DESIGNS
60% DRAWING SUBMISSION
EAST ELEVATION


INNOVATIVE DESIGNS
WEST ELEVATION