

Engineering Strategies & Practice

University of Toronto
Faculty of Applied Science and Engineering
APS111, ASP112 & APS113
Conceptual Design Specification CDS

Project #	Date 26 March 2023
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Project Title	Confederation Trail
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Executive Summary

The project builds many conference trail rest stations. The design provides a rest stop for passing passengers based on the customer's feedback and project requirements. These designs will be processed inside the customer's Own boundaries, including different weather, cultural, and environmental locations. Customers, travelers, PEI government, University of Toronto School of Engineering, Forest Service, and others affected the project. They limit the project's implementation at any time.

The initiative stores mass by offering areas to rest, eat, mingle, and spend time. The project promotes social interaction, renewable energy, reliability and long-term goals, plentiful natural illumination, and local culture and community awareness. As the team designs, these basic objectives will be expanded and maybe supplemented.

S1: The cabin-like design is octagonal with wide windows for natural illumination. The interactive wall, fireplace, and balcony promote social interaction and sustainability while meeting all project goals, restrictions, and functions.

S2: The one-story rest room has an all-gender lavatory, greywater harvesting, PIR-controlled LED lights, and a PedalCell charging station. It has stunning views of the Midgell River and environs. The open interior design includes an interactive Confederation Trail map, hanging monkey bars for kids, and chairs. Premium materials and a buoyant floating mechanism protect the construction from floods and high tides.

S3: The Pavilion combines modern aesthetics and art with outdoor natural flair. The design meets users' fundamental necessities while letting them relax and impress passengers.

Out of the three alternate designs, the Octogono Resting Spot was chosen as the main design with the help of Pugh method

The proposed dates for testing the measures of success are March 30th - April 1st for solar panels installation and material prototyping; Then note water level and and Tank prototype along with a miniature prototype.

1.0 Introduction



Figure 1: This image represents the sample site location (the area surrounding Midgell River Bridge) along the Confederation Trail

The Confederation Trail is a popular network of trails that spans across Prince Edward Island. The trail is used by tourists and locals and allows for recreational purposes such as biking, hiking, and snow. Due to its previous function as a railroad track, the trail lacks structures and rest stops throughout, leading to it not being used to its full extent. This has led to a request by Nine Yard Studios to develop resting spots throughout the trail. This document will go over a problem statement, service environment, stakeholders, functions, objectives, constraints, and finally a conclusion.

2.0 Problem Statement

According to the client statement, the Confederation Trail on Prince Edward Island(PEI) has no proper resting spots for users throughout the pathway. From this, the need, gap, and scope for this issue are shown below:

- **Need:** Provide resting infrastructures for users to use when needed across the confederation trail.
- **Gap:** There is a lack of pre-determined resting locations for users throughout the pathway, leading to reduced tourist attraction on site.

- **Scope:** The scope includes a small area located around Midgell River Bridge near the small town of Midgell as indicated using the red box in figure 2. The vertical range of the scope is 30 feet[1] and the horizontal range is 10-20 feet which can hold up to eight people at once. We chose this location as it is located in one of the popular parts of the trail, is located far from civilization (~4km from the closest small town, Saint Peters Bay and ~7km from Morell, one of the spots located in the client statement document), This chosen site is also next to water (Midgell River), and lastly, it is relatively isolated, providing a more natural feeling. All these factors enable easy implementation of the design at other locations of the trail as well.

This scope serves as one of the prototypes that could be modified and used at various other locations mentioned in the client statement.



Figure 2: Represents the scope along the Midgell river bridge

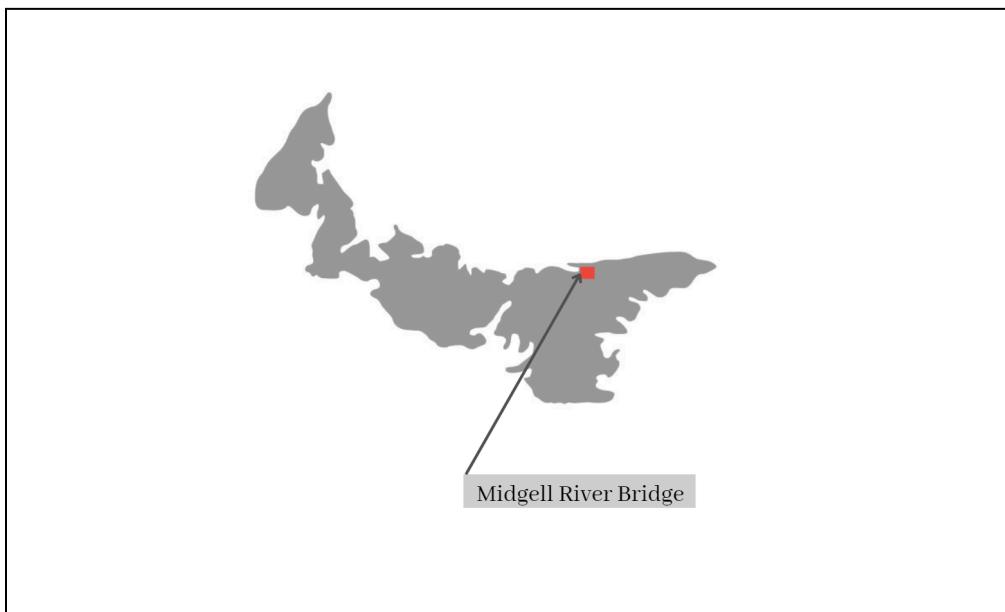


Figure 3: Location of Midgell River Bridge

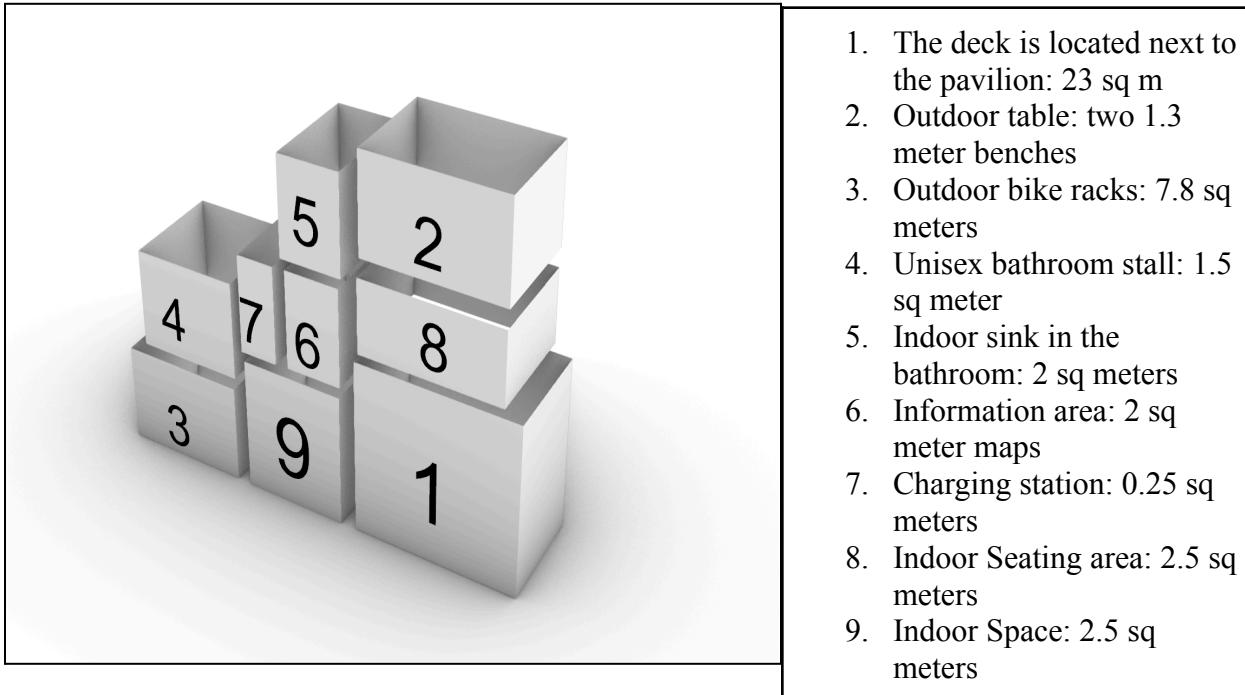


Figure 4: The problem statement diagram shows what the structure will include; in this case, the structure will include three main rooms: a washroom, a resting area, and an information area.

4.0 Stakeholders

Stakeholders are people or organizations that will be affected by the design, its construction, and its completion. The Stakeholder Analysis graph is used to determine stakeholders' priority (a reference to Appendix).

The primary stakeholders are:

- Client: Nine Yards Studio
- Users: tourists, locals, hikers, bikers, and snowmobilers
- Operators: construction crew, electricity company, and maintenance crew

The secondary stakeholders and their interests and impacts are listed in the table below:

Stakeholders	Interest	Impact
PEI Snowmobile Association	Social: Snowmobilers that use the trail belong to this group	Positive: Will have more members due to people using trail more consistently
Nature PEI[12]	Environmental: Regulate changes to natural environment	Negative: Opposition towards changing natural features in the area
PEI Museum and Heritage Foundation [13]	Educational: Educate visitors regarding the trail's history	Positive: Will receive more attention due to more visitors to the trail interested in learning more regarding history of PEI
Nature Conservancy Canada [14]	Environmental: Deal with the addition of new structures	Negative: Opposition to adding structures in a previously unincorporated area
Indigenous People [15]	Ethical: The trail land was once their land	Negative: People are building on their land
Local Businesses	Economic: Users of the trail stop at local businesses	Positive: Influx of customers
Tour companies[16]	Economic: Give tours of the trail to tourists	Positive: More customers
PEI government	Social: attracts more people to the trail	Positive : Brings people outside and brings more economy
Emergency services	Environmental: Deal with the additional of new areas to cover	Positive : Brings more jobs

3.1 Physical Environment

Table 1. The natural elements are listed. Since the sample location is away from urban areas, data are collected from Saint Peters Bay (a small town ~4km from the sample site)

Relevant Elements	Implemented in the Outdoor Environment
Light	<ul style="list-style-type: none"> Saint Peters Bay's daily sunlight ranges from 8.59 hr to 11.46 hr year round
Temperature	<ul style="list-style-type: none"> Saint Peters Bay's atmosphere temperature ranges from -8.4°C to 21.9°C year round Saint Peters Bay's water experience temperature ranges from -1.6°C to 19.9°C year round
Wind Velocity[4]	<ul style="list-style-type: none"> Saint Peters Bay's average wind velocity between 29.3 km/hr to 24.3 km/hr year round
Precipitation[5]	<ul style="list-style-type: none"> Saint Peters Bay's an average rainfall between 218.4mm and 46.8mm per month. In winter(between October to May), Saint Peters Bay experiences an average snowfall between 43.5cm and 8.3cm per month.
Humidity[5]	<ul style="list-style-type: none"> Saint Peters Bay experience an average humidity between 88% to 78% year round
Pressure[5]	<ul style="list-style-type: none"> Saint Peters Bay experience an average atmosphere pressure of 101.40 kPa (same atmosphere pressure throughout PEI island)
Tide	<ul style="list-style-type: none"> Saint Peters Bay experience an average tide height ranges from 0.8 meters to 0.17 meters throughout the year
Soil	<ul style="list-style-type: none"> The soil type at Saint Peters Bay is mainly ground moraine clay sand phase till and Glacio-fluvial deposits(gravel, sand, silt) as shown by Figure 5 below

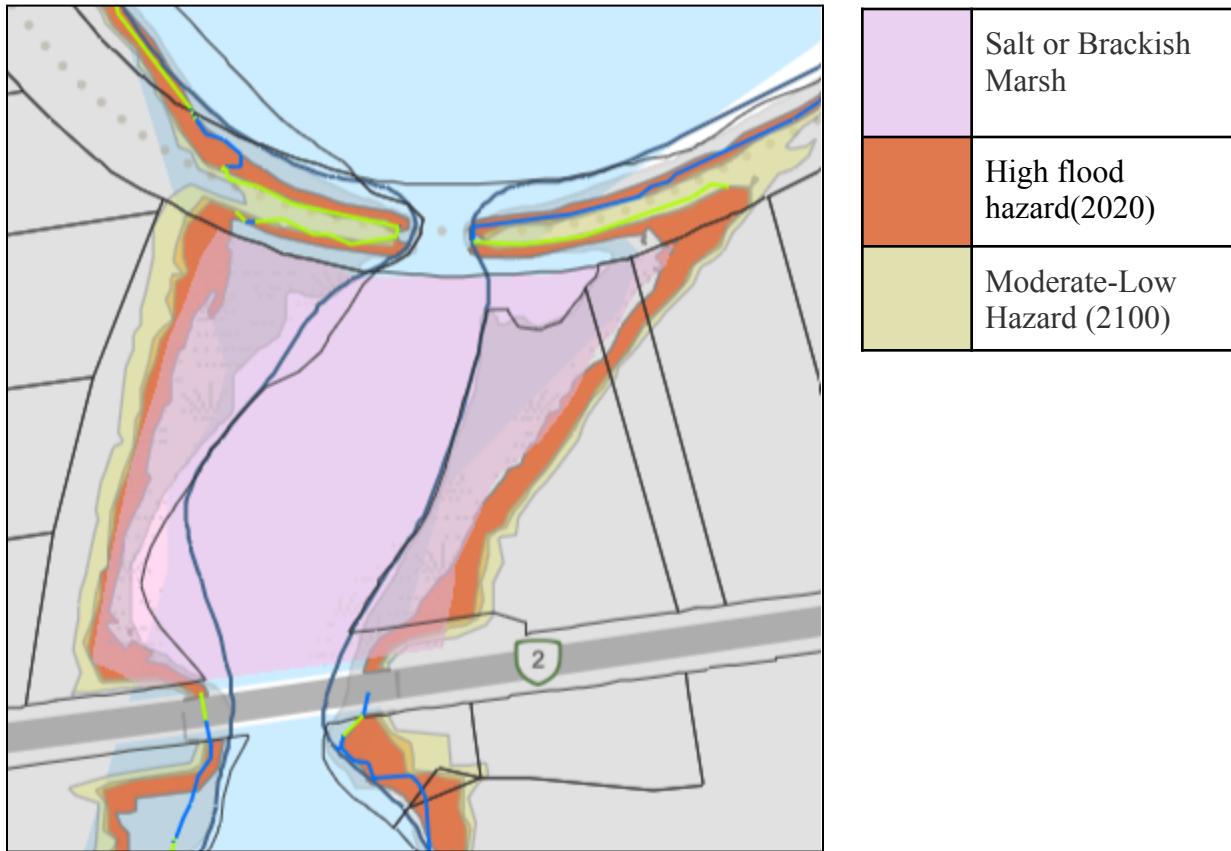


Figure 5: Flood hazard map (37)

Climate Hazard	Scenario	Current Risk Rating (Score)	2050 Risk Rating (Score)
Coastal erosion	Acceleration of the historic rate of erosion	Medium (9.2)	High (15.3)
Post-tropical storm	Multi-day post-tropical storm with heavy rain, storm surge, and wind making landfall in Queens County	High (14.1)	High (14.1)
Heat wave	Three consecutive days with temperatures over 29°C	Medium (7.0)	High (11.7)
Heavy precipitation and flooding	100 mm rain event in 24 hours	Medium (8.4)	High (11.2)
Severe ice storm/freezing rain	Multi-day severe ice storm/freezing rain event in winter	High (12.3)	Medium (9.2)
Earlier, warmer springs	Earlier onset of spring temperatures by two weeks affecting key species	Low (4.4)	Medium (8.8)
Seasonal drought	Months-long severe summer drought affecting the entire province	Medium (7.4)	Medium (7.4)

Figure 6: PEI climate change risk assessment scores for the year 2021 - 2050 [38]

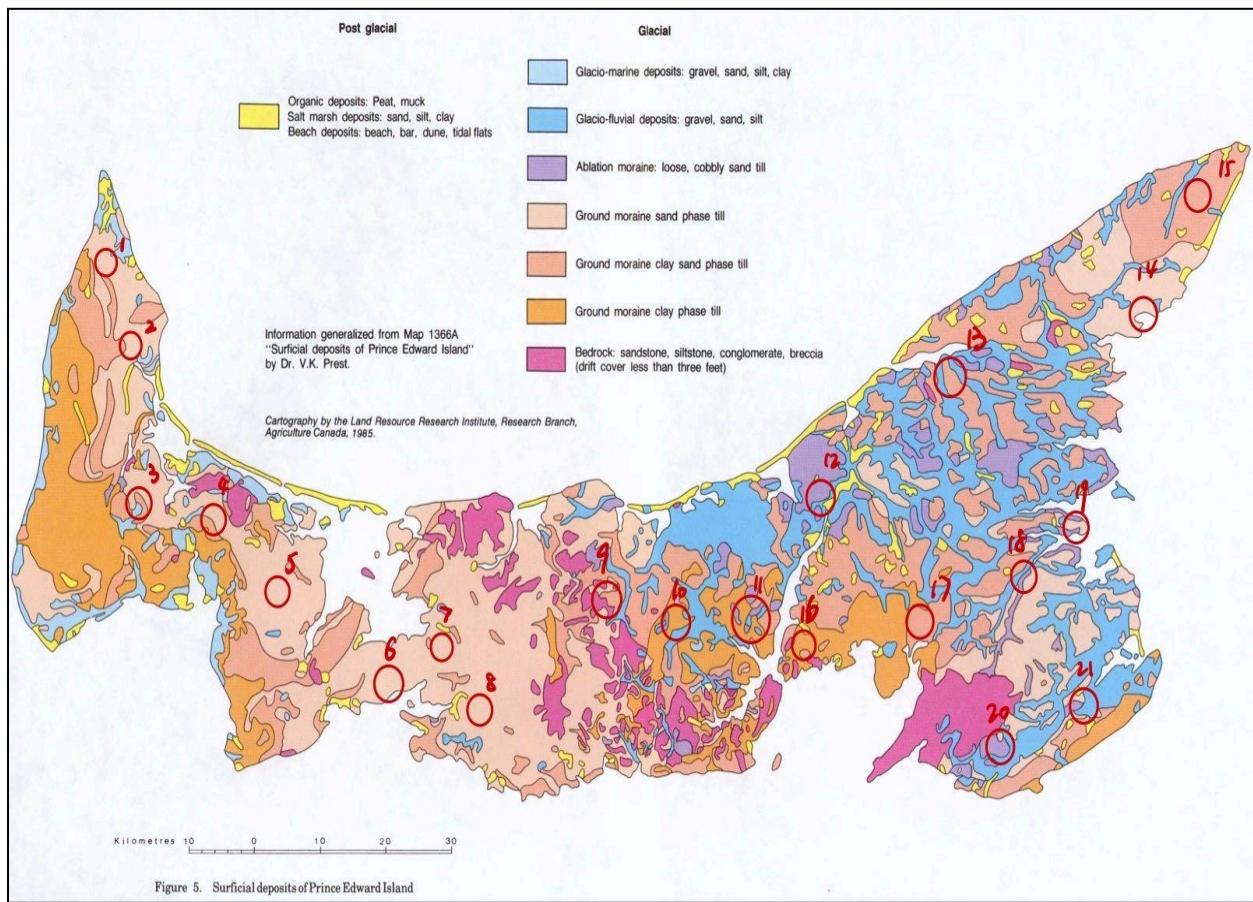


Figure 7: Soil type distribution on the Prince Edward Island (PEI) with red circled area for refuge locations (circle #13 is the sample site)

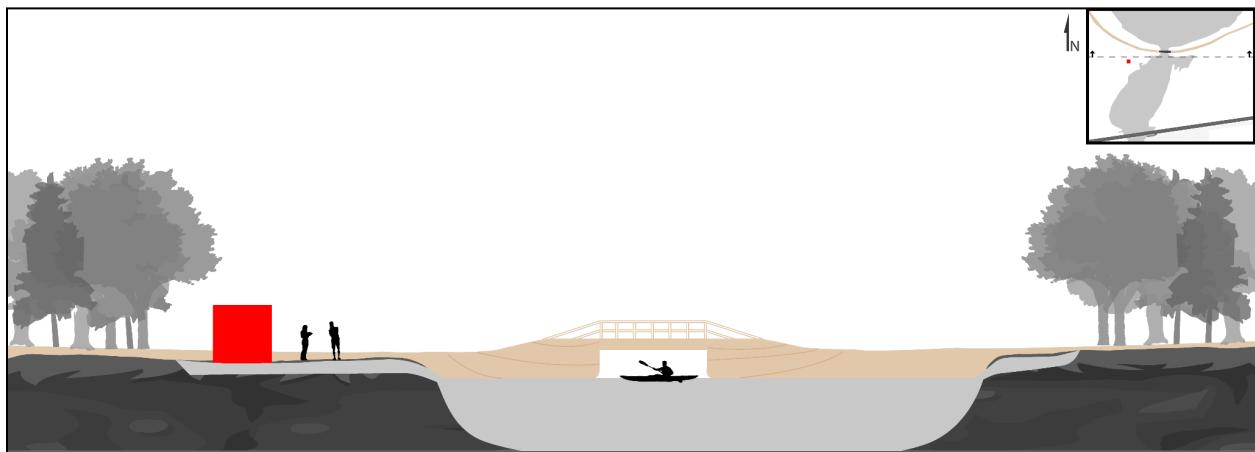


Figure 8: North-facing section diagram for the Confederation Trail at the sample site

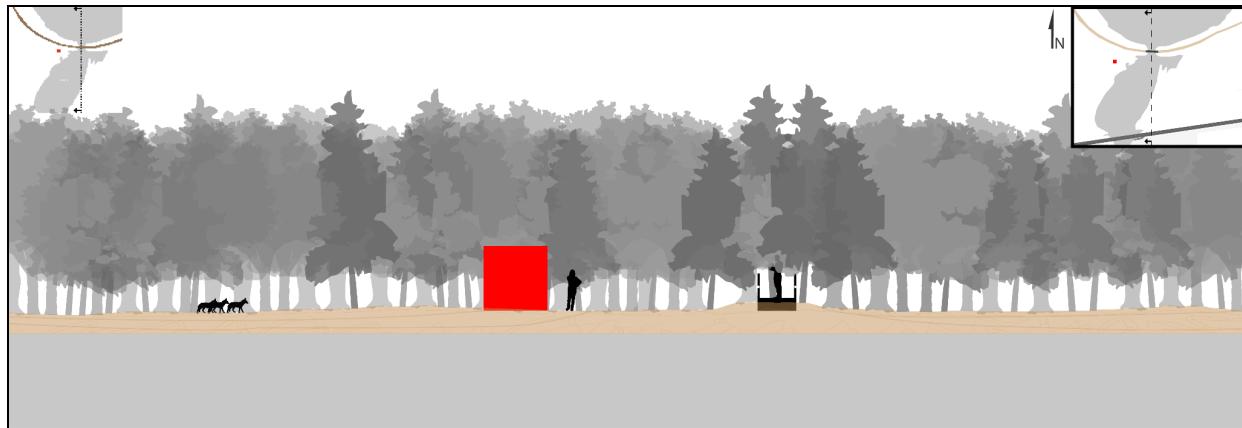


Figure 9: West-facing section diagram for the Confederation Trail at the sample site

3.3 Living Environment

Living organisms that will interact within the design space are included below with examples in Figure 8:

Flora(Plants and Flowers)[7]	Popular plants include; mayflowers, bunchberries, starflowers, violets, other native species, potato crops, and barley crops
Trees[7]	The most commonly found trees in PEI are, White Pines, Red Pines, Red Spruces, Sugar Maples, Red Maples, Red Oaks, and Yellow Birches.
Fauna[8]	Some common animals are Beavers and Eastern Coyotes. Minks, Muskrats., Raccoons, Red Foxes, Red Squirrels, and some Striped Skunks.
Birds[8]	Common birds include Loons, Pied-Billed Grebes, great Cormorans, and American bitter.

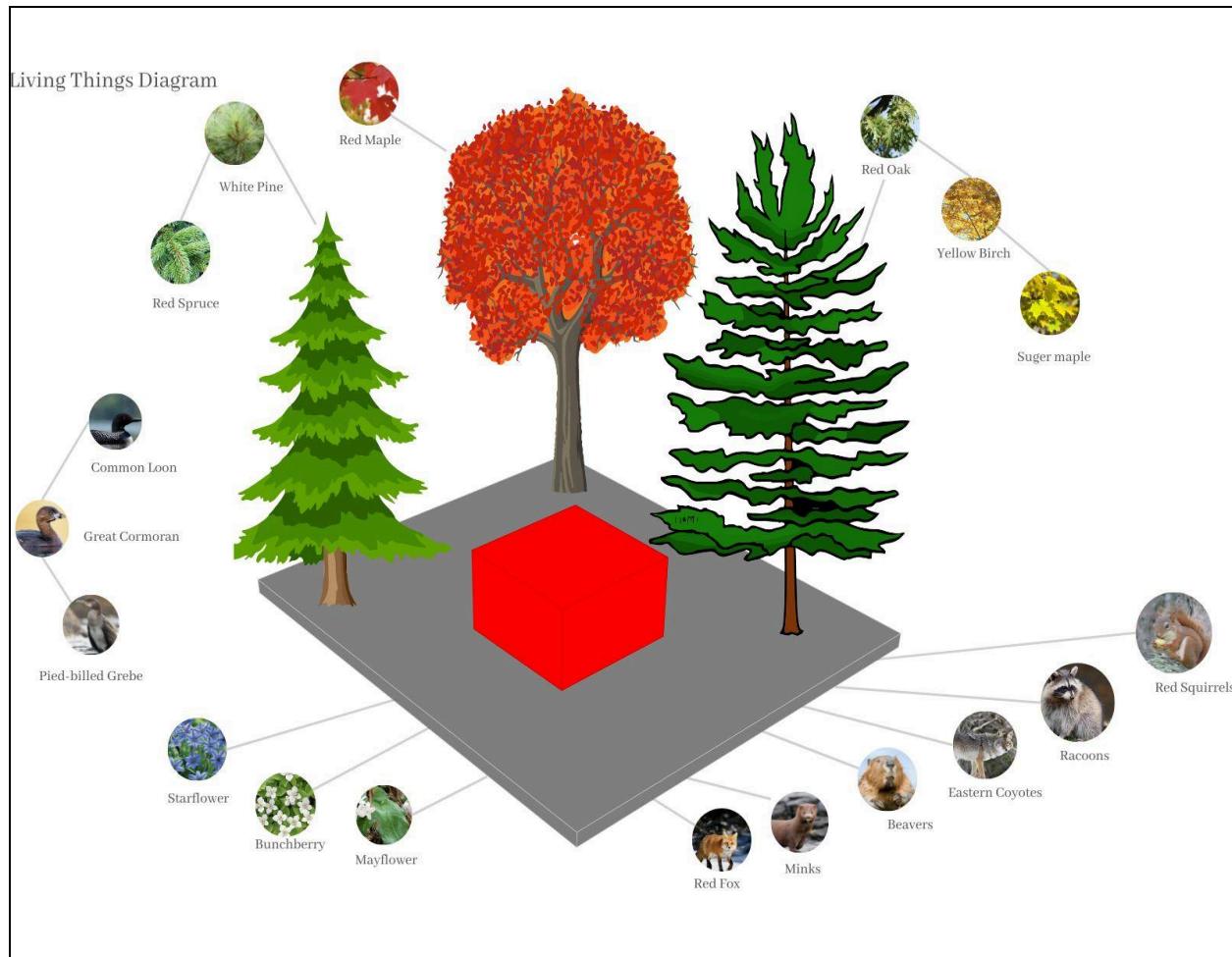


Figure 10: Diagram for common living organisms at the sample site

3.4 Virtual Environment

- Service
 - There is a cellular network in PEI that has high-speed internet (download speed of 50 Mbps and upload speeds of 10 Mbps)[9]
 - Bell and Telus cover 99.95% of the island [10]
- There will be telephone poles and power lines spread throughout the trail [11]

Virtual Environment Diagram

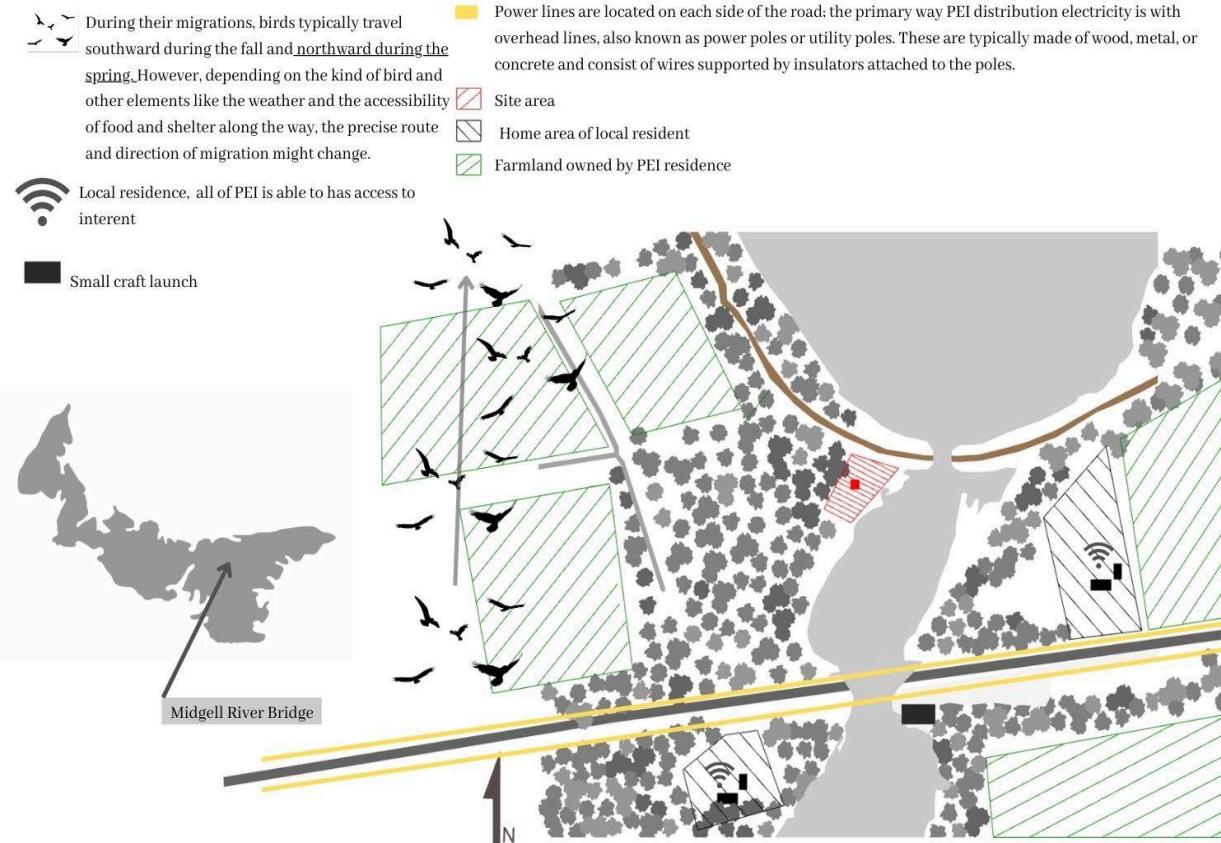


Figure 11: Virtual environment diagram for the Confederation Trail at the sample site

5.0 Functions

The functional basis, primary function and secondary function are listed below by using Black Box Method(reference to Appendix)

- Functional basis:
 - Store mass
- Primary function:
 - Store people to take rest along the Confederation Trail
- Secondary function:
 - The design provides spaces to perform basic activities(ie: water, air,..)
 - The design promotes engagement and social interactions among users
 - The design protects people from the external environment and adverse weather conditions
 - Educates users about the surrounding local community and the confederation trail

6.0 Objectives

Table 3 lists each objective with objective goals, justification and metrics in descending order of importance.

Table 3: Objectives of the Confederation Trail

Objective	Metrics	Objective Goals	Source/Justification
Should accommodate social interactions	Number of furniture for leisure activities on site	Provide at least 2 set-ups for leisure activities.	Leisure activities facilitate people to strengthen social relationships, which accommodate social interactions.[17]
Should be long-lasting	Years	Should have at least 10 years of lifespan without major repairment.	Long-lasting infrastructure ensures long-term stable design for users and reduces the repairing budget[18][25]
Should be sustainable	number of green energy sources used in the design	Should have a minimum of 1 green energy source implemented	Implementation of green energy will protect the surrounding ecosystem and further integrate the design into the nature[21]
Should promote information about indigenous culture and local communities	number of indigenous and local community-related symbols.	Include at least 2 symbols related to the indigenous culture and local communities	Canada is committed to respecting and recognizing indigenous culture and all other local communities[20]
Should have abundant natural lighting	Lux (luminous flux per unit area)	Light level should have at least 300 lux during day time.	Natural lights make people feel safe and comfortable inside the building[19]

7.0 Constraints

Table 4 shows the four major constraints with corresponding metrics, limit and justification for the design. They are the requirements of the design that must be met in order for the design to proceed.

Table 4: Constraints of the Confederation Trail System

Constraint	Metrics	Limit	Justification
Must be climate resistant	Yes/No	Design must safely protect users from extreme external environment[22] [23]	By serving as emergency refuges, the design must shelter users under all weather conditions
Must hold a certain number of people	Number of people	The design must be capable to incorporate eight people at once	The design should be large enough and contain enough resources in order to cope up with the user's load.
Must be self-reliant with air	Yes/No	Design must run independently without external services required for air, for at least for 24 hours [24]	For safety precautions, the design must have sufficient air supply under any situation.[26]
Must be self-reliant with water	Yes/No	The design must function alone for at least 24 hours [24] without any external services required for water	The design must have ample water supply in any circumstance for safety reasons. [26]
Must be self-reliant with energy	Yes/No	For at least 24 hours [24], the design must function without external energy supply	The design must include adequate energy resources in any circumstance as a safety measure. [26]
Must include basic, routine facilities	Number of washrooms, lights etc	As stated in the Building Standards in PEI, the design must	Lacking basic facilities are both inconvenient and illegal

		include facilities like washroom, lights etc) [28]	
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Constraint	Metric	Limit	Justification
Must follow Building code and regulations	Need to change, relate to design phaseApproval from building officer	Dimensions to be determined based on on the basis of calculation, testing or another means of evaluation[28]	To create a safe design to get approved by the building officer or minister
Must abide by the environment hazard plan	Conduct environmental damage assessment	As stated in the plan the design must follow all codes and not negatively impact the environment[26]	To ensure the design is sustainable and environment friendly

8.1: Idea Generation Process

This section highlights the initial process of the potential ideas generated for the client's project.

Overall, the team use the following processes to generate solution ideas:

1. Free Brainstorming (Appendix B1)
 - a. To ensure that the team has explored most of the project's design space, each team member brainstorms a minimum of 20 random ideas related to the project on a shared document in a safe and respectful atmosphere. In total, the team brainstormed 158 random ideas through free brainstorming.
 - b. The team uses sketches (from DRG) and research from precedent studies to further facilitate idea generation(ensure that the team has discovered most of the project's design space) by referencing existing designs or models of the potential design.
2. Structured brainstorming (Appendix B2)
 - a. To ensure that the design satisfied all the project's listed functions and objectives, the team creates a table with the project's objectives and all team members continue brainstorming ideas for each objective on a shared document. Therefore, all team members contributed and in total, another 10 more ideas were generated

for each objective(ie: should promote indigenous culture) during structured brainstorming

3. SCAMPER (Appendix B3)

- a. Through reading the perusal and internal team meetings, the team decided to use SCAMPER to further build upon existing ideas and project's design space. By having a list of ideas from structured brainstorming, more ideas are generated through creative jumps and ensured that the team had explored all of the project's design space during the idea generation process.

4. Morph Chart (Appendix B4)

- a. The team decided to use a rough morph chart to help organize all generated ideas. In a table, all generated ideas are categorized into the corresponding project's objective, where the team combines each other's ideas to utilize the entire space. The created rough morph chart is further used in the idea selection process where invalid ideas are eliminated through various methods.

By following the team rule listed in the team charter, the importance of teamwork was shown throughout the idea generation phase by team members' individual thinking and team collaborative discussions to ensure that all ideas are heard.

8.2: Alternative Design Selection Process

Consolidation eliminates duplicate thoughts and begins this process. By revisiting and actively discussing the ideas developed, combining and eliminating duplication to ensure each idea is unique and comprehensive.

Next was feasibility. Verify that the team eliminated unworkable, expensive, and non-functional concepts. After eliminating duplicates, the team discusses and evaluates each remaining idea to establish feasibility. Little hydro generators in water sources failed. This plan may offer sustainable energy for the building, but not all sites were near the river, and the pace of each river was uncontrollable, therefore it was eventually scrapped. Solar or wind power are better.

Since all ideas and solutions have been examined and polished. Every concept is feasible. The team votes on the remaining ideas. Voting helps the team choose the best design and remove the worst. For each aim, each participant chooses 10 alternatives and adds a different-colored question mark to signify approval. The panellists vote again and choose the top five options for each aim. The statistical method counts "|" symbols after each concept. A short communication vote determines the fifth-place winner if two concepts tie. Need 5 final ideas for each target.

The team then thinks separately to create two complete designs from the final list of evaluated ideas. The design solution is the overall design that meets all restrictions, objectives, and client expectations. Second idea-generation phase. Each design here is based on well-established and determined objectives, therefore it is likely to be feasible regardless of design variation. The team proposed several focus solution plans, including an artistic design, a concise and clean design, a fun design, and the cheapest design.

Choose the three designs that best meet objective and customer needs from all 12 designs. The pairwise comparison table helped us prioritize goals.

Pairwise Comparison chart:

	Social interaction	sustainable	long-lasting	Culture promotion	Natural lighting	Score
Social interaction	_____	1	1	1	1	4
sustainable	0	_____	1	1	1	3
Long-lasting	0	0	_____	1	1	2
Culture promotion	0	0	0	_____	0	0
Natural lighting	0	0	0	1	_____	1

Then, the team used a ranking method of finding the best 3 solutions by evaluating the extent to which the solution satisfy the most important objectives as well as the client's need. And then the team applies the graphical decision analysis.

Graphical Decision analysis (Pick one as the major solution, others are alternatives)

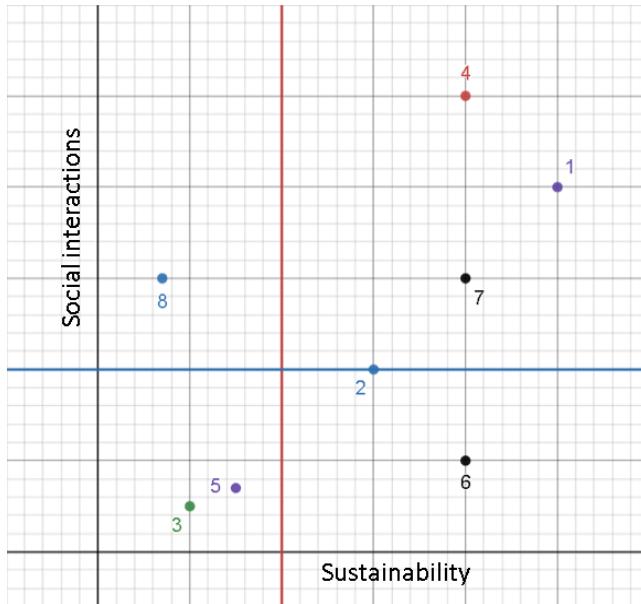


Figure 12: Graphical Decision Chart

Finally, to determine the three final designs, the team used a weighted decision matrix. This matrix shows you the importance of each goal, allowing the team to identify and prioritize designs that meet more important objectives. In addition, by using the tool, the team finally determined the optimal solution, which was adopted as Plan 1. Of course, all weighting decisions are closely discussed by the team to ensure that the weighting of each objective here makes as much sense as possible.

Table: Weighted decision matrix

Objective	Rank(form pairwise comparison)	Weight
Social interaction	1	27%
Sustainable	2	23%
Long-lasting	3	20%
Natural lighting	4	17%
Culture promotion	5	13%

8.3 Alternative Designs:

8.3.1: Solution 1(S1): Octagonal Resting Spot

Components inside S1 are shown in Appendix C1:

In our design, we aimed to create a prototype that is both aesthetically pleasing and functional. Out of the three designs we created, this design was meant to be the most simple, and it mimics an old-fashioned rural building. It is also meant to replicate PEI culture with its lighthouse-like build, and its traditional octagonal shape. Our main goal for this design was to satisfy all functions, constraints and objectives. We chose to create an octagonal-shaped building to allow viewers to experience a more open feel and also incorporated large windows going around the building to allow natural lighting and viewers to further experience the surrounding nature. We also felt as if the octagonal shape and the colours used in the design replicate a cabin and give the viewers a very natural feeling. The bottom is raised on stilts[30], retractable insulation shields, and a composite building[31][33] (concrete and plastic) make the design weatherproof (ie: flooding and hurricane). Solar panels, rainwater tanks, and fireplaces make the design self-sufficient. The design's windows allow ample natural light. Emergency entrances with ramps and counters ensure that all building users may use these facilities in an emergency. The design meets all project requirements.



Figure 13: This is a plan view of design 1 with the roof covering the majority of the design.



Figure 14: Front elevation of Design #1. It is facing West.



Figure 15: Side section of Design #1. It is facing North.

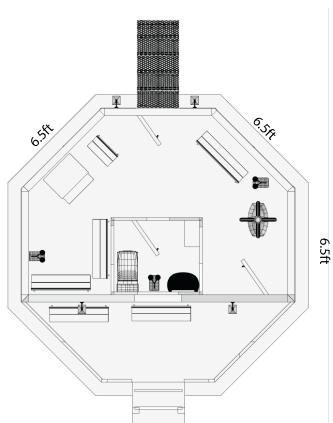


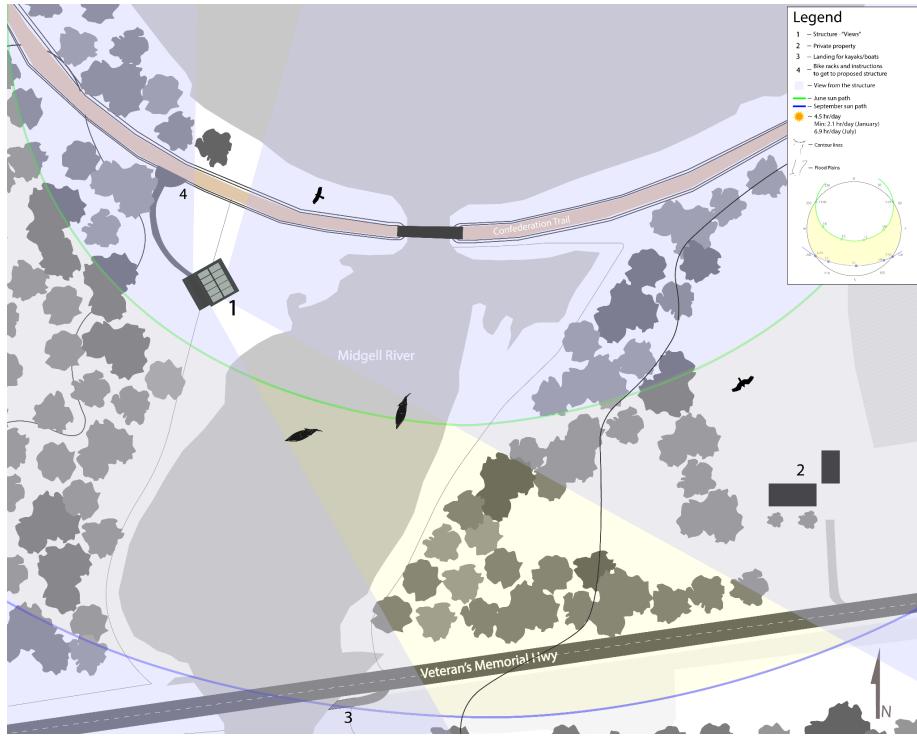
Figure 16: Floor plan of Design #1.



Figure 17: Side elevation of Design #1. It is facing North. For these images, the original scale was 1:50, but has been altered to fit into the document. Each edge of the octagon is 6.5ft, and the height ranges from 8.5ft to 11ft at the highest.

8.3.2: Alternative design 2: VIEWS

The design meets all objectives, functions, and limits while offering spectacular views of the Midgell river and neighbouring environs. This one-story rest stop has a communal seating space, an all-gender bathroom, and a small balcony. High-quality materials are used for durability (Appendix). The buoyant floating system (appendix) protects the structure from floods and high tides, and the entrance is connected to a bridge that connects the confederation trail to the resting spot. Greywater harvesting and PIR-controlled LED lights reduce light waste in the design. The roof slopes to drain snow and enhance solar panel capture. The structure has nighttime outside lamps. The inside has a large corner window with a seating area that overlooks Midgell River, the bridge, and the trail. It will also facilitate user socialization. A PedalCell (<https://pedalcell.com/>) charging station charges tiny devices. A tall window next to the entrance door lets in light and nature. The entrance wall contains a big interactive Confederation Trail map with indigenous information and a weather warning system. Every stop will have a painting as a collection game to draw more people to the Confederation Trail. Kids can use hanging monkey bars. An emergency button and first-aid kit will be at the entryway. The adjoining bathroom features a sink, toilet, and septic tank (appendix). Youth can enjoy views from the balcony.



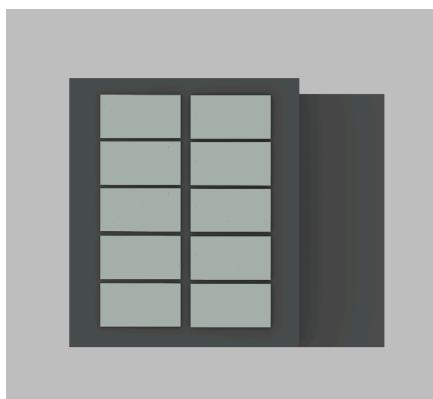
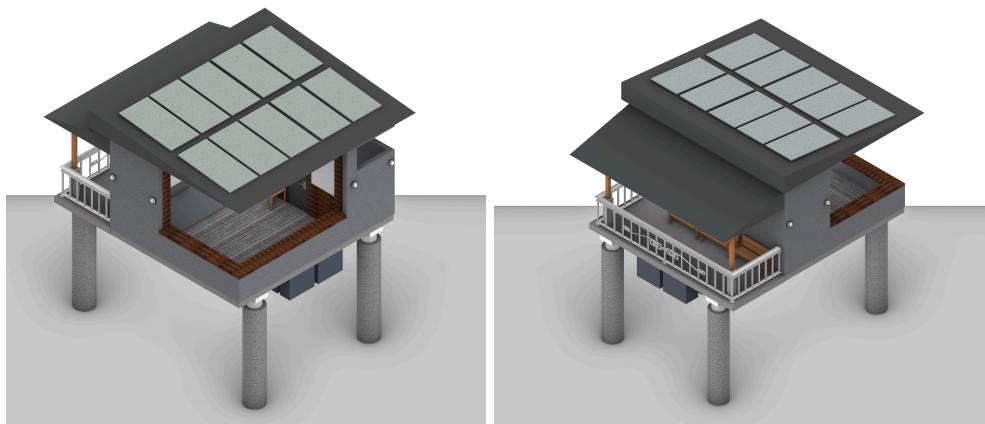


Figure 18: Side view of the design



Figure 19: Top view of the design

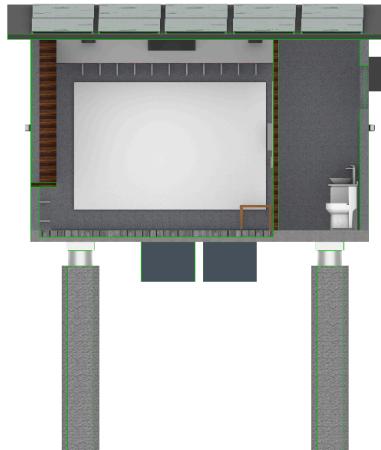


Figure 20: Front view of the design



Figure 21: Isometric view of the design



8.3.3: Alternative design 3: The Pavilion

The third design plan includes the following features:

- Design description table (Appendix)

This is a pavilion design. The aim was to introduce modern aesthetics and technology into the design, while at the same time maximally embedding the design into the surrounding nature and meeting the comfort and basic needs of the users. The design wants to create a perfect rest stop that will impress visitors, but not just a toilet building. In the design, the safety and stability of the building were first considered, including the use of stilts to raise the building against tides and the safety emergency facilities to provide emergency assistance. In addition, to make better use of the space, comfortable sitting areas, gender-neutral toilets, climbing walls for children, and wraparound balconies are implemented. For environment protection purposes, the building is equipped with a solar roof, solar water heater, rainwater collector and underground septic tank. In addition, the building will promote the local culture and community through the extensive use of posters, symbols and other visual design elements.



Figure 22: Back view of the structure

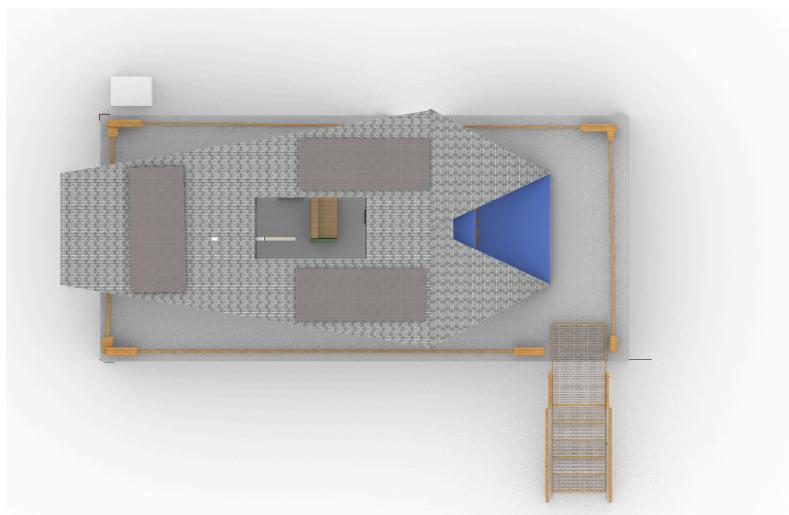


Figure 23: Top view of the structure

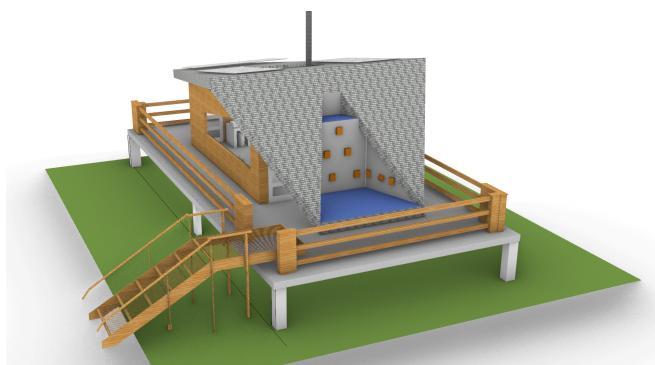


Figure 24: Front entrance and the rock climbing wall.

9.0 Proposed Conceptual Design

Suggested Design: The team selected Octagonal Resting Spot as the proposed design as the proposed design with the help of pugh method(Appendix)

Objectives	Datum	VIEWS	Fin and David	Eda and ben
Social Interactions	2	1	2	2
Long-Lasting	2	1	1	2
Sustainability	2	2	2	1
Indigenous culture	1	1	1	1
Natural Lighting	1	2	1	1
	Total	7	9	7

The design describes a Confederation Trail rest stop. It also provides areas for basic activities, promotes social interaction, protects users from the environment and weather, and educates users about the local community and Confederation Trail.

The building's octagonal shape admits natural light and creates a cabin-like atmosphere. The design includes wooden benches, a toilet, lighting, phone chargers, a fireplace, and a balcony for basic activities and socializing.

Sustainable materials and features like 3D printing the building from recyclable plastic with solar panels and a rain-gathering system make it environmentally friendly.

The raised slab foundation with a hole in the centre and a trap door provides emergency refuge in the event of a major storm.

Table 11. Table of S1 meet the project's objectives

Project's Listed Objectives	Component in Design 1
Should accommodate social interactions	<ol style="list-style-type: none"> 1. fireplace with a chimney <ol style="list-style-type: none"> a. Allow individual/collaborative activities for users b. Create environment that facilitates stronger human connections 2. bird bathing station outside <ol style="list-style-type: none"> a. Allow users to interact with nature and other people 3. Child interactive wall <ol style="list-style-type: none"> a. Allow user to socialize and perform collaborative activities with other users 4. Outdoor balcony with bike rack, wood piles and a motion sensor light <ol style="list-style-type: none"> a. Allow users to interact with nature and socialize with other users through chatting and collaborative tasks 5. wooden benches <ol style="list-style-type: none"> a. Users can sit on benches to socialize(ie: chat)
Should be long-lasting	<ol style="list-style-type: none"> 1. 3D printing using composite material(ie: a mix of concrete and plastic) <ol style="list-style-type: none"> a. Plastic and concrete material lasts over 50 years on average 2. waterproof coated bathroom with septic tank connected toilet and sink <ol style="list-style-type: none"> a. Allow design to be more resistant to water and lasts longer periods of time b. Ensures that the design can function over 10 years without

	<p>major repairs due to the design's simple structure.</p> <p>3. A raised slab foundation made from concrete</p> <p>a. protect design from corruption and flooding</p>
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Project's Listed Objectives	Component in Design 1
Should be sustainable	<ul style="list-style-type: none"> 1. self heat solar panels <ul style="list-style-type: none"> a. Melts snow, provide heating and electricity using sunlight 2. rain water gathering funnel with ultraviolet filtration device on roof <ul style="list-style-type: none"> a. Provide drinkable/usable water through ultraviolet radiation
Should promote information about indigenous culture and local communities	<ul style="list-style-type: none"> 1. pamphlet cabinet with maps and indigenous info <ul style="list-style-type: none"> a. Promote indigenous culture through drawings on cabinet 2. Interior walls with indigenous painting, interactive map and chargers <ul style="list-style-type: none"> a. Promote indigenous culture through painting on wall
Should have abundant natural lighting	<ul style="list-style-type: none"> 1. small skylight on roof <ul style="list-style-type: none"> a. Allow sunlight enter the design through roof 2. plexiglass windows around the wall with retractable insulation shields <ul style="list-style-type: none"> a. Allow sufficient sunlight enter the design through all surrounding side walls

The proposed final design S1 satisfies all objectives (shown in table above), constraints (especially climate resistant and design's user capacity), functions and the project determined scope. S1 provides areas for basic activities, promotes social interaction, protects users from the environment and weather, while also educating users about the local community and Confederation Trail. The design satisfied the gap by creating accessible resting locations for users along the trail, fulfilling the need to provide resting infrastructures for users to use and engage with nature when needed across the confederation trail.

S1's incorporation of a concrete basement with retractable insulation shields for windows, rather than S2's weather warning system, allows S1 to be more resistant to various natural disasters (ie: hurricane). Furthermore, although the buoyant floating system in S2 protects the structure from floods and high tides, the incorporation of the system also makes the design less accessible during flooding (as the structure constantly changes elevation) and more expensive to maintain.

Although S3's child interactive climb

S1's overall octagonal shape (replicate PEI's traditional building culture), fire tank in the middle surrounded by wooden benches (mimic gathering events in indigenous culture), rather than S3's poster with indigenous info, creates a deeper recognition for the local communities . with its lighthouse-like build)

10.0 Measures of Success

The measures of Success for the proposed design are based on the following objectives:

Lighting:

- Illuminance Levels: Calculate the flow of light by creating a light visualisation software with the help of DIALux evo

Durability:

- Structural testing: Test the force components and other stress related components with the help of finite element analysis in ANSYS Mechanical software to measure the durability of the design

11.0: Conclusion

The PEI confederation trail's resting areas could improve users' experiences. The team's final design accommodates users' essential tasks, stimulates social interaction, shelters users from external elements (making the design long-lasting and sustainable), teaches users about the local community, and provides emergency aid equipment when needed. The team selected three designs through team idea selection and will test them in Section 10, Measure of Success.

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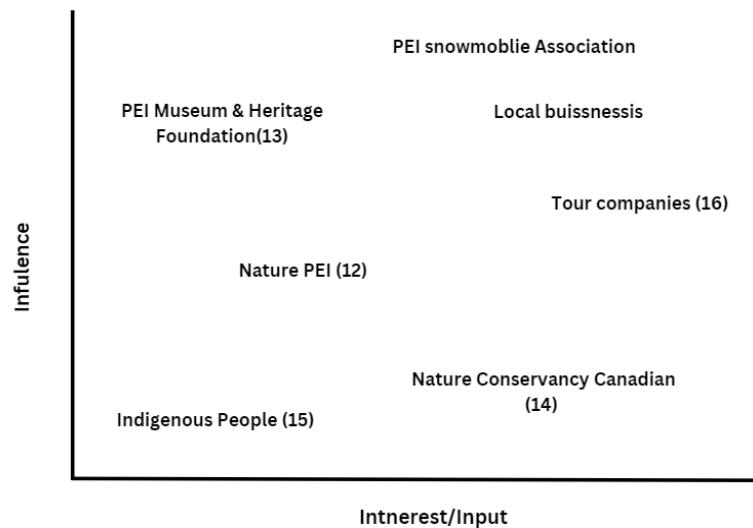
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Appendix A:

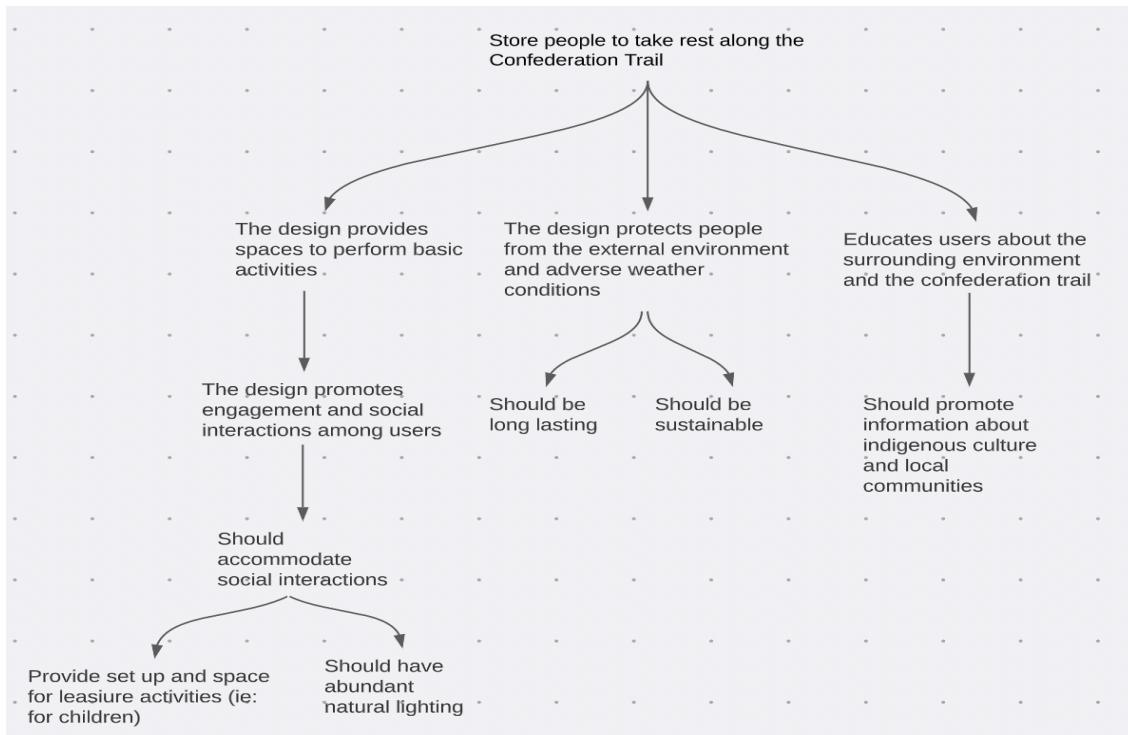
A1: Black Box Method: functions as input and results as output

Inputs		Output
<p>Energy:</p> <ul style="list-style-type: none"> - Electrical - Mechanical - Solar - Potential 		<p>Energy:</p> <ul style="list-style-type: none"> - Electrical - Mechanical - Solar Energy - Potential
<p>Information:</p> <ul style="list-style-type: none"> - Signal - Indigenous poster - Sign - Light 		<p>Information:</p> <ul style="list-style-type: none"> - Direction - Education - Guidance - illumination
<p>Mass:</p> <ul style="list-style-type: none"> - Visitors - Bikers - Kids - Disabled person - Ski man 		<p>Mass:</p> <ul style="list-style-type: none"> - Accessibility service - Ramp - Parking space - Entertainment system - Heating system - Resting places

A2: Stakeholder Analysis:

Stakeholder Analysis is used to determine the priority of stakeholders

A3: How Why Tree:



How why tree is used to break down function into specific objective with goals for the design

A4: Pairwise Comparison:

	Social interacction	sustainable	long-lasting	Culture promotion	Natural lighting	Score
Social interacction	_____	1	1	1	1	4
sustainable	0	_____	1	1	1	3
Long-lastin g	0	0	_____	1	1	2
Culture promotion	0	0	0	_____	0	0
Natural lighting	0	0	0	1	_____	1

Pairwise Comparison is used to determine the rank of objectives

Appendix B:

B1: Free Brainstorming

Ben:

1. Half solar panel and half glass roof design for both the purpose of green energy generation and visibility (aesthetics) for both indoor and outdoor.
2. Bicycle parking racks right beside the building
3. No threshold design (no doors) but a squared C shape building with two entries, the one on the left is normal entry, the other one on the right is a fluted slope. The inside room will be right behind middle wall between the two facing entries as to prevent wind/snow/rain to go inside. (For winter, rubber curtain door could be used to keep warm). The front wall between the entries could be used to promote indigenous and local cultures.
4. Installment of bigger pieces of windows on the sides with better view.
5. If the water current is strong, small scale hydraulic power plants could be installed in the nearby river to supply energy for the building.
6. It is better to use more than one green energy sources (multiples) to make sure short of energy would never happen.
7. Instead off traditional building traditional construction materials such as cement, brick or wood, already formed container could be modified and cut to save expense. (cold weather --- install insulation layer inside to keep warm, nomadic.....)
8. Septic-tank built underground or at lower locations to ensure that toilets can be used without major sewage treatment for a long time period.
9. Wall mounted mother-baby bed for maternal and infant use
10. Pet stakes outside the building for people who have doggies.
11. If the scope are internet covered, maximum of 50 MB hotspot Wifi be installed considering expense(if we have more money).
12. One embedded internet connected screen instead of wifi. The screen can provide basic internet access and guidance plus emergency help and other useful function that people usually don't have on their phones.
13. One portable fire extinguisher placed in cabinet
14. Multifunctional Military shovel restricted with a 10 M rope locked in the cabinet for emergency use (attack wide animal, dig soil, save people.....)
15. Water Pump system that gets water from nearby rivers
16. A rain water collector on the top of the building to collect clean water.
17. Non-toxic and odorless paints for the outside design to better incorporate or embed the building into the surrounding environment.
18. Wall mounted long benches on the outside walls of the building to provide extra seating spaces.
19. Climbing wall for kids installed on the strong side of the building.

20. Wall embedded toys for kids(sudoku, indigenous toy, puzzles...)
21. Binoculars for sightseeing towards the view (paid or free)(inside or outside)(for kids and for adults)
22. True stove inside or outside. (for inside, ventilation should also be considered)
23. Alternative: electrical powered air conditioning, but very energy consuming.
24. Tree House, the travellers can have some fun climbing up the tree/ higher so better view/ Plus a children slider could be used.
25. Cheap plan: modify a portable toilet.(as toilet is quite important and it is one of the most important reason why people stop to rest)
26. Wall mounted Shelves and desks for people to place their stuff
27. Smaller scale Washrooms
28. Public washroom for both man and women
29. Simple shower system, (plus rain water collector) for people in need.(wash body, cars, bicycles, tools, feet.....)
30. Open style rest spot, with no walls. But still have other facilities (Our client's primary goal is to provide rest place)
31. Second floor design? As first floor could be used for major facilities such as washrooms and stuff, the second floor then can be used for view, promoting of indigenous culture and other stud. Plus, a children's slider can be installed)

David:

1. Rain gathering funnel for building water supply
2. Ultraviolet radiation filtration device to clean the gathered water
3. Ramp at the entrance with ceiling
4. Tunnel system
5. Emergency underground building section
6. Geothermal heating system for building
7. AI controlled energy system for building
8. Material that increase friction on floor:ie: rough surface such as rough wooden floor
9. Solar panel for energy gathering
10. Small Hydroelectric power station for energy gathering
11. Small wind power station for energy gathering
12. Emergency lighting and signal at house
13. Plants on building
14. Material for building foundation to prevent erosion from ocean, river etc: ie: concrete
15. Emergency power supply for building

16. Washroom within the building including toilet, shower and sink(waste is exported to the surrounding environment)
17. Retractable hard shield around the building's large window to protect building
18. Human supply energy for building(ie: small paddling device that gather energy for building/enable some light to increase user interaction)
19. Emergency package in building(ie: first aid kit, emergency reference handbook)
20. Pictures or drawing about indigenous culture and small games on building wall, that users can interact with
21. Filtered inward Water flow pipe transparent visible to users
22. Retractable bed on wall/Retractable bed sofa
23. Tables/ desk and a shelf
24. Small animal habitat incorporated on building external wall for users to interact
25. Interactive Map of trail and PEI on wall
26. Water flow through transparent floor
27. Height Adjustable foundation
28. Movable building(ie: with wheels)
29. Small water funnel for bird to drink,bath and users to see in morning
30. Retractable roof (ie: sun room) for building.

Habib

1. circular seating in the structure with a fireplace in the middle to encourage interactions
2. We can use high quality materials such as corten steel and marine-grade plywood
3. Can use a simple column+beam as it is strong and easy to make
4. Use of sustainable materials such as recycled steel, cross-laminated timber (CLT), etc
5. Using green energy to reduce carbon footprint and solar panels, tidal energy and biomass energy
6. Water: greywater recycling
7. Rainwater harvesting
8. Big windows or surround glass for natural lighting
9. Open concept design to allow light to travel around
10. Compostable toilets rather than traditional ones
11. Reflective color/paint to keep the inside bright
12. Sloped roof for solar panels to sit on and to collect rainwater
13. Drinking fountain with water filtrations
14. Having a skylight for lighting purposes
15. Simple playground incorporated in/on the house for kids
16. A device that can be used to talk to other outposts along the trail
17. A safety button that can be used to call for emergency services such as the ones we have on campus
18. Tall ceilings
19. Floor will get muddy/dirty as more people use it so it needs an innovative design to prevent that, gaps between wood?

20. Close off buildings to prevent kids from going far. Can be altered to depending on location of building
21. Reclaimed wood for the furniture inside as they will not be affected by weather

Eda

1. Balcony to show the view, balcony can go all around the structure
2. Patio with tables and fire place in front of the entrance of the structure
3. Bathroom door faces outside so building is not stinky
4. Bathroom interior has ventilation with outside air circulation
5. The wall of the structure is a small rock climbing wall
6. Monkey bars around the structure
7. Sky light for lighting, easier cause electric hard to find
8. Indoor and outdoor seating and table for eating
9. Structure includes information station, maps, good places to go etc...
10. First aid kit
11. Wood fire place, that gets the smoke out of the building, big enough to keep everything warm
12. Wood benches,
13. Waterproof wood used for everything
14. Recycled wood used from fallen trees due to hurricane
15. Fire lanterns
16. Curved roof so weather falls off less damage
17. High ceiling so feels open,
18. Not too large windows to keep space warm.
19. Structure can be painted fun to make it welcoming, example like paint butterflies inside, and each pavilion can have an animal theme relating to PEI.. It can be like a game to find each pavilion cause they all include like something special.
20. Resting hammock area.

Fintan

1. Gazebo shaped exterior
2. Dark grayscale wood
3. Solar panels on roof
4. Pamphlet cabinet with maps
5. Part of building has walls other parts doesn't (enclosed and non enclosed areas)
6. Bike racks right beside building
7. Playground beside building
8. Canoe docking on the river
9. Bridge from path to building
10. Scientific tools to measure change in water levels
11. Wooden benches inside and outside

12. Picnic table beside
13. First aid kid and section in case necessary
14. Power outlets
15. Trash cans (will require maintenance crew)
16. Open walls or large windows to allow light in
17. Skylight
18. Sloped roofs so snow falls off
19. Motion censored lights to conserve energy
20. Rainwater collecting system
21. Big map right outside of the building
22. Emergency life preserver flotation ring hung up near the water
23. Vending machines
24. Water fountains/ water bottle filling station
25. Water purification
26. Indigenous recognition pamphlets and signs
27. Sand pit for horseshoe and kids
28. Coin machine for souvenirs
29. Ladder or stairs to get on the roof
30. Fishing rod holder
31. Outdoor showers for sand
32. Wood is used from fallen trees instead of cutting more
33. Wood coating to make resistant to salt and humidity
34. Design blends into the natural habitat
35. Pamphlets to show the types of organisms in the area

Hardik:

1. The observation deck on the side or on the roof
2. Confederation trail information map hanging around the wall
3. PIR controlled lights
4. Composting toilets
5. Mechanic room to fix bikes
6. Emergency button to call for emergency personal
7. Solar panel on the roof
8. Solar thermal collector for water heating etc
9. Use flood water to generate electricity
10. The charging station
11. Use LED lighting
12. Use stilts or piers to raise house
13. Temporary barriers during the tidal season
14. Kids' play area with an obstacle course

15. Septic sewage system
16. Electric stove/microwave
17. Small height table on the carpeted floor encouraging social interactions
18. Fire extinguisher
19. Wind barrier room
20. Weather warning system to warn about storms or tides
21. Storage area
22. Glass ceiling for natural lighting

C2: Structured Brainstorming and multi voting (| - Hardik, | - Eda, | Habib, | Fintan, | Ben, | - David)

Objective 1: Should accommodate social interactions

1. The observation deck on the side or on the roof { | }
2. circular seating in the structure with a fireplace in the middle to encourage interactions { | }
3. Wall mounted mother-baby bed for maternal and infant use { | | }
4. Wooden benches inside and outside { | | | }
5. Plants on building { | }
6. Picnic table beside { | | | }
7. Structure can be painted fun to make it welcoming, example like paint butterflies inside, and each pavilion can have an animal theme relating to pei.. It can be like a game to find each pavilion cause they all include like side walls of the building to provide extra seating spaces something special { | | | }
8. Retractable bed on wall/Retractable bed sofa { | }
9. Second floor design? As first floor could be used for major facilities such as washrooms and stuff, the second floor then can be used for view, promoting of indigenous culture and other stud. Plus, a children's slider can be installed) { | }
10. Small water funnel for birds to drink, bath and users to see in morning { | | }
11. Small height table on the carpeted floor encourages social interactions { | }
12. Indoor and outdoor seating and table for eating { | | }
13. Ladder or stairs to get on the roof ? { | }
14. The observation deck on the side or on the roof { | | }
1. Playground beside building { | | }
2. Human supply energy for building(ie: small paddling device that gather energy for building/enable some light to increase user interaction) { | }
3. Climbing wall for kids installed on the strong side of the building. { | | | }
4. Wall embedded toys for kids(sudoku, indigenous toy, puzzles...) { | | | }
5. Binoculars for sightseeing towards the view (paid or free)(inside or outside)(for kids and for adults) { | }
6. Kids' play area with an obstacle course { }

7. Filtered inward Water flow pipe transparent visible to users { }
8. Small animal habitat incorporated on building external wall for users to interact ? {|||}
9. Interactive Map of trail and PEI on wall {||||}
10. Water flow through transparent floor {||}
11. The wall od the sture i a small rock climbing wall {|||}
12. Monkey bars around the structure {||}
13. Simple playground incorporated in/on the house for kids {|||}
14. Close off buildings to prevent kids from going far. Can be altered to depending on location of building { }
15. Sand pit for horseshoe and kids {||}
16. Coin machine for souvenirs { | }
17. Second floor design? As first floor could be used for major facilities such as washrooms and stuff, the second floor then can be used for view, promoting of indigenous culture and other stud. Plus, a children's slider can be installed) {|||}

Objective 2: Should be long-lasting

1. Ultraviolet radiation filtration device to clean the gathered water {|||||}
2. Instead of traditional building traditional construction materials such as cement, brick or wood, already formed container could be modified and cut to save expense. (cold weather --- install insulation layer inside to keep warm, nomadic.....) {|||}
3. We can use high quality materials such as corten steel and marine-grade plywood {|||||}
4. septic-tank built underground or at lower locations to ensure that toilets can be used without major sewage treatment for a long time period. {|||||}
5. Can use a simple column+beam as it is strong and easy to make { ||| }
6. Scientific tools to measure change in water levels {|||}
7. Use stilts or piers to raise house {|||}
8. Material for building foundation to prevent erosion from ocean, river etc: ie: concrete{|||}
|
9. Temporary barriers during the tidal season {|||}
10. Height Adjustable foundation {||}
11. Movable building(ie: with wheels) { }
12. Retractable roof (ie: sun room) for building. ? { }
13. Wood coating to make resistant to salt and humidity { ||| }

Objective 3: Should be sustainable

1. Half solar panel and half glass roof design for both the purpose of green energy generation and visibility (aesthetics) for both indoor and outdoor. {|||}
2. Solar panels on roof {|||||}
3. Rain gathering funnel for building water supply {|||}

4. Ultraviolet radiation filtration device to clean the gathered water {||| | }
5. If the water current is strong, small scale hydraulic power plants could be installed in the nearby river to supply energy for the building. {|| }
6. PIR controlled lights {||| }
7. It is better to use more than one green energy sources (multiples) to make sure short of energy would never happen. { }
8. Composting toilets { }
9. We can use high quality materials such as corten steel and marine-grade plywood {||| | }
10. Geothermal heating system for building { }
11. AI controlled energy system for building {||| }
12. Can use a simple column+beam as it is strong and easy to make { }
13. Solar panel on the roof {|| }
14. Solar thermal collector for water heating etc {|| }
15. Use flood water to generate electricity { }
16. Small Hydroelectric power station for energy gathering {||| }
17. Small wind power station for energy gathering { }
18. Use of sustainable materials such as recycled steel, cross-laminated timber (CLT), etc { }
19. Using green energy to reduce carbon footprint and solar panels, tidal energy and biomass energy { }
20. Water: greywater recycling {||| }
21. Rainwater harvesting { }
22. Use LED lighting {||| }
23. Compostable toilets rather than traditional ones {||| | }
24. Water Pump system that gets water from nearby rivers { }
25. A rain water collector on the top of the building to collect clean water. { }
26. Human supply energy for building(ie: small paddling device that gather energy for building/enable some light to increase user interaction) { }
27. Motion censored lights to conserve energy {||| | }
28. Rainwater collecting system {|| }
29. Sloped roof for solar panels to sit on and to collect rainwater { ||| | }
30. Drinking fountain with water filtrations {|| }
31. Septic sewage system { }
32. Sloped roofs so snow falls off { | }
33. Sky light for lighting, cause electricity is hard to find { }
34. Wood fire place, that gets the smoke out the building, big enough to keep everything warm { | }
35. Reclaimed wood for the furniture inside as they will not be affected by weather { }
36. Wood benches, { }
37. Waterproof wood used for everything {||| | }
38. Wood is used from fallen trees instead of cutting more, Recycled wood used from fallen trees due to hurricane {|| }
39. Fire lanterns { }

Objective 4: Should promote information about indigenous culture and local communities

18. Pamphlet cabinet with maps {||| | }
19. Confederation trail information map hanging around the wall { }
20. Pictures or drawing about indigenous culture and small games on building wall, that users can interact with { }
21. Big map right outside of the building { || }
22. indigenous recognition pamphlets and signs {||| | }
23. Pamphlets to show the types of organisms in the area { }

Objective 5: Should have abundant natural lighting

40. Installment of bigger pieces of windows on the sides with better view. {||| | }
41. Big windows or surround glass for natural lighting { | || }
42. Open concept design to allow light to travel around { }
43. Reflective color/paint to keep the inside bright { || | }
1. Balcony to show the view, balcony can go all around the structure {||| | }
2. Patio with tables and fire place in front of the entrance of the structure { }
44. Open walls or large windows to allow light in { }
45. Skylight, Having a skylight for lighting purposes { | }
46. Tall ceilings {|| | }
47. Glass ceiling for natural lighting {|| | }
48. High ceiling so feels open { }

B3: SCAMPER Method

S:

- Wooden benches inside and outside
- The observation deck on the side or on the roof
- Instead of building traditional construction materials such as cement, brick or wood, already formed containers could be modified and cut to save expense. (cold weather --- install an insulation layer inside to keep warm, nomadic.....)
- Wood coating to make resistant to salt and humidity
- PIR controlled lights
- Pamphlet cabinet with maps

C:

- Wall embedded toys for kids(sudoku, indigenous toy, puzzles...)
- Interactive Map of trail and PEI on wall
- Small habitat on external wall
- Climbing wall for kids installed on the strong side of the building.
- Painting on wall

- Half solar panel and half glass roof design for both the purpose of green energy generation and visibility (aesthetics) for both indoor and outdoor

A:

- Can use a simple column+beam as it is strong and easy to make
- Retractable roof (ie: sun room) for building
- Rain gathering funnel for building water supply
- Sloped roof for solar panels to sit on and to collect rainwater
- septic tank for waste

M:

- Installment of bigger pieces of windows on the sides with better view
- If the water current is strong, small scale hydraulic power plants could be installed in the nearby river to supply energy for the building
- Sloped roofs so snow falls off
- The observation deck on the side or on the roof
- Solar panel on the roof

P:

- Public washroom for both man and women
- Wood fire place, that gets the smoke out the building, big enough to keep everything warm with chimney
- Wall mounted mother-baby bed for maternal and infant use
- Outdoor showers for sand

E:

- Remove trees(forest) near design space
- Remove animals and water from land
- remove sand and mud from ground
- remove bridge and road near design space

R:

- Level up the whole building(building fondation high)
- Bicycle dock on plat deck
- canoe dock near river
- underwater /roof opening entrance

B4: Morph Chart(final version)

Should accommodate social	Should be long-lasting	Should be sustainable	Should promote information about	Should have abundant natural lighting
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interactions			indigenous culture and local communities	
Wooden benches inside and outside	Ultraviolet radiation filtration device to clean the gathered water	Rain gathering funnel for building water supply	Pamphlet cabinet with maps	Installment of bigger pieces of windows on the sides with better view.
Wall can be painted fun to make it welcoming,	use high quality materials such as corten steel and marine-grade plywood	PIR controlled lights	Confederation trail information map hanging around the wall	Big windows or surround glass for natural lighting
Small water funnel for birds to drink, bath and users to see in morning	septic-tank built underground or at lower locations for toilettes	Solar thermal collector for water heating	Pictures or drawing about indigenous culture and small games on building wall	Open concept design to allow light to travel around
The observation deck on the side or on the roof (outdoor or indoor)	Use stilts or piers to raise house	sloped roof for solar panels to sit on and to collect rainwater	indigenous recognition pamphlets and signs	Balcony around the design
Wall embedded toys and a possible climbing wall for kids(sudoku, indigenous toy, puzzles)	Wood coating to make resistant to salt and humidity	fireplace with chimney	Pamphlets to show the types of organisms in the area	Having a skylight for lighting purposes

C1: List of Components in S1

1. Octagon shape design with sloped roof
 - a. self heat solar panels and small skylight on roof

- b. rain water gathering funnel with ultraviolet filtration device on roof
- 2. 3D printing using composite material(ie: a mix of concrete and plastic)
- 3. fireplace with a chimney
- 4. waterproof coated bathroom with septic tank connected toilet and sink
- 5. wooden benches and lamps
- 6. bridge to building and canoe docking to river (for this site only due to unique marsh)
- 7. bird bathing station outside
- 8. outdoor shower (using rain water)
 - a. connected to larger tank
- 9. pamphlet cabinet with maps and indigenous info
- 10. emergency counter with phone charger
 - a. landline phone, first aid kit and fire extinguisher
- 11. interactive child wall on interior walls with indigenous painting, interactive map and chargers
- 12. outdoor balcony with bike rack, wood piles and a motion sensor light
- 13. emergency counter with landline phone, first aid kit and fire extinguisher
- 14. plexiglass windows around the wall with retractable insulation shields
- 15. entrance with ramp
- 16. A raised slab foundation made from concrete

D1 Septic Tank:

Underground chamber made of concrete to treat and dispose household water. It works by separating solids and liquids, allowing the liquids to drain into a drainfield, while the solids are partially decomposed by bacteria and settle to the bottom of the tank as sludge.

D2 Buoyant floating mechanism:

Buoyant floats are installed underneath the main floor of the house, along with vertical guide posts that keep the house from moving side-to-side during floods.

With rise in floodwaters, the house rises with them and sits back down on the foundation when the waters recedes. The retrofitting process is inexpensive and simple for single-story, lightweight homes without a basement that are elevated above the ground.

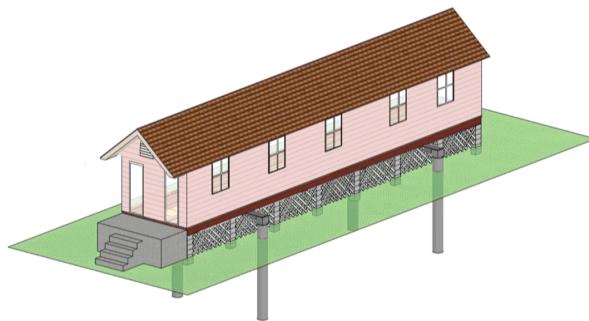


Figure: Hydro slits to elevate house during floods [36]

D3 Grey water harvesting:

Process used to collect and reuse household and river water. The wastewater from these activities, which is referred to as grey water, can be collected, treated, and reused for non-potable purposes such as landscape irrigation or toilet flushing.

D4 Pugh method:

Objectives	Datum	VIEWS	Fin and David	Eda and ben
Social Interactions	2	1	2	2
Long-Lasting	2	1	1	2
Sustainability	2	2	2	1
Indigenous culture	1	1	1	1
Natural Lighting	1	2	1	1
	Total	7	9	7

E1 The pavilion description table

- Solar panels on the roof as a source of sustainable energy supplier.
- A climbing wall with anti skid materials and cache foam on the ground for kids
- A unisex washroom indoor that consists of a toilet, a wash basin with hot water and a mirror.
- Two entrance (two doors with windows), one in the front, one at the back
- An wood fireplace at the centre of building
- Wooden benches that go around the fire place.

- Solar water heating system on the roof, including a water tank and water pump.
- Rain water collector along roof
- Large windows to allow natural light
- Opening on the top of the walls to allow fresh air inside
- An extended roof on the front side of the building.
- A wooden picnic table in front of the building.
- A square window at the centre of the roof to provide natural lighting
- An emergency cabinet at one corner that contained first aid bags, safe hammer satellite phone, and fire extinguisher
- Post bar on the walls to promote local and indigenous culture
- Bicycle racks on the side of the building
- Indoor eco lighting bulbs
- Fluorescent lamp outdoors under the roof or on the ground.
- Eco light bulbs at the two entrances of the building.
- Septic tank underneath the ground near the building site
- An individual wooden bench farther away from the building for temporary users
- Rest stop sign on the ground