Design for Tomorrow:
Future-Proof Arctic Architecture in Cognizance of Shifts in Climate and Regional Livelihood

by

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Figure 0.01
Polar Bears in the Torngat Mountains National Park.

ABSTRACT

Accelerating climate change is dramatically altering environments worldwide, which also has significant impacts on cultural practices and livelihoods in vulnerable regions. Warming at three times the global average, the Arctic and its Inuit population are in a precarious state. This Thesis thus focuses on the future-proofing of the Torngat Mountains National Park Base Camp and Research Station (Nunatsiavut, Labrador). Informed by predictive climate models and a review of architectural strategies to respond to inevitable and expected climate change, the Base Camp is redesigned to ensure short-term and long-term adaptability and resilience. The design is simultaneously informed by land-based ecological and cultural lessons, connecting the building back to the people and supporting the traditional livelihood that is intrinsically linked to their land. The meeting of researchers, Inuit, and tourists in this place should foster opportunities to learn from one another about mitigating and adapting to changes to preserve land and livelihood.

KEYWORDS

Climate Change, Arctic, Nunatsiavut, Adaptive Architecture, Future-Proofing, Traditional Livelihood

Figure 0.02
Sun rays make their way over the ridgeline while trekking in the Torngat Mountains National Park.

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- Thank you.

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'Feet on the Ground' in a Lichen covered Landscape.

PREFACE

A concern for a changing climate stems from a personal adornment of our planet Earth. Through a youth of fortunately being able to experience countless coastlines, mountains, and forests far-and-wide, I realize that this spinning orb we all call home is never short of faultless moments. There has always been an understanding of the respect this planet deserved, but also the impact we, as humans, could have on it. I am extremely grateful for an education that pulled me slightly North, to a city which was born from industrial exploitation. Through seeing its enduring impacts on the landscape, this developed into an interest of working with whatever a place had to offer, be that challenging contexts or climates and all. This entire education has firmly grounded me with an appreciation of place, as well as an acknowledgement that it is changing more quickly than we can ever imagine.

Living in a generation which will spend our entire lives on a planet that has been dying from the minute we entered it, I am often brought back to the thought of what tomorrow, or many tomorrow's from now, will bring. During this thesis I landed upon an out of context quote by Antoine de Saint Exupéry, "*Pour ce qui est de l'avenir, il ne s'agit pas de le prévoir, mais de le rendre possible.*", which translates to *"As for the future, it is not a matter of predicting it, but of making it possible."* So, as this is a **Design for Tomorrow**, the big question remains...what's going to happen then? Frankly, we have no real idea. Even by taking into account every bit of predictive climate science, first-hand observations and accounts, and progressive technological development, it only gets us a well thought-out plan. As everyone well knows, the best laid plans can only go so far. Making tomorrow possible is about acknowledging it won't be perfect, and changing the ways we live and build to work to mitigate this continuous downward spiral, but similarly help us adapt to a planet that isn't the same as it used to be. And while I am fully aware that changes must be made at the top of our governments and industry, I also champion the power and influence that we as individuals have, especially entering an industry that quite literally gets to design our own future.

So, here's to *tomorrow*.

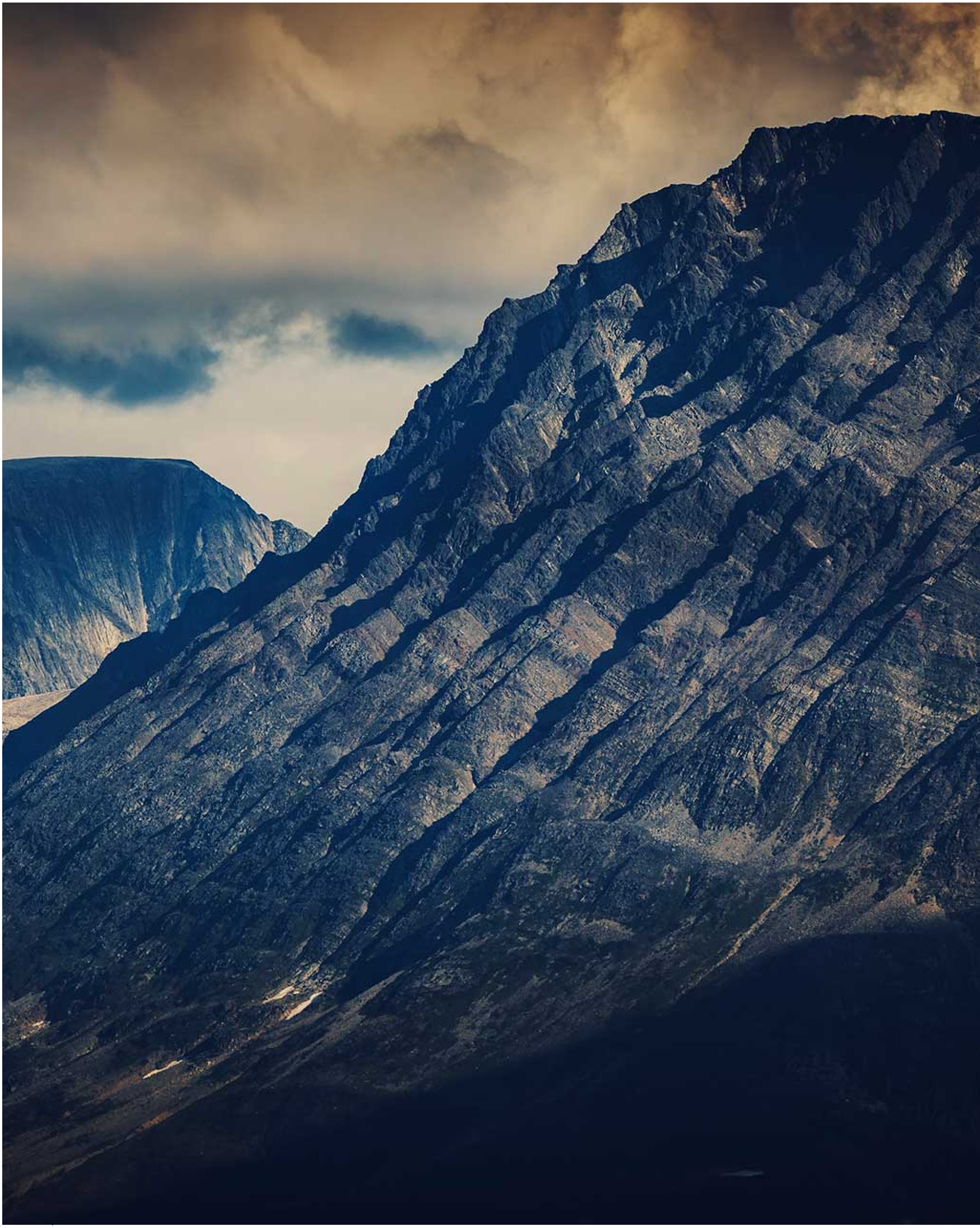


Figure 1.01
Stratified Rocks in the Torngat Mountains National Park.

INTRODUCTION 1

The adverse effects of climate change and ecological breakdown are impacting numerous regions and communities worldwide. A consequence of such is that 20% of infrastructure in Northern regions are rendered uninhabitable or in a state of disrepair each year, which is only expected to increase in the coming decades[1]. Our dependence on all scales of infrastructure combined with their accelerated decline prompts the need to reflect upon future-proofed building strategies that incorporate climate-sensitive practices with passive design and adaptable solutions. Through a deep commitment to future-proofing, and thus to increased resilience, infrastructures can achieve self-sufficiency that supports the socio-cultural and environmental needs of communities, today and tomorrow. Over time, the environmentally-sensitive practices of living and building with the land have become unreliable due to the accelerated changes to the climate. This detrimental impact is exponentially worse in polar regions, where warming is occurring at three times the global average[2]. Through an understanding of the region's transforming climate, informed by scientific data as well as observation by stewards of the land, infrastructure can be developed that withstands these changes while simultaneously respecting the significant socio-cultural elements of the region's inhabitants, their traditional ecological knowledge and their vernacular architecture.-

Due to its rapid deterioration as well as complex geological history, the Arctic is a hub for climate research. The Canadian Arctic has additionally always been home, and still is home to the Inuit, who now live in various administrative regions within Inuit Nunangat. The region therefore presents a charged dynamic between cultural, social, and environmental issues and transformations that have made it a site of interest for a range of disciplines. From an environmental and geological standpoint, the ice and rocks seem like the most basic of elements, but they each hold a world of history which can inform an understanding of what was, and also provide indices of future climatic trends[3]. This scientific knowledge assists with evaluating risk and preparing solutions based on predictive estimations. In-situ research in the Arctic, which allows for the gathering of data and knowledge, is vital to better understand climate change issues and to preserve the place and its inhabitants' traditional livelihood. Additionally, Northern regions are on the forefront of remote tourism development - the Arctic being dubbed *one of the earth's final tourism frontiers*[4]. A limited scale of conscious tourism in these vast regions provides social and economic opportunities for the Inuit who remain on their land, considering jobs are often otherwise scarce. Infrastructures that provide income during the peak season and still benefit the

1 Dimitry Streletskiy et al. "Assessment of climate change impacts on buildings, structures and infrastructure in the Russian regions on permafrost" *Environmental Research Letters,* Vol 14., No. 2. (2019) DOI: 10.1088/1748-9326/aaf5e6

2 Matthew Kuittinen. "Zero Arctic: Concepts for Carbon Neutral Arctic Architecture based on Tradition." *Ministry of the Environment - Finland.* 2020, 7.

3 National Research Council. "Rationale for Continued Arctic Research" in *The Arctic and the Anthropocene: Emerging Research Questions*. (2014) DOI 10.17226/18726.

4 Claire Runge, Daigle R, Hausner V (2020). Quantifying tourism booms and the increasing footprint in the Arctic with social media data. *PLoS ONE* 15(1): e0227189. https://doi.org/10.1371/journal.pone.0227189.

community in the bracket season through youth programs and pedagogical expeditions are essential for sustaining traditional livelihood in these areas. Informing about the climatic changes in the region brings to light its paralleled repercussions on livelihood practices, whereby the importance of learning about and reacting to both becomes critical. Designing today for the snafued climate of tomorrow is no straightforward task. This task is even more challenging in the remote Arctic, considering the difficulties to access materials and labour, and the growing demand for resilient infrastructure. This prods the following question: **how can future-proof architecture be developed to adapt and inform about both climate and socio-cultural changes in arctic regions, acting in stewardship of both land and livelihood?**

The region's rapid natural changes, remoteness, and its government's enthusiastic research and tourism strategies present the Torngat Mountains National Park and Base Camp in Nunatsiavut (Northern Labrador) as the optimal site for this Thesis. This Base Camp is the access point to the National Park for all visitors, but it also houses a scientific station that welcomes international researchers. Currently, this site is filled with temporary structures and bare-bones permanent ones in need of major repairs - resulting in a short season and high costs for upkeep. The Nunatsiavut Government wishes to renovate and extend the Base Camp, and so there is thus an opportunity to transform this site so that it becomes a durable, comfortable and inviting home for researchers, visitors, but also community Elders and youth groups that will be able to preserve traditional ecological knowledge and livelihood by being on the land. The proposed design interventions should not merely house bodies, but act as a place that reflects the values of its users, and that allows the various user groups to gather, exchange, and learn from one another. All parties who make the trek to Northern Labrador and the Torngat Mountains National Park are in search of an immersive experience into the unique geographical and ecological region. While taking in the striking fjords, glaciers, migrating caribou and growing numbers of polar bears[5], there presents itself the opportunity to understand the fragility of these places by way of climate research, tourist experience, and experiential learning on the land.

This thesis begins by studying literature from the fields of architectural regionalism, climatology, self-sufficiency, and future-proofing. This is essential in order to identify appropriate architectural solutions to generate a project which is designed for its context today, but also that can adapt to changing conditions of

5 Zac Unger. "The Truth About Polar Bears" Canadian Geographic. Accessed November 14, 2021. https://www.canadiangeographic.ca/article/truth-about-polar-bears.

6 Hylke Beck., Zimmermann, N., McVicar, T. et al. "Present and future Köppen-Geiger climate classification maps at 1-km resolution." *Scientific Data* 5, No. 180214 (2018) DOI: 10.1038/sdata.2018.214.

tomorrow. A series of cartographic and climatological investigations that probe the geo-political and traditional history of the area, its shared use between people, animals, and its physical context, as well as its geographic and climate properties and predicted changes will help to synthesize the complexities of the region. Chapter 2 dives into the next 100 years of global climate change, focusing on Northern Labrador's shift from a Tundra Climate (ET) to a subarctic climate (Dfc)[6], currently seen hundreds of kilometers south in the province, as well as in Scandinavia and Iceland. While these are still seen as 'northern climates' and the climatic difference may seem minor, it will drastically affect the permafrost underfoot, the weather patterns, as well as the local availability, movement and growth of flora and fauna. These local conditions were further investigated (within Chapter 3) to understand historical, environmental, and cultural perspectives of the place, the variety of users which will interact with it, as well as an in depth study into the specific site's changing climatic conditions. From an understanding of the climatic changes to the place, along with its local context, the four greatest elements of change affecting the region in the coming century were determined: extreme and erratic weather, sea level rise, ground thaw, and disruption of seasonal reliability and access to country food[7]. From this, a network of resilient, future-proofed, and adaptable design strategies are to be developed - consisting of significant systems, structures, and self-sufficiency principles for the specific environment - in order to tackle the issues listed above. The analysis of these issues and their viable solutions is examined in greater detail within Chapter 4.

Concurrently, for each part of the project it is essential to engage with those who have and will continue to live and work in this area to understand the cultural and social significance of the local vernacular and traditional land-use practices. The core fundamentals of these practices can then be maintained as new technologies and building solutions continue to be integrated, as discussed within Chapter 5. Infrastructure has been placed in these regions over the last half century without much regard to culture or effort to be climatically responsive. Contributors to the scholarship and design of the Arctic such as Harold Strub[8] and Ralph Erskine[9] have approached this issue with an initial level of response to the extreme climate, but for the most part ignored the socio-cultural aspects of these built environments. Writings on Inuit Qaujimajatuqangit and lived experiences, as well as the observed changes of those who know the land best are an essential branch to incorporate into the project's design[10]. This design proposal will contribute to practical solutions that consider the needs of today as

7 Country food describes Inuit traditional food sources from game, fish and birds to foraged foods. It is an integral component of their food source and similarly their cultural identity.

8 Harold Strub. *Bare Poles: Design for High Latitudes*. Montreal, Canada: McGill-Queen's Press, 1996.

9 Alan Marcus. "Place with No Dawn: A Towns Evolution and Erskine's Arctic Utopia." University of Aberdeen, 2011, https://www.abdn.ac.uk/staffpages/uploads/enl333/Marcus_2011.pdf.

10 Sheila Watt-Cloutier. *The Right to Be Cold: One Woman's Story of Protecting Her Culture, the Arctic, and the Whole Planet*. Toronto, Canada: Penguin Random House Press, 2015.

well as integrate preventative measures tailored to the types and scope of changes predicted.

The design proposal will be informed by the predicted shifts in climate and livelihood in order to develop a passively designed and adaptable building braced for the changes of the coming century. In order to respond to the various needs of all user groups, the project will include three main typologies of buildings. The largest building, the Hub (1st typology), will house research offices and labs, the Park's offices, a community and teaching space, and the hydroponic food production and preparation areas. The main site will also contain nearby accommodations for anyone visiting the Base Camp during its extended season. Those will include existing domes, but also brand new modular cabins (2nd typology) that will be entirely self-sufficient, and arranged in pods that can be adapted to changing needs and environmental conditions. The smallest scale inventions are four pavilions doubling as emergency shelters (3rd typology) that will be placed throughout the southern half of the National Park, each providing pedagogical opportunities by focusing on a point of change or deterioration caused from the changing climate and providing refuge for expeditioners when the unpredictable weather hits at full force.

The value of predictive bioclimatic design comes from the collective effort of multiple perspectives and disciplines using locally responsive, environmentally conscious and pragmatic solutions to combat the imminent repercussions of climate change while simultaneously benefiting the community socially and economically. The types of strategies developed in the design process will bring socio-cultural shifts into productive conversation with climate change discourse. This knowledge can then further be democratized, supporting Northern communities with similar predicted changes to autonomously develop their built environments in preparation for the inevitable climatic changes while advancing their growth potential and ensuring community traditions and livelihood can be continued.

Figure 2.01
Spring Glaciers moving South down the Labrador Coast.

THE ICY TRUTH 2

In the 21st century, the term climate change is widely known across the globe. Over the last few decades, it has become a topic of interest and grave concern for a variety of research disciplines. Global warming and the climate crisis require our undivided attention as they are some of the most complex and pressing issues facing humanity and our planet today - affecting the environment, the economy, politics, cultural practices and much more. This is due to *The Great Acceleration*, which occurred after the Industrial Revolution and was paired with massive industrialization and urbanization that has resulted in unprecedented and unpredictable change on the entire planet. We as humans currently live in the geological epoch of the Anthropocene, the only time in our planet's history where a single species has impacted the environment enough to constitute a distinct geological change[11]. Anthropogenic carbon dioxide emissions, responsible for current global warming and climate change, linger in the atmosphere for hundreds of years, committing out planet to increased warming and further changes in the foreseeable future[12]. Due to this, we have condemned ourselves to lives of uncertainty. Even if all greenhouse gas emissions were nixed today, the effects of ours and our forefathers' decisions will affect countless generations to come. This chapter delves into the severity of changes facing our planet within the next century depending on the choices society makes in the coming years, and reflects on the impact and responsibilities of the architectural profession within the larger scope of embodied carbon and emissions.

11 John Houghton. Global Warming: The Complete Briefing. Cambridge, England. Cambridge University Press, 2015.

12 NASA. "Climate Change Adaptation and Mitigation." NASA, August 23, 2021. https://climate.nasa.gov/solutions/adaptation-mitigation/.

2.1 | THE NEXT 100

The effects of climate change, global warming, ecological breakdown or whatever name you choose to attach to these changes is a kind of worldwide violence that many do not recognize. It has altered the planet over the past decades as a shadowless presence, an ominous being[13], a slow violence. Without the type of coinciding spectacle that is often attached to the violence of war or natural disaster, the creeping effects of climate change are not given the same attention or urgency that others are[14]. As these impacts become more tangible, more deadly, more frequent, and more 'spectacular', perhaps now is the time that climate change gets the attention and consideration it needs. Now we sit at a crucial junction facing the next 100 years, now is the time when we must wholly address the situation, change course, work to minimize destruction, or face the reality of crossing a no-going-back threshold of irreversible life-threatening damages.

As we stand now, the planet's temperature fluctuates above a 1˚C rise since pre-industrial levels[15]. Various degrees of warming bring about different types and intensities of change. In *The Physical Science Basis* released in 2021, in part of the IPCC's Sixth Assessment Report, there are five future climate scenarios outlined, as illustrated in Figure 2.02[16]. The worst of which is the 'business as usual' scenario, SSP5-8.5, where no policy changes are made and the planet's temperature is allowed to rise more than 5˚C by the end of the century and over 60% of global CO_2 emissions are trapped in the atmosphere. This is incomprehensibly catastrophic, resulting in two or more metres of sea level rise, year round drought in countless regions, increasingly regular centenary storms, increasing food insecurity, displacement, loss of biodiversity or identifiable ecosystems - to name a few. Even the lesser scenario of SSP3-7.0 presents unequivocal changes to our planet with warming up to 4˚C. With sea level rise exceeding one metre, extreme heat days tripling, the poles melting exponentially, and nearly 300 million climate refugees requiring relocation from the displacement of flooding alone[17], this situation should by no means be an achievement to aim for.

More 'favoured' scenarios may include SSP2-4.5, where temperatures rise to around 2.5˚C by the end of the century and where we are able to sink half of carbon emissions. With slow steps towards sustainable policies, emissions have no hope of reaching

13 Rachel Carson. *Silent Spring*. (Massachusetts, USA. Houghton Mifflin Publishing, 1962), 100.

14 Robert Nixon. "Introduction." In *Slow Violence and the Environmentalism of the Poor*. Boston: Harvard University Press, 2011.

15 International Panel on Climate Change. "Global Warming of 1.5˚C". IPCC. 2019. (https://www.ipcc.ch/site/assets/uploads/sites/2/2019/06/SR15_Full_Report_Low_Res.pdf), 31.

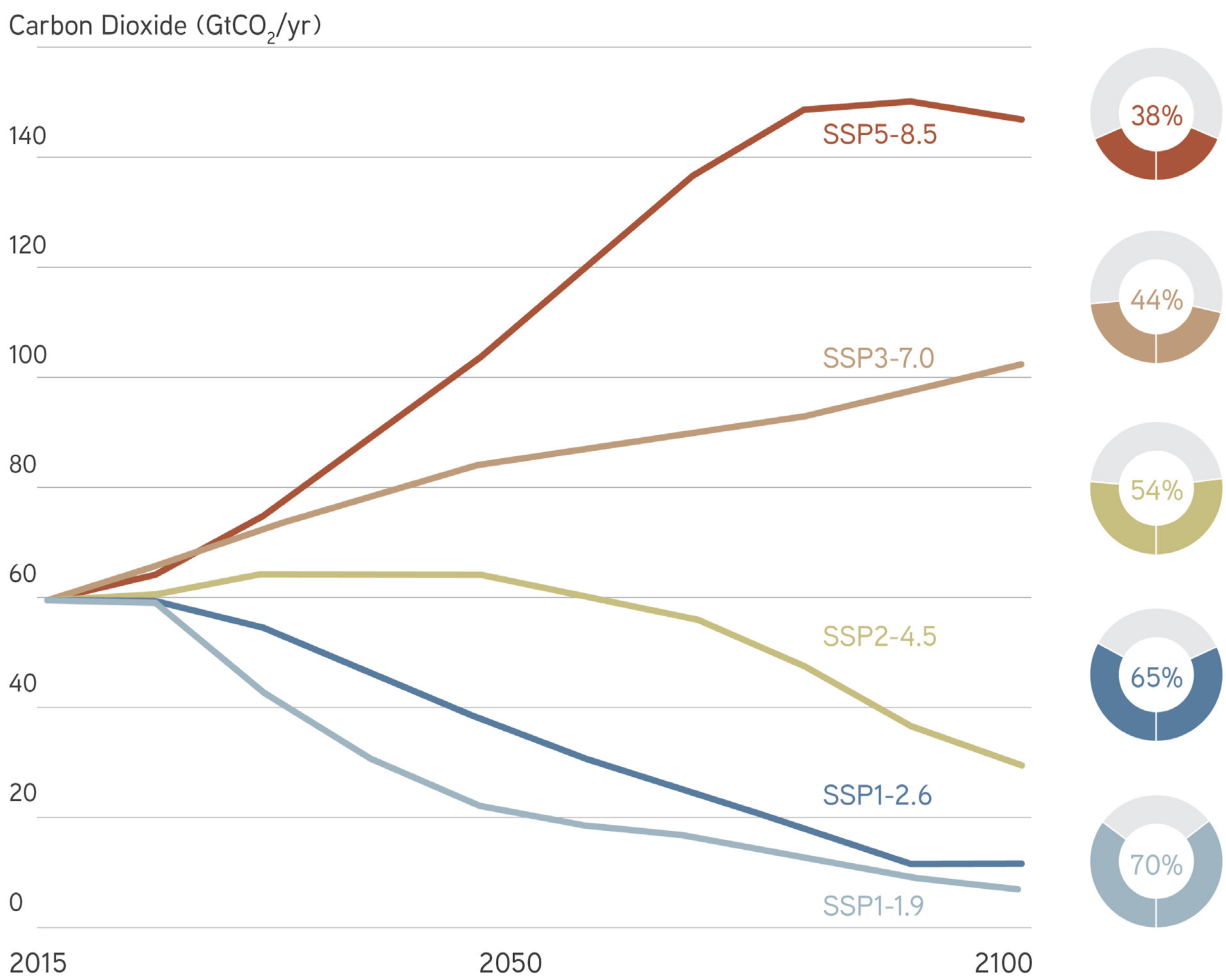
16 International Panel on Climate Change. "Climate Change 2021: The Physical Science Basis". IPCC. 2021. (https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf), 13.

17 Acciona. "What will the world look like 100 years from now? Climate change in the year 2100." Sustainability for all. Accessed November 22, 2021. https://www.activesustainability.com/climate-change/what-world-look-like-100-years-climate-change-year-2100/?_adin=02021864894.

net-zero by the end of the century and future generations are still faced with daunting and unpredictable climate scenarios. With the 2100 goal of stabilized temperatures scraping by below 2˚C, SSP1-2.6 provides the first notion that productive shifts in climate policy require acknowledgment and attention to its related socio-economic challenges[18]. In this scenario, ocean temperature and sea level rise are but a quarter of the worst case scenario. The IPCC's most optimistic scenario tells tales of a world where global CO_2 emissions are cut to net zero by 2050. While extreme weather and pipeline climate change are still in effect, a stabilization in climate by the end of the century allows humans worldwide to adapt and settle in a more consistent climate, but one that has nonetheless changed.

18 Andrea Januta. "Explainer: The U.N. climate report's five futures - decoded". Reuters. August 9, 2021. https://www.reuters.com/business/environment/un-climate-reports-five-futures-decoded-2021-08-09/.

Figure 2.02
Future annual emissions of CO_2 within each of the five IPCC AR6 scenarios, coupled by the percent of emissions that can be contained in land and ocean sinks in each scenario.



The importance of staying below a 1.5˚C rise and executing the IPCC's best-case-scenario are indisputable. Keeping global temperature rise as low as possible through the coming century - and beyond - is critical to the ongoing livelihood of the entire planet. This should be the goal of policy makers worldwide, supported by the IPCC's shortened version of each report specifically written to be more digestible for policy makers as they develop protocol and legislation. The 1997 Kyoto Protocol was a massive climate pledge for its time, responding to already decades of publication on Earth's warming. This protocol was the first edition to the 1992 United Nations Framework Convention on Climate Change (UNFCCC). As part of Kyoto, countries were intended to report back periodically on mitigation measures working to achieve agreed upon individual targets. Under the principle of *"common but differentiated responsibility and respective capabilities"*, Kyoto bound first-world countries to the protocol, acknowledging their contributions to Greenhouse gasses while allowing other nations to develop their economies[19]. Following the first fifteen years after the signing and implementation of these regulations, targets were all but ignored by the majority of countries - a financial crisis, purchasing carbon offsets, and carbon leakage are only some of the scapegoats hiding the just how unsuccessful Kyoto was. Even as many first-class emitters seemed to have 'met' their targets on the surface, major players such as Russia, the United States, Japan and Canada chose not to participate in a second commitment.

The Kyoto Protocol does not stand alone in terms of unmet, over-promised, and surface level government declarations. The fault of Kyoto was initially said to be better tackled by the Paris Agreement as it involved a greater array of countries. Signed in 2015 as the largest climate agreement of its kind, 196 parties came together with the goal to *"keep the rise in mean global temperature to well below 2 ˚C above pre-industrial levels, and preferably limit the increase to 1.5 ˚C, recognizing that this would substantially reduce the effects of climate change."*[20]. While in its essence and presentation the Paris Agreement aims for exactly where we should be, it is little more than a performative political act. With next to no substance to hold countries accountable for their 'nationally determined contributions' to reduction in greenhouse gasses, nations standing on the planetary emitters podium have been able to withdraw or avoid their promises without repercussions. With some of the largest global agreements to combat climate change falling far short, now three decades after initial discussions for Kyoto and well over a half century since scientists voiced significant worrying concerns about our species impacts on the planet, the

19 UNFCCC. "What is the Kyoto Protocol?". United Nations. Accessed December 3, 2021. https://unfccc.int/kyoto_protocol.

20 UNFCCC. "The Paris Agreement". United Nations. Accessed December 3, 2021. https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement.

most optimistic scenario of the IPCC's AR6 seems often like an improbable outcome.

With people worldwide feeling their generational practices and lived experiences changing as drought settles in, forest fires blaze through entire countries, or ice roads never freezing over, visualizations often help to unscramble the scientific jargon and present simply the gravity of the situation. The Köppen climate system uses temperature and precipitation data to categorize the planet into thirty zones. When comparing the worldwide map of today's climate zones to that of 2100, huge movement is evident without even taking into account the placement of these zones in a pre-industrial setting[21]. What is excessively notable is that Northern regions are experiencing a greater shift, with moderate temperatures creeping their way into frozen regions and is paralleled with the information that nearly every IPCC impact to human and ecological ecosystems is remarked as very high in these regions, shown in Figure 2.03[22]. In fact, the North is warming at three times the global average[23]. This accelerated warming creates another stark reality as to today's situation, and questions what action should be taken next.

To sidestep their own responsibilities, governments love to double down on blaming individual actions to avoid the hard work of modifying laws and creating binding policies. While individual action and making personal choices towards a greener planet are important in their own right, it is a fact that large scale changes stem from the choices and policies of government and industry. Relying on the people who reap the reward of toxifying the planet is a risky path to take. Looking at the recent COP-26, the level of accepted failure is evident from governments, as the agreements reached there are still more than likely to see the world at well above 2˚C increase by the end of the century[24].

In the state that we are in, there are two main strategies to consider as we address the future - mitigation, and adaptation. NASA says it well stating that

> *“Because we are already committed to some level of climate change, responding to it involves a two-pronged approach:*
> *Reducing emissions of and stabilizing the levels of heat-trapping greenhouse gases in the atmosphere (“mitigation”);*
> *Adapting to the climate change already in the pipeline (“adaptation”)[25]”*

21 Beck, “Present and future Köppen-Geiger climate classification maps at 1-km resolution.” DOI: 10.1038/sdata.2018.214.

22 International Panel on Climate Change. “Climate Change 2022: Impacts, Adaptation, Vulnerability”. IPCC. 2022. (https://report.ipcc.ch/ar6wg2/pdf/IPCC_AR6_WGII_SummaryForPolicymakers.pdf), 11.

23 Kuittinen. “Zero Arctic: Concepts for Carbon Neutral Arctic Architecture based on Tradition.”, 7.

24 UNEP. “COP26 ends with agreement but falls short on climate action”. United Nations. November 15, 2021. https://www.unep.org/news-and-stories/story/cop26-ends-agreement-falls-short-climate-action.

25 NASA. “Climate Change Adaptation and Mitigation.” https://climate.nasa.gov/solutions/adaptation-mitigation/.

Mitigation is reducing our future impact, and adaptation is changing the way we live in reaction to the changes that we are committed to already. Additionally, in acknowledging that big enough changes are not being made at the top, we also plan to adapt to a worsening condition within the next century and beyond. While mitigation holds the majority of attention in terms of 'dealing with climate change', there is less understanding of or action towards the ways in which we will need to reinvent the very ways which humans live and build. Being one of the largest industries contributing to emissions, construction and architecture can mitigate its impact through renewable energy and materials, passive design and long-lasting infrastructure, but it must also adapt to be prepared for a different future, and to increase its resilience in the face of uncertainty.

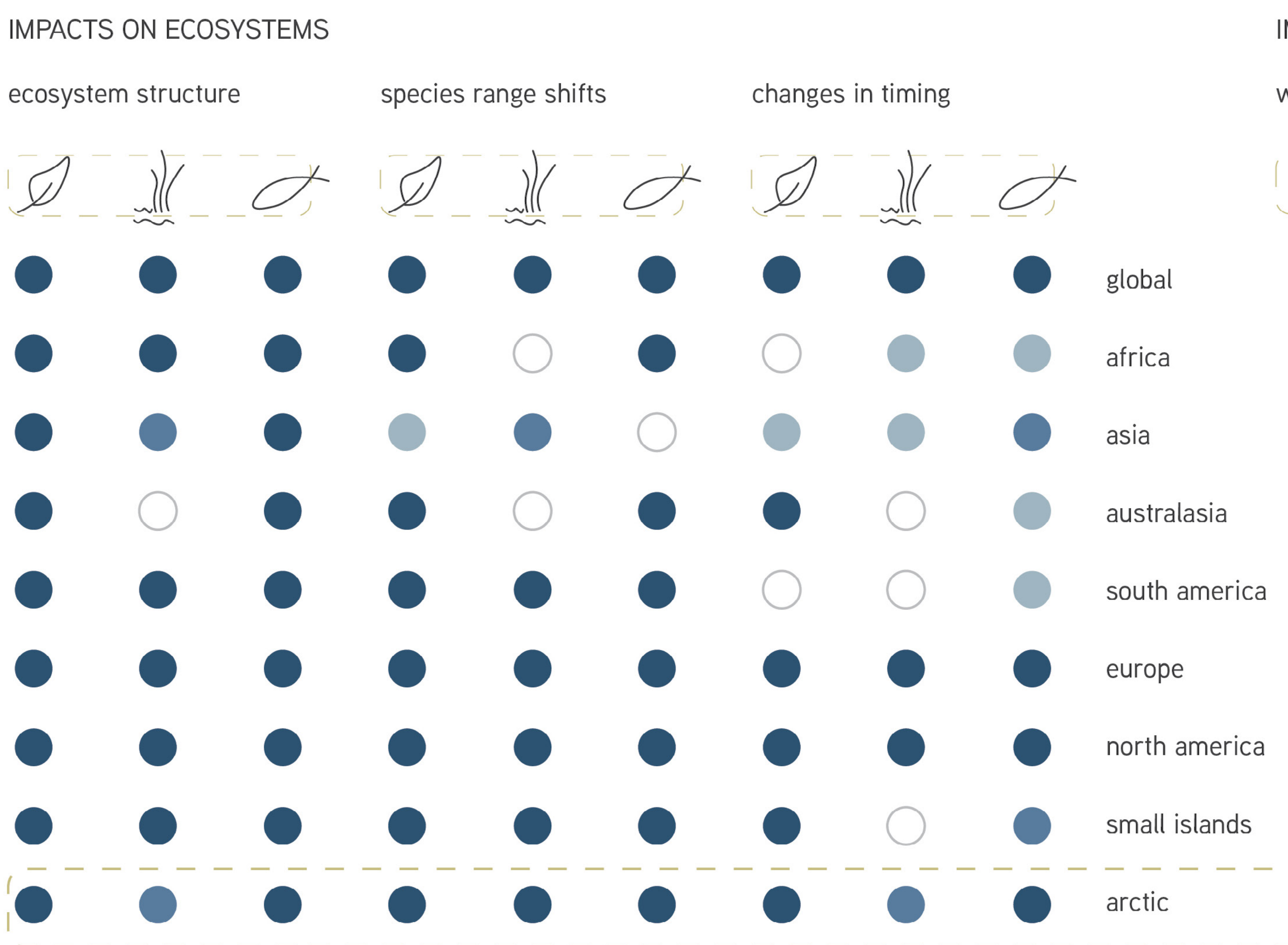


Figure 2.03
From the 2022 IPCC Impacts, Adaptation and Vulnerability report, various impacts of climate change observed in a variety of human and ecosystems globally.

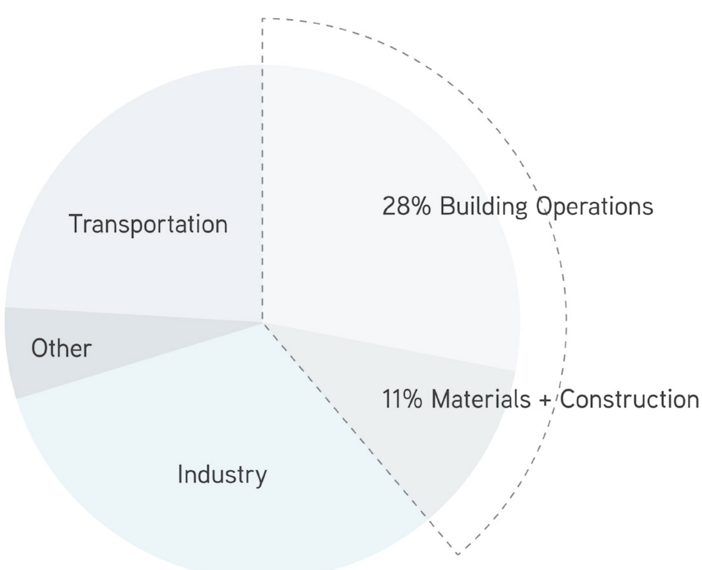
2.2 | THE ROLE OF ARCHITECTURE

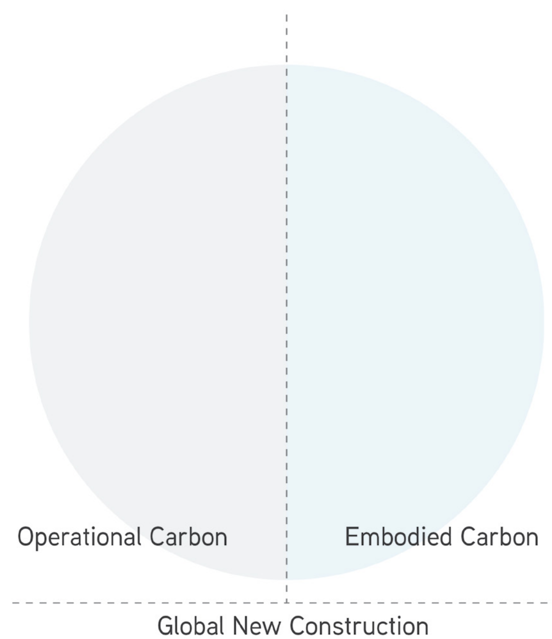
Architecture and the built environment are huge players in worldwide emissions. The World Green Building Council states that nearly 40% of global CO_2 emissions stem from buildings and the construction industry[26], of which 28% stem from building operations (carbon emitted to operate, maintain and manage buildings), and 11% come from building materials and construction (embodied carbon)[27]. Figure 2.04 provides additional information on the other sectors responsible for global emissions. Both building operations and embodied carbon can be tackled through mitigation principles. It is not only crucial that buildings use less energy and emit less carbon through their operations but that we similarly pay extra attention in the design and construction phase in order for the materials used to have low embodied carbon. Material selection has multiple facets in what compounds into a low carbon selection. A notable one to be considered is the entire building life cycle. Durable materials are consideration one, but additionally the notion of structural materials versus service life in increasing the lifespan of all aspects of the project is vital.

A well-built building lasts on average 120 years; however, many modern, low-quality and non-flexible constructions can have life spans one-third of that, and even less when buildings are

26 Global Alliance for Buildings and Construction. "2018 Global Status Report". United Nations. 2018. (https://www.worldgbc.org/sites/default/files/2018%20GlobalABC%20Global%20Status%20Report.pdf), 11.

27 Ibid, 11.





created without site specificity or in harsh climates. When thinking of 'strong' materials, concrete and steel are front of mind. However, these generally have a service life of 50 years or less and concrete is nearly impossible[28]. The lifespan of these buildings is often further shortened if they are not adapted to the climate of tomorrow and the increase in potentially dangerous extreme weather events. Therefore, strong materials do not necessarily increase a building's lifespan, while a 'less strong' material such as wood, can. Perhaps instead of assuming an infinite future of a project that would only be possible with perfectly consistent conditions, we instead select adaptable materials with low embodied carbon. Here, the focus shifts from surface level durability of materials, to flexible and resilient solutions in the face of a changing climate and an uncertain future. Resilience is where a new definition for longevity begins to take shape, being able to recover from storms or harsh conditions, adapt to situations not present at the time of construction, and operate without constant outside inference. The aforementioned accelerated Northern warming sets the stage for this project to react to predictive climate studies and test potential strategies for adaptation.

Furthermore, as shown in Figure 2.05, at the time of new construction, embodied and operational carbons are equal contributors. Embodied carbon can be tackled through material choices, local labour, and additionally carbon offsets through a sequestration - an additional unique potential for wood. Operational

28 Jennifer O'Connor, . "Survey on actual service lives for North American buildings". Woodframe Housing Durability and Disaster Issues conference. Las Vegas. (2004) https://cwc.ca/wp-content/uploads/2013/12/DurabilityService_Life_E.pdf.

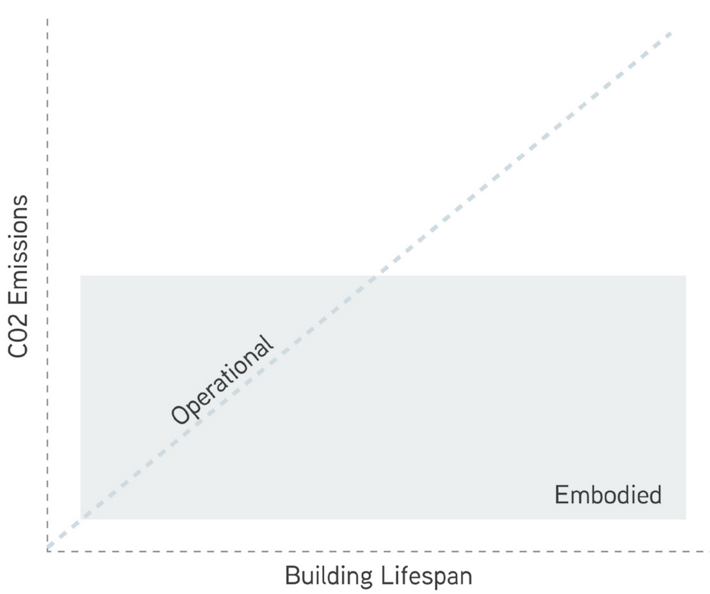


Fig 2.04 (Left)
Global sectors of carbon emissions, indicating the building and construction industry as a high contributor.

Fig 2.05 (Middle)
Carbon emissions at time of new construction, showing equal contributions from both embodied and operation carbon at this time.

Fig 2.06 (Right)
Carbon emissions over building lifespan, indicating how embodied carbon remains static, but operational carbon rises steadily.

carbon needs to be tackled from the get-go as well, as it has further contributions over the building's life, as noted in Figure 2.06. Consequently, an off-grid and self-sufficient building will be required to reach zero operational carbon which is only possible through on-site renewable energy. Solar, wind, geothermal, hydro, and biomass are all options available globally, however the specific amenities that the site has to offer need to be taken into consideration for efficient systems selections.

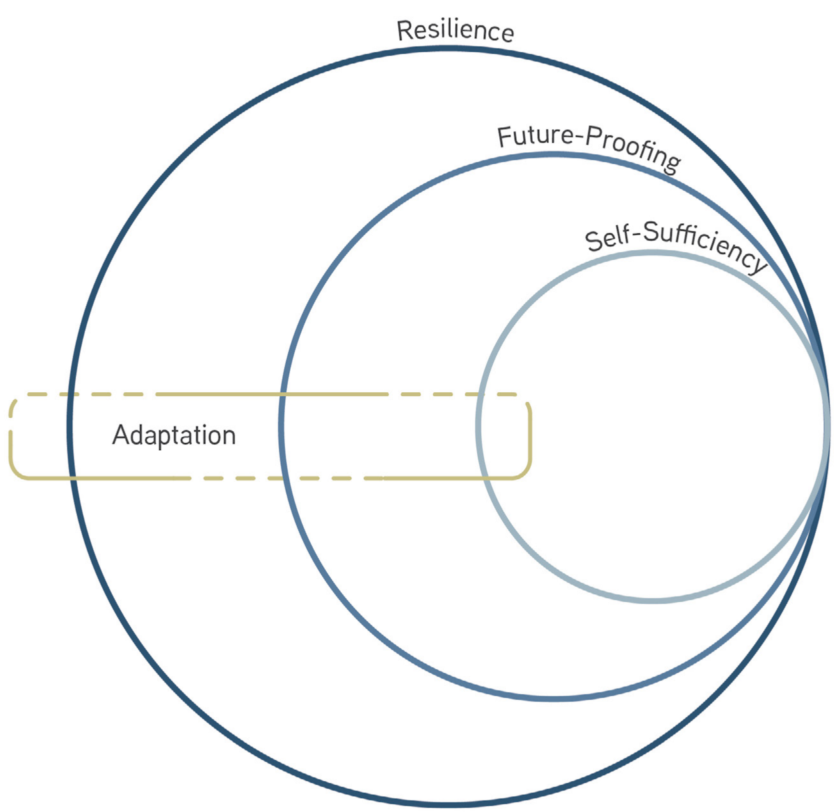
While a combination of Passivhaus, LEED, and Living Buildings provides a basis for embodied and operational carbon reduction, they primarily tackle mitigation, whereby adaptation is left out of the equation. An issue for new sustainable construction in a changing North is that standards in the building industry are not based on very cold climates, but also do not take into account changing climates or the complexities of remote locations. Simply ramping up the insulation thickness to meet Passivhaus standards in an 8000 Heating Degree Day climate when it has been designed for half of that is not likely the most rational nor sustainable solution to the context. In development of this project, these limitations need to be realized and their solutions work in conjunction with adaptation principles as well.

The adjacent Figure (2.07) is a representation of many of the conditions which are key to this thesis and the project's design goals. Resilience is the overarching achievement that the building is aiming for. The resilient design institute highlights this as being intentional design which responds to the vulnerability of a place - be that from disaster or other forms of disruption[29]. This is a building that is able to withstand the changes that are coming. To achieve this, the project uses future-proofing strategies. Being future-proofed is altering the ways we live and build in order to prepare for the predicted situation of the next century. Within this, the project is additionally required to be self-sufficient. Not having to rely on the energy grid or a more fragile global system of goods is essential. This is inclusive of water, energy, labour and repairs, food and more. Due to increasingly erratic weather conditions, the risk of remote and Northern regions being cut off makes this increasingly vital. Self-sufficiency is the first step to the overall future-proofed and furthermore resilient project. Intertwined within each of these is adaptability. Not only is this an architecture that is adapted towards future conditions, which can often be static, it is an architecture which is constantly adapting itself to short or long-term conditions of the site. A true living building is able to efficiently operate throughout these changing conditions. The conditions that

29 Resilient Design Institute. "What is Resilience?" Resilient Design Institute. Accessed November 22, 2022. https://www.resilientdesign.org/defining-resilient-design/.

allow the project to run self-sufficiently today will change in the coming decades, and through strategies which are prepared for future-proofing, the building is able to adapt in order to continue its self-sufficient operation. Adaptability allows for adjustments and alterations that ensure resilience is maintained. In learning from the sustainability standards mentioned above, it is understood that good passive design focused around energy efficiency and robust systems is the foundation. However, because the climate is changing, the efficiency of that passive design will change unless the building has the capacity to adapt itself to new conditions.

Fig 2.07
The incremental design goals of a project which is prepared for the unprecedented changes of tomorrow.



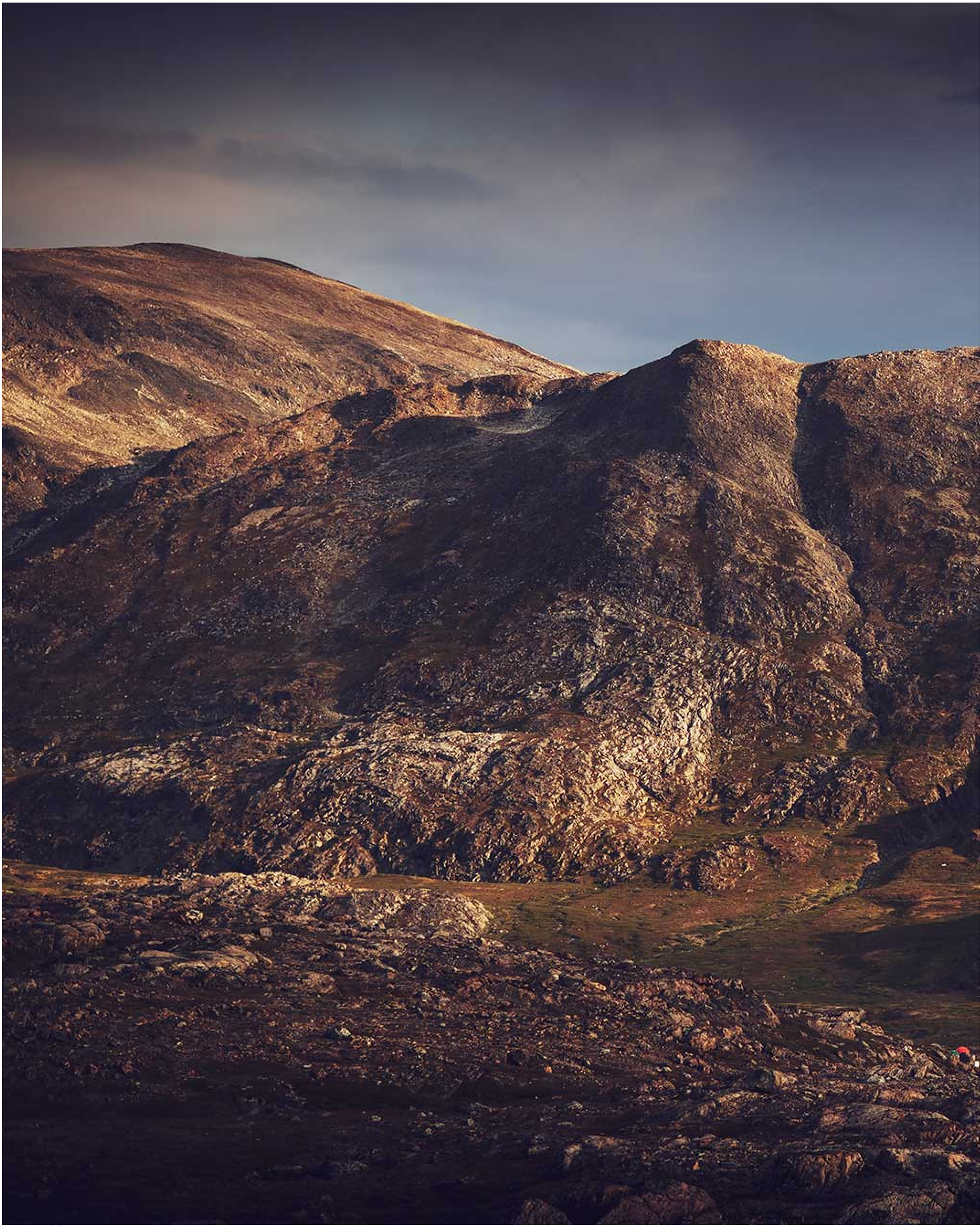
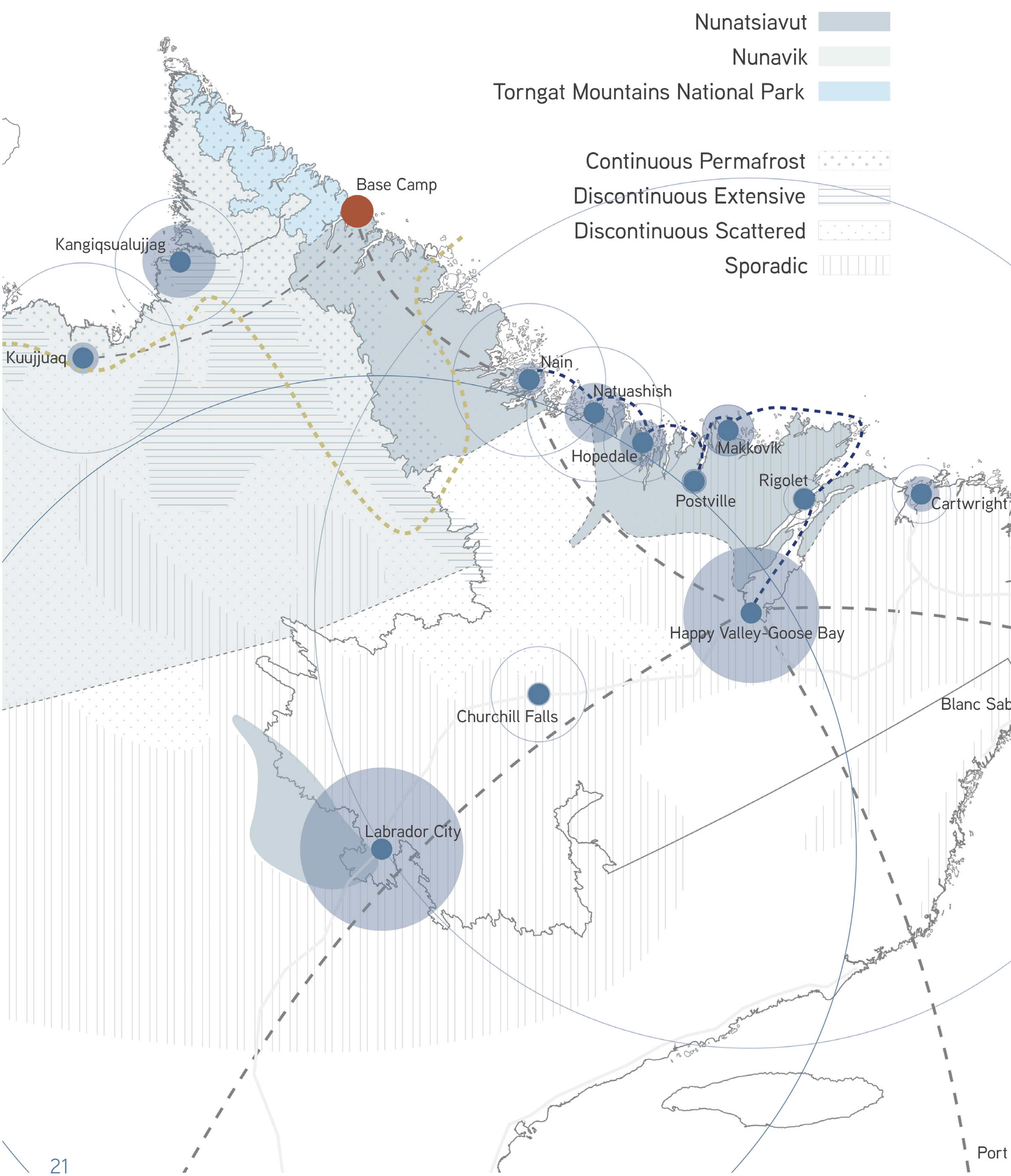


Figure 3.01
Gentle Elevations within the Torngat Mountains National Park.

SUBARCTIC: LABRADOR 3

As this thesis focuses on the rapidly changing climates of northern regions, as well as the resulting impacts on the livelihood of the people occupying these locations, one specific region quickly emerged as a relevant case study: Labrador. Indeed, this region is experiencing important climate change right now, which has been measured by scientists[30], but these changes have also been reported by the stewards of the land, the Inuit people that have lived there for hundreds of years. Unfortunately, these are seeing climate change negatively impact their traditional way of life. Moreover, there exists a National Park that is co-managed by the Inuit in this region, the Torngat Mountains National Park, which is located at the northern edge of the autonomous Inuit region of Nunatsiavut, which houses a Base Camp and research station for the Inuit community, tourists and international researchers. This Base Camp is in dire need of repair and it is slated for expansion in order to meet a growing demand from the community and the tourism industry. This is the perfect place to explore how to design future-proof architecture that can adapt and inform about both climate and socio-cultural changes in arctic regions, acting in stewardship of both land and livelihood. This section will thus firstly present in detail the self-governed region of Nunatsiavut, through an historical, environmental and cultural perspective. It will then focus on the Torngat Mountains National Park and its existing Base Camp in an attempt to better understand the various user groups and their specific needs, which should inform the project's program. Finally, it will end with a current and future site analysis in an attempt to better understand the site and generate design principles for a building that is well adapted to the site of today and tomorrow.

30 Beck, "Present and future Köppen-Geiger climate classification maps at 1-km resolution." (DOI: 10.1038/sdata.2018.214), 2.


Nunatsiavut
Nunavik
Torngat Mountains National Park
Continuous Permafrost
Discontinuous Extensive
Discontinuous Scattered
Sporadic
Base Camp
Kangiqsualujjag
Kuujjuaq
Nain
Natuashish
Hopedale
Makkovik
Postville
Rigolet
Cartwright
Happy Valley-Goose Bay
Churchill Falls
Labrador City
Blanc Sab
Port

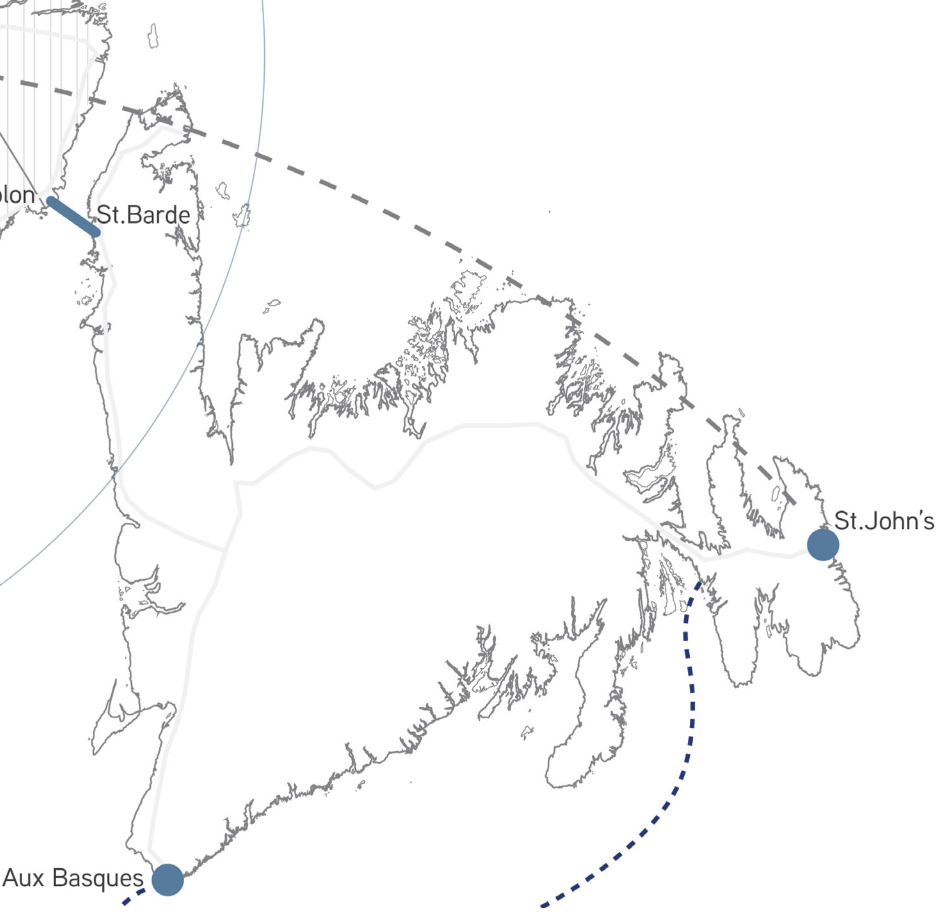
3.1 | NUNATSIAVUT

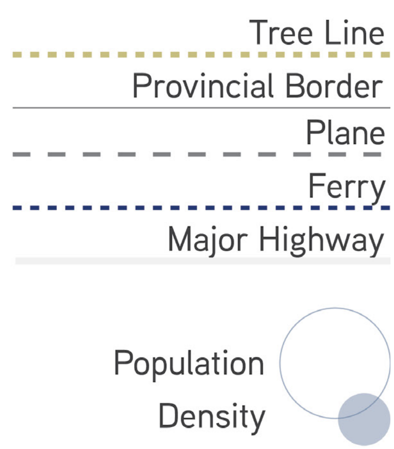
Labrador is home to a complex dynamic of geographic, economic, and socio-cultural situations. It similarly hosts Inuit Nunangat's smallest settlement region[31] - Nunatsiavut, a self-governed Inuit territory, covering much of the Northern shoreline of Labrador. In Inuktitut, Nunatsiavut means 'Our Beautiful Land". Within Nunatsiavut Territory there are five communities, Nain being the largest, northernmost, and administrative capital[32]. Each of these communities sit off of automobile arteries, Happy-Valley Goose-Bay being the 'end of the road'. The northernmost tip of Labrador and Nunatsiavut is the site of the Torngat Mountains National Park, with its Base Camp being located on the park's southern edge, just outside its border (see Figure 3.02). This location serves as the starting point into the park for visitors, as well as a research station. It is located two-hundred kilometres from the northernmost permanently inhabited community in the province and is only accessible by plane or boat. It is not itself a permanently occupied community. The uniqueness and remoteness of Nunatsiavut, the Torngat Mountains National Park and its Base Camp will be further explored and presented in this section.

31 Inuit Nunangat is the term for the Inuit homeland within Canada. It consists of four settlement regions - Inuvialuit, Nunavut, Nunavik, and Nunatsiavut.

32 France Rivet. "Nunatsiavut" The Canadian Encyclopedia. Accessed September 17, 2021. https://www.thecanadianencyclopedia.ca/en/article/nunatsiavut.

Figure 3.02
Newfoundland and Labrador map depicting various political, social, transportation, and geological factors.



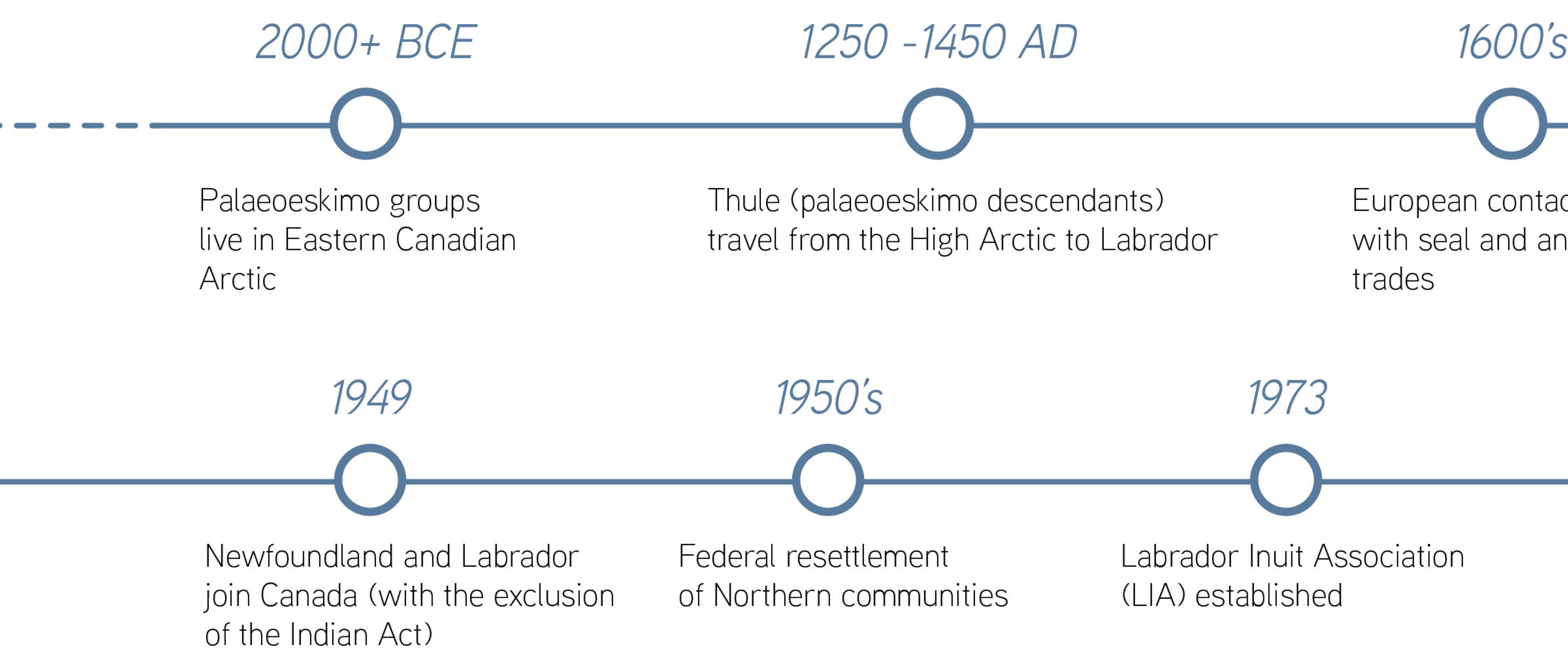


3.1.1 | Historical Perspective

In order to better understand the cultural and geo-political nature of the place and its people, this subsection will present an historical overview and timeline of the Indigenous peoples that inhabited the region, their relationship with European settlers, and key moments in their territories' history (Figure 3.03).

Paleoeskimo were the first peoples in Canada's Arctic. Around 1000 years ago during a warmer period in history, the descendants of these groups made their way to Labrador and are historically referred to as the Thule[33]. Living in small settlements at the Northern edges of Labrador, they slowly moved south over the coming centuries. As they are known by the mid 1500's, Inuit groups had made their way to the Nain-Hopedale region. By the end of the 1600's, European contact occurred through primarily sealskin and oil trades for various items of European manufacturing. In the mid 1750's the Inuit population along the coast was around 1500. It is at that time Moravian missionaries arrived and became the

33 M.A.P Renouf. "Palaeoeskimo in Newfoundland and Labrador" The Rooms. Accessed October 3, 2021. https://www.therooms.ca/palaeoeskimo-in-newfoundland-labrador.



first Non-Indigenous peoples to settle north of the Hamilton Inlet in present day Nain[34]. Their presence became less isolated when Newfoundland cod-fishermen began flocking the Northern Labrador coast in the mid 1800's. It is estimated that in the late 19th century, over 1000 boats made their way around the coast within a three month season[35].

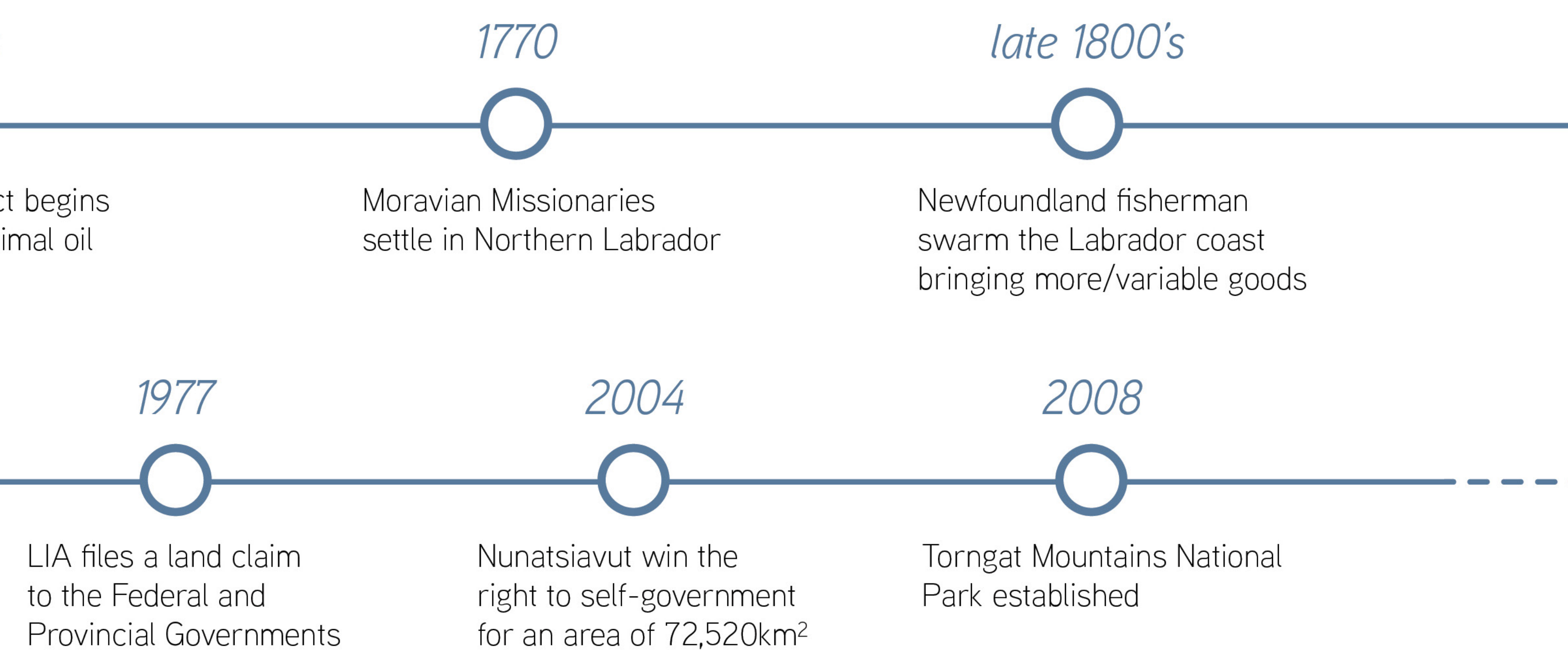
In 1949, Newfoundland joined the Canadian Confederation and became the tenth and final province. One Newfoundland condition to join Canada was that Labrador, which was then part of the province of Quebec, be ceded to them based on a 1927 British decision about the border dispute. The province thus became known as Newfoundland and Labrador. The Indian Act was also not applied to the new province at that time, which meant that "the province's Innu and Mi'kmaq were ineligible for the range of programs and services enjoyed by their counterparts in continental Canada. In fact, they did not exist in law and thus lacked the recognition as previously sovereign nations that their counterparts enjoyed elsewhere in Canada."[36] Consequently, recognition for Innu, Mi'kmaq and Inuit peoples in the province has come very slowly and their situation is relatively unique in the country.

34 France Rivet. "Moravian Missions in Labrador." The Canadian Encyclopedia. Accessed September 17, 2021.https://www.thecanadianencyclopedia.ca/en/article/moravian-missions-in-labrador-emc.

35 Lev Bratishenko and Mirko Zardini. *It's All Happening So Fast: A Counter-History of the Modern Canadian Environment*. Montreal, Canada. Canadian Centre for Architecture, 2016.

36 Maura Hanrahan. "The Lasting Breach: The Omission of Aboriginal People From the Terms of Union Between Newfoundland and Canada and its Ongoing Impacts". *Royal Commission on Renewing and Strengthening Our Place in Canada.* March 2003. (https://www.gov.nl.ca/publicat/royalcomm/research/Hanrahan.pdf), 3.

Figure 3.03
Brief Timeline of Inuit, Labrador, and Nunatsiavut history in the Province.



In 1973, the Labrador Inuit Association (LIA) was established with the goal to promote Inuit health and communities, as well as support land claim efforts[37]. Within two decades, this group expanded to include economic development, language, and cultural sectors. Four years after its establishment, a land claim was filed to the federal and provincial governments. Over two decades after its submission, in 2004, the Inuit people of Labrador finalized their land claim agreement and won the right to self-governance. This resulting area was from that time regarded as the independent Nunatsiavut territory. The land claim area consists of 72,520 kilometres of land and nearly 50,000 kilometres of sea[38]. The settlement agreement also consented to the establishment of the Torngat Mountains National Park Reserve which was formally made a National Park in 2008.

The Torngat Mountains National Park (see Figure 3.04) was named in reference to the Inuktitut word 'Torngait', meaning 'The Place of Spirits'. At this time, it became Canada's 42nd National Park, the first in the Northern Labrador Mountains Terrestrial zone, checking another zone of the list in Parks Canada's goal to protect an area in each zone[39].

This National Park is unique in the sense that it is operated and managed by both the federal government and the Indigenous stewards of the land, the Inuit people. Indeed, a cooperative management agreement was formed between the Nunatsiavut Government and the Government of Canada. Consequently, the people living on the land, that better know the land, will ensure it is protected for future generations[40]. To ensure that the Torngat Park, as should be the case which each National Park, understands and protects the land from the point of view of its Indigenous stewards, cooperative management is essential[41,42]. The cooperative management agreement formed between the Nunatsiavut Government and the Government of Canada is essential to this park's formation and connection to its adjacent Indigenous territory. The Park's Impact and Benefits Agreement lays out that from establishment to operation and management, the Inuit are recognized as equal partners. The Torngat Mountains National Park, as well as its Base Camp, will be presented in further detail in the next subsection.

37 Nunatsiavut Government. "The Path to Self-Government". Nunatsiavut Government. Accessed September 22, 2021. https://www.nunatsiavut.com/government/the-path-to-self-government/.

38 Her Majesty The Queen in Right of Canada. "Land Claims Agreement" Nunatsiavut Government. 2004. (https://www.nunatsiavut.com/wp-content/uploads/2014/07/Labrador-Inuit-Land-Claims-Agreement.pdf), 45.

39 As of 2021, 31 of Canada's 39 terrestrial zones have a represented National Park - there exist a total of 47 National Parks within the country.

40 Parks Canada History eLibrary, "The National Parks Act. Statutes of Canada, 20-21 George V, Chap. 33. Assented to 30 May 1930," http://parkscanadahistory.com/publications/national-parks-act-1930.htm.

41 Harvey Lemelin et al. "Two Parks, One Vision - Collaborative Management Approaches to Transboundary Protected Areas in *Northern Canada: Torngait KakKasuangita SilakKijapvinga/Torngat Mountains National Park, Nunatsiavut and le Parc national Kuururjuaq Nunavik" in Indigenous Peoples' Governance of Land and Protected Territories in the Arctic.* (2015)

42 John Stix. "National Parks and Inuit Rights in Northern Labrador" *The Canadian Geographer.* Vol 26. No. 4. (1982) doi.org/10.1111/j.1541-0064.1982.tb01460.x.

3.1.2 | Ecological Perspective

Labrador, Nunatsiavut, and the Torngat Mountains National Park all have an abundant array of geographical and ecological characteristics that make this region unique. In understanding the ecological workings of various regions, they are categorized based on their shared characteristics within a variety of scales. The largest are ecozones, an area of the earth's surface that shares characteristic geology and climate, expressed as a distinctive mosaic of landforms, vegetation, plants, wildlife and human activities[43]. At a smaller scale are ecoregions, a portion of an ecozone characterized by distinctive regional ecological characteristics of climate, physiography, vegetation, soils, water and fauna[44]. The smallest regions are ecodistricts, a portion of an ecoregion denoted by distinctive local patterns of relief, landforms, soils, vegetation, water bodies and fauna[45].

Consisting of three ecozones; Arctic Cordillera, Taiga Shield, and Boreal Shield, the area of Labrador covers nearly 300,000 square kilometers. Within these fall a multitude of glaciers and some of the tallest mountains in Canada, east of the Rockies, along with rugged shorelines and thick forests to the south.

The ecozone of Northern Labrador, the Arctic Cordillera, consists of only the Torngat Mountains ecoregion, and of course encompasses the Torngat Mountains National Park. It is commonly known as the place *"where rocks revel in their own freedom"*[46] as over two dozen geological formations are present in contrasting landscapes between the George Plateau and the Torngat Mountains. Within this ecozone fall five ecodistricts, illustrated in Figure 3.04, each with their own climate nuances and characteristics[47]: These are, from North to South: Cape Chidley, Seven Islands, Torngat Mountains, The Domes, and Saglek. Additionally, there are four ecosystems in this region : tundra, alpine, coastal and freshwater[48]. Ecosystems are the most intimate workings of specific organisms in an area.

Consequently, unique flora and fauna scatter the area, where visitors can see rare tundra plant species or rare animals like the polar bear[49]. Sitting above the treeline (noted previously on Figure 3.02), the Torngat Mountains National Park is home to shrubs, lichen, moss, and vascular plants sitting above a tundra expanse underlain with various portions of permafrost[50]. The tall rocky

43 John Riley, Notzl, L., and Greene, R. "Labrador Nature Atlas. Ecozones, Ecoregions, and Ecodistricts." *Nature Conservancy Canada*. Volume 2. 2013. (http://support.natureconservancy.ca/pdf/blueprints/Labrador-Nature-Atlas-Vol2.pdf), 7.

44 Ibid, 7.

45 Ibid, 7.

46 Oscar M. Lieber, 1860.

47 Riley. "Labrador Nature Atlas. Ecozones, Ecoregions, and Ecodistricts." (http://support.natureconservancy.ca/pdf/blueprints/Labrador-Nature-Atlas-Vol2.pdf), 8.

48 Adam Fischer, Christopher Duschenes, Markovich, J., Sheldon, R. "Improving public-private collaboration to sustain a remote Indigenous tourism venture: The case of Torngat Mountains Base Camp and Research Station in Nunatsiavut." *The AAEDIRP.* (2017). Accessed September 24, 2021. (https://www.apcfnc.ca/wp-content/uploads/2020/06/CBOC_Final_Revised_TMBCRS_2017.pdf), 15.

49 Unger. "The Truth About Polar Bears". https://www.canadiangeographic.ca/article/truth-about-polar-bears.

50 Emma Davis et al. "Rapid Ecosystem Changes at the Southern Limit of the Canadian Arctic, Torngat Mountains National Park." *Remote Sensors,* Vol 13(11), No. 2085. (2021) https://doi.org/10.3390/rs13112085.

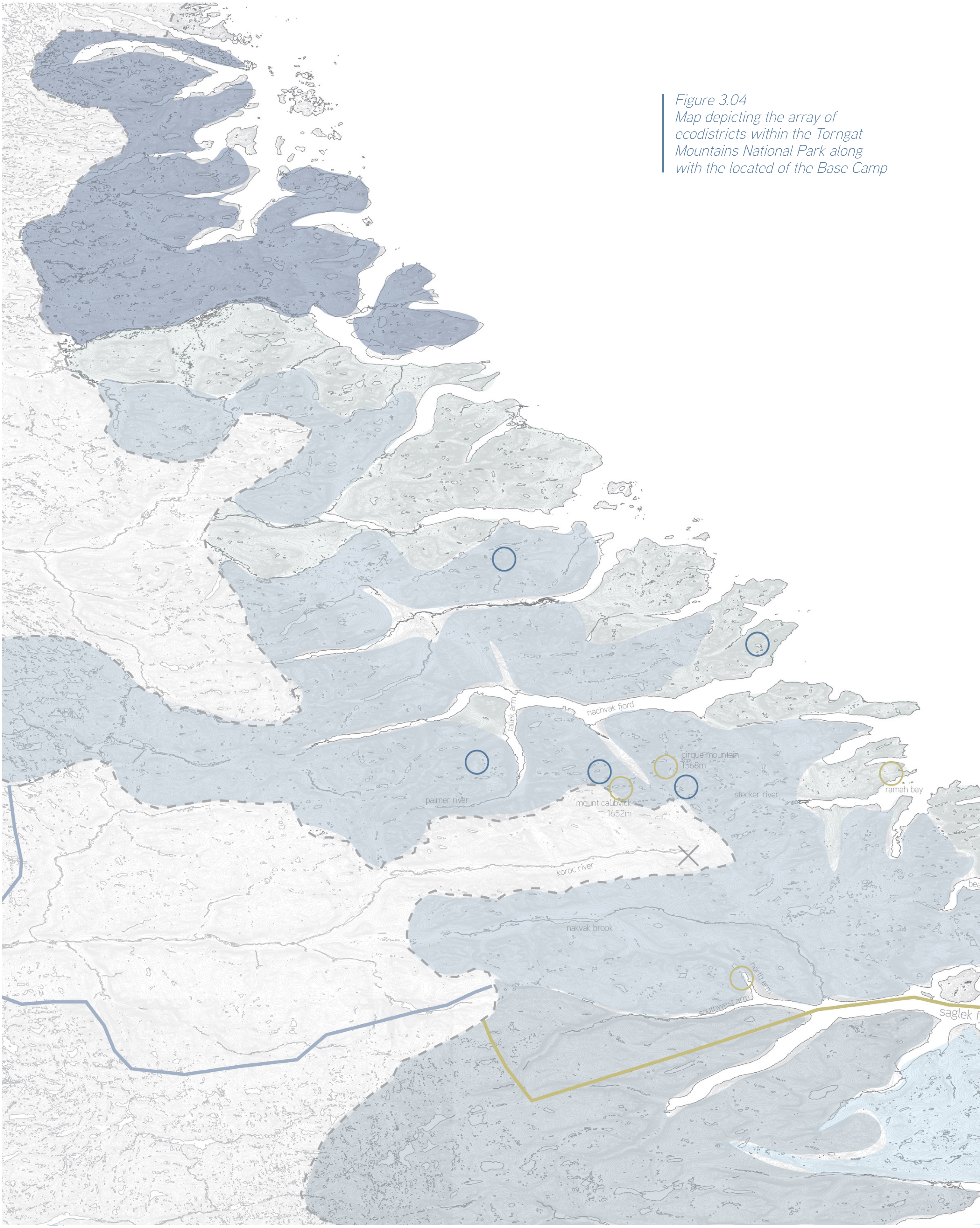


Figure 3.04
Map depicting the array of ecodistricts within the Torngat Mountains National Park along with the located of the Base Camp

mountains also make for a very unique landscape that attracts more and more visitors to Labrador, who wish to see with their own eyes one of the most beautifully striking places in the country (see Figure 3.05). The Honourable Stéphane Dion described this very well at the signing of the Parks Establishment Agreement:

> *"This place of rugged beauty, sweeping wild coastlines and jagged peaks rising sharply from frigid seas. Encompassing mystic fjords, gentle river valleys, precipitous river falls and icebergs. With Southwest Arm, Saglek Fjord polar bears roaming the coast and caribou ranging through the homeland of the Inuit, just as it has been for thousands of years. Hundreds of archaeological sites stand witness to that extraordinary heritage. It is no wonder that the Inuit call Labrador, 'Nunatsiavut - Our Beautiful Land.'*[51] *"*

Figure 3.05 (Following Page) Trekking through valleys within the Torngat Mountains National Park, a glimpse at the striking landscapes that draw visitors in.

51 Parks Canada. "Welcome to the Torngat Mountains National Park of Canada". Government of Canada. Accessed September 20, 2021. (https://www.pc.gc.ca/en/pn-np/nl/torngats/visit/~/media/x91E5B647AB84DCABE04263BFFDACD03.ashx), 9.

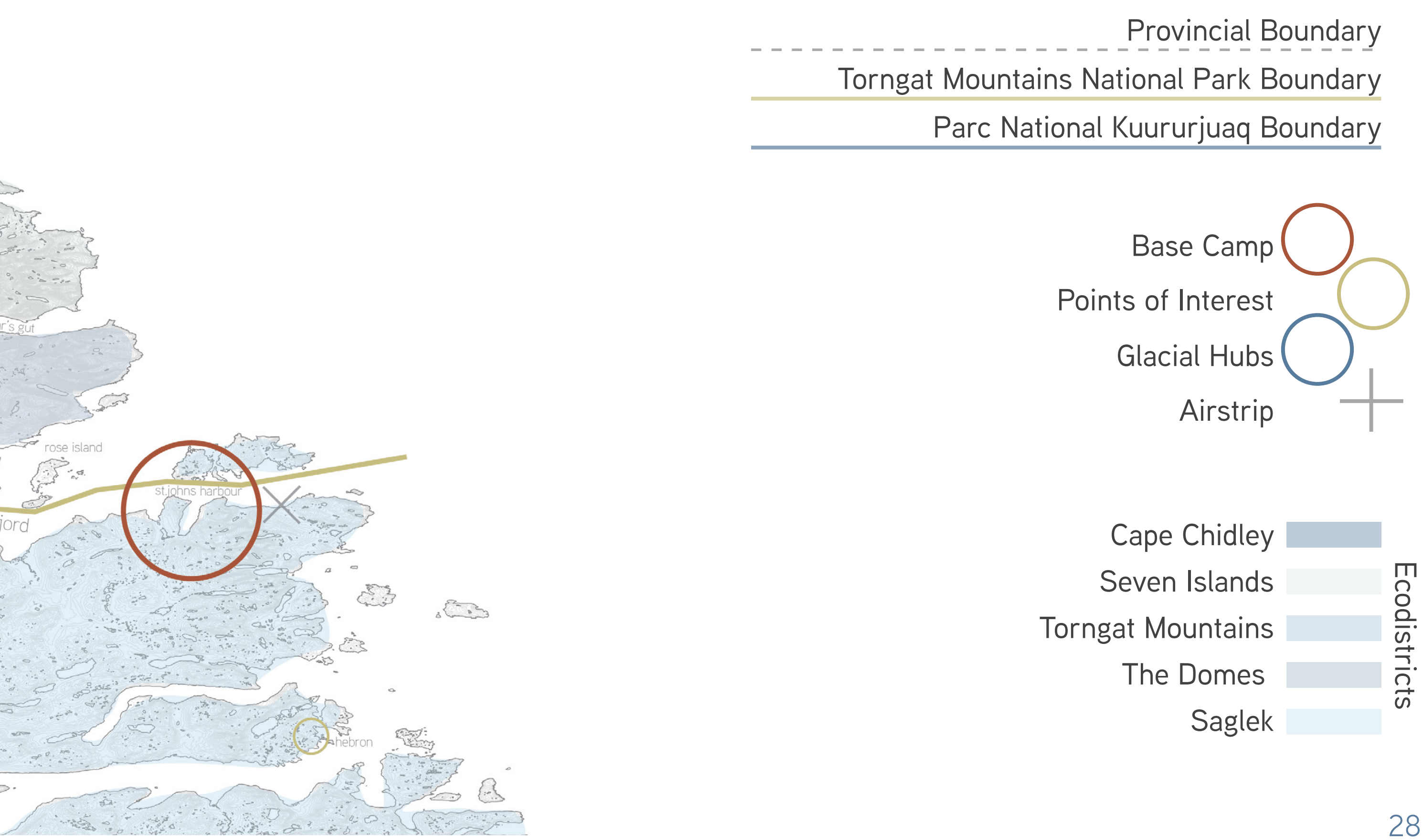


Figure 3.06
Inuit Elder carving stone within Nunatsiavut.

Figure 3.07
Community Event for Inuit and Visitors at the Base Camp.

Figure 3.08
Inuit Elder with an Inukshuk in the Torngat Mountains National Park.

3.1.3 | Cultural Perspective

While much of the history of the province's development was covered in subsection 3.1.1, it is important to realign the place with the people who live there. The Labrador Inuit have been living in the region since time immemorial through subsistence practices of fishing, hunting and harvesting their country food, made possible by a knowledge of the land and its patterns. While Nunatsiavut is home to only 3000 residents, the land has an extremely high percentage of Inuit as southern-based communities established for resource extraction did not develop here the way they did in other Inuit Nunangat regions. As with many Indigenous communities who are in the process of reclaiming aspects of their culture which have been pushed down through Western influence, Nunatsiavut has recently integrated a cultural centre in Nain working to preserve the culture, language, and history.

Nunatsiavut President Johannes Lampe remarked that

> "*By understanding where we came from and how we have survived as a people, Labrador Inuit and indeed the rest of the world will have a better appreciation of who we are as individuals and as a culture continuing to evolve in a modern society.*[52]"

The Base Camp can thus play a crucial role, by supporting land-based pedagogical and experiential opportunities for younger generations, in order to preserve traditional ways of life. Through the interdisciplinary approach to spaces and programming, the varied users can also develop an understanding of how a culture is evolving as well as the continued importance of stewardship.

52 Rivet. "Nunatsiavut". https://www.thecanadianencyclopedia.ca/en/article/nunatsiavut.

3.2 | TORNGAT MOUNTAINS NATIONAL PARK + BASE CAMP

The Torngat Mountains National Park is an outdoor enthusiast's playground with countless challenging long-distance treks, climbing, kayaking and fishing, as well as skiing and snowboarding on the western border through access from Nunavik. The National Park is a Parks Canada operation, and while entry only requires a permit and registration, the vast majority of visitors need to additionally coordinate with the Nunatsiavut Group of Companies (NGC) in order to arrange transportation, a guide, as well as the potential accommodation - through the Base Camp (Figure 3.10). Not only do visitors take an interest in the natural spectacle of the Park, but scientists and researchers visit this essentially untouched sub-arctic tundra to study its geological formations, unique flora and fauna, and changing climatic conditions. Each of these users need the Base Camp as an access point as stays are at minimum a few days in the area, but often up to weeks at a time. Currently the Base Camp is staffed by Parks Canada as well as employees through the NGC from Southern Nunatsiavut communities. Additional Inuit community members, youth and Elders, make their way to the Base Camp throughout the year for educational and cultural programming

> *"Inuit elders and youth from Nunatsiavut and Nunavik come together here with visitors, researchers and Parks Canada staff to share adventures and connect with their Inuit homeland. This is Torngat Mountains Base Camp and Research Station, ideally situated for anyone wanting to explore this unique and special landscape and experience the rhythm of a traditional Inuit way of life.*[53]*"*

The Torngat Mountains Base Camp began operations just over ten years ago and has undergone multiple managerial shifts. At present, the Base Camp is operated by the NGC and works in conjunction with the Nunatsiavut Government, Parks Canada, as well as various community groups and individuals and sits on the southern shore of St.John's Harbour, off of Saglek Bay (Figure 3.09). The economic benefits of the Base Camp fall to Nunatsiavut because it is located outside of the National Park border. Due to its remoteness, this also allows the NGC to control much of the travel to and programming within the area, supporting the potential for a conscious operation. This was discussed as a growing intention

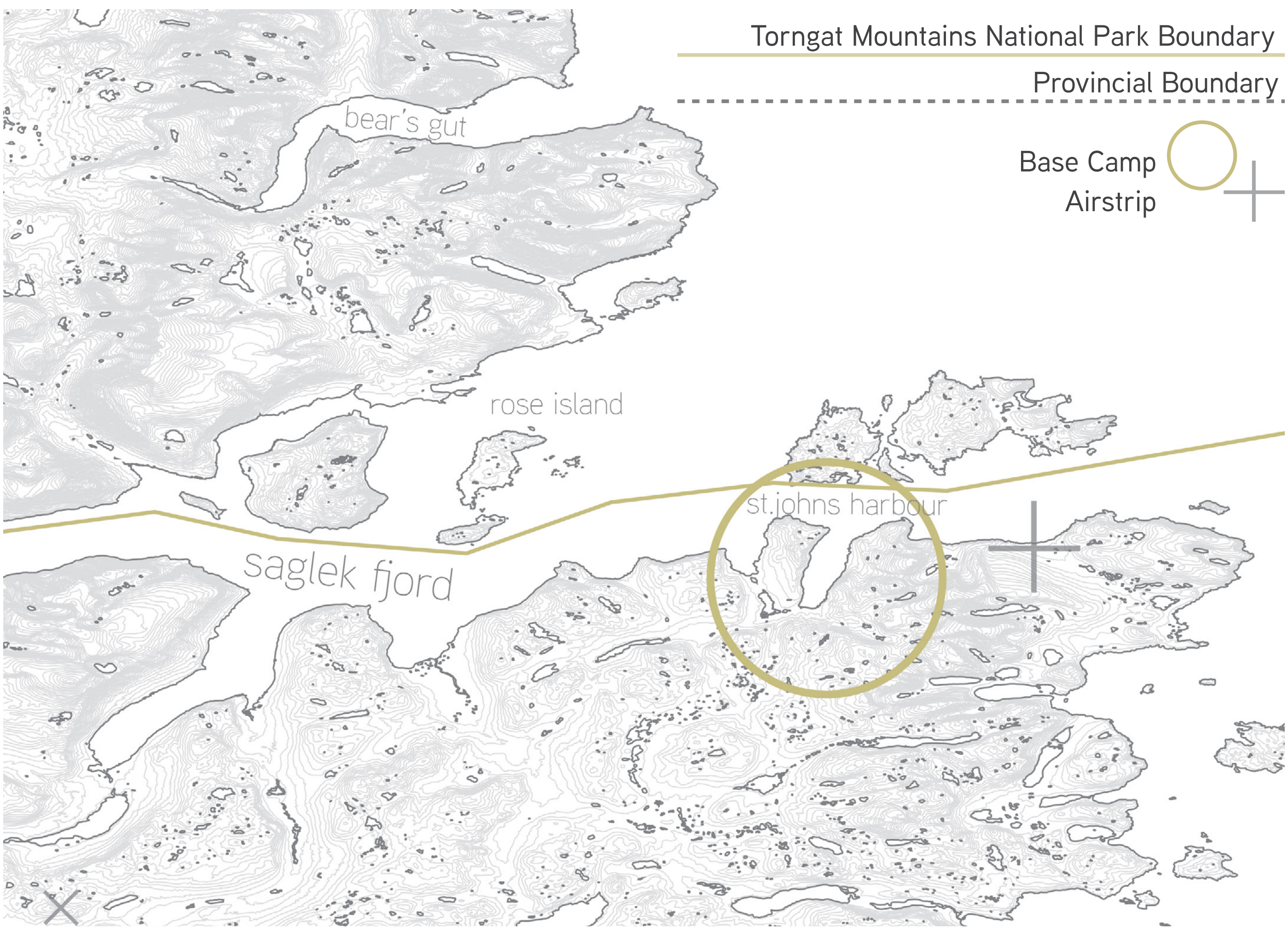
53 Nancy Arsenault. *Nunatsiavut's Tourism Strategy 2014-2020. A 2017 Mid-Point Review and Tactical Update*. Published 2017. (https://www.nunatsiavut.com/wp-content/uploads/2014/02/2017-Tourism-Strategy-Refresh.pdf), 11.

of the NGC as well as Nunatsiavut Government through both their 2017 Tourism refresh strategy and an economic development report for the Base Camp completed in the same year. These additionally state the requirement for critical infrastructure on site, a program that supports each of the aforementioned users, and discussed the needs of the various users and stakeholders involved in the site's operations.

In summary, due to the remoteness and unique nature of the Base Camp, it is only occupied a maximum of nine weeks per year, from late July until September, by a variety of users, including the Park's staff and guides, researchers, tourists, and community groups who come here for youth trips and teaching events. The last three user groups, as well as the existing buildings and amenities, are presented in further detail below to better understand the programmatic needs of the Base Camp if it is to be renovated and expanded to be able to support an extended season.

Figure 3.09
A closer look at the context of the Base Camp, situated near a military airstrip, on the Southern point of St.John's Bay.

Figure 3.10 (Following Page)
The existing infrastructure of the Torngat Mountains Base Camp, pictured from the South.



3.2.1 | Arctic Research Users

The largest user groups at the Base Camp are the researchers and the tourists. Those provide nearly all of the revenues required to operate the National Park. Both are thus essential to the Base Camp's operation, but they each have a unique role to play at and beyond the camp. Firstly, we'll address the researchers.

The Base Camp's research station hosts international researchers that work on a variety of issues that relate to the subarctic region, depending on the interests of the scientists hosted on any given moment. These issues can pertain to climate change, geology, ecology, etc. Consequently, this research station plays an important role as it provides arctic research that has the potential to tell us about the planet's past, but also about its future. Indeed, considering that the arctic is the planet's *canary in a coal mine,* the location of this station is especially important as it can act as a beacon informing us about the changing climate and the effects coming down the road[54].

These users require a home base for various scales of expeditions into the Park to observe or retrieve data, as well as places to store and test potential flora, fauna, or geological samples. While this information is important to disseminate to the other users of the site, it would be important for a semi-private work space with secure storage. A separate lab space with increased ventilation and washability accompanied by desks, both complementing the daily tasks of a researcher's stay. The average number of researchers between 2012 and 2016 was 10, however, more recently, the number was over twice that, indicating a growing demand[55]. Figure 3.11 presents the researchers' current season length, which is around eight weeks, as well as the proposed extended season, which will reach close to six months once the new infrastructure will be in place.

54 National Research Council. "Rationale for Continued Arctic Research". DOI 10.17226/18726.

55 Fiser. "Improving public-private collaboration to sustain a remote Indigenous tourism venture: The case of Torngat Mountains Base Camp and Research Station in Nunatsiavut." (https://www.apcfnc.ca/wp-content/uploads/2020/06/CBOC_Final_Revised_TMBCRS_2017.pdf), 63.

3.2.2 | Tourism Users

The Arctic being noted as being the *earth's final tourism frontiers* leads us into the second critical user group that is also the most populous: the tourists that come to the Base Camp for a few days and use it as a starting point to explore the National Park. Small scale conscious tourism also plays an effective role in the Base Camp's operations. Each year, a small number of tourists make their way to the Base Camp as a jumping off point for single or multi day excursions into the park. In 2014 Nunatsiavut released an economic and tourism plan that established the wishes for various tourism endeavours across the territory, including the Base Camp site and its operations[56]. In 2017, this plan was updated and a separate economic analysis was released, which highlighted the remaining gaps and requirements for improvement on site. This plan stated the intentions to upgrade the research facilities to meet the needs of the variety of parties who use them - the current facilities were identified as 'lacking' on a multitude of occasions[57]. The second identified upgrade to Base Camp infrastructure is through more permanent and higher quality accommodation[58].

These identified upgrades inform the programmatic requirements of the tourists user group which come here for single or multi-day trips into the Park. While primarily it is a place to stay between single or multi-day trips into the park, these users additionally seek 'increasingly authentic experiences', which means it is essential to provide spaces to interact with other user groups, such as researchers and Inuit community individuals. The fact that much of the infrastructure on site has been dubbed to be in a state requiring urgent repair and maintenance presents the site with the opportunity to develop high quality scientific facilities that similarly provide visitors with a cultural experience and opportunities to engage with the Park. Combining these two programs creates an opportunity for the same visceral and intellectual realities about a changing place to be realized by both the researchers and tourists.

The current tourism season shown in Figure 3.12 is approximately five weeks. The season is very short due to the fact that brining in food, goods, fuel, is extremely expansive, as well as because the existing infrastructure is only designed to support a warm season use. The purpose to extend the season is not to develop a massive tourism operation, but instead attract conscious visitors, which through sustainable operations can eliminate many of the negative impacts of eco-based tourism[59].

56 Arsenault. Nunatsiavut's Tourism Strategy 2014-2020. A 2017 Mid-Point Review and Tactical Update. https://www.nunatsiavut.com/wp-content/uploads/2014/02/2017-Tourism-Strategy-Refresh.pdf.

57 Fiser. "Improving public-private collaboration to sustain a remote Indigenous tourism venture: The case of Torngat Mountains Base Camp and Research Station in Nunatsiavut." (https://www.apcfnc.ca/wp-content/uploads/2020/06/CBOC_Final_Revised_TMBCRS_2017.pdf).

58 "[Long-Term Infrastructure] More upgrades, repairs, and developments are to be considered including [...] eventually developing new accommodations and recreational features." Arsenault. *Nunatsiavut Tourism Strategy*.

59 Runge. "Quantifying tourism booms and the increasing footprint in the Arctic with social media data". https://doi.org/10.1371/journal.pone.0227189.

3.2.3 | Community Users

For the Torngat Mountains Base Camp to operate with any kind of longevity it needs to serve not only far-away users, but similarly the nearby communities and Inuit of the region. The 2017 Mid-Point Review and Tactical Update of the Nunatsiavut Tourism Strategy identified five strategic pillars for tourism development and sustainability. Three of these pillars are to preserve and celebrate Inuit culture, developing a visitor economy through highlighting the place's uniqueness, and creating an economic network that supports Nunatsiavut[60]. The integration of these into the program and design of the new infrastructure is vital. While these are depicted in a 'tourism refresh plan' they are equally if not more important in the way they create a scene of belonging for community members, and a system that consciously supports the Inuit co-management and pedagogy on site.

The programming also must allow student programs to run more effectively and allow for connections to land-use as well as paces which support local subsistence practices and encourage pedagogical opportunity and a rekindling of traditional skills[61]. The primary connection in place is with the *kANGIDLUASUk Student Program,* a non-profit focused around Inuit culture, Arctic science, and outdoor adventure. A facility that fosters the continuation and growth of this program, and potentially others of its kind, provides opportunities for future-generations to similar benefit.

Elders have also been noted as a vital connection within Base Camp life, whereby they work in association with the student program, but also speak to and share with researchers and tourists alike. John Jararuse, an Inuk from Saglek, shares this notion by saying

> "*The park will help us protect our land and our memories and our stories. I want to go back to my homeland. Maybe I can go back and help tell our stories to the visitors.*[62]*.*"

Currently, Inuit who are not part of activities with travelers and researchers are only able to visit the Base Camp for a small amount of time at the beginning and end of the season, (Figure 3.13).

60 Arsenault. *Nunatsiavut's Tourism Strategy 2014-2020. A 2017 Mid-Point Review and Tactical Update.* (https://www.nunatsiavut.com/wp-content/uploads/2014/02/2017-Tourism-Strategy-Refresh.pdf), 2.

61 Mandy Arnold. "About Us". Kangidluasuk Student Program. Accessed October 4, 2021. http://www.torngatyouthcamp.com/about/.

62 Parks Canada. "Welcome to the Torngat Mountains National Park of Canada". (https://www.pc.gc.ca/en/pn-np/nl/torngats/visit/~/media/D91E5B647AB84DCABE04263BFFDACD03.ashx), 8

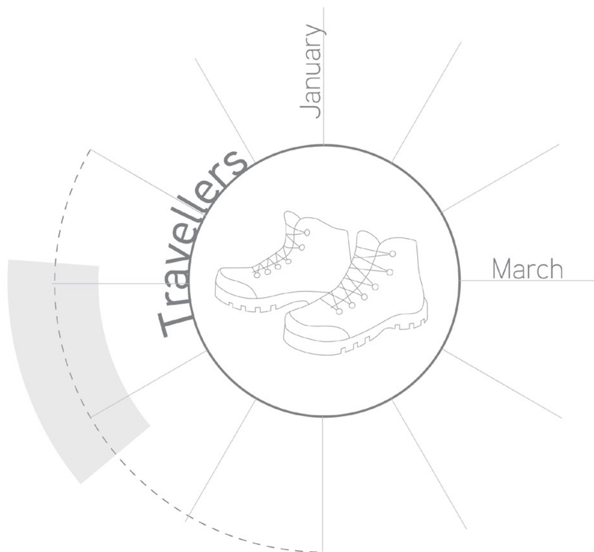
Combined with staff opening and closing the site at consecutive times - this formulates a maximum season of eight to nine weeks in use each year (Figure 3.14). It is proposed that with more infrastructure, and to facilitate interactions, Inuit youth as well as Elders would sporadically be at the Base Camp throughout the entire proposed season. Facilities need to act as a place to stay, but reflect Indigenous teachings and promote culture and storytelling. Those who operate and assist with the community being created at Base Camp become a temporary community at the Base Camp, perpetuating the need for a variety of scales of social and private spaces. The opportunities for teaching and protection of local teachings and traditional ecological knowledge must additionally be reflected in the program and facility.

Figure 3.11 (Top Left)
Existing (grey fill) and proposed (dotted line) season for tourists + travellers.

Figure 3.12 (Top Right)
Existing (grey fill) and proposed (dotted line) season for researchers.

Figure 3.13 (Bottom Left)
Existing (grey fill) and proposed (dotted line) season for the Inuit Community, both Elders + youth.

Figure 3.14 (Bottom Right)
Existing (grey fill) and proposed (dotted line) season for staff from NGC + Parks Canada.



3.2.4 | Existing Building + Amenities

Understanding what is currently in place at the Base Camp is helpful to not only identify functional and programmatic holes, but also to identify what can be reused or needs to be replaced (Figure 3.15). There are currently five existing 'permanent' buildings - two storage buildings, an EcoNomad[63], a facility building, and the main building with kitchen and offices. The permanent buildings have not only been dubbed as functionally insufficient, but their construction is also substandard and did not take into account climate or site specificity at all. The average building in Nunatsiavut, of which these are the same construction, has a lifespan of around ten years before they are in need of major repairs[64]. Moreover, 85% of buildings in the region display significant foundation damage within that time[65]. At its current operation time of eleven years now, these buildings are in a state of disrepair. Due to this, as well as the current infrastructures inability to support programming outside the summer season, new permanent infrastructure will need to be developed from the ground up. This would begin with the primary building, as storage and facility infrastructure can continue to operate in some capacity as it degrades. One main building could replace all the functional infrastructure on site, making it easier to move between and maintain in an extended season, accompanied by unheated storage to reduce energy use.

The second form of infrastructure on site is the accommodations. This mainly comprises the thirteen steel domes which can fortunately be entirely reused. Sleeping two guests apiece, these have a lifespan of fifty years and can withstand the conditions to some degree, making them ideal for a higher site capacity in peak season. As the domes are moveable and on wooden platforms, they can be relocated to suit the site arrangement with new buildings. Additionally, there are a multitude of 'design shelters'[66] - military type tents in different sizes that accommodate services such as community gathering and the Parks office staff, as well as sleeping quarters The fabric tents have a lifespan of approximately twenty years. These tents are used in various locations, however their listed lifespan is a global average and does not account the subarctic climate including freeze thaw and harsh winds which can destroy these in a matter of seasons. With the intention of extending the operational season on site, these are also unsuitable for working or sleeping in those bracket months. However, these are temporary and deconstructable so ideally they

63 Using passive heating and naturally occurring bacteria, an EcoNomad is a waste to energy system for small scale agriculture operations.

64 Trevor Bell, Goldhar, C., and Sheldon, T. "Planning Sustainable Nunatsiavut Communities from the Ground Up." Memorial University of Newfoundland. 2013. (https://www.northernadaptation.ca/sites/default/files/8_mapping_and_community_planning_in_nunatsiavut_-_bell_0.pdf), 11.

65 Ibid, 13.

66 Design Shelters are military style temporary tents that come in a variety of sizes. The H and P series are the main two utilized on site at the Base Camp.

can be relocated to a less extreme climate where their lifespan can be used to its fullest. The accommodations that remain will be supplemented with more permanent structures that will cover users for the entirety of the proposed extended season of around six months. While current infrastructure could never support users in these cooler temperatures, small buildings with self-sufficient heating would allow for an extended economic season as well as the ability for community groups to visit outside of the peak tourist season. The benefits of keeping the operation to three seasons avoids the complexities of designing for winter operations, as well as travel within the site as well as transport to it during that time.

Finally, there is some supportive infrastructure on site. A variety of storage tents and regular camping tents scattered the site for overflow. A small selection of storage tents can be reused on the new site, as peak-season storage requirements are greater and allow smaller kayaks and ATV's to be kept closed to the dock during seasonal use. The EcoNomad, used for on-site waste and energy, is currently situated within the potential future flood zone and would therefore have to be removed; a more integrated waste-system is to be included in the new project which functions optimally through its extended season. The entire Base Camp is then surrounded by an electric fence for protection against polar bears. At least half of the fence currently sits within highly probable sea level rise boundaries, and will therefore need to be removed and rearranged for the orientation of the new buildings.

Figure 3.15 (Following Page) Existing Situation at the Base Camp, highlighting elements to be be removed, relocated, and reused.


0
100
500m
N

Keep
Attempt to Re-Use
End of Life
Re-Used Off Site
Steel Accomodation Dome
Accomodation Tents
Services Tents
Storage Tents
Camping Accomodation
Permanent Buildings
Water Line (to be moved)
Open View (to be maintained)
Electric Fence (to be moved)
NG Proposed Additions
No Build Zones (to be maintained)
Shallow Sand | Gravel
Lichen | Low Vegetation

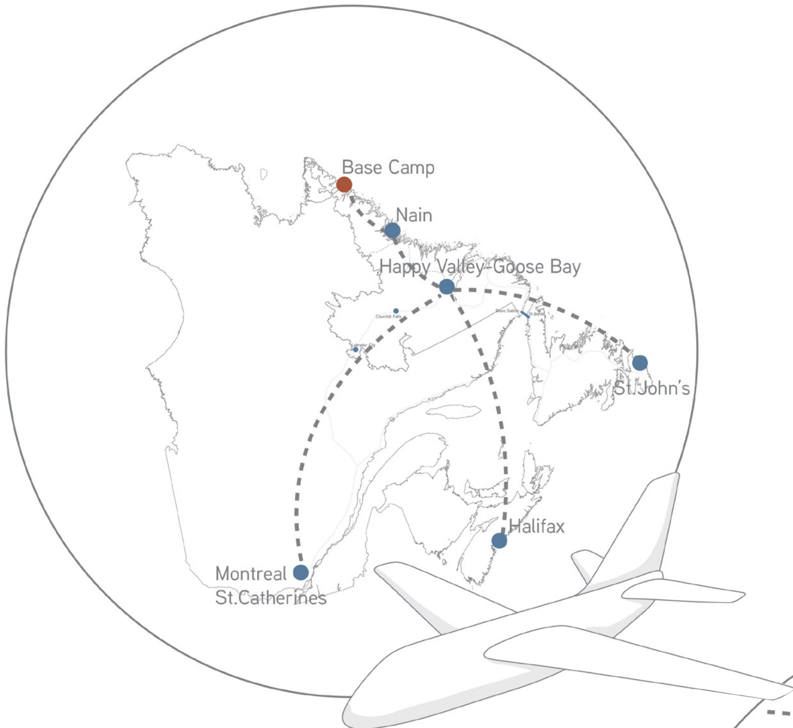


Figure 3.16 (Left)
Plane route beginning at most major airports, then through HV-GB, Nain, to Base Camp.

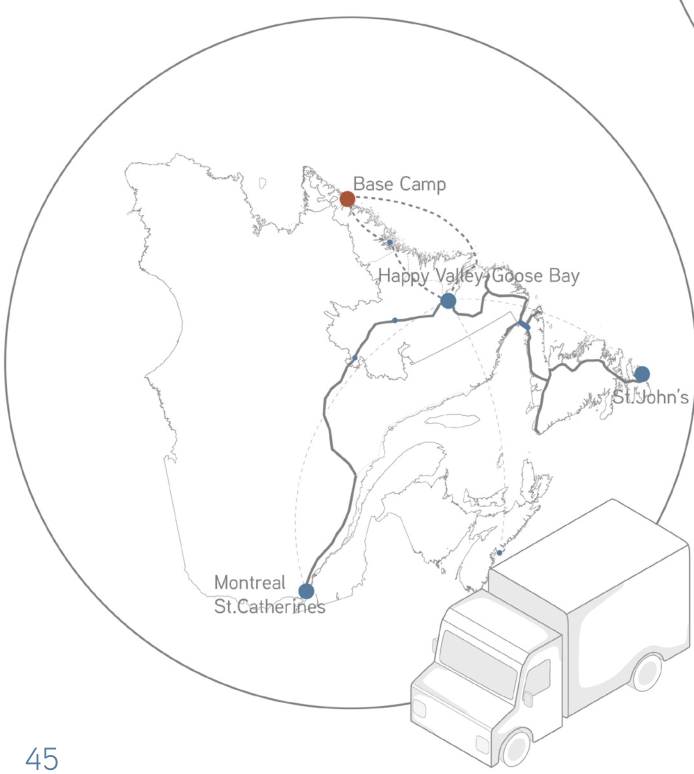


Figure 3.17 (Above)
Marine route to Base Camp. Beginning in Montreal, the SeaLift can deliver major goods to site.

Figure 3.18 (Left)
Vehicle route to Base Camp. Roads ending at HV-GC means a transfer to plane or marine is required.

3.2.5 | Moving People + Product

All users have to travel a long distance to get to the Base Camp, some more than others, but this highlights the importance of providing quality spaces and comfortable accommodation to work and live during their stay at the site. Indeed, the main route for many users starts with a flight (Figure 3.16) to Happy-Valley Goose-Bay, a key Labrador city, followed by a second flight to Nain, the northernmost community in Nunatsiavut, and then by a third flight (charter only) to the Saglek Air Strip, just East of the Base Camp. People are then shuttled via boat into St.John's Harbour, which allows people to then directly access the Base Camp. Because of the difficulty getting in and out of the camp, staff members generally remain on site for the entirety of the season, currently nine weeks.

In addition to providing quality and comfortable spaces and buildings, it is also essential to pay special attention to the durability of the construction considering how difficult and expensive it is to bring new materials on this site. Indeed, products for new building construction would be moved through the Arctic SeaLift (Figure 3.17). While materials are ideally sourced locally, the site being above the tree line makes this difficult. The SeaLift leaves St.Catherines, Quebec twice a year - in June and September. Depending on the number of ports along the way, the load can take between seven and thirty days to reach Saglek. Additionally, Saglek is not on the regular port route and needs to in most cases be requested for delivery an entire season in advance. The boat also leaves from Happy-Valley Goose-Bay, the 'end of the road', (Figure 3.18). so more local products do have the opportunity to be loaded from there. After being unloaded at Saglek, smaller vessels take product to site. Currently frequent products such as food, fuel, and other goods are brought from Nain by charter, which is also the route for forgotten construction or repair items. The infrequency and expense of shipping product to the site further supports the goal for self-sufficiency.

Concluding section 3.2 and its research into the various user groups, their programmatic needs, the limitations of the current season and potential for an extended one, the transportation distance to site, as well as the state of disrepair of a majority of buildings on site results in a further understanding of the requirements of the project to be durable. The unique characteristics and challenges of the site speak to the project's need for resilience through the seasons and adaptability to changing users, doubling up on the climate resilience and adaptability established by the end of Chapter 2.

3.3 | CURRENT + FUTURE SITE ANALYSIS

In order to further expand the knowledge relative to the site, the Torngat Mountains National Park Base Camp, the next important step consists of performing a site analysis of current site conditions, but also of future conditions. It is indeed essential for future-proofing to also understand the climate of upcoming decades. The site analysis conclusions will thus inform the program, for which the groundwork has been laid in the previous subsection, but also key design decisions to come for the thesis project.

To perform this current and future site analysis, predictive climate modelling was utilized. This method covers a longer time frame than standard weather predictions do. Another benefit of predictive climate modelling is that it also takes into account atmospheric conditions as well as land and hydrological processes[67]. When comparing the predictive numbers to current and past weather conditions, it allows for not only an understanding of the gravity of changes but similarly gives us the information required to prepare the optimal solution and mitigation strategy for each scenario. The well known saying "the climate is what you expect, the weather is what you get"[68] relates well to the way in which the project needs to operate. Thanks to predictive climate modelling, the resulting design will be able to adapt to climate changes that are expected to happen in the next decades. The rest of this subsection will present the main findings of the predictive climate modelling analysis that was done through the collection of a variety of quantitative and qualitative climate data for Saglek and Hebron area in recent years, but also from future predictions (found in more detail in Appendix A). The findings are followed by resulting design guidelines.

The first important baseline is basing predictions and changes on a timeline relating to the end of the century. This is used for various climate modelling and mapping. A globally used system such as the Köppen climate classification, touched upon in section 2.1, allows for simple visualizations of changes (full world maps in Appendix B). The Köppen system is the world's foremost classification system, taking a variety of climate data to categorize the planet into thirty climate zones. Five majors groups - tropical, dry, temperate, cold, and polar - are further subdivided based on temperature and precipitation into thirty subdivisions[69]. A comparison of today's map to that of 2100 allows for a distinct

67 Lauren Harper. "What Are Climate Models and How Accurate Are They?" Columbia Climate School. May 2018. Accessed September 22, 2021. https://news.climate.columbia.edu/2018/05/18/climate-models-accuracy/.

68 Jeff Andersen. "Climate Basics". Michigan State University, 2015. (https://www.canr.msu.edu/uploads/resources/pdfs/climate_basics_(e3151).pdf), 1.

69 Beck, "Present and future Köppen-Geiger climate classification maps at 1-km resolution." (DOI: 10.1038/sdata.2018.214), 2.

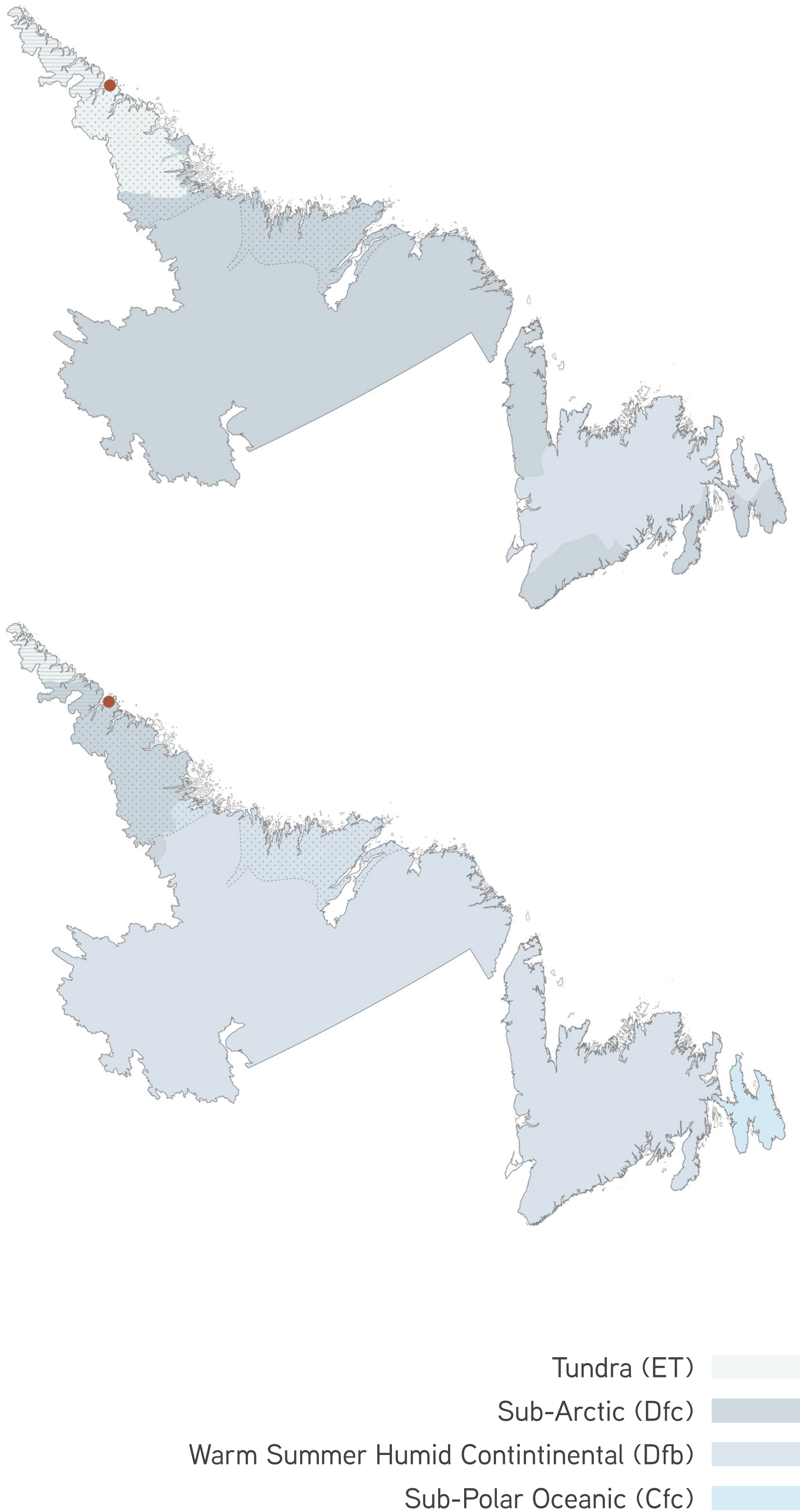


Figure 3,19
Newfoundland and Labrador Koppen climate classifications - present day (top) and 2100 (bottom)

visual shift that can provide regular people with an idea of how their home will change[70]. Climate analog mapping is a technique by which the expected climate at a location - generally one's location or the site in question - is matched with the current climate in another location[71]. Ideally this connection is made to a similar location in order to create a relatable situation to be understood. Climate analog mapping can also be used for design, providing a qualitative comparison as to what a location will be experiencing in the future. When looking at Labrador in Figure 3.19, the regional shifts coincide with the drastic predictive changes seen in Northern regions. Presently, in the Northern extent of the province, climate zones are expected to shift from tundra to cold[72], relating to the current climate seen hundreds of kilometers south in the province and across the Atlantic in Western Scandinavia

After the collection of a variety of quantitative and qualitative climate data for Saglek and Hebron area in recent years as well as future predictions, based on Köppen as well as various additional predictions from provincial, federal, and private sources, many of the most crucial climate based findings which affect site design are discussed below.

Firstly, solar radiation conditions were examined, knowing that those are not directly affected by climate change and are thus not expected to change in the foreseeable future. The Base Camp does not experience the polar night, but does have a winter season with only a few hours of very low sunlight, and comparatively over twenty hours of sunlight in the summer[73]. Even with an extended operational season for the Base Camp (May-November), limited daylight access should not be a problem as this season avoids the core winter months. However, very long daylight access in the summer can have a significant impact on the building operations, as it will receive a large quantity of solar thermal energy when occupied, which should thus significantly impact design decisions. To this effect, it is important to know that the Sun sits relatively low in the sky even in the summer, reaching an altitude of 55 degrees at the June solstice, which is due to the high latitude of the site in the northern hemisphere (58°N), as shown in Figure 3.20. Based on these findings, it is clear that solar shading for visual and thermal comfort, as well as for controlling high solar gains, will be of great importance, even though the building is located in a very cold climate. This can be more easily achieved with a building facing the south, which will be of key importance here. Moreover, this also informs us on the ideal angle of photovoltaic panels or solar thermal collector panels. Knowing that energy production needs will

70 Markus Kottek, Gieser, J. et al. "World Map of the Köppen-Geiger climate classification updated" *Meteorologische Zeitschrift* 15, No. 3, 259-263 (2006). DOI: 10.1127/0941-2948/2006/0130.

71 Matthew C. Fitzpatrick, Dunn, R.R. "Contemporary climatic analogs for 540 North American urban areas in the late 21st century." *Nature Communications* 10, no. 614 (2019): 2, DOI: 10.1038/s41467-019-08540-3.

72 Beck, "Present and future Köppen-Geiger climate classification maps at 1-km resolution." (DOI: 10.1038/sdata.2018.214), 2.

73 -----. "Climate and Average Weather Year Round at Saglek Bay." Weather Spark. Accessed November 27, 2021. https://weatherspark.com/y/147469/Average-Weather-at-Saglek-Bay-Canada-Year-Round#Sections-Precipitation.

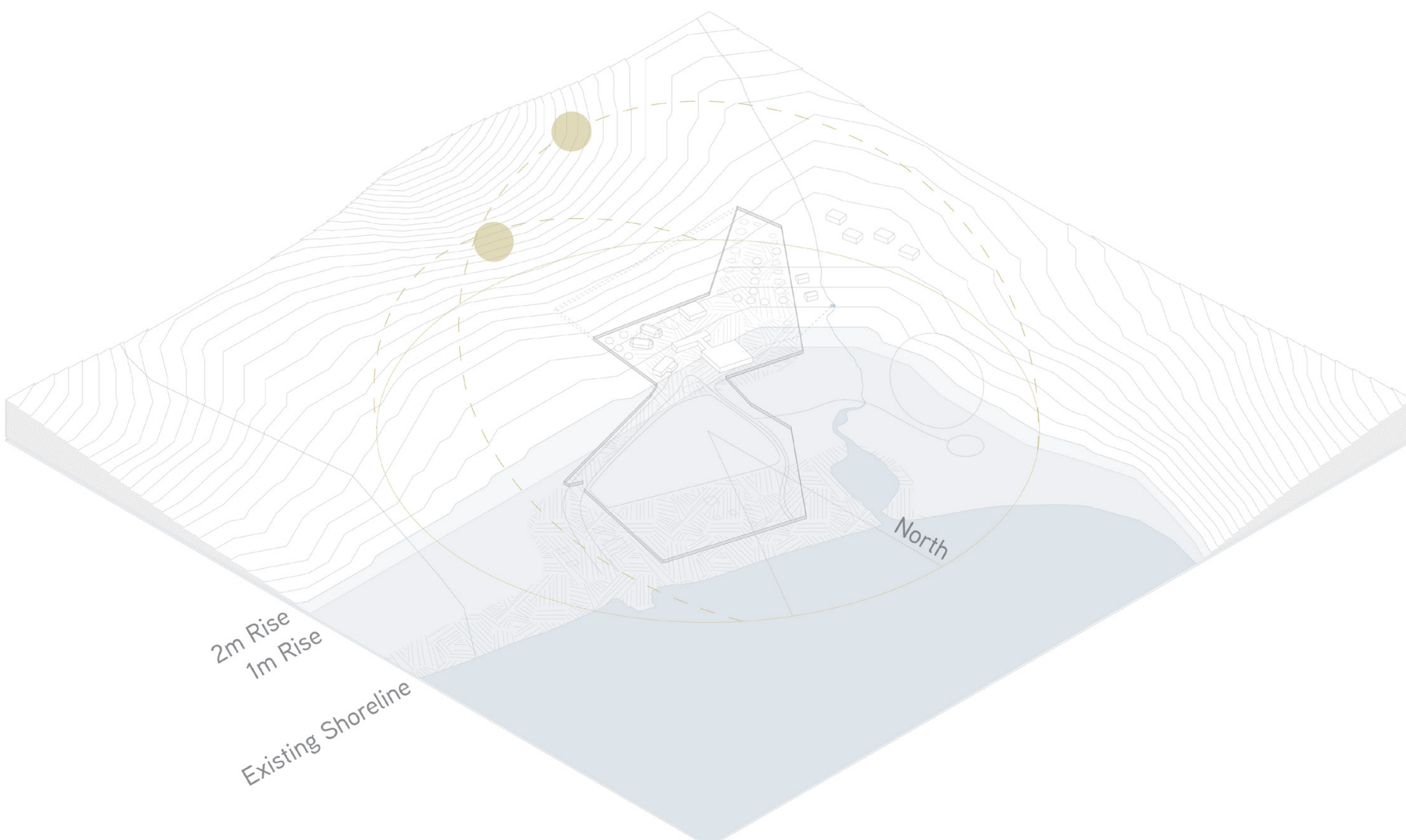


Figure 3.20
Base Camp from North-East. Highlighting sun angles at each solstice (55 and 8 degrees) as well as the shoreline, and its reach at 1 and 2m of sea level rise, not taking into account storm surges.

be higher in the summer when the base camp is occupied, panels should ideally have a +/- 45˚ angle (latitude (58˚) minus 15˚ in the summer). If some energy production is still needed in the winter, then the optimal angle should be +/- 75˚ (latitude plus 15˚)."

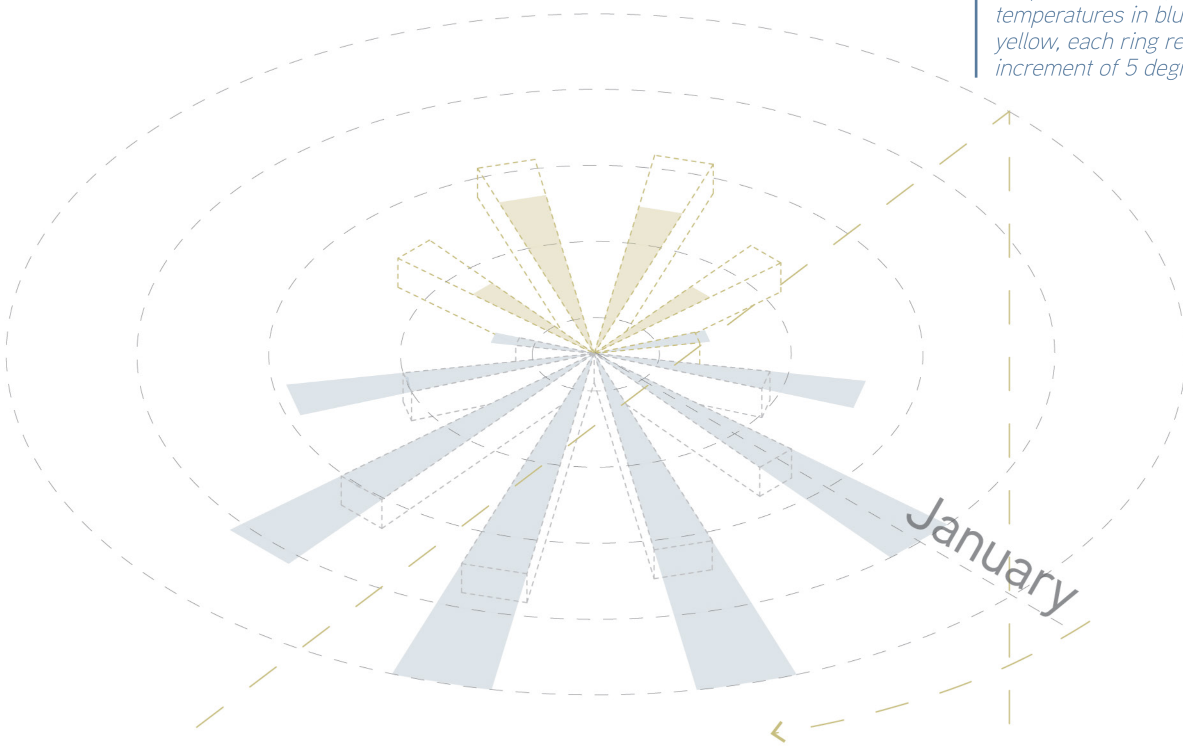
In the future however, temperatures will be rising, which will have a big effect on the impact of solar thermal gains in the building during the occupied season, especially in summer. In fact, Figure 3.21 illustrates that average monthly temperatures in this region are expected to rise between three and ten degrees by the end of the century[74]. With little to no sunlight relief in certain seasons, it is crucial to mitigate this through proper envelope and facade design. This means that solar shading will become even more important for this building in the next decades. This is even more important in a highly insulated building, which will have to be the case here, to make sure heat is not trapped inside, creating overheating and thermal discomfort issues. The building's solar shading strategy will thus have to be adapted, or to have the capacity to adapt, to today's and tomorrow's thermal conditions.

Another essential site condition that was studied was prevailing winds, which can also have a big impact on the thermal balance of the building. Wind speeds in the arctic are fast and consistent, averaging up to twenty-five kilometers per hour in the winter months, with gusts doubling that. While there is little quantifiable writing on the predicted changes in wind speed, the general consensus is that they will increase as well as change direction (towards the north pole)[75]. Cold and strong winds can be extremely challenging in the arctic, but considering the building is occupied during the summer, winds are actually quite useful as they can be harnessed for natural ventilation. As we have said before, strategies to avoid overheating in the building will become even more important in the future climate. It is thus essential to design the building in a way that can easily harness winds for cross-ventilation knowing that wind direction may change in the future. A curvilinear and thin shape is more prone to provide this kind of flexibility, compared to a deep and rectangular shape. Moreover, winds can also be quite useful when it comes to renewable energy production, so the building should rely on the prospect of stronger winds in the future and integrate wind turbine strategies. With Figure 3.22 showing how prevailing winds come from the Northwestern direction nearly year round, a wind production placed to account for this is optimal. Wind turbines should be located and oriented in a way that is consistent with this information.

74 Climate Atlas of Canada. "Hebron". Climate Atlas of Canada. Accessed September 20, 2021. https://climateatlas.ca/map/canada/

75 S. Eichelberger et al. "Climate Change effects on wind speed" *Research Gate*. January 2008. https://www.researchgate.net/publication/281611243_Climate_change_effects_on_wind_speed.

Figure 3.21
Current (filled) and predicted (dotted) average monthly temperatures. Negative temperatures in blue, positive in yellow, each ring representing an increment of 5 degrees.



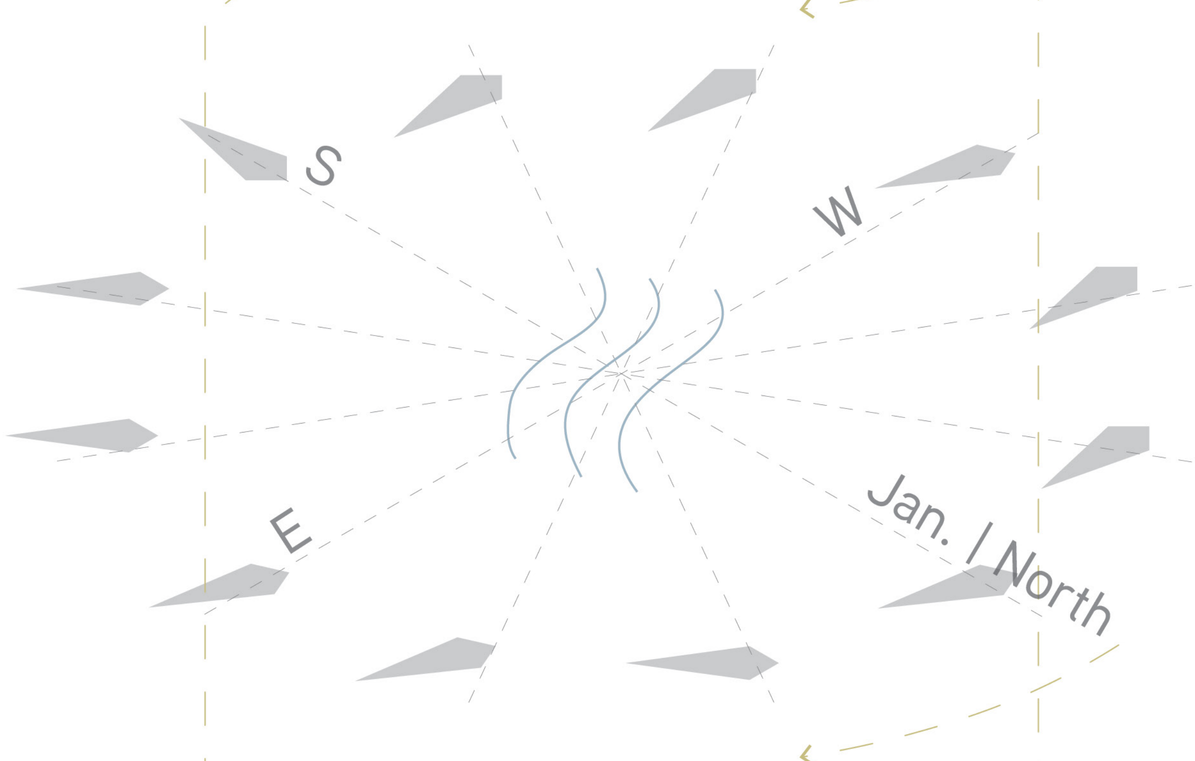


Figure 3.22
Prevailing wind direction on site. Long arrows point in the direction which the wind is blowing.

The next important site condition that was studied was precipitation, which can also have an impact on parameters such as rainwater harvesting or building durability in the face of extreme weather events. The location already has relatively high precipitation rates and this is expected to rise moderately (Figure 3.23). The issue here comes from storms and erratic quantities of precipitation that can affect flooding and cut the site off from outside sources. This presents the need for the building to protect itself from extreme weather events in the future. The potential opportunity arising from these climatic changes is a prolonged growing season. Growing season is based on the number of continuous frost free days, as the percentage of each month where the average daily temperature is above 5.6˚C[76]. Figure 3.24 shows how the future growing season is naturally extended weeks on either end, even further stretched indoors when harnessing long daylight hours and accessible water. Rainwater collection is a design element which arises from this need, not only diverting rainwater so as to not flood over entrances, but additionally funnelling it into storage where it can provide a primary source of water.

The final critical site condition that was studied was sea level rise, which is important to address as the base camp is located near the sea. The Labrador coast is one of the few places in the world where sea level rise is partially counteracted by natural uplift, a causation of glacial and geological history[77]. The expected sea level rise at current trends is expected to be below one metre here[78]. Best practice is to double the rise assumption to accommodate for worst case scenarios, as illustrated in Figure 3.20. To additionally compensate for storms and associated waves, a new building would have to be placed back three meters in elevation above the current shoreline. Regardless of their current state of disrepair, this puts nearly all of the Base Camp's current infrastructure within the oceans' new reach. This situation puts most of the infrastructure discussed in subsection 3.2.4 within the oceans new reach, reinforcing the need for relocation. An understanding of how to tackle each of these climate conditions optimally in their state today, as well as in the future, is essential for this resilient project.

76 —-. "Climate and Average Weather Year Round at Saglek Bay.https://weatherspark.com/y/147469/Average-Weather-at-Saglek-Bay-Canada-Year-Round#Sections-Precipitation.

77 D. Liverman and M. Batterson. "Past and Future Sea-Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning" *NL Department of Natural Resources.* Report 10-1. (2010).

78 Department of Municipal Affairs and Environment. "Turn Back the Tide: Climate Change in Newfoundland and Labrador." Newfoundland and Labrador. 2016. https://www.turnbackthetide.ca/impacts-of-climate-change/slr-overview.shtml.

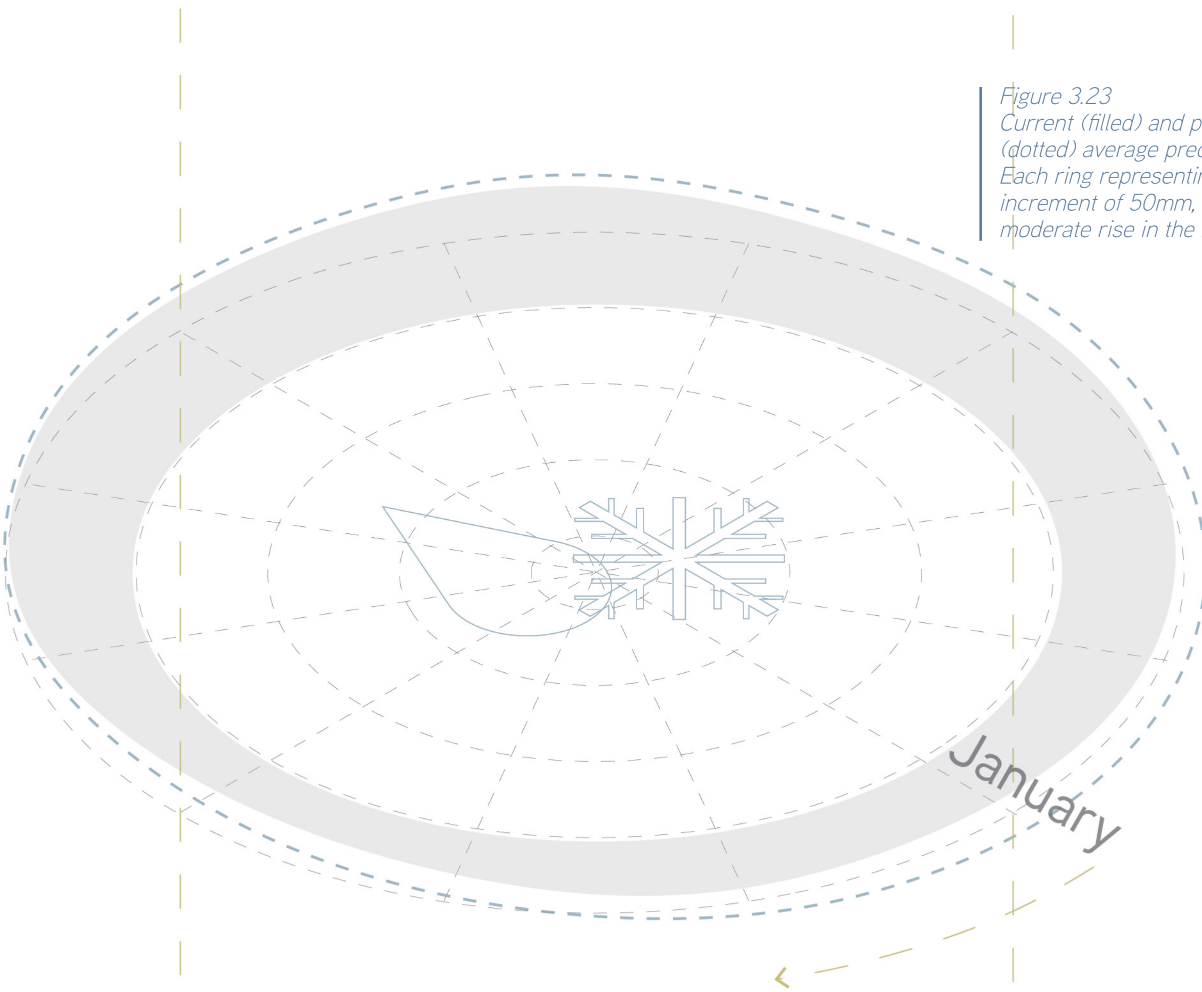


Figure 3.23
Current (filled) and predicted (dotted) average precipitation. Each ring representing an increment of 50mm, depicting a moderate rise in the next century.

Figure 3.24
Current (filled) and predicted (dotted) growing season. Lighter shades represent higher temperature brackets, resulting in peak or bracket growing seasons.

Figure 4.01
Canyon rivers in Torngat Mountains National Park.

FUTURE-PROOFING 4

Future proofing provides the opportunity for a place, a people, and a project to anticipate, work with, and minimize the impacts of a changing climate[79]. As discussed in subsection 2.3, future-proofing a building will ensure it is resilient, which comes not only from adapting the way we design and inhabit buildings, but also through designing self-sufficient buildings that are not dependent on outside infrastructure. In order to determine the best design strategies to achieve these goals, it is essential to first understand the changes that will befall the place, impacting the climate, but also the regional livelihood of those living off the land and relying on the way of life that has been developed in harmony with the climate. Consequently, four major climate change issues, impacting the Torngat Mountains region and the Inuit people living there, have been identified in order to orient the search for appropriate future-proofing design strategies. These are **extreme and erratic weather**, **rising sea levels**, **permafrost thaw**, and **disruption of seasonal reliability**. The impacts of these changes on landscape, the people, and on infrastructures are outlined for each issue, as well as design solutions which can be integrated to inform the design of the Thesis Project. The challenges that arise from these macro issues and their solutions make clear the interconnectedness of change on site, and the solutions begin to address these complexities by identifying overlaps and cohesive solutions.

79 Bailey Rich. "The Principles of Future-Proofing: A Broader Understanding of Resiliency in the Historic Built Environment". *Preservation, Education, and Research.* Vol 7(14). (2016). (https://www.researchgate.net/profile/Brian-Rich-2/publication/333856761_The_Principles_of_Future-Proofing_A_Broader_Understanding_of_Resiliency_in_the_Historic_Built_Environment/links/5d09635d92851cfcc622b21c/The-Principles-of-Future-Proofing-A-Broader-Understanding-of-Resiliency-in-the-Historic-Built-Environment.pdf?origin=publication_detail), 24.

4.1 | DESIGN FOR TOMORROW

Designing for an unpredictable and unprecedented tomorrow is no straightforward task. The strategy for future-proofing within the site in question is based around climate-driven design. Bioclimatic design theory has had plenty of research and application within the industry through a variety of scholars in both global and more local contexts[80,81,82]. While these take into account designing for the climate of a location, they largely disregard associated socio-cultural elements of place, let alone the myriad of ways those two elements can change in the future. Some of the main takeaways from the study of place-based design literature are that each strategy cannot be considered independently, as the various strategies utilized to improve the performance of the building affect each other. Moreover, simple and robust strategies provide the greatest resilience and longevity. Additionally, while systems can be optimized and calibrated to function efficiently today, they may not do so tomorrow if they are not provided with the capacity to adapt. New infrastructure must be able to react to both short and long term changes which will in turn maximize the lifespan of the project. We must thus design optimally for today, 2100, and somewhere in between, which forces us to reflect on how a building may be able to transition between those stages as easily and sustainably as possible - ideally through minimal alterations through repair, replacement, transformation and more. This is even more important for a remote building considering the very high cost of construction, and the material supply challenges.

This section will explore as many future-proofing strategies as possible for each of the four main climate change issues facing the studied site (extreme and erratic weather, sea level rise, ground thaw, and disruption of seasonal reliability). Those are based on the expertise reviewed from within traditional scientific literature, however each section will begin with an observation from Inuit community members in and around Nunatsiavut to better understand the livelihood related challenges pertaining to each of the four issues. Even though the lessons from ecological knowledge and cultural values are explored in detail in Chapter 5, we can only start investigating future-proofing strategies once we fully understand the issues as they are happening and being perceived on the ground by the stewards of the land, those who have known it for generations. As Inuk activist Sheila Watt-Cloutier eloquently explained, these observations are an integral part of the scientific process to understand, and eventually address, the issues:

80 Victor Olgyay. *Design with Climate: Bioclimatic Approach to Architectural Regionalism*. New Jersey, USA: Princeton University Press, 2015.

81 Marcus. "Place with No Dawn: A Towns Evolution and Erskine's Arctic Utopia.". https://www.abdn.ac.uk/staffpages/uploads/enl333/Marcus_2011.pdf.

82 Strub. *Bare Poles: Design for High Latitudes*.

> *Science [as] a body of knowledge, and a way of knowing based on rigorous observation. By this definition, the hunters who criss-cross the ice and snow and embody centuries of observation are scientists. When they describe what is happening to their landscape, the world needs to listen*[83]*.*

This research has allowed for a large number of issues to be explored, as well as the identification of potential solutions to address those issues. An array of issues as well as strategies such as crumbling foundations, the use of piles, flooding, various sea-water mitigation strategies, passive design principles, and place-based design factors such as material and transportation availability are recorded in Figure 4.02.

83 Watt-Cloutier. *The Right to Be Cold: One Woman's Story of Protecting Her Culture, the Arctic, and the Whole Planet*, 199.

Figure 4.02 (Following Page)
The complexities of designing for change in an Arctic environment. Place-based design considerations, issues, and solutions.


NaCl
NaCl
NaCl

4.2 | Extreme + Erratic Weather

> *In the past our Elders knew exactly [...] what the weather was going to be like, but today it's so unpredictable. In one day it could be really, really sunny, and then the weather will come down all of sudden, out of nowhere*
>
> Julian Ikkusek[84]

The first of the four major issues of change affecting the site of the Torngat Mountains Base Camp is an increase in extreme and erratic weather conditions which are unpredictable and intense on both the landscape and the infrastructure upon it. While the changes in climate affect every component of the ecosystem, there are three main elements in this category that have the greatest implications and require mitigation design strategies: rising temperatures, changes in wind patterns, and more frequent storm surges.

Beginning with rising temperatures (Figure 4.03), the average monthly temperature is expected to rise between three and ten degrees by the end of the century, as elaborated upon in section 3.3.[85] Warming temperatures provide a unique opportunity in terms of food production at this latitude. Long sunlit days and daily summer temperatures increasing into the mid twenties towards the end of the century provide better conditions for greenhouse and vertical growing systems. Even as outdoor vegetation seasons remain short and are further impacted by storms and freeze-thaw variance, interior spaces can make use of these conditions and provide on-site, consistent, and extended food production. This can prove beneficial and should be drawn on to its fullest potential in this region as an offset for other changes in the climate, elaborated upon in section 4.5, that are expected to disrupt traditional food sources, like hunting, fishing or gathering.

Rising temperatures will also have beneficial and detrimental impacts on the thermal performance of the building and thus on thermal comfort, depending on the seasons. In the winter, the heating energy requirements will diminish, but in the summer, the need for cooling strategies will increase. A robust and energy efficient building which incorporates passive strategies is first and foremost priority through the use of ample insulation, the elimination of thermal bridges, the use of thermal mass to increase thermal

84 Mary Simon. *The Caribou Taste Different Now - Inuit Elders Observe Climate Change*. Nunavut, Canada: (Nunavut Arctic College, 2016), 287.

85 Climate Atlas of Canada. "Hebron". https://climateatlas.ca/map/canada/plus30_2030_85#z=4&lat=60.35&lng=-51.86&grid=132.

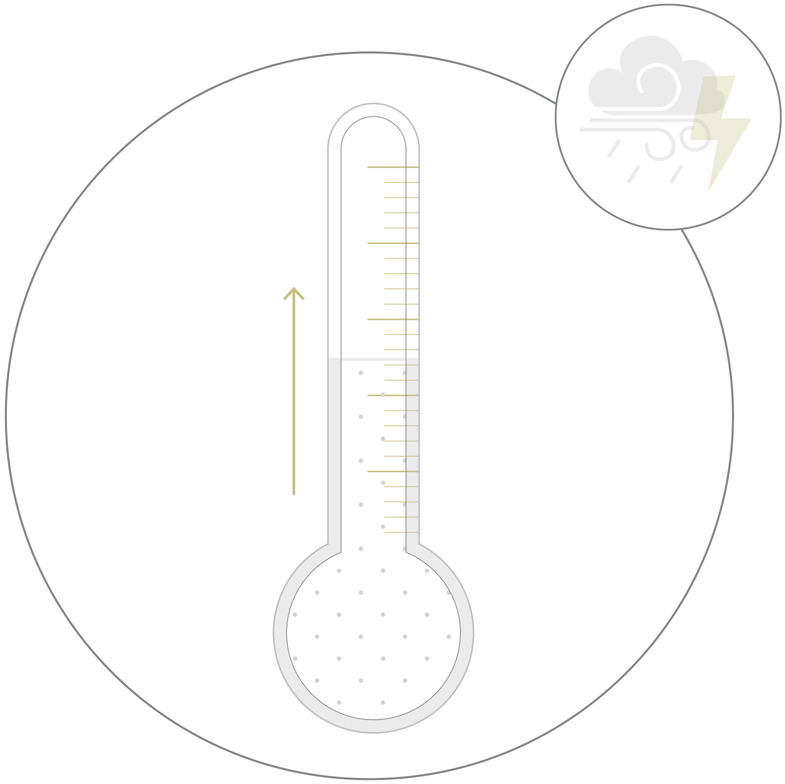


Figure 4.03
Rising Temperatures, a corresponding impact of a changing climate.

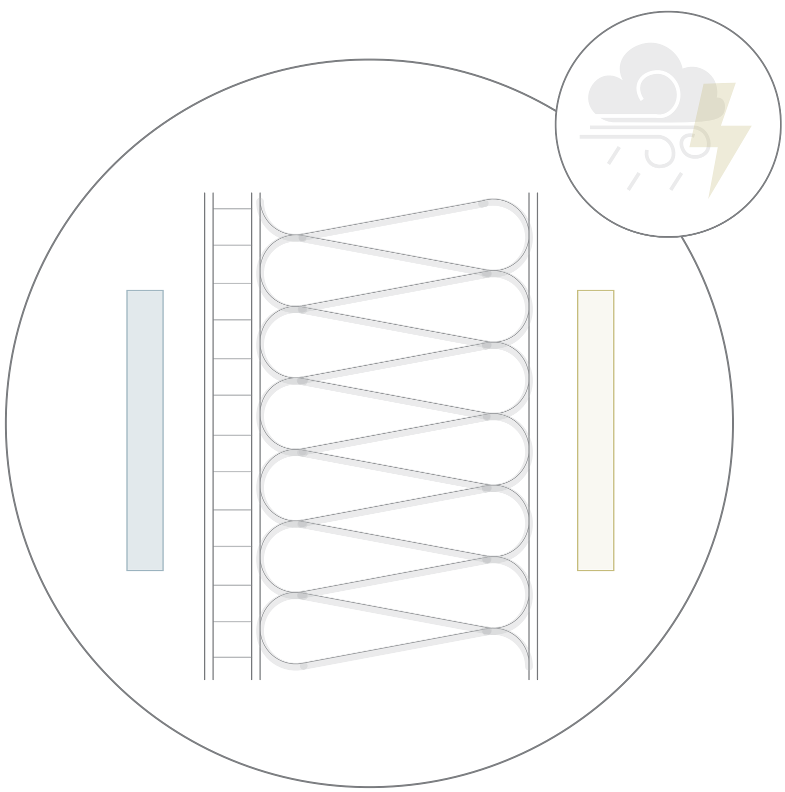


Figure 4.04
Efficiently insulted envelopes provide a strategy for mitigating against changing temperatures and reducing energy requirements.

inertia, the use of thermal buffer, the use of solar shading and more (Figure 4.04)[86]. Under present conditions, solar gains should be harnessed almost year-round, but in 50-100 years, this will change as harnessing may no longer be desirable in the warmer summer. In fact, as temperatures rise, the building will still need to harness the southern sun to passively heat interior spaces in the bracket seasons and during the winter, even though those will be warmer. The well-designed efficient envelope will simply allow the building to use less energy to keep the spaces warm and comfortable in the cold season. However, due to the increased risks of overheating in the summer, solar protection, natural ventilation and high thermal inertia will become more important to the passive thermal performance of the building in the future. Maximizing insulation to align with goals for an energy efficient envelope today will become even more beneficial in the future as it will further reduce energy consumption. This will help the building reach its goals of self-sufficiency[87]. However, the building must also be designed in a way that passive cooling can become more efficient in the future as the climate changes, otherwise this will undermine the goals of self-sufficiency as active cooling demand will increase.

The second aspect within extreme weather that provides challenges for the site is a repercussion of the Gulf Stream breakdown and changes to the Labrador Current (Figure 4.05). What has been described as "an almost complete loss of stability"[88] in Atlantic currents over the last century results in wind patterns that are stronger and less consistent than historically. Prevailing on-site winds come from the Northwest and are expected to increase in speeds and tilt polarly in the coming century[89]. Due to the Torngat Mountain Base Camp being located at the bottom of a narrow fjord, wind tunnels and pockets are expected to drastically increase and affect the site, increasing heating demand due to more important cold air infiltrations, as well as reducing thermal comfort of exterior spaces and increasing wear and damages to buildings due to increased wind gusts. The building's shape can thus act as a windbreak to create a more protected outdoor space on its southern side. Additional windbreaks, such as freestanding walls in the landscape, can be used to protect entrances and increase building durability while reducing energy consumption through the prevention of frigid wind gusts reaching the building. As stated earlier, it is essential for such a remote building to be entirely self-sufficient, which means that stronger winds can be harnessed to generate on-site electricity for lighting, appliances, heating, etc. Wind turbines are easy to integrate in the landscape or on the building to provide renewable and sustainable electricity.

86 Lauren Georges, Berner, M., and Mathisen, H.M. "Air heating of passive houses in cold climates: Investigation using detailed dynamic simulations" *Building and Environment*. Vol 74(1-12). (2014). https://doi.org/10.1016/j.buildenv.2013.12.020.

87 Adrian Pritts. "Future proof construction—Future building and systems design for energy and fuel flexibility" *Energy Policy*. Vol 36(12). (2008). https://doi-org.librweb.laurentian.ca/10.1016/j.enpol.2008.09.015.

88 Damian Carrington. "Climate crisis: Scientists spot warning signs of Gulf Stream collapse" The Guardian. August 2021. https://www.theguardian.com/environment/2021/aug/05/climate-crisis-scientists-spot-warning-signs-of-gulf-stream-collapse.

89 S. Eichelberger, *et al*. "Climate Change effects on wind speed". https://www.researchgate.net/publication/281611243_Climate_change_effects_on_wind_speed.

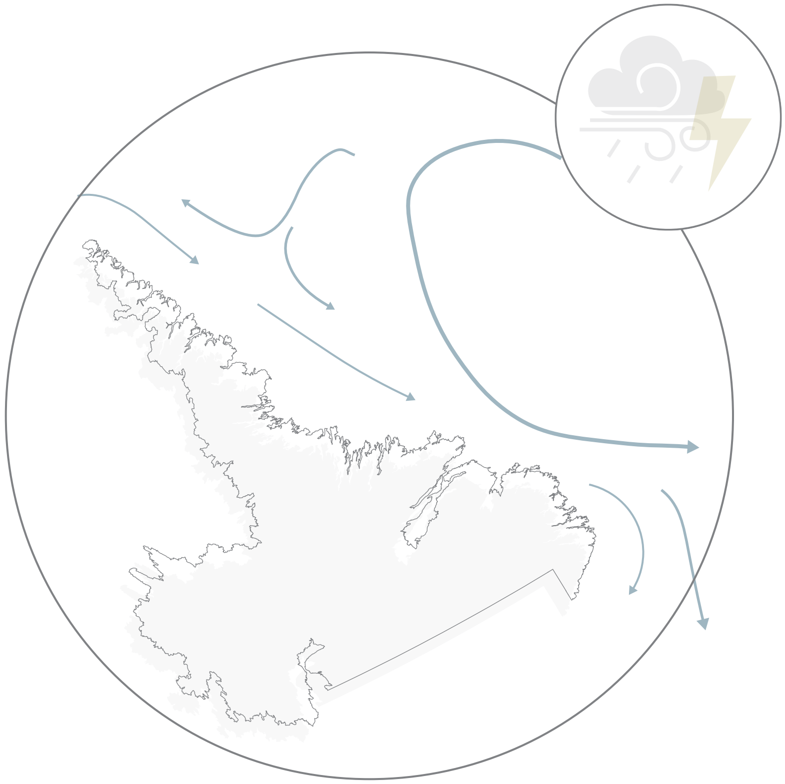


Figure 4.05
The breakdown of the Gulf Stream and Labrador Current along the shores of Labrador results in an increase of erratic weather.

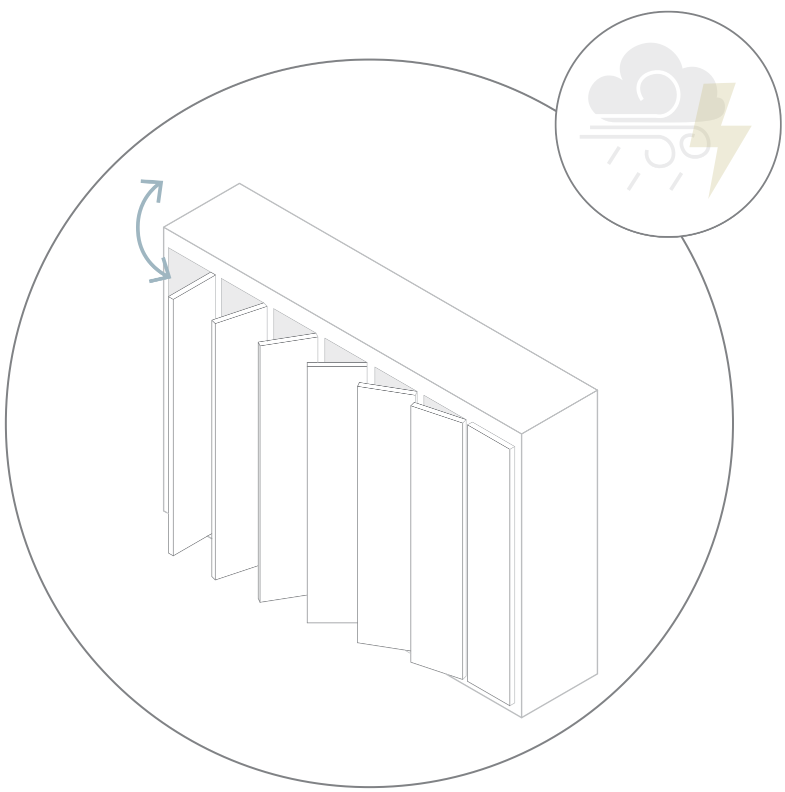


Figure 4.06
Adaptable facades provide opportunity to manually open or close the building to changing weather conditions.

Considering the important need for passive heating in current winter conditions, the increasing need for passive cooling in future summer conditions, and the increasing potential to harness wind for energy production, a well-insulated but dynamic facade, embedded with integrated wind turbines, could provide the solution to each of these issues. Indeed, by developing a facade that is not fixed and solely calibrated for today's climatic conditions, but that is in effect capable of adapting to meet the needs of tomorrow, is vital to a resilient building. This aligns with ongoing industry development on CABS - Climate Adaptive Building Shells - facades, which are able to transform within various spans of time to optimize performance and comfort. Most existent CABS testing - especially in harsh environments - had limited success as it focussed around active systems which resulted in recurring repairs and high operations costs[90]. Applications for the Torngat Mountains Base Camp should thus be based on passive strategies and low-tech manually operated strategies to provide a solution that is resilient, durable, and easy to use by all occupants. An interesting benefit of low-tech manual systems is that they allow user interaction, which means the building can become a pedagogical tool, informing the users on the issues and how solutions can respond to address those. The use of operable panels on the facade (Figure 4.06) can add to the user experience, allowing them to open up the facade to harness the sun and to create visual connections to nature, or to close the facade to protect the building from winds, from the sun, or to create a dark atmosphere inside for presentations, exhibitions, sleeping, etc., during times with long daylight hours.

While Arctic winds are prevalent year round, which is good for energy production, they come in bursts or change direction, which means wind turbines can't provide a constant source of electricity. During the time that the building is occupied, in the summer, solar energy is available in great quantities as the sun is more powerful and present for almost the entire day. Consequently, it would be wise to complement wind energy by solar energy (photovoltaic panels or solar thermal collector panels for example), which would help achieve self-sufficiency, but also increase resiliency as the building would not be dependent on only one source of renewable energy. Solar panels can be integrated on a south facade and/or on sloped southern surfaces (Figure 4.07).

The breakdown of ocean currents additionally results in warmer temperatures in the water and up to shorelines, furthermore resulting in a change in marine animal health and availability. This minimizes the reliability and quantity of land-based food sources for

90 Adele Ricci, Ponzio, C., Fabbri, K., Gaspari, J., & Naboni, E. (2020). Development of a self-sufficient dynamic façade within the context of climate change. A*rchitectural Science Review*, 64(1-2), 87–97. https://doi.org/10.1080/00038628.2020.1713042.

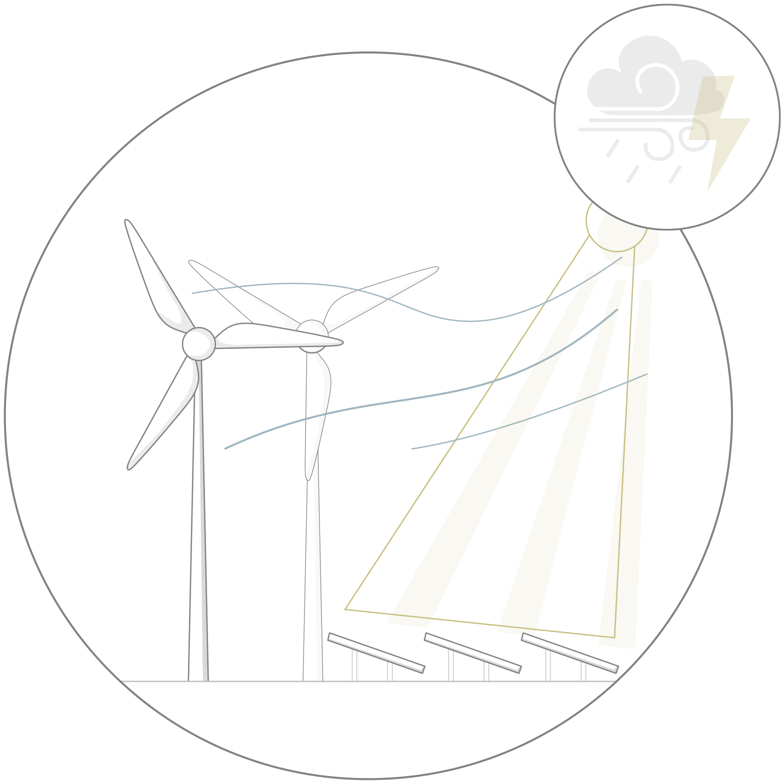


Figure 4.07
Mixed renewable energy production of wind and solar is required to achieve on-site self-sufficiency.

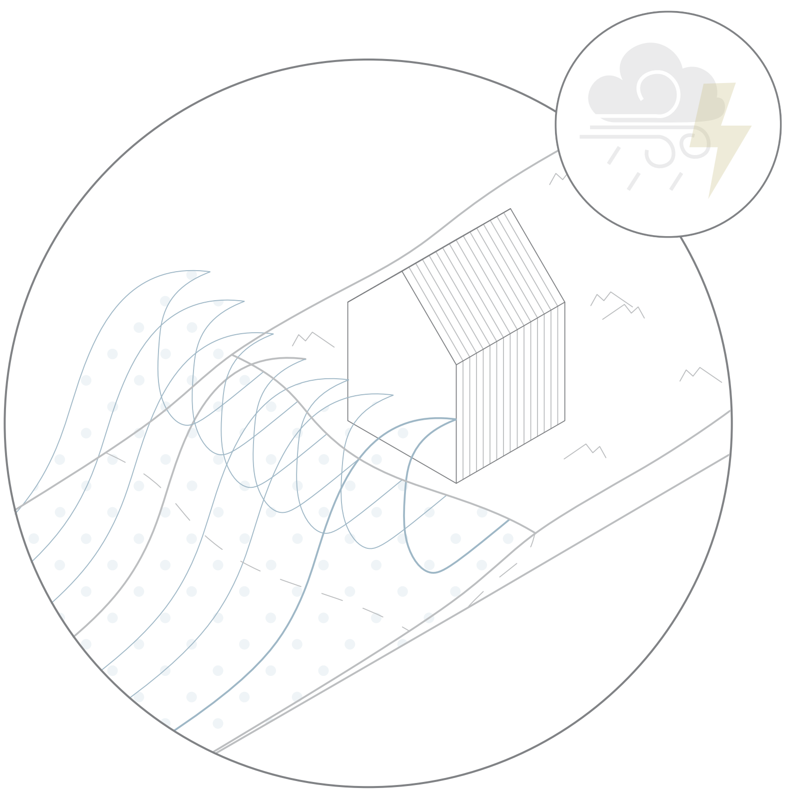


Figure 4.08
Storm surges from increased century storms provide stress on coastal infrastructure and result in a necessity for dryproofing.

hunting and fishing practices, reaffirming the importance of adding on-site food production through a greenhouse benefiting from increased temperatures, as explained earlier. The indoor greenhouse is one component, but this can also be extended to aquaculture with micro-farmed kelp and mussel deposits along the fjord.

The final major aspect of extreme weather taking its toll on the site is storm surges. Storm surges, another repercussion of Atlantic current breakdown, bring with them not only intense waves but also downpour, wind, and unsafe land and water travel conditions. At the shoreline itself, crashing waves result in erosion and washouts of soil and sand deposits putting shoreline infrastructure in peril (Fogire 4.08). Heavy rainfall without proper building and site drainage can result in flooded areas and building damage. Creating an extended overhang on the project along with the adaptable facade could help create another level of separation from the building and the elements. Temperature and moisture fluctuations create a difficult environment for building materials resulting in expansion and contraction that can degrade them over time. The longevity and exposure to exterior conditions need to be taken into account within the design and materials of the project. Storm surge mitigation solutions heavily fall in-line with strategies used to combat other cryosphere related shifts described within section 4.3.

4.3 | Sea Level Rise

> *[The ice] doesn't even freeze up. It's dangerous all the time. The snow goes on top and you can't tell [how thick the ice is], it's really, really dangerous now to travel by skidoo.*
>
> Eli Merkuratsuk[91]

One of the most recognized repercussions of climate change globally comes from the *'spectacular'* comparison images of past and present glaciers, ice caps, the shrinking poles and Arctic animals clinging to their lifeline on the ice. This melting of our frozen water deposits is partially responsible for sea level rise that is only going to continue in the future as warming oceans perpetuate the cycle. In the province of Newfoundland and Labrador, with a coastline of 17540km and nearly 90% of its inhabitants living close to the sea[92], an encroaching shoreline and rising sea levels present major issues.

The predicted sea level rise for the next century does vary significantly worldwide. As was mentioned in section 3.3, Labrador is one of few places in the world undergoing natural uplift. Of the 91 tide gauges across the province, Nain - the northernmost and closest to the site - was the only one which recorded sea level fall within the 1990-2007 test period[93]. This fall was only measured at about 1mm, but is caused by readjustments in the earth's crust, an historic geological processes called 'isostatic rebound'. In the future, the sea level rise affecting the site will be informed by two factors, local uplift which will continue for the foreseeable future, and the global trend of sea level rise. As sea levels rise, driven by climate change, this phenomenon is only expected to accelerate in the future. Sea level at the Torngat Mountains Base Camp is predicted to be at around one metre above current level in 2100[94]. Best practices mean planning for more than this, as the aforementioned tide gauges throughout the province picked up on average over 150% rise from the predicted models at the start of the evaluation period. To play it safe, we should plan for a more catastrophic scenario of sea levels increasing by around two metres.

There are two important implications to consider as potential solutions are considered to address sea level rise. The first resulting implication is on the infrastructure built within the oceans' new

91 Simon. The Caribou Taste Different Now - Inuit Elders Observe Climate Change, 292.

92 D. Liverman. "Past and Future Sea-Level Change in Newfoundland and Labrador: Guidelines for Policy and Planning", 129.

93 Ibid, 135.

94. Ibid, 137.

reach. As sea level rises and storms send water further inland, coastal infrastructure may now be consistently wet and begin to rot and deteriorate (Figure 4.09). Consequently, we need to make sure the infrastructure can resist water damage. The second implication is coastal degradation which is due to crashing waves eroding and affecting the landscape (Figure 4.10). Consequently, we need to make sure the infrastructures will not be affected by this phenomenon; ideally, we would also find ways to protect the landscape from these ecological damages. Despite the fact that the Eastern Arctic has geographical features and elevation on its side to prevent extensive inland flooding, even minor amounts resulting in washouts and erosion present a serious issue. These flooded areas have the ability to hinder transportation routes and reach non-shoreline infrastructure that was otherwise unperturbed to the ocean due to natural barriers, further extending the damage. Solutions responding to flooding and the impact of raised sea levels on infrastructure are to move away from the water, move with the water, or stop the water.

In terms of moving away from the water, a new build can map out expected sea level rise and then move further inland to accommodate for worst case scenarios, (Figure 4.11). This works to mitigate the issue of water reaching infrastructure and degrading the materials. Moving away from the water can also be done vertically, through stilts. When taking into consideration storm surges and waves, stilts alone leave the building in harm's way of the ocean and do not provide the optimal solution. Used in conjunction with setting the project back, stilts put additional distance between moisture and the building as a second level of resilience. Consequently, considering the uncertainty facing expected sea level rise, the best solution may consist of moving back, horizontally, and moving up, vertically, to account for the worst case scenario while doubly providing distance for spring run-off to pass through, without having to locate the building exceedingly far from the shoreline.

In terms of moving with the water, floating infrastructure like that of Figure 4.12 can be used as it moves with the changing sea level. This is not the optimal solution as it is hard to apply to large buildings, it does not protect the building from crashing waves, and could make for a more fragile building that is not very resilient in the face of extreme weather events. Moreover, during the off season when staff are not on site, sea ice will also build up around the project, which could damage the unattended building. For these reasons, a floating structure should not be considered for the main

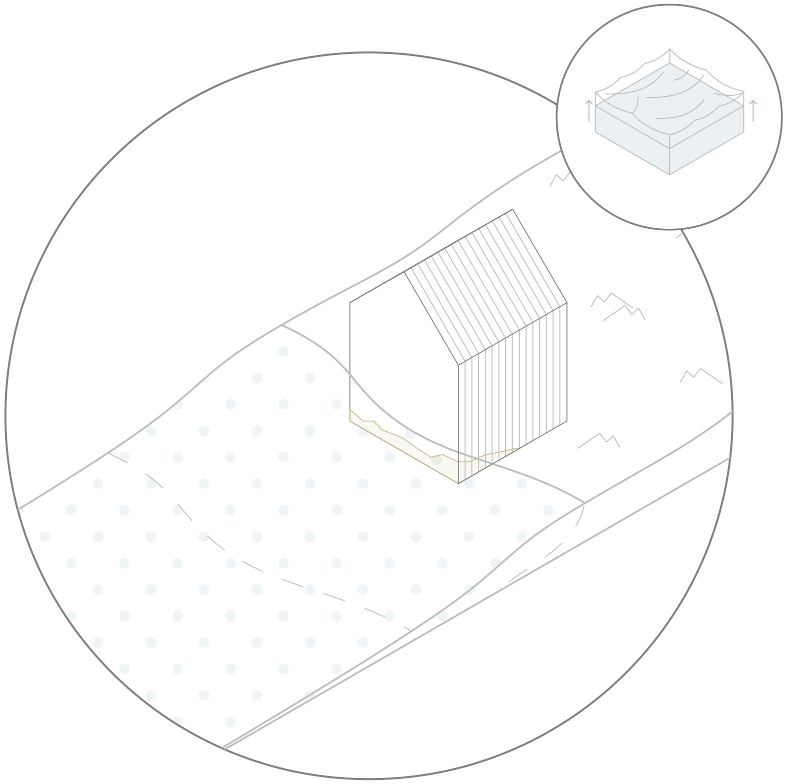


Figure 4.09
An encroaching shoreline puts coastal infrastructure in a precarious position for damage due to moisture and rot.

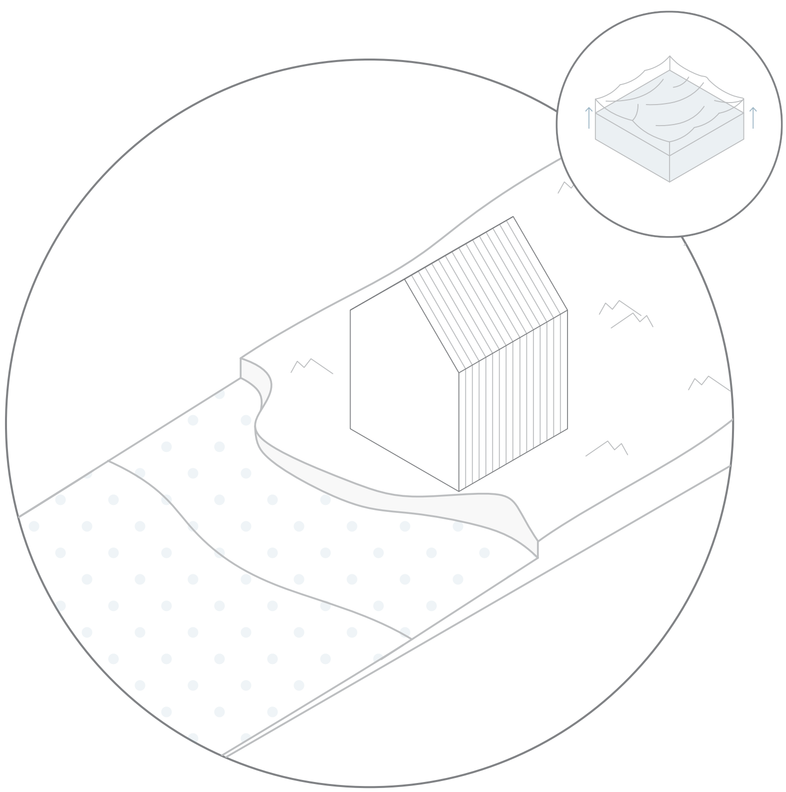


Figure 4.10
Erosion and landslides create issues for buildings near shores and elevation changes.

building and for dealing with sea level rise. However, this strategy is a viable solution for a small component like a dock. Such an infrastructure will be required to support the Base Camp as people and goods arrive by boat, from the Saglek air strip. An infrastructure that is able to rise with the sea level and be adjusted manually back to the new shoreline works well in such a case, as it prolongs the lifespan of such a simple structure. Indeed, this infrastructure has no wires, piping, or other complex systems, which means that the costs will only be minimal if it is to be damaged by the water. Stopping the water is the final broad stroke solution to address sea level rise. While this cannot be done to the scale of stopping global sea level rise, it can be done on-site through dikes (Figure 4.13) or other in-ocean mitigation acting as a barricade for ocean water reaching further inland. This is not the most applicable to this project as it requires massive transportation of materials as well as additional infrastructure, conflicting the economy of means on the site. As the building has the ability to be moved back from the shoreline, this strategy can instead be tested to future-proof smaller, shoreline infrastructure in narrower fjords such as the coastal pavilion in section 6.5.

Whether from the ocean, the ground, or the sky, water making contact and potentially entering the building is an ongoing concern. Dry and wet floodproofing are types of strategies which work to mitigate the effects of this. Firstly, wetproofing applies when a building is not going to be damaged once water penetrates inside, knowing that this is bound to happen. This can be done with materials that will not rot or generate mould when soaked in water, or by locating the water-sensible equipment up so that they don't floor and break. While this is essential in places where water infiltration is next to impossible to avoid, the second type of strategies, dry proofing, provides a better alternative for the environment in question. This applies when an entire building is kept dry, away from water at all times[95]. This can be done through some of the strategies presented earlier in this section. Not having a basement can be a relevant strategy in itself, as it reduces the risks of damages due to flooding. Dry proofing also includes avoiding condensation within walls and at windows by reducing the leakage and thermal shock at these places. Further solutions include ensuring windows and glazing do not extend to the ground where snow and moisture can accumulate around material connections, as well as furthering the 'batten down' principles of the facade within the winter to include thermal and moisture weak points such as doors and mechanical openings. This comparison culminates in dry proofing being the most effective solution for this project, as it aligns

95 Patricia Skinner. "Dry Floodproofing" LSU AG Center. Accessed March 3, 2022. https://lsuagcenter.com/topics/family_home/home/design_construction/design/remodeling%20renovation/preventing%20flood%20damage/dry-floodproofing.

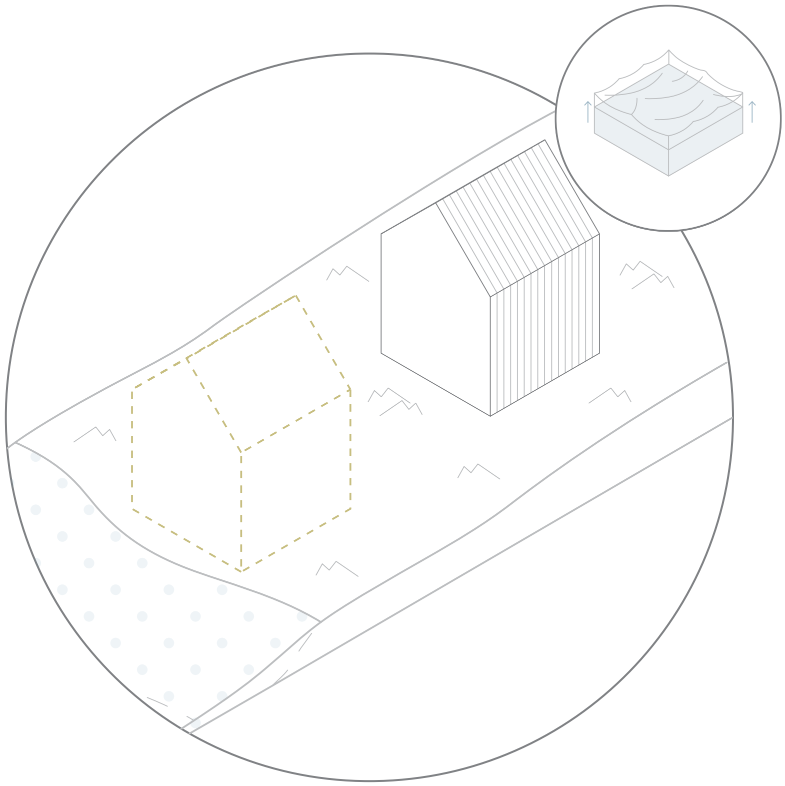


Figure 4.11
Moving away from the predicted sea level rise is a simple strategy for new builds.

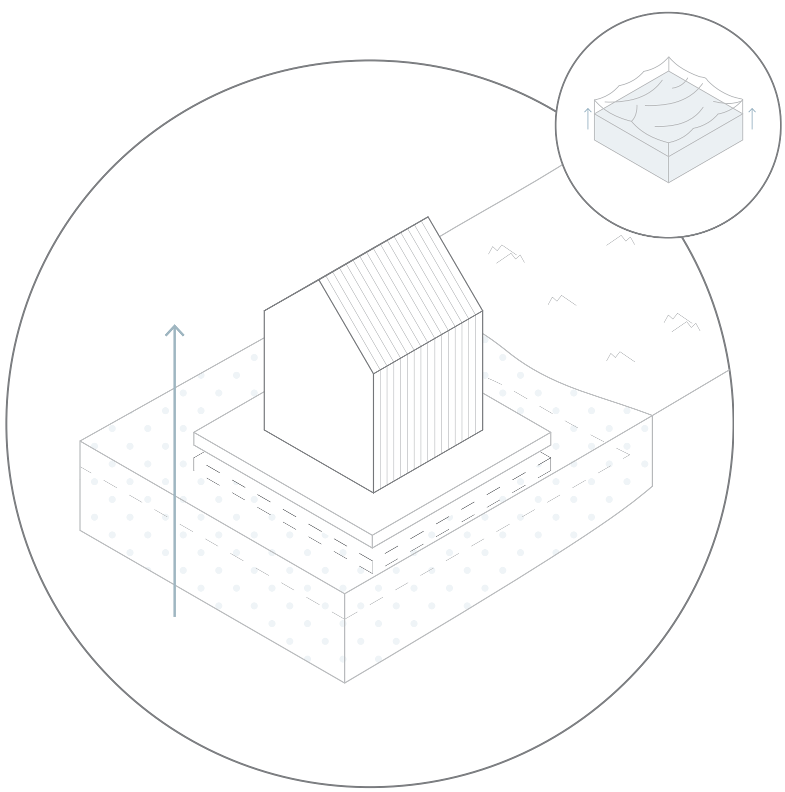


Figure 4.12
Moving with the sea level through floating infrastructure is a mitigation strategy of consideration for shoreline builds.

with an air and watertight envelope that is required within passive design, as well as doubles up with an adaptable facade design to keep out indescribable conditions.

The final corresponding issue of sea water reaching new heights is the increased likelihood of saltwater intrusion into freshwater streams or the water table (Figure 4.14). This impacts plant and animal life and often ruins entire lake ecosystems as freshwater species are overtaken. Caribou and birds similarly find these places inhospitable and they become a dead-zone for most wildlife[96]. Saltwater intrusion also impacts potable water sources for people. The Torngat Mountains Base Camp gets its fresh water from a stream on site. While this nods to the addition of dike infrastructure, the more prudent solution is to follow the principle of moving back and keep all infrastructure out of the oceans reach, meaning the source point for stream water should be set at minimum as far back as the building, ideally up to double.

While preventative systems and blockages can assist with reducing the impact from the shore, the most reliable solution is to move the building away from the problem and keep it dry. Moving away from the water will be the core strategy for this project. Stilt systems will additionally be integrated on smaller building components where the potential of runoff from slopes beckons for more distance between infrastructure and ground. Moving with the water will be used for the dock. Stopping the water is only to be used on a smaller scale within one of the National Park Pavilions to minimize waves and pack ice reaching a floating building[97].

96 Ed Struzik. "As Arctic Sea Ice Retreats, Storms Take Toll on the Land" Yale Environment 360. June 2011. https://e360.yale.edu/features/as_arctic_sea_ice_retreats_storms_take_toll_on_the_land.

97 See section 6.5, Coastal.

Figure 4.15 (Following Page) A wayfinding Inukshuk placed on the landscape, acting as a landmark or in commemoration.

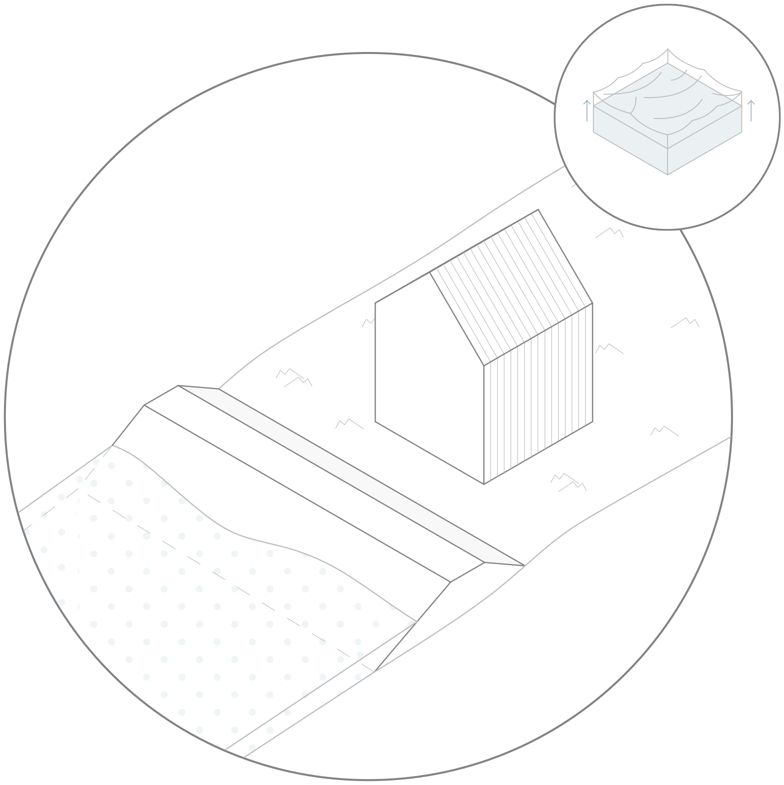


Figure 4.13
Dikes and other in-ocean blockages can stop the way from damaging inland ecosystems or existing buildings.

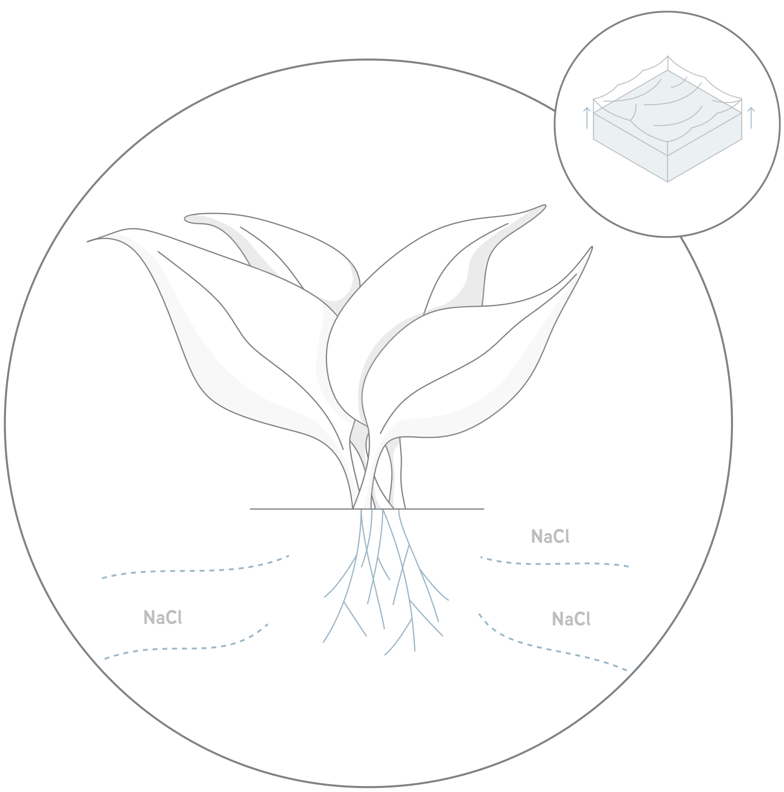


Figure 4.14
Rising sea level and storm surges increase the risk of salt-water intrusion into the water table, damaging ecosystems and contaminating fresh water supply.

4.4 | Ground Thaw

> *There used to be ice under the ground, and we used to [gather] ice for melting water. These days there's nothing like that; there's no ice under the ground anymore.*
>
> Edward and Louisa Flowers[98]

Permafrost thaw is the most prevailing issue that Arctic infrastructure is facing as this ice-bearing frozen ground is the physical support for human and animal ecosystems alike. Broken down, permafrost is when soil, sediment, or rock in the ground remains below freezing temperatures for at least two years consecutively. In addition to the loss of structural support for buildings, the melting of permafrost also has other dire consequences for the entire planet. Indeed, almost one quarter of the entire Northern Hemisphere is underlain by permafrost, and it contains nearly 1.7 trillion tons of carbon dioxide - this is considered to be twice as much carbon as is in the atmosphere today[99]. When the earth warms, permafrost melts, releasing carbon (Figure 4.16). The melting of permafrost will thus contribute to the acceleration of global warming, further worsening the climate crisis.

There are two primary layers in permafrost ground composition, the first being the active layer. This is the depth of ground that freezes and thaws each season, ranging from as thin as a few centimetres to as thick as a few metres, being at its thickest at the end of the warming season - late summer or early fall. Below that is the frozen layer, which is permanently frozen year round. Beneath that is, at some point, bedrock. Northern Nunatsiavut and the edge of the Torngat Mountains National Park sits somewhere on the border between continuous and extensive discontinuous permafrost zones, meaning that between 50 and 100% of the area is underlain with permafrost from a few to hundreds of metres in depth[100]. Areas where it may not be present consist of exposed bedrock, south facing slopes, places with thick tree cover, or below rivers or large lakes. Permafrost and underground ice build-up are often uneven, the melt resulting in sinkholes and collapsed land that disrupts waterways, transit routes, and infrastructure as well as causing landslides and erosion.

98 Simon. The Caribou Taste Different Now - Inuit Elders Observe Climate Change, 298.

99 Kenyon Wallace. "Beyond Frozen" The Star. July 2019. https://projects.thestar.com/climate-change-canada/nunavut/.

100 Antoni Lewkowicz, and Way, R. "Overview Report for Nunatsiavut Government on Permafrost Conditions in the Nain Area" University of Ottawa, Department of Geography. July 2014.

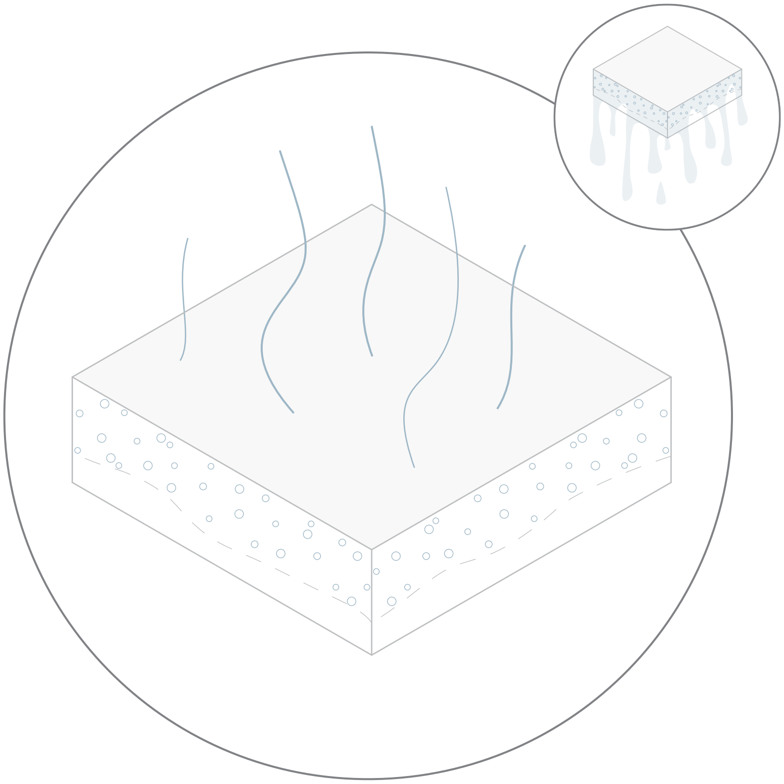


Figure 4.16
Permafrost contains a dangerous amount of carbon dioxide which will be released into the atmosphere through thawing.

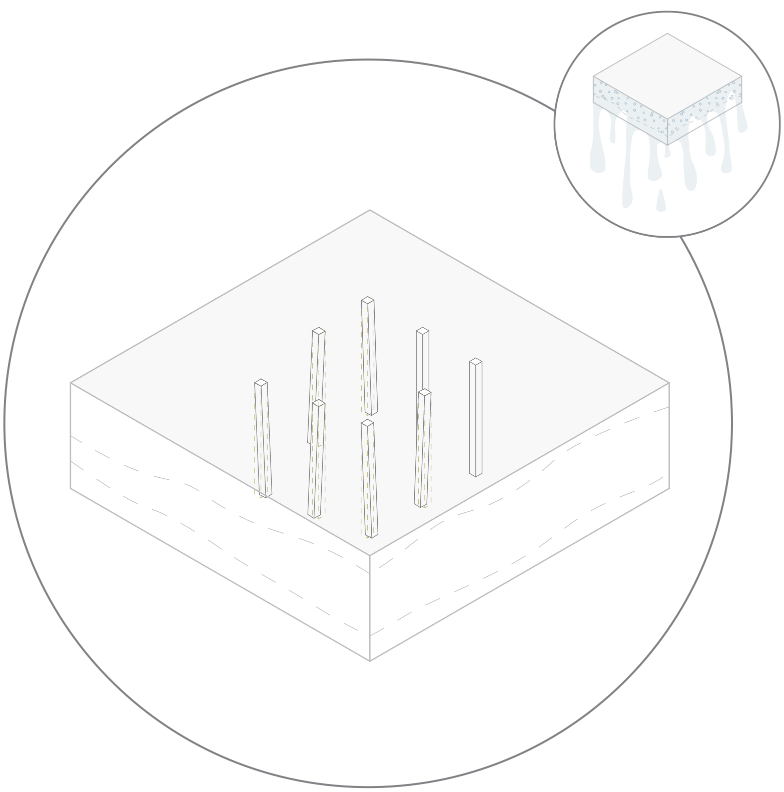


Figure 4.17
Piles constructed within the increasing active layer will begin to shift, damaging existing infrastructure.

The main issues affecting buildings which arise from permafrost thaw and a warming climate is that the active layer grows, resulting in instability and creating uneven terrain. Buildings that are currently built on the ground or even reaching to what was previously the top of the frozen layer will now begin to shift, resulting in cracks, foundation damage, air and water leaks, and even collapse (Figure 4.17). Knowledge of permafrost thaw and its impacts on infrastructure has been known for decades. After much development, there are now multiple well-known strategies within the industry that help to both mitigate the impact of localized thaw, but also provide resiliency for new buildings to adapt to thaw caused by global factors. The primary method for this is through piles that are driven until the point of refusal, or ideally bedrock[101]. Even when piles are driven to the point of refusal in a decades-old frozen layer, there is still potential for shifting and instability due to the constantly changing climate. Because of this, better permafrost and ground mapping in the Arctic is essential to pinpoint areas where bedrock can be reached in order to construct new buildings and infrastructure there[102]. When this is not possible, or on existing infrastructure, adaptable piles or foundation repairs which allow readjustments are an adequate solution (Figure 4.18). When even the slightest misalignment is addressed and readjusted immediately, this drastically reduces the stress on the entire building, therefore prolonging its lifespan.

Localized conditions can also impact permafrost thaw and building stability. When buildings are constructed low to the ground, snow drifts pile up around them (Figure 4.19). Snow is an excellent insulator but in this instance it is insulating the wrong thing. In these situations, the snow is keeping the active layer warm and not allowing it to properly freeze during its winter cycle. When the warmer season arrives, the active layer reaches deeper as it does not need to undergo its initial thaw. In an attempt to combat localized thaw caused by snow drifts and pile up, the building should be raised adequately (Figure 4.20). This is easily incorporated with pile foundations and allows the ground below the building to remain cool year round and reduces the points of contact to the earth.

Taking into account the Inuit observations of change prefacing this section, the availability of freshwater on site needs to be considered in response to this issue. The lack of freshwater availability due to reduced amounts of permafrost in the ground does present an issue in many surrounding regions. However, due to the site of the Torngat Mountains Base Camp being on primarily bedrock and near running freshwater streams, this means that freshwater supply is not a critical issue. Not only is there minimal permafrost to

101 John Nixon and Edward McRoberts. "A Design Approach for Pile Foundations in Permafrost" *Canadian Geotechnical Journal*. Vol 13(1). (2011) DOI:10.1139/t76-005.

102 Michel Allard et al. "Permafrost and Climate Change in Nunavik and Nunatsiavut: Importance for municipal and transportation infrastructure" *Permafrost and Infrastructure*.

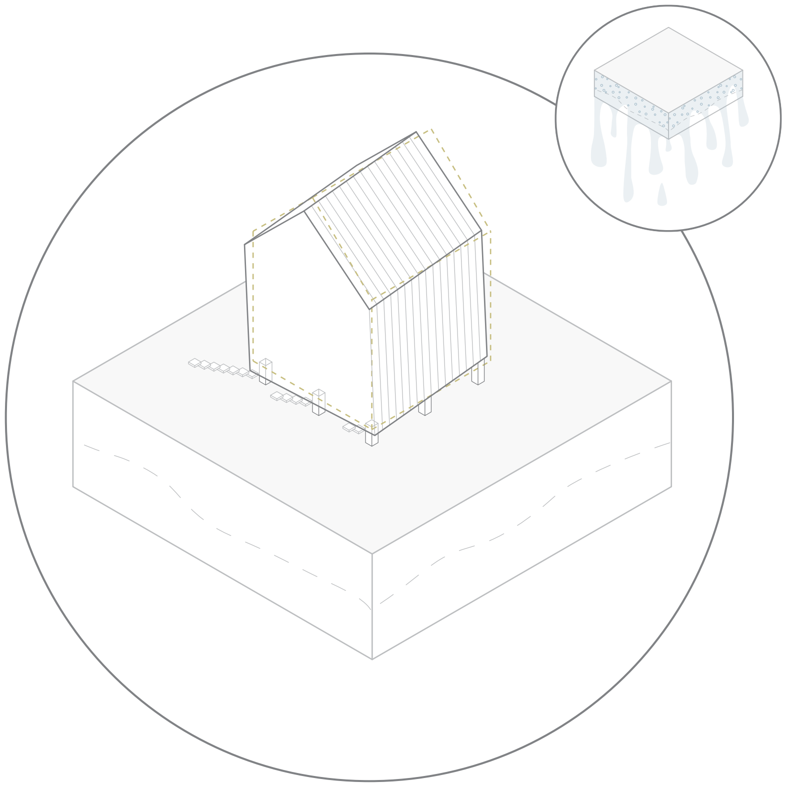


Figure 4.18
For existing constructions, monitoring and urgently adjusting piles can prolong building lifespan.

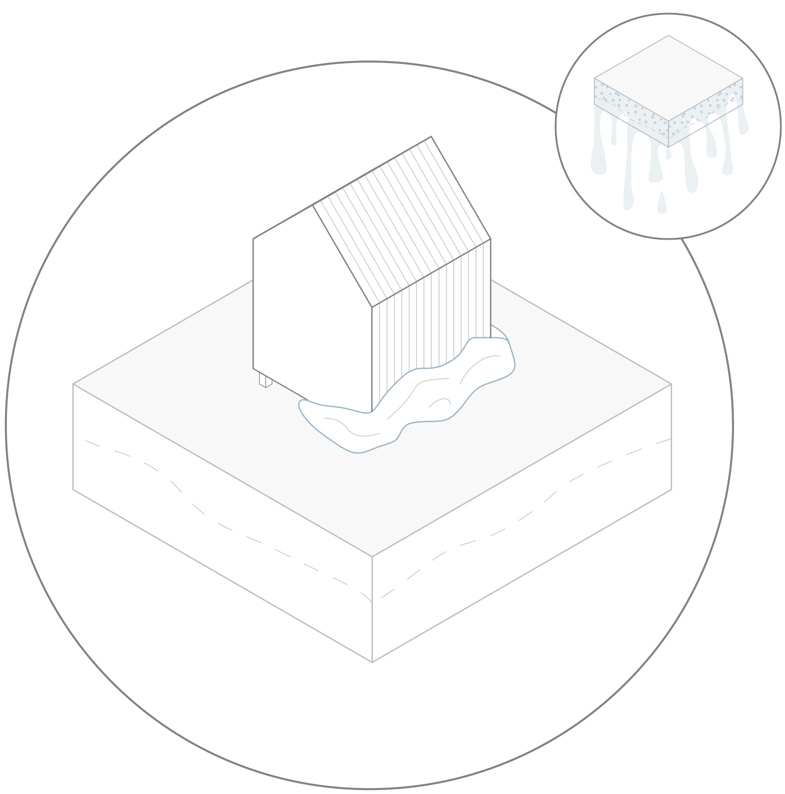


Figure 4.19
On-grade buildings result in snow pile-up, causing localized thaw to the permafrost below.

source from, but a running water source remains usable year round, additionally supported by the project being in operation only three seasons.

A future-proofed building needs a literal strong foundation to stand on (Figure 4.21). Understanding and finding the proper ground on-site for buildings and its adjacent solution is the first step to ensuring their longevity in the changing landscape. In terms of the Torngat Mountains Base Camp, the site has mostly exposed bedrock with small pockets of shallow sand and sediment-like ground cover. The tried and tested method for this ground composition is piles to bedrock and the main building should follow this, while remaining slightly raised to allow airflow underneath. Areas with more sand and silt cover or patches of discontinuous permafrost should raised higher to minimize snow build up and reciprocal thaw. In landing on piles as the optimal future-proofing strategy here, initial connections can be drawn between various issues and solutions. For example, in the previous section, *Sea Level Rise*, stilts are an applicable method for buildings near slopes where more runoff may occur, thereby requiring the building to have more separation from the ground. Doubling this with piles and infrastructure needing to combat localized thaw, the project can begin to create a resilient system which tackles a variety of climatic issues through simple and robust systems.

4.5 | Disruption of Seasonal Reliability

> “*It's especially hard on the hunters and providers because they can't get out on the land. They feel stuck. We're like an island, really. We need the ice to connect us.*”
>
> Paula McLean-Sheppard[103]

The fourth issue of climate change majorly impacting the site is one that is perhaps least quantified through science, but felt most strongly by the people living on the land. That is of seasonal disruption and its resulting issues of isolation on site. While remoteness in itself is a situation of place, the unreliability of generations-old land-use practices along with the erratic changes in food supply and animal migrations makes this separation from food sources an inclusive cultural, economic, and health issue[104]. Not

103 Greg Mercer. “Sea, Ice, Snow… It's all changing - Inuit Struggle with warming world”. The Guardian. May 30, 2018. Accessed October 20, 2021. https://www.theguardian.com/world/2018/may/30/canada-inuits-climate-change-impact-global-warming-melting-ice.

104 Ashlee Willox, et al. “From this place and of this place: Climate change, sense of place, and health in Nunatsiavut, Canada” *Science Direct.* Vol 75. No 3. (2012). https://doi.org/10.1016/j.socscimed.2012.03.043.

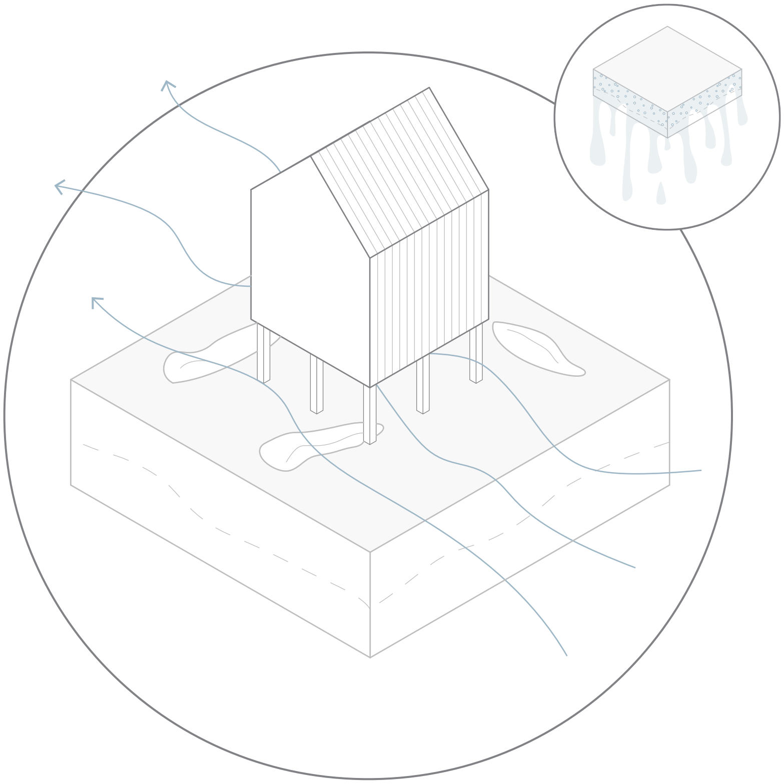


Figure 4.20
Raising the building to allow airflow not only reduced localized thaw but assists with dryproofing.

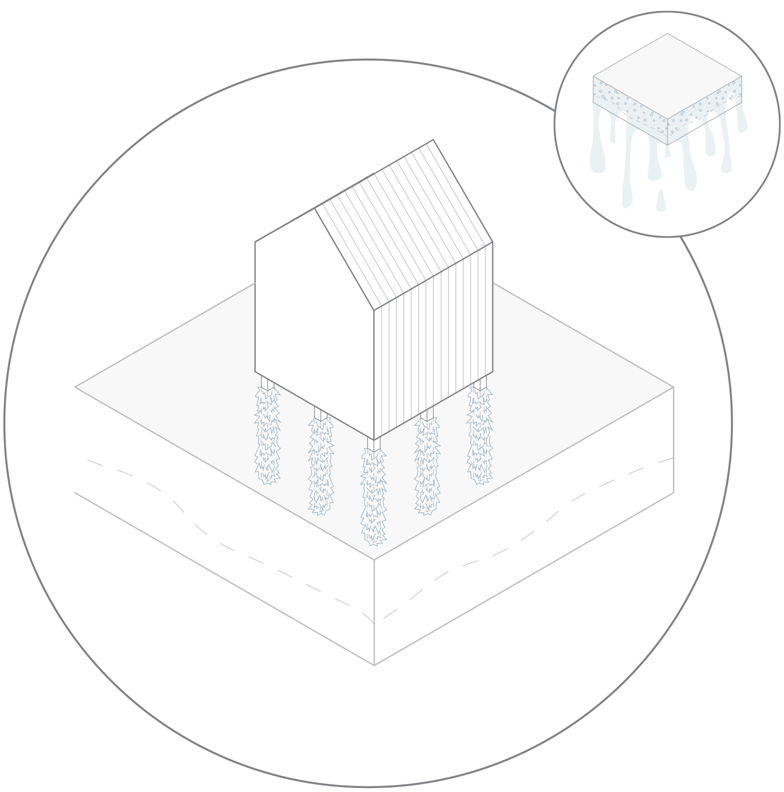


Figure 4.21
A strong pile foundation embedded into solid ground supports the buildings longevity.

only that, but as with Indigenous cultures globally, land is life to the Labrador Inuit, and a changing climate disrupts the knowledge and understanding from time immemorial. As patterns change, the ice thaws, flora die, fauna move, and the regional livelihood also risks disappearing.

These ecological shifts along with political influence and conflict have developed over decades into an Arctic-wide reliance on southern fuel, goods, and food supply that has skyrocketed the cost of living (Figure 4.22). This has abetted a food insecurity crisis, which is affecting residents of Nunatsiavut at a rate of more than twice the National average[105], promoting the possibility for pedagogical agriculture within the Base Camp's programmatic planning. Many societal changes have left youth unprepared to live with the land even if climate shifts were not a major issue[106]. When country food can make it through to harvest, crops are not as bountiful and the quality is understood to be changing[107]. Hunting has become more treacherous as the thickness of the ice is unreliable as well, with ice breaking early or not freezing at all (Figure 4.23). Consequently, many hunts cannot be followed through. The issues that surround food acquisition in major Nunatsiavut communities are not indifferent from that of the Base Camp, and issues such as freeze-thaw and late frost (Figure 4.24) make local foods unavailable. The Torngat Mountains Base Camp currently feeds its inhabitants by recurring deliveries of southern food throughout the occupied season. As extreme weather persists among a changing climate, the risk of being cut off due to storms heightens, resulting in an operation without food supply.

As has been acknowledged throughout Chapter Two, some changes to the climate, and indirectly to the livelihood of people living off the land, are unavoidable. It is thus essential that we work to slow down the speed at which changes are happening, so that regions can adapt to live in the changing conditions. Relying less on traditional hunting and fishing is unfortunately inevitable, which emphasizes the need to incorporate other food production techniques into the livelihood, such as producing vegetables and fruits in a greenhouse. That being said, this cannot physically or spiritually fully replace the importance of country food, and we can only hope that climate change mitigation will be a key priority in the future in order to limit the need for more dramatic adaptation, allowing for the preservation of traditional ways of life on the land, even if this livelihood has been disrupted by the climate crisis.

By preserving country food, and teaching Inuit youth how to hunt and fish on the land at the Base Camp, the goal is to preserve

105 Bell. "Planning Sustainable Nunatsiavut Communities from the Ground Up." (https://www.northernadaptation.ca/sites/default/files/8_mapping_and_community_planning_in_nunatsiavut_-_bell_0.pdf), 9.

106 Watt-Cloutier. *The Right to Be Cold: One Woman's Story of Protecting Her Culture, the Arctic, and the Whole Planet,* xvi.

107 Simon. *The Caribou Taste Different Now - Inuit Elders Observe Climate Change,* 298.

Figure 4.22
Absurd food costs create food insecurity and skyrocket the cost of living in Northern communities.

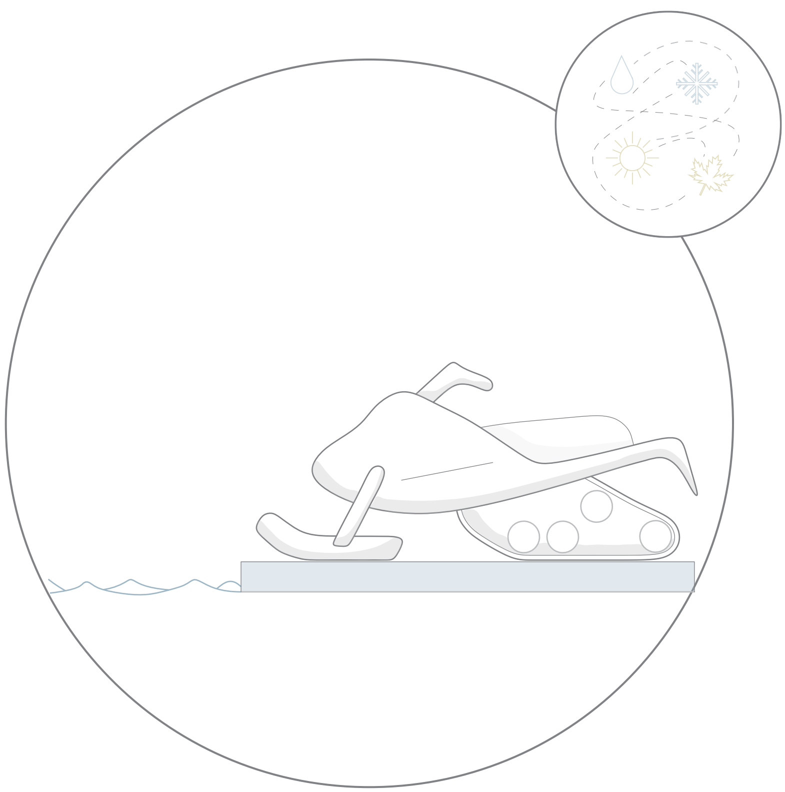


Figure 4.23
Melting ice coverage and shorter winters create unsafe and unreliable hunting routes.

a way of life that is entirely self-sufficient and not reliant on imports from the south, as is currently the situation. The 2017 Nunatsiavut tourism plan brief states that more country food opportunities and experiences are to be integrated, providing a higher quality of food for the staff and visitors[108]. Previously mentioned in section 5.2, warming temperatures and long daylight hours provide conditions which, when incorporated with proper spatial planning, create a successful environment for food production through greenhouses or hydroponics.

The three essential components of food self-sufficiency are simply stated as produce, process, and prolong. Incorporating on-site growing into the Base Camp's operation could mostly be done through hydroponic and vertical growing systems (Figure 4.25). Hydroponics is a soilless branch of horticulture which allows plants, generally crops, to grow in a nutrient rich water solution. Hydroponics produce 30-50% faster and have a 30% higher output than soil plants due to the fact that it relies on vertical stacks and a highly controlled environment[109]. Due to the shorter season of operation at the Base Camp, a system with a reduced lead time at the start of each season and seed to maturation time frame is vital for food to be ready when the majority of researchers and guests begin to arrive. Indoor farming through various ponic systems has been proven to work in Arctic communities with precedents in Alaska[110], Svalbard[111], and Nunavut[112]. The Torngat Mountains Base Camp not only operates for three seasons, but it additionally sits at a lower latitude than any of these case studies which rely on artificial lighting and heat lamps in a windowless environment, both indicating the potential for a successful operation at near 60 degrees North.

Incorporating as many familiar country food varieties such as berries, sorrel and roots with additional fresh food with shorter maturation periods and shallow roots provides a balance of locality and consistent supply to the operation. The adaptive architecture strategies mentioned earlier, which could allow the battening down of the building, could help insulate the building and conserve heat in the building during the off-season (winter). This would help seeds and longer germination plants survive the cold season with little heating energy input. Additional on-site food supply could be produced through aquaculture. Bivalves such as mussels require no feeding, no agrochemicals, and next to no tending to until harvest[113]. Uniquely, their growth also sequesters carbon! Kelp is another low maintenance aquaculture that could be easily implemented into the fjord and gathered in short distances from the site. To achieve self-sufficiency and assist with food production, water collection should

108 Arsenault. *Nunatsiavut's Tourism Strategy 2014-2020. A 2017 Mid-Point Review and Tactical Update*. (https://www.nunatsiavut.com/wp-content/uploads/2014/02/2017-Tourism-Strategy-Refresh.pdf).

109 Greentrees Hydroponics. "Hydroponic Gardening for Beginners." Greentrees Hydroponics. Accessed November 22, 2022. https://www.hydroponics.net/learn/hydroponic_gardening_for_beginners.php.

110 Rachel D'Oro. "Growing Food with Hydroponics could provide Lifeline in Arctic". Popular Mechanics. November, 2016. Accessed October 27, 2021. https://www.popularmechanics.com/technology/a23723/hydroponics-arctic/.

111 David Nikel,. "Achieving the Impossible: Growing Food in the High Arctic" Forbes. 2019. https://www.forbes.com/sites/davidnikel/2019/04/13/achieving-the-impossible-growing-food-in-the-high-arctic/?sh=afcd35f111ce.

112 Greta Chiu. "A Haven for Northern Growth" Greenhouse Canada. 2020. https://www.greenhousecanada.com/a-haven-for-northern-growth/.

113 Rachel Lovell. "The Simple Food that Fights Climate Change" BBC. Accessed March 2, 2022. https://www.bbc.com/future/bespoke/follow-the-food/the-simple-shellfish-that-fights-climate-change.html.

Figure 4.24
Erratic freeze-thaw cycles damage potential country food harvests.

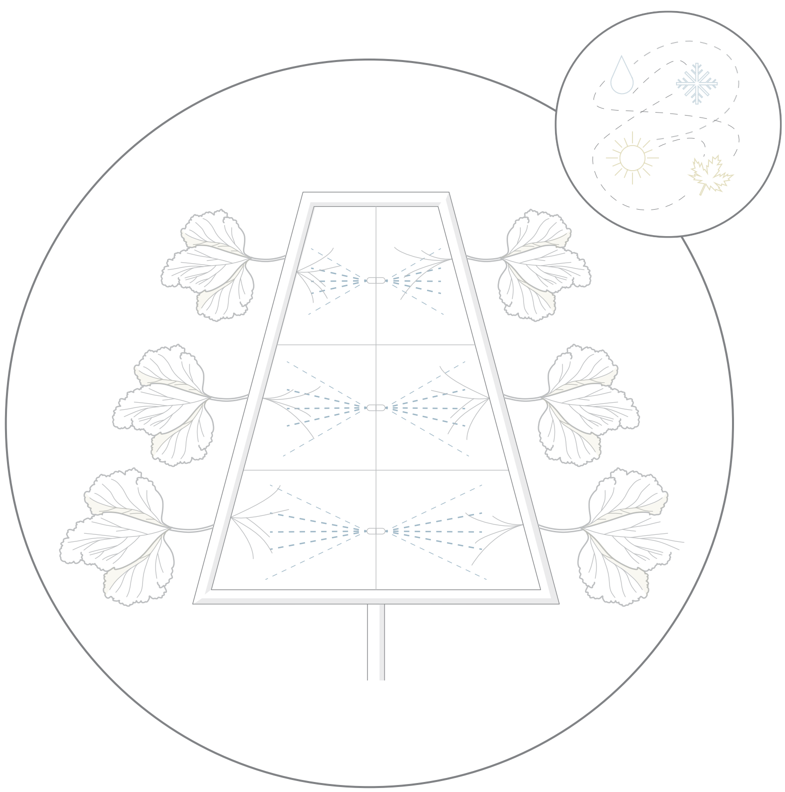


Figure 4.25
Indoor agriculture provides opportunity for consistent food supply in remote regions.

also be considered to address freshwater needs in the building. Not only could there be water collection from the stream running through the centre of Base Camp, but the building form can also support an efficient rainwater collection strategy to complement stream water collection (Figure 4.26).

The second necessity is spaces to process. The Inuit of Nunatsiavut not only have hunting and fishing rights to their own self-governed land, but exceptionally to the National Park as well. From the site, a variety of birds, fish, land and marine animals can be hunted. While the supply may not be as great as before and the quality not as high, hunting and fishing still provide major health and cultural benefits to the hunters/fishermen, their community, and those who can learn from this traditional way of life. The gathered country food requires room to be processed in the traditional way, which is an important part of the pedagogical objectives of the Base Camp. This is quite different than what Euro-Canadians expect from a food processing room, like a kitchen, as this was traditionally done on the ground, often outside[114]. The most important of these is a space for cleaning and butchering the hunt, as well as adjacent tools and racks for drying both the meat but also the associated skin or hide. Preparing and sharing a hunt has traditionally been a social gathering event, as well as a way for youth to learn about their country food[115]. In order to support the traditional way of life and to allow for the teaching and preservation of this livelihood, the building should contain a centrally located space to process food and teach about this process. This space should have an interior as well as an exterior component and should allow many people to gather around to engage and observe the process.

The final requirement to a reliable food network is the element of prolonging (Figure 4.27). While hydroponic and indoor growing systems extend the food production season, local harvests and hunts nevertheless need room to be preserved and held for the duration of the in-use season. Organizing these spaces which require less heating on the Northern side of the project could help create an efficient thermal buffer to protect the occupied southern spaces that are visually connected to the land and harness solar radiation.

Proper facilities for growing, drying, storing, and freezing various food types is critical to create a closed loop on site. Ensuring through design that each of these stages of food self-sufficiency are optimally incorporated as well as providing pedagogical opportunities for those skills to be taken back to the users home communities is vital to adapting towards the livelihood shifts of climate change.

114 Robert Bone. *The Canadian North: Issues and Challenges*. 3rd Edition. Don Mills, Canada: Oxford University Press, 2009.

115 Watt-Cloutier. *The Right to Be Cold: One Woman's Story of Protecting Her Culture, the Arctic, and the Whole Planet*, xvi.

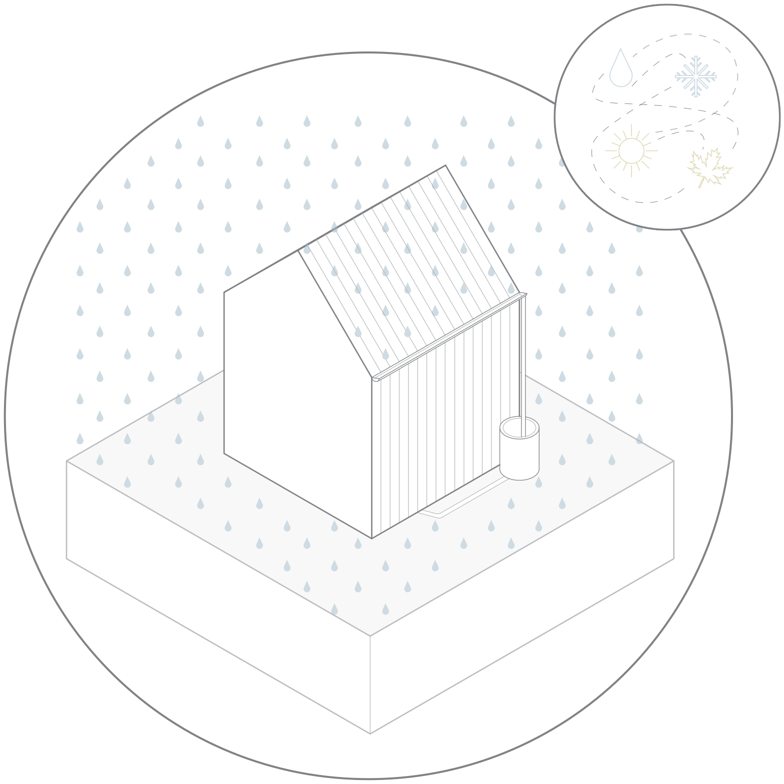


Figure 4.26
Rainwater collection is essential producing food on-site and furthermore operating self-sufficiently.

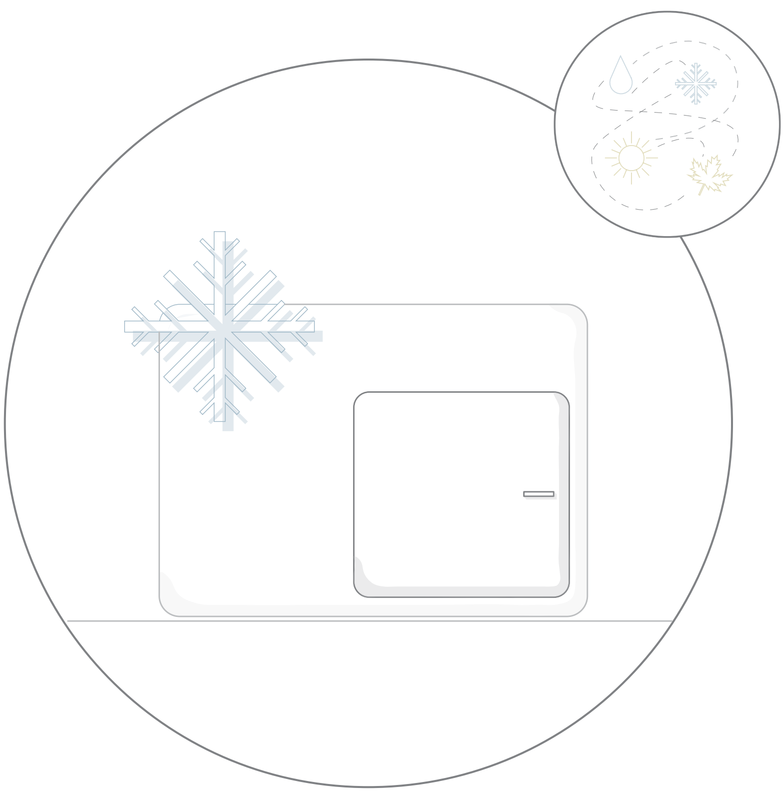


Figure 4.27
Preserving and prolonging food sources is key to sustaining the sites users with no off-site interference.

Figure 5.01
Wildflowers making an appearance in the Torngat Mountains National Park.

5 LEARNING FROM THE LAND

What cannot be ignored in Designing for Tomorrow is also an understanding of the past. Those who have lived with the land for generations understand its inner workings best and have been the first to note its changes. Inuit observations of climate change are vital to complement quantifiable scientific findings to validate and inform the changes occurring on the land. When referring to the scholarship of bioclimatic and passive design principles in a cold climate, these have been understood long before their written documentation and have been developed from an understanding of the land and formulated into vernacular architecture that has adapted to the environmental conditions of the place for centuries. Indigenous peoples have also been the stewards of the land for generations. The Traditional Ecological Knowledge[116] (TEK) which comes from this connection of people to the land and practices of living with the land are essential to respect, understand, and incorporate into the design and organization of the project. Consequently, the first contained section will investigate land-based ecological lessons, while the second will investigate land-based cultural lessons, in order to identify design strategies or guidelines that can support the upcoming design. Those will complement the strategies and principles pertaining to future-proofing architectural theory which have been identified in the previous Chapter.

116 Traditional Ecological Knowledge is a combination of observations, experience, practice, beliefs, and skills about life and living on the land, which has been transferred through generations.

5.1 | ECOLOGICAL LESSONS

Lessons learned from the ecology of a place include how plants and animals, as well as humans, act, adapt and thrive in their environment. This includes an examination of how vernacular buildings were designed in direct response to the local climates and how these traditional strategies can be included in contemporary design. Additionally, this includes an understanding of how biophilia can inform the design so that the building can adapt to seasonality.

Firstly, in order to identify architectural strategies that could be used to inform the design within Chapter 6, it is essential to start with the investigation into vernacular architecture, considering that traditional local buildings and strategies

> *"Provide information on local and global solutions that Arctic cultures have developed to adapt to varying local climates and resources for thousands of years. Therefore, vernacular architecture contains a wealth of knowledge on a global scale that can be applied to solve present-day problems of sustainability[117]."*

The Inuit have been a semi-nomadic culture (Figure 5.02) with seasonally specific structures that travelled with them or were crafted from the minimal resources that a treeless expanse had to offer. From the most identifiable igloo, to the summer skin-tent (tupiq) dwelling, to their predecessors, the whale bone and pit house, each building provides ecological lessons of climate responsiveness, locality, and seasonality[118]. The aim is thus to understand the site-specific strategies and how they respond to the environmental conditions and the traditional way of life, and not to imitate or reproduce vernacular forms for the simple purpose of mimicking the past. Indeed, it is essential to avoid the caricature and iconographic architecture that is often stereotyped in these regions[119].

The igloo and skin-hut are temporary dwellings, lightly sitting on the land, that are well adapted to environmental conditions to provide comfort to inhabitants while using very little resources. Indeed, we can learn from the fact that the igloo relies entirely on passive design strategies, meaning that comfort in a very cold climate is maintained without the need for energy-consuming active

117 Kuittinen. "Zero Arctic: Concepts for Carbon Neutral Arctic Architecture based on Tradition.", 7.

118 N.P. Mackin. "Future Architecture, Ancient Wisdom: Adaptable Structures from Arctic Tradition" *Int. J. Comp. Meth. and Exp. Meas.* Vol. 5, No. 4. (2017). (DOI: 10.2495/CMEM-V5-N4-583-592), 589.

119 Brett MacIntyre. "Unknown Ground: The Case For Ambiguity in Indigenous Design" (2016), 2.

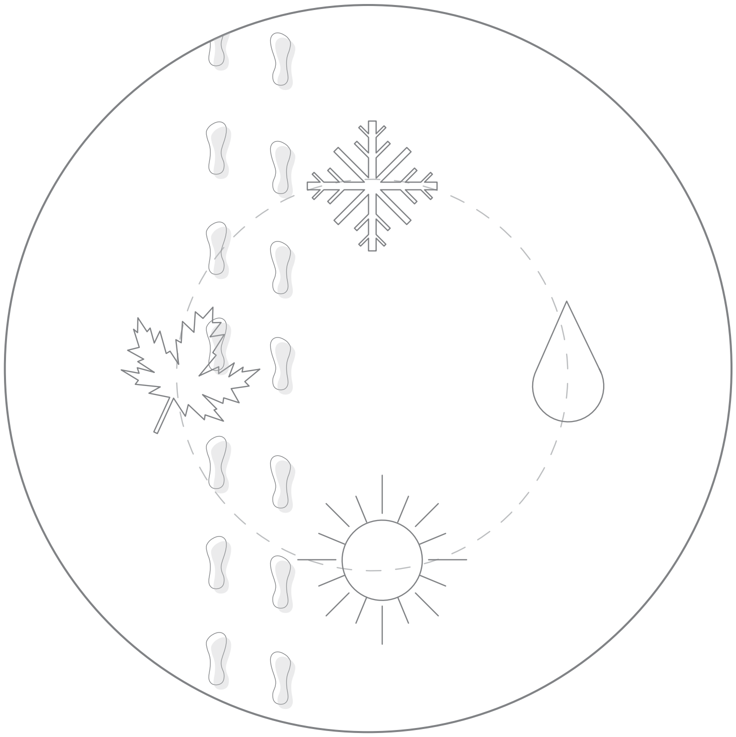


Figure 5.02
The seasonality and semi-nomadic nature of the Inuit culture is key to reflect in site buildings and operations.

Figure 5.03
The igloo's principles of heat management and low thermal conductivity translate to passive design strategies.

systems. The igloo is mostly constructed of packed snow, which has a very low thermal conductivity due to the fact that it is mostly made of trapped stagnant air (Figure 5.03). When used to create a thick layer, this provides a well-insulated envelope to efficiently manage heat transfers[120]. Consequently, it is essential to rely on a highly-insulated envelope for the Thesis Project, and ideally it should be built with local, sustainable, and eco-friendly materials, to tie the building to the place, but also to go back to the notion of being good stewards of the land. Moreover, other strategies to improve the thermal performance of the building should be considered, in addition to thick insulation, such as thermal buffers, to do everything possible to reduce energy use.

Both the igloo and the pit house share additional thermal strategies worth looking into. The idea of cold sumps or 'suspended basements' refers to the notion of entering the building from a slightly lower level before moving upward to the living and sleeping spaces, the principle of which is captured in Figure 5.04. This allows cold air to sink and be trapped below, while heat moves up into the areas where people gather[121]. Small openings are also often located at the top of these dwellings in order to allow light to enter, but also to allow for stack ventilation. Consequently, this 'suspended basements' strategy is worth considering for the design of some spaces like the accommodation cabins, where it would be easy to implement in a small space, not unlike an igloo. This would provide a comfortable raised sleeping zone for guests without having to heat the entire space to the same temperature, reducing energy use. Moreover, the use of a skylight at the top of that same space could help provide daylighting near the beds and facilitate the evacuation of heat on warmer days, through stack ventilation, to avoid overheating in the sleeping zone.

These nomadic dwellings were often left for a time and returned to when that site was once again seasonally optimal for its connection to water or near migration routes. This opens the potential to develop an architecture that could be less permanent, for example by using modules that could be adapted, moved, or removed based on the seasonal and long-term needs as weather and climate conditions change in the near as well as distant future.

Indeed, from vernacular to biota to land-use practices, seasonality is an essential component to the Inuit way of life; this needs to be reflected in the contemporary buildings as well, adapting its needs for the seasons. Arctic flora and fauna provide excellent inspiration for this through their resilience to harsh environments

120 N.P. Mackin. "Future Architecture, Ancient Wisdom: Adaptable Structures from Arctic Tradition". (DOI: 10.2495/CMEM-V5-N4-583-592), 589.

121 Carol Brice-Bennett. "Inuit" Heritage Newfoundland and Labrador. Accessed September 27. 2021. https://www.heritage.nf.ca/articles/aboriginal/inuit.php.

Figure 5.04
The heat sump principle creates temperate sleeping and living spaces by trapping cold air below.

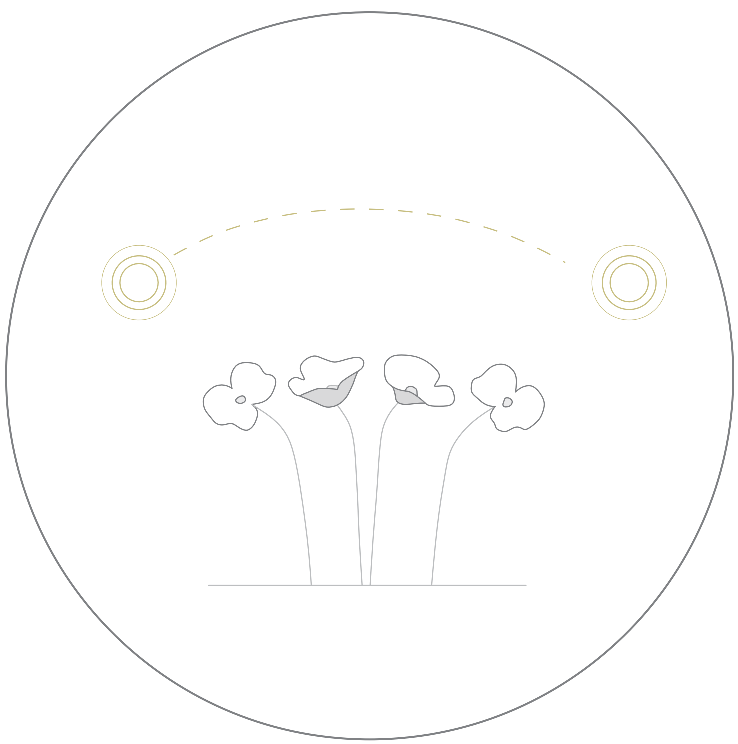


Figure 5.05
The Arctic poppy adapts to optimize its solar gain throughout the day.

and optimization of nature's bounty. As it has existed long before us and will persist near indefinitely after us, it is humbling to remind ourselves that *"nature doesn't have a design problem, people do"*[122]. The most pertinent flora to draw from for this is the Arctic poppy, Figure 5.05 depicts how this plant moves its head with the sun to absorb as much energy as possible[123]. Soaking up as much solar radiation as possible after a long dark winter or during a brisk day is exactly what any plant, human, or building should aim to do at this latitude. The entire building may not shift towards the sun, but manual facade panels could work to maximize or mitigate solar gains when daily or seasonally required.

We can also learn from the fauna, for example by looking into how animals like the polar bears or the seals stay warm in the very cold environment. Both use a double-skin strategy, consisting firstly of a thick waxy and water resistant layer of fur (Figure 5.06), and secondly of a thick layer of fat (blubber) that can swell or compact to manage thermal transfer (Figure 5.07). Consequently, it might be worth it to consider utilizing an adaptive envelope, as we said before, but also one made of a double-skin, increasing thermal resistance as well as allowing the building to transform in function of the seasons and thermal needs[124].

The development of systems which have strong synergies with the natural environment and include passive strategies for heat, light, and air management can help inform a resilient design which has historic precedent for being climatically responsive. While these are all age-old practices and important knowledge to learn from, it is similarly essential to listen to knowledge from locals and elders on the changes they see happening to their homeland. A future-proofed design is not solely about responding to the change in climate, but also to its associated changes to a region's livelihood. Consequently, after having looked into ecological lessons from the land that can inform the design, we now need to look into cultural lessons from the people living on and off the land.

122 William McDonough and Braungart, Michael. *Cradle to Cradle*. (New York, USA. North Point Press, 2002), 16.

123 Andrea Corbett. "The Influence of Petals on Reproductive Success in the Arctic Poppy (Papaver Radicatum)" *Canadian Journal of Botany*, Vol 70(1), No. 200-2004. (1992) https://doi.org/10.1139/b92-027.

124 National Wildlife Federation. "Polar Bear" The National Wildlife Federation. Accessed October 22, 2021. https://www.nwf.org/Educational-Resources/Wildlife-Guide/Mammals/Polar-Bear.

Figure 5.08 (Following Page) Locally caught Arctic Char, am Inuit country food, drying in the Torngat region of Labrador.

Figure 5.06
A polar bears waxy fur acts to increase thermal comfort and as a moisture control.

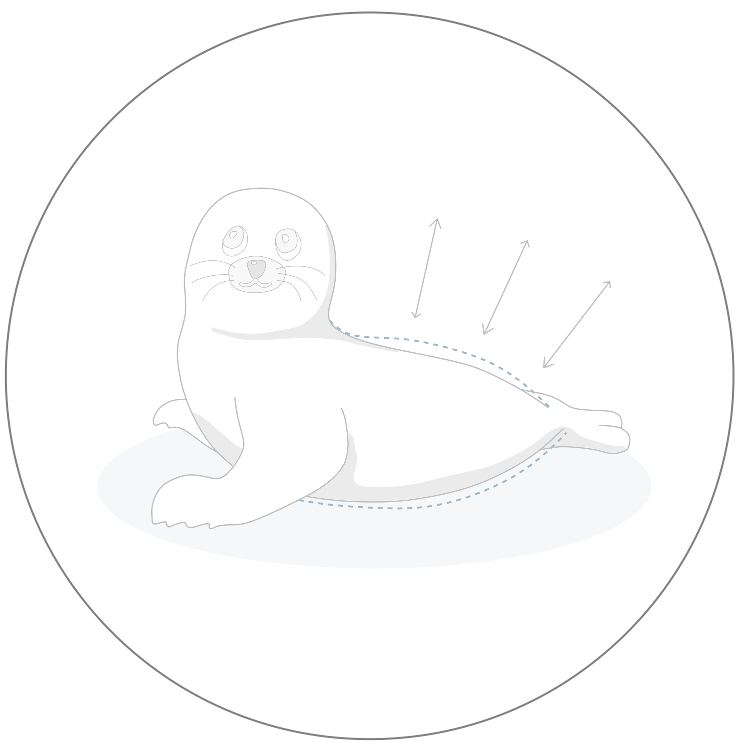


Figure 5.07
The Arctic seal has a layer of fat which expands and contracts with the seasonal need for insulation.

5.2 | CULTURAL LESSONS

Designing in a way that acknowledges the ecological lessons of the place is important, but we also need to learn from the traditional knowledge of its people. Unfortunately, as Greg Mercer explains, *"climate change is disrupting hundreds of years of knowledge and wisdom, and connection to the land, [which is] a scary thing for humanity"*[125]. Sheila Watt-Cloutier adds to this when she says that *"if we allow the Arctic to melt, we lose more [than what] has nurtured us for all of human [history, we] lose the wisdom for us to sustain it"*[126]. Learning from the cultural lessons of the Inuit people when designing in Nunatsiavut is thus not only essential to make sure the design is culturally significant for the people, but also because it will inform us on the best way to design on that land, and, most importantly, it will help preserve traditional knowledge as the building can then become a teaching tool for future generations.

Inuit Qaujimajatuqangit (IQ) is a specified branch of Traditional Ecological Knowledge which speaks towards a set of life principles reflecting Inuit epistemology. Released by the Nunavut government, the concept translates to "*that which we have always known to be true"*. The framework, developed by Elders, provides four 'big laws', or 'maligait', that should inform the project's design. The four 'maligait' are:[127]

1. Working for the common good
2. Respecting all living things
3. Maintaining harmony and balance
4. Continually preparing and planning for the future

Additionally, there are six guiding principles which together form a plan for the continuous application of IQ: [128]

1. 'Pijitsirniq' (or the concept of serving)
2. 'Aajiiqatigiingniq' (or the concept of consensus decision making)
3. 'Pilimmaksarniq' (or the concept of skills and knowledge acquisition)
4. 'Piliriqatigiingniq' (or the concept of collaborative relationships or working together for a common purpose)
5. 'Avatimik Kamattiarniq' (or the concept of environmental stewardship)
6. 'Qanuqtuurunnarniq' (or the concept of being resourceful to solve problems)

125 Mercer. "Sea, Ice, Snow… It's all changing - Inuit Struggle with warming world". https://www.theguardian.com/world/2018/may/30/canada-inuits-climate-change-impact-global-warming-melting-ice

126 Watt-Cloutier. *The Right to Be Cold: One Woman's Story of Protecting Her Culture, the Arctic, and the Whole Planet,* xvi.

127 National Collaborating Centre for Aboriginal Health. "Inuit Qaujimajatuqangit" NCCAH, 2010. https://www.ccnsa-nccah.ca/docs/health/FS-InuitQaujimajatuqangitWellnessNunavut-Tagalik-EN.pdf, 1.

128 Ibid, 1.

These overarching laws and principles should be incorporated in many realms of decision making but should also be incorporated into built form as they not only can drive environmental choices but socio-cultural ones as well. A pedagogical and interdisciplinary approach to programming and operations forms a basis in addressing the first guideline. Growth can best be achieved in a variety of facets when varied approaches and reciprocal respect come together in *Working for a common good*. *Respecting all living things* as well as *Maintaining harmony and balance* align with an overall approach to mitigate harm by way of self-sufficiency, negligible operational carbon, and an approach towards ecological, economic, and socio-cultural longevity for the site and its users. The final function goal of *Continually preparing and planning for the future* is firmly planted in the roots of a project driven towards future-proofing. Whether quantitative or qualitative, the past, present, and future of the site's climate and users need to be taken into consideration. Stewardship, *Avatimik Kamattiarniq*, - the fifth guiding principle - is grounded within each of these laws, and the project should respect the past, provide for the present, and do its part to maintain if not enhance the situations of tomorrow.

Each of the additional principles have an important role to play within the development of the project as well. *Pijitsirniq,* speaks to a project which serves its users, disseminating knowledge and skills for those who use the spaces to take back to their communities about a changing place. *Aajiiqatigiingniq,* taking into account a multitude of knowledge streams, using them in conjunction for decision making. *Pilimmaksarniq* ensures that strong pedagogical opportunities are tied into each piece of infrastructure, along with *Piliriqatigiingniq* through the interdisciplinary dialogue of different lived experiences. (Collectively diagrammed in Figure 5.09). Finally, *Qanuqtuurunnarniq*, the project's resourcefulness ties itself back to self-sufficiency, additionally developing strategies which work to solve and react to the problems created by climate change. Conclusively, these principles do not instruct on a way which things need to be done, but instead inform a way of doing things which focuses the design on both ecological and cultural sustainability.

The myriad of changes happening within the Northern Labrador landscape are evident within both climatic and subsistence impacts through food sources becoming unreliable, hunting routes unsafe, and a generational understanding that the language of the land is no longer as prevalent. In acknowledging that change is multifaceted, the project looks to not only inform itself through climate science and ecological findings, but additionally through the lived experiences of a place. Not only does this allow the building to physically prepare itself for the future, but similarly allows community members and youth to do so, through educational opportunity, reconnecting to country food, displays of local craft, and a passing of knowledge from one generation to the next. In venture to not catalogue or literalize elements of a diverse culture nor superimpose what they need to protect their livelihoods, it is to be reiterated that more than a representation of common items, dwellings, or objects is needed as these *"only tell part of the story. It elevates the specifics at the expense of the experience, which is what it truly means to be part of a culture"*[129]. Design which does not caricaturize a culture, but instead speaks to how it has been shaped by the land, its principles of living with the earth, and invites further dialogue and exploration into the experiences and lore contained within a place are critical to articulating the Inuit operation and use within the project.

Both TEK and IQ are a multi-generational understanding of the place's teachings, which have always been most effectively passed on by being present on the land, by sharing knowledge from the Elders to the youth. Observing, showing, explaining, teaching, from one generation to the next, highlights the importance of having an architecture that supports this collective way of learning, and promotes this way of intellectual growth. All buildings constructed on and around the Base Camp should support pedagogy, engaging with the site to allow the staff, or Elders, to teach about the land, on the land, to community youth or to visitors (Figure 5.10). Visitors would then be allowed to more wholly connect to the place, and learn about traditional ecological knowledge, regional livelihood, but also climate and way of life changes. All users should have the ability to interact with one another through flexible and multipurpose spaces, which could promote dissemination of knowledge, including IQ principles, TEK, scientific research through researchers meeting with visitors, Inuit staff meeting with researchers, visitors meeting with Inuit staff and a variety of other possible interactions.

Historically, as Inuit communities were forced to move into government dictated spaces, they were compelled to alter the spaces to better suit their needs[130]. Inuit culture stems from living actively, through transforming materials and spaces for the climate and the activity in question. The new Base Camp should thus be designed in a way that incorporates the important spatial qualities and requirements of Inuit life, including the ability of spaces to adapt to changing needs. This architectural ingenuity and adaptability will therefore generate a project that is continuously transformative.

129 MacIntyre. "Unknown Ground: The Case For Ambiguity in Indigenous Design", 2.

130 Susane Havelka, "Building with IQ (Inuit Qaujimajatuqangit): The Rise of a Hybrid Design Tradition in Canada's Eastern Arctic," (Thesis, McGill University Libraries, 2018), 237.

The notion of combining ecological principles and an understanding of traditional ways of life and grounding cultural principles with that of modernity provides the opportunity for a new cultural landscape and a hub that responds to complex socio-cultural and climate driven dynamic[131] By providing spaces that reflect past knowledge but also support its further development, understanding of change goes far beyond the direct users of the building. Acting as a catalyst for the synergies between not only community members, but also researchers, staff, and visitors alike to collectively experience and share the realities of change, the architectural response of this project can be prepared for whatever tomorrow brings.

Susane Havelka, "Building with IQ (Inuit Qaujimajatuqangit): The Rise of a Hybrid Design Tradition in Canada's Eastern Arctic," (Thesis, McGill University Libraries, 2018), 237.

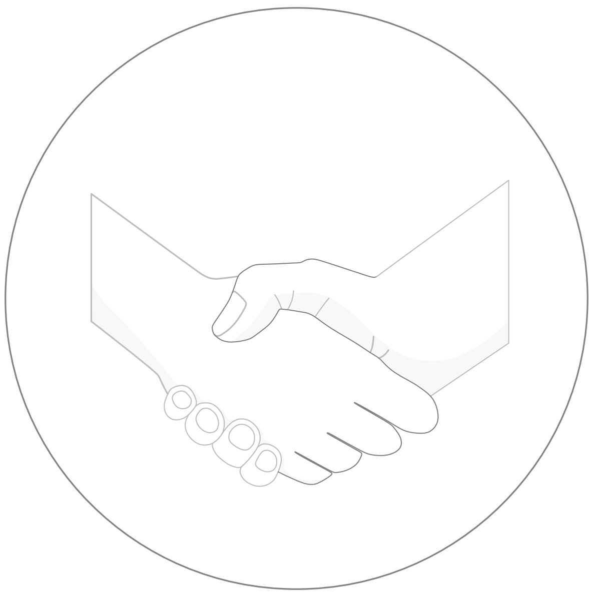


Figure 5.09
The first four guiding IQ principles can be incorporated into the design and fostered through cooperative environments and acting as a catalyst for interactions.

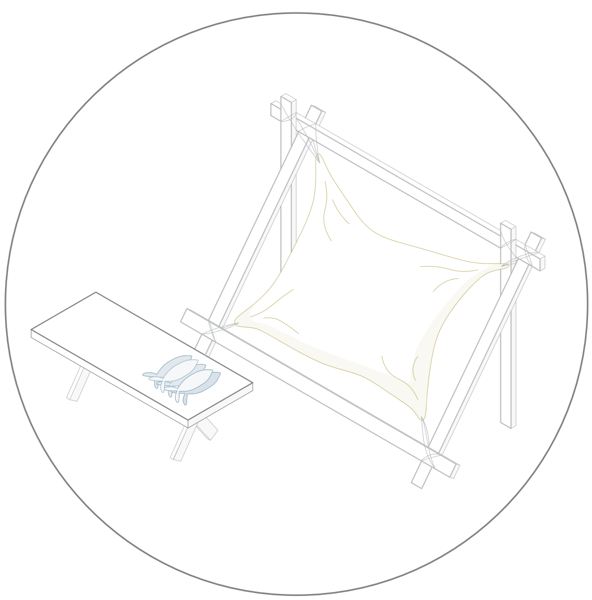


Figure 5.10
Cultural sustainability can be supported through gathering and teaching spaces which support regional livelihood practices.

Figure 6.01
Nakvak Brook in the Torngat Mountains National Park.

ARCHITECTURAL RESPONSE

6

This chapter presents the architectural response which culminates with the design of three distinct building typologies. The Hub, containing all daily operations and research programs. The Cabins, adjacent accommodations for anyone visiting the Base Camp during its extended season. And the pavilions, interactive pedagogical shelters disseminated throughout the National Park. Before presenting the three typologies in detail, this chapter firstly outlines each of the site's main user groups and their various programmatic needs in order to lay the ground for concept design. Next, the overall site of the revamped and extended Base Camp, which houses most of the buildings, is presented. The chapter aims to demonstrate that each portion of the project operates in harmony with various elements of its place, and responds to the four major climate related shifts covered in Chapter Four while being a pedagogical tool teaching about shifts in climate and regional livelihood. Focusing on energy efficient envelopes and robust systems which are manually operated on site, the entire system operates not only to mitigate further harm to the environment, but additionally to adapt to incoming shifts outside of its control through a future-proofed and resilient operation.

6.1 | USERS, PROGRAM, + CONCEPT DESIGN

The greatest opportunities for growth and productive change occur when multiple viewpoints, disciplines, and lived experiences come together. These types of synergies and connections occur and are fostered within the project's buildings and spaces, and through the interactions between the users that this program creates. The various users and some of their programmatic needs for the Torngat Mountains Base Camp and Research Station were introduced in subsection 3.2, but those will be further explained here.

Considering the fact that the local authorities wish to expand the Base Camp, extending the operational season from one season to three seasons (from May to November - see Figure 6.02) would allow more visitors and community youth groups to benefit from the Park. The existing infrastructure could hardly support this, but the new buildings, which will be entirely self-sufficient, better adapted to the context, and more resilient, should make this possible. Moreover, the total number of occupants present at the site at any given time can also be increased thanks to the new, larger, infrastructure, further increasing the use of the Base Camp. The maximum capacity of the site is thus expected to increase from twenty-five to just over fifty, including staff, housed in permanent infrastructure. On-site capacity at the existing Base Camp is generally higher due to camping tents scattered throughout the site, which functions only during the peak season like most of the site.

To reiterate from Chapter 3, there are four main user groups to the new Torngat Mountains Base Camp. Three of those (researchers, tourists and Inuit - Elders and youth groups) reside for shorter periods of time. The last group (staff from Parks Canada as well as operational workers and Inuit guides) reside for the full extent of the season, now proposed to be from May through into November. Each user group thus has different spatial needs, which are based on the fact that they reside on site at different times, and for different lengths of stay, but also because they have different roles and will undertake different activities at the Base Camp. The key goals are thus to make each user group feel comfortable and at home, to offer privacy and comfort, as well as to create a sense of belonging, of purpose towards the collective goal, which is to learn and inform about changes in climate and livelihood, and to contribute to the preservation of this climate and the traditional way of life on the land that depends on it. To this effect, as explained above, it is important to also make sure the entire Base Camp feels like a knowledge sharing community, which means that the main spaces should provide opportunities for social interactions and group gatherings. This will allow each user group to learn from one another and collaborate with one another.

Programmatically, there are three typologies spanning the Base Camp site and stretching into the adjacent National Park. The largest typology, which is being denoted as the Hub, is a 1,200 square metre building that includes all the main spaces being used daily by all user groups, The Hub is the main entrance to the Base Camp and it thus houses the large multi-functional community area, which can be used as a dining area, a teaching space, a gathering space for social activities, an exhibition space, etc. Moreover, this building also includes a large greenhouse for food production, food preparation areas (exterior and interior, for country and non-country food), research offices and labs, Parks Canada offices, Elders quarters, a sleeping area with multiple shared rooms (for staff and long-stay researchers), and of course amenities like storage and bathrooms (see Figure 6.03).

The program is laid out so that the community space acts as the heart of the Hub, and each other space (interior and exterior) can be accessed from here. The entire Hub curves around a courtyard that can be used for gatherings around the traditional fire (see Figure

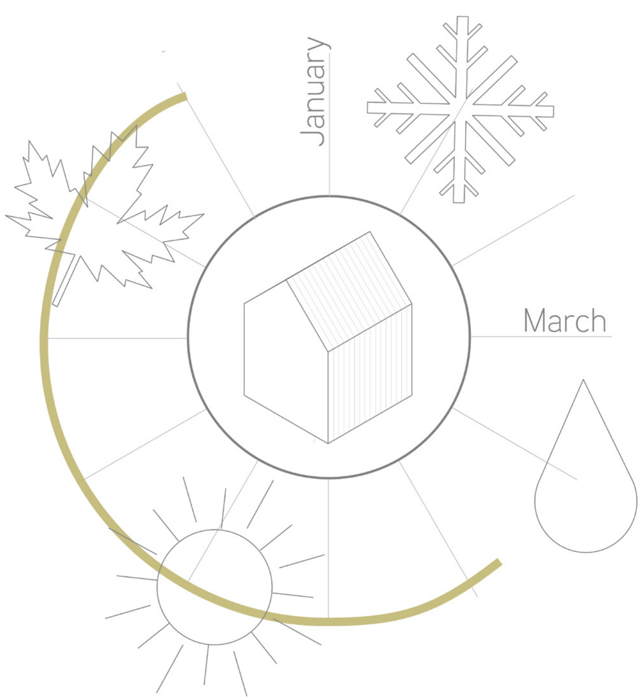


Figure 6.02
Illustrating the extended three-season operation of the Base Camp. Developed in combination with extended user seasons described in Chapter 3.

6.04). The curve provides protection from cold Northern winds to the courtyard, but it also maximizes visual connections out onto the land. This more organic form is symbolically significant to the Inuit as it responds to a cyclical understanding of life as well as gestures to multiple vernacular forms. An adjacent unheated storage building acts as the reciprocal portion of the curve, encircling the courtyard in order to create a more intimate environment in-between the two buildings. The program in the Hub is laid out in a way that the main living spaces are located on the south portion of the curve, so that the northern portion of the building can provide a thermal buffer to increase thermal performance. This buffer houses storage, mechanical rooms, circulation, restrooms, and an enclosed double-skin exhibition space (see Figure 6.05). Twice, when glazing and views to the north side are not desirable, the southern portion is separated from the northern buffer by a large thermal mass, which will increase the thermal inertia and energy efficiency of the building. Views onto the landscape are thus mainly directed towards the south, for passive heating reasons, but also to the north in the main community space, so that the building, which is the entry to the Base Camp, feels welcoming. This will also provide quality views to the sea in the heart of the building. The double-skin exhibition space will however thermally protect the gathering space from the cold north exposure, whilst allowing views to the exterior.

The cabins are grouped into a pod (each pod houses three cabins and a systems unit) and are connected to one another through a platform that provides a small exterior gathering space. This space can be used by guests to socialize, or by community youth groups to learn about the land. Each pod also contains a shared bathroom (to reduce resource use), which is attached to a building services room connected to renewables. This room is essential so that each pod becomes entirely self-sufficient. This is more easily achieved thanks to the notion that cabins have limited building services (electricity for lighting and appliances), reducing their energy needs. In the winter, the cabins can be entirely closed off and will need no energy thanks to a highly insulated envelope and insulated shutters protecting the windows. Existing sleeping domes have also been relocated, as they are still in good condition to be reused, allowing more visitors to sleep at the Base Camp. Those will provide a distinct experience, in comparison to the more permanent and enclosed cabins.

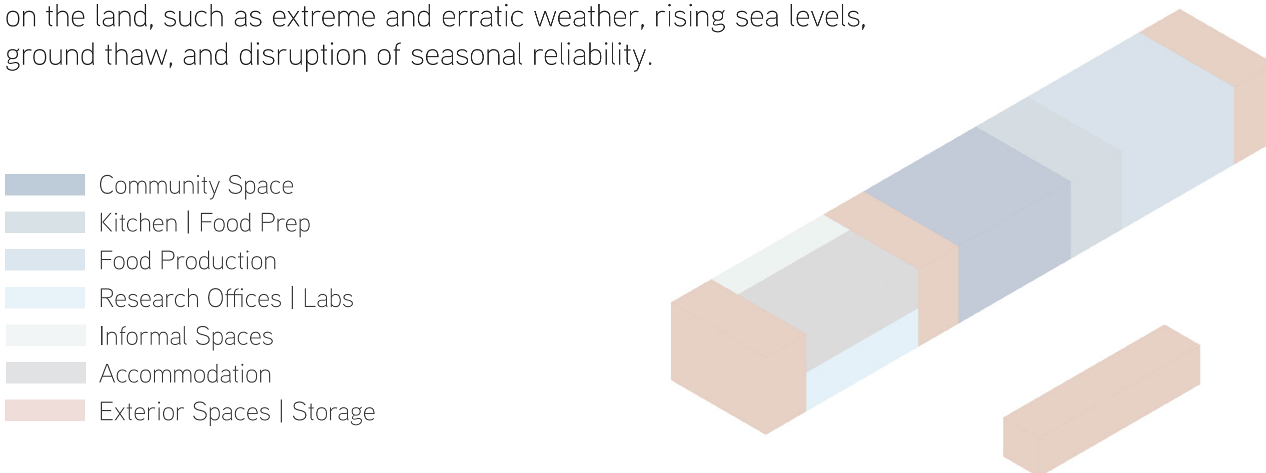
The final typology consists of four pedagogical pavilions doubling as shelters distributed across the Park's major hiking routes. Such shelters are commonly required on remote and very long hiking paths, but the goal with this project is to allow them to

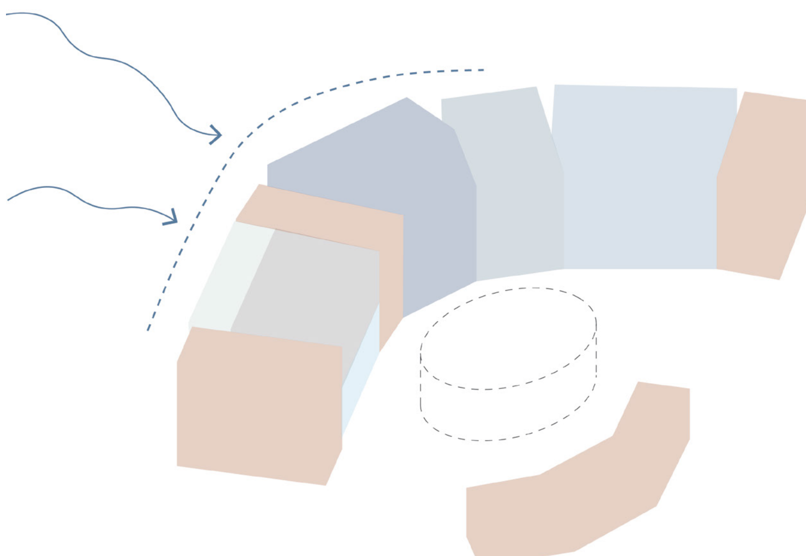
Figure 6.03 (Opposite, Top)
Program orientation, a public and more private mass, each book-ended by covered outdoor spaces.

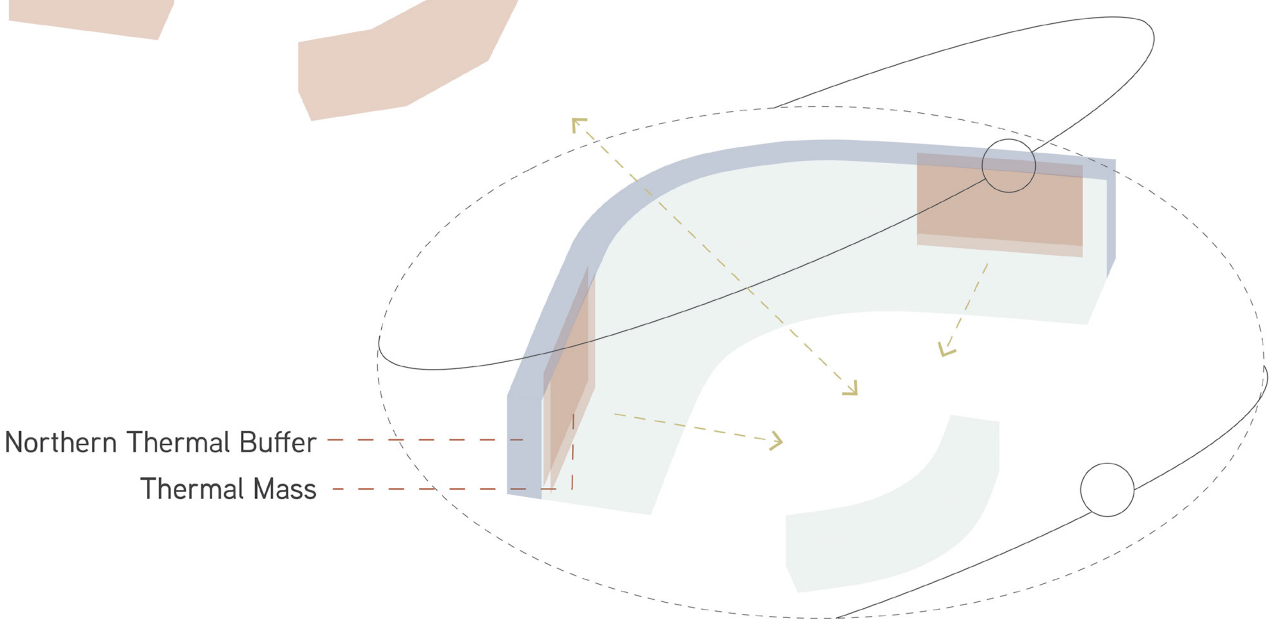
Figure 6.04 (Opposite, Middle)
The overall mass is curved to create a shelter belt from Northern winds, and countered with a storage building to form a courtyard.

Figure 6.05 (Opposite, Bottom)
The northern thermal buffer, and thermal mass on both ends. Views to the courtyard throughout and to the sea in the community space.

also become tools for learning that are located on the land, where changes can be more easily observed. These correlate not only to unique ecozones within the Park, but each highlights one of the four issues outlined within Chapter Four. They thus help visitors better understand issues pertaining to changes in climate and livelihood on the land, such as extreme and erratic weather, rising sea levels, ground thaw, and disruption of seasonal reliability.







6.2 | BASE CAMP

The Base Camp, which includes the Hub, the Cabins, and a number of other amenities, is illustrated in Figure 6.06 on the following spread and described in the remainder of this section - the Pavilions are the only project components that are not located in and around the Base Camp. The main three typologies (Hub, Cabins and Pavilions) are presented in further details in the following sections. As explained in section 3.2, the renovated and expanded Base Camp is located at the south end of St.John's Bay on Saglek Fjord, at the exact same location as the existing Base Camp. This location is still considered to be beneficial as it is semi-secluded down a narrow fjord that provides better shelter, compared to more coastal locations. Moreover, because it is located at the bottom of a valley, with mountains on the eastern and western sides, this provides direct access to a freshwater stream that flows into the bay. As explained in subsection 3.2.4, arrival at the Base Camp is done by water transport (zodiac or other small vessel), after leaving the Saglek Airstrip. Consequently, a dock at the northern edge of the Base Camp is necessary to welcome all visitors and receive goods. Considering the fact that the sea levels are rising, it is essential to think about future-proofing this important amenity. As we've learned previously, this can be done by means of floating infrastructure (move with the water), which lends itself perfectly to the dock. By moving with a changing water level, the lifespan of the dock can thus be prolonged, reducing new material and repair requirements on site. In summary, the dock, which will be covered to protect visitors and equipment arriving at the Base Camp, will be pulled back and anchored as the sea level rises, providing more resilience in the face of climate change.

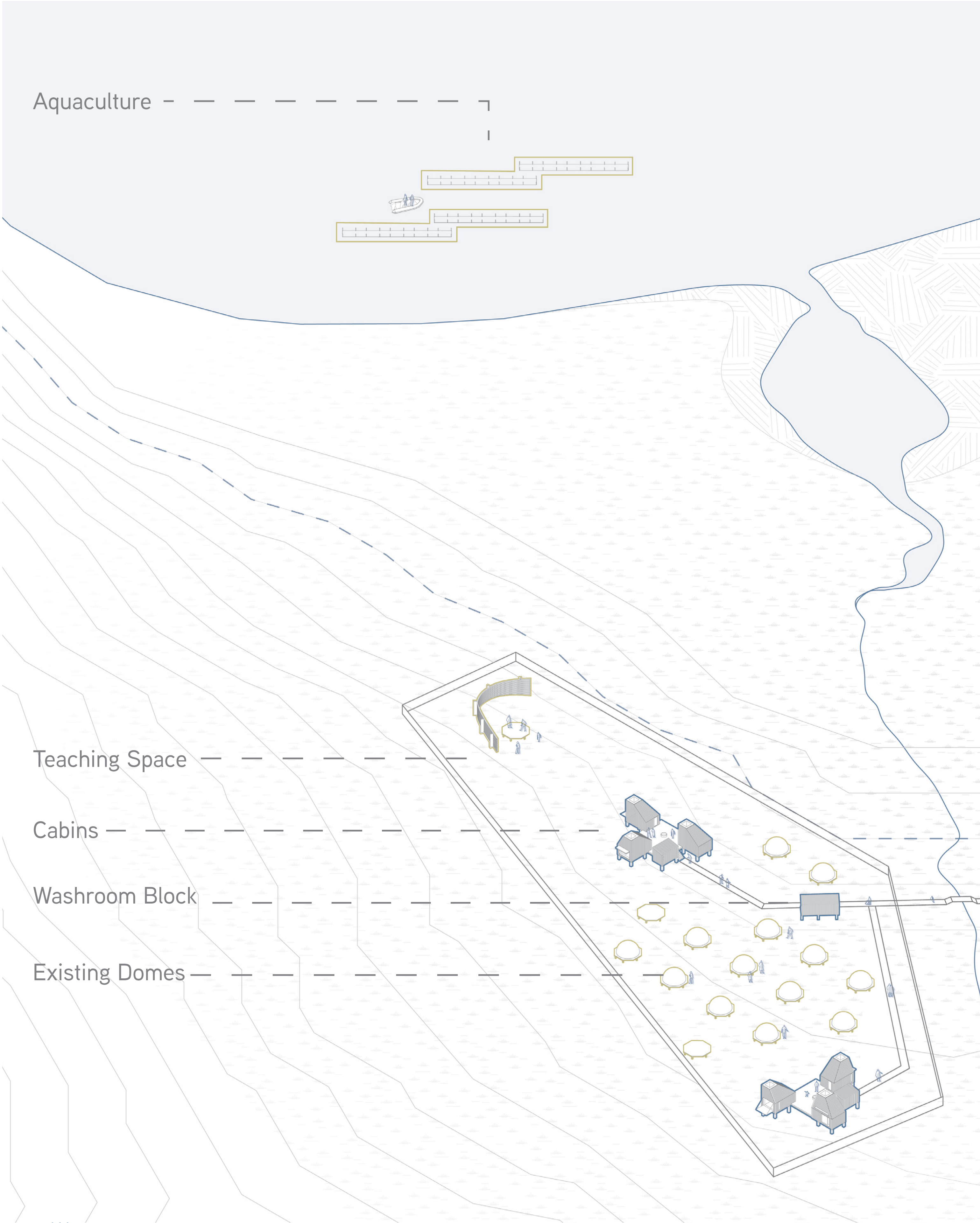
The eastern side of the Base Camp houses the Hub, which can be accessed from the dock, welcoming all visitors before they move on to other buildings or amenities. This is also where the courtyard and the fire pit, as well as the primary storage building, are located. The community fire pit facilitates outdoor community gatherings, and temporary smoke huts can be set up in this courtyard area to facilitate hide and fish smoking, so everyone can see and participate in the process. That part of the Base Camp, on the east side of the stream, also houses some existing temporary tents, which have been relocated and are now used for additional storage. The western side of the Base Camp, which is located on the opposite side of the stream and is connected by a boardwalk, houses most of the accommodations, including the new cabins and the existing and relocated domes[132]. The domes are installed on tent platforms to reduce ground disturbance and to avoid any warming of the ground/permafrost. The cabin pods each have a shared washroom, but the domes do not, and so an additional washroom block has been added alongside the boardwalk for these users. Additionally, a more secluded and quiet gathering space sits north of the cabins, featuring a raised platform and a windbreak wall echoing the curved shape of the hub. This protected exterior area can support smaller and more intimate teachings while providing a high vantage point of view on the entire site and fjord. Finally, a polar bear fence, dubbed essential at coastal sites for safety, is installed around the eastern side, as well as around the western side of the Base Camp.

On-site food production is one of the essential requirements in order to achieve self-sufficiency for the Base Camp. Consequently, multiple food sources are needed to generate a reliable and plentiful food supply. These sources begin at the shoreline through micro-aquaculture practices of kelp and mussels. Bivalves such as mussels can be easily grown with no agrochemicals, little to no human interference until harvest, and require no feeding. Moreover, they sequester ocean carbon throughout their growth. Kelp is another low maintenance aquaculture and Inuit country food. Other food sources, as well as the food preparation spaces, are located within the Hub itself, and will be presented in further detail in the next section.

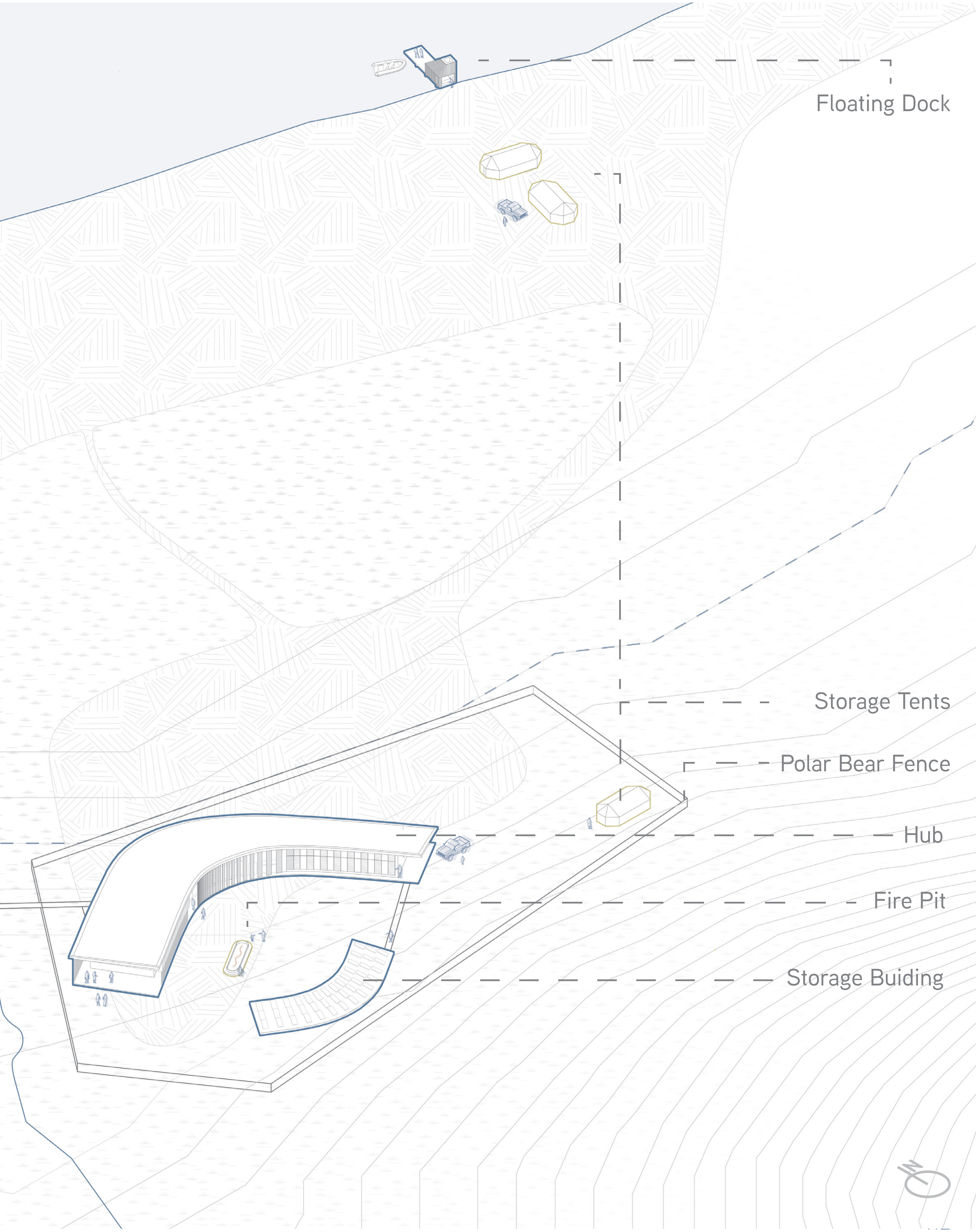
In order to achieve self-sufficiency, energy production, by means of on-site renewables, for heating, hot water, lighting, etc., is required. Consequently, the roof of the storage building has been sloped towards the south in order to provide much of the electricity required by the Base Camp thanks to photovoltaic panels. Additionally, photovoltaic glass systems have been used on the southern glazed facade of the Hub in order to generate electricity when the sun is lower. Moreover, photovoltaic cells have been integrated in the siding of the cabins to provide electricity for the pods. Due to the site's three season use and long daylight hours in peak season, enough energy would be produced through these means. In order to complement solar energy, the use of a kinetic facade on the north-west side of the Hub will harness wind energy. By celebrating, not hiding, the energy production elements, a lesson of proper stewardship for the land can be shared. In the event that more energy is required, it would be relatively easy to add more wind turbines around the buildings, as the valley is swept by strong winds. Finally, the position of the Hub and the cabins near the stream is strategic as it will facilitate freshwater collection, which will complement rainwater collection, in order to achieve water self-sufficiency.

Figure 6.06 (Following Page) Base Camp, including Hub, Cabins as well as site amenities such as floating dock, aquaculture, boardwalk, firepit

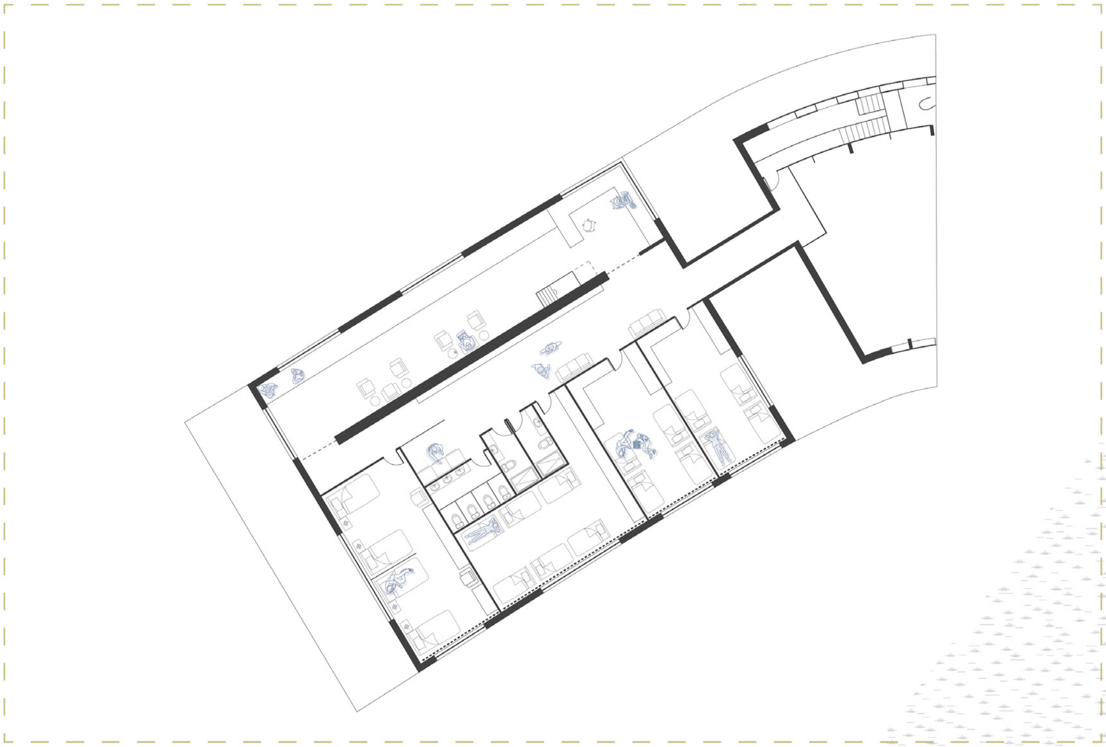
132 Refer to subsection 3.2.3. for an overview of the sites existing situation.

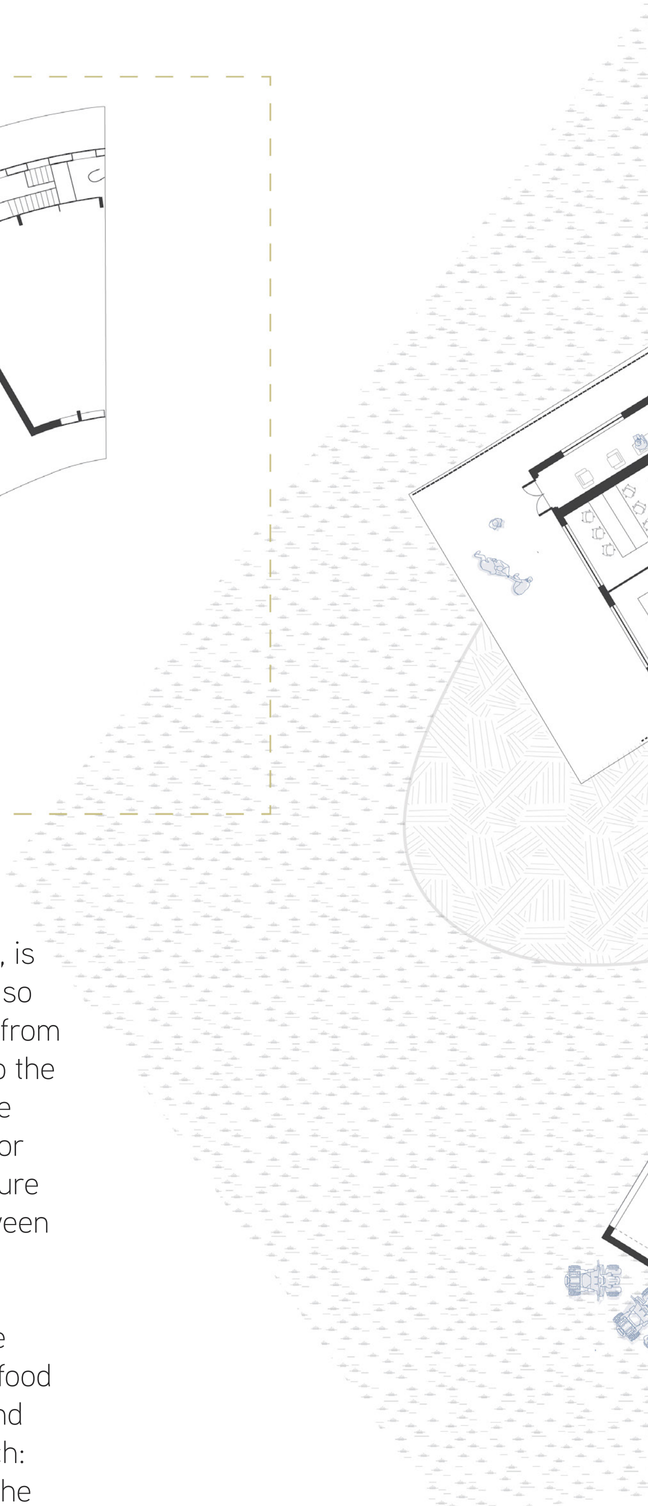


Aquaculture
Teaching Space
Cabins
Washroom Block
Existing Domes


Floating Dock
Storage Tents
Polar Bear Fence
Hub
Fire Pit
Storage Buiding

6.3 | HUB





The main building, central to the site's varied operations, is the Hub. As explained previously, the form has been generated so that the building creates a shelter belt protecting the courtyard from northern winds, whilst generating multiple visual connections to the landscape (mostly to the south, but also to the north through the double-skin space where artwork is exhibited). The detailed floor plan of the first floor and the second floor can be viewed in Figure 6.07. Upon approaching the Hub, visitors enter the breach between the building masses, which allows a sightline to the courtyard. This draws people into the heart of the building, the community space. This covered exterior space can also serve as one of the many exterior gathering spaces, classroom spaces, or exterior food preparation areas - the two other ones being located at each end of the Hub. There are two entrances on either side of the breach: the western one providing access to the research spaces, and the eastern one serving as the main entrance for visitors. After going through the vestibule, users enter the semi-heated double skin (northern thermal buffer), where they can move up to the second story (sleeping quarters) or enter the community space. The double

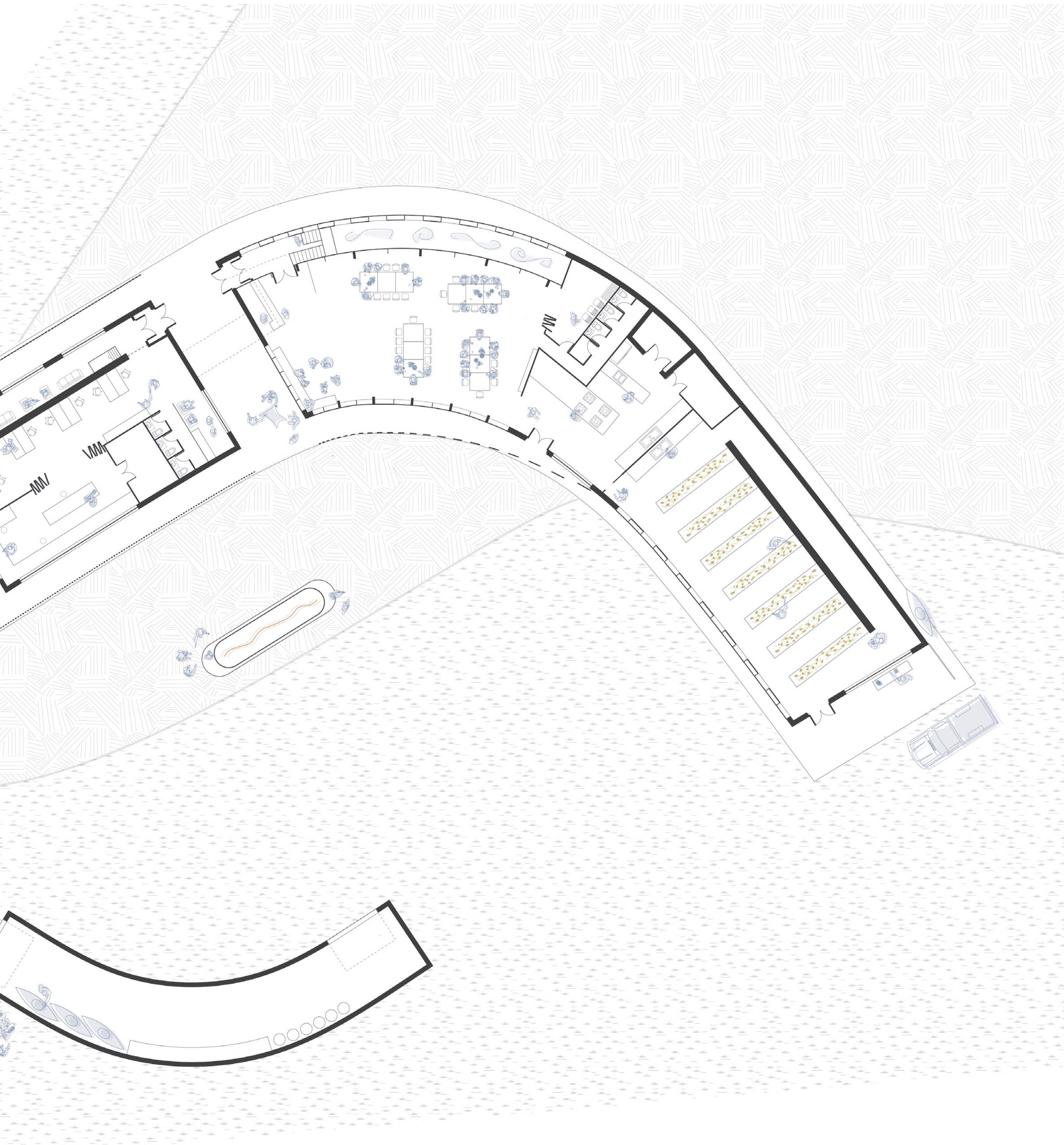


Figure 6.07
Detailed floor plan, second storey separated o the left.

skin allows for the exhibition of Inuit art in a protected area, bathed in diffuse northern light.

Upon entering the main space, visitors have access to the reception area. Passing through into the community space, this is where daily meal times occur (illustrated in Figure 6.09), as well as research exhibitions, and community gatherings and indoor teachings. This is consistent with Inuit building and community arrangements which "consisted of a central multi-functional, multi-person living space that fostered intimacy and easy nonverbal communication among household members"[133] The timber curtain wall wraps both sides of the space, allowing sightlines to the Northern art, and the sea, as well as out into the landscape and adjacent courtyard on the southern side. This material choice doubles back on earlier discussion about material longevity and embodied carbon: using timber post-and-beam to provide unobstructed views and warm interior spaces as seen in Figure 6.08.

To the east of the community space is the interior food preparation area, which is directly connected to the greenhouse and growing area at the eastern end of the Hub (Figure 6.11). Providing a majority of the site's food supply, this space uses hydroponics

133 Erin Hampson. "Arctic Adaptive: Responsive Design in the Canadian North". Thesis, Toronto Metropolitan University. (2011). (https://doi.org/10.32920/ryerson.14662005.v1), 13.

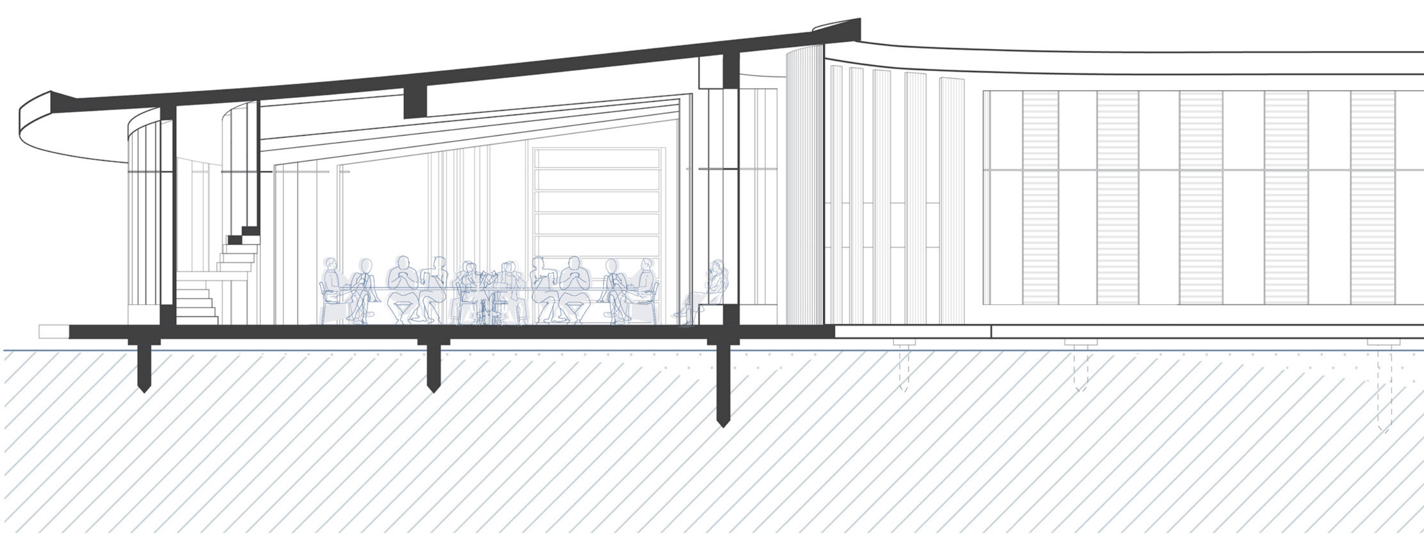
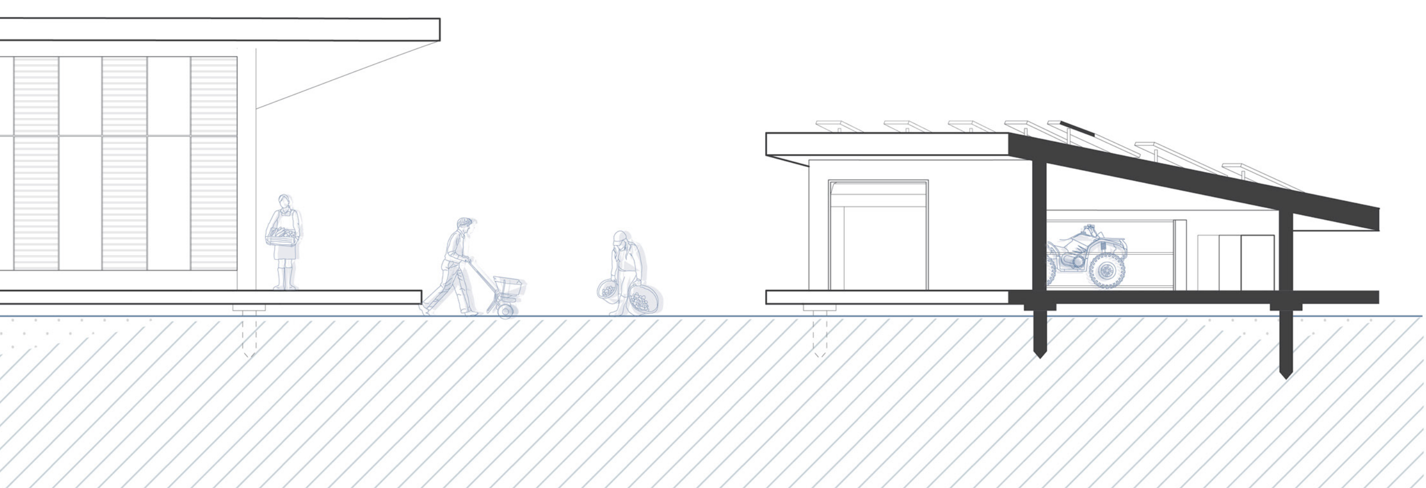
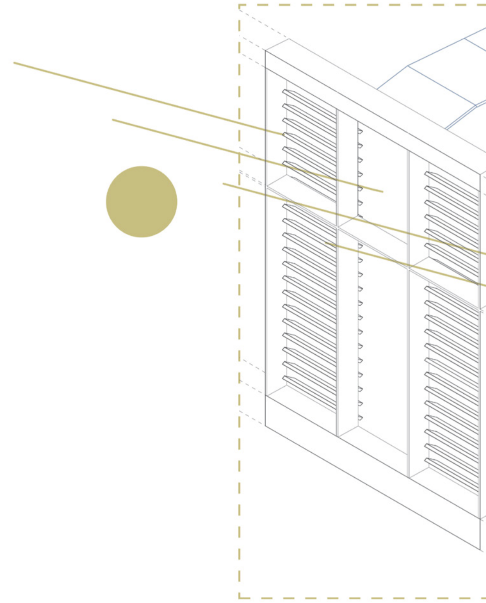


Figure 6.08 (Above)
Interior community space perspective, features the timber enveloped space hosting an event.

Figure 6.09 (Below)
Section cutting through the storage building, courtyard, and community space - presently hosting daily meals.



and vertical growing to continuously generate fresh produce for the site (Figure 6.12). The northern thermal buffer in the greenhouse acts as a storage space, as well as a mechanical room for systems related to the growing of food, like water tanks. To the south, a large glazed facade maximizes passive solar heating to help with food production. The roof angle maximizes the glazed area to the south, while minimizing the north facade area, increasing thermal gains and reducing thermal losses. The south facade is a dynamic system that can adapt to changing seasonal and daily weather conditions. Indeed, in order to reduce thermal losses, the facade can be closed off. This is done through roll-down insulated panels (every two curtain wall bays) and pivoting insulated louvres (every two curtain wall bays). When solar gains are needed the roll-down panels can be raised back up and the louvres can be adjusted to the best possible position depending on the angle of the sun. Having two types of insulated shading devices allows more control on the quantity of solar gains to be admitted at different times. This dynamic and flexible facade system is especially important to adapt to future climatic conditions as well. Specifically, as can be seen in Figure 6.10, in peak season, when the sun can reach up to 55° in altitude and solar gains are to be maximized for plant growth, one set of panels is completely open, while the manually operable louvres are set to the prime angle for the season. In the bracket



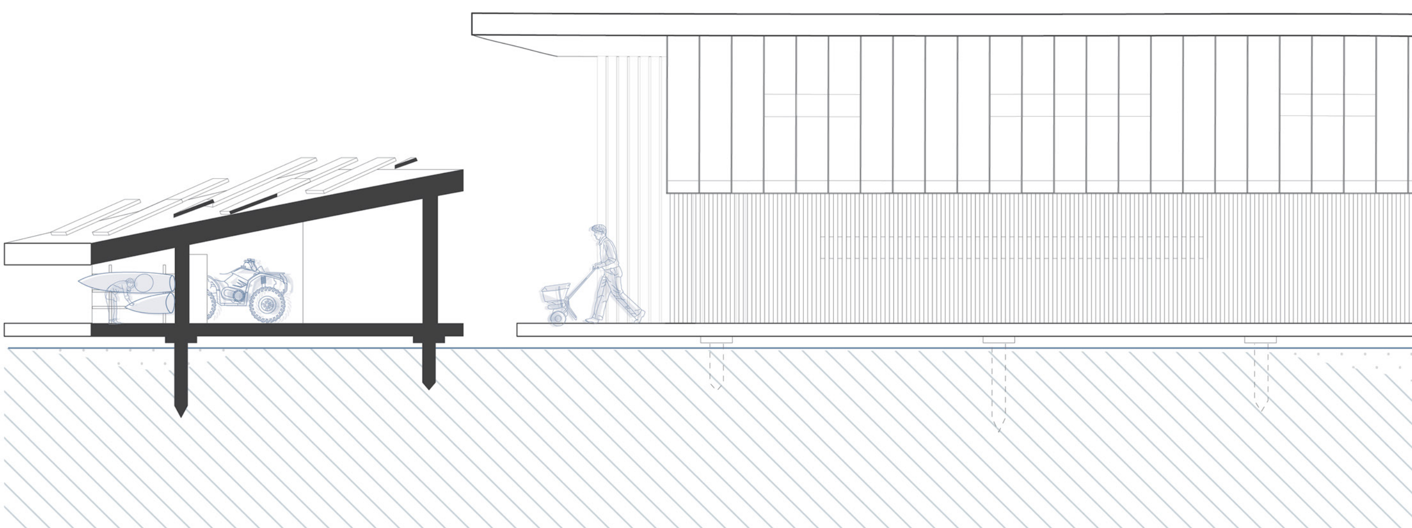


Figure 6.10
Food production facade panels with manually operable adjustments reacting to peak season (left), bracket season, and off-season - or future when solar shading is required.

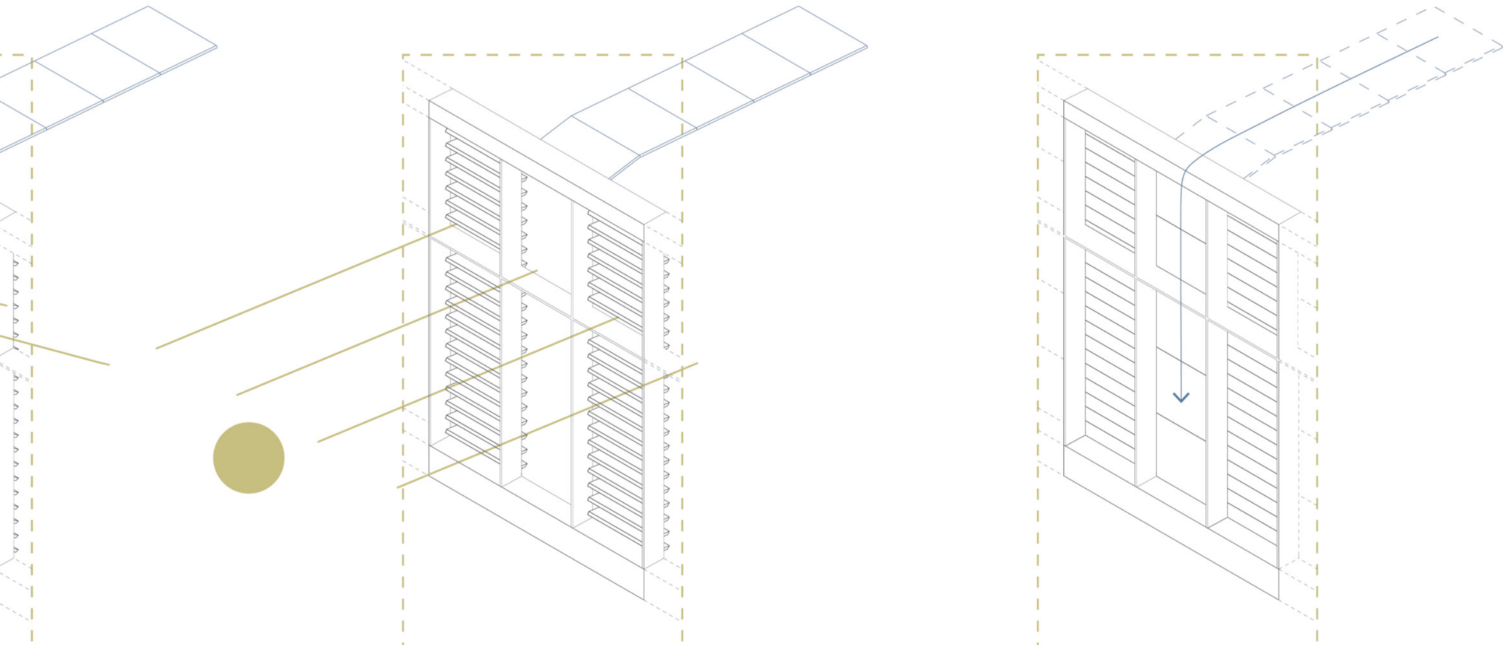
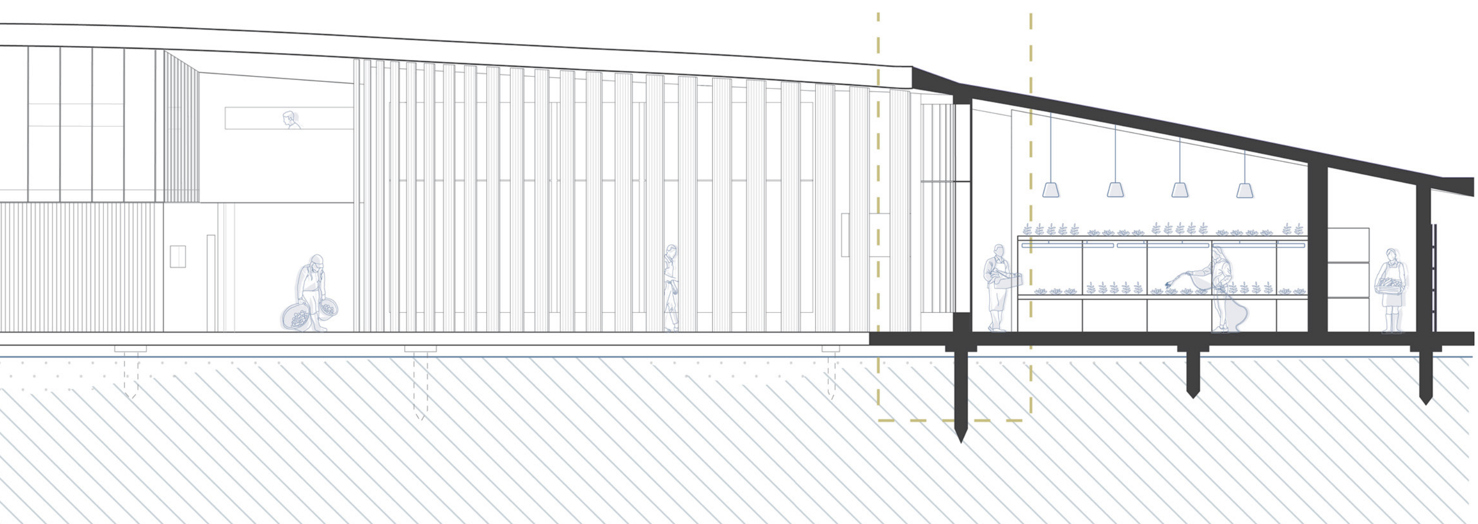


Figure 6.11
Section cutting through the food production area, highlighting the placement of operable panels, drastic roof angle, and Northern thermal mass, acting as a thermal buffer.

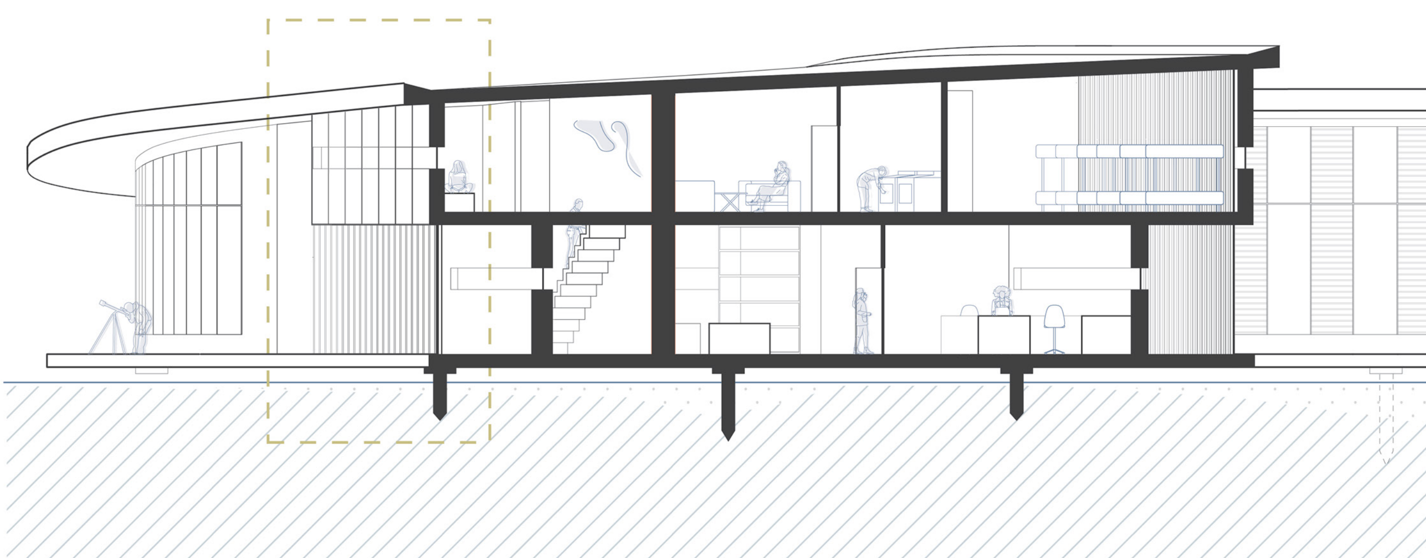


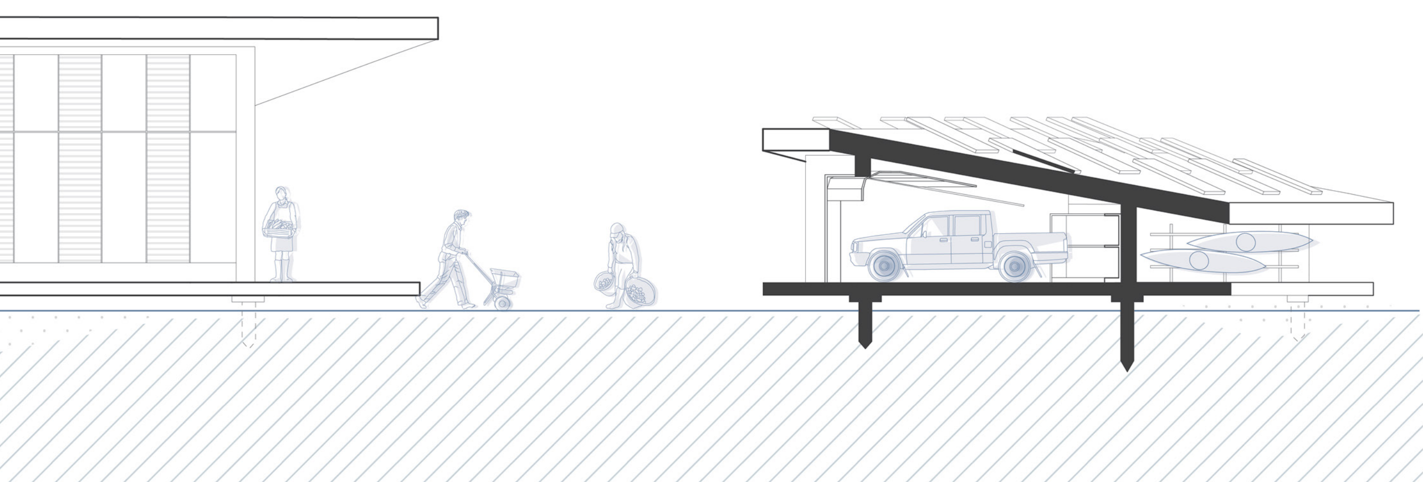
season, when the sun is lower in the horizon, these louvres can be adjusted to allow for maximum sun penetrating into the greenhouse space. In the future, if additional solar shading is required, these louvres can be readjusted at any point to the needs of the users and the space. In the off season, when the entire building battens down, the louvres are adjusted to sit vertically, their angled edges allowing for a snug fit. The secondary panels, which are generally open throughout the on-season, are pulled down from the ceiling similar to the motion of a garage door, closing off the curtain wall to reduce thermal losses in the winter.

Due to the fact that staff and many researchers stay at the Base Camp for multiple weeks or months, a diversity of spaces, including some private and some gathering spaces, is essential so they can feel at home and can also feel like they are part of an active community. This is the premise of the northern thermal buffer space in the western wing of the Hub (Figure 6.13). The thermal buffer is separated from the research spaces by a large thermal mass wall made of soapstone. This northern space is semi heated and reaches a comfortable temperature at various times during the occupied season, at which point individuals can use it to socialize or spend some personal time. Through doors on either side of the soapstone wall, the user enters the research spaces. This space consists of

Figure 6.12 (Right)
Interior perspective of the food production space, seeing sunlight entering the growing area through facade panels,

Figure 6.13 (Below)
Section cutting through the two storey area - gathering spaces and bedrooms above, research offices and labs below. The thermal mass wall can be seen as the only vertical wall running through both floors.

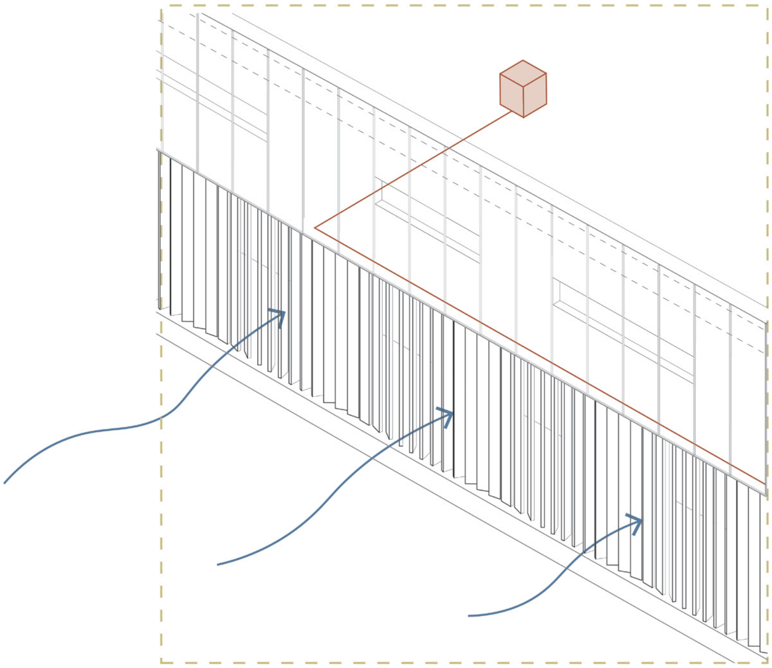


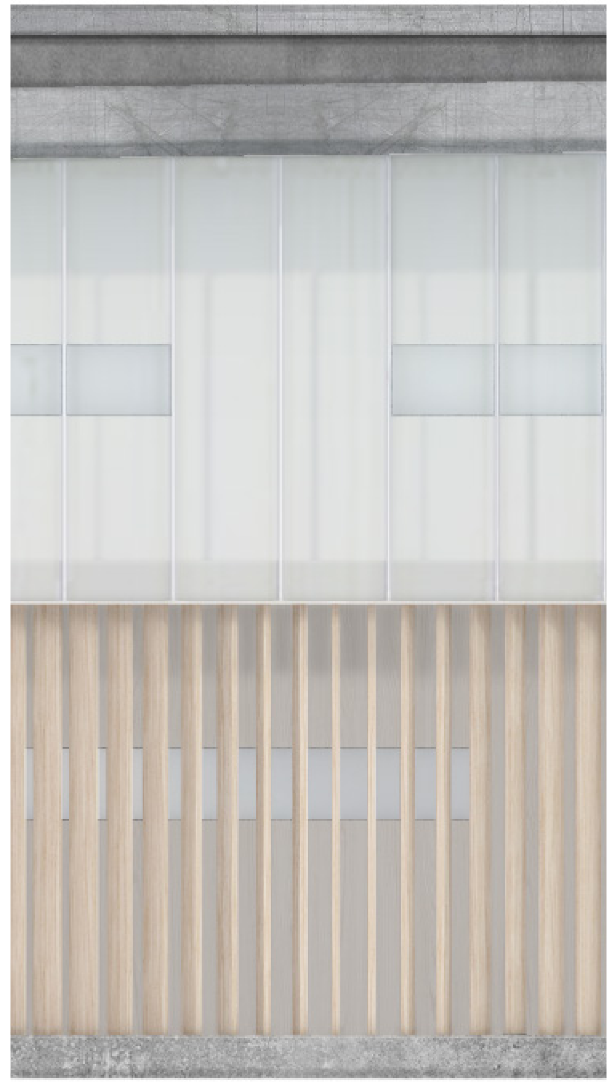


desks, a lab, storage, and a small nook which looks onto the central outdoor gathering space. Thanks to the overhang generated by the second floor, and the exterior slats on the southern side, harsh, direct light into the labs and office spaces is reduced. On the second floor, the northern side of the thermal mass wall provides a larger social space as well as the main Parks Canada office, which requires direct sightlines to the fjord and approaching boats. On both stories, the soapstone wall not only provides beneficial thermal properties, but it also ties back to Inuit culture as it has been a primary material used for carving and artistic practice.

The southern face of the second storey is clad in insulated photovoltaic glass panels, generating electricity, but also providing diffuse daylighting. On its Northern portion, a kinetic wall allows for energy production from the strong, year-round Arctic winds (Figure 6.14). Designed to be aesthetically pleasing as well as functional (Figure 6.15), this kinetic wall celebrates nature as an amenity which can sustain us indefinitely if used consciously. Made up of rotary blades with angled edges to catch wind (Figure 6.16), these blades spin individually, driving a generator and creating electricity for the project, travelling a short distance to batteries in the western portion of the building.

While the North side of the building protects itself through various thermal buffer techniques running throughout, the Southern side opens itself up for solar gains and views. As conditions change at both short and long term intervals, the ability of the southern facade to adapt and close itself off is vital. This facade features wood panels of varying widths throughout, starting from small fixed slats on the west, to larger slats to the east (over one metre in width for the greenhouse panels, discussed in detail on page 117), creating movement along the curve (Figure 6.24). The smallest slats are only two inches wide, providing privacy to the research spaces. The slats bordering the outdoor teaching spaces additionally have a small detail while allowing them to be folded down, creating racks for drying of food and hide. The central panels slide closed during the winter to batten down this portion of the building (Figure 6.17, Figure 6.18). Using spring lock pins, two panels are 'stacked', locked in place with pins (Figure 6.19). These wooden facade panels extend up to the roof, as seen in Figure 6.20) and will patina over time along with all the exterior wood. This design intentionally reflects on the passage of time, which is a core ethos of this project, and will create a beautiful contrast between the grey, aged exterior and the warm coloured interior spaces. The interior panels are set on a rail, whereby each panel's pins can be pulled, slid, and relocked into its





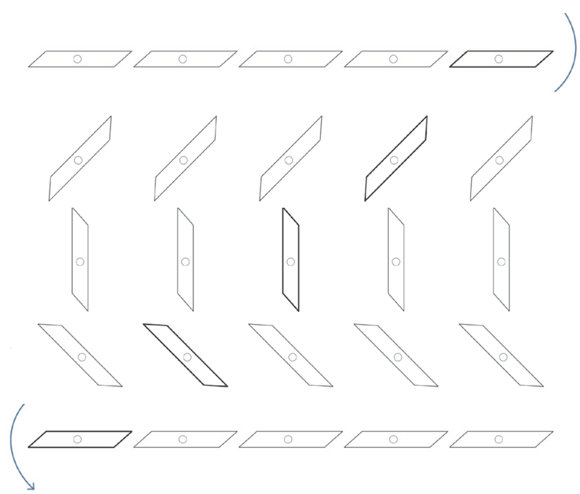


Figure 6.14 (Top Left)
Kinetic facade blades in motion, provided with enough space behind them to catch and divert wind away.

Figure 6.15 (Right)
Slice elevation of the Northern kinetic facade. Above, insulted glass panels (additional photovoltaic on the south side) and kinetic blades in motion below.

Figure 6.16 (Bottom Left)
Rotary blades on the kinetic facade shown in plan, the angled edge made to catch wind and provide just enough tolerance for two blades to pass.

neighbours. The size increase of the panels is taken into account, with the spacing matching the side of the next larger panel, allowing for consistent overlap and a closed wall.

Completing the circular form which wraps the community courtyard and firepit is an unheated storage building, seen aerially in Figure 6.23. The boardwalk which wraps the entire exterior of the Hub continues across and leads into a large garage door opening on the storage building. This space can allow for vehicle storage as well as their fuel, maintenance equipment and any other on-site tools. A shallow southern roof overhang allows for a protected outdoor short-term storage space. The roof sits at a steep angle, housing solar panels that are raised to reach an even steeper angle (over 50˚) for optimal solar orientation in order to generate enough electricity to meet the needs of the Hub throughout the operational season. The fixings supporting the PV panels are adjustable to provide optimal efficiency at various solar angles if and when needed.

In regards to the building service systems of the project, electricity, heat, water, and ventilation needed to be taken into consideration. Each of these systems allow for the building to operate self-sufficiently and are future-proofed to take into consideration changes. Beginning with electricity, sun and wind energy best work in combination on-site, due to vast variance in solar availability and wind patterns throughout the year. Energy gained through photovoltaics is two fold. Firstly, the large field of panels on the southern portion of the storage building. Additionally, photovoltaic glass on the second storey portion of the building, sitting vertically to capture the last remnants of sunlight in the evening as well as bracket season. There are two electric storage areas within the building. On the west, within the research offices storage room, and on the east, on the cooler side of the greenhouse's thermal buffer. Electrical energy is additionally produced through the Northern kinetic facade, providing movement to the otherwise more static Northern facade.

Electrical energy is utilized for lighting and power within the building, but also for space heating and water heating - collectively shown in Figure 6.21. This is due to the fact that, according to Fin MacDonald of the Canada Green Building Council, electricity is "the only fuel that we can truly make 100 per cent carbon neutral"[134], but also because it's the only appropriate energy source for truly self-sufficient buildings, especially those in extremely remote areas. Consequently, electric radiant heating floors are use throughout

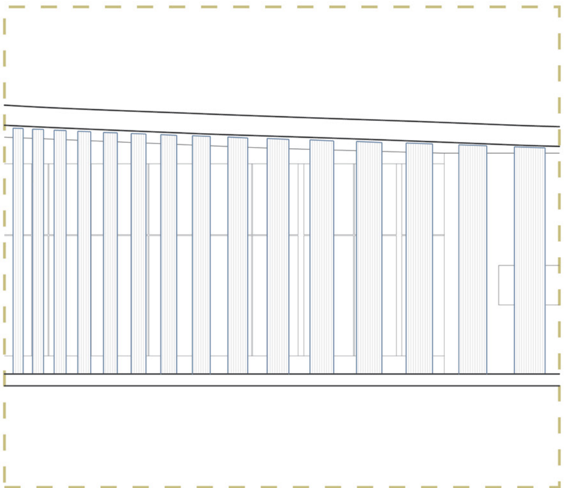
Figure 6.17 (Top Left)
The central portion of the southern facade when open, allowing sightlines and sunlight through.

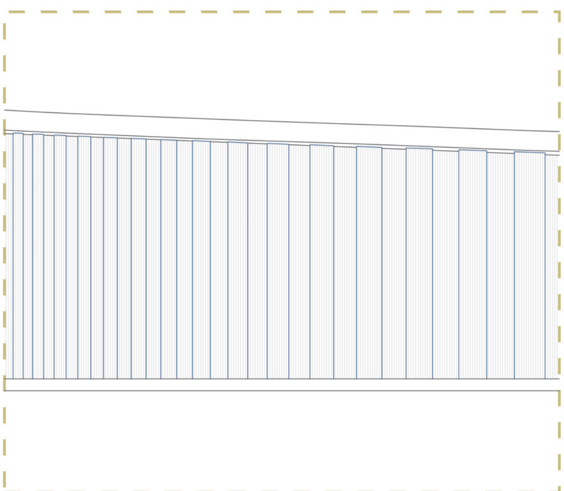
Figure 6.18 (Middle Left)
The central portion of the southern facade when closed, acting as an additional thermal barrier.

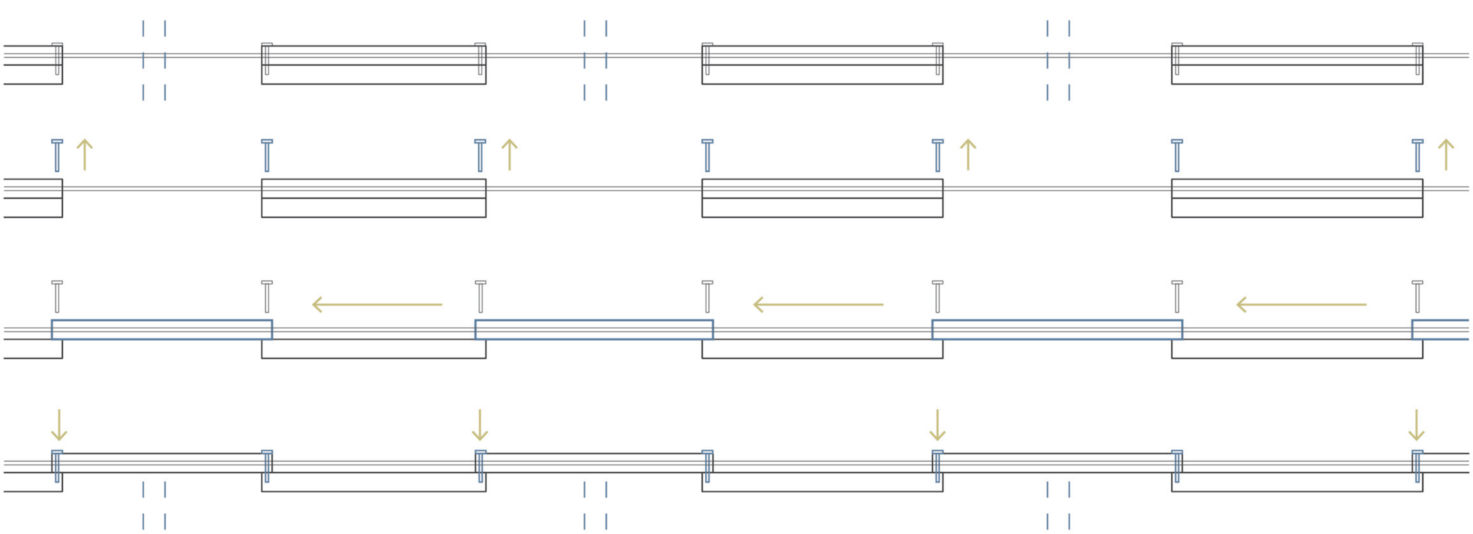
Figure 6.19 (Bottom)
Spring lock pin system in order to manually batten down this portion of the facade.

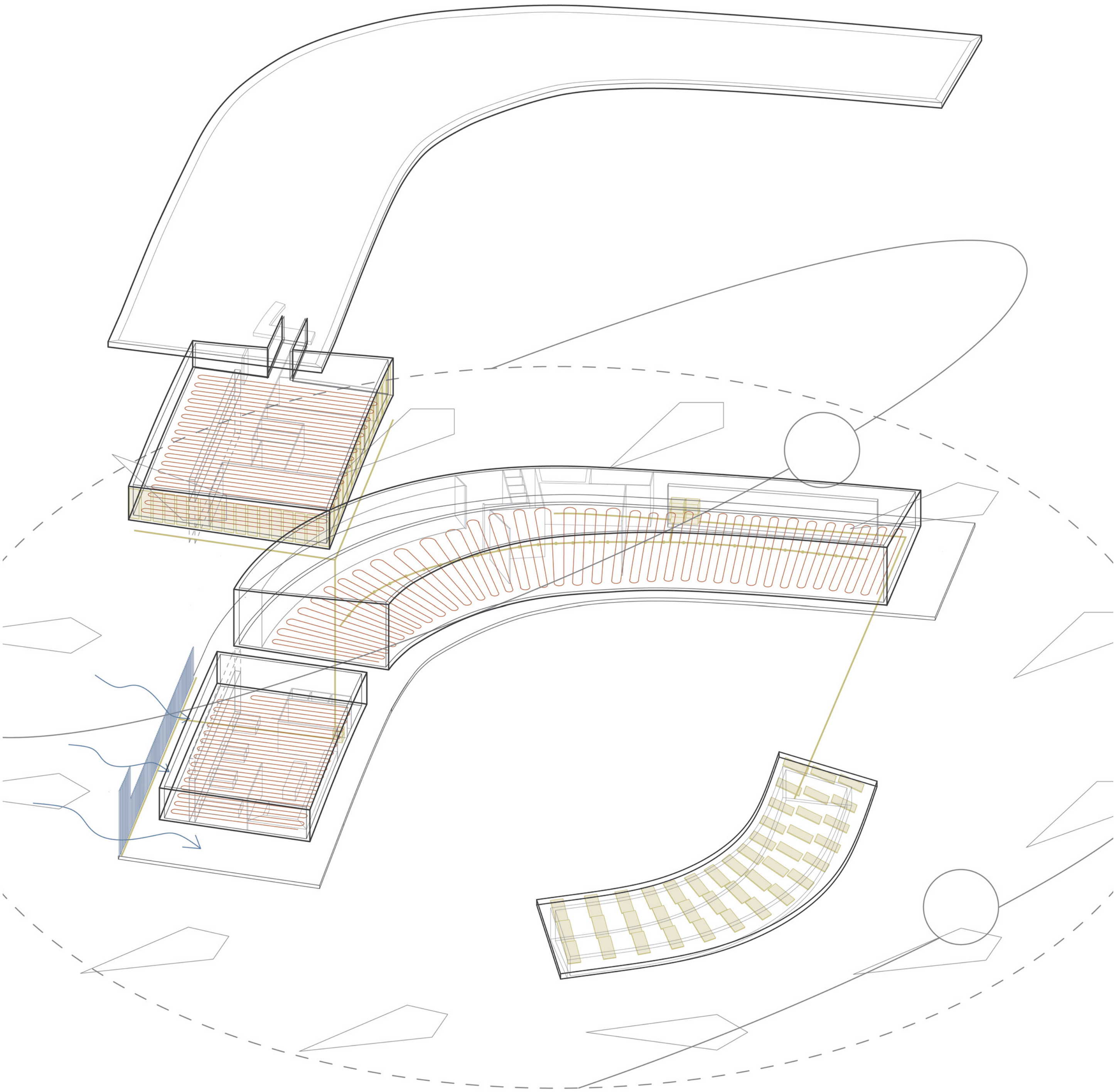
Figure 6.20 (Right)
Slice elevation of the central portion of the southern facade, shown open with floor to roof panels which will patina over time.

134 Emily Chung. "Goodbye Gas Furnaces? Why Electrification is the Future of Home Heating". CBC. January 20, 2020. https://www.cbc.ca/news/science/greener-heating-1.5429709.







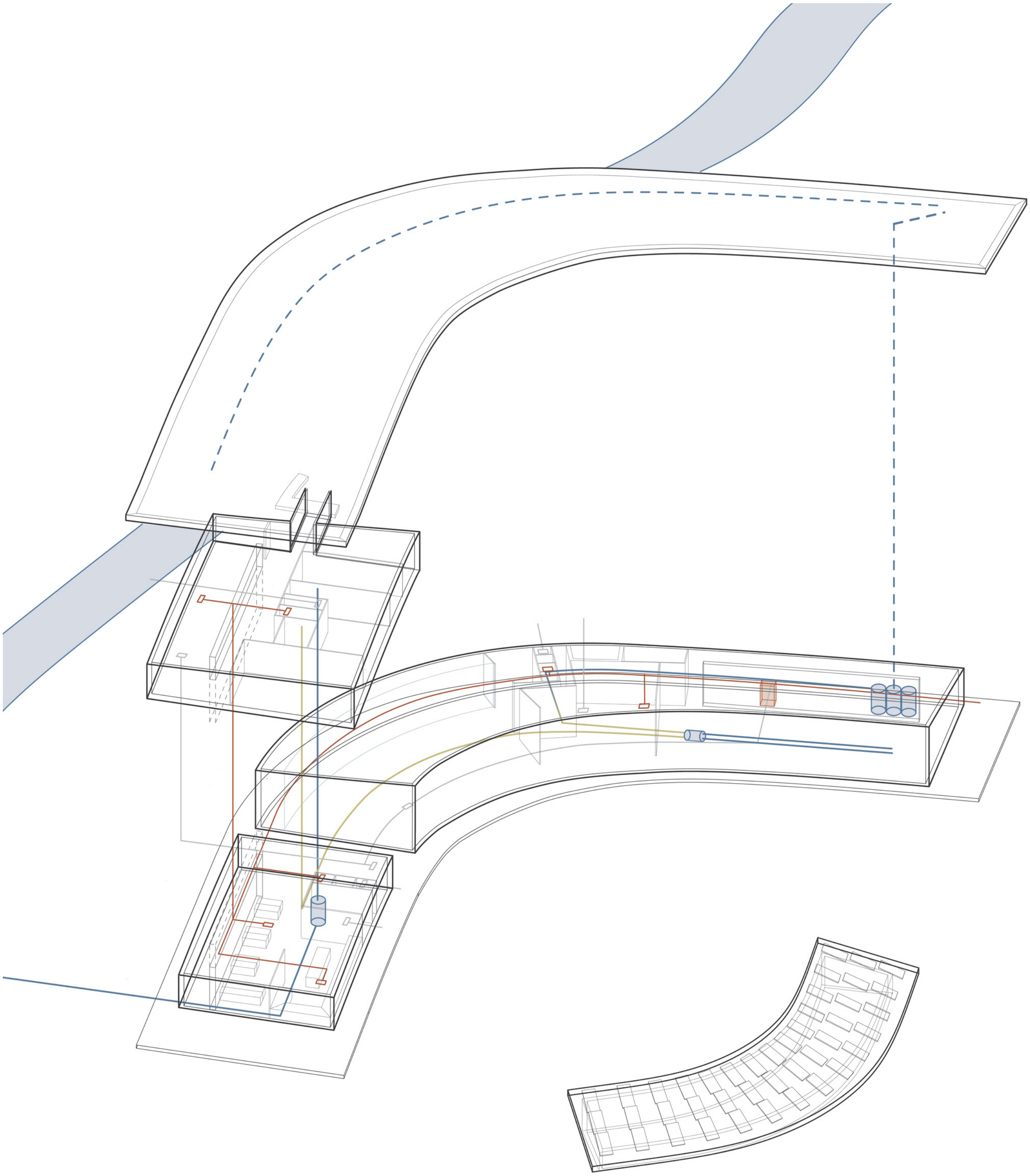


Photovoltaic Energy Collection

Wind Energy Collection

Radiant In-Floor Heating

Figure 6.21
Electrical systems for heat, lighting, and appliances. Mixed renewable energy sources maximum gains and ensure the building operates self-sufficiently.



Ventilation from HRV

Ventilation to HRV | Exhaust

Filtered | Clean Water

Greywater directed to Food Production

Figure 6.22
Ventilation and water systems. Water is collected from two sources, and greywater filtered for secondary use for food production.

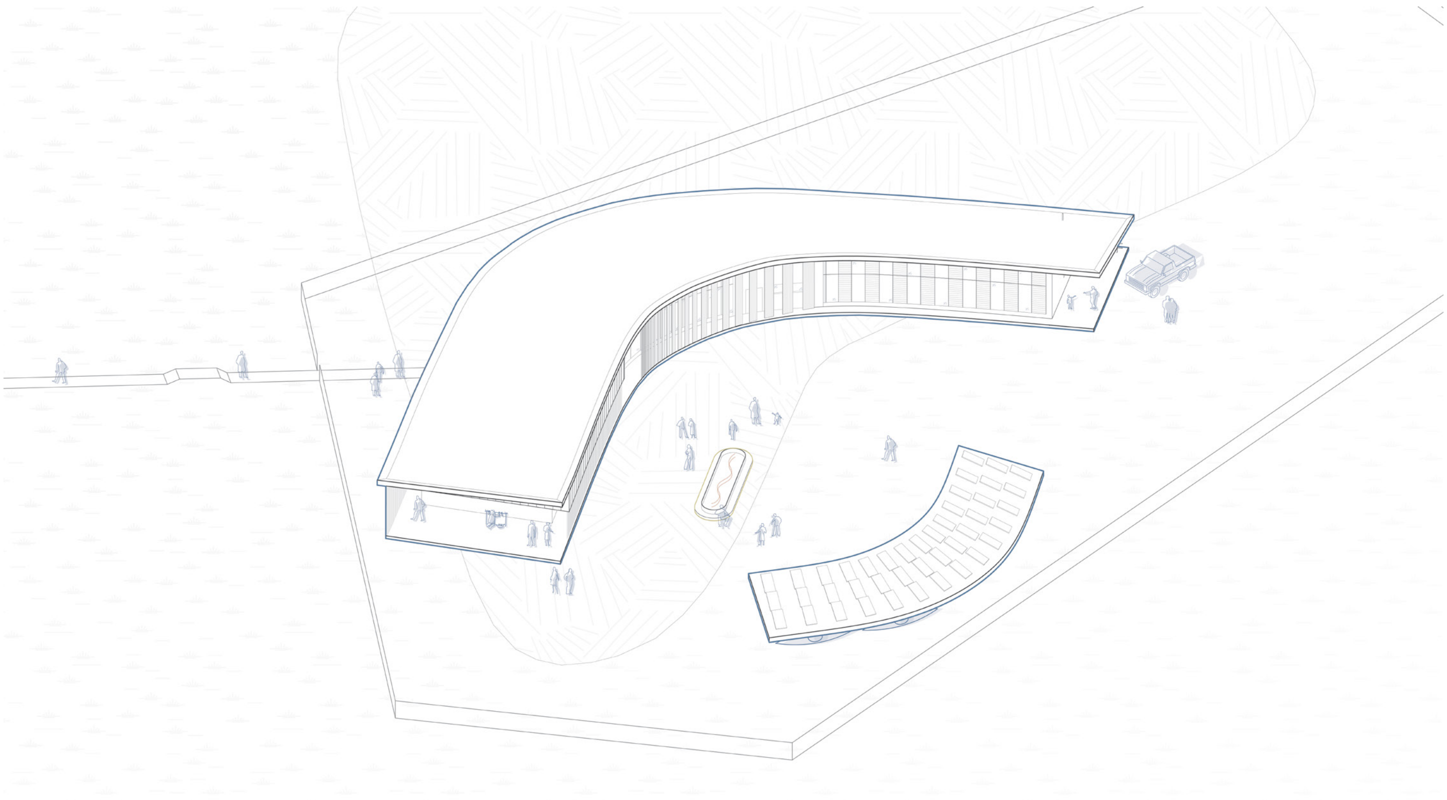
the entire building. This is especially relevant in the tall spaces, like the community space, as no energy is wasted heating the air at the top of the space. In the off season, the building is uninhabited, and the heating temperature set point can remain in the low teens for maintenance. The wall between the greenhouse and the remainder of the building can be closed, and temperatures within the greenhouse can be kept slightly higher, reducing the season's germination and restart time in the spring. In terms of ventilation a Heating Recovery Ventilator (HRV) is used to minimize thermal losses (Figure 6.22). Ventilation ducts are thus integrated in the ceiling and in the walls to provide oxygenation to the various spaces, but this entire ventilation system can be turned off in the winter, when the building is not occupied, relying entirely on insulation and the heating system in maintenance mode to keep the building warm enough to get through the cold season.

For water collection, shown in Figure 6.22, the roof slope is used to collect rainwater, along with the nearby stream providing additional supply. The lowest point of the roof allows for rainwater drainage into filtration and storage tanks in the service wing on the building's North side. This is fed through to the kitchens, greywater returning to be filtered and used for food production. Stream water is first utilized in the building's western mass, greywater flowing east to reduce the use of water pumps and further supporting the greenhouse's water requirements. The entire building sits on an area with primarily exposed bedrock, some spots with shallow sand and silt deposits and resulting short grasses. Due to the unevenness of the terrain, the Hub uses shallow piles into bedrock to provide a level base for construction, as well as allow a small gap for water runoff in the spring season.

Inuit culture stems from living actively, through transforming materials and spaces for the climate and the activity in question. This ingenuity and adaptability is reflected in a project that is continuously transformative. While the building may operate on passive systems, an active relationship between users will foster an understanding of the project's grounding cultural principles within spaces that promote dissemination of a myriad of knowledge sectors. For the building to further adapt and *'batten down the hatches'* on increasingly erratic storms, the manually operable panels unfold and lock to act as an additional barrier to the building envelope. Through the overall design of the building and the varied uses of its flexible indoor spaces, connections are continuously fostered between various users - acting as a catalyst for knowledge dissemination and exchange.

Figure 6.23
Isometric view of the Hub, featuring users at multiple gathering outdoor gathering spaces and the circular form.

Figure 6.24
Exterior south perspective, where the changing dimensions of slats can be seen, starting small on the left, and expanding to one metre inside the growing spaces.



6.4 | CABINS

On the western side of the stream are the site's main accommodations (Figure 6.25): steel domes as well as cabin pods. Lifted on tent platforms, thirteen steel domes are reused, sleeping a total of twenty-six guests. Additional tent platforms are available for temporary tents, the site's expansion, or simple flat surfaces for trip preparation. These tent platforms provide the opportunity for wood from the old Base Camp to be reused. Indeed, this would be beneficial because, as noted in the Zero-Arctic project, *"Should the wooden materials be reused in subsequent buildings, carbon emissions from wooden material incineration are not realized and the biogenic carbon content from wooden based materials is extended to the next building Case."*[135]

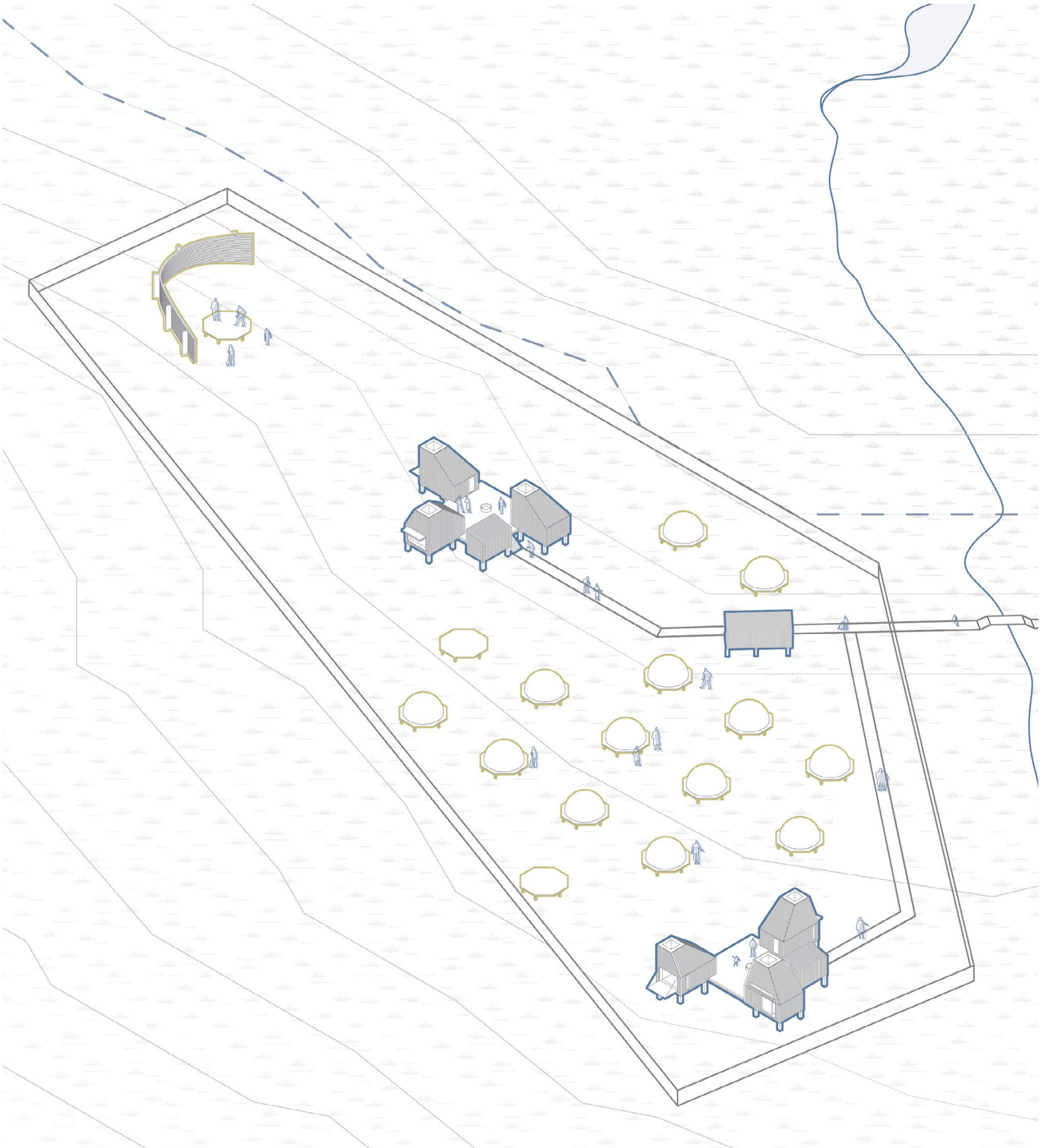
A boardwalk which leads from the hub connects to each of the cabin pods, and holds along its path an additional washroom unit. This unit is essential for the visitors sleeping in the domes, as those don't have washrooms. The pods, however, each have one shared washroom space. In all cases, the visitors need to leave their sleeping space to get to a washroom, preserving the existing camping-like experience in this natural and remote site. Walking outside to get to a washroom should not be a problem in this northern region because the Base Camp is not used during the winter. Also, in the bracket season, a lower number of visitors are most likely able to be housed within the Hub itself. The entire pod sits on rock-socket piles as this area of the site contains shallow but not exposed bedrock, and discontinuous permafrost is likely present underfoot. These piles allow for bedrock to be reached, as well as airflow and water runoff from spring thaws to be distanced from the building.

Looking at the design for the cabins, they are arranged in pods, each providing a central community area, three cabins, and a module housing a shared washroom and a utility block, which is playing a key role in making sure each pod can operate in a self-sufficient manner (Figure 6.26, Figure 6.27). This is reflection of the Inuit view on dwelling, in the "small-scale and intimate dwelling clusters of traditional Inuit community"[136]. Two pods are proposed, able to sleep up to twelve people each. The interiors of the cabins are minimal, providing some storage, outlets for power, and two sets of bunk beds (Figure 6.28). Their materiality is similar to the hub, wood siding being allowed to patina and weather over time, allowing the warm interior glow to extrude out through the varied windows.

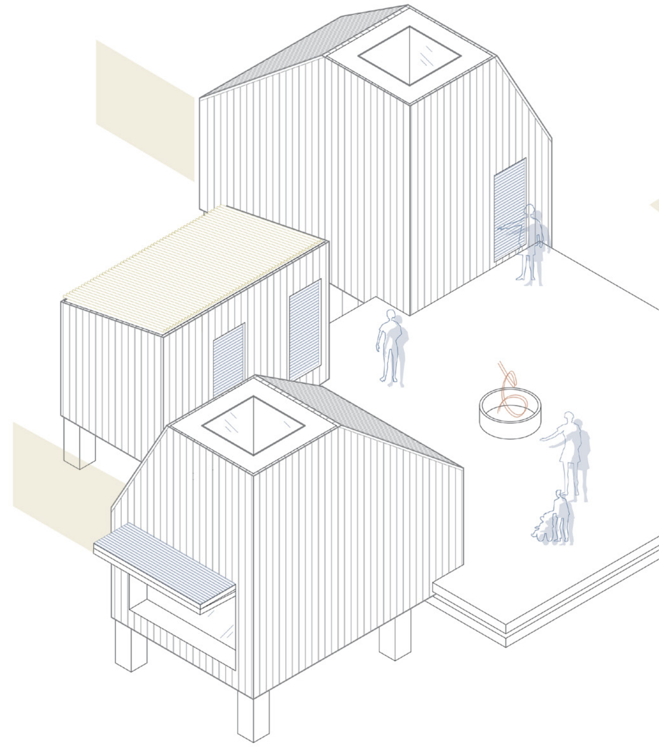
135 Kuittinen. "Zero Arctic: Concepts for Carbon Neutral Arctic Architecture based on Tradition.", 5.

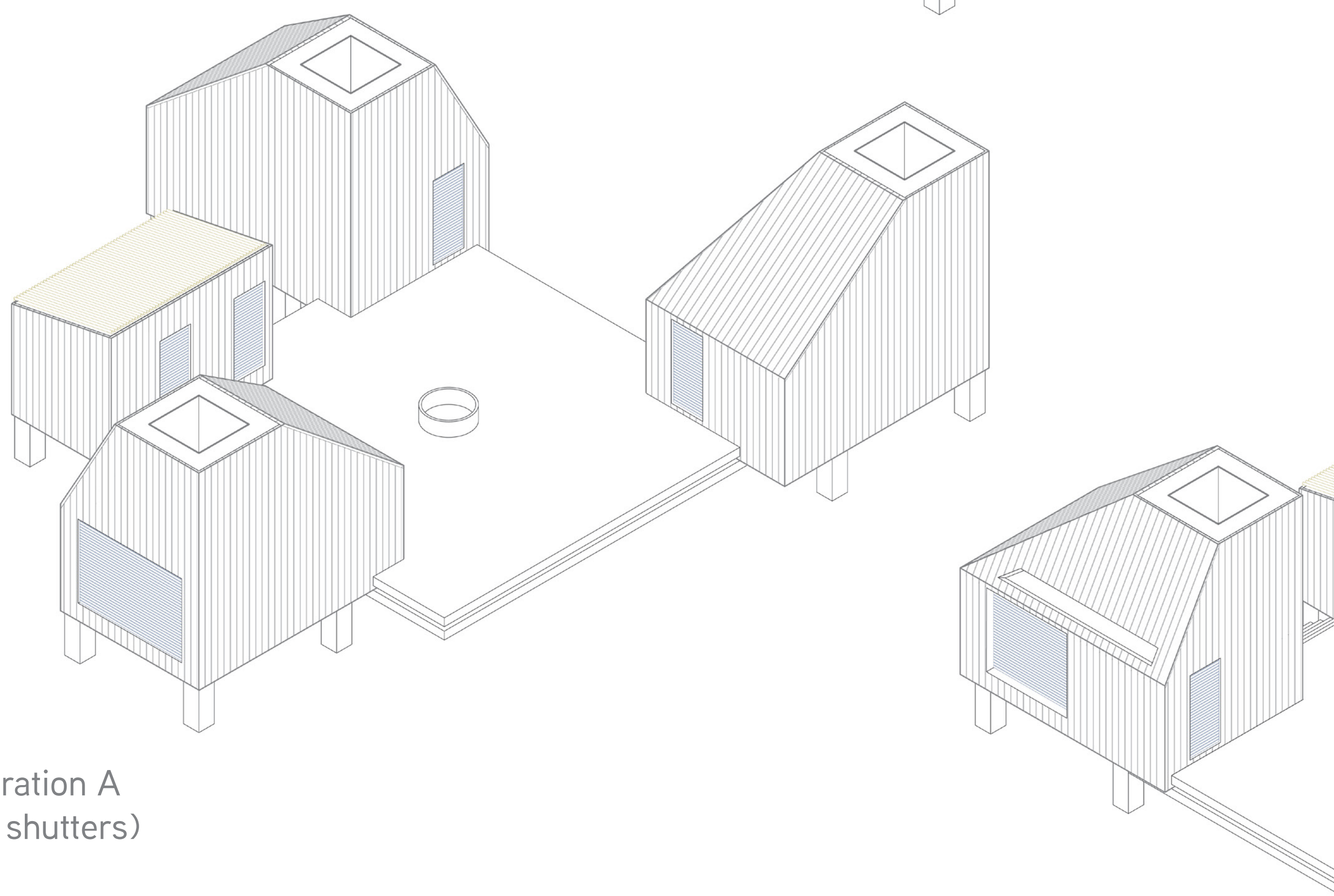
136 Peter Dawson. "Variability in traditional and non-traditional inuit architecture, AD 1000 to present" (Unpublished doctoral thesis), *University of Calgary*. Calgary, Alberta, (1997). doi:10.11575/PRISM/13000.

Figure 6.25
The western side of the stream features the Base Camps accommodations, including cabin pods and steel domes.



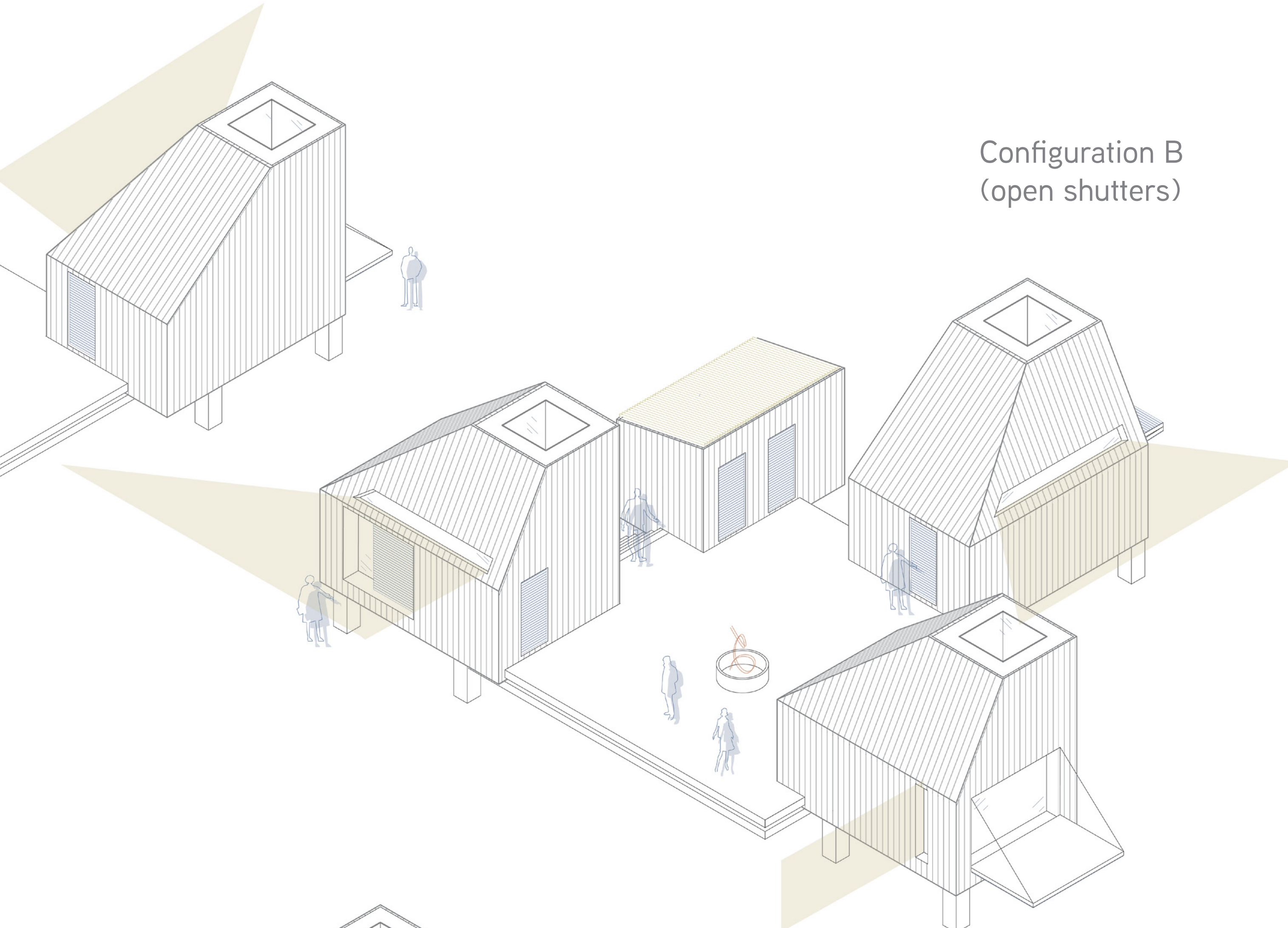
Configuration A
(open shutters)

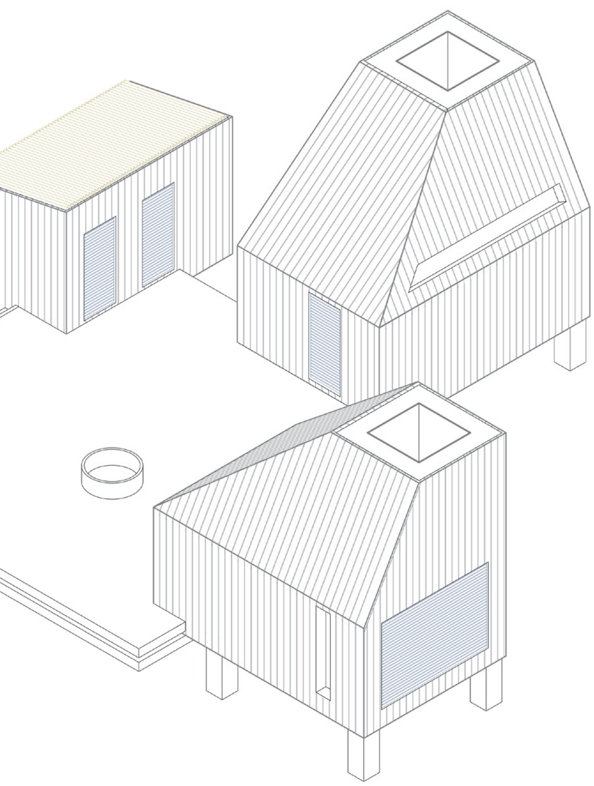




Configuration A
(closed shutters)

Configuration B
(open shutters)





Configuration B
(closed shutters)

Figure 6.26 (Above)
Open configurations of cabin pods, highlighting slit windows which are directed as specific on-site views.

Figure 6.27 (Left)
Closed configuration of cabin pods, each featuring three cabins, a exterior gathering space, and a utilities and washroom block.

Learning from various vernacular forms and biophilic principles, the form of the cabins reflects the direction upwards, providing a view for locating oneself among the night sky and traditionally a place for smoke to escape (Figure 6.29). Contemporary new Arctic architecture must adapt, and *"open like flowers to the sun of spring and summer but, also like flowers, turn their backs on the shadows and the cold northern winds"*[137]. With this notion in mind, each cabin has large faces directed south for optimal solar gain, and similarly each contains a large window oriented towards one of six spectacular on-site experiences - mountains, fjord, culture, valley, stars or aurora borealis. The larger windows are directed away from paths of travel and community spaces to provide privacy and are accompanied with three varied panels, or shutters, which are manually operable and locked by compression (Figure 6.30). Along with the Hub's strategy to batten down in the off season, the cabins follow the same strategy. Along with an energy efficient, air tight passive wall design with low thermal conductivity, similar to the igloo, the cabin insulated panels allow the units to close themselves off during the winter (Figure 6.31).

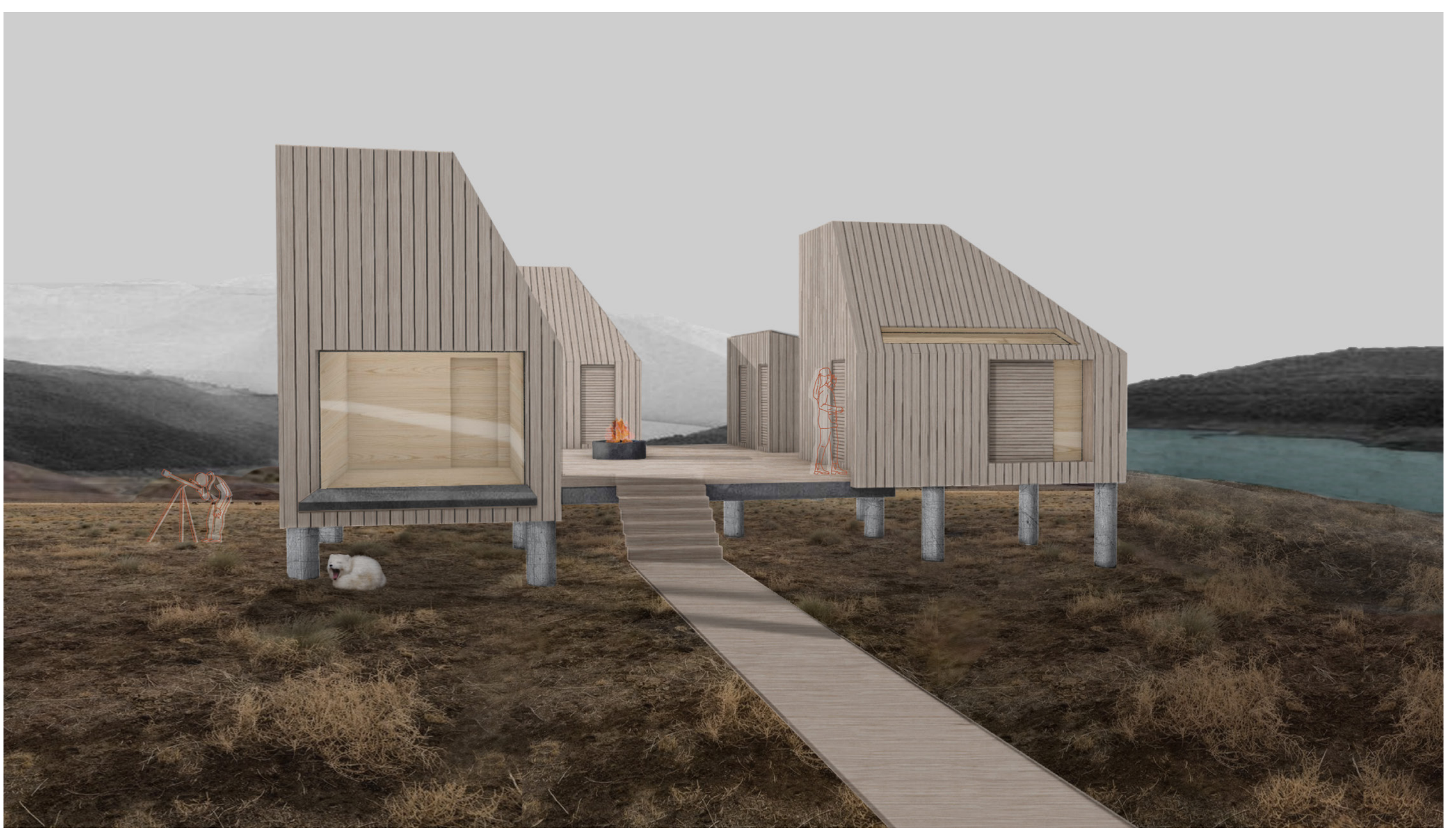
The pods and cabins are arranged in a way that they can be used to do real-life research on solar orientation and solar shading and insulating shutter systems. Indeed, three types of shutter or panel systems have been developed and are used on different cabins, or orientations, to see how they fare when used by visitors (Figure 6.32). This rotation of orientation and closure gestures to the way the Arctic poppy moves itself to capture the sun's warmth year round. For experiments to have understood cause and effect, the setup must allow one variable to change while the others remain constant. Applying the same form and amount of glazing while testing various orientations and types of manually operable closures provides information into which configurations are most utilized and how this impacts the energy efficiency of the unit. Currently, six combinations are tested (additionally noted in Figure 6.28). With the potential for the site to expand, the remaining combinations could be tested to allow for additional research findings.

The pod-like design results in each set of cabins being accompanied by a small utility building containing HVAC and washroom facilities, acting as the nucleus of the pod. Beginning with the heating and electric systems, photovoltaics are integrated into the siding on the south facing facades and roofs. Providing power for emergency plug in space heaters if used in the bracket season or a cold night as weather becomes more erratic, the energy additionally runs to battery storage in the nucleus, providing lighting and heat

Figure 6.28
Cabin floor plans with minimal furnishings, centralized around an elevated gathering space, large windows directed outwards.

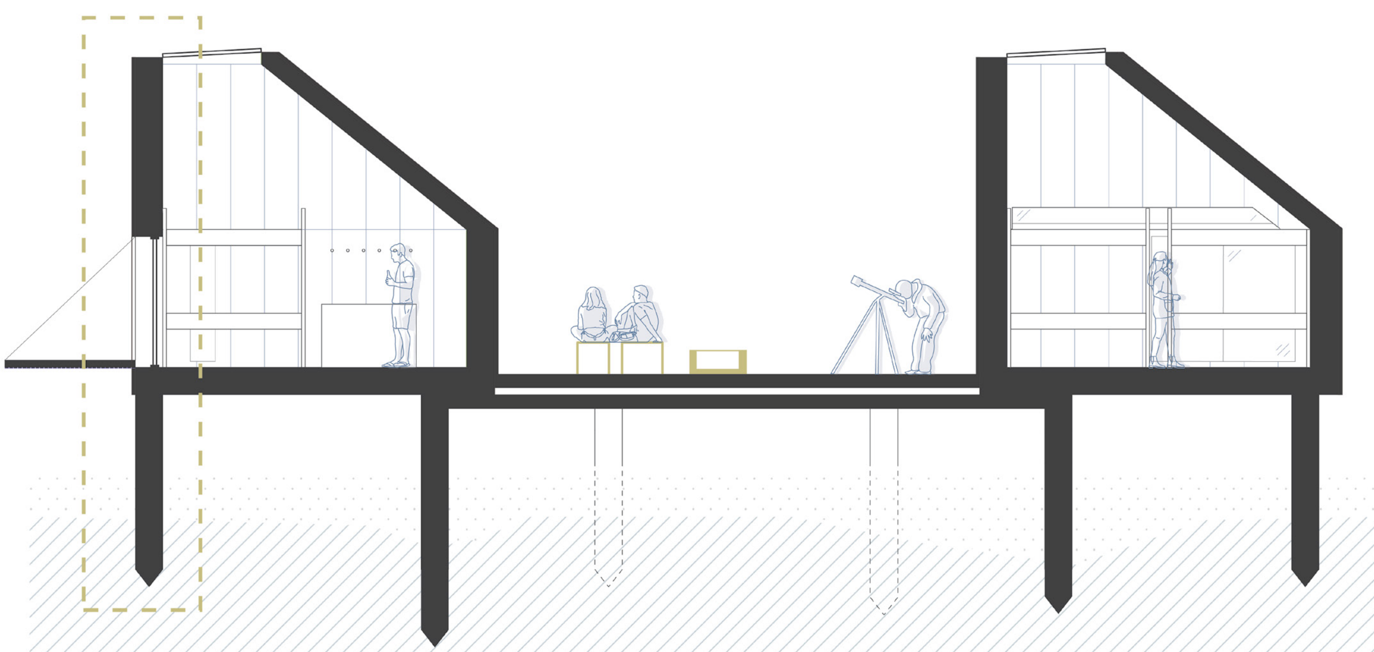
Figure 6.29
Simple exterior forms echoing vernacular and biophilia principles, cabins can be seen on slits with slit windows and opened shutters.

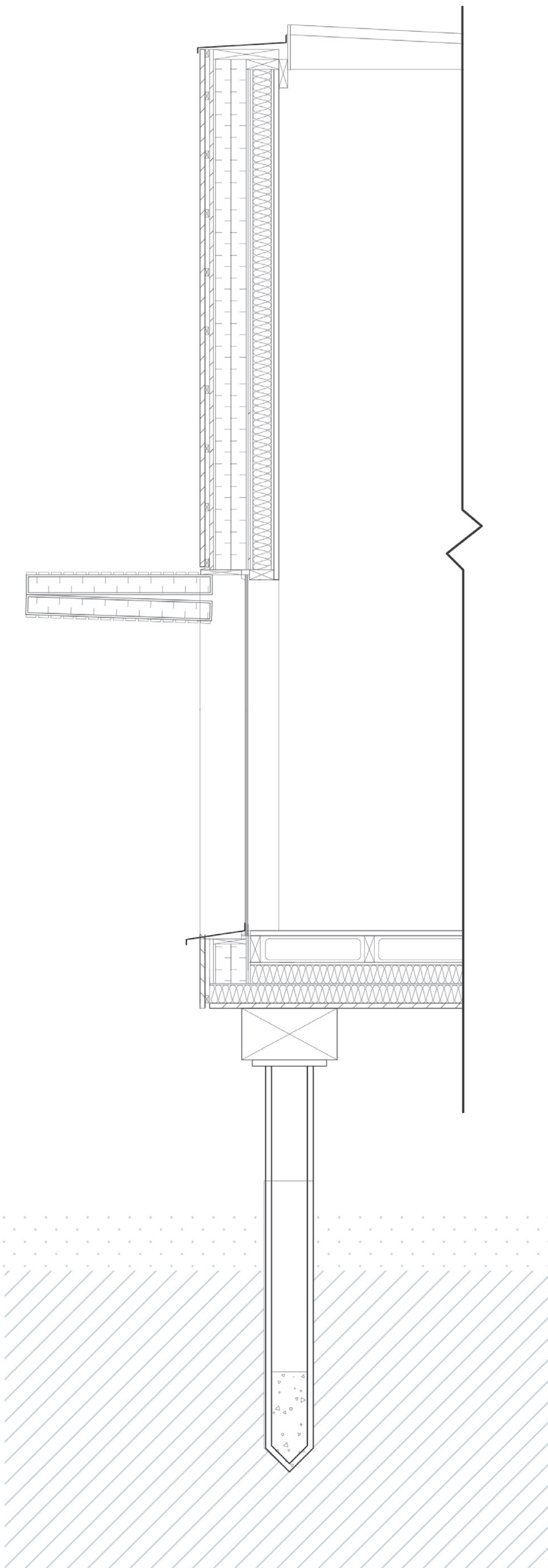
137 Ralph Erskine. "Architecture and town planning in the north." *Polar Record* 14 no. 89. (1968). (https://doi.org/10.1017/S003224740005659X.), 167.



(Figure 6.33). In terms of ventilation, mechanical ventilation is only used in the utility building to exhaust air and moisture from the washroom (Figure 6.34). In the pods, the small windows and skylight are operable, allowing for natural stack and/or cross ventilation. Due to the scale of the cabins and the site's remote location, using only natural ventilation aligns more with an economy of means. The slope of the roofs are integrated with rainwater collection, allowing for storage in shallow water tanks in the cabins' flooring, as well as an additional tank in the nucleus. Both south facing, the nucleus are covered in solar thermal collector tubes, passively heating the water during long daylight periods along with the assistance of heat recovery coils (Figure 6.35). Water from the cabins' storage basins are pumped into the washroom as needed. The deck additionally acts as a protected space for services to run through, the two layer system allows for systems to exit the cabins and run through insulated, moisture protected spaces in the deck and reach the utility box. Similar strategies allow water to reach the boardwalk's additional washroom facilities, relying on its close proximity to the stream. When cabins are not occupied or are in need of repairs, they are able to be "unplugged", essentially disconnecting from the pod and allowing resources to remain solely in the HVAC or nucleus component, which can remain in a maintenance phase throughout the off season (Figure 6.36). This can be done easily because the only connections necessary are electrical wires and water pipes, as the cabins don't have any integrated HVAC system. This system design allows for energy efficiency and reduces the potential for systems to be damaged when the site is not occupied and reflects a less sedentary building typology of place.

Figure 6.30 (Below)
Section of cabin pod, depicting roof slope and oculus, piles to bedrock, and manually operable panels.





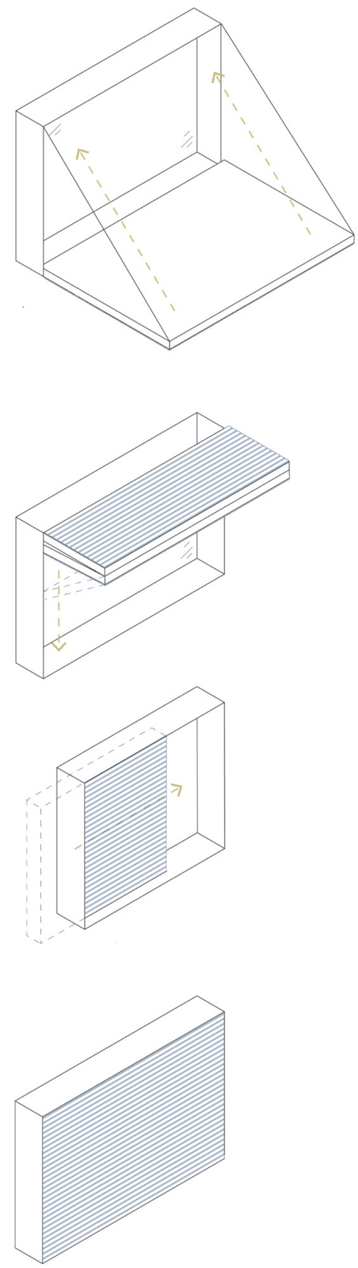


Figure 6.31 (Left)
An air-tight passive design focussing on low thermal conductivity, this detail section shows direct to floor windows, rock-socket piles, and compression locking window panels.

Figure 6.32 (Above)
To test energy efficiency and user interaction, three variable panel designs are used. Configurations shown in Figure 6.28.

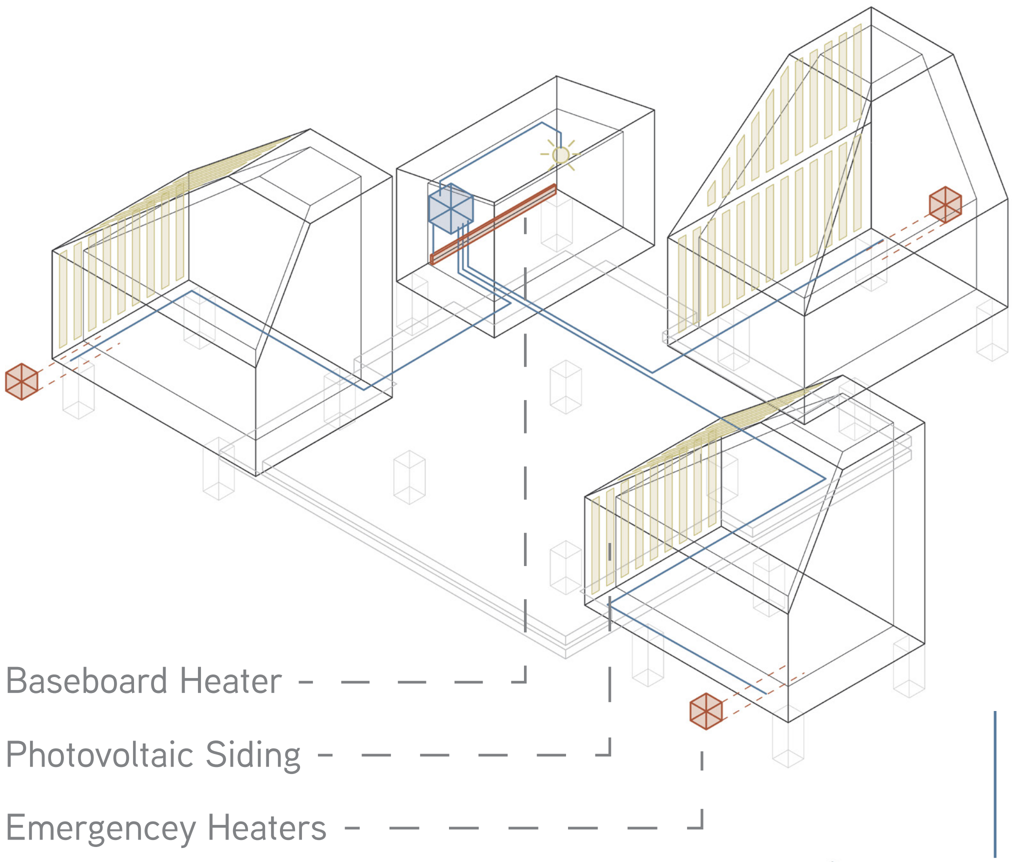


Figure 6.33
Electrical systems for the pod, photovoltaic siding providing heat for the utility block and power for small appliances and emergency heaters in the cabins.

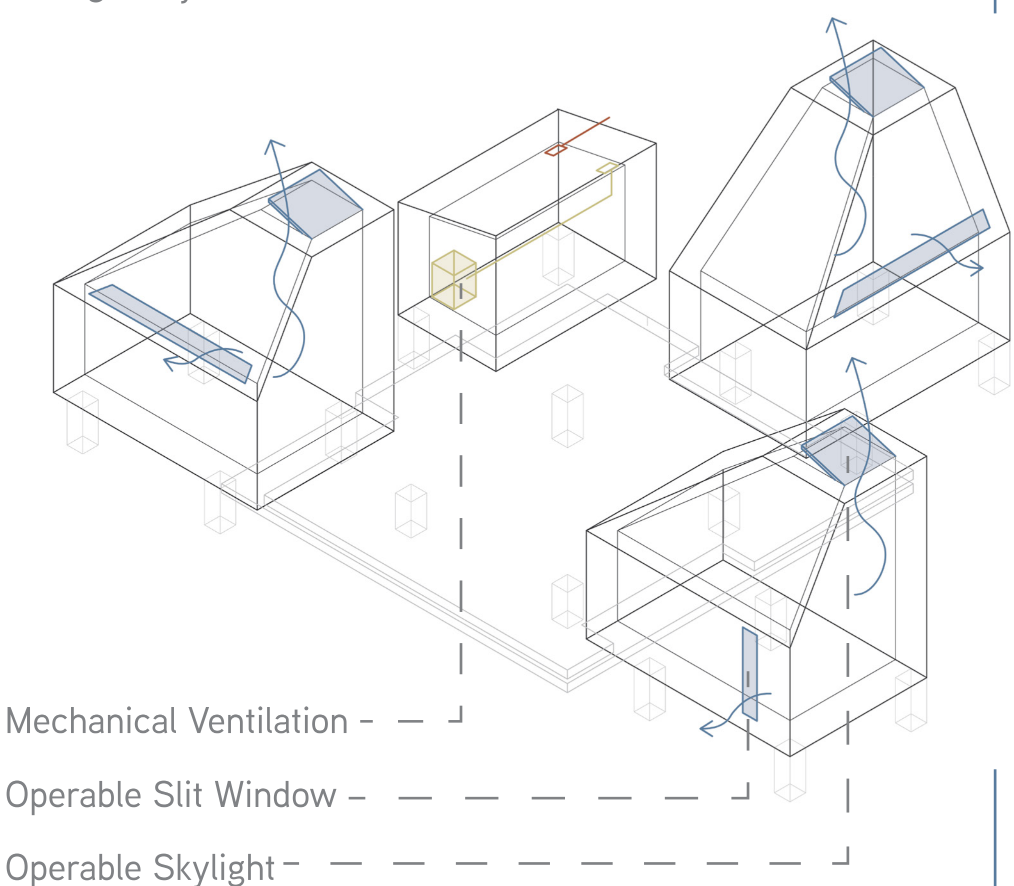


Figure 6.34
Ventilation systems focus on achieving cross and stack ventilation through operable windows, a small mechanical unit services the washroom space.

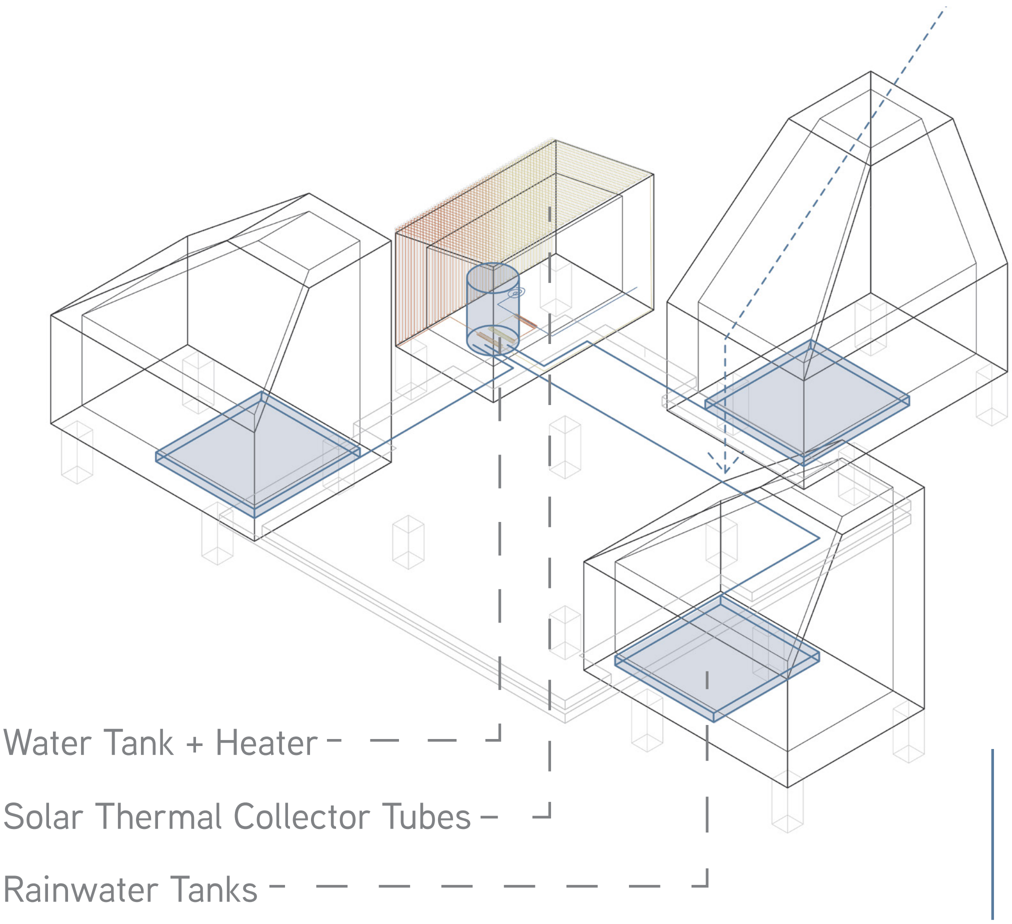


Figure 6.35
Water is collected through the slanted roofs and stored in the floor, pumped to the utility block when needed and heated though solar collector tubes + heat recovery coils.

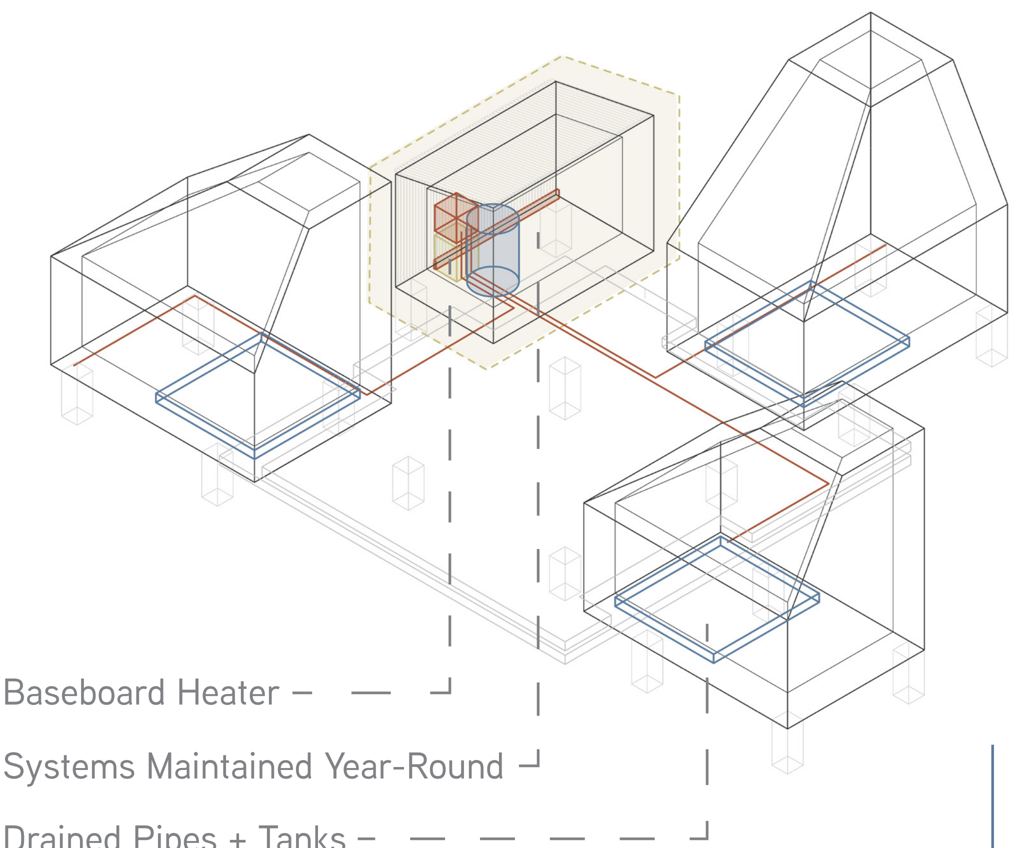


Figure 6.36
When "unplugged", the pods disconnect utilities from the cabins, allowing the utilities block to maintain itself during the off-season.

6.5 | SHELTER PAVILIONS

The final typology is the shelter pavilions, which provide a heavily immersive didactic approach forcing users to interact experientially with the changes occurring around them. This produces awareness of both the climatic and livelihood transformations occurring in the area. The Torngat Mountains National Park is nearly 10,000 square kilometers and contains four long distance hiking routes in its southern half, each of which uses the Base Camp as its jumping off point. In this remote, mountainous terrain, that stretches from the Northern Quebec border up to the Labrador Sea, hikers, researchers, and youth groups truly can get their feet on the ground and experience a changing place, spectacular scenery, and an array of Arctic flora and fauna.

These four hiking trails are located in each of the four National Park ecosystems: **coastal, freshwater, tundra, and alpine** (Figure 6.37). One shelter was located within each of the four ecosystems, on each of the four hiking trails, each focusing on one of the specific major climate change issues, as presented in chapter 4. Consequently, the coastal shelter addresses the issue of rising sea levels; the freshwater shelter addresses the issue of disruption of seasonal reliability; the tundra shelter addresses the issue of extreme and erratic weather; and the alpine shelter addresses the issue of permafrost thaw. By aligning an ecosystem with the most drastic change felt in this location, this provides researchers or guests, accompanied by their Inuit guide, with an interactive experience while crossing the expansive landscape.

The reliance on an Inuit guide in each expedition group is a matter of both safety and pedagogy, as the guide can act as an interpreter to the pavilions, sharing with the visitors their knowledge of the land they are passing through, and the changes it is experiencing. Indeed, as Parks Canada states *"the accompaniment of a bear guard will allow you to relax and enjoy your hike, but will also give you the opportunity to experience the park with the help and guidance of Inuit who truly know the land."*[138]

Providing formal inspiration to the pavilions is the following statement from Indigenous Architect Brett MacIntyre:

138 Parks Canada. "Bears Gut to Branigan Island Valley". Government of Canada. Accessed November 10, 2021. (https://thetorngats.com/site/uploads/2016/04/torngats-bears-gut-hiking-route.pdf), 4.

> *"it is complex and often contradictory, shifting with time and circumstance to reveal hidden truths and deeper questions. By its very nature something which is ambiguous must be carefully considered, laboured over, and debated. When confronted with an ambiguous object we are forced to take an active interest in it, to see something rather than just look at it. This implied active relationship between ambiguity and audience is particularly important*[139]*"*

The changes experienced in this Northern place are constantly kinetic and ephemeral, and the pavilions sitting lightly in this landscape should reflect this, fostering dialogue and connection to place.

Alpine | Koroc-Palmer River

The Koroc/Palmer River hike is the longest of the four hiking routes, covering over 90 kilometres and gaining over 1000 metres of elevation. Much of this trail takes you through an Alpine ecosystem, which is described as a *"wide valley [stretching] from east to west and [bound] by smooth, rolling hills to the south and rugged sharp peak to the north and particularly the northeast, where the highest summits in the Torngat Mountains are found"*[140] It is in the landscape, characterized by majestic peaks, headwalls, steep ravines, and picturesque waterfalls, that the tallest mountain east of the Rocky Mountains, Mount Caubvick, can be found.

The alpine ecosystem is the coldest of the four present in the Park, which is mainly due to the high altitude. This makes travel more difficult due to the harsh weather conditions. Around kilometre 73 of your hike, likely your last overnight, travellers reach a summit overlooking Mount Caubvick and its associated glacier in Iberville valley. This site is located a short distance from the existing suggested campsite, but does not alter the suggested daily progression of the hike. This is where the alpine pavilion is located (see Figure 6.37 - UTM 20V 454812 E 6525875 N)

This pavilion, like all other shelters, is intended to sleep six hikers, each taking up minimal space with their camping mat and sleeping bag, with some additional space for bag storage. The interior space has room for four hikers on the floor, and two additional hikers on the fold down platforms. By providing a sleeping space above the entrance, the idea of a suspended basement from

Figure 6.37 (Following Page) Map of the Southern portion of the Torngat Mountains National Park, depicting the four long range trails as well as their corresponding issues and pavilion locations.

139 MacIntyre. "Unknown Ground: The Case For Ambiguity in Indigenous Design", 2.

140 Parks Canada. "Koroc River - Palmer River Loop". Government of Canada. Accessed November 10, 2021. https://www.pc.gc.ca/en/pn-np/nl/torngats/activ/randonee-hiking1/koroc.


nakvak fjord
tallek arm
1. Alpine
Ground Thaw
Glacial
Mount Caubvick
cirque mountain
1568m
palmer river
mount caubvick
1652m
stecker river
Extreme Weather
Tundra
Wildflowers
2. Tundra
koroc river
nakvak brook
4. Freshwater
Seasonal Disruption
Freshwater
Migration Routes
southwest arm


1. Koroc-Palmer River (90km, 7-8 days)
4. Nakvak Brook Trek (68km, 5-6 days)
2. Ramah to Saglek Bay (67km, 5-6 days)
3. Bears Gut to Brangain Island (40km, 3-5 days)
Provincial Boundary
Torngat Mountains National Park Boundary
Parc National Kuururjuaq Boundary
Base Camp
Airstrip
ramah bay
Sea Level Rise
Coastal
Fjords
3. Coastal
bear's gut
rose island
st.johns harbour
saglek fjord

vernacular architecture in the area is used (Figure 6.41), adding additional thermal comfort to the raised sleeping spaces.

Sitting in a landscape riddled with changes caused by ground thaw and permafrost melts, thermokarst holes, landslides, sites of erosion, and glacial receding are evident throughout the alpine landscape. The alpine pavilion thus reflects these issues through its initial gesture of a shift, looking slightly off kilter, the form echoing the shifting ground below, as highlighted in Figure 6.39. Sitting on piles so as not to disturb and further warm the ground below, the cladding which allows for air movement wraps the stilts and gives the visual effect that the structure is nestled into the ground.

Upon entering the pavilion, a narrow rectangular window can be seen, right in front of you, wrapping the top of the space. From this vantage point, the peak of Mount Caubvick can be observed, 8 kilometres away with an extra 1000 m in elevation from the site of the pavilion (Figure 6.38). Stepping up a few steps into the sleeping area, the angle of vision changes by approximately 7°, directing the view through the narrow window down to the base of the mountain, where erosion and a retreating glacier are in view (Figure 6.40). This design forces the user to experience not only the star of the panorama, the ridgeline, but additionally face the reality of a climate change driven thawing ground. If travellers reach this site mid day and intend to travel to the next campsite, they can still experience the perspective change through an attachment on the roof. Open slats allow for the slant to be climbed like a ladder (Figure 6.41), and a viewfinder and lens provide the same directional view change (see Appendix C for more details)

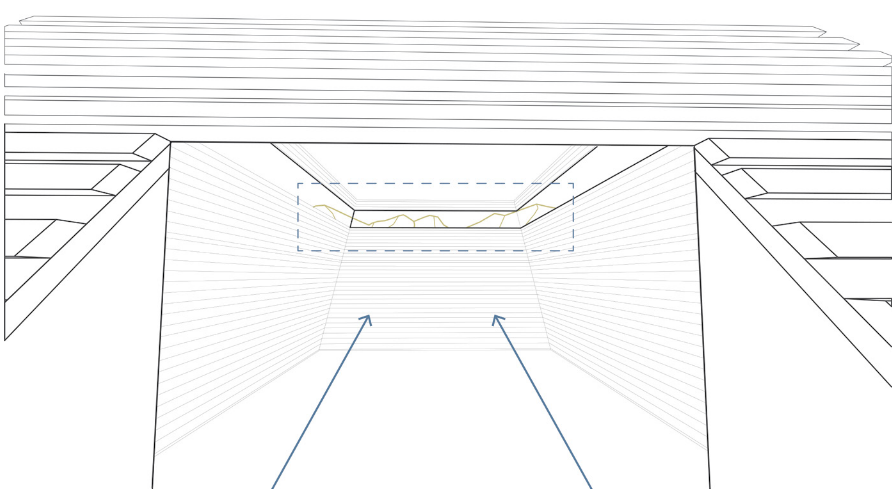
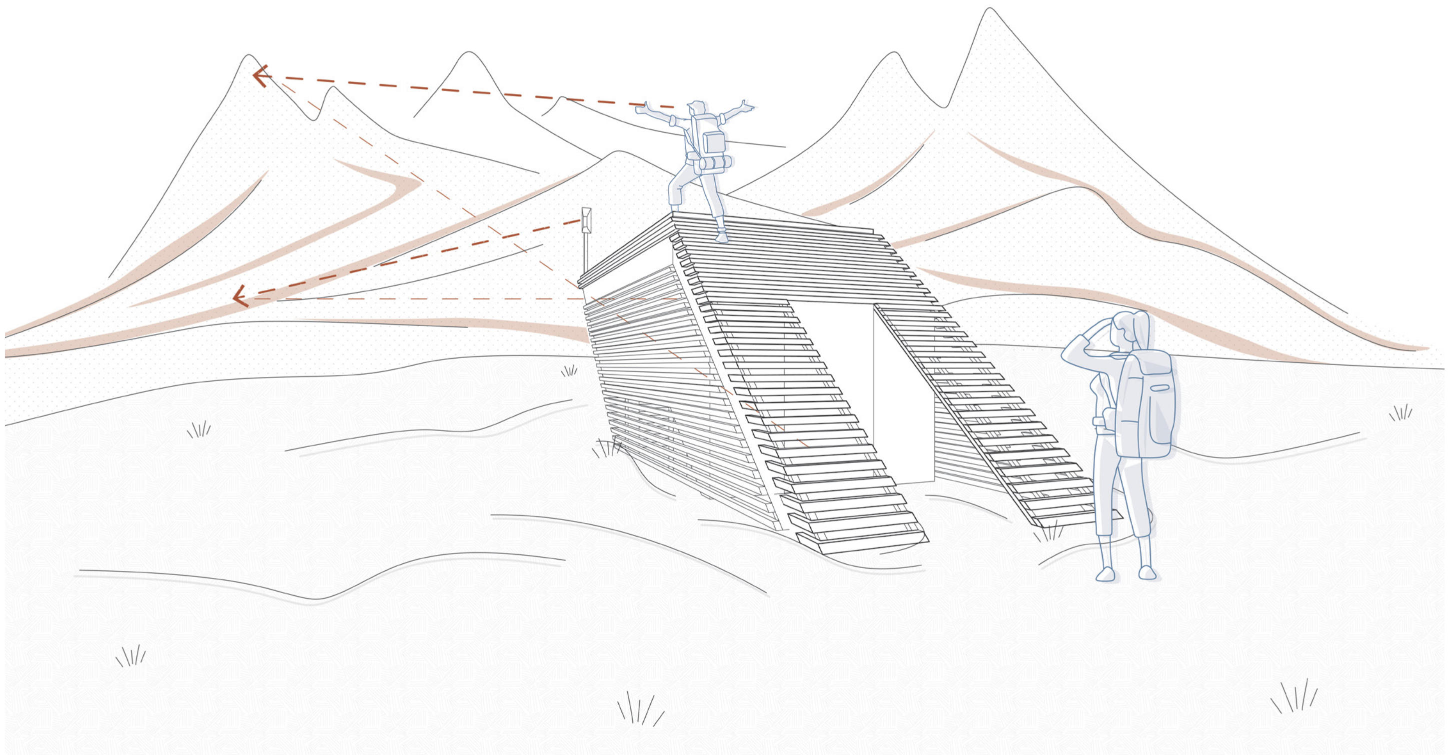


Figure 6.38
View upon just entering the Alpine pavilion, a slit window framing the view to Mount Caubvick in the distance.

Figure 6.39
Vignette upon approach to the Alpine pavilion, showing how is it appears off kilter in the barren, rocky landscape.



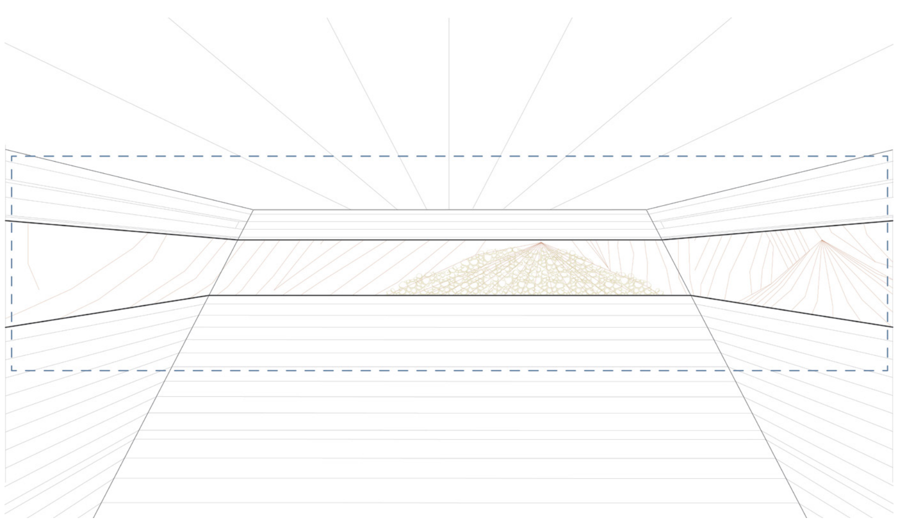
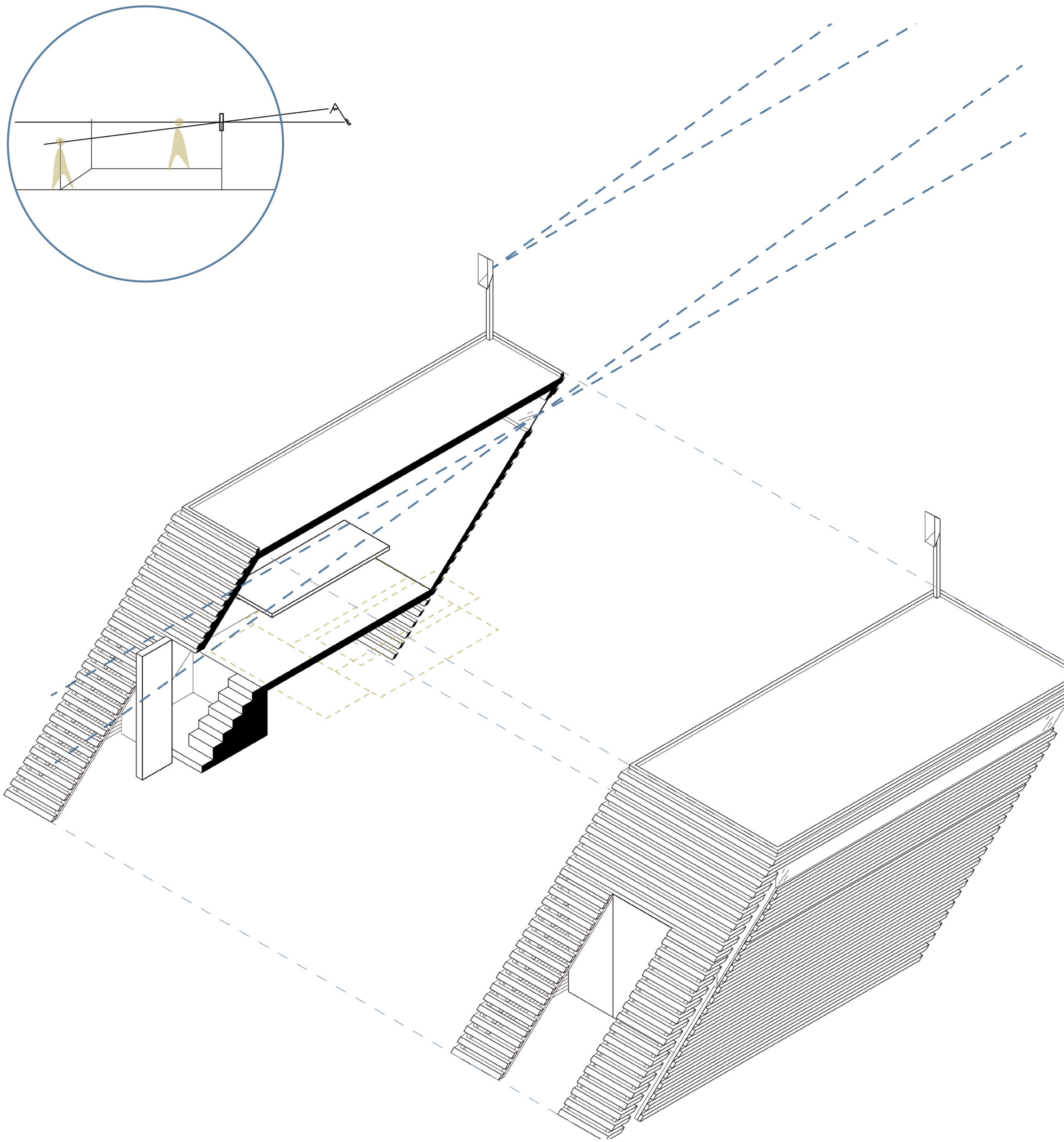
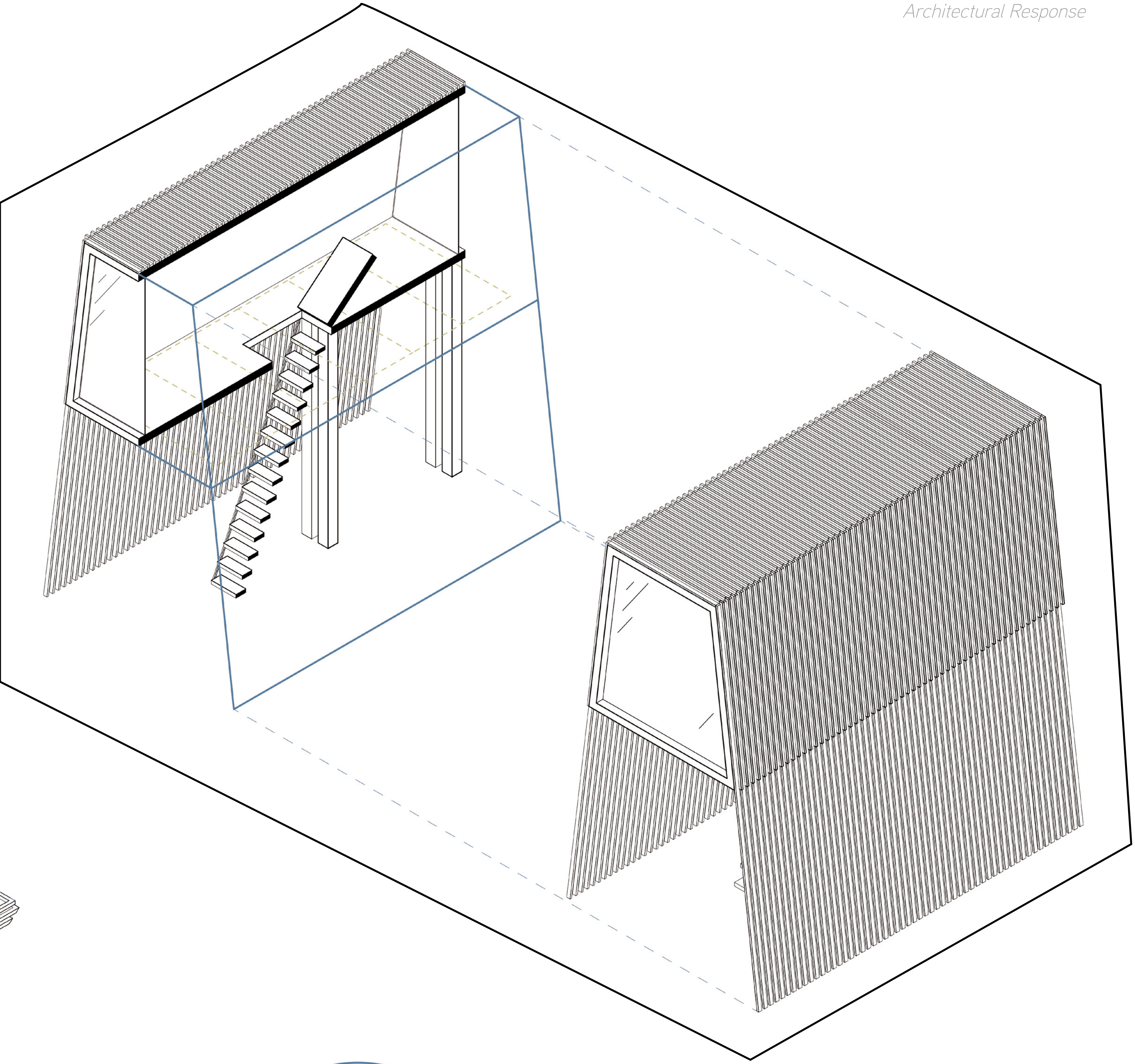


Figure 6.40
View once rising into the sleeping portion of the Alpine pavilion, the window now at eye-level, it directs your view down to the base of mountains, where ground thaw is present.

Figure 6..41 (Below)
Isometric and section of the Alpine pavilion, showing the shifting form, 'suspended basement' principles, and angle of views.





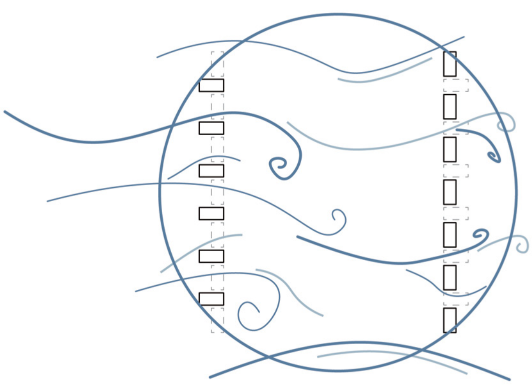


*Figure 6.42 (Above)
Isometric and section of the Tundra pavilion, showing the elevated sleeping spaces as well as alternating cladding, additionally shown in plan to highlight the vortex shedding effect.*

Tundra | Ramah Bay

The Ramah to Saglek Bay hike is nearly 70 kilometres and takes you from one fjord to another, crossing through a vast tundra for nearly the entire length between them. Described as a *"challenging hike [which] takes you through some of the most beautiful and varied terrain in the southern half of Torngat Mountains National Park, [it is filled with] rolling green tundra meadows"*[141]. The three main valleys of this hike are traditional travel routes which have been used by the Inuit of the area for generations, connecting families and communities between Nunavik and Nunatsiavut"[142]. At kilometre 29, an alpine valley spans just before the high point of the hike. This is where the tundra pavilion is located (see Figure 6.37 - 20V 472383 E 6511063 N)

As with any hike in mountainous regions, the weather can be challenging. This hike follows deep valleys that funnel winds, increasing their speed to over 100 kilometres per hour. Pitching traditional trekking tents can be difficult in these areas, as the legendary winds of the Torngat mountains can easily destroy and dislodge them. These vast valleys above the treeline are rugged, rocky barrens. The vegetation is sparse and contains primarily grasses, mosses, and lichen. In this horizontal landscape stretching out in front of travellers, the vertical tundra pavilion acts as a beacon of refuge as further changes occur in the climate and the extreme and erratic weather will become even more prevalent.

The pavilion is clad with two by one inch pieces of wood. The orientation of the slats alternate on one side of the pavilion to the other, interlocking as they wrap the enclosed area to create a textured facade. Oriented to create larger gaps on the windward side, winds speed up and are then trapped as they travel towards the leeward side (Figure 6.42). This creates the effect of vortex shedding, producing whistling winds that buildings are most often designed to avoid. The whistling sound can be heard upon approach to the structure, getting louder as you get near. Users must face the noise and travel through it, as they rise to their sleeping area as it forces a confrontation with a portion of the issue faced in this region (Figure 6.43). The sleeping space is held through heavy timber posts piled into the ground, and includes sound proofing to provide a comfortable overnight space above the whipping winds. The pavilion is bookended with glass panes to provide to travellers uniquely elevated views of an otherwise flat landscape.

141 Parks Canada. "Ramah Bay to Saglek Bay". Government of Canada. Accessed November 12, 2021. (https://www.pc.gc.ca/en/pn-np/nl/torngats/activ/activ1/~/media/94695ECBCCB542BF8D6339A123F3E374.ashx), 4.

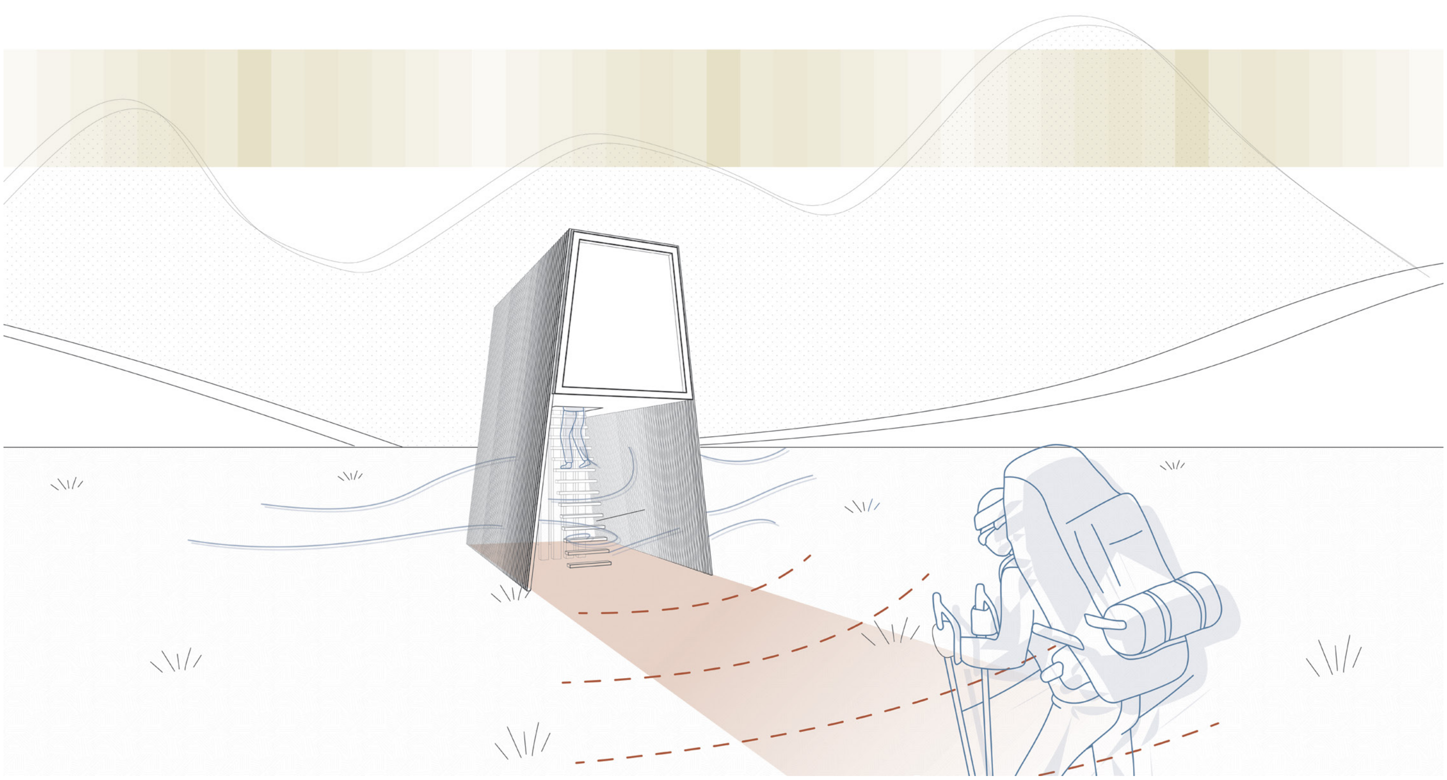
142 Ibid, 4.

Coastal - Bears Gut to Branagin Island Valley

The coastal pavilion is situated at the end of Bear's Gut, the final destination on the 40 kilometre Bear's Gut to Branagin Island Valley hike. With a coastal ecosystem on both ends of the trail, this hike best illustrates the issue of sea level rise. Indeed, despite natural isostatic rebound of the area, sea level rise in this specific region can still be expected to reach at least one metre in the next century. The coastal pavilion is thus located in the sea, near the shoreline, to raise awareness on the rising sea levels issue, (see Figure 6.37 - 20V 494958 E 6503450 N).

The coastal pavilion utilizes two of the strategies for combating sea level rise that were presented in section 4.3. This floating pavilion rests on UV stabilized polymers which allows it to rise with the ocean's new height as well as the shallow tide changes present here. Crossing a suspended bridge, which is anchored to

Figure 6.43
Vignette upon approach to the Tundra pavilion, hikers fighting strong winds upon approach and hearing an amplified whistling noise s they near.



account for business-as-usual sea level rise, the traveller reaches the pavilion wrapped in a minimal outdoor deck. A drastically sloped protective roof faces out into the fjord to combat waves and divert storm water down and off the structure (Figure 6.45). Shiplap siding additionally helps with dry proofing the structure. The floating portion of the structure is complemented by a fixed potion, which allows people to become cognizant of how much sea level rise has happened since the time of installation. Anchored into the sea bed, this more shallow sloped roof allows for users to lounge on it while visiting the pavilion. On its stilts are marked the tide lines at different points of the day, allowing visitors to easily note the sea level. If less interested in the exact rise, the fact that the roof slopes no longer align as the ocean rises alludes to how out of alignment the climate is (Figure 6.44).

The second adaptation strategy is to 'stop the water'. Through the use of in-ocean mitigation such as dykes slightly down fjord, much of the storm surge and pack ice accumulation which can potentially damage the structure are stopped. The combination of these two strategies allows for the building to be protected from damages of sea level rise, as the impacts of this change require the pavilion to be resilient for changes to be seen over a longer period of time.

Freshwater - Nakvak Brook

Further into the Saglek fjord marks the beginning of the Nakvak Brook trail. One of the park's major rivers, Nakvak is a traditional route that has linked Nunavik and Nunatsiavut for generations, by foot, dog team, and today, snowmobile[143]. The trail follows the river, situated in a freshwater ecosystem. Due to the generation connections of both Inuit and a variety of fauna to the area, this pavilion aligns its pedagogy with lessons about the seasonal disruption and shifts to regional livelihood in the area. Jumping off from Base Camp, the Nakvak trail can be up to six days in length, with easy day trips possible as well. One possible day trip taken more consistently by Base Camp visitors is to the Inukshuk, just a few kilometres from the beginning of the hike. Commemorated in 2009 to signify the generational bond between the two bordering Inuit Nunangat territories, *"it is a place that has gained significance for youth and Elders, who recognize the importance of passing on Inuit Knowledge and connecting Inuit youth to their culture and their land"*[144]. The location allows for more users to have prolonged learning with the land and become cognizant of the culture and traditional livelihood in the region.

143 Parks Canada. "Nakvak Brook Trek". Government of Canada. Accessed November 12, 2021. (https://thetorngats.com/site/uploads/2016/04/torngats-navak-brook-hiking-route.pdf), 4.

144 Ibid, 5.

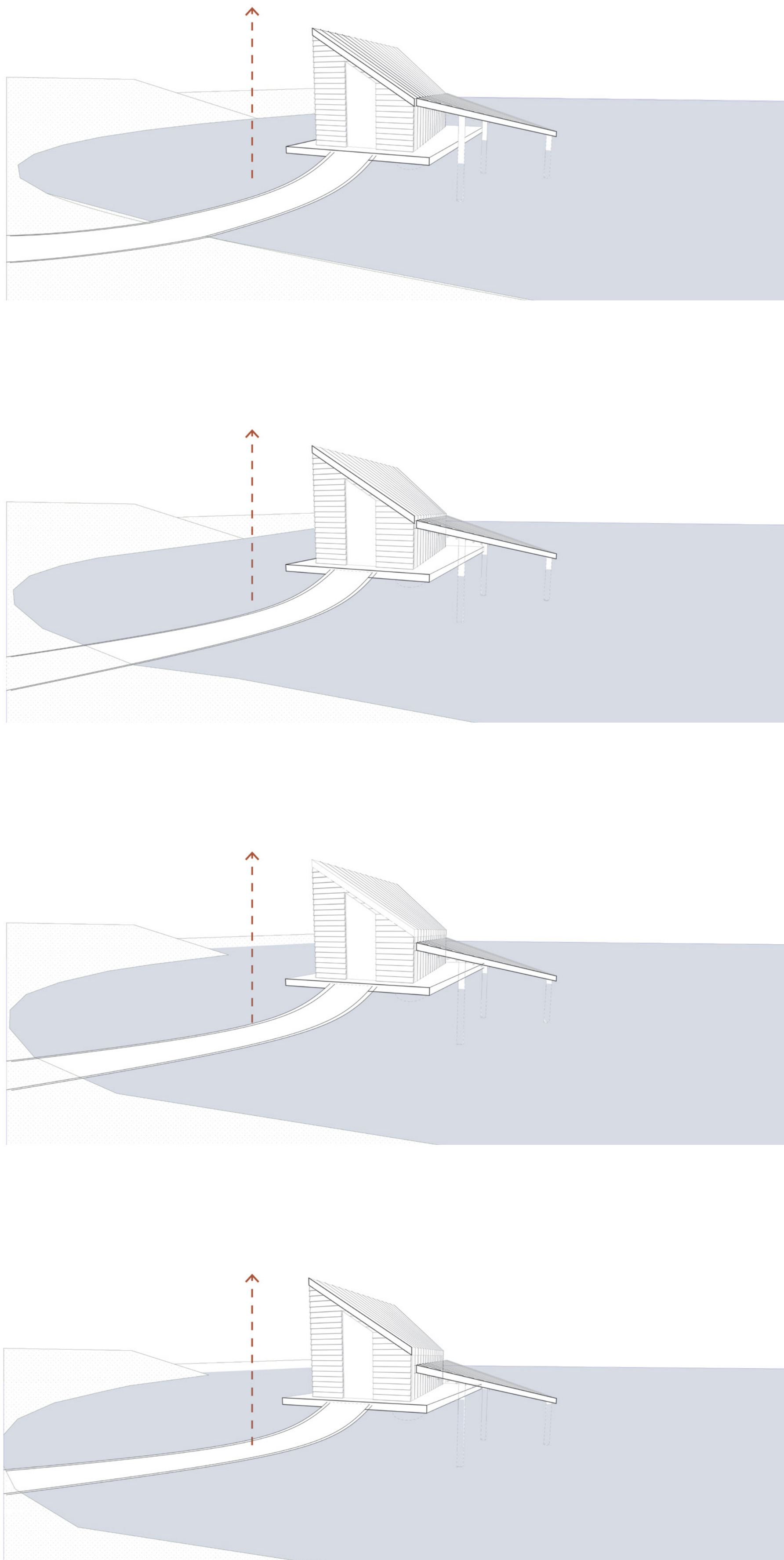
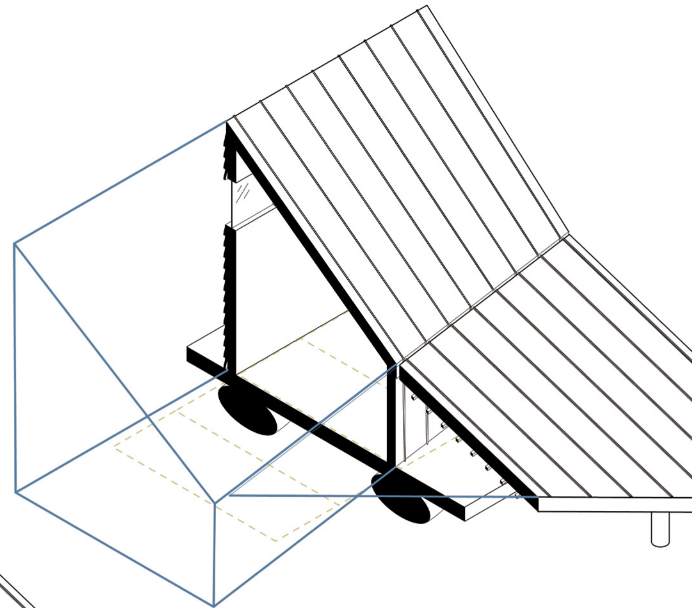
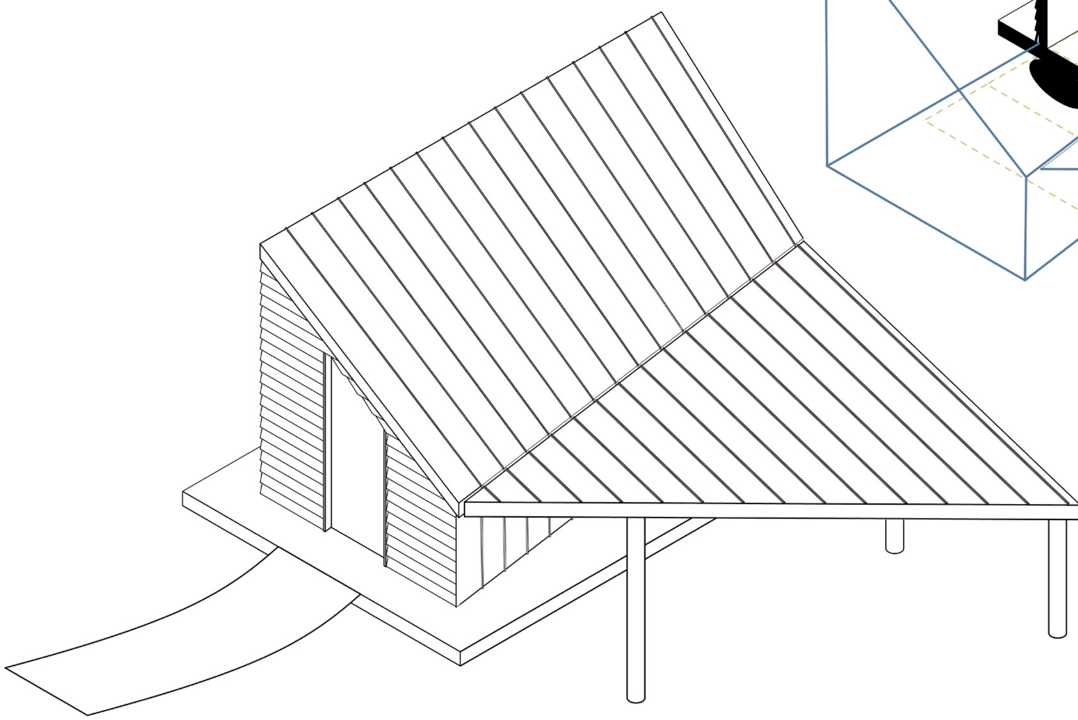
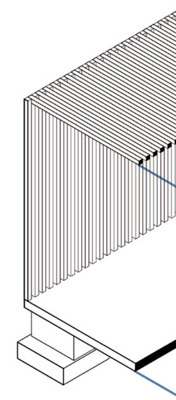


Figure 6.44
Vignette progression showing the floating portion of the Coastal pavilion rising with the sea level, while the anchored portion remains fixed, showing visitors the change in sea level since time of installation.







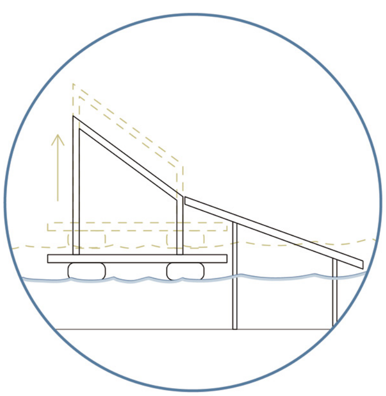


Figure 6.45 (Left)
Isometric and section of the Coastal pavilion, highlighting the drastic roof angle to protect from storms, as well as the fixed and floating portions.

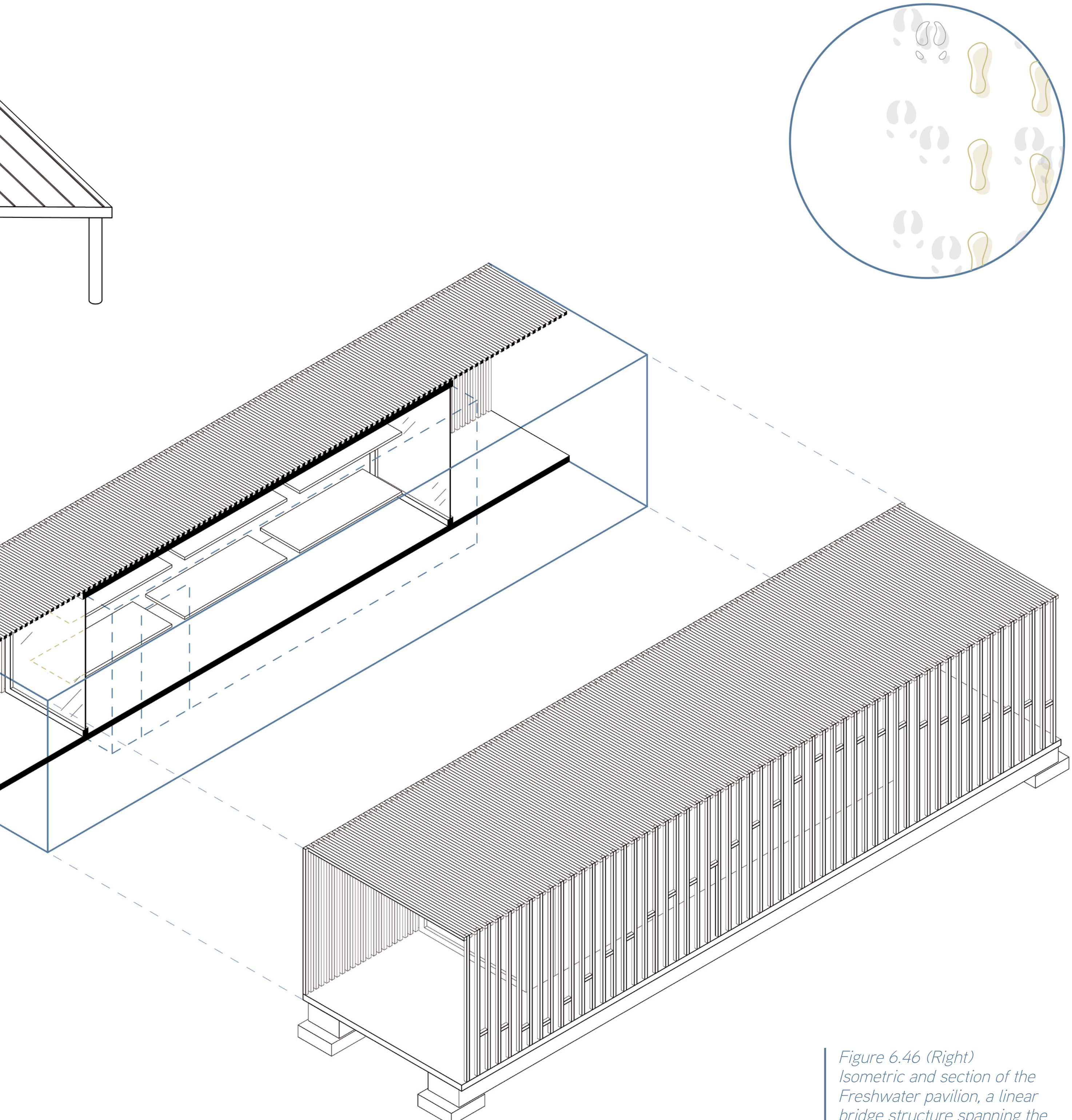


Figure 6.46 (Right)
Isometric and section of the Freshwater pavilion, a linear bridge structure spanning the Nakvak Brook, providing spaces for nesting birds in its cladding.

As you continue upstream on the multi-day hike, you will quickly discover caribou trails meandering their way through low lying thickets and shrubs while easily discerning century old walking trails over more open ground. Around kilometre 27 is a best spot for river crossing, which is where the pavilion is located (see Figure 6.37 - 20V 468594 E 6500706 N). To assist with this still challenging river crossing, the freshwater pavilion doubles as a bridge, taking into account the river's edge has some variance in size depending on the season, responding to spring thaw and heavy storms, Figure 6.46). Consisting of a small interior space with three linear bunk beds and minimal room to walk along, the bridge's exterior space extends the width and length of the structure to not only span the river but allow for outdoor observation areas. The surrounding infrastructure additionally provides nooks for various birds to nest.

For many Arctic species, the park lies within their migration routes to and from their wintering grounds at Ungava Bay each year[145]. Specifically, the rivers directionally mark these paths and show proof of generations of passage on its shores. Caribou trails are everywhere, though in recent years these paths are not as worn down due to a decline in the Torngat Mountains herd[146] (Figure 6.47, Figure 6.48). This provides one of the observations of the land which Inuit guides can present to travellers along with educating on the multitude of fauna which live on this land, and how that land has provided for the locals for all time. In parallel, one becomes aware of shifts in these patterns: more southern species of birds nesting in the north, drastically fewer caribou travelling through, and flora generally ready for the picking through the peak trekking season are scarce, late, if not nonexistent. Encouraging users to be still, observe and listen to lived experiences on Inuit lands, while perched above a frigid fast flowing river, is the way to willfully learn from a place.

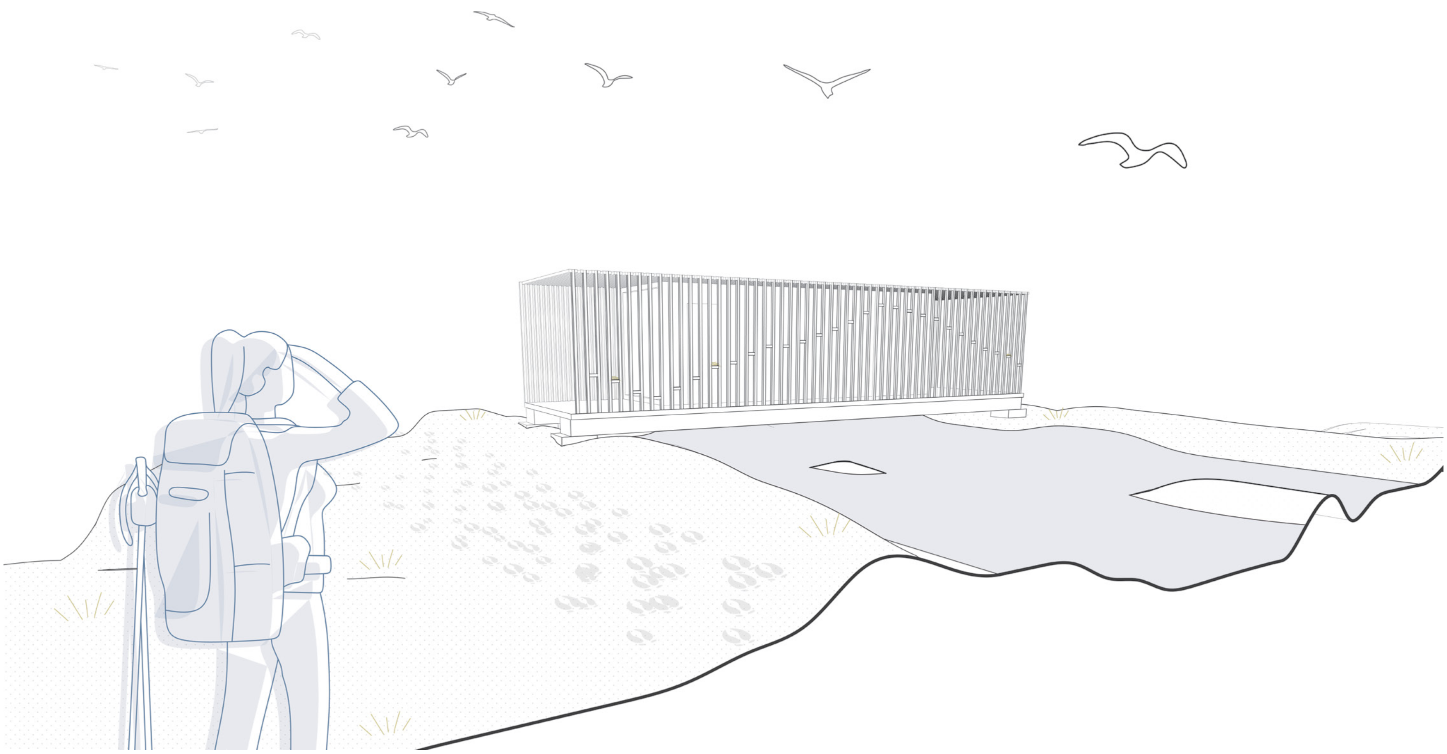
Incorporating lessons from climate science, lived experiences, and future-proofing, the smallest scale interventions focus and educate on a point of deterioration in a changing landscape, while still providing practical refuge for travellers when increasing harsh weather conditions come barrelling down. The pavilions should be as transient on the landscape as the animals who pass through, but create long-standing, visceral understandings for their users.

Figure 6.47 (Top Right) Vignette upon approach to the Freshwater pavilion, where centuries of caribou tracks are evident in the battered landscape.

Figure 6.48 (Bottom Right) Vignette upon interpretation by your Inuit guide on the changes in the landscape - southern birds, out of season flora, and a scarce numbers of caribou.

145 Parks Canada. "Torngat Mountains National Park - Nature and Science". Government of Canada. Accessed November 13, 2021. https://www.pc.gc.ca/en/pn-np/nl/torngats/decouvrir-discover#a3.

146 Parks Canada. "Ramah Bay to Saglek Bay". (https://www.pc.gc.ca/en/pn-np/nl/torngats/activ/activ1/~/media/94695ECBCCB542BF8D6339A123F3E374.ashx), 5.



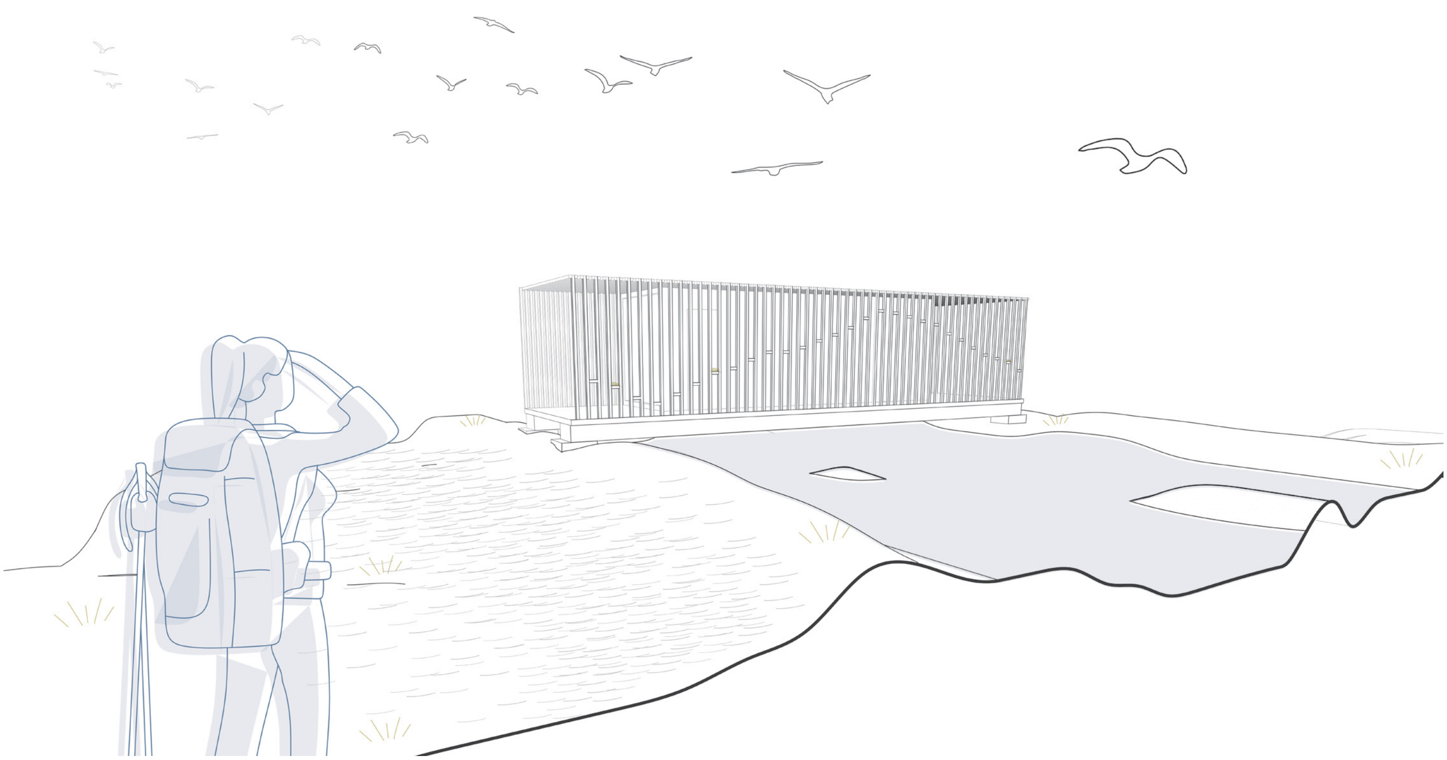


Figure 7.01
Trekking through the Torngat Mountains National Park.

CONCLUSION 7

The greatest threat to the continued livelihood of this and future generations is the repercussions of anthropogenic climate change. Bringing socio-cultural aspects into productive conversation with climate change discourse, this thesis probed the question: **how can future-proof architecture be developed to adapt and inform about both climate and socio-cultural changes in arctic regions, acting in stewardship of both land and livelihood?**

Realizing that "applying universal technologies to local circumstances does not work"[147], place-based solutions needed to be developed in order to respond to the current as well as changing situation of a place - both to its climate and regional livelihood practices. This was addressed through a three pronged research approach of climate change science, lived regional experiences, and exploration of potential future-proofing strategies, whereby the guidelines for the project's design began to take shape. Where difficulties in this research arose were through the inability to

147 McDonough. Cradle to Cradle, 8.

reach the Base Camp site, due to it being closed for the season, and furthermore being unable to participate in any sort of in-situ collaboration with the Inuit, due to COVID-19. This segwayed the acquisition of lived regional experiences to memoirs, stories, films and other published works which spoke about the regions livelihood and its observed changes. Additionally, the remoteness of the site meant that climate and geological data were often sporadic or generalized to larger areas, creating limitations in determining exact placements of buildings based on bedrock depth, or developing pin-point accurate climate metrics. Evolving from these limitations was a project that, while climatically responsive and site specific, was designed from the development of general strategies which are equally applicable to similar climate and geographical regions, increasing the transferability of the work.

It is a fact that even if all further harm to the environment ceased today, a certain amount of climate chaos and degradation are already in the pipeline. As climate modelling timelines are being overtaken by actual pace-of-change events, the need for the building to be resilient, future-proofed, and functioning around the goal of self-sufficiency becomes critical. With the Arctic warming aggressively faster than the rest of the planet, the gravity of changes felt here is near incomparable. Self-sufficiency is protecting a place and its resources for this generation, as well as many generations to come. Future-proofing is acknowledging that tomorrow, next decade, or next century's situation will be different from today, and preparing for the worst of what it may bring. Resilience is being able to exist and thrive in the future no matter what those future challenges may be. Adaptability additionally runs through every aspect of the project, as this allows the architecture to react to both short and long term changes in conditions. This is coupled by the project's ability to mitigate, if not negate, further harm along with proactively preparing for changes to come.

In order to best identify the most relevant future-proofing strategies, it was important to first identify the main climate change issues in the region, as the strategies needed to directly respond to those issues. Those were: extreme and erratic weather, sea level rise, ground thaw, and disruption of seasonal reliability. "In addition to integrating architectural strategies that would allow the building to cope with the climatic issues, it was also important to seize the opportunity to design buildings that would educate its users about the issues and how we can respond and adapt to them. Generating a design that directly supports pedagogy was thus essential to create a cognizance among users as to the myriad of complexities that a warming planet brings with it. There were thus three interventions that were proposed to tackle and inform about these: the Hub, Cabins, and Shelter Pavilions. All buildings were future-proofed by incorporating strategies that are adapted to today's climate, but also to tomorrow's climate. The strategies were various and included, among others,: dynamic facades; both kinetic and manually operated; mixed renewable energy generation, energy efficient envelopes, learning from local flora and fauna, self-sufficient systems and optimizing food supply potential, etc. In the end, the project responds to short and long-term climate changes, supports scientific research, strengthens community ties by enabling activities that allow for the sharing of Inuit values, and disseminates an understanding of the complexities of change acting on a place.

The lessons of this Thesis, on how technological and observational science about climate and livelihood changes can inform design, are not only applicable to this site, but transferable, adaptable, and scalable to countless other regions. This can hopefully inform how we can design buildings that are better adapted, but also more adaptable, and thus more resilient to respond to the uncertainties of the future. While climatically responding to these issues was essential to responding to the question, it became similarly important to include an aspect of pedagogy, creating a cognizance among users as to the myriad of complexities a warming planet brings with it.

Pedagogy provides the opportunity for more than the direct users of the site to be impacted by the changes happening there. As users come to realize the human aspect of climate change, that which affects long standing traditional livelihood practices, the issue becomes more visceral and is propagated to more and more people. A design which additionally reflects Inuit Qaujimajatuqangit principles and includes spaces which foster dialogue between users, expand knowledge about varied lived experiences and disseminate different understandings of changes are critical to progressive development in working towards both environmental and cultural sustainability, providing stewardship towards both land and livelihood. Designing with informed response to both shifts in Arctic climate and regional livelihood allows for a continued existence and ability to thrive in any place one chooses to call home. This the essence of resilience. **This represents bracing for the future. This is designing for tomorrow.**

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Figure A.01
Snacks in shrubs.

APPENDIX A

CLIMATE DATA

Variable	Period	1976-2005 Mean	 Low	2021-20 Mediu
Precipitation (mm)	annual	641	585	705
Precipitation (mm)	spring	125	93	136
Precipitation (mm)	summer	192	144	204
Precipitation (mm)	fall	177	141	194
Precipitation (mm)	winter	147	111	171
Mean Temperature (˚C)	annual	-5.8	-5	-3.4
Mean Temperature (˚C)	spring	-9	-9.4	-7.1
Mean Temperature (˚C)	summer	6.4	6.2	8
Mean Temperature (˚C)	fall	-2.1	-1.8	-0.3
Mean Temperature (˚C)	winter	-18.5	-17.8	-14.5
Tropical Nights	annual	0	0	0
Very hot days (+30˚C)	annual	0	0	0
Very cold days (-30˚C)	annual	15	0	3
Date of Last Spring Frost	annual	June 28	June 3	June 1
Date of First Fall Frost	annual	Sep. 5	Sep. 4	Sep. 1
Frost-Free Season (days)	annual	65	64	88
Climate Zone	annual	ET	-	-
Heating Degree Days	annual	8662	7128	7815
Freezing Degree Days	annual	2847	1697	2221
Growing Degree Days (Base 5˚)	annual	243	229	376
Growing Degree Days (Base 10˚)	annual	40	27	83
Growing Degree Days (Base 15˚)	annual	3.5	0.5	9

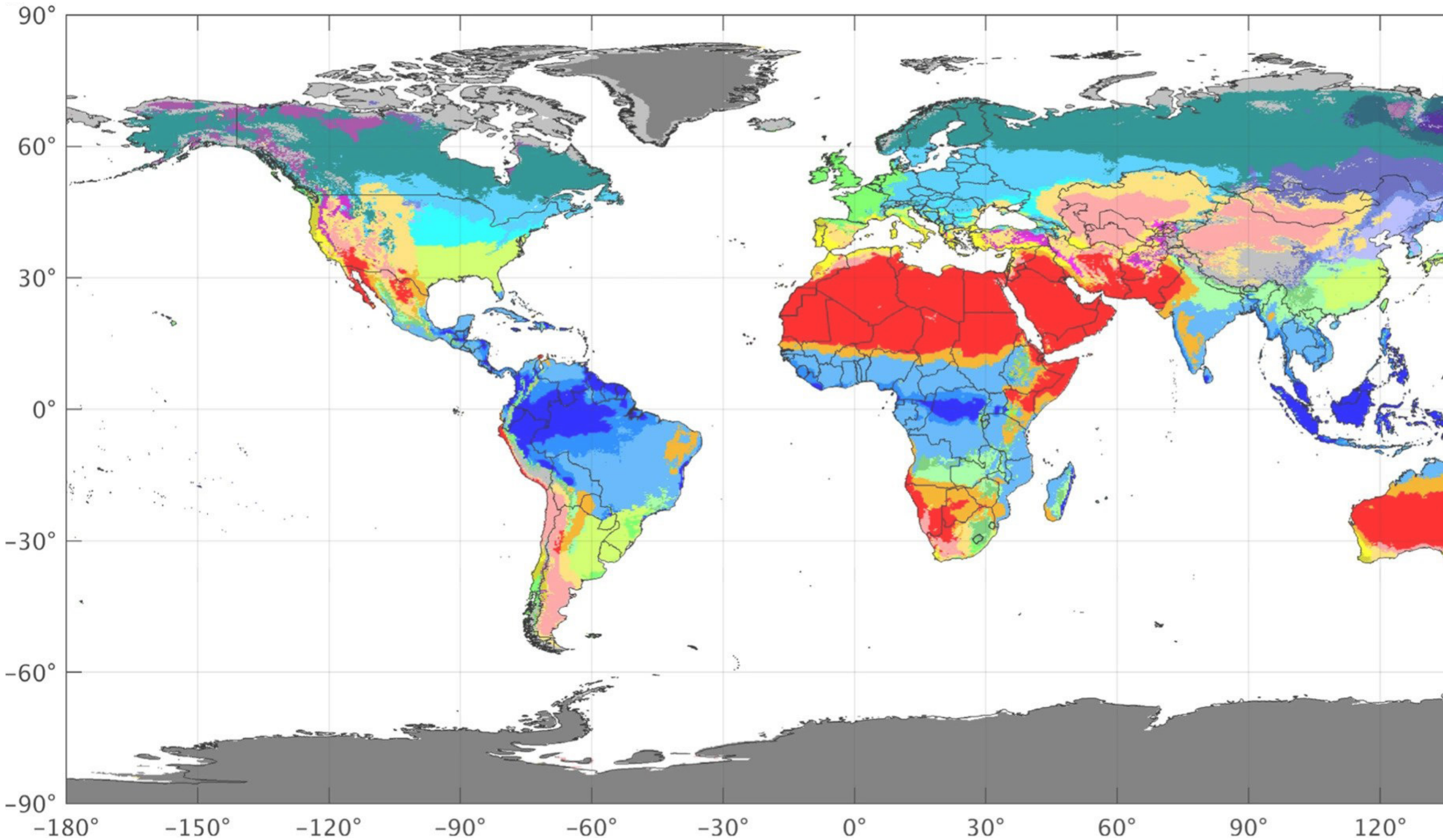
050			2051-2080	
m	High	Low	Medium	High
	825	630	753	881
	188	98	148	203
	266	148	213	277
	251	149	202	261
	237	126	190	264
	-1.6	-3	-0.9	1.3
	-4.6	-7.6	-4.9	-1.6
	9.9	7.7	9.8	12.3
	1.2	-0.4	1.5	3.5
5	-10.7	-13.8	-10.3	-6.5
	0	0	0	0
	0	0	0	1
	9	0	0	1
7	July 3	May 18	June 5	June 22
7	Sep. 29	Sep. 14	Sep. 29	Oct. 13
	111	85	112	139
	-	-	Dfc	-
	8392	6078	6914	7652
	2662	1048	1604	2103
	545	357	566	838
	158	66	166	310
	26	2.5	24.5	62.4

Figure A.02
Predictive Climate Data for Hebron, the geolocation which contains the Torngat Mountains Base Camp. Based on high carbon emission rates. Used to develop climate diagrams in Chapter 3.

Figure A.03
Iceberg Drifting down the Labrador Coast.

APPENDIX B

KÖPPEN WORLD MAP


90°
60°
30°
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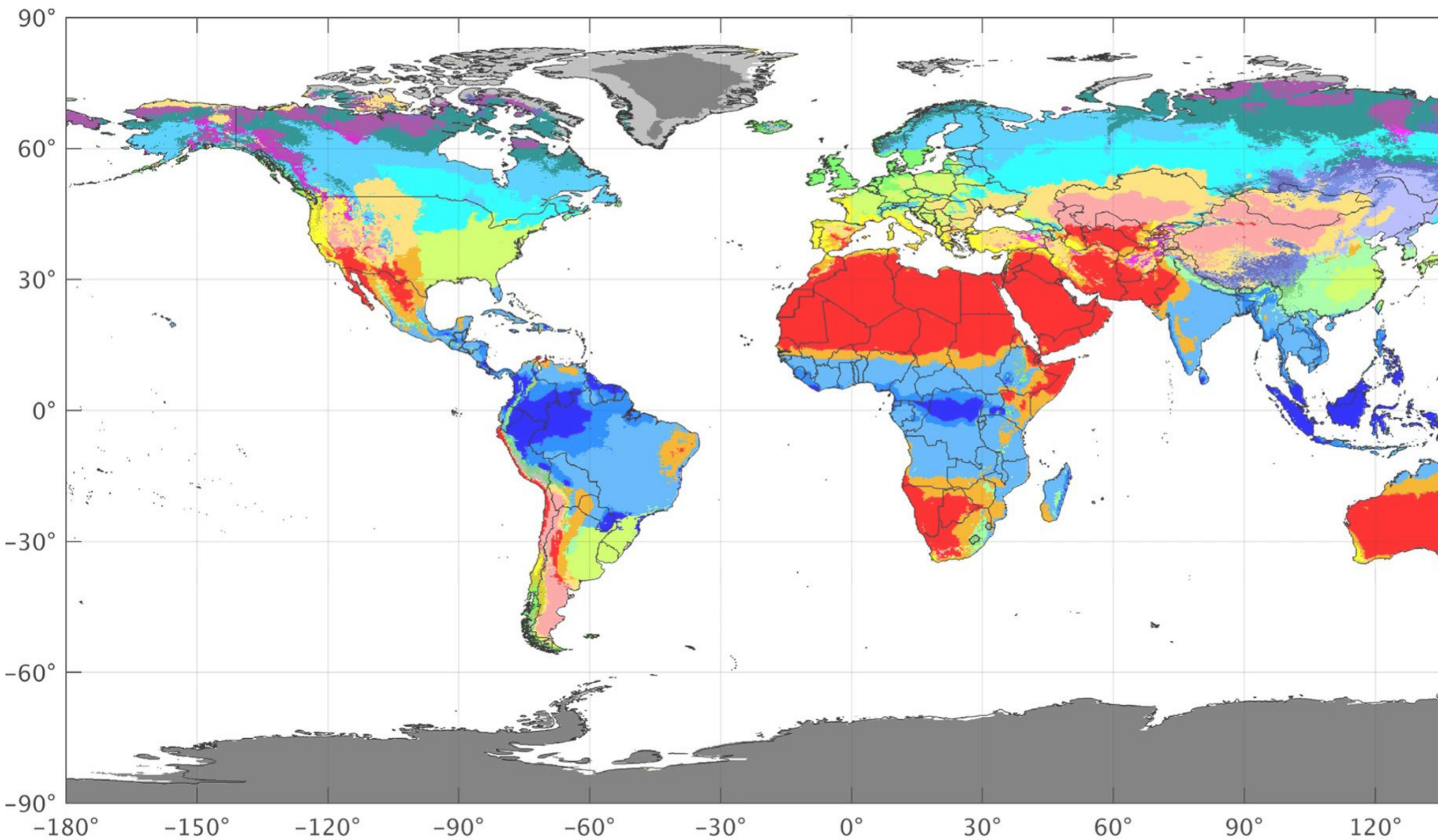
30°
60°
90°
120°


90°
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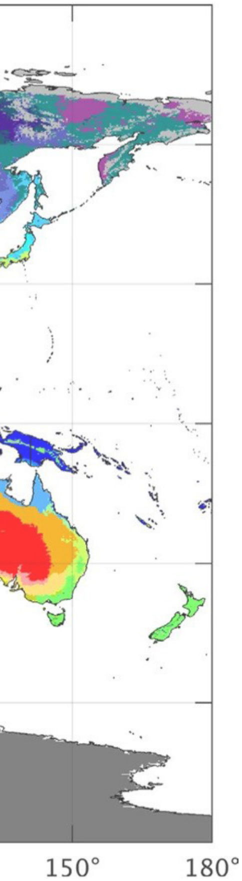
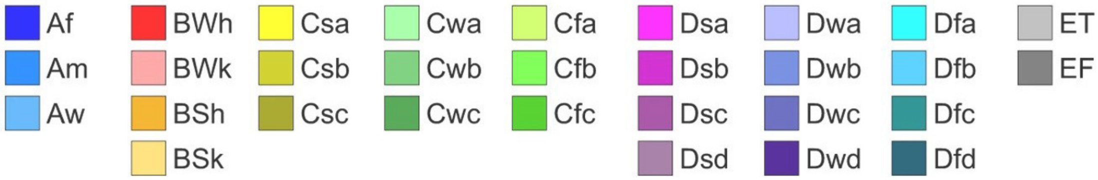
90°
120°





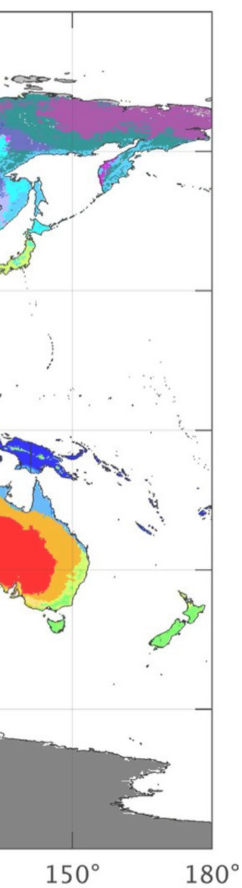


Figure A.04
Present day world map with Köppen climate zones, 1980-2016.

Figure A.05
Future world map with Köppen climate zones, 2071-2100. Note the drastic shifts occurring in Northern regions.

Figure A.06
Boulder scrambling in the Torngat Mountains National Park.

APPENDIX C

VIEWFINDER ARTEFACT

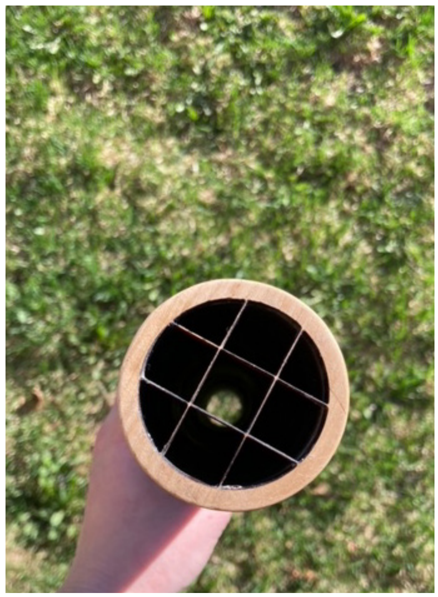
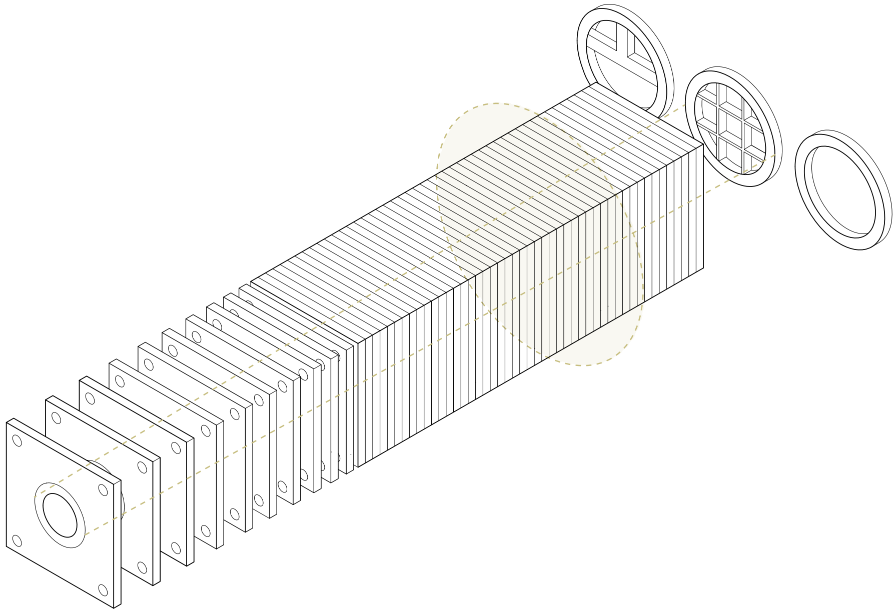


Figure A.07 (Top)
Viewfinder.

Figure A.08 (Middle Left)
Grid lens, pivoted away due to small earth magnets.

Figure A.09 (Middle Right)
Grid lens, held in place as two sets of magnets connect.

Figure A.10 (Bottom)
Viewfinder end-grain detail + inlaid walnut band.



The viewfinder acts as an additional tool in association with the thesis' overall goal to draw attention to and educate about the changes within the Torngat Mountains region. Through acknowledging both the beauty and fragility of a place, as well as interacting with each of its user groups, this object forces every user to interact at this junction of past-present-future, as well as nature-culture-science. Positive change can best be achieved when the same realities of a changing place are understood and shared between a variety of disciplines.

The viewfinder additionally can be capped by various 'lenses' which assist in directing sightlines to specific points of change or helping with transferring views and research to documentation. The artefact will be completed with two lenses as a starting point for the expeditioners kit. A first lens will have a drawing grid, separating the view into a nine square grid for distance and size referencing. The other lens is a site specific one, associated with the Alpine pavilion The interior of this pavilion forces the user's view from the tip of Torngat's tallest peak, down to its base at the side of rockslides and erosion, a result of climate change and associated permafrost and ground thaw. This lens allows for users to experience this same forced awareness of change from outside the shelter as those who occupy it.

Constructed primarily from ash, for its durability and hardness, the main body is inlaid with a walnut band. The sliver of contrasting wood represents the slice in time that humans have been present on the planet, and the reciprocal major impacts (in view) that have been caused by such a limited span of our existence.

APPENDIX C

Figure A.11 (Above)
Viewfinder construction, featuring additional lenses.

Figure A.12 (Following Page)
Group trek through the Torngat Mountains National Park.