REEFS, POINTS AND PERCEPTIONS:

AN ARCHITECTURAL CATALOGUE OF COASTAL STRATEGIES AND A DESIGN PROPOSAL FOR LAWRENCETOWN BEACH, NOVA SCOTIA

by

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CONTENTS

ABSTRACT

This thesis proposes coastal architecture interventions in Nova Scotia by focussing on the forces and elements that exist in unique combinations at the coast. Using surfing as a source of inspiration, these interventions mediate the relationship between natural world and the built environment.

The combination of this proposed catalogue and in-depth site analysis results in design proposals for Lawrencetown, Nova Scotia. These proposals both capitalize on opportunities and address problems specific to coastal building.

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The support and guidance of many made this work possible.

I would like to sincerely thank my supervisor, Steve Parcell, for his continuous guidance and rigorous attention to detail; without him this work would not have been possible.

I would also like to thank my advisor, Roger Mullin, whose constructive criticism brought this project farther than I would have ever thought possible.

I would like to thank Michelle for your unwavering patience and constant enthusiastic support.

I would like to dedicate this work to my mother, for her encouragement and unquestionable belief in me, and my father for his support and for having always inspired me with his incredible work ethic.

CHAPTER 1: INTRODUCTION

Critique of Nova Scotia Coastal Architecture and Development

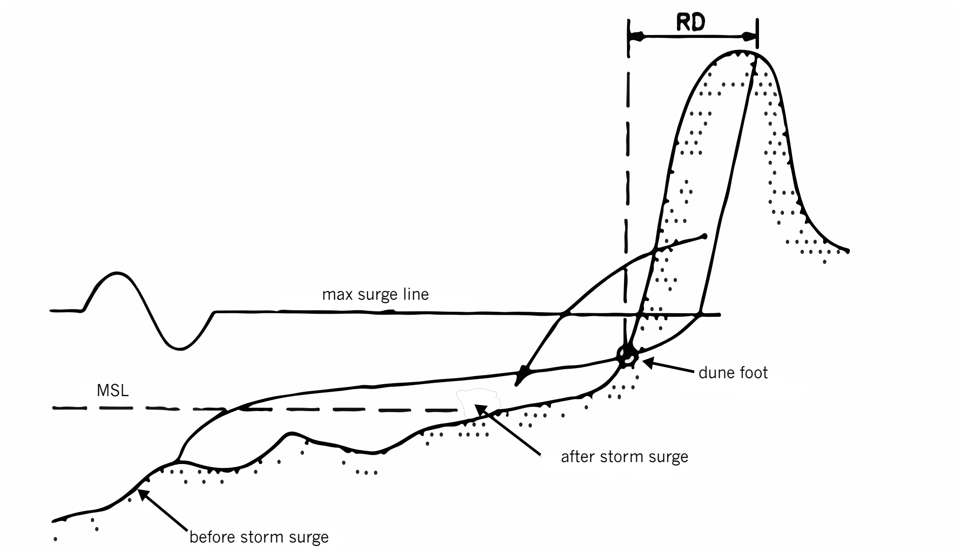
> Beaches mark this strange boundary of an illusion, that humanity is somehow separate from nature and in control of the natural world. Our illusion of dominion leads us to treat the beach as if it were part of the land and similarly vulnerable to our will. But the beach does not belong to the land, nor does it belong to the sea; it is a different reality submitting for brief periods to human designs on it, but sweeping them away as it yields to the fury of the sea. It is a unity of disunities, a frontier, a paradox, at once stable and volatile. It is more like a dance than a place.[1]

Shifting site: Still from a video depicting temporal site evolution

The illusion of dominion that Silver Donald Cameron alludes to in *The Living Beach* has resulted in many shortsighted development efforts along the coast of Nova Scotia. These ill-conceived development strategies litter the coastline, resulting in high maintenance costs and harsh weather vulnerability of both public and private property.

1 Silver Donald Cameron, *The Living Beach* (Toronto: Macmillan Canada, 1998),10.

Common methods of coastal reinforcement are effective at slowing erosion in the short term; however in the long term they can actually be detrimental. For example, seawalls are a common short-term solution for coastal roads in Nova Scotia. In the long term they expedite erosion of the beach in front of the seawall and, in turn, the force at which the sea impacts the seawall is amplified.[2] Dunes react to storm surges by redistributing sand to impact areas. Solidly built seawalls lack this sedimentation for redistribution.



Dune redistribution after a storm surge; image source: W.W Massie et al, "Seawalls and Shoreline Protection"

The result is increased reinforcement at a great expense and a disruption in the natural sequence. Expedited erosion leads to breaching of the natural system. This overwhelms nature's response mechanisms and leads to the irrecoverable loss of natural protection (i.e., sand dunes and salt marshes) along the beach.

In many instances these roads lead to developments that have also repeatedly paid a cost for attempting to project an idealized vision onto volatile sites. There are multiple examples of buildings that have been placed on the coast, rather than designed to withstand coastal conditions. The result is an unsupportive relationship where both the coast and building are bearing the burden of the other. Usually the coast's

2 L.C. Van Rijn, "Coastal Erosion and Control," *Ocean & Coastal Management* 54 (2011): 867-87.

natural defenses are destroyed as it submits to development and is left vulnerable. The fury of the sea relentlessly punishes human ignorance until both land and building have succumbed to the elements.

This thesis asks what lessons can coastal architecture learn from coastal activities that are dependent on the understanding and collaborative use of coastal forces, such as surfing; then, how can these lessons be incorporated into strategies to help shape coastal environments that are dependent on mutually beneficial relationships between users and the coastal forces? The coastal architecture proposed in this thesis is the catalyst that enables this relationship.

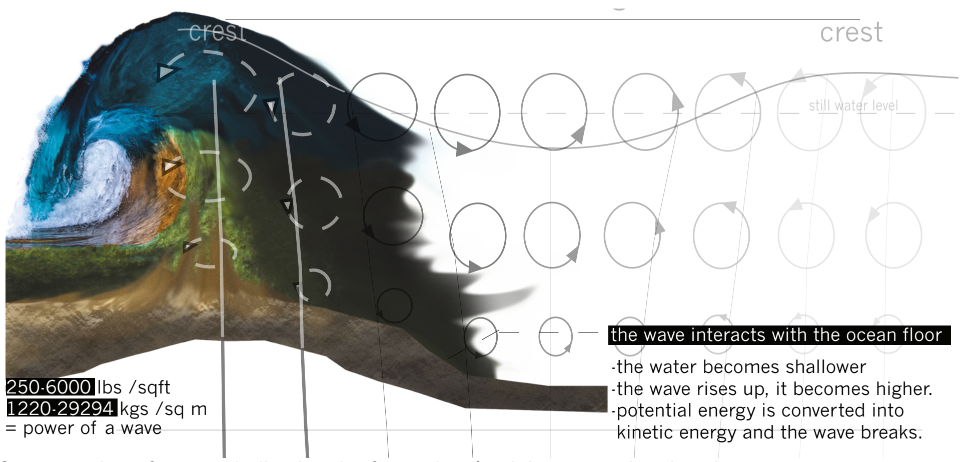
The realization that there must be an alternate solution to common building practices resulted in an attempt to understand how architecture can productively use the volatile forces found along the coast. To do this, the activity of surfing was studied and used as a source of inspiration.

Learning from Surfing

Cumulative and combined effects of coastal forces must be understood and considered when proposing architecture in a coastal environment. Surfing, as an activity, capitalizes on an in-depth understanding of the interaction of coastal forces and has become a popular winter pastime in Nova Scotia.

Surfboard resting on the snow covered boardwalk in Lawrencetown Nova Scotia.
Photograph by Jared Acorn from Acorn Art and Photography.

Surfers' understanding of forces begins well offshore. Storms out at sea create surface chop, which, when combined with enough wind, turns into heavy seas. Energy from these storms travels outward in the form of waves. Groups of waves become more and more organized as they travel together. Each wave produces a column of orbiting water, most of it below the surface. These groups of waves, known to surfers as swell, can travel countless miles. The larger the storm, the more powerful the swell and the farther it can travel.



Cross section of a wave indicating the forces involved that cause it to break

As the swell travels and becomes organized, the distance between the waves becomes constant and predictable. This is known as the period or interval. When these columns of orbiting water reach the coast, they begin to interact with the sea floor. As the water becomes shallower, the column of orbiting water causes the wave to rise up, the potential energy becomes kinetic energy, and the wave breaks when it reaches eighty per cent of the water's depth. (An eight-foot wave will break in ten feet of water) Countless other factors influence where and how each wave will break: wind, bottom contour, swell angle, currents, etc. "As surfers, we're just hoping that it has a catchable moment (a takeoff point), and a ridable face, and that it doesn't break all at once (close out) but, instead, breaks gradually, successively (peels), in one direction or the other (left or right), allowing us to travel roughly parallel to the shore, riding the face, for a while, in that spot, in that moment, just before it breaks."[3]

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3 William Finnegan, "Off Diamond Head," *The New Yorker* (June 1, 2015):

This knowledge of wind, bottom contour, swell angle and currents becomes paramount for those who surf during the Nova Scotia winters. Exposing oneself to the frigid Atlantic waters in sub-zero weather is not for the faint of heart.

> On a steely grey morning. I put on my drysuit and wetsuit hood, slide my board into the uninviting grey-brown sea of winter and paddle out to surf. The wind is north -– offshore– and conjures up a squall of pelting ice pellets so that when I take off on my first wave, my face is stung by these small, savage bullets. I shield my eyes so I can make the drop, turn, pull up high onto a wall of dense winter wave. I tuck my head down to avoid the assault and the wave allows me safe passage on a long smooth wall, steep and stiff in the offshore wind. If I'm lucky, I'm not alone.[4]

The knowledge of elements allows experienced surfers to safely position themselves in the proper place at that exact moment in hopes of the opportunity to grasp that catchable moment. However, without a surfboard to mediate between ocean and surfer, the fleeting moment slips by.

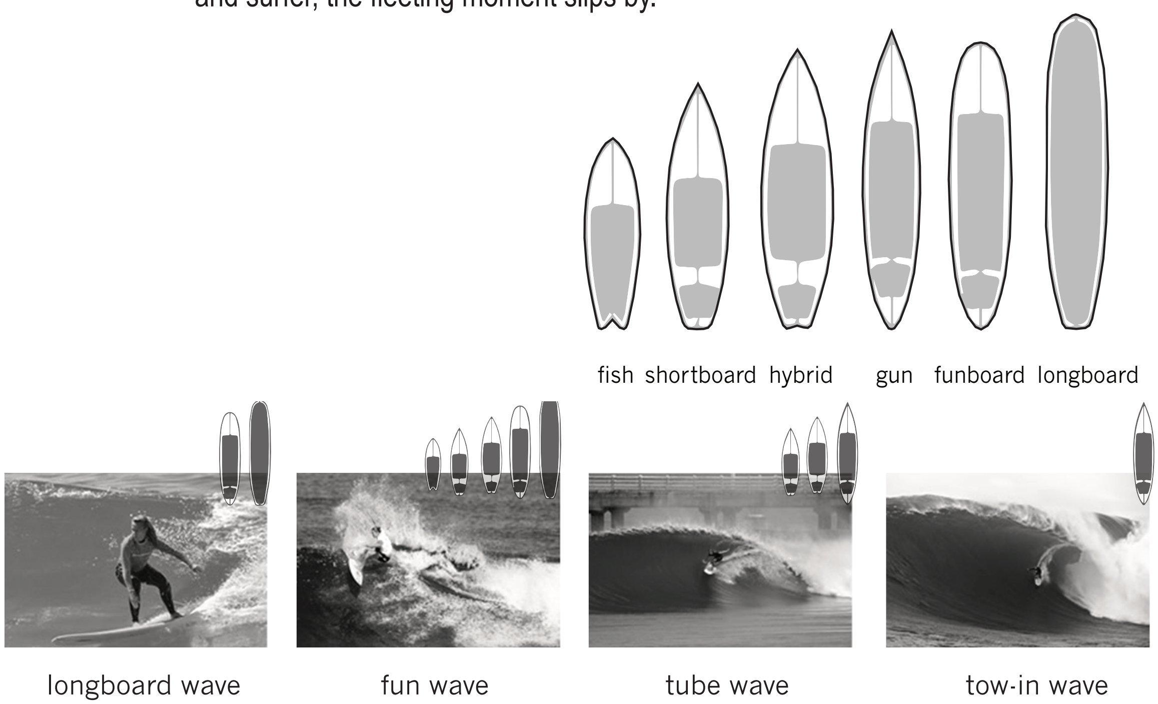


Diagram showing board types and how they relate to wave types.

4 Lesley Choyce, "Surfing,"Lesley Choyce, Music, Poetry, Surfing (blog). Accessed Oct 2. 2014, http://lesleychoyce.wordpress.com/surfing/.

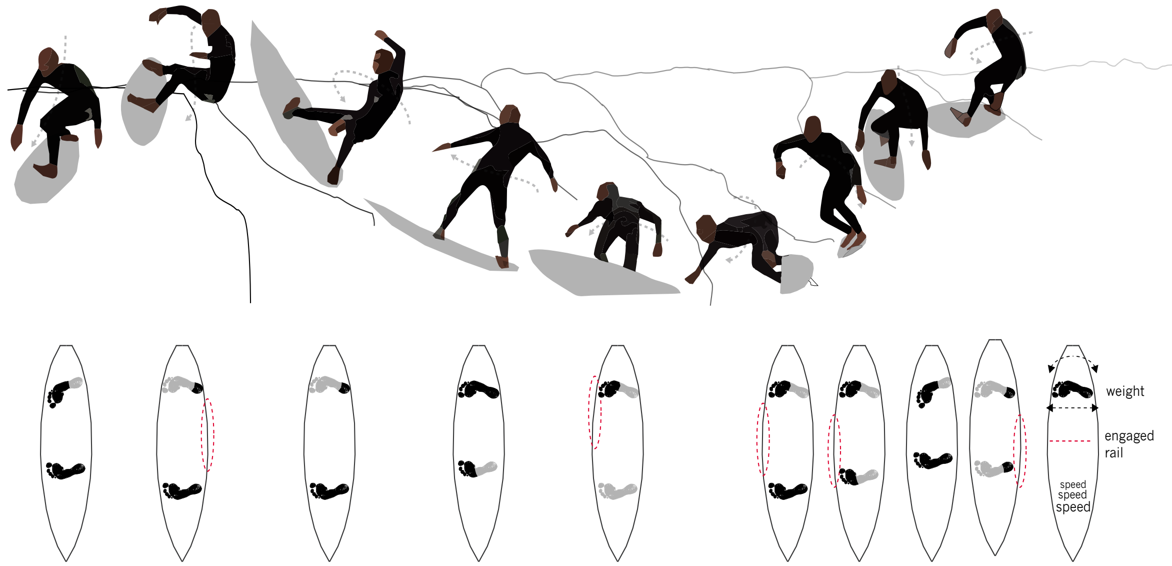


Diagram showing how a surfboard mediates between user and wave

Each session is different and many surfers will change boards and fin set-up accordingly. Experienced surfers will have a quiver of surfboards that cover the multiple conditions in which they choose to surf. The types of boards surfers own coincide with their local surf break. For example, surfers on Hawaii's north shore own a variety of "guns," long, stable high performance boards that allow them to surf the large powerful tube waves. Nova Scotia surfers are more likely to own a fish, a longboard and a shortboard. This allows them to surf in the summer on days when the waves are small and mushy (do not have a surfable face), while the shortboard works for winter days when there are larger, more powerful waves.

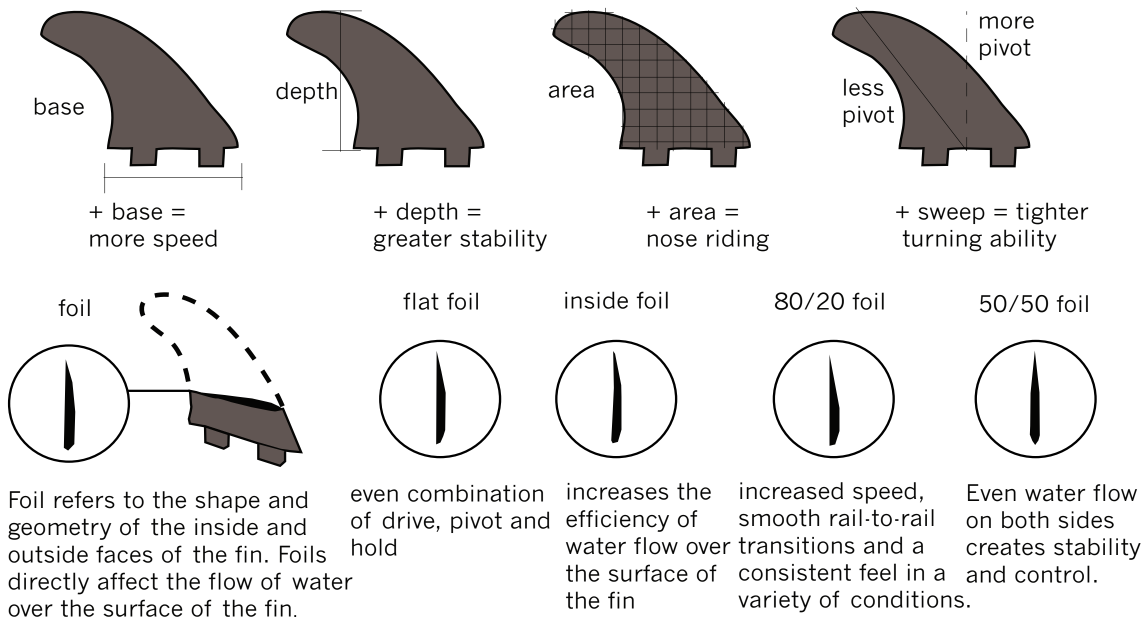
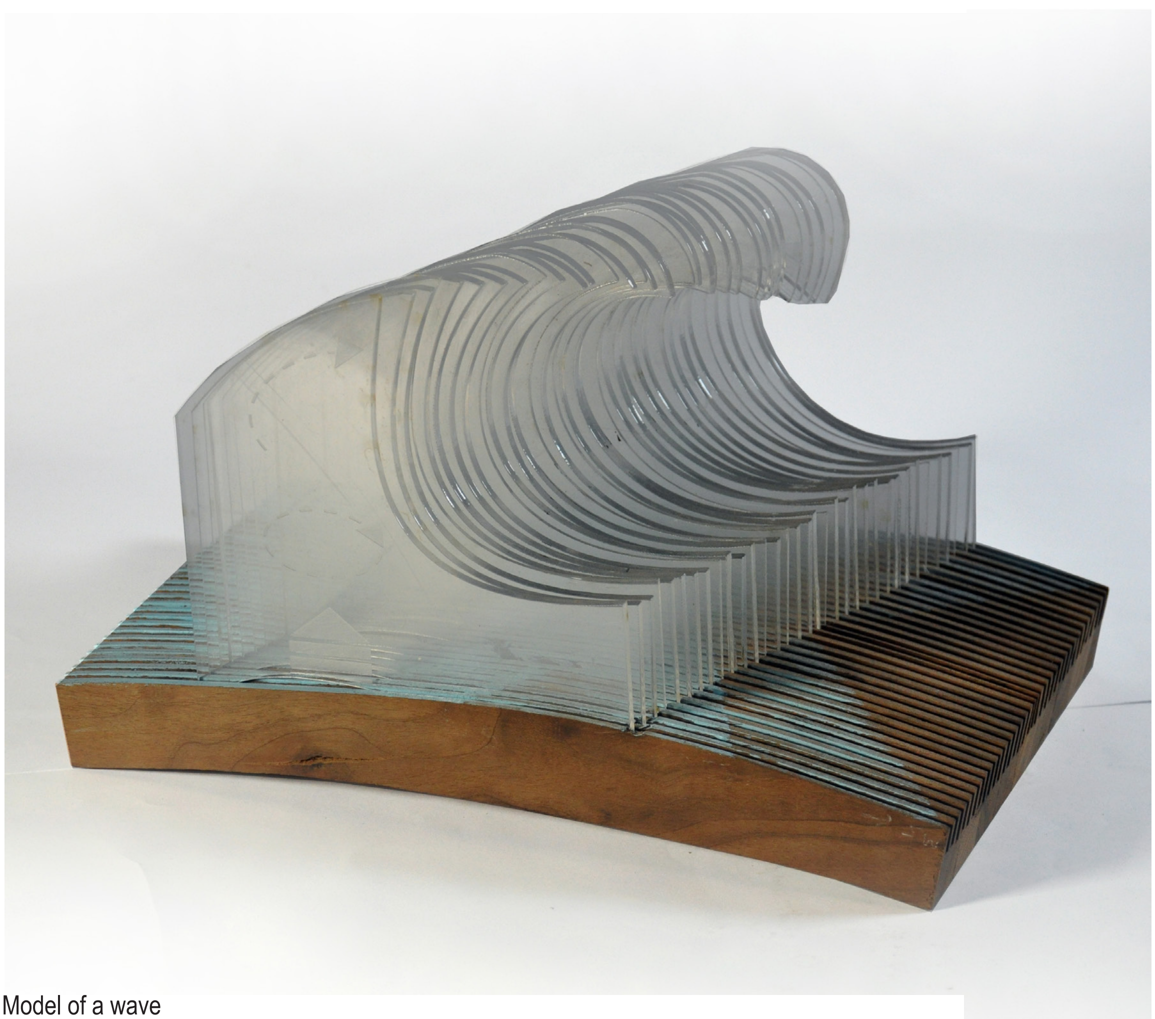
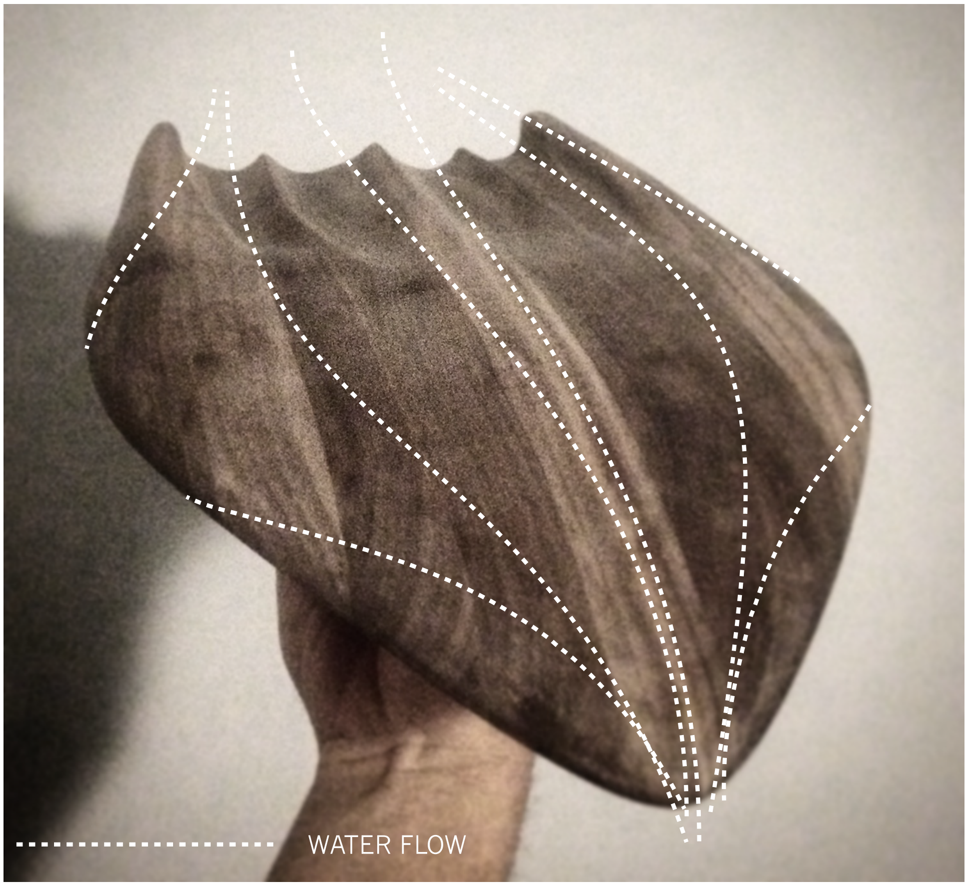


Diagram showing how the shape of fins influences board movement.



Model of a wave

Shapers who create surfboards understand how the board interacts with the water and the surfer. Concave channels and/or fins at the rear of the board allow it to grip the water. This allows the user to have more control. The front rails have to be able to dip into the water, just enough to set a guide as one is propelled down a wave, yet not enough to pull the board under water. The bottom needs to be flat enough to plane and keep propelling the surfer forward. Every curve and surface have a role and come together to create an instrument for harmonizing human and water.

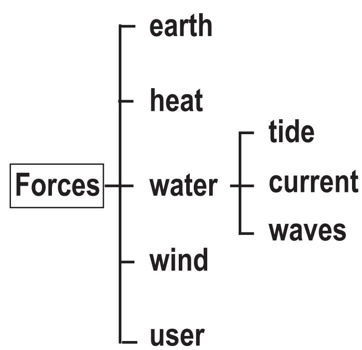


Model of a handplane (for body surfing), demonstrating water flow and its relation to shape

It's not difficult to draw architectural inferences from the process of shaping a surfboard to mediate between user and environment. The role of an architect is to harmonize site and user through built form, to shape experiences through built form. The hand plane allows you to experience a wave in a way that you never have before. Can a building allow you to experience a site in that same way? Can it engage the forces on the site, and emphasize them to the user?

Forces, Elements and Purposes (Catalogue of Architectural Interventions)

One goal of this thesis was to assemble a catalogue of theoretical coastal architecture interventions. To avoid conventional limits it started by going back to basics: studying coastal forces and existing devices that engage them. Innovative devices then were developed. Once forces and devices were catalogued, they became a “kit of parts” with which to work on the coast. The forces were classified into five categories. The devices that engage these forces could be extended and modified into many more examples.

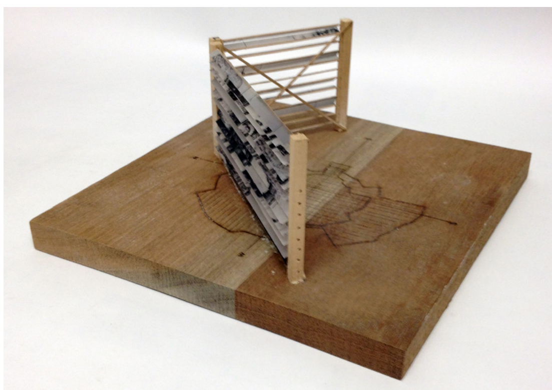


The forces are typical for the coast but can be tuned and adapted for specific site conditions. Therefore, this catalogue can serve as a base for adapting and combining devices for particular locations.

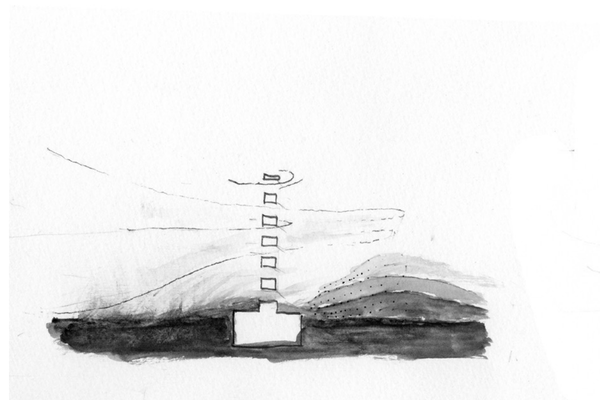
Wind

Wind in Nova Scotia is unpredictable because it can often be the result of competing weather systems. The varying temperatures between land and sea control local wind conditions. The wind usually shifts in the evenings and mornings due to the change of temperatures between the ocean and land. In the mornings the land is cool and the ocean is warmer; therefore, the wind is offshore. On a summer afternoon the land is warm, the ocean is cool and there is an onshore wind. Since the ocean can store heat better than land, we generally have offshore wind for most of the winter. The unpredictability comes from larger weather systems that travel up the eastern seaboard. These systems will have predominant winds attached to them that can supersede local conditions.

Traditional sand fences work well in areas that have predictable wind, allowing the sand to be redirected strategically. They are composed of vertical wooden slats and allow the wind to pass through. They slow the speed of the wind, allowing the sand to drop out of it and pile in a location. In this catalogue a traditional sand fence has been adapted so wind can travel through in only one direction. The force of the wind closes the openings when travelling in the other direction.



Concept model being tested in a wind tunnel.



Concept sketch

The aperture adaptation allows more control of where the sand is redistributed, this becomes especially useful in Nova Scotia where the wind is not constant . It can also be combined with other methods and tuned to specific site conditions to create strategies for regeneration of threatened dune systems.

Water: Tide

A similar strategy for capturing sedimentation travelling with the tide was developed. In this instance the method was developed while studying coastal infrastructure which was threatened by erosion. Longshore drift (the deposition of sand and gravel by waves that hit the beach at an angle) provides barrier beaches with sedimentation from headlands. Changes in site geomorphology and improper shoreline reinforcement can cause waves to refract, causing the swash to travel in the opposite

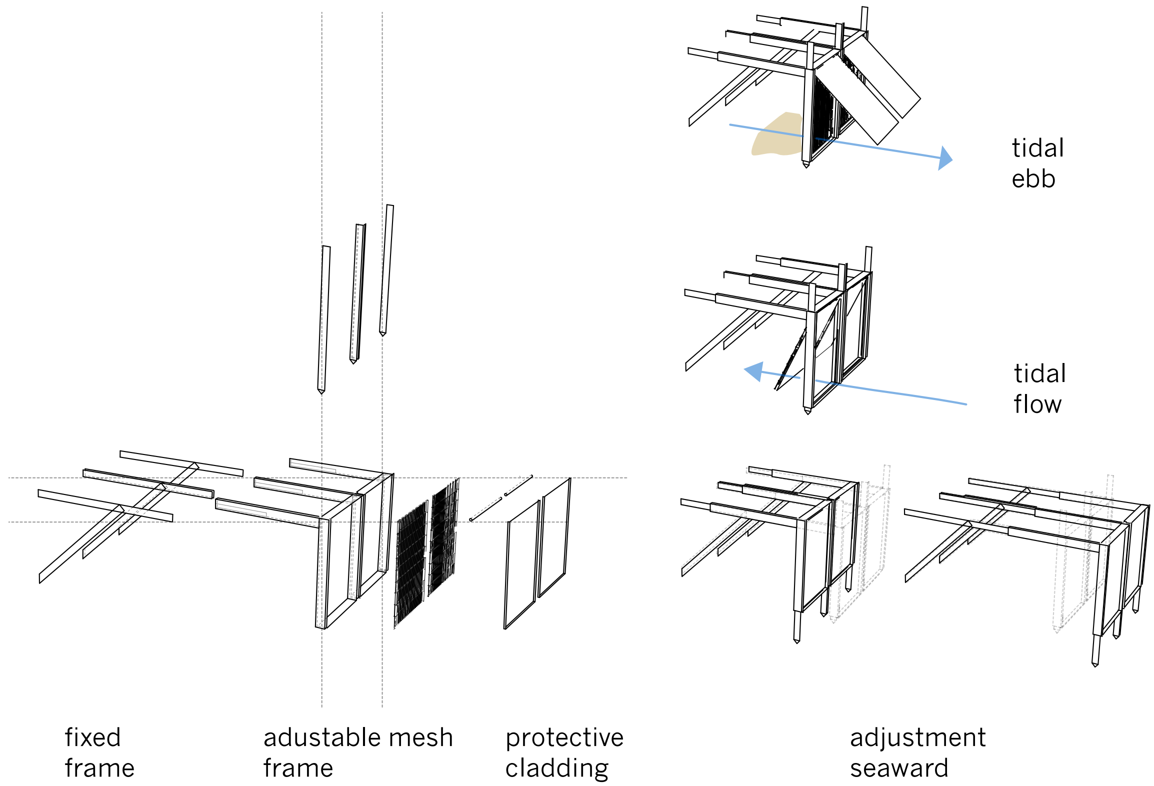
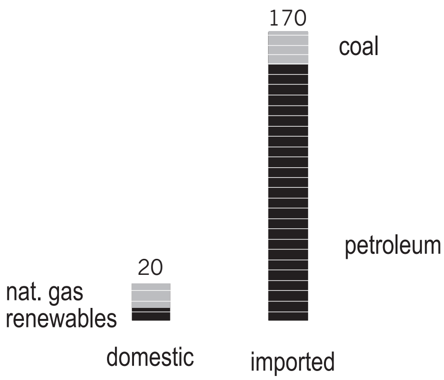


Diagram of the sediment trapping fence

direction as the longshore drift. This prevents the build-up of sediment and expedites erosion. The method developed in this situation was a boardwalk along the reinforcement fitted with a layered swinging cladding. A mesh layer and a protective outer layer make up the cladding. The two layers swing inward with the impact of waves and the tide, but only the protective layer swings outward. The mesh remains parallel to the shoreline, trapping the sediment carried in with the water. The whole system can then be moved seaward as the sediment builds up, essentially creating land.

Water: Waves

The ocean can be used as a source of energy. Currently Nova Scotia has an energy system that used to rely on the domestic coal supply but has become outdated because the province has run out of coal that is clean enough to burn. Now there is a reliance on imported petroleum products.[5] The Department of Energy is exploring the potentials of renewable energy in the forms of wind, tidal and solar power but has not yet started to study the potential of wave energy.



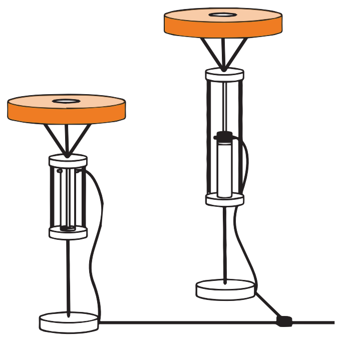
Nova Scotia total energy use import and domestic 2005 (petajoules). Source: Catherine Abreu, *Electricity and Nova Scotia's Future*

The potential for developing energy off the shores of Nova Scotia is high. There is approximately 50 KW/meter of available energy in the Atlantic Ocean off Nova Scotia. When the energy potential is compared with the amount of energy needed for an average size home (1000KW per month) it is clear that the clean energy potential of the ocean is enormous when compared to our societal needs.

Wave energy map. KW/ wave front. Source: Sam Green, *The Changing Renewable Energy Market in Australia.*

5 Catherine Abreu, *Electricity and Nova Scotia's Future: Hurdles and Opportunities* (Halifax: Ecology Action Centre, 2013) 20

Wave energy is converted to electricity by hydraulic pistons attached to buoys on the surface of the water. The pistons pump seawater, pressurized by the wave action, to hydroelectric turbines. These turbines are small in size and can easily be fit into the mechanical space of a building.

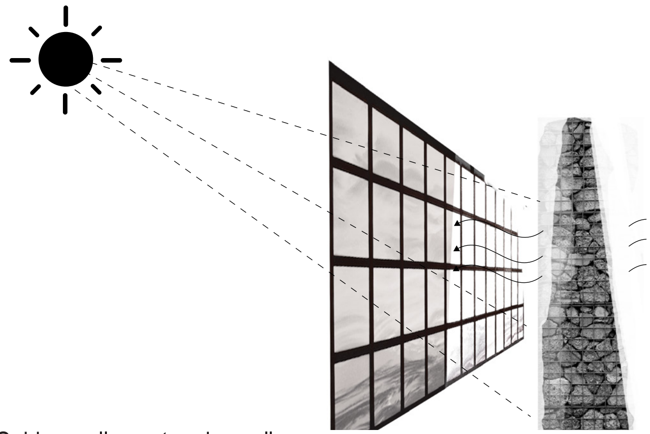


Example of hydraulic piston configuration

Earth

Earth itself is a dynamic force along the coast. It can absorb the energy of waves in the form of sand dunes, protecting land from the forces of storm surges. It can be moved by both the wind and water. Crashing waves and currents can move the underwater sand, creating reefs which produce breaking waves for recreation. Wind can shift the sand dunes, covering or exposing beach structures.

Rock is another available material within the category of earth. Each fall, as hurricane season hits, the Atlantic Ocean churns up significant amounts of rock and spews them onto the beach. These rocks usually stay until they are pulled back into the water by ebbing tides or are buried over by the shifting sand. Weathered and stable, these provide useful building material.



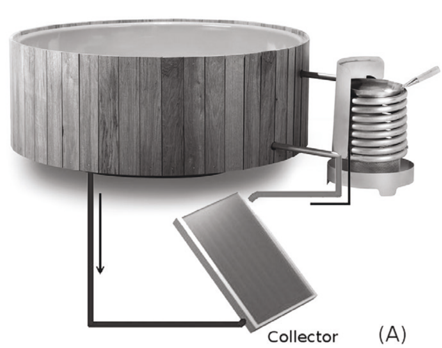
Gabion wall as a trombe wall

Heat

Heat, as a force, is available from the sun or by burning fossil fuels. It becomes important in coastal areas of Nova Scotia because the winter is the preferred season for surfing. Capturing and storing heat that can be made available to users helps improve the safety of winter surfing.

Stones can also work as a thermal mass. Merged into a larger mass, the potential for heat storage is significantly increased. A simple use of the material and energy storage potential is creating gabion walls. These gabion walls can be glazed on the south face, with the potential to create a trombe wall system, improving winter building efficiency.

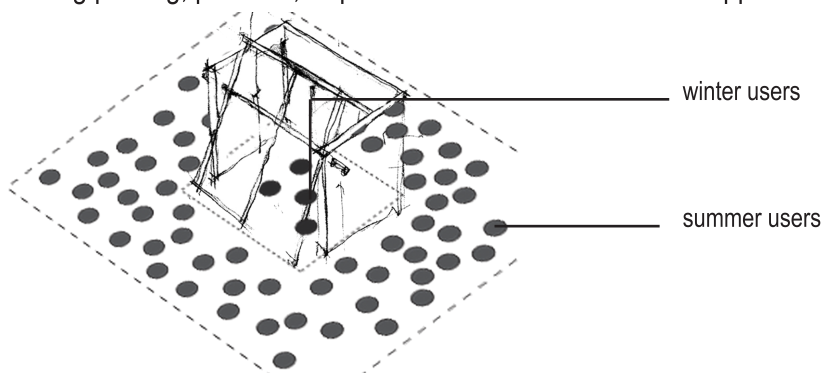
Tidal pools can also be used as thermal masses, as water is a good way of storing large amounts of heat. Fire pits and solar panels can be used to generate heat to be stored in these thermal tidal pools.



Tidal pool used as heat storage device

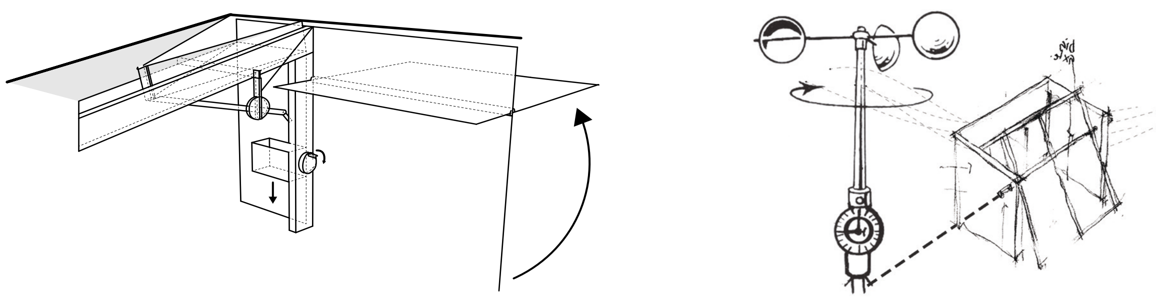
Users

As with the other forces, users also vary seasonally. During the summer months the number of people who visit coastal sites increases significantly and decreases as the weather turns cold. With this influx of users come multiple considerations, including parking, pollution, required amenities and economic opportunity.



The number of users fluctuates seasonally

As a device, an operable wall allows for an increase in sheltered space, and can create areas for food sales or board rentals. During the winter months, the facade can be closed and the enclosed space can be used as storage.



Operable facade paired with other forces

These operable facades can be paired with other forces. Using forces already present on site reduces the energy consumption of buildings. The examples above explore how the weight of sand or the wind can be used to power the mechanical system of an operable facade. Combining devices with site and a specific user group allows for integrated site strategies. These strategies can help shape coastal environments that are dependent on mutually beneficial relationships between users and the coastal forces. The coastal architecture proposed in this thesis is the catalyst that enables this relationship.

CHAPTER 2: SITE

This chapter studies site at two scales. First, at the provincial scale, it analyzes the effects of climate change on the coast of Nova Scotia and proposes a method for organizing the province into manageable sections. Second, it focuses on a particular site, Lawrencetown Beach, to analyze its current conditions, predicted change, and user requirements.

Analysis of Coastal Nova Scotia (Macro Scale)

Nova Scotia claims boldly on the provincial license plate that it is Canada's ocean playground. Finding evidence to support this claim is not an easy task. As a beach vacation destination it pales in comparison to its neighboring province of Prince Edward Island, with its sandy beaches and considerably warmer water temperatures. With only 7579 km of coastline, it ranks an unremarkable sixth compared to the other thirteen provinces and territories. It is, however, one of Canada's prime surf locations. Unfortunately, the best time of year for waves is during the coldest months of the year.

The coastline of Nova Scotia is harsh and weathered. Like a protective older brother, it shields the two other Maritime provinces from a temperamental North Atlantic, known for the suddenness and ferocity of its storms.

1. Bedrock 2. Glacial Till 3. Sand Dunes

Models depicting the type of coastline found in Nova Scotia

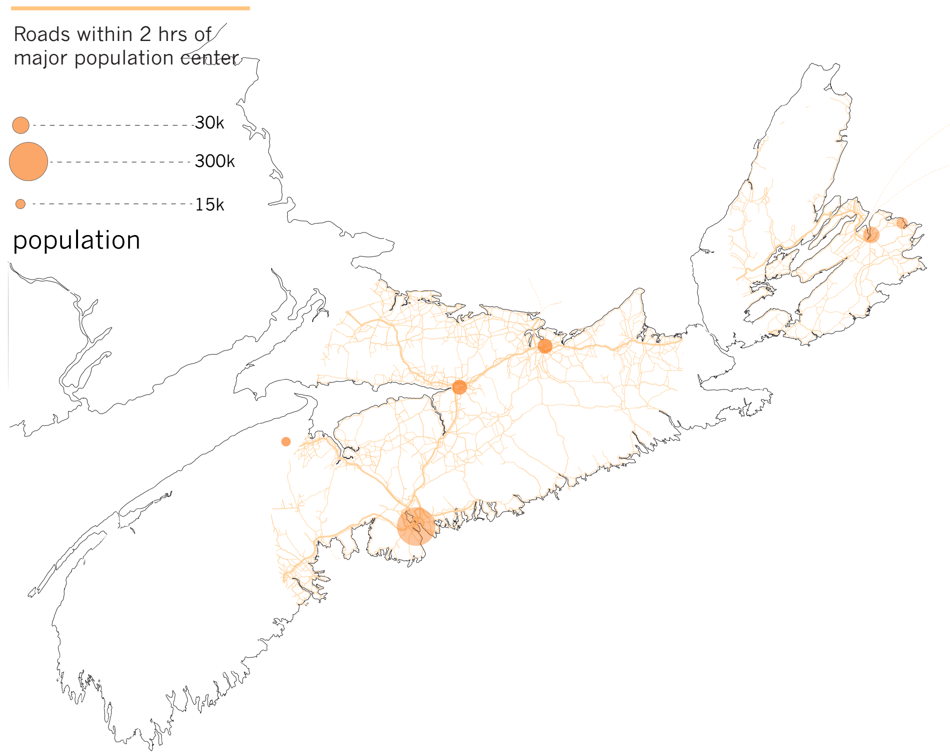
Perhaps this is what makes Nova Scotians so enamored with the ocean and defensive of their beloved coast. In the fall, hurricanes travel up the coast and, despite all warnings, people still flock to witness the howling winds and thunderous crashing of waves, watching the drumlins standing like soldiers engaging in battle with an angry North Atlantic Ocean. After all, this threshold between ocean and land is where the action is, and where the history of Nova Scotia was played out. Nova Scotia writer Lesley Choyce put it best when he wrote, “I feel connected to this place. Because of the harsh and rugged shore losing its battle with the sea, I feel rooted here. This is not a land of comfort. I did not come here to feel ease and surround myself with the relentless, soothing junk of consumer living. We remain a place apart, thanks to the harshness of climate, the ruthlessness of a sea that is prepared to steal our land and tear us apart at any time.” [6]

Large waves caused by offshore tropical storms crash at Lawrencetown Beach.

Regardless of the reasons, locals and non-locals alike are drawn to the coast every year. Some come for employment, some for research, but many purely for pleasure. Nova Scotia Lifeguard Service estimated that 340 000 - 380 000 people visited 23 supervised beaches in 2013 and Nova Scotians will drive approximately two hours to access the coast.[7]

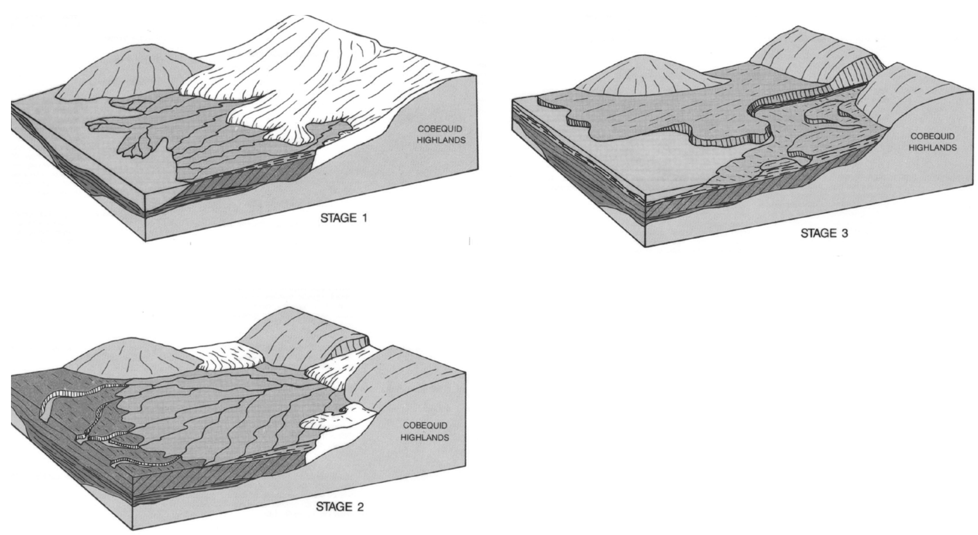
6 Lesley Choyce, “Surfing.”

7 *Nova Scotia Lifeguard Service Annual Report,* 2013.



Population centers are situated so that most of the population is within driving distance of the coast.

In Nova Scotia, the coast was formed as glaciers retreated. The three main geomorphological forms that remain are bedrock, glacial till, and sand dunes.



Stages of glacial retreat. Source: D. Keppie, *2000: Geological Map of the Province of Nova Scotia*

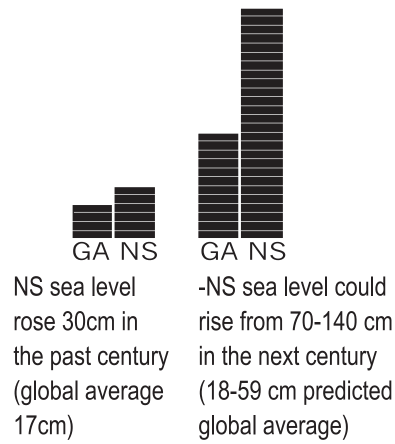
Flooding and erosion impact glacial till and sand dunes far greater than bedrock.[8] Global warming has caused an increase in water levels as well as more frequent tropical storms. Warmer temperatures will cause these storms to move inland and not dissipate over the cold North Atlantic water.[9] Also, it's expected that because of the rising temperature, storm tracks will shift northward, changing Nova Scotia's wind patterns and increasing precipitation.

Map showing coastline on the eastern shore that is highly sensitive to erosion caused by flooding.
Source: *Our Coast Live, Work, Play, Protect: The 2009 State of Nova Scotia's Coast*

2007 the number of hurricanes affecting Nova Scotia has dropped during the past 7 years but is predicted to steadily increase as the ocean temperature increases. Nova Scotia's water level is rising faster than the global average, and is expected to increase far more significantly over the next century. Specifically, the eastern and southern shores of Nova Scotia will have increased wave activity, higher water levels and a lack of sea ice protecting the coast. The inevitable result of these three conditions will be expedited erosion.

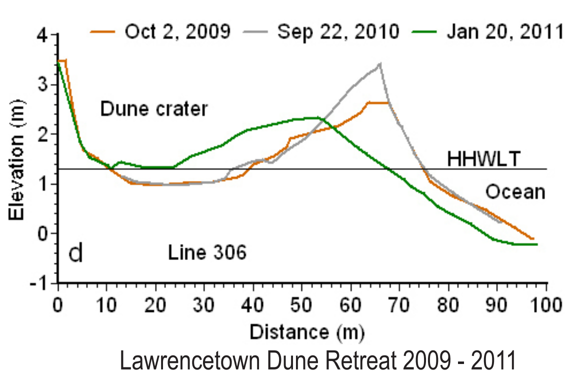
8 *Our Coast Live, Work, Play, Protect: The 2009 State of Nova Scotia's Coast (*Halifax: [Dept. of Fisheries and Aquaculture], 2009),160.

9 Ibid.,162.



Nova Scotia sea levels compared to global average Data from Catherine Abreu, *Electricity and Nova Scotia's Future*

In 2001 the Bedford Institute of Oceanography began monitoring the rate at which land is subsiding in Nova Scotia. As the study continues, the accuracy of predictions will increase. Currently it is estimated that, on average, land is subsiding at approximately 15-17cm per century. As an average, this rate is not overly alarming with regards to the built environment on the coastline; however, site-specific studies show much more concerning results. For example, near Lawrencetown Beach the shoreline was measured at three points, as a result of three storms in December of 2010: one section of the shoreline extended 14.5 metres seaward as the beach crest was rebuilt, and at another point it retreated 6 metres landward. The scale of land movement is an obvious hazard to anything built in these environments.[10]



Graph measuring dune retreat on Lawrencetown Beach. Source: R.B. Taylor et al, *Geological Survey of Canada*

10 R.B. Taylor, D. Frobel, C. Mercer, C. Fogarty and P. MacAuley, Geological Survey of Canada, Open file 7356 (Ottawa: Natural Resources Canada, 2013).

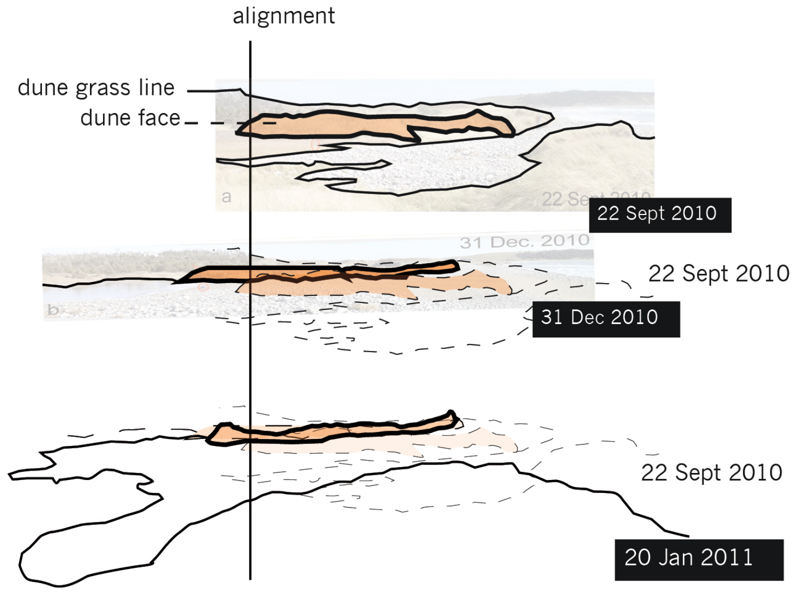


Diagram mapping the impact of three significant storms at Lawrencetown Beach in Dec. 2010.
Source: R.B. Taylor et al, *Geological Survey of Canada*

Another study at Lawrencetown Beach showed the dune crest retreating 10 metres and the dune crater behind becoming filled in with water. When the crest of the dune is breached by the waves and water pools behind it, the risk of the entire dune system being washed out to sea is increased significantly. This is known as over-washing and is a major threat to dune systems. The systems rarely recover naturally.

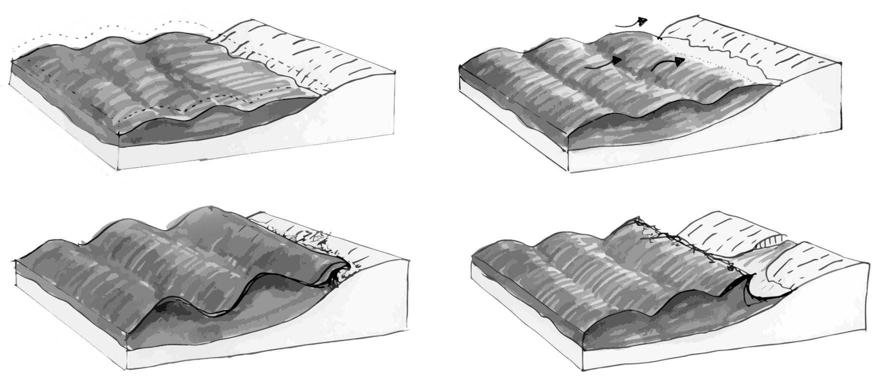


Diagram showing the stages of over-washing

In order to understand and manage coastal erosion, the coast can be broken down into various sizes of littoral cells, a concept refined by the Dutch over centuries and commonly used in California to manage developed oceanfront areas. Categorizing the coast into littoral cells allows it to be broken down into manageable sections. Littoral cells consist of two headlands and a sandy beach or beach barrier that is formed by the erosion of these headlands. In Nova Scotia these headlands are drumlins: elongated landforms with long axes parallel to ice flow, composed of up to three tills. These drumlin fields are well documented and allow for the coast to be easily organized, based on the littoral cells they create.

If extreme weather instances increase as predicted, the coast of Nova Scotia will be intensely affected. Conventional building methods need to be improved. The proposed catalogue offers various methods for interacting with coastal conditions.

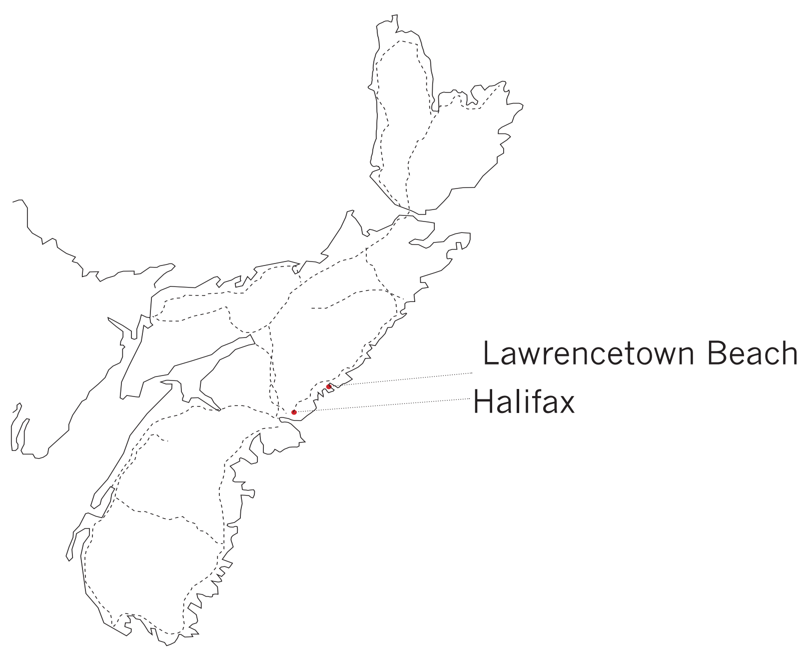
Map showing drumlin fields in Nova Scotia. Source: J.D. Keppie, *2000: Geological Map of the Province of Nova Scotia*

A site with a specific user group and program was chosen to enable some of these methods to be tested. Lawrencetown Beach is a littoral cell that has a close proximity to a major population center (Halifax) and is heavily used for recreation. This makes it an ideal testing ground for architectural interventions.

Analysis of Lawrencetown Site (Micro Scale)

This section introduces Lawrencetown and its specific site conditions of water, wind, heat, earth and users. It explores the problems created by the interaction of these forces and identifies opportunities for implementing a unified site strategy.

Lawrencetown Beach is located with Halifax Regional Municipality (pop. 390,095 in 2011) and is 26 kilometres east of Halifax's urban center. It is located along a 32 km biking and walking trail (a converted railway track) and is recognized as Atlantic Canada's most popular surf location.



Lawrencetown Beach location in Nova Scotia

The site is shown in the drawing below. The green indicates the provincial park boundary. The orange is the access roads leading from a major highway. The black line is the former railroad track, which has been converted to a walking and biking trail. The hatched area is the salt marsh.

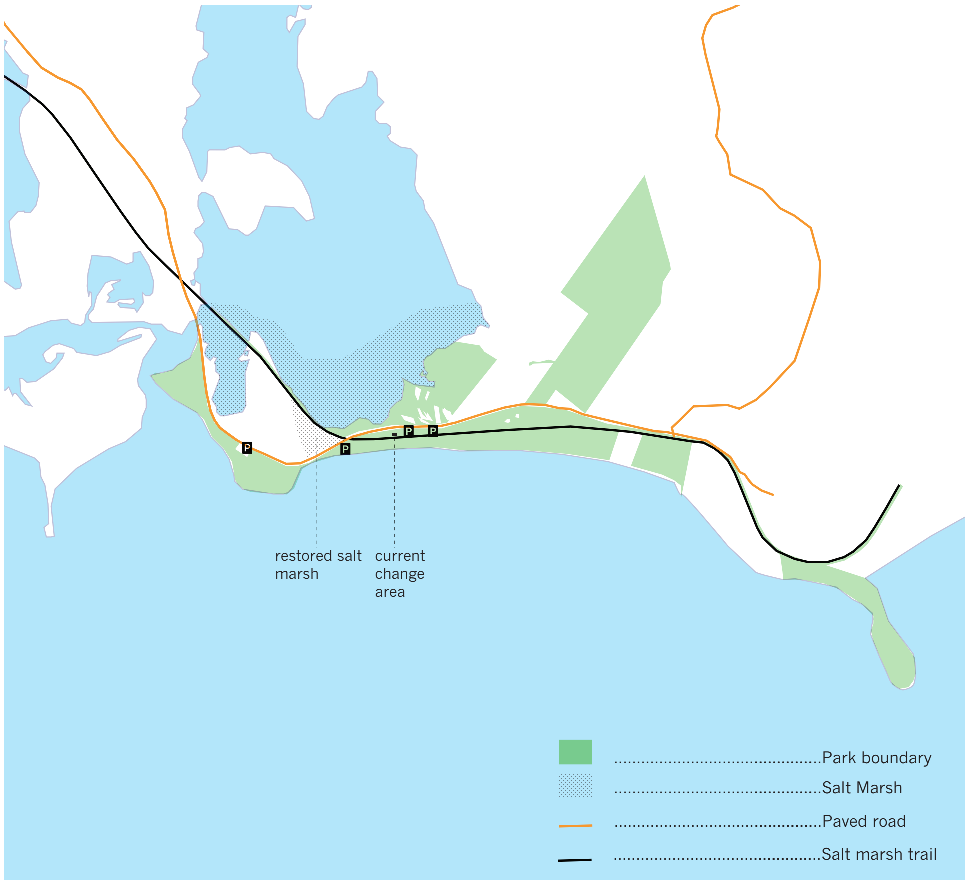
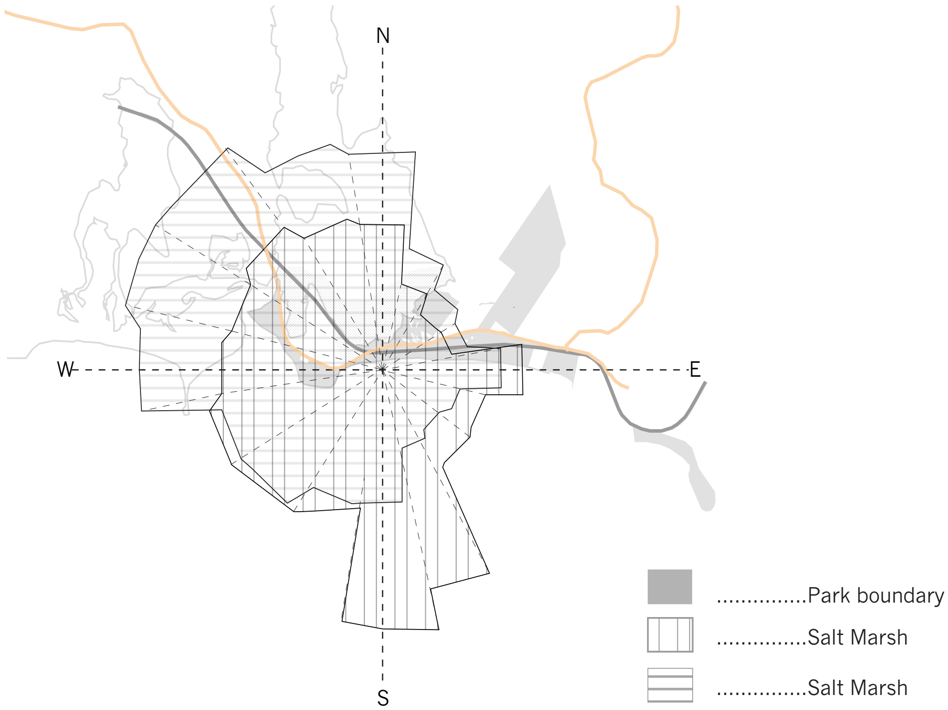


Diagram of Lawrencetown Beach

Being highly publicized as the surfing destination of Nova Scotia, Lawrencetown's popularity is reflected in the number of summer visitors. In 2013 over 40,000 people visited the beach in July and August.[11] This popularity has also resulted in increased pollution and ecosystem destruction from human activity, as well as crowded surf conditions. The local community has expressed frustration in the media with the lack of respect shown by beach visitors; however, the seasonal influx also supports a number of coast related economic ventures, such as surfing lessons, board rentals and equipment sales, and provides other retail opportunities.

11 *Nova Scotia Lifeguard Service Annual Report 2013,* http://www.nsls.ns.ca/sites/default/files/publications/2013%20NSLS%20Annual%20Report%20FINAL_0.pdf.

The site in Lawrencetown has a number of natural forces acting on it. The direction and magnitude of these forces change as they are influenced by both local weather patterns and larger systems. The winds shift daily because of the change in temperature between the land and sea, creating offshore breezes in the morning and evening; however, larger systems usually overshadow these local patterns. In the winter the wind is primarily from the northwest, while in the summer it shifts to the south.

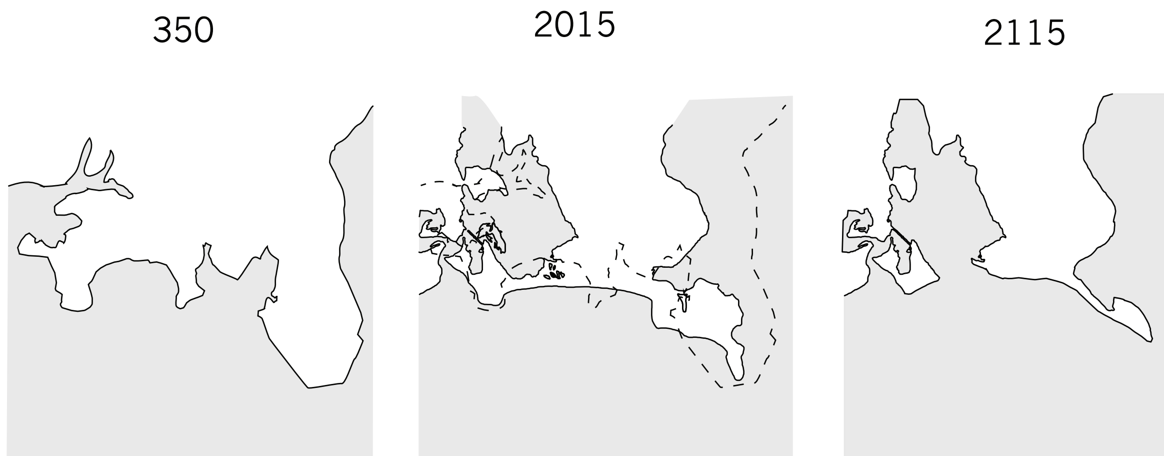


Wind rose for Lawrencetown Beach. Source: Windfinder - Wind, Wave & Weather Reports, Forecasts

Wind conditions distribute sand and influence dune formation. Offshore wind is responsible for creating ocean swell. The ocean's swell size and direction can change multiple times a week and are influenced by the tides which change every seven hours and by offshore currents. In Lawrencetown the swell is generally SE-SW. SW works better for the point break, and is the preferred direction for surfing.

Offshore currents not only play a role in determining the direction of the swell, but because they are consistent they influence the direction of the re-distribution of eroded sediment and therefore the change in geographic morphology. The drawing below shows soil types and the offshore currents that have influenced geomorphic change at Lawrencetown Beach.

Research has confirmed that the coastline shifted from four protruding drumlins into the littoral cell barrier beach that exists today. This shift took approximately 450 years.[12] The barrier beach then advanced seaward to its current position as the remaining drumlins eroded. As sediment supplies diminished, the barrier beach reduced its advancement and has since begun to retreat. This information is relevant because an in-depth understanding of the site sets the stage for a site strategy.

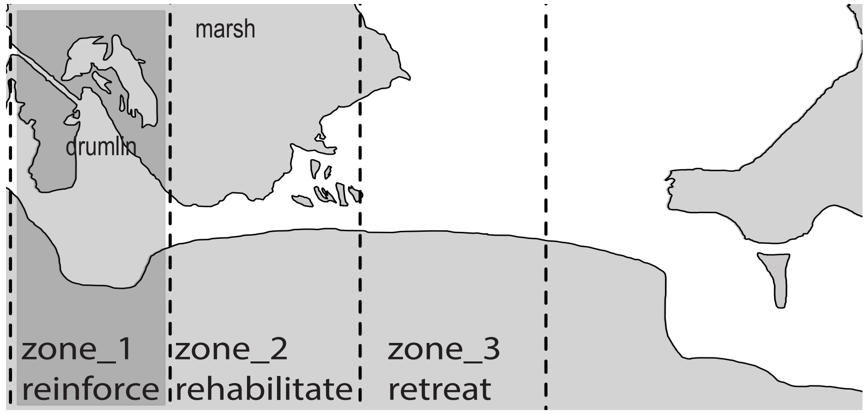


Geomorphic shift of Lawrencetown beach

Site Strategy

The site strategy takes into account user requirements and geomorphological transformation, both spatially and temporally. The forces within these zones are thoroughly analyzed to ascertain where friction may exist. This friction serves as an initiator for program and/or architectural response. Using surfing as a metaphor, together with the dynamics of the surfer and the surfboard, it considers how architectural moves can respond to these forces.

12 Duncan M. FitzGerald, “An Evolutionary Model for Transgressive Sedimentation on the Eastern Shore of Nova Scotia,” *Glaciated Coasts* (San Diego: Academic Press, 1987)93.



Zone 1 of the three zones that create the site strategy

Reinforce

The three zones are organized by their relationship with the natural landscape. The strategy for the first zone is “reinforce.” This area includes one of the two drumlins that make up the two heads of the littoral cell. This western drumlin rises 25 meters above sea level and is topped with a wooded area that plays a role in reinforcing the drumlin with its root system, offering protection from erosion. There are hiking paths along the top of the drumlin that allow for overhead views of the surfing area. There are also walking paths formed by surfers taking short cuts to the point from the nearby surf shop and surf rental truck. The base of the drumlin transitions into a stony beach on the oceanfront and into a salt marsh farther inland. The highway runs down the east side of the drumlin, dividing the barrier beach from the salt marsh.

Remnants of eroded portions of the western drumlin extend into the Atlantic at its base in the form of a boulder shoal. What is left are stones that were too large to be moved, even by the Atlantic at its angriest. These underwater contours, combined with a regular southwest swell direction, create consistent surf conditions at the point. When these waves interact with the submerged land they are refracted into the base of the drumlin and over time have eroded the shoreline to the road.

Lawrencetown Point, 2013; photograph by Scott Sherin from Scotty Sherin Photography,

Analysing the forces in this zone results in the following interactions:

1. Users surf on waves

2. Waves break because the land extending into the ocean creates a shallow reef

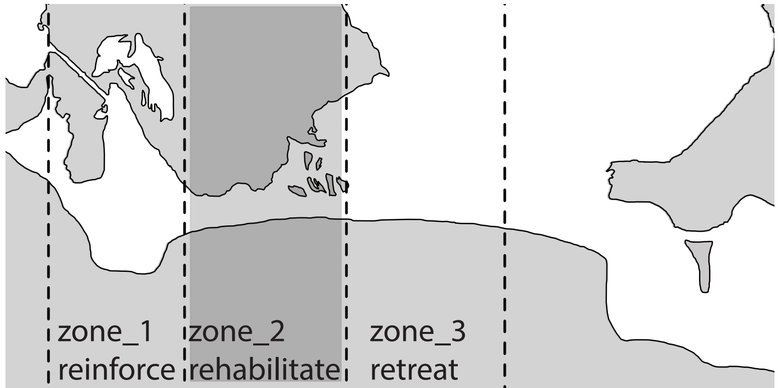
3. Point erodes because of waves

4. Infrastructure is at risk because of erosion

5. This erosion is exaggerated because of current infrastructure

In this instance the point of friction is between the eroding coast, user recreation and infrastructure. The expedited erosion caused by user interaction is threatening the infrastructure and natural conditions that create the opportunity for recreation.

Rehabilitate

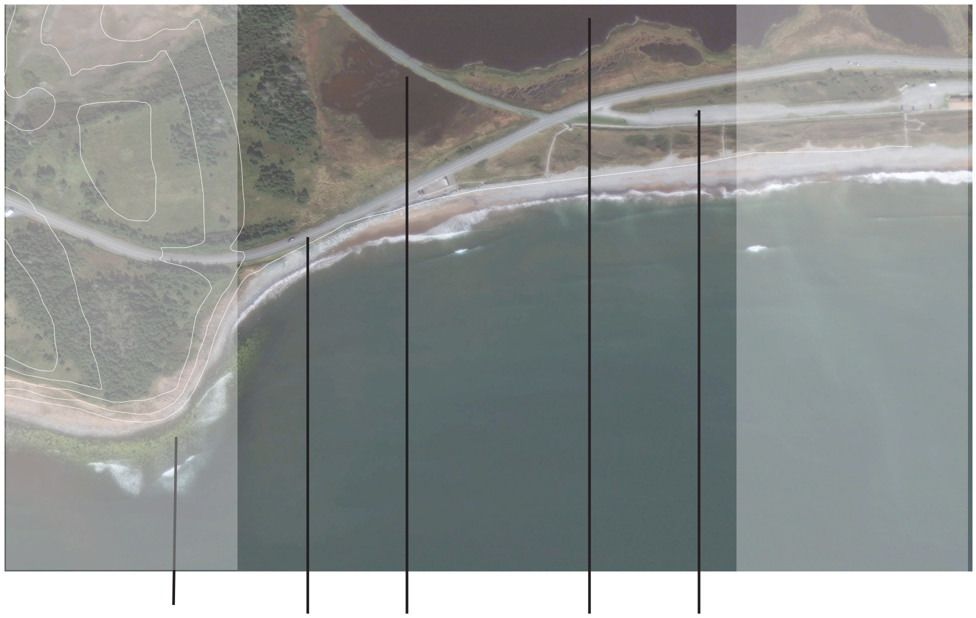


Zone 2 of the three zones that create the site strategy

The strategy for the second zone is “rehabilitate.” The landscape is characterized by the transition of the base of the drumlin into dunes. There is a salt marsh that is fed from farther west that mirrors the tides evident on the oceanfront. This marsh contains unique flora and fauna and serves as protection during floods and storm surges.

Salt marsh trail leading to Lawrencetown Beach.

This area of the site marks the arrival of users by vehicle on the highway and by foot and bicycle on the trail. In most cases these visitors move through this area of the site to access the ocean. This is where many surfers enter the water to paddle out to the point.



Satellite image of Lawrencetown Beach. Source: Google Maps

The remainders of ill-advised development strategies are embarrassingly obvious in this area of the site. The introduction of a railway track separated the salt marsh from the ocean. The railway has been converted into 32 kms of hiking and biking trails and successful restoration efforts have been made to allow tidal flow to return through the marsh. A highway runs along the barrier beach, separating the salt marsh from the ocean. The barrier beach is gradually retreating and this has required constant maintenance of the highway as winter storms wash it away. The province has responded by creating a large stone seawall that has expedited erosion along its leeward side.

The higher sea levels are causing higher storm surges. These surges are continuously threatening both infrastructure and natural defenses.

The following forces interact in this zone:

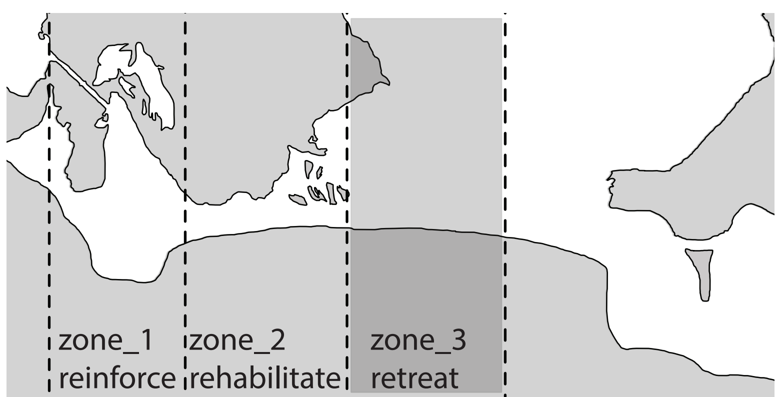
1. The ocean has a tendency to overwash the dunes during storm surges, causing the dunes to wash out.

2. Human activity causes damage to marram grass, leaving the dunes more susceptible to ocean washout.

3. The dunes absorb wave energy.

The friction in this area exists between the users and the landscape. Users walking on the dune system is counterproductive to the natural protection it offers because marram grass gets trampled and the dune system becomes unstable. An opportunity exists to create a more complementary relationship.

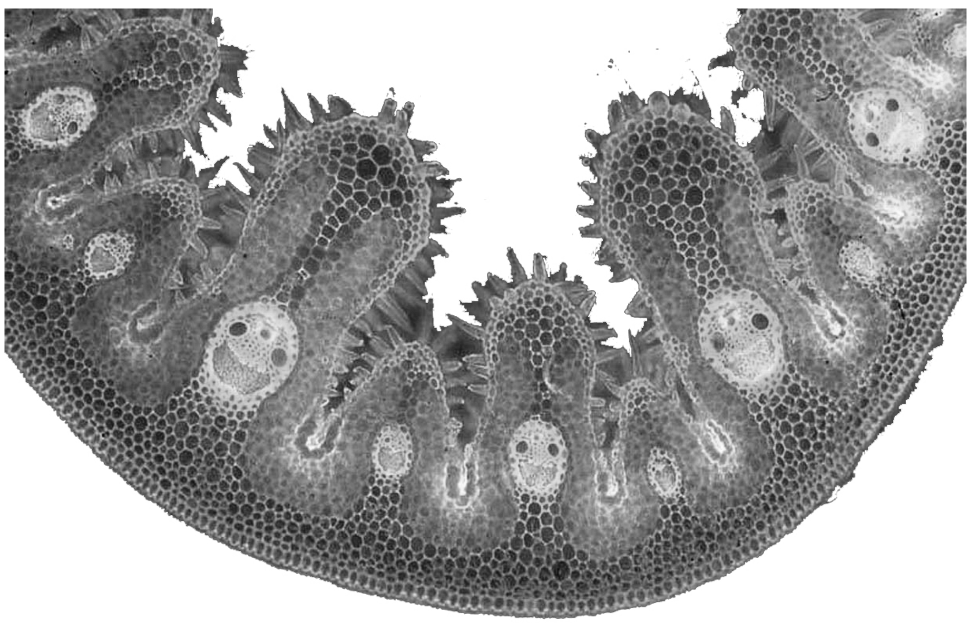
Retreat



Zone 3 of the three zones that create the site strategy

This area is located midway along the barrier beach. There is a gravel walking and biking path that runs parallel to the beach. This pathway is separated from the beach by a dune system that is 3 metres high and 10 metres deep. Multiple pathways have been formed through the dunes by users travelling from the pathway to the beach.

The dunes are dynamic; they rely on their Marram grass vegetation to trap sand and build dunes. Its root system acts as reinforcement to hold the dunes together. This unique plant survives periods of drought or unfavorable weather by rolling itself inward, turning its protective thick skin to the wind to protect its stomata or breathing cells, minimizing water loss.[13] Although resistant to wind and drought, the flexibility of Marram grass leaves it susceptible to destruction by trampling.



Microscopic section of Marram grass, showing the thick skin on the outer surface
Source: Phil Gates, "Beyond the Human Eye: Dune Builder"

This area of the site also serves as a corridor for access to the beach, as well as supplies and equipment. The dunes separate the main parking lot from the beach. Currently there are walkways that provide a pedestrian path over the dunes; however, there is no way to transport larger materials or equipment without disturbing the dune grass.

13 Phil Gates, "Beyond the Human Eye," *Dune Builder*, June 25, 2009, http://beyondthehumaneye.blogspot.ca/2009/06/dune-builder.html.

The following forces occur in this area:

1. The broad dunes in this area offer substantial protection to inland infrastructure.

2. Human activity leaves dunes susceptible to erosion from the elements

3. The dunes, wind and water interact and causes a dynamic landscape that shifts over time

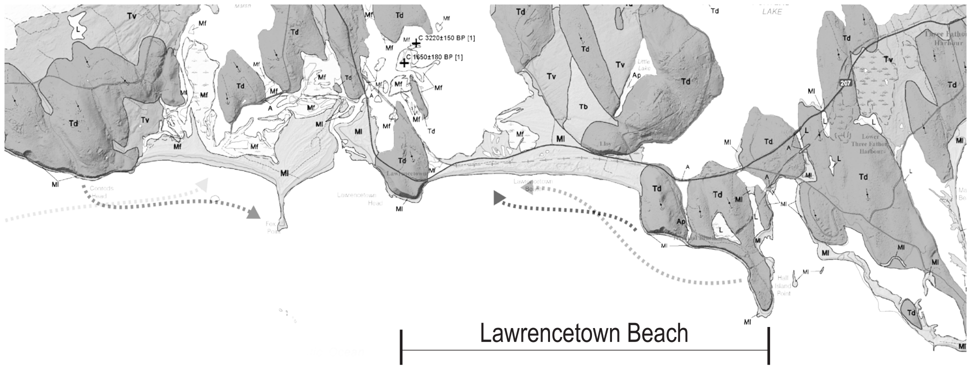
4. The fragile nature of the dunes discourages access to the ocean front for recreation

This demonstrates that friction exists between human and landscape as their interaction leads to undesirable results due to landscape destruction or limited beach access for recreation. Here, there is an opportunity to create a relationship where both requirements are achieved.

Surfing and Site

Lastly, for surfing, a site is not an address or a set of GPS coordinates; it is simply where the ocean meets the land. The same forces are at work in Nova Scotia, Hawaii and California. An in-depth understanding of how these forces work enables a surfer to adapt to a different location. An intimate understanding of the local complexities of these forces distinguishes a home break from anywhere else in the world.

Site strategy must be considered at two scales: a general understanding and an intimate understanding. Intervening at littoral cells is a starting point for localized interventions but a larger understanding of how the whole coast is shifting allows for a much more comprehensive approach. In Lawrencetown there is a sediment supply west of Lawrencetown Head, in the form of the mouth of the salt marsh. The longshore current distributes this sediment to the east. There is an opposing current east of Lawrencetown Beach that is distributing sediment west. This understanding of soil redistribution influences where the littoral cell can be reinforced and influences the design of shoreline reinforcement because if a structure is placed where it cuts off the sedimentation supply, this will increase erosion farther down the shoreline.



Offshore current patterns at Lawrencetown Beach. Source: D. Keppie, *2000: Geological Map of the Province of Nova Scotia*

A general understanding informs design decisions at the smaller, more intimate scale. These small-scale interventions, combined and coordinated with a larger objective, is where detail meets master plan.

Author entering the surf at Lawrencetown Beach. Photograph by Donna Macdonald, 2015

CHAPTER 3: DESIGN

Proposal for Lawrencetown Beach

The design proposal for Lawrencetown Beach consists of four buildings formed by applying concepts developed in the catalogue, placed in strategic locations on the site. Programmatically separate, these buildings are connected by a boardwalk, which doubles as a utilidor, supplying water and electricity. Each of the buildings interacts with landscape, both quantitatively and qualitatively, by using the forces present to perform a function and shape an existential experience.

The boardwalk, the landscape interactions, the material choices and the building form unify the project, encouraging its understanding as a whole. Coastal traditions are developed and reinterpreted with an understanding of climate change, user requirements and relationship to the landscape.

This project attempts to be understood on multiple layers, through originality and innovation. It provides enough existential enticement to garner a pause and contemplation; it is here where the project becomes exciting.

Building 1: Tidal Shower

As the conceptual devices become more refined and more complex, they begin to take on architectural form. An example of this is a tidal shower that utilizes multiple forces that exist at any coastal site: heat, earth, water, and users. The user group defines the program, which in this case is fresh water showering, with partitions for privacy. The shower is composed of four main elements: a tidal pool that gravity-feeds salt water to the structure; a platform and diaphragm that interacts with vehicles to move water; a roof that desalinates and warms water; and gabion walls that provide privacy and support the roof.

Water is captured via a one-way valve in a tidal pool when the tide flows in. The water is then gravity-fed to a diaphragm encased in a platform that acts as a parking space. The car applies pressure to the diaphragm and transfers the water through the gabion wall and onto the roof it supports. The roof is made of two south-facing glass chambers, covered by sloped glazing. The condensation created by the sun runs along the underside of the sloped surface, then pools into the second chamber, which is a fresh water reservoir. This reservoir is heated by the sun and available for fresh water showers.

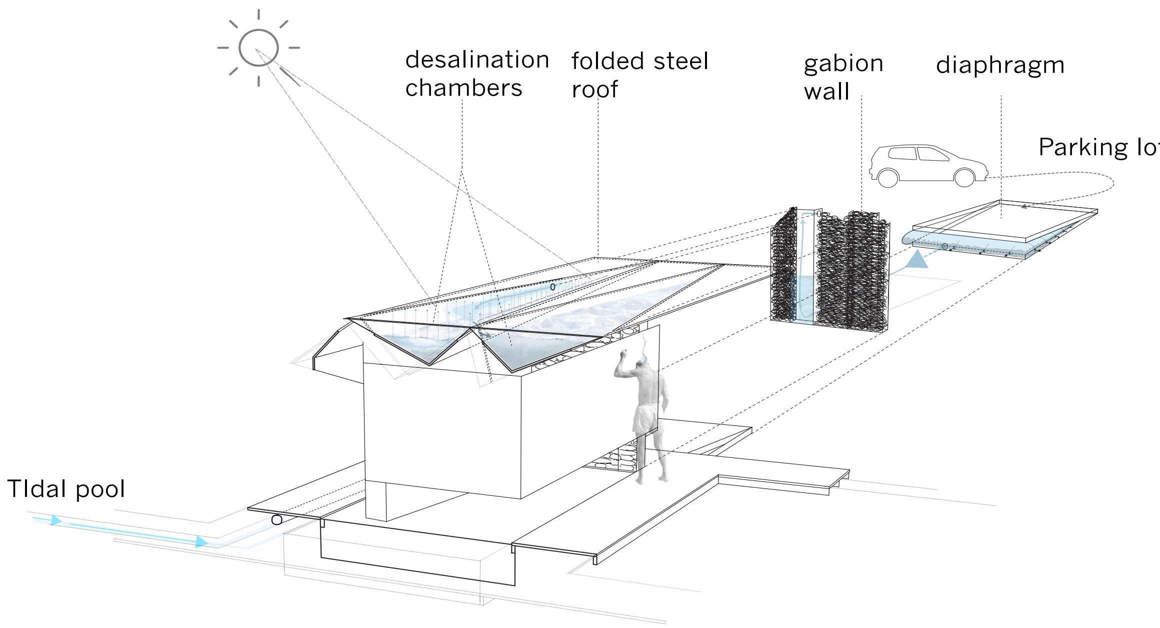


Diagram showing components of the tidal shower

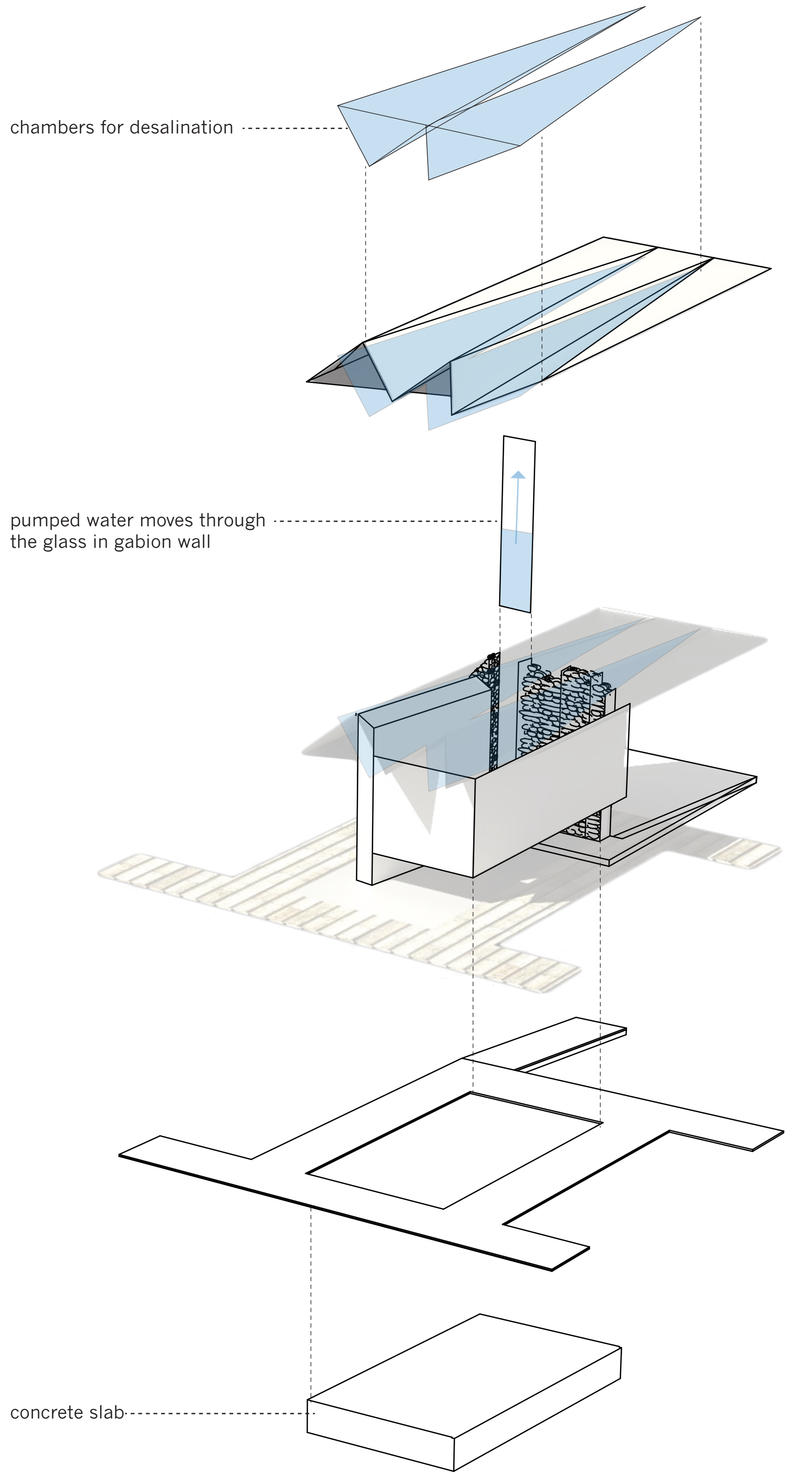
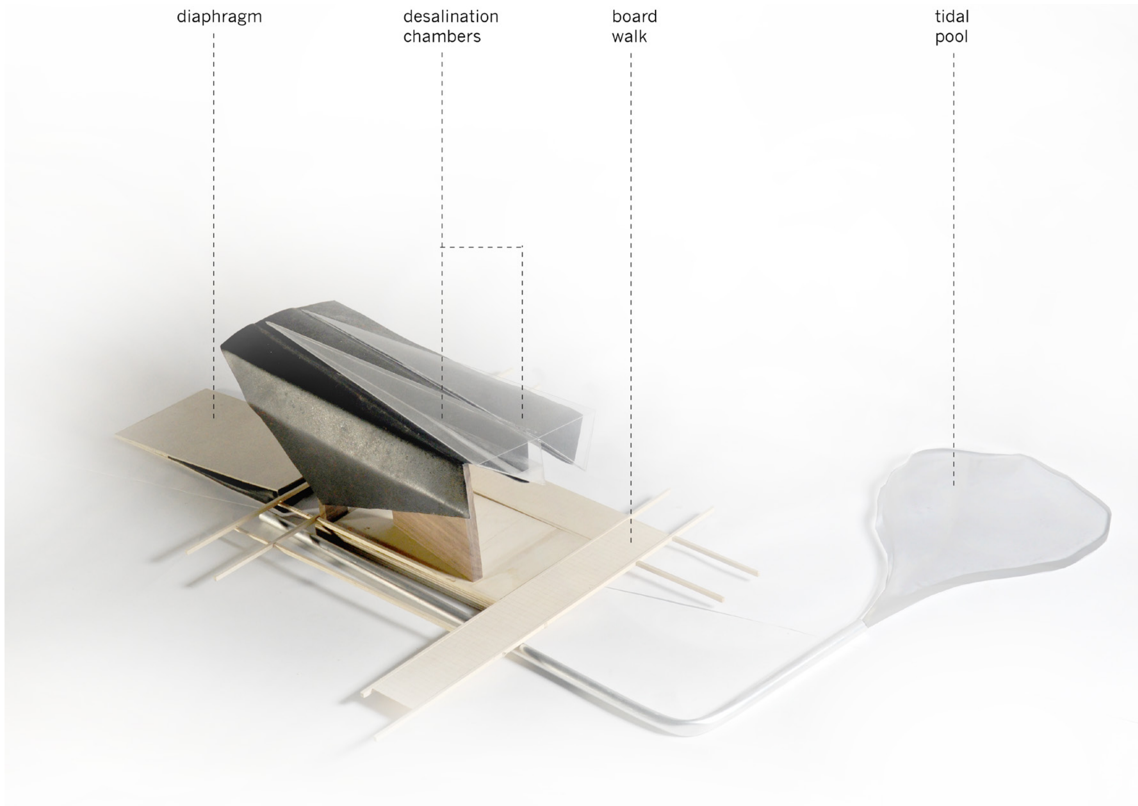
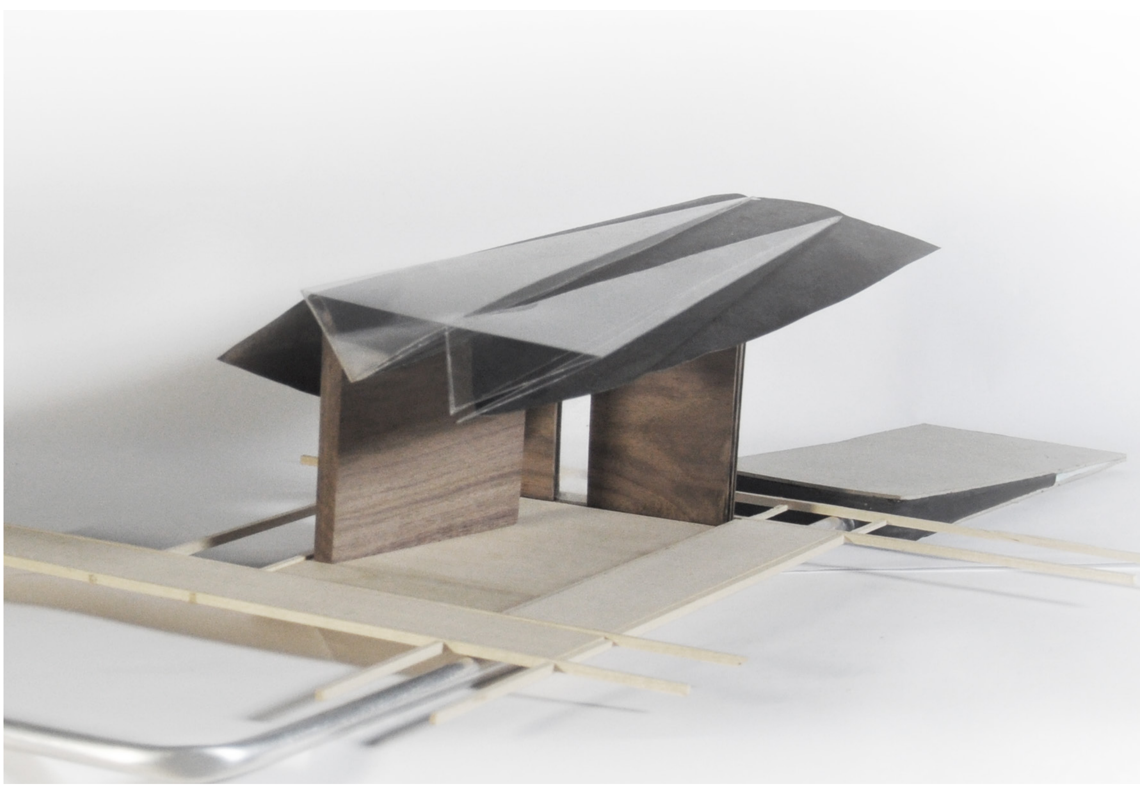


Diagram showing components of the tidal shower



Physical model of the tidal shower



Physical model of the tidal shower

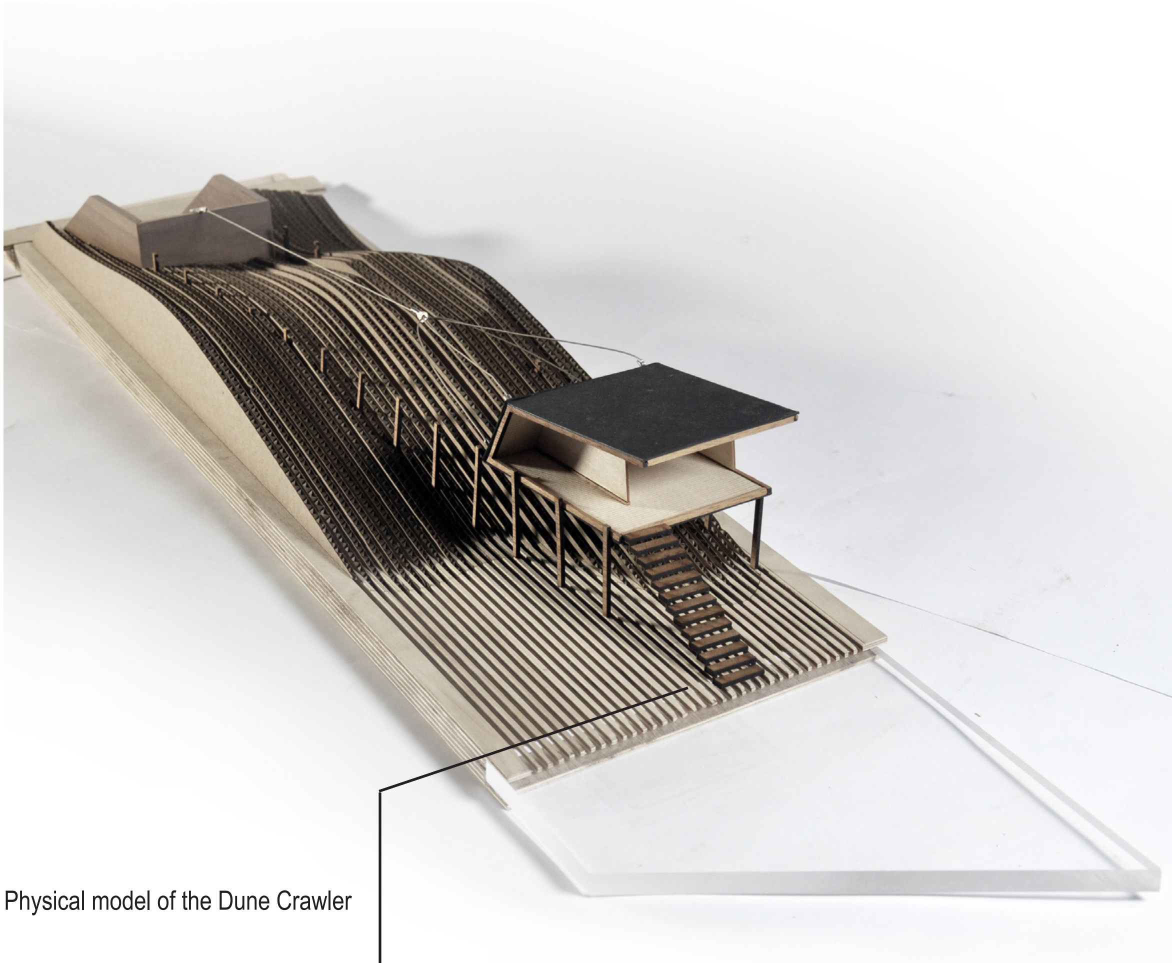
Building 2: Dune Crawler

This building acts as shelter and equipment storage for the Nova Scotia Lifesaving Society surf guards. Vandalism and exposure to harsh weather have destroyed past storage facilities. Machinery used to repair those buildings has taken a toll on the landscape by destroying marram grass and leaving the dunes exposed.

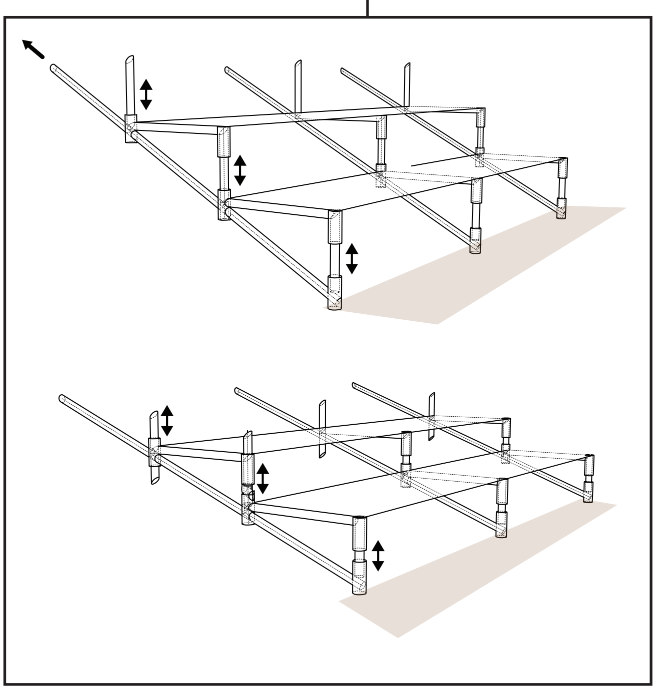
The design of this new building takes lessons from native flora such as marram grass, which rolls itself inward and turns its protective thick skin to the wind. The building retreats into a protective casing inland during the harsh winters and emerges for use during the summer months. The track remains in the sand, acting as yardsticks measuring the movement of the dunes over the landscape.

The building emerges from its casing, propelled by its users, floats over the sensitive area of the site and lightly touches down on the shore. When the building is not occupied the access stairway can be retracted, leaving it inaccessible, patiently waiting for its users to return.

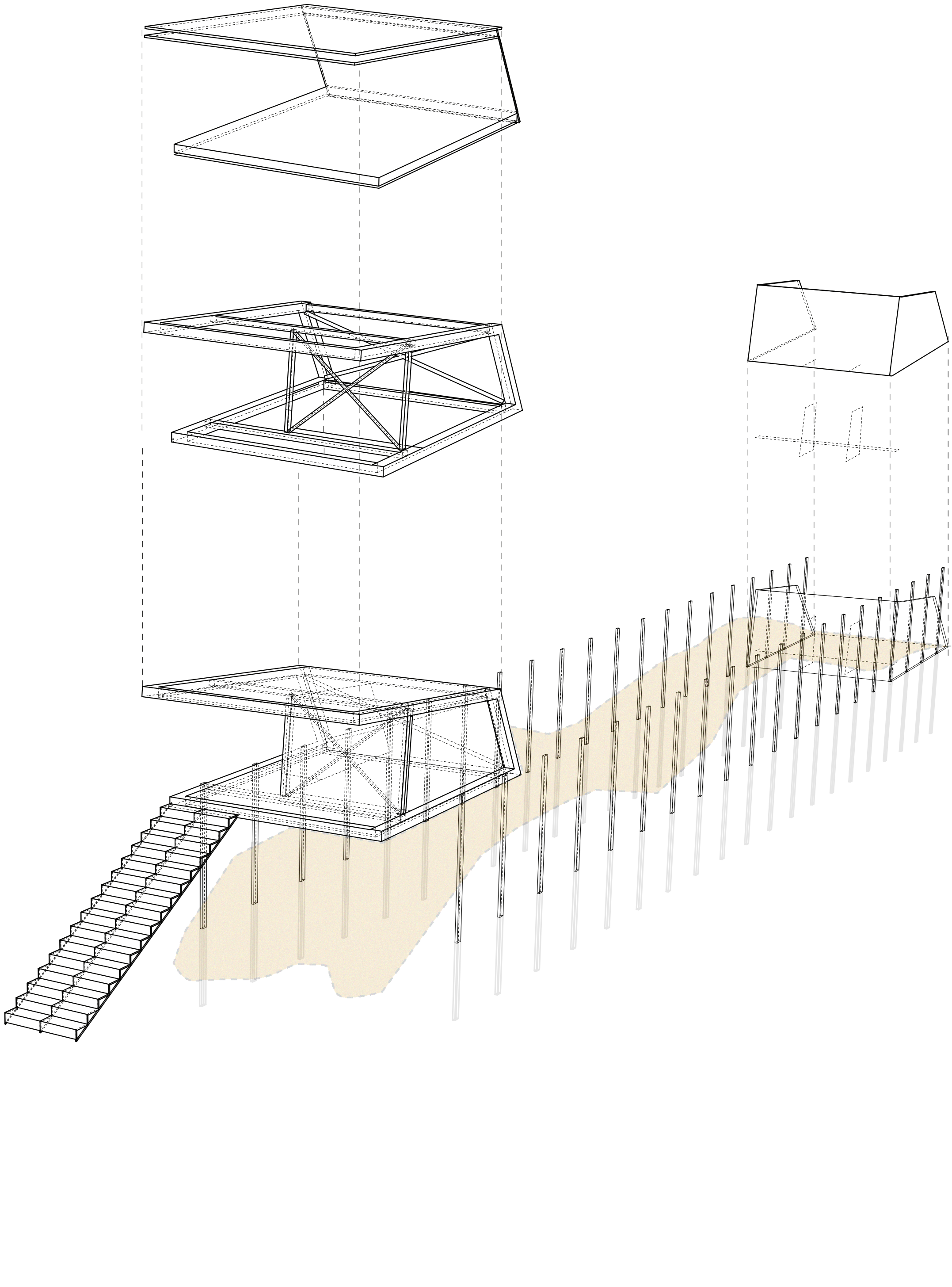
Diagram demonstrating the building’s seasonal movement



Physical model of the Dune Crawler



Telescopic legs allow the stairs to adjust to the changing dunes



Components of the dune crawler building

Building 3: Sand Shifter

This building allows the landscape to remain dynamic and uses wind to fuse the built form with the landscape. It draws from a surfing analogy. A crashing wave is dynamic. Depending on wind and bottom contours, the lip of the wave can be dangerous to surfers because the force of the water landing on a surfer can cause injury by sending the surfer to the ocean bottom and/or holding a surfer underwater for an extended period of time. Skilled surfers can use their speed and positioning to thread a path on the wave face under the crashing lip. This is called “getting barrelled” and is one of the ultimate goals in surfing. It allows the surfer to enter into a zone completely sheltered from other elements by the water.

Responding to the seasonal wind directions, the building is designed to encourage sand to build up over time, creating two dunes parallel to the two seasonal wind directions. The roof of the building slopes windward and is folded, creating voids to be filled by sand. A gabion wall supports the roof and strategically delaminates to become a wind fence. Visually shifting to emphasize the direction and strength of the wind, it encourages sand to build up by reducing wind velocity, allowing the sand to “drop out” of it.

Programmatically, the building serves as the main gathering area during the summer months, providing space for change rooms, toilets, equipment rental and food purchase. In the winter months the south-facing portion acts as a greenhouse, growing marram grass to ensure that a healthy dune system is maintained on the site. The gabion wall performs a third duty as a thermal mass, helping maintain thermal stability.

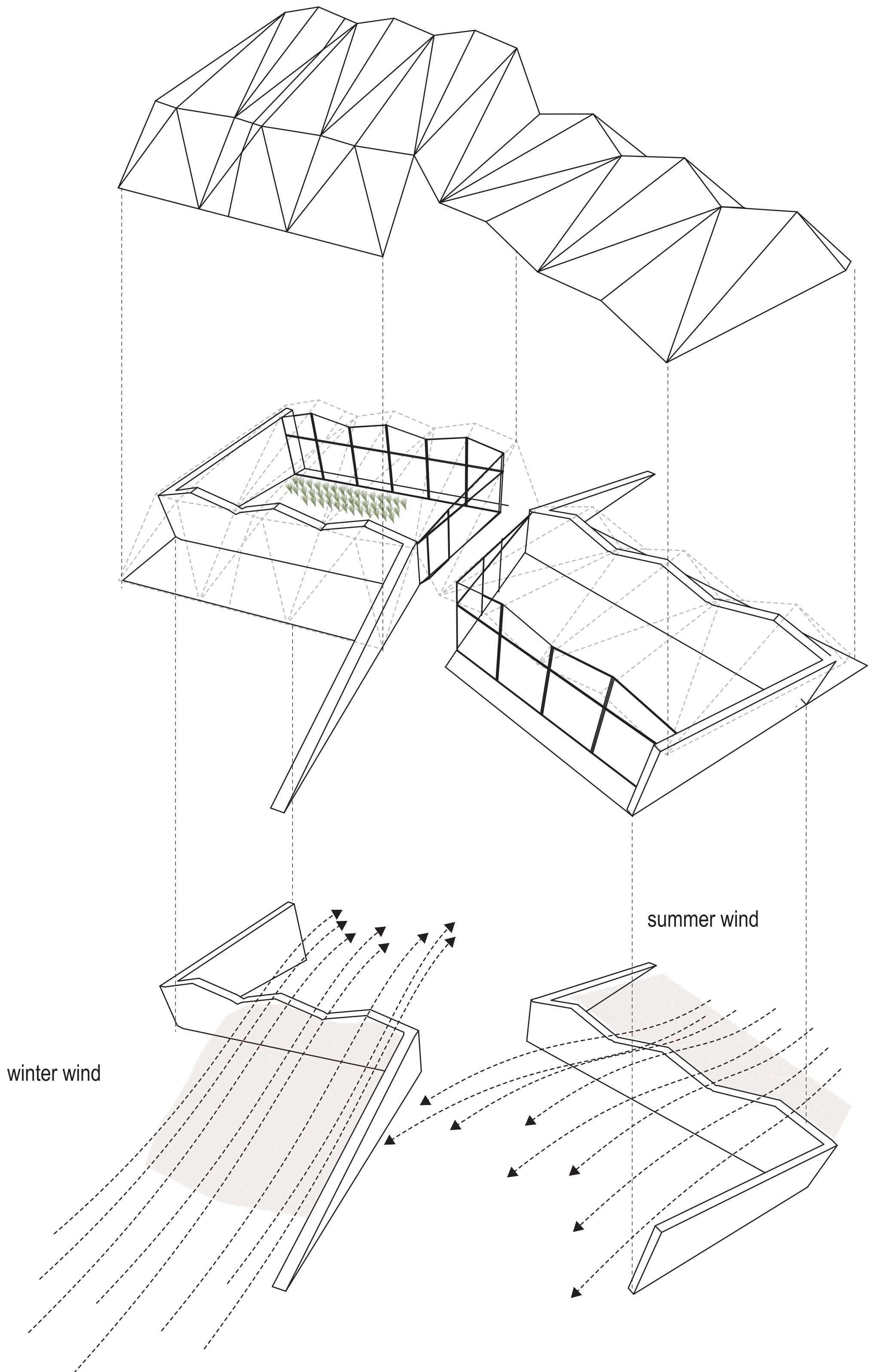


Diagram showing the gabion wall and roof engaging the wind at different times of the year

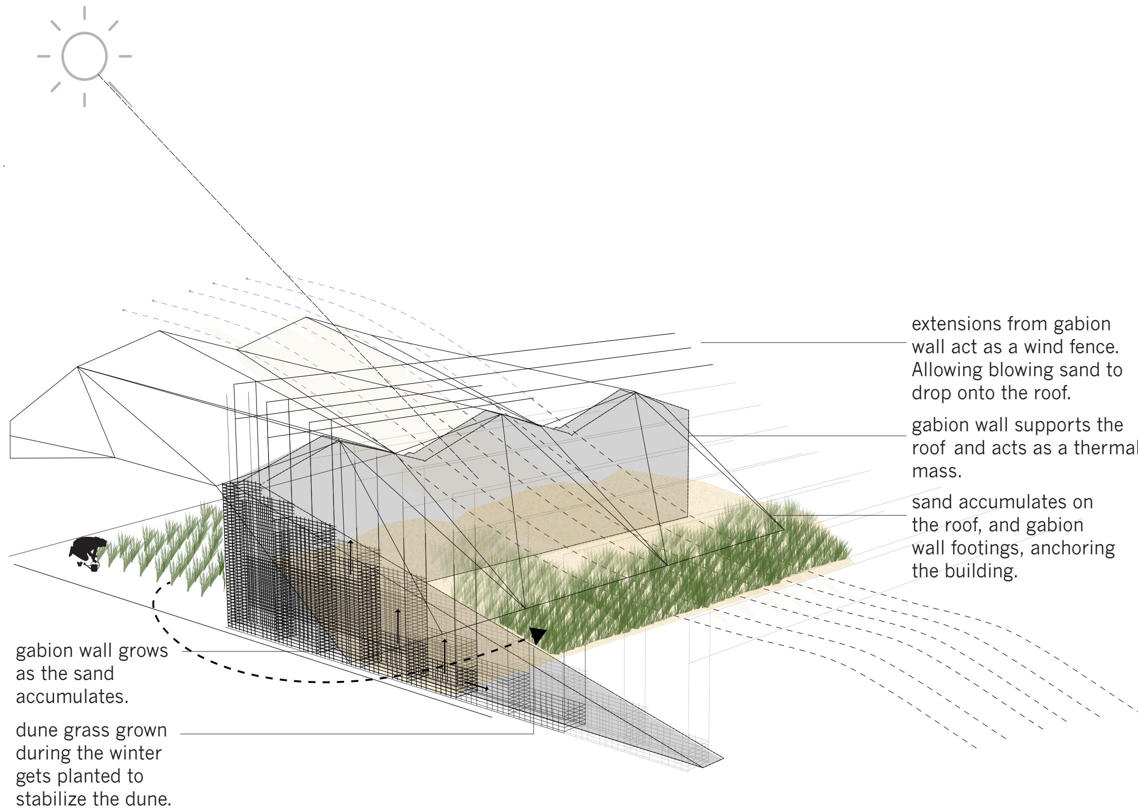


Diagram demonstrating the gabion wall and sand dune development

Physical model showing the build-up of sand over time

Physical model showing the build-up of sand over time

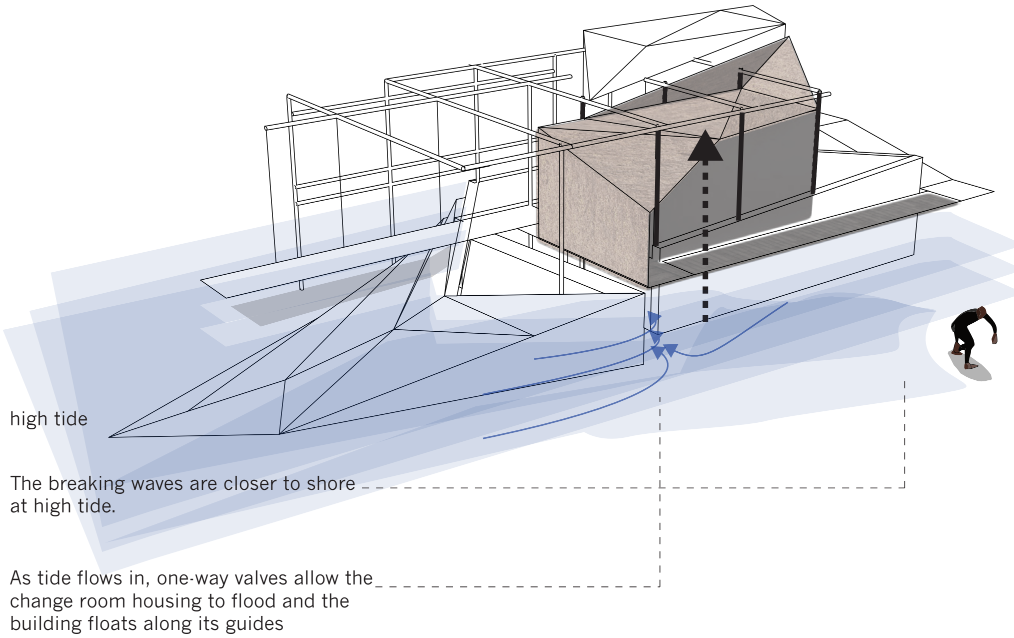
Building 4: Flow Conductor

Located at the west Lawrencetown point, this building provides access to the surf and blurs the boundary between land and sea. Its program is to provide changing areas and a warming pool for surfers, particularly during the winter months, when surfing conditions are best.

This structure combines multiple devices from the catalogue. A gabion structure re-inforces the point and re-directs waves, causing them to break farther offshore and helping to protect the area of the site most susceptible to erosion. Water from the tide is captured, distributed and warmed. The structure draws on techniques used by the original Acadian settlers in the area. The Acadians used an aboiteau system of one-way valves to drain salt water from the fields. Reversing this system allows water to be captured from the tidal flow and stored on the tidal ebb. The temperature of the water can then be controlled by solar and manual techniques.

This water is directed towards various tidal pools using the weight of the changing rooms, which float with the rising of the tide. The rooms rise out of their protective casing during high tide, emphasizing the force both visually from the beach and existentially for users.

Finally, the building houses a processing area, converting high-pressured water de-livered from offshore buoys, as previously outlined in Chapter 1. The electricity can then be transferred throughout the site via the boardwalk utilidor.



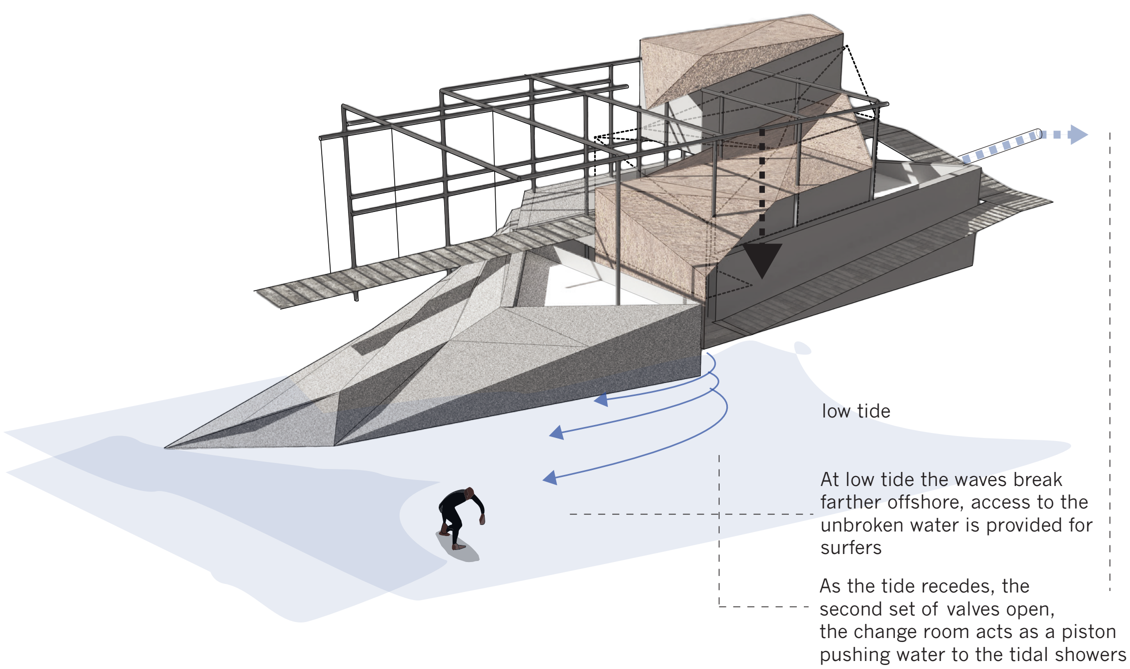
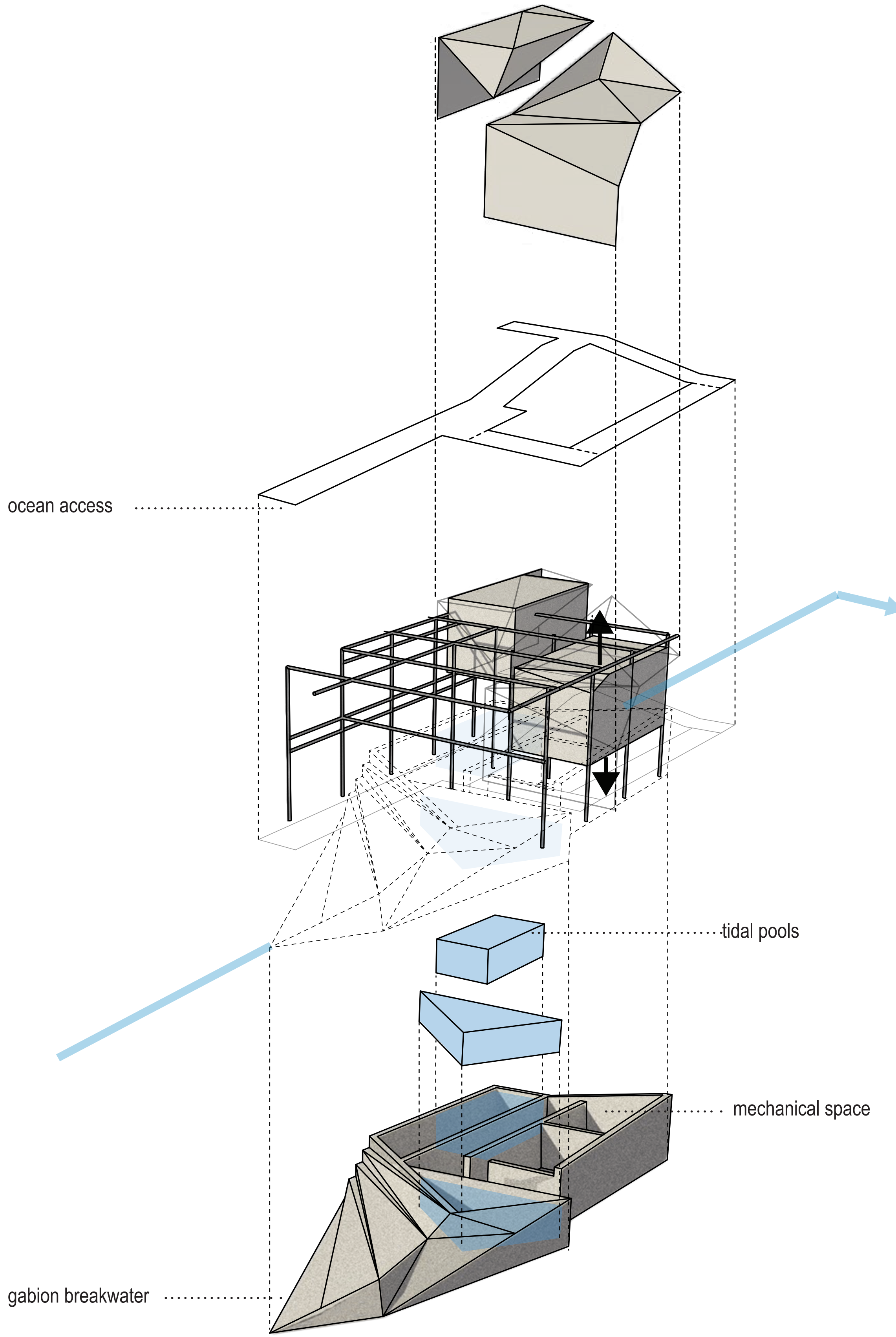


Diagram of high tide and low tide conditions


ocean access
tidal pools
mechanical space
gabion breakwater

Physical model showing the two different tide conditions and the breakwater structure

Physical model of the flow conductor

CHAPTER 4: CONCLUSION

Surfing is an industry that thrives on progression. The industry was built by youth with limited budgets who relied on innovation. Over the past 3 decades surfing has shown exceptional progression as both a sport and an industry. It has developed into a multi-billion dollar industry. This project strives to bring that progressive innovation to architecture. There is a need to support innovative designers and builders. This begins with realistic, feasible design, integration and collaboration. The proposed interventions are conceptually progressive but rely on tradition and proven techniques, ensuring the feasibility of the project, bridging the gap between academics and practice.

Potential project improvements include a more detailed catalogue of devices, separating proprietary devices from innovative devices. This separation can be made distinct and evident in the architecture. Lessons can be taken from the more successful design interventions, allowing the forces to drive generative design. The tidal shower and sand shifter were both shaped by the forces on site and are expressive of these forces in their form.

As a whole these architectural devices are intended to have a common design language but are specific to each coastal site they inhabit. A strongly developed design and material language will allow these devices to be constructed by local workers on site, but allow the project to be understood hermeneutically. The individual sites and devices are part of a greater coastal response.

Designing on the coast provides a challenge for architects. Utilizing and expressing coastal forces is an important aspect to coastal design. As the climate and coastlines change, innovative design and research will be essential to continue advancement in coastal architecture.

Final presentation for thesis defence

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