RESILIENT COUPLING:
THE SYSTEMS OF COASTALLY DEPENDENT COMMUNITIES

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Resilient Coupling: The systems of coastally dependent communities

Master of Architecture, 2018
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Abstract

As climate change becomes a more prevalent reality, rising sea levels are increasingly a threat to cities and communities in coastal regions. In light of this it is important to consider architecture's role in the strategizing of defences and resilience. The major issue with traditionally implemented coastal defence programs, such as those considered by the US Army Corp of Engineers, is their brute force approach is repressively one dimensional, undermining the diverse, and complex realities of any community. Orienting itself in the diverse and complex communities of Atlantic Canada, this thesis operates in the face of these challenges and shortfalls. Instead a coupling of systems, activities and events in these coastal communities can make possible an architecture that accommodates, and makes visible, the realities of its changing environs at a multitude of scales, allowing the continued success of human settlement.

Acknowledgements

There are a great number of people who I have to thank for this body of work some of whom I will undoubtedly forget to thank here. The following however have contributed in a recognizable way to this thesis.

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Dedication

To my family, and especially my parents, whose love and support were invaluable in completing this degree and this thesis.

Poppy, you were a carpenter by trade but the family's first architect at heart.

Contents

Part Two – Atlantic Canada

Part 3 – Response

Appendices

List of Figures

Chapter 02 – Current/Traditional Human Responses
Figure 9: Matrix of Current Tactics
Source: Compiled by Brandon Bortoluzzi

Image Sources Organized Top to Bottom, Left to Right

Source: Photo: Ed Dahl, 2005
Accessed via: FEMA Media Database, https://www.fema.gov/media-library

Source: Photo: Dan Koeck, 2011
Accessed via: The New York Times, https://www.nytimes.com/2011/04/09/us/09flood.html

Source: https://www.holland.com/global/tourism/destinations/provinces/south-holland/the-maeslantkering-storm-surge-barrier.htm

Source: Photo: Ruth Gorba, Video Still, https://www.youtube.com/watch?v=8cRTif2uSwQ

Source: https://sprayfoaminsulationmaine.com/maine-foundation-waterproofing-concrete/

Source: Structures of Coastal Resilience, http://structuresofcoastalresilience.org/locations/norfolk-va/

Source: City of Orem, https://orem.org/storm-water/

Source: Growing Green Guide, http://www.growinggreenguide.org/technical-guide/design-and-planning/site-analysis/drainage/

Source: WXY /West 8,
Accessed via: Blue Dunes – Climate Change by Design, ed. Jesse M. Keenan, Claire Weisz (New York: Columbia University Press, 2016) 223

Source: Global Risk Forum, GRFDavos, https://www.slideshare.net/GRFDavos/water-management-in-singapores-bishan-angmo-kio-park-herbert-dreiseitl

Source: Credit Valley Conservation, https://cvc.ca/wp-content/uploads/2012/02/cvc-lid-swm-guide-appendix-a1.pdf

Source: Photo: Tom Bricker, https://www.disneytouristblog.com/disneys-boardwalk-inn-review/comment-page-1/

Source: Photo: Oliver Laumann, November 2010, http://www.informatik.uni-bremen.de/~net/photos/thailand-cambodia/cambodia-misc/

Source: Unknown

Source: Vincent Callebaut Architect, Lilypad Project, 2008
Accessed via: http://vincent.callebaut.org/object/080523_lilypad/lilypad/projects/user

Source: Buoyant Foundation Project, Elizabeth English, *Amphibious Architecture: Float when it Floods*, 2010, accessed October, 2017
http://buoyantfoundation.org/wp-content/uploads/2017/12/Strategy-for-flood-resilient-housing.pdf

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http://buoyantfoundation.org/wp-content/uploads/2017/04/elevarca.pdf

Source: Donald Watson and Michelle Adams, *Design for Flooding: Architecture, landscape and urban design for resilience to climate change* (Hoboken: John Wiley and Sons, 2010, 176

Figure 10: Vincent Callebaut Architect's Lilypad Project for climate refugees
Source: Vincent Callebaut Architect, Lilypad Project, 2008
Accessed via: http://vincent.callebaut.org/object/080523_lilypad/lilypad/projects/user

Figure 11: Elevated homes in (a) Florida and (b) Cambodia
a)Source: Taylor Made Homes, https://www.taylormade-homes.com/stilt_homes.php

*b)*Source: Photo: Oliver Laumann, November 2010, http://www.informatik.uni-bremen.de/~net/photos/thailand-cambodia/cambodia-misc/

Figure 12: Buoyant Foundation Project's, Amphibious House
Source: Buoyant Foundation Project, Elizabeth English, *Amphibious Architecture: Float when it Floods*, 2010, accessed October, 2017
http://buoyantfoundation.org/wp-content/uploads/2017/12/Strategy-for-flood-resilient-housing.pdf

Chapter 03 – Evaluation Criteria

Chapter 04 - Design Methodologies (Modes of Operation)

Preface/Introduction

This thesis is about architecture in the context of climate change. As simple an introduction as that may appear, such a statement may lead to a number of different interpretations and so it is important from the start to distinguish what this means. There are two major realms of work which I believe can easily be intended when discussing sustainability and climate change in design and so it is important from the outset to define what this does and does not mean within this thesis.

The first of these, and likely the most common, is the area of research and practice dedicated to greening, which includes: renewable energy technologies, reduced resource consumption, and (in many cases) adherence to specific standards to prevent further environmental damage to the planet. These practices have an important place in considering human impact to our environments and should be continued as we work to combat the severity of the climate changes we experience. Despite these practices however, it must also be noted that we are seeing – and will continue to see – these changes occur, and the only true variables are the severity and time scale at which this happens. For these reasons this thesis is concerned with the second definition.

This thesis concerns itself with how we operate in the face of these impending changes. Despite even the best efforts of those operating in the previously outlined manner of prevention, the climate will continue to see fluctuations on the short term and more significant changes in the long-term, regardless of their successes or failures, and thus we must begin to think about what it means to design accordingly. This is in no means a doomsday scenario but rather the understanding that some of these changes will require rethinking of the way our economies, infrastructures and societies operate.

This area of research is best described by the term *resilience*, a word with widely debated meaning. While in some cases resilience refers to an adaptation or changing to stay the same, in other scenarios it is used in a regenerative capacity to begin to redevelop or resume operation after a disaster, and in some cases it is used most simply as a synonym for survival. In their essay Resilience Theory and Praxis: a critical framework for architecture, Michelle Laboy and David Fannon go deeper into defining both an ecological-resilience and adaptive-resilience which, rather than a return to status quo through rebuilding efforts (as is the case in engineering-resilience), looks to respond to changing contextual conditions and create an improved existence with each iteration.[1] While the effectiveness and definitions of modes of resilience can be debated, in all cases it refers to design in response to disaster or pressures, or in this case specifically the symptoms of climate change. In particular the symptoms of climate change that this thesis is concerned with are those related to Sea Level Rise (SLR) and water-based forces associated with increasing temperatures and the accelerated melting of glaciers and ice-caps.

Climate change is a topic that is easily confounded by forces acting from three major areas of operation; (1) the political, (2) the cultural and (3) the physical. To get caught in debate in any of these areas individually would undermine the purpose of this work, which is to posit a mode of working architecturally to help shift our relations to changing ecologies. Thus, to overcome this confounding of positions and thoughts, the thesis is organized into 3 parts, each with a particular area of interest.

Structure

Part One, titled Contextualising concerns itself with establishing the 'why', and 'how' through an exploration of a range of background information and data as well as the establishment of certain principles and priorities for design intervention. Firstly, it explores notions of water, specifically the physical implications of coastal conditions such as tides, waves and storms. It takes a direct look at sea level changes to establish a condition for operation including the defining the parameters for the design work carried out within this thesis. From here an examination of existing disaster mitigation strategies implemented in real world projects or explored in academic and research work helps to inform evaluation criteria and operational strategies for design research work. All of this exists in the early stages of the thesis for two main purposes. Firstly, the establishment of technical metrics early on removes the uncertainty that may come from their lack of resolution grounding the work in fact instead of allowing for later conjecture. Secondly it allows certain directions and goals to be established from the outset for how the work looks to respond to the issues being faced.

Part Two *Atlantic Canada* is primarily concerned with the required specificity of this work. By including a chapter highlighting the generalities of Atlantic Canada, it permits the section to further devote itself to a deeper exploration into some of the conditions that may present opportunities for design exploration. Operating through a multi-layered analysis, carried out through preliminary mapping and onsite exploration, it essentially works as an introduction to the final Part of this book through an exploration of where the intervention is best suited to take place. Part Two concludes with a selection of a site of intervention (Halls Harbour, Nova Scotia) and a more in-depth exploration of that community considering its internal systems, the systems of which it is a part of and a series of other information sets which will help drive the final design exploration.

If Part One is considered the 'why', and 'how' and Part Two the 'where' then Part Three largely concerns itself with the 'what'. Building from the evaluation criteria and means of exploration explored in Part One and context of Part Two, this section presents a strategic exploration and deployment of design methodologies. As the original evaluation criteria demands the work is multi-scalar, looking not only at the systems and organizations of the Halls Harbour community (the project's selected site of intervention) but also the larger systems to which it connects and depends, and the tectonics which allow its function throughout the range of coastal conditions described in Chapter One.

(Endnotes)

1 Michelle Laboy and David Fannon, "*Resilience Theory and Praxis: a Critical Framework for Architecture,*" *Enquiry 13* (1) (2016): 44

"How high's the water mama? She said its three feet high and rising" - Johnny Cash

Figure 1: Peggy's Cove, 2018

Part One – Contextualising

This thesis contains a fair amount of background research and knowledge, that if permitted can become a convoluted rabbit hole of debate and research. Background technical scenarios for climate change and sea-level rise are multifaceted, with aspects grounded in science, politics and cultural among a number of other areas. This first section establishes the parameters accepted for the purposes of this design research body and allows the rest of the thesis to operate with these based as fact rather than conjecture.

(Endnotes)

1 Johnny Cash, *Five Feet High and Rising,* (Columbia, 1959) https://genius.com/Johnny-cash-five-feet-high-and-rising-lyrics

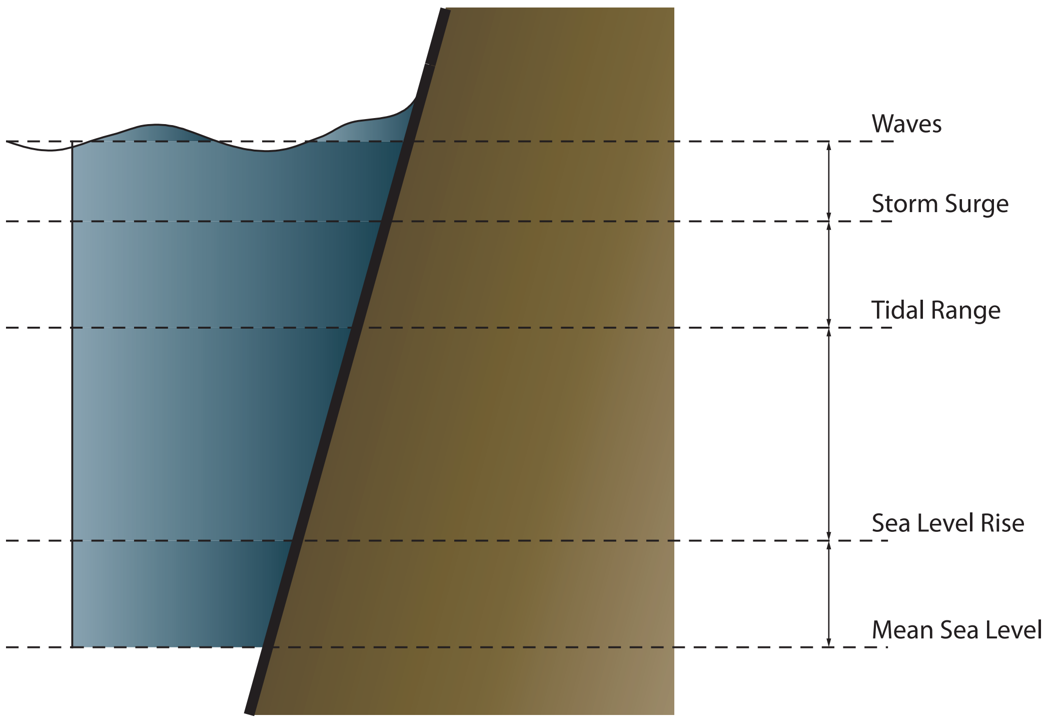


Figure 2: Layers of water dynamics

Chapter 01 – Rising Water Levels and Coastline Variability

A common misconception is that a coastline is a hard edge as it may appear on a map, or other graphic representation. In reality, coastlines are in constant states of flux and along every coastline there are large swaths of land that exist in multiple states of being. If this is the case, then to think that any design done for the coastal region can exist as a singular condition for a fixed water level is naïve and underserving. To understand this better it is important to understand the elements and phenomena that contribute to these fluctuations, and how the realities of these are in a constant state of evolution.

The lateral limits of a coastline are largely determined vertically by the water level. The water level at a given moment in time can be understood as the combined total of a number of phenomena with 4 major factors; (1) sea level (2) tides (3) waves, and (4) storm and other surges. Each of these factors contributes to fluctuations at different scales and intervals and the effects of each vary by regional conditions, however in general their relationship can be understood by the manner shown in *figure 2* on the opposite page.

To fully develop an understanding of these factors and how they may affect the spatial and defensive criteria of the coastline, it is important that a basic knowledge of the operation and scale, (physical and temporal) of each of these phenomena are understood. The following will look to explain the ranges in value, the causes and the regularity of these occurrences in a manner that, while not overly technical, permits the work contained later in this document to be better understood. In addition, appropriate means of responding to each will be explored.

These modes of response will be; (1) Operation, (2) Survival, and (3) Mitigation. The factors affecting which mode of response is appropriate include the magnitude, regularity, and impending damage caused. Designing for *Operation* refers to the ability for continued function throughout a range of fluctuations. Design for *Survival* refers to designing in a way that avoids as much damage as possible allowing as quick a return to normal operation as possible. Finally, *Mitigation* is the reduction of the impact to prevent its effects carrying forward or perpetuating.

1.1 | Waves

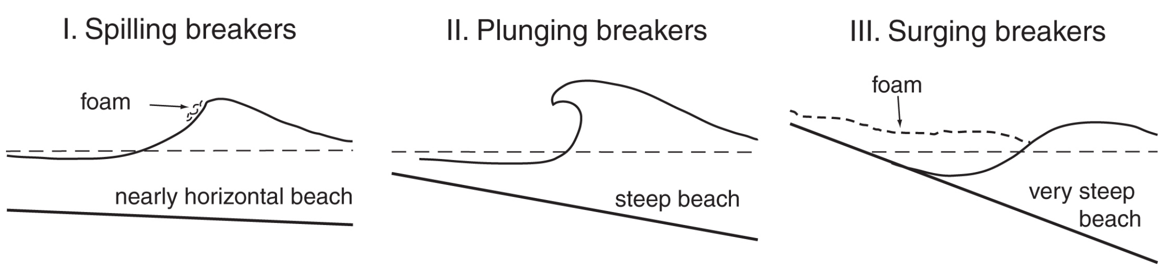
The first layer explored are waves. Waves are a regular occurrence in any coastal region with extremities dependant on a large range of regional factors. Predominantly waves are dependant on weather, specifically wind, patterns with some effect also spurring from tidal conditions. While waves are a normal part of any water system and its flows, the actual magnitude varies as much as the severity of the conditions. In a high wind or stormy condition large breakers can occur, whereas in calm weather they may be as minute as rolling waves or even surface ripples.

With regards to their time cycle waves are relatively short repeating cycles and are much more unpredictable than some of the other layers. Similar to the way their magnitude and frequency are variable, impacted by weather and tidal conditions, so too are their impacts on the coastline. The means by which a wave breaks are directly affected by the depth of water they are entering, and the degree to which their progress is impeded either through large vertical, or steeply sloped elements or natural formations causing large splashing breaks, or a shallow gradual slope which leads to a softer diffusion[1]. This difference in break is due to a need for the energy to diffuse and either creates a powerful release able to cause damage, or a low impact wash up the shoreline.

Figure 3: Types of breaking waves

Source: Paul D. Komar (1998)

Obtained from: http://booksite.elsevier.com/DPO/gallery/ch08/008005_full.jpg



In most cases due to their relatively small scale and regularity the goal with waves is *mitigation*. In many regions large piers and wave breaks are created along the coastline to force the energy release to happen away from boats, harbours, buildings and other coastal infrastructures and activity. This is similarly the position that will be taken in the design work of this thesis, looking to treat waves as something to be controlled and diminished rather than something that forces conditions upon the coastline.

Figure 4: Storm Surge Photograph from Lawrencetown Nova Scotia

Photograph by: Andrew Vaughan, 2018

1.2 | Storm Surge

Storm surge is the next factor in water's vertical shifts in coastal regions. In many ways it can be seen as a similar force to waves in that it is a direct product of coastal weather conditions, storms and wind. Essentially storm surge, are larger scale waves caused by the displacement of large volumes of water by the powerful wind forces of tropical and ocean storms. In this way they operate almost like sustained, powerful waves forcing water inland for a longer period of time before it eventually shifts back to the sea to return to a balance.

Calculating storm surge as a base variable is a difficult and inefficient task due to the large number of factors that must be considered and so in many cases design guides use set values based on past observation and experience to set a baseline for design.[2] While data for this in Canada is again hard to come by, personal accounts by those living in Atlantic Canada echo the design standard of 1.5m to 2m used in other places.[3,4]

The other important factor to consider with storm surge in the context of Climate Change and Sea Level Rise are the effects of shifting ocean conditions on the occurrence and magnitude of these storm events. It has been observed that storm events of higher severity have become more common as our climate experiences changes[5] and it is believed that for each foot of sea level rise the occurrence of these severe storms could increase as much as twenty-five-fold, representing the occurrence of a 100 year storm event – those most associated with storm surges and flooding – as often as every four years.

The handling of these storms and their associated flooding is handled differently in different places and conditions. In many cases a similar mitigation approach as used with waves is used, at a larger scale. This is particularly true in regions at or near sea level where large storm barriers are used to hold out influxes of water in hurricane and other storm events; the benefits and downfalls of these approaches will be discussed in Chapter Two. Alternatively, it is possible, and more in line with contemporary thinking to design in ways that allow survival throughout these events without expending the energy to completely impede the natural flow of water. This second option focusing on *survival* through the event without seeking to combat the flow of water is the approach that will be focused on within the design portion of this thesis.

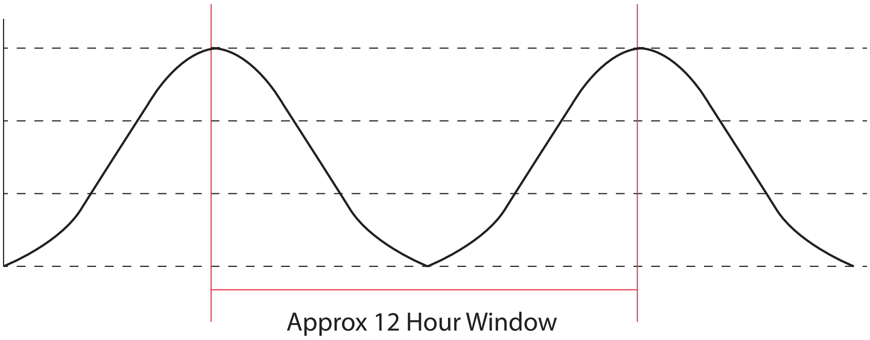
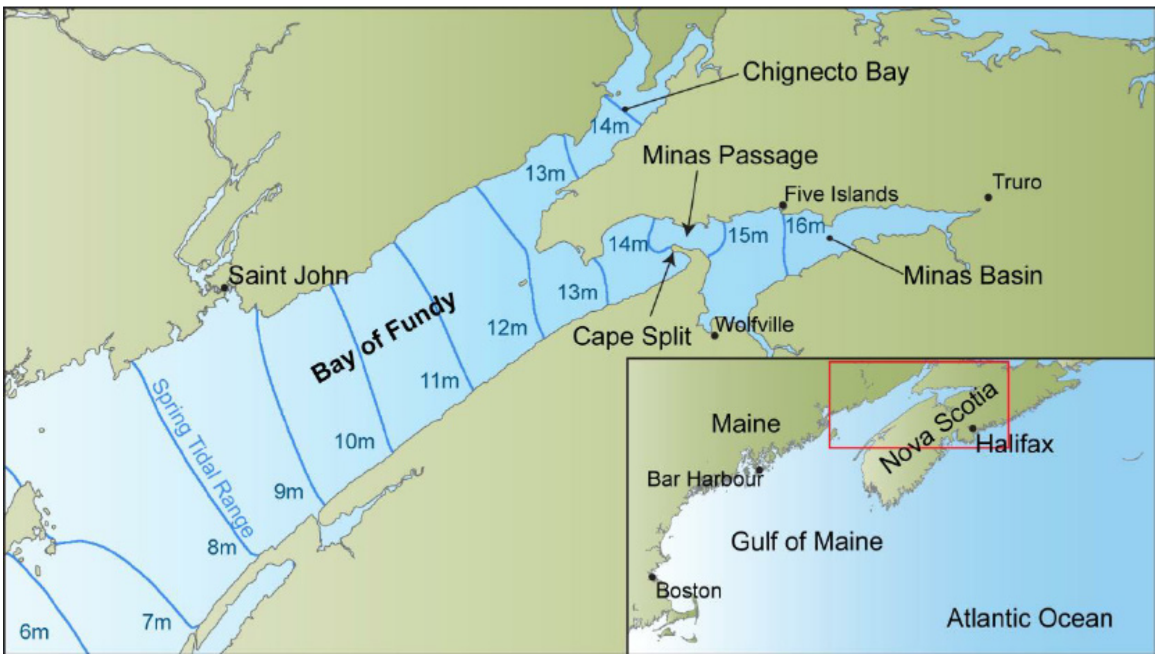


Figure 5: Graphing tidal cycle

24 hour cycle with 12 hour peak to peak highlighted

Figure 6: Map of Bay of Fundy tidal ranges



1.3 | Tides

Tides are a regular occurrence in all large bodies of water – although more drastically so in the Oceans – and their extremities are based on a variety of factors. While the regular occurrence of tides makes them most consistent of the forces described in this chapter, it is the way in which they compound with other factors outlined in this section – as well as the overwhelming force associated with them – that make them so dangerous. In general tides can be understood as an outcome of the Earth's relation to the moon and its gravitational pull on water as a loose component of the planets surface. This displacement occurs approximately twice daily meaning that on a regular basis two full tidal ranges will occur in the day.[6]

The magnitude of tidal pull is based on a number of factors. Foremost is the proximity of the moon to the earth, the differences caused by the planet's orbit and rotation are the primary reason that in one place the tide cycle is not always perfectly replicated, some days staying above the base sea level for a whole tidal cycle while other times dipping slightly below, and not always reaching the highest maximum level. Also factoring into tidal range however is the depth or volume of water affected, and the makeup of the surrounding geographic region in which they are occurring.

In Atlantic Canada for example, the average tidal ranges along the Eastern Coast of Nova Scotia tends to be between 2 and 3m per cycle. The Bay of Fundy however breaks this cycle with the most drastic tidal ranges in the world with the highest tides nearing 18m as seen in the map on the adjacent page.[7] These differences in tidal extreme are due to secondary causes aside from the lunar cycle. Particularly the size of the Bay of Fundy and its funnel like form contribute to extreme highs further in to its narrow portions as the bay becomes both shallower and narrower. This drastic change also means an increase in the force of the tides not only in their magnitude.

The goal with tidal forces is to design for continued *operation* due to the normality and predictability of these forces. Often times, to accommodate this continuous operation coastlines (harbours, ports etc.) are designed at a tide's extremes meaning that its accommodation for the ranges is handled largely through avoidance and designing to its upper limits. For example, a dock in an area that has a tidal range of 6m may be designed to the 7th metre to allow its surface to always remain above the water level. Other ways of accomplishing this will be explored through the design explorations of this research based on the criteria and methodologies developed in Chapters three and four respectively.

1.4 | Sea Level (Rise)

Sea level is the most impactful variable of those contributing to this understood verticality of the oceans as it is the base from which the others operate. In one sense sea level is considered as a static level from which the other contributing factors vary, and as a reference point for elevation of objects on land and water (the mountain peak is x metres above sea level). However to think of it in this way alone is problematic, particularly in our current climate change epoch. An understood and observable symptom of the changing climate, our oceans are rising at varying rates from year to year influenced by a number of factors, particularly thermal expansion and glacial melt.[8] This means that like the other described forces sea level should not be considered as a static value.

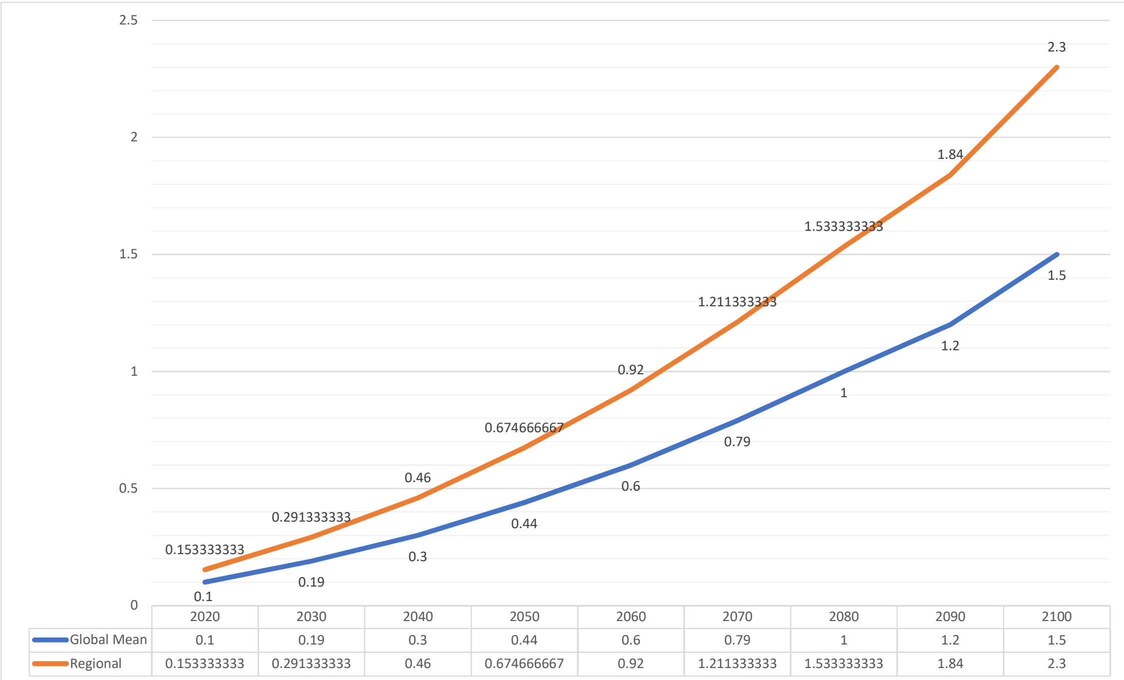
In order to understand how one must design for the changing climate it is important to first develop an understanding or model of what those changes are. Many models currently exist for the measuring and prediction of climate change and these are dependant on a variety of criteria, including CO2 emissions and global mean temperature increase. Within each of these models is usually some built-in understanding of a range of scenarios from a low-impact to high-impact situation. When adopting a model for this thesis it was important to keep a number of critical implications in mind; (1) the *visibility* of the impact, (2) the *appropriateness* of the selection to a range of outside viewers, and (3) current *political* global trends.

The visibility of the impact is important as it can make or break the need to intervene at all. When operating in the short term it can be easy to think of small changes as problems for later when new, possibly more appropriate, technologies and techniques may be more readily available. It is this thinking that makes climate change and sea level rise a largely hidden danger as will be discussed later in Chapter Four of this thesis.

The optics of the selection in contrast are equally as important but can go a few ways in trying to balance the perspective. In his book Energy for Future Presidents, Richard Muller outlines a spectrum for climate change attitudes ranging from Alarmist to Denier that, although skewed to his perspective, does a good job in not only acknowledging the diverse opinions on the matter but also in understanding that each group within the spectrum views each other at some other extreme.[9] For this reason, while the work must use values that make the issue visible as previously mentioned, it must also be aware that at a certain point it may be dismissed for operating at too far an extreme as well.

Finally considered is the grounding of the selected data model in reality. Despite efforts to increase visibility or overcome political classification at extremes, there are still the scientific, and global trends that can be used to identify what is most likely. The previously mentioned classification of low-impact to high-impact (or some variation on this terminology) are typically measured and trended against observable data in attempting to manage consumption and emissions, and through scientific modelling this information is used to create outcome scenarios relating to values of temperature, CO2, sea level rise, etc.

For the purposes of this project a model from 2017 *National Oceanographic and Atmospheric Association* (NOAA) report was selected and is presented in figures 7 and 8 showcasing the regional variations to their *Sea Level Rise* (SLR) values, and an overall graphing of these values to the year 2100 respectively. Selected from this NOAA model was the Intermediate-High scenario which accounts for a 1.5m increase in *Global Mean Sea Level* (GMSL) by the year 2100 and a 2.3m relative rise in Atlantic Canada when the regional variation is considered.[10] The NOAA model was selected due to its numerous improvements over other models which include the analysis of regional variations, a concept that has been under explored in other literature and studies beyond acknowledging their existence.[11] The other Item that this study benefits from is the decade by decade breakdown of their model, making it more useful as a tool for design research allowing an extrapolation over a specific timescale such as would be the case with implementation of an architectural or infrastructural intervention.



	2020	2030	2040	2050	2060	2070	2080	2090	2100
Global Mean	0.1	0.19	0.3	0.44	0.6	0.79	1	1.2	1.5
Regional	0.153333333	0.291333333	0.46	0.674666667	0.92	1.211333333	1.533333333	1.84	2.3

Figure 7: Graphing of SLR effects on GMSL and regionally in Atlantic Canada

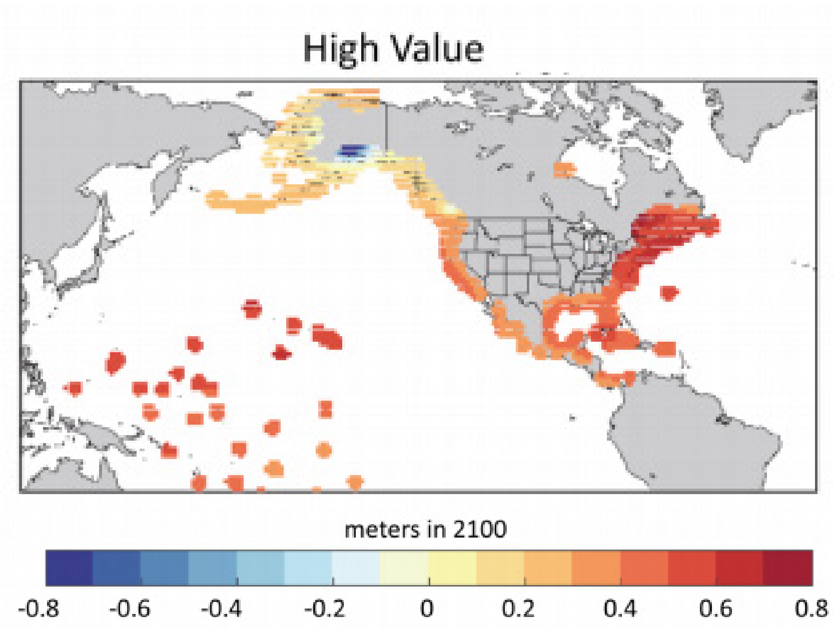


Figure 8: NOAA map showing regional variations in SLR values

Source: National Oceanic and Atmospheric Administration,

Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report, 2017

While the GMSL values are presented as a point of comparison, all work undertaken herein will be based upon the Regional values indicated and by locating this work in Atlantic Canada, as will be discussed in Part Two of this thesis, specifically an SLR of 2.3m is the significant value to remember.

When looking at SLR and considering its shifts to be a new normal and part of a dynamic context, it becomes clear that design response similarly to that of the tides would require a design for continued operation. What becomes the interesting consideration here is how this may be achieved when considering the shifts over a longer time scale and how they effect the seemingly knowable forces of the tides.

1.5 | Thinking of Water Systems

When working in this sphere it is important to challenge normative modes of thinking and observations of dynamic entities. Da Cunha and Mathur outline a suggested methodology for considering the hydrological cycle (a related but not congruent water based system) from non-normative perspectives that privilege different conditions. In their example they ask their reader to consider the hydrological cycle from the starting point of the rain as opposed to the normally planted position of the river[12]. For the purposes of this work – and as has been previously stated – it is important to consider the ocean from all perspectives, not simply as its static entity, but also as the waves, the tides, and the dynamic changes to its baseline, as well as the perspectives of other entities it effects and influences.

(Endnotes)

1 Donald Watson and Michelle Adams*, Design for Flooding: Architecture, landscape and urban design for resilience to climate change(*Hoboken: John Wiley and Sons, 2010) 155

2 Department of Transport and Main Roads*. 2014. Storm Tide - Issues for Design of Road Infrastructure in Coastal Areas. Technical Report,* Queensland: State of Queensland.

3 *Ibid*

4 Mauro, Dr. Ian *2015. Climate Change in Atlantic Canada. Directed by Dr. Ian Mauro.*

5 Sebastian Weissenberger and Omer Chouinard*, Adaptation to Climate Change and Sea Level Rise: The Case Study of Coastal Communities in New Brunswick, Canada (New York: Springer, 2015) 15*

6 Tides4Fishing. 2017. *"Tides" Tides4Fishing.com/*Tides

7 Tides4Fishing. 2017. *"Tides and Solunar Charts." Tides4Fishing.com.*

8 Weissenberger and Chouinard*, Adaptation, 7-8*

9 Richard Muller, *Energy for Future Presidents (New York: WW Norton, 2013)*

10 National Oceanic and Atmospheric Administration*. 2017. Global and Regional Sea Level Rise Scenarios for the United States. NOAA Technical Report, Silver Spring Maryland: NOAA.*

11 *Ibid*

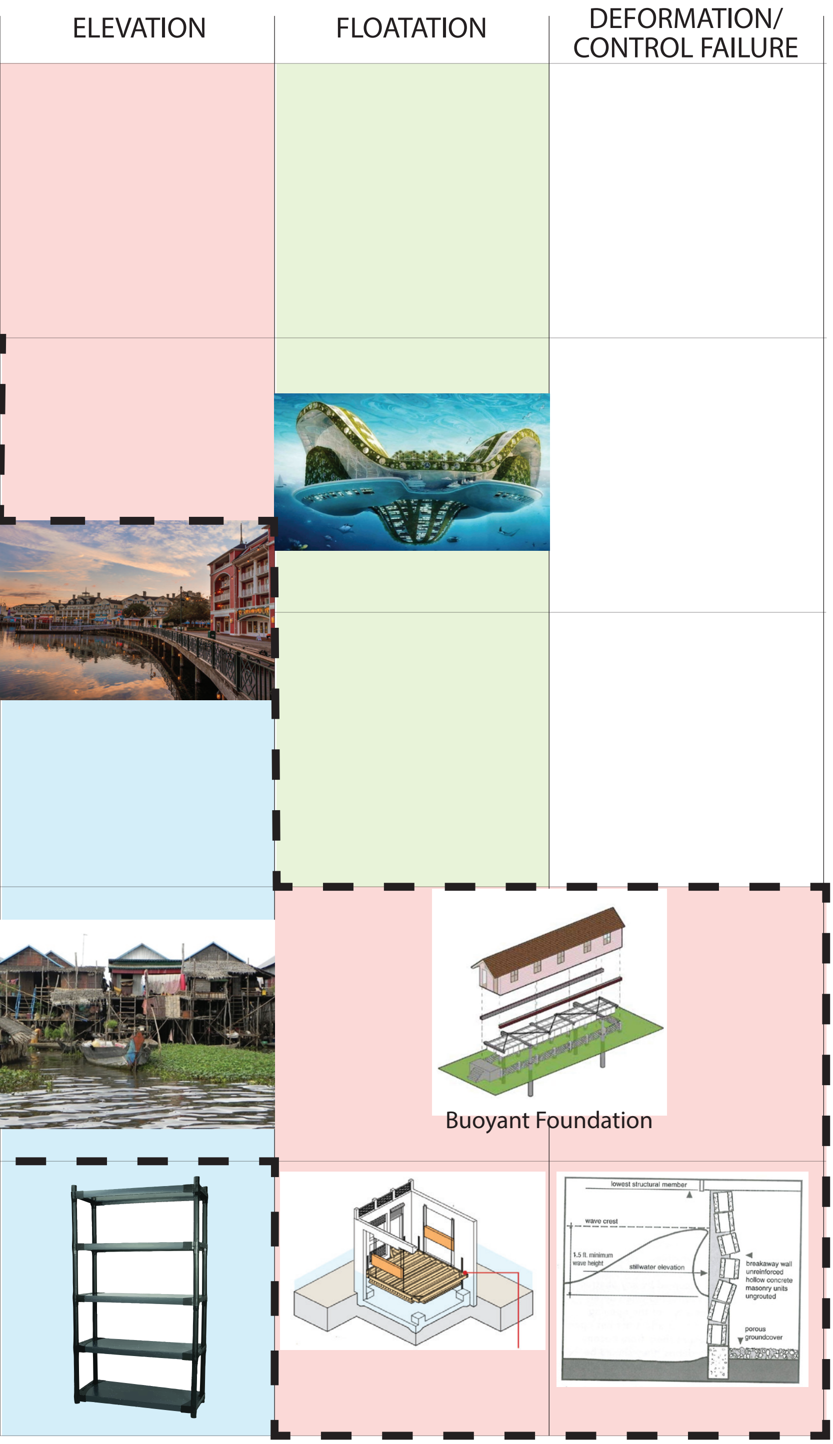
12 Anuradha Mathur and Dilip da Cunha*, Designing the Coast in the Moment of Rain, in Infrastructure Space (Berlin: Ruby Press, 2017) 346*

Chapter 02 – Current/Traditional Human Responses

In designing to respond to the forces and coastal pressures identified in the previous chapter there is a large body of existing work to reference. In many cases cities, and even nations rely on various infrastructural and planning principles to control and divert water to allow their existence. New Orleans and large swathes of land in the Netherlands for example are actually located below sea level meaning complex – and sometimes brutal – systems of defence to either divert and control waters flow or impede it all together are in place to protect these environments.

Figure 9 shows a sort of precedent matrix of a series of tactics for coastal defense or other forms of controlling and accommodating water. The matrix is organized by strategy or intent along the horizontal axis, and by scale along the vertical axis working from entire large areas to individual tectonic components. Within the matrix there are a number of other layers of information. Firstly, the tactics are colour coded to refer to a few things: Blue highlights more traditional strategies and modes of thinking, Red are strategies that are part of an evolving body of thought on these issues and finally, Green represent proposals which are part of a futuristic or utopian dialogue on the topic. Finally, the outlined region highlights specific tactics that at an early stage presented ideas that may align with this thesis' thinking.

Figure 9: Matrix of Current Tactics



From those tactics outlined in the matrix a few particular examples have been selected for a more in-depth analysis as their successes and failures help in begin to inform the evaluation criteria outlined in the following chapter. The modes of responses explored in more depth are: (1) Reactive Responses, (2) Utopian and futuristic proposals, and (3) Planned Management Strategies with (a) Elevation of homes and buildings, and (b) Control and Resistive infrastructures. Within each of these areas, specific examples (or in the case of some specific projects) have been selected and details of the mode of response will be explored including ways that these can contribute to thinking about coastal design.

2.1 | Reactive Response

As major storm events increase in frequency and magnitude the reactive modes of responding (such as planned procedures by the US Army Corps of Engineers) are becoming less commonly understood as acceptable while more commonly needed due to the overwhelming of existing infrastructure, yet even the most current and advanced methods are less efficient and effective. For this reason these strategies, while a part of the background in this field, offer little in terms of adapting new strategies.

The major critique would of course be that often times these strategies can be described as too little too late. While the sand bag method of water diversion may work in small instances of flooding within a couple of feet, it cannot suffice for the increased magnitude, and frequency of events that may be possible through climate change.

These modes of operating do however offer something to the thinking of these problems and that is the accommodation of uncertainty. Despite the outdated nature of some of these responses they continue to be used not in place of other systems but rather because these other systems have upset limits that may lead to failures after which 'any means necessary' are required to control flooding and water.

2.2 | Utopian Proposals

In contrast to the normative responses currently employed for flood and disaster relief, there have been some proposals from architects, and students of architecture which look to more dramatically shift the way we think about flooded communities, architecture at sea, and climate displacement. These projects or proposals often operate at the opposite extreme of the reactive responses planning out completely new communities, buildings etc., centred around the idea of how the change or move with the impending forces of ocean storms and rising sea levels.

Two of these projects are explored here and are critiqued for both their positive ideas, which may contribute to future design exercises, as well as for their shortcomings. It is important to note that in many cases the shortcomings appear to be due to a limited perspective from which the project is developed. This perspective may be the result of a focus on certain goals, or it may be due to the complexity associated with the issues which inevitably lead to ideas lost in the process.

The Lilypad Project

The Lilypad Project by Vincent Callebault is one of a series of utopian projects produced by the architect. Callebault's firm works primarily in the mode of 'paper architecture', operating at the extremes of specific ideas (often times environmental) to propose radically different ways of thinking about issues. The Lilypad was selected for review however due to its specifically stated goal of creating a "floating ecopolis for climate refugees".[1] In a very general sense the project is a floating city or state apparently inspired by the structural make-up of the lilypad, and meant to house displaced peoples and migrate in a continuous fashion around the world.[2]

Figure 10: Vincent Callebaut Architect's Lilypad Project for climate refugees

In many ways this project would seem to respond perfectly to the problems identified in the standardised solutions to disaster. The floating nature of it means that it can step in to replace island nations for whom the other solutions aren't viable, and it is by no means a rigid proposal as his world map outlining its proposed path of travel indicates. It is through these two avenues however that the proposal falls short.

What Callebaut does well, and this is evident throughout the full series of projects presented on his webpage, is present his work in a way that is technical enough to pass as possible or probable. Profusely rendered Callebaut provides a level of detail that goes as far as presenting spatial properties in floorplans and even outlining areas for outdoor gardens and greenspace. What it suffers from however is a utopian ideal sometimes necessary in examining the future, but not when producing real proposals for a current intervention. What the Lilypad project neglects to acknowledge in its design is the prescriptive ways of living it entails, in fact it does little to showcase the human side of the project at all; where people live, eat, work etc., are all absent elements in the drawings Callebaut puts forward. The environment that it creates as seen through the imagery presented, along with its constant motion gives the feel of a futuristic cruise ship, in other words an environment that may not even be desirable for long periods for those accustomed to Western living.

Ultimately the goal of Callebaut's work is to successfully create a striking image that may lead to discussion and further proposals for what climate displaced architecture may look like. What he does not in this proposal achieve however is the successful creation of an environment for people to inhabit as a sustainable model of society.

Cellular Growth

In 2009 the Rising Tides competition was held to create a body of work considering some of the very same issues explored in this thesis; Cellular Growth was one of many responses to this design competition.[3] Using clearly Metabolist ideas it works to create an architecture that can grow and adapt as the environment in which it is constructed changes. Its proposal however lacks any sort of intrigue as it presents as a dull series of cube forms that communicate some semblance of a building but certainly not of a larger response to systems, communities, cities, and regions as it purports.

The idea of metabolist growth, and potential for change embedded in design is certainly an intriguing response to problems of Sea Level Rise that may benefit future proposals, but it is important that they not sacrifice a humanistic element in doing so. Unfortunately for this proposal there was little consideration of the relation to other existing systems of buildings and infrastructure nor the operation of such a construction aside from a general framework for operation.

Similarly to the Lilypad Project this proposal seemingly presents the spark of an interesting new way to consider design but unfortunately due to limited scope and focus falls short in presenting a cohesive strategy. Its biggest benefit to the discussion is, once again, the discussion it is able to generate about changing how we think about building in coastal regions in times of change.

2.3 | Planned Management

Aside from the reactive and the futuristic proposals for design there are of course the normative ways of operating in many coastal regions threatened by flooding from tides, storms or SLR. Writing for Harvard Design Magazine on the topic of designing for sea level rise Krisitina Hill and Jonathan Barnett outlined what they believe to be the three options for designing in coastal regions threatened by sea level rise and other flood events: (1) relocation, (2) elevated development, and (3) management and resistive systems.[4]

The first of these design options is acknowledged by the authors as impractical for development of any significant scale as it essentially calls for the *relocation* of settlement away from coasts and shores. As a strategy this type of movement is only a viable option when considering individual homes or areas where a specific relation to their coastal environment is not required, and is also potentially prohibitively expensive as it calls for the abandonment of the existing to build from scratch.[5] The other two strategies they outline are however widely adopted means of operating in practice and form an excellent point to understand and critique what may work and not work in a number of ways.

Figure 11: Elevated homes in (a) Florida and (b) Cambodia

Elevation of Homes and Development

Hill and Barnett identify elevated development as their second mode of response.[6] Houses on stilts have long been a strategy for building in areas prone to flooding and this trend continues today. In the United States there are guidelines developed specifically for the development of elevated houses in flood prone regions.[7] These guidelines, an almost secondary building code, prescribe the modes of construction acting as both a method of safety as well as a requirement for home insurance in some areas. Stilt homes are built on foundations that extend up above the potential flood, often times storm surge, line with the home itself out of reach of the flooding while the space below is utilised as storage or parking similar to a garage or basement. Sometimes this underneath region is left open as a column structure while in other scenarios panelized walls that are designed to buckle under the forces of water.

These strategies extend beyond the United States however as regions like Thailand and Cambodia include these stilt homes as part of a vernacular, regional architecture in response to flood plains that regularly flood in monsoon and wet seasons. In most cases this strategy operates at the individual building scale, though in some regions large piers form a part of the public realm allowing multiple buildings to share a connection.

As a strategy for organizing and designing in coastal regions the concept of playing with elevation and allowable separations is valuable. The major issue presented by this approach however is its highly individualized nature. The separation created may work on an individual home basis but unless it is scaled up in other contexts it begins to lead to a break down of infrastructural and systems connections for activity in the coastal region.

Buoyant Foundation Project and the Amphibious House

The Amphibious House and other proposals and trial projects by the Buoyant Foundation Project team begin to create an interesting development on elevated home concept. The Buoyant Foundation Project team was formed in response to the Hurricane Katrina flooding of New Orleans and has a mandate very similar to that of this thesis.[8] Essentially the team explores methods of resilience in architecture with a goal of being able to preserve traditional cultures and modes of settlement. Their most widely published and disseminated work is their Amphibious House, a project which looks to retrofit existing and new housing stock with a foundation system that, in flood scenarios, may detach and allow the home to float freely.

In many senses this project can be viewed as an improved version of the elevated strategy outlined in the previous section. As with that scenario the home (or other building) finds itself raised above the flood water, however in this case it is dynamic, elevating only to the level needed and resting at a regular elevation otherwise.[9] While this project appears to succeed in response at this micro level, it is in turn too small scale and short term of a solution. The primary issue is its isolation from other infrastructure and networks during high water periods creating what has been referred to as an 'island of resilient architecture;'.[10] This may lead to a protection of the physical construct however, when a major event occurs each building is separated from its larger network, a phenomenon which often times leads to the greatest sense of panic during disaster. This does however present an interesting condition when designed as part of a more regular short cycle of change such as that of tides, and at the smaller scale of individual components or buildings.

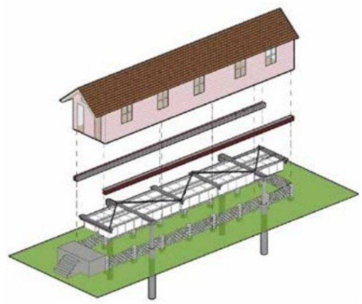


Figure 12: Buoyant Foundation Project's, Amphibious House

Management and Resistive Systems

In many cases planners and engineers have opted to use the third strategy proposed by Hill and Barnett to deal with issues of coastal flooding. These systems include; flood walls, pumps, and naturalized regions to manage, control, or divert flood and storm surges away from developed areas.[11] These systems can be further broken down into the natural, the built, and hybrid systems.[12]

Natural

The natural systems described in this case are similar to the strategies of moving away from the region however by using naturalized systems including beaches, sand bars, and mangroves to dampen the impact and divert the impact of storm surge and flooding events. Often times these strategies use the dross or empty dead space between inland and ocean conditions to create recreational or naturalized zones that allow flooding to prevent the water from being forced to hardscaped areas where it will pool, creating greater long-term flooding effects. Despite being described as natural in many cases these may also be constructed, either to supplement something that previously existed or to create new systems of mitigation.

These tactics are actually quite effective and progressive in their thinking about coastal design and flooding. The major issue however is they can not be deployed in all scenarios, particularly where there is a lack of space to deploy the interventions. These solutions like many of those presented within this planned management section operate best or most effectively at a large scale limiting their application in certain communities and settings.

Built

As the name may suggest the built systems contrast the naturalization as they are major infrastructural projects that in many cases are required for the ongoing survival of below, at, or near sea level communities. Built forms such as sea walls, flood gates, dams and other structures whose primary purpose is the blockage, control or diversion of water. Large parts of the Netherlands are only dry due to its extensive system of dikes which protect the nation's land, a majority of which is within one metre of sea level. Similarly, London is protected from storm surge only by the surge barriers located at the mouth of the Thames Estuary.

Figure 13: Large scale resistive infrastructure

In most cases these walls operate to either completely block water from accessing certain areas, or control the flow through a flood gate. These solutions are very effective in the contexts where they are currently deployed but there are a number of significant downfalls to them which bring their effectiveness into question. Firstly, they often times, specifically in the purely resistive scenarios, present a binary in that they are either functioning or they are not. While this tends to not be an issue it sometimes exacerbates the problem where a failure in its resistance allows water to flow into a region but then prevents its easy return to a base condition. Such was the case with Hurricane Katrina; the walls protecting the city failed, allowing water to create extreme flooding in its below sea level communities, and yet this same infrastructure caused delays in the ability to 'drain' the region, so to speak, in the days following.

Secondly, these resistive systems are prohibitively expensive pieces of infrastructure and require large investment of time and resources to build and maintain, something that may be possible in large economically diverse cities and regions but not in other smaller communities. While this issue is partially rendered moot by the move towards urbanization Chapters Five and Seven of this thesis goes in to more depth on the importance of some of these smaller communities.

Hybridized

Finally, the hybridized systems discussed look to use some of the means of both natural and built systems to dampen the blow passively while supporting in case one system or the other fails. Often times flood walls will be located around beaches that also use sand-bars or naturalized environments to diffuse storms, and flooding. The success as well as the failures of the previous two sets of tactics described largely covers these hybridized systems as well, though they do begin to present how a layered approach can create a more resilient and diverse coastal condition.

2.4 | Critiques

While each section of this chapter included specific critiques for the strategies or modes of operation being discussed, this section will attempt to consolidate those critiques into overall impressions that will help to define the operating criteria for the rest of this thesis.

The elevating of homes presents an interesting scenario for disasters particularly related to flooding and water related disaster. In one sense it is a very rigid system planned to work to a certain level and no more or less. What is most interesting about these elevated structures however, particularly in Florida is how they begin to move into a territory of considering how to succumb to some force to prevent more widespread damage. In many cases people look to use the area beneath the piles as a storage or garage area, which makes sense when considering the space sacrificed. However, by enclosing these areas with walls to create almost an above ground basement there is greater risk that the force of water and wind would tear down the whole structure. In response, the standards have developed what does begin to show signs of a more developed way of considering these problems. Strategies of either flood prevention venting, or breakaway walls begin to show an understanding of where a line can be drawn between resisting and succumbing to the forces at play.[13] Even still however the implementation on a home by home basis means that while the homes may physically survive they will be uninhabitable for either the short or long term due to their isolation from the rest of their infrastructural network, as well as each other; this is not inherently an issue but can only be effective when the function and the conditions of that specific building of component are considered in conjunction with the networks and buildings around them.

While the planning of the larger infrastructural systems begins to show a level of foresight not present in the reactionary strategies these systems begin to present their own problems for implementation. Primarily they are very rigid, very large and very expensive. The investment in such a strategy may be worthwhile when it protects from an expected event, but as we move towards a time of more uncertainty the scale to which they may need to operate is a variable. Similarly, they don't provide any contingency for failed operation, sometimes exacerbating the problems as was the case with the failed flood gates in New Orleans during Hurricane Katrina.[14] This short-sightedness is also the case with the stilt homes yet is something that is covered within the amphibious houses and surprisingly the reactive responses, and that is a degree of flexibility that allows layering and shifting modes of response.

In addition, the ability to deploy these larger scale solutions is limited heavily to the large coastal mainland regions of large continental bodies (mainly cities and urban regions) and this is not something that anyone denies as important, but it is to an extent problematic. While these large areas may see benefit from these systems despite their weaknesses the translation of these strategies to small island regions can be quite problematic. When constructing sea walls for example in an island region (particularly those with low average elevations) an isolation from the ocean, often an important part of local culture, occurs. In small atolls the naturalization may require the entirety of the land space available and often the natural systems referred to in the coastal strategies are not applicable in these environments. Similarly, small coastal fishing villages and other hamlets cannot justify the scale or cost of intervention that these methods require yet they too require some form of coastal protection.

Finally, it seems that the solutions put forth operate at two main scales. At one end of the spectrum, larger systems focus on protecting urban coastal regions, and larger areas where defensive infrastructures such as storm walls, and coastal rehabilitation projects may be both necessary, but also economically justified. At the other end however are solutions focused on the individual buildings in a way that still leaves the rest of the community or region unprotected, and neglects to consider the way in which multiple elements within the variety of systems affected are connected. To become more effective, coastal design and planning needs to begin to consider various scales and modes of operation within a single cohesive proposal. This is an idea that is beginning to come forward in more recent proposals but even here seems focused on larger regional planning without going in depth into the more specific spatial and tectonic qualities.

These critiques are not meant to say that any of the examined tactics is inherently wrong. In many cases these tactics have developed over long periods of time and various iterations to where they are most effective at achieving their intended goals. The critiques, in as much as they are to inform the evaluation criteria for future proposals presented in the next chapter, are trying to point out holes in the scope and comprehensiveness of these tactics to allow a more holistic way of thinking in this thesis' design explorations.

(Endnotes)

1 Vincent Callebaut Architectures. 2008. *Projects: Lilypad.* Accessed December, 2016. http://vincent.callebaut.org/object/080523_lilypad/lilypad/projects/user.

2 Ibid

3 Donald Watson and Michelle Adams, *Design for Flooding: Architecture, landscape and urban design for resilience to climate change* (Hoboken: John Wiley and Sons, 2010)

4 Hill, Kristina, and Jonathan Barnett. 2007. "*Design for Rising Sea Levels*." Harvard Design Magazine F/W (27).

5 Watson and Adams, *Design for Flooding*

6 Hill and Barnett, *Rising Sea Levels*

7 Watson and Adams, Design for Flooding

8 Buoyant Foundation Project. n.d. The Buoyant Foundation Project. Accessed September, 2017. http://buoyantfoundation.org/.

9 Elizabeth English, *Amphibious Architecture: Float when it floods* (Buoyant Foundation Project, 2010)

10 Michelle Laboy and David Fannon, "*Resilience Theory and Praxis: a Critical Framework for Architecture," Enquiry 13* (1) (2016): 39-52

11 Hill and Barnett, *Rising Sea Levels*

12 Arian Sutton-Grier, Kateryna Wowk and Holly Bamford, *Future of our coasts: the potential for natural and hybrid infrastructure to enhance the resilience of our coastal communities, economies and ecosystems* (Environmental Science and Policy, 51) 137-148

13 Watson and Adams, *Design for Flooding*

14 Hill and Barnett, *Rising Sea Levels*

Chapter 03 – Evaluation Criteria

Based upon the critiques in Chapter Two, a framework of objectives for future design strategies and proposals can be developed. While this thesis is architectural in focus it is important to note that many of the strategies explored in the previous section engage with an infrastructural discourse. Thus, it is important at this stage to determine these criteria for evaluation not only to allow a direction for any design research proposals but also to determine what it means to operate in the overlapping spatial realms of architecture and infrastructure; a "copulation" that Francois Charbonnet notes is both necessary, while possibly difficult and even problematic as we move into thinking about infrastructural space.[1]

When speaking about architecture and its relation to infrastructure, Jesse Lecavalier states in a similar manner that he believes that there is an incongruency to their collusion and instead suggests the operative realm of "infratecture" as a basis to engage seemingly systems-based infrastructural problems, with an architectural spatial attitude.[2] As part of this proposal he outlined the following categories of concern for this new discipline.[3]

A) Rules
B) Scenarios
C) Resilience
D) Urban
E) Architectural Intelligence
F) Squishy Potential
G) Regionalism
H) Standards
I) Bundling
J) System Building/Service Supply
K) Representation

From the critiques presented in the last chapter as well as Lecavalier's evaluation I have simplified to 4 main criteria; in some cases combining similar elements of his proposal while in others treating them as means more than ends. Each of these criteria are expanded further in this chapter and figure 14 diagrams the connections to, and differences from Lecavalier's proposal. Firstly, as a statement of assumption rather than a specific criteria, the proposal must not be reactionary, simply responding to current or past events, but must rather have the foresight to consider what will be. Design proposals must allow a flexibility, yet also provide a structure allowing for adaptation to both expected and unforeseeable changes in the future. This work must be focused on both the micro and macro scales, allowing the integrity of individual components as well as the larger systems. Design proposals should reflect not only a technical understanding of the requirements for disaster response, but also an understanding of humanistic principles of culture, and place understanding that while some disaster effects may be temporary, such as a storm surge, others, like sea level rise, may lead to permanent changes. Finally these design proposals must be comprehensive by thinking in a systems manner so as to keep systems intact through changes across a variety of time scales.

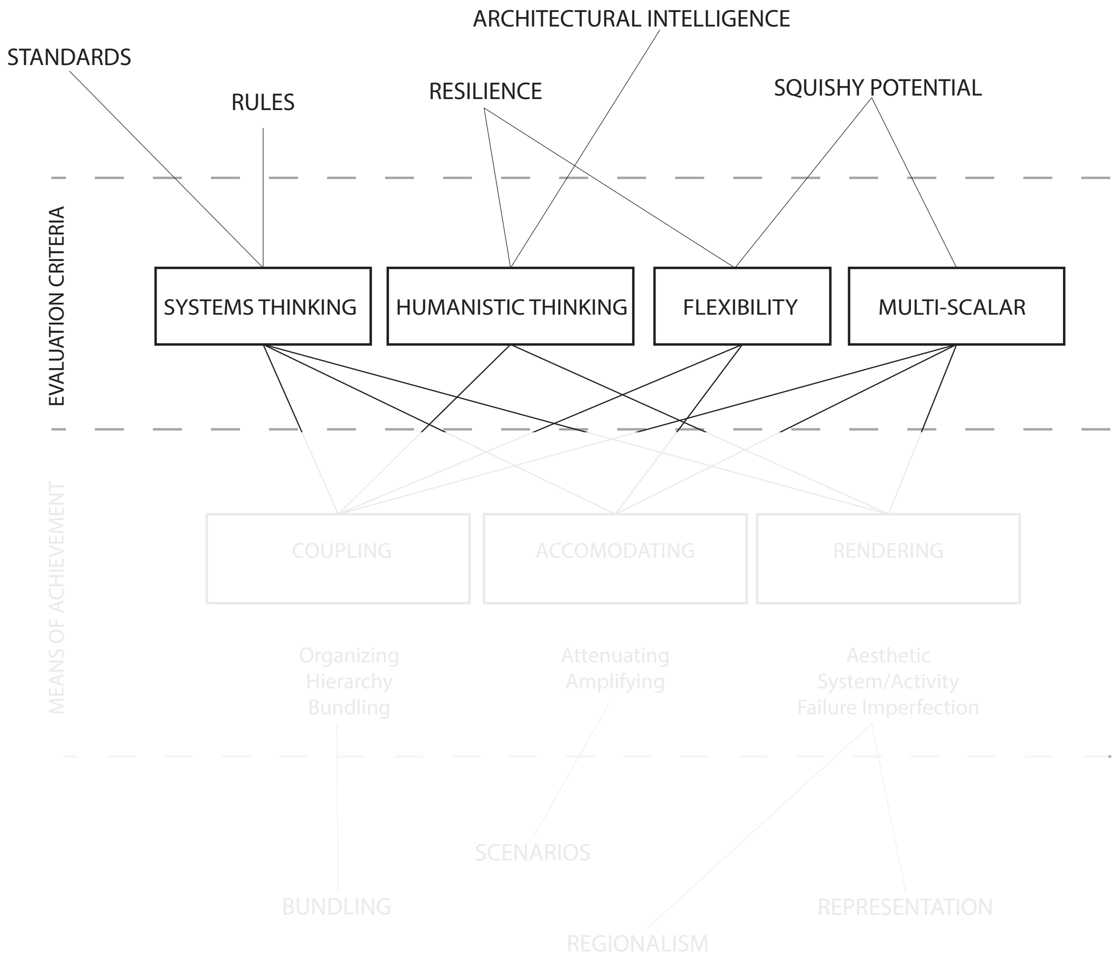


Figure 14: Theoretical structure focusing on Evaluation Criteria

3.1 | Systems Thinking

To achieve the complexities of such an objective as designing in response to climate change requires an understanding of how those intricacies can be understood in relation and contrast to one another. To achieve this the adoption of a systems approach is required. It is important to start by understanding and accepting the assertion that in some way everything is a system or part-there-of and thus systems thinking is a part of many diverse spheres of research and operation from government and regulatory structures to engineering and electronics.[4] For the sake of this thesis however it is important to understand that this means when we think of the activity of a harbour or other coastal condition relative to the dynamic systems of the ocean what is really being undertaken is a relation of two, or more, systems. To allow these systems to cooperate requires an understanding of variety and regulation (a topic covered in Chapter Four).

As was previously mentioned, this thesis will have to consider the relationships of architecture and infrastructure, a discipline that is actively part of a systems thinking culture. The major issue here is in determining what is meant by infrastructure as it could mean anything from the hidden and underlying structures to the organizational and distributed networks and roadways, as well as physical form to implied or ordering principles.[5,6] In many cases infrastructure is considered in terms of its physical manifestations; it is easy to name pieces of infrastructure such as a bridge, a telecommunications tower, a sewer, etc. These physical

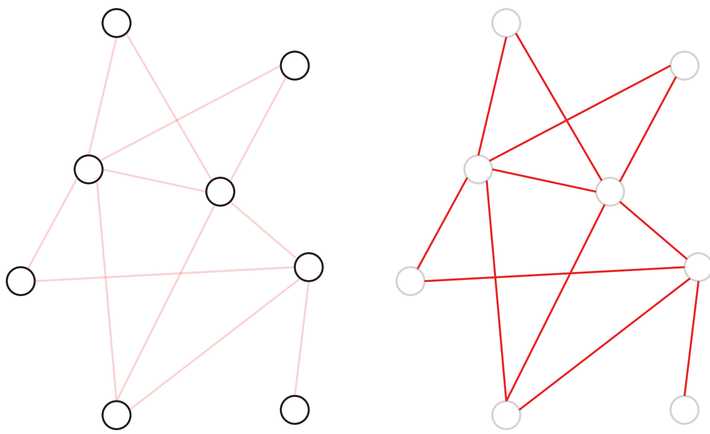


Figure 15: Systems thinking diagram showing a focus on the nodes and their relations as well as the connections equally

manifestations are important as they help shape our comprehension of space however, these are only one side of the coin. These pieces of infrastructure are what Keller Easterling would refer to as object-form as opposed to active form, the organizing and thinking around which object-forms are created. [7]

The idea of active-form is directly related to the concept of infrastructural space, and the idea that this infrastructural space is not the space defined by those specific artifacts of infrastructure previously described, but rather the space between other spaces creating relations and links between them.[8] Where this relates back to the systems thinking required for operating in this area of research is operating beyond just the system of the water and analyzing the activity flows inland that are affected by the changing context. These flows are linear engagements with a number of systems (economic, ecologic, recreational etc.) and are where design and planning begin to overlap with the systems discipline.

Systems Terminology

As is the case with all of these criteria It is important to outline crucial vocabulary that will aid in the discussion of design decisions later within the thesis. The first of these sets of terms are the idea of *inputs* and *outputs*. To create a better understanding it is important to begin, once again, with the idea that everything is a system. This means that as an individual, a product, or an entity flows from one system to another it is considered as an *output* or an *input* depending on which system perspective is being considered. For example an item leaving a processing system and entering into a commercial distribution system would be considered an output of the processing system while simultaneously being an input to the distribution. While these terms may seem to be a generalization and irrelevant to the discussion of systems thinking in design they become important when beginning to consider *flows* as defined in the Humanistic Thinking portion of this chapter.

Also important is the idea of components or events within a system. As was previously mentioned everything can be considered a system or part there-of, however subsystems within larger systems may present as more finite and momentary. Especially within an architectural discourse it is important to be able to actively describe these moments be they programmatic events, or buildings and other constructed entities. For this reason, the terminology of *components* – to describe physical moments – and *events* – to describe programmatic or active moments – are used within this thesis. When describing design elements within the thesis project components are the physical manifestations of a specific activity or parameter of the system.

3.2 | Humanistic Quality of Place

Largely informed by the oversight of the human condition through cultural, economic and other modes of thinking within the previously explored tactics, humanistic thinking is a response to the non-specific, and one dimensional thinking often undertaken when considering coastal defence or design for flooding. In the utopian proposals of Vincent Callebaut for example, the largest problem of the proposal is its separation of people from existing ideas of culture, and identity with home; instead placing them in a bland environment that seems much like a large cruise ship. Even in larger infrastructural responses this issue must be considered with regards to the inhabitability and overall effect of large, often purely utilitarian, pieces of infrastructure. These approaches all seem to prioritize a monumental and object centred idea of design

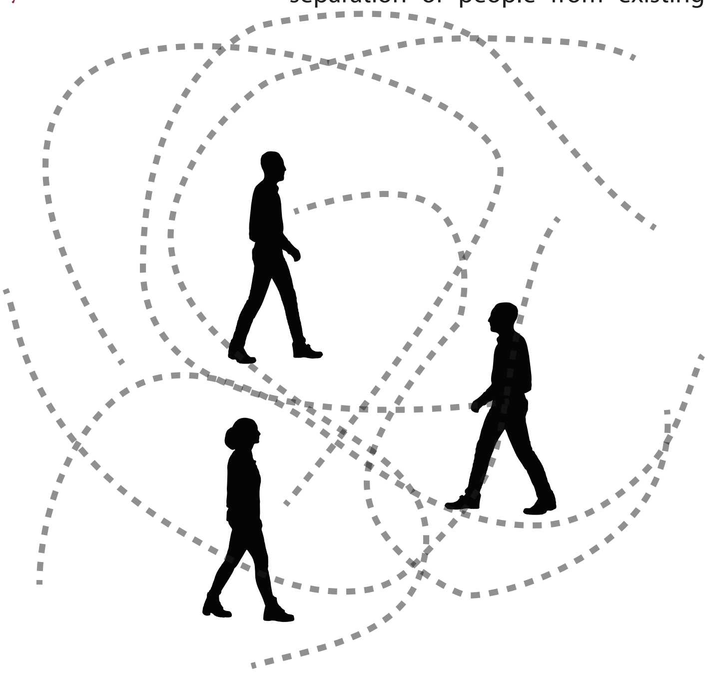


Figure 16: Humanistic thinking diagram showing a focus on people at the centre of systems and flows

In many ways the humanistic examination of site is directly aligned with the systems thinking approach. Where many solutions to deal with climate change and SLR seem to be object based this may be due to the fact that they are focused so highly on the natural systems at play and impeding or controlling them. A humanist approach allows the work to be more concerned with how the human activity occurs in the face of these changes and forces. In an interview with Charbonnet he identifies that the creation of infrastructural space and the kind of systems thinking it entails, allows for the weaving of man made with natural.[9] In many cases this possibility is treated as subservient or overlooked completely.

The thinking here also has relation to a number of other diverse backgrounds including humanistic geography as employed by Yi-Fu Tuan but is in its essence rooted in a continuing re-evaluation of all human activity and its relation to a changing spatial condition. In Space and Place the Power of Experience, Tuan discusses architectural space as being a primary mode of human comprehension of space in general.[10] This is an important consideration because it is through this thinking that the cultured systems of economy, and social activity formulate our spatial relation to an ever-changing coastal condition. It is then also possible to consider that if we begin thinking about infrastructural space in an architectural manner, it too can have an effect on this experience.

Flows

The previous criteria discussed in this chapter was that of systems thinking. Within that discourse the concept of inputs and outputs was described as a way to describe entities moving from system to system. The course or path these entities take through and even across systems will be further described in this thesis as flows. This becomes an especially important concept as the design is considered through the lens of human experience and the ways by which people – or groups – each with distinct identity flow through the intervention and experience the space.

3.3 | Flexible and Adaptable

In many proposals relating to the discussion of building for sea level rise and climate change, resilience is thrown around as a buzz word. In some cases this is used inappropriately to speak more to ideals of resistance, while in others it is meant as the ability to regenerate after disaster. In this thesis resilience is more active than that. Design interventions must be flexible and adaptable, not only to survive, built also grow and modify based on new conditions and understandings of disaster and change that develop over time.

When considering this flexibility alongside a systems thinking approach, then Ashby's Law of Requisite Variety becomes an important part of the discussion[11]. Essentially defined by the need to match variety and variability in systems in order for them to co-operate. Ashby's law and more specific notions from it will be explored in Chapter Four as a means of operation to achieve this accommodation.

Modes of Flexibility (Rigid to Soft, Fixed to Free)

Within the discussion of flexibility, it is important to note the different ways in which this can be achieved. While the term flexibility refers to a dynamic nature of existence – essentially the ability to accommodate for changes and shifts – it operates differently and should be treated differently at different scales and over different timelines. To respect the differences in large-scale, long term shifts and short-term fluctuations specific terminology will be used throughout the rest of this thesis.

In the short term the ability to fluctuate and absorb or diminish small variances is referred to using the scale of *rigid* to *soft*. A *rigid* object is one that does not buckle under short term forces and largely refers to most standard construction methodologies. A *soft* intervention on the other hand has an embedded ability to fluctuate and move temporarily with short term forces such as waves or tides. If we consider this in relation to the explored tactics, then the most appropriately defined as *soft* would be the Amphibious House which floats when required but returns to a controlled base point.

This is in contrast to the longer-term consideration of *fixed* to *free*. Operating in a *fixed* manner refers largely to an inability to accommodate change or translation over a longer period of time, whereas a *free* mode of operation would allow for drastic shifts such as moving inland or further along a river as conditions change in the long-term. If you consider these terms to their extremes a *fixed* coastal defence would include dams, dykes, fjords, etc., while a *free* response would be more in line with Callebaut's floating ecopolis.

These varying degrees of flexibility are represented in the matrix in figure 17. Mapped onto this matrix are some of the tactics explored in Chapter Two to help contextualise the types of shift and adaptation being referenced.

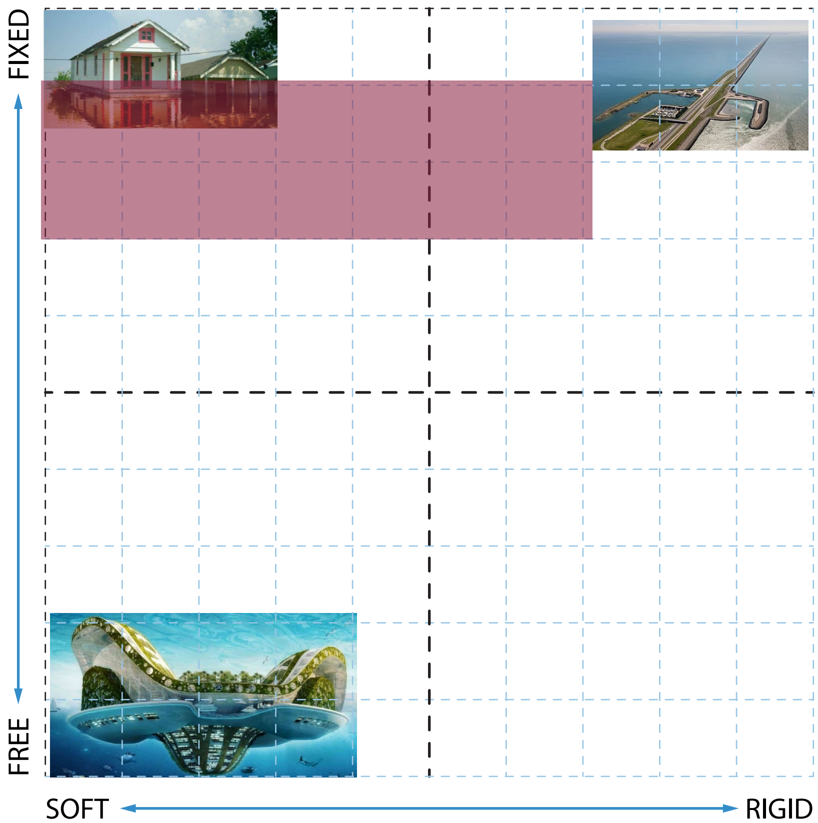


Figure 17: Modes of flexibility matrix with design strategies

3.4 | Macro to Micro

Finally, to allow all of this to be possible it needs to work across the spectrum of scale. The outcomes of the research in Chapter Two noted a focus on either the small scale of the individual building as well as the large scale of urban centres or larger regions. The problem is this emphasis does not only exist in practice. This restricted way of thinking also perpetuates itself into the theoretical, ideologies on the topic. Henk Ovink in his essay "The Transformative Capacity of Resilience: Learning from Rebuild by Design" begins by states the following.

"these risks demonstrate a clear and strong interdependency on the regional and metropolitan scale. While this larger scale may multiply these risks' complexity and impact, this is also the scale at which we humans can best adapt to and mitigate these risks. This is the scale at which we can – and must – act."[12]

The problems with this regional approach are two-fold. Firstly, it prioritizes urban and metropolitan regions an ideology that, while in line with most global trends, does not translate to all regions particularly in coastally dependent scenarios (an idea that will be further explored in Part Two of this thesis). Secondly however, despite is references to complexity it seems to again be a return to one dimensional in thinking on these issues, this time in terms of scale. While Ovink's essay does go on to in passing mention the multi-scalar approaches within the Rebuild by Design proposals, its demonstrated belief seems to be that success for a coastal intervention comes from the top.[13] It is this thesis' position however that the other objectives and rules explored in this document must be equally explored from the system to the node, to the coupling and to the individual components. These terms are expanded upon and explored at the end of this subsection.

When considering systems, the scales are endless with a system possibly being a part of or tapping into any number of other systems as well as containing a large number of subsystems that contribute to its overall make-up[14]. When considering the design of a coastal project in terms of its relation to climate change and sea level it is important to understand it from an overlapping and interdependent series of scales. Firstly, if you treat the project or project site as a *node*, then it is important to consider the scale of the *larger system* it falls within as well as what larger systems may have inputs into it and how its success, or failure may affect those larger systems. Next of course the scale of the *node* itself must be considered, including developing an understanding of the systems inherent to it, how they feed from its larger systems, and how they relate to the activities and events within this node's subsystems. Next the *coupling* or relational scale of these events/components and subsystems must be considered insofar as it begins to define an organizational and spatial manifestation of program and design. Finally, the previously discussed adaptability and flexibility must be applied to the *component* level considering *tectonic*, formal, and spatial requirements of all the previously outlined scales of thinking. It is also important to note that while they have been outlined in this top-down manner the exploration of these scales should not necessarily be linear and should rather consider a variety of scales simultaneously.

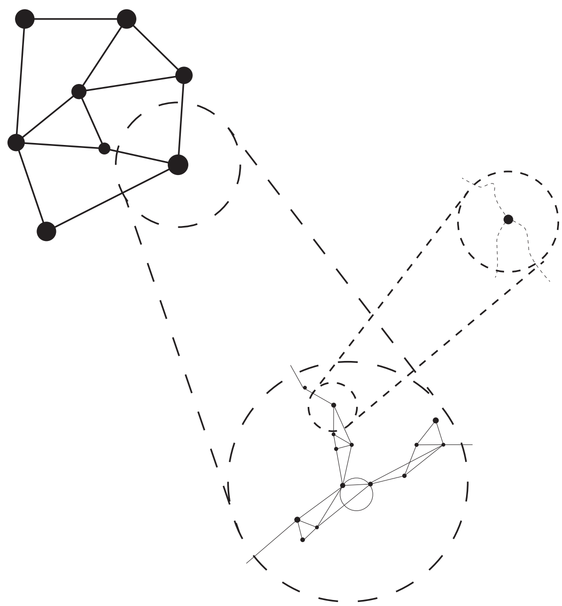


Figure 18: Multi-Scalar approach to systems

The Node

While the term node may seemingly refer to a static condition along a path, in the context of this thesis it is being used to refer to a particular site of intervention. This terminology has been chosen to allow discussion of systems to continue at the internal scale of site as well as at the larger external context within which it falls. If for example the design intervention is a harbour, then the harbour as a whole is the node, the moment in the larger system upon which the designer is working.

The larger system

With the node defined, it is next important to define what will be referred to as the larger system within this text. As previously mentioned all systems have contained activities, as well as inputs and outputs that interface with other systems. In the case of this thesis the larger system refers to that system towards which the inputs or outputs of the specified node (or site) systems contribute.

If we continue with the harbour example from the node then the larger system(s) could be numerous. For one it could be part of a larger economic region of which its residents and visitors are a part of. More specifically though, when considering inputs and outputs it may be part of a specific fishery, fishing industry or larger system of food harvesting, and distribution. In all cases however this larger system's flows, and any issues or threats it faces often time have a direct relation to the flows and threats of the node.

The Coupling

The term coupling refers to a number of things simultaneously. In one sense it refers to the bundling or combination of a number of systems through shared elements, or events, however in a much looser way it simply refers to the organization of them. While in one case proximity may be the means of relation, in another a specified separation could have equally important impacts on the active flows of a system. This is expanded upon in Chapter Four where coupling as a verb is explained as one of the modes of operation for design.

Regardless the coupling can be considered as similar to the scale of the node but with a further attention to each of the divergent systems contained within it. For example, in the case of a harbour operating at this scale would place a greater emphasis on the tides, the specific operations of a commercial harbour, tourism and recreation systems around the harbour etc.

The Tectonic or component

Finally, the Component or tectonic scale is the exploration at the scale of objects. This physical manifestation while noted as one scale of operation is also multi-scalar as well; considering not only the overall composition of a building or built piece of infrastructure but the detailing and tectonics which allows it to function in a way that serves the higher levels of systems operation and flexibility. This means that while a dock or a ramp may be a component scale exploration equally so is the way it hinges, floats and moves, or alternatively maintains a fixed position throughout the dynamic flows.

(Endnotes)

1 Francois Charbonnet, "*Shades of Gray and a Green Thumb with Out-of-the-Blue Couplings*" interview by Cary Siress, Infrastructure Space, Ruby Press, July 14, 2016, print

2 Jesse Lecavalier, "*Let's Infratecture,*" in *Infrastructure as Architecture Designing Composite Networks*, ed. Kristina Stoll and Scott Lloyd (Berlin: jovis Verlag GmbH, 2010) 107-111

3 Ibid p 109-111

4 Stafford Beer, "*The Real Threat to "All We Hold Most Dear",*" in Designing Freedom (Toronto, CBC, 1974) 1

5 Mason White and Lola Sheppard, "*New New Deal: Infrastructures on life support*," in *Infrastructure as Architecture Designing Composite Networks*, ed. Kristina Stoll and Scott Lloyd (Berlin: jovis Verlag GmbH, 2010) 57-58

6 Alexander D'Hooghe, "*The objectification of Infrastructure: The cultural project of suburban infrastructure design,*" in *Infrastructure as Architecture Designing Composite Networks*, ed. Kristina Stoll and Scott Lloyd (Berlin: jovis Verlag GmbH, 2010) 78-79

7 Keller Easterling, "*Split Screen*," *in Infrastructure Space* ed Ilka and Andreas Ruby (Berlin, Ruby Press, 2017) 264-268

8 Jesse Lecavalier, Jason Young, "*The Metropolitan Relational Matrix*" in *Infrastructure Space,* ed. Ilka and Andreas Ruby (Berlin, Ruby Press, 2017) 30-31

9 Charbonnet, *Shades of Gray,* III

10 Yi-Fu Tuan, *Space and Place: The perspective of experience* (Minneapolis: University of Minnesota Press, 1977)

11 Stafford Beer, The Disregarded Tools of *Modern Man*, in Designing Freedom (Toronto, CBC, 1974) 8-11

12 Henk Ovink, “Transformative Capacity of Resilience: Learning from Rebuild by Design,” in *in Infrastructure Space* ed Ilka and Andreas Ruby (Berlin, Ruby Press, 2017) 337

13 Ibid

14 Kristina Stoll and Scott Lloyd, “Regional Fields: Infrastructure Proposition, IP2100,” in Infrastructure as Architecture Designing Composite Networks, ed. Kristina Stoll and Scott Lloyd (Berlin: jovis Verlag GmbH, 2010) 48-49

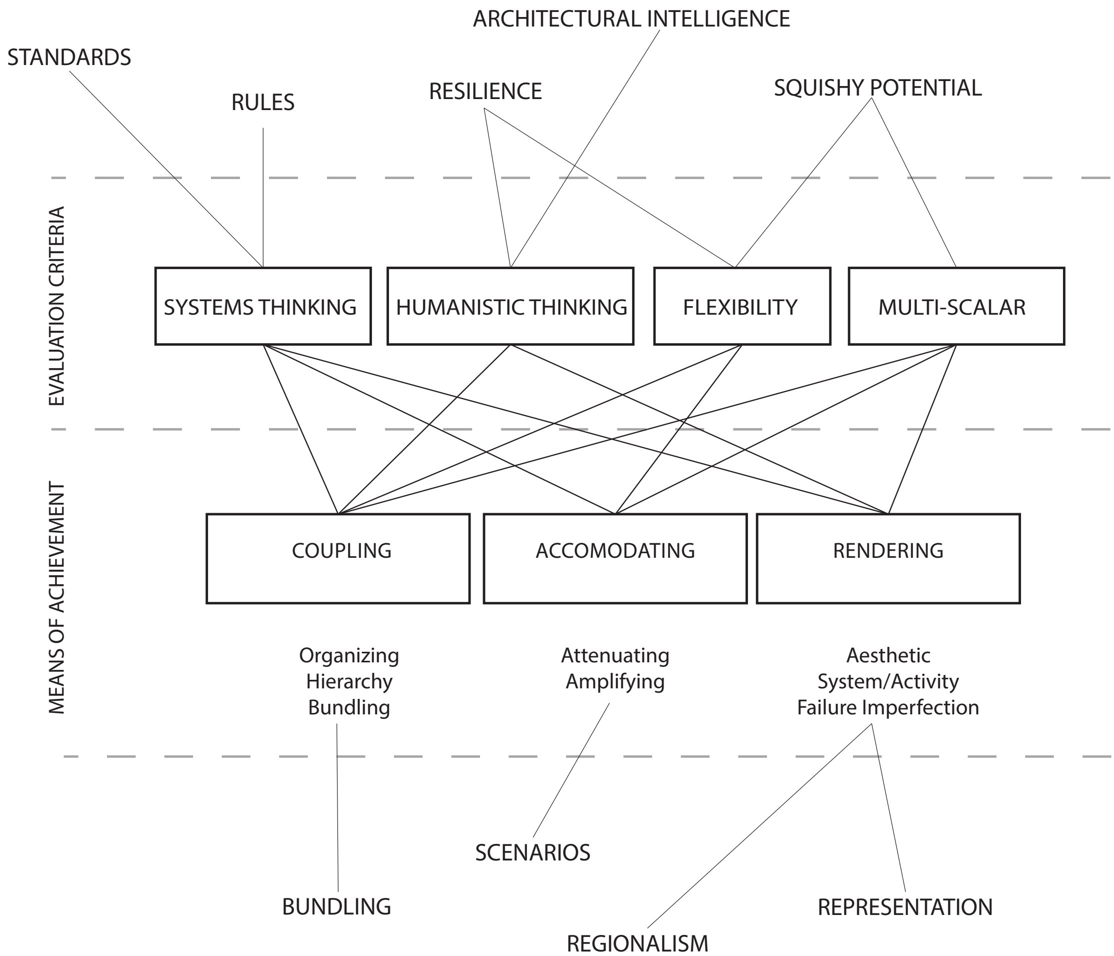


Figure 19: Theoretical structure including Means of Achievement

Chapter 04 - Design Methodologies (Modes of Operation)

To achieve the evaluation criteria – or strategies – explored in the previous chapter requires specific methodologies to be carried out to prioritize the four outlined modes of thinking. Figure 19 expands upon the theoretical framework from the previous chapter to include the modes of operation and their relation to Lecavalier's framework. These design methodologies considered are: (1) *Coupling*, or the relational qualities of systems and their components; (2) *Accommodation*, considering the varieties of systems; and (3) *Rendering*, or the visual presence of diverse, and convergent systems as well as particular moments or shifts within them.

4.1 | Coupling

First of these methodologies is coupling; a term that while sometimes used to refer to the specific grouping of components or elements more generally is used in this thesis as referring to the relational qualities of systems and components. In literature on Infrastructure and Architecture the term coupling is a common occurrence.

In their essay The Metropolitan Relational Matrix Jesse Lecavalier and Jason Young describe infrastructure space not only as the physical elements of infrastructure, but rather as spaces characterized by the systems around them stating "Infrastructure space exists between other spaces, providing switches and couplings that link diverse systems"[1]. This is perhaps the best way to think about the term coupling; when two or more diverse systems, components, activities etc. require a link between them, be it through a defined separation or a mediated connection – circulatory or otherwise – they are coupled.

When considered in this way, coupling becomes the overarching organizing principle for design within systems thinking. The design can then be approached in two ways; through either a top-down mode considering the larger systems and events and working through multiple scales to begin to define the relationships, or a bottom up mode picking a specific system or idea and stepping towards the bigger picture from there.

In many cases the top-down approach allows one to consider the big picture and develop a design that operates throughout all scales creating relations only where necessary. In contrast the bottom-up approach may be effective in creating more complex relationships and overlap. When considering the conditions of SLR and other coastal pressures the bottom up approach allows careful consideration of how each component and system relates to the threats of the coastline. These two approaches begin to enter the territory of multi-scalar thinking and as such should both be considered to capture all of the complexities inherent to different scales of thinking.

4.2 | Accommodating Variety

As was previously mentioned all things can be described as systems or parts there-of; within these systems is embedded a variability or variety. As described by Stafford Beer, in order for any two systems to interact or begin to cooperate with one another, a similar level of variety is required otherwise there is an increased potential for failure[2]. Working through this mode of thinking with *Ashby's Law of Requisite Variety*, Beer goes on to describe how the only means to achieve this similar level of variety is by regulating the variety of the two (or more) systems. Ashby's Law states that the only thing able to regulate variety is variety itself.[3]

By Ashby's Law this regulation of variety can occur in one of two ways. Either the higher variety system works to regulate and amplify the variety in the lower variety system or the lower variety system attenuates the variety in the other[4]. What this leaves us with is the concept that all modes of accommodating variety must then be working to attenuate or amplify it in some way.

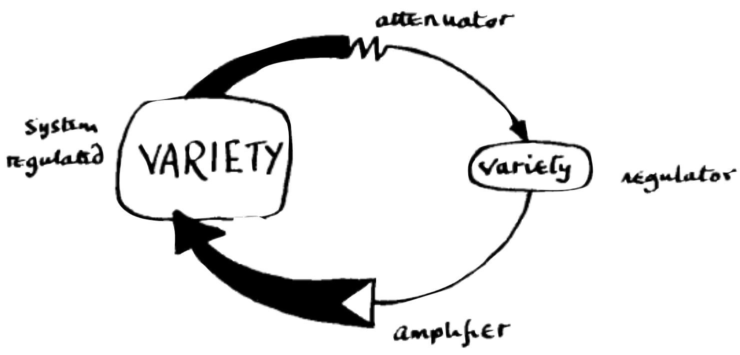


Figure 20: Stafford Beer's Illustration of Ashby's Law

When Stafford Beer explains Ashby's Law he is deploying it in a more general or non-application specific sense and describes how it can be applied to systems of government and politics, or computing and organization; the diagram in figure 20 highlights the way in which he is discussing where one of the systems themselves act as the regulating entity.[5] When this mode of thinking shifts to an architectural context however the control that design has is not directly over the systems themselves but rather through an intervention which utilizes and creates certain parameters within which the systems operation is controlled. The use of this regulating element is displayed in figure #21, an adaptation of Beer's diagram.

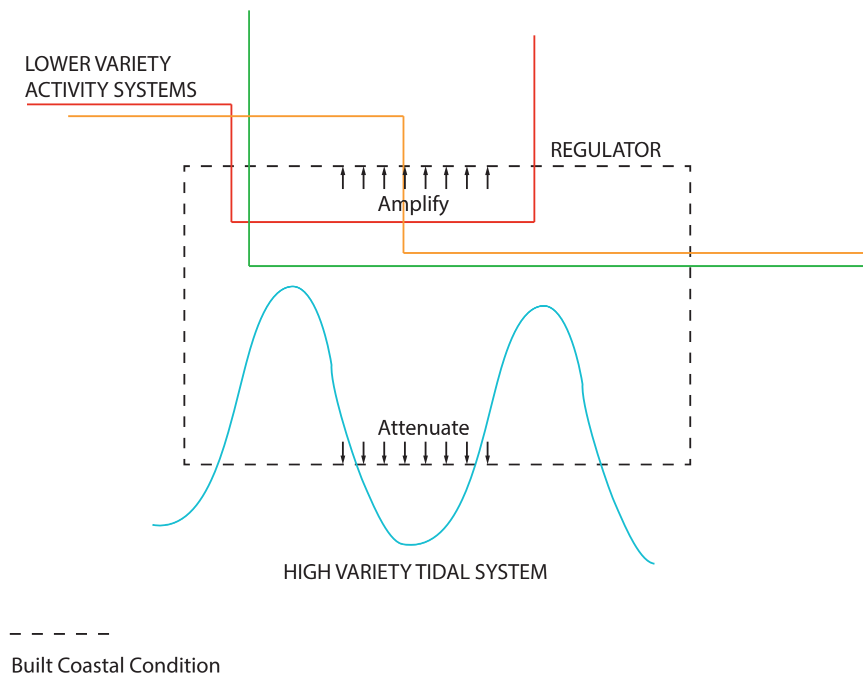
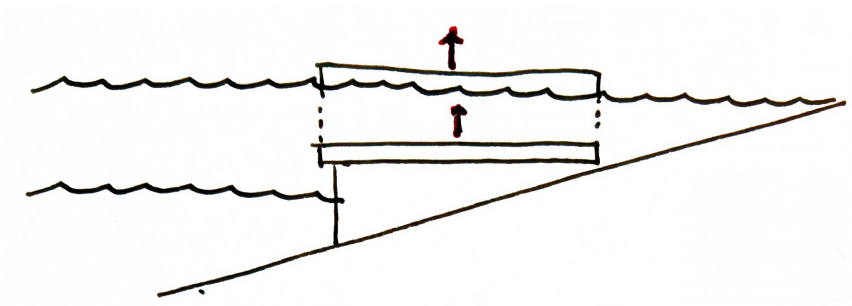


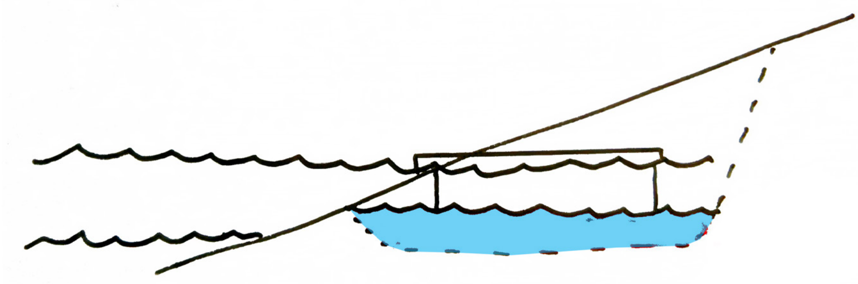
Figure 21: Ashby's Law modified for architecture with a common regulating element

In the architectural context the amplification and attenuation are also slightly different in that they are physical manifestations of control being applied. For example, if we think of a high variety tidal system and its interface with a low variety harbour system then we can attempt to manage this variety in two ways. Either the variety of the harbour can be amplified through the introduction of a floating dock allowing it to adapt softly to the tidal variety, or the tide itself can be attenuated by dredging of a controlled inner harbour which maintains a certain lower limit water level as shown in figure 22. In either case the variety described in this example is positional considering the elevation of the activity relative to sea level. The variety being attenuated could however relate to any number of variables such as decisions within circulation controlling the flows or allowing an open-ended freedom.

Figure 22: Ashby's Law modified for architecture with a common regulating element



a) Amplification of the harbour through floating docking



b) Attenuation of the tides through dredged condition

4.3 | Rendering Systems

The final mode of operation is the rendering of systems. The term Rendering in the discipline of architecture tends to typically refer to a visualization created for the purposes of sales, design and communication; this is unfortunately the extent to which Vincent Lecavalier pushes the topic in his essay on *Infratecture*[6]. In the context of this thesis however rendering refers to something much more real, that being the realization or revelation of certain aspects of the designed condition to communicate certain ideas or facts.

It is most effective to describe this in terms of the ways in which it operates. There are three main types of rendering to be explored within this thesis and particularly its design exploration: (1) differentiation, or the identification of discrete systems and their components within the design, (2) observation or the ability to visually experience parts of the design and (3) designed failure.

The first of these modes of rendering, the *differentiation* is an important concept when considering overlapping infrastructures and systems which may at some points connect while at other times demand isolation or separation. While this separation is partially covered in *coupling* through the relational conditions it creates, the visual characteristic adds a depth to the functional.

Similarly, when dealing with overlapping systems which require this level of separation it may be advantageous in certain scenarios to allow or plan for what is seen from within, this is the *observation*. We often consider how things look from other perspectives but as was the intent with the *View From the Road* studies – a set of studies that looked at highway design from the experiential and outward views rather than the view of the highway as an object – the perspectives from within the system can be equally important to experience.[7] The truth of this expands when you think not just of highlighting the surroundings of a circulation or transportation system but rather begin to consider how one system visually connects to those around it possibly allowing glimpses into, or at least an awareness of, adjacent but separate program and activity.

While the first two modes may have a fairly direct relation, the final rendering definition is somewhat unique to considering design in a Climate Change and SLR epoch. In the introduction to his book Slow Violence and the environmentalism of the poor Robert Nixon speaks about modes of representation and visualization of climate change as being difficult due to the long-term nature of its physical effects[8]. In many cases attempts to represent this are treated quite similarly to the changing of water systems over time as explored by Anuradha Mathur and Dilip Da Cunha in their series of books and publications[9,10]. While these graphic visualizations or representations may create awareness or reference for discussion on an abstract level, it is possible that the physical manifestation of these changes as they occur may provide a level of urgency of understanding not possible through 2-dimensional representation.

To bring this visibility to the design project it is instead possible to create moments of planned or designed 'failure' to highlight in real time the changes that may be occurring. Walter Hood speaks, quite poetically, of water and its impacts on human senses when experienced in some proximal way[11], as simple as being in its presence, that really speaks to this manner of thinking. Essentially, this design for failure manner of thinking looks to highlight moments where the change can be actively experienced without negatively effecting the surrounding systems and activities. This may be as simple as allowing the staining of changing datums on a material profile or as complex as allowing areas of controlled flooding within the design.

Through the development of these three modes of operation and thinking, a toolbox for design exploration into a specific intervention can take place in a precise and intent manner.

(Endnotes)

1 Jesse Lecavalier, Jason Young, "*The Metropolitan Relational Matrix*" in *Infrastructure Space,* ed. Ilka and Andreas Ruby (Berlin, Ruby Press, 2017) 31

2 Stafford Beer, The Disregarded Tools of Modern Man," in Designing Freedom (Toronto, CBC, 1974) 8

3 Ibid 8

4 Ibid 8-9

5 Ibid 11

6 Jesse Lecavalier, "*Let's Infratecture,*" in *Infrastructure as Architecture Designing Composite Networks*, ed. Kristina Stoll and Scott Lloyd (Berlin: jovis Verlag GmbH, 2010) 107-111

7 Donald Appleyard, Kevin Lynch and John Myer, "*The View from the Road*" in *Environmental Perception and Behavior* ed. D. Lowenthal (Chicago, University of Chicago, 1967) 75

8 Robert Nixon, Slow Violence and the Environmentalism of the Poor, (Cambridge, Harvard University Press, 2011) 1-44

9 Anuradha Mathur and Dilip da Cunha, Mississippi Floods: Designing a shifting landscape, (New Haven, Yale University Press, 2001)

10 Anuradha Mathur and Dilip da Cunha, Design in the Terrain of Water, (Philadelphia: Applied Research and Design Publishing, 2014)

11 ibid 84

“Oh me name’s Able Rodgers, a share man am I On a three masted schooner from Twillingate Isle”

- Alan Doyle (Great Big Sea)

Figure 23: Halifax at night, 2018

Part Two – Atlantic Canada

With a major part of the critique in the previous section relating to the impersonal nature of coastal defences, as well as a failure to consider a diversity of scales of operation, to continue in a generality from this point forward would seemingly be a disservice to the work. Instead consideration was given to the specific areas of possible intervention that could be a source for the work.

Originally a Small Island Nation State such as Tuvalu was considered due to the prevalent threat to their very existence let alone their ways of life, however consideration of a large cultural gap and accessibility to the types of issues they may face made this seem like an inappropriate choice. Instead however this lead to a consideration of what may be a more appropriate cultural relationship and an interest in Atlantic Canada developed due to its largely western way of life with the twist of cultural and economic dependence on its coastal conditions.

Beyond the generalities, a series of explorations into four communities sharing commonalities of scale and coastal dependence but presenting unique organizational structure. Based on the selection of one of these communities a more in-depth examination begins to setup the discussion for design in the final part of this thesis.

(Endnotes)

1 Jim Payne, Janice Spence, *Wave over Wave,* (Warner Music Canada, 1995) https://genius.com/Great-big-sea-wave-over-wave-lyrics

Chapter 05 – Atlantic Canada and The Small Coastal Dependant Community

Atlantic Canada or the Maritime Provinces is the Eastern region of Canada including New Brunswick, Nova Scotia, Newfoundland and Labrador, Prince Edward Island and parts of Eastern Quebec. While in many regards they are very similar to the rest of Canada, there are specific defining characteristics they share as well as nuanced – and sometimes not so nuanced – specific differences to each province and sub-region.

5.1 | Economy

Economically these provinces have a very strong reliance upon their coastal location on the Atlantic Ocean. In each the specificities of industries vary but they are at least in part defined by large fishing industries; including anything from Atlantic fish to seafood such as scallops and of course lobster. These provinces are also tied to their coasts through shipping, tourism and a variety of other locally specific industries.

In addition, agriculture is a large industry in parts of the East Coast, with specific crops specialized in each region. Prince Edward Island for example is famous for their potatoes, while the soil conditions in the Annapolis Valley make Nova Scotia a prime location for the growth of wild blueberries.

Finally, these provinces have a wide range of tourism-based economies dependant on everything from their unique culture (fishing harbours and historic roots), geological formations (cliffs, waterfalls, and other interesting formations particularly caused by coastal erosion), diverse history (early Canadian settlements, forts and landmarks) and of course their relation to the ocean. The brutal winters and character of these activities however makes these a largely seasonal tourism-industry similar to the two previously described.

Due to the seasonal nature of this industry, as well as the other main industries in the Atlantic provinces a large percentage of the population works in part time and/or part of the year jobs. The 2016 census for Nova Scotia indicated that of the roughly 500,000 residents who stated that they worked at some point during the census year, just over 50% worked full time for the entire year.[1] While this number may be slightly skewed as it includes anyone aged 15 or over who worked at some point during the year, its removal of those who did not work paints a clear picture of the limited availability and uncertain conditions of the type of work available in this part of the country.

5.2 | Distribution (Population)

The types of work discussed in the previous section also have a strong relation to the population distribution of the region. Keeping with Nova Scotia as the example case only Halifax, as the capital city, was designated as Large Urban in the census population centre size groups while the rest of these centres were classified as small.[2] In total only three population centres (Halifax, Truro, and Cape-Breton/Sydney) counted more than 20,000 residents in their population and in some cases even these are drawing from larger agricultural, and rural regions to reach that total.[3]

5.3 | Culture

This population distribution leads to a very particularly rural culture in most of the towns and communities. In each such place the local arena or hall is the centre of the community and activity centres around social life and interaction within the community. Local community newsletters are a normal fact of life and often keep their calendars full of social gatherings and events.

5.4 | Defining the Small Coastal Dependant Community

Despite the preceding general overview painting a broad strokes picture of Atlantic Canada, these Provinces are quite diverse, not only from one another but also in the characteristics of different types and sizes of community. In continuing this body of work the focus will be on what will be referred to as *Small Coastal Dependant Communities (SCDC).* While the name begins to give some hints about what this means there are specific defining factors for what is considered within this category.

While the term *small* is relative, this essentially only removes the major ports and capital cities from consideration as the previous section indicated. The first part of this thesis discussed how many research and design projects have looked at coastal defences in larger cities with Coastal Harbours, and while the specifics of each such city are different these were not the realm of interest to this thesis, which instead places emphasis on the small scale due to this Atlantic Canada condition. In trying to place a definition on small a number of factors were considered including but not limited to: population (generally considering in the hundreds perhaps as high as 2000), economic diversity, and physical sprawl (selecting a community physically centred around a particular relationship with the Atlantic Ocean.

The next part of that title is the *Coastal Dependant*. While defining coastal is very objective in that it would refer to any community located along the coastline the dependant part adds a layer of subjectivity to this criterion. While it can be argued that anyone who establishes a homestead along the coastline may feel that they 'need' the view or vantage it provides the use of the term here refers to a cultural, economic, or other systematic reliance on its coastal condition. In this sense port and harbour towns, water transportation hubs, industry towns and to a certain extent tourism destination were established with a reliance on the ocean. The importance of this distinction is the breaking point in the validity of this body of work. Essentially this dependence means that in the face of a large threat from SLR more than just a home would be lost, or more simply put the relocation of residents would result in the loss of a particular economic, or cultural need to connect with the Ocean.

Finally, the term community is used over town, city, village, harbour, port, or any number of other descriptors simply because in all cases it is different. While in some cases an entire town locates itself by the water around a fishing port, in many other cases a larger town inland operates fishing activity out of an almost satellite hamlet or harbour. By referring to community the work can capture all of these scenarios while maintaining a focus only on that in the immediate vicinity of the coast.

(Endnotes)

1 Statistics Canada, *Census Profile, 2016 Census, Nova Scotia [Province] and Canada[Country]*, accessed July, 2018

2 Statistics Canada, *Population and Dwelling Count Highlight Tables, 2016 Census, Nova Scotia*, accessed July, 2018

3 Ibid

Figure 24: Explored sites in Atlantic Canada

Chapter 06 – Mapping Coastal Types

The work within this section was carried out in trying to identify a site that appropriately could be used as a testing grounds for the objectives and evaluation criteria of this thesis. As such an exploration of a small set of SCDCs was undertaken.

To structure the explorations into these coastal communities a classification by type was created to organize the work in the following chapter. While any number of factors such as industry, or population could have been utilised to categorize, these presented too much potential for overlap. When considering the effects of coastal tide and sea level variations on a community the physical construct of that community is a definite influencing factor for this reason, through a scan of maps of the Maritimes 4 primary Coastal community types were identified for further examination via mapping and visits to the communities.

These four types are as follows: (1) The natural occurring harbour town, (2) the coastal stretch, (3) the riverbank and (4) the peninsula. Within each of these types an example from New Brunswick or Nova Scotia was selected and analyzed through a mapping of information discernible through online sources, as well as a site visit in February of 2018.

6.1 | Natural Harbour

The first of the typologies identified for the mapping exercise is that of the naturally occurring harbour town. As the name suggests the primary physical feature of this typology is a harbour formed around a naturally occurring; inlet, river, valley or other formation. In many cases these towns were settled due to this natural advantage for protection from storms, and safe harbouring of boats during high range tides. These are typically not fully self-reliant communities but rather small hamlets of larger towns with the population typically centred around those involved in the seasonal fishing industry. Towns of this type are particularly prevalent within the Bay of Fundy as the high range of elevation from harbour to its banks allows an operating harbour with the tidal shifts while allowing the protection of residential and other infrastructures on higher ground further inland.

Selected Town

For this research, *Hall's Harbour* located on the Nova Scotia coast of the Bay of Fundy was selected as a test case. A community proud of its heritage as "*One of the few authentic fishing villages surviving along our shores*", it is an operational fishing harbour, primarily in the Lobster industry. At dock level within the harbour there is a 65,000-pound lobster holding and processing facility in addition to a restaurant and dining areas and harbour space for the mooring of commercial fishing vessels and private watercraft.[1]

The harbour is a continuous development of the community's history, repurposing a number of old buildings significant to the community into the existing lobster pound.[2]

> *The buildings which are presently known as the Halls Harbour Lobster Pound, date to the 1820's. They have served in former years as a school house, church, meeting hall, a general store, way station, customs office, blacksmith's shop, etching studio and shipyard from which the Ella Moore Tarquentine was launched as well as three 60-70 ft. schooners. The smaller buildings were used as fish sheds, summer camps and an ice house.*
>
> *The Halls Harbour Lobster Pound now serves as one of the largest lobster holding facilities in Canada with a capacity of up to 65,000 pounds. It features state of the art technology including refrigerated water, a new trickle tray and a "floating pools" holding system.*
> *From this facility, lobsters are packed and shipped wholesale to points from Europe to Asia. Our business is expanding with new products, services and markets all over the world.* [3]

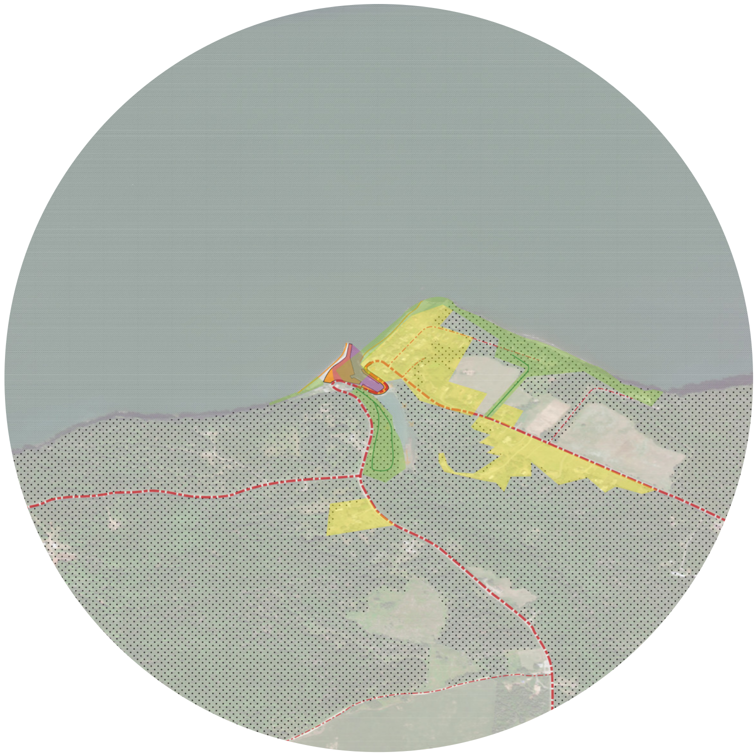
Running Halls Harbour through basic mapping exercises for analysis and speculation a number of items become important to note. Firstly, when looking at transportation to the hamlet there is one major access road relied upon for locals, tourists, business/shipping, and crossing through town to other communities down the coast. Considering the scale of the community and particularly the harbour there is a seemingly complex relationship of a number of systems related to the lobster industry and the harbour itself, as well as a vibrant tourism industry and of course the local community.

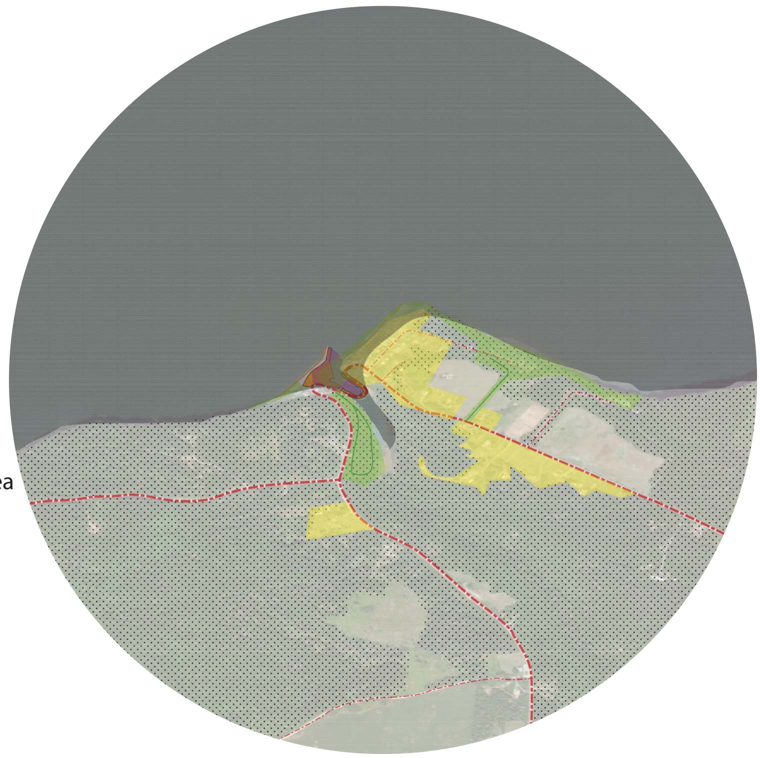
Considering the threat of sea level rise and applying the future water level data to this mapping a number of threats become clear. The current tidal range due to its location on the Bay of Fundy is extreme (~13m) meaning with sea level rise it could reach in excess of 15.5m above sea level.[4] The road in its current location low in the valley is at high risk for flooding even under current circumstances in a storm surge and thus will not survive a significant rise in sea level. The commercial operation including the lobster pound, processing facilities, offices and docks, as well as the restaurant/dining area, are all located similarly to the road in range of flooding under a current extreme or future normal high tide.

The residential zones are well protected at least under currently projected tidal ranges on the hillside and appear to have space to retreat should a change in sea level begin to pose a risk. With these the greater risk may be the erosion of the hillside.

Under current circumstances the only major coastal protection in place appears to be the formation of the wharf which also acts as a wave break keeping the water in the harbour nearly flat in most tide scenarios. This deals with wave forces but this limited scope along with the seemingly flat level of all harbourside activity means that Halls Harbour, despite its advantageous topographic condition is at a high risk under flooding scenarios.

Figure 25: Early mapping excercise exploring Halls Harbour systems





LEGEND

- Residential Area
- Tourism Area
- Industrial/Harbour Area
- Commercial Mercantile Area
- Coastal Defenses
- Current High Tide Level
- Project High Tide Level
- Wooded Area
- Main Roadway/Highway
- Secondary Roadway

Figure 26: Site photographs of Halls Harbour, February 2018

a-d) Harbour condition in low tide showcasing the complex mooring of boats and the differential between the harbour floor and docks area

e-g) Roadways surrounding the harbour including approach and harbour side conditions

h) the bank of residential zone (erosion risk) in low-tide


e


f


g


h

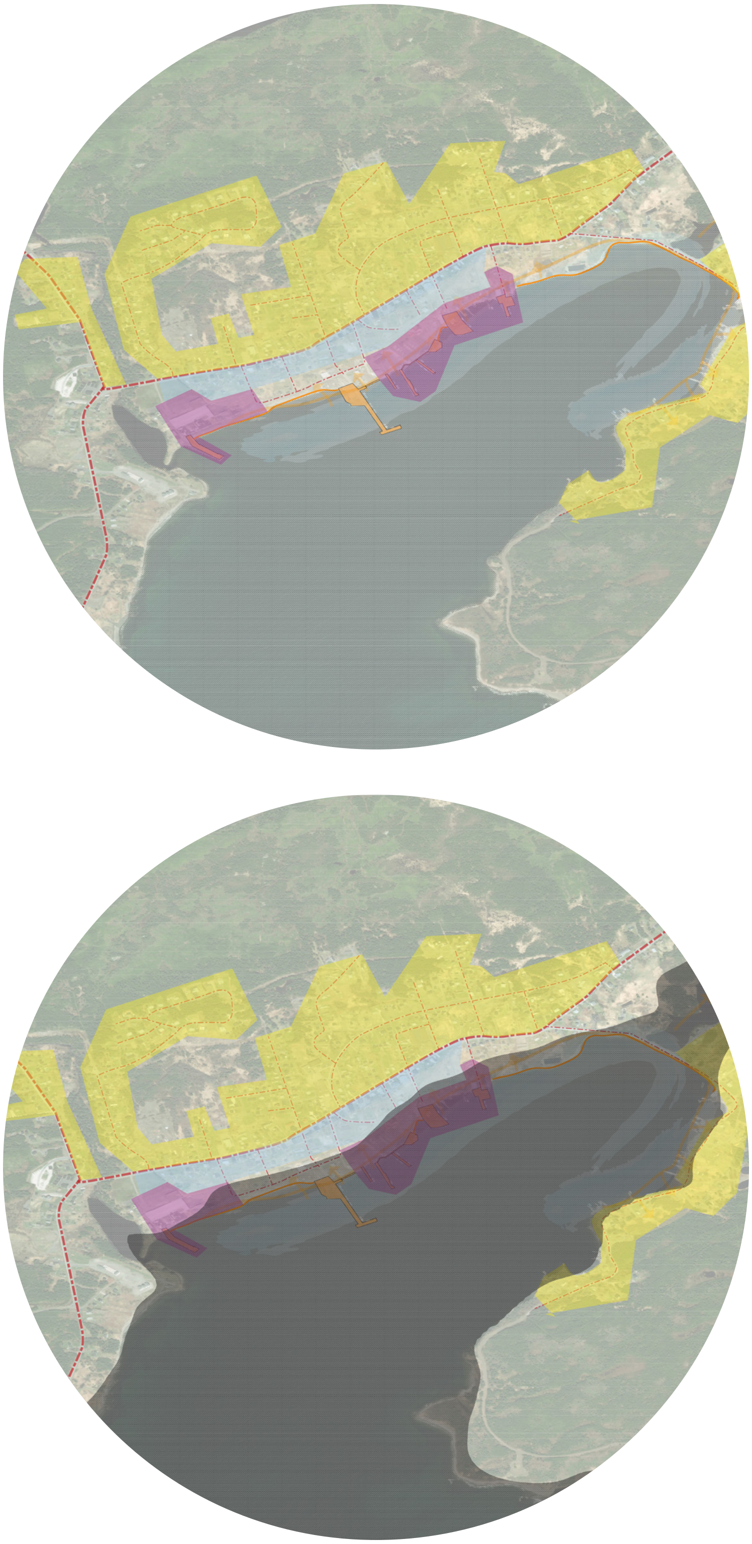


Figure 27: Early mapping exploring Louisbourg systems

6.2 | Coastal Stretch

The Coastal Stretch may be the most common or recognizable type of these coastal towns. Characterized by a gradual slope inland from the coastline the scale of these towns varies widely as they are not defined by a single physical formation but rather by the scale of population and established industry or town structure. Often times however it is easy to observe an almost layered condition to their development that prioritizes the relation of certain activities (tourism and industry for example) to the water, while others (residential and program associated with this) are relegated to a position further inland.

Selected Town

Louisbourg located in Cape Breton faces out across a bay into the open ocean of the North Atlantic and is a prime example of this organization and an ideal test case for a number of reasons. Firstly, it adds another scale of operation to this research, where Hall's Harbour and most harbour conditions are small hamlets focused around a single point of relation to the coastline and a one-dimensional industry, Louisbourg not only features a number of larger fishing operations along its coast but a National Historic site that draws visitors from around the world.

Based on similar mapping exercises it was found that Louisbourg is layered in its organization as a town. Immediately at the coastal edge is primarily ocean-related industrial space consisting mostly of both fishing operations and their docks as well as a coast guard base. These are connected by a small secondary road called Commercial Street which is all on built up land at the coast line to deal with the minimal tidal range that Louisbourg has to deal with. Next is a buffer zone of what is commercial and public buildings including a number of small stores, banks, churches, a playhouse and a motel along with a large amount of underutilized open space separated from the mainly residential areas by Main street.

Figure 28: Site photographs Louisbourg, February 2018

a)Unused buffer space along the Louisbourg coastline

b/c)Hardscaped spaces creating flowing water towards harbour during rain

Aside from the elevation of the ground plane immediately at the coastline and the natural bay in which it is located there does not appear to be much in the way of coastal protection currently in place. Based on the SLR scenarios uncovered in the mapping water will start to infiltrate back through these zones meaning that defenses along the stretch of coast would be required. The largely hardscaped condition of the area along the coastline would most likely exacerbate the problem as even in a rain storm it is clear to see the pooling and flowing of water on the roads and surfaces in this area.

d-g) Undesigned and underutilised space along mainstreet as a buffer between coastline/industry and residential neighbourhoods potential area for a layered design buffer to the coastline

6.3 | Riverbank

Riverbank towns are not as explicitly coastal as the other types explored here and yet in many ways they have similar characteristics to the natural harbour towns. They similarly are formed around a natural formation, in this case a river as their name suggests, that provides them similar physical characteristics with less explicit high and low ground areas.

Selected Town

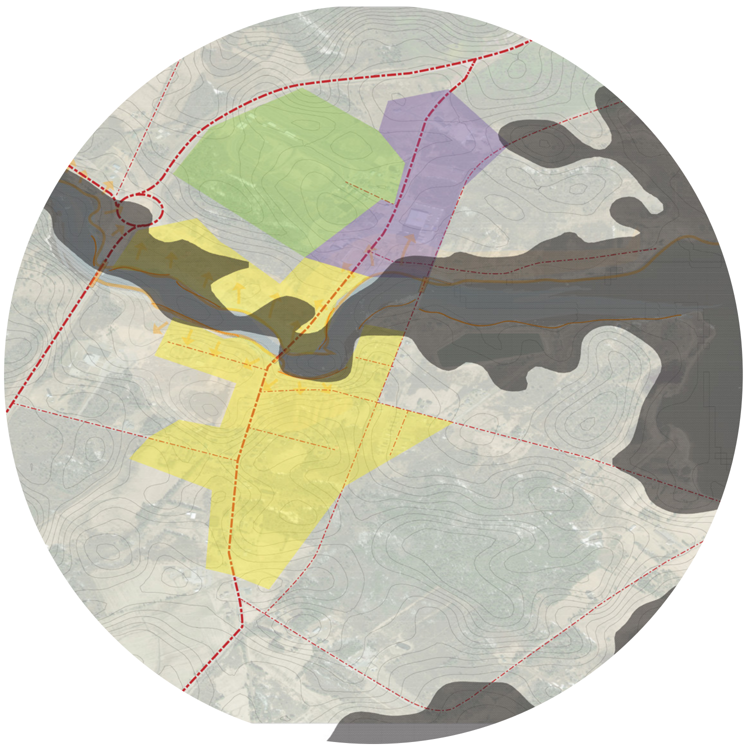
Port Elgin in New Brunswick was selected as the test case for this type. As was observed to be the case in many of these riverbank areas the density is much sparser and in the case of Louisbourg there does not seem to be much connection to the water aside from proximity. The local industry mostly centres around a window manufacturer whose facility is in the local region.

As was mentioned previously not much in terms of constructed facilities are in danger in the Port Elgin scenario any longer as its required connection to the water seems to have ceased long ago. A number of residential properties along the banks may need to consider moving or relocating, however its nature as a floodplain has already led to this beginning to occur.

Infrastructurally and as part of a system the only two major points of failure would be the roads. Though not an important part necessarily for the sustainment of this community a number of routes through the region require you to pass through Port Elgin and under current and future flood scenarios both river crossings in their current state are at risk.

While this may seemingly make this community insignificant to this research what this community does is highlight a condition that is most likely inappropriate for the type of intervention this thesis is interested in. While at one time the community may have been directly related to the water do to transportation and other uses for the factory in town this relationship is no longer required and thus this community would more appropriately be recommended for relocation of residents. This course of action appears to have already begun to some extent as was revealed through my site visit and is the result of economic and cultural shifts even preceding those environmental.

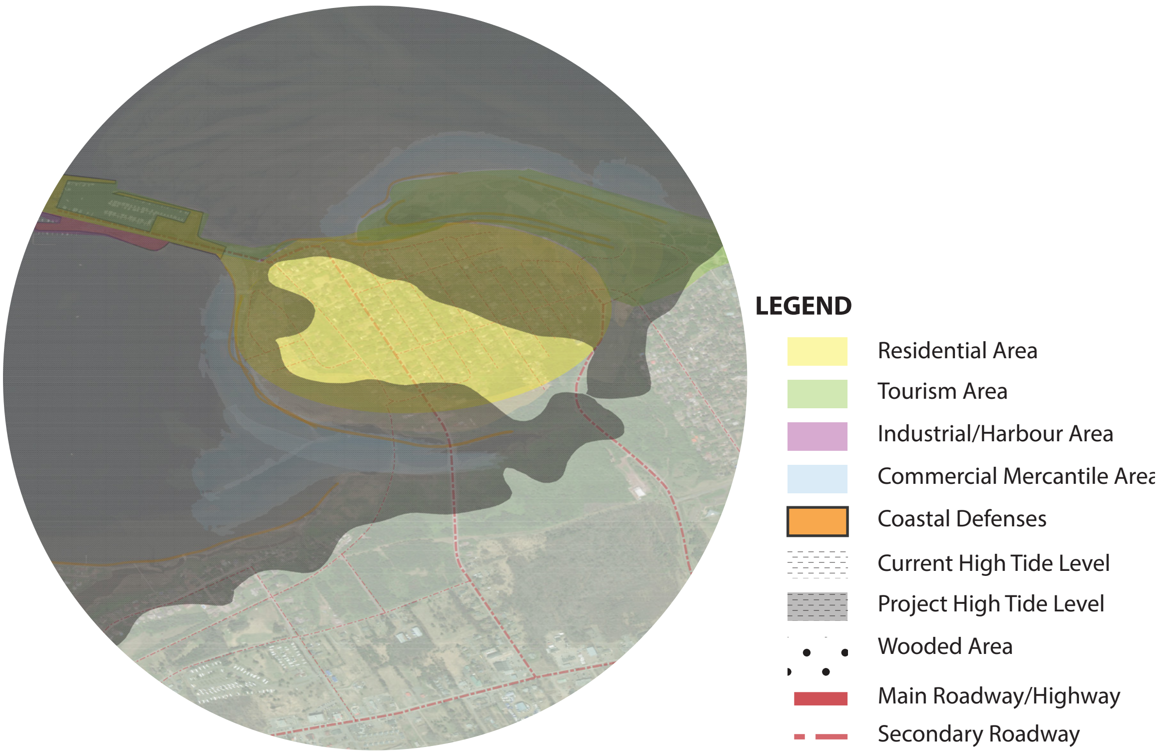
Figure 29: Early mapping exploring Port Elgin systems



LEGEND

- Residential Area
- Tourism Area
- Industrial/Harbour Area
- Commercial Mercantile Area
- Coastal Defenses
- Current High Tide Level
- Project High Tide Level
- Wooded Area
- Main Roadway/Highway
- Secondary Roadway

Figure 30: Early mapping exploring Pointe-du-Chene systems



6.4 | Peninsula

The peninsula type is again largely defined by its natural physical formation. A piece of land jutting out into a body of water presents these communities with an interesting relationship to their environ as they are surrounded on almost all sides. While not as common as a type of town defined by specific programmatic or economic elements there are a number of them spread throughout Atlantic Canada.

Selected Town

In the case of this thesis Pointe du Chene New Brunswick, a part of the larger Shediac Region near Moncton, though on the Atlantic coast as opposed to the Bay of Fundy, was selected. This selection was due to the considerable built up nature, and relative low and flat elevation of this peninsula. Primarily a vacation or cottaging town Pointe du Chene reaches further into the Ocean by way of a large wharf that features most of the commercial activity, primarily restaurants and shops with some small fishing (lobster) operation.

The analysis mapping of Pointe du Chene indicated what has previously been alluded to that aside from the wharf which is located at the tip of the peninsula and thus at a very high risk of flood impact, most other properties both at risk and not are privately owned residential. Because of this aside from flood walls around the peninsula it would seem that the only logical distribution would be a widespread network where each property employs its own protections connected by an appropriately designed network of transportation. Currently the town has used berming and natural formations along the beach front to keep the water at bay, but it has been indicated that significant flooding already happens in the community on a somewhat regular basis.

(Endnotes)

1 *Halls Harbour Lobster Pound About Us*, https://www.hallsharbourlobster.com/about-us/ Accessed December, 2017

2 Ibid

3 Ibid

4 Tides4Fishing, *Tides and Solunar Charts: Baxter's Harbour*, https://tides4fishing.com/ca/nova-scotia/baxters-harbour, Accessed December 11, 2017


CAMERON SEAFOODS
Hall's Harbour
LOBSTER POUND

Chapter 07 – Halls Harbour in Depth

Before continuing forward with a test site for this intervention, an in depth understanding of the community selected is required to allow the response to be effective in addressing not only the complexities of such a place but also appropriately considering its applicability to the thesis, its multiple systems and depth, and any threats to the community as well. Halls Harbour was selected based largely on the points explored within this chapter that respond directly to three validation criteria.

7.1 | Halls Harbour a Validated Test Case

Based on the previous analysis of communities it became more important to identify a single site of intervention to support the further exploration of this thesis. In doing so a number of factors had to be considered, and in selecting a location the following questions were asked.

1. Does the site present the opportunity to highlight the change in operation at different levels of tide and sea level?

2. Does the site represent part of a larger system, thus justifying its intervention for sustainment economically, culturally or otherwise, and providing a means for exploring the relations of this system to its internal systems?

3. Are there a number of complex systems at play through which differing relationships within the design can be explored?

Based on an examination of the explored example sites, Halls Harbour immediately presented itself as the ideal scenario to explore this work further.

<
Figure 31: Halls Harbour in Winter, February 2018

7.2 | Amplified variety

Halls Harbour makes for an excellent test case due to a range of factors explored earlier in this thesis. Primarily, it presents as an expedited test case of the effects of rising water due to its extreme tides that amplify its variability. Located fairly deep into the Bay of Fundy, Halls Harbour regularly sees tides in the 12m range with the upper end hitting over 13m[1]. This creates an interesting test case in the way that the daily change in tide far outweighs the projected SLR values.

In its current state Halls Harbour falls into a very Rigid and Fixed position on the flexible design matrix meaning that its current construct does not dynamically allow for short term variability or long-term adaptation despite its current condition already inherently handling high variety. The docks maintain a constant level through the whole harbour meaning that boats are limited to certain tide times not only to enter and leave the harbour but also for ease of loading and unloading. This single height solution, while showing a creative way of adapting to changing tides as is required of the site, is an area of possible improvement for new proposed strategies to tackle. The building programs are in an even worse position due to this static condition. With an inability for any of the system, docks, roads or otherwise to adjust and couple the building to the rest of the network it must instead be fused to them.

In many ways the site has not been altered too drastically from its starting state. The docks and other infrastructural components seem to very lightly touch the ground which in some ways lend themselves to change over time though not in an easy manner. The harbour itself has undergone some dredging through what appears to be a combination of human and natural processes allowing the docks to operate at the standard fixed height throughout.

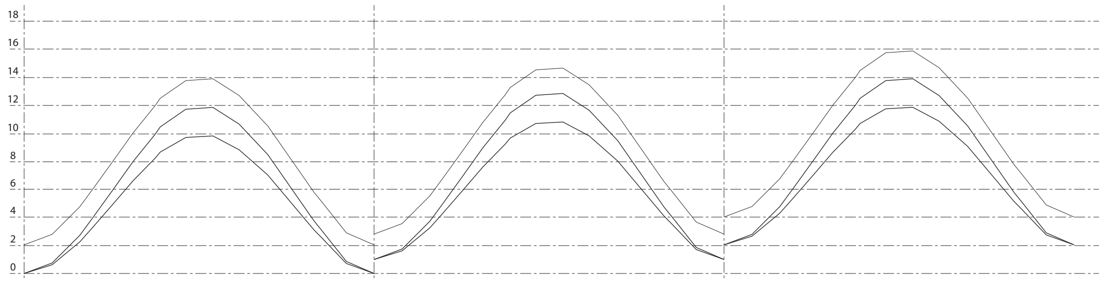


Figure 32: Graph showing the amplified tidal ranges of Halls Harbour on the Bay of Fundy compared to their change over time with SLR

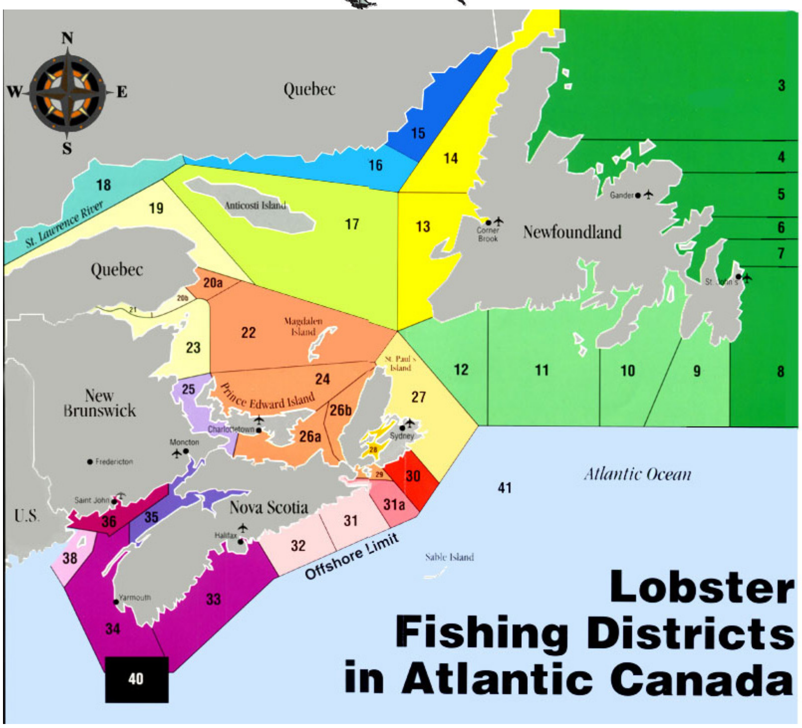


Figure 33: World map diagramming international distribution of Canadian lobster

France, Germany, Switzerland, China and Korea are the major importers of Canadian lobster

Source: Hope Shanks, Interview 2018

Figure 34: Lobster Fishing Districts in Atlantic Canada

7.3 | Larger System

It is in many cases difficult to justify large scale intervention to protect small towns when considering them in isolation. Hall's Harbour is one such example, where its limited population (in the hundreds not thousands) and limited prominent business (the lobster pound and a few small art studios) make it a side note when considering overall economic impact to the region, and industry. In many cases it would seem to be the type of project to pass on for a larger multidimensional project elsewhere however, considering Halls Harbour in isolation is the primary issue not only for its survival but of the larger network of which it is a part. Being part of a larger fishery network, under threat from climate change as well as a number of other factors, provides a means of justification for investment in these smaller communities. [2]

As has been previously identified, to achieve resilience an understanding of operations at all scales is necessary. What this means in the case of systems thinking is that the resilience of one community or node should be understood in the way that it relates to the larger resilience of its parent systems.

In the case of Halls Harbour, this larger system includes a few different things. At one level it may refer to its relations to the county and larger municipality within which it falls, where the fishery operations are only one contribution to a local economy that has a larger focus on agriculture, and industrial operations for the food industry in a more general sense; through a number of farms and a Cavendish foods facility.

More pertinent to this thesis however, Halls Harbour is part of a larger system of operations that is the Atlantic Canada lobster industry. As is the case with many commercial fishing industries in Atlantic Canada the lobster industry is controlled through a series of carefully managed fisheries with limited licenses and controlled procedures for fishing. The region which Halls Harbour is located within (Lobster Fishing Area 35) is at the North end of the Bay of Fundy and has a maximum of 93 licenses, however most recently reported statistics indicate that only 75 full licenses are active within the region.[3] Fishermen licensed in the LFA35 must adhere to a number of rules and procedures intended to protect not only the fishermen themselves but the prosperity of their operation by maintaining stock and preventing overfishing with the region. Licenses are only good for the region they are assigned, for a particular seasonal opening and a limited number of traps. LFA35 restricts fishermen to 300 traps operating from October to December and again from March through to mid July[4]. This limited licensing has led to a number of pressures on Halls Harbour from outsiders looking to cut into the market of their fishery.

The primary threat to the Harbour's continued relevance is the move towards paying fishermen to "stay home". This is in reference to the growing trend for businesses from larger fishing towns, and specifically Digby, further south on the edge of the region purchasing licenses from fishermen in smaller communities at a premium in order to boost their own potential market share.[5] On the surface this trend may appear to be a positive when considering coastal protection as larger established centres may begin to justify larger investments for protection and consolidation, as well as a move to urbanizing. A cursory analysis of some of the more impactful and well thought out proposals from architects and planners in response to current flooding events (mainly related to Hurricane Sandy, and Hurricane Katrina), the areas for suggested investment tend to focus on the larger cities, and this aligns with a growing urban population. When looking at the maintenance of the overall industry however, the impact of centralizing could be detrimental to all parties involved. When speaking of the strength in Walmart's distribution and logistics, Jesse Lecavalier points to the work of Paul Baran for the RAND corporation who classified network organizations as: centralized, (one focal point) considered the weakest mode; decentralized, (multiple focal points); or distributed the strongest distribution, wherein all activities are equally spread, creating better resilience in the system.[6] If you consider the distribution of the lobster fishing system and specifically that within Lobster Fishing Area 35, while it does not achieve a completely distributed structure due to physical and logistical constraints, it currently operates in a decentralized manner. Because most lobster fishermen locate their traps within 9 miles of shore due to access and lobster's tendencies to focus in shallower waters[7] a multi-nodal system ensures a distribution of fishing activities around both smaller nodes (a few boats in a small harbour) and larger (large commercial operations as in Digby) alike all with equal access to the resources (as represented in figure 35) as opposed to one major centre. When all fishing centers are able to sustain themselves the lobster populations are able to do likewise, replenishing in natural cycles and preventing overfishing. If instead an individual center, such as Digby, is able to monopolize the market by purchasing licenses from those further into the Bay of Fundy, then most fishing activity relocates to its focused region, and while some fishermen may begin to push the 9-mile radius the re-concentration could have detrimental effects on the lobster population and industry sustainability. As a result of this relocation combined with the impending pressure for increased lobster volume on Atlantic Canada as much of the American lobster industry shifts north with rising ocean temperatures and emphasised by the already growing level of fishing activity in this LFA[8], these focused regions will risk overfishing causing a larger collapse to the industry, this redistribution is shown in figure 36.

Thus, the choice to protect Halls Harbour needs to be considered for more than just its local impacts but rather as a part of a larger network of communities receiving protection so as to sustain the overall fishery population and industry survival, a key economic driver in Atlantic Canada. The threat of license redistribution not only threatens the economic viability of Halls Harbour as an active harbour and lobster processing facility but also the larger success of the industry across all communities.

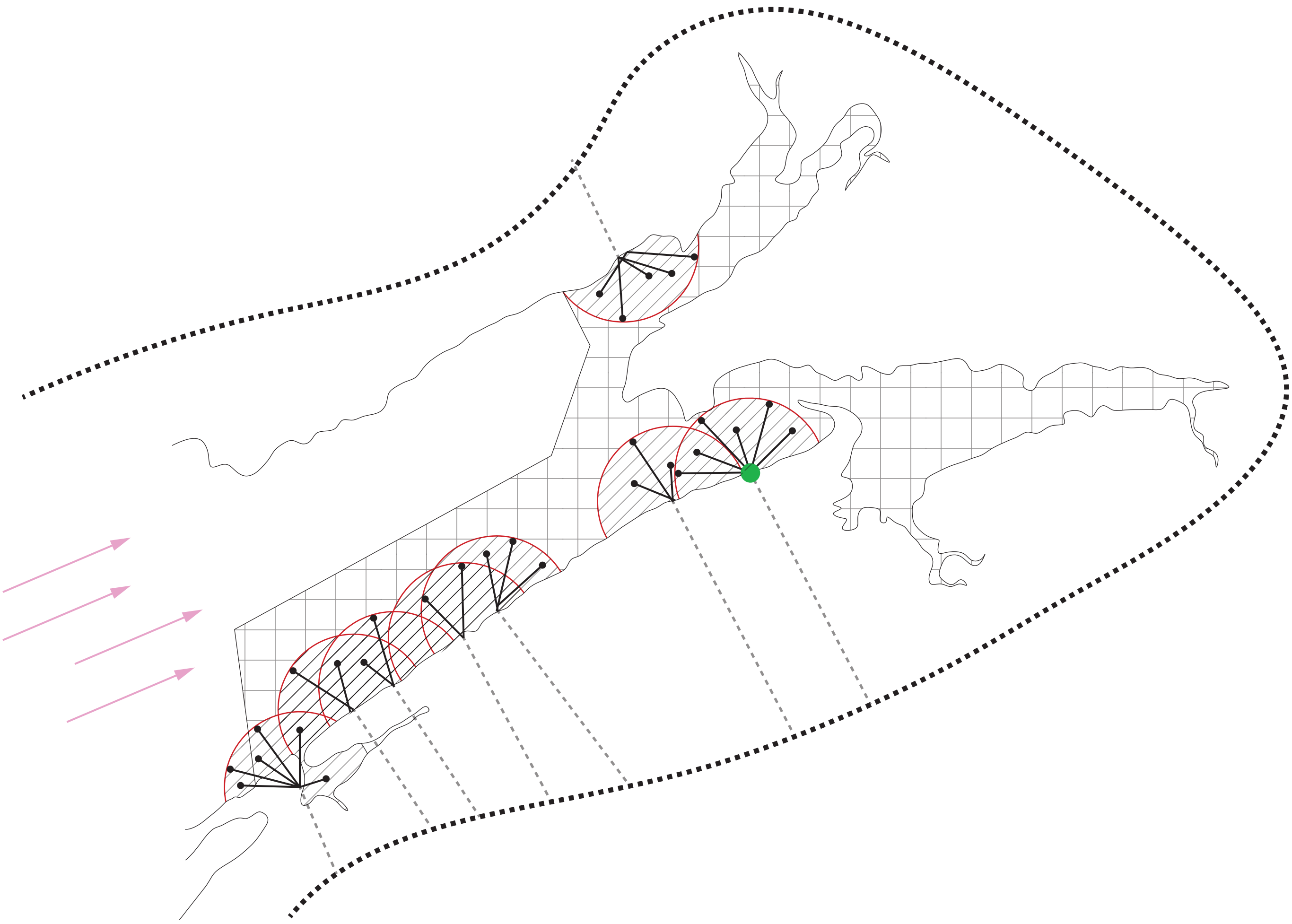


Figure 35: Map showing the current decentralized LFA-35

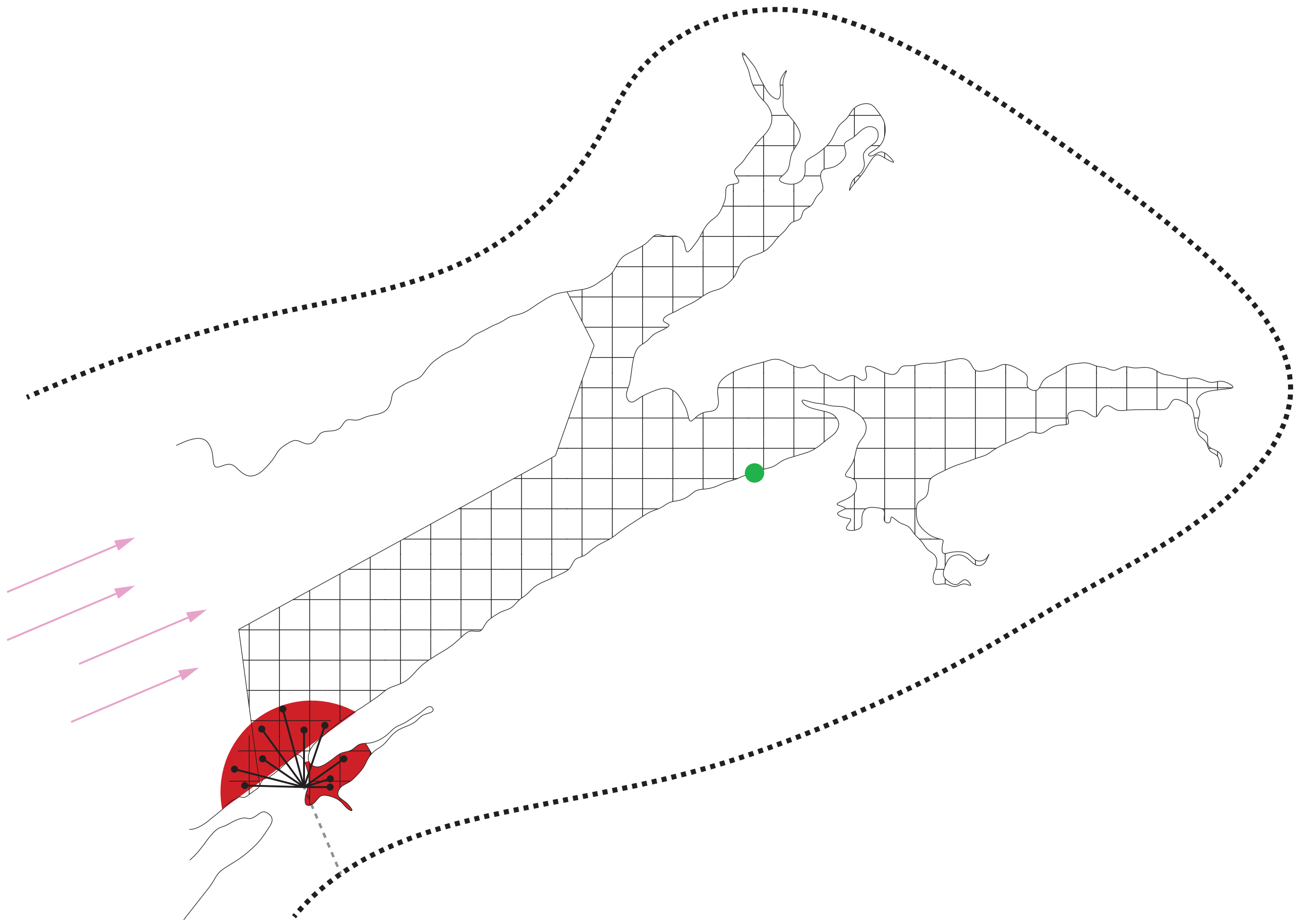


Figure 36: Map showing the shift to a centralized LFA-35

7.4 | Layered Complexity

Finally, the diversity of Halls Harbour programmatically, relative to its size, allows creative exploration into the ways systems may begin to overlap and separate. Within Halls Harbour the fishing harbour is just one sphere of activity. There is a vibrant tourism industry focused on three main areas; firstly the environment and spectacle of the harbour operation, secondly the high tidal ranges of the Bay of Fundy, and finally the hiking and exploration of a number of natural formations including the cliffs along the coastline and the interior valley beyond the harbour. This means that at any given moment, the natural systems, the harbour activity, tourism, as well as a local body of residents may be overlapping within their spheres of operation creating interesting moments for design exploration. These systems are explored further in the following subsection

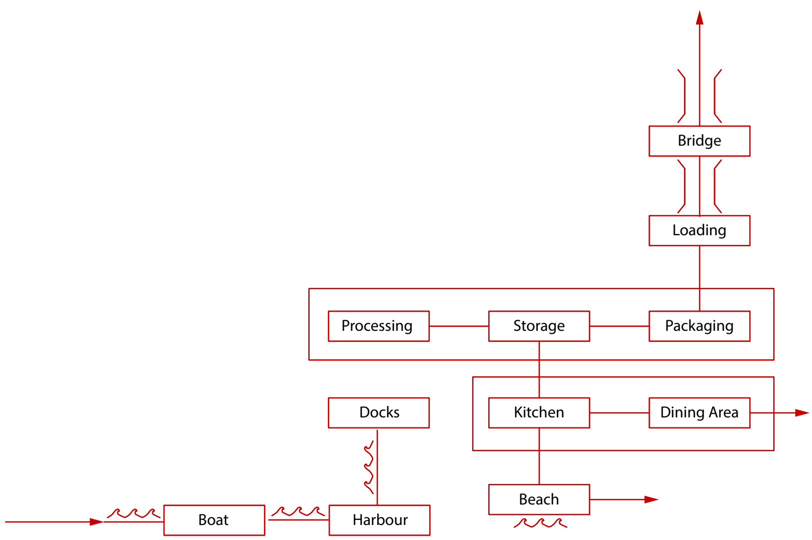


Figure 37: Diagram of the lobster industry of Halls Harbour as a system

7.5 | Systems of Halls Harbour

While Halls Harbour is a small and not extremely populous hamlet it does include a diversity of systems some of which are out of the scope of this thesis, while others have a direct relation to the body of work developed. Creating an understanding of these systems will allow the design work in the final part of this thesis to consider the flows of people as they engage these systems to help define not only the experience of the intervention but also the relational coupling requirements. By presenting these systems and their components as they exist now, a functional understanding can be brought forward into the design that while allowing changes to the manifestation does not undermine any of these diverse layers.

Economic Systems

Economically Halls Harbour is very limited in terms of the size and diversity. The primary economic drivers for the community come from two industry systems which overlap in some ways.

The first of these economic systems is the fishing industry; more specifically a majority of this activity is related to lobster fishing industry. The largest business in the community is Cameron's Seafood which operates the Halls Harbour Lobster Pound and the Halls Harbour Lobster Restaurant[9]. In terms of area the lobster fishing economy also takes up much of the community through the harbour, pier and dock spaces.

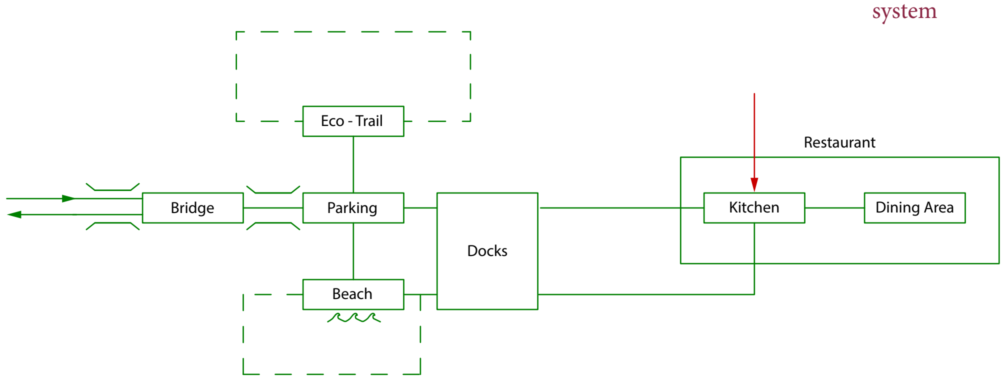
The lobster fishing industry as a system internal to the community includes a number of events, and processes. As a whole the system can be visually represented by figure 37 showing the components involved and the relationships formed between them.

The second of the primary economic systems is the tourism industry; a seasonal flow of activity to the community connected to two primary drivers. The first driver is the previously described activity of the lobster system, a traditional industry which brings in tourism for the sights, and experience, as well as the flavours of fresh lobster.

The second driver is more diverse in that it is the natural conditions that the harbour presents. The inlet and its location on the Bay of Fundy provide an exceptional vantage to experience the extreme tidal ranges of this region; the tides have also created conditions along the Coastline that draw tourists in as well, including a series of hiking trails within the valley, and Cave and waterfall formations along the coastline created through erosion.

This tourism system presents itself in a much less linear manner than the lobster fishing industry. The diverse drivers of tourist activity mean that there is a much greater divergence in the components where one may have little or no direct relation to another. When the flows of people are considered in the design and coupling stage this means that a greater number of possible unique paths exist within this system. All in all however the components of this system and the connections that exist between them are displayed in figure 38.

Figure 38: Diagram of the tourism industry of Halls Harbour as a system



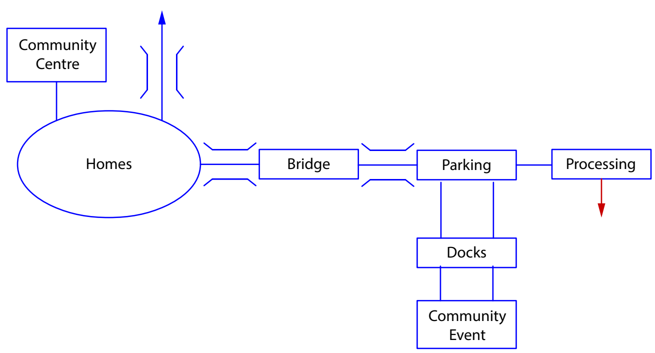
Other Human Related Systems

While the activity of the harbour largely focuses around the two major economic systems there are also a few other systems which bring people into the site and its surrounding community. There is of course the circulation systems relation to the larger region as access to some smaller hamlets along the Bay of Fundy currently requires one to pass through Halls Harbour. There is however one larger human system not yet described.

That is the local residential system or sphere of activity. The local residents engage with the harbour and the surrounding community in a number of ways. Directly related to the harbour they engage as employees of the lobster pound, or through their use of the docks and harbour area for local community events such as barbecues and musical performances as well as larger gatherings associated with festive activities such as Canada Day celebrations.

The system of the local residential life is displayed in figure 39 below. Similarly to the other two systems shown it includes the components directly related to it but also includes linkages into the other two systems for work in those economic areas or the use of some of the amenities the components of those systems include.

Figure 39: Diagram of the local residential system of life in Halls Harbour



Components

As was mentioned, each of the system diagrams shown previously include the major components that contribute to their activity. Many of these components are the points of exchange between systems or even begin to overlap into multiple systems. This overlapping is shown in figure 40 which brings those system diagrams together to create a more complete and complex understanding of the components and the connections between them within the harbour. Thinking at this level however only really benefits the thinking of the infrastructure space or the active form of the systems.

Figure 41 showcases the current physical manifestations of some of these major components. While in most cases these are components that will be redesigned in the design intervention proposed in the last part of this thesis, presenting them in this way begins to allow thinking of the object-form of the design. By observing the existing condition it becomes possible to visualize how the flow from one physical object to another requires a particular mode of thinking about how that component itself is designed.

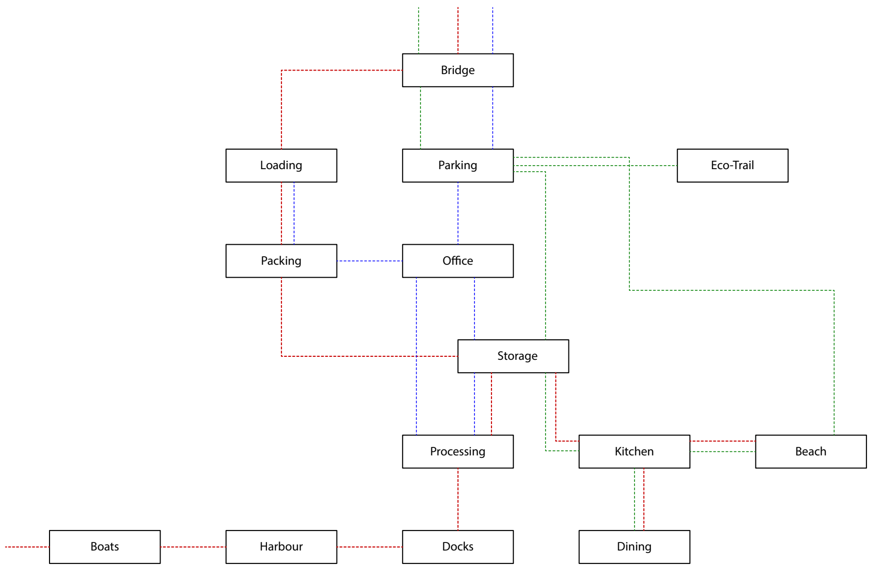


Figure 40: Diagram of the combined human systems of Halls Harbour

a) Harbour

b) Road/Bridge

c) Boat

d) Restaurant

e) Lobster Storage

f) Pier/Docks

Figure 41: Select components of the Halls Harbour systems

g) Lobster Pound/Processing Facility

Natural Systems

As was noted in the tourism system, some of the most important drivers of this economy stem from its natural systems. The first and most prominent of these is of course its Coastal tidal conditions. Under the current conditions Halls Harbour sees a tidal high of 13.3m above sea level. While this is not the daily occurrence its tidal ranges usually fall in the 10m – 12m range meaning a high level of variety for operating in relation to the coast. This system will of course also change as sea level rise occurs resulting in a future high tide that is as much as 15.5m above current sea level. This also means that when the other water layering is considered a storm surge could create a temporary condition where the water approaches 17-17.5 m above the current sea level. Understanding this system is therefore not only important for its relationships to the community's tourism but also for the ways in which it helps inform the coupling process through the bottom up approach described in chapter four.

Another important natural system is the geological and topographical make-up of the community. The community is located on either side of a fairly significant inlet which forms a sort of valley, with the harbour located at the mouth. This topographical configuration is both the reason for this settlement – as it allowed the original settlement to operate adjacent to such high tidal range – and a key tool to leverage in responding to the design challenges as it presents the potential for a gradient of activity down to the water level. Understanding this alongside the water system creates a full picture when the organization of the design proposal begins to come together.

7.6 | Threats to Halls Harbour

Based on the ideas discussed in this chapter, and the rest of this thesis, thus far it is also possible to outline the key challenges and threats faced by Halls Harbour and begin to develop the appropriate responses each of these requires.

Firstly and most obviously with the stated intent of this thesis is to design for the various water based forces and of course SLR in particular. For each of the water forces explored in Chapter One a particular plan of attack at a high level can be described. For waves the intent is to maintain the status quo condition of mitigating their effect on the internal harbour. For the tides the goal is to begin to leverage their forces to create a harbour that is able to efficiently operate at a greater percentage of the tidal range including at the lower tidal levels. For storm surges the design will place all those programs which can not survive the flooding out of reach of the projected water levels while simply allowing the other areas to temporarily flood in these conditions. Finally, as with the tides the redesigned harbour will consider the future tide levels associated with SLR to maintain an operation that is maintained or improved but not impeded by this change.

The second major set of threats are of course those related both economically and ecologically to the lobster industry posed by consolidation in centres like Digby. To combat this Halls Harbour must maintain its viability as an active harbour and be designed in a way that may accommodate increased demand on the industry as its overall demands shift north with water temperatures. By creating a viable and large enough operation in a different area of the fishery than Digby, Halls Harbour will create a stability in its region meaning a more equal distribution of fishing practices and thus its economic fruits, and ecological responsibility.

7.7 | Other Conditions of Note

This section is largely reserved for other notable conditions observed upon the site visit to Halls Harbour that while not directly a part of earlier discussion have a significant level of influence upon the design work carried out in part three of this thesis.

Chief amongst these observations is the flattened condition of the community's organization. Aside from the residential activity placed higher on the hill side away from all water forces the rest of the harbour based activity is treated equally all occurring at approximately 13-14m above sea level meaning that all of this is at threat of flooding under current storm conditions. While this forced relationship to the water may work for some of the harbour-based docking activities it is unnecessary for many other systems particularly the tourism and recreational.

This flattening becomes even more problematic in the wayfinding of the harbour. Upon arriving into the harbour area it is unclear where you are supposed to park, and what areas are accessible to who. An area that potentially presents itself as a public parking area for example is also utilised to store unused lobster traps and harbour equipment as shown in figure 42. While at a small scale this rawness may work as the harbour maintains its rough and industrial edge, however when complexities of varying levels and layers of accommodation enter into the discussion the small inconvenience of this lack of clarity may begin to cause more functional issues.

As the design looks to accommodate the variety of the systems and human flows involved this flattening becomes problematic and requires a more thought out organization and circulation. Thus this circulatory organization and overall identification of clear zones becomes an important part of the coupling process in planning the harbour, and the representation of these zones becomes an important task in the rendering of systems.

Figure 42: Photo of the current storage and lack of spatial definition in Halls Harbour

(Endnotes)

1 Tides4Fishing. 2017. *"Tides and Solunar Charts: Baxters Harbour."* https://tides4fishing.com/ca/nova-scotia/baxters-harbour, accessed December 11, 2017

2 Hope Shanks, *Halls Harbour Lobster Pound: Operation and General Information*, interviewed by Brandon Bortoluzzi (2018)

3 Canadian Science Advisory Secretariat, Assessment of Lobster (Homarus Americanus) in Lobster Fishing Areas (LFA) 35-38 (Fisheries and Oceans Canada, 2013)

4 *Management of Lobster in Atlantic Canada*, Cape Breton Fish http://capebretonfish.com/sustainability/management/

5 Hope Shanks, interview

6 Jesse Lecavalier, *The Rule of Logistics: Walmart and the Architecture of Fulfillment* (Minneapolis: University of Minnesota Press, 2016)

7 *Lobster by Trap, Bay of Fundy, Nova Scotia – Lobster Fishing Area 35*, This Fish https://thisfish.info/fishery/atlantic-lobster-canada-lfa35/

8 Canadian Science Advisory Secretariat, *Assessment of Lobster*

9 Ibid

“I’m sittin’ on the dock of
the bay
Watchin’ the tide, roll away
I’m sittin’ on the dock of
the bay
Wastin’ time”

- Otis Redding

Part 3 – Response

Based on the discussion and evaluation criteria presented in Part One and the studies in Atlantic Canada from the previous two chapters it is necessary to begin to test some of the ideas and concepts within the realm of a design proposal. Within the next few chapters the depth of systems, their organization, and interrelations will be explored through a design proposal. The proposal and the individual parts of it are to be seen as a cohesive whole but they should also be considered individually in as much as they explore specific ideas or experimentations that will be discussed in this Part.

Chapter 08 – Couplings of Halls Harbour

This design project, as a compliment to the preceding research body, is operating on two separate levels simultaneously. In one regard it is an experimental testing ground for a variety of tactics and methods of applying the modes of operation from Chapter Four. This means that in some ways it will present design work which may be somewhat redundant or unnecessary (for example multiple methods for designing the docking area of the harbour). At the same time however, the importance of the systems thinking within the theory means that a cohesive and comprehensive proposal for Halls Harbour must be the outcome of this series of explorations. To ensure this comprehensive and functioning proposal is possible it is important to start with the coupling as previously explained in Chapter Four.

8.1 | Top-Down Coupling

In Chapter Four two modes of operating within the coupling were considered. The first of these modes was the top-down approach in which the node was considered first and by running through its sub-systems in a descending order an organizational understanding could be developed. In Chapter 7, this process was started as the major systems of Halls Harbour and their components were considered. To push this further however, and to ensure the humanistic thinking carries through, 6 actors can be defined and their flows through the harbour treated as modes of engaging with these systems.

For the sake of this work these actors not only contributed to the coupling through their need for connection between various activities but also in defining what some of this programming and the space for it may be. It was previously noted that much of the area at harbour and dock level was very non-descript during the visit to Halls Harbour and so by considering ways tourists, locals and other groups alike may use the harbour allowed more informed decisions about how certain spaces should be structured. This means that while the components they engage with largely coincide with those from the previous systems diagrams there may be some new additions that a multitude of perspectives brought to the project.

Actors and Flows

The first group is the typical group of tourists to the community represented by the Harvey family. The Harveys represent the typical East Coast summer vacationers looking to get the experience of the fishing harbour town for which Halls Harbour is known. This means that their trip involves taking in a number of vantage points within the harbour as well as enjoying a meal from the restaurant. While their flow largely touches on a number of the components of the tourism system it helps define the connections and contributes to a way about thinking about a dynamic engagement. This path is represented in figure 46a.

The Harveys

Cathy

Next, Cathy is also a tourist to the site but of a different variety. A resident of Halifax Cathy makes trips out to Halls Harbour regularly for the eco-tourism opportunities. This includes engaging with the inland hiking and walking trails as well as the cliffs, caves and waterfalls along the eroded shoreline. Cathy's flow, indicated by figure 46b, informed the addition of certain pathways to access features of the site that may have been otherwise overlooked.

Jim and Edna

After the two tourist groups were explored in the previous actors flows a number of local residents also presented as important to consider. Firstly, Jim and Edna are an elderly couple who do not take part in much intensive activity in the harbour but rather use it to get out in the fresh air and read a book. For this reason, their path is not all that intense but nonetheless presents a unique look at the harbour. They largely come from their home to the pedestrian bridge access and down to whatever level of the 'leisure dock' is available at the current tide.

Mark

The fourth user, also a local is more a part of social gatherings on the site. For Mark the harbour is his time to shine in the planning of local events. Often at the helm of social gatherings Mark can usually be found socializing all around the leisure docks area but in particular at the community living room/ amphitheatre where many of these events occur. Marks flow (relatively simple) is highlighted in figure 46d.

Despite the simplicity of the two previously discussed locals' flows they were largely important in defining the spatial considerations of the more recreational 'leisure docks' area. The non-descript current layout of the harbour means that when activity is not present (as was the case during the winter site visit) then the uses not physically defined within the harbour are not visible. By choosing to consider these users, based partially off a knowledge of the types of activities hosted locally it became possible to determine spatial and formal needs for their activity including these community events.

The other major local flow is the lobster pound employee Hope. Hope lives in town and works at the lobster pound and so her flow as identified here runs from the local resident system to the lobster processing system. This flow is outlined in figure 46e. While Hope engages with some of the other local resident activities as explored in the previous two actors, the purpose of this flow is to identify the dispersion into a variety of activities at the lobster pound.

Hope

Finally, where the flow of the local resident employee ends and disperses to various activities at the pound the path of the lobster also overlaps but in a much more linear manner. The lobster is of course the major input into the system as it relates economically and culturally to the activity and is also the major output whether to the restaurant on site or to international and domestic distribution. The flow of the lobster is outlined below in figure 46f. The lobster starts externally to the harbour at the point of catch, next entering the harbour and being transferred to the lobster processing facility at provisional dock. From here it goes through the 4 steps within the pound and processing facility, which will be detailed further in Chapter 9, and finally exits the system to the distribution. The lobsters path finally concludes in one of 3 ways, either going to the restaurant, external shipping, or release to the ocean by a naïve tourist.

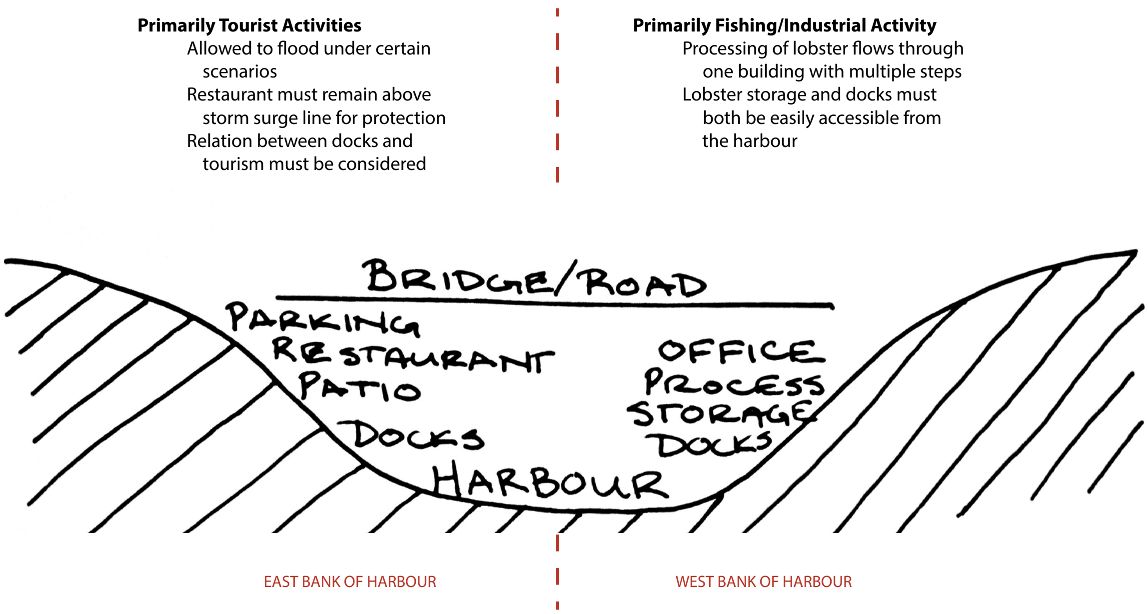
The Lobster

8.2 | Bottom-Up Coupling

Simultaneously the systems of Halls Harbour and more specifically the components were considered in a bottom up manner which privileged the water as the main entity to which their relation was considered. Figure ## shows a table highlighting this relationship of certain elements to possible elevations that relate their existence to the specific water levels that the harbour occupies (from tidal ranges, SLR and storm surge). This manner of thinking creates a gradient of connection that when paired with the topographic conditions of site begins to structure the project.

Figure 43 shows the combination of these two factors in a schematic manner. The East Side of the harbour where a majority of the residential activity is located takes on much of the tourist activity while the west side continues to be the main industrial (fishing) program. The layering within this organization creates a spatial distribution which, when paired with the flows and ideas developed from the top-down approach, leads to a comprehensively structured design.

Figure 43: Schematic organization of Halls Harbour



	Water Level Relation	Harbour Activity	Tourtist Activity	Lobster Pound Activity
24m				
23m				
22m			Vehicular Bridge	
21m				
20m				Office Level
19m				
18m			Visitor Parking/Pedestrian Bridge	
17m	Project Storm Surge Level at Future High Tide		Restaurant	
16m			Restaurant/Patio	Loading and Packing
15m	Approximate Projected High Tide Level (15.6m)	Docking Ability	Various Staggered Decks	Sorting
14m		Docking Ability	Various Staggered Decks	Lobster Storage
13m	Approximate High Tide Level 2018 (13.3m)	Docking Ability	Community Area	Lobster Storage
12m		Docking Ability		Lobster Storage
11m		Docking Ability		Lobster Storage
10m		Docking Ability		Lobster Storage
9m		Ability to Enter Inner Harbour (~9.5m)		Lobster Storage
8m	Current Designed Control Harbour Level	Docking Ability		Lobster Storage
7m				
6m	Lowest Level Within Harbour			

Figure 44: Program of Halls Harbour and its relation to varying water levels

8.3 | The Outcome

The sum of these efforts is presented in figure 45 which shows the entire layout of the proposed design intervention in axonometric. The major components that are part of the user flows are highlighted along with their level relative to sea-level and a description of which systems they belong to. It is important to note that while this coupling is presented first in this thesis document the level of resolution in this axonometric and some fine tuning to the actual organization is due to a simultaneous exploration of accommodation at the component level as will be explored in the following chapter.

Figure 46 shows the user flows described earlier overlaid onto the axonometric view. This illustrates in a visual manner how each component is engaged by different users, a concept further explored in Chapter Nine. With these larger coupling and organizational moves made clear it is now possible to go through a detailed view of the individual components of the design.

COMMUNITY SPACE
ELEVATION 13m - 14.5m
System: This falls within the realm of tourism as well as the local residential system as it shares a relationship with both sets of activities

PEDESTRIAN BRIDGE
ELEVATION 18m
System: The bridge acts to connect the other components and was a response to the lack of flow organization in the current Halls Harbour

CONTROLLED HARBOUR
ELEVATION 8m+
System: The controlled harbour attenuates the tidal variety by creating a bottom parameter allowing continuous harbour activity

RESTAURANT
ELEVATION 17m
System: The Restaurant is a key feature of the local tourism but also directly relates to the systems of the local residents and of course the lobster who has it as a possible destination

BOARDWALK
ELEVATION 14m
System: The boardwalk connects to the tourism systems and adds a layer to the existing hiking and natural sight seeing. It also serves as an erosion control measure on the residential shoreline

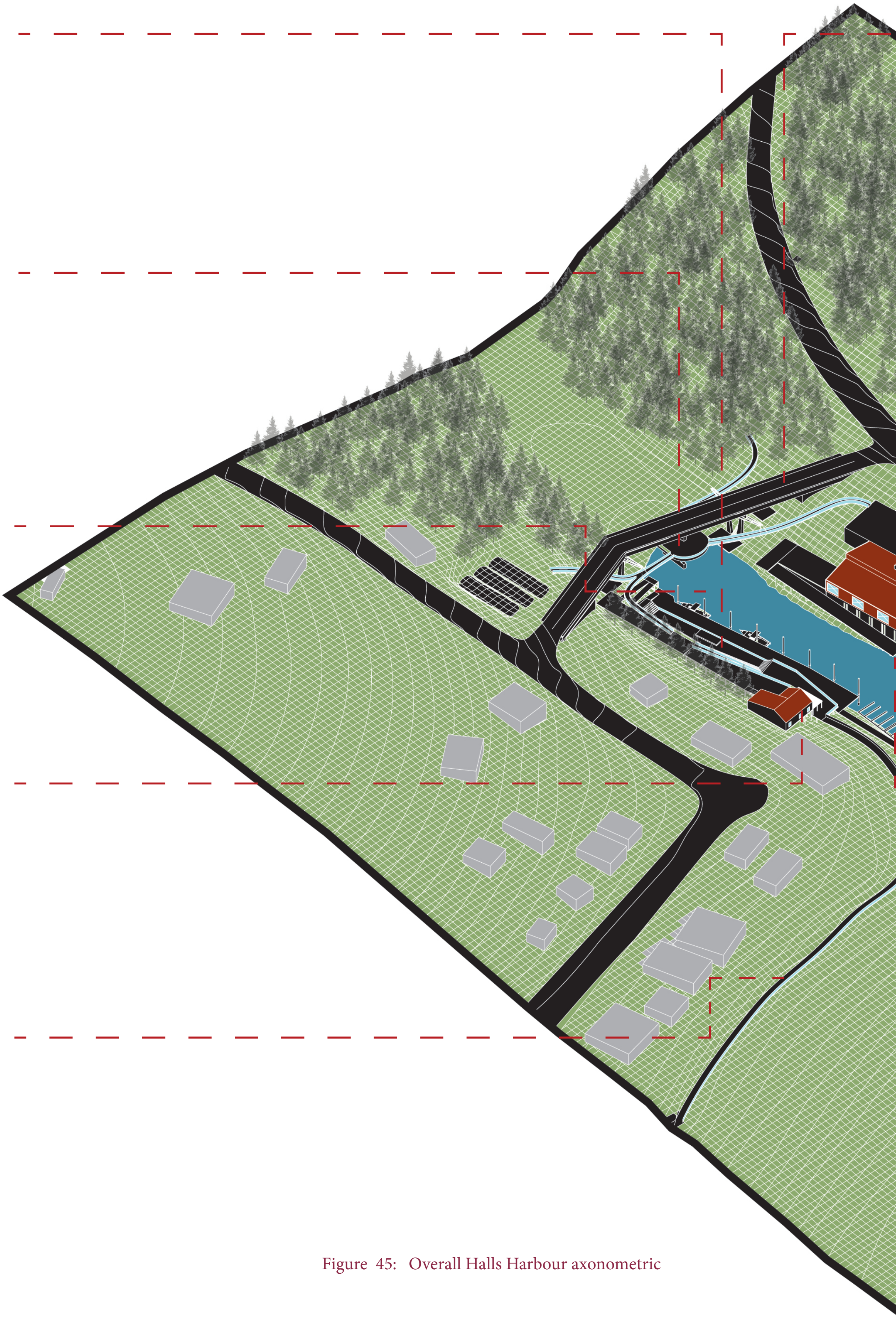
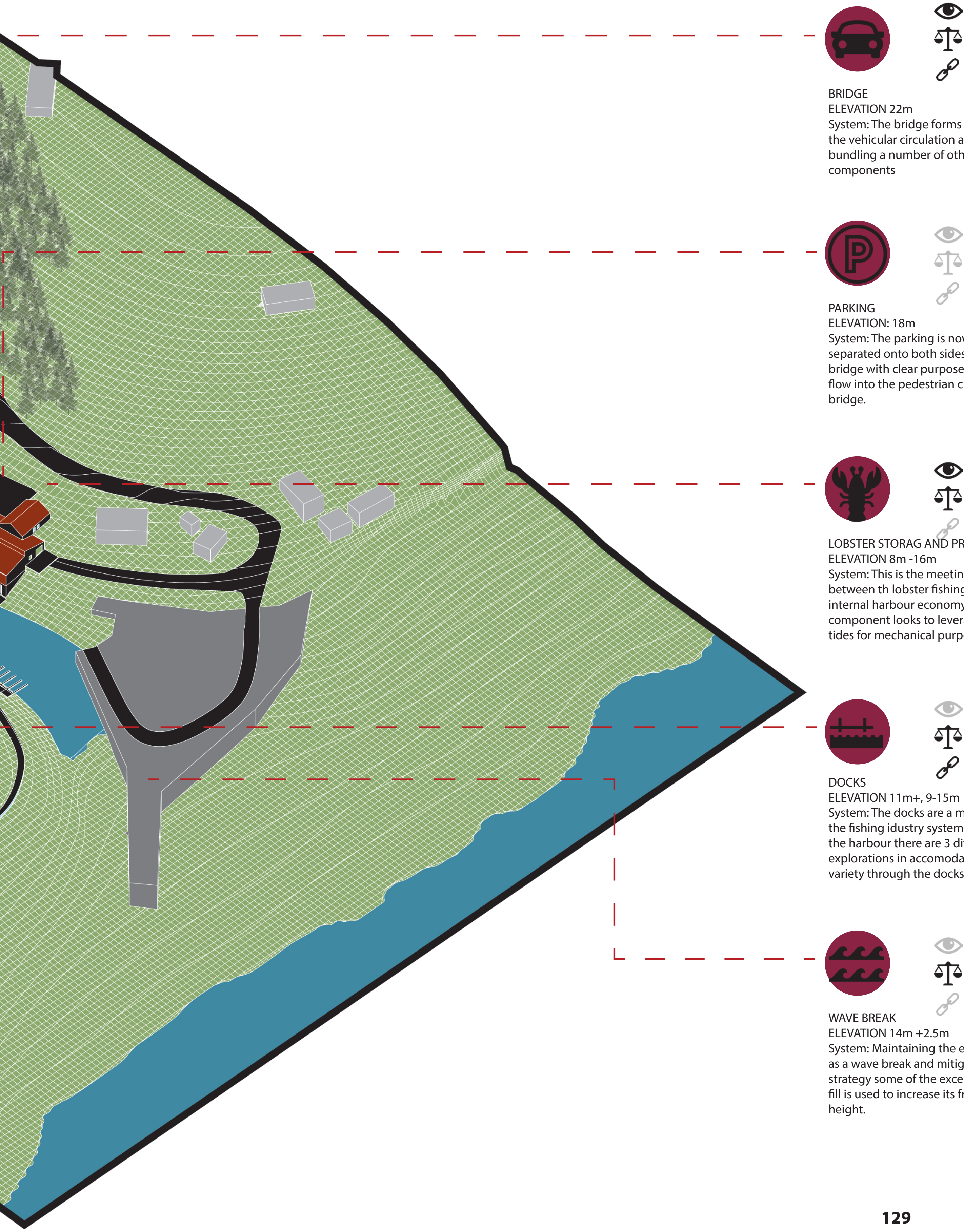


Figure 45: Overall Halls Harbour axonometric



BRIDGE
ELEVATION 22m
System: The bridge forms a part of the vehicular circulation as well as in bundling a number of other components

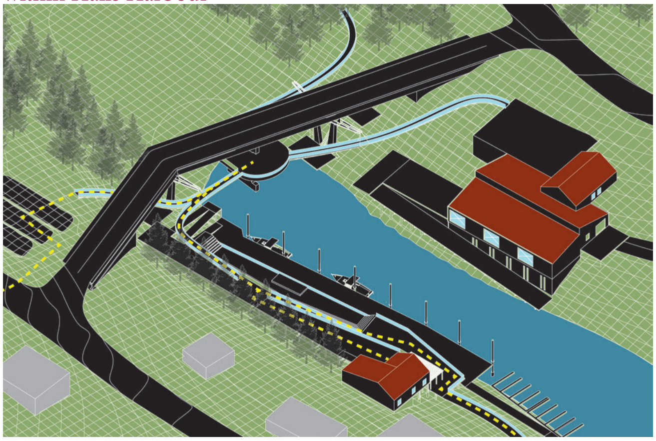
PARKING
ELEVATION: 18m
System: The parking is now separated onto both sides of the bridge with clear purpose. These flow into the pedestrian circulation bridge.

LOBSTER STORAG AND PROCESSING
ELEVATION 8m -16m
System: This is the meeting point between th lobster fishing and internal harbour economy. This component looks to leverage the tides for mechanical purpose.

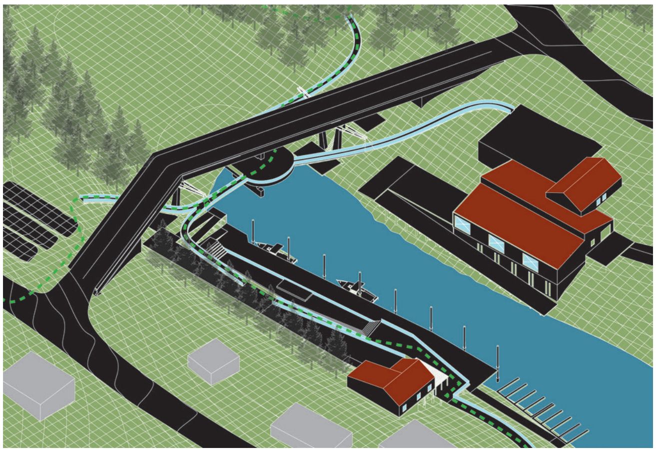
DOCKS
ELEVATION 11m+, 9-15m
System: The docks are a major part of the fishing idustry systems. Within the harbour there are 3 different explorations in accomodating variety through the docks.

WAVE BREAK
ELEVATION 14m +2.5m
System: Maintaining the existing pier as a wave break and mitigation strategy some of the excess removed fill is used to increase its front edge height.

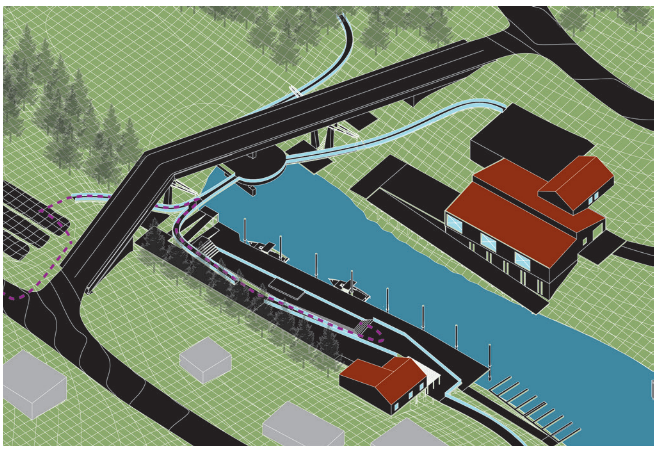
Figure 46: Activity flows within Halls Harbour



a) *The Harvey's - A young family on an East Coast vacation they want to take in the sights, sounds and eats of a true fishing harbour.*



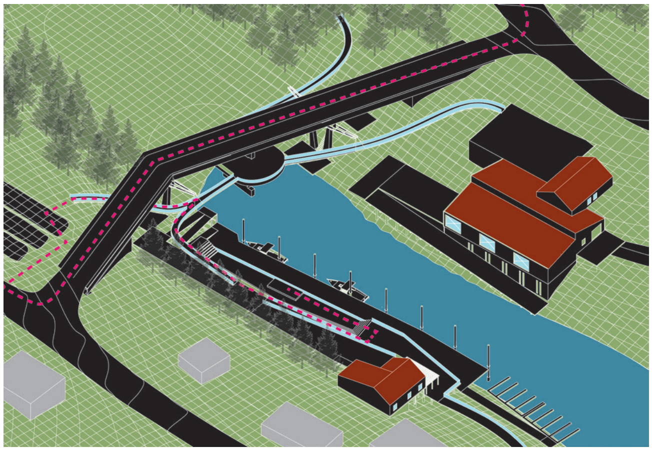
b) *Cathy - Is native of Halifax, but makes regular trips to Halls Harbour not for the harbour itself but rather the hiking trails both inland and along the cliffs*



c) *Jim and Edna - An elderly local couple who visit the harbour on weekends to sit in the sunshine and read a book. Their visits have become a tradition.*

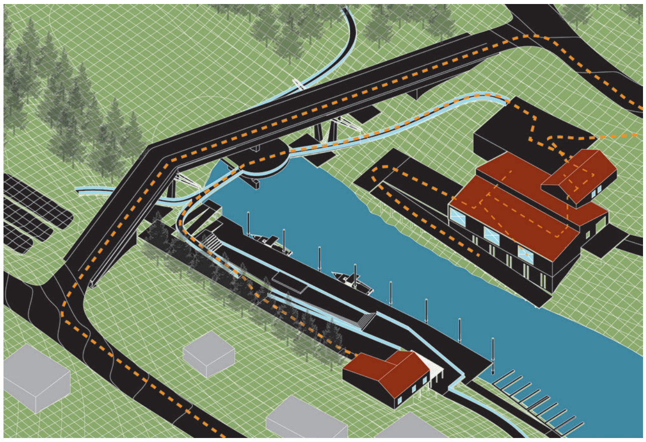
Mark - is the local social king, always involved in running events particularly in the dockside amphitheatre. He prefers to get to the harbour on foot using the boardwalk out his back door.

e)



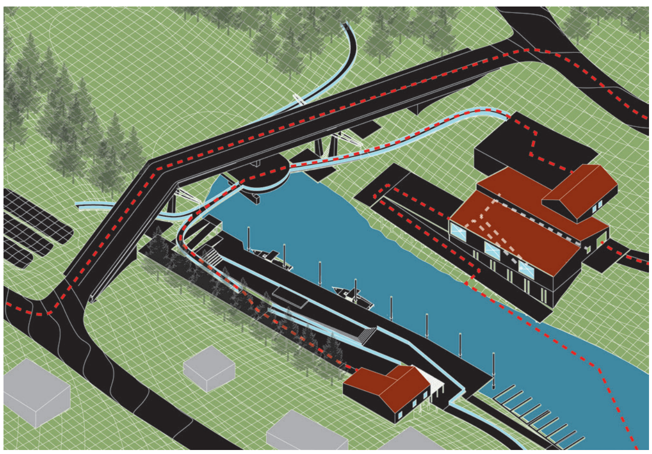
Hope - is not only a local resident but also a staff member at the local pound, while her days vary greatyl they could take her anywhere from the office to the dockside receiving the latest catch.

f)



Lobster - The raison d'etre for the harbour this creature is caught in the Bay of Fundy by a local fisherman who brings him in for sale to the pound where he is sorted, and distributed for market sale.

g)



Chapter 09 – Accommodating Variety in Halls Harbour

Alongside the coupling and organization of proposed design elements the specific details and functions of these components, and how they work to accommodate variety and create parameters for the harbour, are of equal importance. As was discussed previously (in chapter four) variety can be accommodated in one of two ways; through either an amplification or an attenuation by some regulator.

9.1 | Attenuating Variety and Defining the Harbour Condition

The first components of the design explored here are important elements in defining the harbour's extents and creating a controlled condition within it. In both cases these interventions work to create this controlled harbour through attenuation though in both cases the actual means and thus the components are very different.

The first of these is the dredging and berming used to create the controlled harbour condition. In its current operation the slope into the harbour mixed with the tides means that it is very difficult, if not impossible to dock in the harbour at all when tide levels drop below 8m, and certainly not within the inner harbour whose current maximum ground height is at that 8m level. Along with this any boats in the harbour when low tide occurs sit on the bottom making the conditions harder for provisioning and servicing boats to be ready to head out at the next tide.

This first component uses that current 8m entry point (a normal around which the harbour scheduling already operates, and which will begin to last longer as the sea level rises) but creates an inner harbour which never fully drains meaning that boats within the harbour can move around, be launched or pulled and be serviced or provisioned at any time. To do this the mouth of the harbour is bermed to the aforementioned 8m height while the inner harbour itself is dredged to a depth of 6m. Thus, when the tide is high boats may enter and leave the harbour as they currently do, and as the tides go out again there is still a 2m depth within which boats may float. While this is new to the current harbour condition it actually reflects a previous condition of the harbour which was considered one of its great draws in previous years.[1]

This is a form of attenuation by the way it begins to apply a control variable to the water within the harbour shortening its bottom parameter to 8m as opposed to 0m above sea-level. This also begins to work towards allowing the intended goal of operation throughout tidal ranges as was mentioned in the first chapter of this thesis. The images in Figure 47 which continues through the next few pages are frames from a video depicting one-foot increments of tide and how the harbour activity changes with each indicating a number of things including the point at which a boat can enter the harbour, the current high tide, and all water levels from 0m to the future high water level.

Accompanying this intervention, the harbour also continues to be defined by the pier that sticks out into the Bay of Fundy from the western side of the harbour. This pier acts to attenuate the wave forces effects on the harbour by dispersing the forces outside of the inner harbour condition. To achieve this largely maintains the pier as it currently exists however shifting the function to largely boat storage and servicing as well as launching/pulling, as the building programs currently located there are moved to more appropriate elevations relative to their function. In addition, the rock wall built up along the north edge which works to block much of the wave forces will need additional height as SLR occurs to accommodate the shifting heights of waves; some of which may come from the dredged harbour material.

It is also important to note that this element is the only resistive strategy deployed within the project. While the early chapters of this thesis stated some issues with operating in a resistive manner the operation for wave mitigation is not only a small enough scale deployment of the strategy but also reflects the intended goal of mitigating or eliminating wave effects as explained in Chapter One; the only water related force for which this was a stated goal.

Figure 47: Stills of changing tides in the controlled harbour (one foot increments)

1

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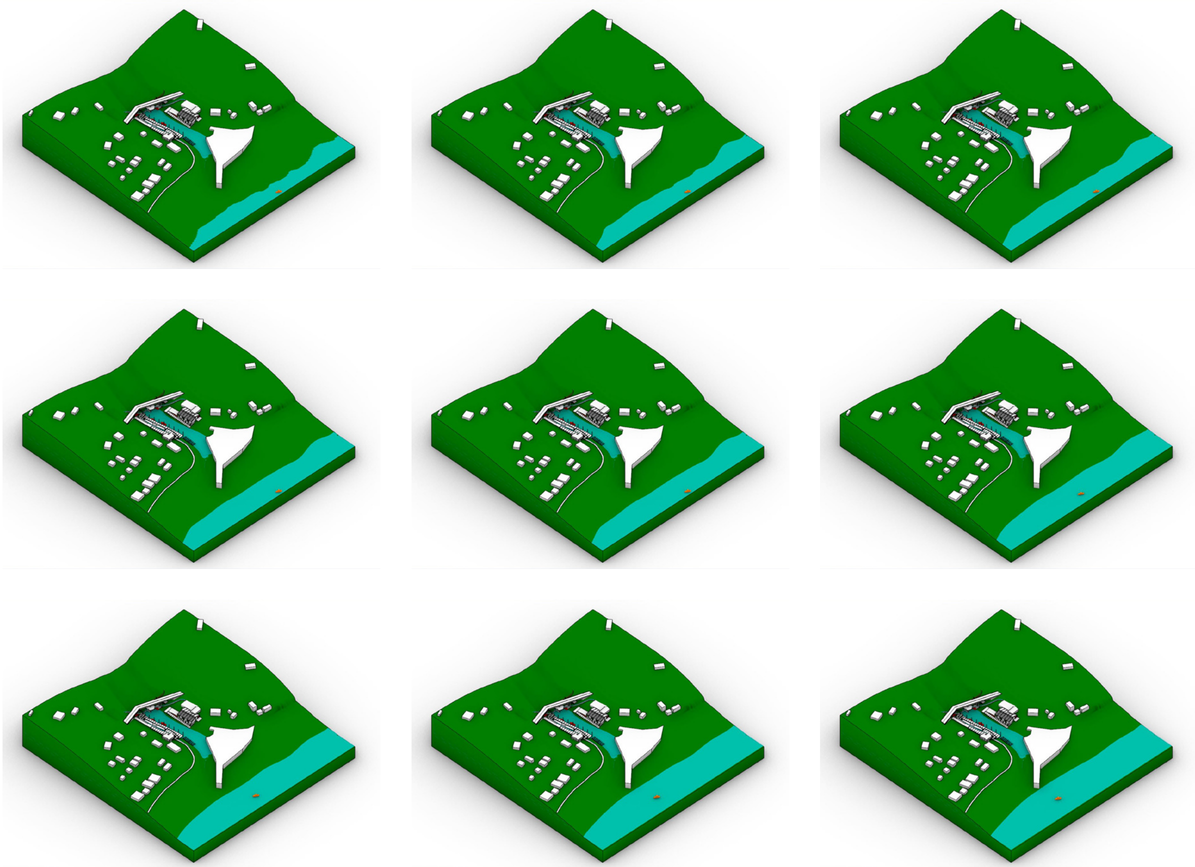

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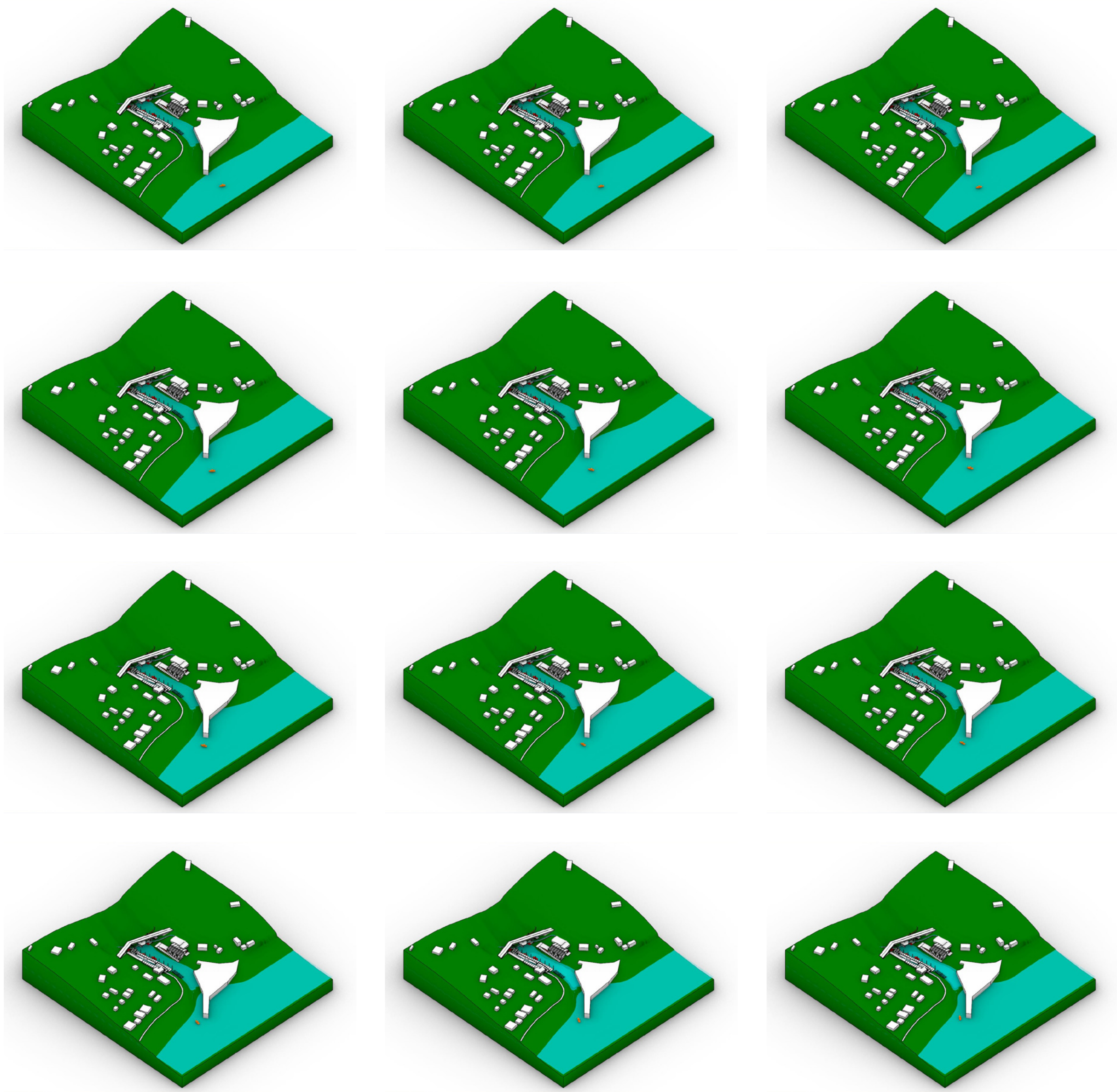

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10
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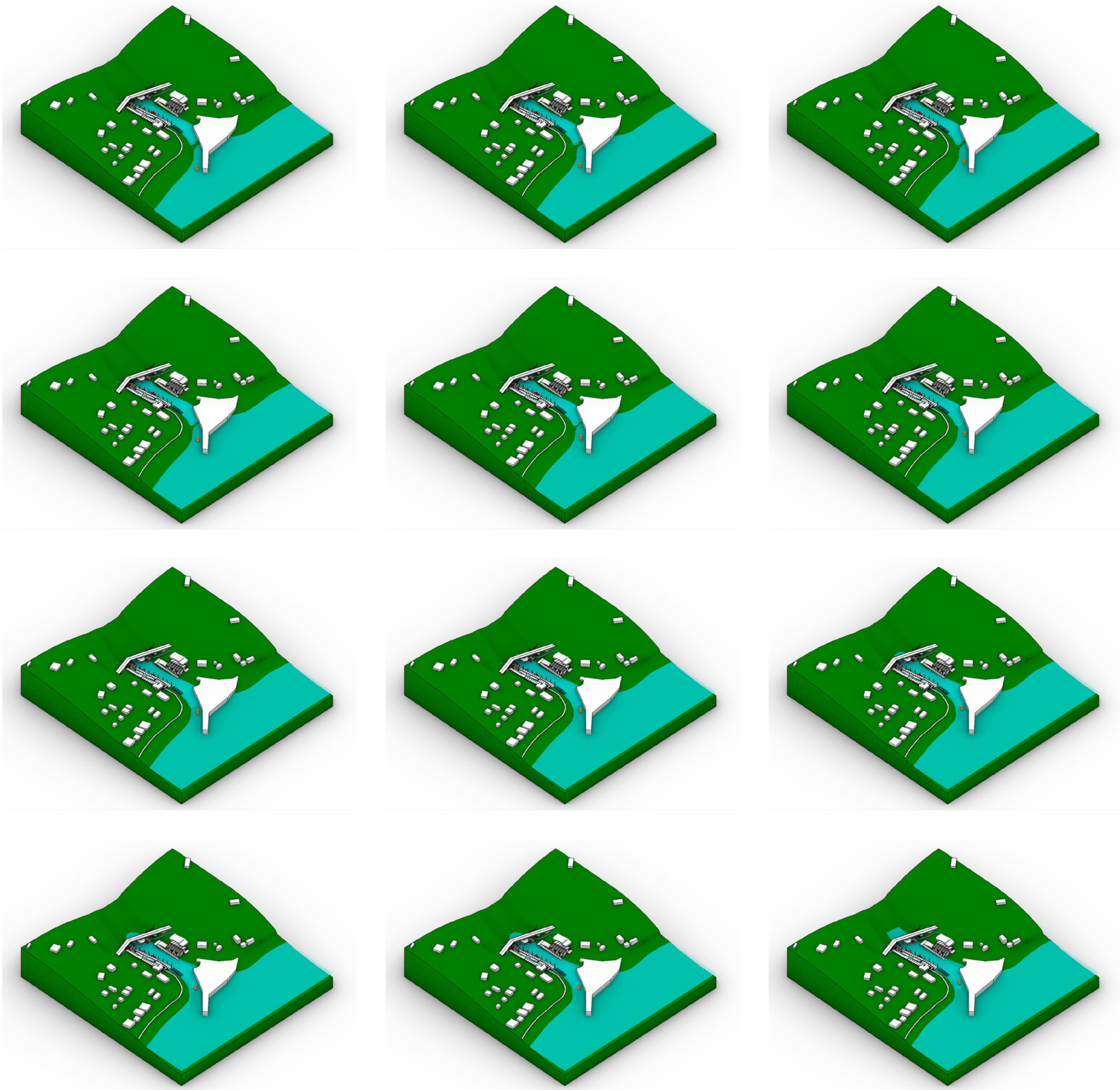

12
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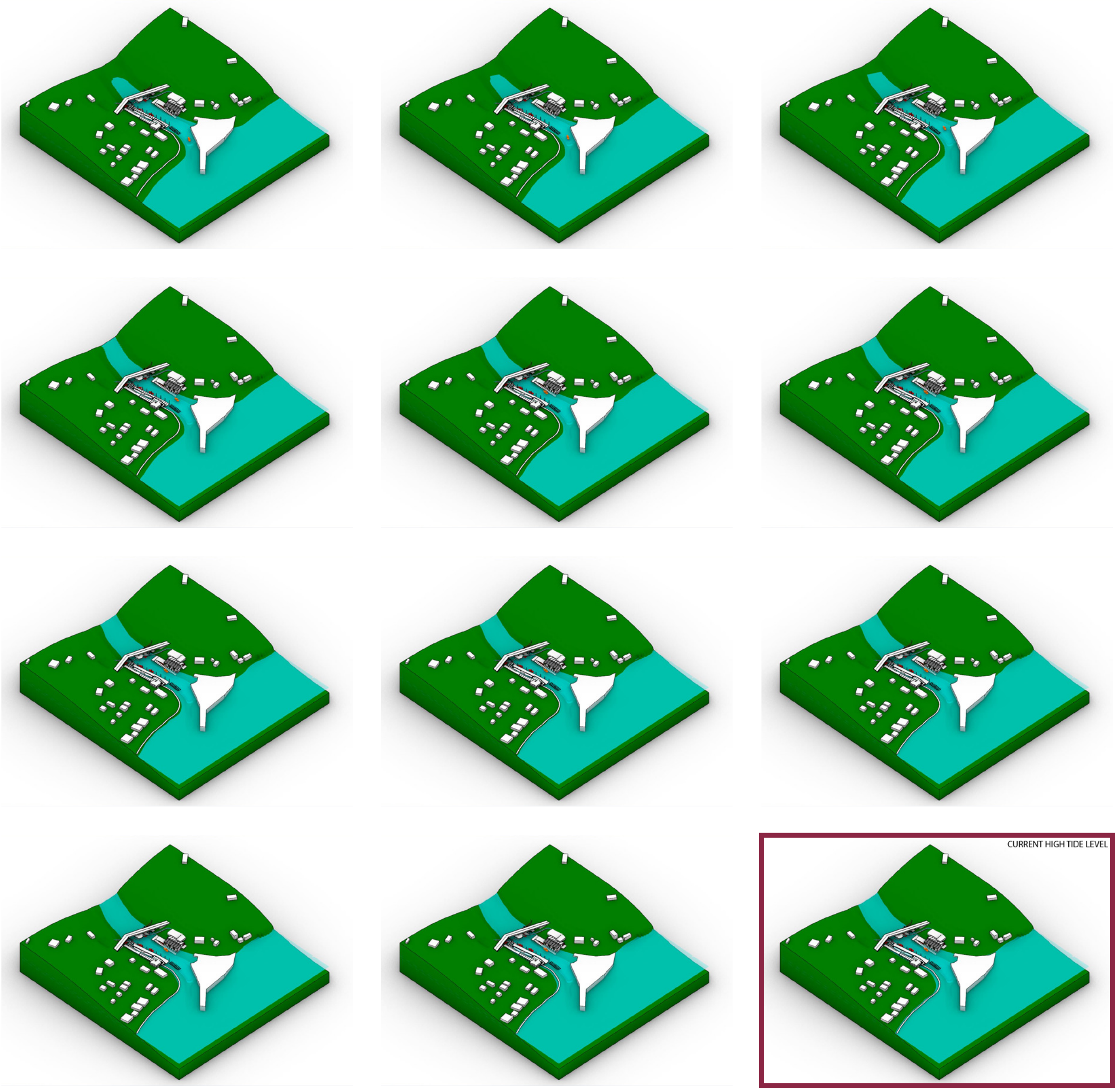
14
15

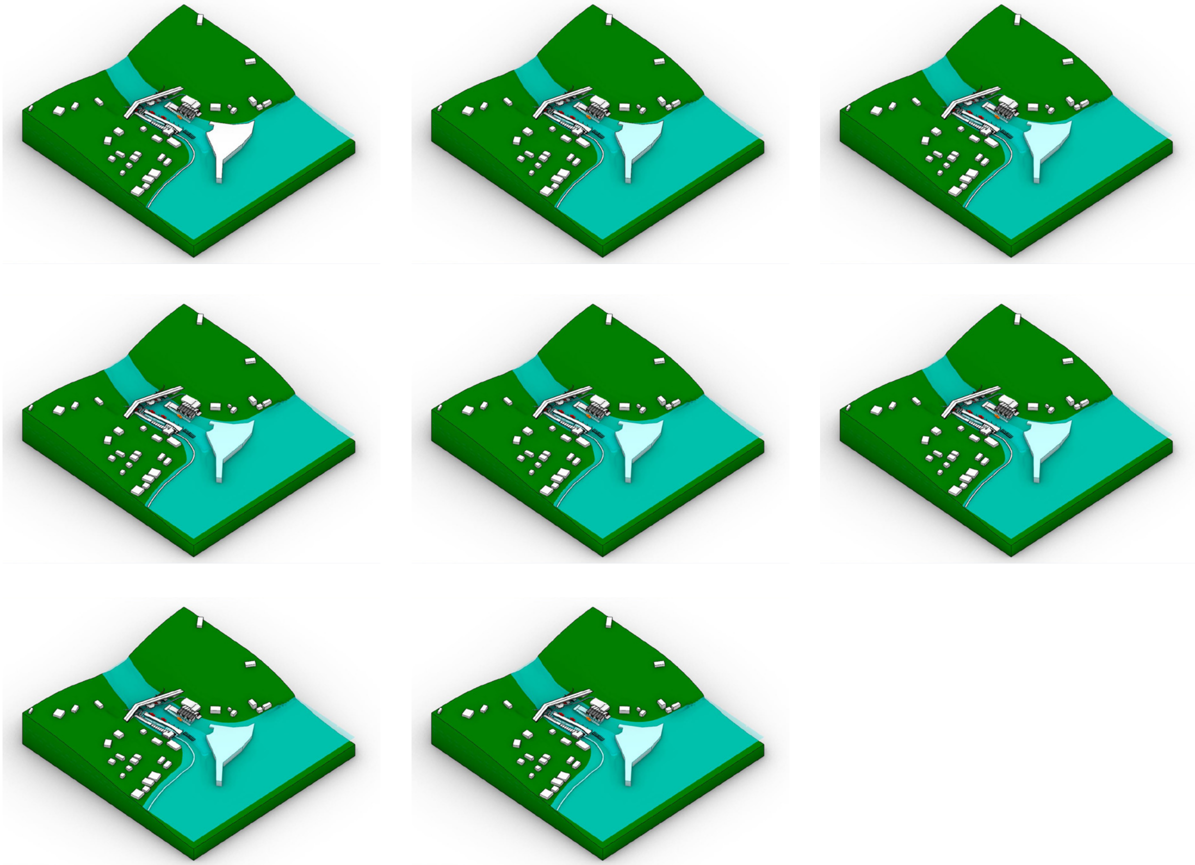


CURRENT HIGH TIDE

16

17

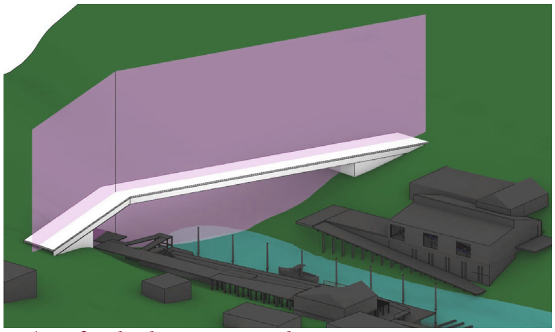
18



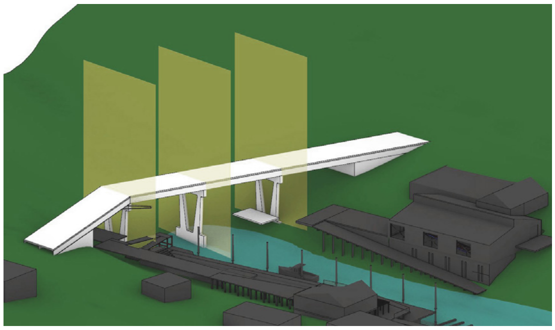
9.2 | The Bridge – Bundling and the Accommodation of Circulatory Variety

The rest of the components described within this chapter can largely be explored or at the very least introduced by the user flows which aided in their design. The bridge however represents the one component with which all of these flows interact in some way. Within the bridge component there are a number of components each of which interacts with one or more of the flows and systems and works to accommodate varying forms of variety. The components which make up the bridges bundling are: (1) the main vehicular bridge (2) the pedestrian bridge with a lookout platform at the midpoint, (3) the structure, and (4) the floating docking

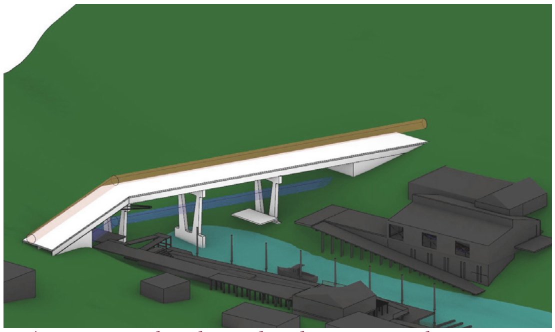
Overall the bridge bundles each of the aforementioned components while its design was largely driven by 4 main ideas. (1) The bridge was to define a rear condition for the harbour largely in line with the accessible zone under current and projected tidal conditions, (2) the structure of the bridge was to be spaced (20m) and positioned (parallel to the harbour banks) in such a way to



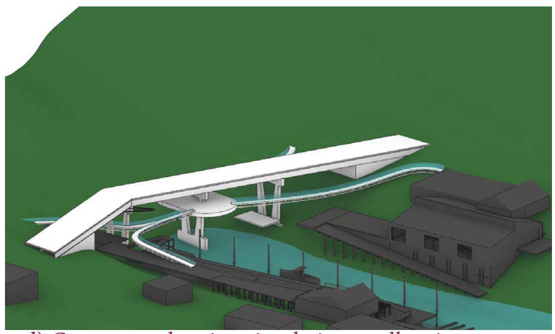
a) Define harbour rear condition



b) Space structure (20m) for boat docking and future expansion inland

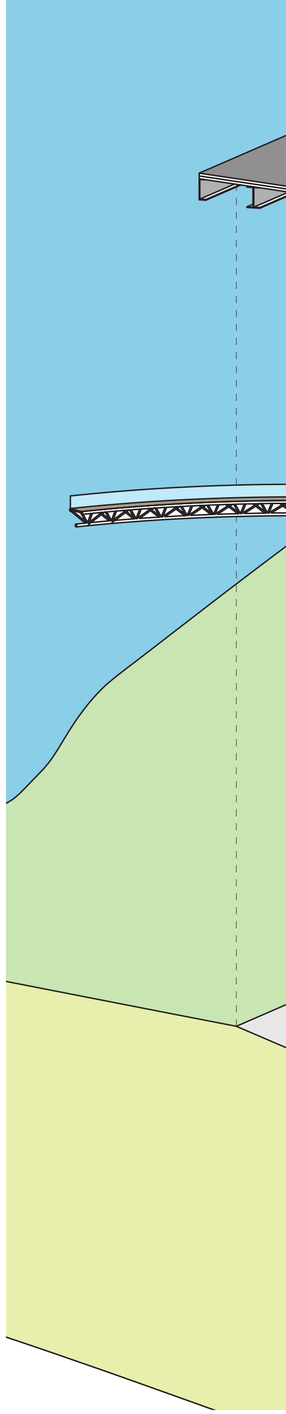


c) Separate vehicular and pedestrian circulation routes



d) Connect pedestrian circulation to all active zones

<
Figure 48: Bridge design drivers



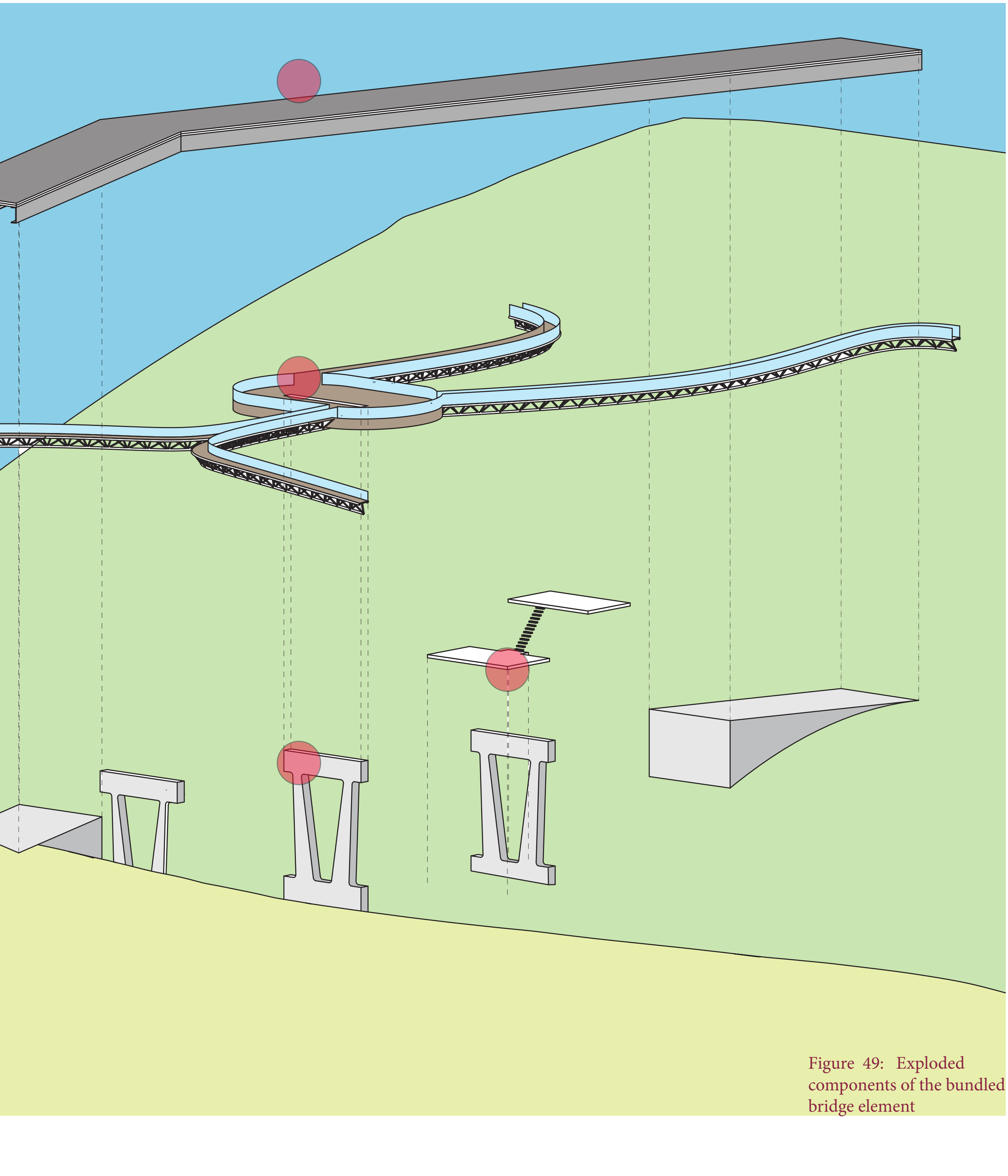


Figure 49: Exploded components of the bundled bridge element

allow possible future expansion of the harbour beyond the bridge as the sea level continues to rise, as well as allowing ample space for docking and boat movement underneath, (3) to incorporate a clear separation of pedestrian and vehicular circulation paths in response to the previously discussed flattened condition of the site, and (4) to allow the pedestrian circulation path to clearly define routes for different users looking to access different parts of the harbour.

The separation and clarification of circulation routes is a mode of attenuating the variety of circulation flows (which largely stems from choice). The flattened condition of the site as described in Chapter Seven which left the choice of route open-ended is no longer viable with the current site coupling and thus to make the circulation clear an obvious delineation is required. This separation of paths is also a mode of rendering as was described in Chapter Four, by making clear the systems of different groups.

The docking under the bridge is the first of three docking explorations within the design. In this case as with the others the docks look to amplify the variety of the inland activity to match the variety of the harbour and tidal systems using the dock as the regulating component. In this case the dock is anchored to tracks on the bridges main structure which hold its lateral position while it floats up and down with the tides making it an always viable docking option. To access the docks a similar idea was translated into steps which use treads that individually float and interlock to create a path of travel. While these steps mean this dock is not wheelchair accessible all other docks within the harbour are meaning this could be used to experiment with this system. The dock and its accompanying floating steps are shown in the plan and section in figure 50 as well as the model photograph figure 51.

While the bridge is universally used as a circulation and access point by all users the other two interventions or high-level components are the main points of activity and program within the harbour. These two interventions are located on either side of the bridge on the east and west shores of the harbour and represent the split of the two major economic systems described in the previous chapter.

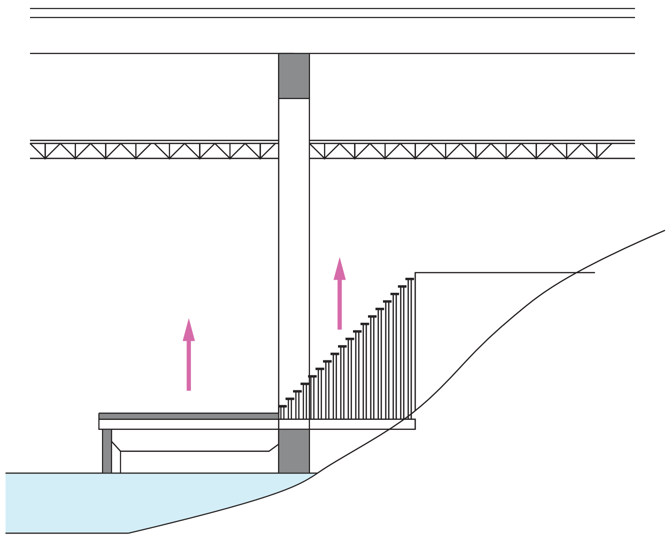


Figure 50: Section of under bridge dock

Figure 51: Physical model of under bridge condition 1:100

9.3 | The East Harbour Bank – The Intersection of Tourism, Recreation and Industry

When organizing the coupling in the previous chapter a clear separation of much of the industrial (fishing) and recreational activity in the harbour was defined at a high level to begin to structure the programmatic functions. Despite this the relationships to the water as defined by the bottom up approach means that it made most sense to keep docks at the harbour level meaning that the area on the east begins to represent the interaction of recreational and industry activity.

The various activities and components of the east bank are shown in the plan in figure 52. Related to the tourism industry and local residential activities the 'leisure docks' contains the Halls Harbour Lobster Pound Restaurant as well as outdoor areas for eating. In addition, it connects to a boardwalk system which leads across the beach section to the cliffs to the far east of town and is an erosion control buffer for the residential area. Finally, as the harbour is an important part of social activity in the community including barbecues, holiday celebrations and other large events including music and festivals a sort of community living room in an amphitheatre form completes the recreation programming.

Legend

1) Connection to Pedestrian Bridge

2) Halls Harbour Restaurant

3) Community Amphitheatre

4) Leisure Decks/ Patio Space

5) Commercial Fishing Docks

6) Connection to Boardwalk

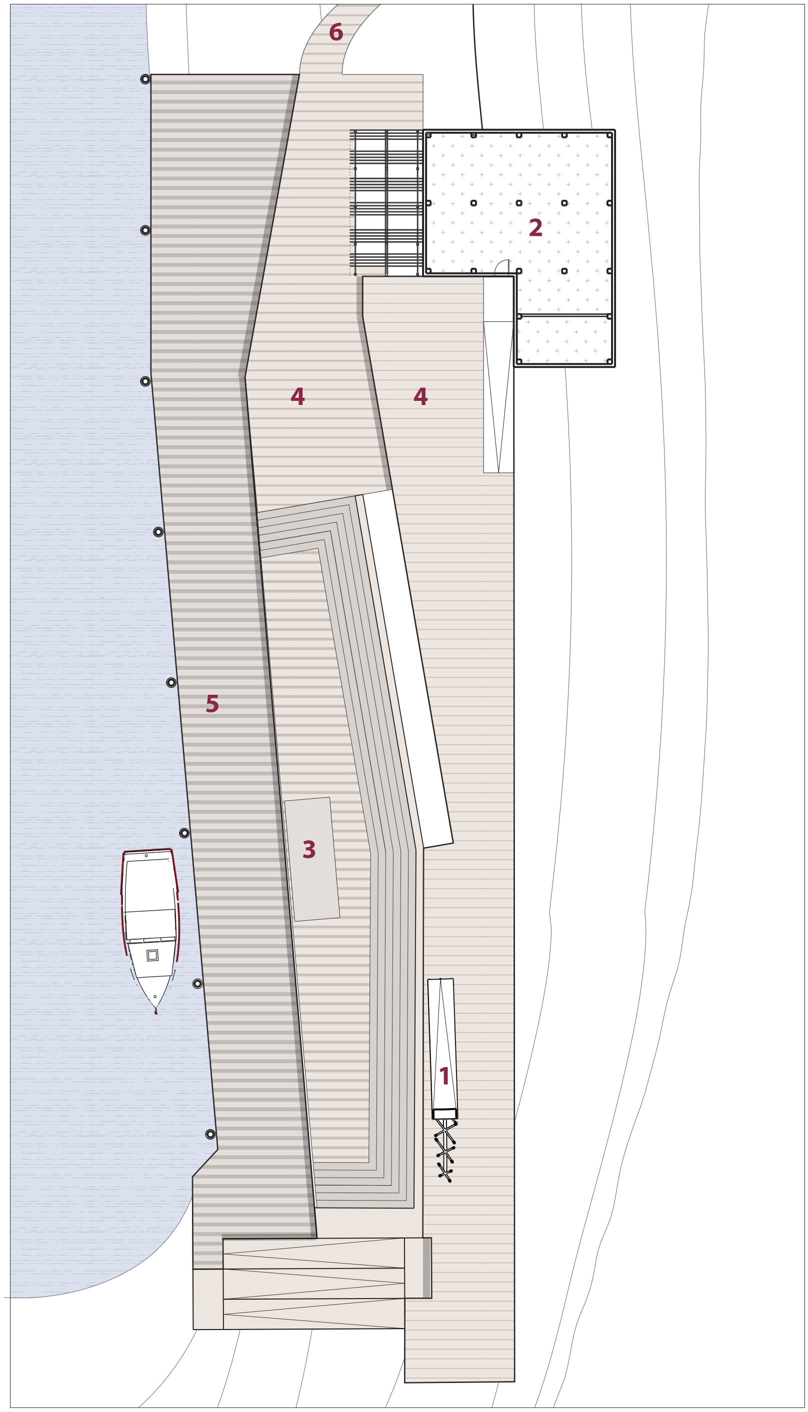


Figure 52: East bank leisure docks area

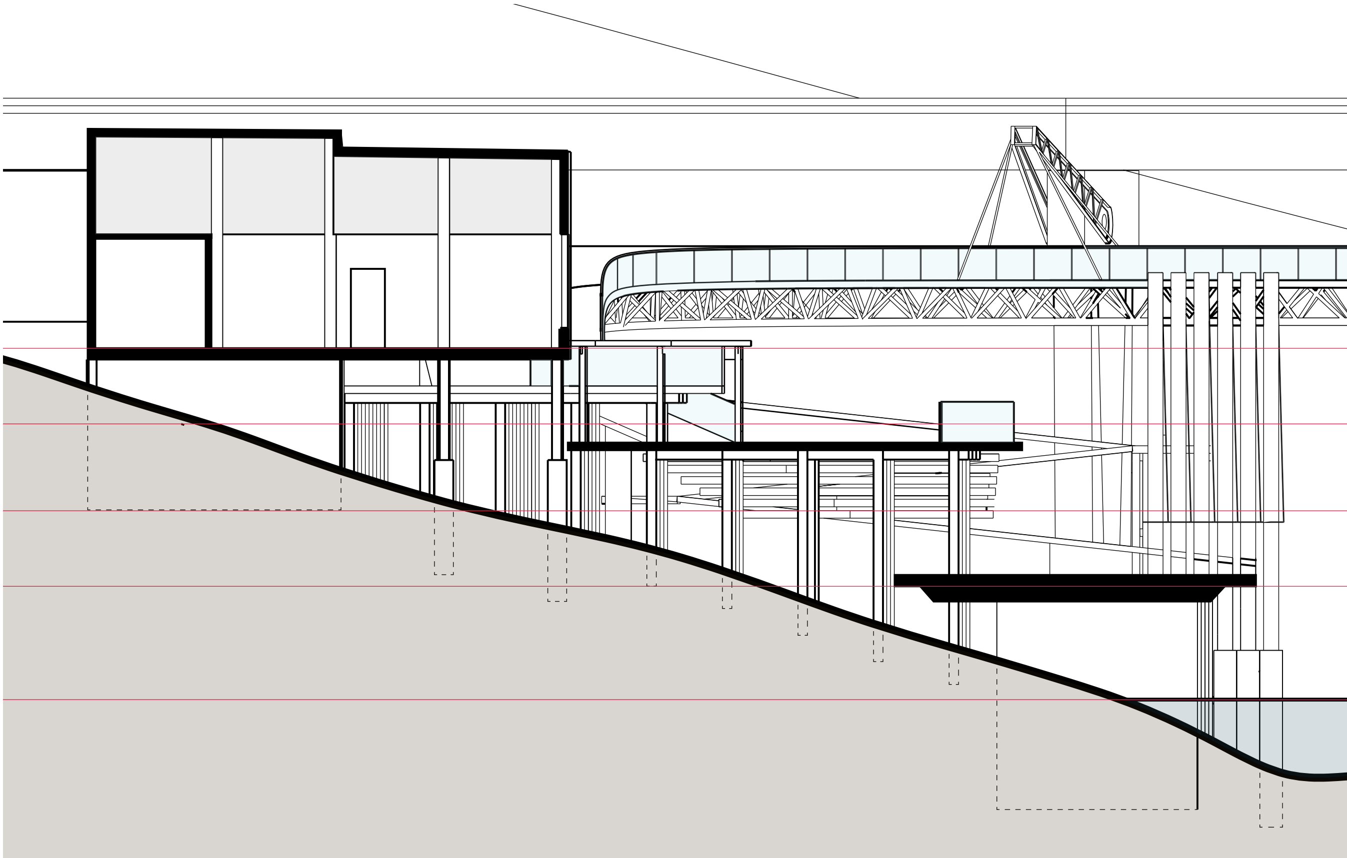
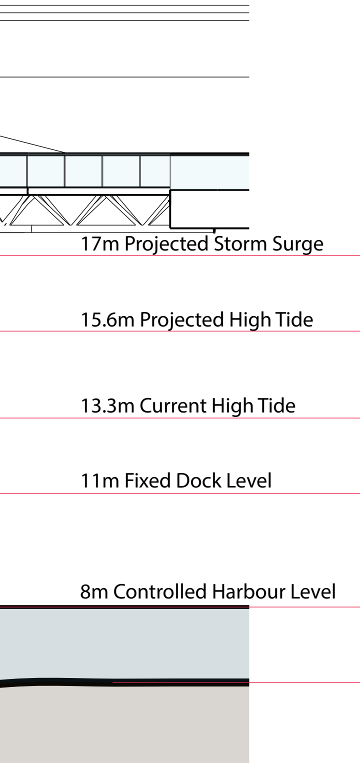


Figure 53: Section through restaurant and docks 1:200

Section through restaurant and docks showing various water levels relation to dock/harbour levels. Key items to note are the bottom of the community amphitheatre at the current high tide level and the restaurant located above the projecte storm surge level.



Most of this program accommodates variety through its staggered layering of activity up the bank of the harbour. While the amplification to accommodate variety is most often made easiest through dynamic components as regulators this staggering actual falls on the rigid side of the flexibility matrix. It also considers the goals for accommodating the different water forces from Chapter One. As figure 53 shows it allows function to operate in some capacity by retreating up to a higher elevation at the different heights associated with tidal range and SLR. Under storm surge conditions however most activity is unable to take place due to being overcome with water, however these areas are largely outdoor spaces that would not be damaged by the flooding. The restaurant however is isolated above all of this meaning that in a storm event it would not be accessible but would also be protected from the brunt of the flood and water damage. This multi-layered structure is shown in figure 53 showing a section through the area with major waterlines under different scenarios indicated.

Functionally the dock area required some more in depth thinking about accommodation of variety. This is the second exploration of docks and variety within the project and operates somewhat similarly to the previous docks in the bridge bundle. Figure 54 shows the exploded layering of this dock which rests on concrete piers above the harbour's controlled 8m water level. Similarly, to the bridge docks it acts to amplify the inland harbour activity's positional variety relative to the tides and water systems. As the water level rises the docks floats lift it above the water level while the steel posts anchor its lateral positioning. Access to these docks is done through a series of hinged ramps which shallow out as the tides bring the dock closer to the top level and return to a normal slope when the dock comes to rest. Figure 55 shows the docks in plan view at various tidal heights focusing on the relation to water level.

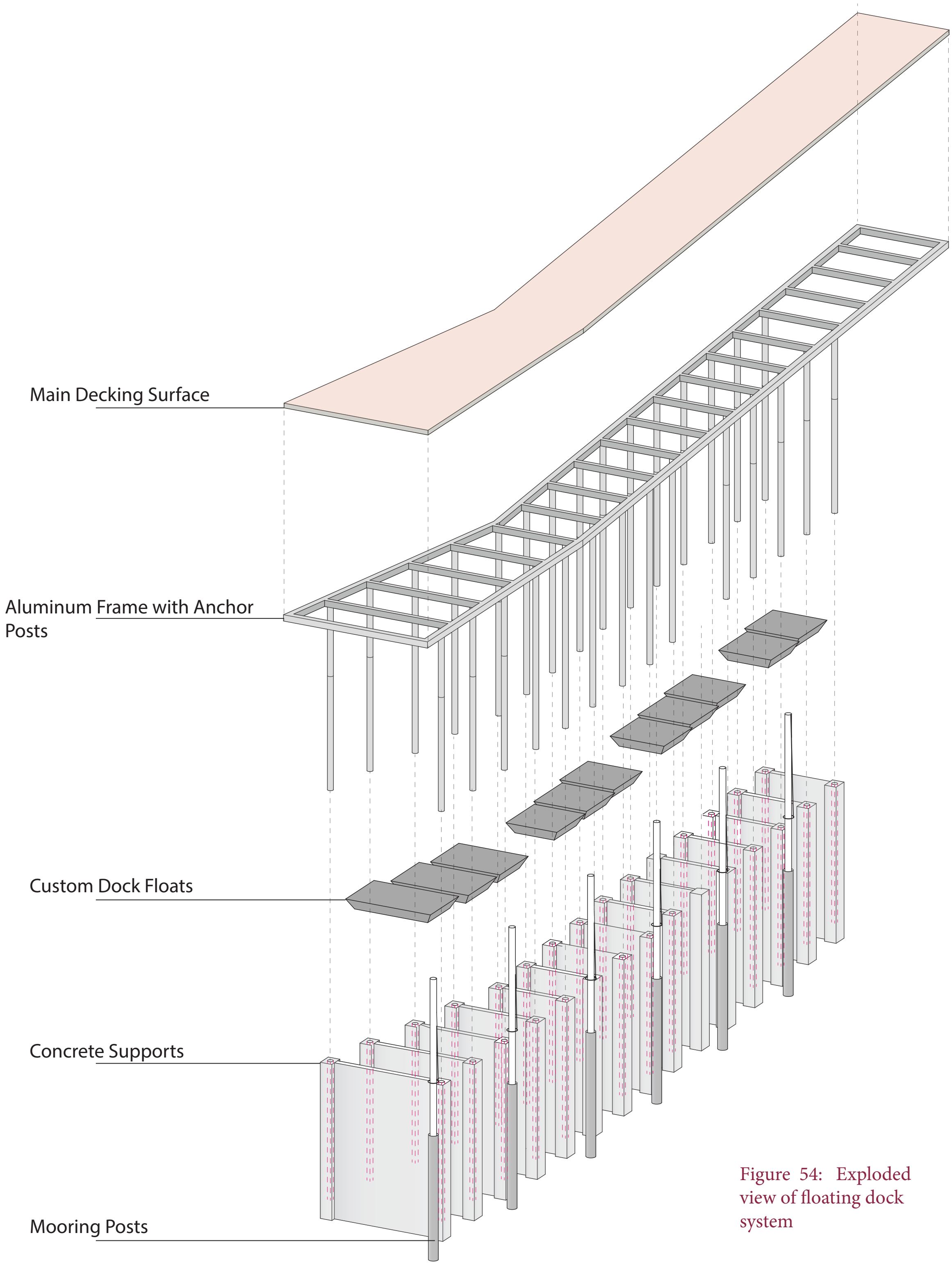
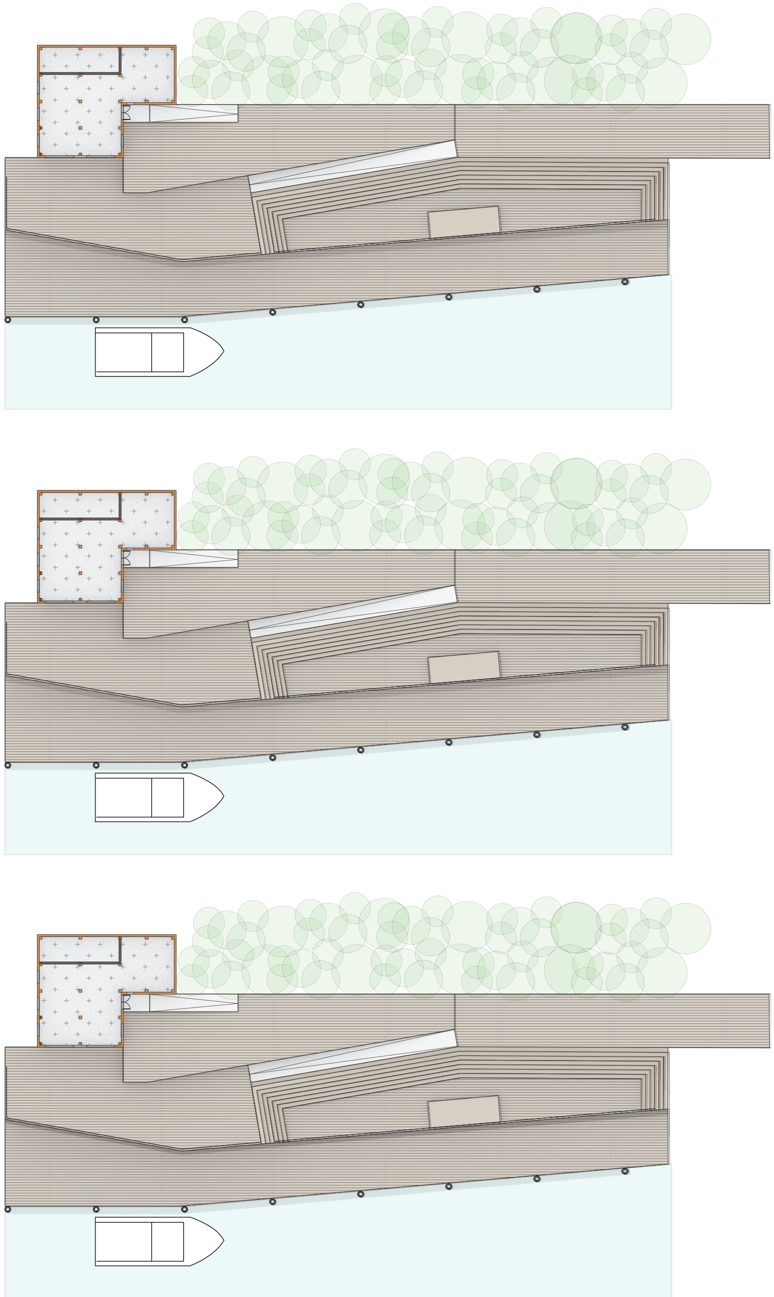


Figure 54: Exploded view of floating dock system

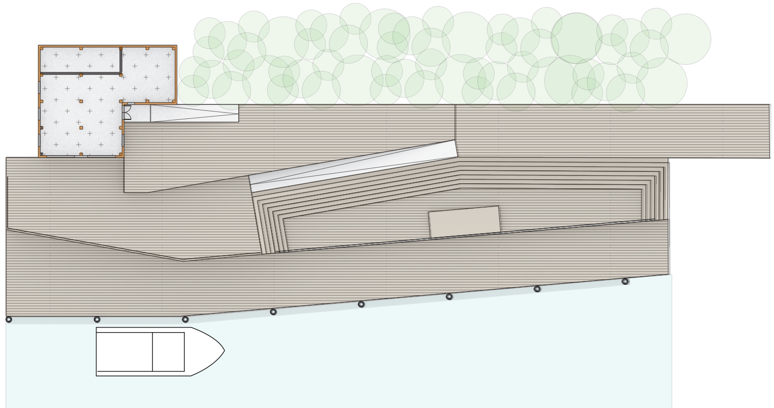
Figure 55: Changing relation of floating dock



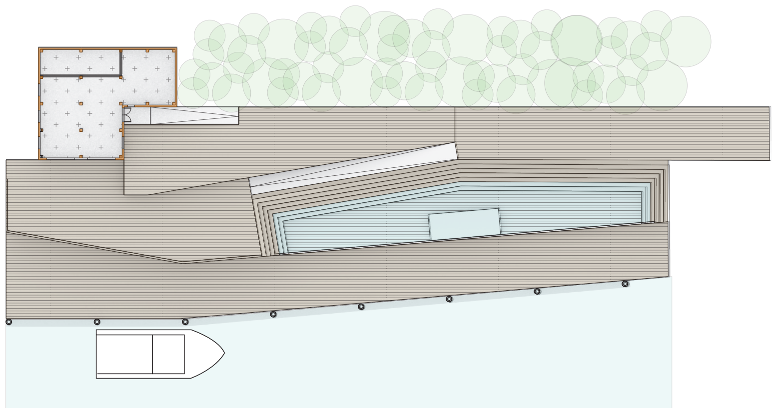
a) Water Level = 0m

b) Water Level = <8m

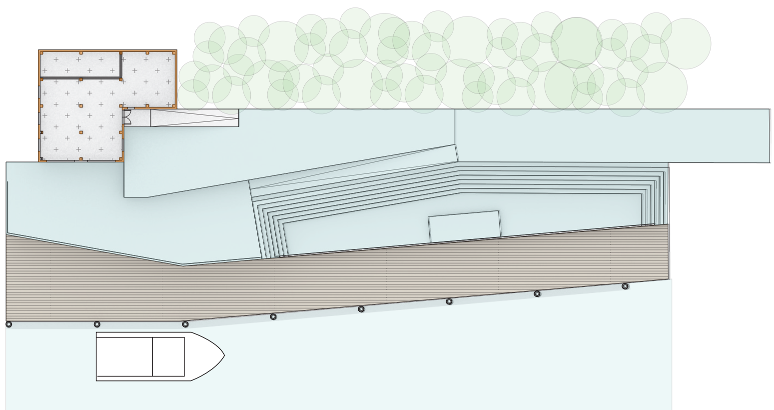
c) Water Level = 11m



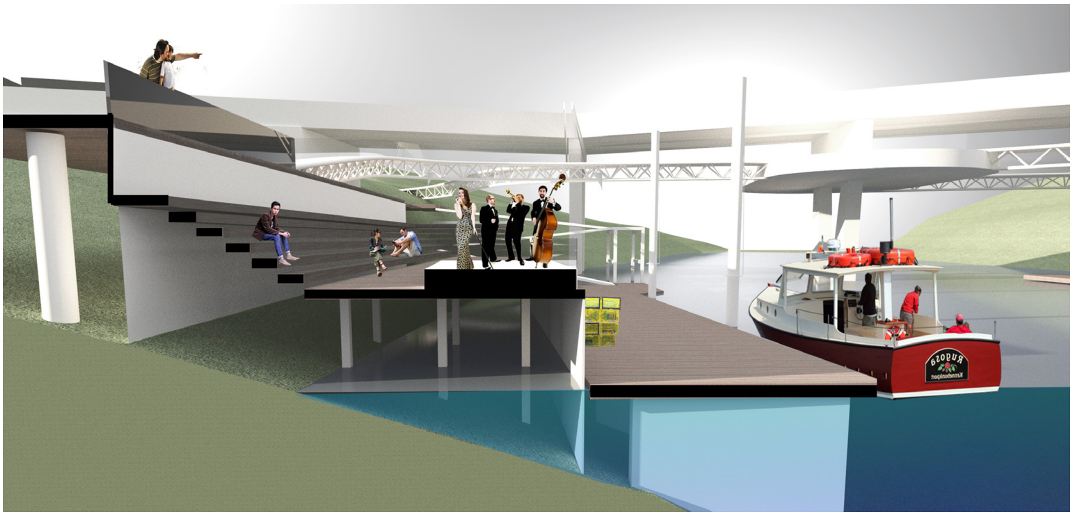
d) Water Level = 13m

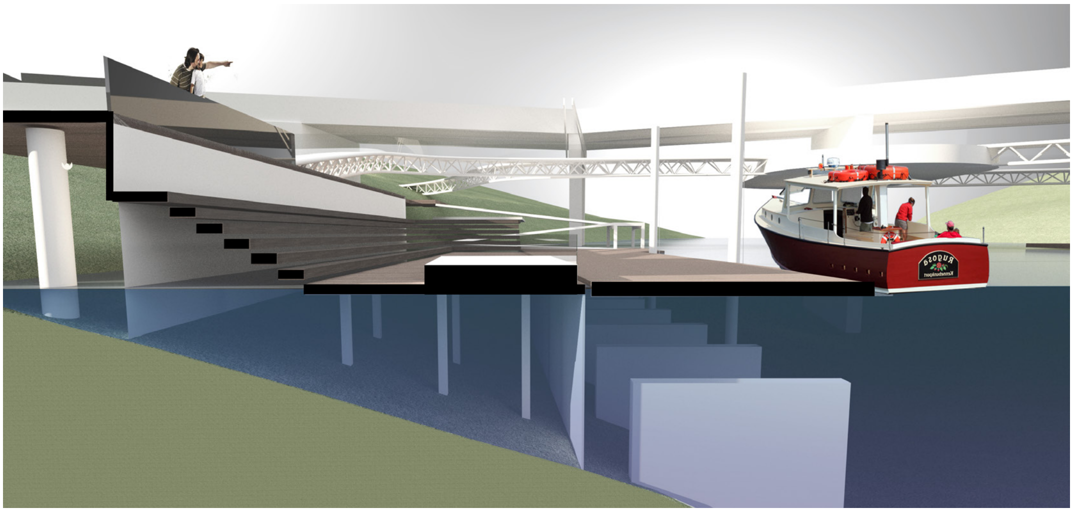


e) Water Level = 14m



f) Water Level = 17m
Storm Surge level





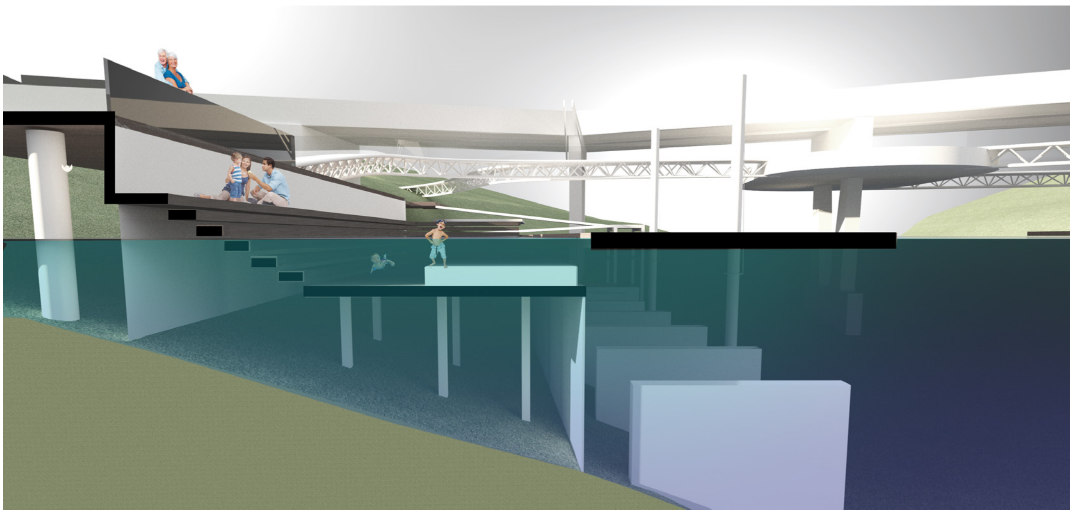


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Figure 56: Rendering change with floating dock design

This floating docking and its adjacency to the rigid conditions of the staggered 'leisure docks' also means that a unique and dynamic relationship is created. At the current tidal range, the lowest level of the community amphitheatre space is located just out of reach of the high tide condition. This of course means that with each increase in sea level so too does the amount of flooding the amphitheatre can possibly experience. This controlled and allowed flooding is an example of the third mode of rendering described in Chapter Four. While a visitor on any given day may see and experience a singular condition of this relationship over time it becomes an indicator of the overall rise in sea level that makes itself apparent and experiential to both regular visitors and local residents of the community. This relationship at 3 different stages of water level is shown in the visualizations in figure 56.

9.4 | The Lobster Pound and Provisional Docks – Leveraging Tidal Forces

If the east bank represents tourism and recreational activity, the other side of the harbour of course houses the rest of the activity at the intersection of lobster processing and the harbour. This set of activities and its components are largely housed by a singular larger component that is the lobster pound building. While this building represents the intersection of two user flows, their actual flow through a process of processing can be described by a singular path as shown in figure 57. This outlines the seven main steps in the processing of lobster from catch to distribution.

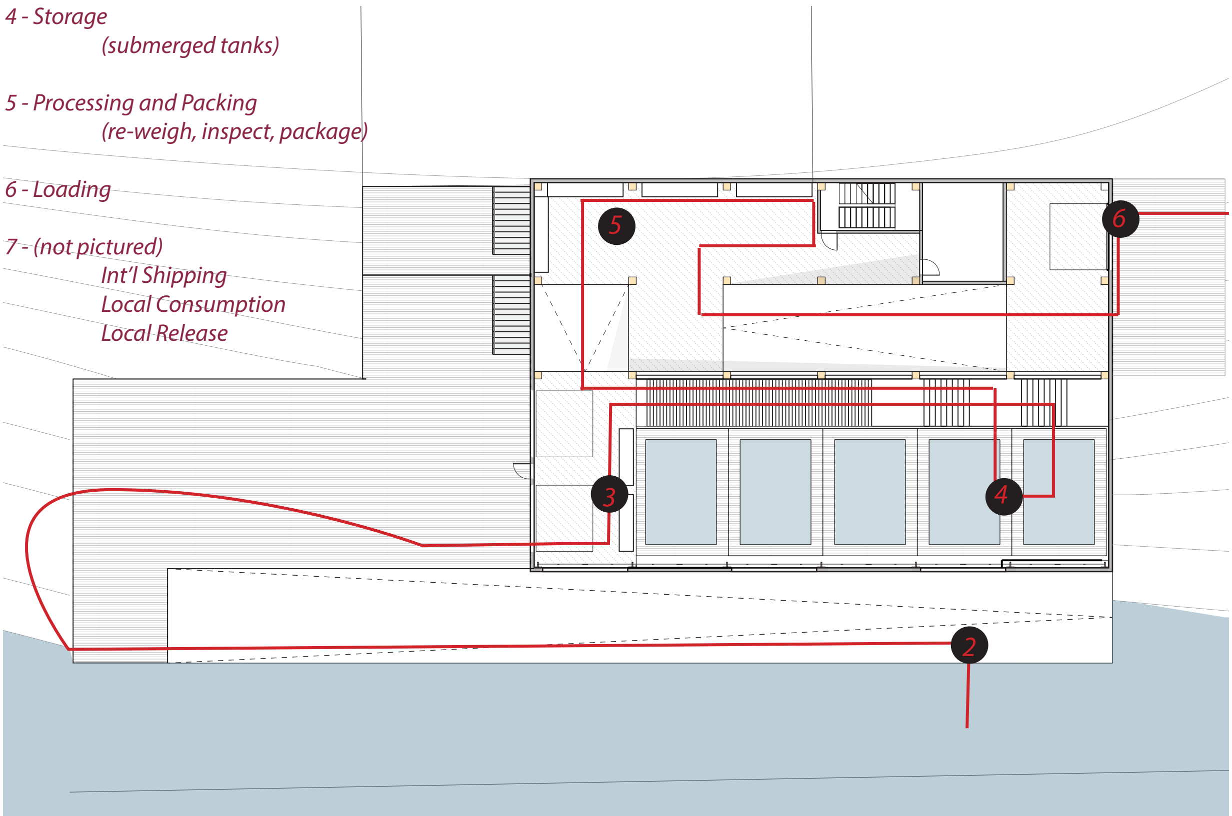


Figure 57: Flows through the lobster pound

1 - (not pictured) Live Catch

2 - Unloading in Harbour
(point of sale)

3 - Sorting
(weight, condition etc.)

4 - Storage
(submerged tanks)

5 - Processing and Packing
(re-weigh, inspect, package)

6 - Loading

7 - (not pictured)
Int'l Shipping
Local Consumption
Local Release

At a more in depth look the lobster pound's operation is only possible through a number of tectonic explorations contained within. Each of these is highlighted in the sectional perspective view in figure 58 and expanded upon further in the following text.

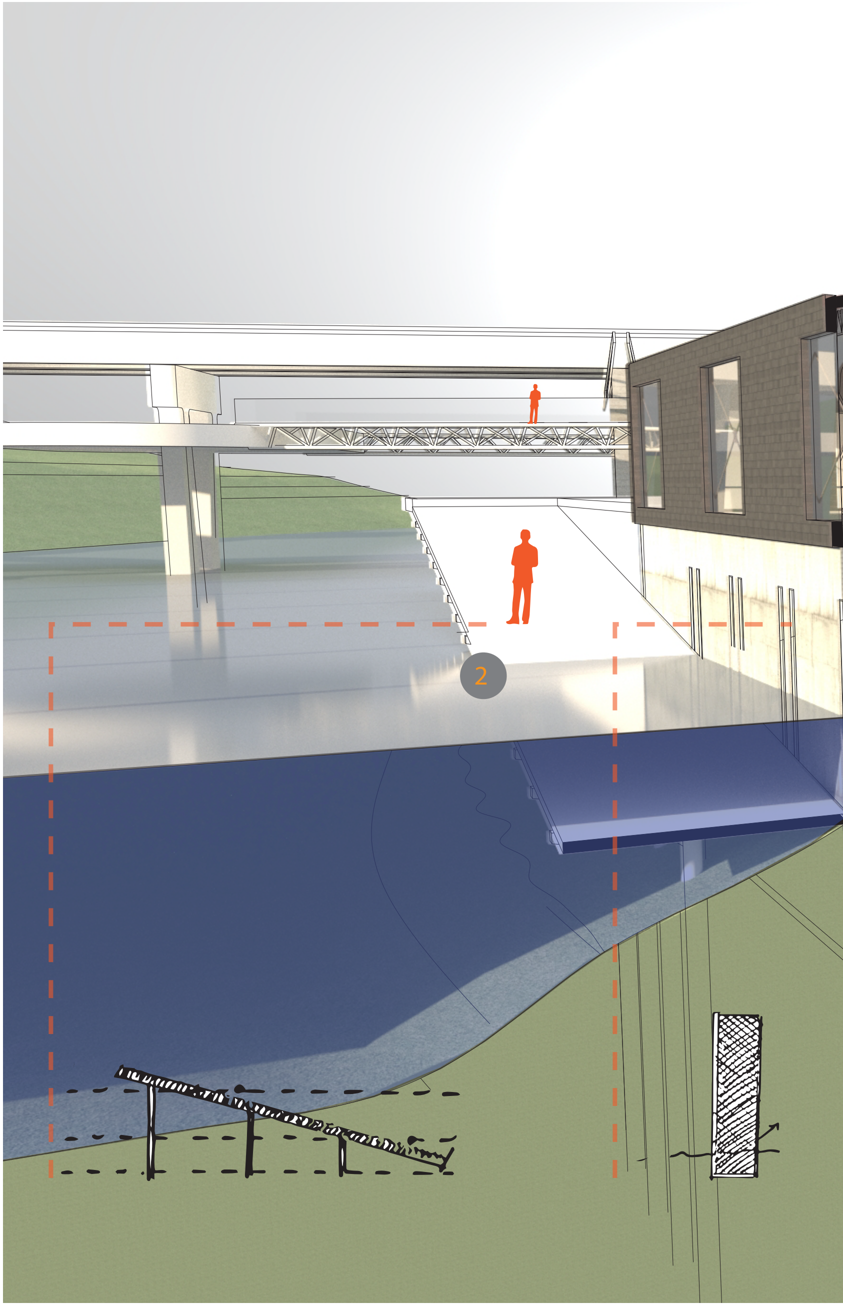
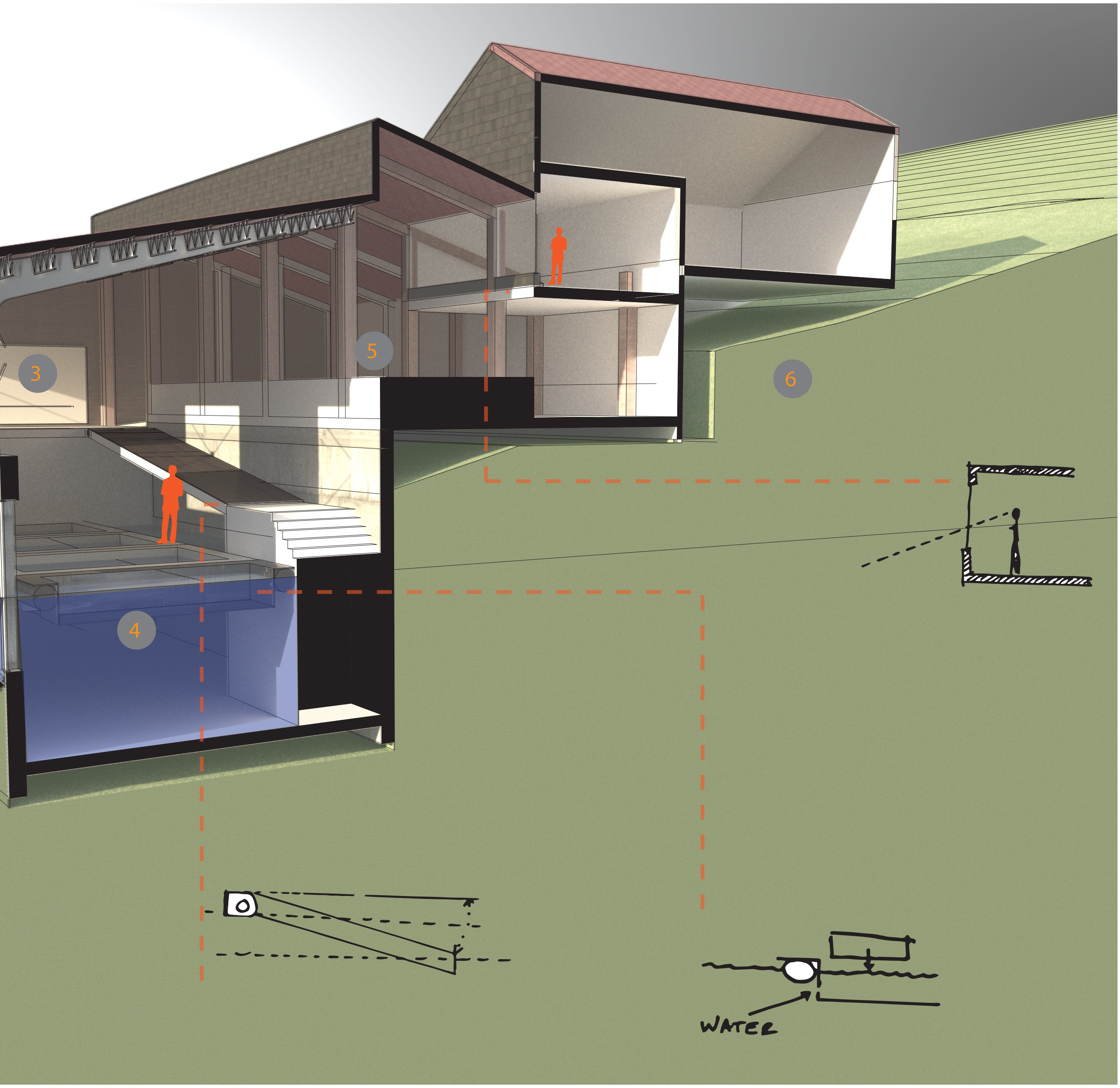


Figure 58: Rendered section of lobster pound highlighting key elements and stops within the flows


3
5
6
4
WATER

Provisional Dock

The provisional dock is the third dock created within the harbour and is the most unique in terms of its mode of accommodating the variety of the water. While the other two docks were similarly dynamic using floats and different methods of lateral anchoring, the provisional dock for the lobster pound is completely static deploying a rigid mode of operation. That being said, its use is still very dynamic in nature. By ramping the dock from a position slightly above the low water height of 8m to the future high water level of 15.6m it allows a fisherman or other boater to determine its required relationship to the dock for loading and unloading meaning that at any tide level it could position its hull in line with the dock or allow the dock to be at any given height above it by moving further into the harbour making it ideal for loading and unloading any boat no matter its size and requirements.

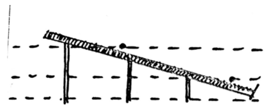


Figure 59: Sketch of provisional dock

Submerged Storage Tanks

The other main subcomponent is the central point of the internal function of the building which is the lobster storage tanks. The storage of lobster requires them to not only remain in temperature appropriate water but also for that water to regularly circulate to not lose oxygen or stagnate which would kill the lobsters and ruin their meat.[2] The idea of leveraging a natural condition to achieve what would normally be completed mechanically is not foreign within architecture.[3] This leveraging is exactly the tactic used for the lobster storage tanks. Rather than pump water through the system to oxygenate the water the foundation of the pound is treated as a large storage tank holding a series of floating tanks in which the lobster crates are to be kept. As the tides increase these floating tanks float up within the space and return to a base position as the tide goes out.

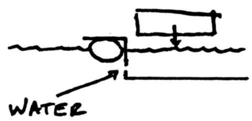


Figure 60: Sketch of submerged lobster tanks

The rest of the components explored here support this lobster storage function and its dynamic nature.

Screened Openings in the Foundation

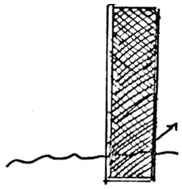


Figure 61: Sketch of screened openings

To allow the tanks to fluctuate their position with tide requires water to be able to freely flow into the storage area as the tides shift. To achieve this while maintaining an enclosure for the tanks screens along the harbourside of the foundation allow the free flow of this water while preventing large contaminants and settlement from entering the system. The positioning of these openings with their base at 10m above sea level means that when the tides go down the storage area is able to retain a depth of water for the tanks to float in.

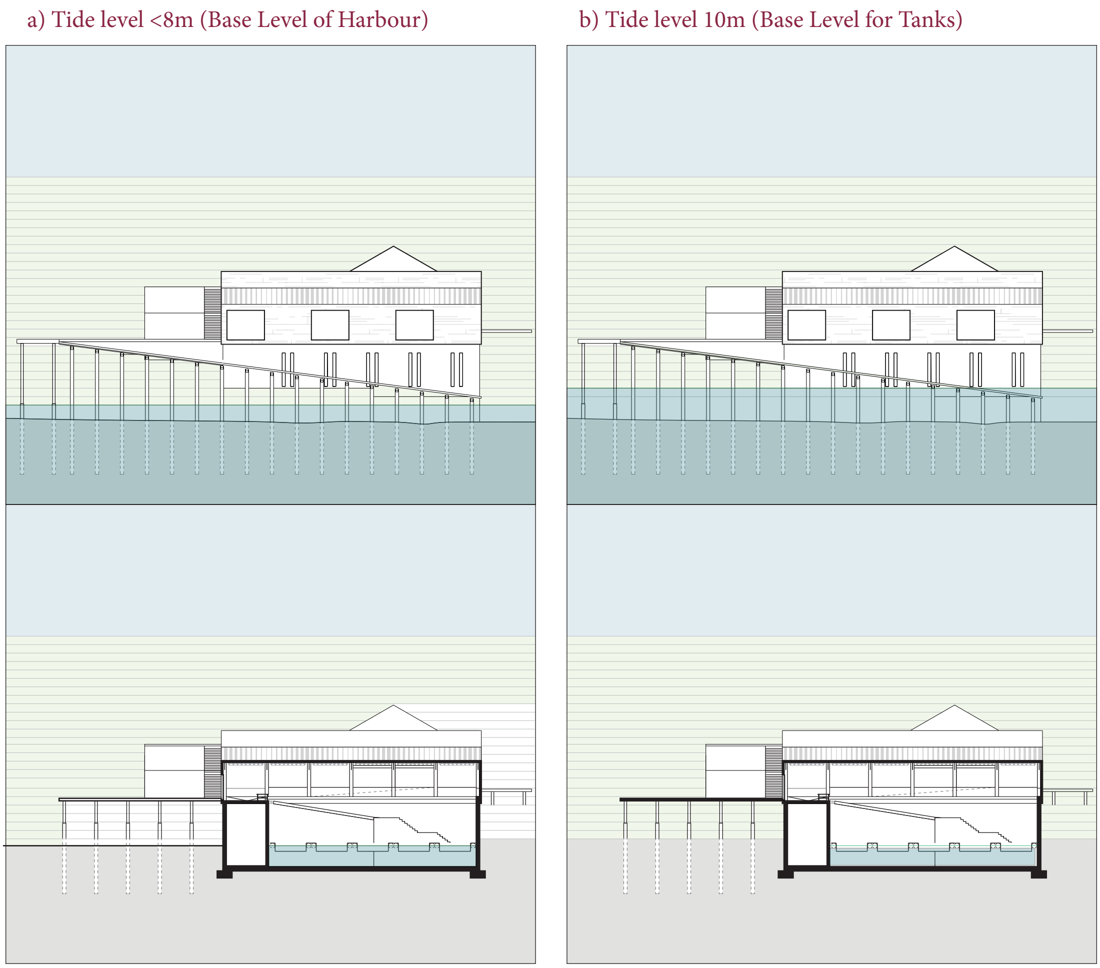
Access Ramp and Stairs

Figure 62: Sketch of access ramp and stairs

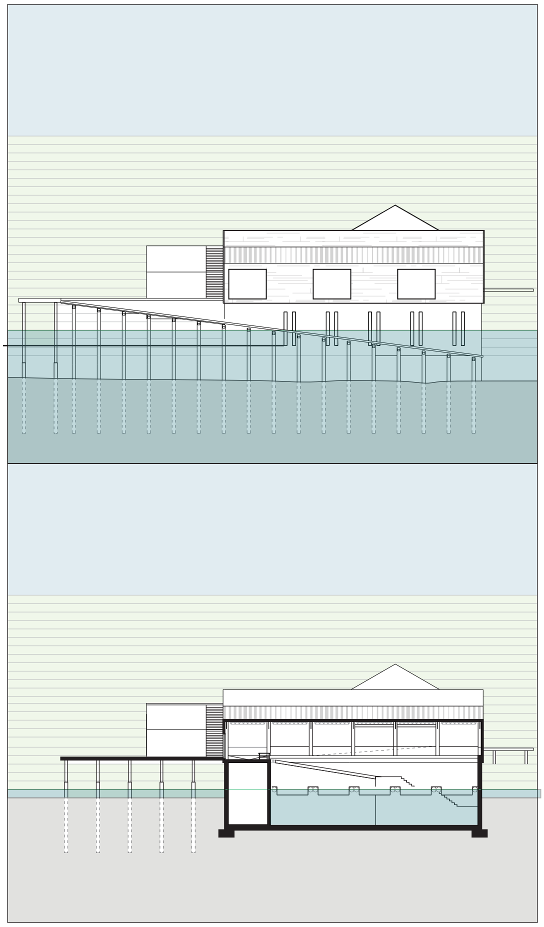
Accessing these storage tanks to intake lobster from earlier processes or pass along to the next steps in processing must be as dynamic as the tanks themselves. At the lower levels a stairway allows access to the tanks at their varying positions. Sometimes however when multiple crates are being processed the forklifts must be able to access the tanks, thus a ramp has been created to reach the tanks at their current high tide level which hinges to allow access at all levels above this as SLR occurs.

Based on the components described the lobster pound creates a unique relationship between inside and outside conditions that operate simultaneously, leveraging the power of the tides while using very different methods. This changing relationship of inside to outside whereby both amplify variety, one through a rigid tactic and the other through a soft tactic, and creates a harmonious flow that is unimpeded is shown in figure 63 which comparatively shows the condition at 4 different water levels.

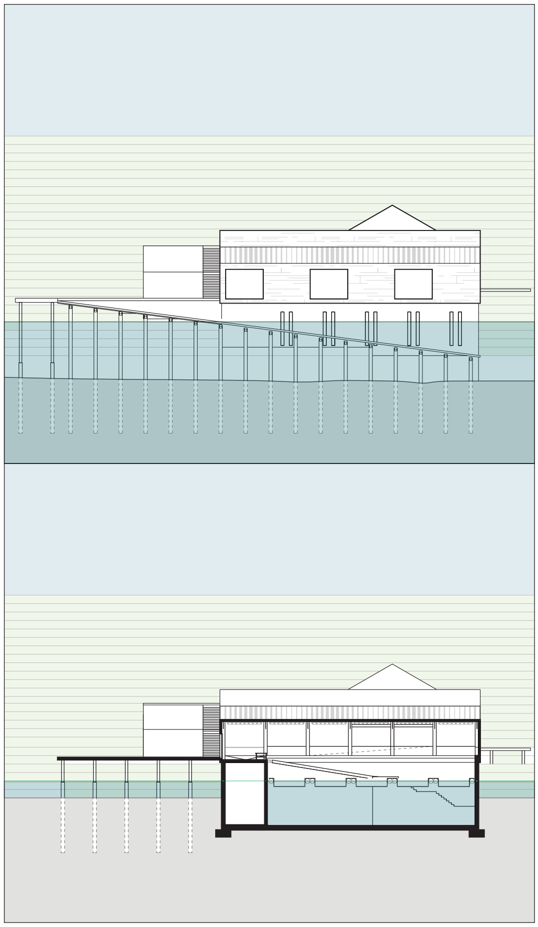
Figure 63: Changing interior to exterior relation



c) Tide level 12m



d) Tide level 13m (Current High Tide)



(Endnotes)

1 http://www.hallsharbour.org/images/soundings/Soundings_20170401.pdf

2 Lobster Institute, *Lobster Holding Tank System Manual,* Year Unknown, http://www.tradewindchillers.com/downloads/lobster-tank-guide.pdf, accessed April, 2018

3 Kathy Velikov and Geoffrey Thun, *"Territorial Infrastructures: Recognizing Politico-Environmental Ecologies,"* in *Infrastructure Space*, ed. Ilka and Andreas Ruby (Berlin: Ruby Press, 2017) 196

Chapter 10 – Experiencing the Harbour – Rendering Systems

While the previous sections were able to explore a number of the components and design ideologies in various ways there are some aspects which can only be recognized in an experiential way.

10.1 | Rendering of System Components and Materiality

Figure 64 (following page) shows a complete perspective view of Halls Harbour. Chapter Four outlined the 3 methods of rendering systems. The first of these was to make the individual components clear and visible and is the first one explored here. In Halls Harbour a major differentiation had to be made between certain components, the first set of which are the tourism areas and the lobster pound. Where the lobster pound maintains its current iteration's dark stained cedar shake siding and larger dominant form the restaurant uses lighter siding and a less assuming form and mass to appear more a part of the community. These materials not only reflect the differences between these buildings and the systems they belong to but also are largely functional for their individual needs.

The second clear delineation that needed to be made at a glance was between the circulation systems. Not to clarify their existence but more for aesthetic purposes the vehicular bridge and the pedestrian bridge had to adopt differing material and formal characteristics. While the vehicular bridge remains largely utilitarian and plain in its design, utilizing typical concrete and steel hybrid construction the pedestrian bridge uses a light-steel structure suspended from the structure of the vehicular, allowing it to meander and split to connect the various parts of the project into a cohesive whole.

The main vehicular bridge uses a very simple composite construction with its only real expression coming through the columns. This is to showcase its largely utilitarian purpose of coming to or through the site.

The restaurant building uses light ship lap siding and a simple form to appear more cohesively as part of the surrounding community. The idea being that as part of the tourist function of the sight it is a place for seeing not being seen.

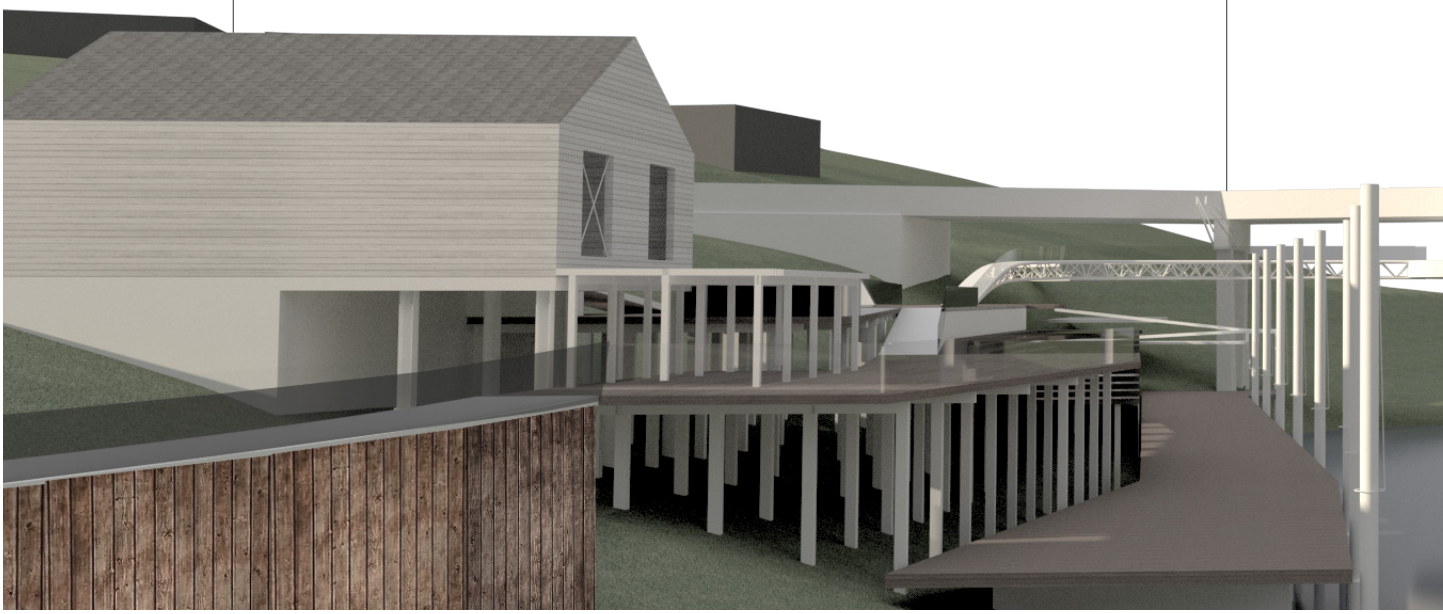
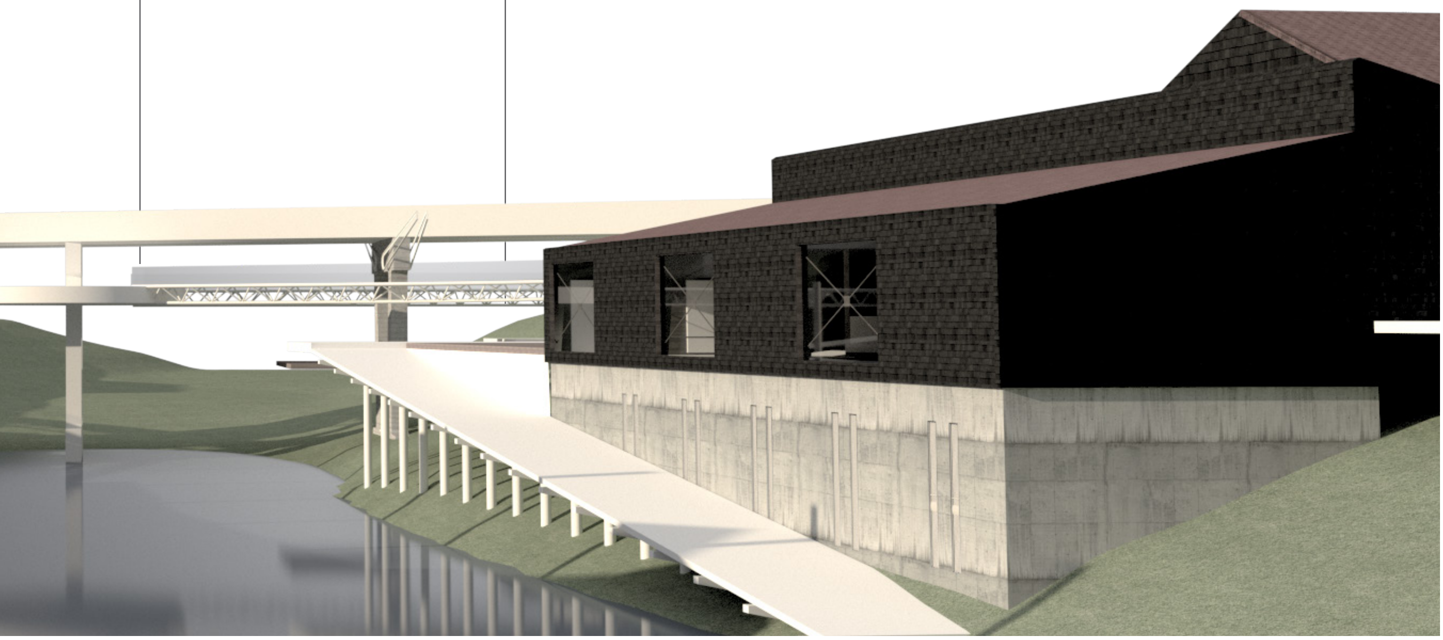


Figure 64: Activity flow of Tourist Group #2

The pedestrian bridge contrasts the vehicular bridge with a munch lighter and more playful expression. Using a light steel structure along with suspension from the vehicular bridge allows the pedestrian bridge to more playfully meander to each of the points it touches down.

The Lobster pound contrasts the restaurant by using a much darker finished cedar shake finish. The materialty at one time is functional to suit the coastal conditions while simultaneously continuing an aesthetic from the existing lobster pound building.



10.2 | Experiential Views

While the leisure docks component in the previous chapter was able to explore some examples of the third form of rendering through the controlled failure condition the second method of seeing the happenings and systems around the user are only really possible through the experiential process of placing yourself within certain vantages and locations on site. The rest of this chapter will explore these experiential views by presenting a 'rendering', in the traditional visualization sense and then overlaying on that image the types of information that can be read from that vantage.

The first such view (figure 65), taken from the pedestrian bridge's lookout point allows a fairly comprehensive view of the entire project. While this view allows one to see a great deal of the design, it does a particularly good job of highlighting access zones within the project, that is areas accessible to certain users. Figure 66 shows the same rendering with some content removed and these individual access zones highlighted.

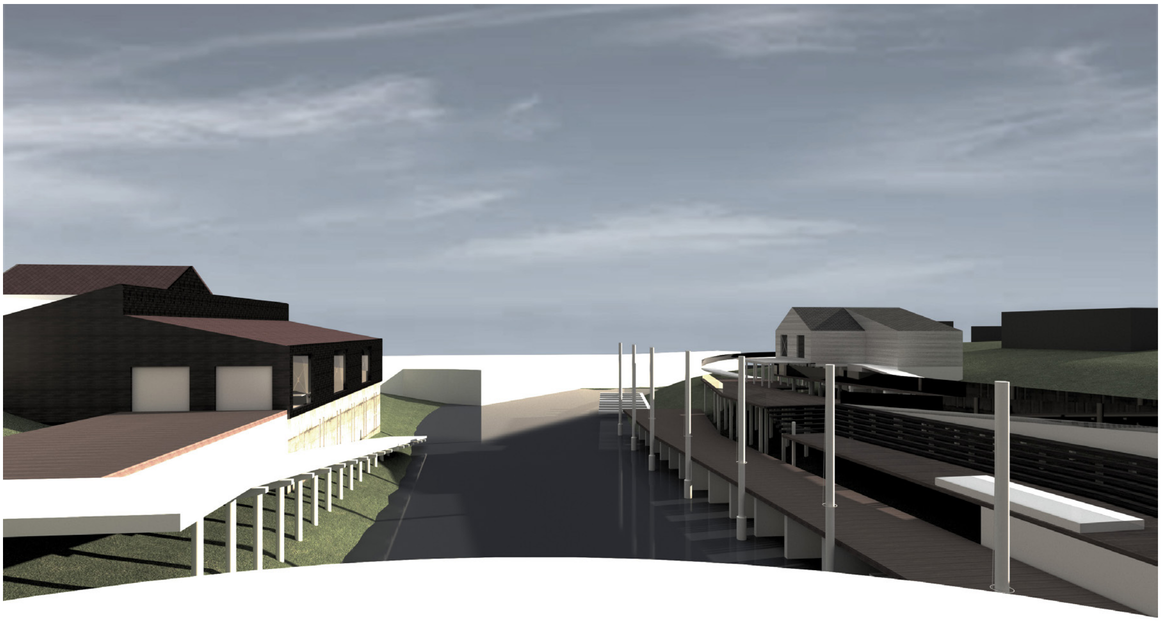


Figure 65: Render from lookout point

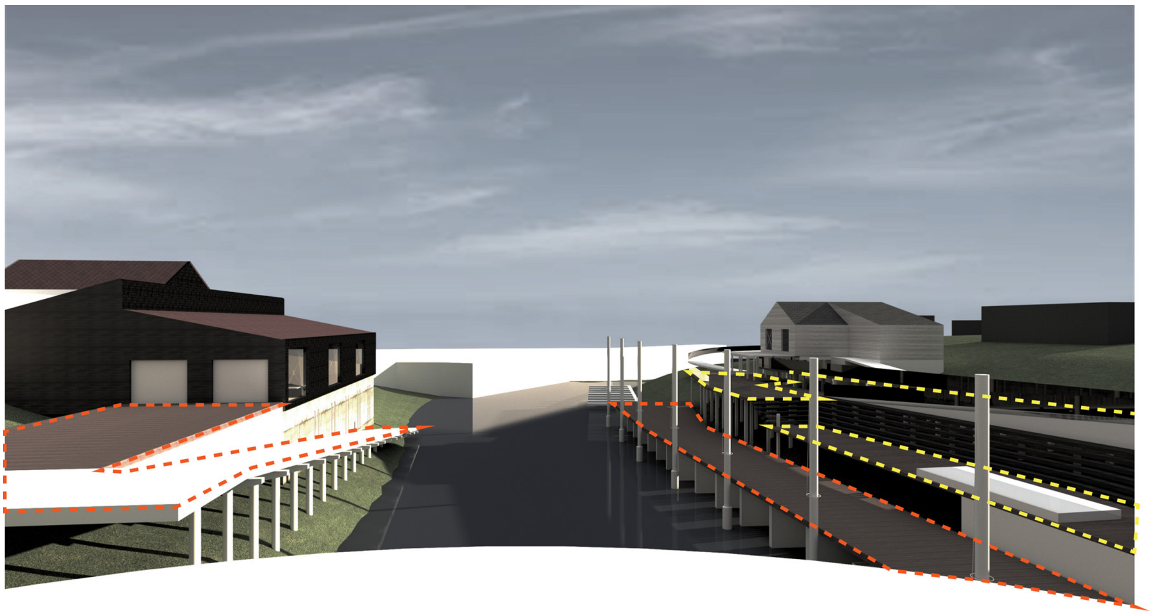


Figure 66: Defined areas visible from vantage`

Figure 67, a view along the top level of the leisure docks towards the restaurant and adjacent to the connection to the pedestrian bridge similarly highlights experiences or system and flows ideologies of the design. Figure 68 is again a simplified version of this rendering but this time highlighting the clearly demarcated possibilities for pedestrian paths. It becomes clear through this visualization that all such paths converge at the pedestrian bridge connection regardless of their parent system meaning a moment of connection between fisherman and tourist becomes a possibility.

Figure 67: Render towards restaurant view

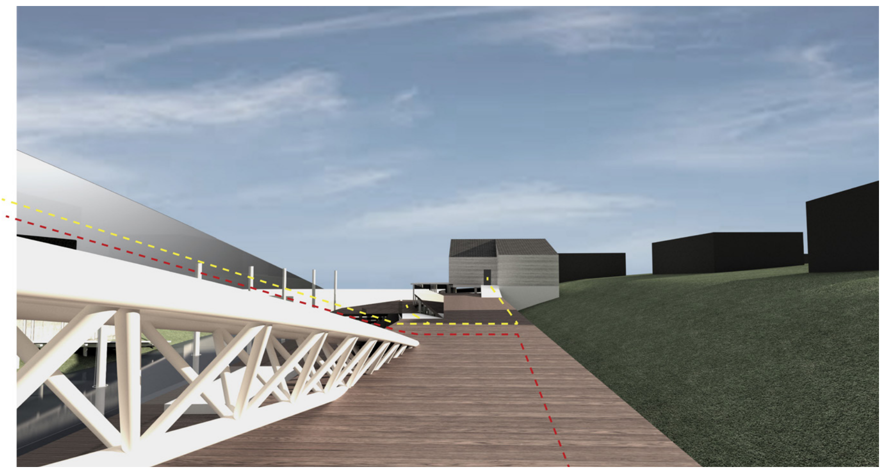


Figure 68: Clearly defined paths and flows

Figure 69 tries to achieve a similar highlighting of an experiential move within the design this time focusing on the framing of one system from another. The view from inside the lobster pound makes clear the series of large windows that work to frame visual relations between it and the tourist activity that is largely interested in the pound's activity. While the relationship is shown from inside the pound as figure 70 highlights this is the same condition looking towards the pound from the recreation and leisure area.

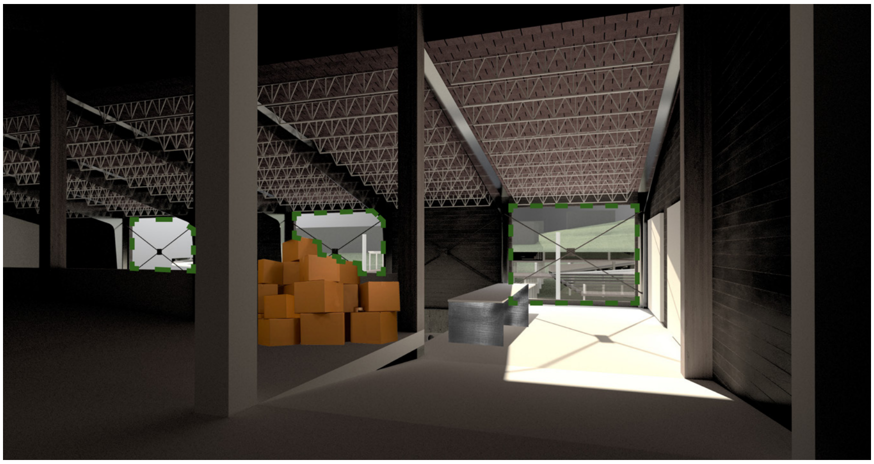


Figure 69: Lobster pound interior render

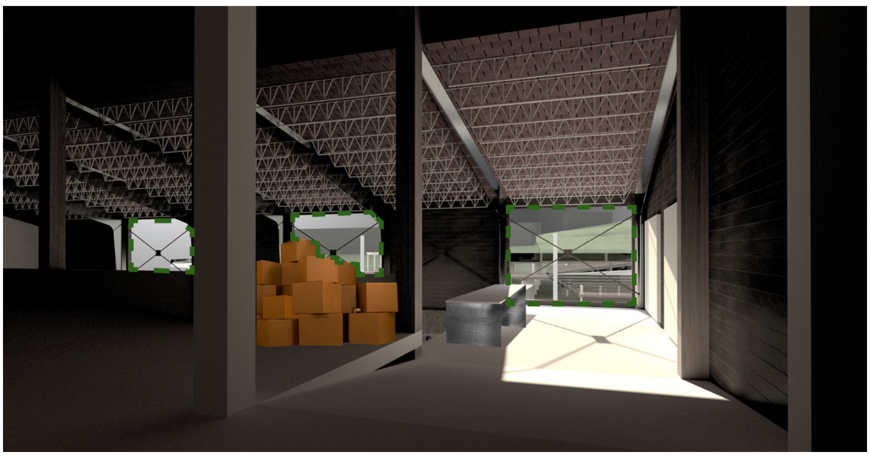


Figure 70: Clear visual connection between systems

Finally figure 71 highlights some of the same things explored through the rendering of a system. Looking towards the bridge from anywhere within the harbour it makes visible the flows of the other people and thus allows systems to reveal themselves. Rather than concerning with the materiality and form of the bridge it is concerned with who is doing what on the bridge. Figure 72's overlays on this render show how each user path can be interpreted to make clear not only what system they belong to, but also which activities are creating a demand within the site.

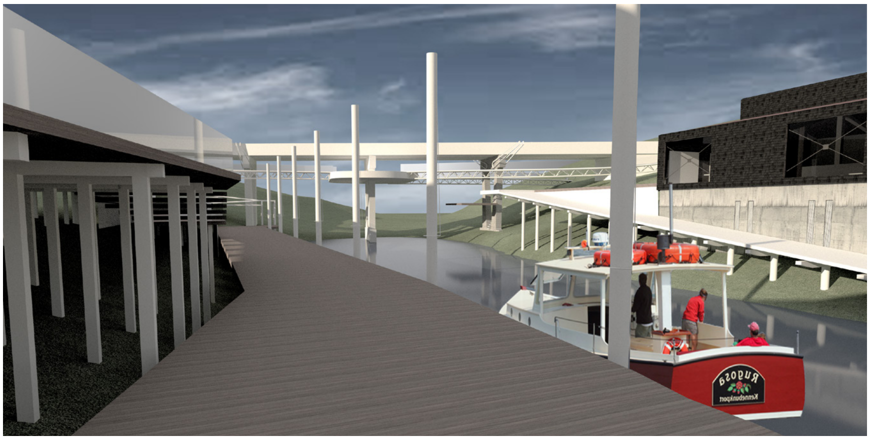


Figure 71: Render from fishing docks

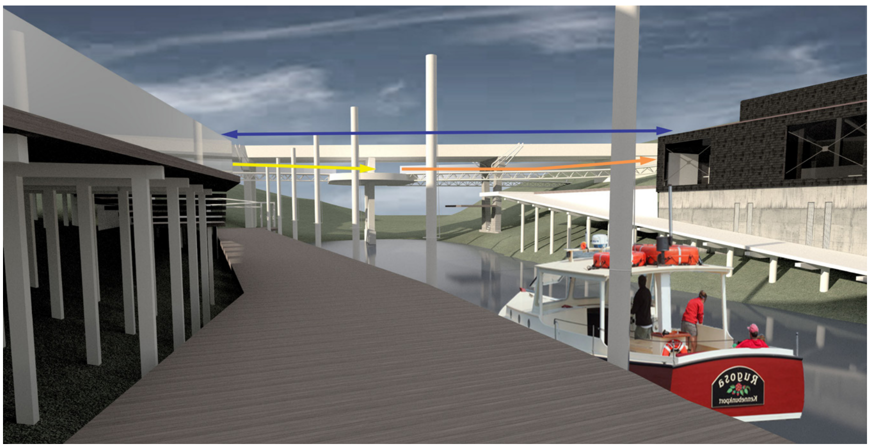


Figure 72: Visible flows and circulatory separation

Reflection

At the outset of this research and project I was completely unsure of where it would lead or what it may entail. Upon the completion of this body of work I am beginning to find relations back to a larger narrative that this topic has in my mind. My original body of work actually came out of another project looking at political refugees in the Mediterranean and was very much planned to work in the area of environmental refugees (although this status in and of itself may make them political). When I transitioned away from that theme to a North American, Western, context I at first questioned the novelty of my work when we seem to be seeing such an influx of work focusing on protecting the coasts of the biggest cities and 'most important' regions in the world. The revelation of this body of work for me was the complexities inherent in even the smallest places when you begin to consider their systems and modes of operation.

The other thing that most impacted me in the design work related to this thesis was the idea of scale. An early critique of the 'traditional' solutions I explored in the first chapter were the coldness or sweeping strategy that neglected to consider human activity and experiences that they would impact. Throughout the design process I found myself entangled in designing strategies for a lot of moments, rather than overall planning. For the final design I was able to take these moves as a toolkit of solutions designed from the bottom up and to deploy them through a masterplan as a top down approach allowing me to edit in what I felt was most appropriate and leave out that which was not.

Early in the thesis (Chapter 3) I set out four evaluation criteria for the research work and design explorations to be run through. While at times the focus shifted to the science and technicalities of climate change and sea level rise, and other times towards tectonic design explorations, these evaluation criteria were a helpful tool in keeping the thesis direction organized and creating a narrative for my year of work. I recognize that in some regards some of my design proposal may seem prescriptive, an idea I was at first critical of in the first part of this work, however I believe that the strength in the thesis is that, despite this appearance, it was all driven by the physical site, and the systems at play (including the actors flowing through them) in direct response to the evaluation criteria.

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Appendices

Appendix A - Site Visits in Atlantic Canada Winter 2018

Appendix B - Early Design Charette Explorations, Halls Harbour

Appendix C - Final Model Photographs

Appendix A - Site Visit to Atlantic Canada

In February of 2018, following the preliminary mapping excercises for the various community types, I travelled to Nova Scotia and New Brunswick to gain a better understanding of the communities and the East Coast way of life, as well as insight into the most appropriate site for my thesis' design project.

Along the way I had planned interviews with a number of people, many of which fell through due to seasonal conditions, and visits to all of the sites explored. Upon arrival Port Elgin was cut from a full visit as it was clear that there was nothing much of a town left there.

The slides in the following pages are a presentation I put together upon my return to begin to summarize key points of the trip for communication with my committee members and as a form of note taking for myself. For each community I wrote down a set of assumptions and while there made observations to validate or challenge these assumptions. These helped inform not only the decision making process moving into the design portion of the thesis work but also a set of ideas about modes of operation in the coastal condition.

Figure 73: Intro and timeline of travel including key stops and appointments

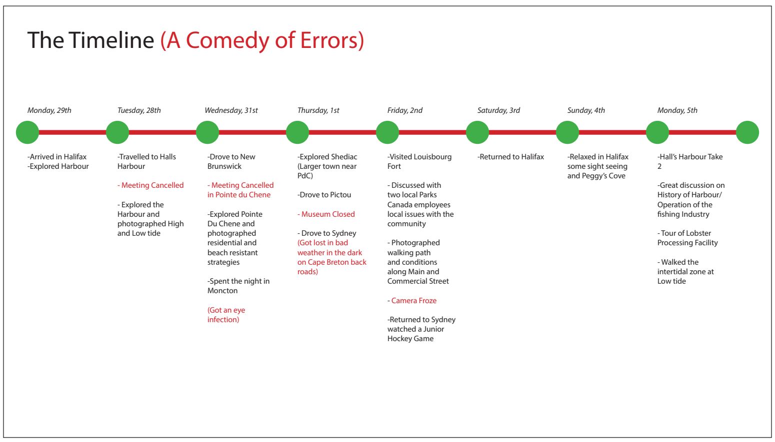


Figure 74: Overview of Halls Harbour visit

a) Overview and assumptions pre-visit

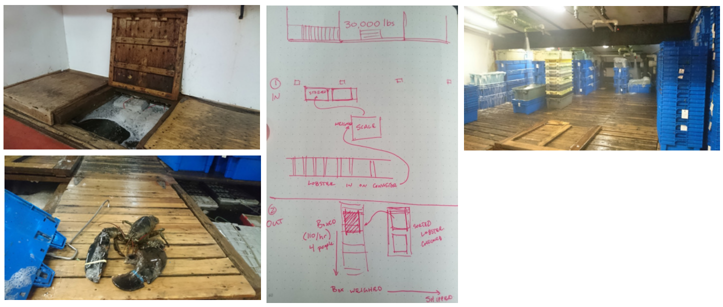
b) Inland conditions to the rear of the harbour

c) Eroded coastline and hi and low tide in the harbour

Halls Harbour

d) Lobster pound and operation

Halls Harbour



e) Key observations from visit and comparison to assumptions

Halls Harbour

FISHING OPERATIONS

Fishermen independently licensed
Sell to Cameron Seafood at Shore Price
Cameron Seafood Processes, Packages, Ships and sells at Market Price
Profit Margin from \$0.75 to \$1.25/lb
One of the smaller fisheries (Only 90 Licenses)
Two seasons every year (Fishery map provided by them)

Facility has 19 staff

WHARF AND SEA LEVEL RISE

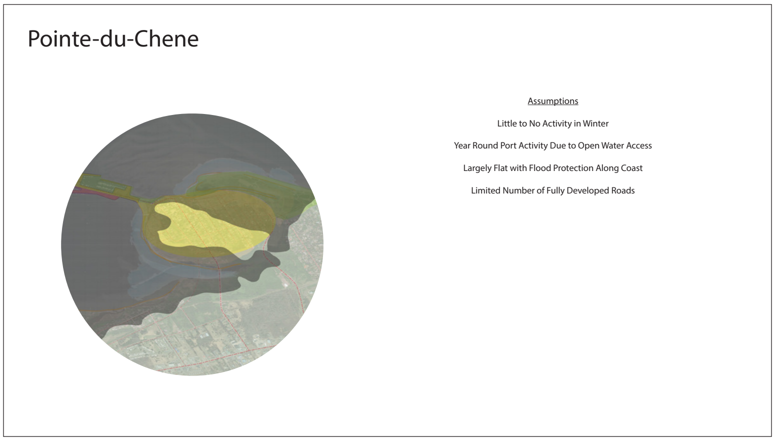
Flooding has occured significantly in the past
- Whole Wharf Destroyed in 1978
- Reconstruction undertaken by volunteers from Katimavic
- 2013 Major flood damaged equipment and buildings on the wharf
- Main Road and wharf occassionally flood in bad storms/weather

Looking to reclaim about 7m where buffer wall is

Noted a visible change of 10 (not sure if m or feet, and vertical or horizontal) in the last 20 years

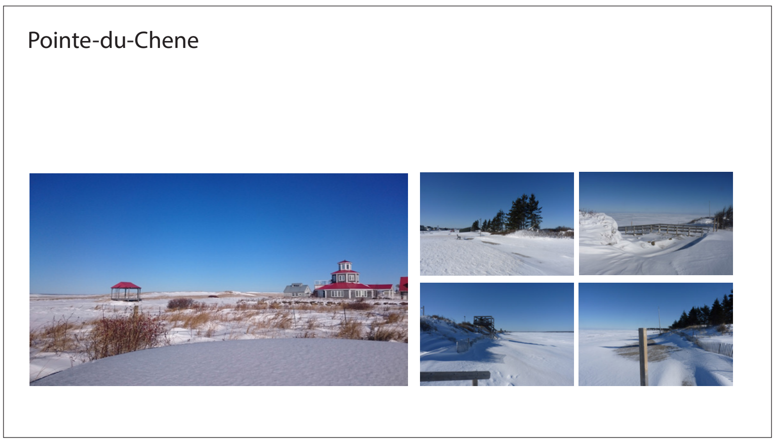
INDUSTRY CHANGES

Economic pressures on operations
Companies paying fishermen to stay home (buying a monopoly)
Chinese looking for direct entry to market



a) Overview and assumptions pre-visit

b) Various modes of elevating homes in low-areas



c) Natural build-up and coastal protection along the beach

Figure 75: Overview of Pointe-du-Chene visit

b) Pier/Harbour condition in winter

Pointe-du-Chene

c) Key observations from visit and comparison to assumptions

Pointe-du-Chene

SEASONAL NATURE

In Summer large tourism hundreds of thousands to millions of visitors
Lots of residential plots owned in bunches and rented as vacation cottages

Mostly deserted in winter though some still in town
Ice fishing in some spots (shallow so frozen)

LOCAL BUSINESS

Most of those who work locally or operate and own businesses live in either Moncton or Shediac
Very little in the way of business except on pier
Also campground
Mostly recreational dock/some fishing

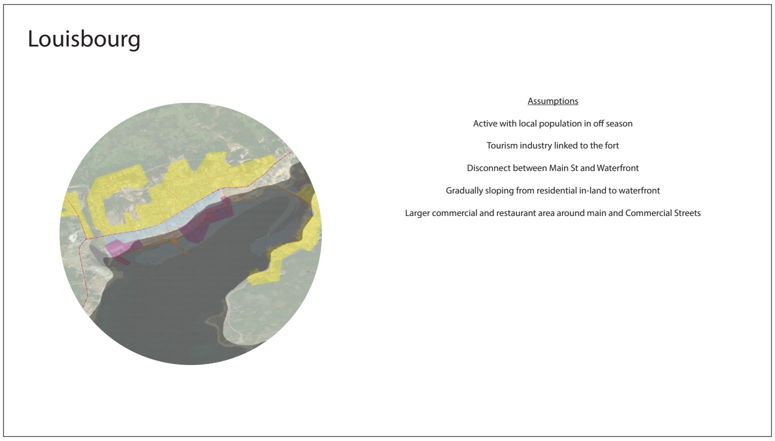
FLOOD STRATEGIES

Larger scale buffering along beach and shore in areas

Recent history of large flood events

Easy to tell new homes from old both visually but as well as through passive strategies employed

Figure 76: Overview of Louisbourg visit



a) Overview and assumptions pre-visit

b) Low land condition connecting to light house and south-shore

Louisbourg

c) Largely underutilised shoreline conditions

Louisbourg

d) Pooling and flow of water in hardscaped in-land areas

Louisbourg

TOWN AND FORT RELATION

No real connection economically
Some small business through town
Town blames the fort for their problems and vice-versa

Town divided on capitalizing on tourism, avoiding it, or maintaining current condition

Park development required expropriation of land from residents, still some generational bitterness

Most people seasonally unemployed
Fishing/Labour
or
Tourism (Fort between 100 and 200 employees)

TOWN AND WATERFRONT

Town aside from fishing facilities and CCG Dock not connected to water
Large swathes of seemingly under or un-used space

Supposed boardwalk zone (small/unrecognizable and hard to access)

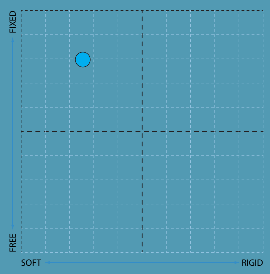
e) Key observations from visit and comparison to assumptions

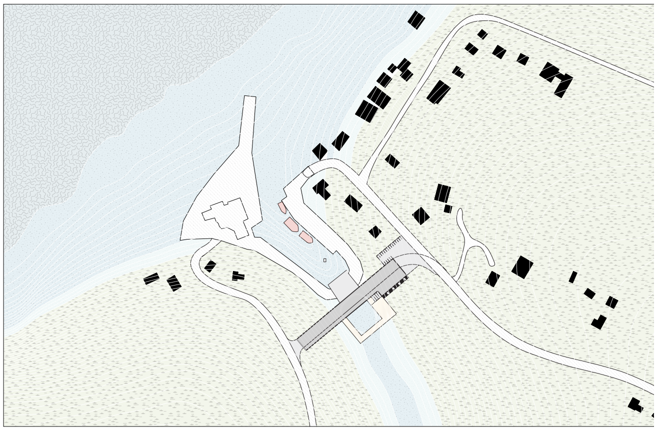
Appendix B - Earlier Design Charette Explorations

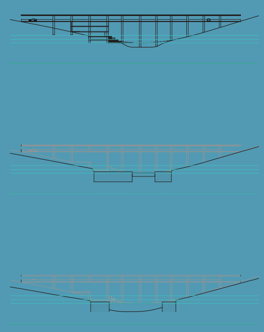
At an early stage of the design work, a charette excercise was undertaken to generate a volume of tactics that would inform the final design exploration. To generate ideas within this charette 3 schematic designs for the Halls Harbour site were developed based largely on deploying unique tactics to employ amplification and/or attenuation.

In each case a position within the flexibility matrix was chosen to allow the tactics to explore as wide a range of ideologies as possible. The images on the following pages are the presentation posters of these charettes utilised at the *Substantial Completion Review* (SCR).

PROPOSAL A - SOFT AND FIXED



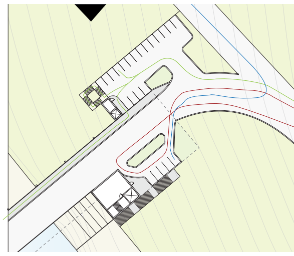


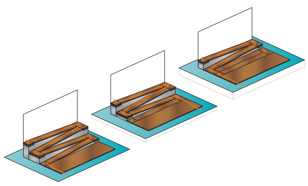


COUPLING 1

The first proposed coupling looks at a moment in which several different systems overlap and looks to attenuate or control the possible variety that this could cause. Due to the bridge being used as a fixed anchor point for the proposal it is unsurprising that this is one point in which multiple system paths collide. Everything from the tourist coming in, the local employee coming to work and the loading van picking up a lobster delivery must navigate this moment which also must function as a road for those simply passing through.

This control is achieved by the clear definition of roles and pathways for each. Primarily the tourist while interfacing the others at some points has little required interaction with the other systems, for this reason their own parking and vertical circulation is provided to maintain this level of separation. Opposite this is a loading and employee parking zone with access to the office, packing and lobster processing facilities, as well as direct access to the docks.

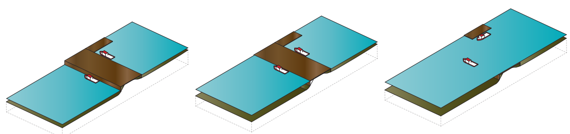




COUPLING 2

The second coupling looks at the relation of the docks as the transition point from the water based systems (fisheries, harbour, tides, waves) to the land based processing, tourism and shipping systems. The proposed coupling utilizes soft strategies to work to amplify the allowed variety of the docks. The tidal ranges especially within Halls Harbour on the Bay of Fundy represent a high variety system, with loose limits but large fluctuations within them. This looks to adapt to the upper end of that spectrum, that which will see bifurcation with climate change events.

The vertical gap between dock and building is navigated through two mechanisms. Firstly, as it remains at the lower end of its spectrum, this navigation is through a series of ramping allowing carts, or forklifts to navigate from the boat intake to the processing and storage functions. As water levels begin to exceed its current day upper limit however, the floatation capacity of the ramp sections allows their steepness to shore up eventually extending the flat plane of the dock proper.



COUPLING 3

The third coupling in proposal A looks at a similar tidal to harbour relation as coupling 2, however it looks to help attenuate the problem as opposed to amplifying the range. Under current conditions as the tide goes out boats come to rest on the bottom of the harbour, a practice which while effective for current use does still present issues when considering the upkeep, stocking and protection of boats during this period.

To navigate this problem a natural harbour is created through dredging, behind the existing harbour condition. This dredging will create a shallow but constant harbour for boats which can only be entered during certain higher tide periods, but also maintains a minimum depth after the tides go down.

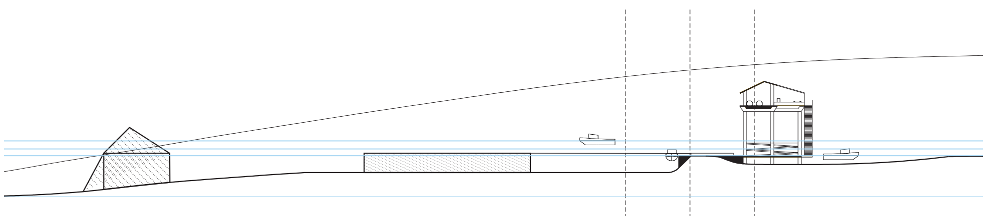
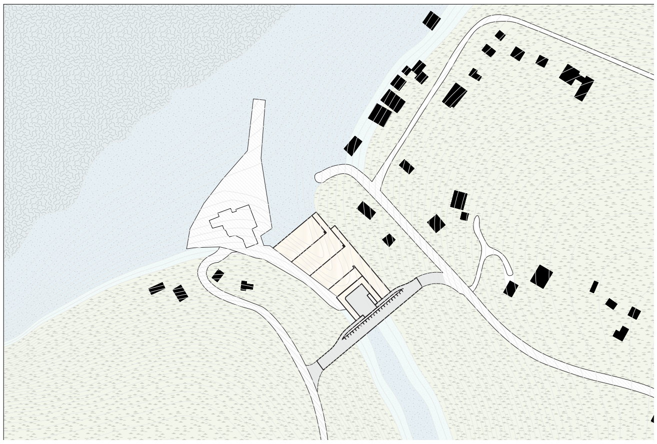
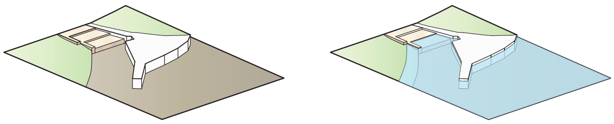


Figure 77: Charette Proposal A - Soft and Fixed

PROPOSAL B - SOFT AND FREE

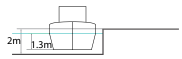




COUPLING 4

The first coupling in this proposal responds to many of the same problems explored in the previous two coupling proposals. As water levels rise (short term due to tides, and long term) how can boats navigate the harbour more freely at different water depths. This represents an amplification when compared to the current single docking solution of the harbour as it exists today.

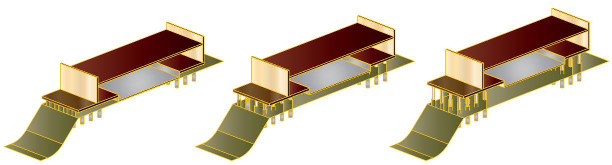
The interior harbour area created by the maintained break wall and pier is leveraged to create more docking opportunities in a variety of scenarios through the tiering of this space. A series of stepped docks fills this void and can be populated with human activity (fishing related, outdoor dining for tourists, or otherwise) when the tide is below each tier level. The steps are 2m intervals allowing the boats which have roughly a 1.3m draft with .7m preferred clearance to navigate safely and come to rest at an accessible height as tides go down.



COUPLING 5

The other exploration in the second proposal is the first into the amplification of variety for the whole building over time while attenuating the gap in the short term. This proposal operates in the long term range and therefore does not have the ability, on its own to fluctuate in the short term. As was seen in the previous proposal the high range of the Bay of Fundy when coupled with tidal range presents issues for placement of dry components. While the floating and ramping solution allowed the fixed location of the building it is possible to consider if the building was more free.

Hydraulic foundations have been used in a number of notable projects, particularly in cases where the ground being built upon is unstable fill, as seen in reclamation of landfills. And recently has been proposed as a solution to the flooding at Mies Van der Rohe's Farnsworth house. In this proposal however this would not look to operate for individual events but rather for the continued elevation of the building over time (proportional to the timescales of SLR).



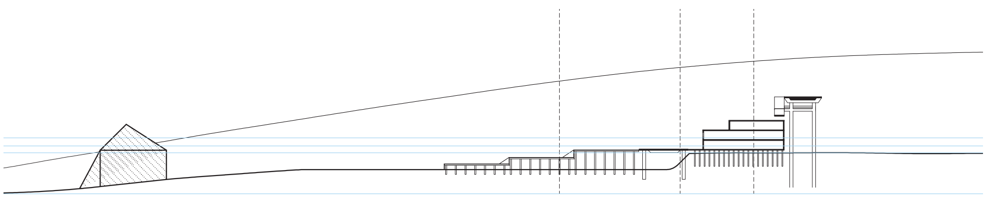
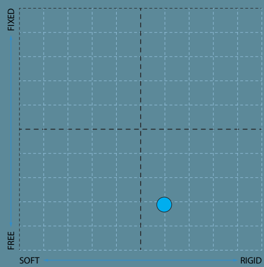
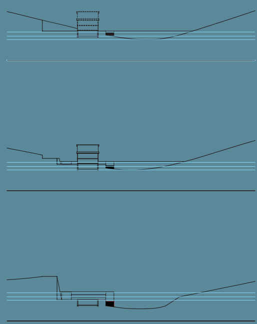
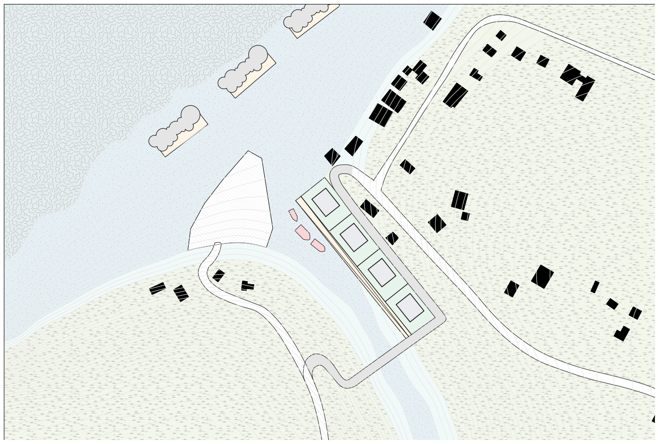


Figure 78: Charette Proposal A - Soft and Free

PROPOSAL C -
RIGID AND FREE



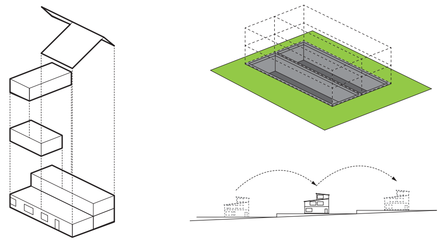




COUPLING 6

Similarly to the hydraulic system explored prior, this coupling looks at the long term position of the building and seeks to again amplify its long term variability while not creating much change in the short term. The proposed coupling uses an approach that would require planning and a timeline to be established of major SLR expectations.

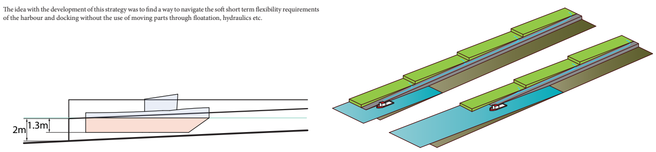
Along a series of terraced landscape flats, foundations would be pre-constructed at a unit dimension appropriate to both building foundation and lobster storage. While the building, modularly would be moved further up and inland as the sea levels rise over time, the foundations can continue to be used as lobster storage in the long term, allowing the tides to circulate the water, and expanding the harbours storage capacity over time as may become necessary with the northward shift of lobster.

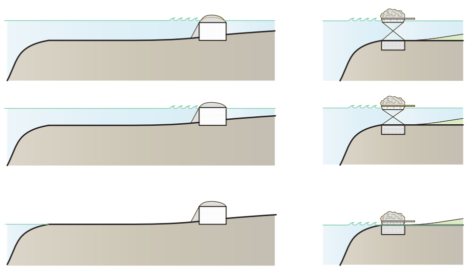


COUPLING 7

Adjacent to these tiered landscapes and allowing their easy navigation is a low sloped dock extending in land through the valley. This docking looks to amplify the variety of docking availability by allowing this availability to directly mirror the tides. As the tide rises the available positions along the ramp would change accordingly, and due to the relation to the intertidal ground level boats will be permitted to rest lightly on the ground, and still proximate to the dock level as the tides go down.

The idea with the development of this strategy was to find a way to navigate the soft short term flexibility requirements of the harbour and docking without the use of moving parts through floatation, hydraulics etc.





COUPLING 8

The final coupling explored is actually a comparative study of two strategies that can be universally applied to any of the proposals contained here. This looks at the idea of waves and seeks to attenuate their impact to activity within the harbour.

The first proposed method considers maintaining the existing wave break wall/pier for the current harbour. During current tidal fluctuations it would continue to operate as it does however it would require the distribution of more rock and fill on top to continue building it up as the overall water levels and storm events change. The major downside to this is its large and restrictive visual appeal along the coastline.

The second proposal would look to something now being used in a number of harbours around the world. This is the idea of a floating wave break. While this works to cut wave fluctuations the same way the other proposal does, its ability to lower and rest on the ground as well as rise to the required levels make it a less invasive option along the coast and something that could be deployed further along the coast to minimize coastal erosion.

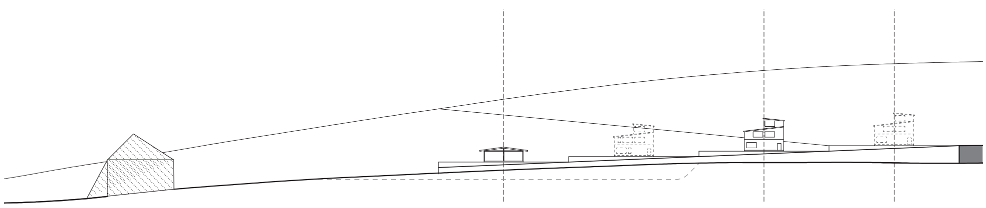


Figure 79: Charette Proposal A - Rigid and Free

Appendix C - Model Photographs

Figure 80: Halls Harbour overall model 1:1000
CNC chipboard, cast resin and 3D printed PLA

Figure 81: Halls Harbour Overview Model Various Views

a) View to the lobster pound on the West shore of the harbour

b) View into the harbour with the bridge as backdrop element

c) View to of the entire design proposal from the North West

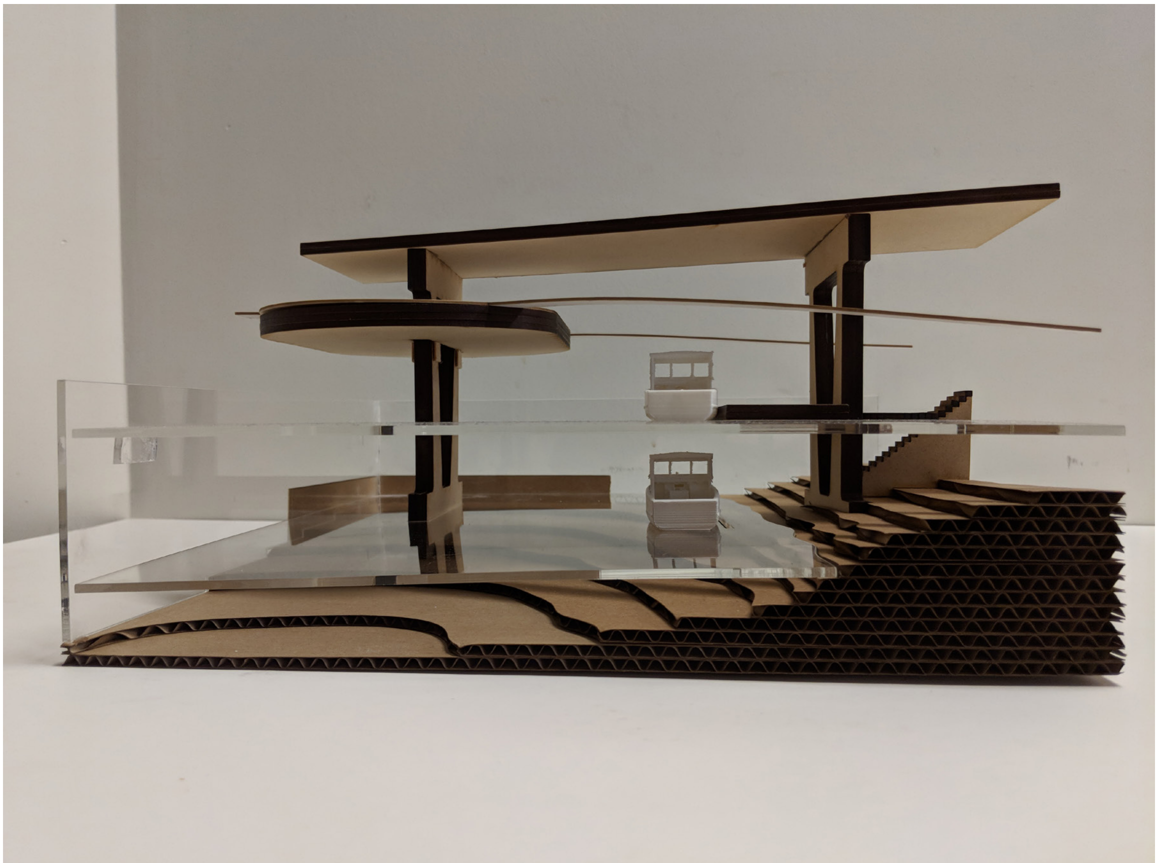
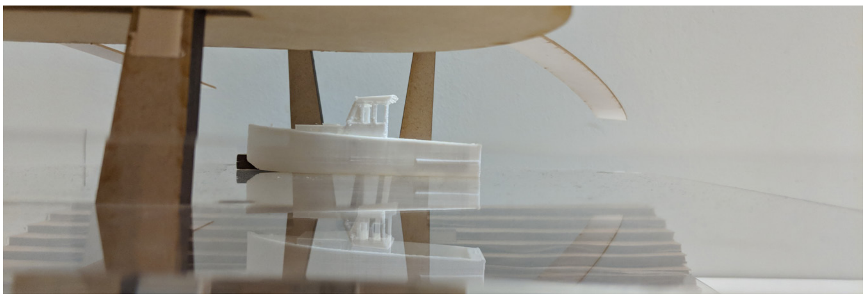


Figure 82: Bridge
Model 1:100
Cardboard, acrylic, mdf
and 3D printed PLA



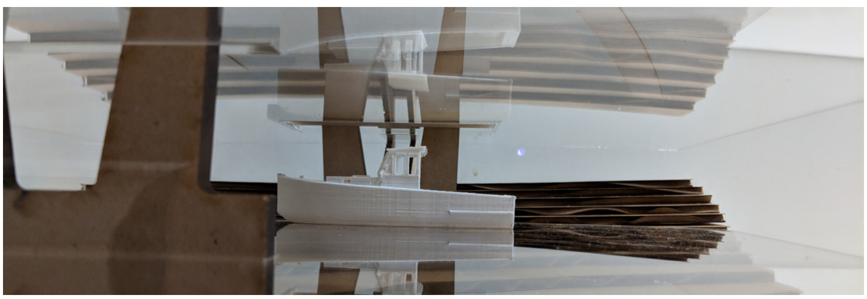


Figure 83: Bridge Model Closeups 1:100

a) Boat docked at a higher tide condition

b) Overhead showing layering of paths

c) Boat docked at a high tide condition side view

d) Boat docked at low tide side view