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RESILIENT ARCHITECTURE:
ADAPTIVE COMMUNITY LIVING IN COASTAL LOCATIONS

A Thesis Presented

by

ERICA MARIE SHANNON

Submitted to the Graduate School of the University of Massachusetts Amherst in
partial fulfillment of the requirements for the degree of

MASTER OF ARCHITECTURE

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Department of Architecture

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ABSTRACT

RESILIENT ARCHITECTURE: ADAPTIVE COMMUNITY LIVING IN COASTAL LOCATIONS

MAY 2018

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How can architects design for coastal inundation caused by climate change, what are the methods and strategies currently being implemented as a response to coastal inundation, and how can these strategies influence the design approach for a self-sustaining community that can survive and thrive in a low-lying coastal area?

Climate change is caused by an expenditure of planet-harming resources being improperly or inefficiently utilized and consumed. This can lead to a rise of global sea level and an increased severity of storm surges.

Resilience is defined as the ability to overcome challenges and difficulties. Coastal resilience is the ability for a coastal community to independently withstand shocks caused by hazardous storms and coastal flooding, adapt to future occurrences, and rebuild when necessary. Incorporating resilient and

adaptable design elements into architecture could help to create a more sustainable built environment that reacts more efficiently to challenges and difficulties that occur in the natural world.

The intent of this thesis is to design a coastal community-living development that serves as a case study for how communities in low-lying areas can be elevated in order to sustain fluctuating coastal conditions.

An ideal setting for the implementation of this thesis is Pleasure Beach Park, a low-lying barrier beach located on the coastline of Bridgeport, Connecticut. Through research and analysis of this location, this design responds to and includes essential programmatic elements deemed necessary for a community to exist in the area, as well as vital attributes that collectively form a resilient coastal community.

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CHAPTER 1

INTRODUCTION

1.1 Thesis Problems

Among the various outcomes of a changing climate is the escalation of sea levels around the world. Rising sea levels and the increased frequency of unpredictable storm surges are becoming more prevalent, as scientific projections pertaining to climate change grow progressively more drastic and alarming.¹ Current projections indicate that sea levels will continue to rise and storm surges will continue to grow in strength, resulting in plausible damage to the built environment, as well as a significant reduction in habitable dry land area.² This prediction could have a substantial impact on the near forty percent of the United States population that lives in coastal areas at high risk for flooding and destruction due to storm surges, as well as other coastal communities around the world.³

1.2 Thesis Objectives

This thesis presents an architectural solution to addressing rising sea levels and increased weather severity, whilst allowing residents of low-lying urban areas to continue to live and thrive along the coast. This thesis presents

¹ US Department of Commerce, National Oceanic and Atmospheric Administration. "Is Sea Level Rising?" *NOAA's National Ocean Service*, 1 June 2013.

² Union of Concerned Scientists—USA, "Infographic: Sea Level Rise and Global Warming", Web.

³ US Department of Commerce, National Oceanic and Atmospheric Administration. "Is Sea Level Rising?" *NOAA's National Ocean Service*, 1 June 2013.

the development of an elevated coastal residential community development that serves as a case study for an efficient way that communities in low-lying land areas can survive and thrive, regardless of fluctuations in sea level and weather patterns. This design implements a 'Timeline Design' approach, in which the building program of this resilient coastal project can evolve its functions and occupancy uses based on the phases in which the sea is predicted to fluctuate. This design approach also conveys the idea of implementing compartmental stewardship within a coastal community, meaning that each resident can play a role in the contribution toward resilience and self-sustainability within the community.

The implementation of anticipatory urban residential design as a method for coastal resiliency possesses the ability for a community to endure coastal inundation caused by the alteration of water and weather patterns in the future, while also continuing to capitalize on the potentials of viable coastline acreage rather than resulting to moving inward toward higher land. As a result, this strategy encourages the population to coexist with the changing climate conditions throughout all phases of the structure's life cycle.

The setting of this prototype is Pleasure Beach Park, a barrier beach located on the Bridgeport, Connecticut coastline. The proposed design reclaims parts of the Bridgeport shoreline from its industrial dominance through the

inclusion of both community-driven public and residential-based private programmatic experiences. This location provides the ability to reinvent the conventional residential way of life, by introducing a prototypical elevated community that resides above sea level projections and is responsive to a fluctuating coastline.

1.3 Methods

This thesis provides an extensive investigation of social, structural, and architectural methods for addressing coastal flooding. The analysis of this research is derived from both theoretical and actual precedents, and establishes the basis for the development of this design proposal. This design is comprised of scrutinized parts extracted from methods and theories found in the literature review and precedent analysis segments of this investigation. These parts were then analyzed and rearranged to defend the conclusion that developing an elevated community in a low-lying coastal area is a resilient response to coastal flooding and global sea level rise.

CHAPTER 2

COASTAL INUNDATION

The controversial issue of climate change has become increasingly visible over the past several years due to heightened awareness of its potentially damaging outcomes. Climate change occurs as a result of resources being improperly or inefficiently utilized and consumed in industrial and post-industrial societies. Among the numerous outcomes of a changing climate is the issue of rising sea levels around the world. Based on scientific predictions, the fluctuation of sea levels may pose significant dangers to major cities that occupy coastlines, including chronic inundation and flooding damage to urban systems.

2.1 Cause of Coastal Inundation

Climate change is occurring primarily due to human-induced impacts on the essential greenhouse gases in the atmosphere that protect the planet from excessive solar radiation.⁴ According to global climate change investigations conducted by NASA, human activities such as burning fossil fuels and clearing land for the establishment of infrastructure lead to elevated concentrations of greenhouse gases, whose constituents are crucial for the regulation of the

⁴ "Global Climate Change." NASA. NASA, 02 June 2014. Web.

earth's climate.⁵ It is projected that the human impact on the 'greenhouse effect' will produce increasingly detrimental climate shifts in the future.⁶

Sea levels around the world are rising at an increasingly rapid rate. The Union of Concerned Scientists claims that sea levels are rising due global warming's increased temperatures, which induce melting glaciers and ice sheets, as well as the thermal expansion of ocean water.⁷ This can lead to coastal communities experiencing chronic inundation, or "flooding that occurs 26 times per year (on average, once every other week) or more".⁸

2.2 Projections + Predictions

It is predicted that the global sea level will rise between one and four feet throughout the course of this century, with sea level increase equal to that or greater estimated for future centuries.⁹ This increased projection rate is due to the anticipation of continual resource expenditure, including oil and fossil fuels, thus potentially transforming the way humans occupy the planet in centuries to come.¹⁰ This global rise of sea level can have many negative outcomes, including permanent evacuation of low-lying areas and abandonment of existing architecture and infrastructure along coastlines.

⁵ "Global Climate Change." NASA. NASA, 02 June 2014. Web.

⁶ "Global Climate Change." NASA. NASA, 02 June 2014. Web.

⁷ Union of Concerned Scientists—USA, "Infographic: Sea Level Rise and Global Warming", Web.

⁸ "When Rising Seas Hit Home: Hard Choices Ahead for Hundreds of US Coastal Communities (2017)."Union of Concerned Scientists", Web.

⁹ "Global Climate Change." NASA. NASA, 02 June 2014. Web.

¹⁰ Union of Concerned Scientists—USA, "Infographic: Sea Level Rise and Global Warming", Web.

2.3 Methods of Addressing Coastal Inundation + Their Impacts

There are a variety of design tactics and response strategies that are being implemented around the world in efforts to mitigate the effects of rising sea levels and coastal flooding. Implementations can be categorized within five major architectural and landscape strategies for addressing coastal inundation; flee the area, harden the landscape, soften the landscape, elevate the architecture, and float the architecture. These categories are illustrated in the figure below.

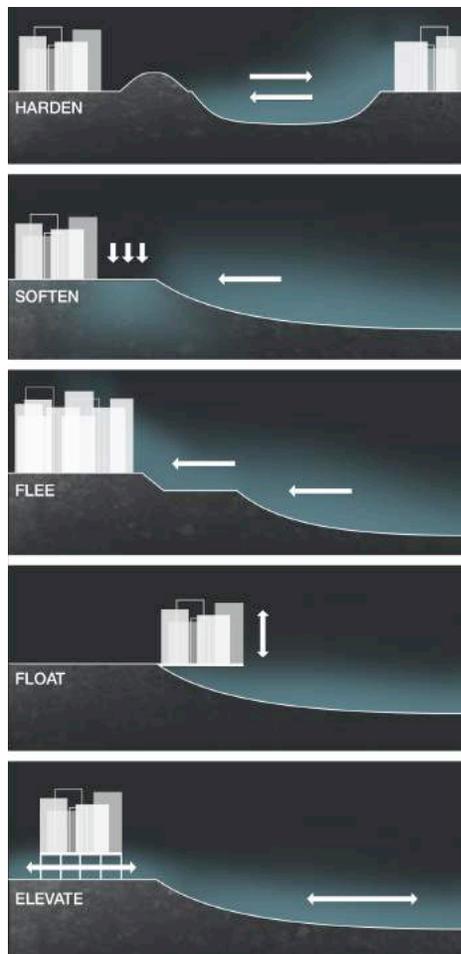


Figure 1: Coastal Flooding Response Methods

2.3.1 Harden

A controversial response employed to mitigate destruction to coastal areas caused by sea level fluctuation and damaging storm surges is coastal hardening, a method that prevents water permeation almost entirely. This process occurs when heavily reinforced structures or landmass in the form of levees or dams are constructed to prohibit water from infiltrating low-lying land. An example of this process is Japan's application of massive earthquake-resistant levees that protect many of its cities from flooding nearby rivers. The Japanese government implemented "gently sloping embankments with earthquake-resistant foundations and widths almost 30 times their height," that serve to control flooding, while providing ecological benefits as well as public amenities and purposeful infrastructure.¹¹



Figure 2: Japan's Super Levees
["IMPLANT Levee" IMPLANT Levee, 06 January 2012. Web.]

¹¹ Delta Coalition. "Delta Coalition." *Delta Coalition*. Web.

Although coastal hardening may appear to be a straightforward response to flooding and rising sea levels, it is questionable as to whether or not this is the most effective solution. There are many factors that must be considered pertaining to this method, including practicality and expense. Also, there is the question of whether the practice of redirecting water to other areas becomes problematic for adjacent coastline towns and cities. Theorists explain, "The only good thing that can be said about seawalls is that they are quite successful in saving buildings. But as our shores become walled in and our islands and beaches become walled fortresses, what do we do for beaches?"¹²

2.3.2 Soften

More recently, researchers and designers have adapted a more effective method to address the issue of coastal flooding. The term "shifting from resistance to resilience," described by Hillary Brown, author of *Next Generation Infrastructure*, calls for creating a 'soft' coastline that can efficiently adapt to altering water conditions.¹³ This method depicts the idea of designing coastlines that accommodate excess water, rather than blockading it. However, one of the drawbacks associated with softening landscape and accommodating water often

¹² Pilkey, Orrin H. *Coastal design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. 159.

¹³ Hillary Brown. "Next Generation Infrastructure". *Island*, 2014. Print. 134.

leads to designating a majority of low-lying area for landscape, resulting in straying away from architectural development in these areas.

2.3.3 Flee

One response strategy currently being used is evacuating areas prone to damage prior to a predicted storm surge or coastal disaster. In the case of an anticipated natural disaster, individuals are often strongly urged to vacate their homes and move to higher elevations. Though this may be portrayed as the most obvious initial strategy, there are a variety of cascading repercussions associated with this method of response. Mass migration to higher land, whether it may be a temporary arrangement or a permanent solution, can cause negative outcomes such as crowding and encroachment of inland regions, as well as abandonment of viable architecture and infrastructure in the endangered locations that can take decades to rebuild.

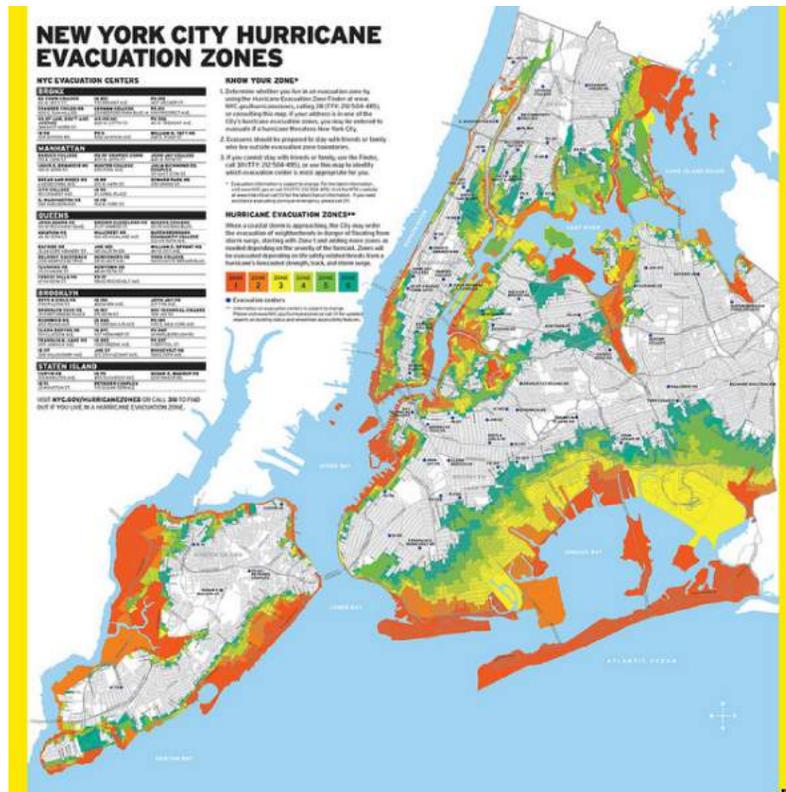


Figure 3: NYC Hurricane Evacuation Zones
 ["NYC Hurricane Evacuation Zones Map Updated Months After Hurricane Sandy (MAP)." Web.]

Overpopulation of inland areas can generate substantial issues if the universal solution to coastal flooding was to refrain from building in low-lying areas, and instead move the entirety of the built environment to higher ground. Due to the fact that almost forty percent of the United States population currently resides in flood-prone areas, continuing to put the response strategy of fleeing inland into effect could lead to large-scale resettlement of almost half of the country's population.¹⁴

¹⁴ US Department of Commerce, National Oceanic and Atmospheric Administration. "Is Sea Level Rising?" NOAA's National Ocean Service, 1 June 2013. Web.

2.3.4 Elevate

Elevating coastal structures can mitigate the cascading damages to urban systems caused by flooding. Hillary Brown, author of *Next Generation Infrastructure*, states, "Because critical urban systems such as power stations, waste-water treatment and solid-waste management plants, and pumping stations have historically been sited along rivers or on or near coasts, they, along with their associated substations, gas pipelines, and landfills, are subject to inundation."¹⁵ This statement implies that there are cascading repercussions of global warming's effect on water bodies that extend beyond regions subjected to flooding.

Urban systems often have ties to components within the innermost elements of a city, implying that even urban systems that are not in close proximity to water bodies may be indirectly affected by the aftermath of fluctuating ocean and weather patterns, and may sustain impacts such as power outages and transportation failure. By designing coastal architecture with the approach of locating structure and mechanical systems above the projected sea level, damage caused by coastal flooding can be prevented, while also preserving the potential usage of low-lying areas as buildable land.

¹⁵ Hillary Brown. "Next Generation Infrastructure". *Island*, 2014. Print. 131.

2.3.5 Float

Another resilient strategy being executed in low-lying coastal locations is the concept of floating architecture. This concept involves the process of designing buoyant structures that always remain above sea level. Though floating architecture may respond well to the gradual rise of global sea level, it may not react positively to fluctuating storm surges and increased wave momentum, which is are becoming increasing characteristics of the predicted severity of coastal weather. The practicality of an individual being able to remain in a floating home throughout the duration of a storm surge may not be feasible as coastal storms get progressively worse due to climate change.

Though this strategy may be an efficient solution for locations such as lagoons or inlets that are protected from wind and wave impact, this strategy may pose further complications for low-lying areas located directly along the coast of major water bodies that will experience storm-induced impacts. Philip Wilson, a professor of ship dynamics and engineering at the University of Southampton, states, "If you built a floating city where you are making half the population sea sick, that is not going to be economically viable".¹⁶ Another potentially negative impact of creating floating architecture is that due to its

¹⁶ Cosgrave, Ellie. "Future - The Future of Floating Cities – and the Realities." *BBC*, BBC, 29 Nov. 2017, Web.

relative newness in the development world, designers are not entirely sure of its long-term effects on ecology and marine environments in the locations where floating architecture is constructed.¹⁷

2.3.6 Analysis of Approaches

Based on the variety of tactics researched and analyzed regarding solutions for coastal inundation described in previous sections, it can be concluded that the strategy of designing for the allowance and adaptation of water fluctuation on coastlines produces a more successful outcome than the design decision to control water or prevent it from permeating coastal communities. Orrin Pilkey, author of *Coastal Design*, states, "It is wise to work with and not against nature".¹⁸ Due to the fact that natural occurrences are often too powerful to be fully controlled, designers of the built environment should shift toward the objective of adapting to natural occurrences, and deter from the act of preventing natural instances from taking place through the development of coastal berms and levees. That being said, the strategy to flee and abandon low-lying regions also possesses many negative outcomes, including the potential of overcrowding of inland areas if mass migration occurs, as well as the

¹⁷ Lima, Rui & Boogaard, Floris & De Graaf, Rutger & Dionisio Pires, Miguel & Sazonov, V. (2015). MONITORING THE IMPACTS OF FLOATING STRUCTURES ON THE WATER QUALITY AND ECOLOGY.

¹⁸ Pilkey, Orrin H. *Coastal design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. 2.

possible abandonment of thousands of historic architectural and infrastructural landmarks that reside along coastlines.

The strategy depicted in this thesis is a derivative of successful resilient solutions extracted from these methods, primarily the tactic of elevating architecture and building systems. Bill Reed, author of *The Integrative Design to Green Building*, explains the fact that regardless of how sustainable or resilient the built environment may be, individuals must be cautious of the fact that we are inevitably “replacing the natural environment with the built environment.”¹⁹ Despite how sustainable coastlines are designed, “Our current practice is one that systematically replaces a self-sustaining system with one that requires constant investment, maintenance, and replacement.”²⁰ The design approach depicted in this thesis addresses Reed’s statement because it proposes the creation of a self-sustaining built development within a viable land area that poses very little impact on the already existing ecological system. This elevated design approach also encourages designers to merge the gap between human control and natural occurrence, and find the balance between controlling the coastlines and abandoning them altogether.

¹⁹ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. 43.

²⁰ *Ibid.*, 43.

CHAPTER 3

RESILIENT DESIGN AS A RESPONSE

"It's how are we going to live in it, not how are we going to stop it..."

- Leslie Koch, of the Trust of Governors Island ²¹

3.1 What is Resiliency?

Resiliency can be defined as "the ability to overcome challenges of all kinds—trauma, tragedy, personal crises...and bounce back stronger, wiser, and more personally powerful."²² Coastal resilience is the capability for a coastal community to independently withstand shocks caused by hazardous storms and coastal inundation, adapt to future occurrences, and rebuild when necessary. In order to prolong the lifespan of coastal municipalities, it is crucial for designers and architects to consider strategies to mitigate damage within coastal communities caused by climate change. Implementing resilient design tactics in cities in close proximity to water bodies and coastlines is an effective response to addressing the issue of climate change, specifically pertaining to rising flood levels and increased severity of storm surges.

²¹ Leslie Koch, quoted in Sam Lubell. "NY's Clever New Park Will Weather Epic Storms and Rising Seas." *Wired*. Conde Nast, 07 July 2016. Web.

²² "What Is Resiliency and Why Is It So Important?" *Resiliency in Action*. Web.

3.2 Resilient Architecture is Not Static

The Integrative Design Guide to Green Building, a publication written by 7Group and Bill Reed, emphasizes the importance of sustainable architecture, and critiques the current manner in which sustainability is being implemented. The authors depict the theory that sustainable and resilient design is not static, but rather a continuous process. The authors defend this concept by explaining that the primary goal of the current sustainability movement is to replace environmentally harmful products and technologies with eco-friendly alternatives. However, 7Group and Reed argue, "If we are to have any chance of creating a fundamental shift in the way that we inhabit the planet, improving our products is only part of the story."²³ Instead, *Integrative Design* encourages designers and developers to rethink sustainability by transitioning to the mindset of continuous design, in which the built environment not only addresses the issues of today, but also considers solutions for addressing matters to come.

There has been a recent drive towards incentivizing resilient design, similar to the Leadership in Energy and Environmental Design (LEED) approach of creating a more sustainable built environment. RELi, a resilient framework that can be put in place to improve the resilience of future designs, "combines a comprehensive list of resilient design criteria with the latest in proven integrative

²³ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. 41.

process for developing next generation communities, neighborhoods, buildings, homes and infrastructure".²⁴ RELi was developed in order to encourage "advanced, and even revolutionary resilient, regenerative and healthy outcomes that support the whole of life".²⁵ Architects and developers can incorporate RELi's principles, categorized as 'Resilience, Restoration, Regeneration, Sustainability and Wellness' into their designs in order to create an overall more resilient built environment.²⁶

3.3 Structural Strategies for Resilient Coastal Design

In order to develop resilient structures in coastal areas, the ability for the structure to withstand potentially damaging coastal forces is a crucial aspect of its longevity. According to *Coastal Design*, "One of the principle rules of beaches is that they exist in a dynamic equilibrium controlled by four factors: the energy of the waves, the shape of the beach, the supply of beach sand, and the level of the sea".²⁷ A coastal structure must be designed to protect its inhabitants against rising sea levels, flying debris caused by wind forces, erosion of sand beneath the structure, and potential landslides.²⁸

²⁴ "RELi." C3 Living Design Project, 10 Dec. 2017, Web.

²⁵ Ibid.

²⁶ Ibid.

²⁷ Pilkey, Orrin H. *Coastal Design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. Print. 4.

²⁸ Ibid., 35.

In regards to the materiality of a resilient coastal structure, it has been determined that the structure should consist of materials that are pliant and flexible, in order to resist impacts caused by wind and water forces. According to *Coastal Design*, naturally durable wood, non-corrosive steel, and reinforced concrete are sufficient coastal building materials, whereas hollow masonry, brick, and precast concrete panels are not considered adequate materials for resilient design.²⁹ Additionally, a building design that includes smaller areas of translucent materials will improve the façade's overall strength against wind forces.³⁰

Building form also plays a significant role in a structure's ability to withstand coastal impacts, primarily wind damage. According to Pilkey, author of *Coastal Design*, "Wind is one of the most severe natural hazards, second only to fire in terms of lives lost and property damaged".³¹ Pertaining to building irregularity, "Experience shows that [wind] damage is concentrated at points of structural discontinuity. When irregularities are absent, [the building] reacts to the storm winds as a complete unity".³²

²⁹ Ibid.,37.

³⁰ Ibid., 64.

³¹ Pilkey, Orrin H. *Coastal Design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. Print. 92.

³² Ibid., 37.

When determining programmatic layout within a building along the coast, it is suggested that the lowest level is designated a 'Sacrificial First Floor', implying that any programmatic elements located on this level could be allowed to endure impacts caused by potential inundation.³³ The first floor of a resilient coastal structure may consist of piers, typically made of reinforced concrete and spaced at a maximum of 8 feet in the direction perpendicular to the joists, and 12 feet in the direction parallel to the joists.³⁴ The 'Sacrificial First Floor' concept also applies to mechanical system locations within the structure. In regards to building systems, Pilkey states, "The design [should] be such that essential services will not be interrupted. Machinery for elevators, stand-by generators, boilers, and air conditioning [should] be located above the predicted high water".³⁵

³³ Ibid., 67.

³⁴ Ibid., 69.

³⁵ Pilkey, Orrin H. *Coastal Design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. Print. 131.

CHAPTER 4

LITERATURE REVIEW

4.1 Anticipatory Design

Stewart Brand, author of *How Buildings Learn*, discusses his belief that buildings are constantly growing and evolving in accordance with their occupants and their surroundings. Brand claims, "All buildings grow...most grow even when they're not allowed to."³⁶ Brand highlights the inevitability of growth or internal change in buildings of all types, and explains the multiplicity of phases within their adaptation. According to Brand, though no buildings adapt well because they are not currently designed to, they adapt anyway, as they respond to the changing circumstances around them. However, one can argue that if new buildings were designed to adapt to future circumstances, then this could improve the built environment's overall capability to adapt.

Brand emphasizes the fact that time is essential in order for buildings to evolve. Without time, it would not be possible for a building to grow. Designing for resilience by implementing an anticipatory strategy design approach will ensure that the growth of a building provides for the allowance of successful adaptation throughout all phases of its lifespan.

³⁶ Stewart Brand. *How Buildings Learn: What Happens After They're Built*. 10.

4.1.1 Programmatic Scenario Planning

Brand suggests that individuals should, “Examine buildings as a whole—not just whole in space but whole in time.”³⁷ He criticizes the concept of designing a building as if it is static and whole in space, because he believes that this design process often neglects to consider the possibilities and potentials of the building’s future. Brand points to the conclusion that in order to create successful architecture that possesses the ability to adapt and evolve, architects should examine the present the way that historians examine the past—in regard to changes that have occurred diachronically, meaning over a period of time, as opposed to synchronically, meaning the way components fit together at one specific point in time.³⁸ Architects should be designing structures that serve a variety of purposes over the course of various periods in time, and that consider the concept that the built environment can be designed to accommodate the needs of many different functions beyond the immediate programmatic needs of the initial post-construction occupants.

Brand emphasizes the notion that designers must introduce the concept of developing a scenario plan, a collaborative tactic used to foresee potentials in the building’s future. Scenario planning differs from programming in the sense that it anticipates change in the distant future, and designs for such as well as

³⁷ Stewart Brand. *How Buildings Learn: What Happens After They're Built*. 2.

³⁸ Stewart Brand. *How Buildings Learn: What Happens After They're Built*. 210.

designing a program for the immediate future. Scenario planning suggests a collaborative process that involves all parties investigating and exploring all components within different phases of design development.

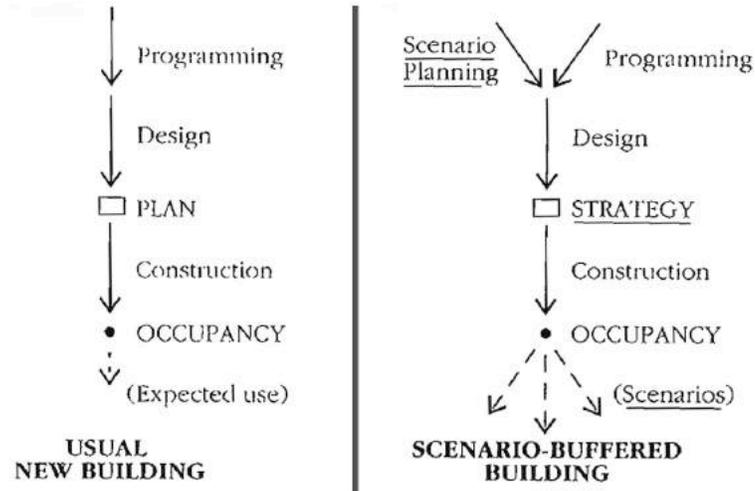


Figure 4: Scenario Planning
 [Stewart Brand. *How Buildings Learn: What Happens After They're Built*. 178.]

Pertaining to resilient coastal design, scenario planning can be utilized by designers to consider anticipatory design incorporations that respond to coastal inundation and storm surges over the course of the entire life cycle of the coastal built environment.

4.2 Designing a System Within a Larger System

Integrative Design introduces the concept that attempting to decelerate the events pertaining to climate change and environmentally damaging impacts will not get rid of them. Reed states, “We might build nothing but LEED Platinum buildings with net-zero energy or water use for the next one hundred

years and still succeed at destroying the system, or web of relationships, that sustains life on the planet.”³⁹ Instead, Reed explains that in addition to mitigating the environmental damages inflicted by individuals, we must also consider the regeneration and restoration of the natural environment that has already sustained the damages that the population has caused.⁴⁰

An effective approach to sustainable design, according to *Integrative Design*, is regeneration, or the design of a whole system intended to “give new life and energy to” the systems within.⁴¹ This can be accomplished through the implementation of what Reed describes as a ‘Nested Systems’ design mentality, a process in which the elements within the built environment are visualized and created as if they are minute components within a much larger system.⁴²

³⁹ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. 44.

⁴⁰ *Ibid.*, 46.

⁴¹ *Ibid.*, 46.

⁴² *Ibid.*, 54.

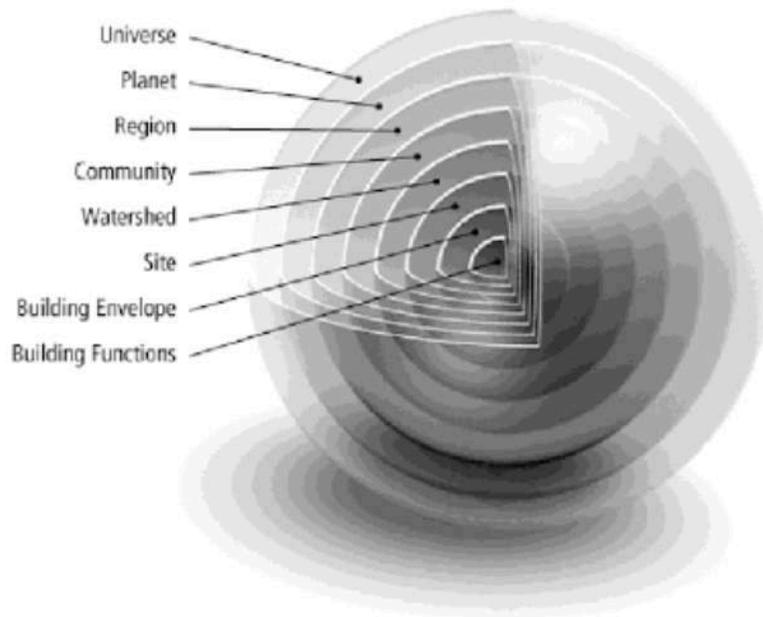


Figure 5: Nested Systems

[Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. 54.]

Reed explains that architects and designers must learn to mitigate the differentiation between humans and nature. Reed states, “The notion that the only way to save the planet is to keep our hands off of it is fundamentally unsustainable.”⁴³ Instead, we must develop a way for humans to coexist and thrive cohesively with the natural world.

Reed introduces the concept of implementing a *Reciprocal Relationships* system into the built environment. This system operates in such a way that “there is no resource that is not created from waste and no waste that is not

⁴³ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. 49.

turned into a resource."⁴⁴ This concept defends the implementation of designing architecture to be part of a greater whole, and in such a way that every building makes a positive contribution to the functionality of this whole.

4.3 The Importance of Aesthetics in Resilient Design

In addition to the significance of functionality and practicality in resilient architectural design, the role of aesthetics shares an equal weight of importance in the success of resilient coastal architecture. Alain de Botton, author of *The Architecture of Happiness*, explains that successful architecture has a "nonchalant appearance."⁴⁵ De Botton claims that the beauty of architecture is portrayed in such a way that despite all of the unpleasant elements involved in architectural construction, the final product almost always portrays simplicity and nonchalance.

Alain de Botton associates beautiful architecture with its ability to afflict a calm, composed and unconcerned manner on its inhabitants, an emotional portrayal that differs from its development. The author quotes Karl Friedrich Schinkel, "To turn something useful, practical, functional into something beautiful, that is architecture's duty."⁴⁶ The duty of resilient architecture, in this

⁴⁴ Ibid., 51.

⁴⁵ Alain De Botton. *The Architecture of Happiness*. New York: Pantheon, 2006. 15.

⁴⁶ Ibid., 47.

circumstance, is to encompass both the practicality of safely living on a coast, while maintaining and preserving the beauty of the coast.

De Botton mentions that the beauty of architecture is often not fully portrayed due to “a host of limitations,” including climate, expense, and the hindering of the spread of knowledge.⁴⁷ The rising concern of climate change has increased the awareness and significance of resilient design, and thus changing the way the world visualizes and creates architecture. However, these limiting circumstances do not have to necessarily hinder a designer’s ability to incorporate beauty into architectural functionality or resilience. Integrating aesthetic into a resilient design through the use of natural elements and carefully planned design will aid in the success of a project and surpass the limitations that de Botton iterates above. Furthermore, architectural aesthetic, whether natural or artificial, could potentially serve the purpose of being an informative or engaging design tool for resiliency.

Alain de Botton explains that architecture is derived from many things. Religion, theory, time, and location, are critical factors in the evolution of the built environment, as well as derivatives of it. The evolution of architecture is a derivative of time, human experience, locational change and the advancement of theory, indicating that architecture is never static. It is constantly changing,

⁴⁷ Alain De Botton. *The Architecture of Happiness*. New York: Pantheon, 2006. 33.

making mistakes, bettering itself, and altering the way that the world functions and history is created.

4.3.1 Relationship of Binary Terms in Architecture

Susannah Hagan, author of *Digitalia*, believes that there are binary terms in architecture that exist in a hierarchical standing, in which one component dictates the other. In her publication, Hagan iterates the fact there should be a sense of complementarity within all binary components; mind and body, nature and culture, material and digital.⁴⁸

Hagan's concept of equal importance of architecture and nature can be applied more efficiently as we migrate into a world that is more increasingly focusing on the exploration of designing architecture that coincides with the natural environment. How can architects design architecture that equally respects and caters to the built environment and the natural world?

Hagan encourages designers to implement the interconnectivity of the natural and material world, perhaps through the exploration of creating a dialogue between the immediate present design and that same design in the future. This theory of interdependency between present and future design corresponds to Stewart Brand's emphasis of the implementation of scenario

⁴⁸ Susannah Hagan. *Digitalia: Architecture and the Digital, the Environmental and the Avant-Garde*. London: Routledge, 2008. Print. 11.

planning in the sense that buildings must not only be designed for the present occupants, but for the potentials of the future. How can architects design for today, while addressing the equal importance of designing for the future?

CHAPTER 5

PRECEDENT STUDIES

5.1 The Vale Living with Lakes Centre

The Vale Living With Lakes Centre, located on the Laurentian University campus in Sudbury, Ontario of Canada, is an example of regenerative architecture that implements Bill Reed's "Nested Systems" design theory.⁴⁹ Designed by Perkins + Will Architects, the primary intent of the project is, "To house a research and monitoring institute dedicated to the protection and management of northern aquatic ecosystems."⁵⁰ According to Jim Taggart of the *Sustainable Architecture and Building Magazine*, the site is located within the largest nickel-mining region in Canada, which is also a shoreline parcel on Ramsey Lake, and one of the most industrially damaged landscapes in Canada.⁵¹

⁴⁹ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. Print. 54.

⁵⁰ "Regenerative Design in Practice." *Regenerative Design in Practice | Sustainable Architecture and Building Magazine*. Web.

⁵¹ "Regenerative Design in Practice." *Regenerative Design in Practice | Sustainable Architecture and Building Magazine*. Web.



Figure 6: Vale Living with Lakes Center Hydrology
["Welcome to the Vale Living With Lakes Centre." *Vale Living with Lakes Centre*. Web.]

The figure above portrays the building layout on the site, and also highlights the building hydrology as well as the design intention of the building footprints to reciprocate the topographical patterns of the site. Though the repercussions of the mining era on the site posed many challenges for the designers and contractors, the waterfront location introduced a variety of opportunities for regenerative and sustainable design, primarily pertaining to water management and conservation.

This project includes many regenerative and restorative design strategies, including the intent to preserve and revitalize the health of the nearby Ramsey Lake and the watershed. Perkins + Will intended to exceed the expectations associated with typical high-performance architecture for this project through an

intensive exploration of the site for the purpose of gaining a thorough understanding of site-specific water patterns, and to decipher methodologies that could restore and revitalize the damaged landscape, therefore making a positive contribution to the larger system in which it resides.

One example of the implementation of a regenerative strategy implemented by Perkins + Will is the fact that 73% of the construction materials of the project were redirected from landfill.⁵² This design tactic supports the closed loop system design approach of *reciprocal relationships*, depicted by Bill Reed in *The Integrative Design Guide to Green Building*.⁵³

A variety of water treatment, management and reuse tactics were incorporated into the regenerative design of the Vale Living With Lakes Centre. Rainwater is captured and utilized for many different purposes on the site. One implementation of rainwater harvesting and treatment is the allowance for infiltration of rainwater into the building's green roofs to be used as non-potable water on the site.⁵⁴ Another usage for excess rainwater is to redirect it to the site's bioswale, which serves as a filtration device before the water eventually

⁵² "Regenerative Design in Practice." *Regenerative Design in Practice | Sustainable Architecture and Building Magazine*. Web.

⁵³ Bill Reed. *The Integrative Design Guide to Green Building: Redefining the Practice of Sustainability*. Hoboken, NJ: Wiley, 2009. Print. 51.

⁵⁴ "Welcome to the Vale Living With Lakes Centre." *Vale Living with Lakes Centre*. Web.

reenters the lake.⁵⁵ According to Laurentian University, the water regeneration strategies integrated into Perkins + Wills' design provide for 80% of the buildings water necessities that otherwise would have derived from municipal water use.⁵⁶

Taggart explains, "As a result of these regenerative design strategies, every drop of rain falling on the building or the site contributes to the rejuvenation of the lake, and over time, the entire ecosystem," implying that this design is making a positive regenerative contribution to the overall system that Reed mentions in *Integrative Design*.⁵⁷ The constant closed-loop cycle of rainwater collection, filtration and redistribution within the site is a successful regenerative design method on a waterfront location that could be incorporated into other coastal designs, therefore making an even larger contribution to the overall environment in which all architecture resides.

5.2 The Brooklyn Waterfront Greenway

A project that enacts strategies addressing climate change in New York City, NY is the Brooklyn Waterfront Greenway design, the revitalization proposal for an existing coastline condition lead by landscape architecture firm, WE

⁵⁵ "Regenerative Design in Practice." *Regenerative Design in Practice | Sustainable Architecture and Building Magazine*. Web.

⁵⁶ "Welcome to the Vale Living With Lakes Centre." *Vale Living with Lakes Centre*. Web.

⁵⁷ "Regenerative Design in Practice." *Regenerative Design in Practice | Sustainable Architecture and Building Magazine*. Web.

Design. This project implements anticipatory design by integrating regenerative strategies that encourage the Brooklyn Greenway to “serve as the spine for a larger storm water management network.”⁵⁸ Brooklyn was one of the primary areas of New York City that was severely damaged as a result of flooding caused by Hurricane Sandy, a disastrous storm that hit the coastline in 2012. This project, completed in 2015, transforms fourteen miles of the perimeter of Brooklyn into a more resilient and adaptable coastline.⁵⁹ New York City officials came to the conclusion that, “Green infrastructure, such as swales and green roofs, would be greater than an alternate investment in traditional ‘grey’ infrastructure,” and in this circumstance, would serve as a rainwater harvesting system and sufficient preventer of raw sewage from permeating into the nearby harbor and rivers in the likelihood that another natural disaster occurs.⁶⁰ This design will allow the Brooklyn Waterfront Greenway to more efficiently respond to anticipated storms that may disrupt the city’s sewer systems, and other mechanical systems that are at risk of potential damages due to future flooding.

According to the Brooklyn Greenway Initiative, “This green infrastructure will capture and treat over 6 million gallons of storm water annually, or 35% of the storm water from the projected area that otherwise would contribute to

⁵⁸ “Brooklyn Waterfront Greenway.” *WE Design Landscape Architecture*. 05 Jan. 2017. Web.

⁵⁹ “Brooklyn Waterfront Greenway.” *WE Design Landscape Architecture*. 05 Jan. 2017. Web.

⁶⁰ “Stormwater Infrastructure.” *Brooklyn Greenway Initiative*. 28 June 2016. Web.

sewer overflows and pollute the East River," therefore mitigating cascading effects of damage to urban systems caused by fluctuating ocean and weather patterns.⁶¹ If this method of anticipatory design pertaining to rising sea level and storm surge resilience were to be applied to other major cities along the coastline, perhaps the outcome could be eventual stability of water treatment systems following storm surges across cities around the world.

5.3 Governors Island

Another implementation of a 'soft' anticipatory approach is the renovation of the once-abandoned Governors Island, a 187-acre landmark located in the New York City Harbor, NY.⁶² The landscape architecture firm, West 8, designed the reconfiguration of the island's master plan, which includes a park and a variety of public spaces.⁶³ This master plan includes design strategies that address coastal flooding in the New York City Harbor. One of the project's main resilient strategies was the decision to elevate the site's vegetation in order to remove it from the dangers associated with flood zones.

As a method of designing with the anticipation of increased occurrence of natural disasters in the area, West 8 designers informed New York City planners that in order to "protect the park's trees...they would need to lift nearly 40 acres

⁶¹ "Stormwater Infrastructure." *Brooklyn Greenway Initiative*. 28 June 2016. Web.

⁶² "Governors Island." *Governors Island*. Web.

⁶³ West 8. "Governors Island Park and Public Space Master Plan." *West 8*. Web.

of land on the southern half of Governors Island.⁶⁴ This was achieved by introducing a series of hills that serve as natural water barriers, while also safeguarding a majority of the island's vegetation from the damages of coastal flooding. These hills are constructed mainly of debris that is covered with jute mesh, a tactic called an "erosion control mat", which are then topped with a variety of greenery, a process intended to "prevent erosion and stabilize the new topography."⁶⁵ Aside from serving as method of resilience for the island, the hills also generate an aesthetic layout for the park design and create a series of aerial views across the harbor for the public.



Figure 7: Rendering of Governors Island Hills
[Sam Lubell. "NY's Clever New Park Will Weather Epic Storms and Rising Seas." *Wired*. Conde Web.]

⁶⁴ Sam Lubell. "NY's Clever New Park Will Weather Epic Storms and Rising Seas." *Wired*. Conde Nast, 07 July 2016. Web.

⁶⁵ Sam Lubell. "NY's Clever New Park Will Weather Epic Storms and Rising Seas." *Wired*. Conde Nast, 07 July 2016. Web.

This case study serves as an example of a way that essential programmatic elements can be elevated in low-lying areas in order to minimize flooding damage and prevent the need for relocation.

5.4 The Dryline

Among the drive toward a more resilient coastline is the proposed Big U, also known as the Dryline. The Dryline, designed by the Danish architecture firm Bjarke Ingels Group (BIG), is comprised of a resilient system located on ten miles of the Southern Manhattan coastline in New York City, NY that serves as an occupant-interactive barrier for rising sea levels and unpredictable storm surges.⁶⁶ BIG set out to prove the theory that resilient anticipatory design can be a highly effective response to climate change for major coastal cities.

According to BIG, the sharp angle of New York City's gulf "acts as a funnel, directing storm surge directly into the heart of the city," and putting a majority of the city's occupants at risk in the event of severe weather patterns.⁶⁷ This depiction indicates the fact that it is essential for significant measures to be taken in this location and other coastal locations along the east coast prior to the occurrence of another major storm impacting the area. The figure below

⁶⁶ "The BIG U: BIG's New York City Vision for "Rebuild by Design". " *ArchDaily*. 03 Apr. 2014. Web.

⁶⁷ "NEWS." *BIG | Bjarke Ingels Group*. Web.

portrays a representation of hurricane routes in the Atlantic Ocean over a 25-year period.



Figure 8: Hurricane Routes in the Atlantic Ocean
[*"The BIG U: BIG's New York City Vision for "Rebuild by Design". ArchDaily. 03 Apr. 2014. Web.*]

The intent of BIG's design is to develop a coastline buffer that allows for rising sea levels and storm surges to permeate the land, while providing a useful array of urban amenities that can withstand future weather fluctuations and maintain functionality of the coastline. Bjarke Ingels states,

"We asked ourselves: What if we could envision the resilient infrastructure for Lower Manhattan in a way that wouldn't be like a wall between the city and the water, but rather a string of pearls of social and environmental amenities tailored to their specific neighborhoods, that also happens to shield their various communities from flooding."⁶⁸

⁶⁸ *"The BIG U: BIG's New York City Vision for "Rebuild by Design". ArchDaily. 03 Apr. 2014. Web.*

The Big U is resilient in the sense that it protects the densely populated neighborhoods of New York City from flooding and storm water permeation by integrating habitable berms that serve as vertical coastal barriers, vegetation that is tolerant to saltwater, transformable walls that adapt to changing water levels, and underwater façade glazing systems at the ground level of a proposed maritime museum for occupants to observe changes in sea level.⁶⁹ The figure below illustrates the functionality of the Dryline in typical weather conditions, compared to its ability to adapt to anticipated harsh weather patterns.



Figure 9: The Dryline in Different Circumstances

[*"The BIG U: BIG's New York City Vision for "Rebuild by Design"."* ArchDaily. 03 Apr. 2014. Web.]

BIG conducted extensive research of the various resilient tactics being implemented around the world, including the concept of blockading the water through the use of a levee or dam. The team concluded that "Rather than

⁶⁹ *"The BIG U: BIG's New York City Vision for "Rebuild by Design"."* ArchDaily. 03 Apr. 2014. Web.

barricade against the water, the Big U could create more land for New Yorkers in expectation of rising tides."⁷⁰

However, it can be argued that while this design may improve the functionality and flexibility of coastal cities by creating a habitable landscape program and potential for possible underground program, this strategy could be visualized as a method of fleeing due to the fact that designing in such a way will restrict a city from being able to develop conventional structures in this area.

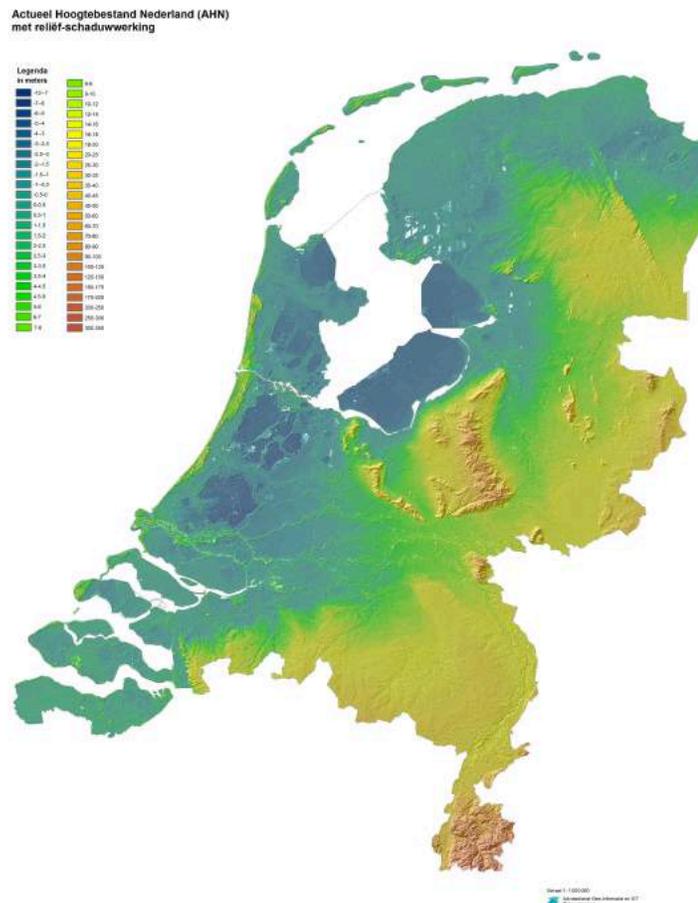
Perhaps this method of resilient anticipatory design could be explored and improved even further by introducing the concept that cities don't necessarily need to move inland in order to allow land for coastal berms and barriers, but rather use landfill, similar to the Governors Island precedent, to elevate the land above projected sea level. Perhaps cities can begin to build upward in these areas, preserving the verticality of their coastal architecture while being free of the restraints associated with moving inland.

5.5 The Dutch Mentality + Amsterdam Housing Developments

The Netherlands is a prime example of a nation who has put forth sufficient efforts to implement anticipatory design for architectural resiliency against rising sea levels and coastal flooding. The Netherlands has been a

⁷⁰ Margaret Rhodes. "A \$335M Project to Save NYC From Climate Catastrophe." *Wired*. Conde Nast, 09 June 2014. Web.

global leader toward coastal resilience for dozens of years, mainly due to the fact that nearly half of their population lies below sea level, as depicted in the figure below.⁷¹



The drive toward developing a more resilient built environment in the Netherlands was initially sparked by the aftermath of a series of major flooding that occurred between 1993 and 1995, forcing 200,000 people to evacuate their homes and causing hundreds of farm animals to die from abandonment as a result of owner evacuation.⁷² The extensive effort of the Dutch government toward the prevention of further anticipated tragedies was derived from the flooding that occurred in this time period. A driving strategy that the Dutch utilizes to ensure consistent prevention is the implementation of anticipatory design in the development of their constantly evolving built environment. According to Harold van Waveren, a water management expert from the Dutch ministry of infrastructure and environment, "There is no end to [climate change]. It's a continuous process. We do not want to be surprised again."⁷³

One implementation of anticipatory design being applied in the Netherlands is the concept of floating architecture. An example of this method is the floating houses in IJburg, located in Amsterdam. However, as noted in the previous chapter, floating architecture can often be accompanied by negative downsides, and usually possess restrictions depending on location.

⁷² Harold van Waveren, quoted in McVeigh, Tracy. *"The Dutch Solution to Floods: Live with Water, Don't Fight It."* The Observer, Guardian News and Media, 15 Feb. 2014. Web.

⁷³ McVeigh, Tracy. *"The Dutch Solution to Floods: Live with Water, Don't Fight It."* The Observer, Guardian News and Media, 15 Feb. 2014. Web.



Figure 11: Floating Houses at IJburg

[Harold van Waveren, quoted in McVeigh, Tracy. "The Dutch Solution to Floods: Live with Water, Don't Fight It." *The Observer*, Guardian News and Media, 15 Feb. 2014. Web.]

The Netherlands differs from the United States in the sense that there is a collective understanding of the implications of a rising sea level and a changing climate, whereas the level of controversy pertaining to the same matter in the United States spans a very broad distance, and the placement of U.S. citizens on this spectrum varies dependent on their beliefs. Perhaps the United States could more efficiently design for coastal resiliency if there was a collective opinion of climate change awareness and severity among the nation, as opposed to a variety of differing opinions.

CHAPTER 6

PLEASURE BEACH: BRIDGEPORT, CONNECTICUT

6.1 Site Context

Pleasure Beach Park is comprised of 37 low-lying acres that is located on a barrier beach at the mouth of the Bridgeport Harbor in Bridgeport, Connecticut.⁷⁴ Its adjacent water bodies include Long Island Sound on the south and the Lewis Gut, a marshland located north of the site.

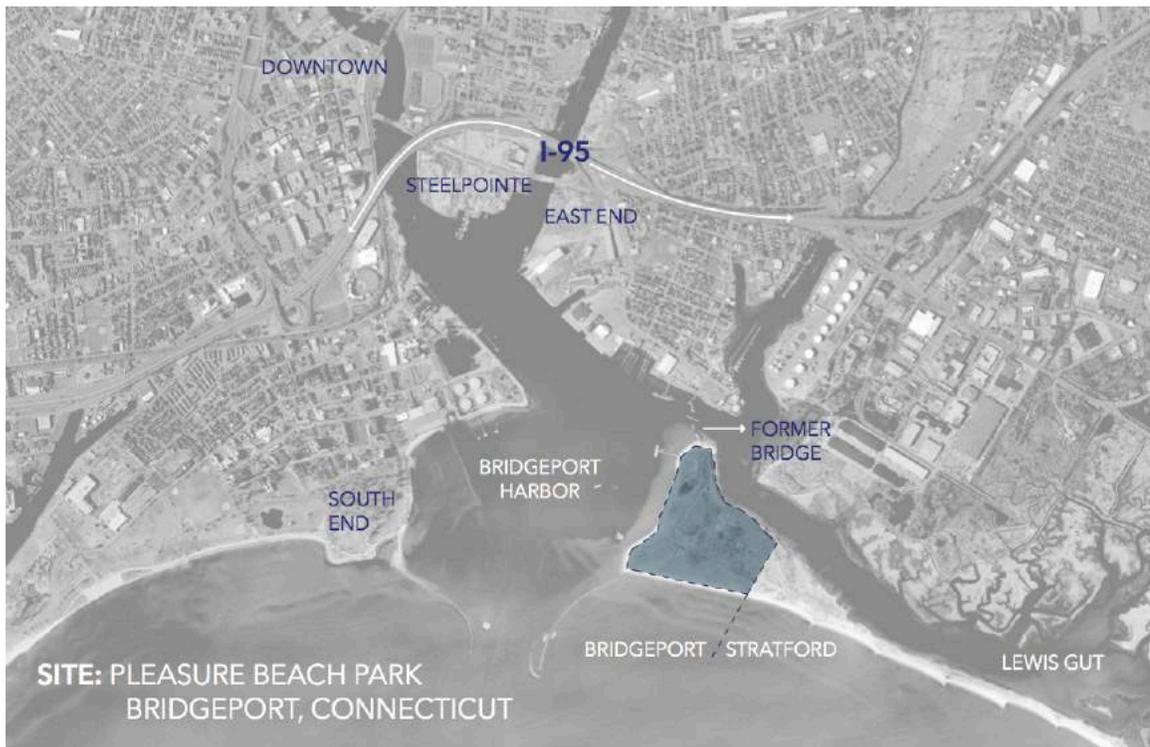


Figure 12: Pleasure Beach Context

⁷⁴ "A Unique Island Attraction in Bridgeport." ConnecticutHistory.org, Web.



Figure 13: Barrier Beach
[“Long Beach West, Stratford, and Pleasure Beach, Bridgeport.” Web.]



Figure 14: Pleasure Beach Aerial View – Current
[“Long Beach West, Stratford, and Pleasure Beach, Bridgeport.” Web.]

6.2 Site History

This site once housed an amusement park, as well as a variety of cottage homes. The park, known as Steeplechase Island, opened in 1905, and soon became a major attraction for locals and visitors.⁷⁵ However, two years after opening, a fallen cigarette caused a large fire to break out within the park, with damages being too costly to repair at the time of the incident. The amusement park remained closed until 1919, when the City of Bridgeport bought and repaired the facilities, as well as expanded the park to include a roller-skating rink, a carousel and roller coaster. Prior to 1927, the only means of transportation to Pleasure Beach Park was by ferryboat. In 1927, a long swing bridge was constructed that connected the barrier beach to the East End of Bridgeport.⁷⁶

⁷⁵ "A Unique Island Attraction in Bridgeport." ConnecticutHistory.org, Web.

⁷⁶ "A Unique Island Attraction in Bridgeport." ConnecticutHistory.org, Web.



Figure 15: Steeplechase Island Postcard
["A Unique Island Attraction in Bridgeport." Web.]

The new and improved park soon became a relic of the area once again, until 1953, when an electrical fire occurred that caused a substantial amount of damage to the park. The severity of the damage was due to the inability for emergency responders to cross the narrow swing bridge. Shortly after, the amusement park closed permanently and remained abandoned for decades, but residential life continued to exist on Pleasure Beach.⁷⁷

⁷⁷ "A Unique Island Attraction in Bridgeport." ConnecticutHistory.org, Web.



Figure 16: Pleasure Beach Aerial View – 1955
[Brian Lockhart. "New Plan for Pleasure Beach." *Connecticut Post*, Web.]

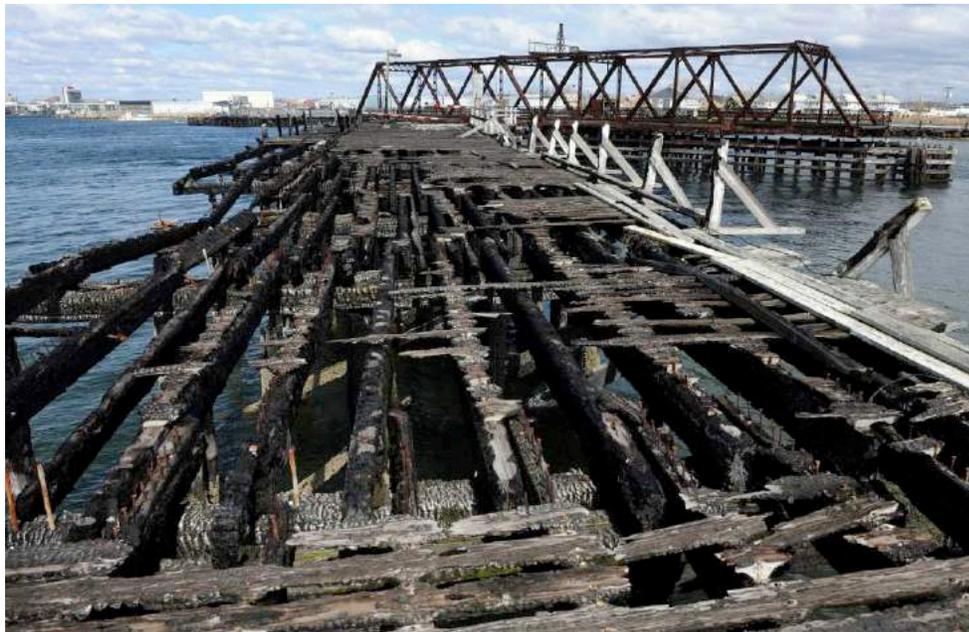


Figure 17: Pleasure Beach Swing Bridge Remains
[Loh, Tim. "As Finch Hails New Waterfront Access, Pleasure Beach Project Crawls Forward." *Connecticut Post*, Web.]

Finally, in 1996, the swing bridge, which was the only vehicular access to the beach, burned down due to unknown causes.⁷⁸ The town could not afford the extensive repair costs necessary to rebuild the bridge, and resulted in conducting a mandatory permanent evacuation of all remaining residents of the beach. The burning of the bridge ultimately ended the legacy of Pleasure Beach Park, because the land was deemed unsafe by the City of Bridgeport due to its inaccessibility.

6.3 Pleasure Beach - Present

After the burning of the bridge, the park remained abandoned and overgrown for decades. In 2014, the City of Bridgeport demolished a large majority of the remaining buildings and cottages, and completed the construction of an informational boardwalk and beach pavilion with restrooms for visitors. The only current means of transportation to Pleasure Beach are by water taxi during weekdays, or by walking an approximate 1.5 miles down the narrow strip of the barrier beach from the adjacent town of Stratford, Connecticut. These transportation routes are depicted in the figure below.

⁷⁸ "A Unique Island Attraction in Bridgeport." ConnecticutHistory.org, Web.

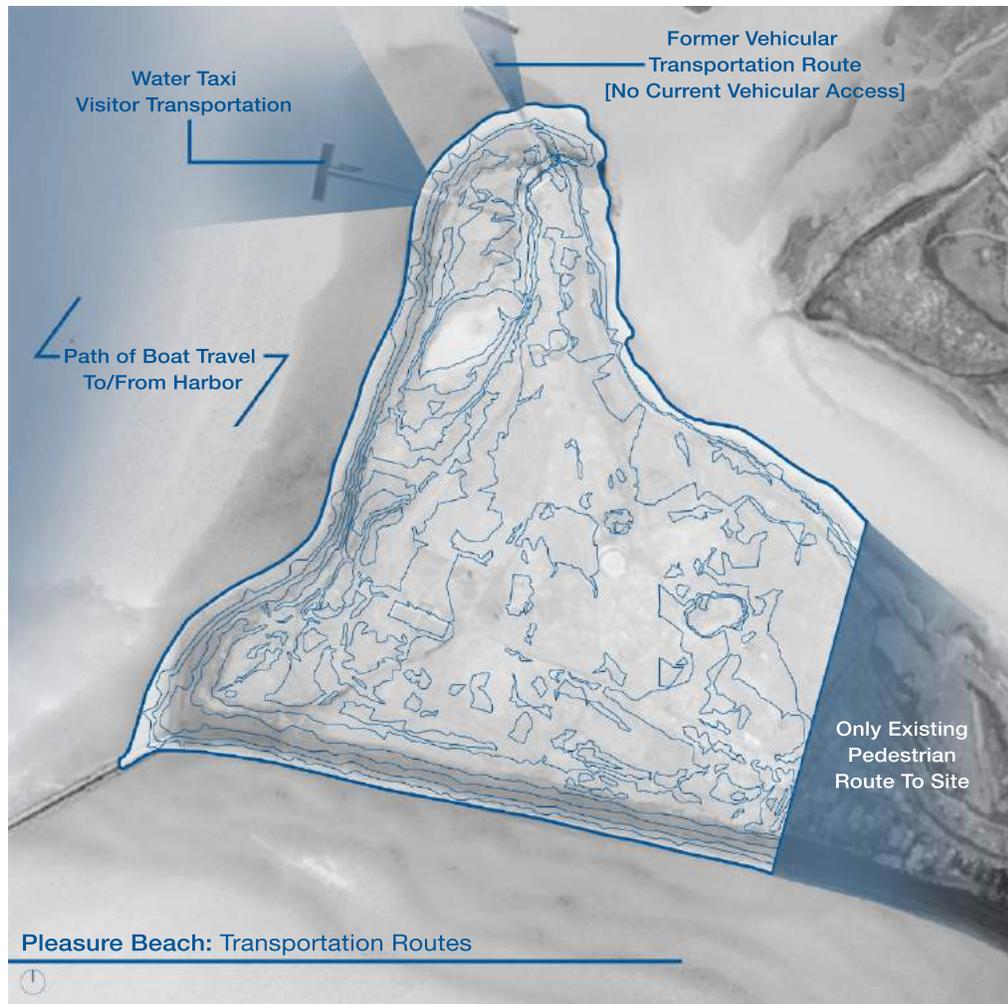


Figure 18: Pleasure Beach Transportation Routes

Certain areas of the site have been designated as wildlife sanctuaries, with enclosures for endangered bird species including piping plovers and herons. There is also a substantial amount of Eastern Prickly Pear Cacti on the site, a plant species deemed by the State of Connecticut as a “Species of Special Concern”.⁷⁹

⁷⁹ “A Desert Exile in Connecticut.” *Trails of Freedom*, 19 Feb. 2015. Web.



Figure 19: Eastern Prickly Pear Cactus on Site

Today, visitors are allowed to access the site, but Pleasure Beach Park continues to give the appearance of forgottenness, and no longer possesses the charm that once attracted hundreds of people to the area.



Figure 20: Remnants of Pleasure Beach – 1



Figure 21: Remnants of Pleasure Beach – 2



Figure 22: Remnants of Pleasure Beach – 3

6.4 Inundation at Pleasure Beach

Pleasure Beach is a low-lying coastal site that is at risk for predicted flooding and storm surge impact. The beach is classified by FEMA as being in Zones AE and VE, as portrayed in the figure below, meaning that it is prone to inundation by the 1-percent annual-chance flood event.⁸⁰

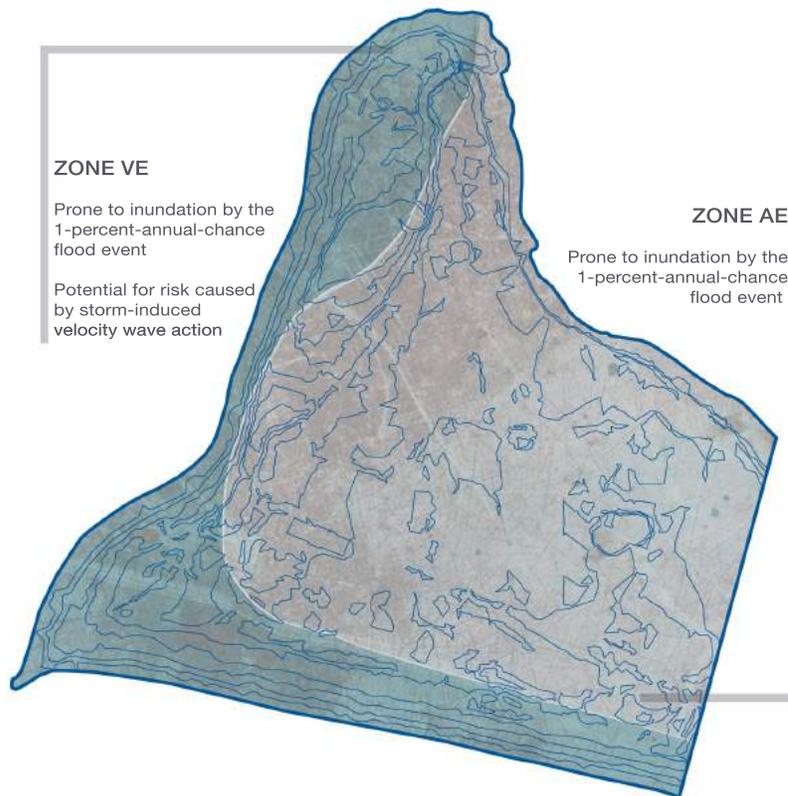


Figure 23: Pleasure Beach FEMA Classification

⁸⁰ "FEMA.gov | Federal Emergency Management Agency." Web.

Chronic inundation is also projected to encroach areas of Pleasure Beach, according to the Union of Concerned Scientists.⁸¹ The projections of chronic inundation pertaining to this location can be seen below.

These projections served as a driving force toward the concept and form exploration executed in the final design. Utilizing the existing topography as a guide for the elevated form allows for a dialogue between natural occurrences and human impact on the site.



Figure 24: Chronic Inundation Projections

Due to the fact that this site is located on a barrier beach, it is unique in the fact that its formation already acts as a protection for the mainland against coastal weather and sea fluctuations. According to the author of *Coastal Design*, “The greatest percentage of the open ocean coast of the United States is

⁸¹ “When Rising Seas Hit Home: Hard Choices Ahead for Hundreds of US Coastal Communities (2017).” Union of Concerned Scientists”, Web.

fronted by barrier islands. Because barrier islands are formed by depositional marine processes, they are a secondary type of coast".⁸²

This characteristic also implies that water surrounds the site almost entirely, shown in the figure below.

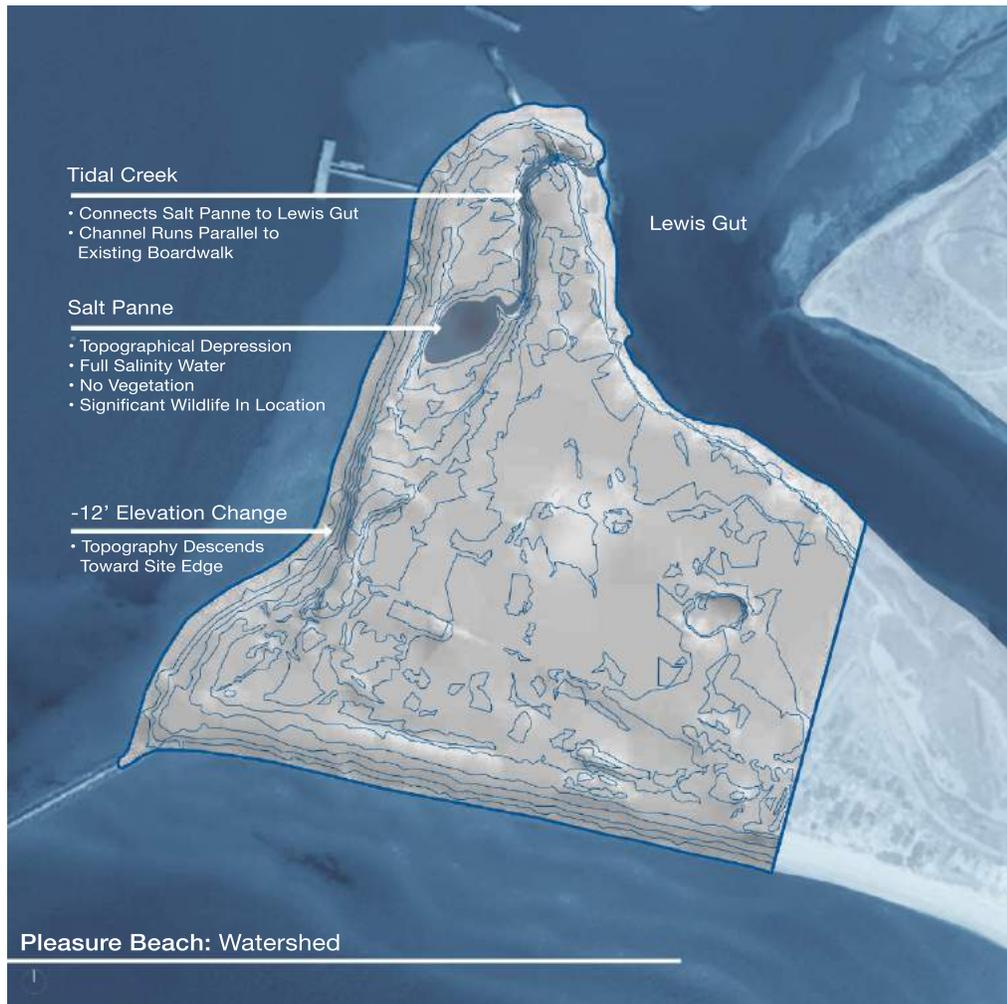


Figure 25: Pleasure Beach Watershed

⁸² Pilkey, Orrin H. *Coastal Design: A Guide for Builders, Planners, and Homeowners*. New York, Van Nostrand Reinhold, 1983. Print. 4.

All of these site characteristics led to the design decision of utilizing the already highest elevation on the site for building location, and electing to furthermore build the landform vertically. Also, the site analysis drove the conclusion of rebuilding the swing bridge as a means of vehicular access for emergency responders, as well as a pedestrian footbridge for residents and community members.

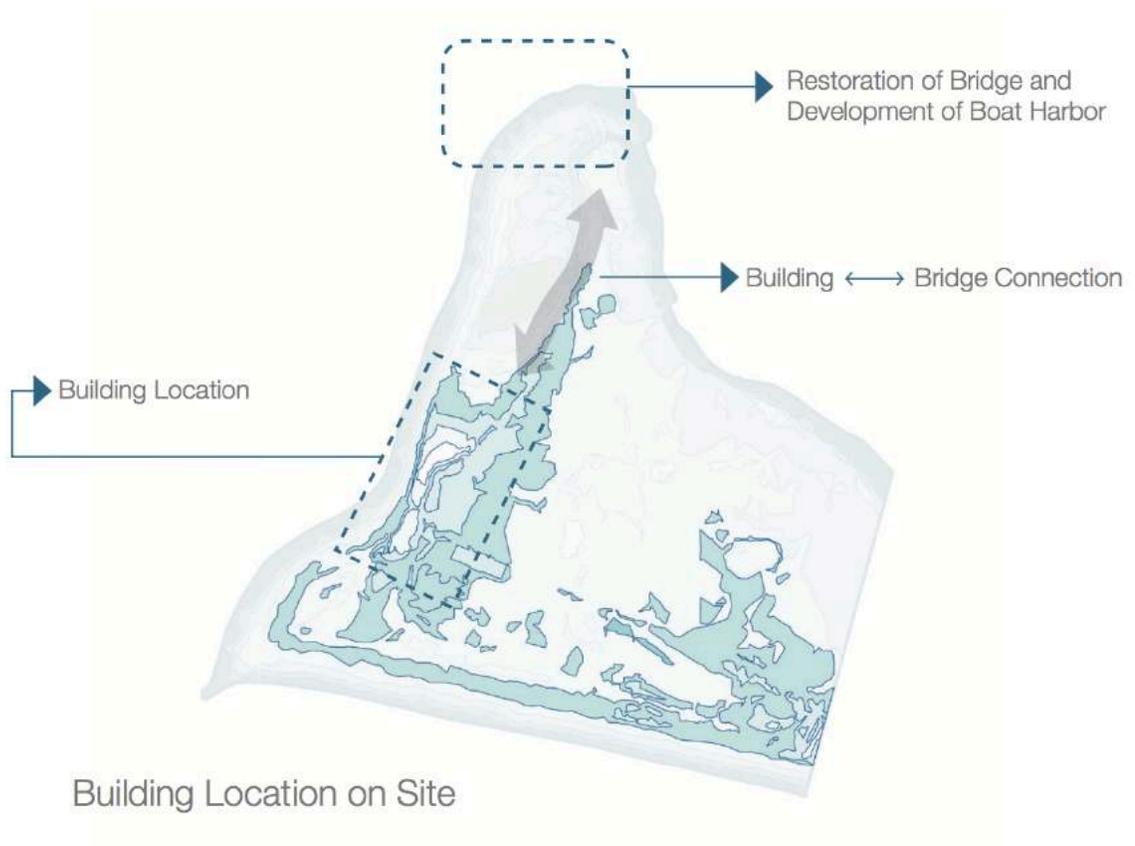


Figure 26: Building Location on Site

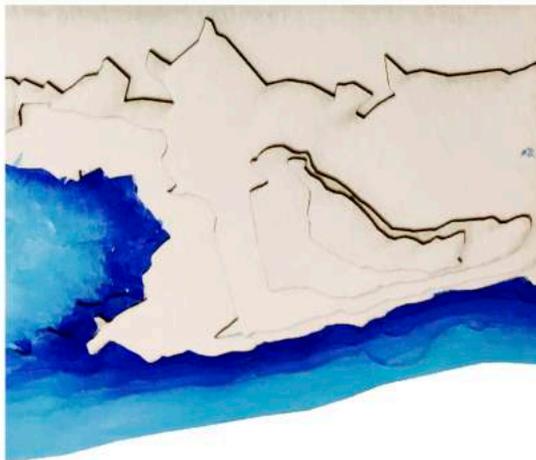


Figure 27: Chronic Inundation Site Model

CHAPTER 7

DESIGN IMPLEMENTATION

7.1 Program

Following site selection, the next phase of the design process was determining the essential programmatic elements that are needed in order for an elevated community to survive and thrive in a low-lying coastal area. The program is comprised of public elements for community gathering purposes, as well as private elements for the residents of this community. This design is also composed of essential resilient building and landscape components derived from research conduction and analysis. All of the indoor programmatic elements reside above the storm surge level for this location.

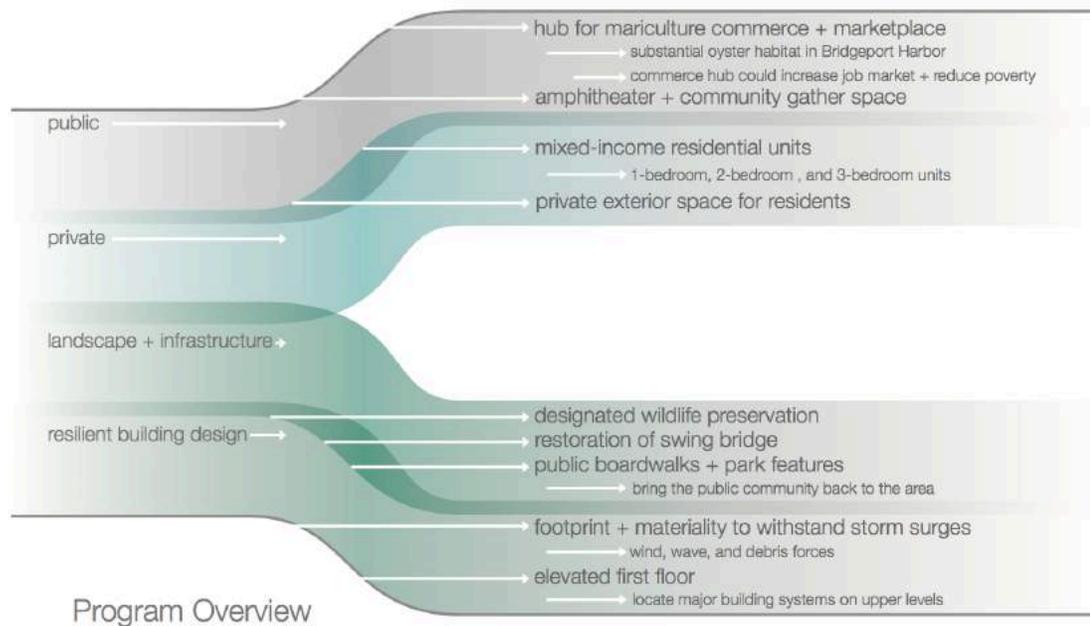


Figure 28: Program Overview

The public program consists of a variety of public gathering spaces that will bring the community back to Pleasure Beach, including an amphitheater and indoor community gathering spaces. The public program also includes a hub for mariculture commerce and a marketplace. There is a substantial oyster habitat in the Bridgeport Harbor, so community members can capitalize on the benefits of the site, and contribute to a self-sustaining lifestyle within the community. This mariculture commerce center may also increase the job market and reduce poverty in the city.

The private program is composed of mixed-income residential units for a diverse range of individuals. These units vary from 1-bedroom, 2-bedroom and 3-bedroom, and every unit receives a private exterior space that serves as an elevated land area to replace the notion of the conventional backyard in the event that flooding occurs in the area.

A majority of the existing site is to remain, allowing for the cohabitation of the built environment and the natural environment on the site. The designated wildlife preservation sanctuaries are left untouched, and several low-impact public boardwalks and pathways were introduced as means of circulation around the site. These boardwalks are intended to be informative and allow community members to experience the natural, ecological and environmental manifestation of the site, while preserving its ability to do so with very little human impact.

Based on research conducted prior to the design phase, it is crucial that resilient elements be included as essential aspects of the program from the initial phases of design. From the earliest explorations of the program, it became evident that resilient approaches such as elevating important building structure and systems, selecting an efficient building footprint and specifying materials that can withstand coastal weather were crucial to the success of this design.

7.2 Schematic Design

The next phase within this design approach was exploring building and landscape forms at a schematic level. The goal in this phase was to incorporate all aspects of the immediate and anticipated programs for flooding conditions into the thought process. As a concrete decision to elevate the building structures emerged, the next step was to explore potential housing unit types.

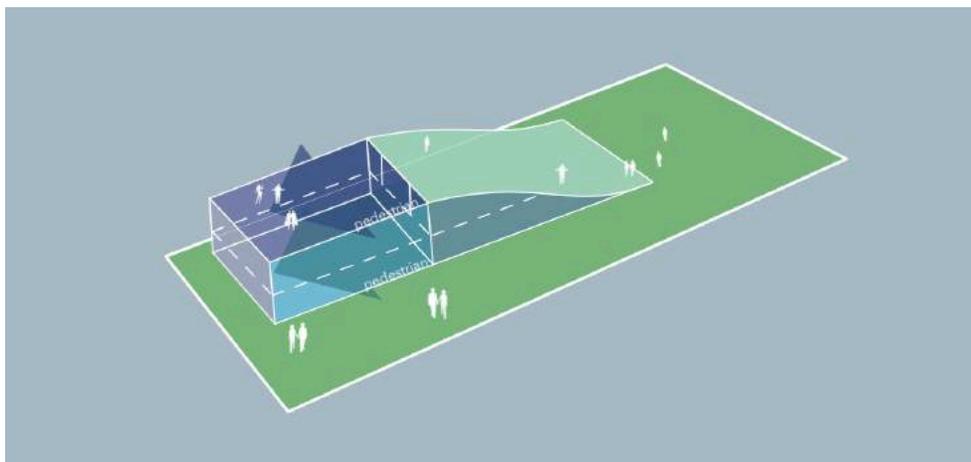


Figure 29: Elevated Landform

There was an exploration including multiple single-family structures, one megastructure that would house all indoor programmatic elements, and a series of multi-function midrises with landscape area interconnecting them. Due to the fact that single-family housing is not a sustainable building approach, and the development of a megastructure did not offer enough potential for landscape inclusion and outdoor community gathering space, the decision to move forward with a series of midrise building structures was made. This exploration can be seen in the figure below.



Figure 30: Form Exploration

Once this design decision was finalized, the next step was to explore the layout of indoor program within these midrise units, determine how many structures the program would divide into, and test the different outdoor layouts that could develop a relationship between the structures.

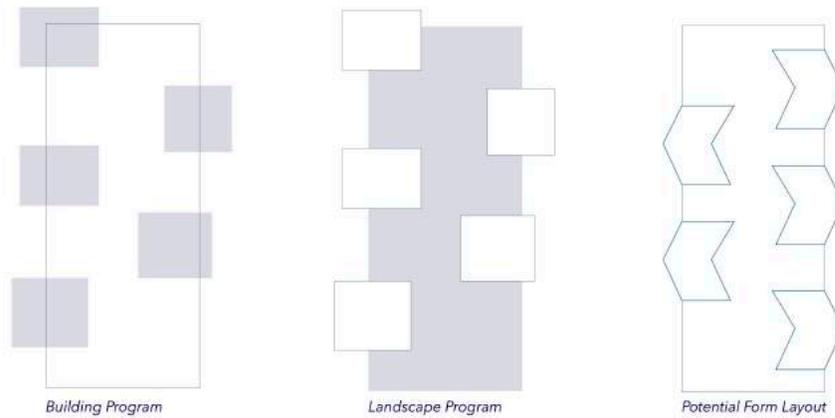


Figure 31: Building Relationships

After exploring and analyzing different building and landscape layouts, it was determined that the most efficient design for this elevated masterplan included two midrise structures; the North Shelter standing five stories high and comprising of 1-Bedroom units, 2-Bedroom units, the mariculture commerce center and community gathering spaces, and the South Shelter, standing three stories high and containing family units, additional community gathering spaces, and a roof garden for residents and community members.

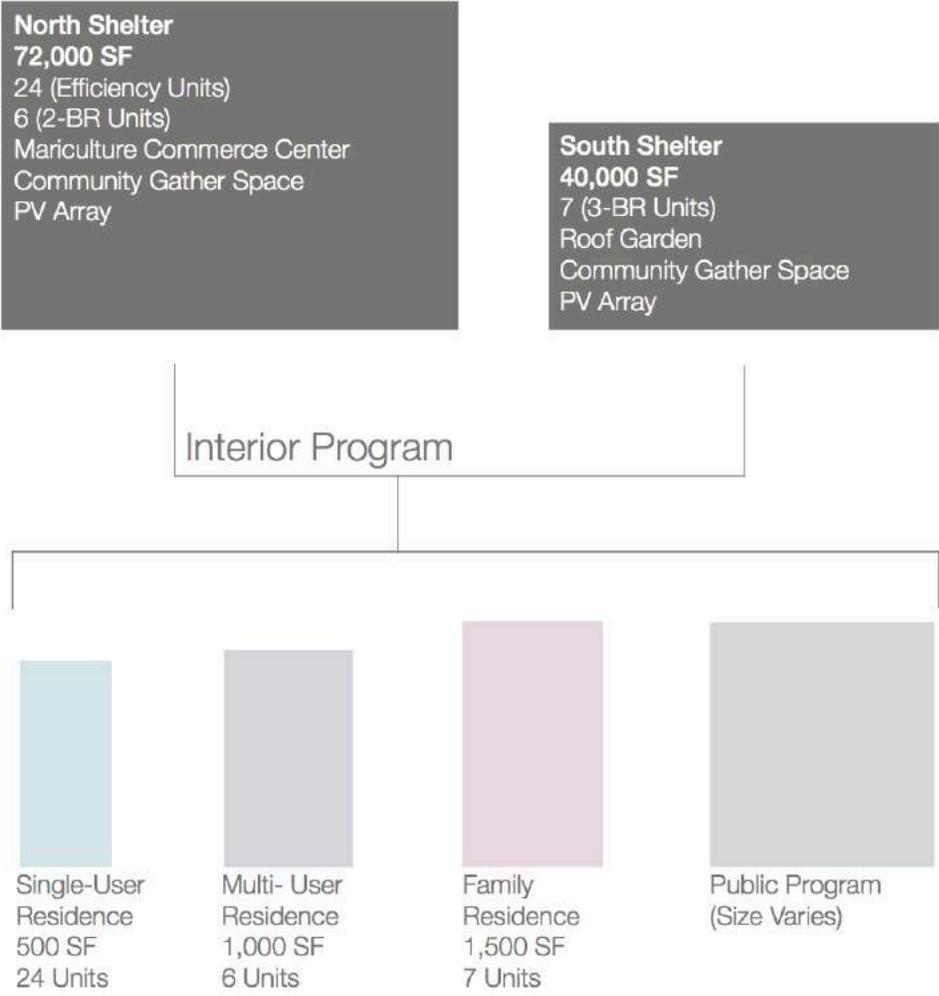


Figure 32: North and South Shelter

Then, there was a drive to create a push-and-pull layout of the units in each building that would add intrigue to the building elevations and floor plans.

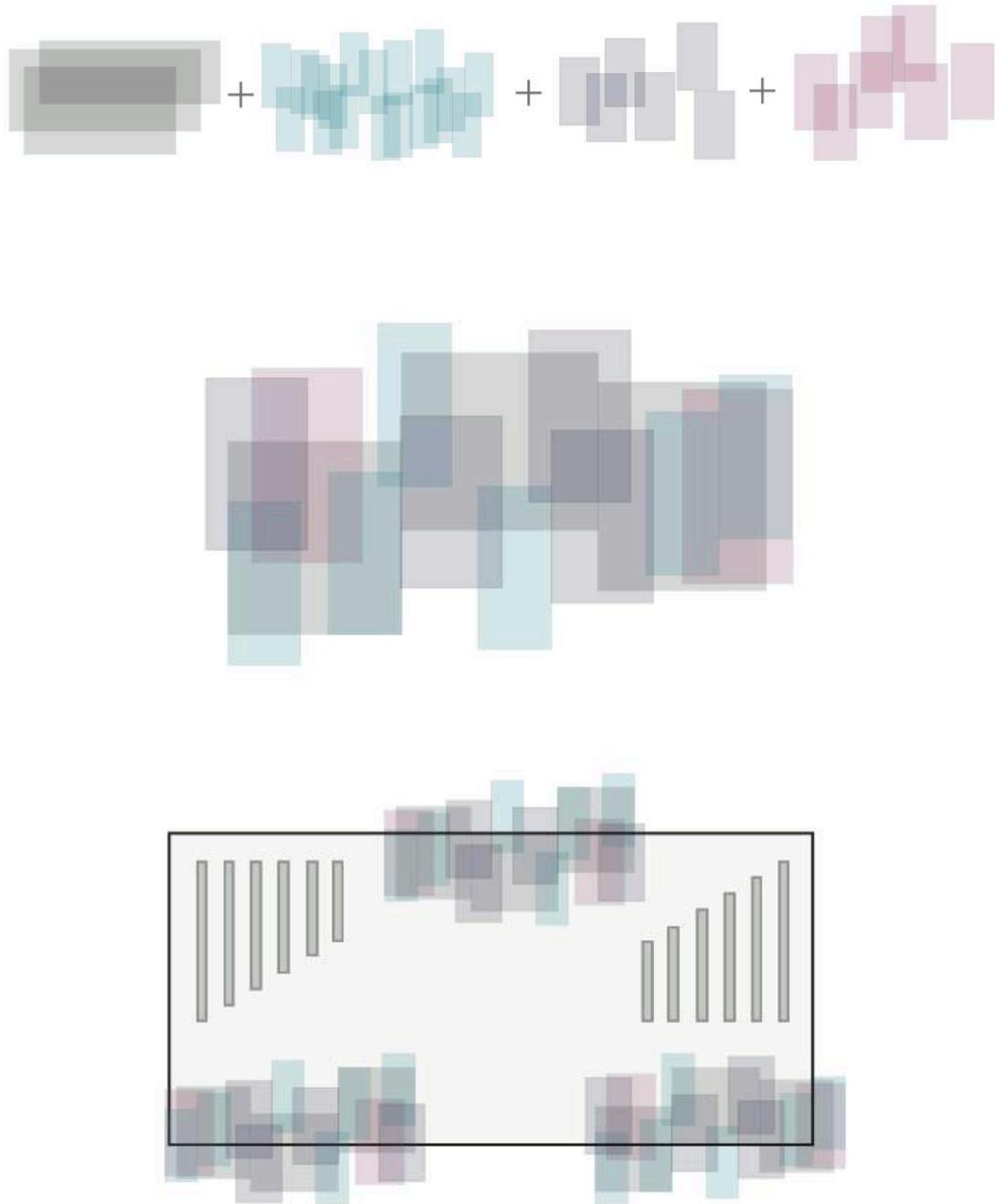


Figure 33: Push-and-Pull

Another phase of the schematic design process was exploring different methods of building form and materiality using new material, such as wood, resin, and oyster shells found on site.



Figure 34: Resin Cast - Oyster Shells



Figure 35: Resin Cast - Wood

7.3 Design Development



Figure 36: Exterior Rendering

The elevated community design provides ample space for exterior gathering, landscape and agricultural production. Locating the agricultural and food production areas at an elevated level enables residents to contribute to the self-sustaining concept of 'off-grid' living, while also keeping these exterior spaces elevated above potential flood zones.

Arranging public pathways and seating between the two structures also provides the opportunity for collaboration and connectivity among residents of the community.

In the masterplan, the existing pavilion remains on the site. A public amphitheater descends from the elevated landscape toward the pavilion entrance, providing circulation from the new structures toward the existing one. The form of the elevated landscape includes stairways and ramps from the reconstructed swing bridge toward the existing pier edge of the site.



Figure 37: Masterplan

The architectural design of the two structures, South Shelter and North Shelter, is efficiently designed to minimize solar heat gain by creating building orientations that maximize the northern and southern exposures while reducing the east and west exposures. The building footprint and materiality of these structures is designed to be resilient to wind and storm damage. The buildings share an architectural relationship within the design of their floor plans, as well as their elevations, and a variety of pathways and landscape spaces provide multiple connections between the North Shelter and the South Shelter.

South Shelter is comprised of seven family-style units, each consisting of three bedrooms, a living and dining space, a bathroom, and sufficient outdoor space for the families with private planting beds and seating. Each adjacent outdoor space provides enough coverage for residents to feel a sense of privacy in the space. This concept explores the idea of proposing a new iteration of the conventional private backyard often accompanied by a single-family home. This structure is also significantly lower in elevation than the North Shelter in order to maximize daylight in the landscape spaces between the structures.

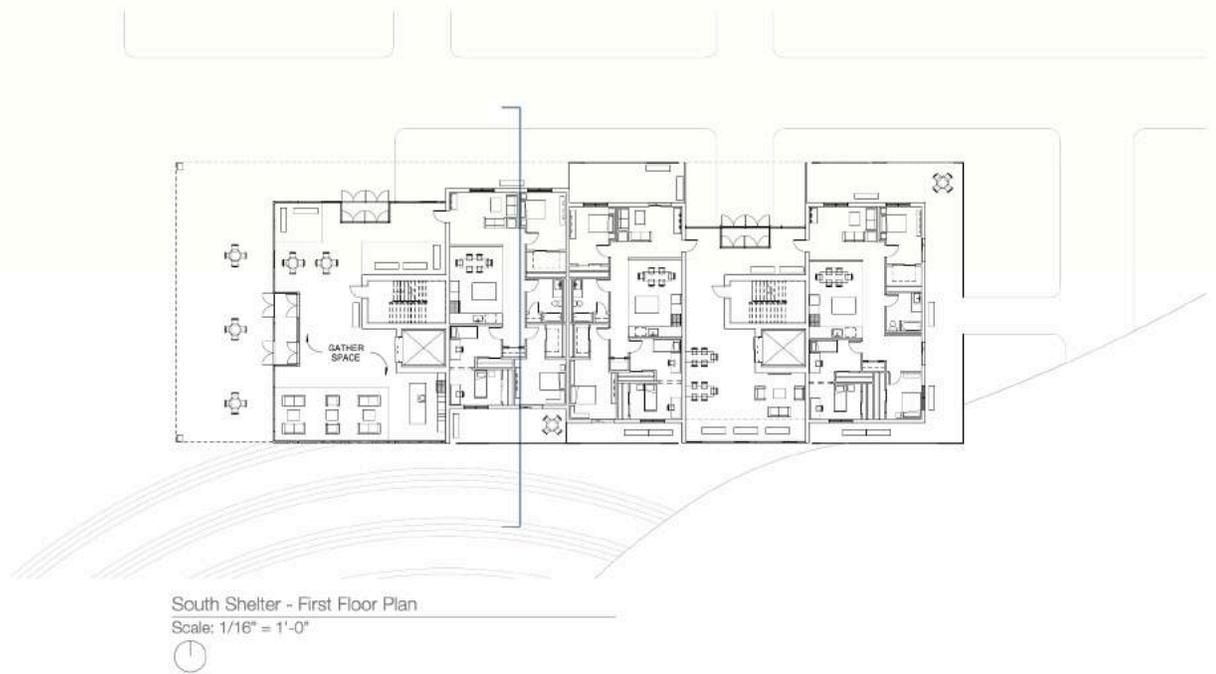
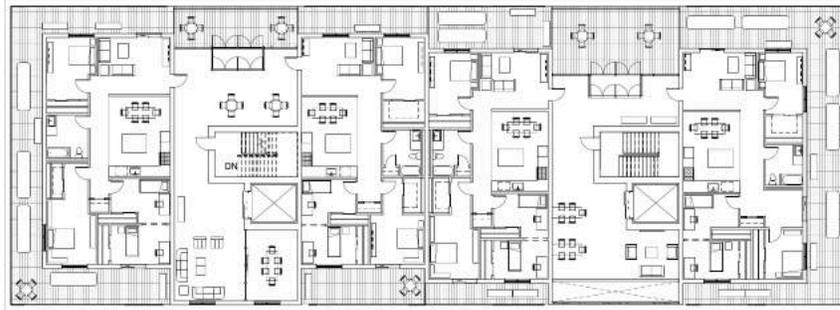


Figure 38: South Shelter – First Floor Plan

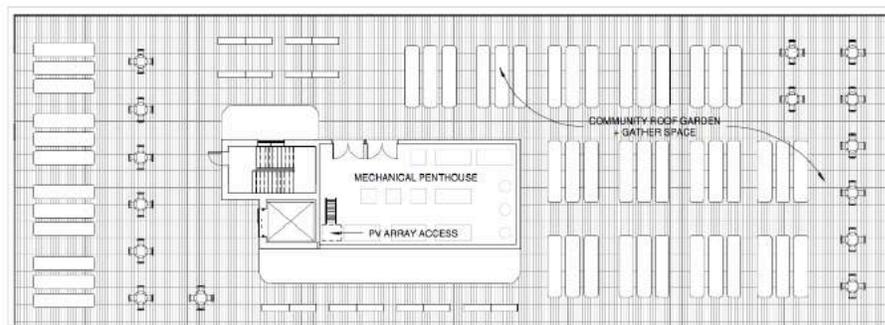
There are three family units on the first floor of South Shelter. The first floor also houses a community kitchen, as well as living and study spaces for residents that encourage unity and socialization throughout the community. Though each unit receives a private entrance, the floor plan is designed in such a way that every resident circulates through a public space in order to enter their private unit. This concept stimulates interaction among community members simply by circulating through the shelter.



South Shelter - Second Floor Plan
Scale: 1/16" = 1'-0"

Figure 39: South Shelter – Second Floor Plan

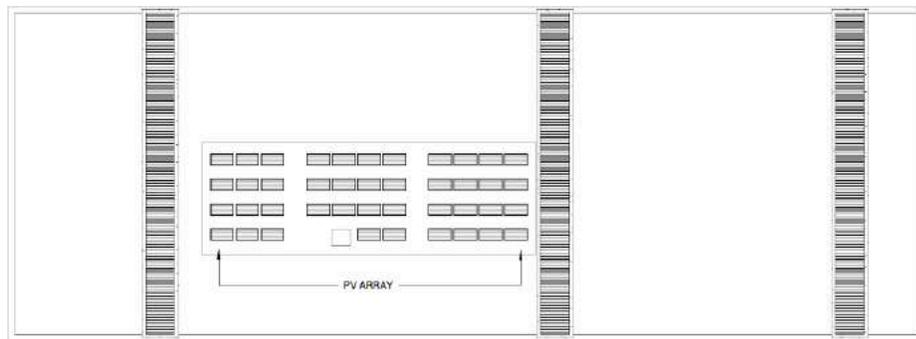
On the second floor of the South Shelter, there are four family living units, similar in size and layout to the units on the base level. Aside from the inclusion of more community living areas, a semi-private conference room is also provided for residents to use on an as-need basis. The exterior balcony spaces for the second floor units allow for overhead shading and privacy coverage for the units below.



South Shelter - Third Floor Roof Garden
Scale: 1/16" = 1'-0"

Figure 40: South Shelter – Third Floor Roof Garden

The third floor of the South Shelter introduces substantial elevated land area for farming, gardening and gathering at the roof garden level. This space can be used by residents of both buildings, and supplies the potential for outdoor event planning. The roof garden is accessible by stair and elevator, and is open to above with the exception of three lattice overhangs that allow for vine growth and shading. The third level also provides space for the mechanical penthouse, which elevates essential mechanical systems above the flood level.



South Shelter - Roof Plan
Scale: 1/16" = 1'-0"

Figure 41: South Shelter – Roof Plan

The uppermost roof plan shows the location of the lattices above the roof garden. There is also a small photovoltaic array located on the roof of the mechanical penthouse, which aids in the self-sustainability of the community.

The North Shelter houses a variety of smaller units, including 1-bedroom and 2-bedroom dwellings. The unique component of the North Shelter that differs from its southern counterpart is the fact that the entire first floor is designated for the mariculture commerce and marketplace for community members. This market provides the opportunity for the community to trade agriculture and marine goods acquired or grown directly on the site, thus implementing a self-sustaining environment. The first floor of the North Shelter also includes a lobby/community gathering space with an adjacent private entry for residents of the building to access their units on the upper levels.

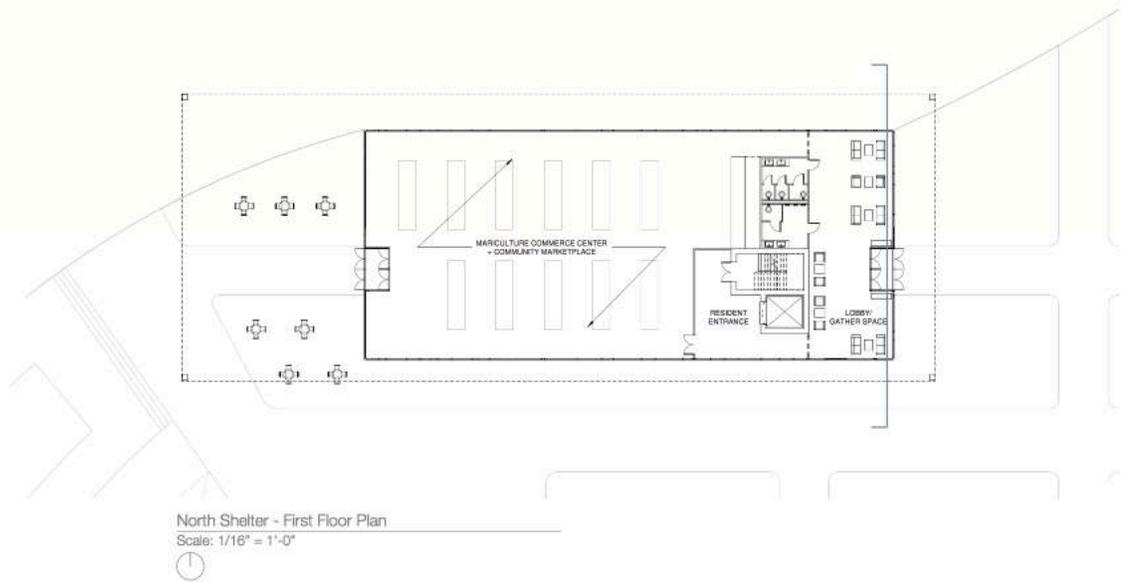
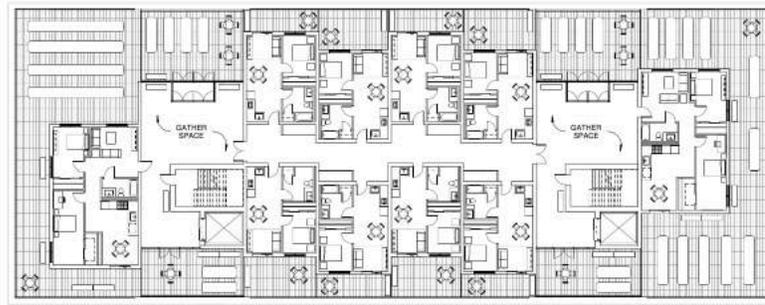


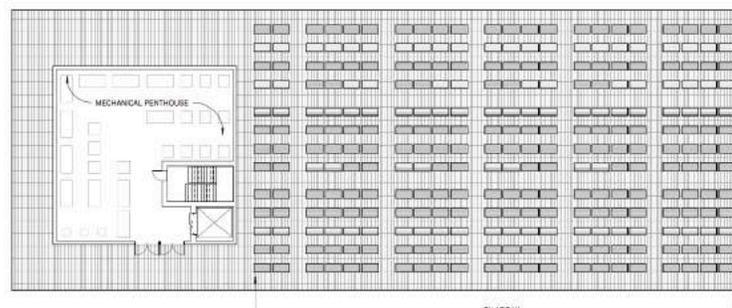
Figure 42: North Shelter – First Floor Plan



North Shelter - Second, Third + Fourth Floor Plans
 Scale: 1/16" = 1'-0"

Figure 43: North Shelter – Second, Third + Floor Plan

The second, third and fourth floors of the North Shelter are repeated, and each floor contains two 2-bedroom units and eight 1-bedroom units. The staggered layout of the dwellings creates an interesting hallway space that provides alcoves for seating and rest. Similar to the layout of the South Shelter, each unit is granted its own private exterior balcony space with planting beds and seating. Another similar attribute is the inclusion of community gathering spaces on each floor of the North Shelter.



North Shelter - Roof Plan
 Scale: 1/16" = 1'-0"

Figure 44: North Shelter – Roof Plan

The roof plan of the North Shelter contains a large majority of the photovoltaic array on the site, and therefore makes a substantial contribution to the community's energy needs. These PV panels present the opportunity for the community to live off of the power grid in the event that flooding or severe weather causes damage to the grid in the area.

Each unit is arranged to function well and provide ample daylight and natural ventilation, with a typical living and dining area that receives natural daylight and views. Each bedroom is equipped with individual storage areas.

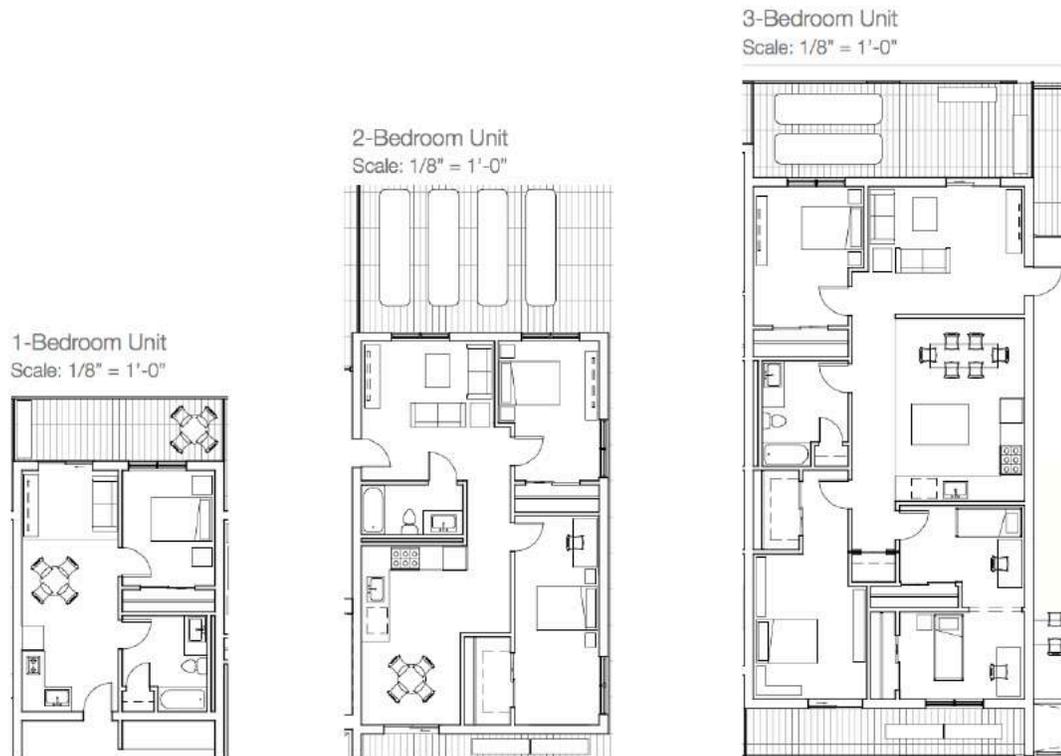


Figure 45: Private Unit Layouts

7.4 Resilient Components

From the earliest phases of schematic design, it was essential to incorporate resilient features in the design. There are five overarching resilient strategies within the design of this elevated community on Pleasure Beach Park. These strategies are: 'Off Grid' Renewable Living, Anticipatory Transportation Hub, Elevated Land + Structure, Resilient Building Footprint + Materiality, and Awareness of Coastal Flooding. These five strategies are depicted below.

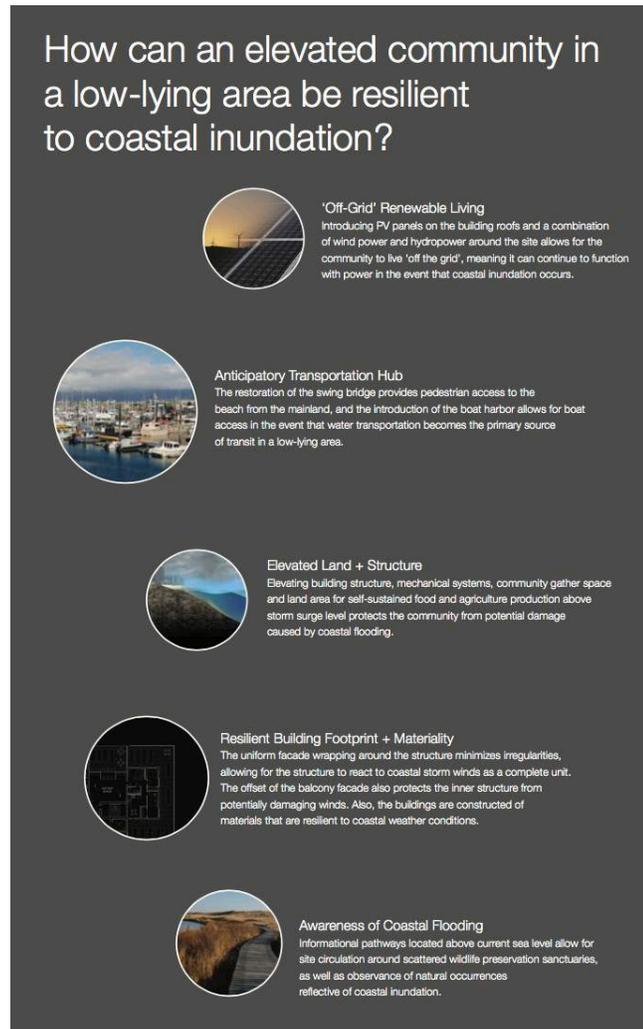


Figure 46: Resilient Strategies

Introducing photovoltaic panels on both of the structures, combined with the inclusion of wind power and hydropower around the site allows for the community to live 'off the grid' as previously mentioned, meaning it can continue to function in the event that coastal inundation occurs.

The restoration of the swing bridge provides pedestrian access to the community development from the mainland. This bridge supplies ingress for emergency responders, which will maintain safety within the development and aim to prevent further disasters resembling that of Pleasure Beach's past.

The introduction of a new boat harbor for residents in close proximity to the existing water taxi dock allows for efficient water traffic in the event that water transportation becomes the primary source of transit in a low-lying area as coastal flooding becomes a progressive norm.

Elevating building structure, mechanical systems, community gathering space and land area for self-sustained food, farming and agriculture production above storm surge level protects the community and its structures from potential damage caused by coastal flooding. This design introduces a moderate ascent from the existing edge condition toward the elevated level, with path and landscape features that are adaptable to flooding. During a storm surge condition, the water can rise substantially above normal conditions, and the elevated structures and land area will be protected.

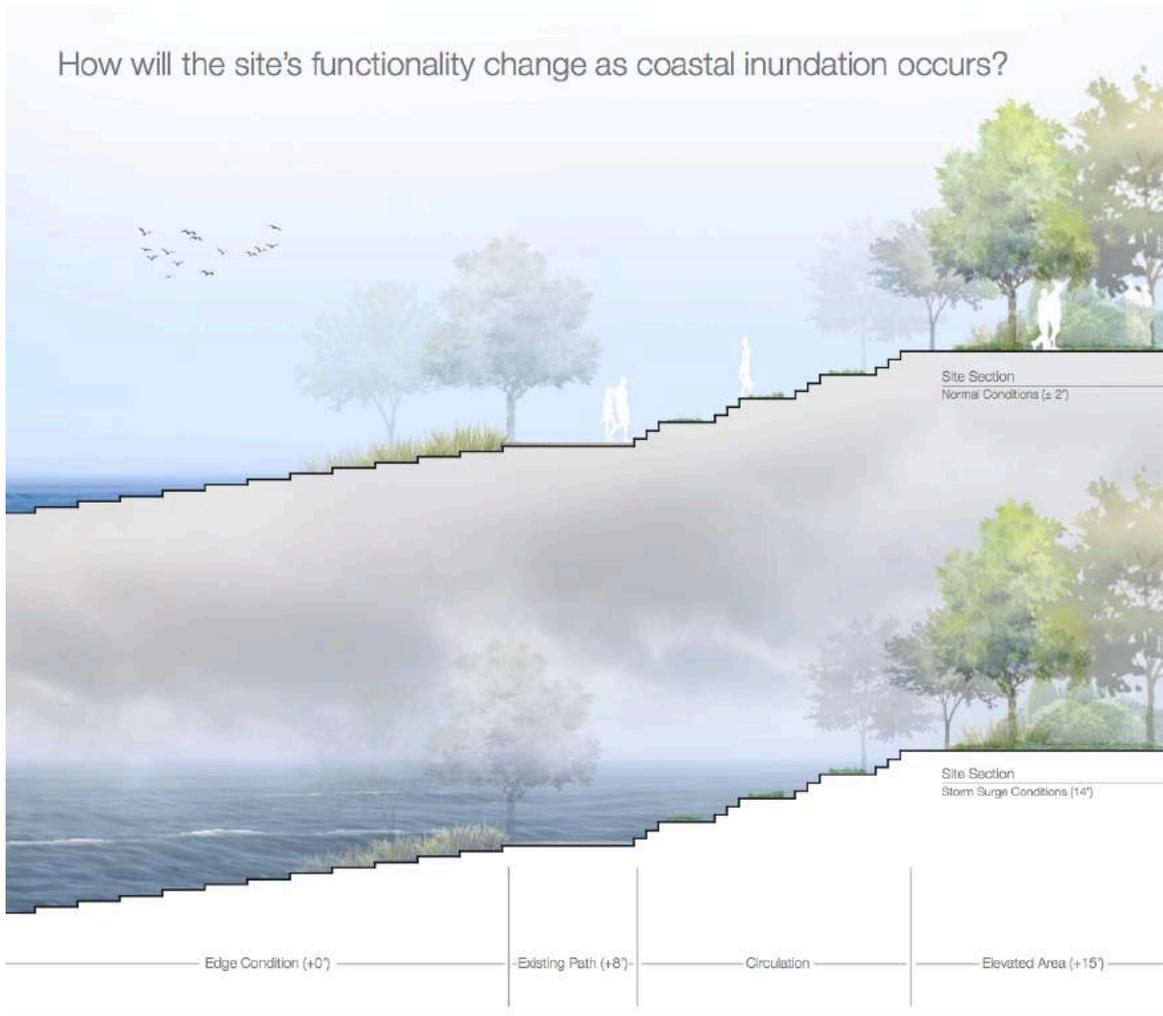


Figure 47: Site Sections

Based on the findings previously mentioned pertaining to resilient architectural design, the building footprint of the North Shelter and the South Shelter includes a uniform façade wrapping around the structures intended to minimize irregularities, thus allowing for the structures to react to coastal storm winds as complete units. The uniformity of the façade also allows for the

staggering of the units within the inner structure which was a concept derived in the schematic design phase. The offset of the balcony facade also protects the inner structure from potentially damaging winds.

In regards to building materiality, the structures are constructed of a variety of materials that are resilient to coastal weather conditions. The façade materiality includes reinforced concrete cladding panels, naturally durable black walnut horizontal wood cladding, and a series of vertical vine walls and oyster gabion walls.

The toughness and ductility of the concrete cladding allows for its ability to resist shock and impact caused by coastal storms. The naturally durable wood is resilient to coastal conditions. The horizontal cladding design also serves as a passive solar shading device for each unit. Vine walls are a low-maintenance method for landscape cultivation within the elevated community, and utilizing the large mass of oyster shells on site and non-corrosive structural steel creates a facade structure that will serve as a coastal wind buffer while preserving some natural ventilation. These materials are portrayed in the figure below.

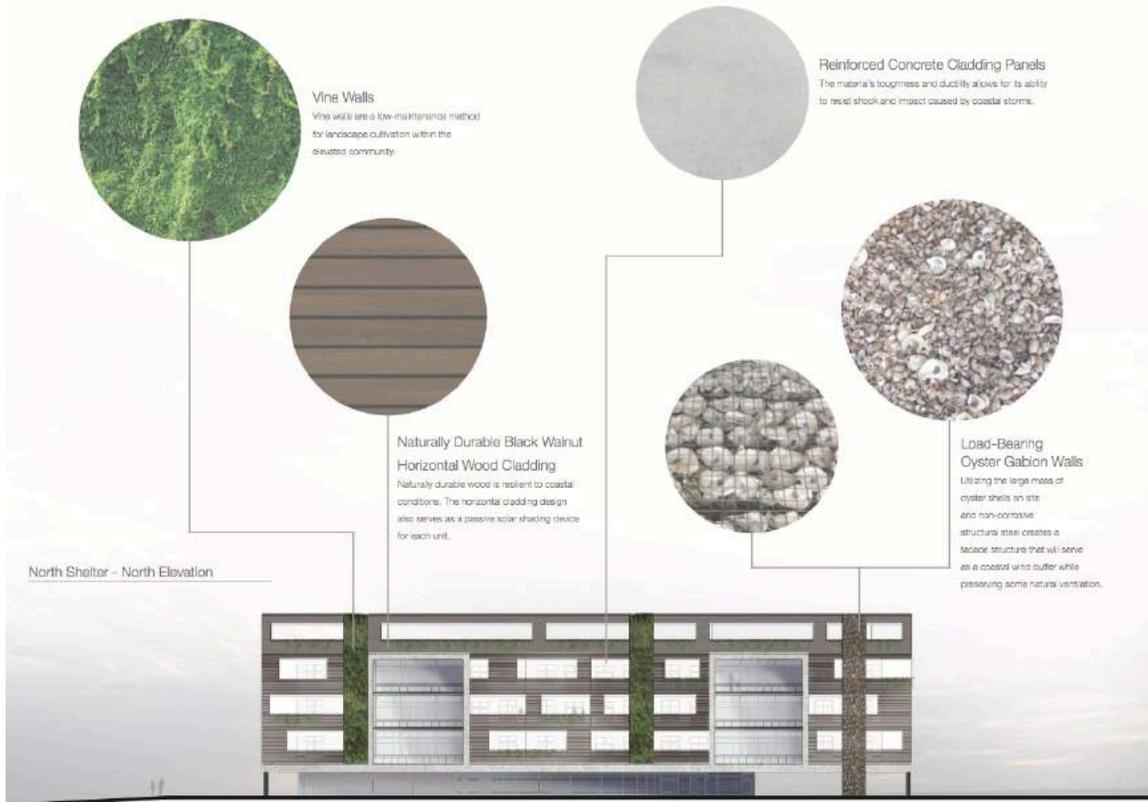


Figure 48: Façade Materiality

The final resilient element within this design is the inclusion of informational pathways located above current sea level that allow for site circulation around scattered wildlife preservation sanctuaries, as well as observance of natural occurrences reflective of coastal inundation.

CHAPTER 8

CONCLUSION + FUTURE WORK

The architectural debate pertaining to resilient coastal design is one that is controversial and becoming more prevalent as climate change progresses. All of the resilient methods being implemented across the world possess positive qualities as well as the potential for negative downsides, and there are a variety of opinions and theories as to which method is the most efficient way to address coastal climate change.

It can be concluded that when introducing resilience into a low-lying site, the existing condition of the site is an important variable in the decision of what resilient method would be most effective for that specific area, more specifically, one resilient iteration may thrive in an area but fail in another. This thesis utilized knowledge derived from research to propose a case study for the most efficient resilient implementation for a specific site.

The next phases of this thesis could be to test other resilient strategies at a variety of locations in order to obtain further understanding of what site characteristics would benefit from specific resilient contributions, and site characteristics that would reject the implementation of other resilient contributions.

APPENDIX

ORAL DEFENSE PRESENTATION BOARDS



How do we design for coastal inundation caused by climate change?

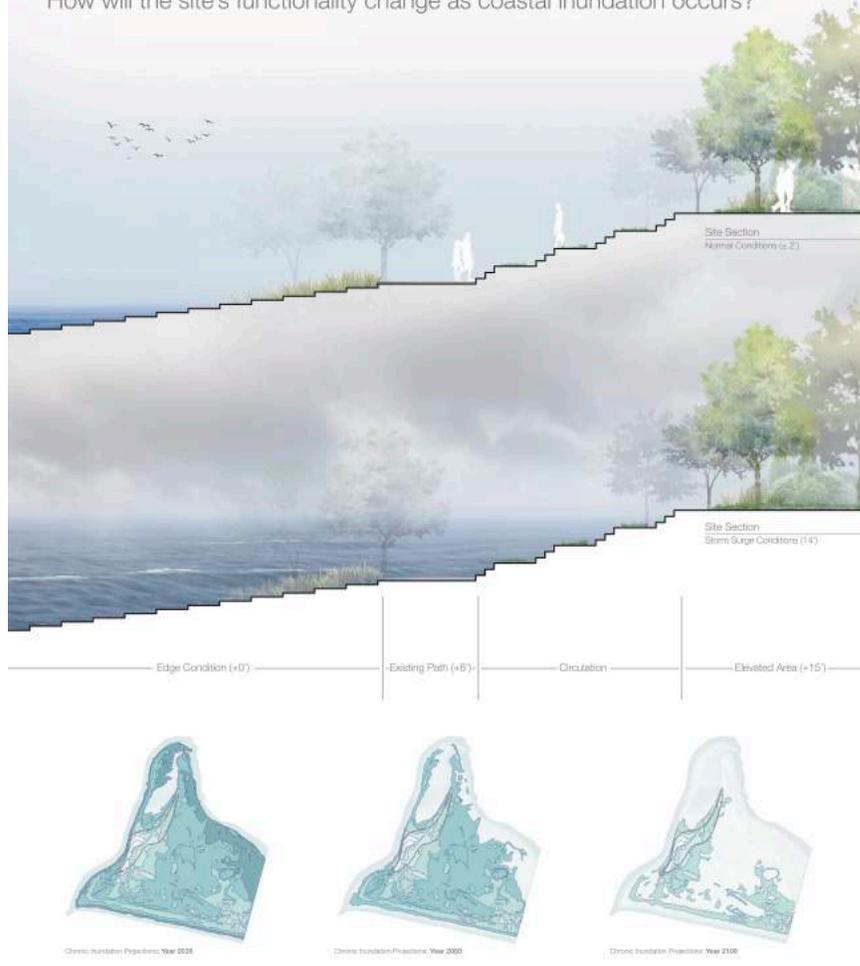
	<p>The Problem</p> <p>Climate Change is causing an acceleration of global warming, resulting in rising sea levels, drought, and environmental degradation. The volume of a rising ocean is expected to increase, which can lead to the melting of glaciers and thermal expansion of the ocean. The result of these increases is a rise of global sea level and increased severity and frequency of storm surges. It is predicted that global sea level will rise between 1 to 6 feet by the year 2100. 40% of the United States population live in low-lying areas that are at high risk for flooding and destruction as a result of sea level rise.</p>
	<p>Current Methods + Strategies</p> <p>Resilience is defined as the ability to recover from or counteract challenges and difficulties.</p> <p>Coastal Resilience is the ability for coastal communities to independently withstand stresses caused by hazardous events and coastal features, through a range of measures, and maintain their sustainability.</p> <p>Current methods of addressing rising sea level and flooding include coastal building, coastal softening, seawall, levee, and dune.</p> <p>The Proposal</p> <p>The goal of this thesis is to design a coastal community development that will not only be a new study for how coastal communities can be designed to survive and thrive, but also a model for how coastal communities can be designed to survive and thrive.</p>

What is an ideal location for the implementation of this proposal?

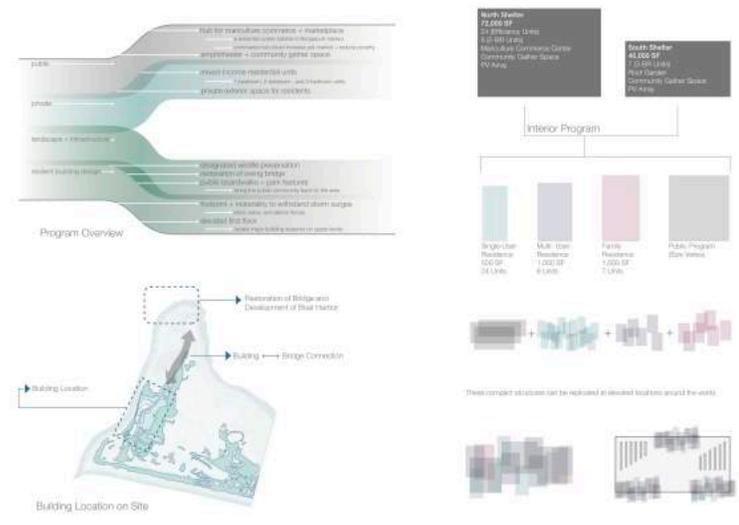
<p>SITE: PLEASURE BEACH PARK BRIDGEPORT, CONNECTICUT</p>	
<p>Bridgeport is a coastal city of approximately 40,000 people, located on the eastern shore of the Long Island Sound. The city is a major port and is known for its historic architecture and scenic views. The site is located in a prime location for development, with access to the waterfront and surrounding areas.</p> <p>The existing bridge structure over the site is a major barrier to the waterfront and is in need of replacement. The site is also a prime location for development, with access to the waterfront and surrounding areas.</p> <p>The existing bridge structure over the site is a major barrier to the waterfront and is in need of replacement. The site is also a prime location for development, with access to the waterfront and surrounding areas.</p>	

Erica Shannon

How will the site's functionality change as coastal inundation occurs?



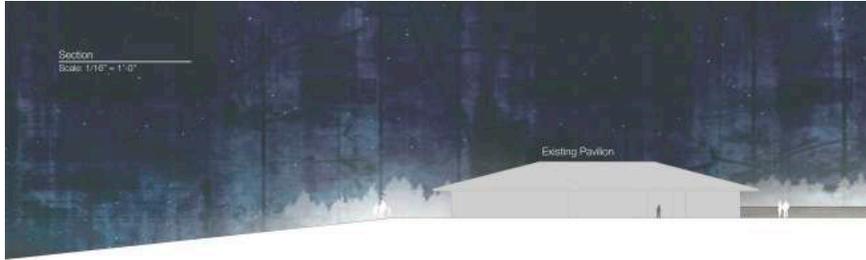
What are the essential programmatic elements necessary for an elevated community to survive and thrive in a low-lying coastal area?





How can an elevated community in a low-lying area be resilient to coastal inundation?





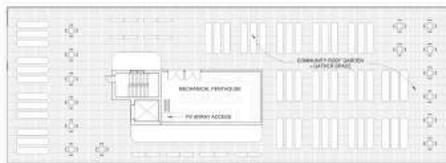
Section
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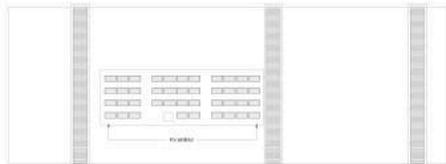
South Shelter - First Floor Plan
Scale: 1/16" = 1'-0"



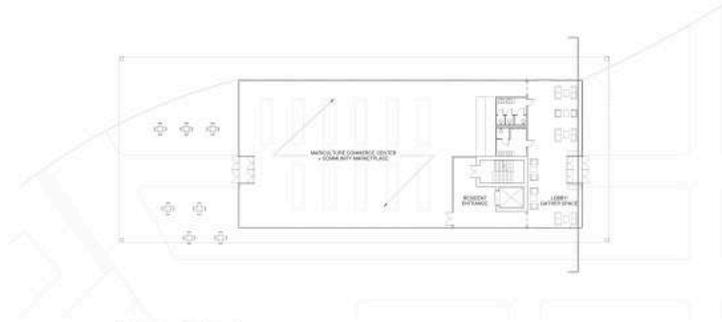
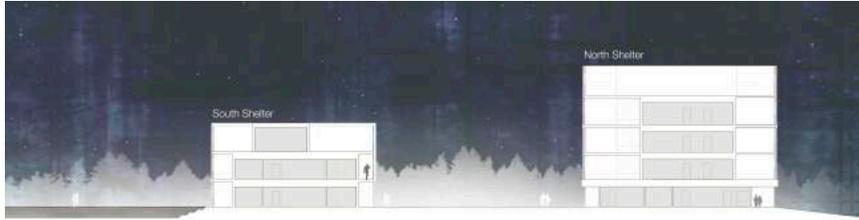
South Shelter - Second Floor Plan
Scale: 1/16" = 1'-0"



South Shelter - Third Floor Roof Garden
Scale: 1/16" = 1'-0"



South Shelter - Roof Plan
Scale: 1/16" = 1'-0"



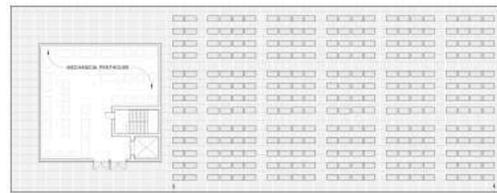
North Shelter - First Floor Plan

Scale: 1/16" = 1'-0"



North Shelter - Second, Third + Fourth Floor Plans

Scale: 1/16" = 1'-0"



North Shelter - Roof Plan

Scale: 1/16" = 1'-0"



1-Bedroom Unit

Scale: 1/8" = 1'-0"

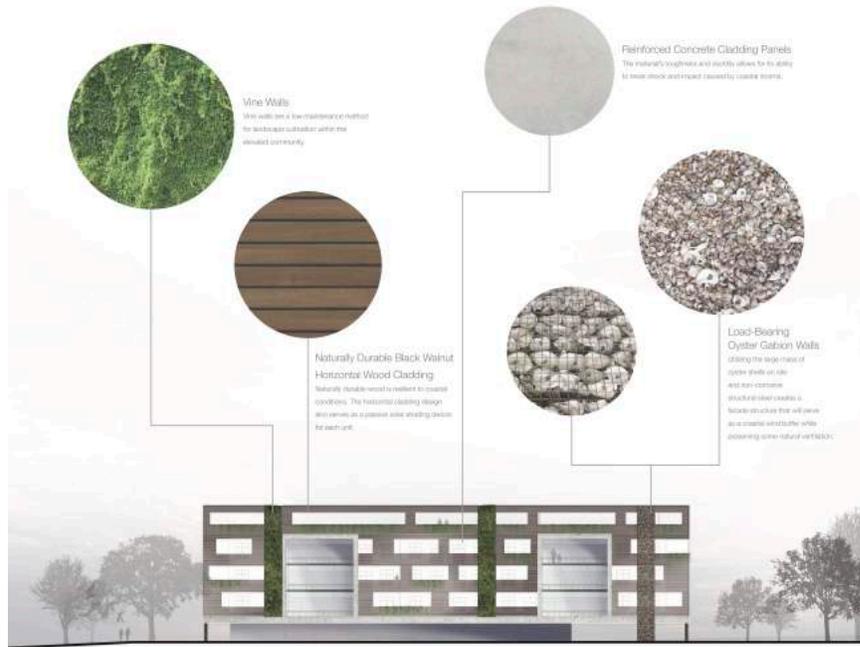
2-Bedroom Unit

Scale: 1/8" = 1'-0"

3-Bedroom Unit

Scale: 1/8" = 1'-0"

What is the optimal facade materiality for a resilient coastal community?



North Shelter - North Elevation
Scale: 1/16" = 1'-0"



South Shelter - North Elevation
Scale: 1/16" = 1'-0"



North Shelter - South Elevation
Scale: 1/16" = 1'-0"



South Shelter - South Elevation
Scale: 1/16" = 1'-0"



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