MARINE URBANISM:
THE IMPACT OF SEA LEVEL RISE ON THE IDENTITY OF FUTURE CITIES OF THE BAHAMAS

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ABSTRACT

As the reality of global climate change continues to augment the dangers of flooding and sea level rise in the world today, it is imperative that innovative methods of adaptive urbanization be considered to sustain the earth's growing populations. This paper presents an exploration into a dynamic form of urban implementation that may present a new frontier for resilience in future cities built in The Bahamas. Interviews conducted with locals, inclusive of educators, researchers, architects and government administrators help to assess the effectiveness of current flood prevention strategies and measure public interest for marine living and its opportunities. Recent articles along with data from local sources such as newspapers and online news organizations provide data that paint a narrative for the need of resilient urban implementation. Scientific literature and case studies reveal the exclusive advantages that maritime urban environments present for resiliency, social, and economic sustainability. The goal of this paper is to illustrate how a floating urban setting can not only neutralize the flood threat to future cities built in the Bahamas but also increase their capacity for economic improvement and sustainability.

Keywords: Disaster Prevention, Global Climate Change, Urban Planning, Ocean Cities, Resilience

INTRODUCTION

The earth's global temperature has always maintained a steady rate of fluctuation throughout the years. It was not until the onset of the industrial age that modern civilization introduced CO_2 emissions into the atmosphere in abundant proportions. Over the years, this and other heat trapping gases have contributed to the warming of the atmosphere, giving rise to the phenomenon of global warming. Global warming is partly responsible for melting ice sheets in the arctic regions and the expansion of the oceans worldwide. The risk of flooding on a universal scale threatens to fully submerge many coastal cities and even whole countries as sea level rises and land is eradicated.

With 80% of the terrestrial footprint resting within 1 meter (3 feet) of sea level, The Commonwealth of The Bahamas is one of these countries whose coastal settlements and their consequent way of life are being threatened by sea level rise in the future. [1] The CARIBSAVE Climate Change Risk Atlas (CCCRA) – an examination of the impacts of climate change in 15 Caribbean countries – shows through their General Circulation Model (GCM) that maximum annual temperatures in the Bahamas are set to increase by nearly 2 Degrees Celsius (3.6 F) by the 2050s and 2.8 degrees Celsius by the 2080s.

In accordance with these temperatures, the aquatic territory is expected to expand, which could lead to an increase of sea level rise by as much as 6m (20 feet) by the year 2100. With most development taking place on the coastal regions of The Bahamas, where also lies their infrastructure, the impact from a 4.7m (15.4 feet) rise in sea level would significantly affect the urban settlements within the country (See Fig. 1). [2] Desmond Brown, a lead environment correspondent of the Inter Press Service (IPS) - a Caribbean-based news agency – writes about this impending threat: "in The Bahamas, if the sea level rises some five feet, 80 percent of the country would disappear."



Figure 1- Climate Central projections for 4.7m (15.4 feet) increase in sea level on the capital of Nassau. Blue regions show the flooding impact to high density urban areas.

Interactive Flood Map. Courtesy of Climate Central

In light of these concerns, the question must be proposed: How can a marine urban setting mitigate the danger of sea

level rise to the islands and help to sustain an economy that will be negatively impacted by the increased rate of flooding? This paper investigates the potential of floating urbanities as a possible answer to this question.

One of the key issues highlighted by opponents who question the integrity of maritime cities concerns the ability to protect them. How they respond to storms, hurricanes and tidal waves – the harsh conditions of the aquatic realm – is a challenge that makes one rethink their legitimacy. Raised awareness regarding the potential of ocean cities has already led to rigorous research efforts that start to address some of these realities. Ultimately, I believe that with modern technology, we may discover the tools that lead to innovative methods for satisfying these concerns.

With the subject of floating urbanities quickly gaining popularity from initiatives taken in places like the Netherlands, China, and French Polynesia, my hope is for this awareness to lead to the manifestation of these cities in regions like The Bahamas where sea level rise is a threat to the urban society.

THE BAHAMAS

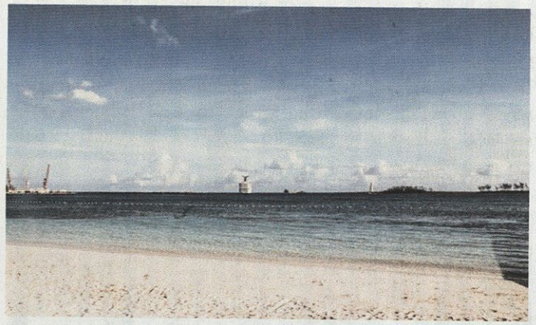


Figure 2 - Junkanoo Beach, Nassau, Bahamas

Photo by Author

Officially known as the Commonwealth of the Bahamas, this Small Island Developing State (SIDS) is home to some 700 islands and keys. It was first visited by Christopher Columbus in 1492 during his voyage to the new world. It is an archipelago of absolute wonder as it boasts the world's clearest waters, allowing over 200 feet of visual clarity beneath the seas. These waters, which are heralded as the most prominent feature of the country, are the nucleus of all the activity that drives its development, and with average ocean temperatures around 80 degrees Fahrenheit, it becomes an ideal vacation destination for individuals from all over the world who visit to experience the beautiful pristine white sandy beaches.

THE URGENCY FOR ADAPTATION

IMPACT ON AGRICULTURE

Sea level rise is a serious threat to the built economy of the Bahamas. [3] The World Bank suggests that just a mere 1m (3 feet) rise in sea levels would affect "11 per cent of the land area, without taking into account, the impact of storm surge, and this will lead to a 5 per cent loss in Gross Domestic Product (GDP)." This in turn could lead to a yearly loss of more than 900 million (USD) in the Bahamian economy. With a lower GDP, we will see unemployment rise in a country that is still being challenged economically as a developing island nation. Therefore, given these dire projections, a platform for resilient planning solutions must be at the forefront for urban development in The Bahamas.

Agriculture is the third most profitable sector in the Bahamian economy behind Financial Services (Banking) and Tourism. It is a dwindling sector that contributes to merely 7% of the GDP. Marine farming, which accounts for a great portion of the agricultural industry constitutes the majority of this figure. The maritime agricultural industry benefits heavily from the dense biodiversity found in the shallow warm banks of the subtropical Bahamian waters, producing up to 70 million (USD) annually from commercial fishing. Land-based agriculture, which is focused more on crop cultivation and livestock management contributes to the GDP in its sale of local vegetables and fruits, inclusive of pineapples, citrus, tomatoes and other common edibles.

Flooding from major storms and hurricanes has continued to serve as a detriment to the agricultural market. [4] CARIBSAVE Climate Change Risk Atlas summarized the aftermath of previous storms: "heavy rains following Hurricane Lili in 1996 led to flooding of land with consequent leaching of fertilizer and delay in replanting. Hurricanes Floyd and Michelle in 1999 and 2001 respectively also resulted in heavy losses in the agricultural sector." In assessing the damage from Hurricane Floyd on all agricultural sub-sectors, it was found that crop loss contributed to a loss of 25 million, livestock totaled almost 4 million and fisheries suffered a loss of approximately 10 million (USD) in equipment and other related marine gear. Not surprisingly, storm surge and tidal waves were the primary cause of livestock death as the animals either drowned or were crushed under the intensity of the waves. These issues still persist today. [5] Lindsay Thompson of the National Emergency Management Agency (NEMA) – a disaster management committee of government officials – reported this on the aftermath of widespread rain and thunderstorms on the island of Exuma in 2013: "The local farms of Mount Thompson were saturated with floodwaters, and the season's crop might have been lost." With the intensity and frequency of storms set to increase in an already active hurricane region due to warming sea surface temperatures, innovative measures for adding flood resilience to the agricultural sector must characterize future development. It becomes critical to the Bahamian economy that this market be sustained so that the country is more independent and self-sufficient in the near future.

SOCIETAL IMPACT

In the Bahamas, we find that the urban infrastructure of most islands is located near the coastlines. As a result of this, the majority of development - whether it be residential, mixed-use or commercial – is found in low-lying vulnerable regions. Flooding due to the sunken position of these areas is exacerbated during hurricanes and major storms. In an interview conducted with a young female homeowner who resides in the Pinewood Gardens area - one of the lowest lying residential districts in the capital of Nassau – she summed up her thoughts on the severity of the flooding epidemic: "grab your jet skis". [6] Larry Smith, writer for Bahamas Pundit - a weblog for Bahamian commentators – writes about the issue: "The Met Office (Department of Meteorology) indicates that a mere 1 ½ inches of rainfall in six hours or less, typical of summertime, can cause flooding in New Providence." In 2013, residents on the island of New Providence – also known as Nassau, the capital of The Bahamas – felt the impacts of record rainfall on the mainland. [7] Krystel Rolle, staff reporter of the Nassau Guardian – a prominent and locally owned news outlet – reported about the event: "thousands of New Providence residents were left bailing out their homes after record rainfall created widespread flooding, catching many people off guard." Local homeowners found themselves waist deep in water, losing thousands of dollars in personal items amid the chaos.

Accounts of the country's experience with Category 4 Hurricane Matthew in 2016 continue to haunt the population to this day (See Fig. 3) Bahamians living in the Faith Gardens areas, a residential district in the southern region of Nassau, were forced to evacuate their homes because of the rapid onset of water due to a 15-foot storm surge. [8] According to The Miami Herald, "30 people who were trapped from floodwaters in their homes had to be rescued by the National Emergency Management Agency (NEMA)."

The perpetual cycle of flooding that residents face must be broken as the "rebuilding purgatory" puts a financial strain on many individuals who already struggle to maintain their standard of living. With the water table being so high in many residential areas and the grounds suffering from oversaturation as a result of this and a lack of proper drainage, the realties already plaguing these regions would only worsen in the future. If the goal is to mitigate the impact of this growing issue on the society, measures must be put into place to ensure that locals are able to maintain their homes and belongings without suffering from the financial burden of frequent flood damage.



Figure 3 - Flood damage from the aftermath of Category 4 Hurricane Matthew (2016)

Reuters. Photo by Carlo Allegri.

INTERVIEW RESPONSES

In response to the data uncovered on the flooding epidemic in the Bahamas, interviews were conducted with 18 individuals consisting of 12 locals and 6 visiting researchers of the marine and geological sciences. The purpose of the interviews was to validate the need for a resilient urban planning strategy and to assess the public's opinion on both the established means of flood prevention and the probability of introducing a radical urban planning solution.

With seawalls acting as the established policy for flood prevention, I asked 12 locals to rate the effectiveness of these walls on a scale of 1 to 5 – with 1 being the least effective and 5 being extremely effective. 8 out of 12 participants rated the walls with a score of 3 or lower, suggesting that while the walls do help with deterring road erosion, they do little to prevent water from overflowing on land. When I asked this question to the 6 visiting researchers, it proposed another issue of the walls contributing to coastal erosion. One

of the educators and frequent visitor to The Bahamas rated the effectiveness of the walls with a score of 1, suggesting that the natural coastlines provide protection and should be left intact. As such, most researchers saw these walls to be counterintuitive as an established means of deterrence. Overall the consensus regarding the effectiveness of the sea walls suggested that this measure was not very effective as a method of flood prevention.

In the case of the need for establishing a platform to combat the forecast of flooding in The Bahamas, all subjects agreed that sea level rise should be at the center of such an initiative. Given the unanimous decision of the interviewees, I decided to jump ahead of my research and ask the critical question: "Would you invite the opportunity to live in an adapted marine urban setting"? As expected, over 70% of interviewees answered "no" with the majority contributing the reason to hurricanes. Of the 5 that answered yes, it was welcomed as an interesting opportunity. However, it was also acknowledged that there would be some challenges to making such a transition. Coincidentally, the very purpose of this paper is to show that in the long run, those challenges can be resolved and that the benefits would introduce a new frontier for resilient urban living in The Bahamas

AGRICULTURAL RESPONSE

THE POTENTIAL OF FLOATING FARMS

Sea level rise and flooding constitute a threat to the food security of The Bahamas by reducing the capacity and potential of the lands for farming in the future. Even today, farming on land is limited because of poor soil conditions. [9] According to CARIBSAVE Climate Change Risk Atlas, "The soils of The Bahamas are very thin, chalky, fragile, inherently of low fertility and prone to drought." The agricultural sector has been steadily declining for these and a host of other factors including a lack of interest from the younger population. With these shortcomings in mind, how can floating farms reveal new methods for marine and land cultivation which will ultimately improve the efficiency and appeal of the agricultural industry?

Dr. Ricardo Radulovich, a professor of Marine Science with a PhD in soil-plant-water relations, introduces the idea of using floating farms for coastal populations to gain a share of the global market. He believes that macroalgae (seaweed) cultivation could help to improve the economies of poor coastal cities. These maritime farms, which can already be found in regions like the Gulf of Thailand and Pacific Costa Rica, can support up to five persons. They are capable of supplying a diverse array of year-round produce, and cost as little as 200 (USD) to get started. Radulovich sees floating farms as the basis for aquaculture and mariculture as they also create habitats for marine animals, which in turn increases the biodiversity. With fisheries being the main contributor to the agricultural sector in the Bahamas, algae farming could subsequently lead to increased populations of farmed fish. [10] Civil engineer Rutger De Graaf remarks about the possible advantages of fish farming in Joe Quirk's book, "Seasteading": "If you compare intensive aquaculture to cattle farming, protein production can be 200 to 300 times as efficient." With the potential of fish farming, Bahamians would be able to expand their services and sell to global markets, increasing the GDP while adding a measure of self-sufficiency to the economy. Additionally, this kind of strategy is positive for The Bahamas because it is relatively easy to execute and requires the least amount of financial venture to get started.

What about growing crops? With his experience managing floating farms aimed at growing medicinal vegetables, Dr. Ricardo Radulovich finds that these structures are easy to manage. They do not suffer from the usual obstacles associated with land farms. These farms are unbothered by pathogens, weeds, pests (and so do not require pesticides), and other animals that may otherwise hinder their production capacity.

Just recently in 2015, Barcelona-based Forward-Thinking Architecture produced a conceptual design for a Smart Floating Farm (SFF) that would make it possible to grow food and fish just off the coast of Costa Rica. The concept consists of a floating multistory vertical farm that utilizes renewable solar energy to operate independently of the mainland.

There are three distinct levels of this multi-story marine setting (See Fig. 4). The top-level hosts rainwater retention systems for water irrigation, surface area for P.V. panels to supply electricity, and skylights for daylight penetration. The second level consist of a hydroponics system – a system that grows plants without the use of soil – along with a greenhouse where vegetation can be cultivated and sold for profit. The ground level is dedicated to marine livestock where fish and other marine delicacies are farmed and sold to the market. The concept also features a closed loop system that supports each level of the structure, giving it a measure of self-sufficiency.

[11] Lorraine Chow, reporter for EcoWatch – a news outlet concerned about the state of the environment – writes about the innovative concept: "designers estimate that SFFs can produce an estimated 8,152 tons of vegetables and 1,703 tons of fish annually." These figures would prove to be significant for the agricultural market of The Bahamas.

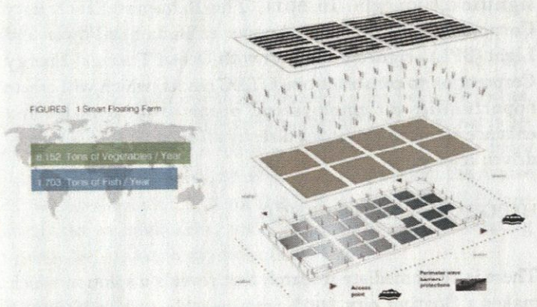


Figure 4 - Smart floating farms uses a symbiotic process whereby each layer contributes to another forming a sustainable closed loop system. P.V. panels power the structure while sunlight is fed directly to the plants which is used to feed the fish whose waste is used to fertilize the plants.

EcoWatch. Diagram by Forward Thinking Architecture

As is typical with these larger and innovative floating farms, the greatest obstacle is the cost required to commence and maintain operation. [12] Julia Calderone, former writer for Business Insider recalls the concerns of James Quinn, a professor of Environmental Science and Policy at the University of California, Davis: "I love the concept, but ... I am skeptical that it could be done without massive subsidies,". The financial concerns of these applications are valid because we must consider their sustainability in the long run. However, when we take into account the size of The Bahamian islands and their small scattered populations, the scale of such an application should not be as significant as most case studies suggest for urban success.

In contemplating the potential of floating farms in The Bahamas, we find that they will negate the concerns of flooding, need for arable land and rich soil as discussed earlier in this paper. I also believe that the interest generated from this innovation will appeal to the younger generation, which will encourage more people to get involved in the agricultural market.

SOCIETAL RESPONSE

URBAN RESILIENCE

If our goal is to mitigate the danger of flooding today along with sea level rise in the future, then it is important that we establish more flood-resistant communities. Before we can do this, we must first understand how these communities can function successfully. What makes a floating city float? Research reveals that while there are many ways of creating these resilient applications, one particular technology is quickly becoming the go-to method because of its ease of construction and flexibility.

In places like London and the Netherlands predominantly, floating homes are becoming the preferred development strategy for creating flood-resistant districts that are safe for inhabitants. [13] Mathias Tobias, Senior Project Manager of Vancouver-based International Marine Floatation Systems (IMFS) - an enterprise that has constructed floating homes for clients living abroad since the 1980s – asserts, "floating properties are engineered and designed to be dynamic." In the magazine "Masterbuilder" – India's most prominent construction magazine – Tobias boasts about using Concrete Floating Foundations (CFF) to construct homes in regions like the Netherlands and the United Kingdom. These foundation systems are constructed of Expanded Polystyrene (EPS) – for buoyancy – and reinforced concrete for stability and protection against damaging environmental agents.

They are built as versatile foundational grids, upon which applications of all kinds can be constructed. There are no limitations on the size or capacity of CFF systems as their modularity allows for easy expansion, and the larger the application, the more stable the system will be. Systems where the EPS is exposed can have a life expectancy of 20 years while those with protective coating applied can last up to 80 years. These systems have gained such popularity that different variations of this concept can be found worldwide in places like Canada and The United States.

An example can be found in a complex of 75 floating homes and waterside dyke houses in the private sector of Amsterdam (See Fig. 5). Designed by Dutch-based firm Architectenbureau led by Marlies Rohmer, the houses within this community are each supported by hollow concrete infrastructure, which keeps them afloat. Lightweight steel construction is used above the concrete "foundation" to create the habitable living quarters. These units rest on mooring poles which allow for vertical movement when influenced by the changing tides.

Because of the successful implementation of strategies like this, in addition to its adaptive properties, I think that there lies an opportunity for The Bahamas to explore the concept of Concrete Floating Foundations (CFF) in depth, given especially their longevity, simplicity of construction, and capacity for urban growth.



Figure 5 - Floating houses in IJburg of Amsterdam.

Archdaily. Photo by Marcel Van Der Burg.

CLEAN UNLIMITED ENERGY FOR ALL

In addition to urban resiliency, improving the standard of living must be a criterion for the establishment of future Bahamian Cities. With this goal comes the introduction of the concept of Ocean Thermal Energy Conversion (OTEC). With some 80% of solar energy being stored in the vast oceans, OTEC offers the possibility of unlimited sustainable and renewable energy. This process uses the temperature difference between the warm surface tropical waters and the cold temperature of deep ocean waters to generate electricity.

[14] Joe Quirk, writer and ocean city fanatic, deliberates on the potential of OTEC plants in his book "Seasteading": "submerged power cables (which are powered by OTEC) have the potential to fuel an entire coastal city." [15] Patrick Takahashi, American Biochemical Engineer and proud floating city enthusiast, informs Joe Quirk about the potential for electricity generation in an interview: "up to 25 terawatts (25 million watts) can be sustainably drawn from the oceans… That's much higher than all of the energy humans use today." With the Bahamas being highly dependent on the importation of petroleum products, which drive up the cost of electricity for residents in the country, this system has the potential to reduce the cost of living for inhabitants while providing the economy with an unlimited supply of clean energy. These plants would also create jobs and generate fresh water as a by-product, which is a plus for the out-lying islands of the country as many are dependent on the capital for supply of potable water.

One of the main obstacles to the implementation of OTEC farms is the cost required to construct them. However, when we think of the long-term advantages of such applications, I would assert that the benefits outweigh the cost by a significant margin. In 2011, The Bahamas Electricity Corporation (BEC) – now known as Bahamas Power and Light (BPL) - signed a contract with Ocean Thermal Energy Corporation to construct two OTEC plants, which will create opportunities for employment, promote aquaculture and enhance all other industries directly affected by the maritime-driven economy of The Bahamas.

HURRICANE RESISTANCE

There is no immediate research that reveals a solution which makes a floating city 100% invulnerable to hurricanes as even our land-based settlements have not solved this issue completely. However, I believe that the resilience of these urbanities against powerful storms will be found in their potential mobility. [16] Koen Olthius, Dutch architect and principal of the firm Waterstudio.NL, introduced the concept of "Floating City Apps" in a TED Talks presentation in Warwick of 2012: "What we actually need is a city structure that is flexible and answers our needs." This concept consists of a portable modular urban grid that can be altered and shifted to suit the needs of the society (See Fig. 6).

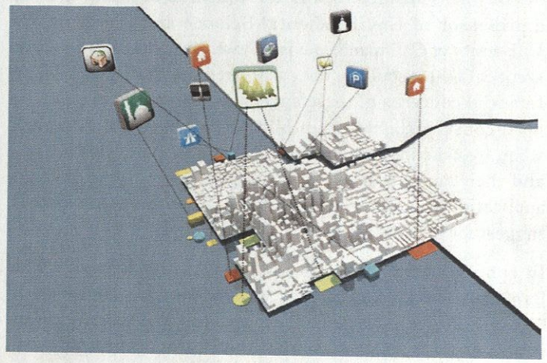


Figure 6- An illustration of Koen Olthius' Floating City Apps. The colored blocks are mobile applications that can be attached to the urban grid as needed. This concept can be used to create modular mobile grids that can be anchored to the land in the event of major storms in The Bahamas

Rendering by WaterStudio.NL

By using this idea, we can allow for these flexible pieces to be detached and transported out of the path of incoming storms. These grids can be towed by larger vessels or self-propelled to facilitate this process. This idea would provide a pleasant alternative for individuals having to abandon their homes at the onset of major storms to seek shelter.

CONCLUSION

The opportunities presented by marine urban environments, while challenging, may prove to be useful in a future that is set to be significantly impacted by radical sea level rise. As more research comes forward and as we learn more about the nature of such applications, I think that the world over will be one step closer to establishing societies on the oceans and creating new worlds for humanity to explore

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Addendum

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INTRODUCTION

My thesis was inspired by the challenges incurred by the intense storms of the Hurricane season in The Bahamas. It prompted an investigation into the effects of Global Warming on the worsening condition of these storms and their consequent impact on the Islands of The Bahamas.

As I conducted my research, I uncovered a daunting reality- one where Global Warming threatened the existence of the Islands of The Bahamas because of radical sea level rise. Hence, I was inspired to create a possible solution for resilient cities for the future which would adapt easily to the impending dilemma. Ultimately, the main goal of my thesis was to illustrate how future Bahamian societies would have to evolve and adapt in a post-apocalyptic future dominated by radical sea level rise. Therefore, my thesis proposal was defined by an independent urban district that enforces a greater connection to the already established maritime culture and employs a host of sustainable innovations that make it self-sufficient.

PROCESS

The research conducted in the early stages of my written thesis revealed the worsening effects of sea level rise over an 80-year timeline (with 2020 as the starting point). Using this information, I sought out a site where development was most likely to increase in the near future and one whose urban center was exposed to the coastline. With the data collected from research, I observed the effects of flooding due to hurricanes and other storm systems along with the impact to the existing towns of various islands. This led to the selection of Georgetown, Exuma as my site to be worked upon. The site was flourishing with development due to its international popularity (Swimming pigs, Regatta, etc.) and booming tourist industry. As a result, the population was increasing as well. With the influence of these factors, I saw that there was an opportunity to create some resilient model that proposed a vision of what a typical Bahamian settlement could be in a future ravaged by sea level rise. My hope was that the popularity circulating around the Georgetown district would allow this proposal to become a paradigm for future settlements in the country - one that preserves Bahamian culture and promotes a local economy.

THESIS STATEMENT

"With severe sea level rise predicted in the future, a marine urban environment can provide flood resilience and improve the city's capacity for economic improvement and sustainability."

INITIAL URBAN PROPOSAL

My initial proposal was defined by a fully developed urban settlement that was to be introduced well into the 80-year timeline where sea level rise had already impacted the terrestrial footprint. The goal was to recreate - in this new marine environment - the typical Bahamian settlement. This initial proposal granted a great wealth of design freedom where due to the exacerbated circumstances, an opportunity to construct an entire city with little to no contextual restrictions was possible. At first, I was very much elated with these kinds of liberties given to me with regard to the design imperative. However, as a result, the project scope grew to an overwhelming scale and the path taken to establish a design solution was severely lacking due to the mitigated site influence. Ultimately, the proposal grew into an illogical and unviable fantasy that did not contribute much to my original thesis statement. I had come to the realization that my proposal was doing too much with regard to an attempt to solve all of the problems prompted by the issues associated with my written thesis. Consequently, at the end of the fall semester review, I came to the decision to rethink my approach for an urban solution over the intercession - one that stressed the viability of my proposal as well as one that conducted a better exploration of the conceptual process. Additionally, I wanted to take a different approach to the 80-year timeline which would help to reduce the scale of the project and consequently the issue of doing too much.

REVISED URBAN PROPOSAL

The urban proposal that I envisioned for my thesis underwent a drastic change. Instead of introducing development late into the 80-year timeline when sea level rise had consumed the land, the idea was to introduce a start-up development - a new district - that would allow inhabitants to experience a new form of urban living that they might be met with in the near future. This development would be presented earlier into the 80-year timeline and connect back to the existing typologies on the island. The idea is that settlements of a similar nature could be created, as sea level rose, forming a series of connected satellite districts as land is eradicated. These new marine settlements would enforce the already established local economy and facilitate The Bahamian culture in a post-apocalyptic society. Moreover, these "networks" would maintain the memory of what I call the Linear Island Networks which define the typical urban condition of the islands today. (Fig. 1 & 2 below).

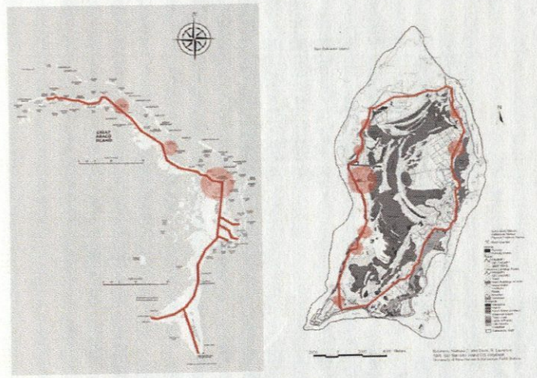


Figure 1 & 2 - Illustrates the Linear Island Concepts. Abaco Island (left) and San Salvador (right).

Right: http://www.caribbean-rental.com/sansalvadormaps.html

Left: http://mapsof.net/abaco/abaco-map

The final urban proposal manifested as a small marine adapted district with housing at the core of the new development and support applications which encourage a local economy. One of such applications included an agricultural center equipped with a fish-farming facility, aquaponics lab and a research facility for marine scientists and reef restoration experts. The other support application is a restaurant/open bar that is intended to create an area of formal entertainment for inhabitants as well as neighboring tourist areas. Aligned with the core of the district is the "Fish Fry" region which is a social space where cultural events may take place. The entire district is connected back to the existing land via a proposed boulevard that runs through the center of the city.

DESIGN REVIEW REFLECTION

Overall, I was surprisingly satisfied with my thesis proposal, especially given the disappointing schematic solution that was presented in the Fall semester. Much like my thesis reviewers, I found myself fascinated with it its viability and potential for actual implementation. I do however regret not being able to put more effort into the master plan design but with the attention to detail in the project scope, time would have not permitted me to do so.

The comments received from the respondents at my thesis review were somewhat expected. Largely, they felt that there was a disconnect between the new district and The Bahamian society. They were concerned that the new district drew a striking resemblance to the typical resort and that it was isolated from The Bahamian way of life. While I agreed with these comments, I understood at the same time that this project had to be defined as a forward thinking urban solution that was to be set into a new kind of landscape. As such, the transition of culture, atmosphere and environment to this new setting would not remain exactly the same. This is why I created spaces within the new district for public activities, cultural events and even introduced green spaces in an attempt to create a sense of place. With regard to the building looking like a resort and potentially not being accessible to Bahamians, the idea was to reflect a kind of vibrancy and create a new experience for the inhabitants. Typically, in The Bahamas, the aesthetic of these building applications are reserved for the tourist districts but at the same time they define Bahamian identity. I was simply instilling that dynamic in the local society. Additionally, this aesthetic was to reflect what I hope in the next 80 years is to be a more advanced urban economy. After all, we do not expect The Bahamas to remain a third world economy forever.

One of the major concerns pertained to the potential cost of living within the district. This was one of the areas that I wished I had more time to improve upon. At the same time, this was an inevitability. These floating cities are a new kind of technology and there is a significant cost associated with their construction. Technology has come a long way and my hope is that in the future, innovation would lead to material substitutes which would make these types of constructions much cheaper after they have become more normalized.

Concerning the master plan, the reviewers appreciated the concept behind its proposal and suggested that I use it to better guide the design of the urban district. One of the reviewers even expressed an admiration for the Linear Island Network preservation.

CONCLUSION

Once again, I was extremely fascinated by my project. I was satisfied with the level of detail that the design illustrated as well as my understanding of those details. This entire process

also opened my eyes to the complexities of the urban design process and how architecture plays a major role in creating successful cities. Consequently, I've realized that I would like to learn more about the planning process so that I may apply what I have learned in professional practice.

I am satisfied with the outcome of my project and stand firm on my vision for future cities impacted by severe sea level rise in the Bahamas. I believe that I was able achieve my overall thesis goal which was to illustrate a potential paradigm for what future cities in The Bahamas may evolve into as they adapt to the changes brought on by Global climate change.

SPECIAL THANKS

This entire process has been extremely challenging and at times overwhelming. It would have not been possible to successfully complete it without the guidance and encouragement from a number of individuals throughout.

First and foremost, I'd like to thank my family for their words of assurance and encouragement. This journey would have been so much more difficult without their continued support.

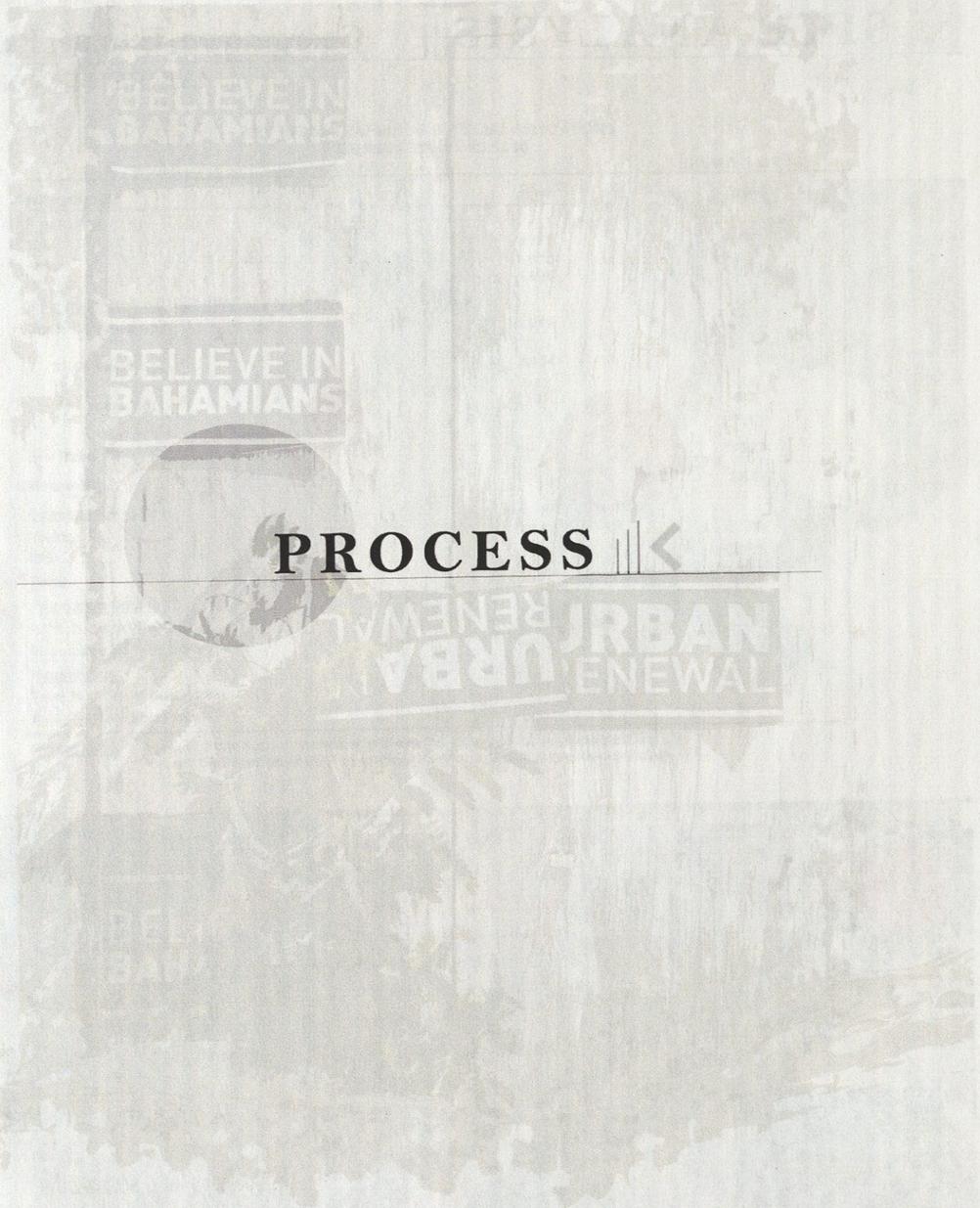
I'd also like to thank my thesis committee members- Craig Hinrichs, Mary Ben Bonham and Mary Rogero - for their patience and guidance throughout this entire process. They encouraged me to look at my thesis from a different perspective and this really helped my progress.

Lastly, I'd like to express gratitude to my Pre-thesis lecturer Diane Fellows for encouraging me to conduct my thesis on the things that are important to me. I also like to thank my Thesis Studio lecturers John Becker **and** Raffi Tomassian for pushing me and challenging me throughout my thesis proposal.

The guidance, support and knowledge imparted by the aforementioned helped to make this thesis journey invigorating, challenging, overwhelming and completely worth it.

Thank you.





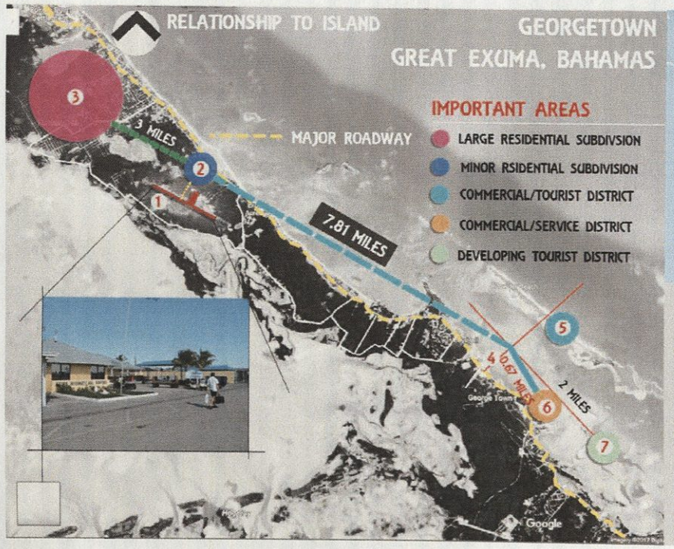
PROCESS

SITE ANALYSIS

Georgetown, Exuma, Bahamas

CURRENT CONDITION







1 | EXUMA INTERNATIONAL AIRPORT
2 | MOSS TOWN
3 | FARMER'S HILL SUBDIVISION
4 | SITE
5 | STOCKING ISLAND
6 | GEORGETOWN COMMERCIAL DISTRICT
7 | CRAB CAY

GENERAL CENSUS DEMOGRAPHIC

KEY DEMOGRAPHIC AND SOCIAL INDICATORS
CENSUS 2000 AND 2010

INDICATORS	EXUMA & CAYS 2000	EXUMA & CAYS 2010
Population		
Total	3,571	6,928
Male	1,875	3,468
Female	1,696	3,460
Total and Percent Distribution of Population		
Under 15 Years No:	1,012	2,336
%	28.3	33.7
15-64 Years No:	2,154	4,071
%	60.3	58.8
65+ Years No:	383	493
%	10.7	7.1
Sex Ratio	110.55	100.23
Median Age	31.3	27.7
Dependency Ratios		
Young	46.98	57.38
Old	17.78	12.11
Total	64.76	69.49
Population Density		
Area (square miles)	112	112
Population Density per sq. mile	31.9	61.9
Households		
Total Number of Households	1,157	2,028
Average Household Size	3.1	3.4

Please Note: Age-Not Stated is not included in the calculations of the following indicators:-
Percent Distribution of the Population, Median Age and Dependency Ratios.

ANNUAL HOUSEHOLD INCOME

PRIVATE DWELLINGS BY SEX OF HEAD,
HOUSEHOLD SIZE AND TOTAL ANNUAL HOUSEHOLD INCOME

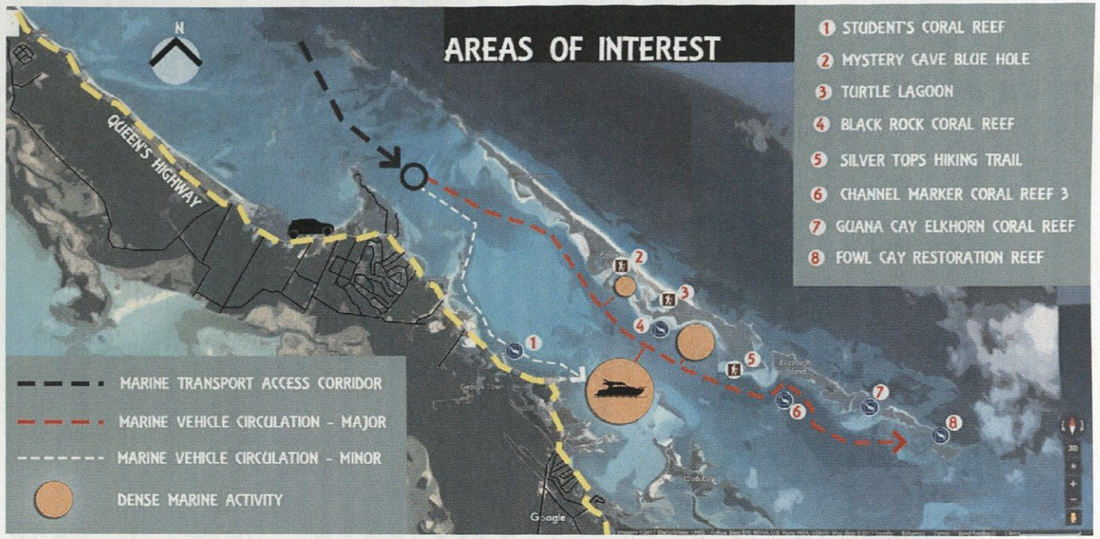
TABLE 20.0 — EXUMA & CAYS

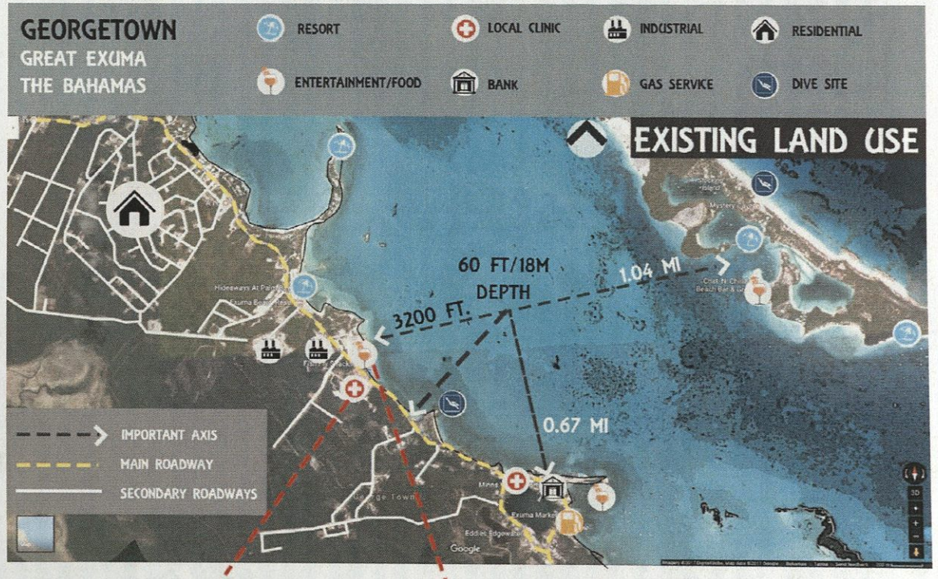
SEX OF HEAD AND HOUSEHOLD SIZE	TOTAL	TOTAL ANNUAL HOUSEHOLD INCOME: 0-5000	5001-10000	10001-15000	15001-20000	20001-40000	40001-60000	60001-80000	80001-100000	100001 AND OVER	NOT STATED
TOTAL	2,027	176	172	169	176	625	331	156	69	78	85
MALE	1,409	102	124	100	128	403	236	121	62	66	67
FEMALE	618	74	48	69	48	222	95	35	7	12	18
" 1 "	610	117	89	70	71	152	44	19	5	8	35
MALE	447	75	71	58	61	102	30	11	5	5	29
FEMALE	163	42	18	12	10	50	14	8	0	3	6
" 2 "	367	23	27	29	32	108	67	24	22	19	16
MALE	248	13	15	18	19	65	47	21	20	19	11
FEMALE	119	10	12	11	13	43	20	3	2	0	5
" 3 "	291	8	24	20	26	106	60	26	6	4	9
MALE	188	3	16	5	18	63	44	22	6	3	7
FEMALE	103	5	8	15	8	43	16	3	0	1	2
" 4 "	215	9	10	13	15	63	50	19	12	13	6
MALE	159	4	7	7	9	49	38	18	10	11	6
FEMALE	51	5	3	6	6	14	12	1	2	2	0
" 5 "	180	6	6	7	12	61	37	24	7	12	9
MALE	127	2	3	5	5	43	29	17	7	10	6
FEMALE	53	4	3	2	7	18	8	7	0	2	3
" 6 "	100	6	4	6	3	42	16	13	5	3	2
MALE	68	0	3	3	3	25	12	12	5	3	2
FEMALE	32	6	1	3	0	17	4	1	0	0	0

PRIVATE DWELLINGS BY SEX OF HEAD,
HOUSEHOLD SIZE AND TOTAL ANNUAL HOUSEHOLD INCOME

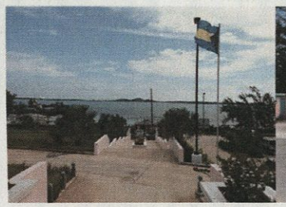
TABLE 20.0 CONT'D — EXUMA & CAYS

SEX OF HEAD AND HOUSEHOLD SIZE	TOTAL	TOTAL ANNUAL HOUSEHOLD INCOME: 0-5000	5001-10000	10001-15000	15001-20000	20001-40000	40001-60000	60001-80000	80001-100000	100001 AND OVER	NOT STATED
" 7 "	95	2	5	11	7	23	27	8	3	8	3
MALE	56	1	3	3	4	13	15	7	3	5	2
FEMALE	39	1	2	8	3	10	12	1	0	1	1
" 8 "	63	3	3	3	2	24	12	6	2	3	4
MALE	40	2	2	1	2	17	5	4	2	2	3
FEMALE	23	1	1	2	0	9	7	1	0	1	1
" 9 "	41	0	3	0	2	12	9	6	4	4	1
MALE	32	0	2	0	2	8	7	5	3	4	1
FEMALE	9	0	1	0	0	4	2	1	1	0	0
" 10 "	26	1	1	0	2	12	2	3	2	2	0
MALE	18	1	1	0	2	8	2	3	1	2	0
FEMALE	8	0	0	0	0	4	0	2	2	0	0
" 11 "	11	0	1	0	2	1	2	5	0	0	0
MALE	6	0	1	0	2	1	2	0	0	0	0
FEMALE	5	0	0	0	0	0	0	5	0	0	0
12 OR MORE	33	1	0	0	2	17	4	4	1	4	0
MALE	20	1	0	0	1	9	4	2	1	2	0
FEMALE	13	0	0	0	1	8	0	2	0	2	0
NOT STATED	0	0	0	0	0	0	0	0	0	0	0





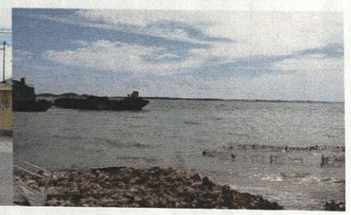
VIEW OF SITE FROM HOSPITAL

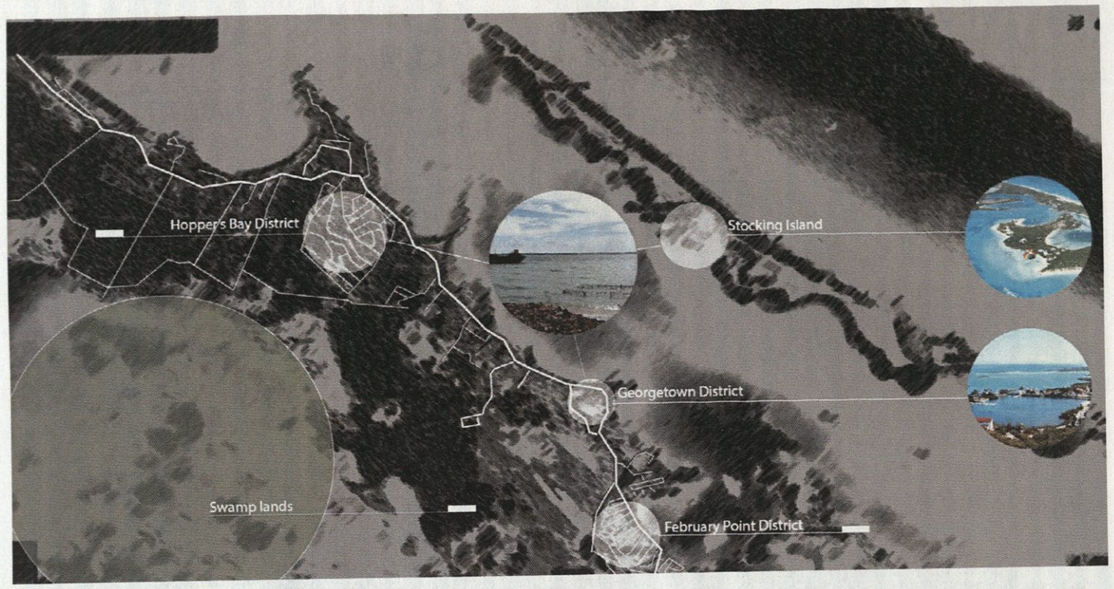


FISH FRY SHACKS



BEHIND FISH FRY SHACKS







1 | LOCAL CLINIC
2 | MINNS WATER SPORTS
3 | PEACE AND PLENTY RESORT
4 | EXUMA POST OFFICE
5 | STRAW MARKET
6 | REGATTA POINT RESORT
7 | REGATTA EVENT SITE
8 | SCOTIA BANK
9 | EXUMA SUPER-MARKET
10 | ROYAL BANK OF CANADA
11 | BTC (TELECOMMUNICATIONS)
12 | SHOP RITE

COASTLINE ANALYSIS

GEORGETOWN SETTLEMENT



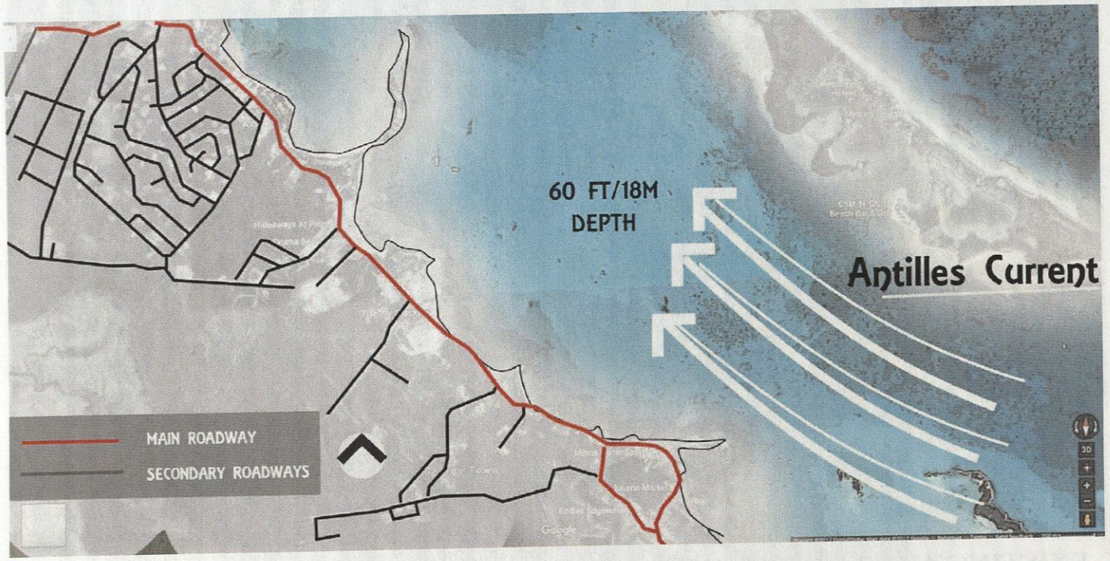
MAIN ROADWAYS (CIRCULATION)



CORRIDORS TO COASTLINE



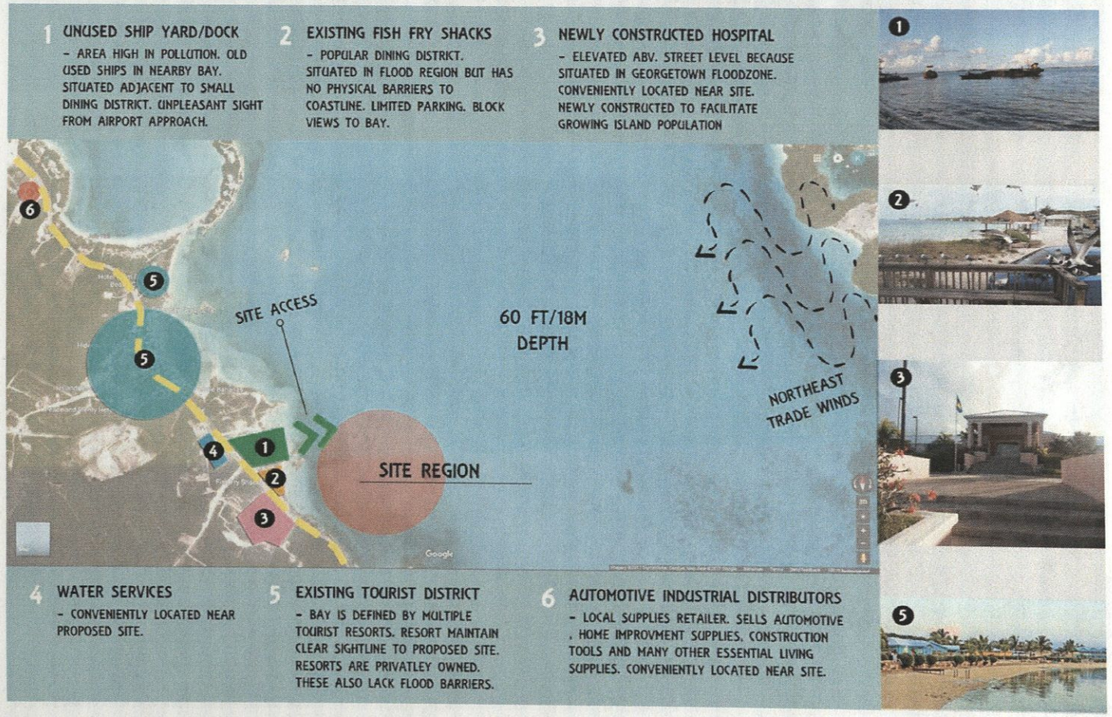
PRIME VIEWS



PREDOMINANT OCEAN CURRENTS

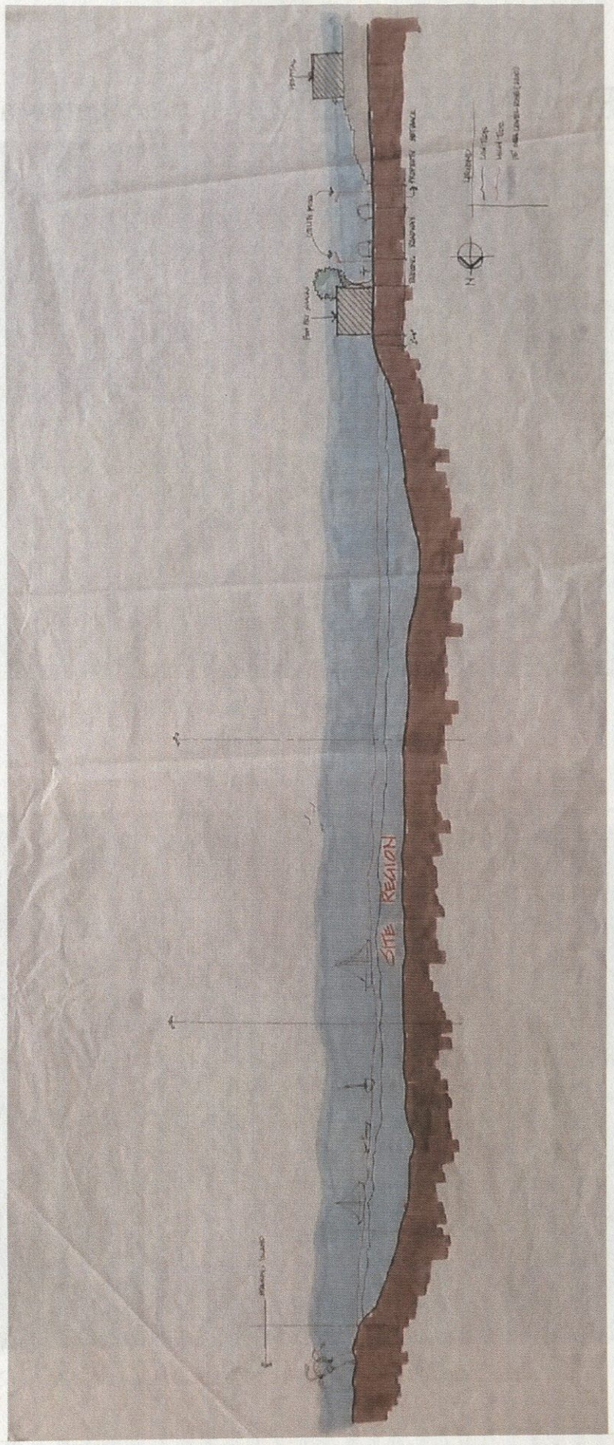


LAND USE



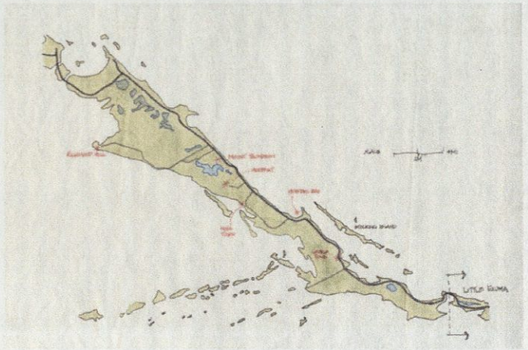
EXISTING APPLICATIONS NEAR SITE

SITE SECTION

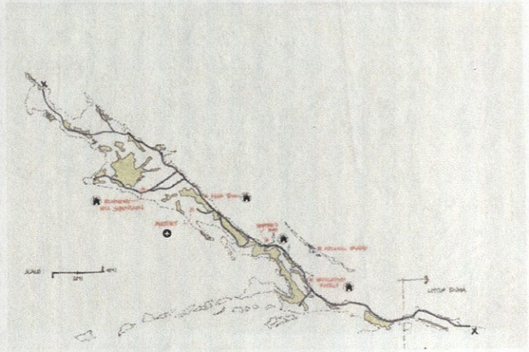


SITE ANALYSIS || Georgetown, Exuma, Bahamas

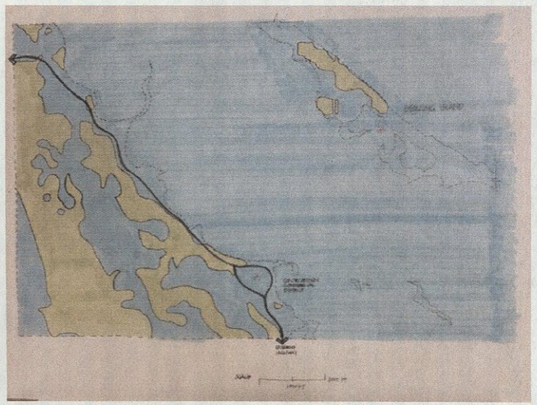
PROJECTED CONDITIONS



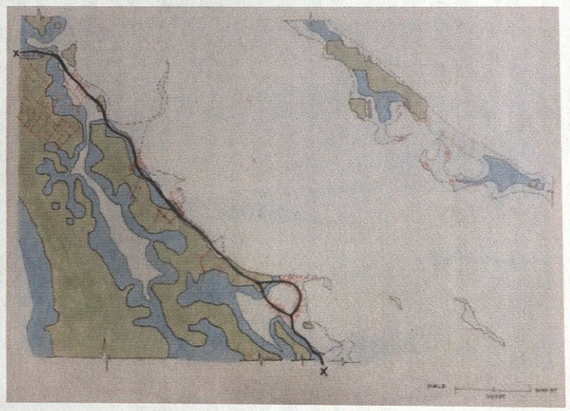
Current Terrestrial Footprint



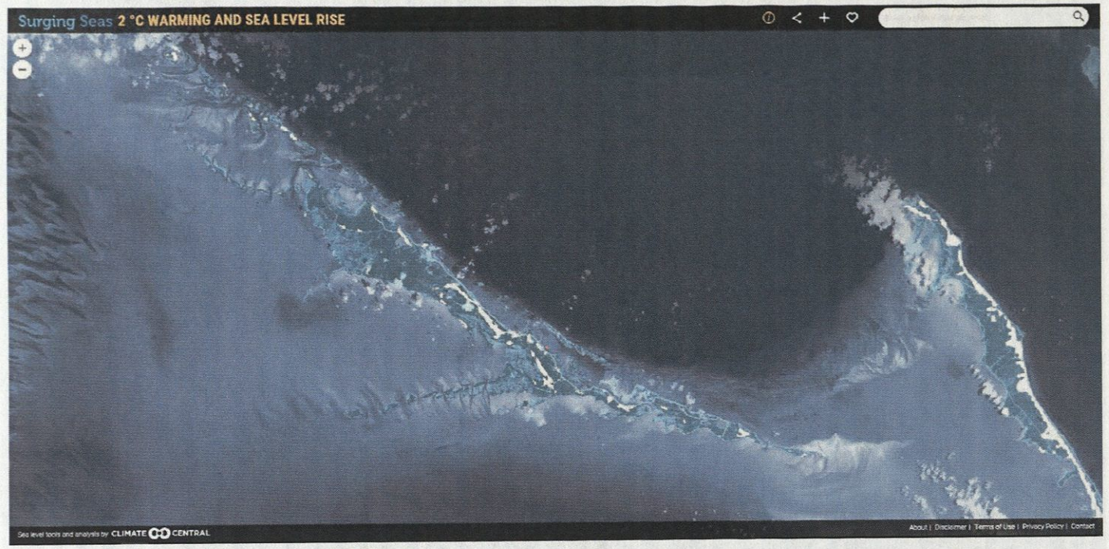
15-foot Sea Level Rise



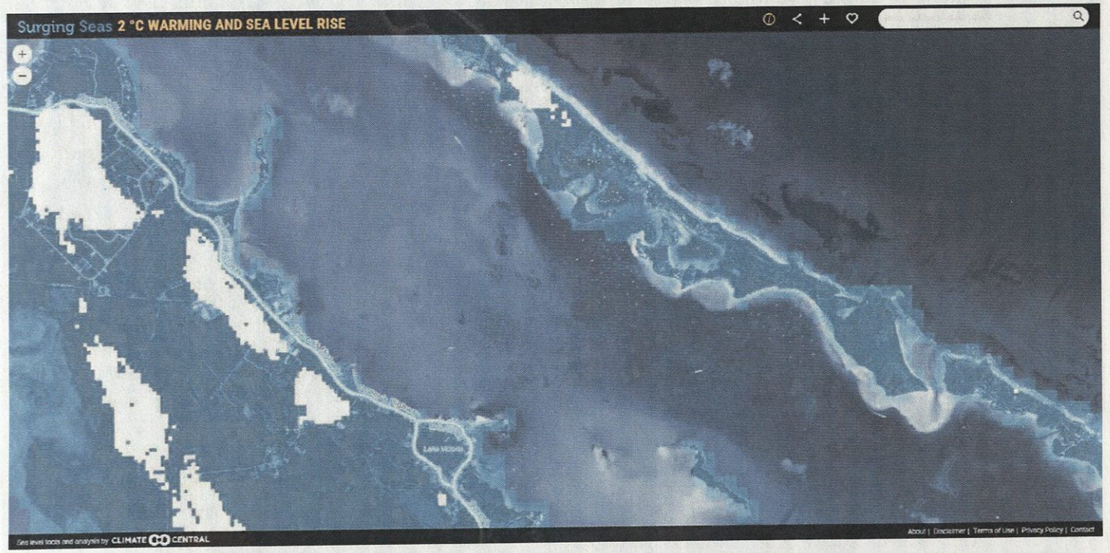
Georgetown Coastline Impact



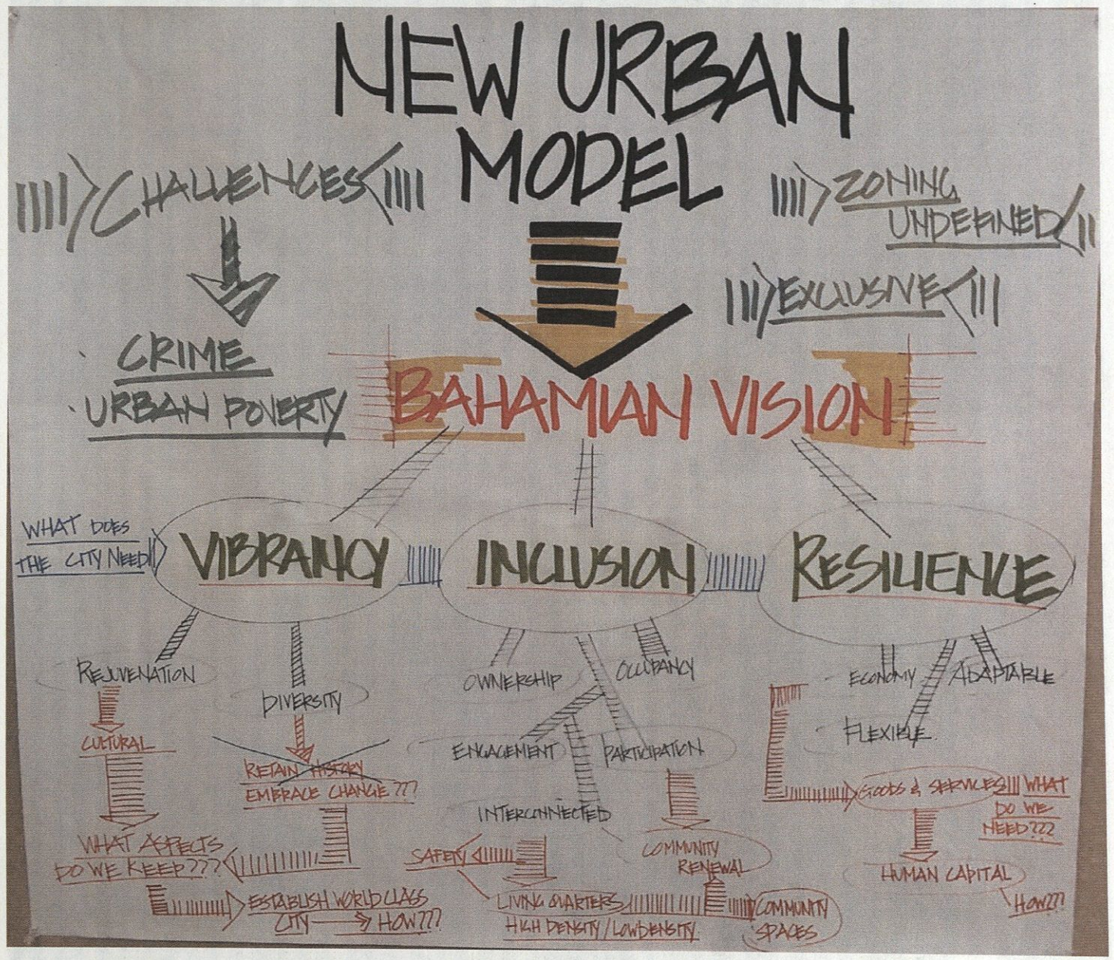
Settlement Clusters Impact



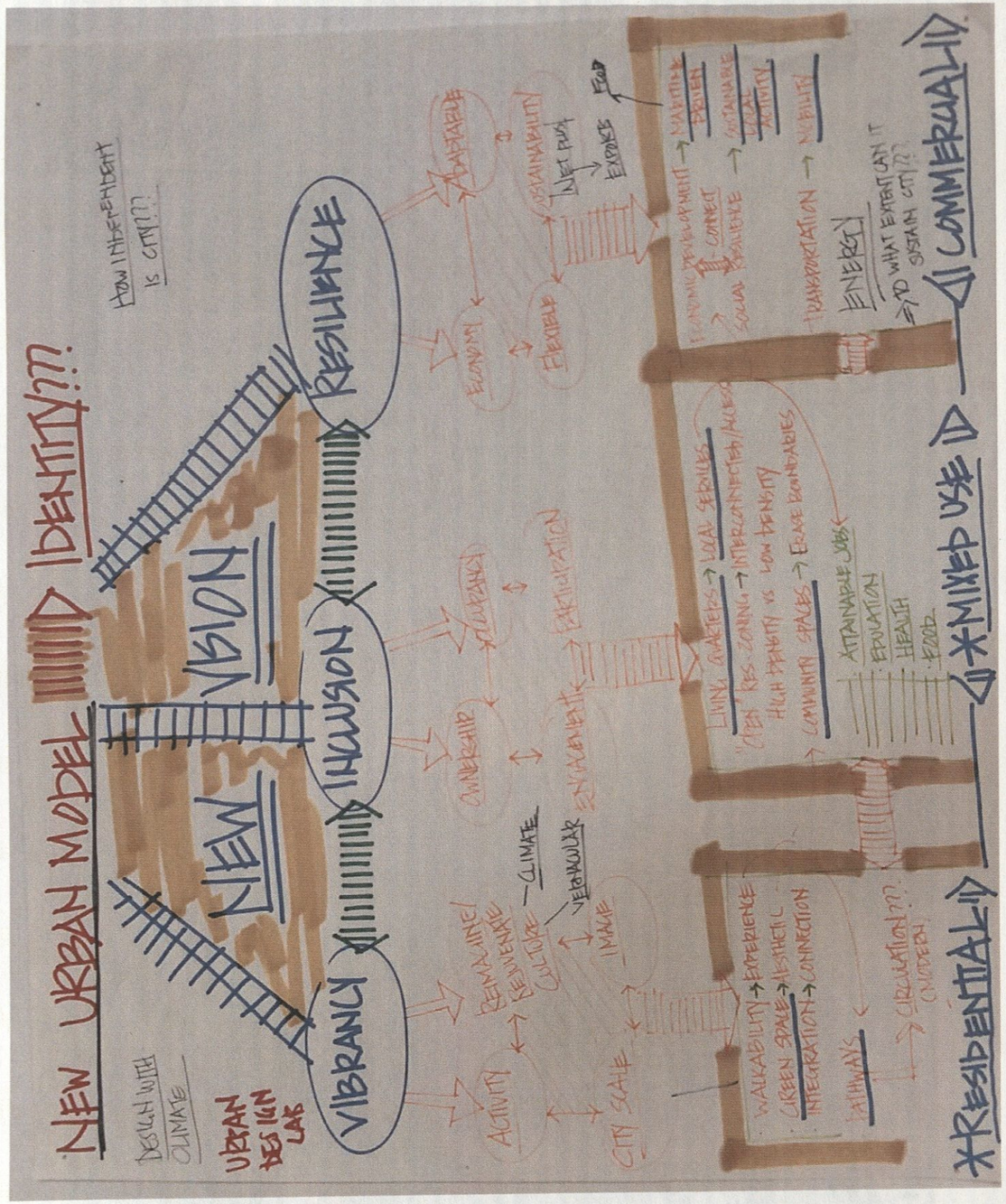
15-foot Sea Level Rise, Overall



15-foot Sea Level Rise, Georgetown Coastline



Initial Urban Model



FINAL (REDEFINED) PROGRAMMATIC MODEL

VIBRANCY | INCLUSION | RESILIENCE ▷ MODEL 01.

CULTURE ECONOMY — HOUSING

PHASE I — AGRICULTURE

(PLAZA CONCEPT)
- VERTICAL HYDROPONIC LAB
- FISH LAB
- PRODUCE MARKET
- AQUARIUM
- CAFÉ

DETACHED
- SOLAR "FIELDS"
- WIND "FIELD"

± 80000 SF

* EXCLUDES DETACHED SUSTAINABLE OPTIONS

PHASE II — MIXED USE RESIDENTIAL

- 1-BED APARTMENT
- 2-BED APARTMENTS
- 3+ BED PENTHOUSE SUITES
- ROOFTOP GARDENS
- URBAN SPACE
- GROUND FLOOR RETAIL
  - GROCERY
  - LAUNDRY

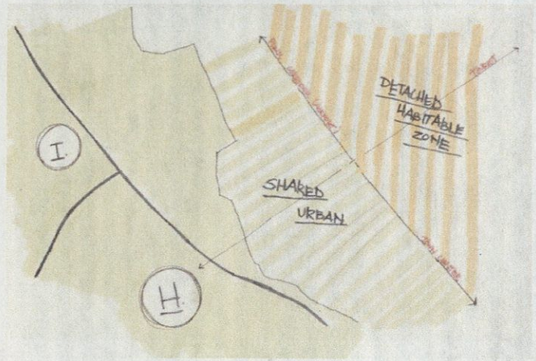
OCCUPANT GOAL: ~~600 – 1000~~ 400 – 600

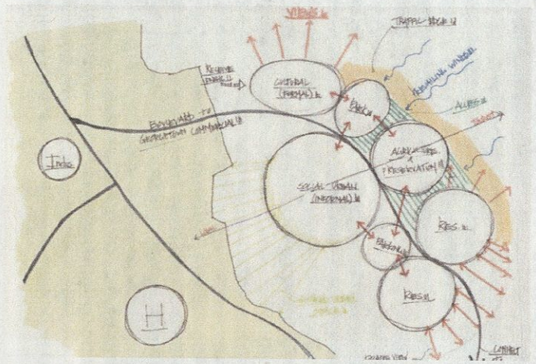
4 - 6 STORIES.

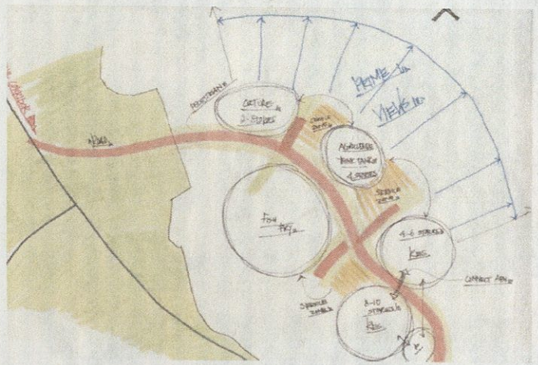
± 150 000 SF

± (3) 50 000 (SF)







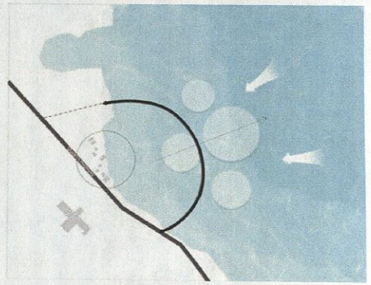




ESTABLISH BOULEVARD



ZONE



RESPOND TO SITE FORCES



CONNECT

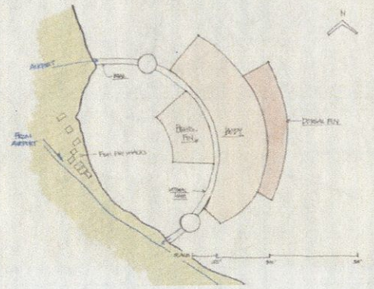
CONCEPT



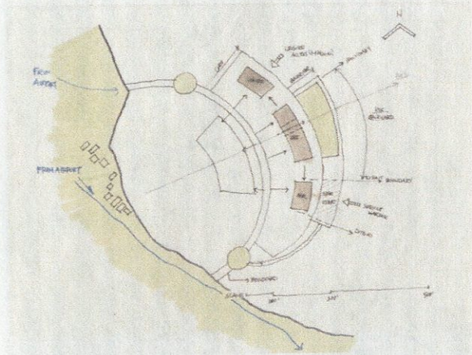
BAHAMAS COAT OF ARMS

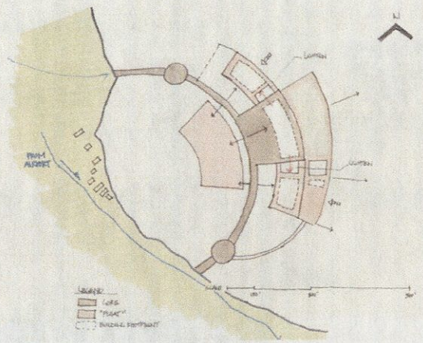


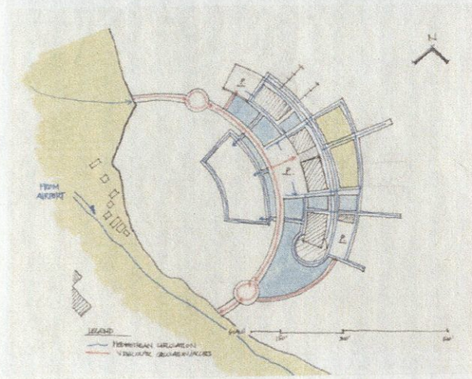
NATIONAL FISH

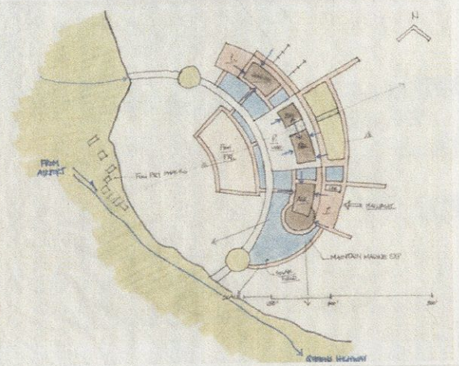


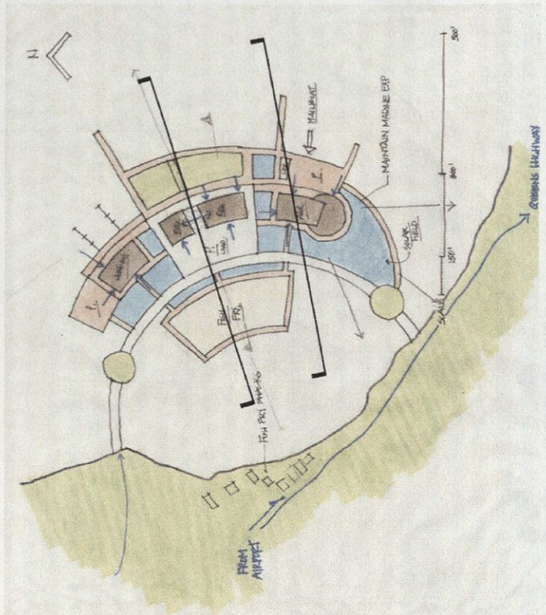
APPLICATION

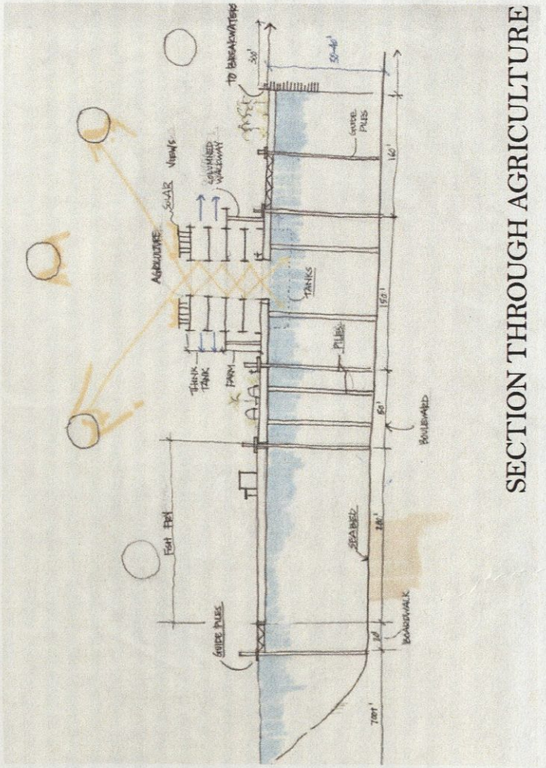




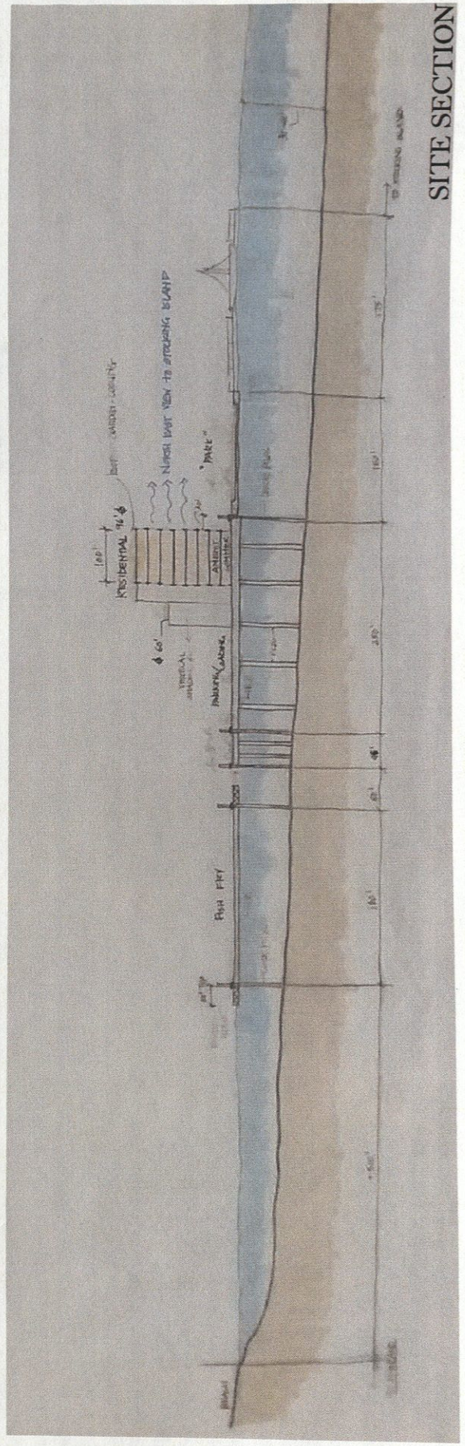








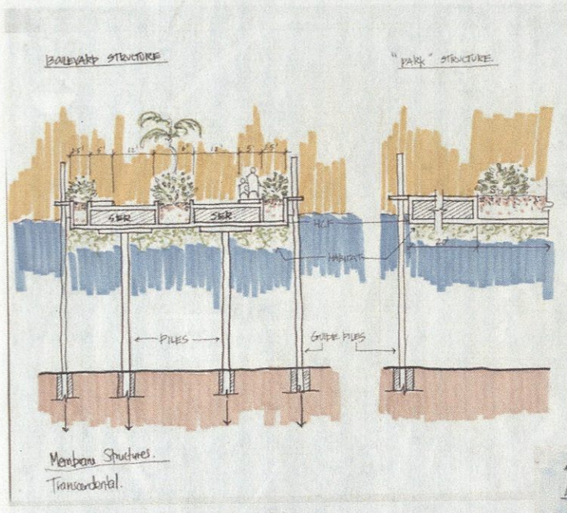
SECTION THROUGH AGRICULTURE



SITE SECTION

FUNCTIONALITY || STUDIES

HOLLOW CONCRETE PONTOONS



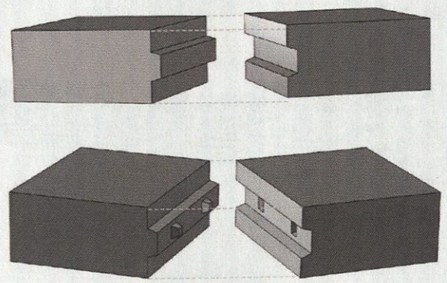


DIAGRAM BY KELVIN KO

Source: Ko, Kelvin. *Realizing a Floating City: A feasibility study of the construction of a floating city.* Civil Engineering and Geosciences, Specialization Hydraulic Structures. Delft University of Technology, 2015

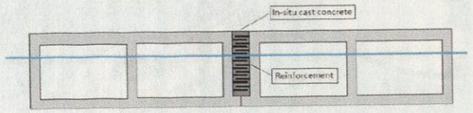
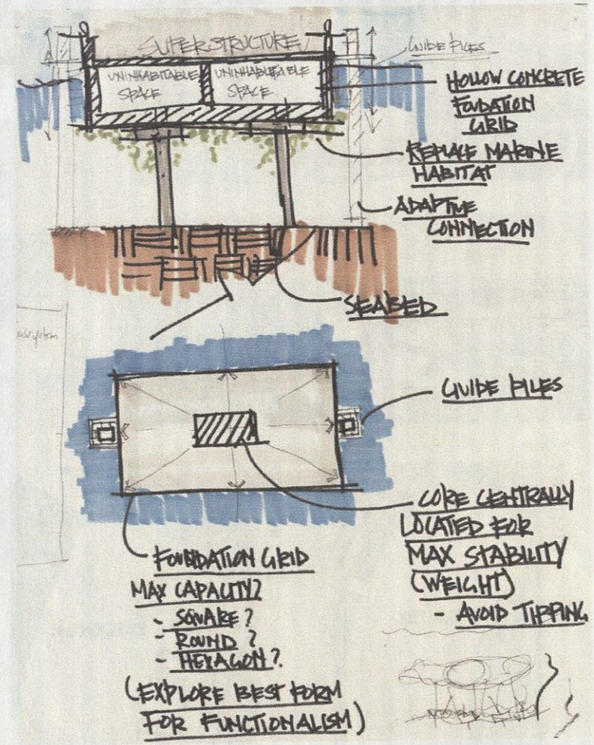
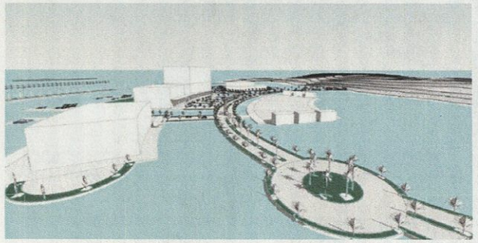


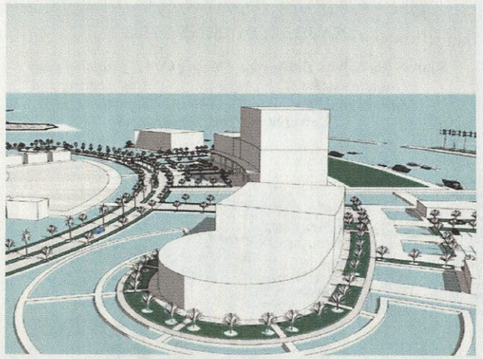
DIAGRAM BY KELVIN KO

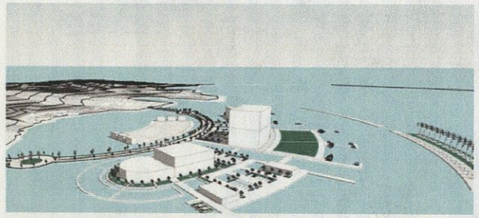
Source: Ko, Kelvin. *Realizing a Floating City: A feasibility study of the construction of a floating city.* Civil Engineering and Geosciences, Specialization Hydraulic Structures. Delft University of Technology, 2015

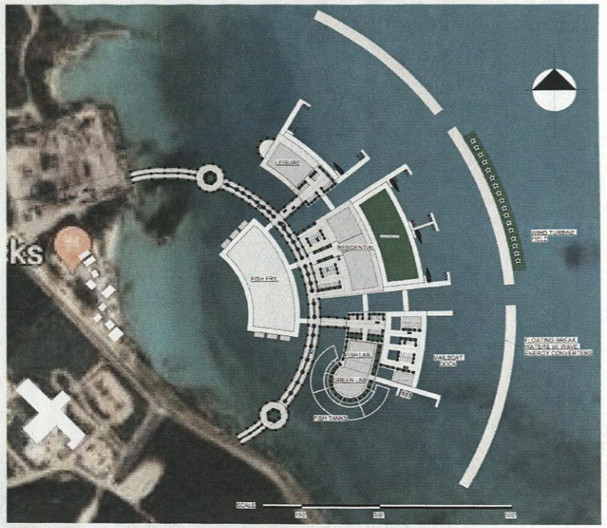


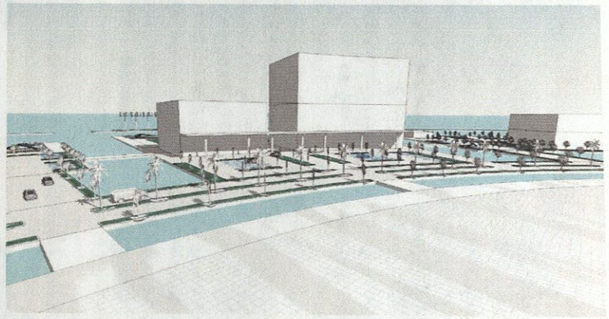
EARLY SCHEMATICS



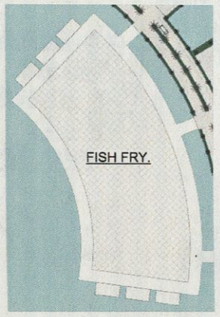




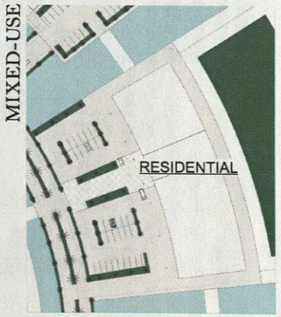




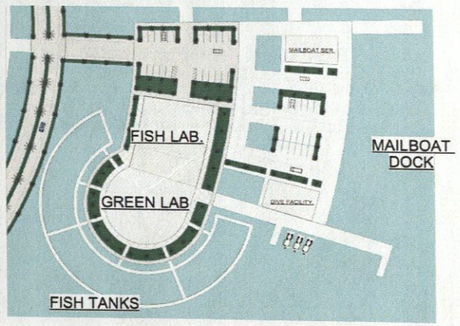
FISH FRY



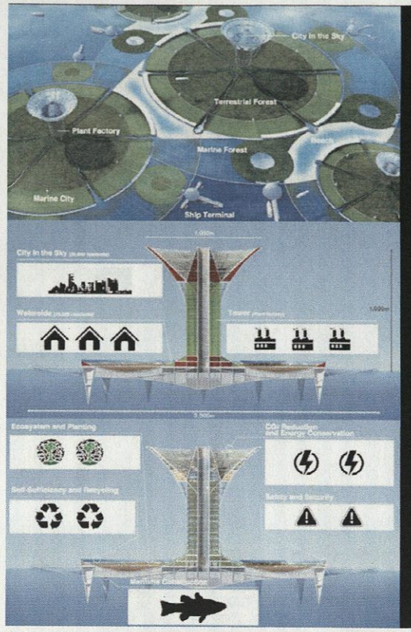
MIXED-USE



AGRICULTURE



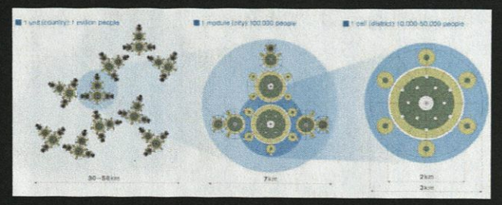
CASE STUDIES



Case Study

Green Float, Shimizu Corporation (Tokyo Bay, 2025)

"Completely self sufficient Eco-topia."
- Inhabitat



Islands are connected together to form modules and a number of modules grouped together form a "country".

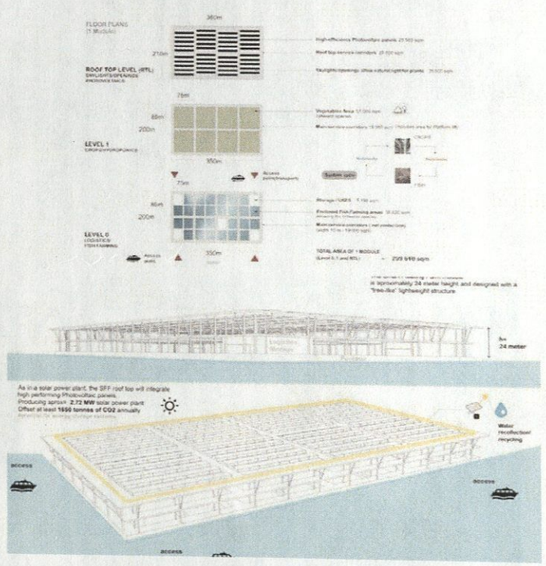
A 1,000 m tower in the center of the island acts as both a vertical farm as well as a skyscraper with residential, commercial and office space.

Energy for the islands would be generated from renewable sources like solar, wind, and ocean thermal

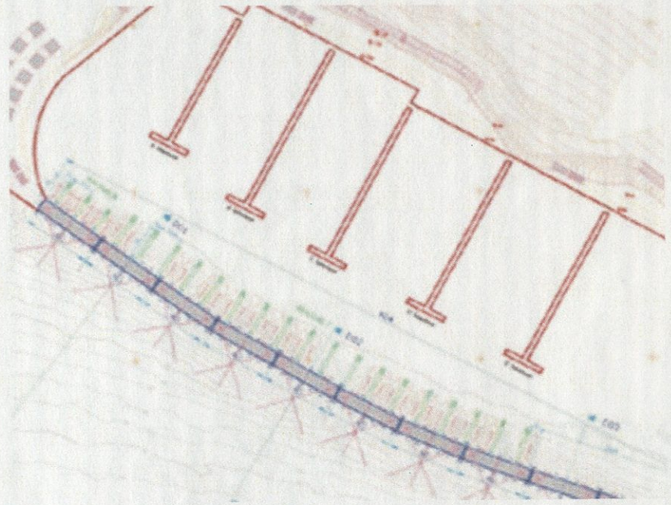
Generate own power, grows food, manages waste and provide clean water.

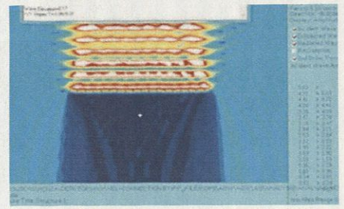
Smart Floating Farms, Forward Thinking Architecture

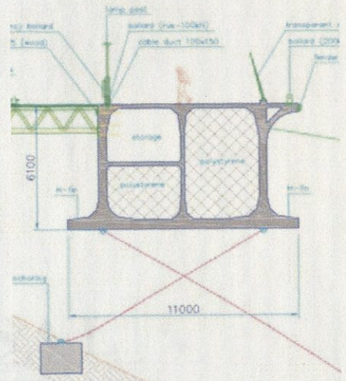




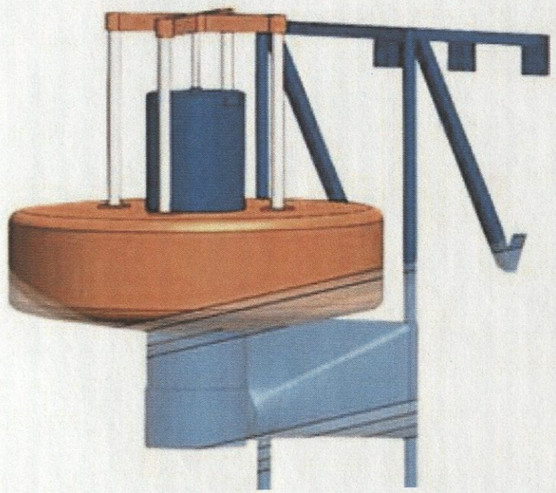
Floating breakwater Gokova Ören marina, Turkey

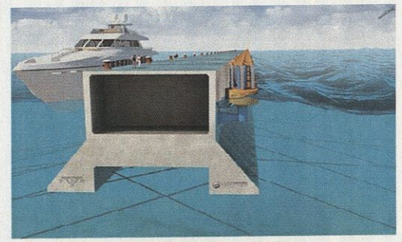


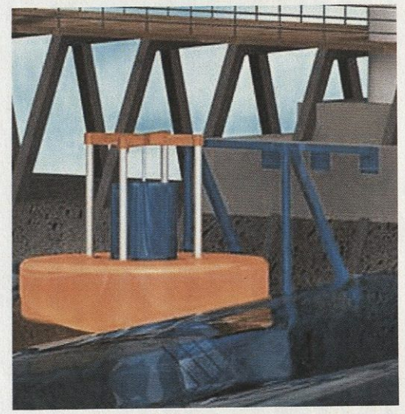




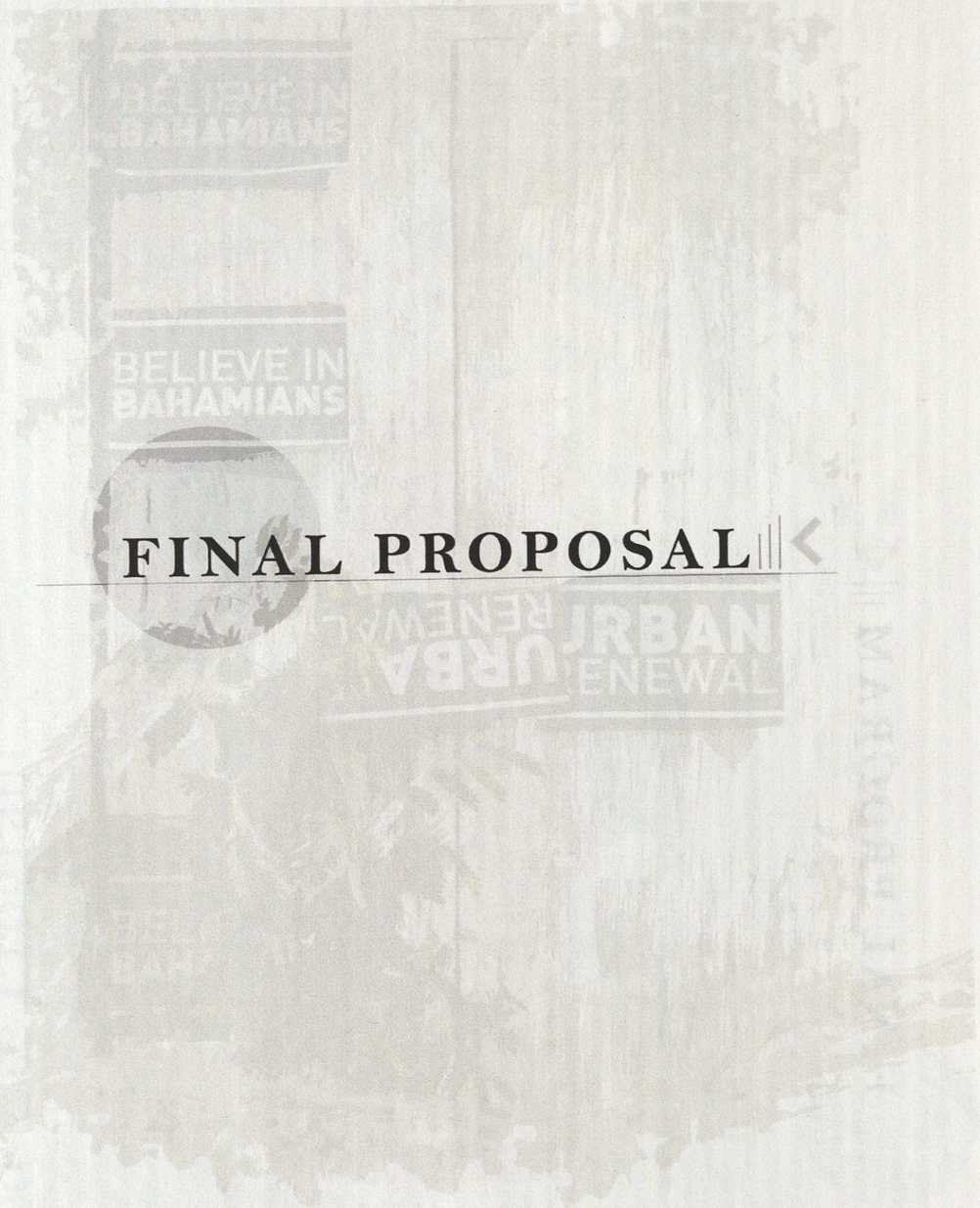
Wave Energy Converter



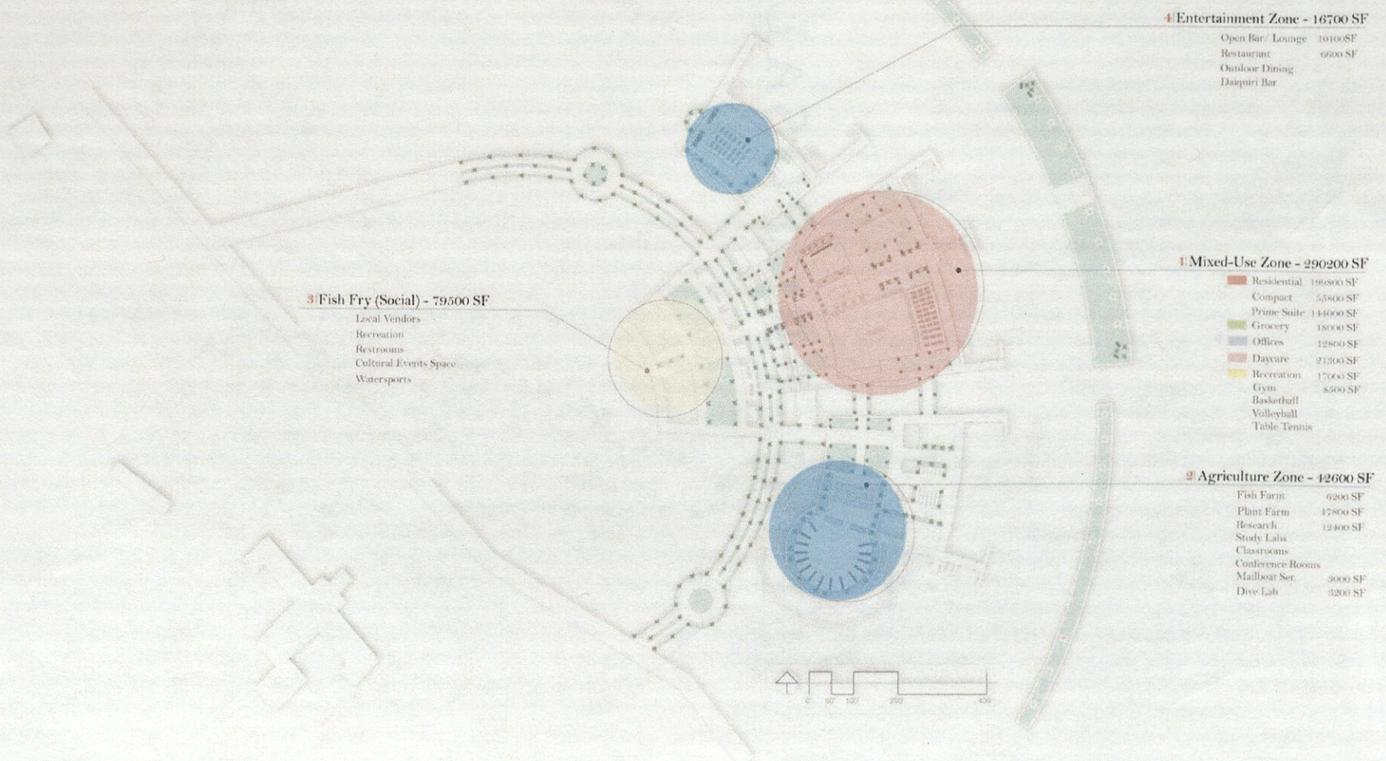




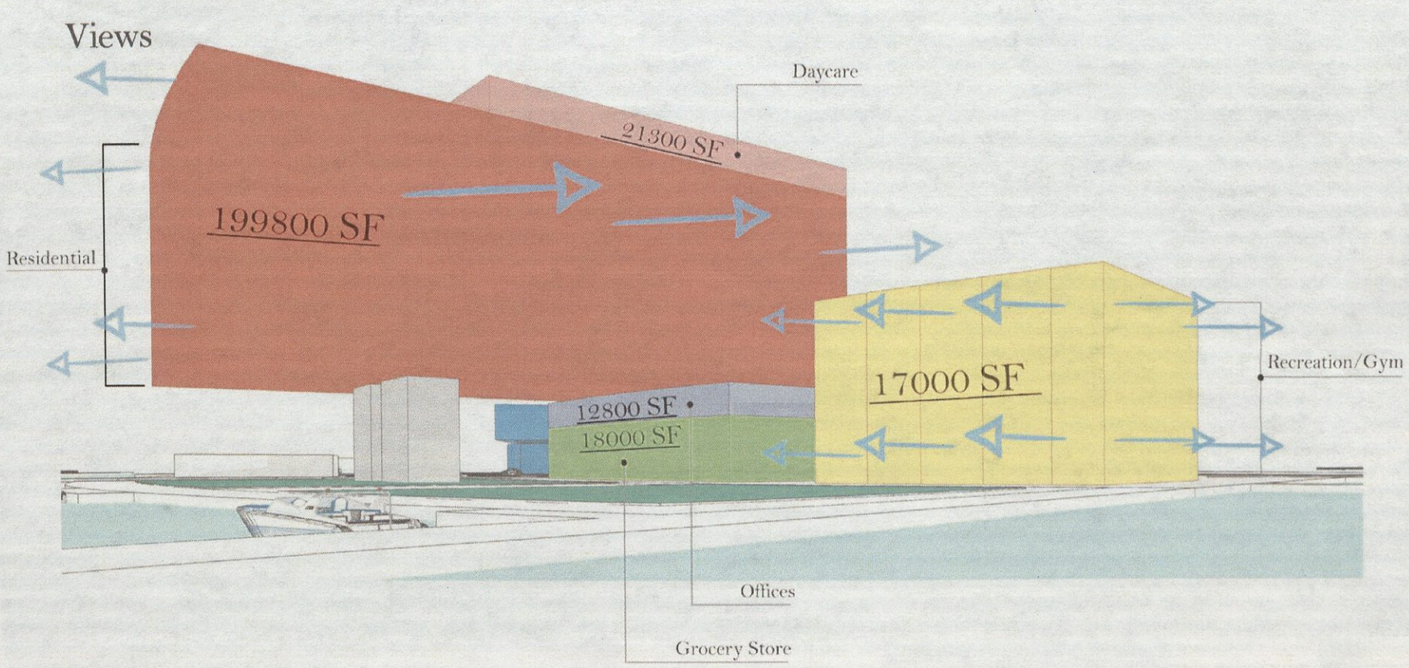
FINAL PROPOSAL



FINAL PROGRAM



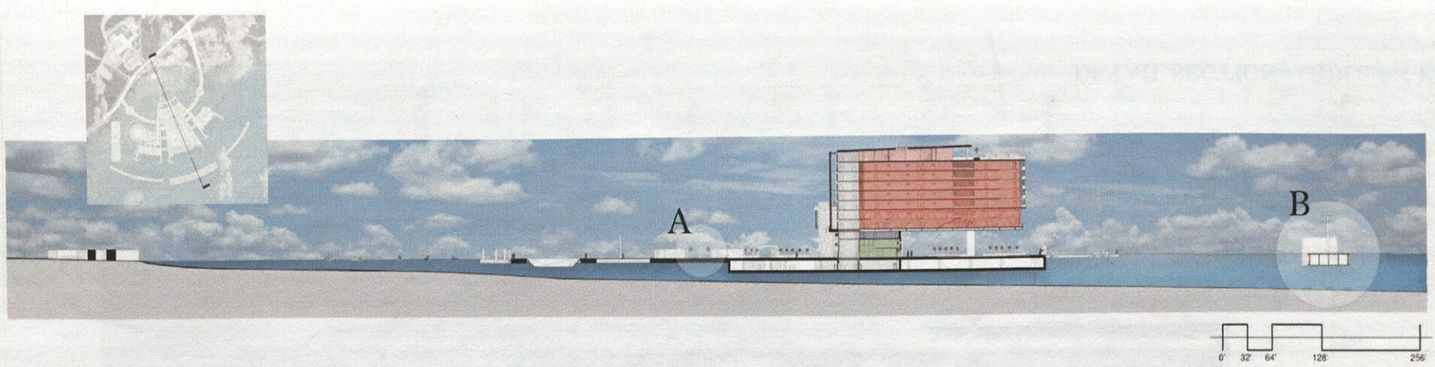
Mixed-Use Program



OVERALL SITE PLAN

1" = 400'

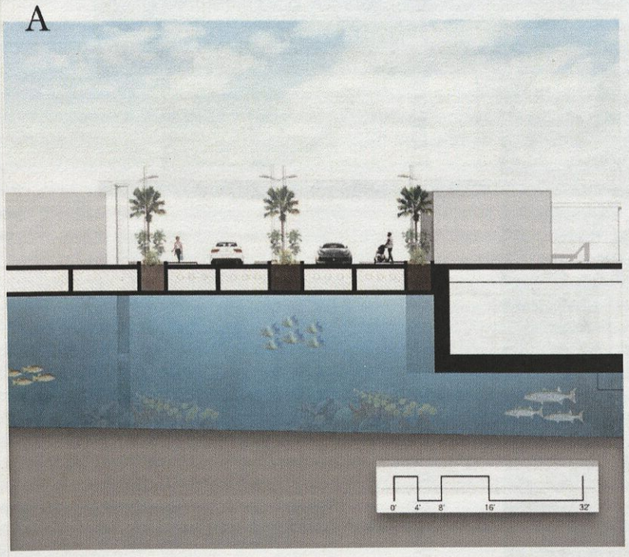




SITE SECTION

1/64" = 1'-0"

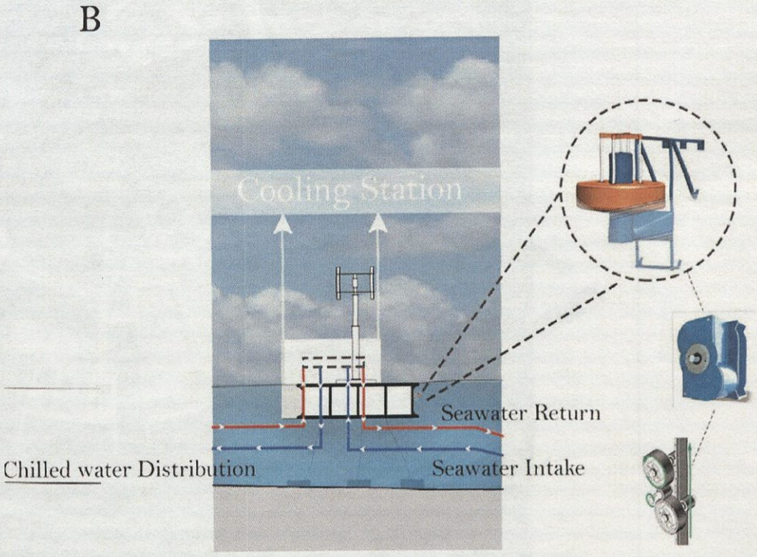
A



BOULEVARD SECTION DETAIL

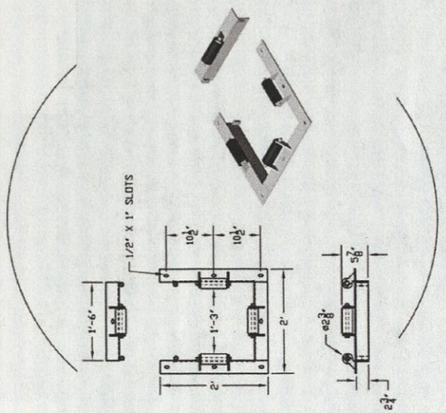
1/8" = 1'-0"

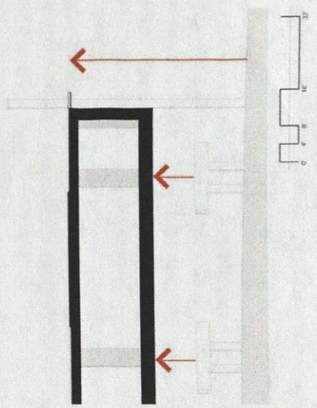
B



SEAWATER COOLING/WAVE ENERGY CONVERTER DETAIL

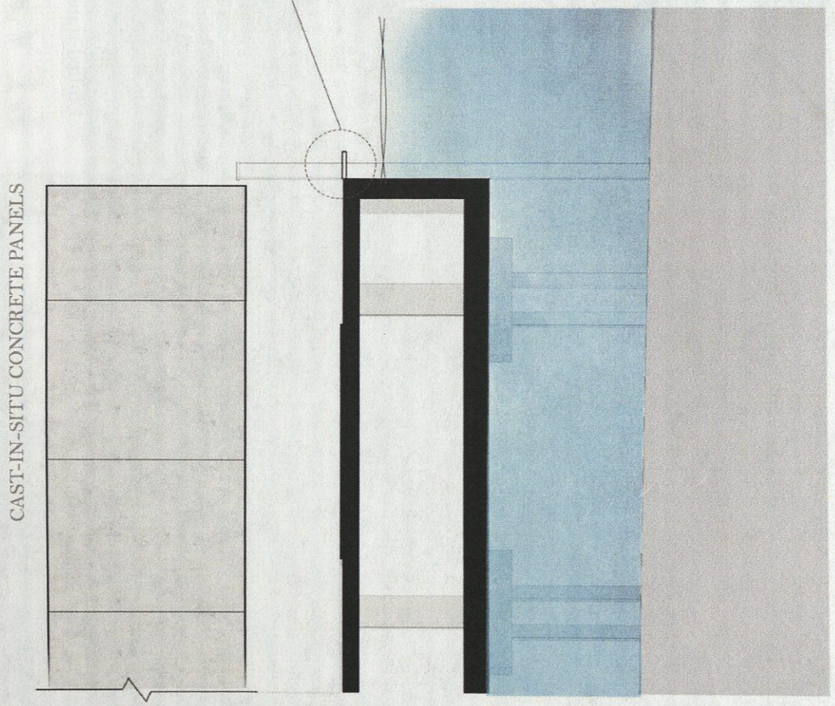
NTS

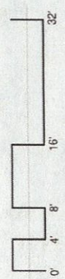




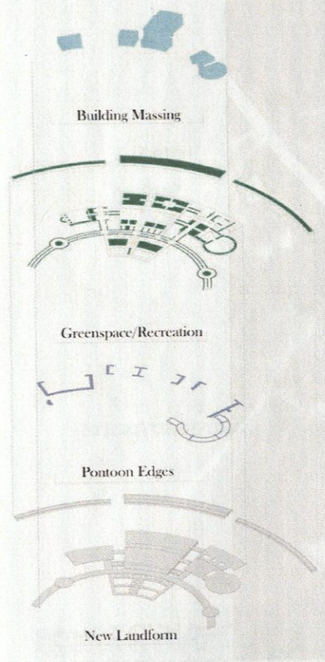
DETAIL SECTION - GUIDEPILES

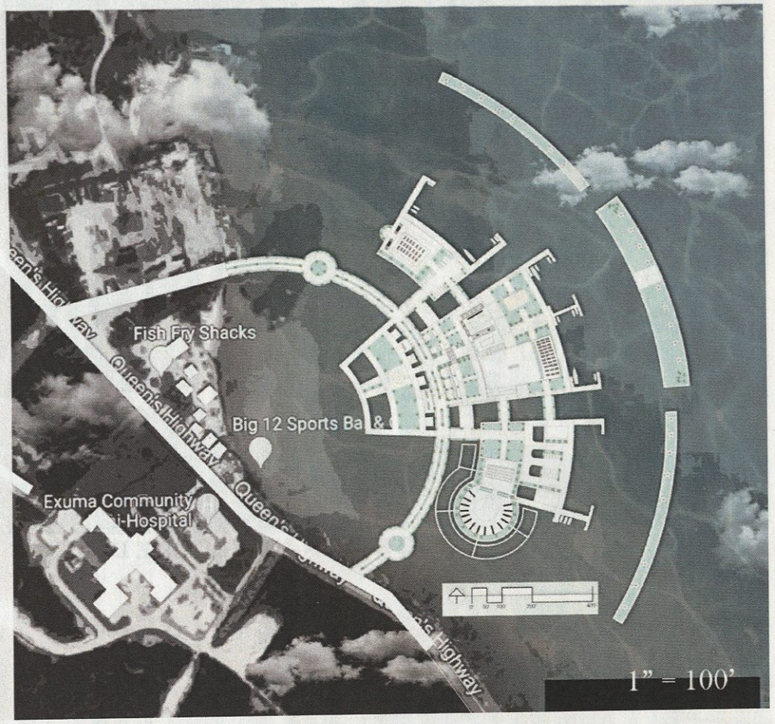
1/8" = 1'-0"



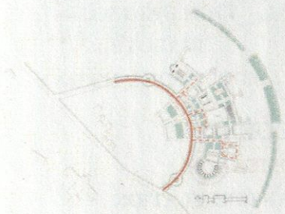


SITE PLAN





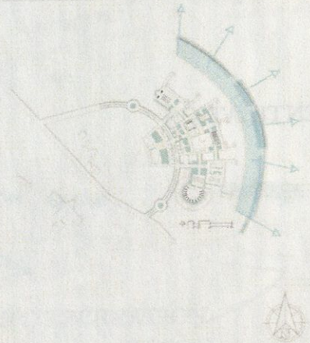
VEHICULAR CIRCULATION



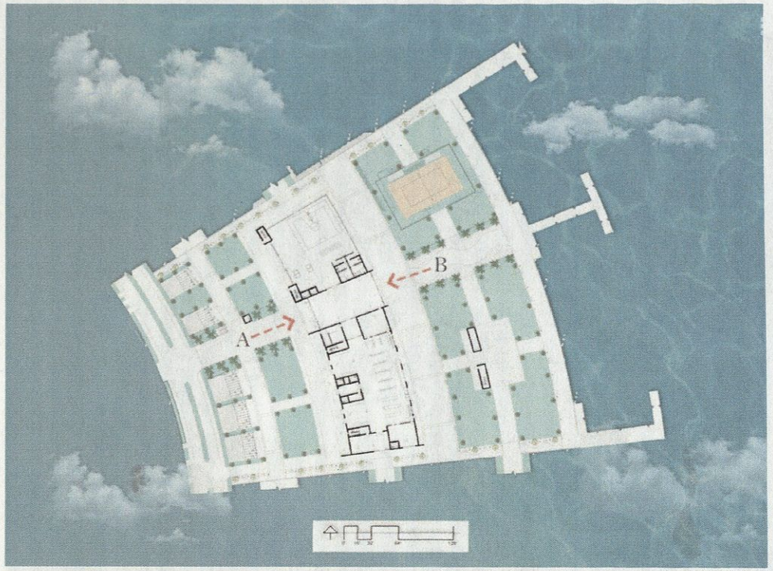
PEDESTRIAN CIRCULATION



PRIME VIEWS



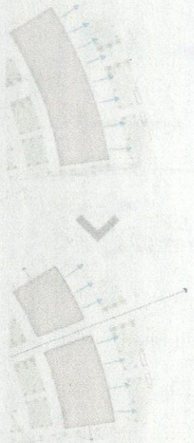
MIXED-USE DISTRICT

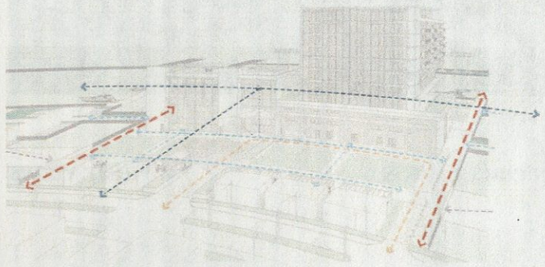


SITE PLAN - MIXED-USE DISTRICT

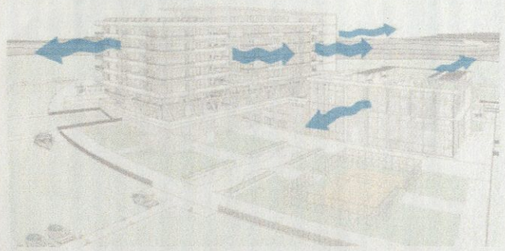
1/32" = 1'-0"

CONCEPT

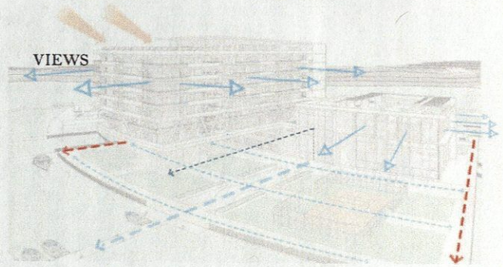




VENTILATION



VIEWS



LEGEND

PROMENADE

PEDESTRIAN CIRCULATION

VEHICULAR CIRCULATION (BUS DROP-OFF)

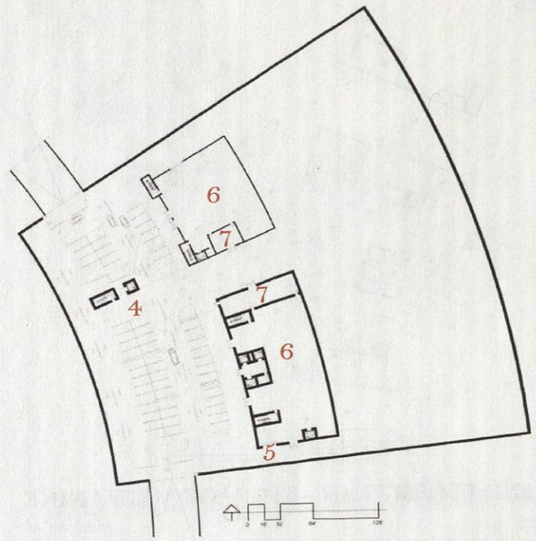
MAJOR AXES

CIRCULATION TO PARKING

FLOOR PLANS

GRID

STRUCTURE (PILES)



OCEAN FLOOR PLAN - PARKING LEVEL/STORAGE

1/32" = 1'-0"

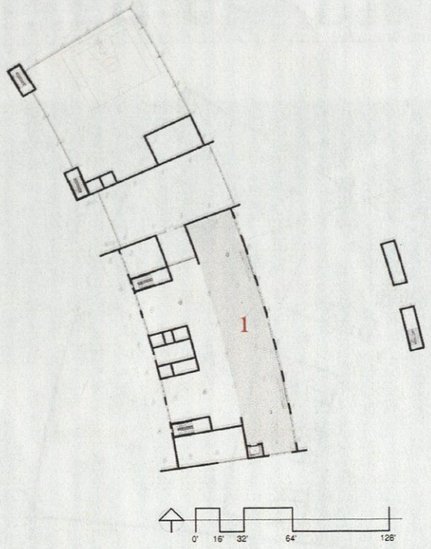
LEGEND

1. GROCERY STORE
2. MAIL/ BIKE PARKING
3. RECREATION
4. PARKING
5. LOADING DOCK
6. STORAGE
7. MECHANICAL ROOM



1ST FLOOR PLAN - GROCERY/RECREATION

1/32" = 1'-0"

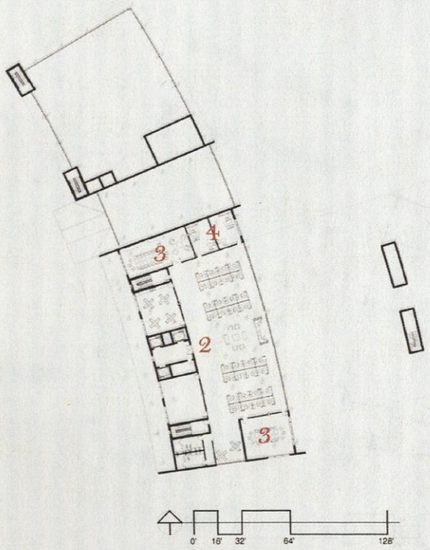


2ND FLOOR PLAN - STORAGE MEZZANINE

1/32" = 1'-0"

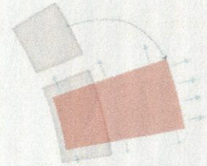
LEGEND

1. STORAGE MEZZANINE
2. OPEN OFFICE SPACE
3. CONFERENCE/MEETING ROOM
4. CLOSED OFFICES

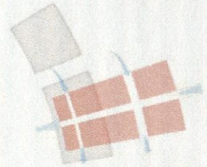


3RD FLOOR PLAN - OFFICES

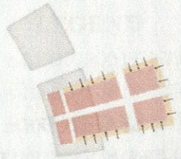
1/32" = 1'-0"



MIN. EAST/WEST EXPOSURE



VENTILATE



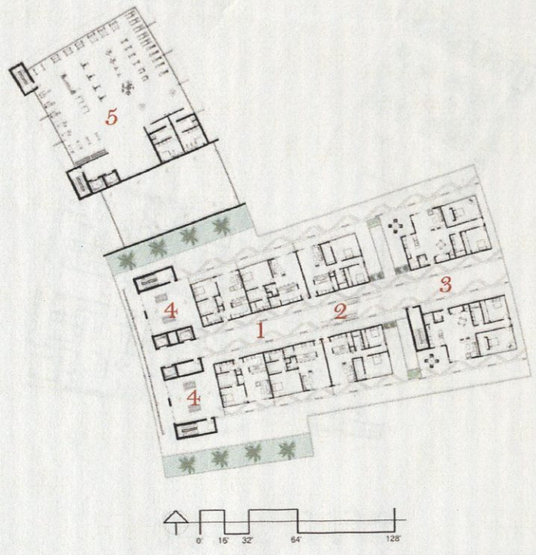
RECESS (SHADE)



ZONE

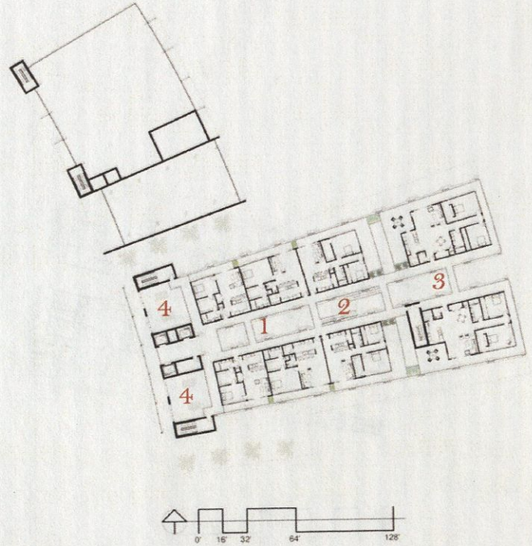
LEGEND

1. 1-BEDROOM UNITS
2. 2-BEDROOM UNITS
3. 3-BEDROOM UNITS
4. COMMON AREA
5. GYM



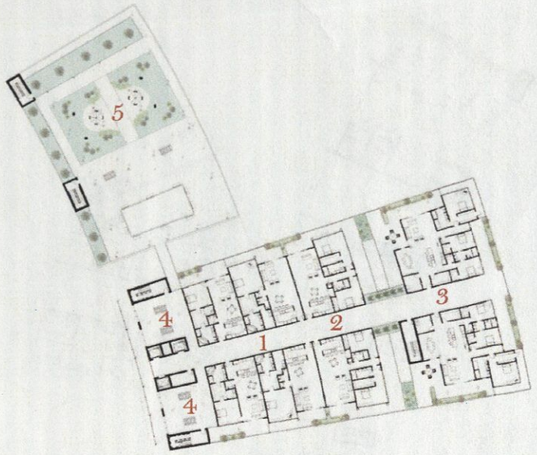
4TH FLOOR PLAN - APARTMENT UNITS

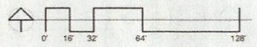
1/32" = 1'-0"



5TH FLOOR PLAN - APARTMENT UNITS

1/32" = 1'-0"



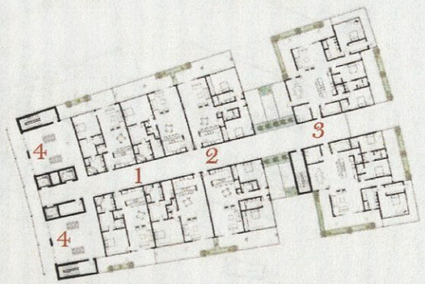


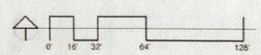
6TH FLOOR PLAN - APARTMENT UNITS

1/32" = 1'-0"

LEGEND

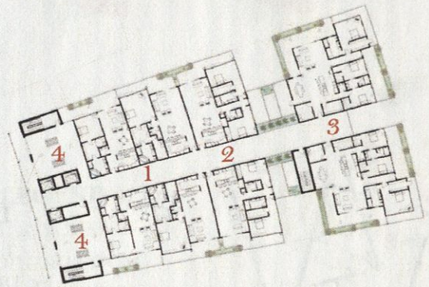
1. 1-BEDROOM UNITS
2. 2-BEDROOM UNITS
3. 3-BEDROOM UNITS
4. COMMON AREA
5. ROOFTOP GARDEN

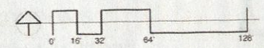




7/9TH FLOOR PLAN - APARTMENT UNITS

1/32" = 1'-0"



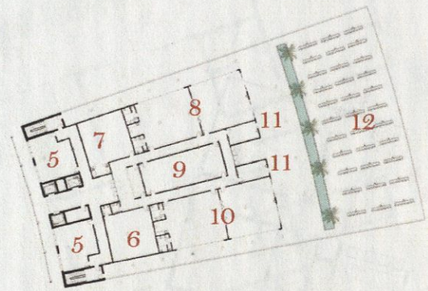


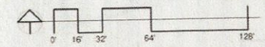
8/10TH FLOOR PLAN - APARTMENT UNITS

1/32" = 1'-0"

LEGEND

1. 1-BEDROOM UNITS
2. 2-BEDROOM UNITS
3. 3-BEDROOM UNITS
4. COMMON AREA
5. STORAGE
6. STAFF ROOM
7. NURSERY
8. TODDLERS
9. MOTOR SKILLS AREA
10. PRE-SCHOOL
11. OFFICES
12. SOLAR PANEL FIELD

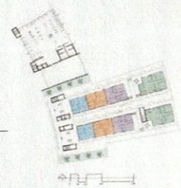




11TH FLOOR PLAN - DAYCARE

1/32" = 1'-0"

4/5TH FLOOR UNITS



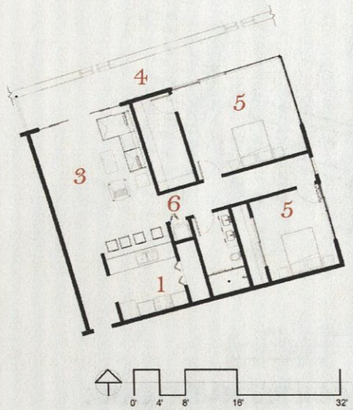


LEGEND

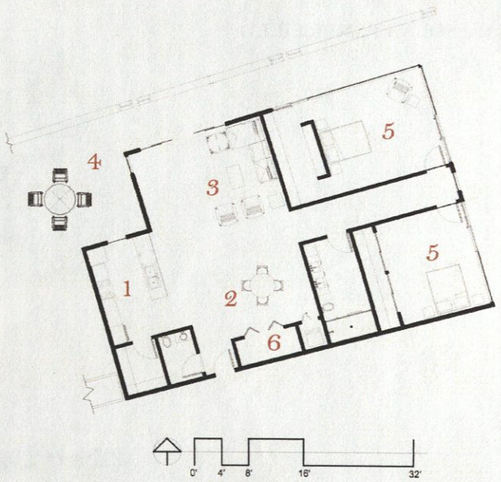
1. KITCHEN
2. DINING ROOM
3. LIVING ROOM
4. PATIO
5. BEDROOMS
6. UTILITY/ LAUNDRY

1-BEDROOM
1/8" = 1'-0"

1-BEDROOM
1/8" = 1'-0"

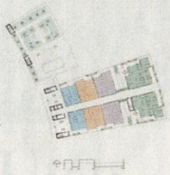


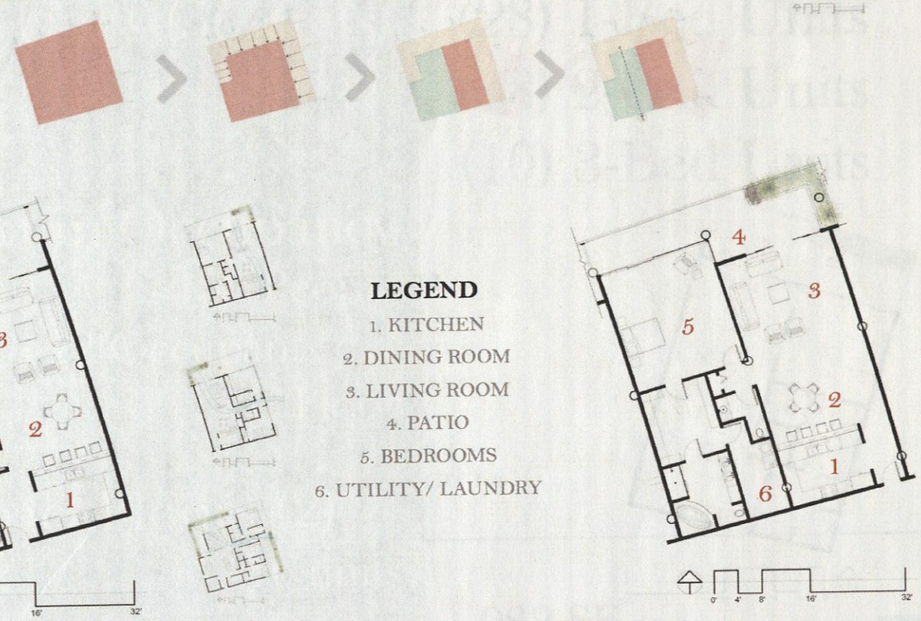
2-BEDROOM
1/8" = 1'-0"



2-BEDROOM
1/8" = 1'-0"

6/8/10TH FLOOR UNITS



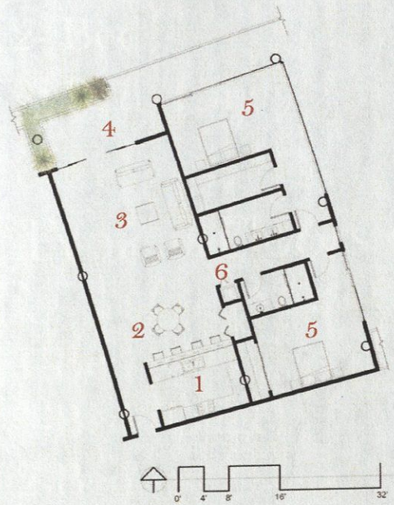


LEGEND

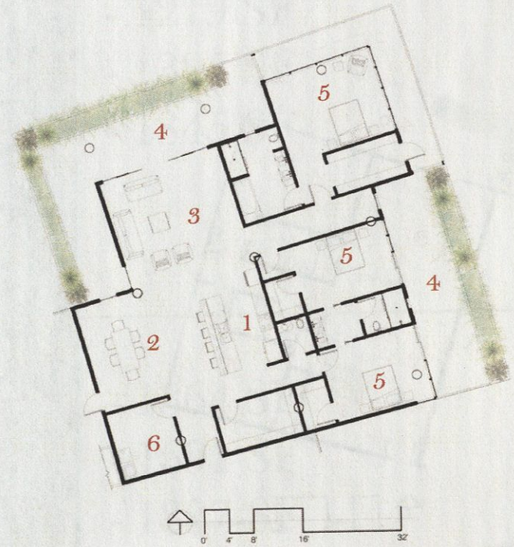
1. KITCHEN
2. DINING ROOM
3. LIVING ROOM
4. PATIO
5. BEDROOMS
6. UTILITY/ LAUNDRY

1-BEDROOM
1/8" = 1'-0"

1-BEDROOM
1/8" = 1'-0"

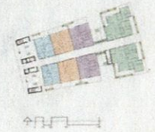


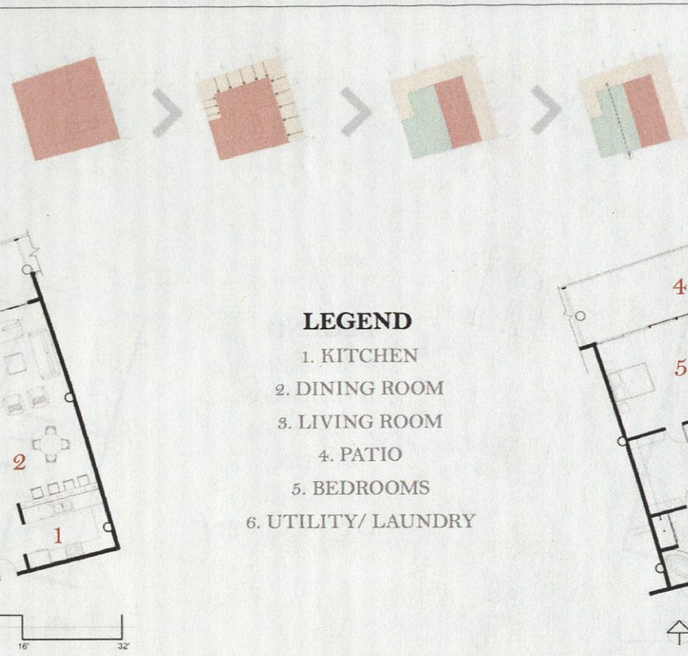
2-BEDROOM
1/8" = 1'-0"



3-BEDROOM
1/8" = 1'-0"

7/9TH FLOOR UNITS



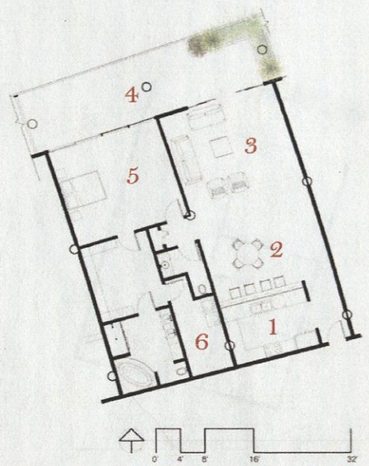


1-BEDROOM

1/8" = 1'-0"

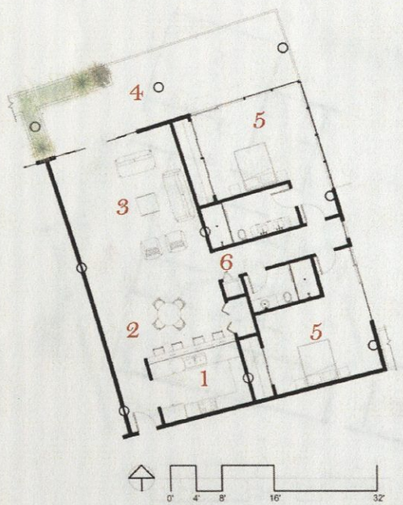
LEGEND

1. KITCHEN
2. DINING ROOM
3. LIVING ROOM
4. PATIO
5. BEDROOMS
6. UTILITY/ LAUNDRY



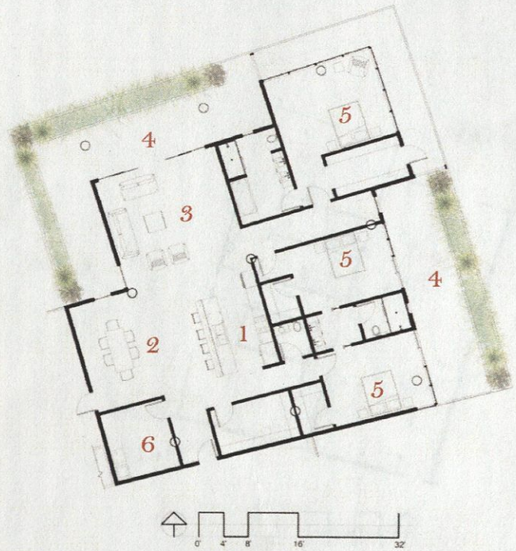
1-BEDROOM

1/8" = 1'-0"



2-BEDROOM

1/8" = 1'-0"



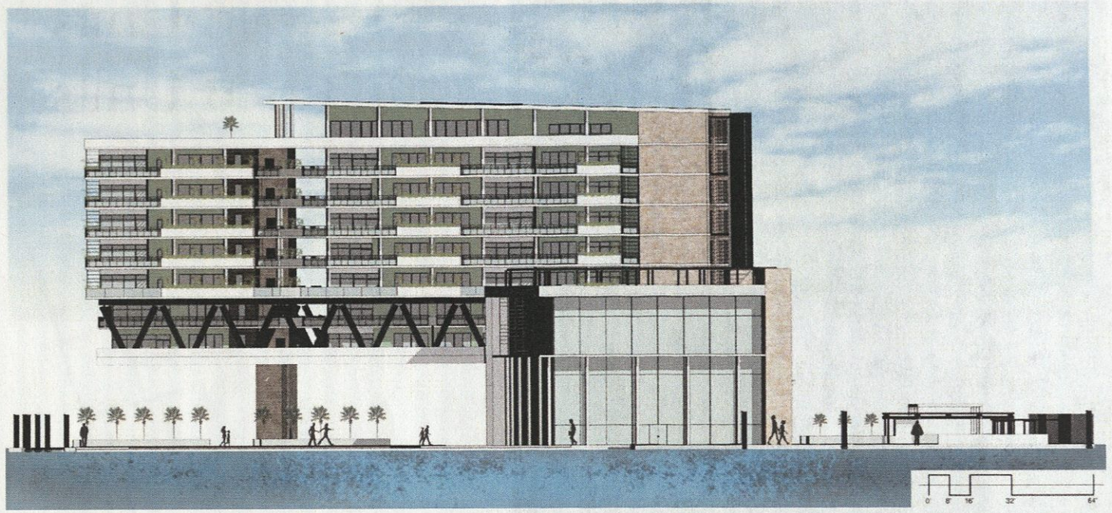
3-BEDROOM

1/8" = 1'-0"

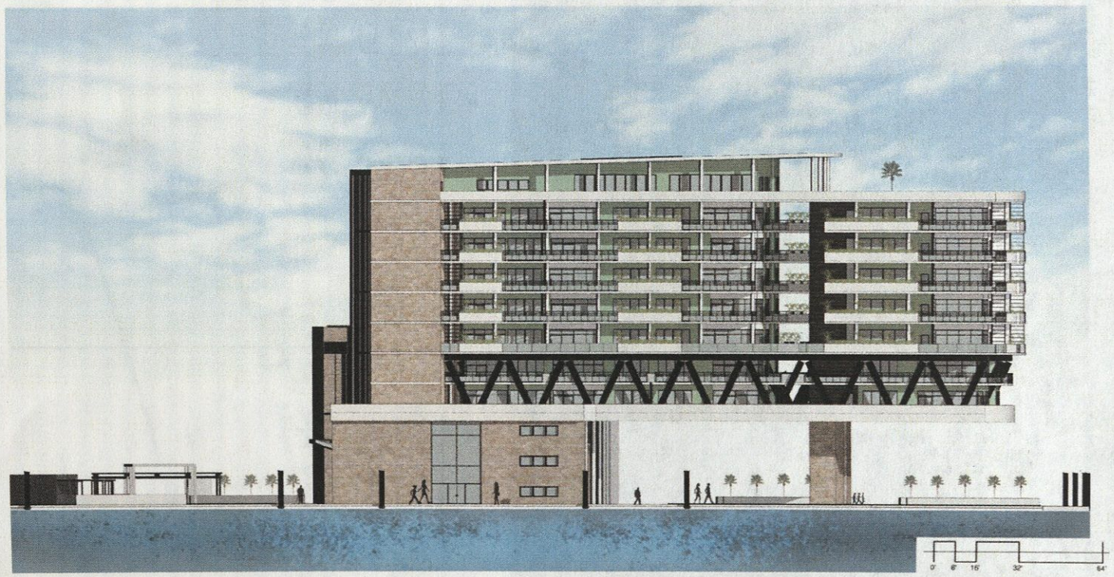
Residential Units

Total Units (56 units) - 4 Units per Floor	(28) 1-Bed Units (18) 2-Bed Units (10) 3-Bed Units
Minimum Occupancy - 150 People - 16-22 Occupants per Floor	
Compact Floors (2)	
-16 units	
1-Bed	- 982 SF
1- Bed (Large)	- 1219 SF
2- Bed	- 1325 SF
2- Bed (Large)	- 1845 SF
Typical Floors (7)	
- 40 Units	
1-Bed	- 1364 SF
1-Bed (Large)	- 1691 SF
2-Bed	- 1837 SF
3-Bed	- 2644 SF

BUILDING ELEVATIONS



NORTH ELEVATION
1/16" = 1'-0"



SOUTH ELEVATION
1/16" = 1'-0"

BUILDING ELEVATIONS

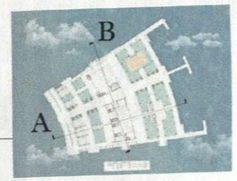


EAST ELEVATION
1/16" = 1'-0"

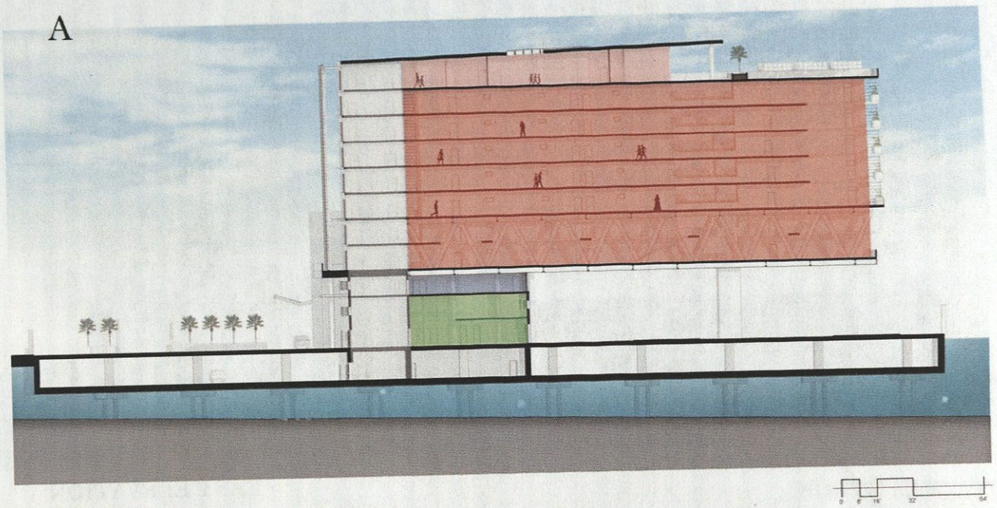


WEST ELEVATION
1/16" = 1'-0"

BUILDING SECTIONS



A

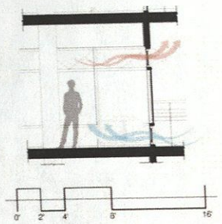


LONGITUDINAL SECTION
1/16" = 1'-0"

B

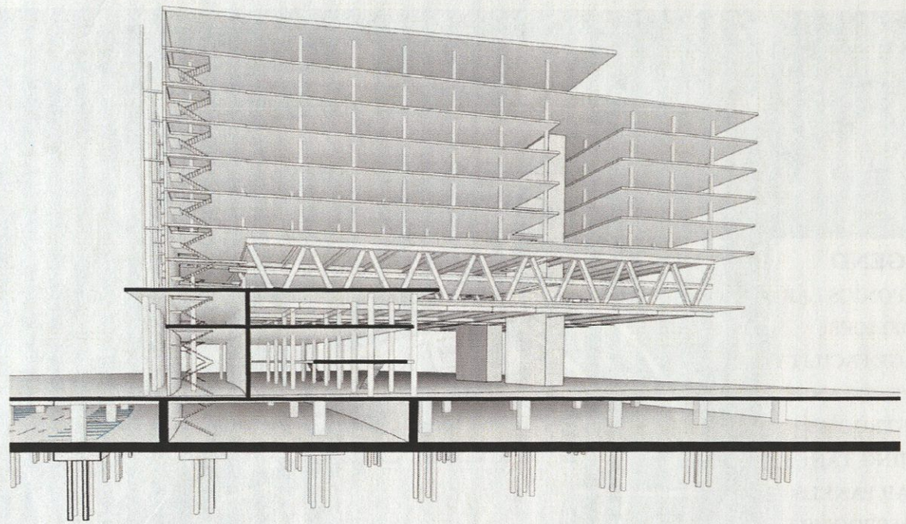


LATITUDINAL SECTION
1/16" = 1'-0"



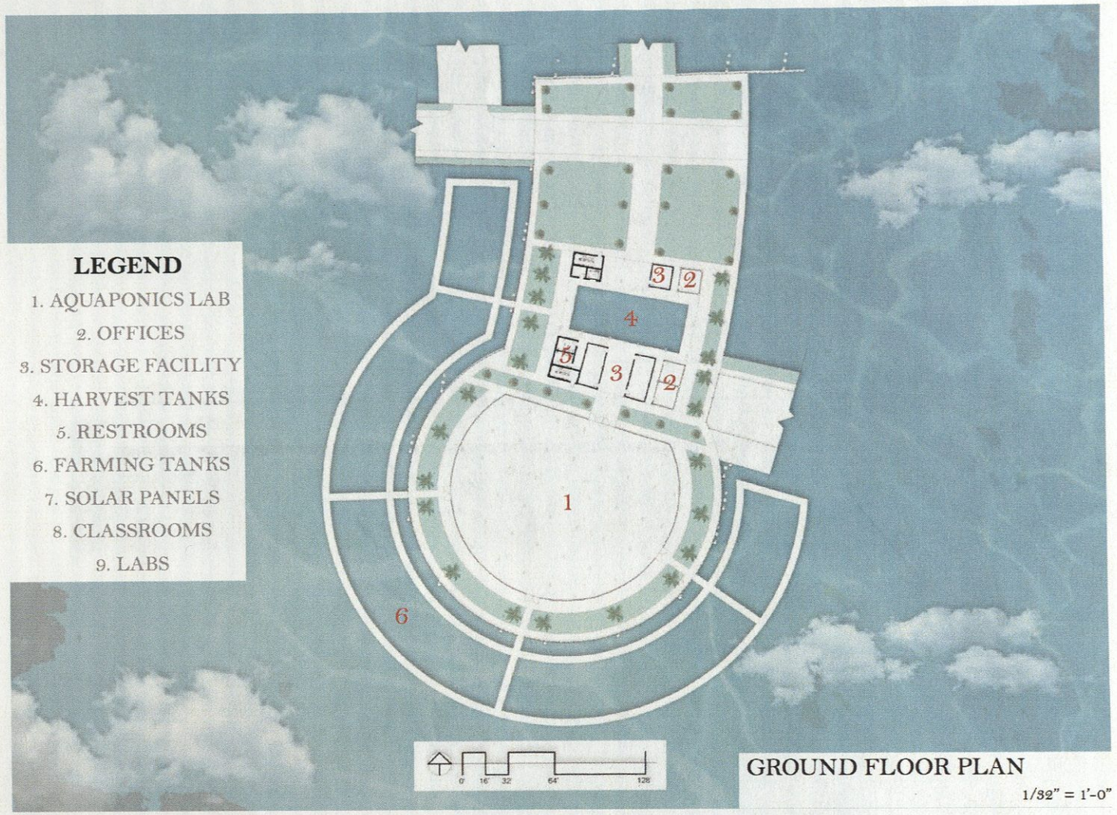
BEDROOM EDGE
1/8" = 1'-0"

GYM
DAYCARE
RES. UNITS
GROCERY
OFFICES



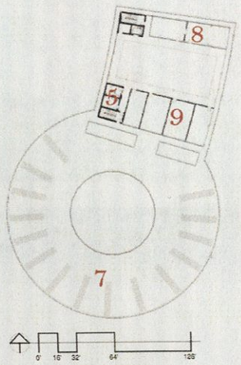
SECTION AXONOMETRIC

AGRICULTURE



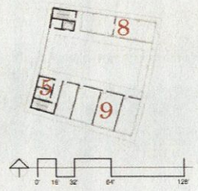
GROUND FLOOR PLAN

1/32" = 1'-0"



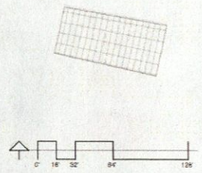
2ND FLOOR PLAN

1/32" = 1'-0"



3RD FLOOR PLAN

1/32" = 1'-0"



ROOF PLAN

1/32" = 1'-0"

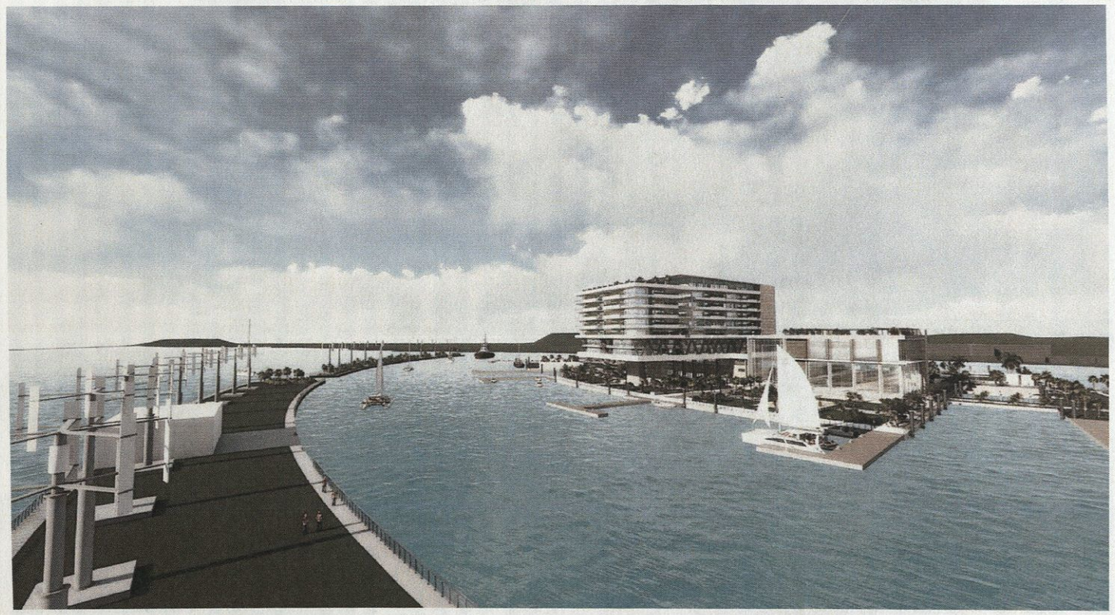
VISUALIZATIONS



































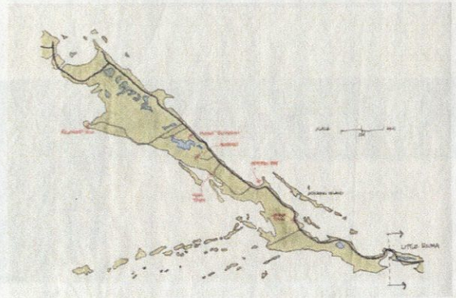


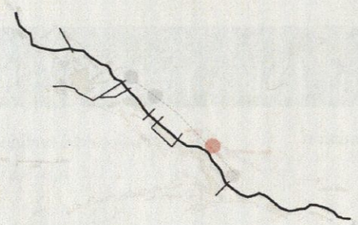


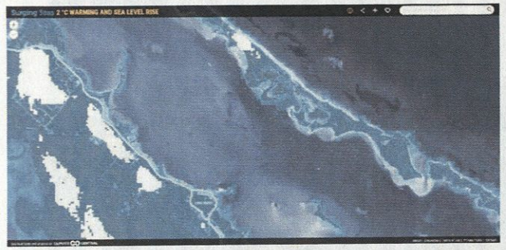




URBAN PROCESS - MASTER PLAN

















MASTER PLAN PROPOSAL

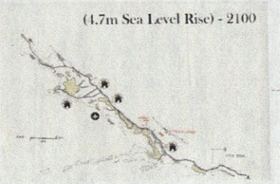
Urban Infrastructure Expansion - Master Plan

Current Condition

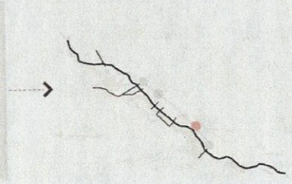


Projected Conditions

(4.7m Sea Level Rise) - 2100



Concept: Linear Island Networks





Sacrifice Existing Connector



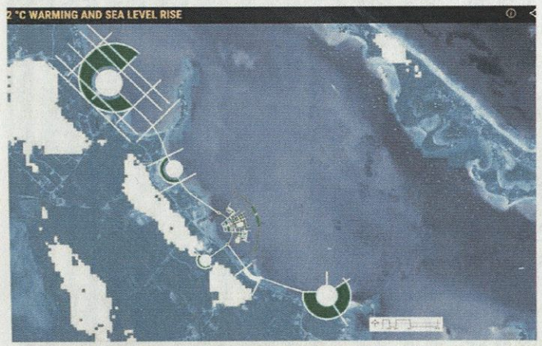
Extend Boulevard



Re-establish Settlement Cores



Introduce Green Landscape

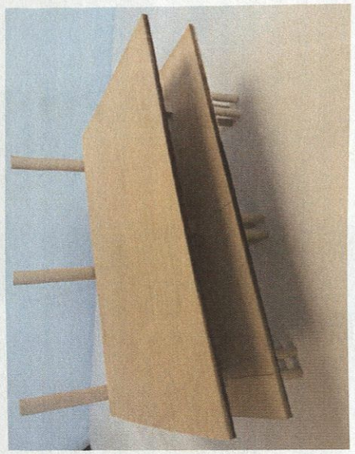


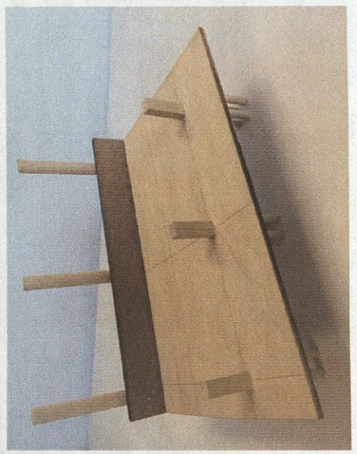
Transition Applications



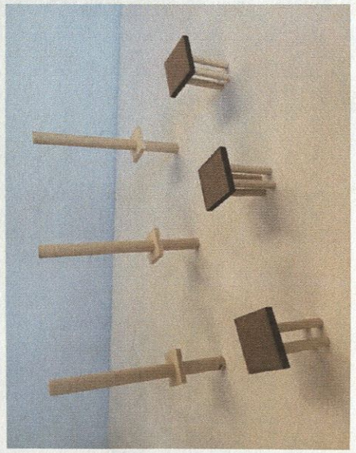
STUDY MODEL











APPENDICES

PROCESS SKETCHES

