

Floating Metropolis: Resilient infrastructure to preempt  
tsunami inundation.

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Abstract

Floating Cities: Resilient Infrastructure to Prevent Tsunami Inundation

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Tsunamis and storm surges are some of the most destructive forces facing coastal cities. With the current rise in sea level, combined with the potential catastrophic impact of natural disasters, coastal regions of these urban centers will need to be redefined with the global environment in mind. Tokyo Japan is the largest urban zone in the world at high risk for natural disasters. The 36 million individuals living there cope with minimal defense in the face of a worse case scenario.

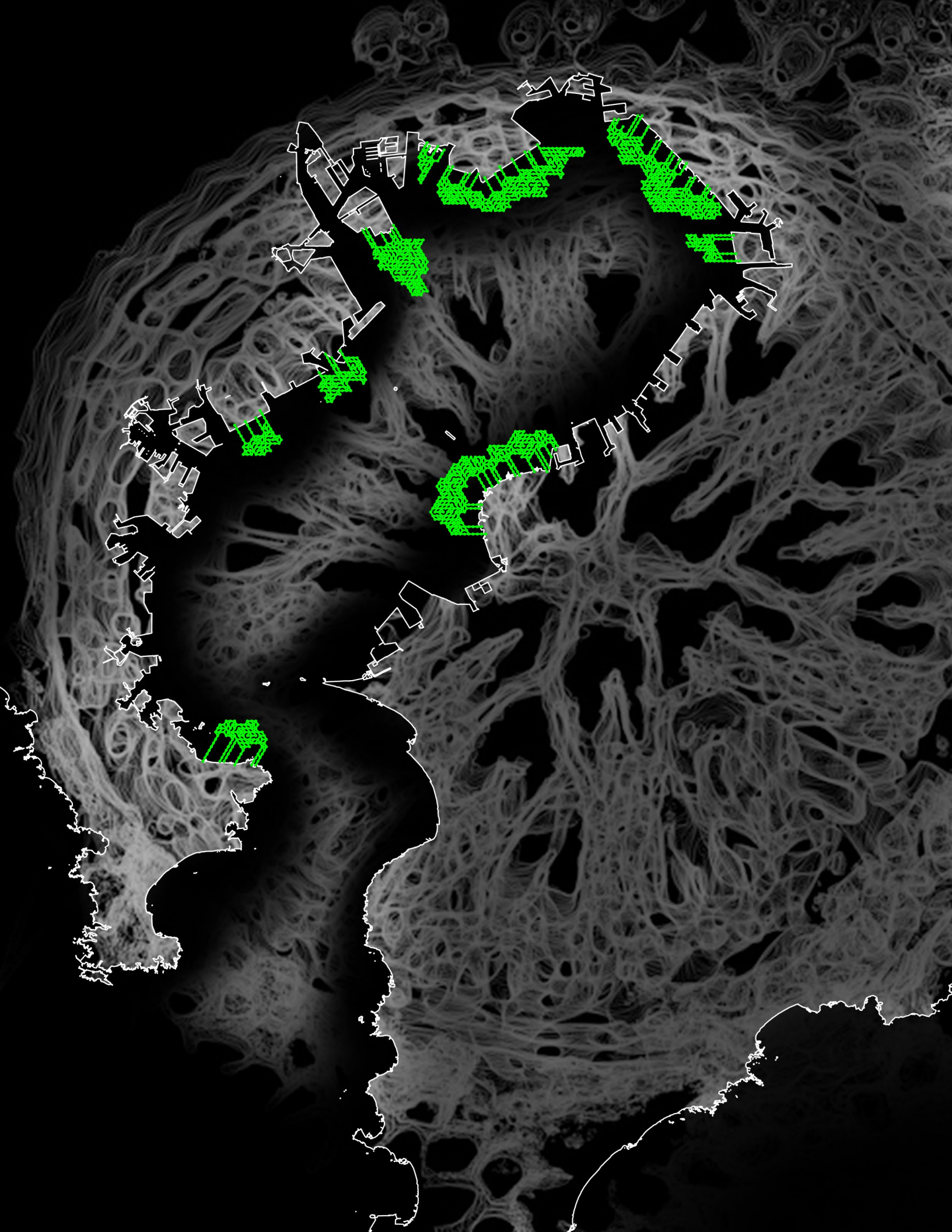
This thesis focuses on leveraging the 2020 Summer Olympics as a catalyst for a new development in floating infrastructure to protect the athletes during the Games and after the event, the residents of Tokyo. A large-scale modular system of floating platforms that addresses all needs of the city will be prototyped for the Olympics, then implemented on a larger scale post games in a phased scheme that looks at the potential risk and urban development of the region. The design will address the structures long-term resiliency and legacy from the Games, while preparing for what many scientists believe is the eventual transformation of urban coastal regions around the globe.

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# Floating Metropolis:

Resilient Infrastructure to Preempt Tsunami Inundation



To my entire family for their support  
of my architectural education



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## CHAPTER 1: INTRODUCTION

*“Even with all our technology and the inventions that make modern life so much easier than it once was, it takes just one big natural disaster to wipe all that away and remind us that, here on Earth, we’re still at the mercy of nature.” - Neil deGrasse Tyson*

## Problem statement

This project will investigate new methods of tsunami protection located off the shore of Japan to prevent another catastrophic disaster from occurring. The Tohoku Tsunami of 2011 displayed the need for a broad reshaping of coastal defenses if we are to continue to develop in these regions. Sea walls designed to protect the citizens of Japan were washed away by the strength of the recent disaster and instead of rebuilding them, a more biophilic approach needs to be taken into consideration to address the long-term requirements of future development.

Rather than develop a single use defensive structure, this thesis will examine the possibilities of generating floating livable structures that add to the value of the city while offering coastal protection. The 2020 Olympic Games will be used as a catalyst to generate a new way of thinking about large scale residential architecture and creating a lasting addition to the city. This integration of usable property with defensive abilities will provide a short term solution while a larger scale, longer term conceptual adaptation looks into the indeterminate future of Tokyo Bay and how it might be fully protected from unknown future calamities.

The thesis will determine the root of the issues in current planning strategies for disaster mitigation and resilient architecture. These existing models will be used to develop a strategy that will address the need for new land while providing protection and additional space to the existing coastline. Rather than continue to create new coastal land, an infrastructural typology that will adapt with the changing conditions of coastal regions and climate change will address the long-term problems facing Tokyo.

Urban conditions of density and quality of life will need to be considered when addressing

the creation of a new city structure. Can a floating city be developed to realize the population density issues rising in metropolitan areas? How will the project adequately protect the inhabitants of Tokyo from future unknown tsunamis and other storms? By applying biophilic design strategies and sustainable solutions, can floating cities be physically as well as economically sustainable? Ecological factors will need to be taken into consideration and can this infrastructure provide for future economic gains from farming and aquatic agriculture?

### Project rationale

Urban coastal cities are the largest metropolitan areas on the planet with an estimated one billion people living within low-lying coastal regions<sup>1</sup>. In their research an estimated 200 million people worldwide live along coastlines less than 5 meters above sea level. With population growth continuing to expand, especially in developing nations, that figure is estimated to increase to 400-500 million people by the end of the century. Currently there are massive construction projects around the globe to fortify our urban centers against the threat of water infiltration, yet as seen in the 2011 Great Eastern Earthquake off the coast of Japan, those preventative measures were inadequate as over 18,000 people lost their lives and cost the Japanese government an estimated \$309 billion U.S.D<sup>2</sup>. As urban populations continue to grow and these coastal regions develop, the vulnerability of assets increases.

Several areas that were inundated by the tsunami following the Great Eastern Earthquake were further at risk because the shaking caused areas of reclaimed land that supported barriers to sink prior to the tsunami hitting. This lowered sea walls and created further

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1 "World Ocean Review." World Ocean Review. N.p., n.d. Web. 06 Apr. 2015.  
2 "VOA - Voice of America English News." VOA. N.p., n.d. Web. 06 Apr. 2015.



Figure 001: Before/ During a Tsunami



Figure 002: Before/ During a Tsunami



Figure 003: Before/ After a Tsunami

devastation. This liquefaction of soil is a major concern as Tokyo has reclaimed around 96 square miles of land since this process began adding to the available area for the city to grow.

Tokyo is ranked as the world's largest city with an estimated metropolitan population of over 37 million people<sup>3</sup>. Tokyo is home to an estimated 25% of Japan's total population, putting the majority of Japanese assets and businesses within this region. The average population density of the metro area of Tokyo, which covers 8,547 km<sup>2</sup>, is 4,300 people per sq km<sup>4</sup>. While this is much less than that of the most densely populated cities, certain districts of Tokyo do become much denser. These include Edogawa with a density of 13,265 people per sq km and Urayasu with 9,430 people per sq km<sup>5</sup>. Both these wards of Tokyo are in extremely low land areas located between the Ara-kawa and Edo-kawa rivers. The average elevation above sea level for these two areas, which measures 66.97 sq km with a total population of just under 800,000<sup>6</sup>, is just two to three meters above sea level making this zone extremely susceptible to flooding, sea level rise and tsunamis. Therefore new design techniques and infrastructural plans need to be implemented before the next large scale disaster to ensure the mitigation of risk for the people of Tokyo.

An article in the Japanese Times explores architect and urban planner Riccardo Tossani's thoughts about the hazards of such low land, stating that everyone within 5 km of the shoreline and below 15 meters of elevation are at risk for flooding and tsunamis. This metric when put against the natural formation of Tokyo Bay to focus any incoming waves directly onto the Urayasu and Edogawa wards makes them the most dangerous areas within

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3 "WPR." World Population Review. N.p., n.d. Web 06 Apr. 2015

4 Newgeography.com | Economic, Demographic, and Political Commentary about Places. N.p., n.d. Web. 06 Apr. 2015.

5 "ArcGIS | Main." ArcGIS Main. N.p., n.d. Web. 06 Apr. 2015

6 "Worldometers - Real Time World Statistics." Worldometers. N.p., n.d. Web. 06 Apr. 2015.

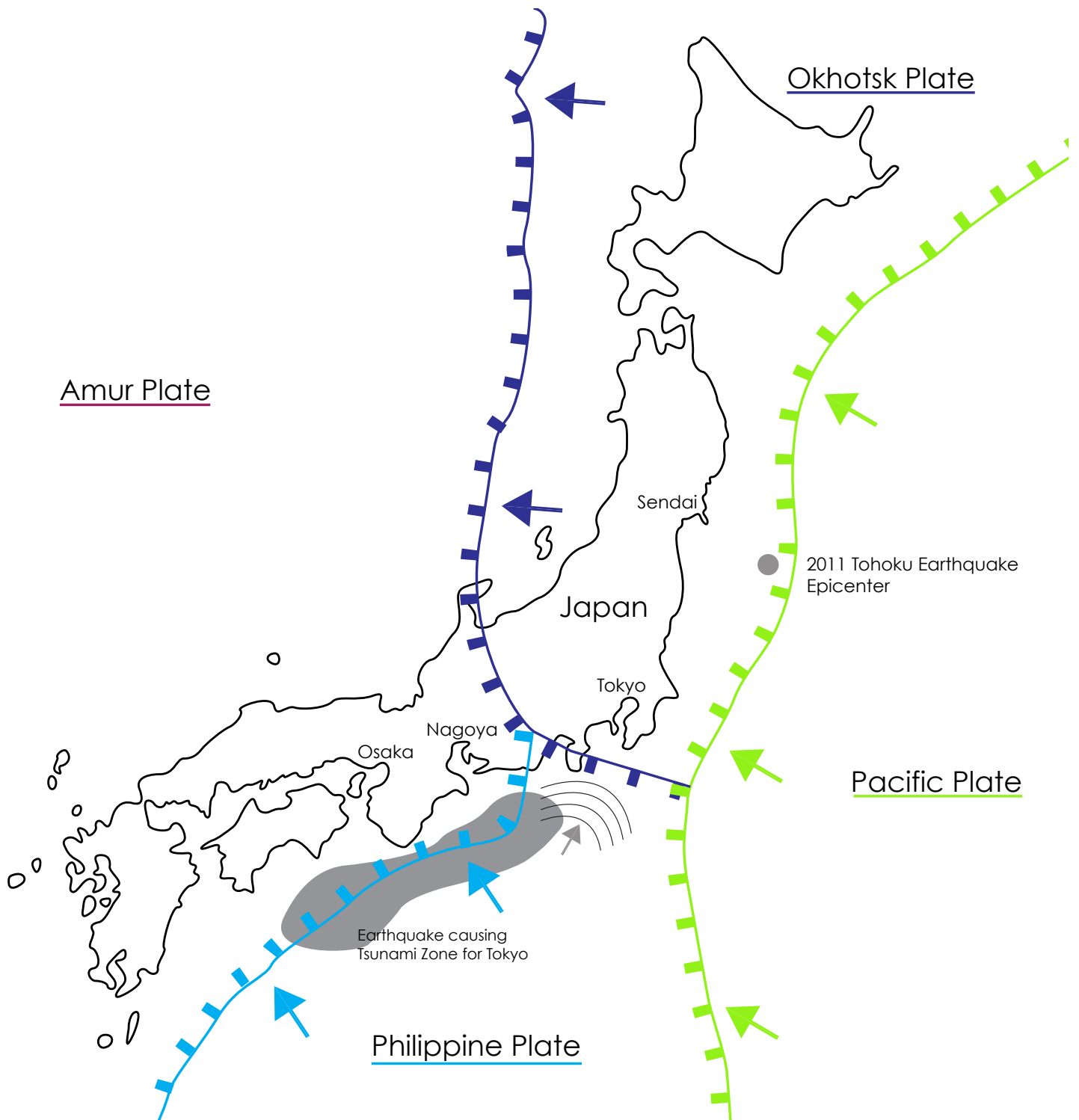


Figure 004: Japan with Subduction Plate locations

Tokyo to live<sup>7</sup>. When researching the tsunami of 2011, 12 of the 25 tsunami evacuation zones in Onagawa were destroyed as they were not high enough areas compared to the amount of water which washed ashore. Further in Miyagi Prefecture (Figure 5), 31 of the 80 sites were inundated by the tsunami causing thousands of deaths during that disaster. This was the primary cause of loss of life from the Tsunami as individuals thought they were safe at these locations. The University of Tokyo's Earthquake Research committee predicted that there is a 70% chance that the metropolis will experience a 7.0 higher magnitude earthquake in the next four years. The primary reason for the coast of Japan's risk to tsunamis come from the type of plate tectonic collision occurring between the Pacific plate and the Eurasian plate colliding. Specifically the Pacific plate is moving beneath the Eurasian plate in an interaction called subduction. This movement causes huge pressures to build and release all at once which causes earthquakes and resulting tsunamis. The map below denotes the fault lines and highest risk zones.

The Olympic Games is a time of innovation, creativity and exploration. As Tokyo was recently awarded with the 2020 summer Olympic Games, it presents a unique opportunity to explore new methods of protection and growth for the city's population. One of the major construction projects for every Olympic Games is the Olympic Village. Currently over 17,000 athletes, coaches, and other individuals from all nations competing descend on the host city for the games. Beginning at the 1992 Barcelona Games, the Olympic village has presented itself as a distinctive occasion to break from traditional housing practices and produce a unique plan that provides the athletes with progressive housing during the games, yet is able to transition into a beneficial long term, economically uplifting, development for the future. <sup>8</sup> Using the development of the Olympic Village as

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7 Solomon Richard. "Urbanites Urged to Head Up, Not Down, to Survive Tsunami | The Japan Times." Japan Times RSS. N.p., 16 July 2012. Wed. 06 Apr. 2015

8 Maria, Martorell Codina Josep. La Villa Olímpica, Barcelona 92: Arquitectura, Parques, Puerto Deportivo = The Olympic Village, Barcelona 92: Architecture, Parks, Leisure Port. Barcelona: GG, 1991. Print.

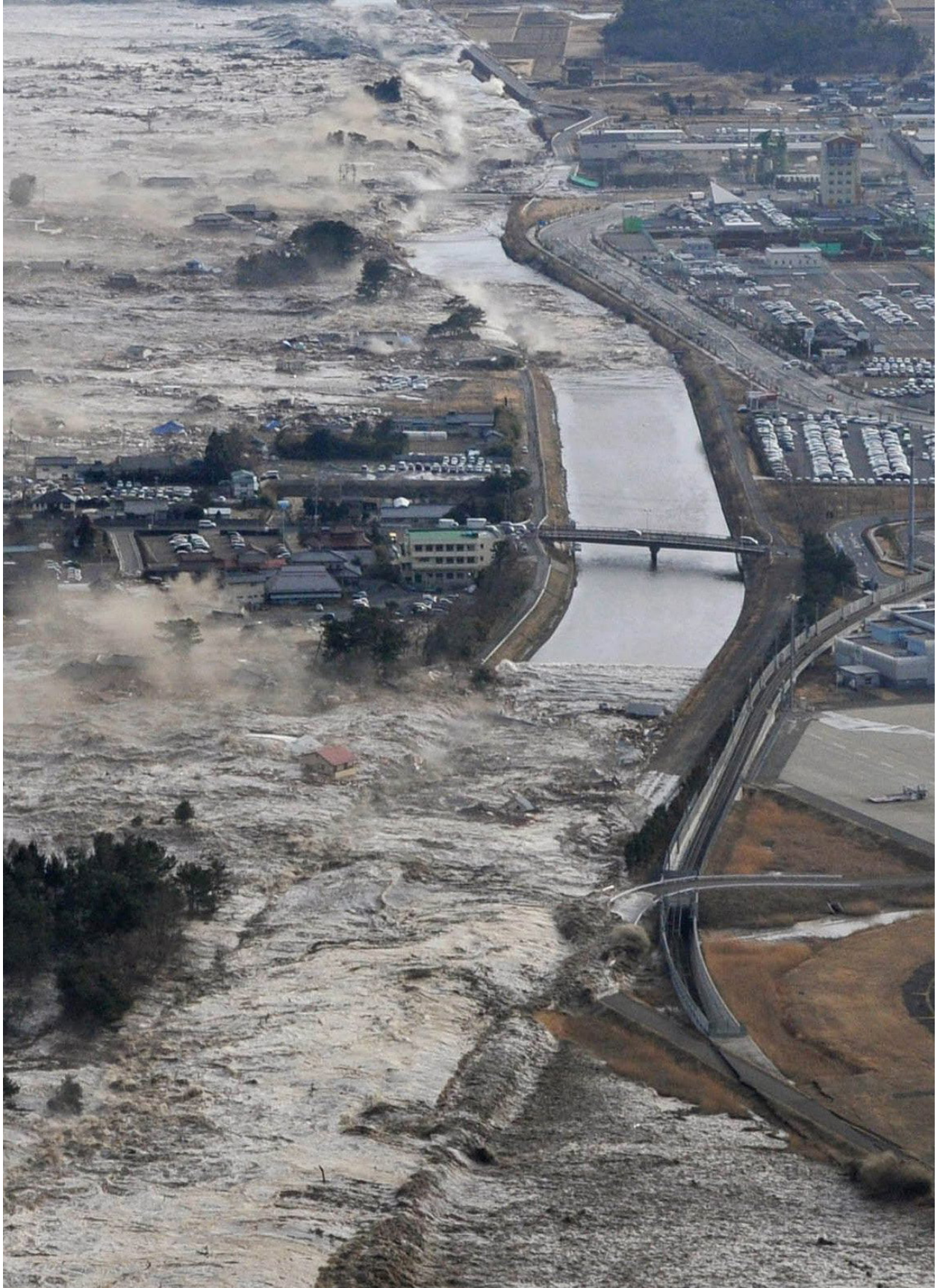


Figure 005: Tsunami hitting coastline of Miyagi, Japan

a catalyst for a larger long term master plan for the protection of Tokyo bay allows for a proof of concept trial along with engaging the greater population in accepting a major infrastructural project such as this.

Reaching back to the 1960's, Japanese architects involved in the Metabolist movement presented multiple ideas for floating infrastructure within Tokyo Bay. The most prominently exhibited concept was Kenzo Tange's Tokyo Bay project, (Figure 006) shown during the 1960 Tokyo World Design Conference. Tange stated, "The city of 10,000,000 is of fundamentally different character from a city of 1,000,000,"<sup>9</sup> in reference to the 1960 Tokyo bay project and understanding that Tokyo had grown from a city of 3.5 million in 1945 to over 9.5 million by 1960 and with that growth came a change in philosophy about how to develop the urban fabric of the city. These past precedents provide for a current basis for new designs both in Tokyo bay and around the world as coastal cities are more vulnerable than ever to sea level rise and natural disasters. Traditionally Japanese construction was build away from the coast to minimize the danger, yet in the modern world, we rely on our connection to the sea for commerce and travel. This connection of culture and economy to the sea is one that should be celebrated rather than resisted which brings into discussion the concept of floating structures to mitigate risk while empowering physical connection.

#### Methods/ strategies

This thesis approaches the creation of resilient floating cities through integrating future design ideas with ecological conditions to protect coastal cities. By careful placement and site analysis, the project will be able to develop resilient strategies for protecting the inhabitants while providing infrastructure and developable structures for future growth.

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9 Koolhaas, Rem, Hans Ulrich, Obirst, Kayoko Ota, and James Westcott. Project Japan: Metabolism Talks---. Köln: TASCHEN GmbH, 2011. Print.



Figure 006: Kenzo Tange's 1960 Plan for Tokyo Bay

Using the natural elements of the bay will be paramount in connecting the project to the land as well as ensuring shipping into coastal ports is unaffected. Understanding how resources will need to be moved as well as potential opportunities for new fishing and farming techniques will provide for financial opportunity for inhabitants. The urban condition will be defined based around adapting the opportunities found in the historical planning of Japanese cities while bringing these concepts into the twenty first century. Understanding the cultural ramifications of certain design intents will shape the development of the floating cities structures and encourage development. A timeline approach will need to be applied in which a series of phases are implemented when certain conditions are met. The first component will be developing the needs of the Olympic Village for the 2020 Games. Phase two will be post Olympics where the athlete housing is transitioned into livable units for the population of Tokyo. Using the Olympic Village as a model for future development, if it proves successful, phase 3 will be implementing the modular concept on a larger scale to both provide more housing for the growing population of Tokyo and assisting with the mitigation of Tsunami risk to new development.



## CHAPTER 2: SCOPE AND SURVEY OF TYPOLOGY

*“Design shouldn’t be just about pure design or technology but rather people and place and their relationship with design and technology.”*

*- Gilbert Rochecouste*

## Japanese Urbanism

Urban design in Asian countries differs from the traditional European typology as western attitudes trend towards refined and permanent solutions while eastern concepts trend towards temporal designs and a chaotic planning. There are three main comparative points as discussed by Barrie Shelton: 1. Behind Japan's urban forms are ways of thinking and seeing that are quite different than those of the West. 2. Their deep roots being cultural are mostly old roots, though modern appearances often appear. 3. Many characteristics of Japanese cities, though rooted in national culture and history, have many connections with contemporary ideas in science and philosophy that are usually more western generated concepts.<sup>10</sup> Western cities are primarily centrifugal in their design with the most prominent buildings at the center and the population decreasing in density in a radial way outwards. Japanese cities have been characterized as cities that are centripetally focused from outside inwards according to Shelton. He calls it a "hard shell, soft yolk" urban plan with a decentralized focus on important structures. Shelton quotes architect Yoshinobu Ashihara in saying,

"One after another, Ashihara pits the characteristics of Western and Japanese life, buildings and cities, past and present against each other. The traditional Japanese architectural focus upon the floor is contrasted against the West's upon the wall, ambiguity between outside and inside against clarity, the irregular and omnidirectional nature of the Japanese building against the western symmetry and formality, elevated floor against ground floor level and elevated furniture, temporary versus more permanent buildings and so on."<sup>11</sup>

This contrasting relationship is important to understand if a truly contextual project is

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10 Shelton, Barrie. *Learning from the Japanese City: Looking East in Urban Design*. London: Routledge, 2012. Print. 10

11 Barrie Shelton, *Learning from the Japanese City* (12)

to be undertaken. This difference in organizational schemes as well as the relationship between tradition and new will focus the design project into one which responds not only to the physical environment but the social atmosphere of the people who live there. Originally when western travelers experienced Japanese cities they disliked them for their confusion and disorganization, but at the end of World War Two, it showed how quickly sections of the city could be rebuilt and reorganized without the constraints of a more ordered system. Further, the temporality of the traditional Japanese structure lent itself to modification and change rather than a stone or more rigid space, making for the inhabitants more able to adapt to new challenges. How can these historic ideas be applied to urban processes that form future cities? As we enter a new era of urban design and resilient construction, new methods must be developed and plans redone to reflect the changing urban fabric. An age of gradual improvement of current conditions and proposal of radical change must be developed if we are to effectively address the problems of coastal cities.

Another important difference between Western and Eastern urban views deals with language. English is a linear language focused upon lines while Japanese characters are defined by area. Western letters are rational yet carry no intrinsic meaning on their own while Japanese characters are stand alone stylized pictorial representations of objects or ideas. Shelton states, "The Realization of this relationship between tradition and the new is something that gives added substance and intellectual depth to some Japanese writing about their built forms, that is lacking in much Western, especially European commentary."<sup>12</sup> With the Japanese idea of area referencing floor versus wall as in Western culture. This spatial demarcation shows emphasis on not only the physical nature of a street but what bounds it. Shelton speaks to Japanese cities being identified as street blocks where the leftover space becomes the street. Thus the city planning appears more



Figure 007: Aerial of Tokyo in 1959

chaotic than European counterparts. Further he states that Japan puts more emphasis on city place making where Western ideas are preoccupied with form. Film critic Donald Richie speaks to this connection in an essay,

“In Europe, one is part of the display- to see and be seen, to look and be looked at. The street is the stage. How different Japan... You the walker, are not the actor. Rather you are an active spectator. The display is not you and the others about you. This display is the street itself. The direction is not from you to it but from it to you. Shops line the street, open up, spill out. Clothes on racks and sides of beef alike are shoved into sidewalks. The fish shop’s scaly glitter is right there, still gasping. Baby televisions piled high blink at you eye to eye... on the Tokyo street, there is the raw profusion of consumptions itself.”<sup>13</sup>

This statement argues the strength the streetscape plays on the urban experience and how the individual interacts with the larger city. Without this context the street becomes just a road with no deeper connection. Understanding this Japanese cultural thinking is paramount to the design of a culturally relevant and contextually responsive thesis.

## The Olympics

Olympic buildings have grown from their humble roots in the beginning of the 19th century to massive expression of urban expansion and redevelopment. The 1964 Olympics were the first held in Asia under the theme of ‘Peace and Friendship.’ It was used as a way to change the view of Japan as a nation from the imperial conquering persona of the 1940’s to a modern developed nation. The people took it upon themselves to aid in the development and construction of the games as they held a great deal of nationalistic pride. This statement makes it clear the intent of not only the government but the people as a

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13 Pocorobba, Janet. “Metropolis - Tokyo Feature Stories: Interview - Donald Richie.” Metropolis - Tokyo Feature Stories: Interview - Donald Richie. N.p., n.d. Web. 14 June 2015.



Figure 008: Aerial of Tokyo 2015

whole, “The restoration of national pride that was staged in 1964 involved the deliberate rehabilitation of classical national symbols, especially the tenno himself (emperor), the hinomaru (rising sun) flag, the kimigayo (his majesty’s anthem) and the army. The method of their revival was to free them their wartime associations and present them instead as symbols of peace.”<sup>14</sup> With the entire city behind the Games, a major infrastructural project was undertaken to modernize the city and create new venues. Citizens dealt with years of construction and displacement, but in the end it ushered a new era of urban growth to Tokyo.

The physical construction projects truly modernized the current vision of how Olympic games are presented to the world, and how nations leverage massive amounts of public funds to create improvement projects for their cities. In Japan, the 1964 Games presence on modernization of the urban fabric presented to the world a new, modern Asian city.

“Banished forever by these games was the tattered but lingering Western image of Japan as a closed, ritualistic, feudal society... Modern Tokyo, extensively renovated, was an ideal setting, and Japanese Architects – with unmatched command of traditional materials and new technology – provided several of the finest buildings ever designed for the Olympic Games.”<sup>15</sup>

The work that was to come out of these games was ambitious as it was costly, yet the infrastructure and facilities created still shape the way modern Tokyo is traveled today. For the athletes competing, they were treated for the first time to pristine facilities never before seen at an Olympic Games. For example, all swimming events were now in a dedicated indoor pool rather than an outdoor complex, allowing for better control of the water and elements. This facility, Yoyogi Sports Park, conceived by Kenzo Tange was

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14 Kelly, William W., and Susan Brownell. *The Olympics in East Asia*. New Haven Connecticut: Council on East Asian Studies, 2011. Print. (62)

15 Gordon, Barclay F. *Olympic Architecture: Building for the Summer Games*. New York: Wiley, 1983. Print. (78)

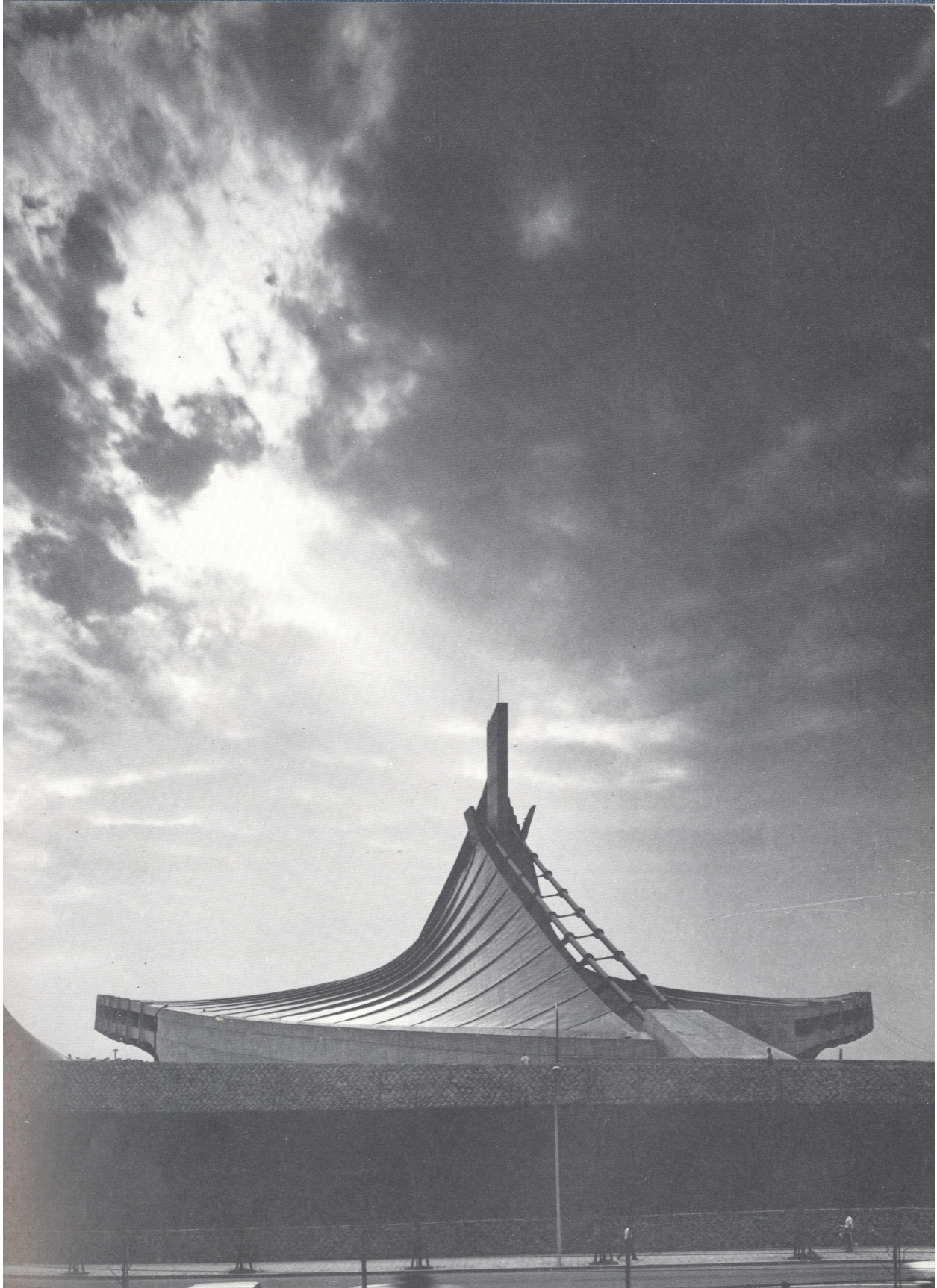


Figure 009: Kenzo Tange's Yoyogi Stadium, 1960 Olympic Games

a marvel of classical Japanese elements used in a contemporary fashion. While they are sculptural in design, it did not detract from their functionality which only enhanced the drama of the athletic feats during the games. Two other complete sports parks were created for the other events and together formed the backbone of the Olympic Games. Also included in the construction for the games were 8 new express ways and 22 motor links for a combined total length of over 50 miles. In total Japan spend over 2 billion USD (1964) to enhance their city for the Games. "These designs were uncompromising modern and international in their outlook, yet in certain of their forms and flourishes they seem to speak of an older, more exclusive Japan."<sup>16</sup> This shows the power the Olympics holds over a city and what can be accomplished when both a government and populous come together to improve their home.

Olympic athlete housing has been a permanent feature of the Olympic venue since the 1952 Helsinki games. It was the first time a dedicated project was conceived for the express purpose of housing athletes during the Games. There was a vary of success from 1952 to 1992 where the Barcelona games finally created the current planing and program attributes we see with current Olympic Villages. "Over the last three decades urban regeneration and transformation have been key but not exclusive drivers associated with hosting the games, evident to varying degrees from Barcelona onwards."<sup>17</sup> The theme of legacy was brought out from these games and since has played a large factor in the wining of an Olympic host bid. The IOC (International Olympic Committee) who select the host nation and city stress the environmental, socio-economic, health and legacy attributes of each venue. While each venue has its own additions to the program, over 17,000 athletes, officials and coaches travel and require a location to stay during the games. This amount of housing in a specific district prompts the host nation to look strategically at where best

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16 Olympic Architecture (78)

17 Olympic Architecture (93)

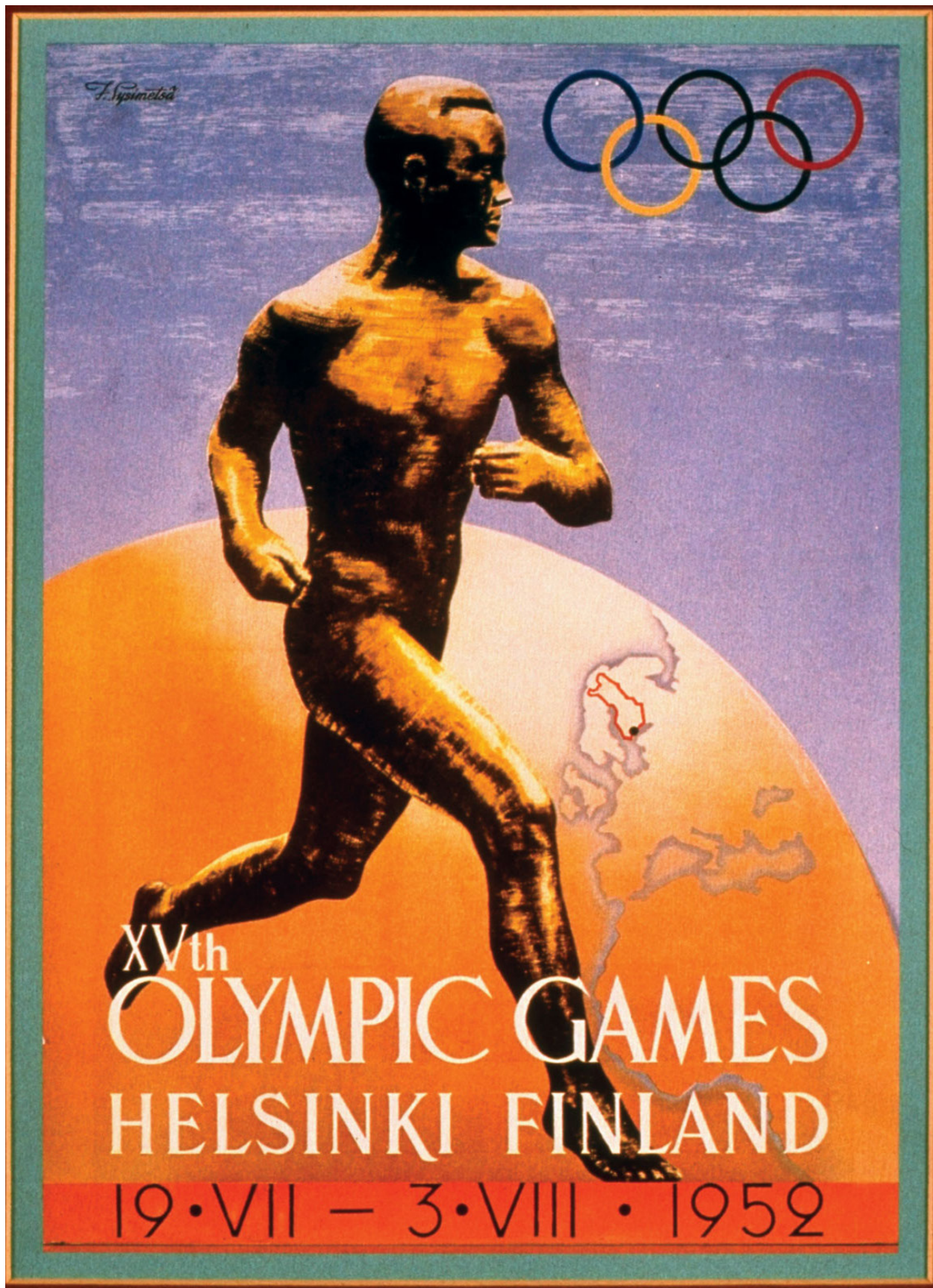


Figure 010: 1952 Helsinki Promotional Poster

to implement a massive development such as it. The ramification of not only the Olympic Village but all the additional private sector development that parallels the games is an important driver in the urban planning of an entire sector of the host city. For the London 2012 games the government spent over 1 billion USD on the development of the Olympic Village with an additional 750 million private sector dollars in additional real estate.<sup>18</sup> With this level of investment in a single area of a city, it understandably draws concern from those who say it gentrifies an area without providing for the citizens who most likely lived on the land previously. Even when the Olympic housing is developed with a percentage marketed as affordable, the overall influx of private development does raise cost of living in the area affected causing for some displacement. This makes the case for a floating city, as it does not displace any individuals from the current urban landscape and keeps the development from adversely affecting the surrounding neighborhood either during construction or afterwards with the growth of gentrification.

## Disaster

Tsunamis are not the most frequent of disasters but when they do happen the damage can be enormous in both loss of life and property. The tsunami that hit Japan in 2011 was one of the largest on record that saw water levels rise as high as 40 meters. Even in Tokyo bay, over 400km away from the epicenter of the quake and protected by the coastline, water levels rose .9 meters. This shows the large area of effect a single event has and the reflective properties of the ocean floor to bounce wave energy around land masses. According to Japanese coastal engineer Hiroshi Takagi of the Tokyo Institute of Technology, Tokyo, Nagoya, and Osaka are all at risk for tsunamis originating from earthquakes in the Nankai trough, a region West of Japan where the Pacific and Eurasian

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18 Paterson, Neil. BREEAM and the Code for Sustainable Homes on the London 2012 Olympic Park: Lessons from the Velodrome, Aquatics Centre and the Olympic and Paralympic Village. N.p.: n.p., n.d. Print.

Normal Waves

- Movement of uppermost layer of water only, motion diminishes with depth
- Caused by wind or storm surge
- **Wavelength: 30-200m**, Period: 1-30s
- Speed: 15-115kp/h

Tsunami Waves

- Movement of entire water column down to sea floor
- Caused by tides or tsunamis
- **Wavelength: 80-500km**, Period: 5-60m
- Speed: 60-900kp/h (function of depth)

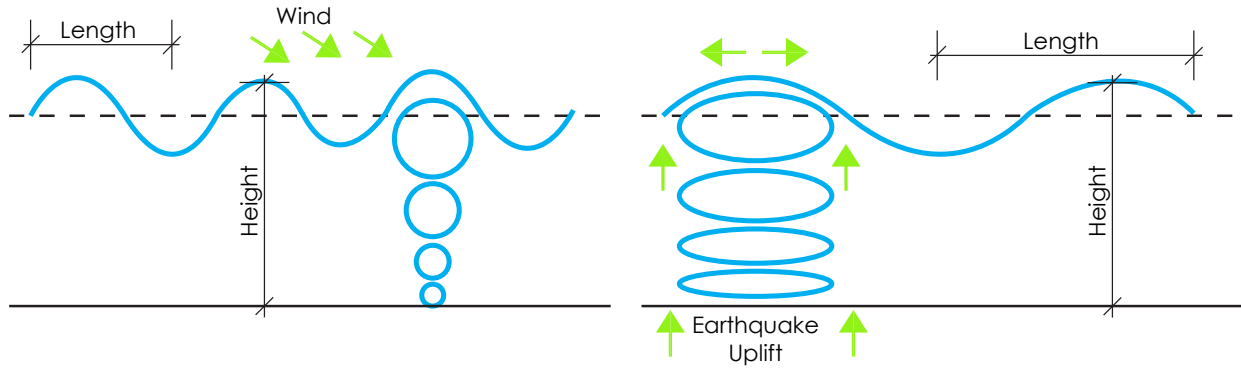


Figure 011: Wave Diagram

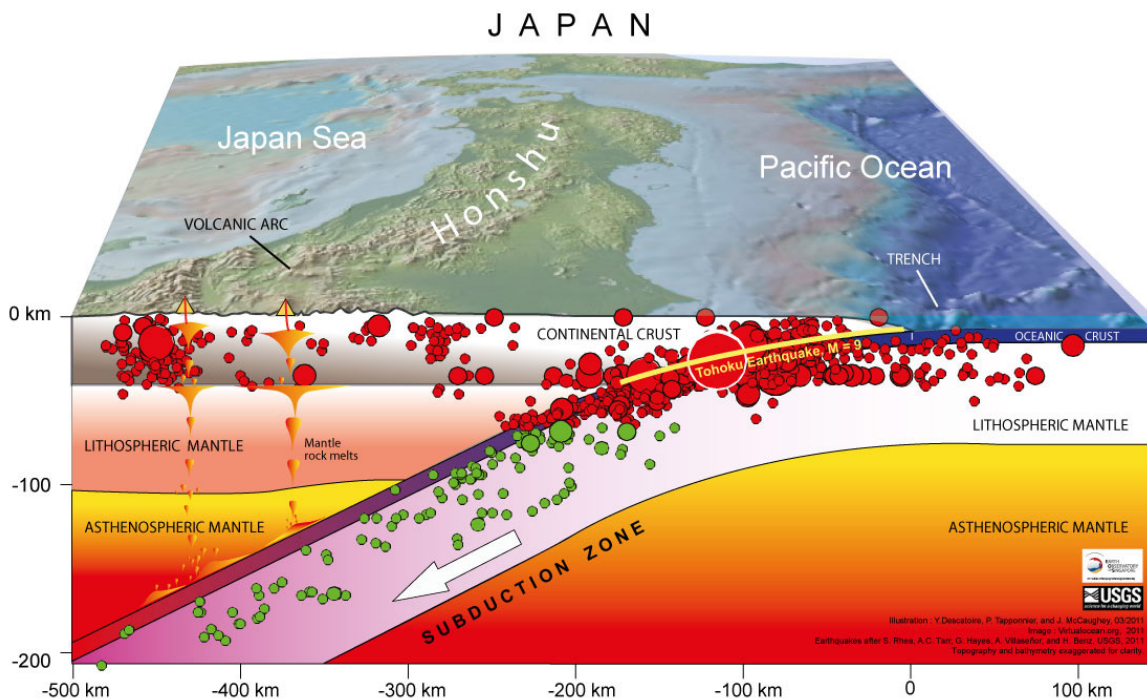
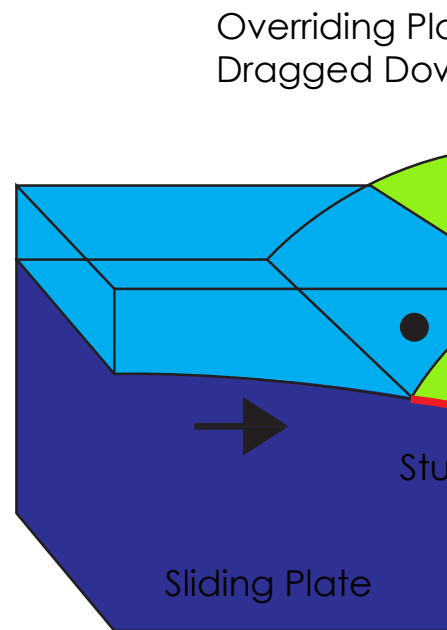
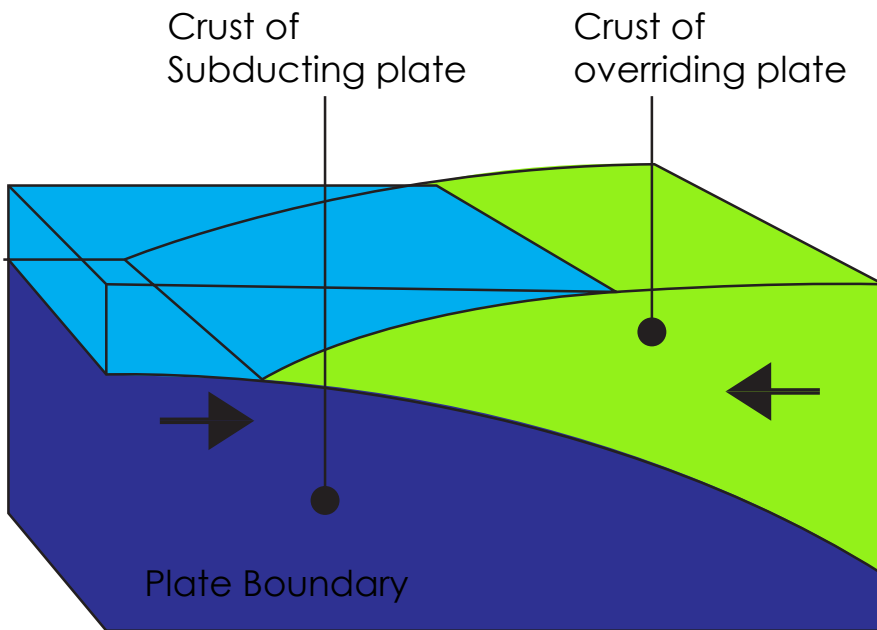


Figure 012: Subduction Diagram from USGS



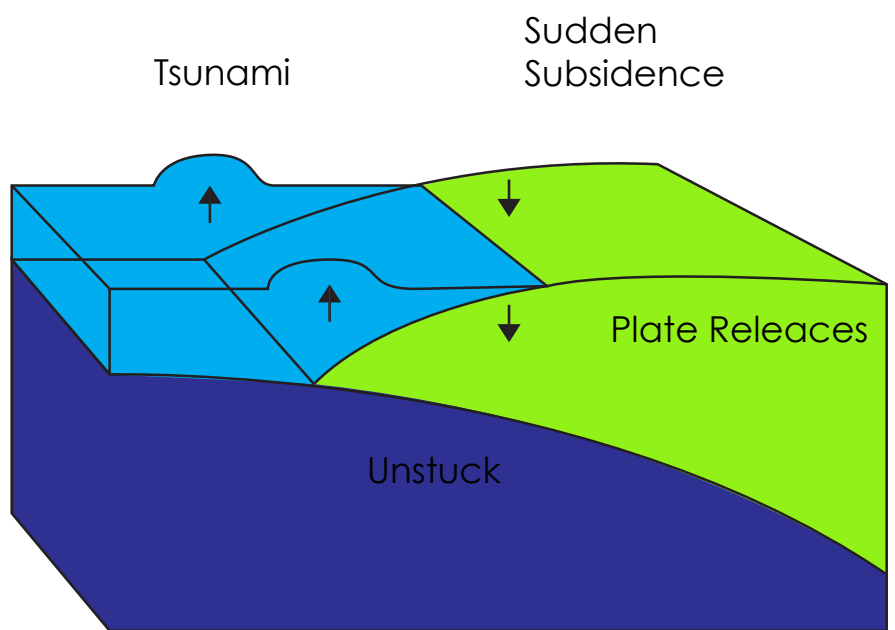
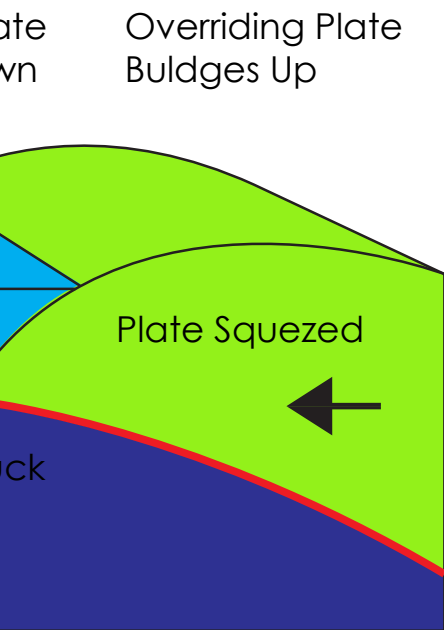


Figure 013: Subduction Diagram

plates collide. This area is subdivided into the Nankai, Tonankai and Tokai regions. Tokai earthquakes, the area that would have the most effect on Tokyo and Nagoya, have occurred on average every 100-150 years. The last recorded Tokai earthquake was in 1854 however making the risk facing these cities high. Between the three regions along the Nankai trough there is an estimate that a large quake will occur within the next 30-40 years.<sup>19</sup> Hiroshi Takagi states “scientists now believe that earthquakes in all three zones could occur simultaneously” as happened in the Hoei earthquake of 1707. This chain reaction would cause devastating damage to coastal regions.

The force of tsunamis is generated when a tectonic subduction plates slip (figure 12-13), thrusting one of the plates violently upwards. This reaction lifts the water above the epicenter and displacing it away from the earthquake. The depth of the ocean plays a major factor in whether an earthquake forms a tsunami (Figure 11). The Nankai trough where this is likely to occur is unfortunately on average 3500 meters deep.<sup>20</sup> The amount of force generated to lift that much water is enormous and generates the waves that destroy coastal areas. Another factor in why tsunamis are so dangerous is as they move towards shore the depth of the water decreases, increasing the height of the wave. In open water a tsunami wave is barely detectable but moves at incredible speeds of up to 400 kilometers per hour. As it nears land, the speed is decreased but height increases dramatically. Land masses both above and below the water play an important role in how a coastal area will be affected. Primary concern is that the cities of Tokyo, Nagoya and Osaka all sit at the end of a bay, which has the potential to further direct the energy from the wave. For example, Tokyo bay is 19km in width along the southwest coast of the Boso and Miura Peninsulas. Tsunami waves entering the bay would be condensed into an opening measuring only 9km before being released into Tokyo Bay proper. Further

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19 Solomon, Richard. “Tokyo’s Exposure to Tsunami, Explained « Beacon Reports.” Beacon Reports. N.p., 19 July 2012. Web. 12 Apr. 2015.

20 NOAA Bathymetric Maps. N.p.: NOAA, n.d. 978664. Print.

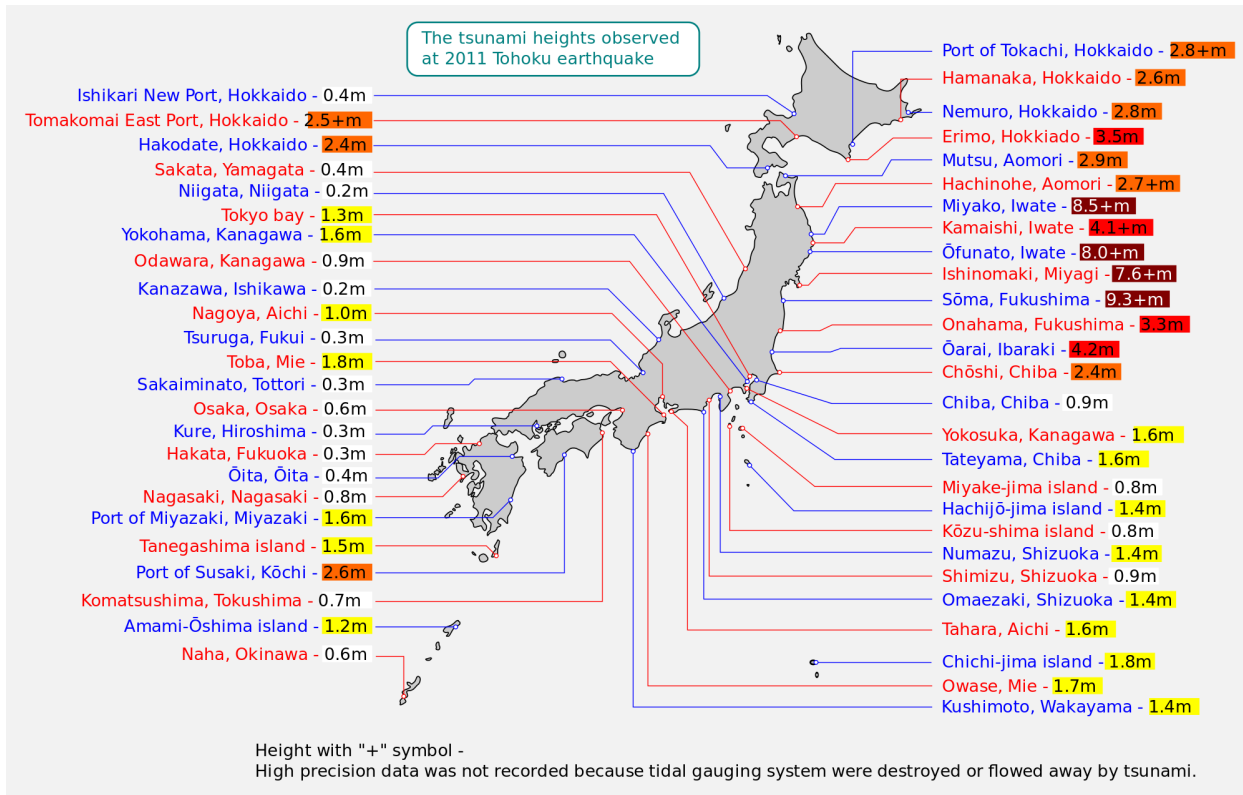


Figure 014: Tsunami wave height during 2011 earthquake

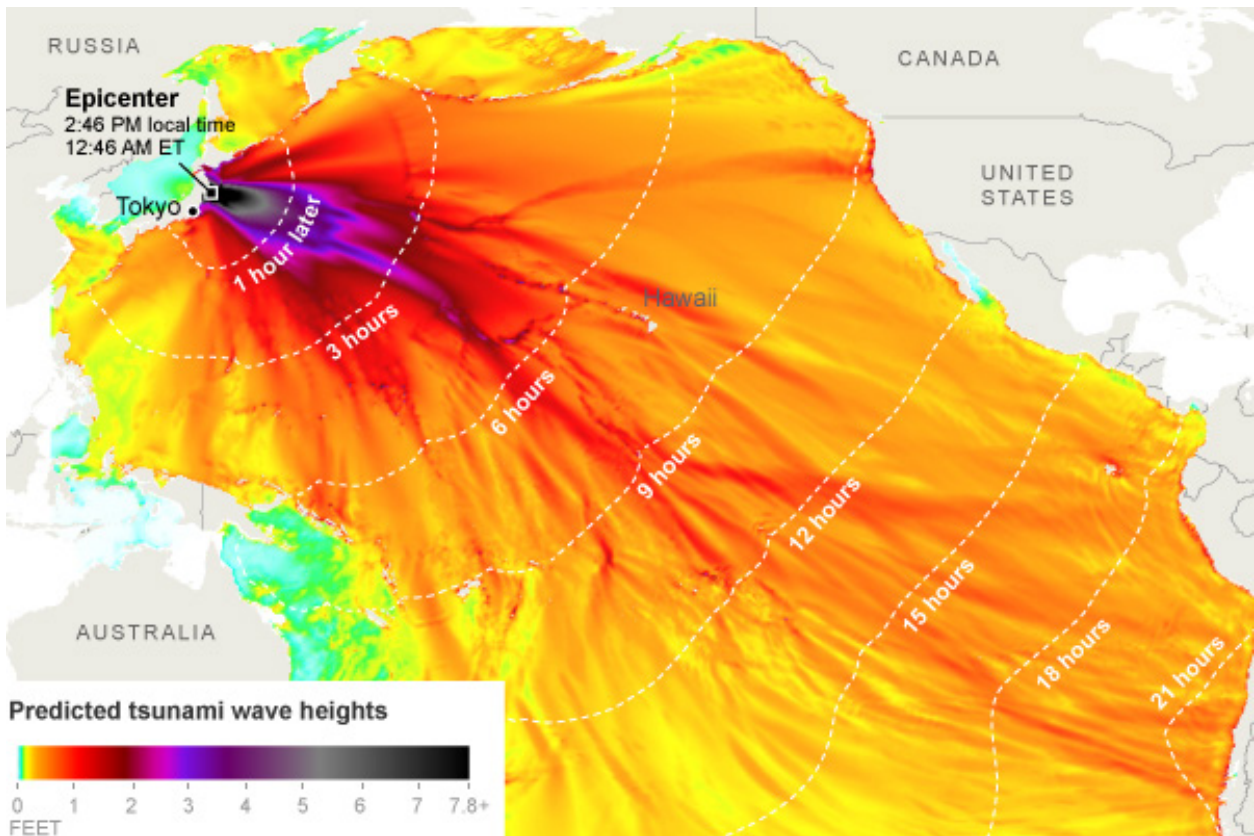


Figure 015: Tsunami Height vs Time

reflection of wave energy would be caused by the shallow depth of Tokyo bay making for higher waves inundating coastal areas. There are no accurate estimates as to the potential height of a tsunami in Tokyo bay as the factors are too diverse to calculate yet experts estimate waves as high as 6-8 meters could reach Tokyo harbor under the right conditions.

Liquefaction can play another important role on the potential devastation from a tsunami. This occurs when an earthquake disrupts the ground tension in water rich soils causing the land to settle and sink. Subsidence of up to 3 meters was recorded in the Great Hanshin-Awaji earthquake of 1995<sup>21</sup>. In areas of Tokyo like the Koto ward where the land is already below sea level, it puts incredible risk on all those living there.

## Tsunami Barriers

Tsunami barriers have existed in Japan for hundreds of years to protect those living on the coast. The earliest forms were rock walls to protect against high waves and help shelter harbors. Currently Japan is spending billions of yen constructing new tsunami barriers to hopefully protect their high-risk coastlines.<sup>22</sup> The current mantra in tsunami barrier design is build it bigger, build it stronger. Plans are on the board for 10-18 meter high barriers along 400km of coastline deemed at risk for future events. These barriers are primarily made from concrete and reinforced steel and located along the coast. Problems with them are primarily related to human interaction with sight lines being disrupted, vacation beaches destroyed and economic factors such as beach farming are disrupted due to their presence. As previously stated in the Japanese Times article, barriers of this design were not able to withstand the forces for the 2011 tsunami and over 80% were either

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21 Project Japan, Koolhaas

22 "Japan Opts for Massive, Costly Sea Wall to Fend Off Tsunamis." The New York Times. The New York Times, 21 Mar. 2015. Web. 21 May 2015.'



Figure 016: Tsunami Barrier



Figure 017: Tsunami Barrier



Figure 018: Tsunami Barrier

damaged or destroyed. This is primarily due to the problem in a large wall that once one point fails the wall becomes weaker leading to total collapse. For the residents who the barriers in 2011 were suppose to protect, they provided a single point of failure between protection or destruction and when the wall failed, there was no other measure in place to help individuals. However, some barriers worked very well, protecting whole towns from being destroyed. For example, the tsunami barrier in Fundai, Japan survived undamaged and protected the town completely.

Another type of tsunami barrier is being developed in areas that cannot afford the billions in construction of concrete barriers. Indonesia and other surrounding countries have turned to a more biophilic approach to protection by developing natural barriers that provide resources, economic dollars and protection all at once.<sup>23</sup>The primary way they are doing this is by planting mangrove and coconut forests along the coast where previously had existed open farmland. This type of barrier is not designed to stop the wave at a single point but rather be a series of sieves that slow the incoming waves force so it does not reach as far inland. This has a documented ability to weaken tsunami waves as shown in coastal areas in Indonesia that were affected during the 2004 Great Indian Ocean Tsunami. Areas that had been clear-cut for farming were devastated, yet areas where mangrove and coconut forests were against the beach were much better off after the disaster.

A third type of tsunami barrier is being developed to protect coastal regions and slow the power of a tsunami. This is still in the conceptual stages but it provides insight into the possibilities for future barrier design. Named the Twin Wing Tsunami Barrier, it was designed by Van den Noort Innovations to be a new way of thinking about how to passively

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23 "Chapter 4 Protection From Coastal Erosion." Chapter 4 Protection From Coastal Erosion. N.p., n.d. Web. 3 June 2015.



Figure 019: Eastern Scheldt Barrier, Netherlands



Figure 020: Delta Works, Denmark



Figure 021: Mangrove Forest, Indonesia

protect our coastal cities without building huge concrete barriers. The design would not obstruct views, or shipping yet if a tsunami struck, the large forces involved would deploy the protective wings without human interaction. This is an interesting concept as it fulfills the needs of the city without compromising on the waterfront areas. The primary downside of this is the maintenance factor as each section would have to be maintained and tested to ensure full barrier deployment.

### Resistant Design Principles

To design a resilient city, many factors must be applied to an overarching set of principles that govern how the urban fabric is planned. Many current cities function well in their present-day configuration, but when an unforeseen circumstance arises, many falter. An example of this was the impact of Hurricane Sandy on New York City and the surrounding areas. They were prepared for a minor storm, but nothing of the magnitude seen in this event. Buildings were destroyed, sea walls crumbled, power stations flooded and many of the lower Manhattan subway stations and tunnels inundated with water. The economic impact of the storm far outlasted its duration causing millions in damages and loss of life.

In the book, *Resilient Sustainable Cities*, authors write about how we need to address future concerns today and start planning for a more strategic approach to future urban design. Peter Roberts states, "Perhaps the single most important challenge for the 21<sup>st</sup> century is to work towards a more resilient and sustainable urbanized world. In this global strategic urban context, resilience concerns the capacity of an urban system – including its natural, built, social and economic elements – to manage change, learn from difficult situations and be in a position to rebound after experiencing significant stress or shock..." By looking towards the future in all aspects of what effects the city, we can be prepared for any eventuality. Another author of the book, Peter Newton, describes the future urban



Figure 022: Twin Wing Tsunami Barrier Concept

environment; “A sustainable city can be defined as one which the needs and priorities of current and future generations are met in ways that do not significantly compromise the well-being of future generations.”<sup>24</sup> This is something that is often overlooked with design of buildings and use of materials is the future impact of that decision. Looking forward climate scientists are predicting a rise in damaging storms as more moisture evaporates with rising global temperatures.<sup>25</sup> Understanding these fluctuations in natural conditions, planning for known disasters and the social/ economic factors that affect the inhabitants is paramount for a future city to survive. Adapting a metabolic system that flows with change in urban functions and quality of life further adapts the built environment to the changing conditions.

“Design shouldn’t be just about pure design or technology but rather people and place and their relationship with design and technology.”<sup>26</sup> This statement from Gilbert Rochecouste and Leonie Pearson in their chapter on resilient cities resounds with the fact that design without the human element is irrelevant in today’s culture. Designers are responsible for not only constructing buildings that stand up to the elements but foster a sense of community, comradery and sustainability in today’s urban culture. Resilient building design has three primary focuses when being designed for the current context. First, the structure must withstand the natural elements for as long as possible, especially high impact storms and disasters. Second, it must be sustainable in construction using materials and practices that will see its impact on the surrounding environment mitigated. Thirdly it should benefit the community on a social level, adding to the overall interaction of the urban sphere. These qualities are paramount for a future city to successful and transcend the current generation into the future.

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24 Pearson, Leonie, P. W. Newton, and Peter W. Roberts. Resilient Sustainable Cities: A Future. New York: Routledge, 2014. Print. (7) (23)

25 NOAA

26 Resilient Sustainable Cities (46)

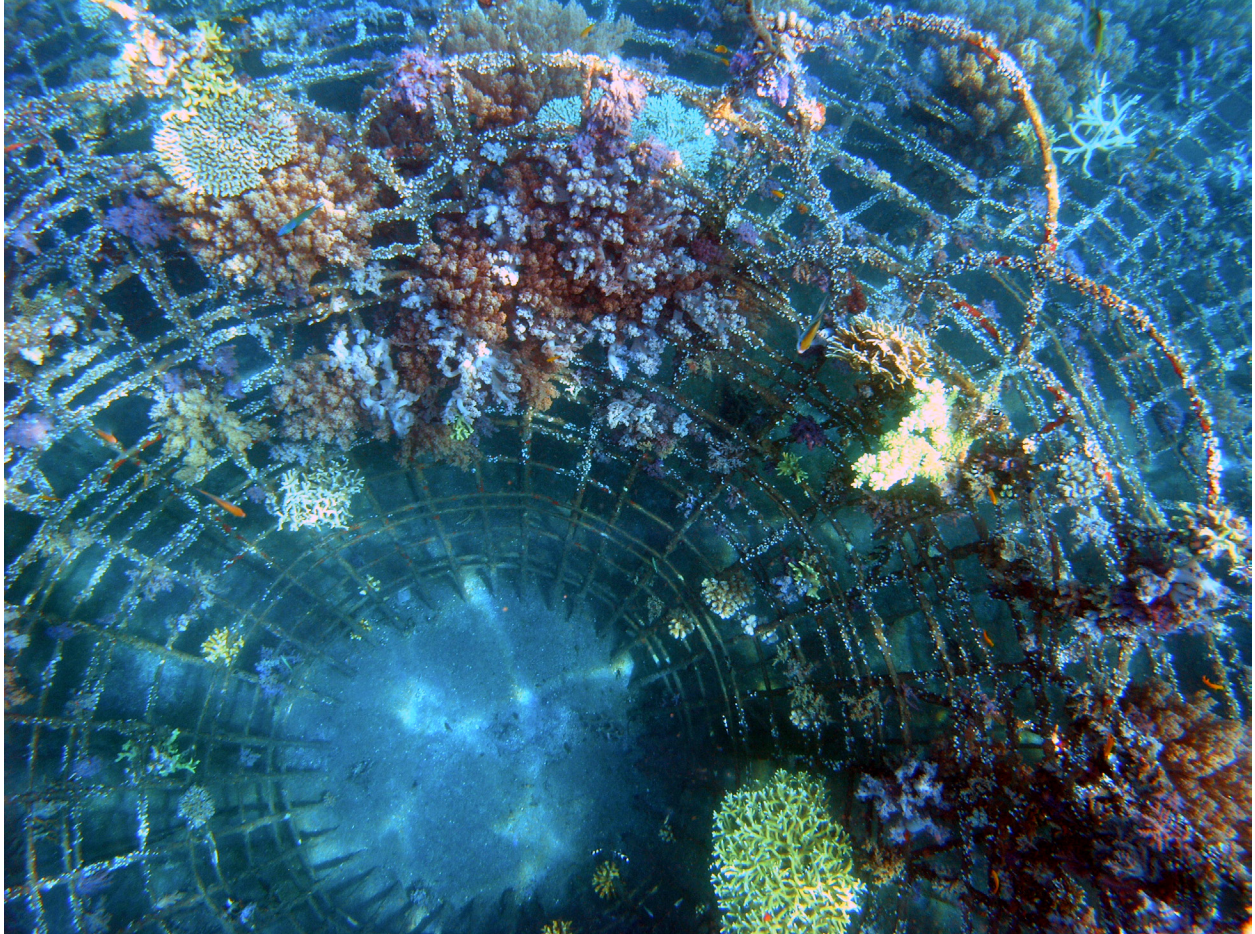


Figure 023: Man Made Coral Reef

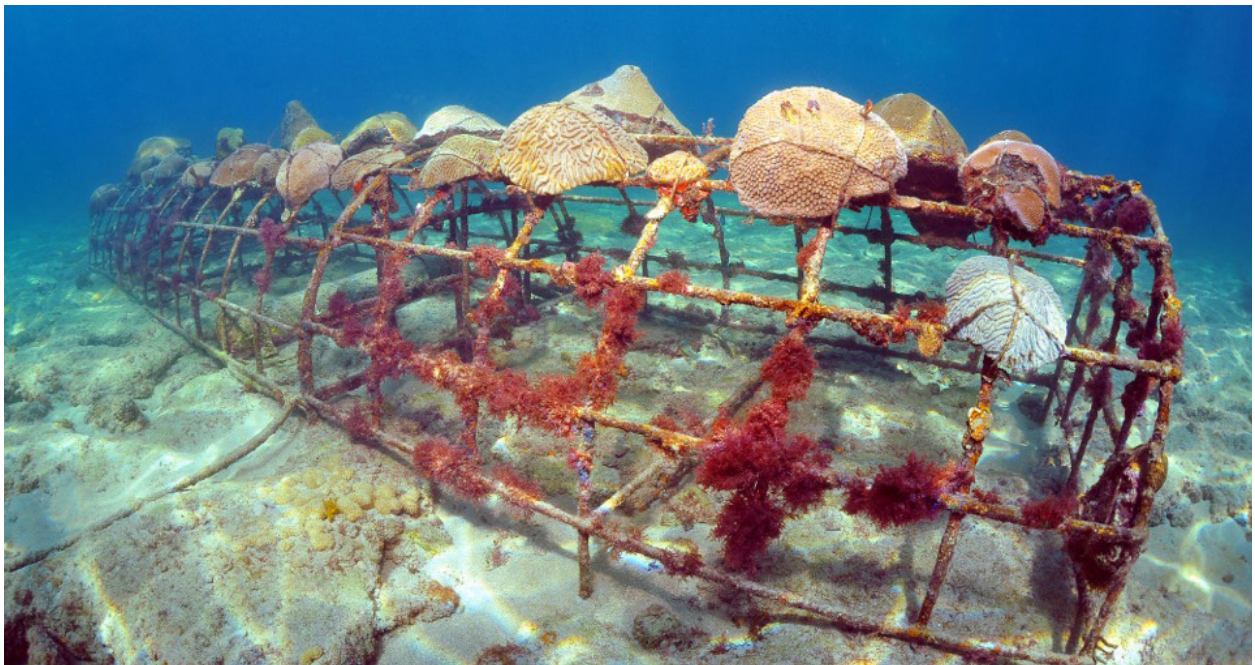


Figure 024: Man Made Coral Reef

## Precedent studies

### Metabolist Japan

Metabolism was born during the population and economic boom of the 1960's. The movement was cultivated by the brightest architects of the era and grew to define an entire period of Japanese architectural history. Noboru Kawazoe is credited with suggesting the term 'Metabolism' in reference to organic function of material and energy exchange between all living entities. This came directly from the understanding that the city should be in continuous growth, expansion and renewal, not unlike an organism. Science played an important role in the development of the architectural theory as many great achievements were happening during this period in history. Biology, chemistry and technology all were developing fields that held a place in the movement by pushing the urban design philosophy towards ideas of influencing social change.<sup>27</sup>

“Metabolism is the name of the group, in which each member proposes future designs of our coming world through his concrete designs and illustrations. We regard human society as a vital process – a continuous development from atom to nebula. The reason why we use such a biological word, metabolism, is that we believe design and technology should be a denotation of human society. We are not going to accept metabolism as a natural historical process, but try to encourage active metabolic development of our society through our proposals.”<sup>28</sup>

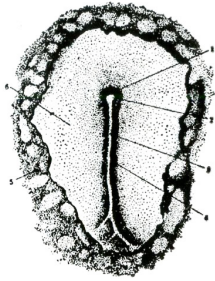
Each architect within the movement had their own idea, theory and understanding of what the movement could and should accomplish. A perfect example of this is the series of plans for the development of Tokyo bay during the 60's. Each designer had very different intent and this can be seen in figure john Despite this divergence of ideas and designs,

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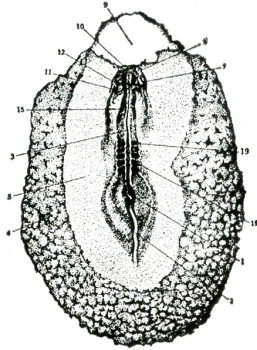
27 Lin, Zhongjie. *Kenzo Tange and the Metabolist Movement: Urban Utopias of Modern Japan*. New York: Routledge, 2010. Print.(18)

28 Kenzo Tange and the Metabolist Movement (23-24)

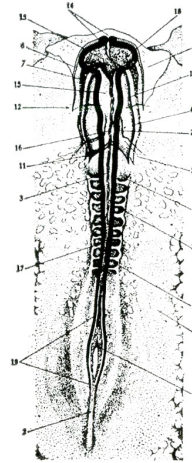
spine in primitive stage



fourth somitic stage



sixteenth somitic stage



nineteenth somitic stage

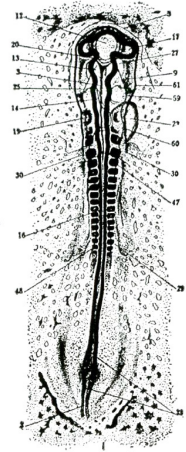


Figure 025: Kenzo Tange's growth process diagram as metaphor for urban development



Figure 026: Kenzo Tange's 1960 Tokyo Bay Plan Model

the overarching theme that connects the group would be the characteristic of change within their design proposals. The large scale urban infrastructure projects put forth were attempting to challenge the current practice of master planning a city. Master plans by their nature are a static entity where as the metabolist intent was to develop a system that “could accommodate any future external growth and internal regenerations.”<sup>29</sup> The group added a fourth dimension in to their plans allowing for time to be an integral part of the dynamic elements they were creating. They attempted to anticipate change and structure it rather than allow it to happen randomly. “ They thus transcended city proposals of the past by demanding incompleteness, open-endedness, and fluidity.”<sup>30</sup> The biological component reflects this attitude of the organic nature of the urban sphere treating the city as a living entity rather than a static form.

Tokyo at that time had doubled in population from 1945 to 1960 and many feared that the rapid growth would only continue. Kenzo Tange theorized that the city would eventually paralyze itself if it did not find a new way of growth capable of sustaining the population. His design to combat the growing forces of urban expansion was proposed in 1960 after his time at MIT. The project proposed a central axis where growth could develop outwards stretching from Marunouchi in Tokyo all the way to Kisarazu in Chiba. Transportation was a major design factor and Tange proposed 10 lane super highways running across this megastructure to connect all of the urban expanse. Within this transportation network were all the pieces that make up a modern city including commercial, civic and retail spaces. Branching outwards across the bay were massive residential pods that connected to one another along this central corridor. This proposal sparked the imagination of many and brought into the spotlight the movement that would grow to define 1960s Japanese architecture.

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29 Isozaki, Arata, Richard Koshalek, and David B. Stewart. *Arata Isozaki: Four Decades of Architecture*. London: Thames & Hudson, 1998. Print. (36)

30 Kenzo Tange and the Metabolist Movement (98)

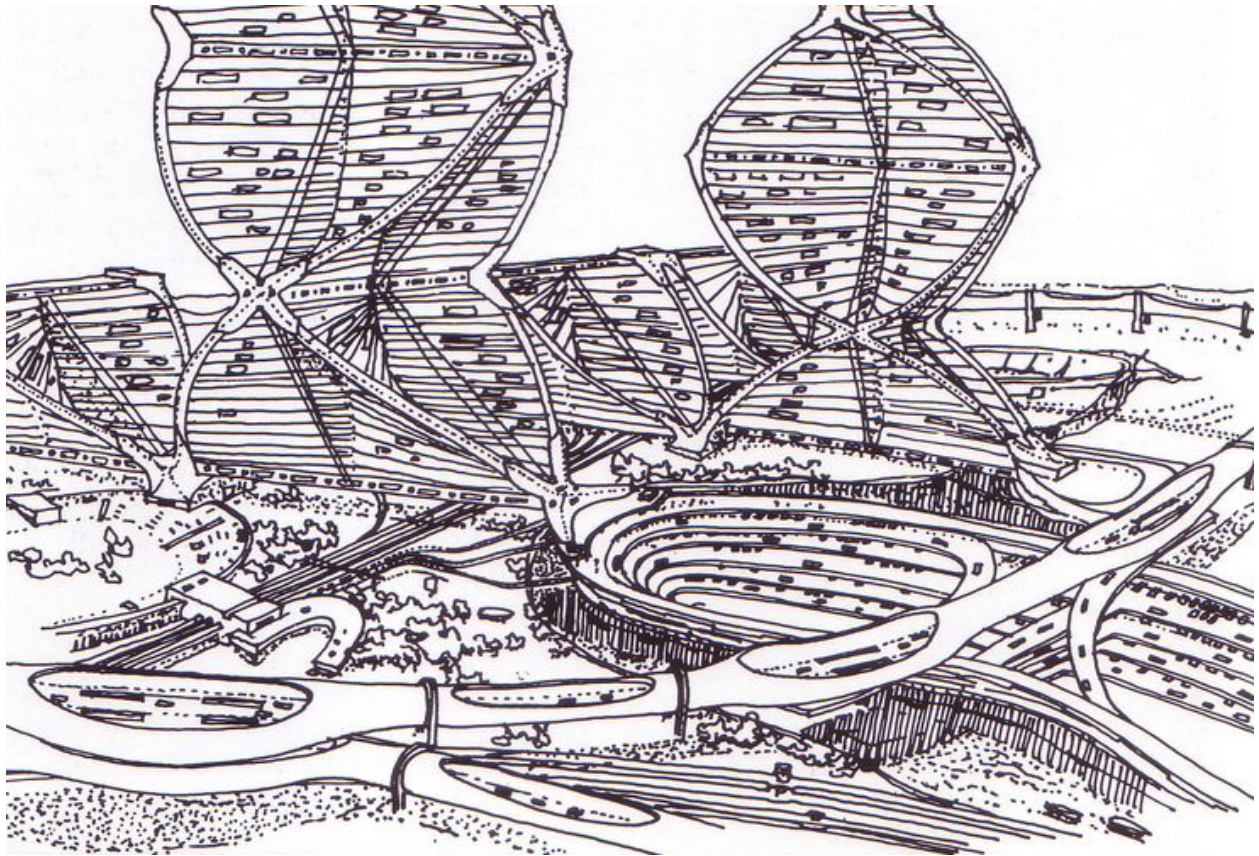


Figure 027: Floating City Kasumigaura by Kurokawa

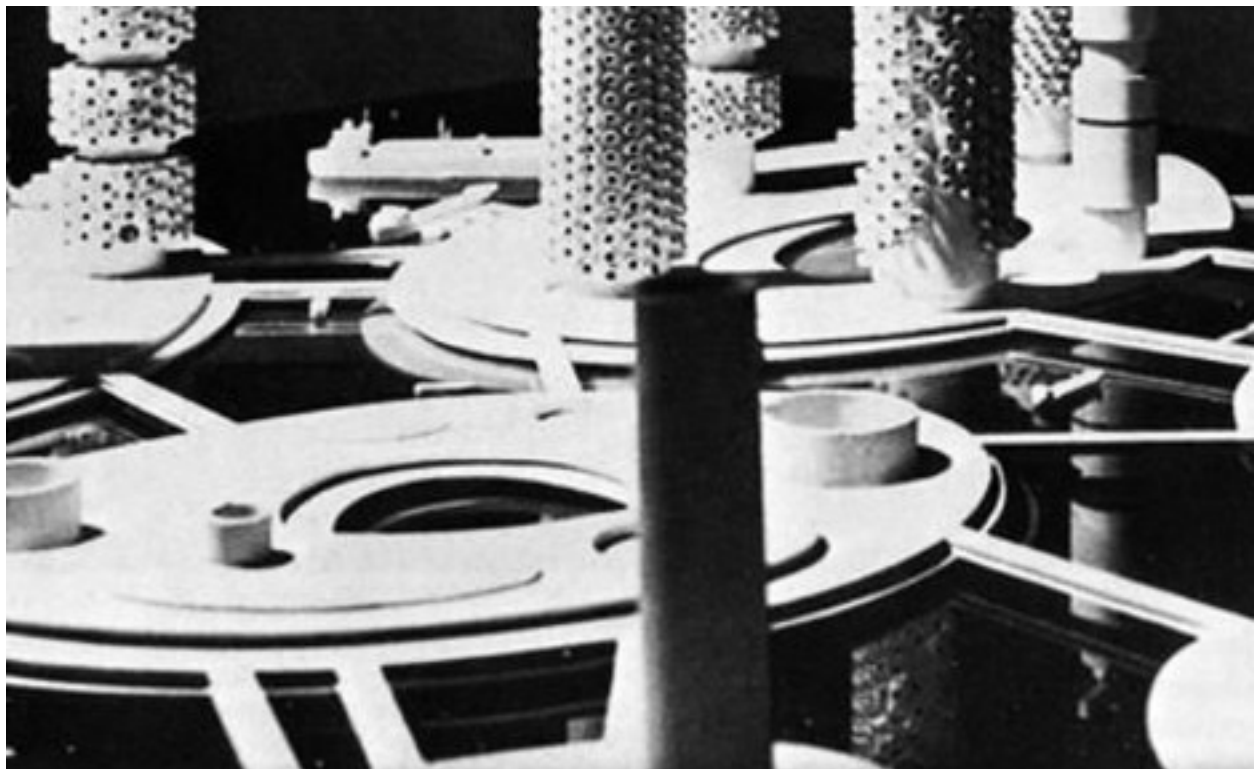
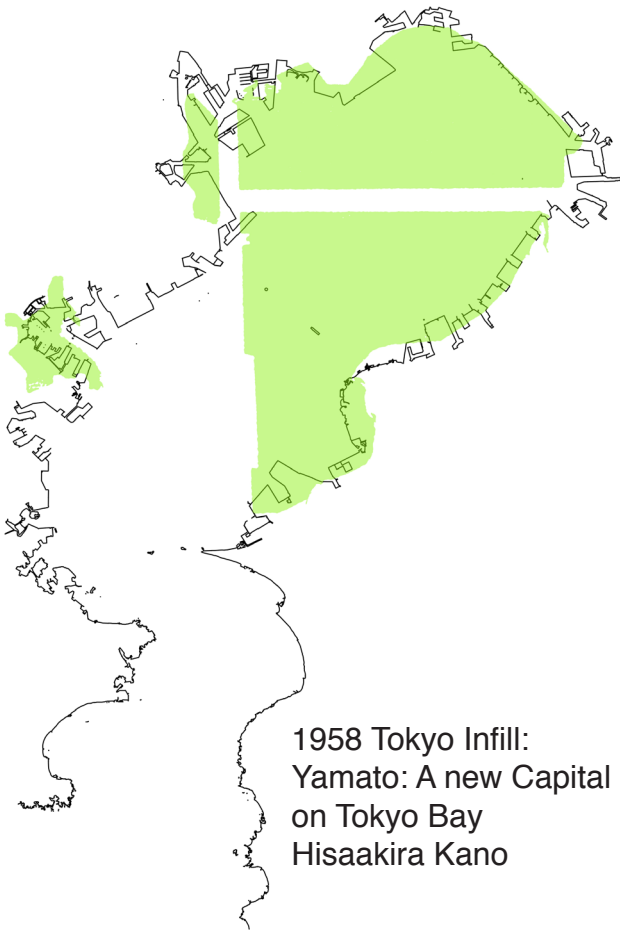
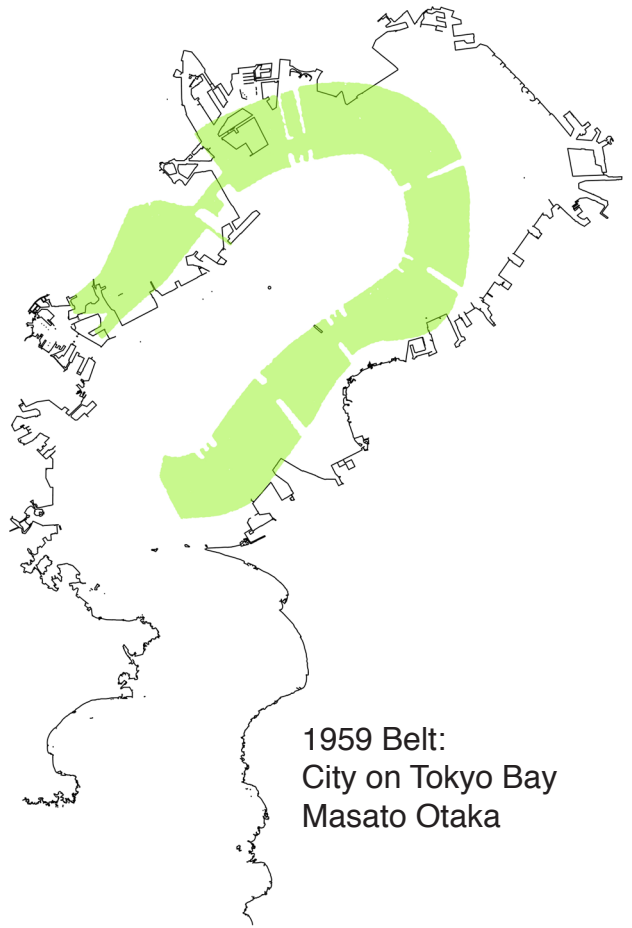


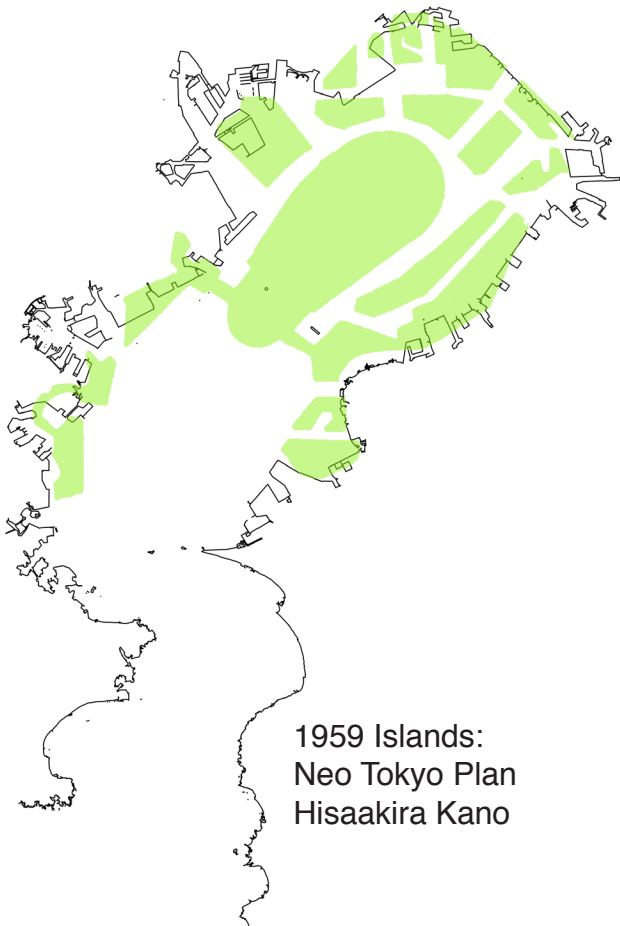
Figure 028: Marine City Model by Kikutake



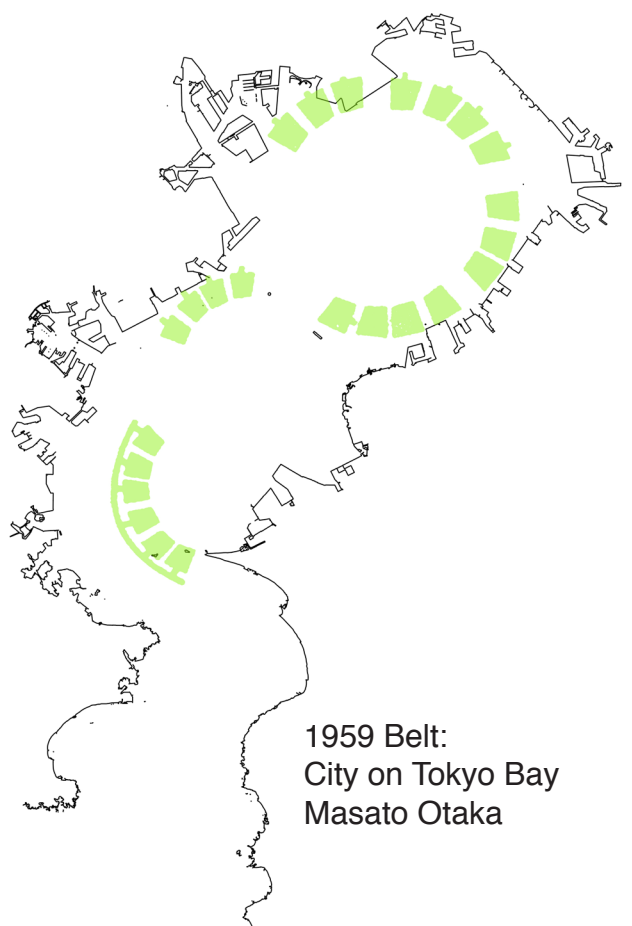
1958 Tokyo Infill:  
Yamato: A new Capital  
on Tokyo Bay  
Hisaakira Kano



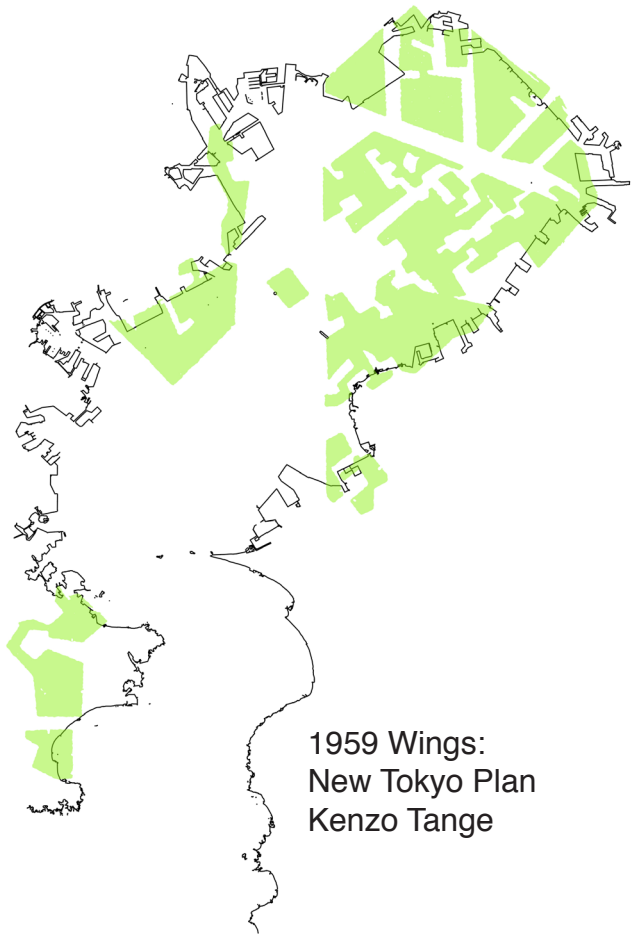
1959 Belt:  
City on Tokyo Bay  
Masato Otaka



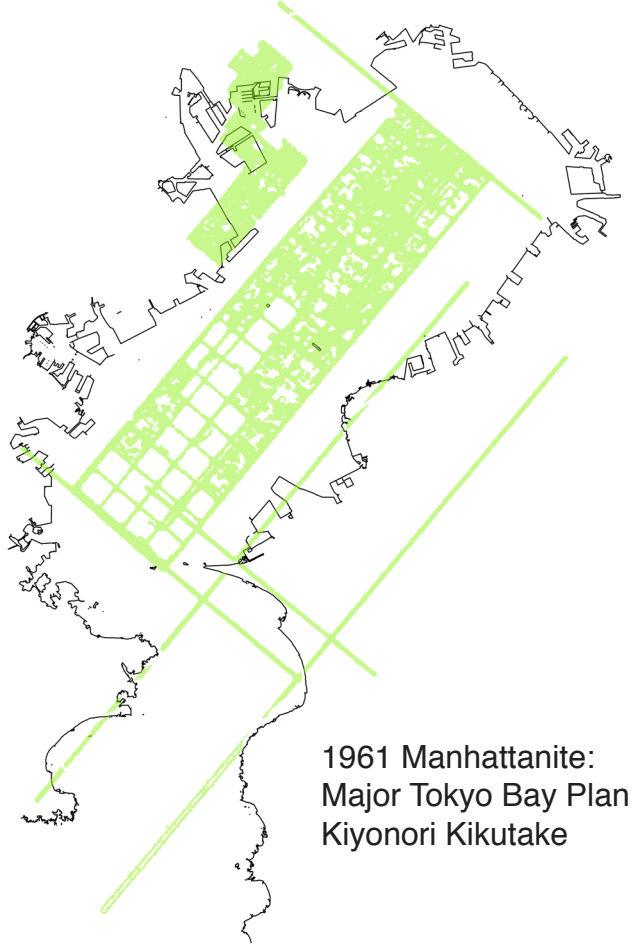
1959 Islands:  
Neo Tokyo Plan  
Hisaakira Kano



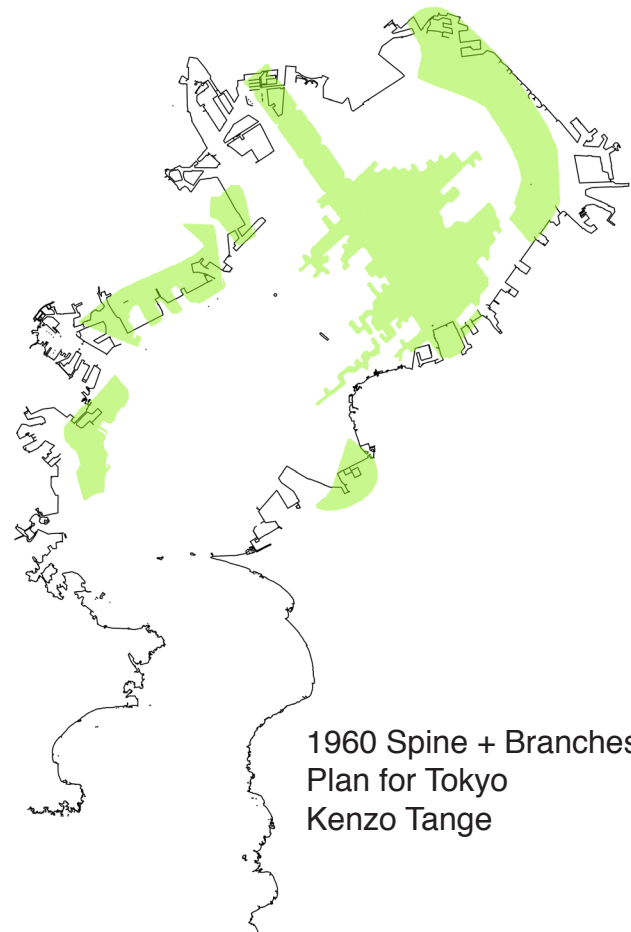
1959 Belt:  
City on Tokyo Bay  
Masato Otaka



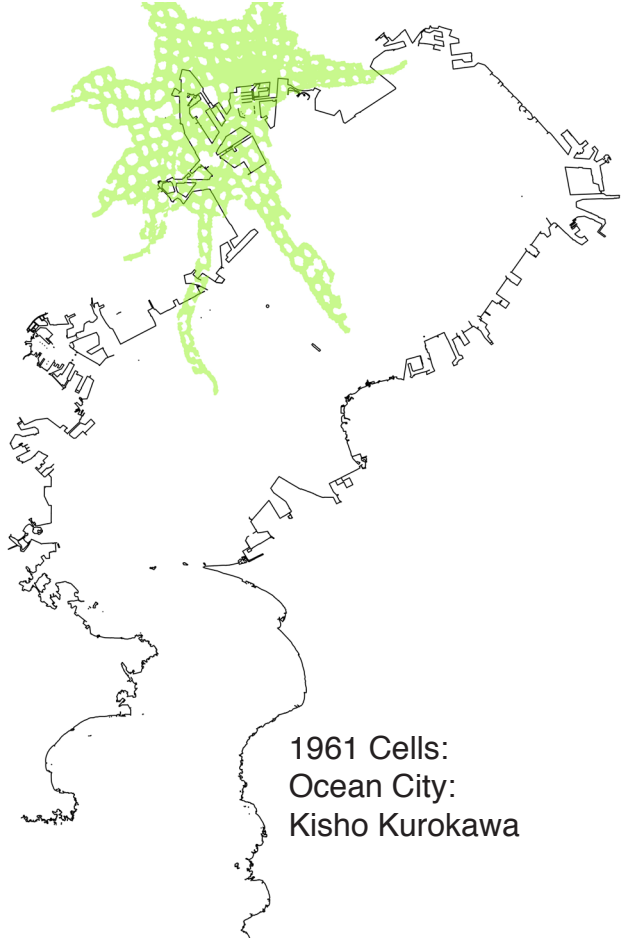
1959 Wings:  
New Tokyo Plan  
Kenzo Tange



1961 Manhattanite:  
Major Tokyo Bay Plan  
Kiyonori Kikutake



1960 Spine + Branches:  
Plan for Tokyo  
Kenzo Tange



1961 Cells:  
Ocean City  
Kisho Kurokawa

## Tokyo 1964 Olympics

The Tokyo Olympic Games held in 1964 were the first to be located on the Asian continent. Originally, Sapporo Japan was slated to host the 1940 winter games, but with World War Two the games were called off. By the time the 1960's came, Japan had developed its economy after the war and the country had blossomed with new growth, energy and prosperity for its citizens. The downside of this rapid growth was Tokyo had become very congested. Luckily, with the Olympics looming, the government stepped in to implement the largest single construction project in the cities history. New highways were built, facilities constructed and the city began to shift from traditional to contemporary. The crowning achievement of these infrastructural projects was the Olympic Highway. A four lane toll road that delivered people directly from the Haneda airport to downtown in less than 25 minutes, which at that time was unheard of with previous traffic and roads.

The Olympic stadium was a retrofit of an existing structure built for the Third Asian Games in 1958. By adding capacity and connections to the new transit network, it became the central hub for the 64 Games. "It was quickly apparent that Japanese hosts had prepared with consummate care. The great machinery of the Games picked up speed smoothly and hardly a complaint was heard from any quarter."<sup>31</sup> The games were not only prepared well logistically but also architecturally. Kenzo Tange designed the Yoyogi Sports Park where swimming, diving and basketball. "A search for the right means of enclosing these volumes led Tange to evocative, long-span tent forms; to a ridge tent for the larger structure, to a bell or parasol tent for the smaller. Transformed to heroic proportions, these forms required the most careful shaping and engineering analysis."<sup>32</sup> As it states, Tange's design was shaped out of a vision for the ethereal lines of the water from the sporting events along with the tendencies of the metabolist movement to look

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31 Olympic Architecture (81)

32 Olympic Architecture (81)



Figure 030: Kenzo Tange Yoyogi Stadium, 1960 Olympics



Figure 031: 1959 Infrastructure Growth in Tokyo

at biomorphic elements of growth and transformation. This building, inside and out, held a majestic quality of organic lines, yet structural rigidity. The forms stability grounded it in the landscape while the peak and spire brought out a sense of reverence. The verticality of the volume coupled with the diffuse natural light that plays across the interior ribbing beautifully focused the energy of the space on the athletes' feats in the pool.

Interlaced with the architectural achievements was the introduction of traditional Japanese gardens. These were used to soften the harsh nature of the materials used and to display the cultural heritage of Japan. A perfect example of this is the complex where the gymnastics events were held. The use of water, stone and landscape coupled with structure created a scene that was both traditional and modern in the same glance. Further, it brought out established forms of Japanese craftsmanship dating back centuries.

“Nearly all of these designs were suitable symbols of a new Japan, and in spirit no less than the time, they belong to the late 1950's and early, 1960's. They belong to a span of years when architects everywhere were intensely interested in structural expressionism and were confident that they were looking out on an expanding horizon of new forms and building technologies.”<sup>28</sup>

Visitors who came to these Olympic Games did not leave disappointed in either modern or traditional architecture. The games had a balance of both that helped to soften the tensions between many western countries and the centuries of isolation Japan had held. The expressive ways of demonstrating both the cultural heritage and modern technology of the country aided in the entire composition of the Games and its successful outcome.

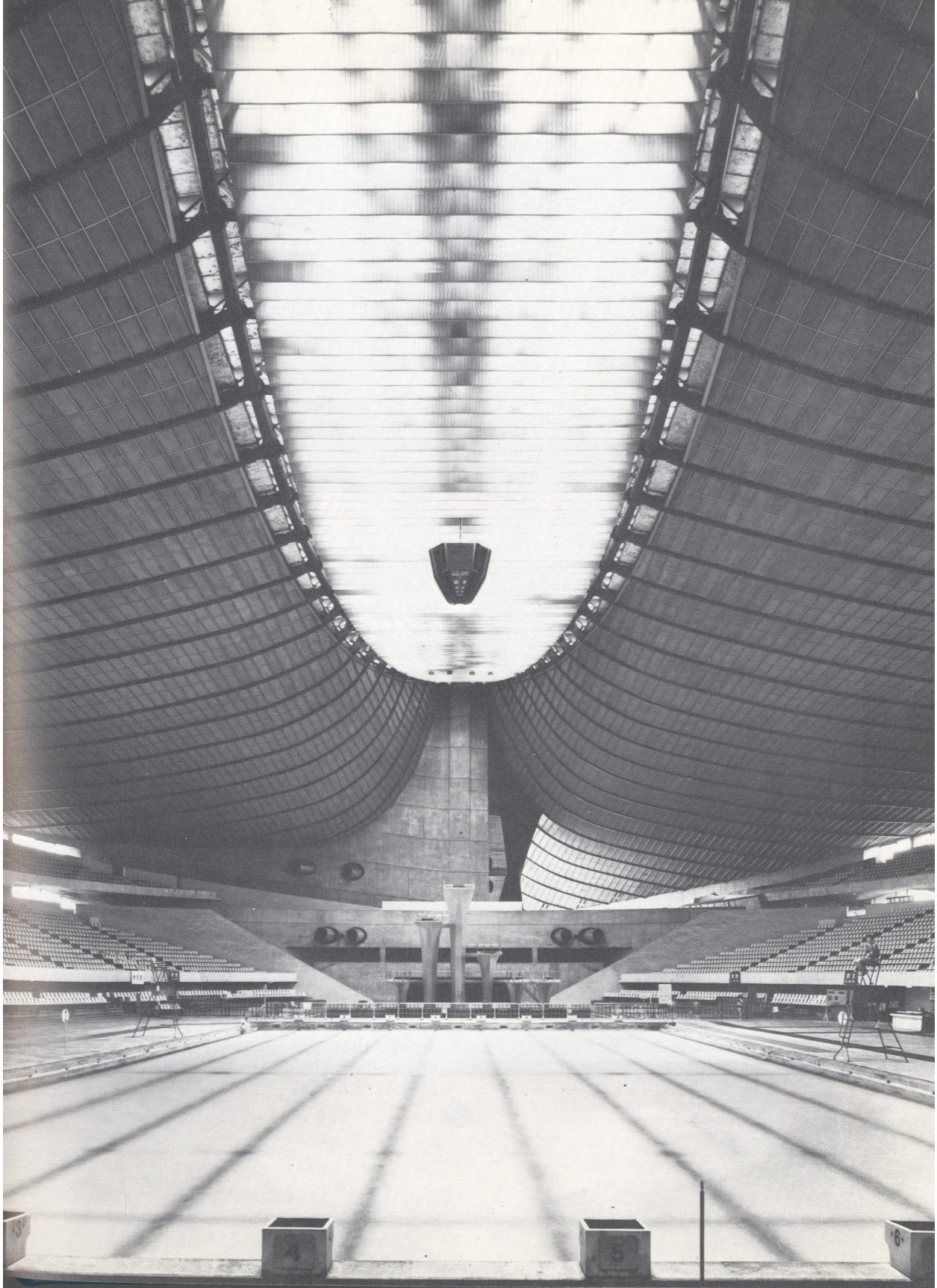


Figure 032: Interior of Yoyogi Stadium, Kenzo Tange

## Barcelona Olympic Village 1992

The 1992 Barcelona Summer Games was the first event to truly integrate the Olympic Village planning into the greater development of an urban zone of the host city. Barcelona city planners selected a section of area that had previously been disconnected urban blight. It was situated between the ocean and major train tracks, effectively cutting off easy transportation to the greater urban area. Further, it was home to many half used industrial buildings with little value. "It was kind of an urban void, and therefore an ideal space in which it carry out an in-depth renovation..."<sup>33</sup> This statement by an individual who worked directly on the urban planning of the site further speaks about how the entire transformation of a district such as this had never been undertaken before, only had it been researched in an academic setting. Major criteria for the infrastructural part of the project was to clean up and make habitable all the beaches along the coast that were at that time undesirable, move or re-route all rail lines to better connect the future Village to the rest of the city and modernize the utilities and other services to serve the new development. Continuity with the existing city was paramount for success. This was undertaken by first applying the cities 20, 50, and 100 year master plans to the district to find commonalities between it and the needs of the Olympic Games. They developed varied and superimposed uses within a larger single coherent plan. The concept was the master plan would determine the invariables and subsequent projects within the zone would become increasingly detailed and individualized. This emphasized the individual experience and aided in its subsequent success.

Several series of mater plans were drawn up from 1986 onward with the final plans being put into motion by 1988. This plan demonstrated the possibility of the succession of alternative designs and uses post games yet adhering to the coherence of the entire project.

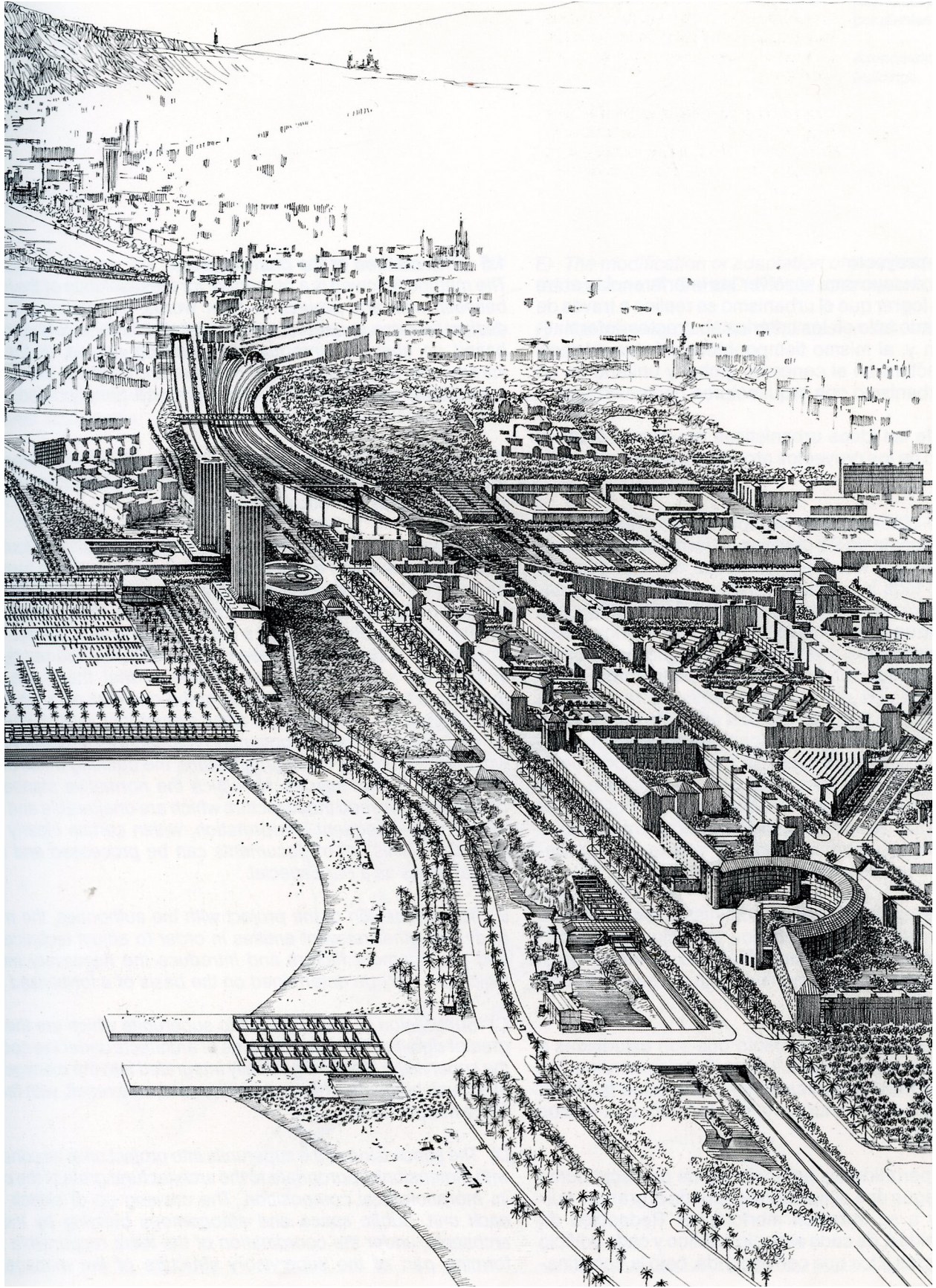


Figure 033: Sketch of Barcelona Olympic Village

“One aspect which deserves special emphasis is the criterion used to delimit the areas of the project units within which each of the architects was to operate. This consisted of retaining the traditional concept of division into plots within a continuous, predetermined urban fabric, but with two new parameters. The dimensions were not to correspond to a simple transaction for the transmission of the property, but to an architectural sketch design, so that without abandoning the differential limits and the necessary continuous juxtaposition, each project could be developed with a sufficiently significant degree of autonomy, and the appropriate modifications carried out within a coherent area.”<sup>34</sup>

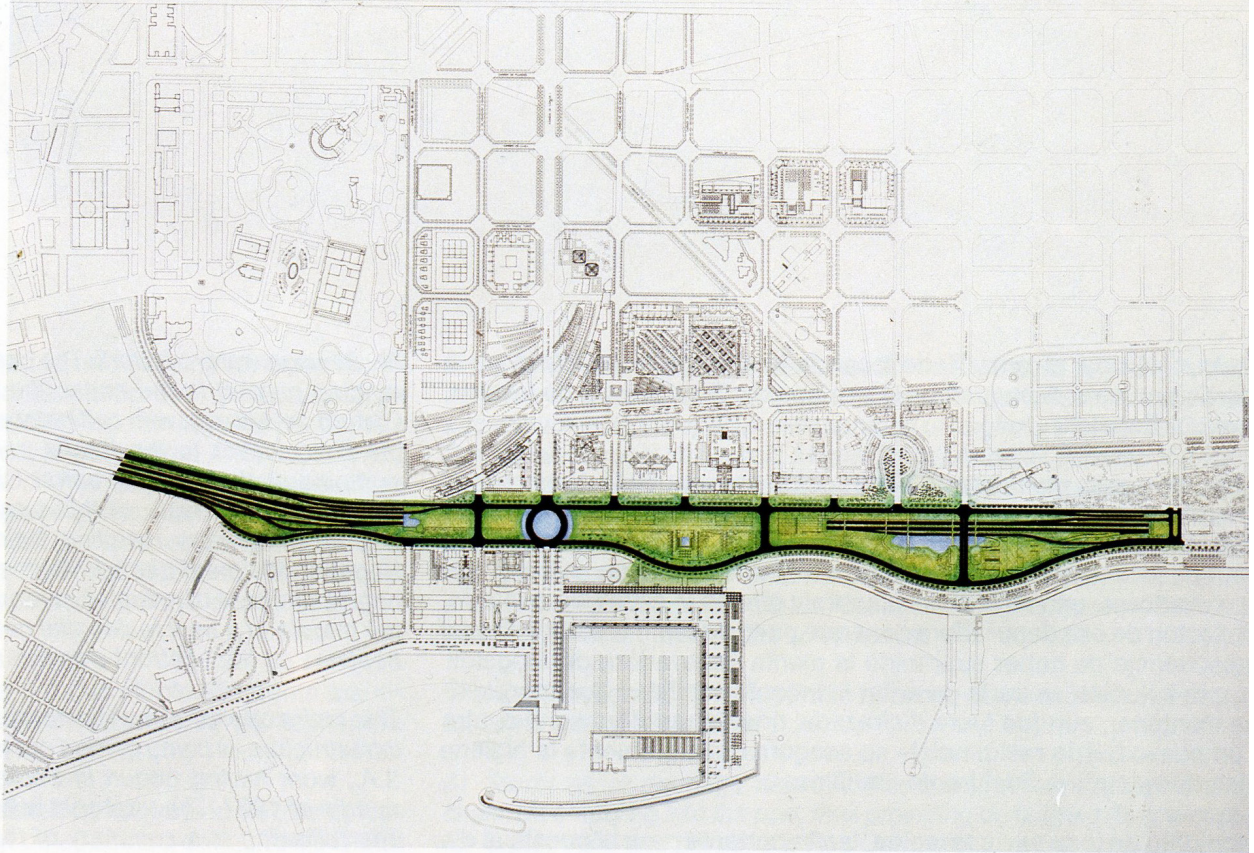
This level of architectural and urban integration is abundantly apparent with the formalization of not only the master plan but the details brought out in each building. By combining the infrastructural moves into the smaller scale plot detailing, it made the project not only successful for the 92 Games but is still working within the urban fabric of Barcelona today. Housing prices in Barcelona increased 131 percent from 1990 - 1996 where the rest of Spain grew at 83 percent.<sup>35</sup> These numbers show the value and legacy impact of the Olympic Villages outcome on housing in the city district.

On an infrastructural level, the master plan rerouted the entire railway network which had previously cut off the Olympic Village site from the rest of the city. Routing this underground led to better connections with existing subway, greater transportation options and a clean slate with which to construct the surface infrastructure. The main arterial lines defined the major moves of the site with smaller tertiary streets tying into the existing grid of Barcelona. Another important part of the project was not only the reconnection of the site to the city, but creating a destination that currently citizens would want to use post games.

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34 La Villa Olimpica Barcelona 92 (22)

35 Bernstock, Penny. Olympic Housing: A Critical Review of London 2012's Legacy. N.p.: n.p., n.d. Print.(88)



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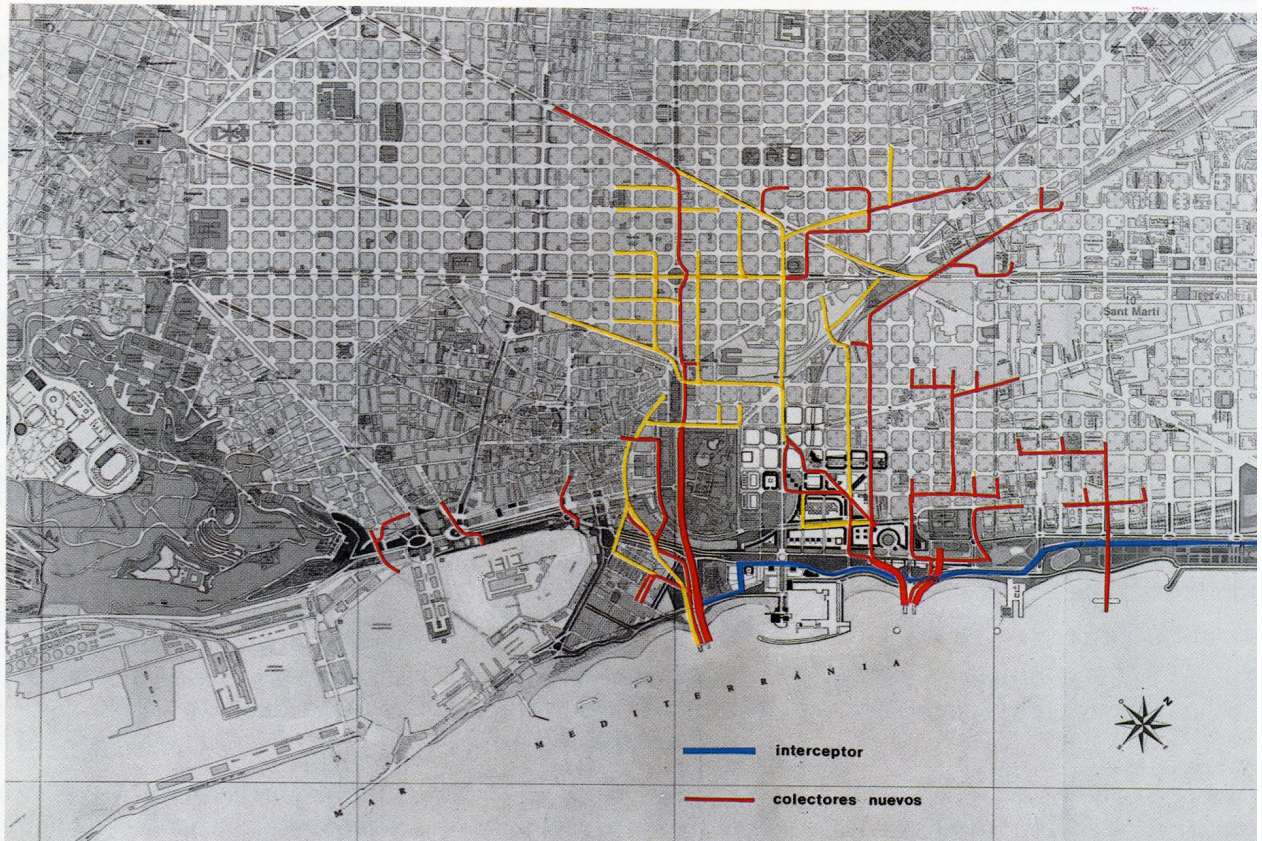


Figure 034: Barcelona Diagrams of Civic Connection

This led to the creation of a multitude of new urban parks and the redevelopment of over 2km of beach. This took an area of Barcelona traditionally known for industry and made it one of the most valuable new districts of the city.

Much of the housing for the Games and beyond was developed in large 'superblocks' of 100 units or more. Each block within the larger master plan was given to a different architect to help the monolithic scale of the entire development. Each individual housing development had a set number of units required and other metrics that governed building height and FAR, but beyond that architects were given a mostly free reign to be individually expressive. They were anywhere between 15,000 m<sup>2</sup> and 25,000m.<sup>2</sup> This led to an amalgamation of building appearances, yet the continuity of the master plan, held them all together. Within these larger housing blocks were what the master plan designers called, gateway buildings. These were used to help break up the feel of the super blocks as well as at as a diaphragm that changed the charter of the street from interior of block to exterior. This concept comes from the famous chamfered corners of traditional buildings in Barcelona. The scale and visual nature of these details helped to signal events within the peripheral streets and aided in the compositional freedom of the architects to use different size and materials in successive facades.

The Barcelona Olympic Village shows a deep understanding of the macro vision connecting and redeveloping an underutilized section of the city with the individual structures and parks making it both a unique setting and destination spot in the city. After the games some of the most sought after real estate in the city was within La Villa Olimpica, proving the legacy effect of the development. Delineating between large super block development necessary for the physical amount of housing for the Olympics and the careful care of each parcel is the intangible feel of the location. This largely successful project proved to future host cities that they could not only use the Games as leverage for new sports

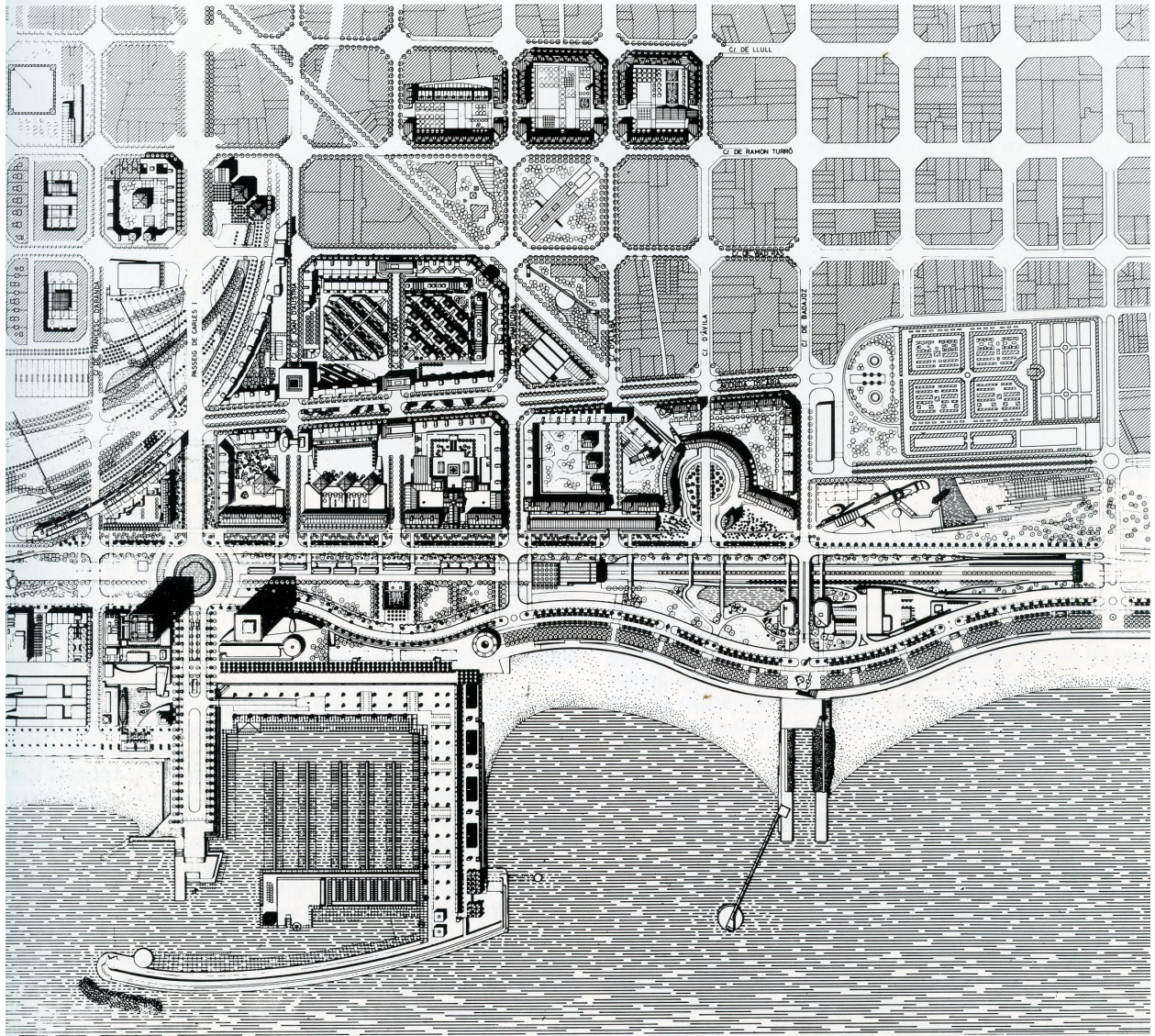


Figure 035: Plan of Barcelona Olympic Village

facilities but act as transformative event for an entire district of the urban fabric.

London Olympic Village 2012:

The 2012 London Olympic Games were constructed on the theme of sustainability and legacy. Major considerations for the project were broken down into six categories across the planning and design phases. These included sustainability, longevity, affordability, biodiversity, economic, and visual guidelines. The Olympic Village extended across a site of 30ha. Split into eleven different plots each with its own design team. The planning phase of this project looked to the Barcelona Games and how successfully it transformed an entire district of the city. “When the Games were awarded to London, the area of Stratford in the east of the city was chosen as the location of the Olympic Park for various reasons, but contributing to this decision was the fact that the area is surrounded by some of the most diverse, and most deprived communities of the country- in desperate need of regeneration.”<sup>36</sup> This prompt was similar to Barcelona, and the planning phase took on much of the same processes. By diversifying each plot to a different design team, they allowed the look of the village to produce a non-uniform appearance, creating greater diversity of visual interest and less of a planned development.

The actual design and construction of the Olympic Village was given to 17 architecture teams with the intent of developing 2818 units encompassing 350,000 m<sup>2</sup> of interior space. They developed a set of standard details and material connections to ease the coordination with the eventual contractors. Further, windows, doors and even kitchen build outs were all standardized to ensure a timely delivery and ease of construction. Even with these guidelines, each plot took on its own visual image, lessening the apparent scale of the project. A new technique was used to increase the number of individuals living in the Olympic Village during the games and then decrease it when it became East



Figure 036: London Olympic Village 2012

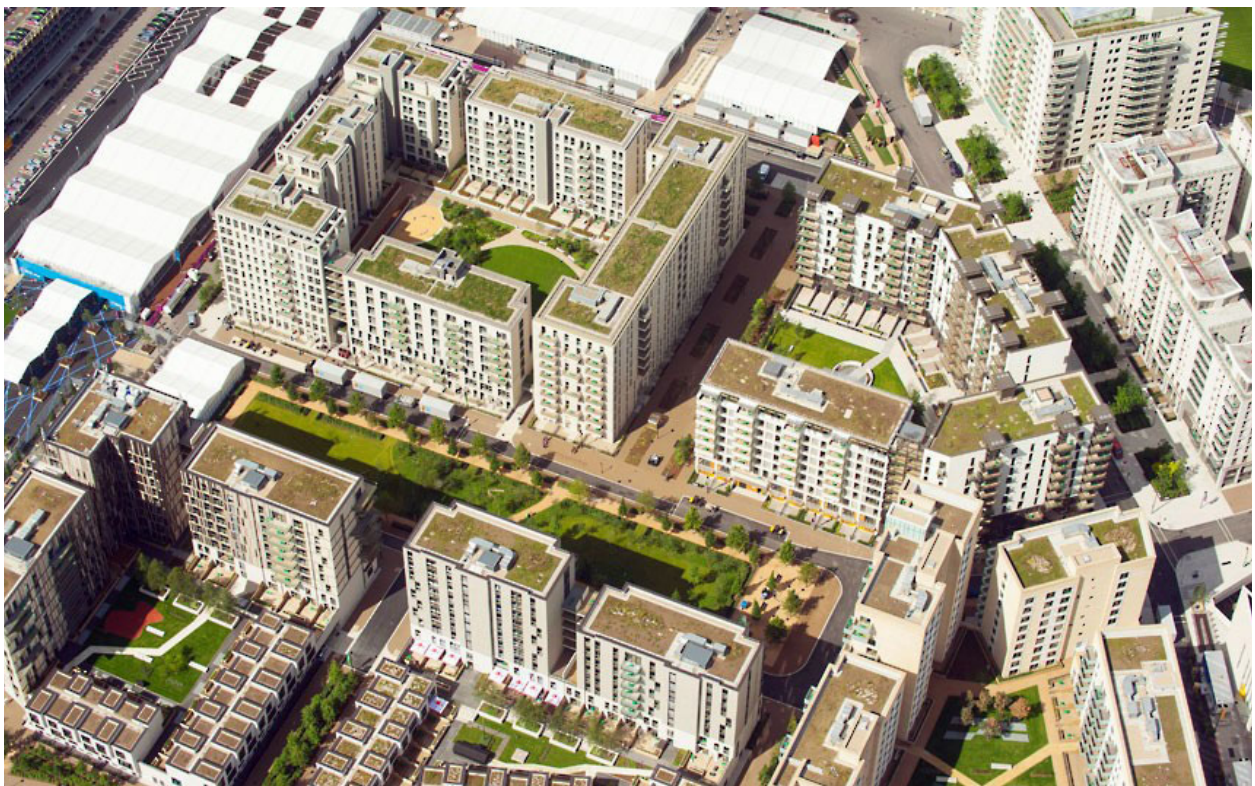


Figure 037: London Olympic Village 2012

Village after. One of the major phasing components was the original lack of kitchens in the units. No units had these features during the games as all the athletes and staff used the many dining halls on the campus. Post Games kitchens were installed, walls were altered and the occupancy went from 18,000 during the games to around 12,000 post. This transformation allowed for less overall construction while still meeting the needs of both stages of use.

This idea of phasing construction and implementation can be applied to this thesis, as the development of the floating Olympic Village is to transform into a floating city. It also brings in the ideas of modularity and rapid production. The legacy aspect of the London project also shows that with the government developing 12,000 units of housing, many more are built by private investors capitalizing on the influx of capital and attention. “The regeneration will create 30,000-40,000 new homes in the area. It will be a catalyst for investment that will create new, quality housing – much of which will be affordable housing available to key workers such as nurses or teachers.”<sup>37</sup> This private sector development is how a Tokyo Bay project could become a reality. By the government creating implementing a trial phase to prove the larger urban plan and concept, and using the Olympics in 2020 to showcase the design and capability of the design, it can be replicated many times over in future phases of implementation.



Figure 038: London Olympic Development 2012

## Contemporary Public Housing Projects: Riken Yamamoto

Riken Yamamoto presents public housing with a new image consisting of community-centered design. This recent approach is meant to achieve new social objectives and enrich spatial experiences for the residents. Previous public housing centered on the layout of individual units and separation from other persons rather than creating connections. The Shinonome Canal Court project in Tokyo Japan along with the Pangyo Housing complex in Pan-Gyo, South Korea express these values of community centered design and provide a case study for how further mixed use residential development can foster socially sustainable communities.

Public housing in post war Japan had demanded more pluralistic and individualized housing environments for an increasingly singular community. During the 1960s with the population expanding at an exponential rate smaller and smaller dwellings were created to meet the demands of housing in a dense urban environment. The new public housing created by Yamamoto pushes against the individualizing and anti community block housing of the 60s-90s and looks towards redeveloping the social and spatial relationships once established in communities of a previous century.

Shinonome Canal Court developed from a master plan overseen by Riken Yamamoto. Six different architects including Yamamoto were given the task of creating 14 story block public housing in downtown Tokyo.<sup>38</sup> This housing focused on the social objectives of enriching the residents experience and fostering the entire project as one micro community within the larger fabric of Tokyo. Toyo Ito and Kengo Kuma among others were apart of the project, adding to its mystique as a turning point in Tokyo's public housing

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38 DIMMER, C., GOLANI SOLOMON, E. 'The Private Case of Public Space - a Visit at Shinonome Canal Court, Tokyo.' *Architecture of Israel Quarterly*, 62, pp. 84-94, 2005.



Figure 039: Pangyo Housing: Riken Yamamoto



Figure 040: Shinonome Canal Court Apartments: Riken Yamamoto

collection. The reasoning was the sub-standard and outdated housing mainly constructed in the 1970s for the Urban Development Corporation was deteriorating and individuals no longer wanted to live in such units. This shift from corporate, individualized units to a broad reshaping of how to design public housing was necessary and this project became the fundamental turning point for such typology in Tokyo.

Pangyo Housing built in 2010 was a competition to develop a varied typology of housing along a diverse terrain. Built specifically for 100 low-income families, this project's aim was to foster connections and provide not only basic units but housing that created social connections within the residents. The complex is located around an hour and half drive from Seoul, South Korea in the town of Seonganm. The balance of family privacy with neighborhood connections is what makes this development a unique precedent that creates rather than detracts from the larger community.

Both the Pangyo housing and Shinonome Canal Court have unique sites that inform their design and connection to the greater landscape. Shinonome has the unique topography of being located on reclaimed land near the city center, yet there is a measured isolation from the main flow of Tokyo by the boundaries of water and ports. Pangyo is located at the foot of rolling mountains whose topography influences the entire layout of the city it is located in. Both sites offer solutions that foster community and connectivity in their own ways. The court yard is central in the design as can be seen in 042. By creating a scale that humanizes the surroundings, it offers a better feeling of space than the vast metropolis of Tokyo, or rolling snow-capped mountains. It grounds the project and forms the basis for civic development. Each court is scaled to the dimensions of the project. Shinonome has a tiered system of courts that help to divide the larger space into more usable and programmable elements while Pangyo has small alley-style courts that flow around and through the nexus of individual dwelling units.



Figure 041: Pangyo Housing: Building interaction with hillside



Figure 042: Shinonome Canal Court Apartments: Court yard interior

From interior, come the exterior connections to the larger city grid. Transportation is a key element of both projects and both take a similar approach of pushing those system elements underground to promote a walkable and functional communal level. This pathway from exterior to interior is not a individualized event but rather a chance for exploration, meeting and social interaction. By purposefully creating and connecting spaces in between the entrance to the site and the destination of the individual unit, it expands on the overarching theme of connection and social growth. The sections in figure 043/044 show this importance of both vertical and horizontal pedestrian circulation. This movement of individuals creates a more diversified path that people will take to their units rather than the typical linear pathway. Transparency is shown in section as light is brought into both the private pathways and open courtyards. This serves as both visual and physical link to the important nodes of the project as well as the larger context of the complexes surrounds. Whether it is tall residential towers or rolling hills of trees, this ability of the inhabitant to at the same time feel contained and secure within their community yet have a relationship to the greater world only serves to enhance their feelings of spatial connectivity.

The defining piece that brings the projects together is the central component of the design concept, community. They use nodes of flexible common space to generate a visual and physical dialogue between residents. In Shinonome these nodes are exterior double height spaces that dot each floor and penetrate the block from interior to exterior. They offer spaces for flexible ad hoc programming by the residents rather than a fixed layout or purpose. In Pangyo, the nodes of connection are the transparent middle layer of the dwelling units. These spaces were intended for the residents to use in a myriad of ways from living room, to kids play area, to home office. This flexibility goes a step further and the living units can be divided into individual families living above and below this flex space and both sharing it for mutual gain. According to the architect, the spaces are being used

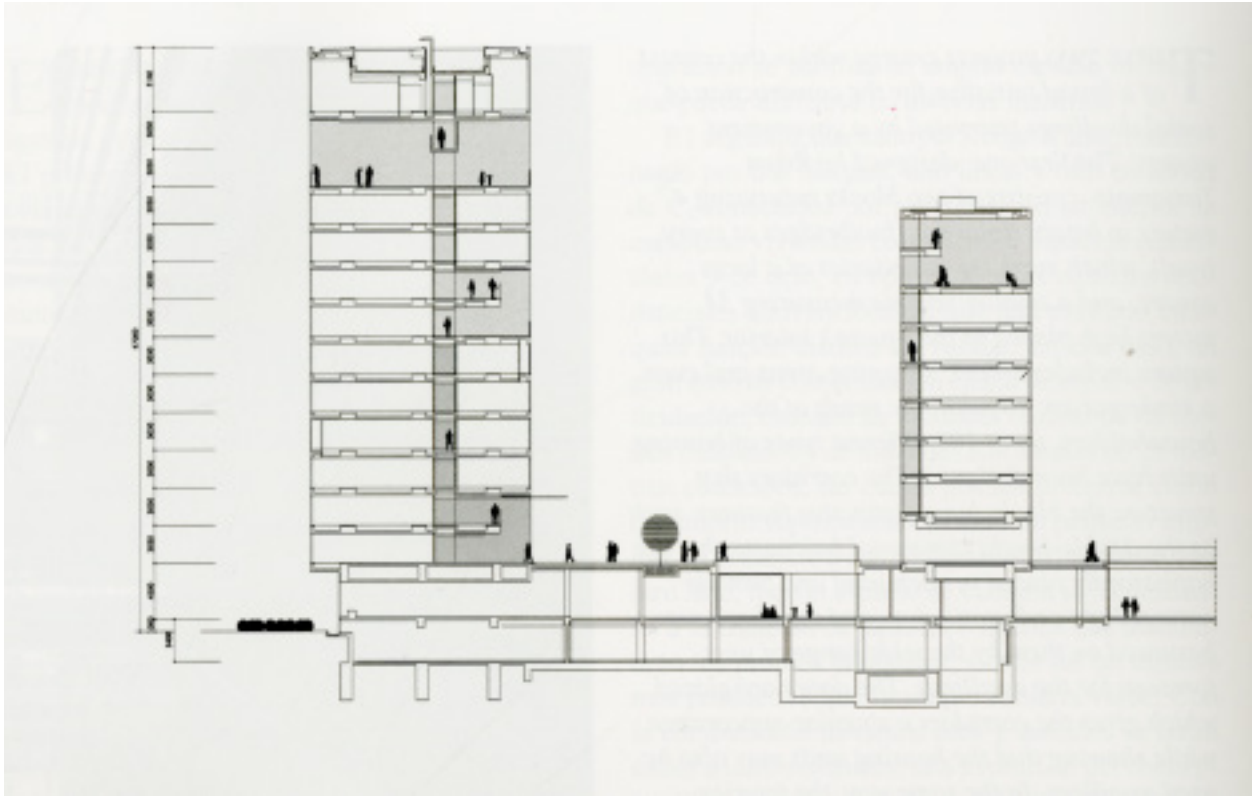


Figure 043: Shinonome Canal Court Apartments: Section

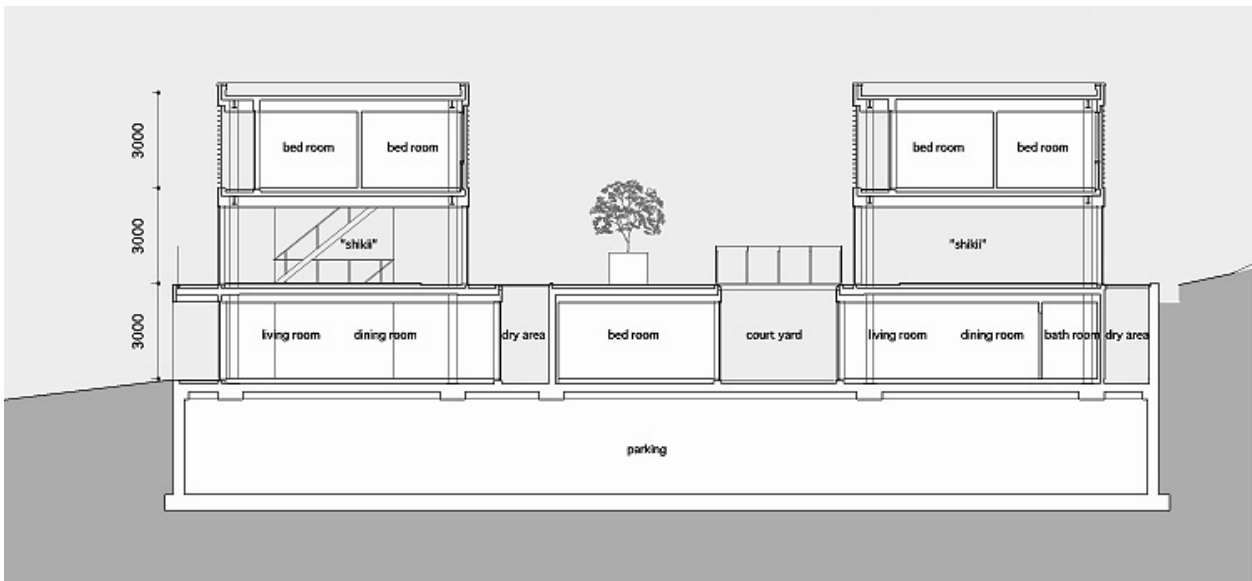


Figure 044: Pango Housing: Section

for a variety of purposes fitting a diverse and complex community of individuals.

Floor plan flexibility is key to these projects achieving the level of user buy in and connectivity intended in the design concept. Both are intended for a diverse user group and are able to meet the needs of changing family dynamics. Shinonome has 450 units of housing while Pangyo is designed for 100 families.<sup>39</sup> Both floor plans are simple with screens that help to divide up the spaces for individual needs, yet are able to be moved to reconfigure the overall foot print at a moments notice. Shinonome Court has dynamic floor plans that can be seen in figure 46/047. This phase of three plans shows how the same room can be reconfigured to meet the changing needs of the occupant.

“The idea is that the comings and goings between the interior and exterior traffic areas will animate the site and consequently stimulate the moods of residents who will be proud to live in such a place.”<sup>40</sup>

From apartment, to small office the units of the Shinonome project are no longer pure residences but able to adapt and generate commercial uses within the overall structure of a residential tower.

Pangyo housing’s floorplans are very simple rectilinear forms that are divided into two elements, public and private. Sleeping, bathrooms and some living are encapsulated in screens that help create a sense of privacy yet still generate views for the inhabitants with the central node layer acting as a portal to the rest of the community. Stairs penetrate each individual volume to connect all layers. Figure 045 shows how each unit is not only connected to those surrounding it but the entire plan of the development. This communal

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39 A&V Monograph: Riken Yamamoto, 116-117

40 “Build High Density and Flexible, Free from Standardization.” : L’Architecture D’aujourd’hui 358 (2005): 55-65. Print. 10 Nov. 2015.



Figure 045: Pangyo Housing: Site plan



Figure 046/47: Shinonome: site plan/ unit plans

connection and simple configuration allowed for easy construction yet generates a diverse set of floor plan configurations that make the individual user feel more connected to the architecture than if they were in standard block housing. They enrich the experience of all who inhabit the space.

Reinforcing the social interaction of private and public spaces is paramount to not repeating the failed attempts at housing from previous generations. Riken Yamamoto proves this can be done while building large dense structures on budget. These community designed spaces have been well received and not only generated better return on investment from the developers but created working communities.<sup>41</sup> Yamamoto has found an equilibrium between public and private spaces from the large master planning of both projects to the small scale details of each floor layout. Further the flexibility and overall modularity of these projects uses the metabolist thoughts of the 1960s and brings that theory into the 21st century. As Yamamoto states, "...the Canal Court in Tokyo is not the fruit of modernist thinking or the adoration of the international style but rather a free reflection that respects life's mobility."<sup>42</sup> This complimentary view of both flexibility and function brings new life into what many see as cold impersonal buildings. This does however have a counterpoint to the public centered community designed thesis of both works, in how much public connection is too much? By integrating people through architectural moves will everyone that not all feel comfortable with their life being partially public? Overall both projects are very well received by their occupants, but looking forward at the larger picture of where to take these concepts it will be important to not force that community interaction but rather use architecture to hopefully create spaces that generate uses naturally.

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41 L'Architecture d'aujourd'hui: Build high density and flexible, free of standardization, 61

42 L'Architecture d'aujourd'hui: Build high density and flexible, free of standardization, 63

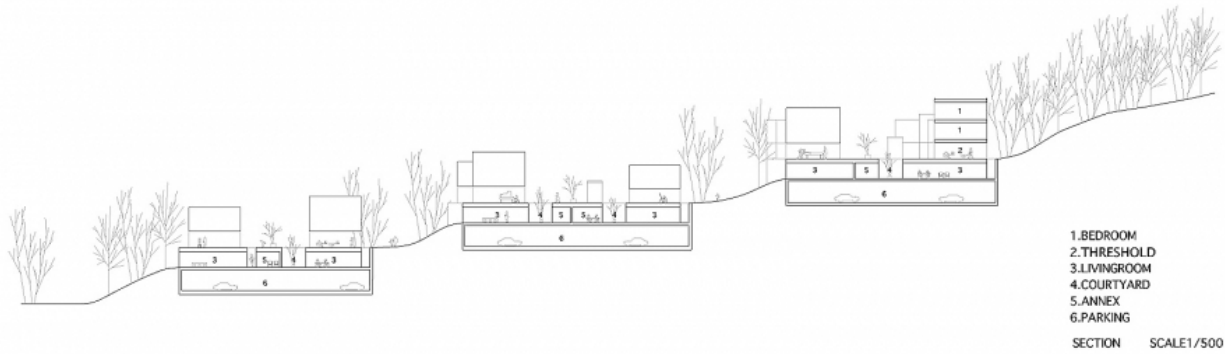


Figure 048: Pangyo Housing: long section

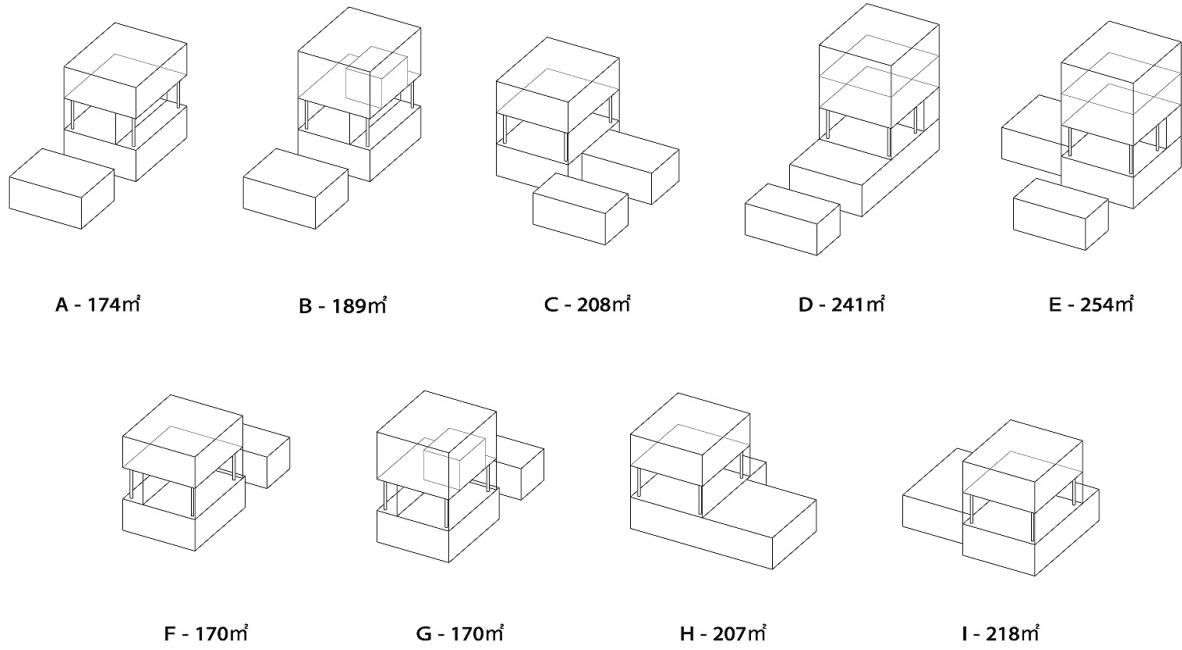


Figure 049: Pangyo Housing: Unit diagrams



Figure 050/051: Shinonome Housing: Interior connections

## Summary of Housing Research

Olympic housing, and in larger part the entire games presents a unique catalyst for design techniques in architecture and urban planning. Today the games are seen not only as a source of pride for the host nation but as a way to leverage billions of dollars in funds to redevelop entire districts of cities. This is clearly seen in all three precedent studies in Tokyo, Barcelona and London. The 2020 summer games located in Tokyo Japan provides a unique opportunity to rethink the broader scale future of development in the region. To this end, research presented here provided a stepping off point into larger urban planning and theoretical discussions about the future structure of Tokyo.

Riken Yamamoto's public housing in Tokyo and South Korea present new ways of addressing the creation of large block structures in the modern era. Looking forward we need to design more integrated spaces that are flexible and modular that addresses the ever changing lifestyle of individuals. Community centered design fosters connections and culture which aids in the overall quality of living within a large unit and the ability to be an individual in a larger group. Yamamoto's work generates positive examples of what the future or large housing blocks should become with personality and cultural connection rather than seclusion and solitude for residents.

## Future Projection

From researching the Olympics and public housing typology, the future will play a key role in how this thesis will address the ever changing landscape of Tokyo. As the Olympics is forward thinking, so to is the thesis in addressing long term problems and generating a phased response over a period of time. The scope of the project would not be able to be developed overnight so putting into place a timeline that reflects changes in society, nature,

disasters and other factors is necessary to plan out the program. The first component of the project must be to address the risk factors facing the population of Tokyo and what might be done to mitigate that. Once risk factors are analyzed and consolidated developing a plan over a period of years would allow a large scale project such as this to evolve and react to ever changing criteria of the urban and natural environment. This brings in the ideas of the metabolist movement of the 1960s as well as the flexibility in design from Yamamoto. By looking outward to the ocean to the themes of how natural systems work we can begin to understand not only how to respond to natural disasters such as Tsunamis but how to develop and generate new, ever improving urban plans for our cities.

### CHAPTER 3: Preliminary Findings

*“The physical environment is not seen only as a container for action but rather a medium with inscribed and reflecting yet changeable meaning and symbolic values. It has a potential of being a fruitful instrument for enhancing, encouraging and sustaining the culture, which indeed should be the essence of sustainability.”*

*- Limin Hee*

## Site analysis/ urban research

Tokyo Japan is the largest city in the world at approximately 37million people.<sup>43</sup> The city is the seat of the Emperor of Japan and the capital of the country. Officially founded in 1869 the city grew from humble beginnings, first as a fishing village and then through the ages an ever increasing city connected to the Emperor. The sea has always been integral to the development and economy of Tokyo. Cyclones and Tsunamis have always created a duality of dependence on the ocean however as inhabitants looked with one eye to the sea for their livelihood, the other to the ever present threat of natural disasters. American Commodore Matthew Perry first sailed into Tokyo bay in 1853 which aided in its eventual development into one of the worlds largest shipping hubs and establishing trade routes between Japan and the USA.<sup>44</sup> Since this connection two major disasters that forever changed the landscape of Tokyo were the 1932 Great Kanto Earthquake and World War Two. The 1932 earthquake was recorded as a 7.9 magnitude. This quake devastated the region and destroyed much of Tokyo's structures. Fires played a major part in the totality of destruction that ravaged much of the city.<sup>45</sup> The bombing of Tokyo during World War Two also brought with it massive conflagrations that decimated the city center. In total it is estimated that over 100,000 Japanese died in bombing raids that destroyed the city.<sup>46</sup> Much of Tokyo needed to be rebuilt post war due to the massive impact US bombing had on the city. It was not until the 1964 Olympics did Tokyo finally recover fully from this damage as the Games prompted this resurgence in development of infrastructure. This changed the overall landscape and urban plan, creating the urban plan we see today.

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43 Worldpopulationreview.com

44 Bunkakyoku, Seikatsu. Tokyo: The Making of a Metropolis. Tokyo: Tokyo Metropolitan Government, 1993. Print.

45 Scawthorn, Eiding, Schiff ed. (2005). Fire Following Earthquake. Reston VA: ASCE, NFPA. ISBN 978-0-7844-0739-4

46 Tipton, Elise K. (2002). Modern Japan: A Social and Political History. Routledge. P141. ISBN 0-585-45322-5

These disasters, from natural to man made have forever impacted the development and growth of Tokyo. The culture of architecture in Japan differs from that of western civilizations to coincide with this relationship with disasters. Looking back to the history of Japanese building style, their design and construction has always been about repair, replacing and a deep connection to time. The modern condition is that individual homes are designed for current needs with the expectation that they will be torn down in 15-30 years as needs change or new owners take over. This temporarily perhaps born in relationship with natural disasters takes new meaning when looking at larger scale infrastructural projects where the time line may be much longer. Understanding the cultural significance of construction and its relationship not only with site context but larger forces is important when looking at a phased system such as this thesis. The ability for change and restructuring would need to be designed into the project as unknown variables in the future would cause a change in thinking about a project such as this.

While in modern history Tokyo has not experienced a severe tsunami, the risk factors only seem to go up with time. The most dense concentration of Tokyo's population is situated at the end of the bay causing for concern because of the shape of the bay itself. Its location makes the natural geography focus and wave energy towards the city center, putting the highest number of people at risk. As stated before, the lowest areas of Tokyo are on reclaimed land which have the tendency to sink or subside during an earthquake. (Figure 047). Coupling these two factors makes much of the area surrounding Tokyo bay a risk zone when looking at water inundation. Another important factor is looking at the bathymetry of Tokyo bay, it is very shallow in most section as seen in figure 048. This exacerbates wave height as the energy will not dissipate due to changes in undersea topography.

Figure 54 shows eight increasing sea level impacts on the land mass surrounding Tokyo

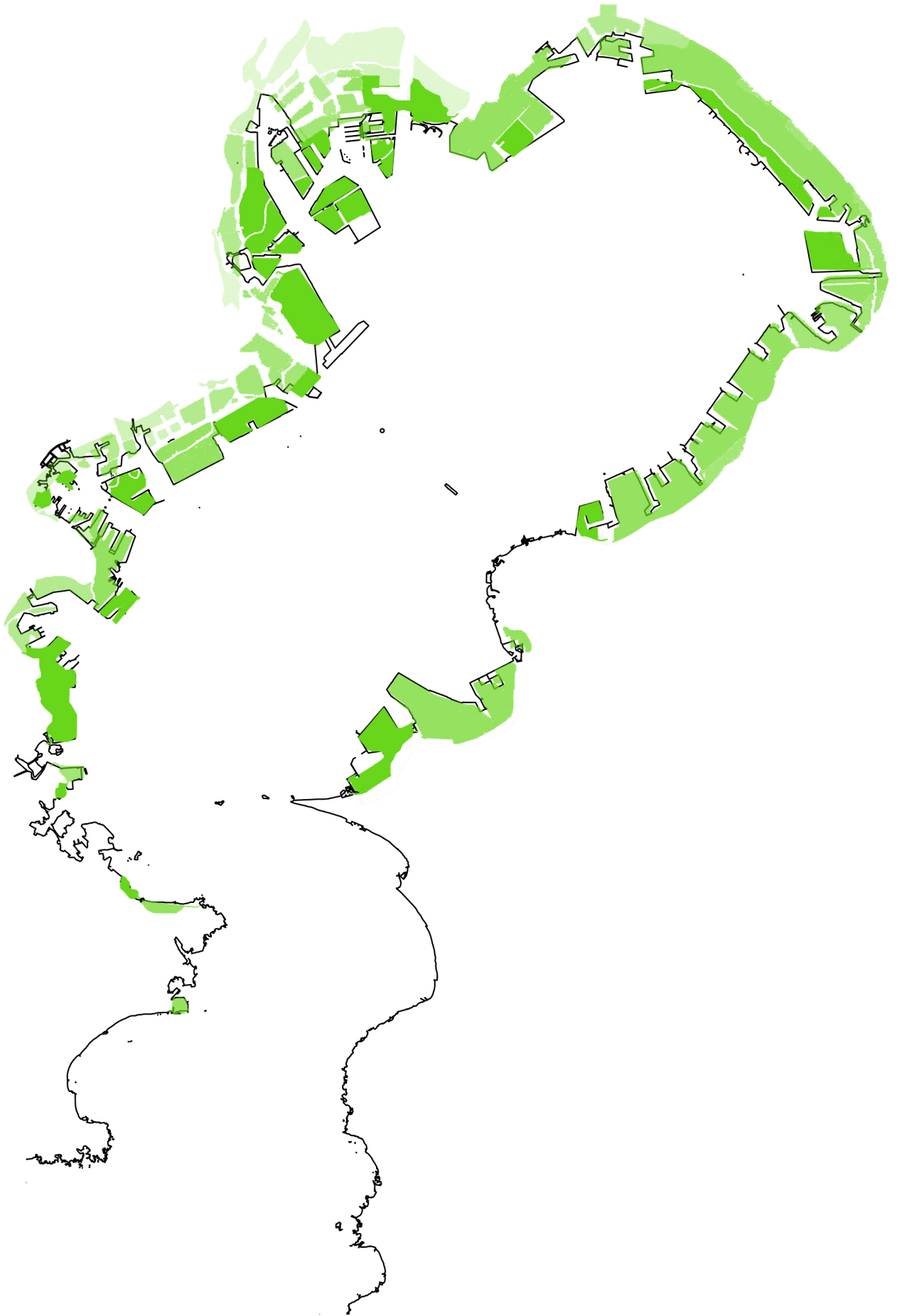
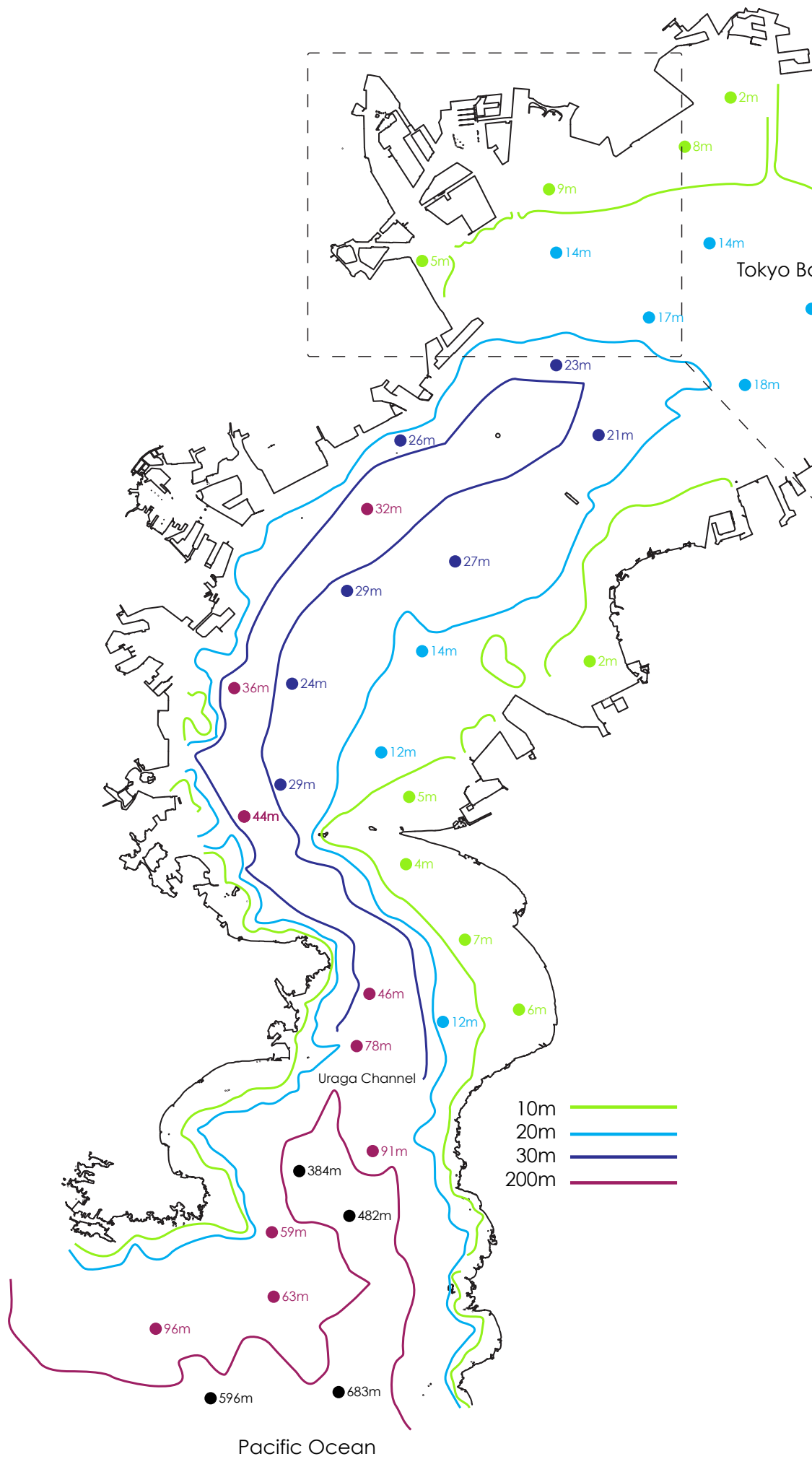


Figure 052: Reclaimed land around Tokyo Bay overtime



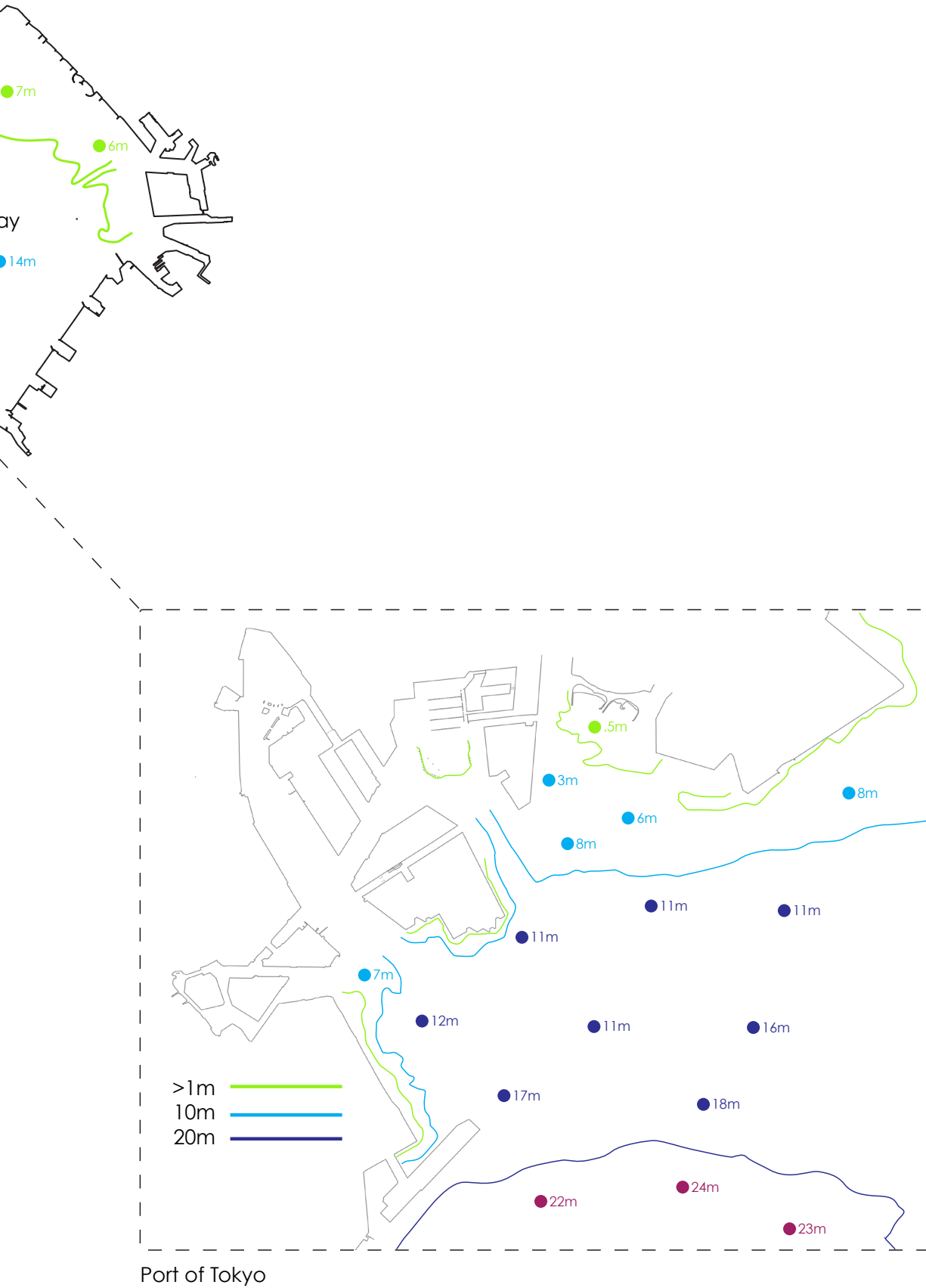
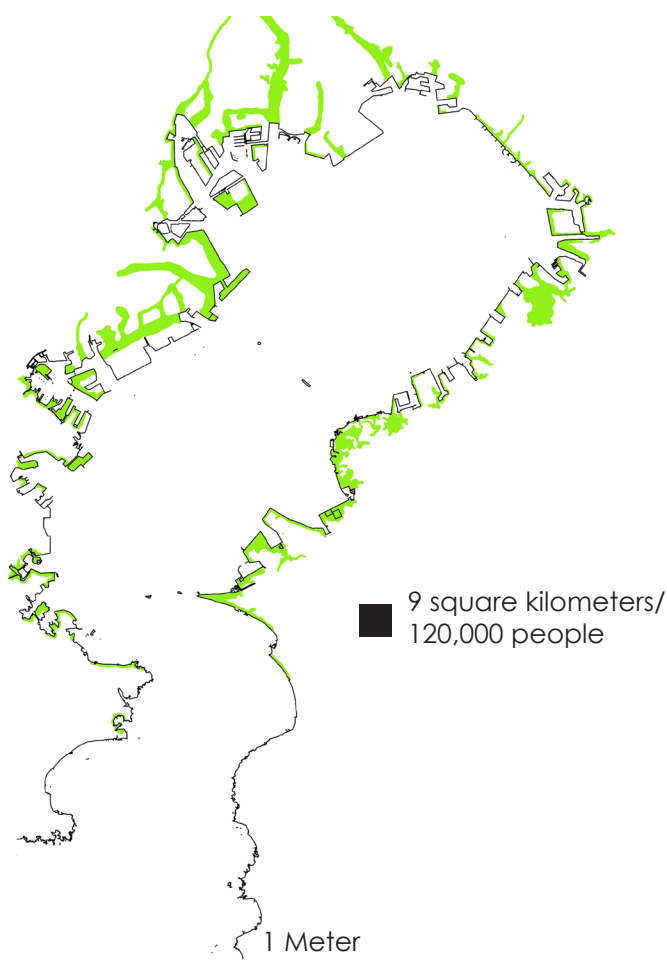


Figure 053: Bathymetric map of Tokyo Bay



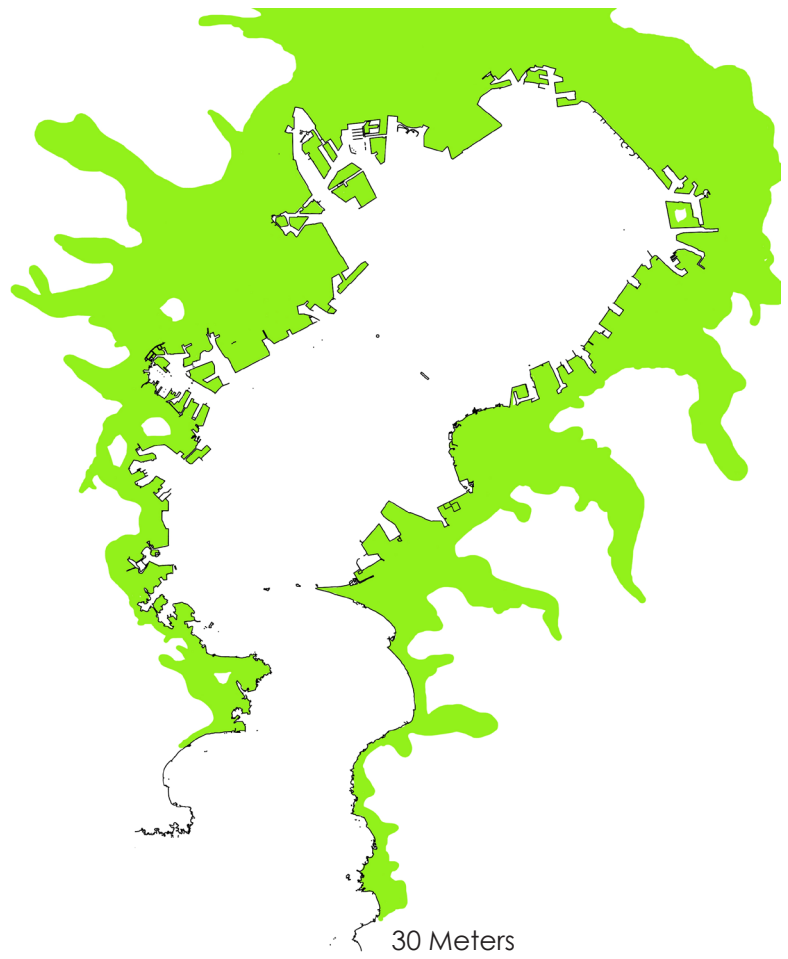
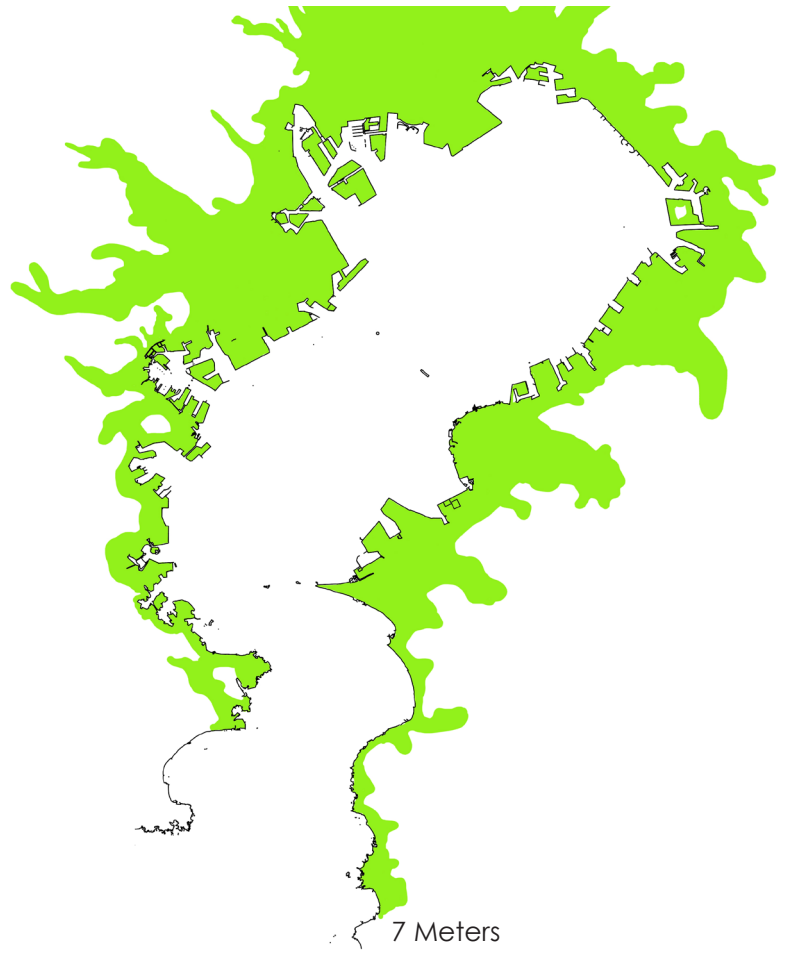


Figure 054: Inundation 075

Bay. In a worst case scenario experts forecast waves anywhere between 10-20 meters. These graphics display humbling data about how a natural disaster might impact the population of Tokyo. Rather than building larger walls and generating more separation between land and ocean, a better solution that looks to the bay as the answer rather than the problem is what came from these diagrams. We cannot fight the energy of a tsunami or earthquake but could the bays own systems be the key to developing a system that works for the population of Tokyo and the natural systems that the city is so reliant on? In researching further about the systems that make up Tokyo bay data from economic as well as natural systems became the basis for understanding the context in which to design. The diagram in figure 055 shows analysis of current flow in Tokyo which would affect the direction and magnitude of tsunami waves. The rivers flowing into Tokyo bay have carved natural channels in the sea floor aiding in the flow of water from the bay into the ocean.

Tides also play an important role in the amount of damage a tsunami causes based on the overall height of the normal waterline at the time of an event. Further if a tide is flowing in more damage might be caused as the tsunami does not have the resistance of natural systems pulling against it. Tokyo has a tidal fluctuation around 1-2 meters based on time of year.

The natural systems set up the framework that the urban community has been built upon. The diagrams below look at how the economic lifeblood of Tokyo, shipping, has been constructed across the bay. With the bay's depth being a concern for large cargo vessels, pathways have been carved in the sea floor to ensure safety of maritime vessels moving through the water. Also, the locations of the major port centers generates pathways of where ships are headed and docking. With this in mind, a integrated system to help protect Tokyo would not be effective if it modified the existing framework of the economy. Further,

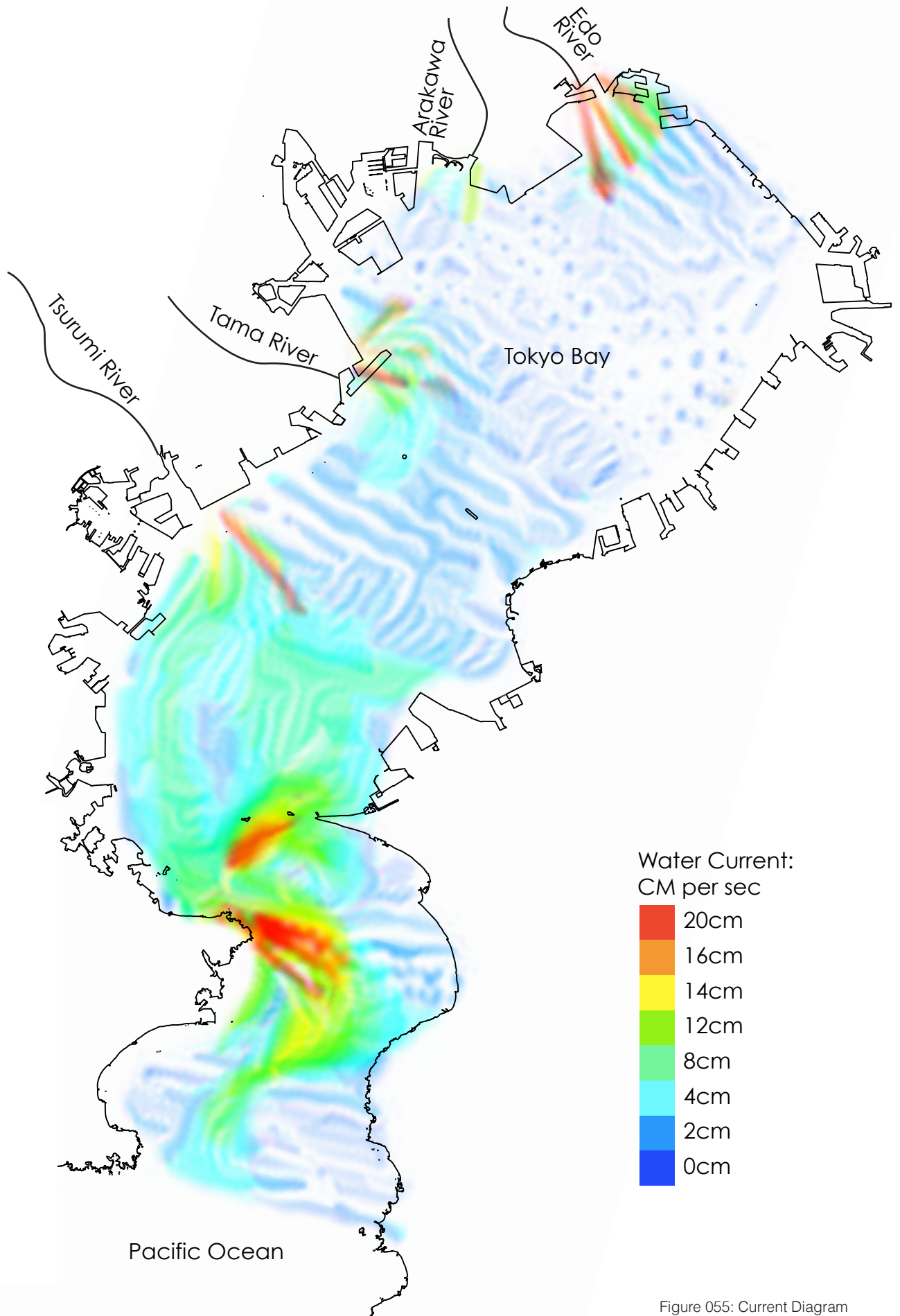


Figure 055: Current Diagram

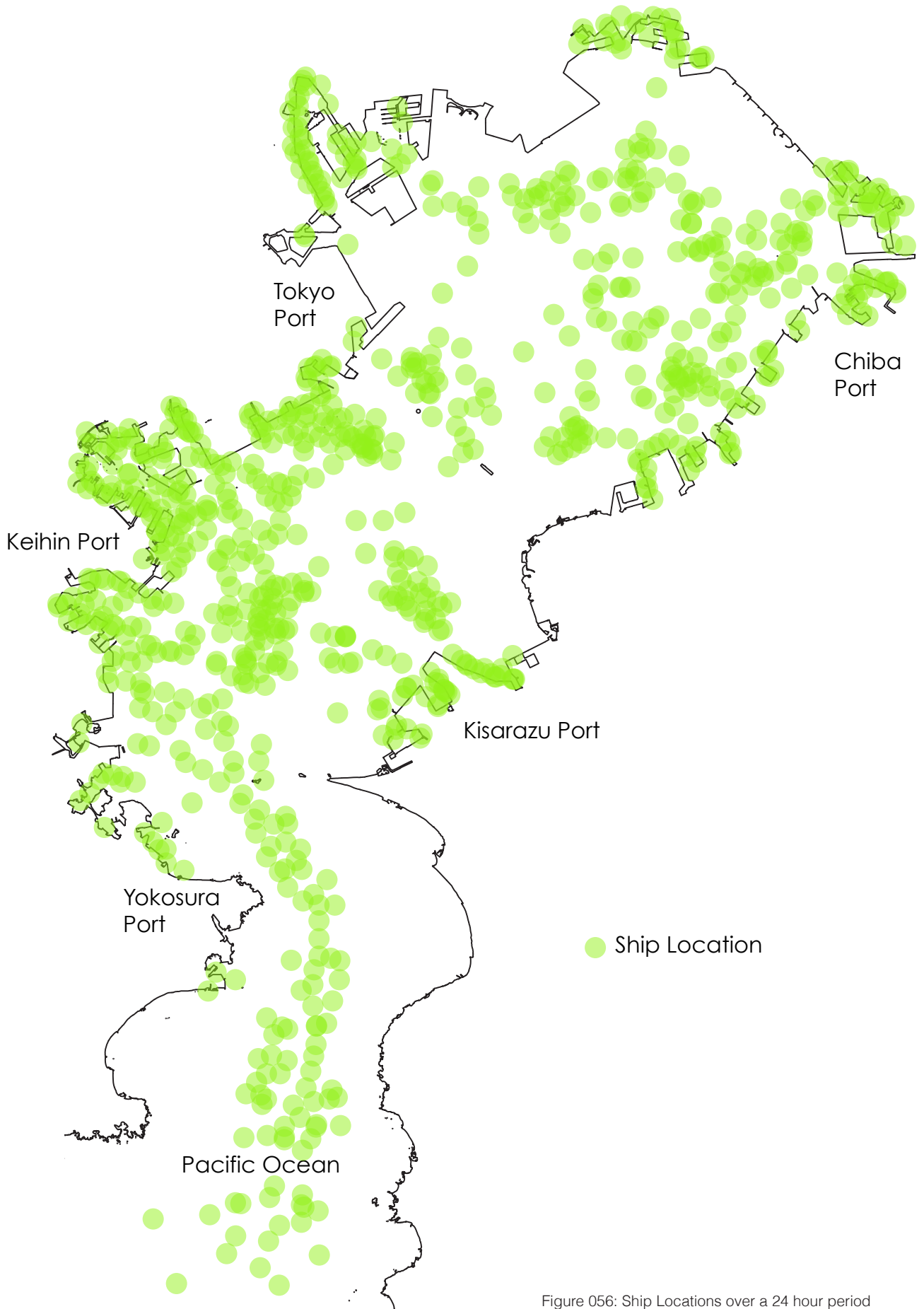


Figure 056: Ship Locations over a 24 hour period

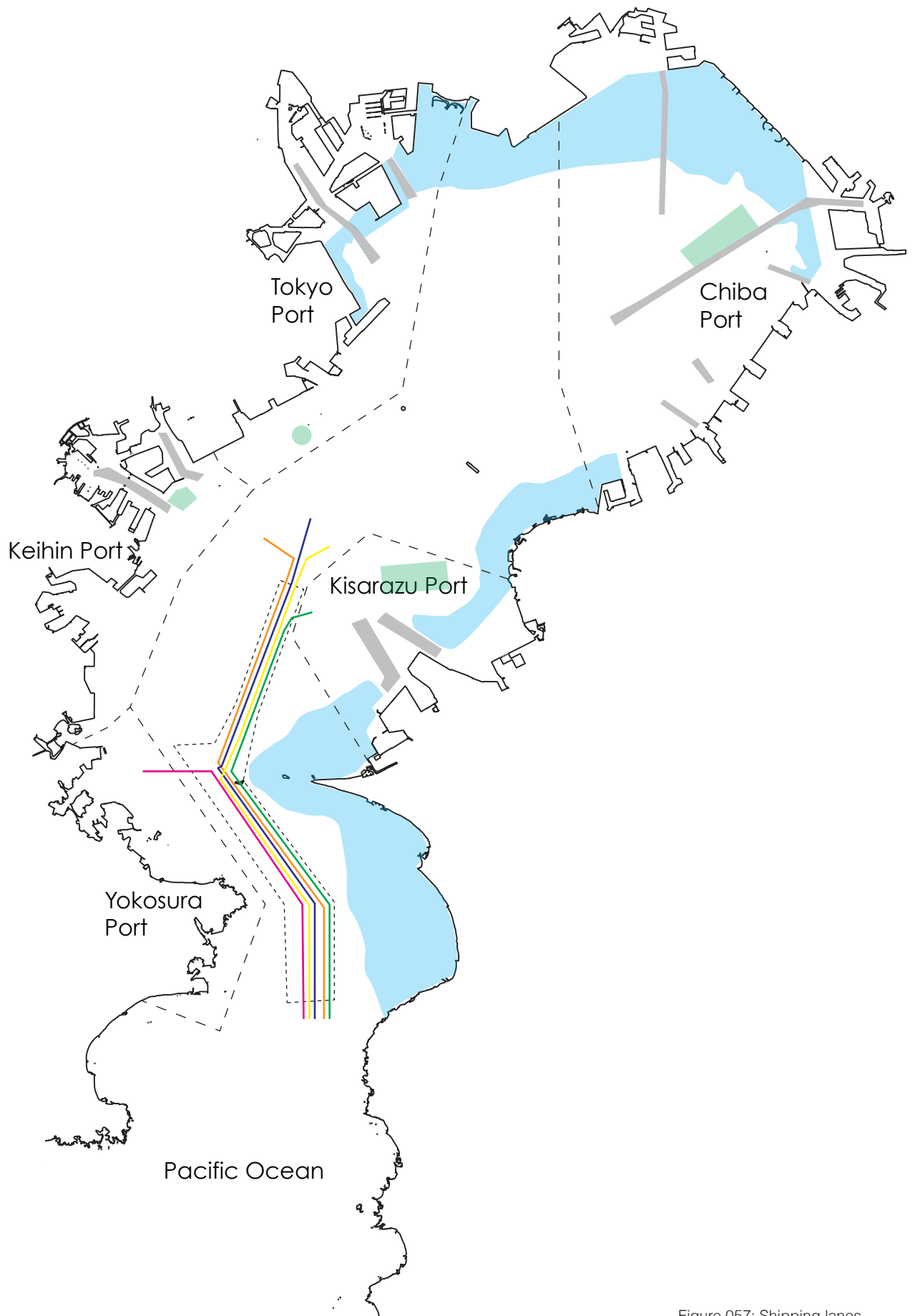


Figure 057: Shipping lanes

working with these systems rather than against, helps to identify the shallow waters that would generate the tallest waves in a tsunami. Therefore ship location, movement and ports coincide to generate a contextual map of where infrastructure is most needed without damaging existing systems. The blue areas in figure 057 distinctly matches up with where major ships do not dock or anchor. This understanding of maritime constraints, when overlaid against population density and major road infrastructure shown in figures 056 and 057 display the area most in need of protection with the ability for a system to be generated is the Port of Tokyo and Urayasu prefecture. Those locations are distinct in their population density and shallow areas directly off shore that present the opportunity for intervention within the current environmental context.

#### Understanding the Program, Scope and Typology

Tokyo bay presents a unique context to design in with its historical, cultural and environmental framework. These all blend together with the theoretical ideas of the metabolist and biophilic approaches to make a truly exceptional location with which to address the issues of resiliency. Individually, residential, commercial or civic programs would fail but by grouping multiple uses together to form an entire community, the program can generate positive collective growth. This merging of typology together will help keep the urban fabric of Tokyo together as the floating system stretches outward from the land. Without integrating this connection the system could become isolated with individuals never passing from land to sea but rather stagnating on in their own current space. This flow of people as well as resources keeps the infrastructure expanding and growing, thus aiding in protection from natural disasters while allowing individuals to live and work where they please.

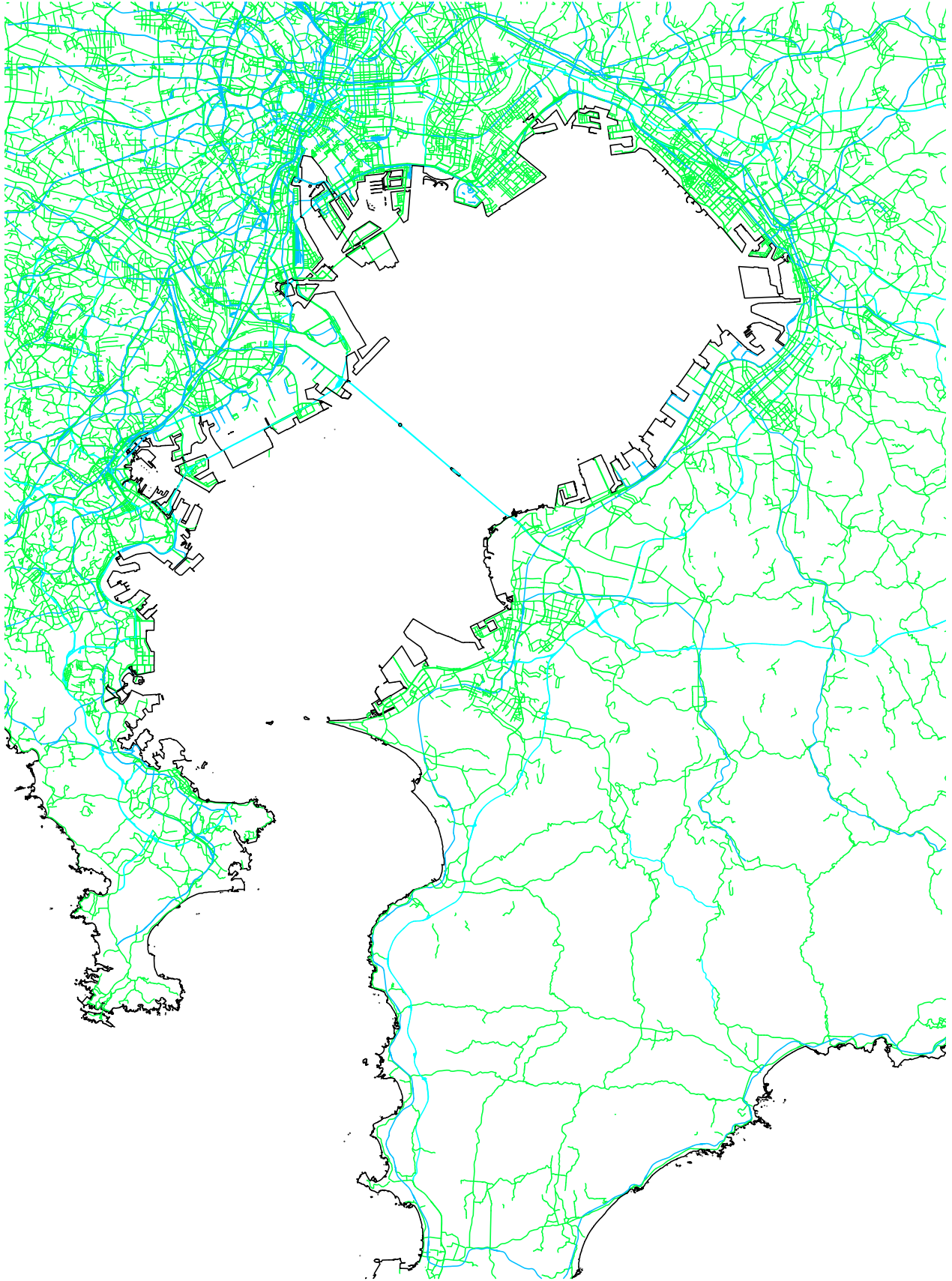


Figure 058: Major Infrastructure

This scope quickly can become overwhelming in the design process as all facets of city life are needed to be accounted for if the system is to function as desired. Instead, in using the metabolist understanding of systems a simple module, both large scale and small is necessary to help define the framework of the thesis in the time given. Further the metabolist theory that looking at urban planning such as this as a constantly changing system rather than concluding product is paramount in order to define the necessities of the design without constricting the future organic development of the entire network. Michael Sorkin in *Future Asian Space* states that “the contemporary utopia cannot be expressed as a formal singularity with universal aspirations.”<sup>47</sup> While this thesis is not about designing a true utopia, Sorkin’s statement holds true in thinking that a single solution or concept will not address all the needs of our ever changing society. Distilling the design into elements that while singular in physicality can be flexible to address many challenges takes these aspects from different context and brings them together.

This thesis will address the overall kit of parts that will make up the framework for design. Within this framework speculative activities will be proposed based on a future end user rather than specific intent. By keeping the typology open, it allows the design of the thesis to be all encompassing while addressing a generalized set of needs and constraints consistent with large scale master planning. Two scales to be addressed in design will be the human scale and the urban scale. Each will need specific elements addressed to their own relationship if the project is to be successful.

## Tsunami Research Data

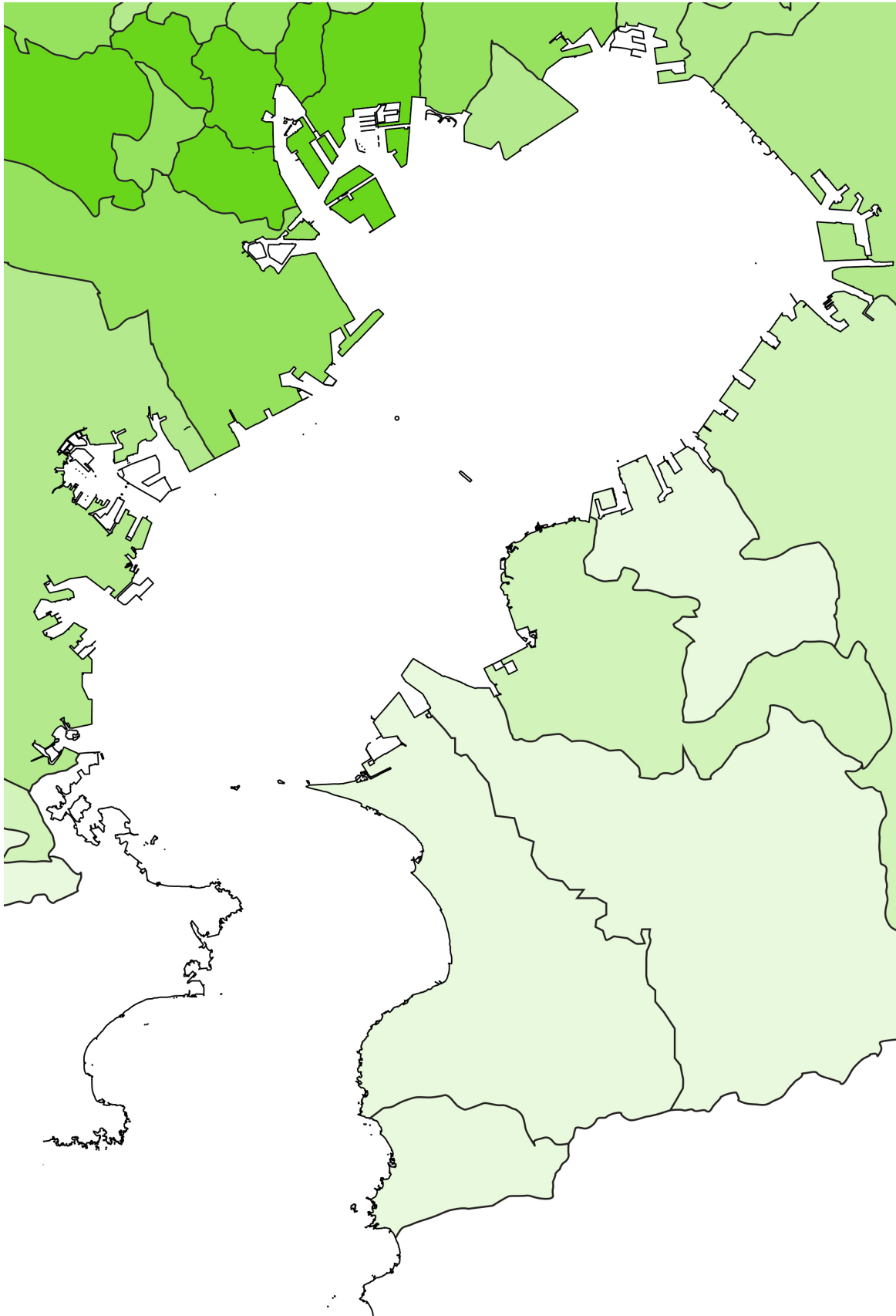


Figure 059: Population Density

From understanding the theory, history and context of the site, this project led towards a study of how tsunami waves might actually react with object in the water. To learn about this, the first step was interviewing several professors in currently doing tsunami research at the University of Washington. They gave background information as well as instruction on how to design and scientifically test different scenarios. This discussion led to the construction of the wave tank seen in figure 060. The tank is six feet long with a viewing port along the side to record data. A weight is dropped into the water at one end and the angled board at the other represents the sloping shoreline, creating a wave. This system proved very effective at creating reliable tests in order to demonstrate the impact of water energy on different objects.

The control for the tank was measured in two metrics, consistent wave height at a given point and amount of movement of scale blocks away from their starting point. Four blocks were placed at the waters edge evenly spaced across the angled board in order to generate four data points per wave hit. The control test numbers were generated over 10 consecutive tests to create an average movement of each block without any protection or object interacting with the wave energy. An interesting data point was that block one was being impacted by much less energy overall than the others, creating an interesting outlier to the other three blocks numbers. The point of each block being independently recorded was to generate its own control, so that even if the tank had preference to how much energy was pushed against the individual blocks it would not skew the overall results.

In research as well as discussions with tsunami experts the hypothesis established was that a series of diffuse objects reacting to the wave energy over a period of space would be able to slow the energy of a tsunami wave enough to mitigate its destructive force without the need of walls or hard barriers to protect coastal areas. The graphs, and images below

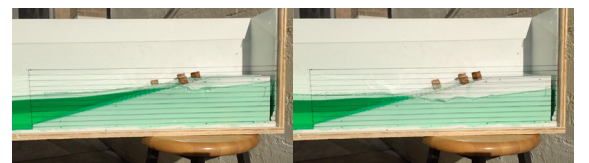
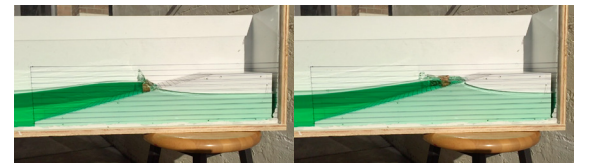
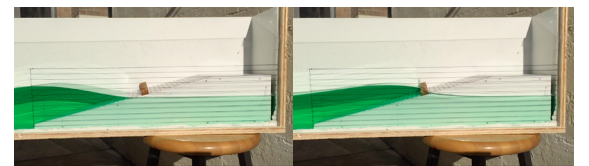
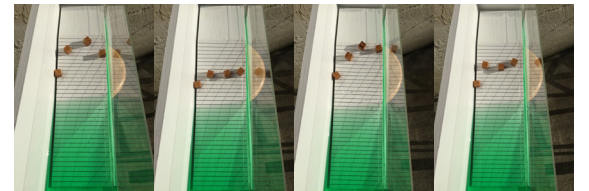
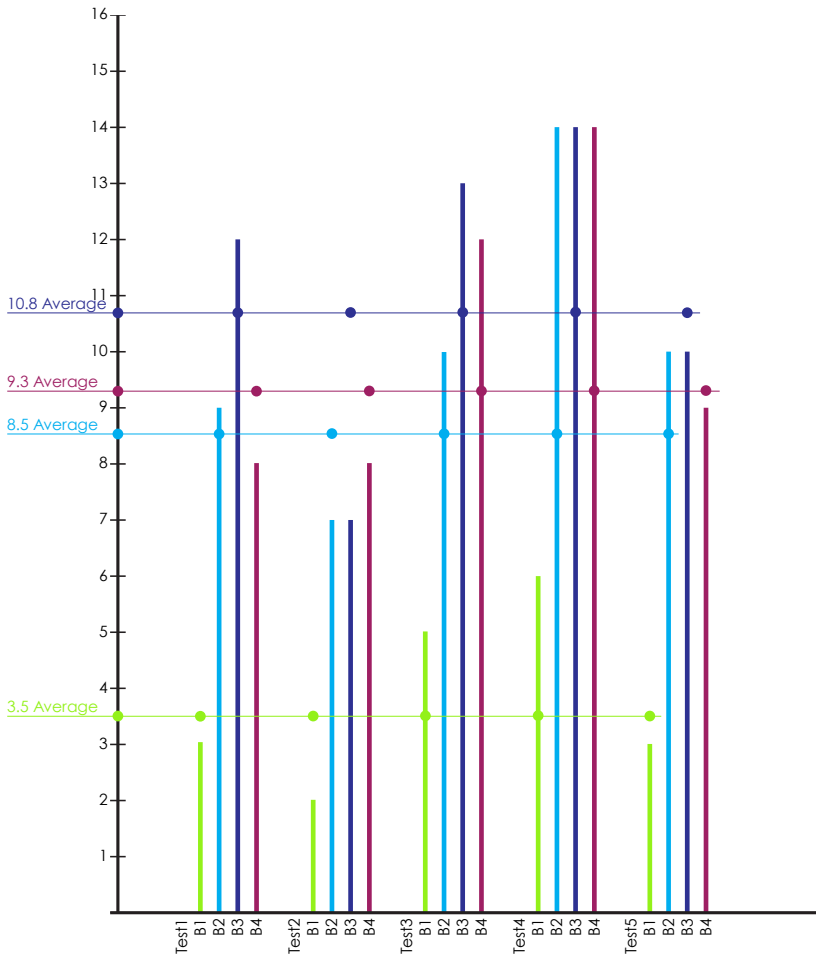
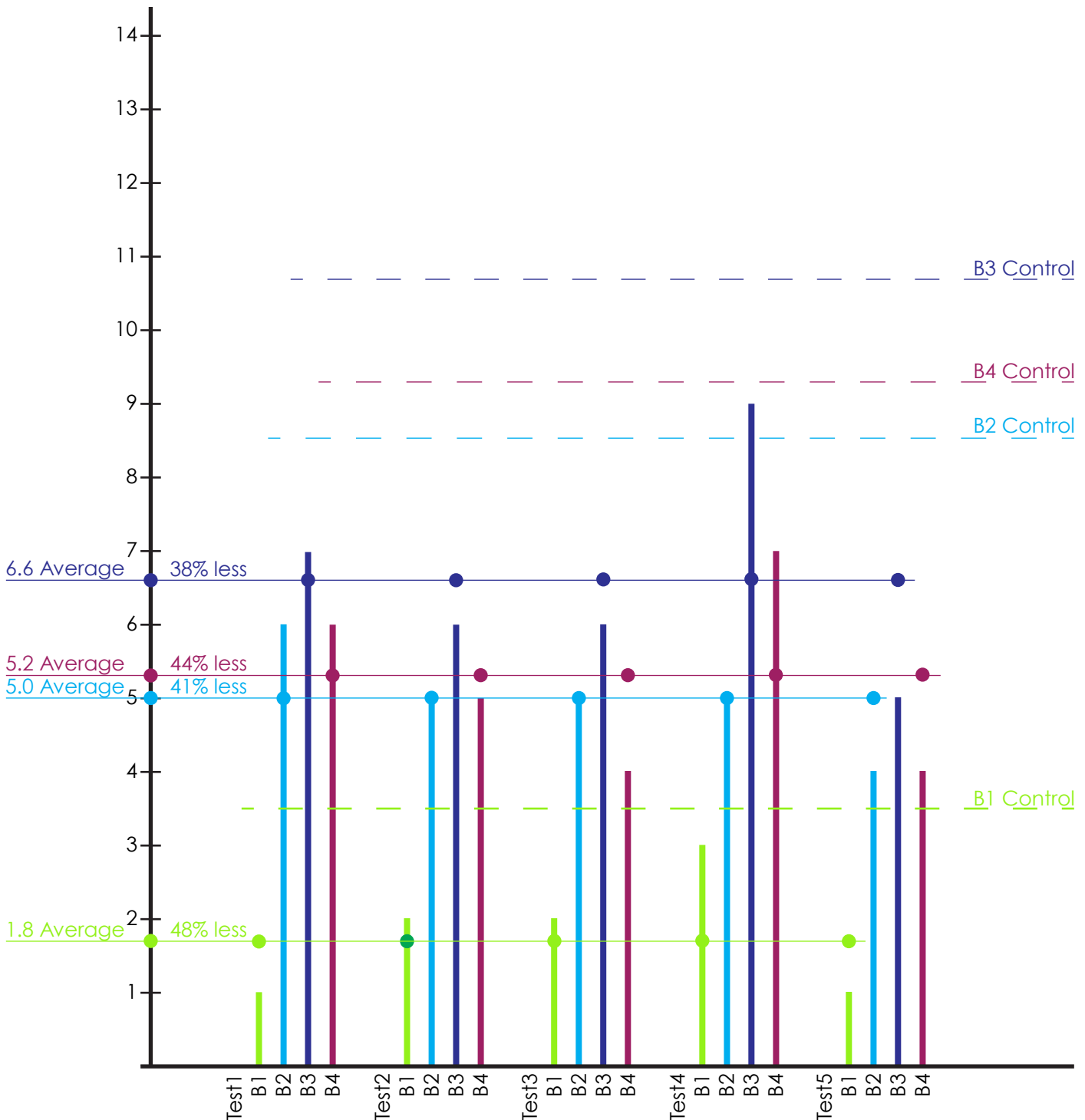


Figure 060/061: Control Test

show the series of test undertaken to learn about how water reacts with screens, walls and other objects both above and below the waterline.

The tests proved at a system other than a wall could be a viable solution to tsunami mitigation. The screens showed that having elements both above and below the waterline



Screen One Test: 43.2% average reduction

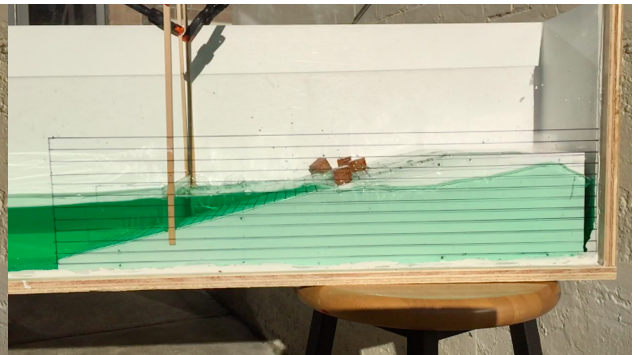
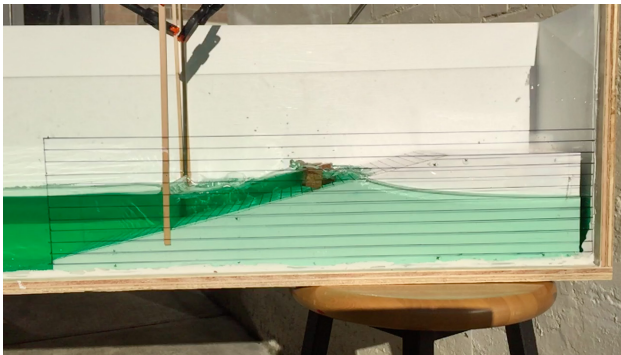
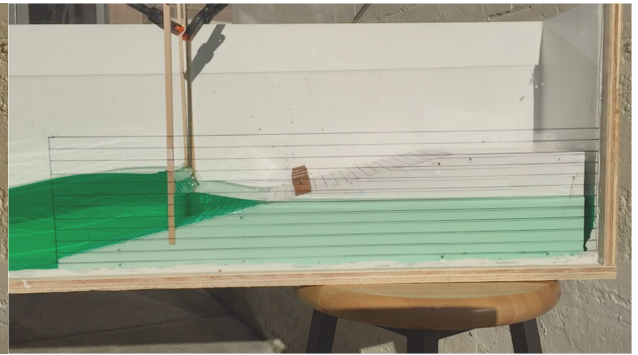
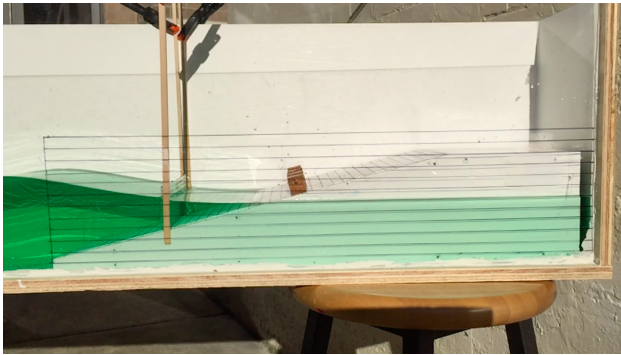
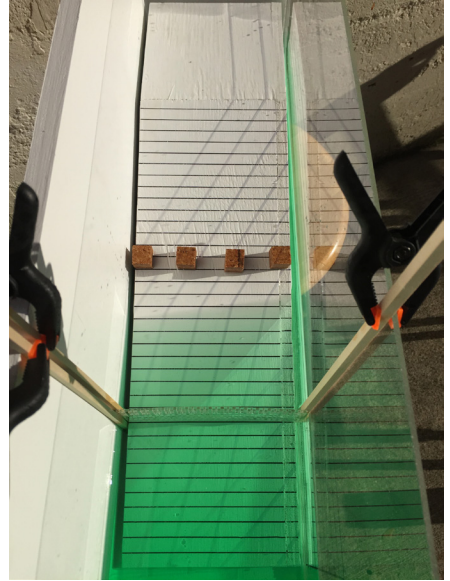
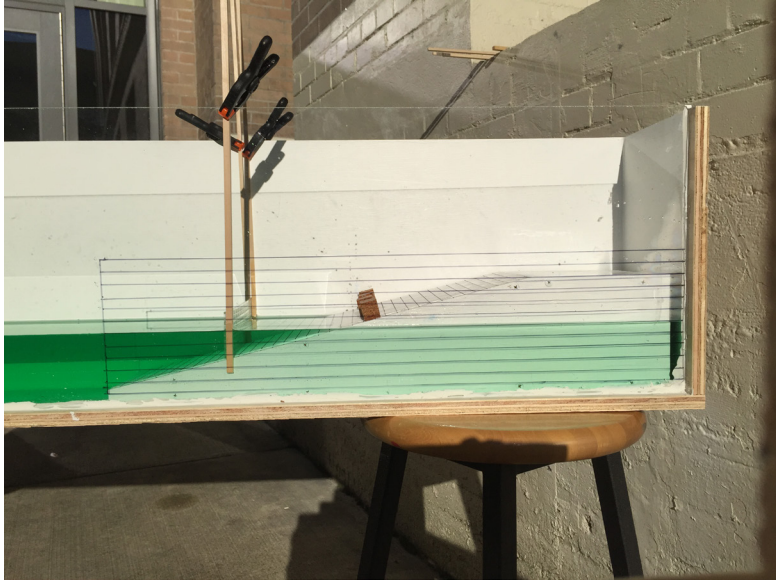
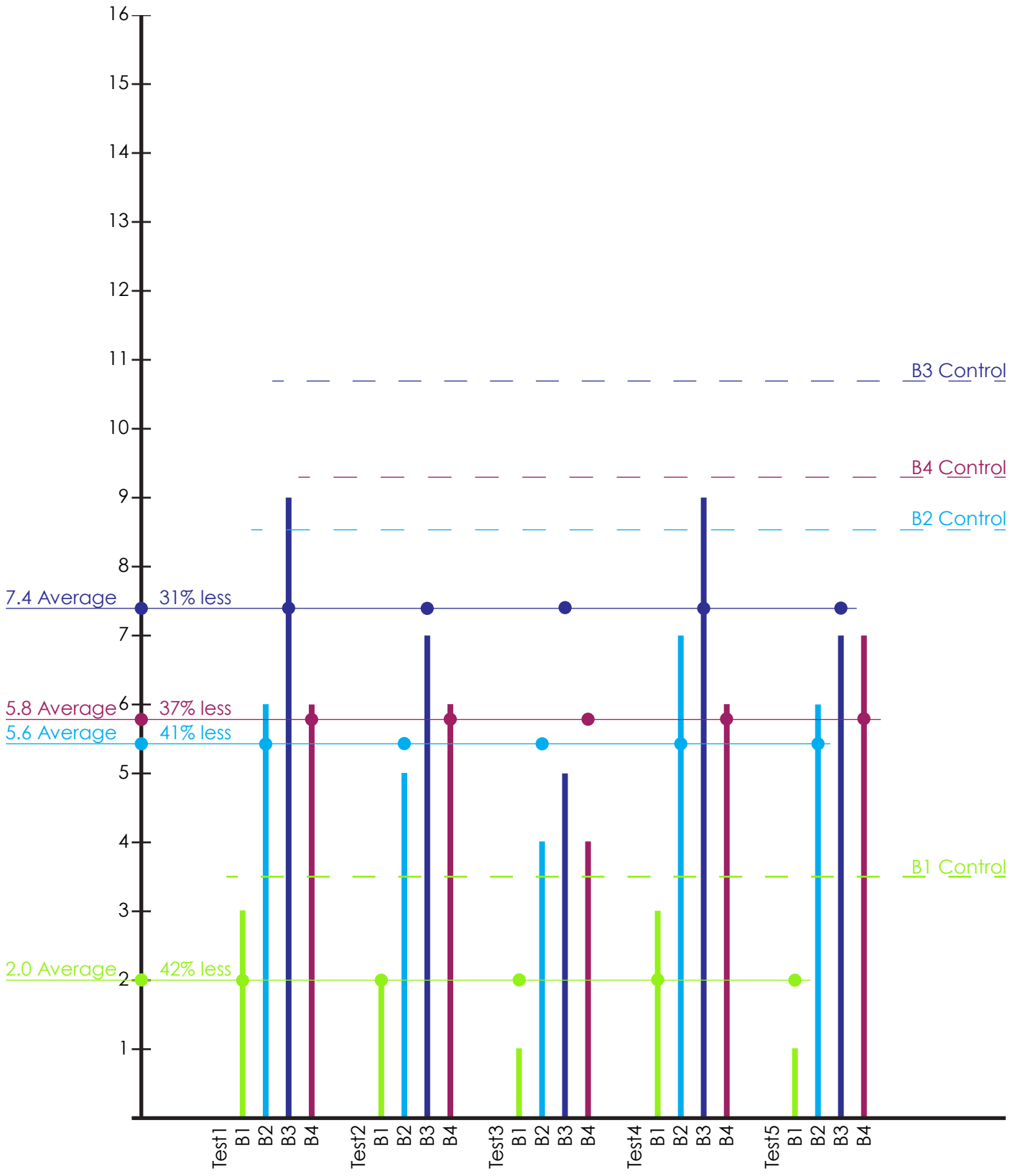


Figure 062/063: Screen One Test



Screen Two Test: 37.1% average reduction

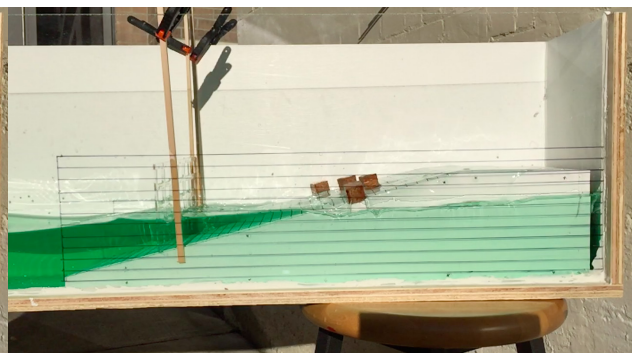
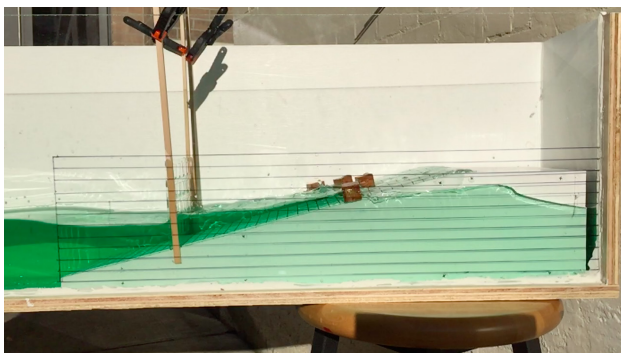
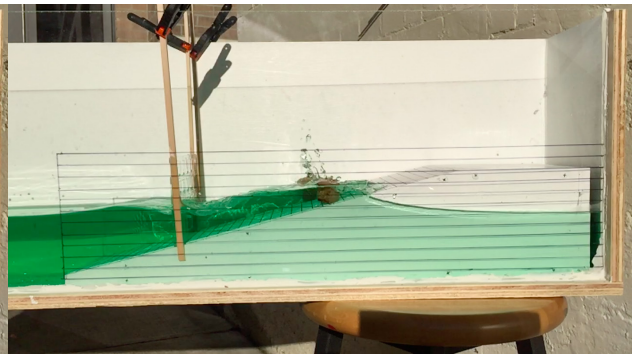
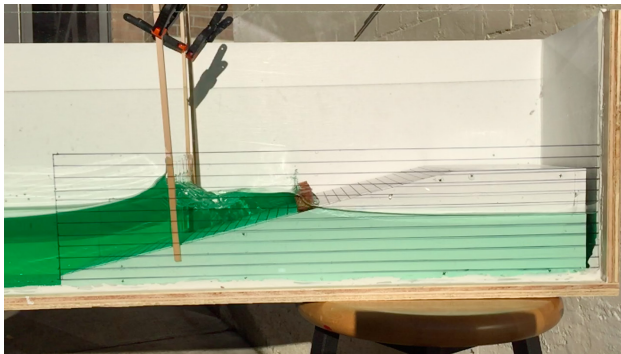
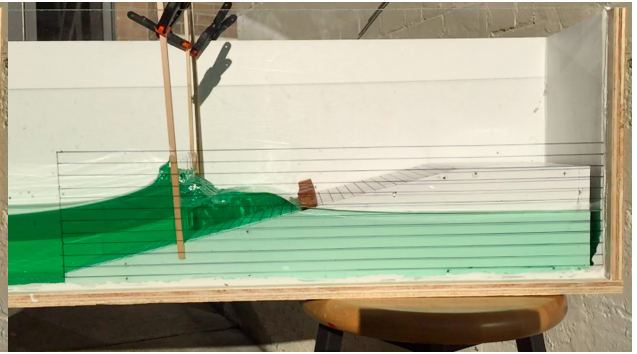
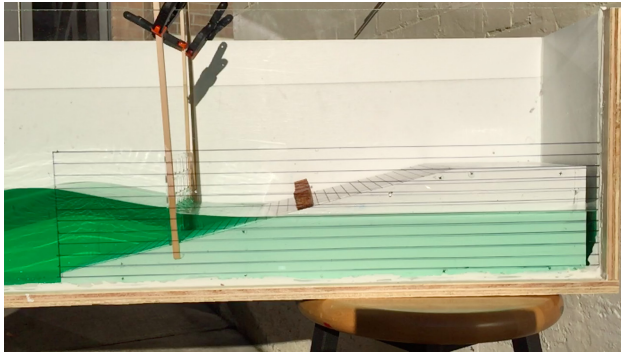
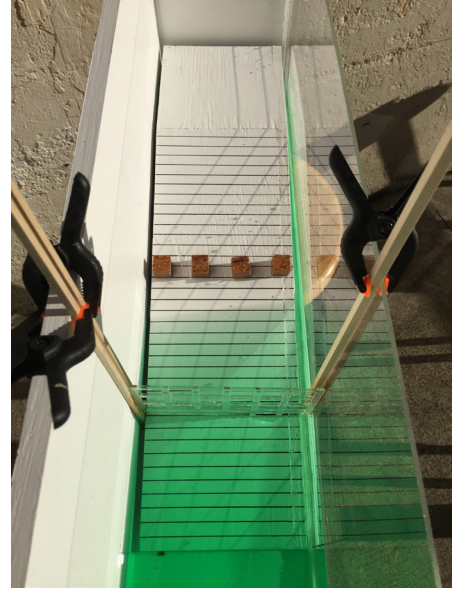
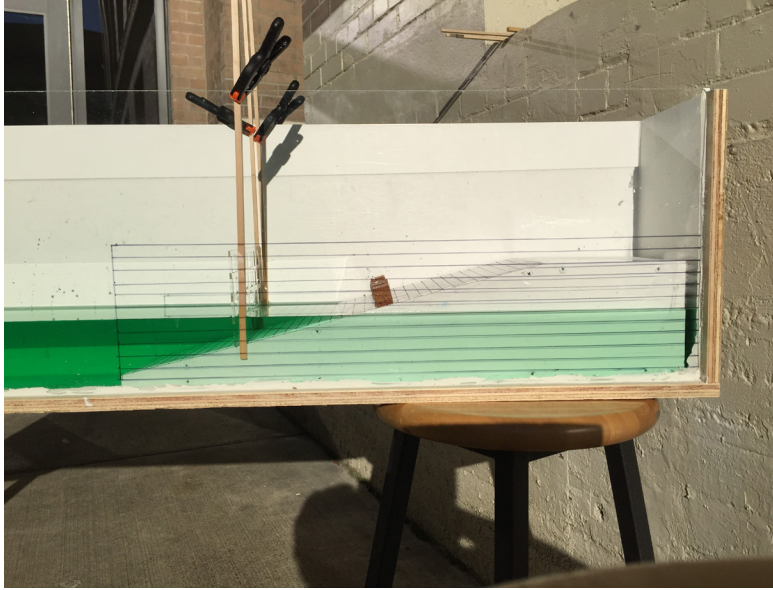
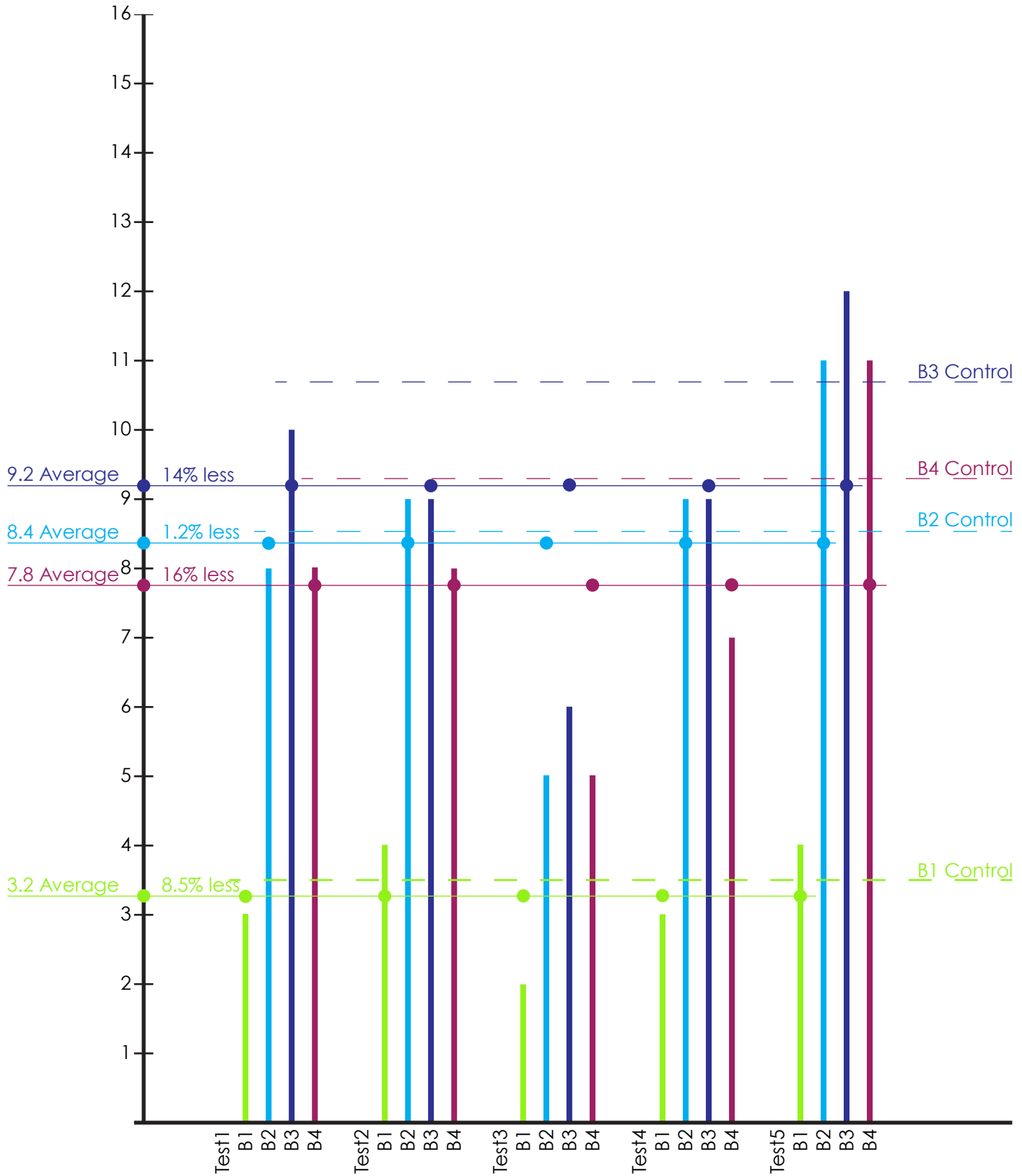


Figure 064/065: Screen Two Test



Screen Three Test: 10.1% average reduction

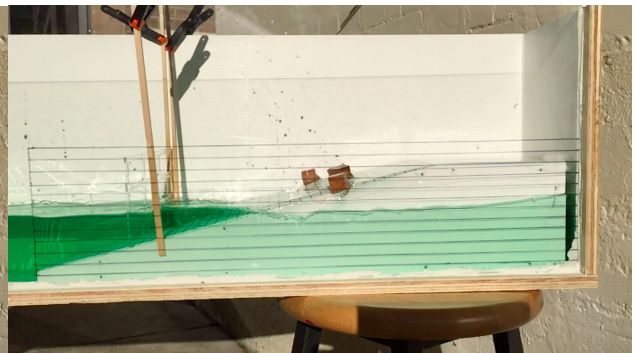
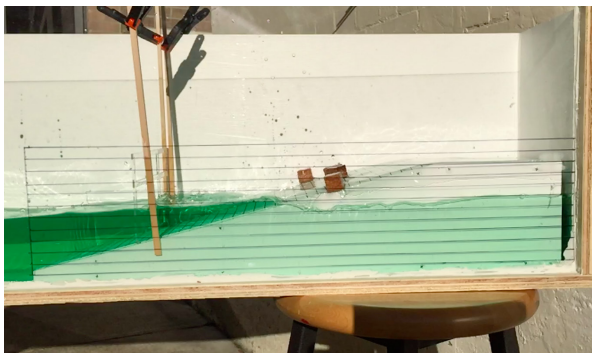
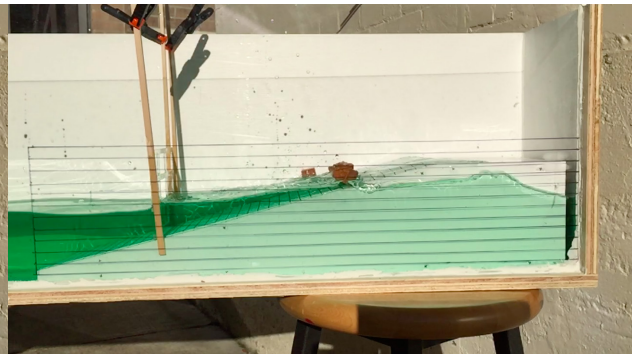
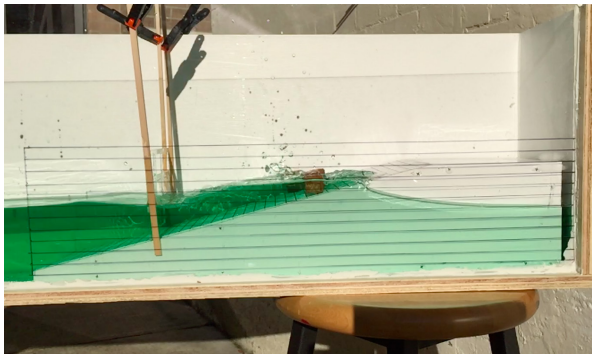
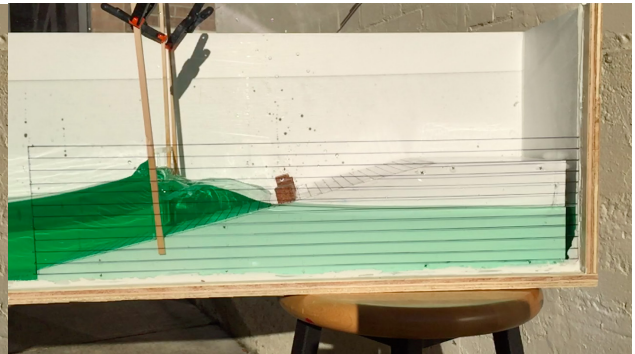
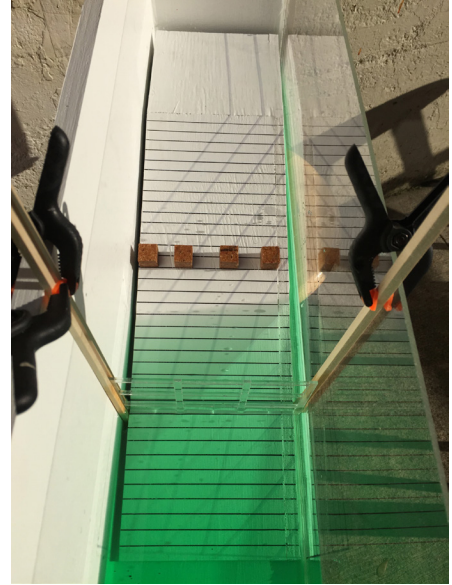
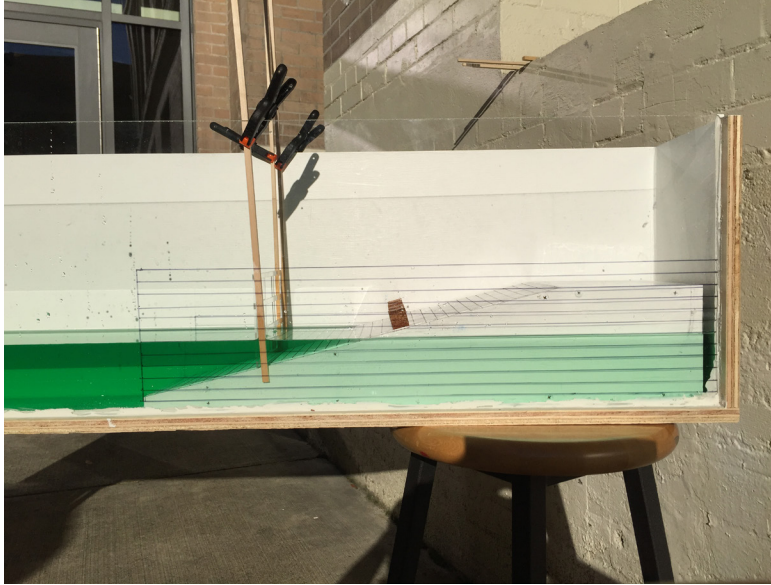
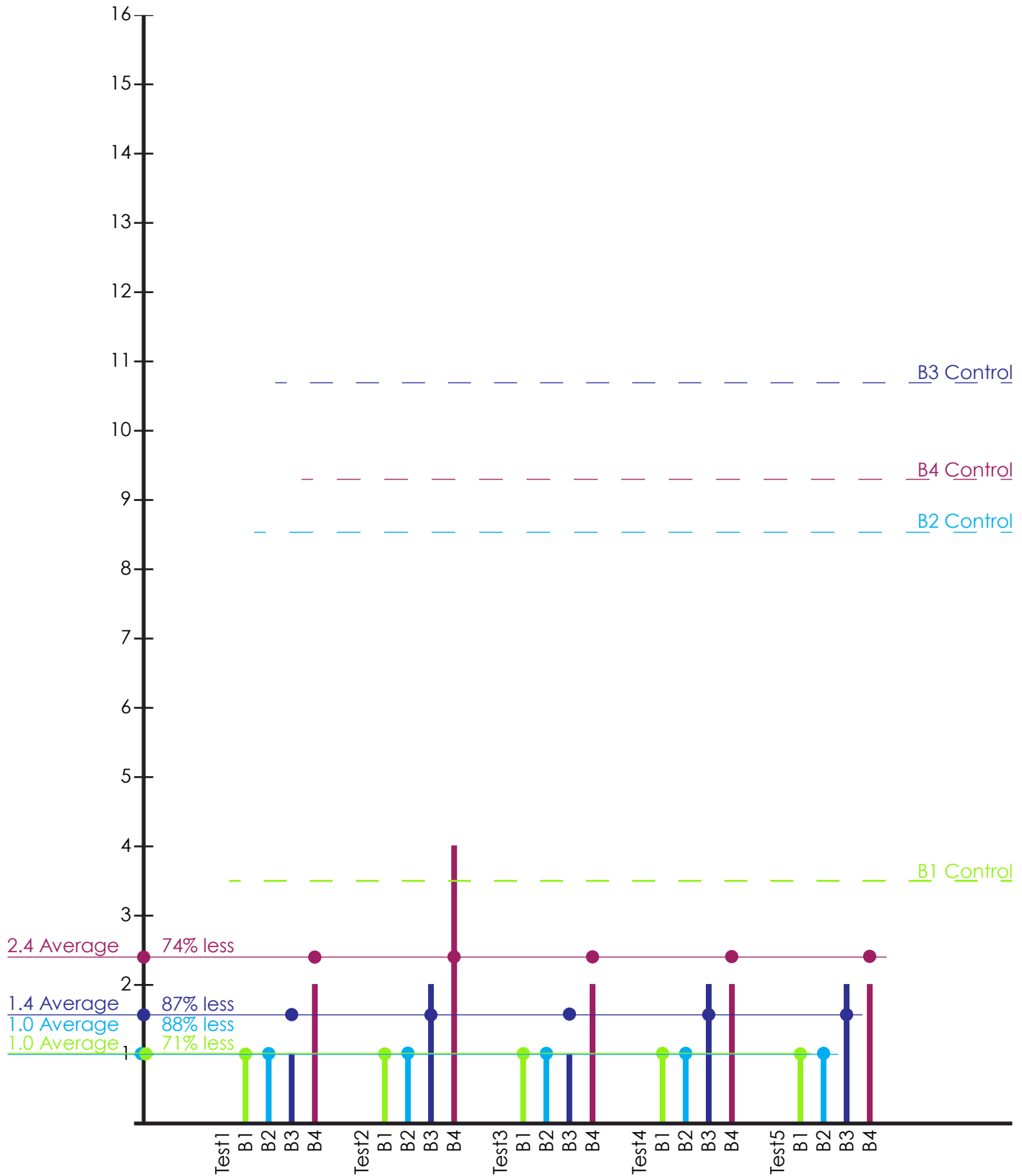


Figure 066/067: Screen Three Test



Secured Wall Test: 80.1% average reduction

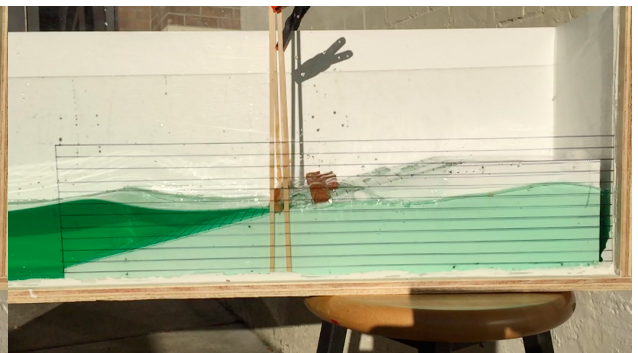
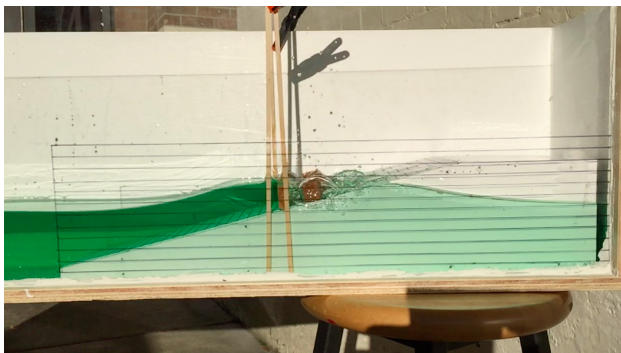
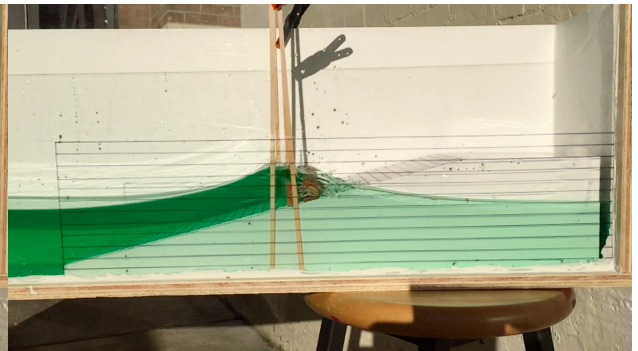
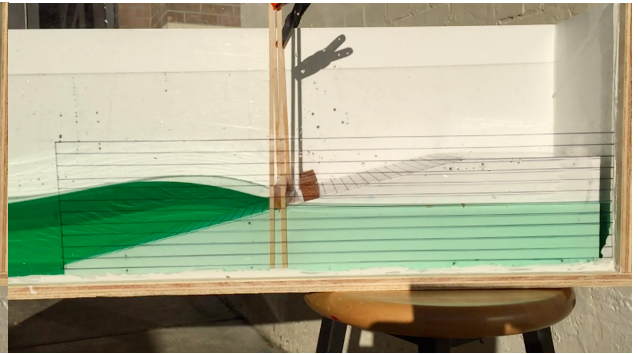
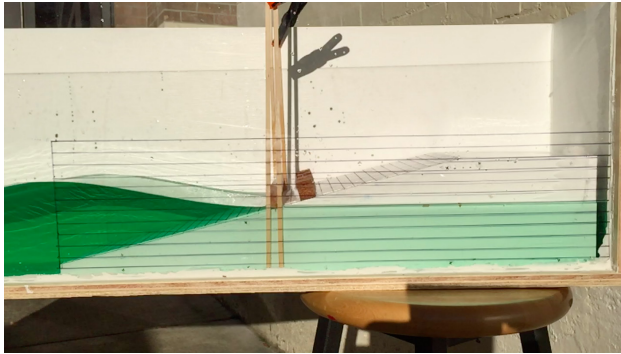
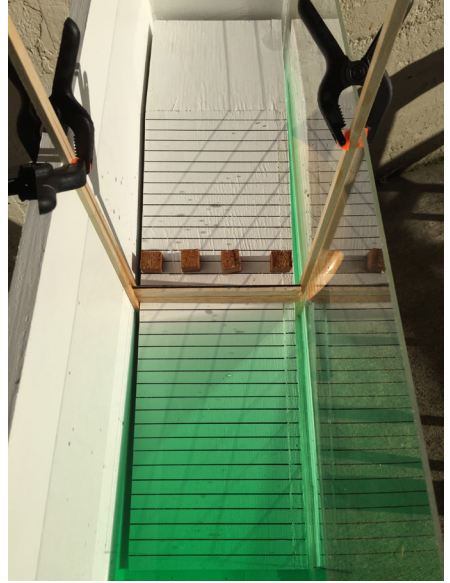
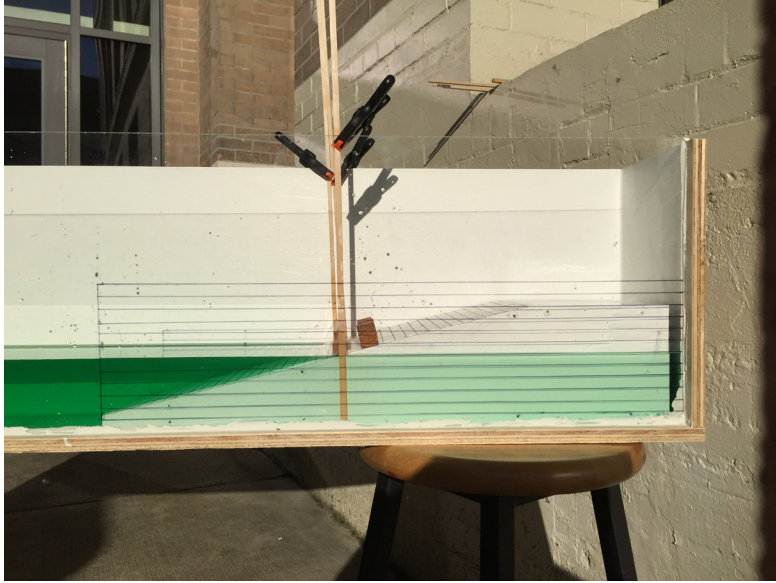
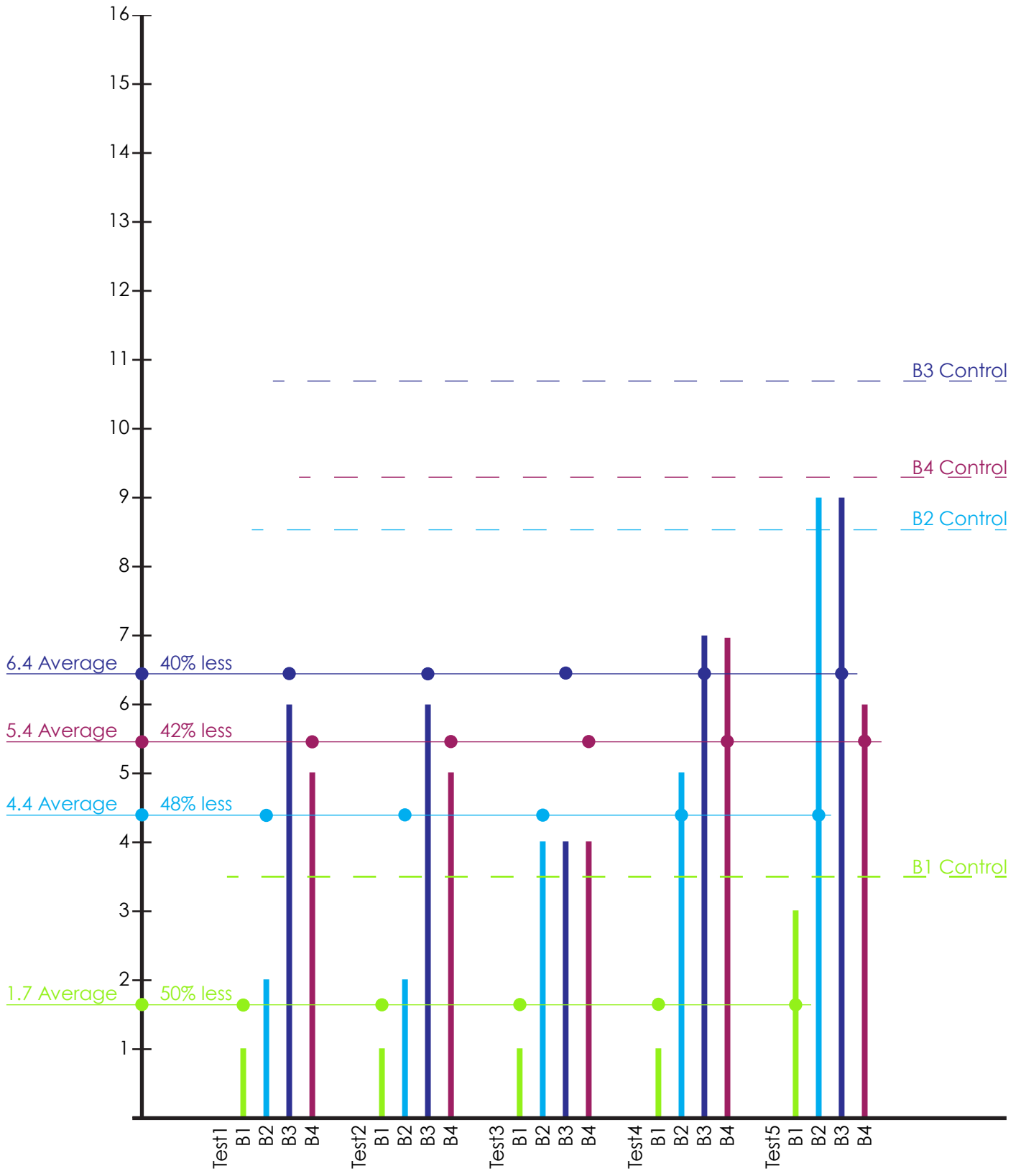


Figure 068/069: Secured Wall Test



Pylon Test: 45.2% average reduction

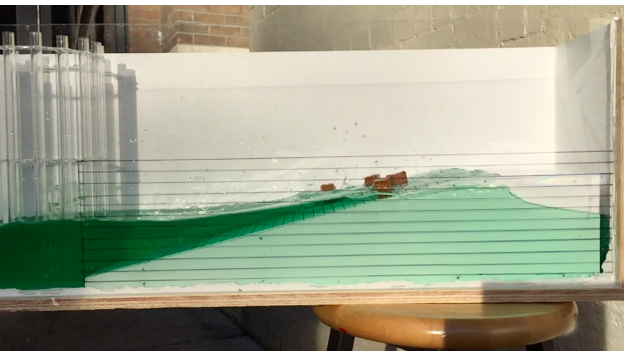
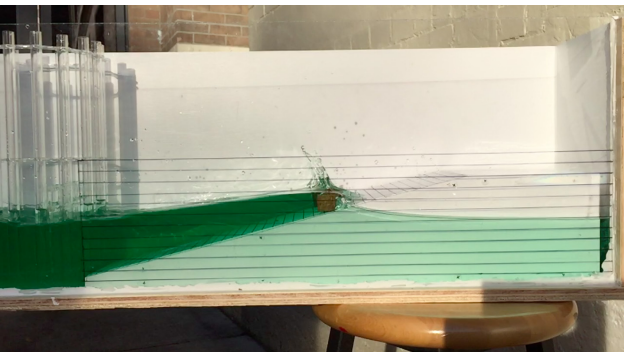
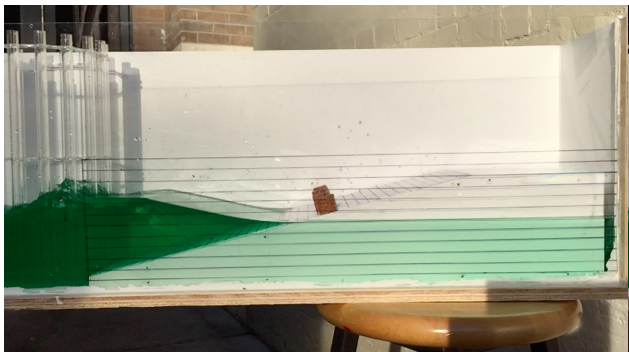
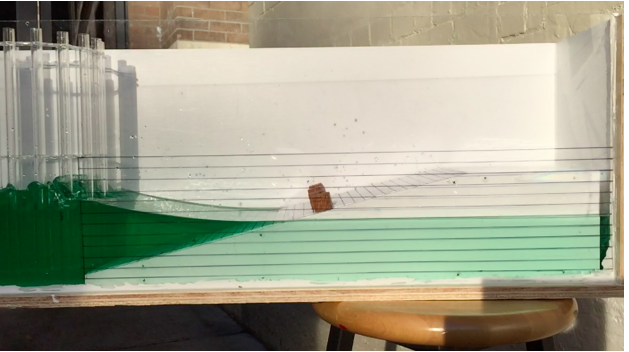
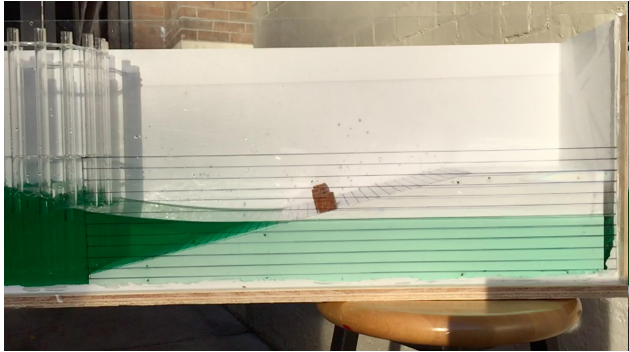
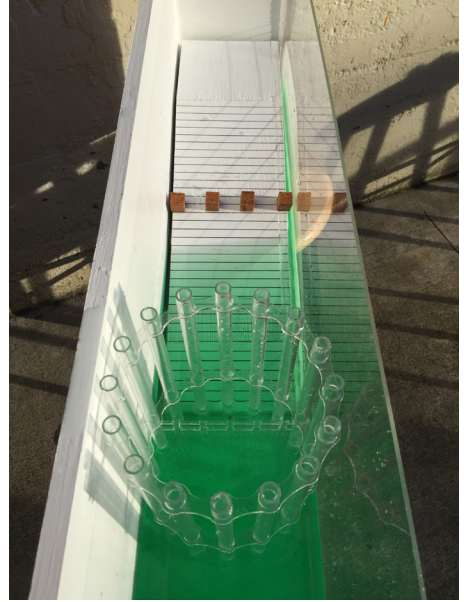
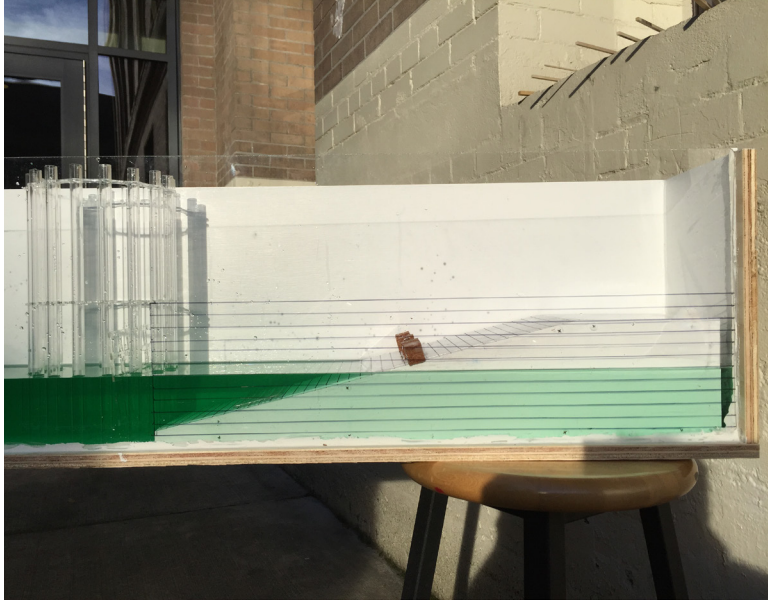
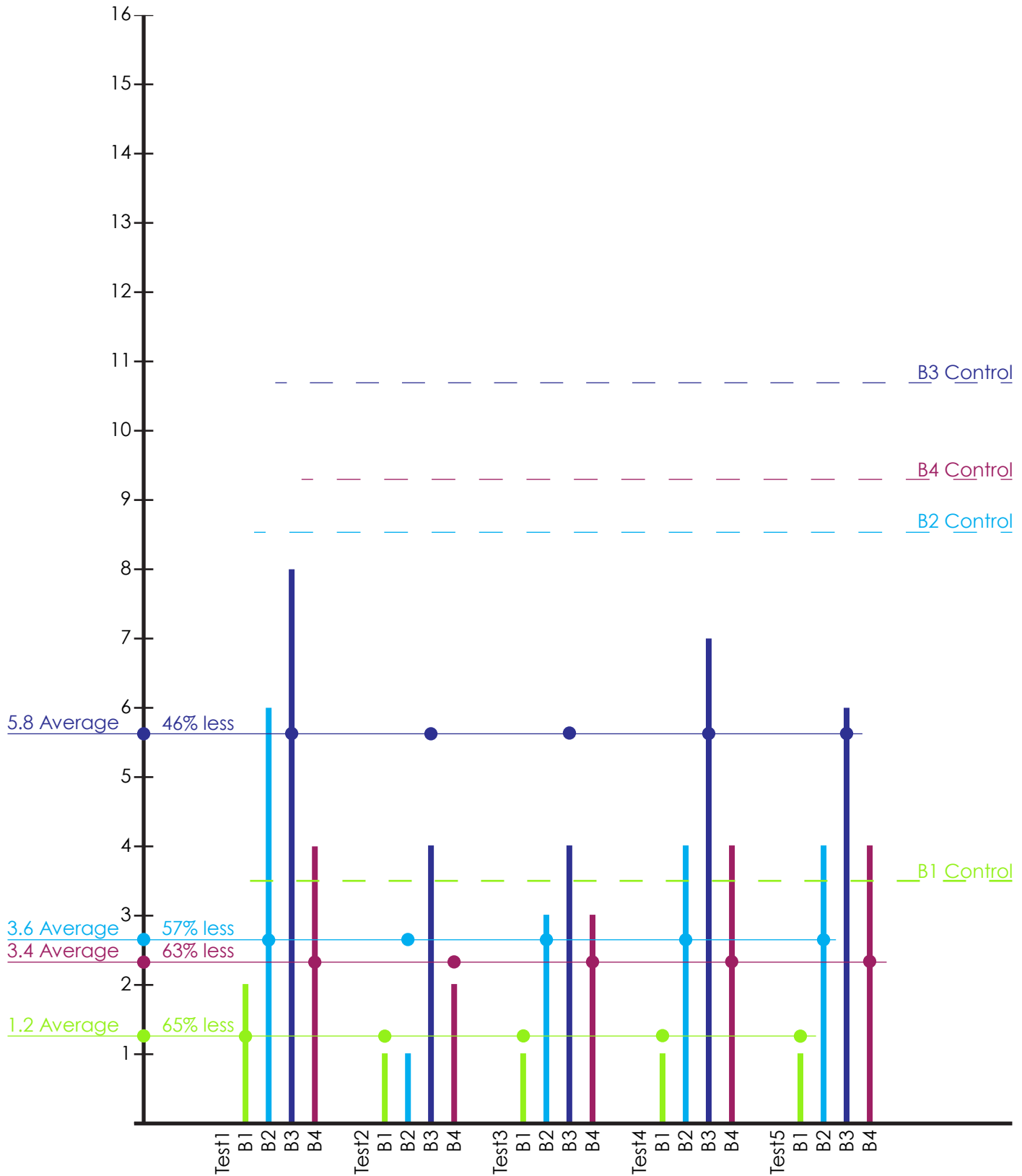


Figure 070/071: Pylon Test



Underwater Grid: 58.2% average reduction

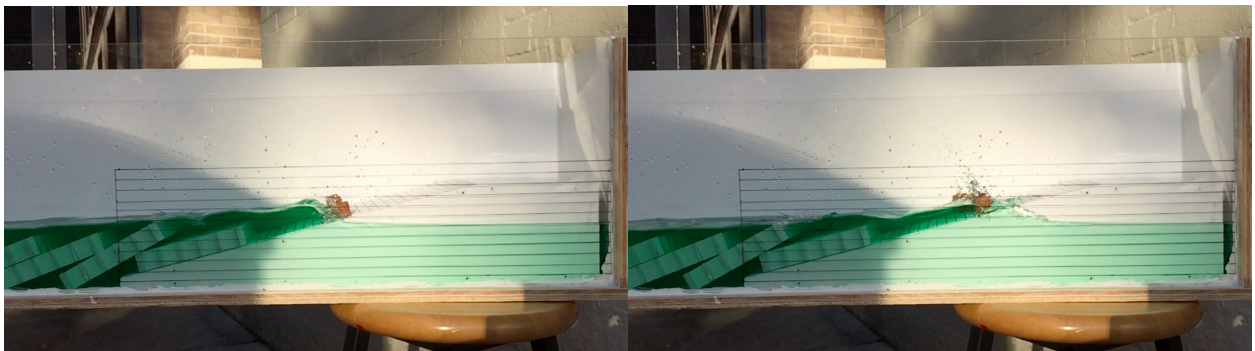
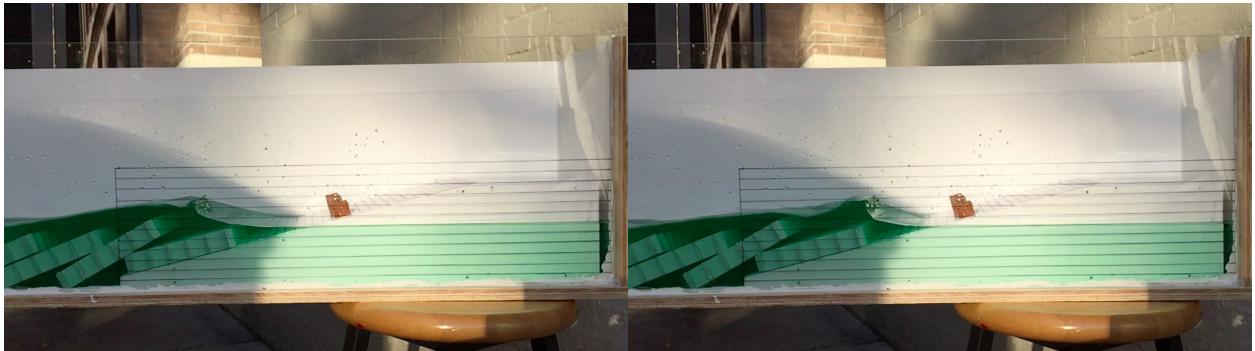
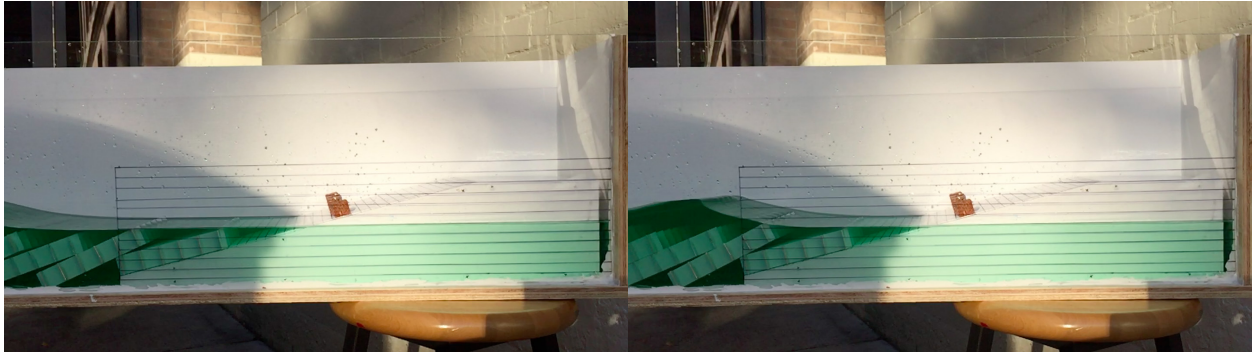
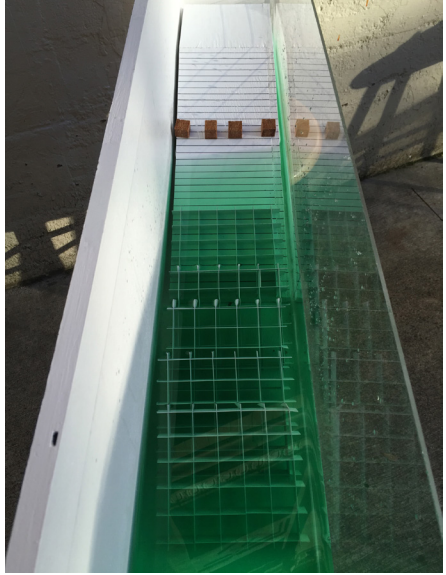
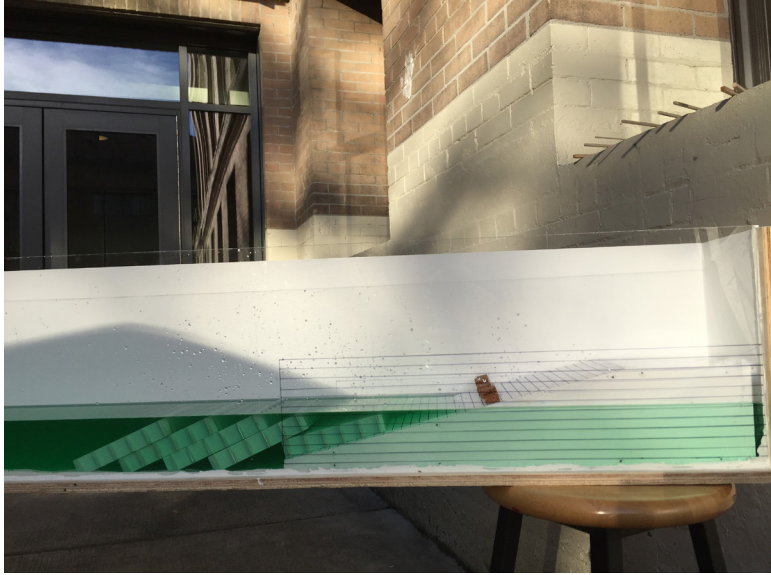
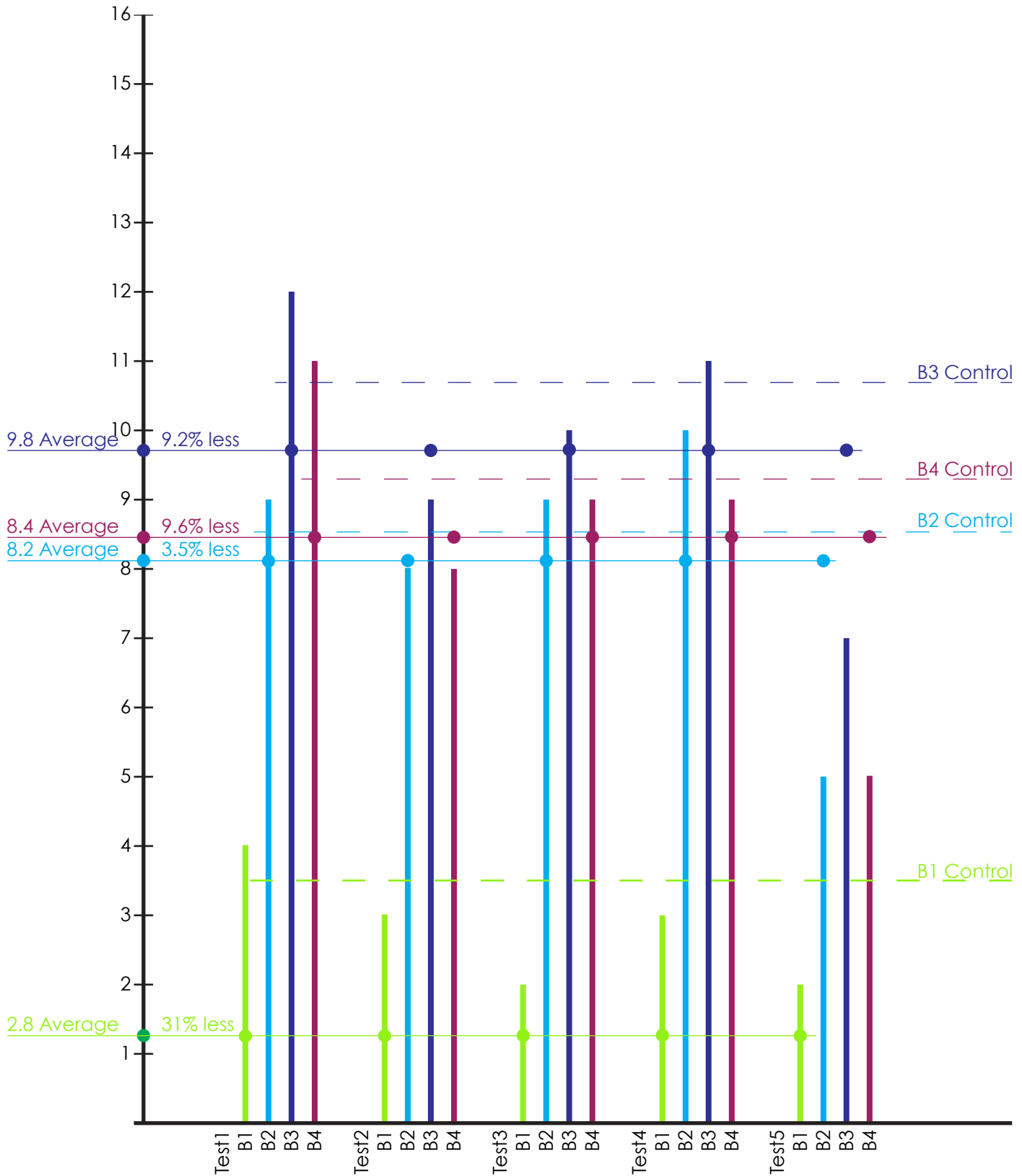


Figure 072/073: Underwater Screen Test



Floating Platform: 13.42% average reduction

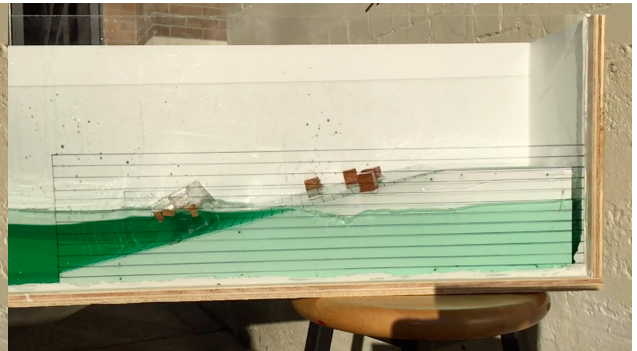
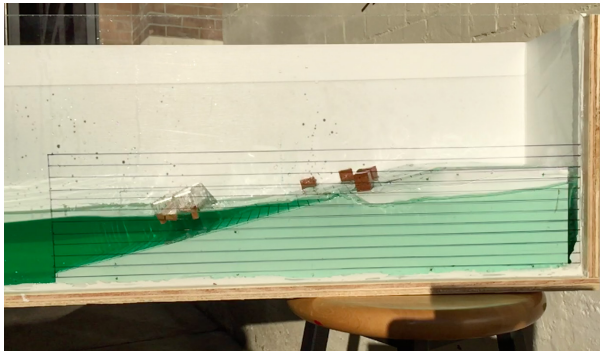
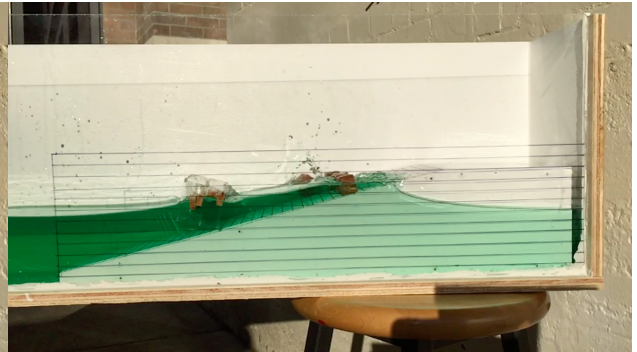
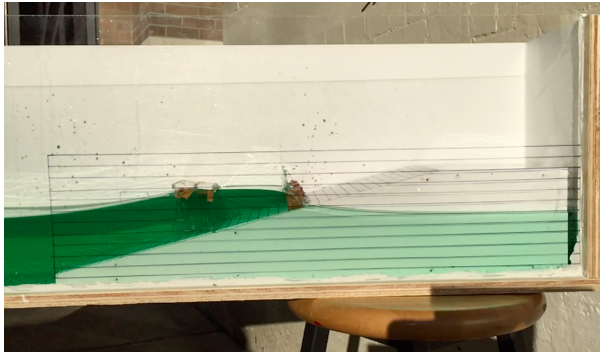
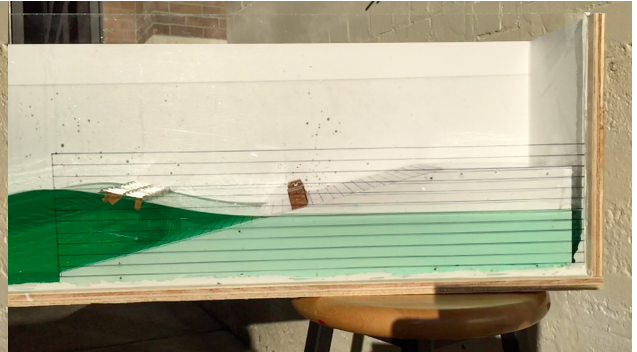
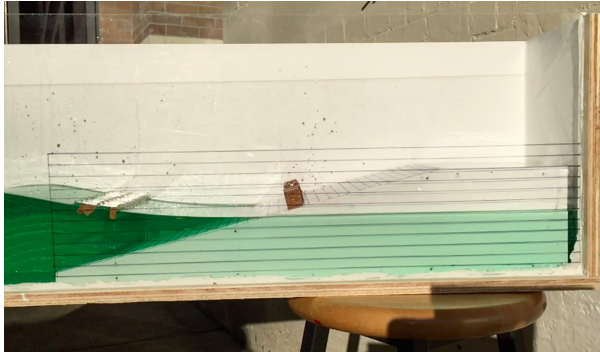
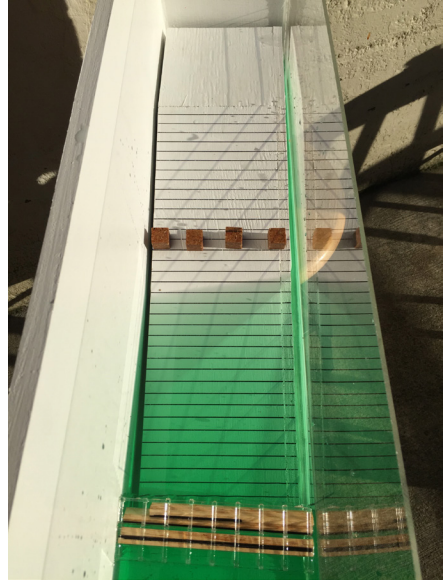
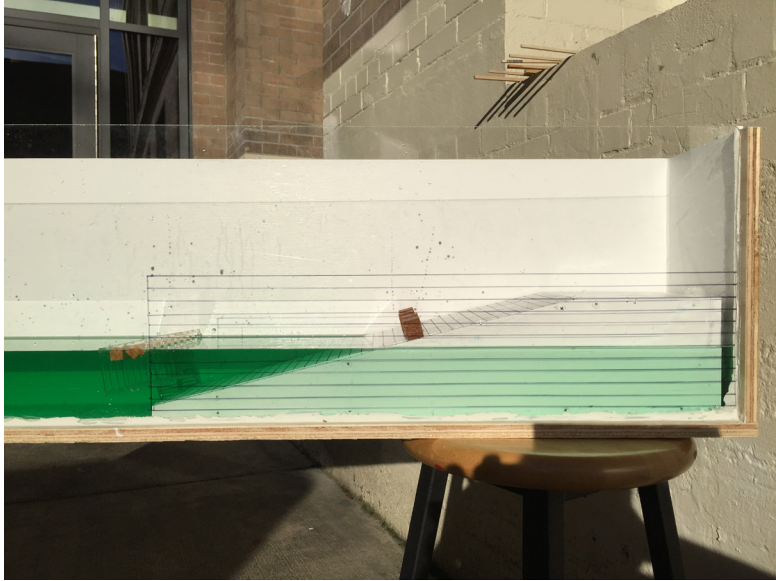


Figure 074/075: Floating Platform Test

is an important factor to help dissipate a wave. The secured wall did demonstrate the reasoning behind the current adoption of this system, but also exposed the reality that if the wall breaks, the inhabitants behind it are left with no alternative options during a natural disaster. The pylon test showed the reasoning why a diffuse system of supports is used on oil rig pylons. This allows for a majority of the wave energy to pass through the structure without stressing the system and is an important proof of concept looking forward to the design and how such a structure could support components of the network without risk of failure. In connection with the pylons ability to have wave energy move through it, unimpeded, the floating platform shows that this is also the case with an object that rides over the wave rather than resisting it. Floating over a wave rather than resisting it creates a unique design opportunity that would allow for components to resist the natural disaster by purely moving over the top of the wave rather than being in its path.

The underwater grid was designed to represent natural coral or rock outcroppings that help slow wave energy. This is seen in reefs protecting shorelines from major waves. Natural systems have been around for much longer than us, and therefore it is important to see how they work and within that, how the concept might be used in contemporary way to mitigate wave energy effectively. Coral is a recurring theme through the research and how its properties of growth and development mirror organic urban design as well as its physical properties of resisting wave energy. It will be an important system to apply to the design.

A final test with three screens in the tank proved the hypothesis of multiple systems working together to resist wave energy. Figure 069 shows the configuration that completely mitigated the generated tsunami wave without walls or hard defense. This is the system that will be used to influence the design of resistive floating systems in Tokyo Bay.

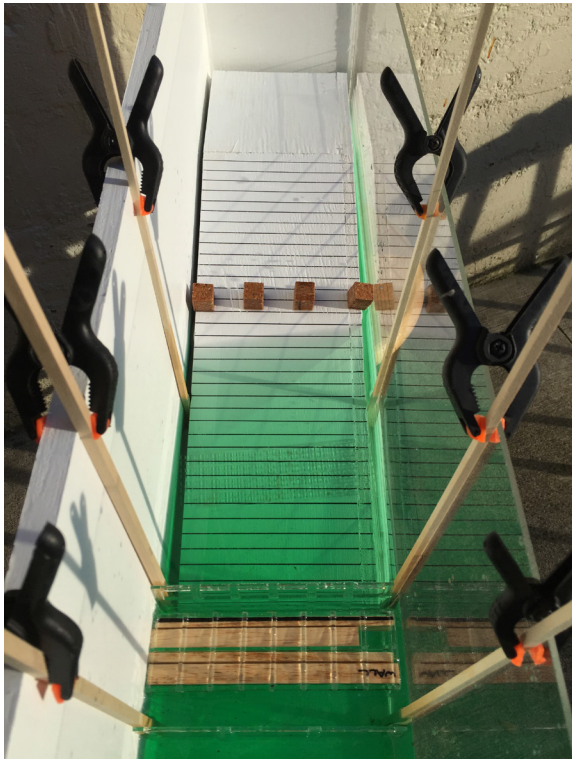
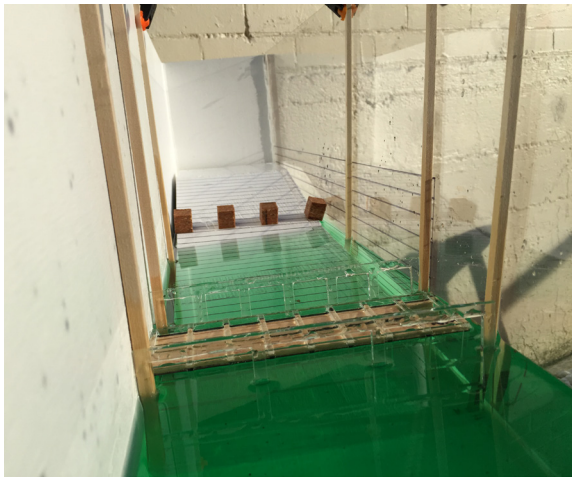
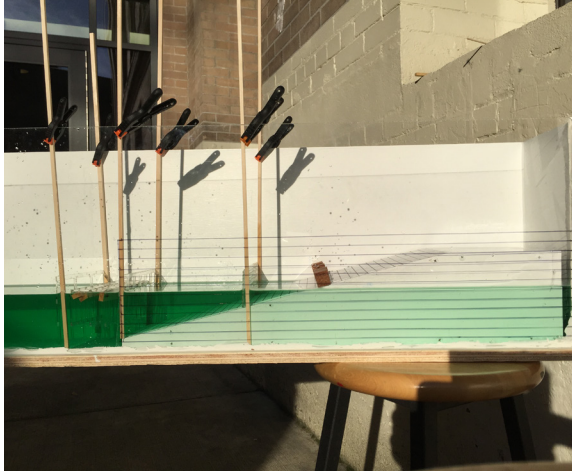


Figure 076: Integrated Tsunami Infrastructure

## CHAPTER 4: Findings

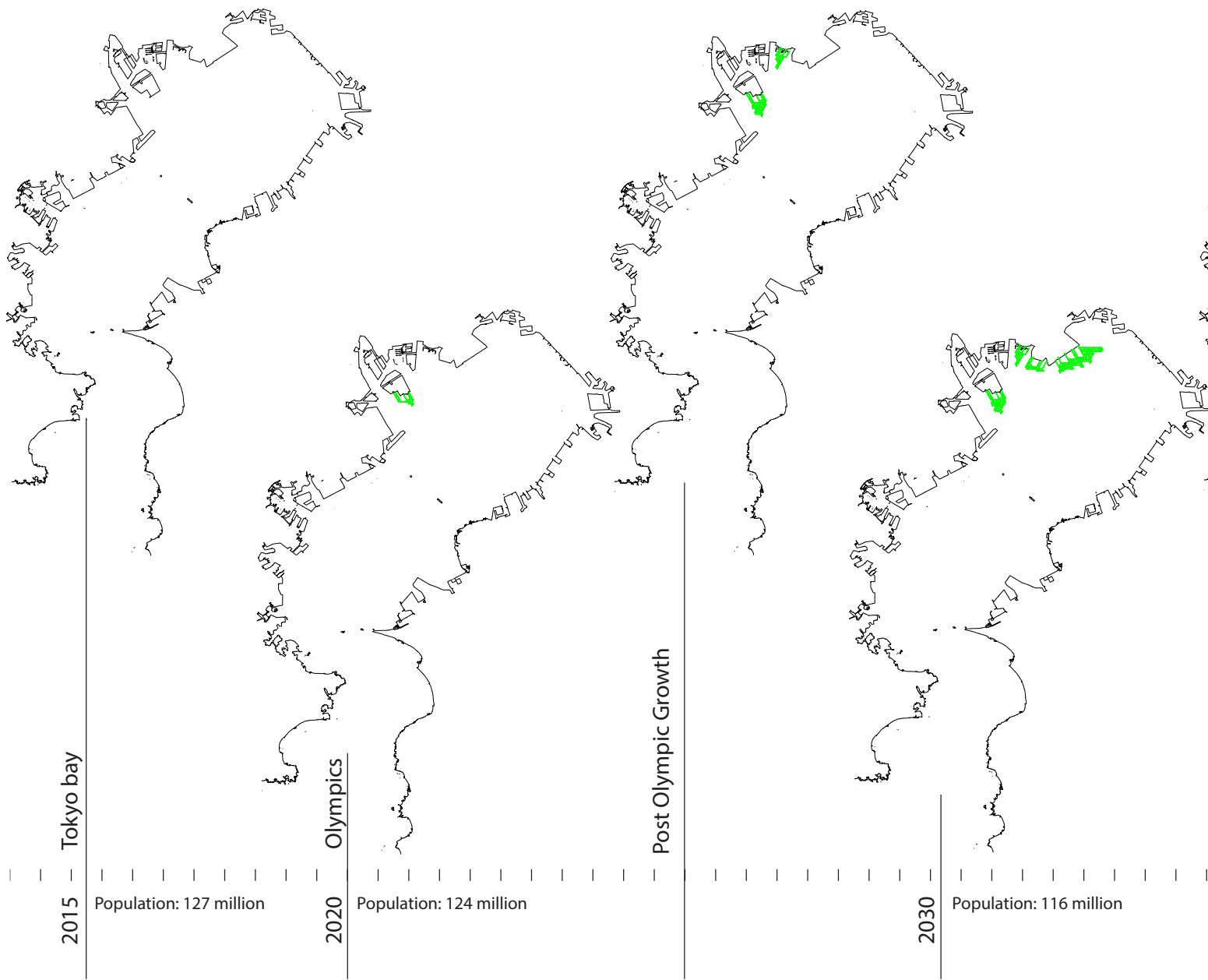
*“Perhaps the single most important challenge for the 21st century is to work towards a more resilient and sustainable urbanized world. In this global strategic urban context, resilience concerns the capacity of an urban system – including its natural, built, social and economic elements – to manage change, learn from difficult situations and be in a position to rebound after experiencing significant stress or shock...”*

*- Leonie J. Pearson*

## Urban Systems

The precedent research coupled with tsunami testing created a unique set of criteria with which to design. The most important component of that is time. Using the 2020 Olympics as a testing ground for a system such as this allows for broader thinking about floating urban systems coupled with tsunami defenses. This first step of implementation proves the overall system and provides a catalyst for further construction. Over a period of years the system would grow, much like coral, diffusely around Tokyo bay to protect the most vulnerable areas as well as providing new space for the city to expand. In figure 077 shows how a network could gradually populate across the bay over a period of time. By integrating the zones with the land as well as reacting to changing economic pulls in economy, the system would adapt to constraints imposed beyond the scope of this specific thesis.

Japans population is currently in a decline from a peak of 128 million people. Over the next fifty years the population is projected to decrease to 97 million individuals. This poses a problem for a large urban network as Japan is no longer expanding. Instead, by migrating individuals from the high risk tsunami zones and onto this floating system it frees up urban land for less infrastructure heavy applications. A twofold occurrence happens here where people moving to this new urban zone will perhaps help reduce the crushing density of individuals in certain districts as well as provide greater and more diffuse tsunami protection as time progresses. This newly open land could provide new access to urban farming, large sports fields or other low infrastructure systems that in the event of water inundation, would be easily rebuilt. As explained before, much of land around Tokyo bay is man made, thus by moving individuals from these high risk zones onto the floating city, the overall number of people that are at risk from a natural disaster decreases.

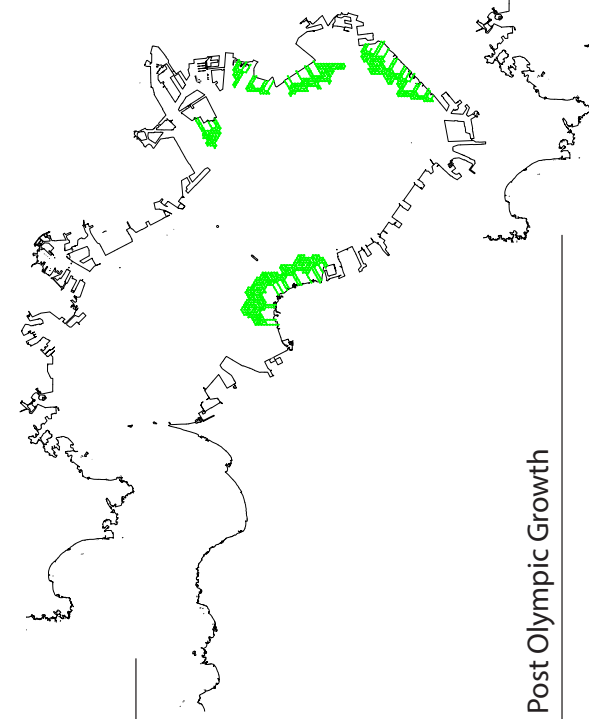


Post Olympic Growth



2040

Population: 107 million



2050

Population: 97 million

Figure 077: Time line of Network Integration Across Tokyo Bay

The makeup of the urban network is divided into two elements, the node and the connector. These two pieces when put together form the interconnected links of floating platforms for people to occupy. The hexagon shape from the system came from a geometric exercise with the outcome being that geometry is both the easiest to nest against one another as well as scale if the proposed size is no longer suitable in future implementations of this system. The diagrams in figure 078 and 079 show the first system and how it connects together with overlaid networks.

Connection to land is very important as this is not a floating city in the middle of an ocean but rather one that responds and depends on the city to maintain itself. The urban plan is designed to stretch from the land with multiple fingers reaching out into the bay. Once deeper water was reached, the majority of the network would grow, thus allowing for a direct path from land to sea while providing the more effective barrier against tsunami waves. As shown in the wave tank tests, if the majority of the system is in the shallow water and too close to shore, it would not be as effective at mitigating energy. The map in figure 073 shows locations where this floating city would best develop while considering depth of water, economy, low land and other risk factors. This uninhibited design makes for a system that could change quickly if conditions changed or different needs arose. Further, with a modular geometry, other configurations could be developed as this system is implemented, allowing for it to grow naturally rather than in a linear fashion.

Locating platforms on the water gives individuals greater connection to the sea and creates new transportation possibilities. Rather than one single system, a large scope of transportation systems could be overlaid onto the floating platforms. Figure 071 shows how three different systems of bike, train and boat would work together to move people to and from locations around the floating city. Water transport presents a unique opportunity for connections to other parts of Tokyo as well rather than relying on existing transportation networks to move through the urban sphere.

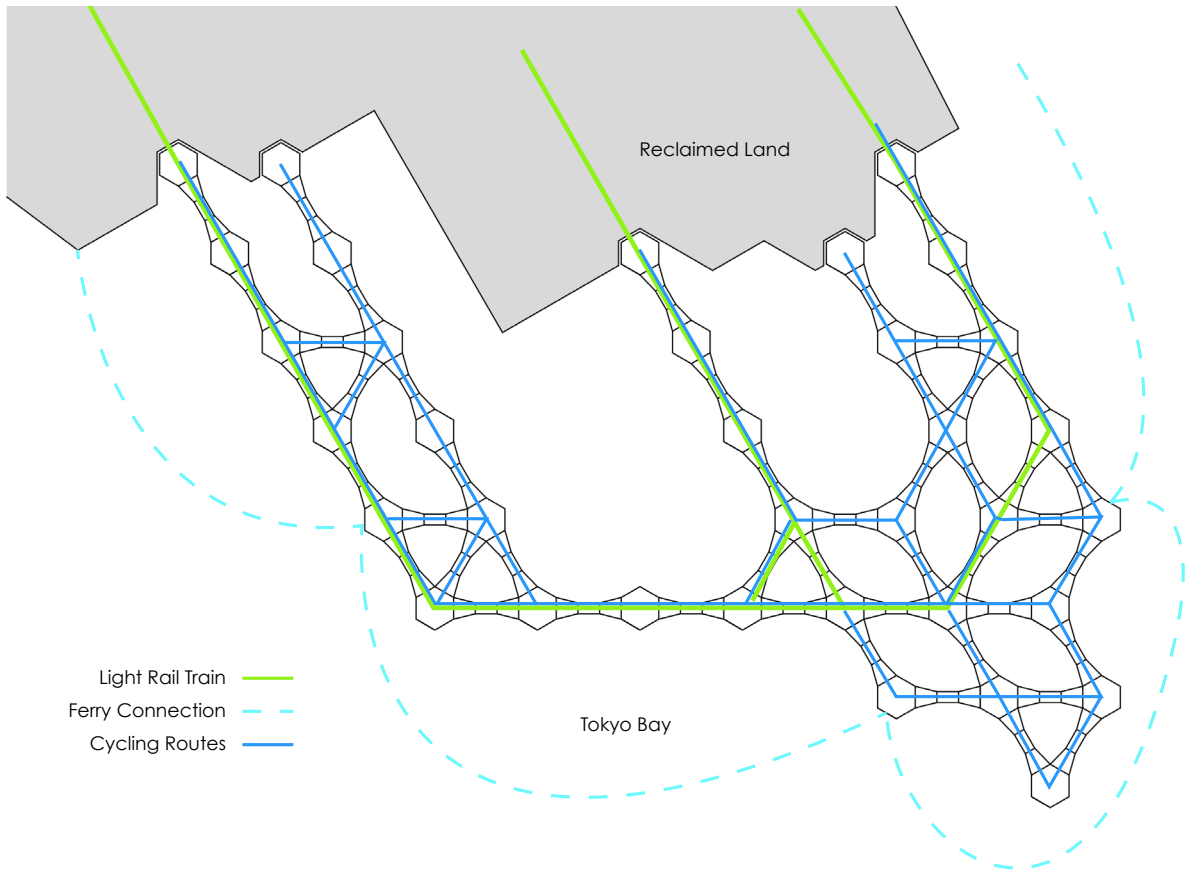


Figure 078: Floating platform network overlaid with transportation systems

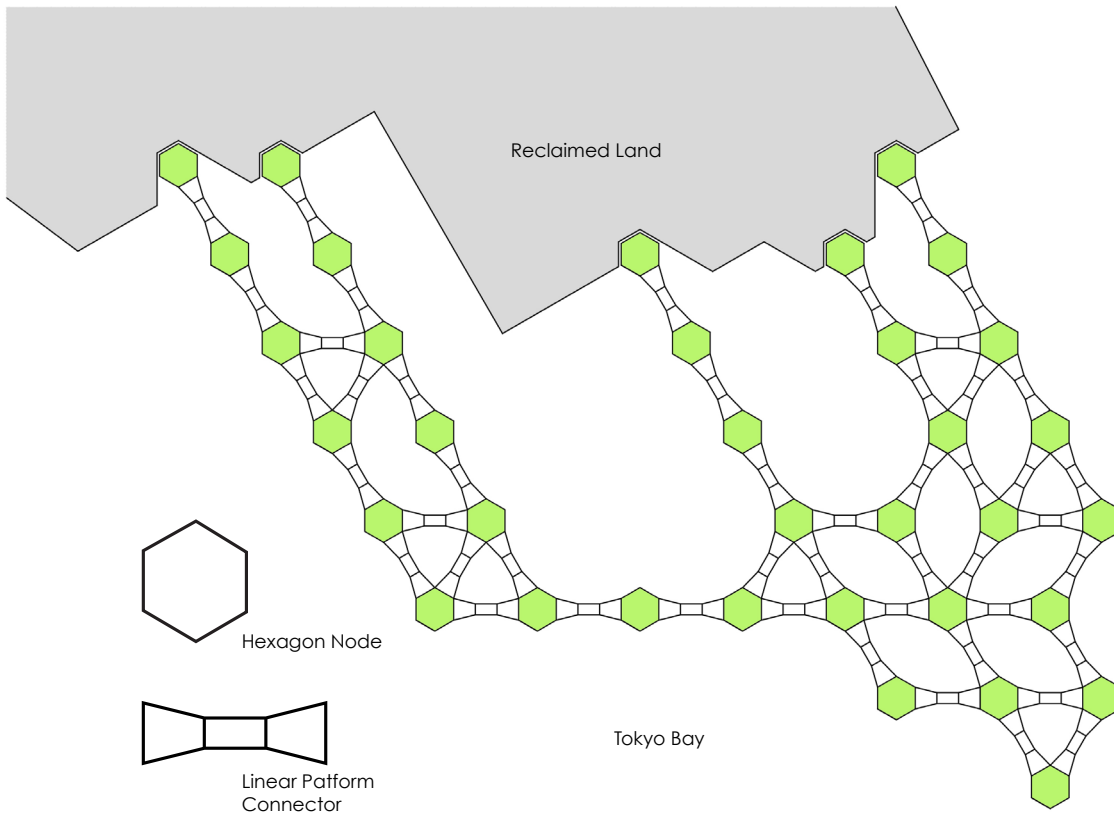
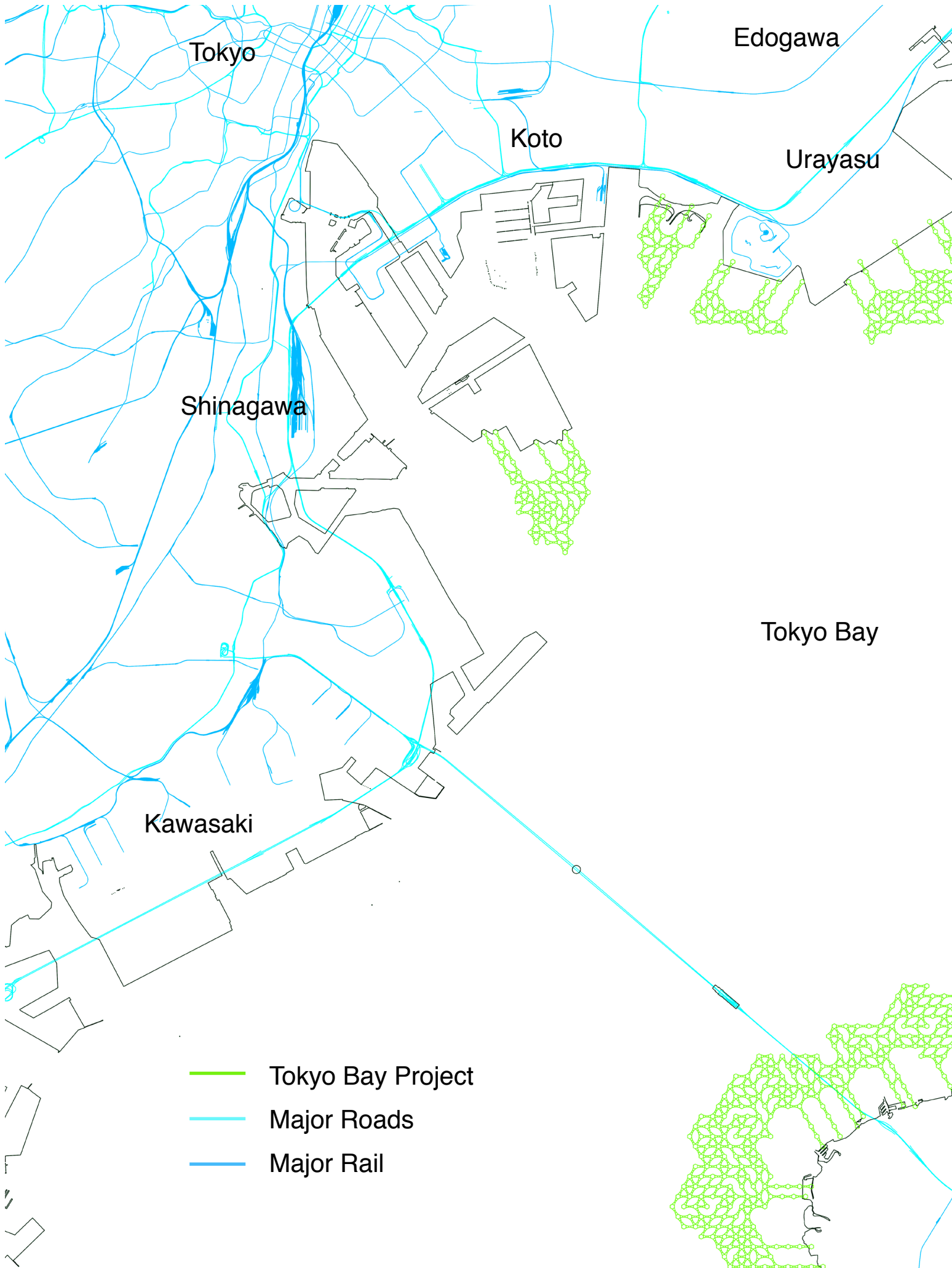


Figure 079: Floating platform network module connections



Tokyo

Edogawa

Koto

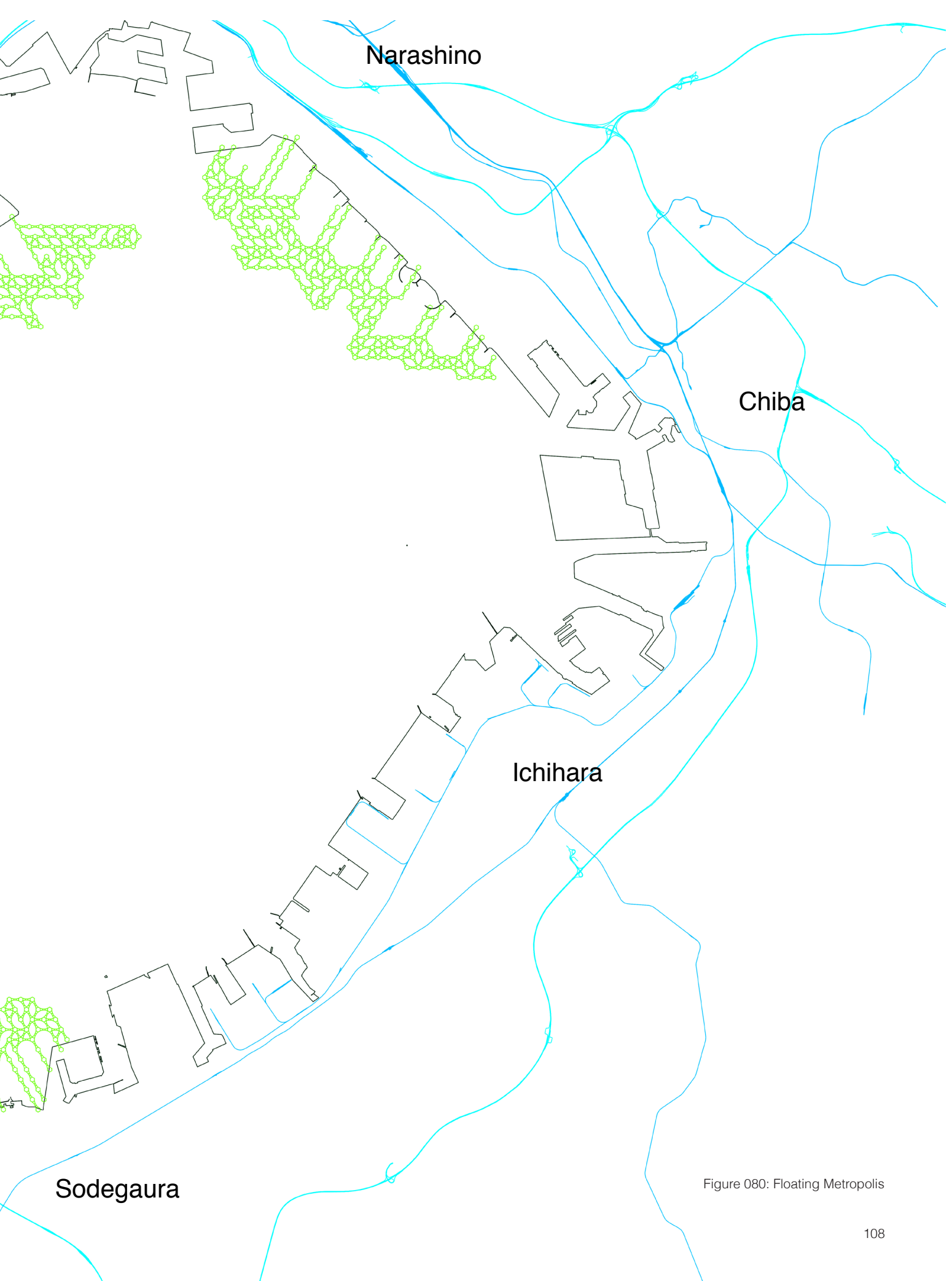
Urayasu

Shinagawa

Tokyo Bay

Kawasaki

- Tokyo Bay Project
- Major Roads
- Major Rail



Narashino

Chiba

Ichihara

Sodegaura

Figure 080: Floating Metropolis

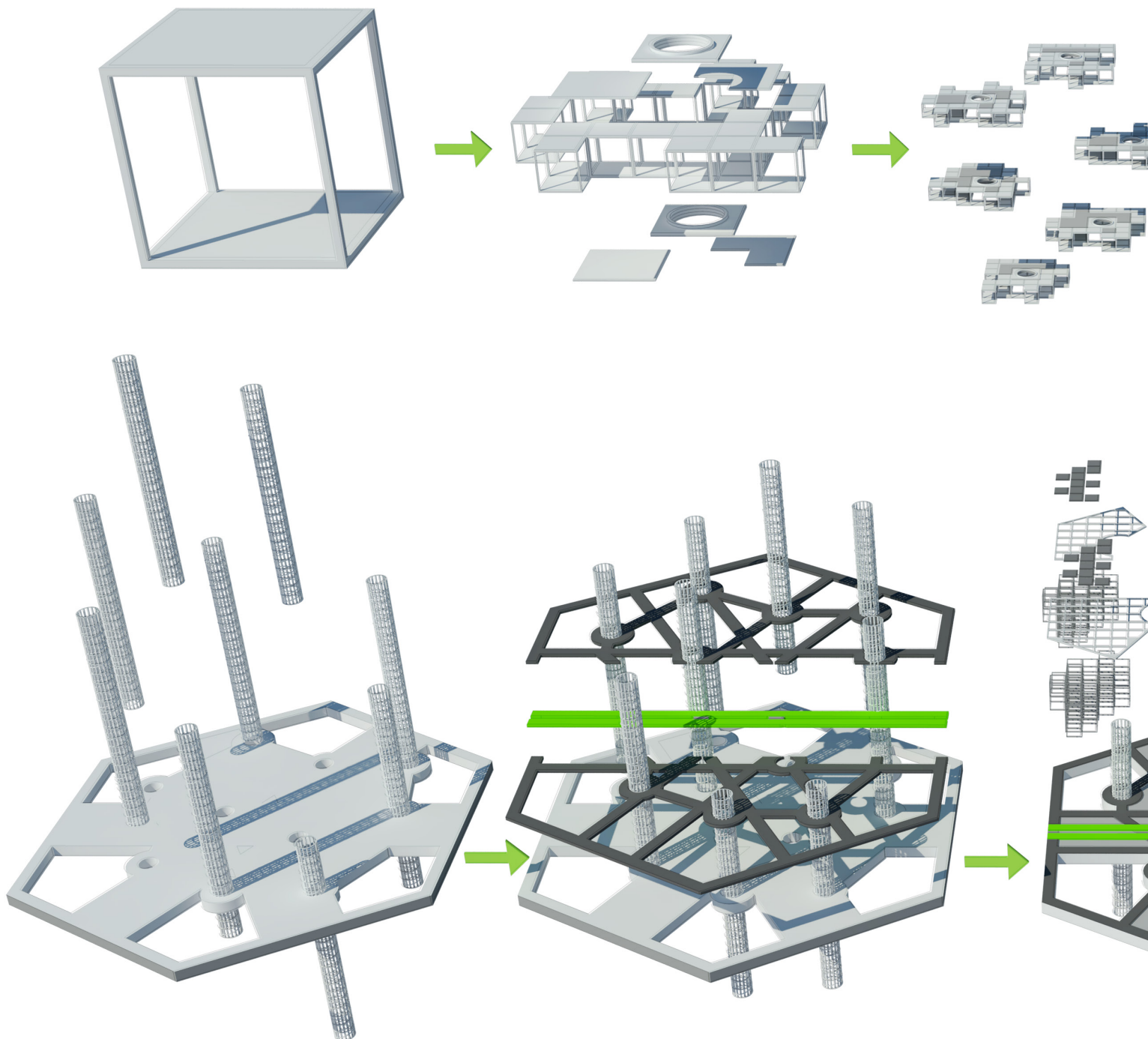




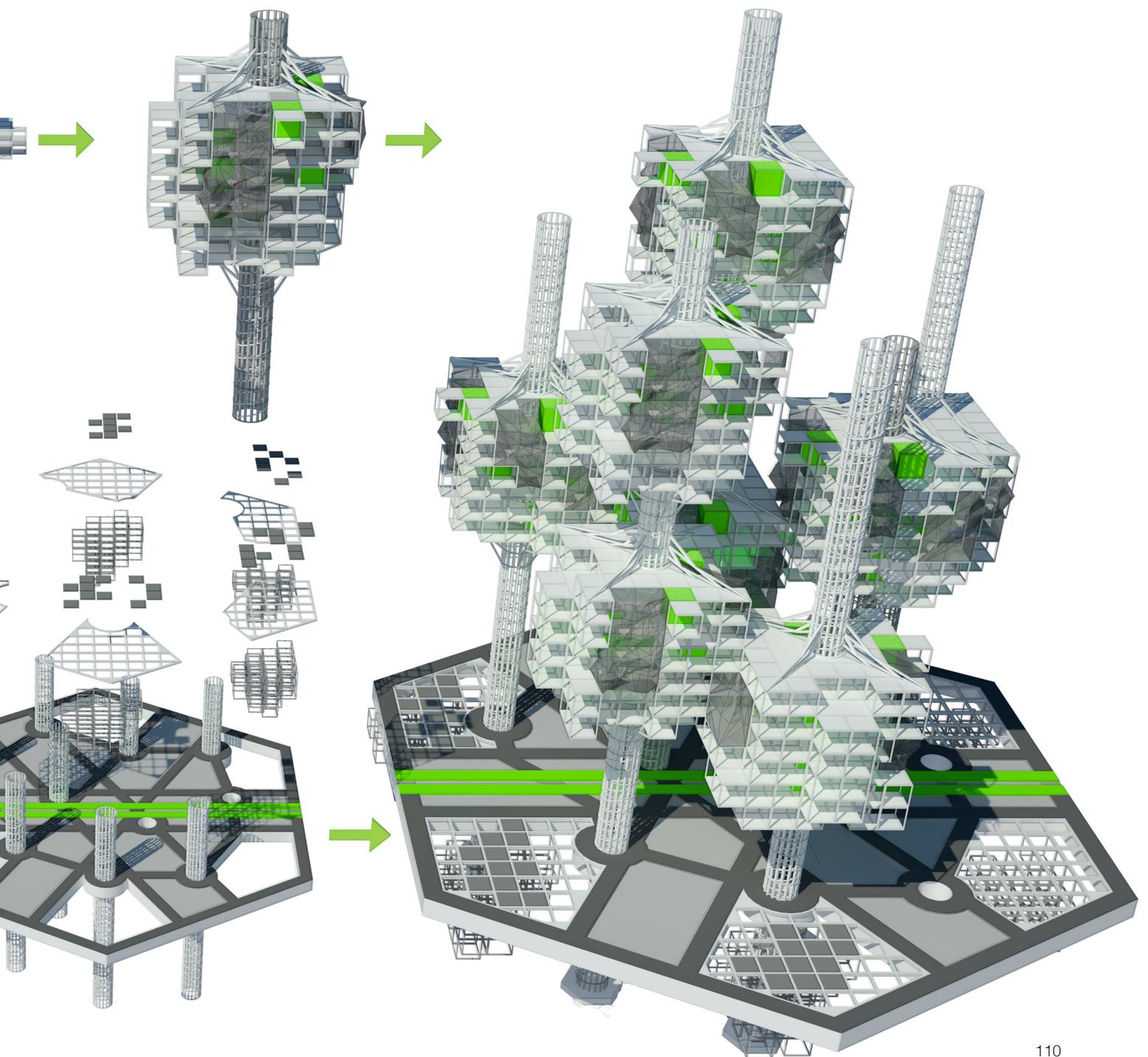
Figure 081: Aerial View

## Kit of Parts

With the connective network established, each node within the system would be developed according to current needs, individual constraints and changing aesthetics but the framework of the system would remain in order to provide structure and support



for the overall plan. This system would be made up of three major elements. The pylons that ground the structure and provide support for the entire system, the floating platform that connects all nodes together and the individual module that makes up the occupy able space within each node.



Construction of such a large scale project would be relatively simple compared to others of its size due to the modularity of the system. This kit of parts can be configured in many ways over long periods of time, allowing the entire network to develop as need arises without formal constraints. These pieces are also designed to scale so in future scenarios this system could change based on needs of individuals.

The pylons are designed after oil rig systems that support drilling platforms in the worst locations on the planet. In having multiple pylons, the system has a large base and distributed structural system to resist wave or earthquake energy. These provide the anchoring points for the floating systems so they do not float away during a tsunami. Further the interior of the pylon would be used for vertical circulation, connecting the urban landscape to the individual units above.

Urban scape would be defined by large floating hexagons and their connectors. This provides a surface that connects with the water and provides access to all the nodes in the system. On this urban scape a multitude of program could take place, just like the everyday streets of Tokyo.

The individual modules were designed through an understanding of both metabolist architecture models as well as traditional Japanese tatami mats. This square unit when connected to others forms floors around the pylon. These floors are then grouped together to form entire units that are supported through the pylon structure. This creates spaces that have the ability to change and shift while being simple to produce. Over time these modules would be changed out as new criteria or needs arose. Instead of destroying the framework, the intent was that they would be stripped of all useful materials and then recycled under the water to provide tsunami protection. Over time this transition of material from above water to below would strengthen the resiliency of the overall design while enabling growth without waste.

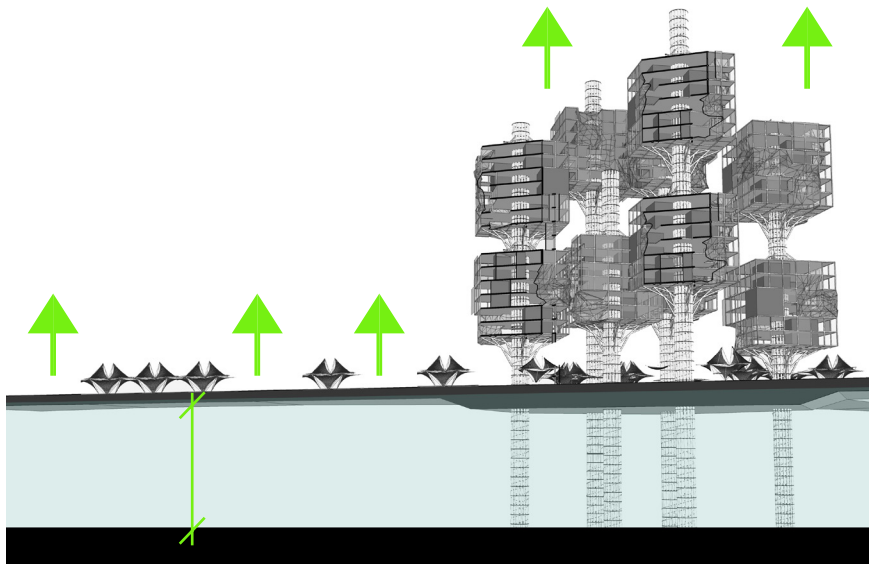
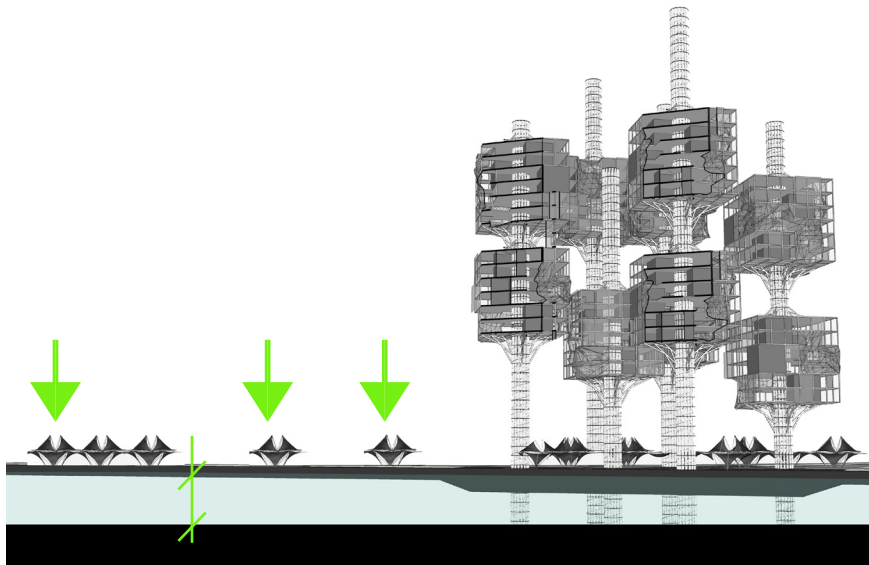
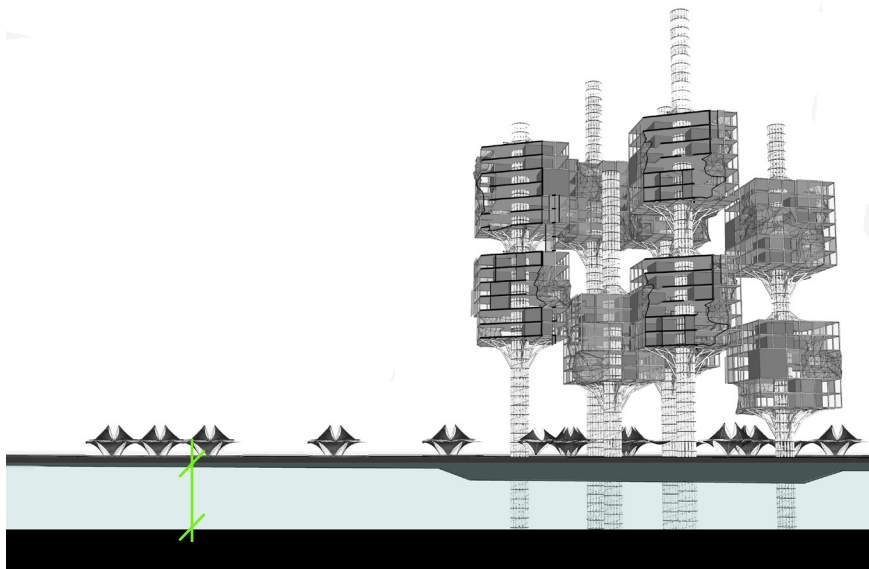


Figure 083: Sea level response

Figure 075 is a series of diagrams showing how the overall system would react with changing sea levels. Over time as sea levels rise, the entire system responds by changing with that overall drift. This makes for a resilient system that works with rather than against natural systems as well as ensures the long term survival of the investment.

## Node and Network

Within each node many units make up the living, working and community spaces that future inhabitants would call home. Rising vertically from the urban zone, these spaces are strategically positioned to be above any risk of tsunami waves while providing individuals with spectacular views of both the city and the ocean. This visual connection was important in redirecting the overall feeling of Tokyo from that of concrete and congestion to one of serenity and nature. Figures 084 through 089 explore the different components of each unit and how they interact with the distinct elements. Each node begins with supports along the pylon that provide the framework for all other components. From the base circulation would be added along with other necessary elements to make the spaces usable. The skins and nodes provide centers for gathering or circulation and provide a focal point within the larger grid.

Each unit would not be self contained however with the ability of floors to extend from one unit onto another without going to ground level. This connection aids in creating open floor plans for different uses as well as ties the entire node together into one strong unit in the face of natural disasters. Over time these units would grow organically on the pylons developing a large presence of usable space above the bay.

## Integrated Typology

The section in figure 091 shows how each piece from the kit of parts would be integrated

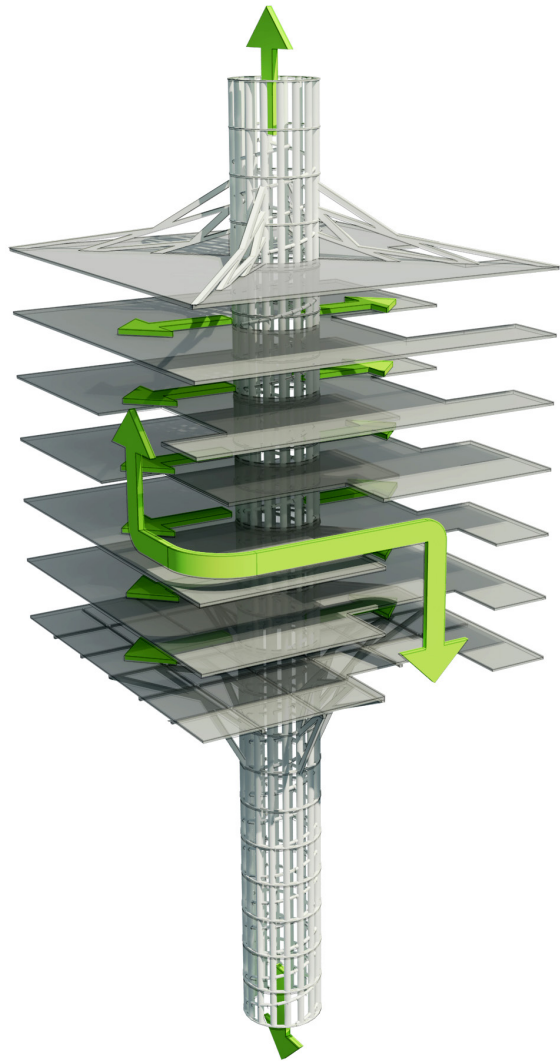
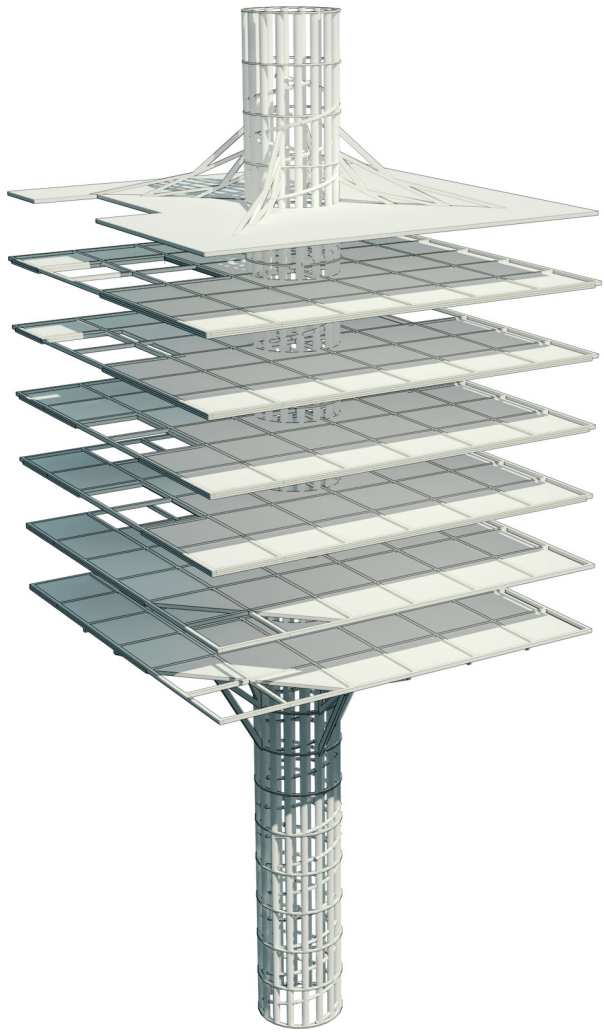


Figure 084/085: Module and circulation

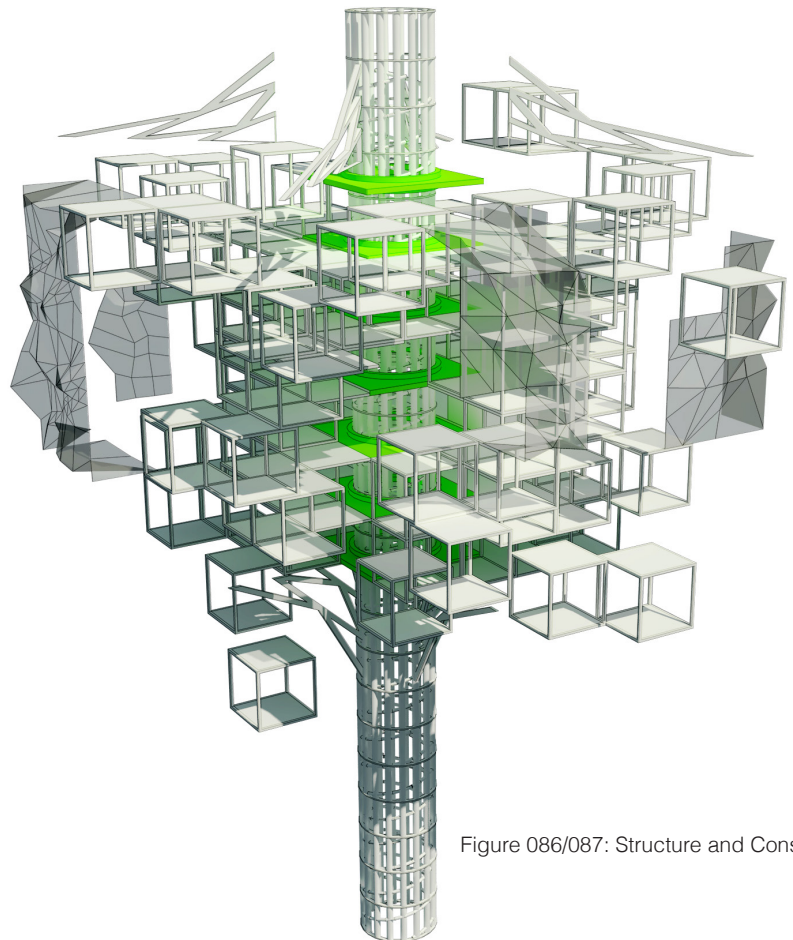
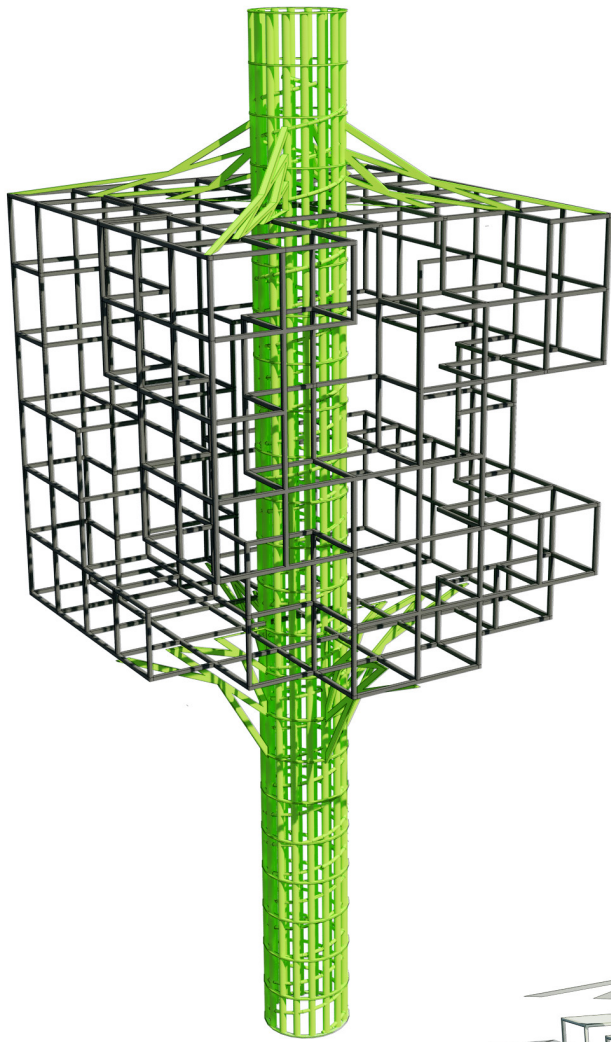


Figure 086/087: Structure and Construction

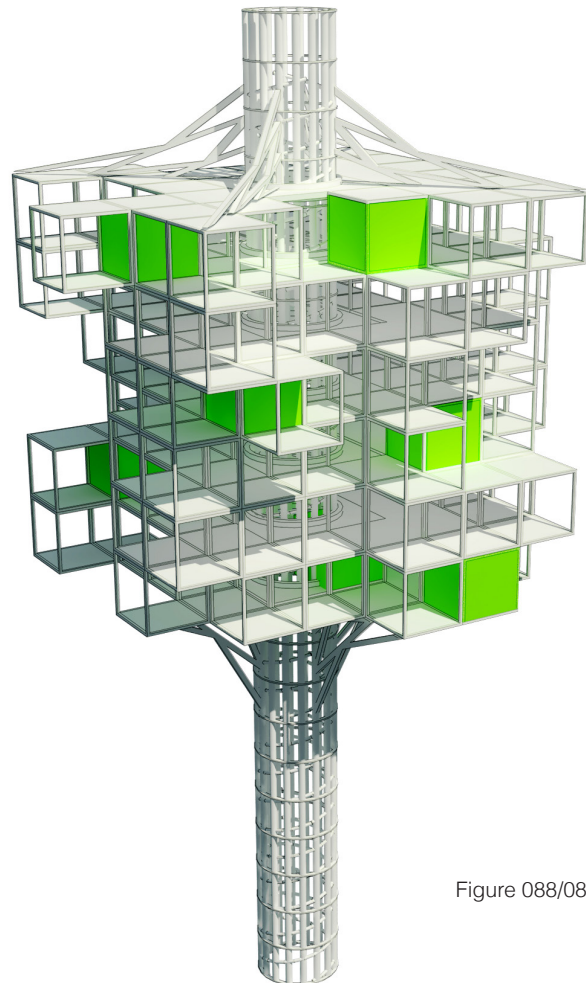
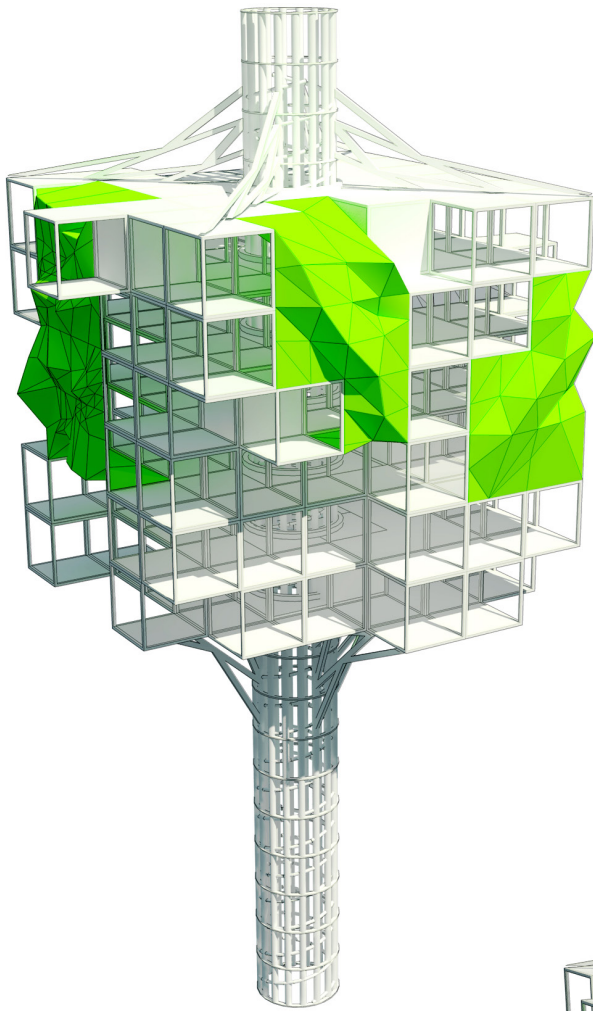
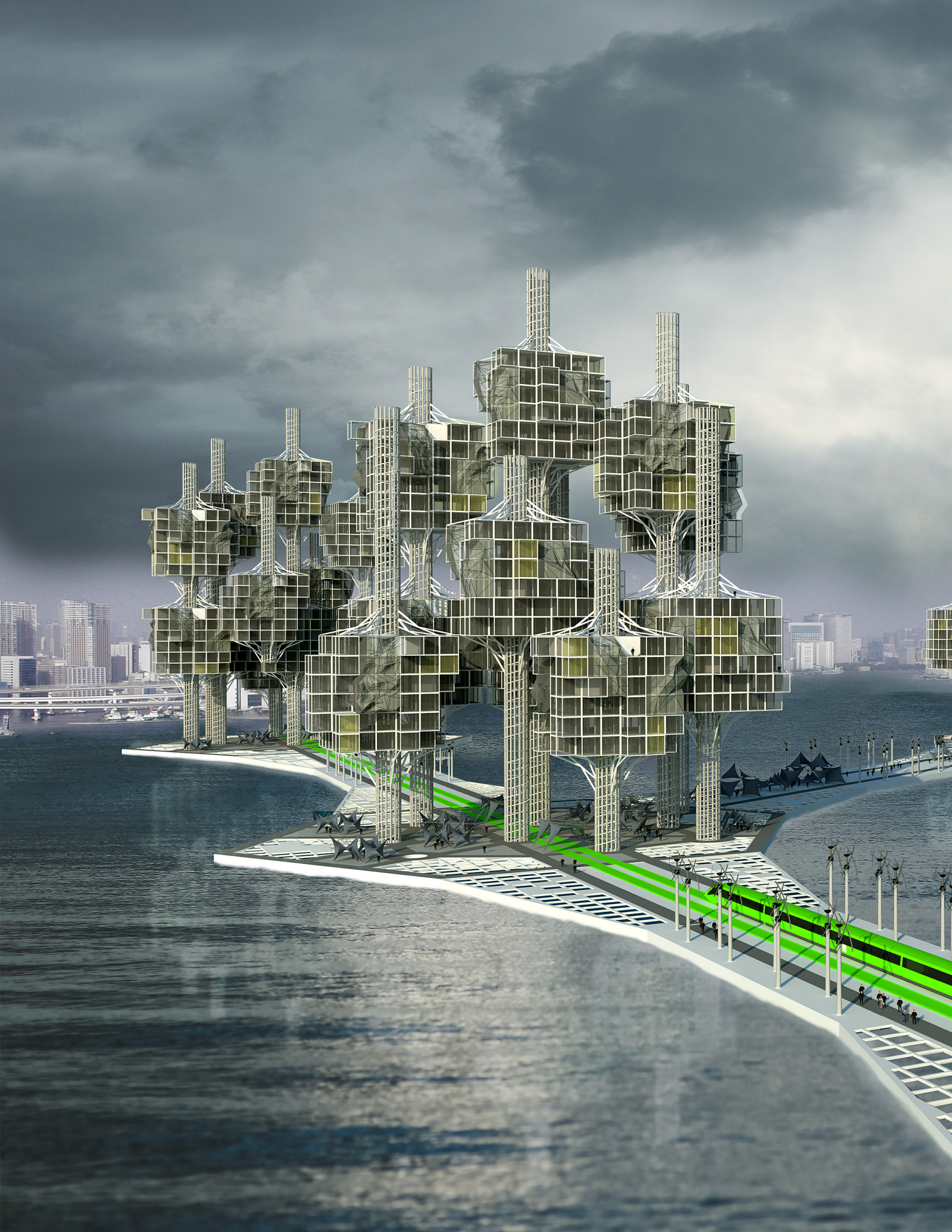


Figure 088/089: Skin and Node



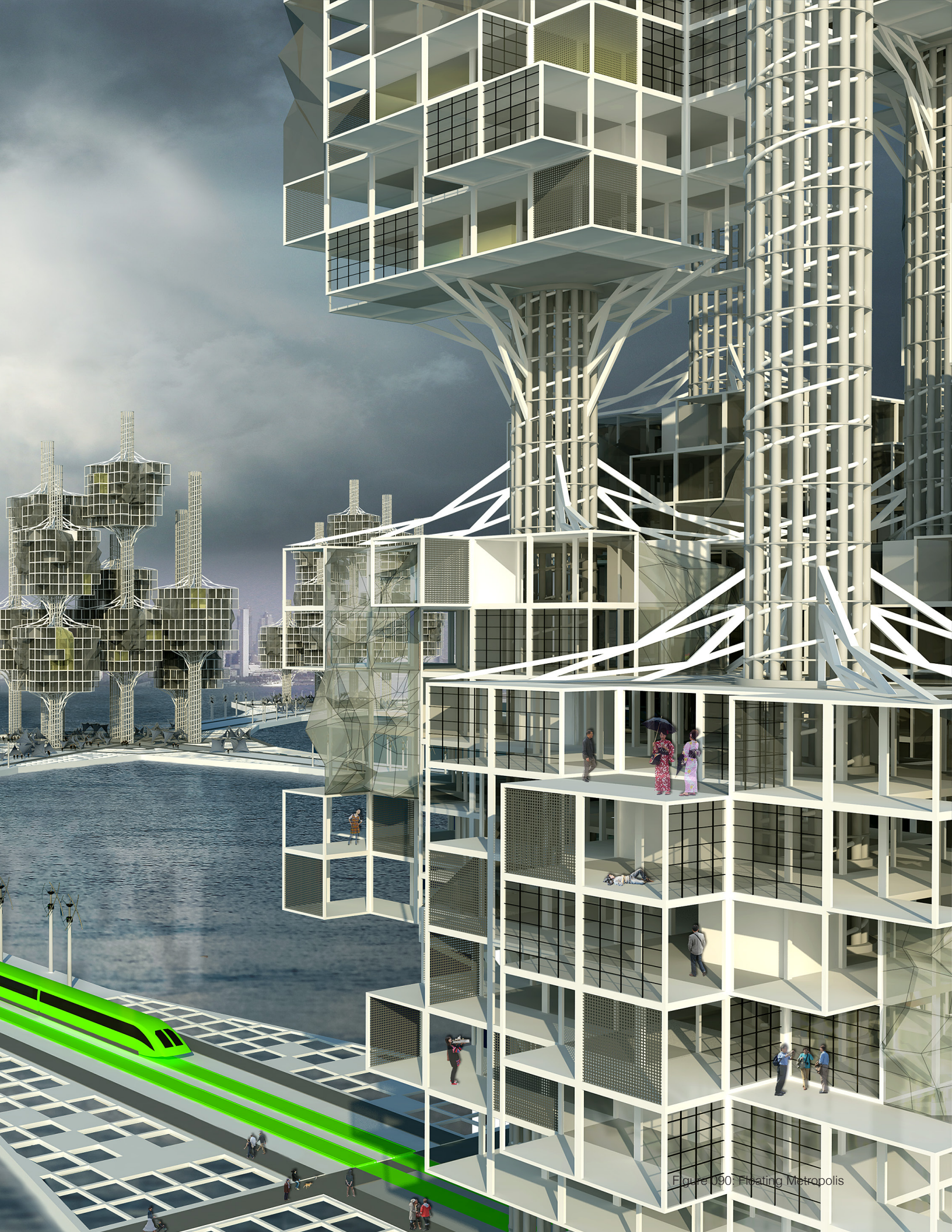


Figure 090: Floating Metropolis

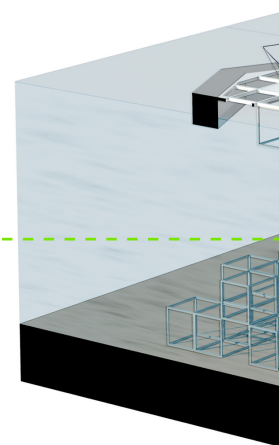
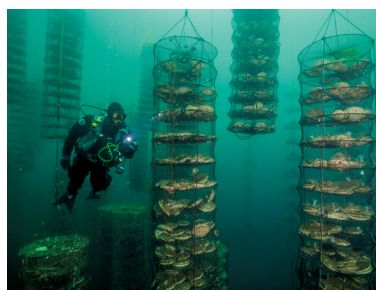
together. This synergistic nexus looks at how multiple typologies can be integrated for mutual benefit. From housing, commercial and transportation to urban scape, energy production and aquaculture, each node functions as a potentially self sufficient entity.

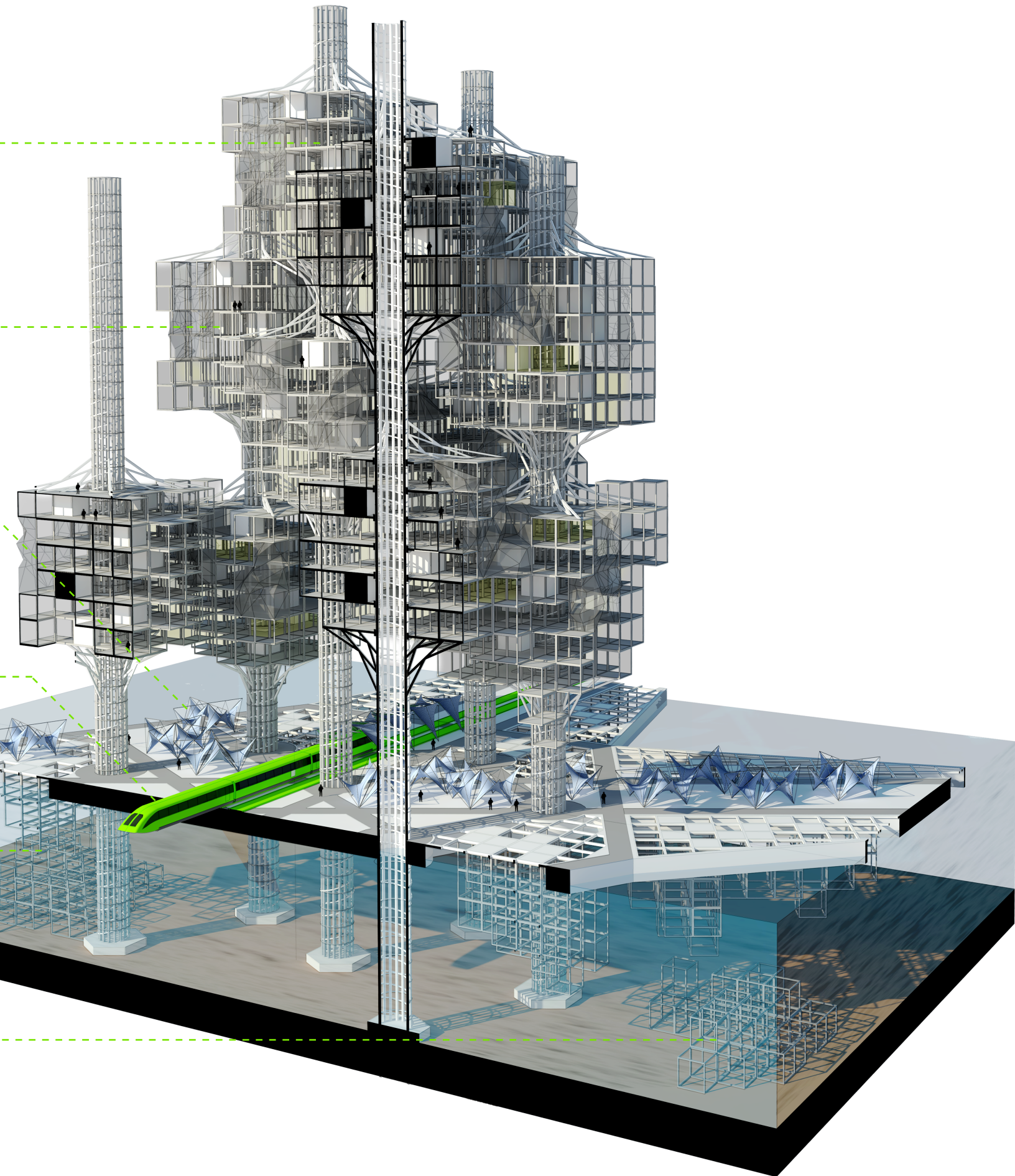
Riken Yamamoto proposed a blending of residential and commercial entities to better reflect the changing job market. This is taken into account with each unit being able to take on a needed typology, thus generating potential for diversified program.

Using the water as not only a form of urban scape but also a generator of energy through tidal fluctuation would aid in the system being self reliant for energy consumption. Below the water, aquaculture could be able to take place, generating food resources for the inhabitants living in each node as well as repopulating the currently depressed ecosystem of Tokyo Bay.

#### Human Scale

The human element is pivotal to the success of a system such as this. The design intent was to create a desirable experience for





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Figure 091: Section Perspective

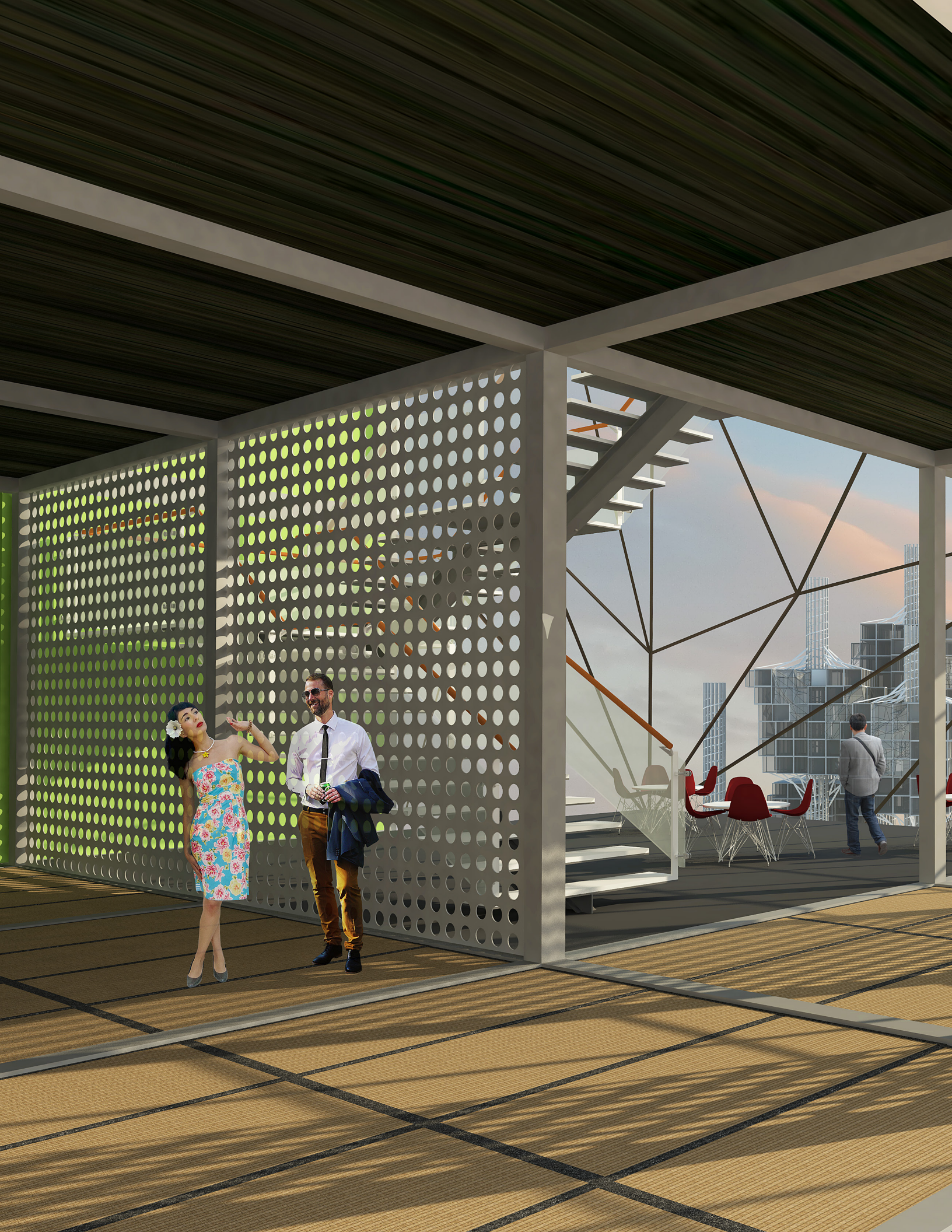




Figure 092: Interior Perspective

people to move from more traditional urban experiences in Tokyo onto this new city. By providing every inhabitant direct water access as well as views across the bay, it has two of the major drivers in the contemporary real estate market.

The image in figure 092 shows what an interior view could look like. Spaces defined by modern interpretations of Japanese shoji screens and use of the tatami mat grid system to delineate spaces. The kit of parts module comes through in the space planning while providing a rigid logic to floor plan layout. The image also shows how one of the skin connections could act as vertical circulation or community centered meeting spaces for the occupants of this unit.

Views outward would be dramatic, connecting the entire population of the floating city together in harmony. From above one could observe the happenings across to other units as well as below on the floating platforms. Each platform's horizontal space would be employed how current Tokyo streets are used with markets, food carts, venues, shops and many other uses working together to create a vibrant culture.

Structures inhabiting this urban component would be made of materials that contrast the large infrastructure of the city. Bamboo woven with lightweight fabrics would populate the urban landscape to provide structures for vendors and other street level functions. These could be easily moved and reconfigured with changing needs of inhabitants. In the face of the platform being inundated by a tsunami, the structures are light weight and easily destroyed rather than adding mass to the waves as they continued through the city.

The urban level will become an extension of Tokyo streets with the units providing natural areas to hang the many advertisement banners seen throughout the city. Rather than push against the norm, this system would need to adopt what makes Tokyo a great urban experience in order to prosper. This connection between land and sea is shown through

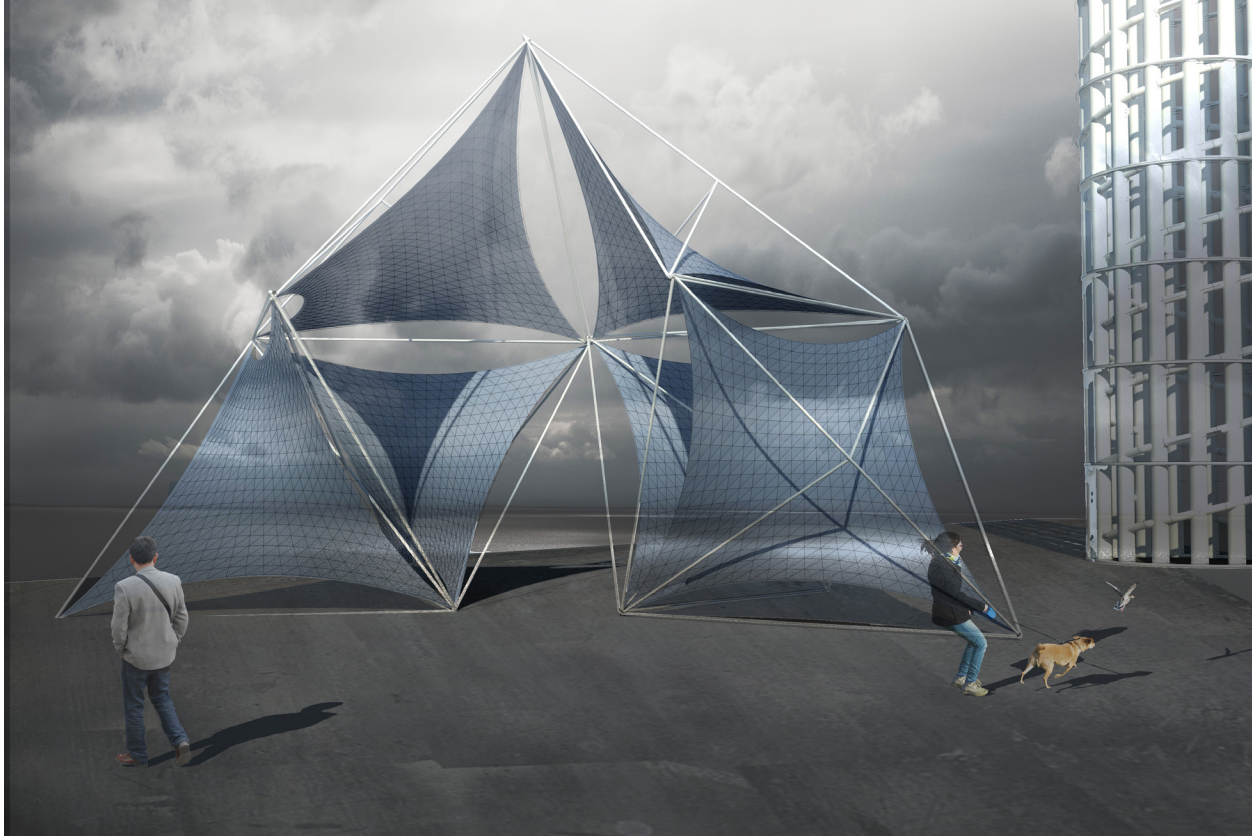


Figure 093: Urban Pavilion One

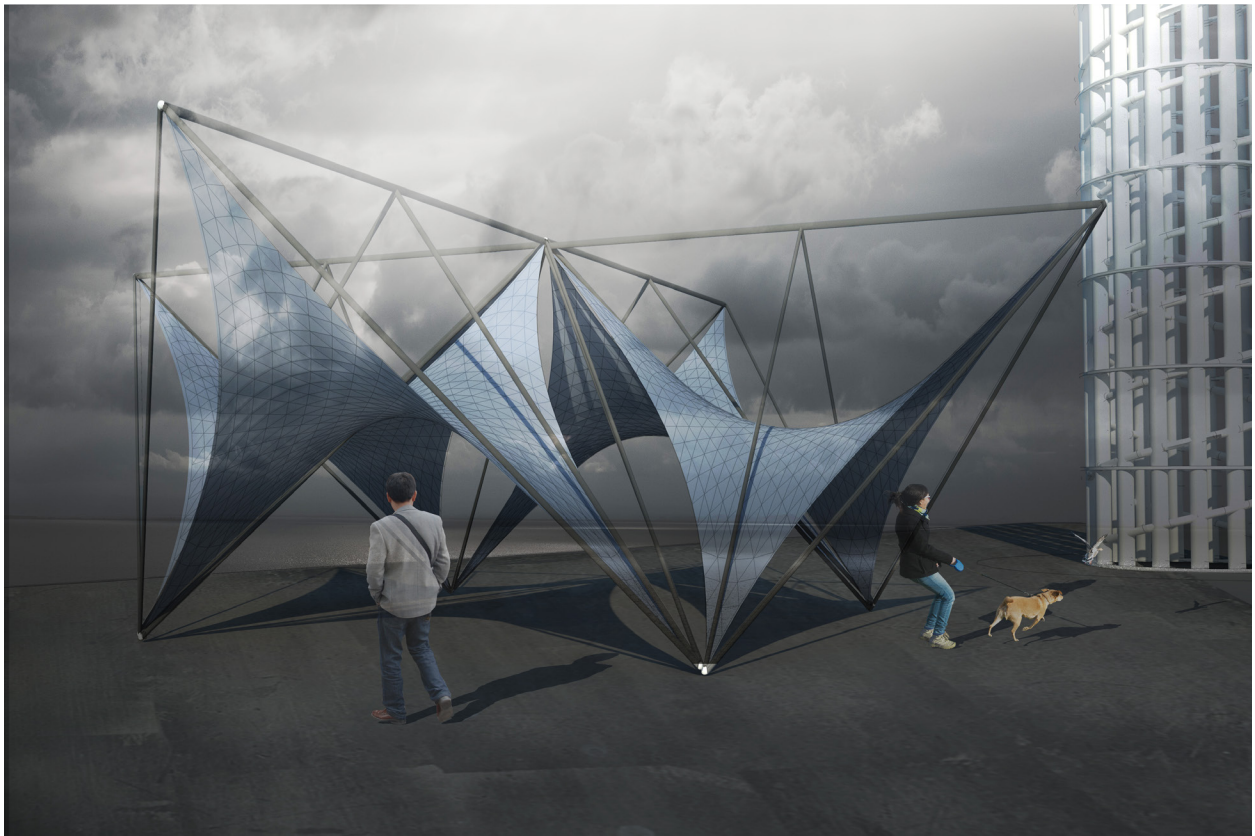


Figure 094: Urban Pavilion Two

カラオケ歌広場

ハコチキ 2F

フェンウェイへ  
ようこそ

一龍買の  
味半ホム子  
堂里大

BAN-THAI RESTAURANT  
タイ料理専門店  
バンタイ  
BAN-THAI RESTAURANT  
3F





ケ  
歌広場

カメラ  
カメラ館

情熱オムニバス

AKB48 神曲たち

ゴジラ  
鑑賞  
金太郎  
グループ  
2F  
要付

Figure 095: Urban Experience

all aspects of the design, reinforcing the symbiotic relationship between the two. Without the floating city, Tokyo is at risk for disaster, and without Tokyo, the floating city would be hard pressed to grow due to resources and systems Tokyo can provide.

Also populating the urban space is aquaculture. The integration of growing food in connection to the urban population aids individuals understanding of resource management as well as connects everyone to the sea. This contrast to current systems of tsunami walls and barriers lets people develop a healthy relationship with the ocean where they can enjoy its benefits but also understand the dangers.

Below the platforms a wide variety of organisms would grow and thrive. The diffuse plan of each node allows for adequate sun to penetrate the water as well as in a tsunami, disperse load of forces across many areas of the city. This system would foster the repairing of Tokyo Bays depleted ecosystem and establish a symbiotic connection between the ocean as a provider and humanities ability to help sea life thrive. The collection of sea life on the man made reefs would also provide for potential tourist activities in sports diving, adding another layer of economy to the floating metropolis.



Figure 096: Urban Pavilion Three

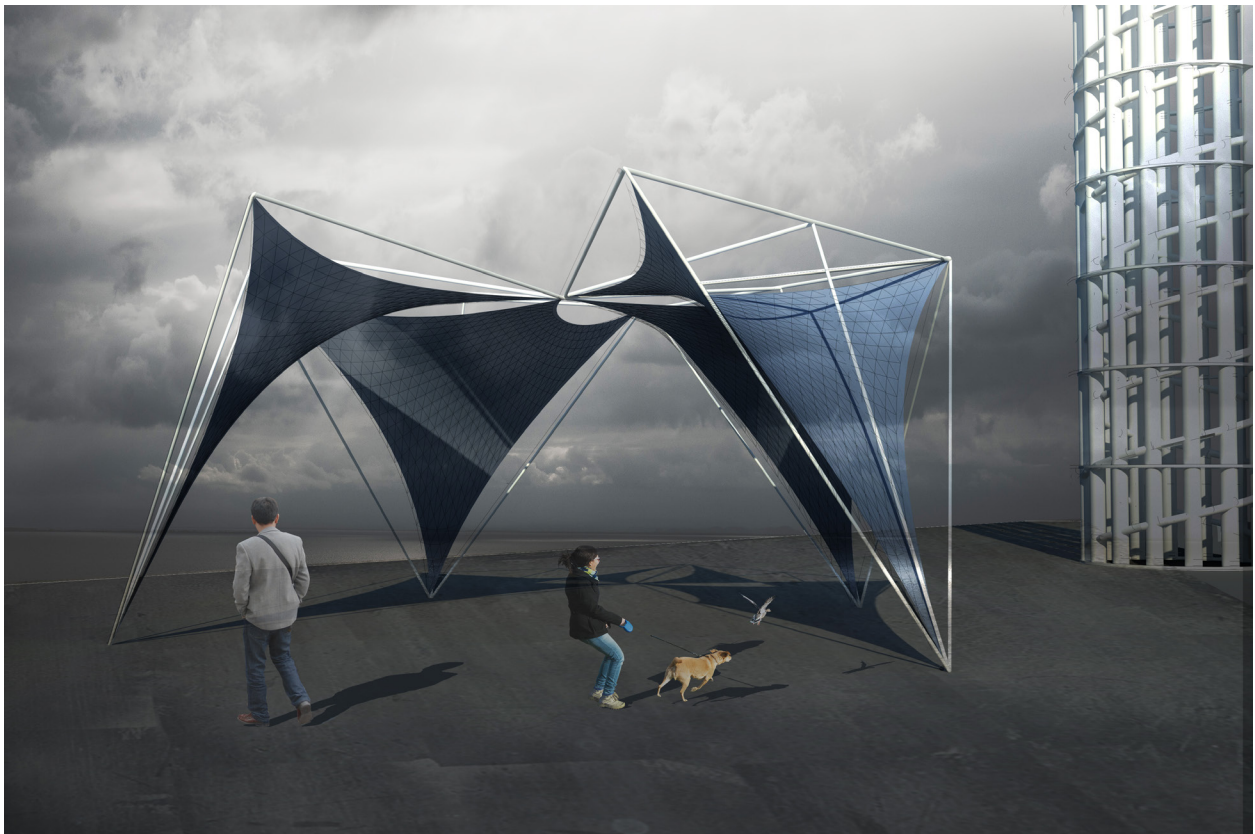


Figure 097: Urban Pavilion Four

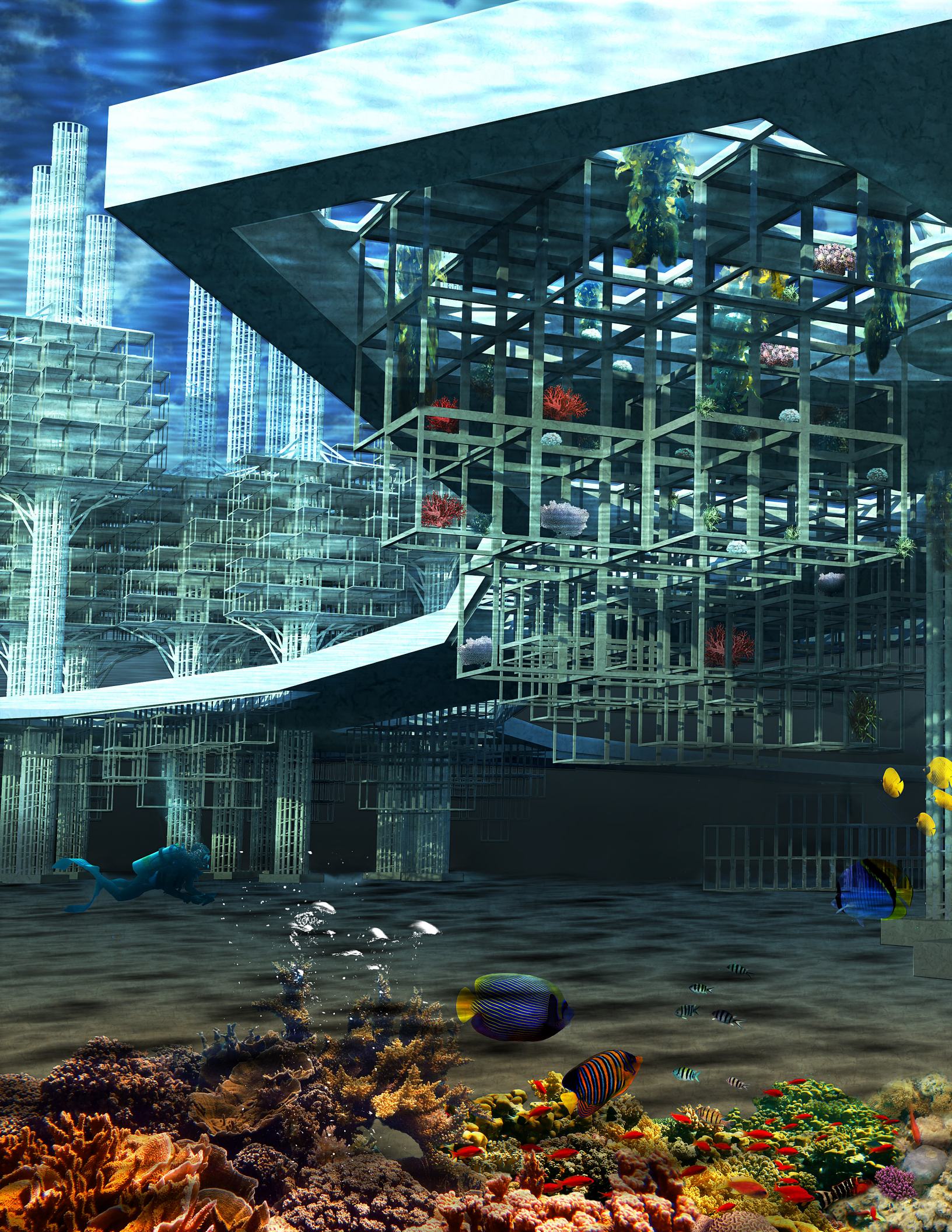




Figure 098. Underwater Seascape

## CHAPTER 5: Conclusion

*“Resilience is all about being able to overcome the unexpected.  
Sustainability is about survival. The goal of resilience is to thrive.”*

*- Jamais Cascio*

Population in coastal urban cities will continue to expand indefinitely, while the risk of natural disasters endures our current ineffective attempts to construct defenses. By developing solutions such as this thesis to work with rather than against natural forces, we will develop cities that are resilient but also sustainable and prosperous. We need to think differently about our relationships between natural and constructed systems if we are to design cities that are fluid and able to react to changing constraints. Overcoming unexpected situations is key to the survival of our coastal cities around the world. Implementing a large scale infrastructural system such as this thesis proposes will take time, but by challenging the current standards now rather than in the future, it gives us a high chance of success when facing adversity.

The 1960s metabolist movement pushed the idea of floating cities into the international spotlight. This thesis took those concepts and applied them to a 21st century approach. By integrating tsunami resistance with a biophilic understanding, this created a design that not only protects the inhabitants of Tokyo, but provides for a new urban landscape that would grow and develop alongside the urban condition.

Integration of ideas was the most important link in order to ensure the network as a whole functioned both in scale and implementation. By analyzing what waves actually do through the tank tests, a greater understanding of how a system such as this would respond was gained. This analytical data grounds the design concept in reality and helps prove the initial intent.

Natural disasters are inevitable, and therefore designing resilient infrastructure in conjunction with the ever changing natural landscape will be key to the future of coastal urban communities.





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