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PLASTIC ECONOMY

PLASTIC RECYCLING | PLASTIC ARCHITECTURE



Anthony Stott | 539 784



PLASTIC ECONOMY

PLASTIC RECYCLING | PLASTIC ARCHITECTURE

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Supervisor: Michael Rayne

Master of Architecture (M.Arch Prof) | 30th March 2017



DECLARATION

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Anthony Stott
24/10/2016



This document is submitted in partial fulfilment for the degree:

Master of Architecture [Professional] at the University of the Witwatersrand,
Johannesburg, South Africa, in the year 2016.

THANK YOU

To Michael Rayne, thank you for your sound advice and endless support. Thank you for your weekly impartation of wisdom and your willingness to assist me in any way possible.

Thank you to everyone who supported this thesis throughout the journey. I appreciate all those whom have given me their time, hospitality and knowledge that I would not have access to on my own.

To those who supported me when it mattered most, thank you for all your support and love.



Figure 0-3: Plastic particles on Tofu Beach, Mozambique [Photograph]

ABSTRACT

Environmental issues are becoming increasingly common topics in the news and posts on social media. On social media it is common to see posts reporting on issues ranging from global warming to endangered animals and occasionally the people who are dedicating themselves to correct humanity's mistakes. One of these environmental concerns has been the increasing amount of plastics collecting in our oceans.

This issue is caused by plastic being discarded improperly and eventually finding its way into our oceans where it breaks down and causes devastating harm to sea life. This serious issue needs to be corrected before the effect become irreversible and their are a number of organisations already taking on the challenge. However the scale of this issue is simply too large, this is a global issue and it needs a global involvement in order for it to be handled and their are economic opportunities to be gained from the situation.

By using the discarded plastic as a raw material for the production of new products, the process is manipulated from one born of consumerist society to a more sustainable option that the modern world strives for. In a world striving for continuous technological advancement, what innovative processes can be utilized to take advantage of this global problem and turn it into opportunity?

This research essay will suggest how the construction of a **PLASTIC RECYCLING AND RESEARCH CENTRE** located in the city of **DURBAN** could act as a catalyst for South Africa to begin to play a serious role in tackling this global issue. Could South Africa capitalise on this opportunity and how could emerging technologies be utilized for the benefit of the country, the oceans, the global community and a sustainable future.

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MAN & THE ENVIRONMENT



Figure 1-1: Factory Smoke [Photograph]

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Figure 1-2: Air Pollution [Photograph]



Figure 1-3: Deforestation [Photograph]

INTRODUCTION

The world is facing ever pressing environmental challenges and it is becoming more and more clear to scientists that humanity is the cause.

"Man was innocent until he discovered the difference between good and evil. When he was no longer oblivious to this knowledge he became a fallen creature. We are not alone on this planet. We are part of a community upon which depend on absolutely. We're destroying the world because we are, in a very literal and deliberate way at war with it."

- Daniel Quinn

Humanities relationship to Earth has predominantly been a one sided , where mother earth provides and man takes. However it is time that the human race pays its dues before the Earth has nothing left to give.

We need to understand the issues facing the planet and work together to solve them in order to a sustainable future.



Figure 1- 4: Acid mine drainage effects on water [Photograph]



Figure 1- 5: Ocean Litter [Photograph]

CHAPTER 01

MAN'S RELATIONSHIP TO THE EARTH

HUMANITY'S ATTITUDE TOWARDS NATURE

We live in a wonderful world full of life, full vibrant colours and incredible beauty. However man has left an impact over the past thousand years has continued to be exponential and the effects are all to apparent. We have treated the planet irresponsibly and the effects are all to apparent.

Humanity's progression, particularly since the 19th century and the industrial revolution, has been in a large part due to our ability to extract and utilise what Earth has to offer. The food we eat, the timber we cut, and the water we consume amounts to an incredible amount of resources that the Earth produces.

The Earth provides is with the resources we need in order to live the lives that we do. However in order for our planet to supply us with these materials we require healthy ecosystems that will flourish with life.

We are only now beginning to understand how fragile the worlds ecosystems are and how our actions in the past have affected our planet. When resources are depleted there will be none left to sustain humanity's current lifestyles.

Humanity needs to change its behaviour and find alternate means of existing in order to preserve the Earth's ecosystems.

PLASTIC PROBLEM



Figure 2-1: Plastic bag in the ocean [Photograph]

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Figure 2 - 2: Early Plastics soccer players from Germany , World War II [Photograph]



Figure 2 - 3: Set of Hyatt Billiard Ball invented by John W. Hyatt ca. 1860 [Photograph]

INTRODUCTION

Due to man's selfishness, the Earth faces a number of environmental issues that will ultimately effect our way of life. Many of these issues are of our own invention that took off before we could fully understand the consequences of such actions.

This discourse will explore plastics and the role it plays as a material in our society as well as its involvement in environmental concerns of plastic pollution around the world particularly in our oceans.

CHAPTER 02 PLASTIC AS A MATERIAL

HISTORY OF PLASTICS

Plastics have been around for a very long time but these are not the kind of plastics we know of today. There are references to early plastics in biblical times, these natural plastic materials were being used as fillers, glues and coatings.

Plastic was born from the creation of early rubber. The very first thermosetting material created was called ebonite, a hard rubber. This was first material that involved a chemical modification of a natural material.

Cellulose acetate was another thermosetting material that was later developed. Cellulose acetate was invented in 1927 and was introduced as a moulding compound.

In the 1930's saw the development of today's major thermoplastics began. These included low density polyethylene, polyvinyl chloride, polystyrene and polymethyl. During World War II in 1939, there was a shortage of materials such as natural rubbers. Plastics became highly valued as it could act as a substitute for these kinds of material and thus production of plastics accelerated

After World War II, the United States started a program which lead to extensive research into the rubbers and the chemistry of polymers in general. This research eventually lead to the development of more plastics.

The development of new plastics such as polypropylene and high density polyethylene began and it was realised that this new material being produced was ideal for all sorts of applications. This sparked major growth in the production of new plastics. Due to the high demand for plastic companies began to mass produce, causing the cost to drop dramatically. As plastics continued to be redesigned they began to compete with the more traditional materials such as timber, metal, paper, leather and even glass. Manufacturing companies began to substitute plastics in their products due to their low cost and advantageous properties.

Chemists realized that by introducing blends of various polymers and alloys, it was possible to adjust their properties in order to fulfil certain performance requirements. As the multiple uses of and incredible opportunities of plastics were realized their demand steadily increased. Today, product designers consider plastic as a basic material along with the likes of timbers and metals. Plastics have been used in the production of vehicles as the use of plastics reduces weight and thus increases fuel efficiency.

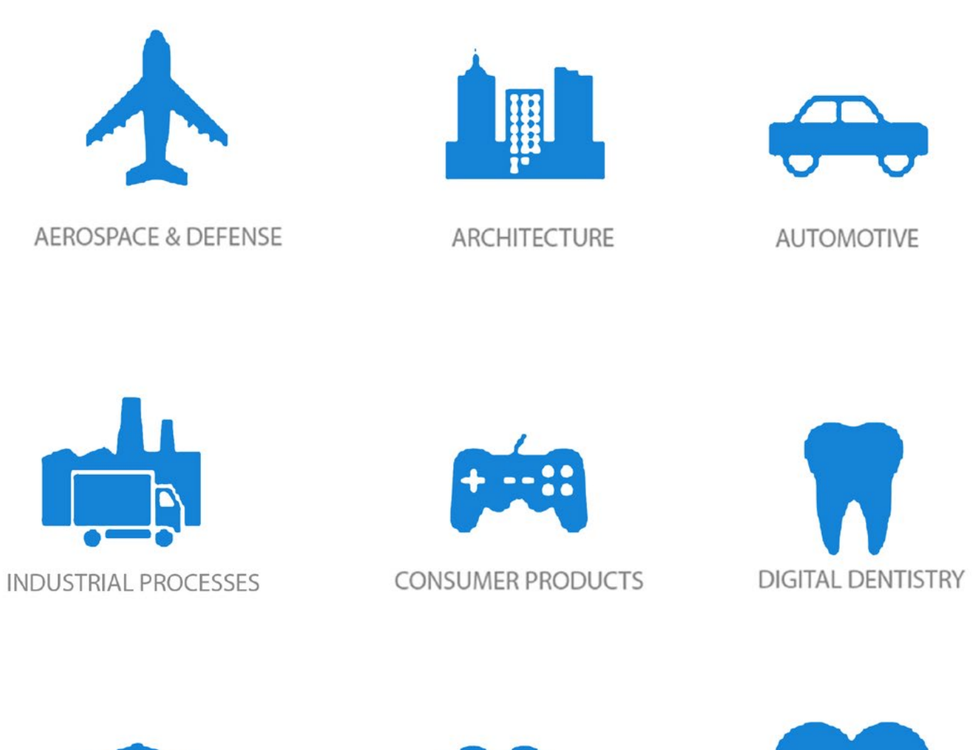


Figure 2 - 4: Industries which utilise plastics [Graphic]

PLASTICS TODAY

Plastics are largely made from oil and today ever more remote locations and ever deeper wells are being drilled to extract this precious resource. This practice has significant economic and environmental implications as oil companies become more and more desperate to find this resource.

Plastics are compounds containing large amounts of carbon molecules strung together and oil is a very good source of these carbons. Polymers are large compounds that are constructed from a number of smaller units called monomers. The combination of various types of monomers in different configurations present an almost infinite selection of plastics, each with different chemical properties.

Plastics are ideal as containers for storing all kinds of liquids, this is because at moderate temperatures most plastics do not react with other materials and thus the plastic container does not react with the contents within. This property combined with the cheap production of plastics have led to it being the material of choice for water bottles, juice bottles, food containers, shampoo containers and many more products which consumers use day to day.

This property has a downside however, plastics do not react with other substances, this means they do not decay and will not decompose over time as many other materials do. Due to this problem, there is extensive research into plastics made from organic materials so that they will decompose and have a better effect on the environment.

The first step to the production of plastic begins at the oil refinery using a process called distillation. This process breaks down the heavy crude oil compound into smaller pieces called fractions. Each of these fractions are made up of a mixture compounds containing carbon and hydrogen.

The next step is a process called polymerisation. This process requires a catalyst to cause a reaction of monomers like ethylene and propylene which then link together to form long polymers chains. Each of these polymers has its own structure, size and properties based on the various types of monomers used in the reaction.

Plastics have become an extremely popular material and today plastics can be seen just about everywhere. Many objects that people use in day to day life are most likely to contain some sort of plastic such as your laptop, your clothing or your cellphone.



Figure 2 - 5: Plastic colour varieties [Photograph]



Figure 2 - 6: Plastic household products [Photograph]

There are two main types of Plastic:

Thermoplastics – These plastics melt when they are heated up and can easily be moulded. These include:

- High Density Polythene
- Low Density Polythene
- Poly Vinyl Chloride (PVC)
- Polystyrene
- Polypropylene
- Acrylo-nitrile (Nylon)
- ABS,
- Poly Vinyl Acetate (PVA)
- Acrylic (Perspex)
- Elastomers

Thermosets – These plastics are initially formed using a heating process and once set it can be very difficult to reform. These include:

- Epoxy Resin
- Polyester Resin
- Glass reinforced plastic
- Carbon Fibre Plastic
- Melamine Formaldehyde

Plastic a material has a number of advantages:

- Easily moulded
- Has a smooth finish
- Very good strength and durability
- Corrosion resistant and chemically inert
- Low thermal expansion of co-efficient
- Possess good thermal and electrical insulation
- Very good water resistance
- Good adhesiveness
- Cheap to produce
- Does not easily break (however will crack)

Due to these properties, plastics have an extraordinary variety of uses in many industries, including the construction industry. Its cost-effectiveness and durability make it the material of choice for a number of manufactures and product designers.

However plastic does have its disadvantages:

- Plastic is a not biodegradable
- At low temperatures it can be brittle
- May deform under high load
- Poor ductility
- Low heat resistance
- Highly combustible if not treated
- Produces toxic fumes when it is burnt
- Recycling maybe be costly
- UV light weakens certain plastics



1

PET

polyethylene terephthalate



2

HDPE

high-density polyethylene



3

PVC

polyvinyl chloride



4

LDPE

low-density polyethylene



5

PP

polypropylene



6

PS

polystyrene



7

OTHER

All other plastics

Figure 2 - 7: Types of plastic [Graphic] Images created using wordificator.com



Figure 2 - 8: Composite Plastic honeycomb structure used in BMW i3 [Photograph]



Figure 2 - 9: Carbon Fibre, a polymer composite [Photograph]

COMPOSITES

A composite material consists of a combination of any two or more materials, usually from very different groups to create a characteristically different material.

The resulting matter typically has inherent properties very different from the base materials, and consequentially can be created with very specific properties and uses in mind. In recent years the applications, and more importantly, costs, have seen great improvements. A specific architectural application, for example, is the combination of glass and concrete, where a structurally strong material is produced but with the additional characteristic of being transparent. Thus very useful in a wide range of architectural applications that would not be possible using the materials in their original form.

These compounds may be produced by consolidating two components, a filler and a matrix. A filler may be any form of carbon, plastic, ceramic or glass, and a matrix is the material used to hold the filler together or suspend it within. This combination is thus considered a composite material, and enables architectural possibilities that was once impractical to become a possibility. Application include combining various material originally used to cover the functions of multiple individual matter groups such as electrical and mechanical systems, or glazing with the structural material itself. These ideals brought a lot of interest and investment to the industry.

Plastic composites provide an ideal alternative building material as manufacturers are able to add various chemicals to it, giving the material different characteristics, such as being fireproof, and, thereby, adding to its versatility.

Plastic composite development is linked to the developement of polymers, where the building of molecules gives almost no limits regarding what can be achieved. Manufacturers can experiment with the material and even reduce the polymer content and significantly reduce costs.

The applications of plastic composites are almost limitless. Popular applications of plastic composites are alternatives to wood in kitchens and bathrooms around washbasins and as decking, owing to its durability and, specifically, water resistance.

ChemCity is currently developing traffic sign poles with an entrepreneur that will fracture on impact, making them a safer alternative to steel.

“We have entered an exciting time owing to the potential for new businesses and employment opportunities that could be created, although I do not expect these developments to replace any existing businesses.” - Hennie Roets (2015)



Figure 2 - 10: Composite products [Photograph]

FIBRE REINFORCED POLYMERS (PLASTIC COMPOSITES)

Fibre reinforcement in thermoplastics has three basic forms; short fibre reinforcement, long fibre reinforcement and continuous fibre reinforcement.

SHORT FIBRE REINFORCEMENT

A fibre is considered having a length to diameter ratio of larger than 1. Short fibres are considered to be such where the ratio is relatively small with the diameter usually at least as small as a human hair. The consistency of short fibre reinforcements thus takes on a more powdery form. Short fibre composites are fairly easy to manufacture, but also has the smallest additional mechanical advantage compared to the longer fibre variety

LONG FIBRE REINFORCEMENT

The raw material form of a long fibre reinforced composite is generally a pellet. Pellets are up to 13mm long and are created using a protrusion process. Protrusion creates pellets by pressing a continuous flow of fibre and thermoplastic resin through a special forming component. The materials is heated and pressurized so that it melts and causes the resin and the fibres to mix. The strands that are created are allowed to cool and then they are cut into pellets. This process creates a fibre reinforced pellet.

To make final parts, the pellets are generally used in a compression moulding process. The pellets are placed into a mould where they are heated and pressurized. When the composite melts it flows to fill the mould and is cooled to form the final component. This process offers significant property improvements over short fibre reinforced parts

CONTINUOUS FIBRE REINFORCEMENTS

The fibres in a continuous fibre reinforced composite vary from as short as a metre in length to a few hundred metres in length. Everything within this range is considered to be called continuous as the length to diameter ratio considerably large. Continuous fibres are process into composite tape so the the fiblres all run along the length of the tape

Considering these various fibrous groups, the continuous fibre type tends to be considerably more expensive than the other types but offers a significant improvement on performance.

HIGH STRENGTH PLASTIC COMPOSITES

Prof. Moshe Kol of TAU's School of Chemistry is developing a super-strength polypropylene that has the potential to replace steel and other materials used in everyday products. This could have a long-term impact on many industries, including the construction industry. (TAU, 2014)

Prof. Kol and his team of researchers have succeeded in developing a new catalyst for the polypropylene production process, ultimately producing the strongest version of the plastic that has been created to date. With their catalyst, the researchers have produced the most regular version of polypropylene ever made. (TAU, 2014)

"Everyone is using the same building blocks, so the key is to use different machinery,"

- Prof. Moshe Kol (2014)



Figure 3 - 1: Plastic bag on Tofu Beach, Mozambique [Photograph]



Figure 3 - 2: Turtle malformed due to plastic waste [Photograph]



Figure 3 - 3: Plastic contents of a dead Albatross [Photograph]

CHAPTER 03 PLASTIC WASTE

PLASTIC POLLUTION

Plastic pollution is the build up of plastic products in the environment which will have negative effects on ecosystems. The large amounts of plastic pollution is due to the high levels of plastics being used every day by humans. Plastics are found in most food packaging, clothing, and other domestic items and if they are not properly disposed of these plastic find their way into environments where they cannot be properly recycled or are discarded in landfills.

Plastic pollutants are categorized based on size and are either micro-, meso- or macro-plastics. Living organisms, particularly marine animals, can be at risk of entanglement in larger macro-plastics and, direct ingestion of smaller micro-plastics. Once digested the exposure to the harmful chemicals within plastics cause problems with their biological functions.

Plastic debris is further categorized into to main groups, primary or secondary. Primary plastics are intact plastic products still in their original form. Plastic bottles, plastic bags, straws and plastic containers are all examples of primary plastic debris. Once these plastics begin to degrade and break down into smaller pieces they are then categorised as secondary plastic debris. These secondary plastics raise the biggest concerns.

Smaller pieces of plastic are much hard to collect and potentially cause more harm to the environment as they form the supply of micro-plastics which smaller species devour. These smaller species are then eaten by fish and birds, and the dangerous chemicals contained in the plastics enter into the food chain (which includes humans). Humans sit high up in the food chain and eventually eat animals containing toxic plastic which can cause the disruption of hormone levels.

Chlorinated plastics can also release harmful chemicals over time. As they degrade chlorine disolves into the surrounding soil and if there is a large enough amount of plastic it will have serious implications to the ecosystems effected. Chlorine finds its way into water sources and can cause serious harm to the plants and animals which rely on that water.

The problem of plastic pollution is further ballooned by the vast distribution of plastic. Plastics can travel over great distances and has spread due to factors such as water currents, winds and vast distribution of the human population.



Figure 4 - 1: Plastic debris floating in the ocean [Photograph]



Figure 4 - 2: Sea life swimming through plastic debris [Photograph]

CHAPTER 04 OCEAN PLASTIC

GROWING CONCERNS OF OCEAN PLASTIC

If plastic waste is not properly dealt with much of it eventually finds its way into waterways and ultimately into the ocean. There is a large amount of non-degradable plastic waste accumulating in our oceans and it is threatening the sea life, quality of the oceans and the various industries which rely on the stability of the ocean.

A study conducted at Santa Barbara's National Centre for Ecological Analysis and Synthesis in 2015, analysed the input of plastic waste into the ocean from land. They concluded that every year approximately 25 million tons of plastic debris ends up in the worlds oceans. (SBNCEAS, 2015)

In addition according to a Greenpeace report, about 10 percent of the plastic produced every year will find its way into the ocean.(Plastic Debris in the World's Oceans, 2006)

The Greenpeace report further estimates that typical plastic debris found on coasts have the following decomposition rates:

- Plastic cups: 400 years
- Plastic bottle: 450
- Foamed plastic cups: 50 years
- Fishing line: 600 years.
- Disposable diapers: 450 year

Beaches act as a natural net for catching plastic debris and many coastlines around the world are littered with plastic debris. This plastic pollution in the ocean as well as on beaches can cause economic losses for a number of parties. Some of these include:

1. Fishing, fish farming and coastal agriculture (Reduced catch, damaged nets,other fishing gear and propellers).
2. Coastal communities (increased expenditures for beach cleaning, public health and waste disposal)
3. Tourism (loss of income, bad publicity)
4. Litter removal and waste management in harbour's
5. Shipping industry (costs associated with damaged propellers and engines)

Due to the persistence of plastic the economic and environmental effects are all long-term. These include:

1. Ecological impacts to sealife : ingestion, entanglement, starvation
2. Economic impact: shipping and tourism.
1. Chemical impact: the build-up of persistent harmful plastic chemicals such PCBs and DDT.



Figure 4 - 3: Plastic bottle on Tofu Beach, Mozambique [Photograph]



Figure 4 - 4: Plastic bag on Tofu Beach, Mozambique [Photograph]



Figure 4 - 5: Plastic bottle on Tofu Beach, Mozambique [Photograph]



Figure 4 - 6: Plastic bucket Tofu Beach, Mozambique [Photograph]



Figure 4 - 7: Plastic particles on Tofu Beach, Mozambique [Photograph]



Figure 4 - 8: Plastic straw on Tofu Beach, Mozambique [Photograph]

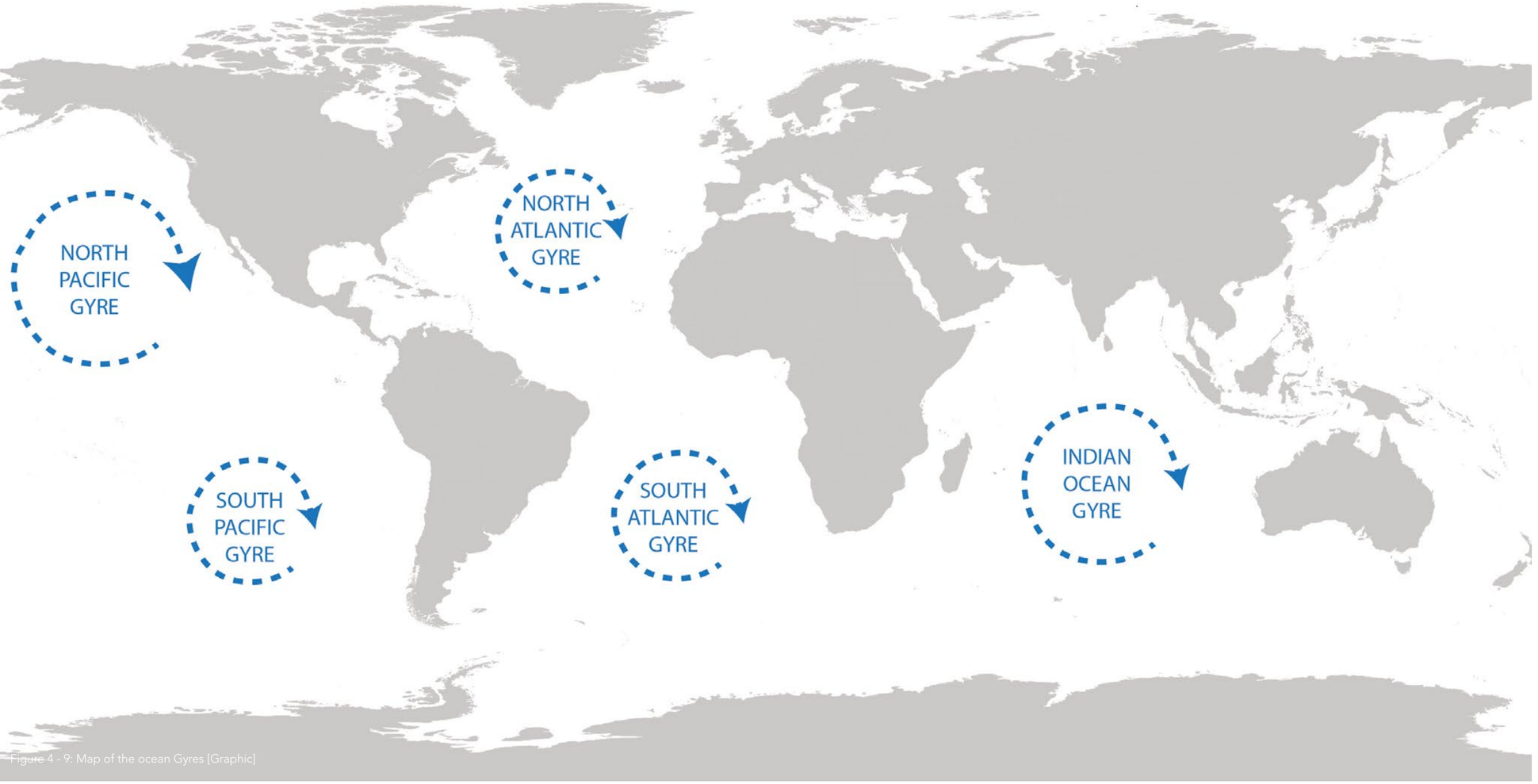


Figure 4 - 9: Map of the ocean Gyres [Graphic]

THE OCEAN GYRES

A gyre is a circular vortex in the ocean generating by the ocean currents passing next to one another. Gyres will circulate clockwise in the Southern Hemisphere and anti-clockwise in the Northern hemisphere

Worldwide, there are five major oceanic gyres that cover over 40% of the global ocean area. Scientists are certain that massive amounts of plastic debris found in the Great Pacific Garbage Patch located at the north pacific gyre also exist in each of the world's ocean gyres as these gyres behave in a very similar fashion.

Plastic debris that finds its way to the ocean via streams, beaches or ships is gradually pulled towards these gyres due to ocean currents to form a swirling soup of plastic pollution.

Gyres are situated in open ocean and do not sit in the national territory of any given country. This means that there is no government to blame or make responsible for cleaning up the plastic. Thus independent private organisations are the only entities likely to tackle this problem.



Figure 4 - 10: Mound of plastic collected on coastline [Photograph]

Over time UV from the sun degrades plastics and with the continuous impact of ocean waves it causes it to fragment into ever smaller pieces. These smaller pieces are known as micro-plastics (pieces smaller than 5mm). Micro-plastics are considered to be among the most harmful types of plastic pollution because they are easily mistaken for food by a marine life.

The smaller the pieces get, the more sensitive they become to mixing due to wind and waves. Knowing up to which depths plastic is spread is important to determine how much plastic is in the ocean.

It is a commonly held belief that plastic pollution spreads itself between the surface and seabed or sinks to sit to the bottom of the seabed. But a study conducted by The Ocean Cleanup Foundation, shows that at least for plastic bigger than a sand grain (0.5mm), it primarily stays on or near the surface.

"Our study revealed that conventional methods to study ocean plastic underestimate microplastic loads by up to 97% due to ocean mixing processes that push part of the debris just below these sampling devices. Understanding how plastic is distributed in the ocean is important to assess its impact, and allows us to adequately dimension our ocean cleanup systems."

Boyan Slat, Founder of The Ocean Cleanup Foundation (2015)



Figure 4 - 11: Boyan Slat [Photograph]

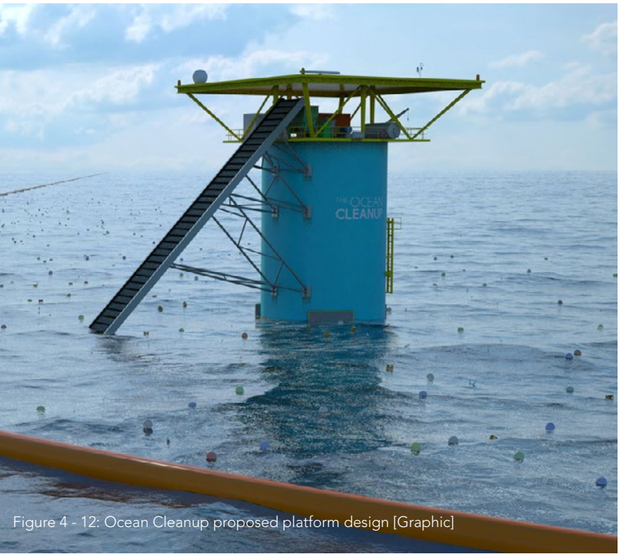


Figure 4 - 12: Ocean Cleanup proposed platform design [Graphic]

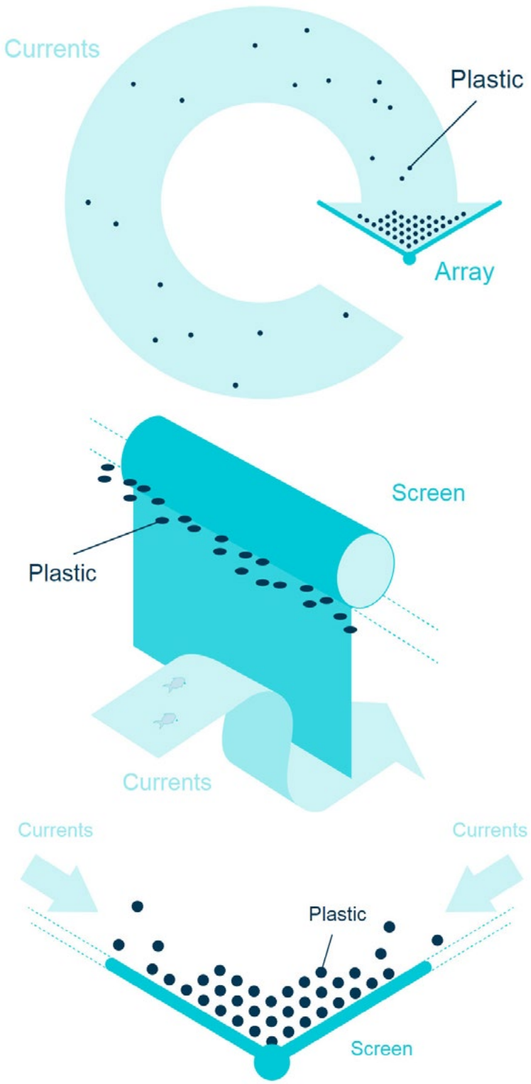


Figure 4 - 13: Ocean Cleanup Diagrams [Graphic]

THE OCEAN CLEANUP FOUNDATION

The Ocean Cleanup project is a foundation started by a young aero-space engineering student named Boyan Slat. When he was 19 years old he developed a passive system to clean the ocean from plastic and debris. The Foundation started in 2013 and through crowd funding and investment from various corporations raised $2 million and as of October 2016 is in the process of testing a prototype of the system.

The Ocean Cleanup foundation are developing the first feasible method of ridding the worlds ocean gyres of plastic and debris . The system they are testing will collect plastic using the movement of the ocean current, collecting the plastic as the current passes through. The debris will then be stored on a platform where it will be collected for transport to the mainland for recycling.

In the Ocean Cleanup feasibility report, the foundation estimates that a system operating at the great pacific garbage patch for 10 years could remove 42% of the plastic pollution in the gyre. Once the plastic is collected it can be shipped to land for recycling.

When Boyan first founded The Ocean Cleanup, there was no feasible solution on how the clear the gyres from plastic, as each is several million square kilometres across. Coastlines act as an effective way of trapping the plastic debris however unfortunately, there is no landmass in the middle of these gyres. Boyan proposes to mimic the effective of coastlines and deploy a very long array of floating barriers anchored to the seabed.

The organisation aims to effectively begin cleaning the Great pacific garbage patch by 2020 and then continue on to the other major gyres.

Boyan hopes the project will not only help to solve the problem but will also have an effect on others who see the work being done. The project has the potential to raise awareness of the dangers of ocean plastic and ignite a movement to work to solve this problem. The Ocean Cleanup wishes to use th tecnology at a later stage to help catch plastics at rivers before they can travel into the ocean.

"It is very difficult to adapt a system designed for rivers to work on the ocean, but once you have something that works in the worst conditions on the face of the planet, I think it should be relatively easy to scale it down to fit the riverine environment."

-Boyan Slat (2015)

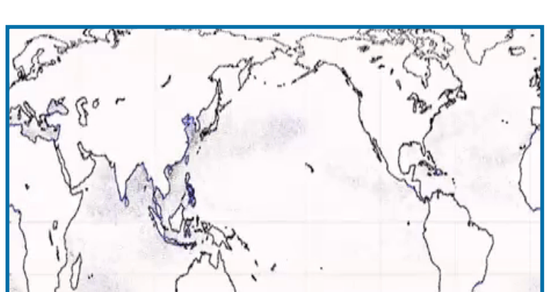
Critics have argued that resources need to be spent on preventing the problem in the first place but the reality is that plastic is resilient and it is not going to go away by itself, something needs to be done to clean it out of the oceans or it will remain to cause harm for many years to come.

"Prevention does not mitigate the need for a cleanup operation. Considering the scale of the problem, I would argue that it is key to tackle the problem from both angles. Don't we all want the future to be better than the past? A cleanup will make that possible."

-Boyan Slat (2015)

COMPUTATIONAL MODEL OF PLASTIC FLOWS

INFLUX AND CONCENTRATION OVER 20 YEARS



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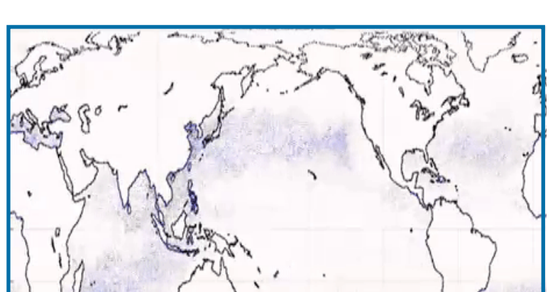

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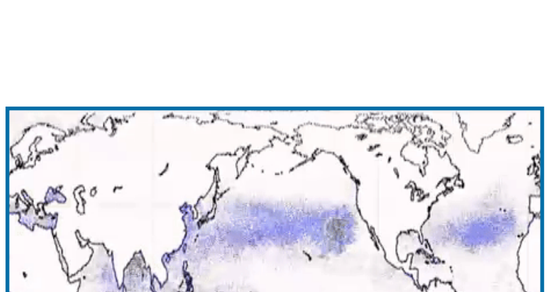

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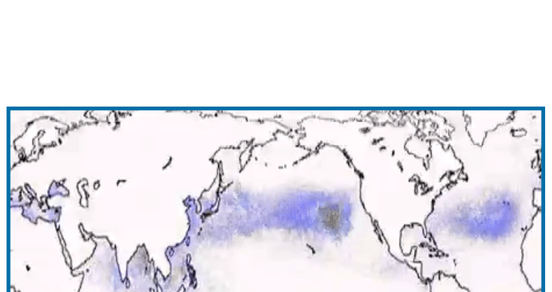

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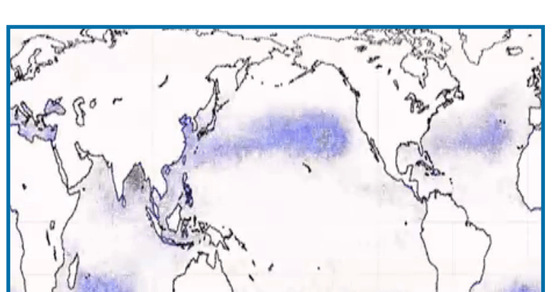

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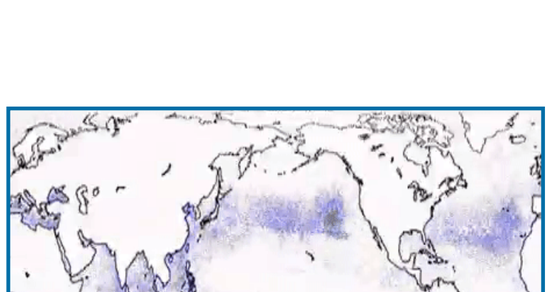

YEAR 20

By cleaning up the plastic that is already in the ocean, The Ocean Cleanup will also prevent the creation of more micro-plastics. If plastics are not cleaned up, there will be exponential increase of microplastics. However in order to effectively clean up the plastic there needs to be a good understanding of where exactly it is.

The Ocean Cleanup Foundation have built a state-of-the-art computer model in order to work out where the plastic is likely to be located. The simulation utilizes data gathered from meteorological and oceanic models which contain data on the behaviours of ocean waves, wind and currents since 1993. Together with data gathered on the amounts of plastic pollution and where it enters into the ocean, they can build a pretty good picture of how and when plastic pollution has entered and travelled the oceans during the past 20 years.

The images (figure 4 - 14) show how the computational model, provides structured guidance on the locations of the most highly polluted parts of our oceans. It clearly shows how plastic enters the oceans and subsequently gets trapped in the rotating currents.

Figure 4 - 14: Computational model of plastic flows [Graphic]



Figure 4 - 15: Deployment of the first prototype segment [Photograph]

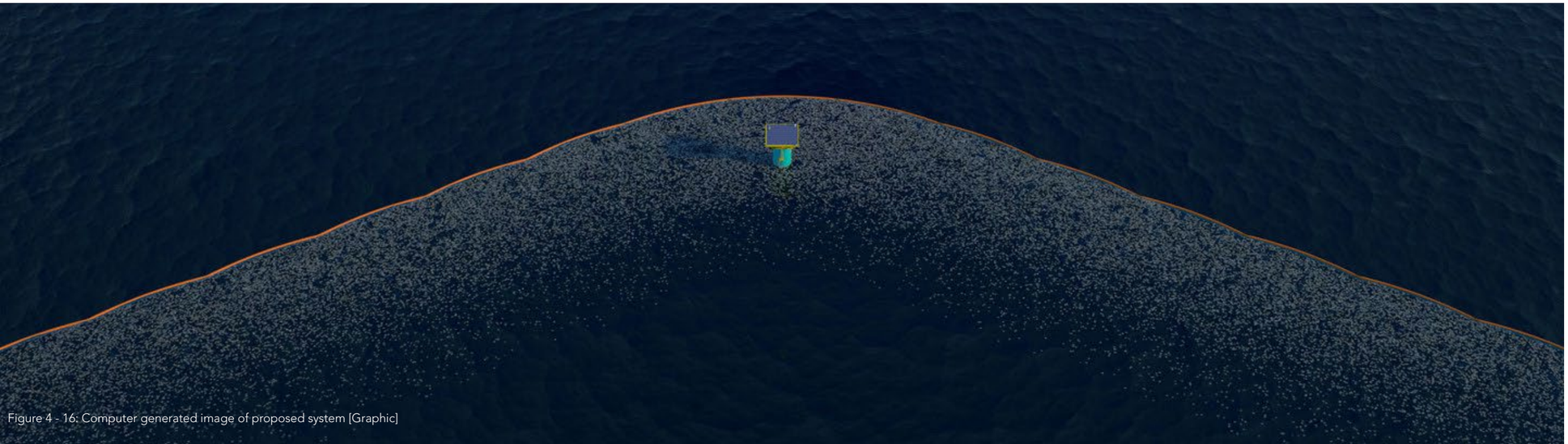

Figure 4 - 16: Computer generated image of proposed system [Graphic]

THE PROTOTYPE

The Ocean Cleanup has deployed a prototype in the North Sea in order to test their design. The 100 meter-long barrier is anchored 23 km off the coast of The Netherlands. This is the first time the design is being test at a one to one scale and the trial period will run for the next year, ending in October 2017.

OBJECTIVE

The key objective of the trial is to test how well the system fares in the rough conditions of the North Sea. This test will simulate the worst conditions the system will need to withstand when deployed in the pacific.

Instead of using nets, these solid screens of the array trap floating plastic on the surface allowing sea life to pass below the barrier along with the current. The barriers will be subjected to extreme forces as they rest on the surface, thus it is important to test the system in the worst possible conditions.

Conditions during a minor storm at the North sea are more extreme than those during heavy storms in the Pacific Ocean making the North Sea an ideal place to put the prototype to the test.

During the trial, the Ocean Cleanup will be able to read off important data gathered by sensors located on the prototype. These sensors track every movement and read the forces the barrier is being subjected to. This data will allow engineers to prepare a system that will be able to withstand any type of sever conditions during the clean up in the Pacific.



Figure 4 - 17: Volunteers cleaning up the beach from plastic pollution [Photograph]



Figure 4 - 18: Family cleaning beach at Addington beach, Durban [Photograph]

CONCLUSION

It is clear that although plastics have and incredible amount of benefits, they are the cause of a great environmental disaster. There is an abundance of plastic debris that is not going anywhere and it needs to be dealt with. This is a serious plastic problem but there are people working to solve it.

What can we as architects do contribute to the solution and how can we turn this plastic problem into a plastic opportunity.

PLASTIC OPPORTUNITIES

Figure 5 - 1: Holding a plastic particle on Tofu Beach, Mozambique [Photograph]

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Figure 5 - 2: Broken up plastic pieces ready for recycling [Photograph]



Figure 5 - 3: Plastic recycling symbol [Photograph]

INTRODUCTION

In the previous chapters exploring the plastic problem it is evident that plastics have caused major concerns globally. However there are ways to reap the rewards that plastics have to offer whilst protecting the environment.

The following chapters explore what can be done about this issue and what plastic solutions could bring light to some incredible opportunities

CHAPTER 05 RECYCLING

THE RECYCLING PROCESS

Recycling is the processing of waste materials into reusable objects or reusable raw material in order to prevent waste being sent to landfill. It is a key to reducing wast and is the only process which completely closes the life cycle of a product so that it can be continually reused.

Material that are typically recycled are paper and cardboard, metal, plastic, tyres, electronics and glass.

Recycled materials are not always recycled to become the same product as it was before it was recycled. Recycled material is often mixed with virgin (new) material as it often produces a better quality product than using 100% recycled material.

The number 1 to 7 can be seen on many plastic products. This number indicates the type of plastic used in the making of the product and makes it easier for plastics to be sorted for recycling.

A material that is in the process of being recycled is referred to as a recyclate. One of the biggest challenges of creating a successful recycling system is maintaining a high quality of recyclate. The quality of a recyclate is generally how much of the material required is present without the presence of any other kinds of materials or contaminants such as food waste.

After sorting only the targeted material is likely to be recycled in that specific process, so if there are more contaminants present in a batch it will yields less recycling product. If there is too many other materials or contaminants, achieving a high quality recyclate can be a very difficult and expensive task.

Higher quality recyclates are worth more to manufacturers, so it is in the best interest of recyclers to maintain a high quality as this would mean more income..

It is crucial for a recycling program to have a steady source of recycling material in order for it to be profitable. Material must constantly be processed or the running costs will outweigh the profits.

One methods which encourages a constant supply is implementing mandatory collection laws. this means that the city will set a target for the amount of material it wishes to recycle. Thus a percentage of any discarded waste must be diverted from landfill and handled by other means such as recycling and incineration.

RECYCLING PROCESS

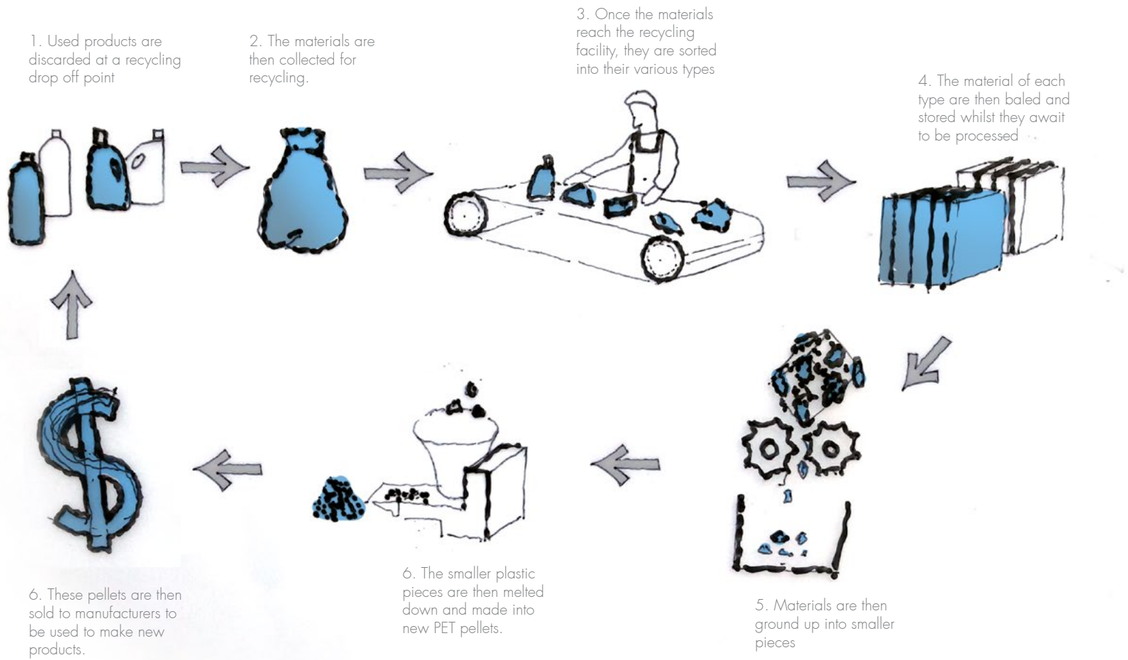

Figure 5 - 4: The plastic recycling process [Diagram]

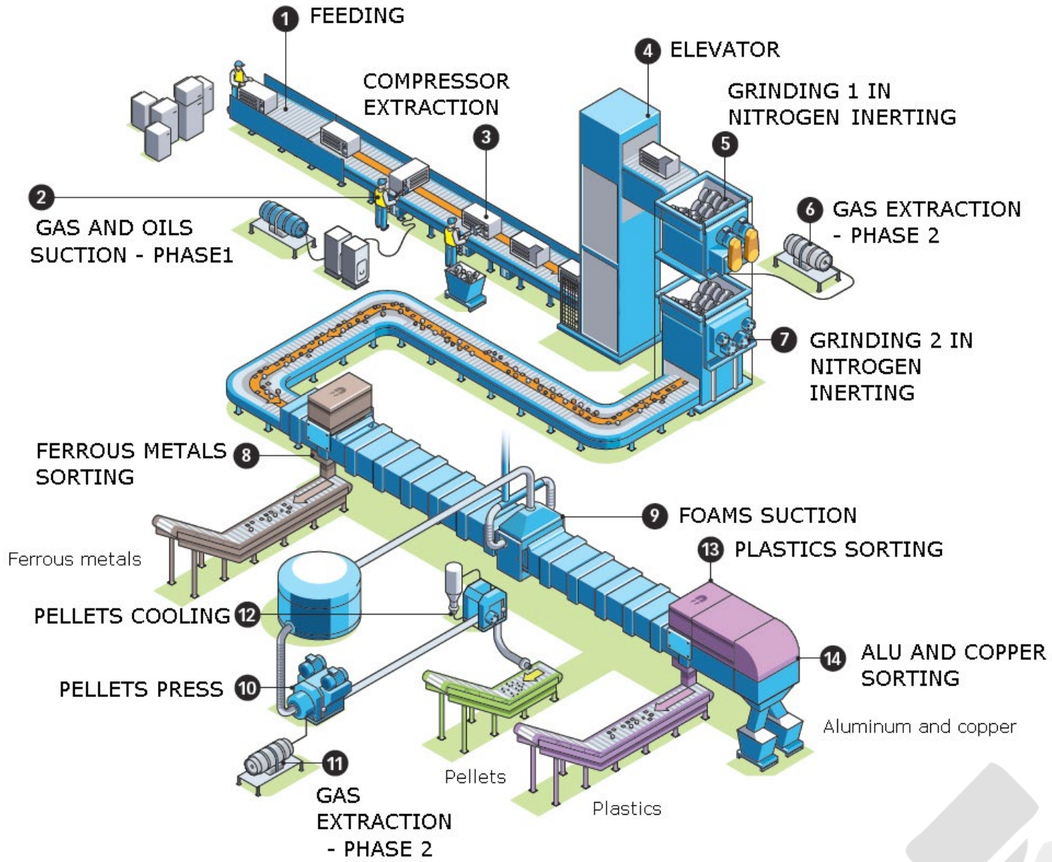

Figure 5 - 5: Example of a recycling process line [Graphic]

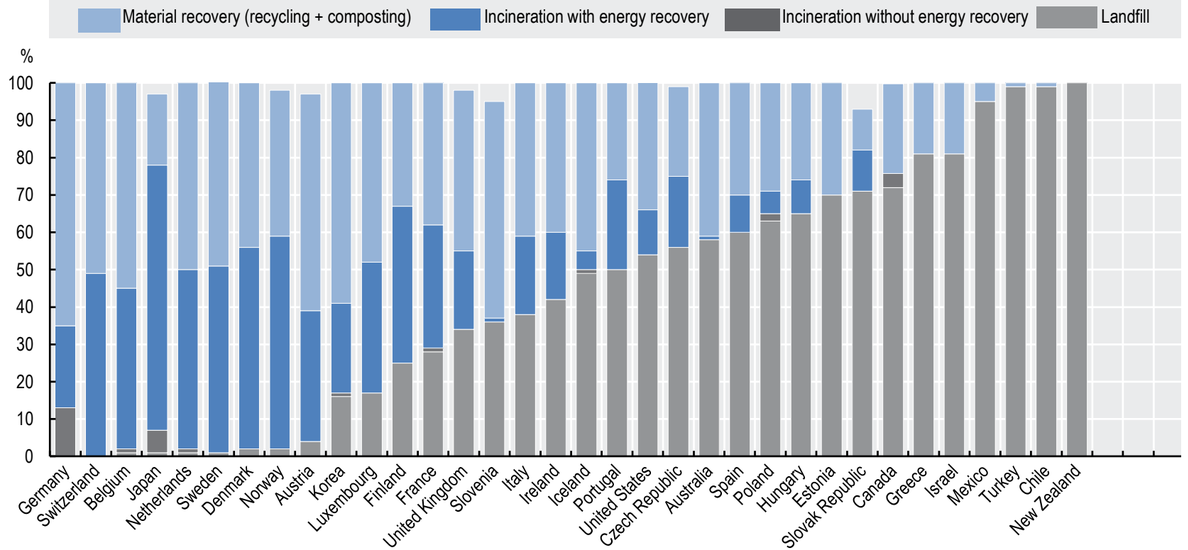

Figure 5 - 6: 2015 Recycling Statistics for selected countries around the world [Graph]



Figure 5 - 7: Waste to energy plant [Photograph]

RECYCLING INTERNATIONALLY

The international movement for handling of waste is to diver as much waste away from landfill as possible. Landfills are unsightly, take up a lot of land and cause a number of economic and environmental problems. There are two leading methods of diverting waste away from landfill, these are recycling and waste to energy conversion. There are a number of countries in Europe that have Waste to energy programs but Sweden has become the world leader of waste to energy.

In Sweden, the average person with throw away approximately 460kg of waste a year which amounts to 4.4 million tons every year. Less than 1% of this waste goes to landfill and the rest of it goes to be recycled and for energy recovery.
Sweden has managed to create a system that converts much of its waste into energy, the country has 32 incineration plants nation wide.

In Halsingborg about 40% of households get their heating from the waste that is incinerated at the local incineration plant. Before the waste is incinerated, it is sorted so that the valuable recyclables are kept.

The remaining ashes is equivalent to fifteen percent of the material before incineration. From this, metals are retrieved and further recycled whilst whatever remains is sifted to extract sand and gravel used in construction. At the end of the process only about one percent is eventually sent to landfill.

Three tons of waste contains as much energy as 12 ton of fuel oil and every year Sweden incinerates about 2.2 million tons of waste.

Not only does Sweden deal with its own waste but they actually import waste from other European countries such as Norway, Ireland, England and Italy. Waste has become a commodity and Sweden has made a business of it by selling a service and importing approx 800 000 tons yearly.

The smoke released during incineration is almost entirely carbon dioxide and water so is not dangerous however the smoke still passes through water and dry filters just to be safe.

RECYCLING IN SOUTH AFRICA

According to the 2015 Plastics|SA figures released in May 2016, the overall diversion from landfill rate in South Africa for the year 2015 was 20.8 %. Considering the statistics on the previous page (figure 5 - 6) this would put South Africa in the same region as Israel and Greece. There is a lot of room for recycling in South Africa to grow and there are benefits to doing so .

For the past two years, stakeholder in the recycling industry have been working together in order to achieve the goal of zero plastics finding their way to landfill. However only 20 % of all the plastics that were manufactured in South Africa were successfully process through incineration or recycling. The remaining 80% ended up in landfills

Anton Hanekom, executive director of Plastics SA, is in charge of understanding all aspects of plastic circulation within South Africa.

"South Africa has a thriving recycling industry that creates jobs for thousands of people. Yet, it is frustrating to see that there is still not an established recycling culture in our country. We still see too much plastics ending up in landfill that could have been recycled many times over into various new products,"

- Anton Hanekom (2015)

Recycling for your average South Africa household is not as easy as in many developed parts of the world. There is a lack of infrastructure for the collection of recycled material in South Africa.

Families would need to take their recycling to a drop off point in order for it to be recyled because there is no form of recycling collection as in more developed countries in Europe.

According to the latest Plastics|SA figures, the lack of a consistent incoming stream of recyclables was the single biggest challenge plastics recyclers had to face during 2015. A large quantity of the materials that were made available for recycling, was recovered by waste pickers off landfill sites, where they were contaminated and therefore of very poor quality. Up to 40 % of materials had to be scrapped or rejected due to impurities. (Plastics SA, 2015)

There is a clear need for an effective recycling infrastructure in South Africa such as systems in parts of Europe. South Africa has a problem with power supply and utilising waste incineration to recover energy could be an immense opportunity.

Pyrolysis is the process of extracting fuel from discarded waste and is slowly developing in South Africa. Plants for this process are still in trial but currently produce crude oil, gas and diesel from plastics and tyres.

According to the Plastics|SA report, the following elements are needed to grow South African recycling figures over the next few years to come:

- Political will – Decision makers and legislators are not always aware of the achievements and challenges at ground level. To address this, the plastics industry will continue to invite decision makers and legislators to recycling plants to inform them about the intricacies of plastics recycling in South Africa. (Plastics SA, 2015)

- Stakeholder commitment - Plastics converters have committed themselves to voluntary levies to encourage recycling and create awareness through the various Extended Producer Responsibility organisations. More products need to be designed with their ability to be recycled in mind. (Plastics SA, 2015)

- Quality of Recyclables - Waste pickers, collectors and recyclers need to be educated on the various materials and basic chemical principles that will impact on recyclable quality. Sorting processes need to be managed better. Recyclers should communicate their requirements to their suppliers all down the value chain to waste picker level.

- Energy efficiency - Electricity usage is three to four times more for recyclers than converters for the same tonnages. Energy management must receive priority to minimise and optimise energy usage – for water and electricity. Recyclers will have to do long-term planning for increased costs of energy and may even have to consider self-generation of energy. (Plastics SA, 2015)

- Public awareness and education - The public needs to be educated about separating-at-source and to insist on recyclable packaging. Consumers need to be educated with regards the removal of shrink-labels, separation of various components and cleaning out of residual contents, etc. (Plastics SA, 2015)

- Alternate technologies - Mechanical recycling has a ceiling, and not all materials can be recycled economically. The plastics industry should find some technology partners to tailor-make alternative recycling methods to deal with plastics waste that cannot be mechanically recycled. (Plastics SA, 2015)

"The plastics recycling industry has achieved outstanding results in the face of many obstacles and challenges. However, we need to use these challenges to help us adapt to changing market needs and expectations. With the help of brand owners and retailers who are willing to get actively involved by putting pressure on the converters to design products that are recyclable and contain a percentage of recycled material, we will be able to take plastics recycling to a totally new level,"

- Anton Hanekom (2015)





Figure 5 - 8: Cage being delivered to Waste Plan facility [Photograph]



Figure 5 - 9: Cage being lifted by forklift, Waste Plan facility [Photograph]



Figure 5 - 10: Cage of recyclables awaiting processing, Waste Plan facility [Photograph]

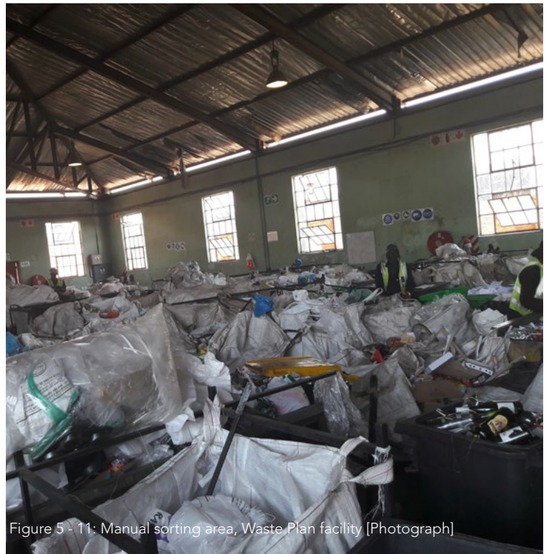

Figure 5 - 11: Manual sorting area, Waste Plan facility [Photograph]



Figure 5 - 12: Seperated plastics, HDPE (code 2), Waste Plan facility [Photograph]



Figure 5 - 13: Seperated plastics, PETE (code 1), Waste Plan facility [Photograph]

Precedent - Waste Plan (Pretoria)

Waste Plan is a company that specializes in recycling and the reduction of waste. It is the 2nd largest company of its kind in South Africa and largest in the Western Cape

They have facilities located in Cape Town, Durban and Pretoria.

Their Waltloo factory in Pretoria is roughly 600m² and handles about 600 tons of recycleables a week. The facility has a large open yard area, open factory floor, small office area ,staff ablution and change room facilities. The building was converted from an old factory and accommodates 60+ staff.

The facility operates primarily using a series of drop off sites located around Pretoria and Centuriuon. These site operate as collection area's for the public to drop off their recycling or for informal recycling collectors to exchange their recycling for money. The recyclables are seperated and stored in large steel cages. Once a cage is full of enough material a truck is called in to come and collect. The cages are continually being retrieved from drop off sites by a fleet of four trucks that the bring the recyclables to the main facility.

Once dropped off a forklift will then carry the cage into the facility where it is emptied out into the sorting area. In the sorting area, recyclables are manually sorted into bags for different grades of plastics, glass, cardboard, steel by a team of roughly thirty workers.



Figure 5 - 14: Seperated recyclables storage area, Waste Plan facility [Photograph]



Figure 5 - 15: Bailing Machine, Waste Plan Facility [Photograph]



Figure 5 - 16: Bailed plastic bottles, PETE (code 1), Waste Plan Facility [Photograph]



Figure 5 - 17: Bailed plastic bags, LDPE (code 4), Waste Plan Facility [Photograph]



Figure 5 - 18: Bailed plastics, HDPE (code 2), Waste Plan Facility [Photograph]

Once sorted the bags are placed in a separate compartment where they await bailing. This facility does not clean any materials, it acts purely as a collection, sorting and material handling facility, the cleaning process will be done once the client has processes the product.

There are two bailing machines at the facility and are always operational during the day. Most of the bulk coming into the facility is cardboard and this takes up a majority of the baling operation. The material is fed into the bailing machine which then crushes it and squeezes it into a bundle where it is bound and then brought outside into the yard where it is stored until a client comes to collect.

Linda Van Niekerk, facility manager, commented on the need for more bulk of material to be collected for these types of facilities to be more feasible. Currently South Africa's simply do not separate their waste for recycling and once waste has made its way to landfill much of it can become spoiled by organic material and become to difficult to clean.



Figure 5 - 19: Informal recycler in Durban [Photograph]

DURBAN AND PLASTIC RECYCLING

According to Luke Riding of the Durban Refuse association, roughly 40% of refuse brought to the Bisasar road landfill in Durban is plastic.

This debris needs to be recycled because it is going to take a very long time to decompose. However Durban does not have a very effective recycling program currently. If the residents of Durban wanted to recycle there simply just aren't the correct or many facilities available. There are very little comprehensive recycling programs available that deal with recyclables appropriately and the city has a long way to go if they wish to be a sustainable city.

Informal recyclers pick up some of the slack of the industry and collect materials from landfills and bins along the route to bring to the few recycling facilities in the city.



Figure 5 - 20: Plastic Fish Sculpture in Rio De Janeiro [Photograph]

PLASTIC RECYCLING INNOVATION

PLASTIC ARTWORKS

Plastic waste can be used to make art. As part of the UN Conference on Sustainable Development, an artist designed and erected an large fish sculpture constructed entirely from discarded plastic bottles. The intervention was placed in full view of the many tourists on Botafogo beach in Rio de Janeiro, Brazil.

Artists from Washed Ashore organization turn plastic into giant sculptures made entirely of beach waste in order to raise awareness of the ocean plastic problem.

These unique art pieces are part of an exhibition that includes educational programs to encourage plastic recycling. Volunteers from all walks are life are able to join in and get involved in these projects.



Figure 5 - 21: Dave Hakkens [Photograph]



Figure 5 - 22: Precious plastic, creations [Photograph]



Figure 5 - 23: Precious plastic, machines [Photograph]

PRECIOUS PLASTIC

Dave hakkens, an industrial designer from the Netherlands has started up a project to help other people to begin recycling plastic. The start up is called "Precious Plastic" and their vision is to create a resource which allows anyone in the world to transform plastic waste into useful items.

Since 2014 Dave Hakkens has been developing a series of "DIY" machines that will process and recycle plastics. His machines can be constructed using basic tools and materials. He has shared the blueprints on how to build these machines on their website so that people around the world can build them.

He has built the following machines:

1. Shredder - Grinds plastic down into plastic flakes
2. Extruder - Melts plastic flakes and extrudes 3D printing filament or plastic pellets
3. Injection Moulding - Plastic flakes are heated and injected into a mould.
4. Compressor - Plastic is heated inside the oven and slowly pressed into a mould with a car jack.

Once people have built the machines, they are able to experiment and produce new products from their own plastic waste.

The primary goal of the project is to show people that they can generate financial value from plastic waste and in doing so help clean up our local environments.



Figure 5 - 24: Martinez Perez [Photograph]



Figure 5 - 25: Conceptos Plasticos Low cost house [Photograph]

Oscar Mendez has founded Conceptos Plasticos, a company based in Columbia that recycles plastic to convert it into construction materials. These materials are then used to provide high-quality, safe and low-cost housing for those in need.

Using plastic extrusion, Conceptos Plasticos uses mixtures of different plastics and rubber to make quality construction materials. These modular construction materials are used to build low-cost, durable housing that can be reassembled elsewhere if necessary.

It only takes about five days for a team of 5 people to assemble a 40m² house. Conceptos Plasticos have so far only built around 40 of these houses in several regions across Colombia but are currently obtaining permits for construction of more units in the city of Cartagena.

Their goal is to is to alleviate the rural housing problem in Columbia which require around 1 200 000 housing units. The project also brings positive social, economic and environmental benefits to the country

"So far these projects have given reuse 300 tons of plastic, we have an installed capacity of 100 tons per month capacity, but seek to expand this capability to deliver 300 tons to 50 homes per month in the first stage, as well as to scale and replicate our solution with technology transfer and assembly plants."

- Martinez Perez (2016)



Figure 6 - 1: Plastic applications in industry [Photograph]



Figure 6 - 2: Composite plastic "timber" product [Photograph]

CHAPTER 06 PLASTIC TECHNOLOGY

PLASTICS IN THE CONSTRUCTION INDUSTRY

There are more and more building products being developed using plastics because of their flexibility as a material, cheap production and physical attributes which are appealing to those in the construction industry, such as; good corrosion resistance, low thermal and very good water resistance.

One of the ways plastic has changed the world was with its low cost. At the time when plastics arrived on the mass market it was considerably cheaper to process into a staggering range of applications. The combination of low cost, versatility and ease of manufacture made plastic a great alternative to a wide range of more traditional materials

Plastic product range in the construction industry:

Piping, cabling, flooring, skylights / Windows, roofing, doors, storage Tanks, insulation materials, wall panelling.

The versatility of plastic is clear when looking into its various properties. In contrast to building materials such as wood and metal, plastic does not rot or corrode in the presence of weather. Plastics are lightweight, making it cheaper and easier to transport, yet has excellent load bearing capabilities. In terms of processing, a wide range of process apply, including, but not limited to, moulding, bending, extrusion and more recently 3D printing.

In addition to the various colours plastics can be manufactured in, they can also be manipulated in terms of their texture.

Plastics are low conductors of heat and are thus used in many thermal insulation products. Plastic products can achieve tight seals have good sound absorption and they are good insulators of electricity. Conventional methods of fastening timber or steel can be utilized and they can easily be removed and recycled.

Plastic products provide a number of advantages to ensure a feasible energy efficient building at the final product. Plastics have good energy efficiency values, lower greenhouse gas emissions and good Durability.

There are however Limitations of Plastic that need to be considered. Plastic may degrade under exposure to direct sunlight unless it is properly treated. Many plastics are highly flammable however they may be treated to avoid this danger. As plastics usually have a fairly high thermal expansion coefficient, sufficient expansion space needs to be provided when detailing. Temperature can considerably alter some thermoplastic properties, such as strength and shape. Some plastics are not suitable for load bearing applications due to its low modulus of elasticity.
Currently the following methods of fabricating plastics are used:

Blow moulding, calendaring, casting, and injection moulding.

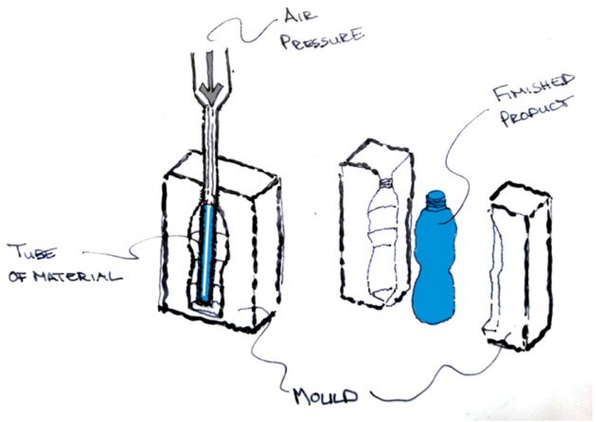

Figure 6 - 3: Blow Moulding [Graphic]

BLOW MOULDING

The blow moulding manufacturing technique is used to create thin walled, hollow products. The three common types of blow moulding include:

- Injection
- Extrusion
- injection stretch

The process, like most plastic manufacturing techniques, starts with heating and melting the material, but is then formed into a tube-like section making it possible to expand using compressed air. A formed tube section may be clamped into a larger mould, and then expanded using compressed air so it takes the form of the mould. The material needs to fully cool and set before removing it from the mould.

CALENDARING

Some techniques are only applied as a finishing process, as is the case with Calendering. PVC is commonly calendered by passing it between various pairs of heated rollers and results in the material having a high-gloss surface finish.

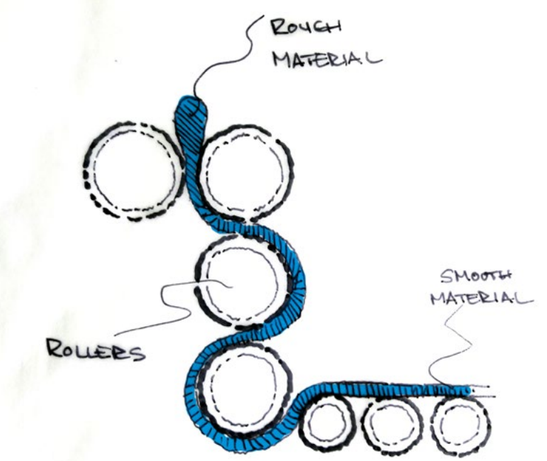

Figure 6 - 4: Calendering [Graphic]

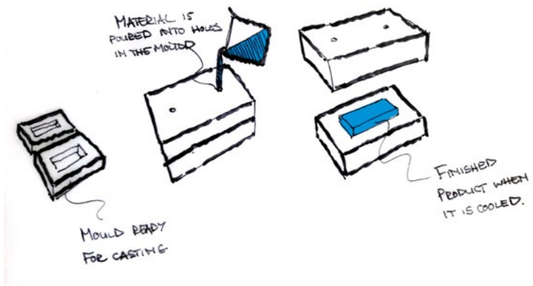

Figure 6 - 5: Casting [Graphic]

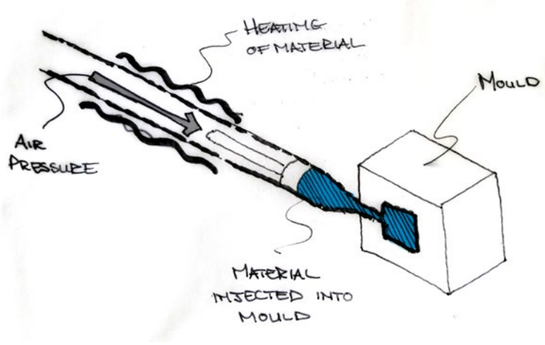

Figure 6 - 6: Injection Moulding [Graphic]

CASTING

Casting is an easy processing method often used in small scale production runs or during prototyping phases. The process involves heating a plastic resin until a flow-able state is reached where it would be able to completely fill a pre-made mould. After the polymerizing process (hardening) is complete, the parts may be removed and any necessary post processing completed, such as removal of rough or sharp edges.

It is often used by amateur hobbyists due to the low capital cost required for the initial set-up

INJECTION MOULDING

Injection moulding is an extremely efficient manufacturing process, especially for large production runs where the initial capital investment may be offset by large production quantities. It involves the heating of the material and then quickly forcing it into a mould using injectors of screw feeders, where it cools quickly and gets ejected. This process is applicable with a range of materials, including metal, glass, thermoplastics and elastomer.

New manufacturing process such as 3D printing has also opened the door to extremely intricate moulds to create advanced products in a simple step, that was not possible with traditional subtractive manufacturing processes. The process is used from small intricate components to large single piece parts such as vehicle body panels

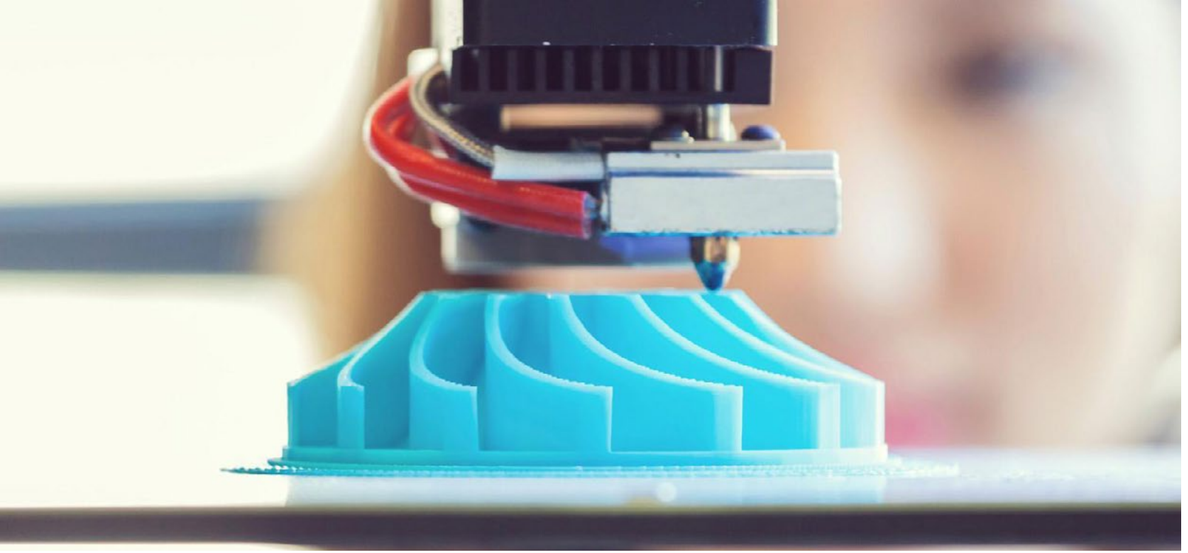

Figure 6 - 7: 3D printing [Photograph]



Figure 6 - 8: Contour crafting [Photograph]

3D PRINTING & CONTOUR CRAFTING

Although 3d printing is not such a new technology, first being utilized in the 1980's, in the last few years it has begun to gain momentum. The technology has many applications and continues to advance with new techniques being developed continuously.

Contour crafting is a technology which makes use of 3D printing methods to print layers of concrete on top of one another in order to construct buildings without using traditional methods.

Contour crafting will reduce building cost by minimising construction time, having less wastage of materials and reducing labour and project team costs. Contour crafting also has a much lower carbon footprint and requires a lot less energy than traditional building methods. The technology is extremely environmental friendly.

This kind of intervention will have drastic effects on the industry and could leave many people jobless however this has been the case with many technological advancement in the past, for example when e-mail was first introduced the postal industry suffered major losses and many people lost their jobs many new jobs were born from this advancement. With these advancements in technology, shelter (One of the crucial needs in South Africa) suddenly becomes something that is inexpensive and available to a lot more people. Provided the technology is properly managed there is a great opportunity for better economies to result from these advancements, allowing for a higher quality of life for those in need.

DIGITAL ARCHITECTURE

The way architecture is experienced has been evolving along with technological advancements. Architecture was consumed in a very different manner a hundred years ago. People would have to walk in order to experience a building nearby and could rarely experience those far away. However as transportation systems advanced, suddenly people were able to consume a lot more in much less time and could visit places far away at more convenience. As technology continued to advance, people begun to be able to experience architecture by seeing it in a newspaper, watching TV or eventually just by looking at social media on their smart phone. This advance has changed the way world interacts with architecture.

In 1997 when the Guggenheim Bilbao building by Frank Gehry opened it fundamentally changed the way the world sees architecture. It is very rare for the public, critics and academics to feel united about a building but this was one of those rare moments. After the building was completed tourism in Bilbao increased by 2500% due to peoples fascination with its design.

Due to access to online media, more people than ever before are able to have an experience of a building without even being there. This gives architecture the power to influence. Building have the ability reinvent ideals or to spark a movement for change and architects need to be conscious of the possiblities and dangers this may have.



Figure 7 - 1: 3D printing design lab [Photograph]



Figure 7 - 2: World's first 3D printed car [Photograph]

CHAPTER 07 MANUFACTURING REVOLUTION

Many speculators believe that digital fabrication and the connectivity of digital culture are cause for a new industrial and manufacturing revolution. Digital fabrication and the rise of 3D printers challenges mass production and product uniformity, instead creating a democracy of product creation and introducing a model of mass customization and diversity.

Industrial practices have always been focused on the manufacture of a single product line. In early years of the industrial revolution factories were simple buildings where a large number of workers gathered to perform a medium of hand labour. In 1764, steam power, and the inventions of the steam engine eventually led to the development of the industrial factory of the 19th century.

This industrial age marked the critical shift of hand production methods to machine methods, as well as the inception of new iron production and chemical manufacturing processes. This shift was not limited to the industry but transformed the construction of architecture and living standards of greater society. Later developments of the industrial revolution led to a more efficient production model where replaceable components and precision machine tools were used to speed up process and generate less waste. Standardisation was also a concept introduced, a system that afforded the production of large quantities of identical objects.

Under the leadership of Henry Ford, mass production was introduced into the factory model in the early 20th century. Specialized workers positioned along a sequence of rolling ramps built the automobile and many products like it. This manufacturing model drastically reduced the cost of production for manufactured goods and was behind the rise of consumerism in the 20th century.

The middle-to-late 20th century saw a rise of next-generation Japanese factories with two significant improvements. The first was advanced methods of quality control through statistical analyses. The second was the introduction of industrial robots to the factory sequence in the late 1970s. These two evolutions in the factory process, spurred a cost effectiveness, speed and production quality that has continued to improve into the 21st century. Presently, factories are medium to large industrial buildings. They contain heavy equipment and machinery along an assembly line that facilitates the manufacture of uniform products or goods.



Figure 7 - 3: Application of Formative Fabrication and Assembly [Photograph]

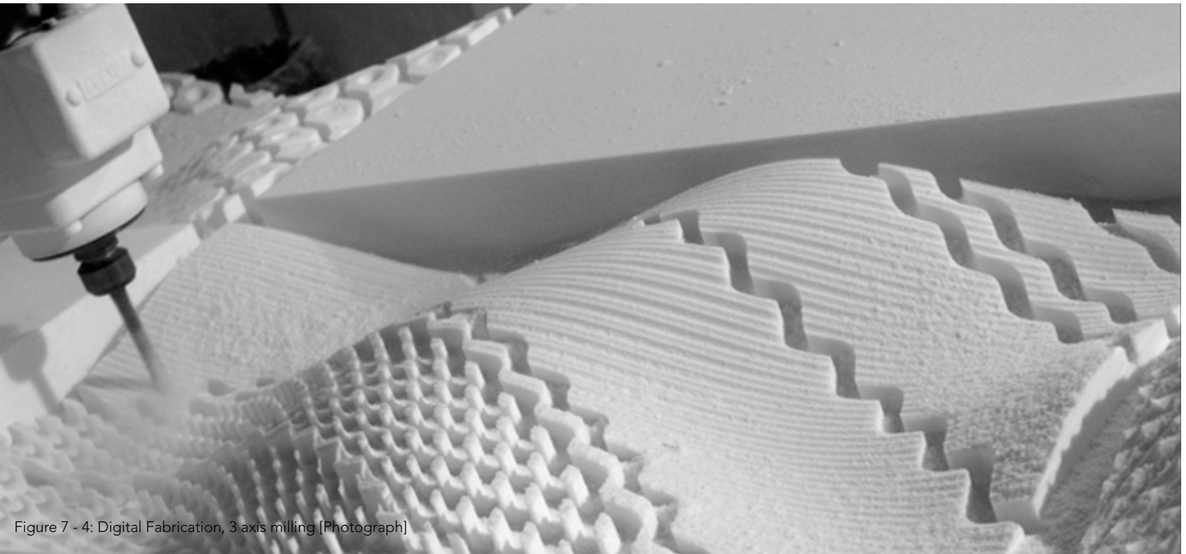

Figure 7 - 4: Digital Fabrication, 3 axis milling [Photograph]

In 1952, researchers at the Massachusetts Institute of Technology (MIT) connected a milling machine to an early digital computer, consequently creating the first numerically controlled machining tool. Instead of incorporating a machinist to turn the screws that shifted the metal stock within the mill, a computer programme was developed to control the milling machine's operation.

Due to this shift, researchers at the university, could produce aircraft components that required much more complexity than was capable with my hand manufacturing and with incredible efficiency.

Neil Gershenfeld is the director of MIT's Center for Bits and Atoms, a facility focused on degrading the boundaries between physical and digital worlds. As Neil Gershenfeld observes, the revolution is not subtractive versus additive manufacturing, but rather the ability to turn data into physical objects, and physical objects into data. Gershenfeld compares the development and cost of digital fabrication technologies (notably 3D printing technologies) to the history of computing. From the development of large mainframe computers in the 1950s, to IBM's personal computer in 1981. Computers evolved from being large and expensive to smaller, easy to use and at a fraction of the cost.

Early versions of digital fabrication technologies developed in the 1980's were expensive and only available to large institutions. However over time the technology has evolved and new generation of fabrication systems is available that are very much more accessible to individuals. Individuals can modify and build their own systems from plans shared online and do so within budget because the parts have become so affordable.

Gershenfeld continues his observation of this technology's development by suggesting that while integrated personal digital fabricators, comparative to the personal computer, are not yet in existence, they will be in time.



Figure 7 - 5: World connectivity [Graphic]

TRANSFORMING INDUSTRY

In his book "Zero marginal cost society", Jeremy Rifkin speaks about an internet of things. He suggests that with every economic boom there are three major Industries that gain rapid growth before there is a boom in the economy. These three Industries are Communication, Transport and Energy. Communication has already received a massive amount of growth with the introduction of the internet and the rate at which people can almost instantaneously communicate across the world for free.

Next will be the boom in Energy and transportation. There is already a massive development into sharing energy in Europe. Germany has begun to convert small building into micro power plants which produce electricity using sustainable technologies such as wind and solar. The buildings generate enough electricity to be self-sufficient as well as sell excess electricity back into the grid. Using systems such as this, large electrical companies are less relied on and once the correct infrastructure has been put in place electricity could become nearly free.

With these innovations taking place, one could question the state of the construction industry and how stagnant it has been in comparison to other industries. The industry has not seen any significant movement forward to improve the way in which building are constructed. Yes new materials and methods have been introduced, but the process is still incredibly inefficient and expensive.

Current construction methods are slow, inefficient, labour intensive, dangerous and costly. Projects tend to be over budget and prone to corruption due to the systems in which the construction industry operates. In a modern society manufacture is predominantly automated and highly efficient with the exception of construction. The construction industry still favours manual labour and although there is advantages in forms of providing jobs, there are significant downfalls in the form of high building prices and inefficiency.

This leads onto the discussion on how this process could be improved, what technologies could be utilised and what benefits will this bring.



Figure 7 - 6: Typical Factory [Photograph]

RE-THINKING THE FACTORY TYPOLOGY

EXISTING TYPOLOGY

The traditional factory building is rough hard wearing exterior with an open plan cold interior designed for the process that runs inside with the inhabitants and public outside as an afterthought. Factories are designed to suite a specific line of mass production and are programmed for the sole purpose of producing at the most efficient rate at minimal expense.

PROPOSED TYPOLOGY

In a modern era of technological advances and development of digital fabrication processes, this typology has the potential of becoming a much more public and transparent typology. Instead of concealing the so called 'ugly' industrial processes the building could open up its exterior to celebrate the process and become a theatre of production.

ARCHITECTS OF THE FUTURE

What will the word architect mean in the next 5 to 10 years' time? This is a question that we as architects need to be asking ourselves in order to protect the profession. Architects need to keep up with the times and make use of emerging technologies in order to keep the profession relevant and in high demand.
Architects are suitable professionals to lead collaborative efforts to enhance the building industry and allow for higher quality building at faster rates and at lower costs. However there needs to be an agenda to protect the quality of the built environment and maintain or enhance standards moving forward.

CONCLUSION

Although the drawbacks of plastics are severe, the material still has so much potential and it seems the possibilities are endless. If plastics are dealt with properly then the benefits can be gained without danger to the environment.

Plastics can be recycled and this creates a closed life cycle where no waste is created by a continuous stream of new products can be generated from the old. This is the sort of sustainable system humanity needs to embrace moving towards the future.

With advances in technology and speculation of industrial revolution there is hope for plastic solutions to overcome these plastic problems.

"Each new hour holds new chances for new beginnings. The Horizon leans forward, offering you space to place new steps of change."

- LTJ BUKEM

PLASTIC SOLUTIONS

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Figure 8 - 1: Concept Diagram [Graphic]

INTRODUCTION

Considering the plastic problems are largely at sea and the recycling issues South Africa is dealing with, the ideal city in South Africa to start actively engaging with these issues is the city of Durban.

The following chapters of this discourse will begin to engage with the subject at hand by proposing an architectural intervention that proposed to act as a catalyst for plastic solutions in South Africa.



Figure 8 - 2: Aerial Photograph of the city of Durban [Photograph]



Figure 8 - 3: Aerial of Durban Harbour, 2016 [Photograph]

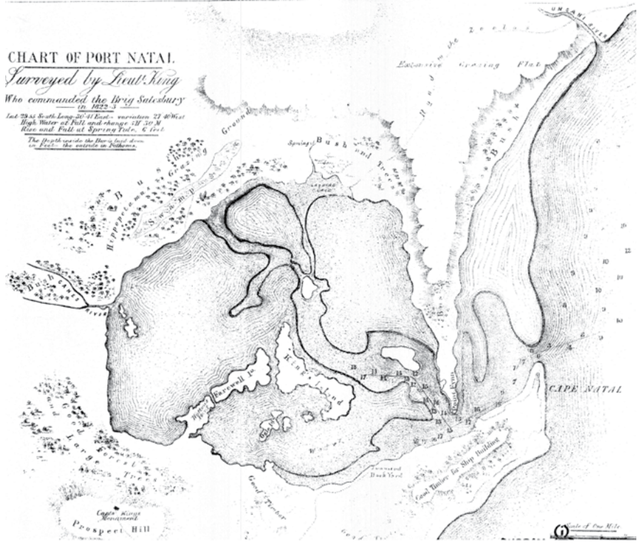


Figure 8 - 4: Map of Durban in 1822 [Graphic]

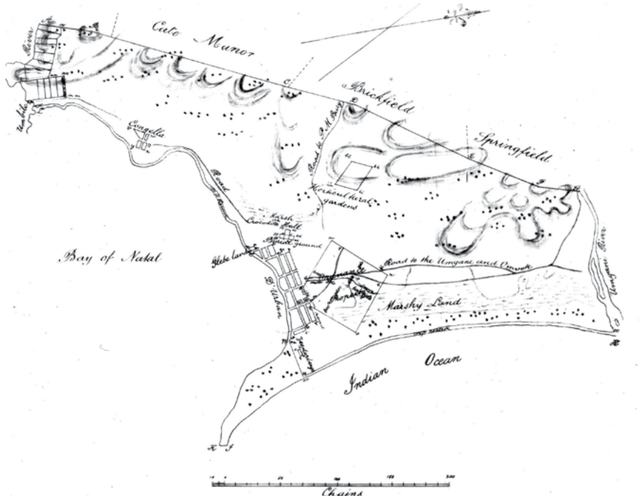


Figure 8 - 5: Map of Durban in 1855 [Graphic]

CHAPTER 08 DURBAN HARBOUR

THE HISTORY OF DURBAN

The Bay of Natal, so named by Vasco da Gama in 1497 (Ports and Ships, n.d.), is the lifeline of the city and has been since it was first established. From the earliest recordings of Natal's history, trading was at the forefront, with the Francis sailing to Natal to trade ivory in 1684 (Footprint travel Guides, 2015).

Vasco da Gama is said to have sighted the Bay on Christmas Day, 1497, when he arrived with his three small ships San Gabriel, San Raphael and Berrio, he named the land Natal as a mark of respect for the Nativity. (Footprint travel Guides, 2015).

The Bay of Natal was one of the few natural harbours available along the east coast of southern Africa between Algoa Bay and Delagoa Bay (now Maputo Bay). (Footprint travel Guides, 2015).

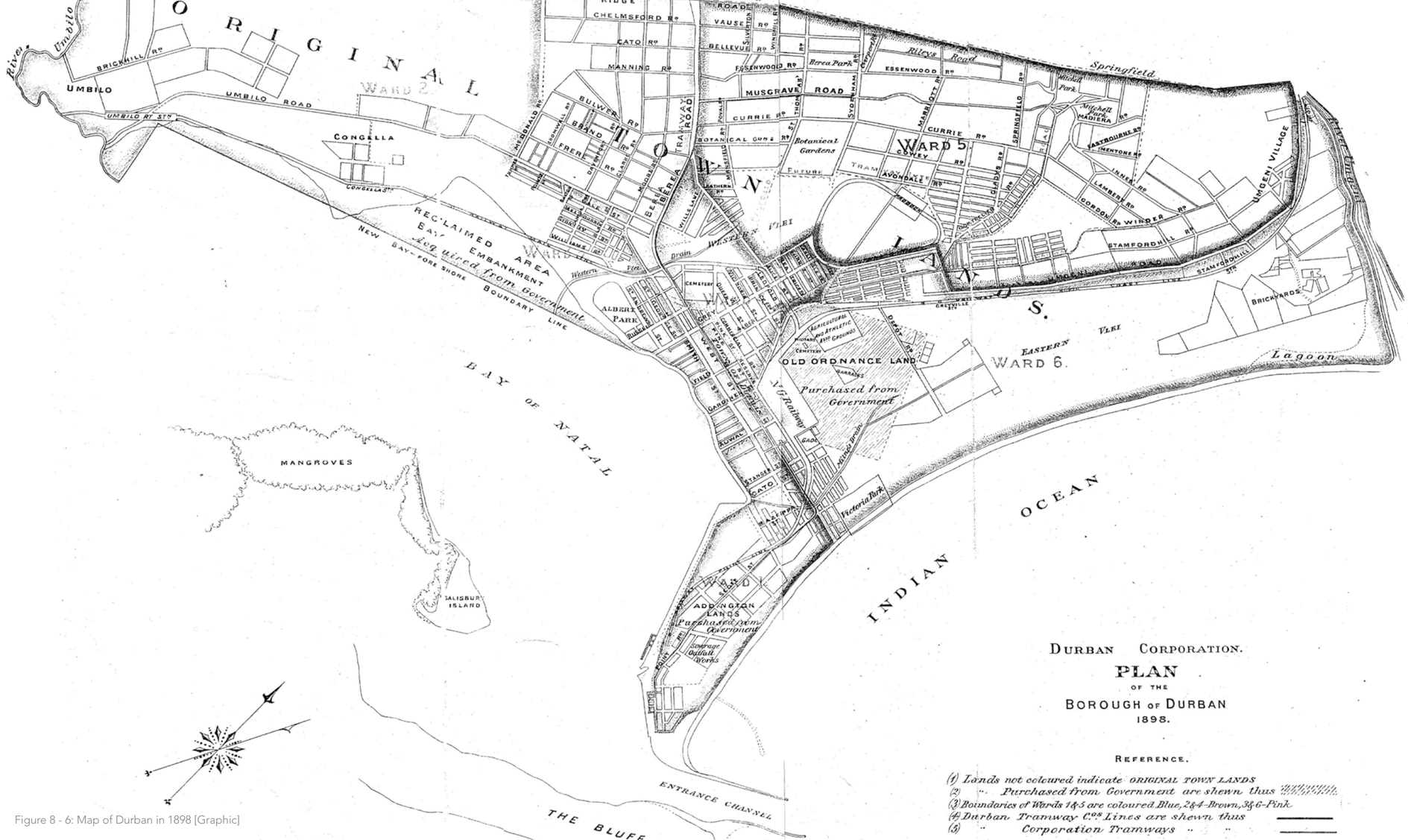


Figure 8 - 6: Map of Durban in 1898 [Graphic]

The first Europeans to settle in Durban were British traders. they first arrived in 1832 and named the capital Durban in 1835 in (Fisher & Clarke,2014). The Voortrekkers then settled nearby and named their capital Pietermaritzburg. In 1844, the British defeated to Voortrekkers and Durban officially became part of the British Cape Colony's territory (Footprint travel Guides, 2015).

The high demand for sugar caused a rapid development of Durban and the British needed labourers to man the plantation. They brought contracted labourers from their colony in India to work the sugar cane fields. Many Indians decided to stay in Natal even after their contracts had expired. This population, coupled with the influx of passenger Indians who came to Durban as traders, enabled the establishment of a thriving Indian community, still evident today (Fisher &Clarke, 2014).



Figure 8 - 7: Container ship in Durban Harbour [Photograph]



Figure 8 - 8: View of the Harbour from Wilsons Wharf, Durban [Photograph]

DURBAN HARBOUR TODAY

Durban harbour is the busiest cargo port in Africa (Arabian Business, 2008) The city depends on the various industries that are accommodated in the port and strives to provide facilities that support these industries.

The port of Durban performs a critical role within the city of Durban as an employer of people. It services its own industrial and commercial region (the second largest in SA), in addition to much of SA's inland areas including the majority of Gauteng and a significant amount of traffic for neighbouring countries.

A total of 302km of rail tracks extends throughout the port area along with several major marshalling yards.

Durban has three marinas, the main marina opposite the Esplanade near the Point Yacht Club and Royal Natal Yacht Club. Wilson's Wharf marina is further along the Esplanade which is used predominantly by small craft. Then lastly the Bluff Yacht Club facility in the Silt Canal near Bayhead. The Silt Canal houses a number of other marine activity clubs.

A large number of other recreational activities take place in Durban Bay including canoeing, kayaking, para-sailing, fishing from boats and bird watching at the Heritage Site (mangrove swamps). There are a number of ferries available from Wilsons wharf which take guest out on rides in the harbour or out into the ocean.

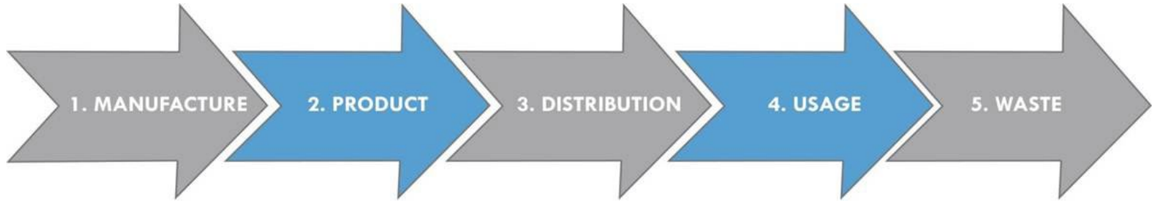
CHAPTER 09 VIABILITY REPORT

Project Summary

There are growing concerns of environmental issues ranging from global warming to endangered biospheres. One of these environmental concerns has been the increasing amount of plastics collecting in our oceans. This serious issue can be corrected and if properly dealt with the plastic collected from the oceans can be an economic opportunity.

By using the discarded plastic as a raw material for the production of new products the process is manipulated from one born of consumerist society to a more sustainable option that the modern world strives for.

The architectural intervention in Durban will act as a catalyst for tackling the recycling issues within the city as well as utilizing plastics collected from the ocean. The project furthermore aims to have a research component which will test how emerging technologies and how plastics can be utilized for the benefit of the construction industry and a sustainable future.



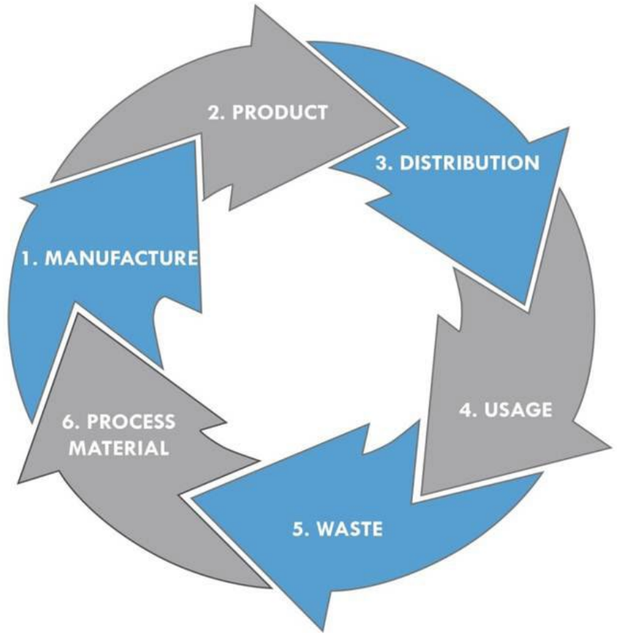


Figure 9 - 1: Concept [Diagram]

Project Brief

The recycling centre will be designed to function within the proximity of the Durban harbour. The centre is to provide a drop off zone for all recyclable materials whilst focusing specifically on plastics. The Building is to house the process of recycling the plastics and processing them into material suitable for 3D printing various products.

The building must attract public attention and effectively interact with the public as to promote the process and educate about recycling culture and the benefits of recycling household waste.
The building must include:

- Recycling collection zones
- Offloading area from the harbour
- Sorting Areas
- Cleaning and plastic material processing capabilities
- Storage
- Research Labs
- Offices and boards rooms
- Design Studios
- 3D printing workshop
- Entrance Foyer
- Reception
- Auditorium
- Coffee Shop/ Restaurant
- All appropriate service amenities
- Sufficient Parking

Design Considerations

- How can a building of this nature attract a public interaction?
- Who would be the suitable clients for this project?
- Who are the potential users of this project?
- What does the building provide to the city?
- What construction methodology will be used?
- What materials will be used in the construction of this building?
- How does the building integrate with the city and Durban Harbour?
- Who would be the key players in ensuring this project is viable?

Clients / Users

The department of Refuse and waste for Ethekwini will be the main tenant for the building along with plastic research organisations and environmental foundations.

Stakeholders

1. THE OCEAN CLEANUP FOUNDATION

The Ocean Cleanup project is a foundation started by a young aero-space engineering student named Boyan Slat. When he was 19 years old he developed a passive system to clean the ocean from plastic and debris collecting in the ocean gyres. The Foundation started in 2013 and through crowd funding and investment from various corporations raised $2 million and as of March 2016 is in the process of building a prototype of the system. The system will collect plastic using the push of the ocean current, collecting the plastic as the current passes through. The debris will then be stored on a platform where it will be collected for transport to the mainland for recycling.

In the Ocean Cleanup feasibility report, the foundation estimates that a 100-kilometer array operating in the North Pacific gyre for 10 years could remove 42% of the plastics in the area, or an estimated 70 million kilograms.

Once the first project has begun at the north Pacific gyre, the Ocean cleanup foundation will begin to clean up the Indian Ocean Gyre, not far from Durban Harbour.

2. THE INDUSTRIAL DEVELOPMENT CORPORATION

(IDC) Established in 1940, the IDC are a national development finance institution set up to promote economic growth and industrial development. The IDC is owned by the South African government under the supervision of the Economic Development Department. The IDC aims to be the primary source of commercially sustainable industrial development and innovation to benefit both South Africa and the rest of Africa. In 2015 the IDC funded developing manufacturing businesses to the value of R5.5 billion

3. ETHEKWINI DSW – CLEANSING AND SOLID WASTE

The DSW unit of Ethekwini Municipality is responsible for waste management and will be a valuable partner for any recycling project. The DSW is responsible for:

- Collection and transportation of domestic, commercial and industrial waste.
- Provision and management of wheelie bins and skips.
- Managing of landfill sites.
- Street cleaning and litter removal services.
- Recycling and minimisation of waste.
- Management of illegal dumping.
- Community waste management awareness and education programmes.
- Research and development of new waste management processes.
- Recovery from landfills of naturally produced methane gas as an energy source for generating electricity.

Social Impact

The project will have a positive social impact in two ways:

- By providing recycling facilities for the city.
- Improving local knowledge of recycling methods.
- Provide roughly 30 skilled jobs as well 100 unskilled jobs.
- Promote recycling and incentivise recycling projects.
- Create a community space for residents in the area.
- Opportunities for partnerships with other businesses
- Possible negative impacts include:
- Relocation of existing workshop.
- Competition for small existing recyclers.

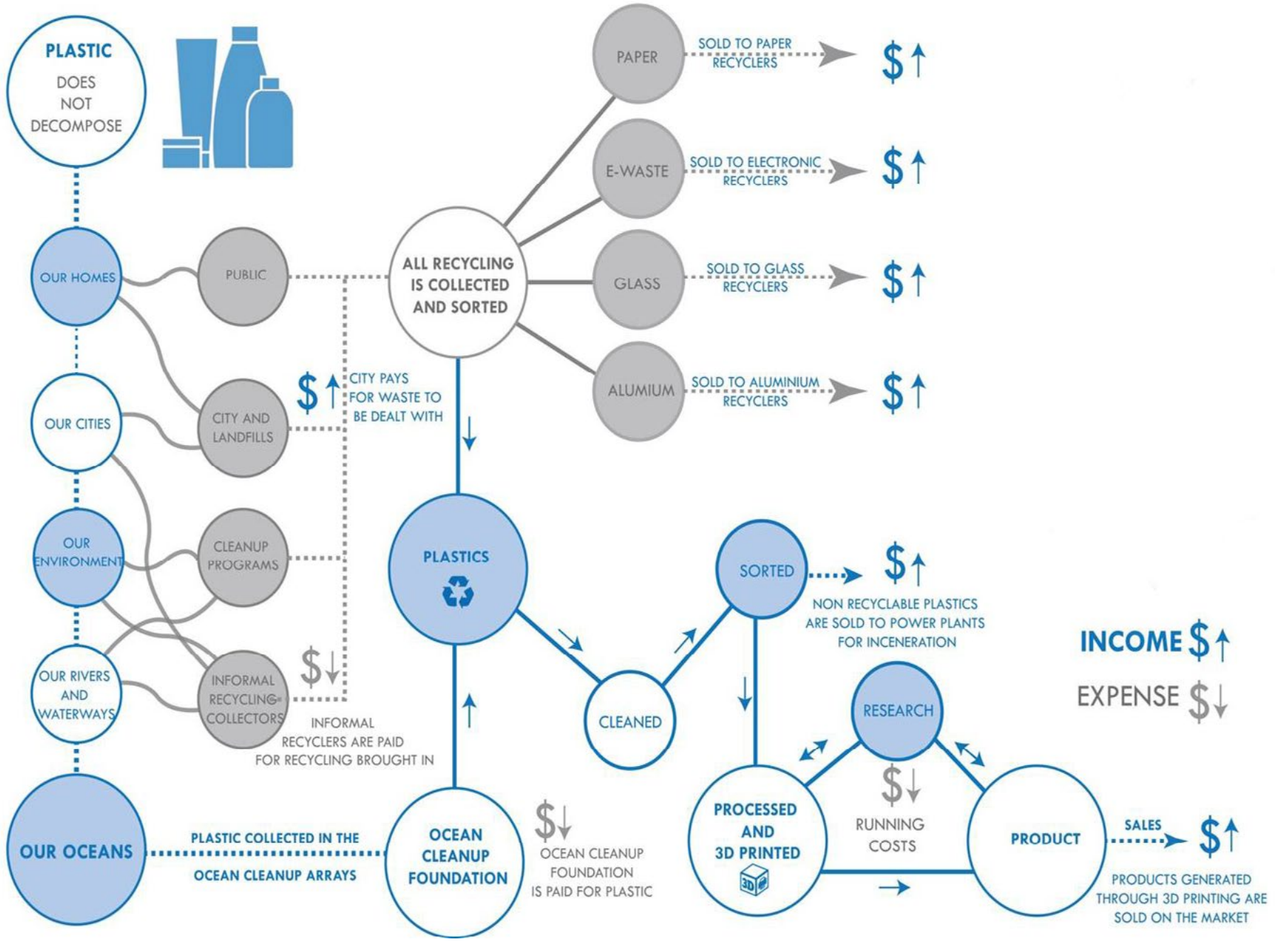


Figure 9 - 2: A plastic economy [Diagram]

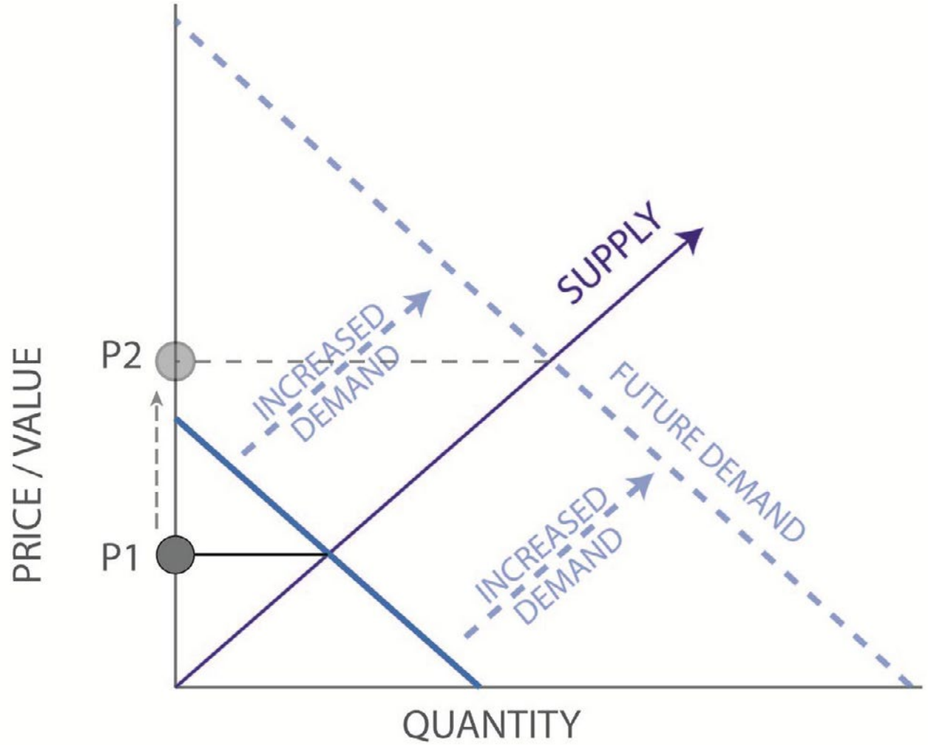
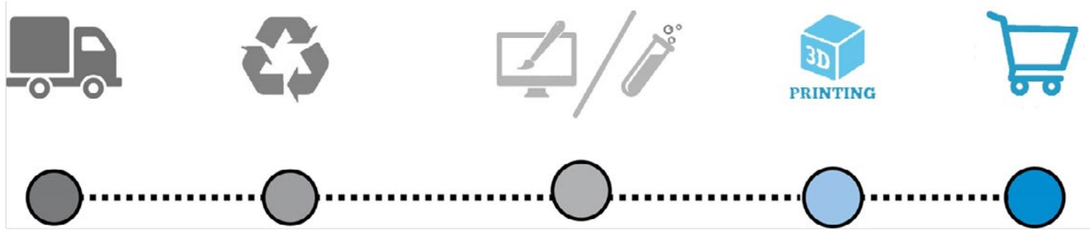


Figure 9 - 3: Supply and demand graph of plastics [Diagram]

Program	Area (m²)
RECYCLING CENTRE	2500
Collection zone (all recycling)	1000
Sorting All recycling	300
sorting zone (Plastics)	200
cleaning zone	200
Processing	500
Storage	200
Ablutions and changerooms	100
RESEARCH CENTRE	500
Offices x 3	60
Board Room	40
Workshop	200
Labs	100
Ablutions	100
PRODUCTION	1580
Design Studio's	200
3D printing workshop	200
Offices x 3	60
Board room	40
Workshop and assembly	500
Ablutions	30
Storage	500
Waste Storage for recycling	50

PUBLIC	1600
Ablutions	100
Reception	50
Auditorium	1000
Gallery and sales	250
Coffee Shop + kitchen	200
SERVICE AMENITIES	295
HT Room	20
LT Room	20
Generator Room	20
Storage	100
Safe Room	30
Dispatch zone	40
Offloading zone	40
Security Office	25
TOTAL BUILDING AREA	6475

OUTDOOR	
Landscaping	2000
Parking and roads (22m² x 240bays)	5280
TOTAL OUTDOOR AREA	7280



DELIVERY

a. Receiving
b. Handling
c. Storage
d. Docking

RECYCLE

a. Sorting
b. Cleaning
c. Processing
d. Storage

DESIGN & RESEARCH

a. Design Studios
b. Labs
c. Offices
d. Boardrooms
e. Bathrooms

PRODUCTION

a. Workshop
b. Assembly

Figure 9 - 5: Program Diagram [Diagram]

Figure 9 - 4: Program Table [Graphic]

Architectural Fee				
			TOTAL BUILDING COST:	R 49 750 000.00
			ARCHITECTURAL FEE = R231 000 (BASE FEE) + 6.25% OF COST	R 3 340 375.00
Work Stages	Percentage of fee (%)	Monetary Proportion	Cumulative Percentage (%)	Monetary Cumulation
1	5%	R 167 018.75	5%	**R 167 018.75**
2	15%	R 501 056.25	20%	R 668 075.00
3	20%	R 668 075.00	40%	R 1 336 150.00
4.1	20%	R 668 075.00	60%	R 2 004 225.00
4.2	10%	R 334 037.50	70%	R 2 338 262.50
5	27%	R 901 901.25	97%	R 3 240 163.75
6	3%	R 100 211.25	100%	R 3 340 375.00
			TOTAL ARCHITECTS FEE	R 3 340 375.00

Professional Team Costs				
			TOTAL BUILDING COST:	R 49 750 000.00
Professional	Base fee	Percentage of building cost	Percentage Fees Required	Total Fee
Project Manager	R 2 245 000	4.63%	R 2 303 425	**R 4 548 425.00**
Architect	R 231 000	6.25%	R 3 109 375	**R 3 340 375.00**
Mechanical Engineer	R 2 270 350	9.00%	R 4 477 500	**R 6 747 850.00**
Electrical Engineer	R 2 235 850	9.00%	R 4 477 500	**R 6 713 350.00**
Structural Engineer	R 1 830 200	7.00%	R 3 482 500	**R 5 312 700.00**
Quantity Surveyor	R 1 592 000	4.00%	R 1 990 000	**R 3 582 000.00**
6				
			TOTAL PROFESSIONAL FEES	R 30 244 700.00

Figure 9 - 6: Fees Table [Graphic]

Funding Sources

Funding is to be sourced through investments from the IDC as well as through the Ethekwini municipality DSW mandate to grow the recycling culture within the Durban City.

Once the building is operational the project will be capable of funding its own operation as well as generate a profit to pay back investors.

Construction Methodology

Once the initial architectural design of the project has been developed the discussions on construction methodology between the architects and the entire project team will commence. The project team will consist of:

- Project manager
- Architect
- Mechanical engineer
- Civil engineer
- Structural engineer
- Electrical engineer
- Quantity surveyor
- Marine Biologist

The Project team will advise on the most effective and economical method of construction taking into account the site conditions, availability of materials, building programs, site context, social and environmental impacts and the overall final product of the building.

Due to the location of the site adjacent to the harbour, the building is likely to require pile foundation but this will need to be determined on site.

CHAPTER 10 SITE ANALYSIS

Durban harbour sits in an ideal location for plastic extraction from the ocean. Situated between two gyres (The larger Indian Ocean Gyre and the smaller South Atlantic Ocean) the harbour is adequately equipped as a port capable of handling industrial activity.

From the Durban Harbour a ship travelling at 40 knots would reach the centre of the Indian Ocean Gyre in under 4 days whilst a ship travelling to the South Atlantic Gyre at the same speed would take just 3 days. Meaning a ship travelling to the Gyres would be out for about a week at a time.

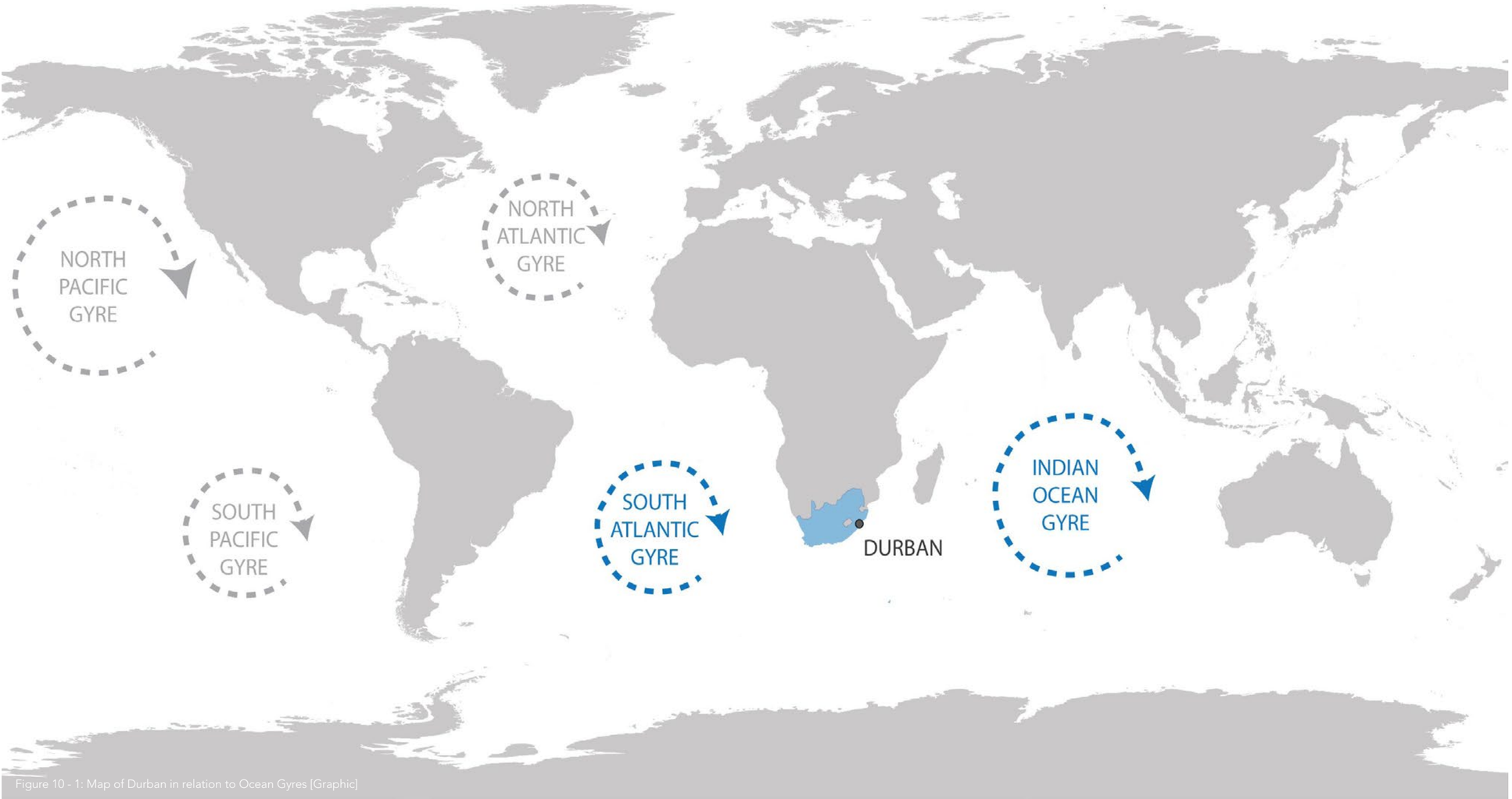


Figure 10 - 1: Map of Durban in relation to Ocean Gyres [Graphic]



Figure 10 - 2: Aerial of the Durban Harbour region [Photograph]



Figure 10 - 3 : Site selection map [Graphic]

Site Selection

The following factors were informative in the process of site selection for the project:

1. Proximity to Durban Harbour.
2. Proximity to main road and Railway lines for transport of raw materials:
3. Vacant land adjacent to the harbour for access of ships.
4. Reasonable zoning and site restrictions.
5. Suitable for a mixed use program of industrial, commercial and retail functions.
6. Reasonable access to the public (vehicular and pedestrian).
7. Positioned in an area where the building can create a positive impact to the environment.

The Durban recycling project must allow for the Ocean Cleanup Project to offload plastic collected from the Collection device located in the Indian Ocean and South Atlantic Ocean Gyres. The Plastic will be offloaded by Ship so requires appropriate docking facilities. The Facility also need to be positioned appropriately to make use of major transport routes.

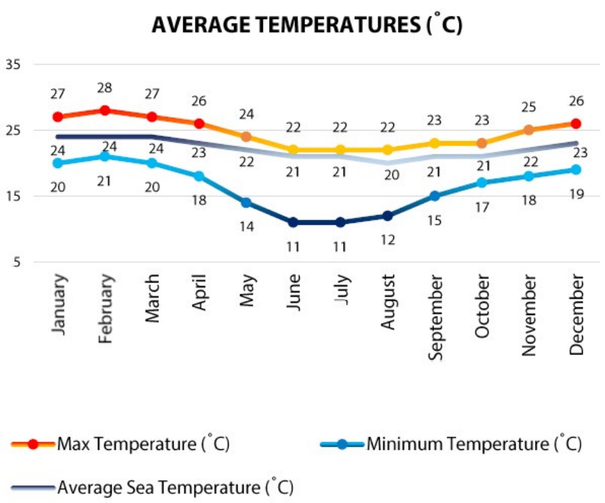


Figure 10 - 4: Average Temperatures [Graphic]

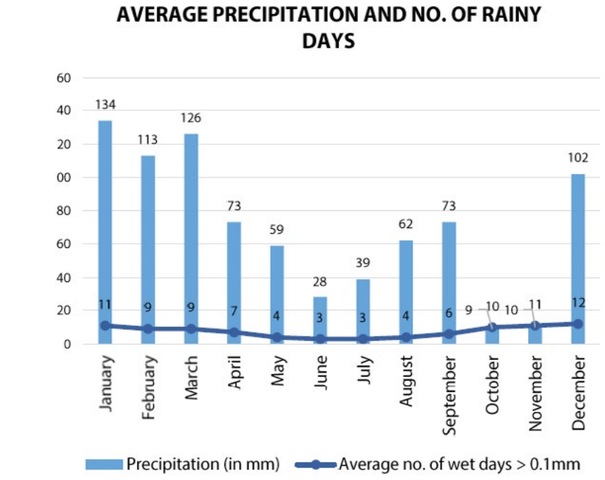


Figure 10 - 5: Average precipitation [Graphic]

DURBAN CLIMATE

Durban is not only an industrial city, but the perfect holiday destination. The city boasts an average of 320 days of sunshine a year (south africa holiday. org.uk, n.d.) and has a pleasant subtropical climate. Maximum temperatures are between 22C and 28°C, while minimum temperatures range between 11°C and 20°C. The area has a warm climate throughout the year, only getting cool at night mid-year.

Winters are dry and mild, while the higher temperatures in summer are counteracted by frequent rainfall. The area can become very humid, especially in the summer months, but with an average sea temperature in the low to mid-twenties.

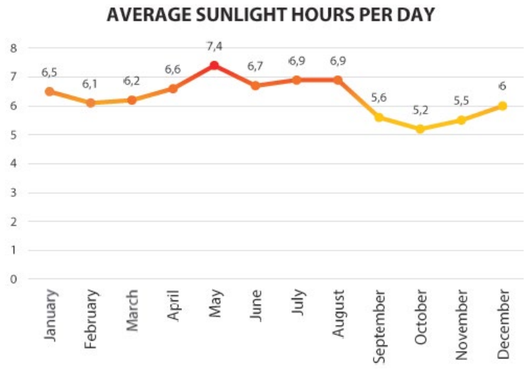


Figure 10 - 6: Average sunlight hours [Graphic]

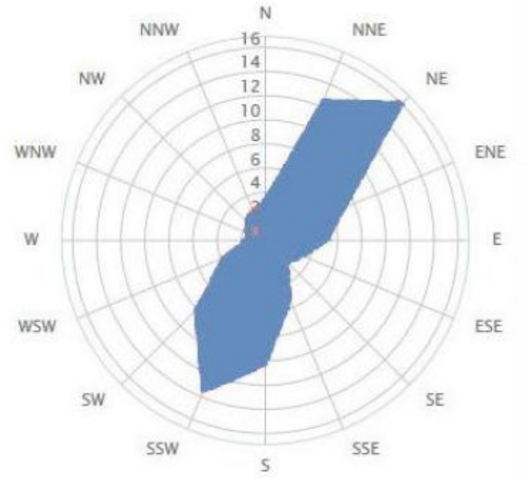


Figure 10 - 7: Average annual wind direction [Graphic]

People visiting in winter avoid the humidity of the summer months and get away from the cold inland areas and rainy weather in Cape Town. The hottest months in Durban are January and February, while rainfall is most common between December and March. Rainfall is light and steady, generally falling in the afternoon (World Guides, 2015).

Durban has two predominant wind directions, primarily blowing from the North East, bringing sun and warm temperatures, or the South West, bringing rain and strong winds (in Motion Graphics, 2015). The area has an enviable climate with pleasant weather lasting throughout the year.

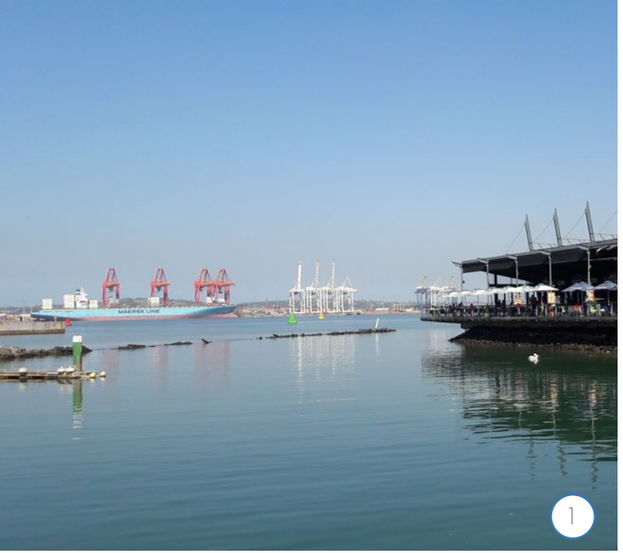


Figure 10 - 8: View out into the harbour, facing South [Photograph]

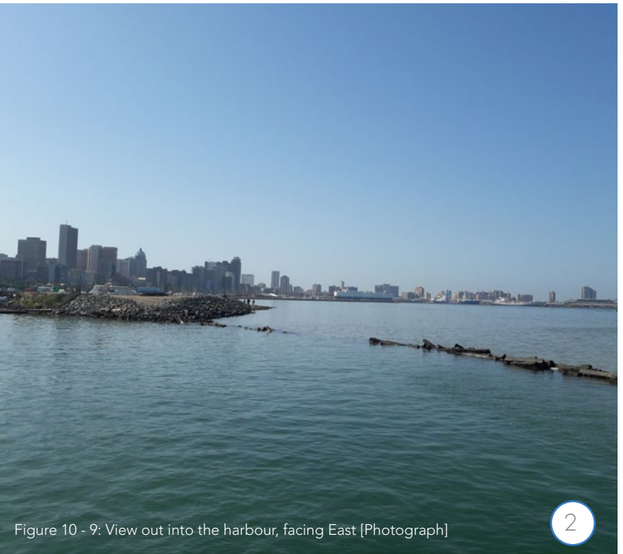


Figure 10 - 9: View out into the harbour, facing East [Photograph]



Figure 10 - 10: View of abandoned building [Photograph]



Figure 10 - 11: View of old fishing boats [Photograph]

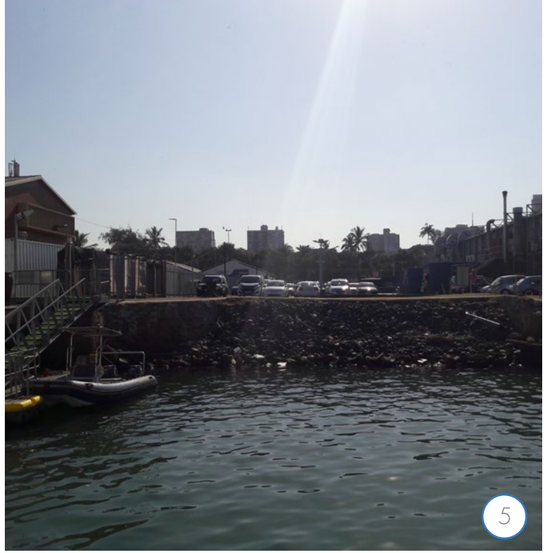


Figure 10 - 12: View of parking lot from the water [Photograph]

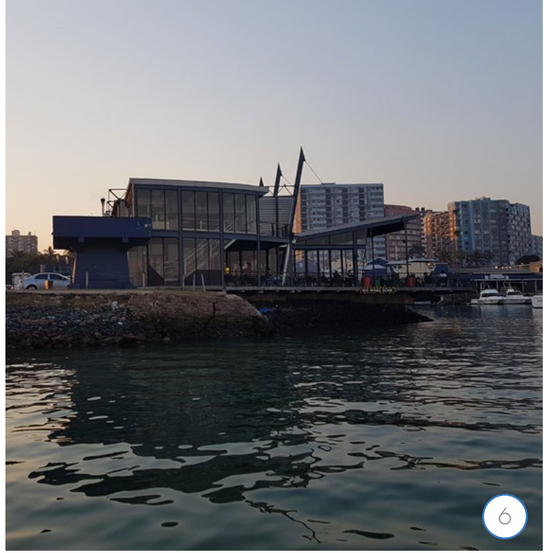


Figure 10 - 14: View of existing retail building from water [Photograph]



Figure 10 - 13: Site photo's Key Plan 1 [Graphic]



Figure 10 - 15 : View of boat maintenance warehouses [Photograph]

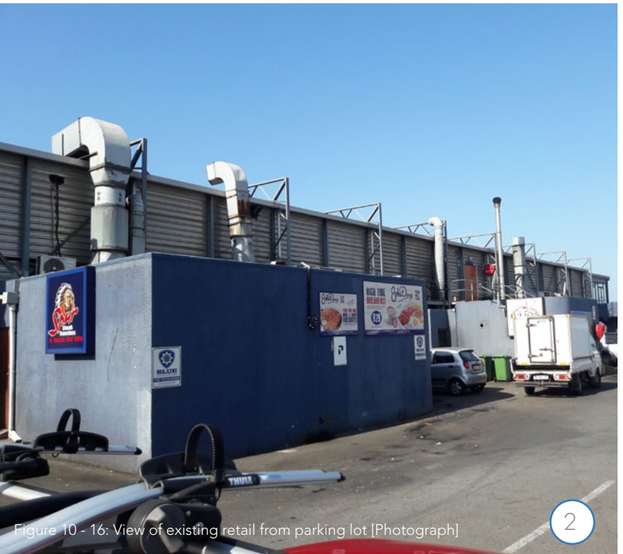


Figure 10 - 16: View of existing retail from parking lot [Photograph]

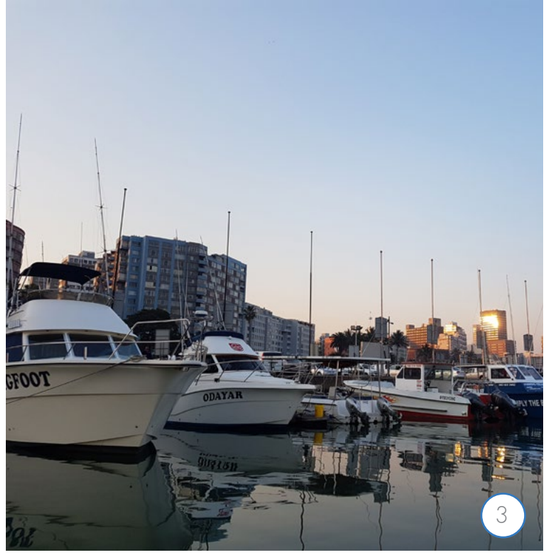


Figure 10 - 17: View of docked boats [Photograph]

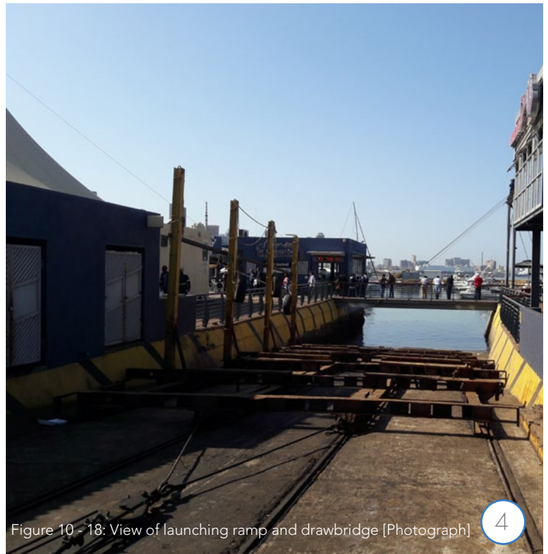


Figure 10 - 18: View of launching ramp and drawbridge [Photograph]



Figure 10 - 19: View of existing retails and parking [Photograph]

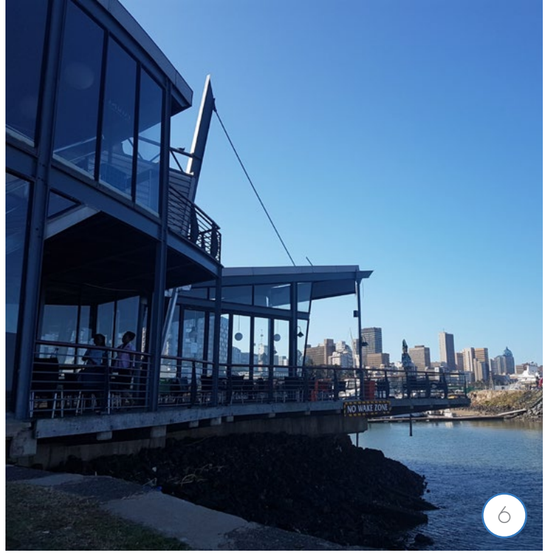


Figure 10 - 21: Close up view of Existing retail [Photograph]

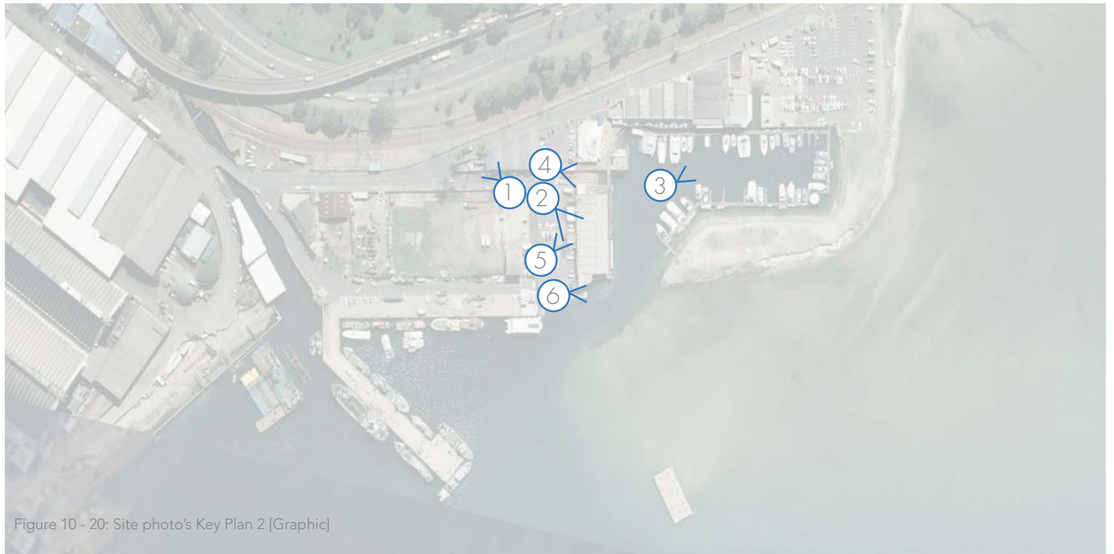


Figure 10 - 20: Site photo's Key Plan 2 [Graphic]



Figure 10 - 22: View of intersection roads [Photograph]



Figure 10 - 23: View of railway [Photograp]

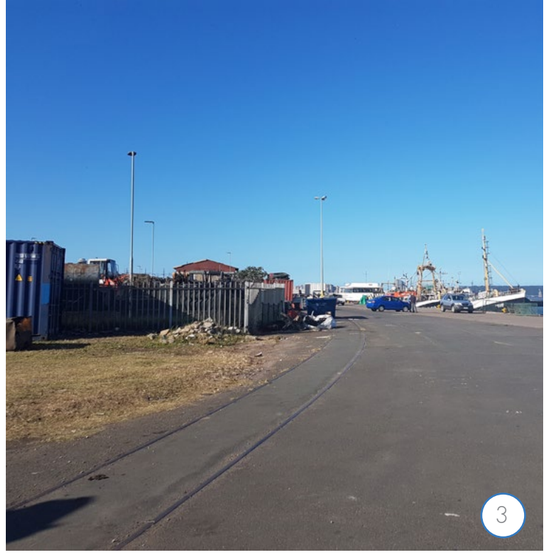


Figure 10 - 24: View of fishing wharf [Photograph]



Figure 10 - 25: View of service road [Photograph]



Figure 10 - 26: View of temporary police offices [Photograph]

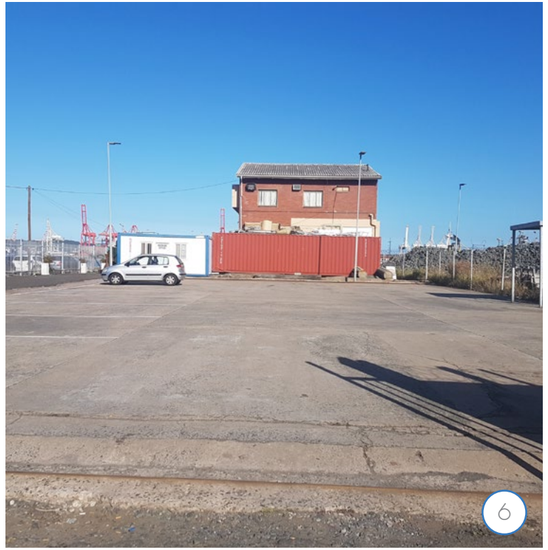


Figure 10 - 28: View of open space and abandoned building[Photograph]

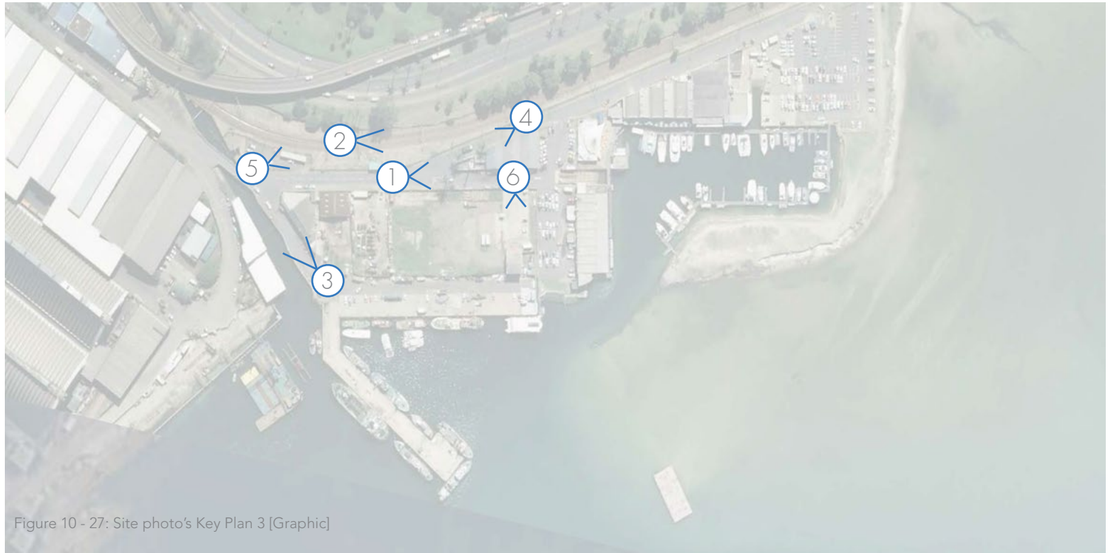


Figure 10 - 27: Site photo's Key Plan 3 [Graphic]



Figure 10 - 29: Map of Trees and harbour edge [Graphic]



Figure 10 - 30: Map of the built environment [Graphic]



Figure 10 - 31: Map of streets [Graphic]

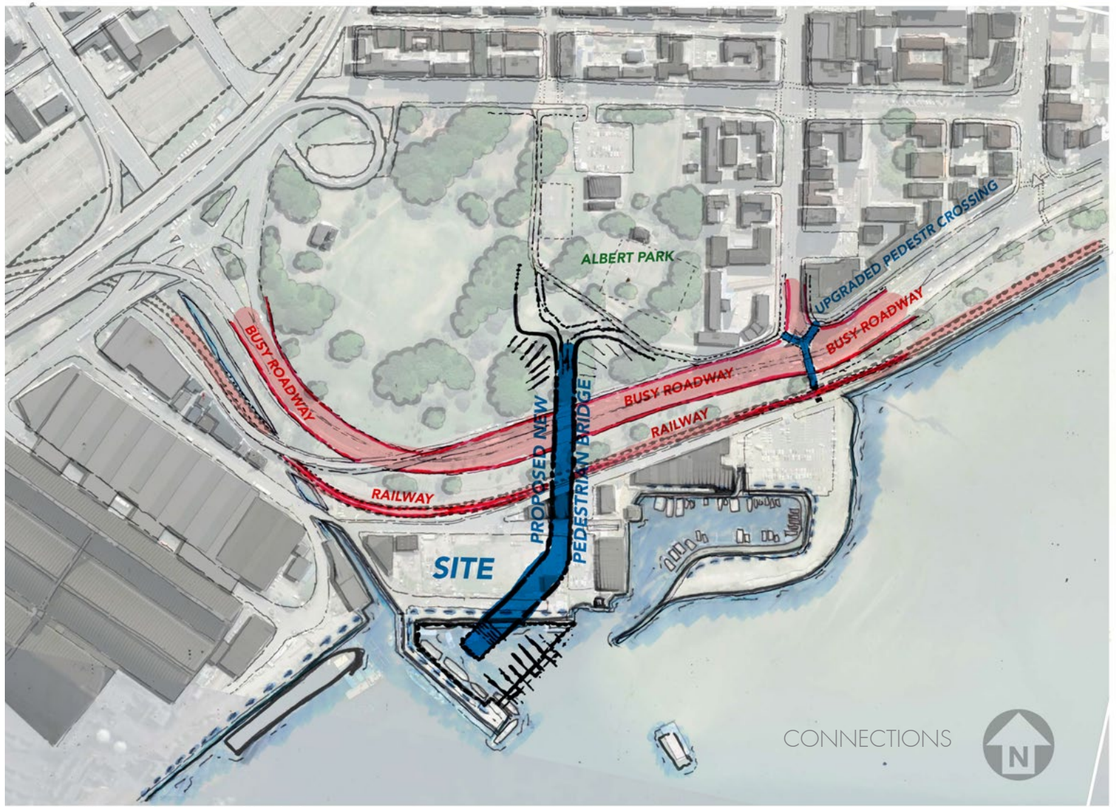


Figure 10 - 32: Map of connectivity [Graphic]



Figure 10 - 33: Map of building uses [Graphic]

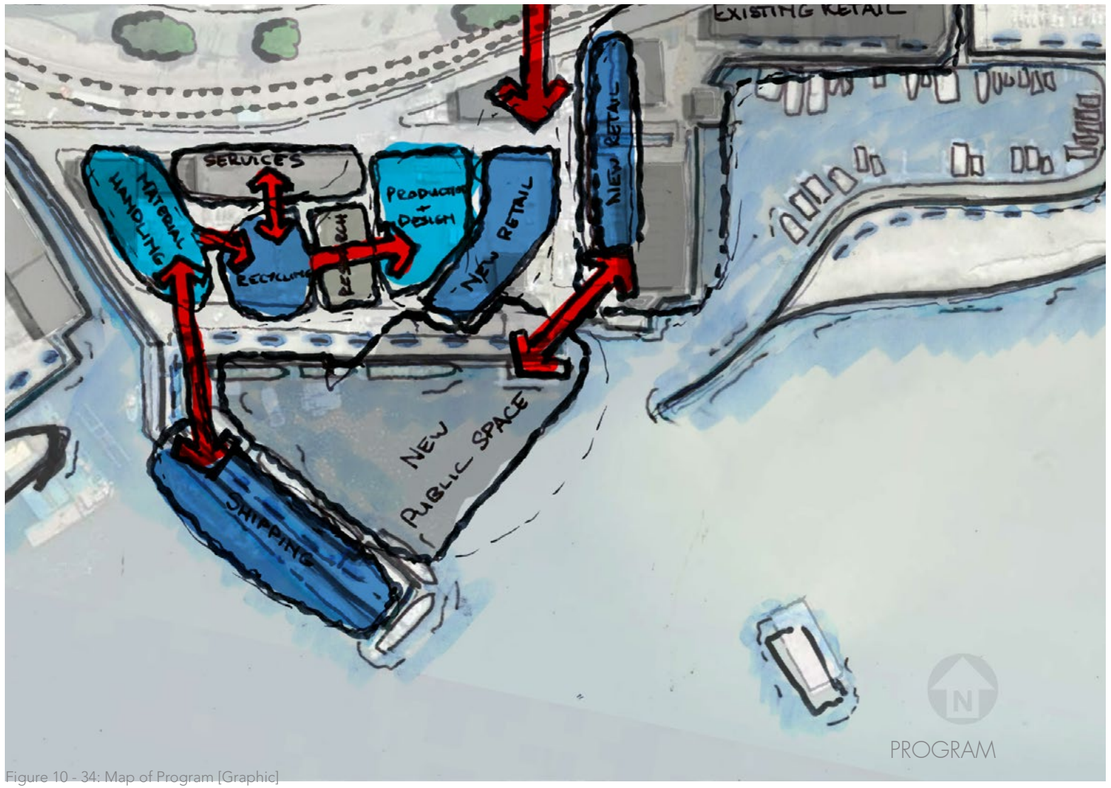


Figure 10 - 34: Map of Program [Graphic]

CHAPTER 11 PRECEDENT STUDIES

HEAD IN THE CLOUDS PAVILION (NEW YORK CITY) - STUDIO KCA

This temporary pavilion was made from 53,780 recycled plastic bottles. The form, colour and light quality gained through the use of plastic bottles presents a very unique feel the building. The open vault spaces inside the pavilion together with the soft glow of sunlight shining through the plastic material crate a very calm and comfortable space.

This installation perfectly presents the possibilities of constructing using plastic when a bit of creativity is utilised.



Figure 11 - 1: Head in the clouds pavilion, lawns [Photograph]

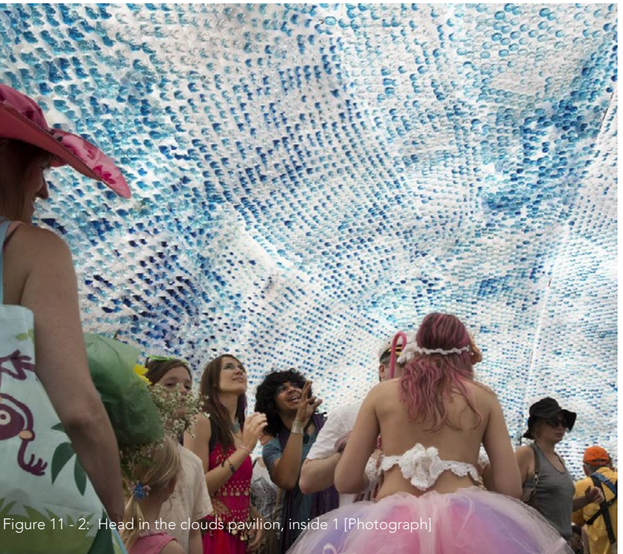


Figure 11 - 2: Head in the clouds pavilion, inside 1 [Photograph]

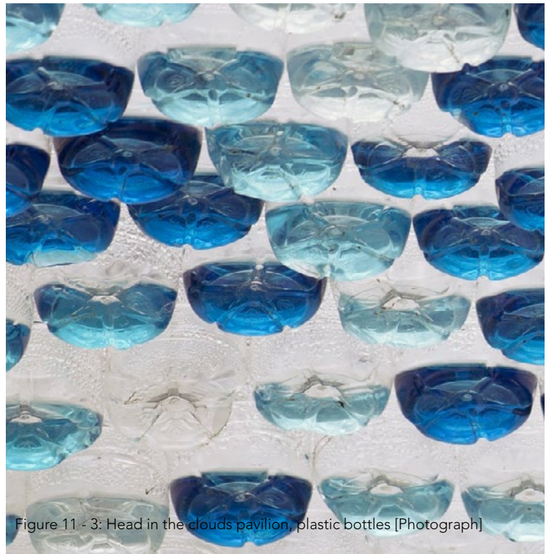


Figure 11 - 3: Head in the clouds pavilion, plastic bottles [Photograph]

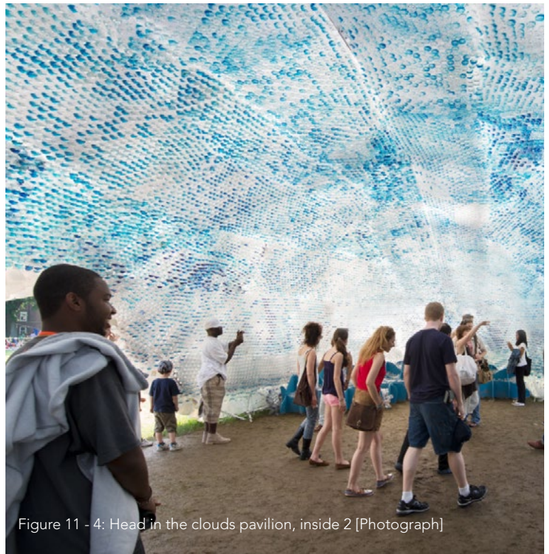


Figure 11 - 4: Head in the clouds pavilion, inside 2 [Photograph]



Figure 11 - 5: Mobile Europe building 1 [Photograph]



Figure 11 - 6: Mobile Europe building 2 [Photograph]



Figure 11 - 7: Mobile Europe building 3 [Photograph]

MOBILE EUROPE BUILDING - DUS ARCHITECTS

DUS Architects has combined 3D-printed bioplastic with a tensile fabric structure to create a sculptural facade for the building where European Union meetings will take place over the next six months.
The firm based in Amsterdam is currently two years into a project to build the world's first 3D-printed canal house, so decided to use their knowledge of the technology to create the facade for the Mobile Europe Building. DUS Architects decided to create a facade that can be recycled. Tensile fabric structures are commonly used for temporary structures, so the architects decided to combine this with their recent research in bio-based 3D-printing filament.

"We're collaborating with Henkel, a global multinational that does innovative work with materials, and we're investigating the possibilities to create new printed bio-based printing materials. We've developed a special plastic that is entirely bio based, made out of linseed oil. The advantage of this material is not only that it is made out of plants, but that it can be shredded and reused in the print cycle." - Hedwig Heinsman, 2016

The fabric structure provides the main shape of the facade – a series of vertical panels that appear to have been lifted up at the base to create triangular openings reminiscent of tent entrances. The intention was for these forms to reference the sailing ships that were historically built in this area. Within these openings, faceted blue surfaces extends out to create benches. These elements were all created using one of two 3D printers involved in the construction of the canal house.

According to DUS Architects, this is the first time in the world that these kinds of "XXL 3D prints" are being shown in the public. They were created using fused deposition modelling, the same form of additive manufacturing used by most household 3D printers. The building will be used as a "global flagship warehouse" for 3D-printed construction.

"The FDM technique is the most common way of producing small objects, but what we've done is scaled up this technique for much larger elements. We can create elements up to five metres high, two metres wide, and two metres deep" - Hedwig Heinsman, 2016

"The 24-metre-tall building will combine traditional building techniques with XL 3D printed building elements, all related to digitally customisable construction: fully printed rooms, walls, facades, ornamented interiors, etc. The 3D Print Flagship Warehouse will consist of print production areas, workshop areas, a cafe, event space, flex desks, a roof terrace, located on a great waterfront location with amazing views in a booming part of Amsterdam." - Hedwig Heinsman, 2016

The building suggest the possibilities of 3D printing in construction and the interesting forms that can be achieved through this technology.



Figure 11 - 8: Taipei Ecoark 1 [Photograph]



Figure 11 - 9: Taipei Ecoark 2 [Photograph]

TAIPEI ECOARK - MINIWIZ GROUP

The "EcoARK" was built exclusively for the 2010 Taipei International Expo. The structure was built using steel framing and 1.5 million POLLI-Bricks as the facade. POLLI-Bricks are a building material invented by the architect group called Miniwiz. A POLLI-brick is a bottle that has been shaped in such a way that it has an interlocking system and can be stacked like bricks. The structure is 130m long and can be completely taken apart and then reassembled again at another location.

This building revolutionizes the way plastics are used in buildings, combining the bottle and brick into one element that can by stacked to build walls whilst the air inside the bottles acts as a cavity to insulate the building.

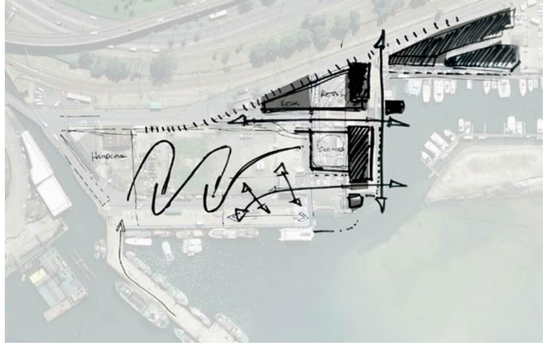


Figure 11 - 10: Concept 1 [Graphic]

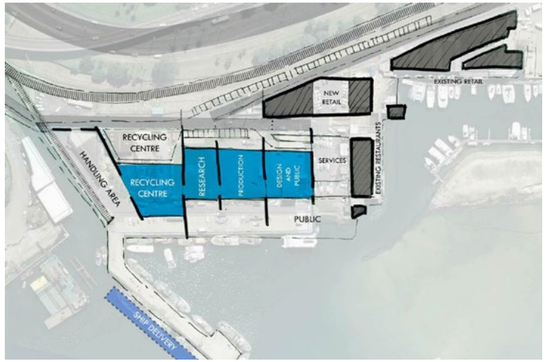


Figure 11 - 11: Concept 2 [Graphic]

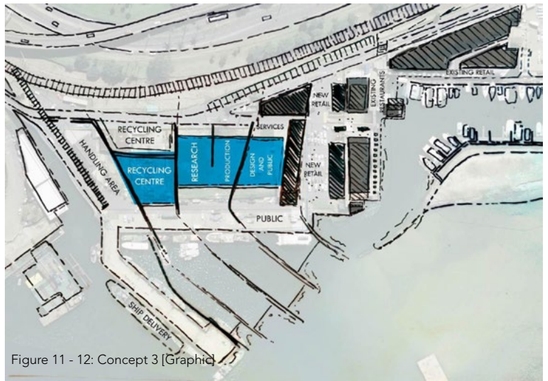


Figure 11 - 12: Concept 3 [Graphic]

CHAPTER 12

DESIGN DEVELOPMENT

The initial intention of the design was to open up a set of axis through the site and to create a public space in front of the building against the waters edge.

The building followed the process contained within it moving from left to right. The idea was for materials to be brought into be recycled and then move through the building to become new products on the other side.

As the design progressed the strict vertical axis became more flexible and the site area began to push into the harbour create a public deck. New retail was introduced to tie into the back of the existing retail in order to conceal a service corridor.

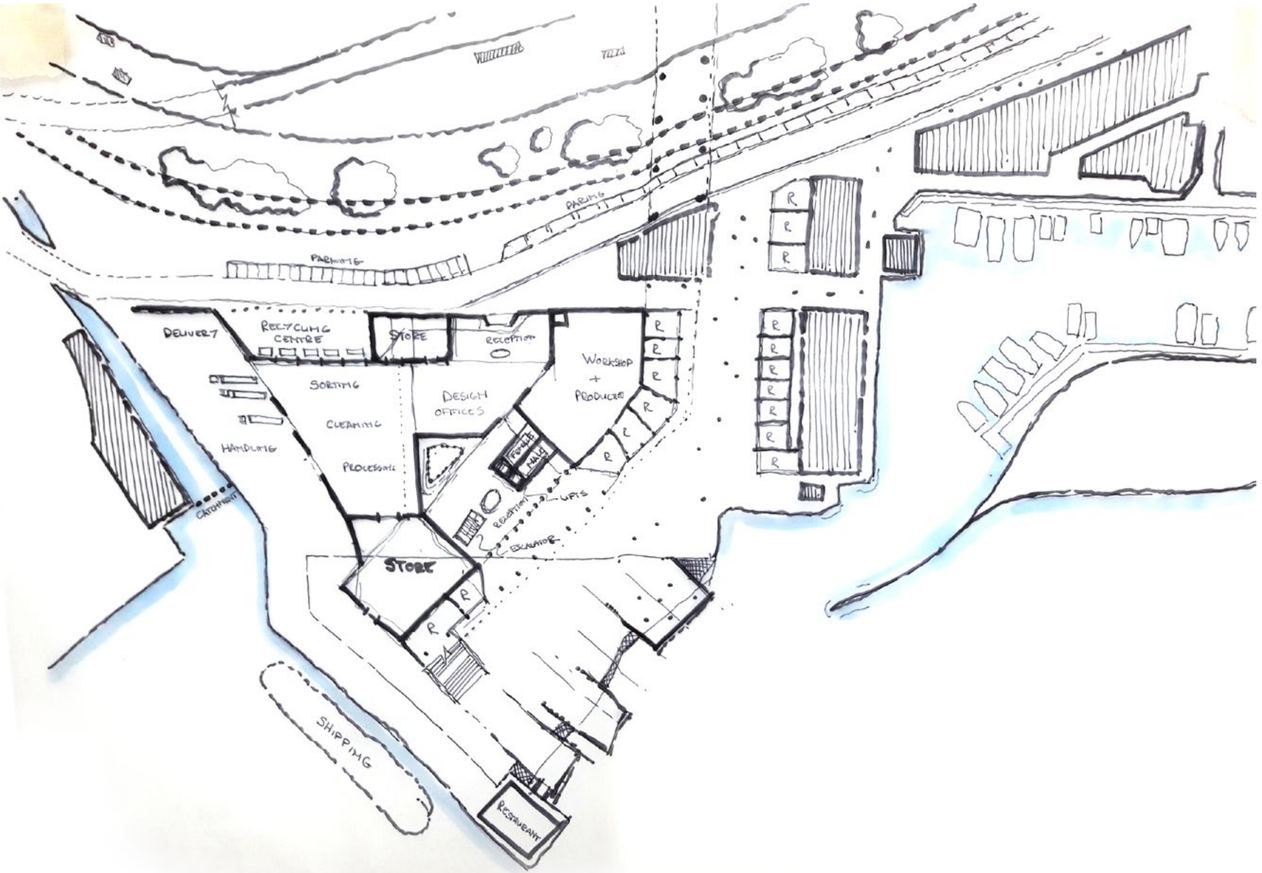


Figure 12 - 1: Concept 4 [Graphic]



Figure 12 - 2: Concept 5 [Graphic]

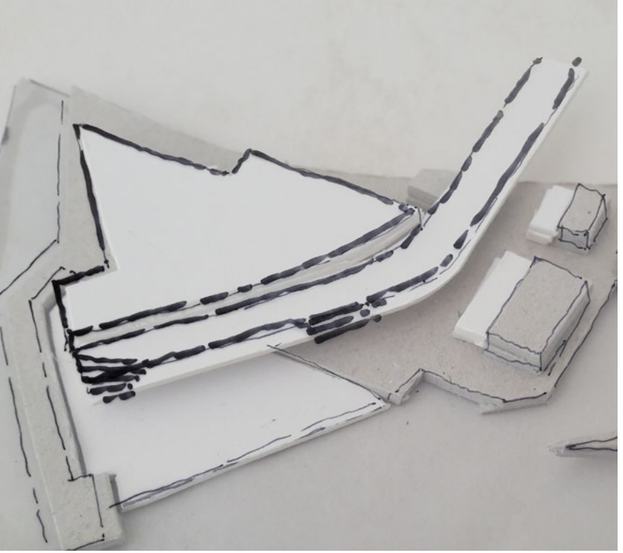


Figure 12 - 3: Concept 6 [Graphic]

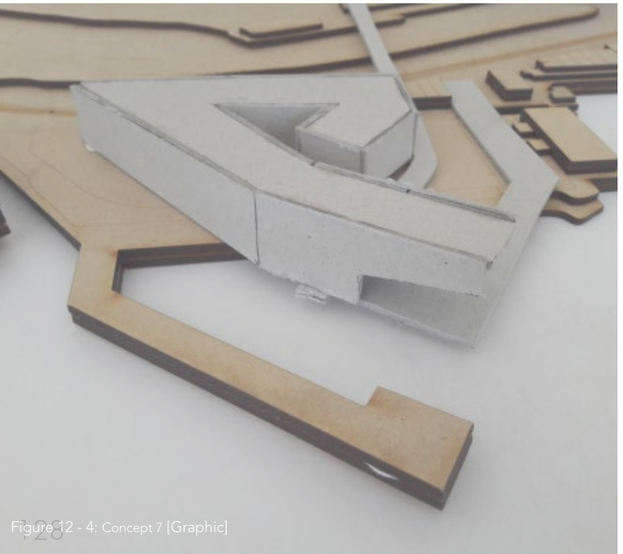


Figure 12 - 4: Concept 7 [Graphic]



Figure 12 - 5: Concept 8 [Graphic]

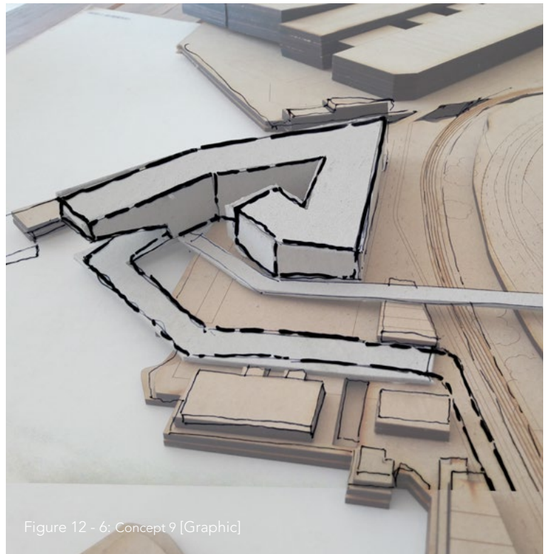


Figure 12 - 6: Concept 9 [Graphic]

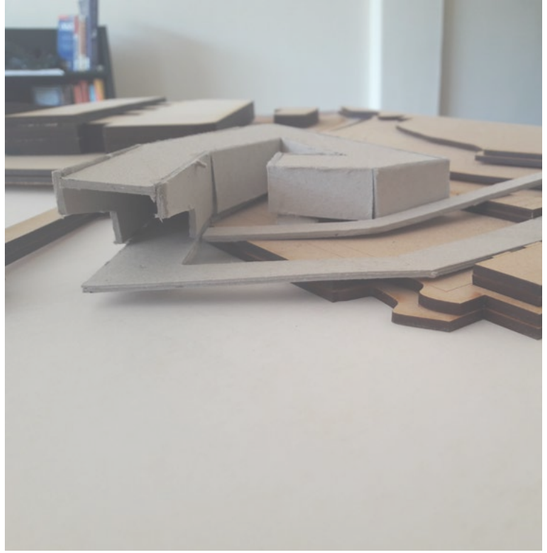


Figure 12 - 7: Concept 10 [Graphic]

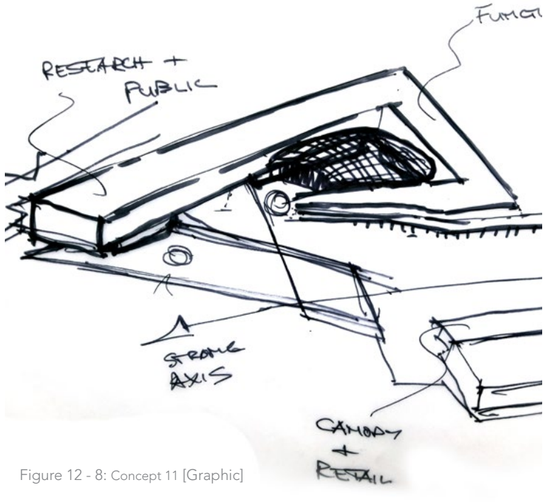


Figure 12 - 8: Concept 11 [Graphic]

The form of the building was generated from the triangular shape of the site. The building squeezes into the centre of the site allowing for public space along the waters edge and between itself and the existing retail component.

The design attempts to create an interaction between the building and the harbour by jutting out into it and maintaining a strong entrance to the building over the water.



Figure 13 - 1: Site Plan [Graphic]

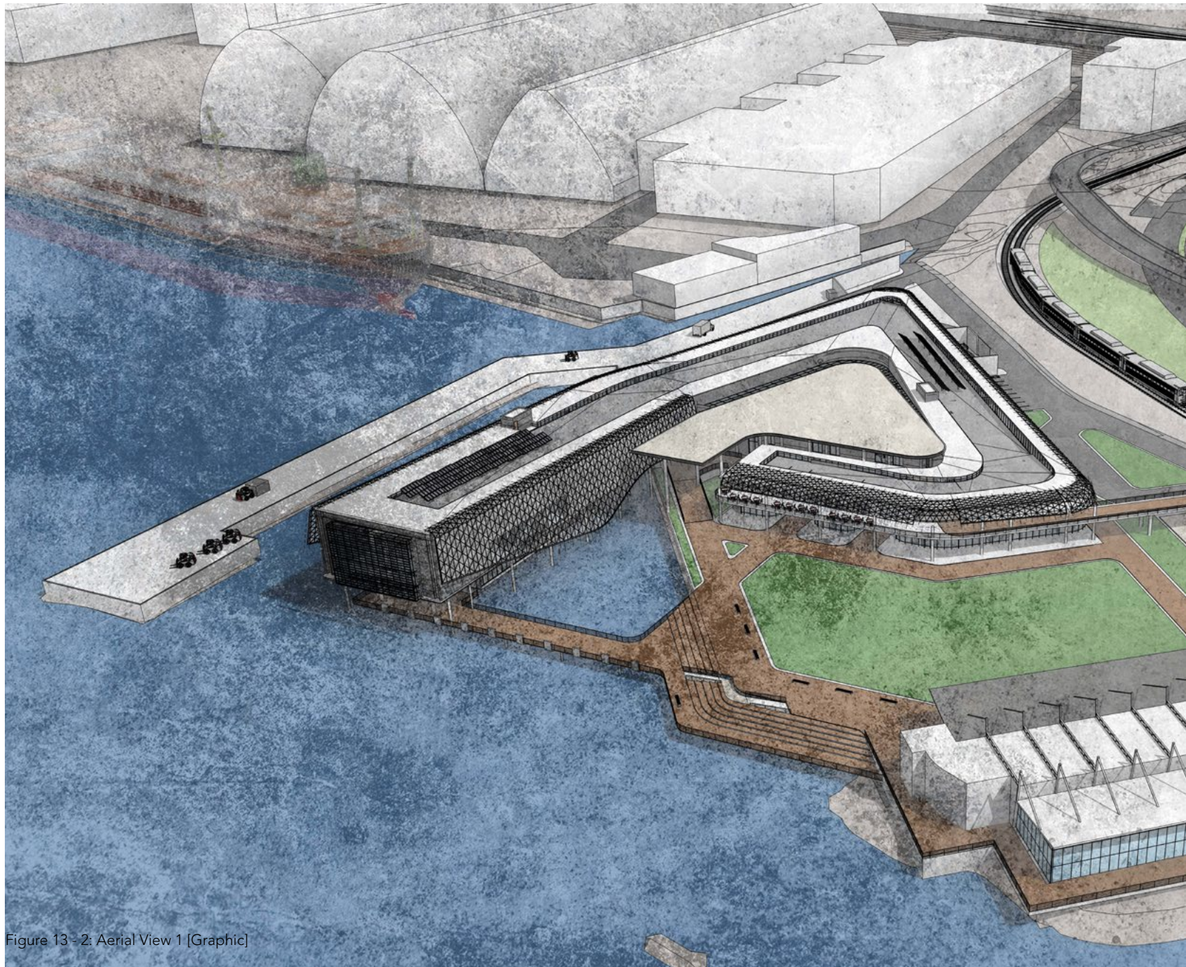
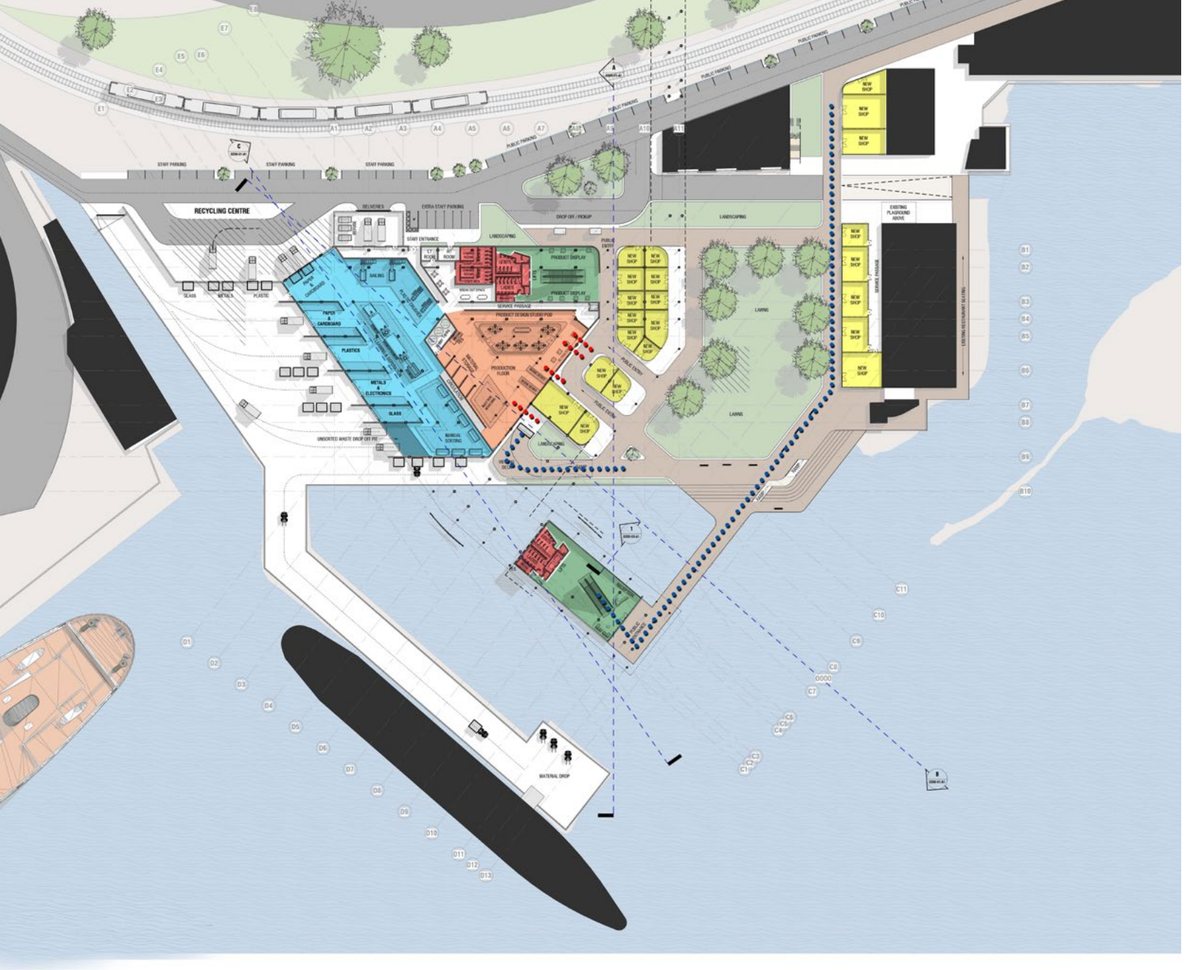


Figure 13 - 2: Aerial View 1 [Graphic]





GROUND FLOOR
NOT DRAWN TO SCALE

Figure 13 - 3: Ground Floor [Graphic]



Figure 13 - 4: Ground Axo [Graphic]

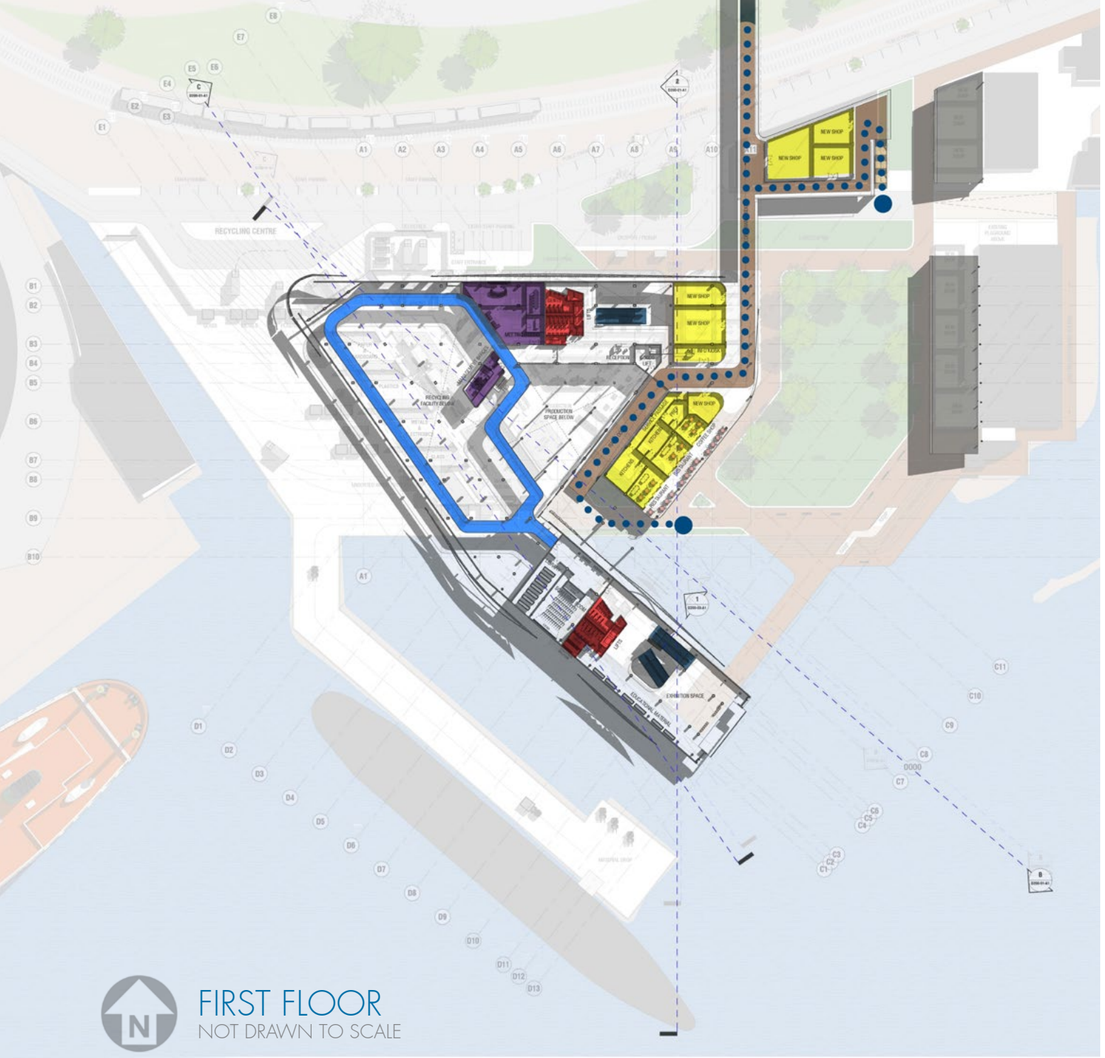


Figure 13 - 5: First Floor [Graphic]

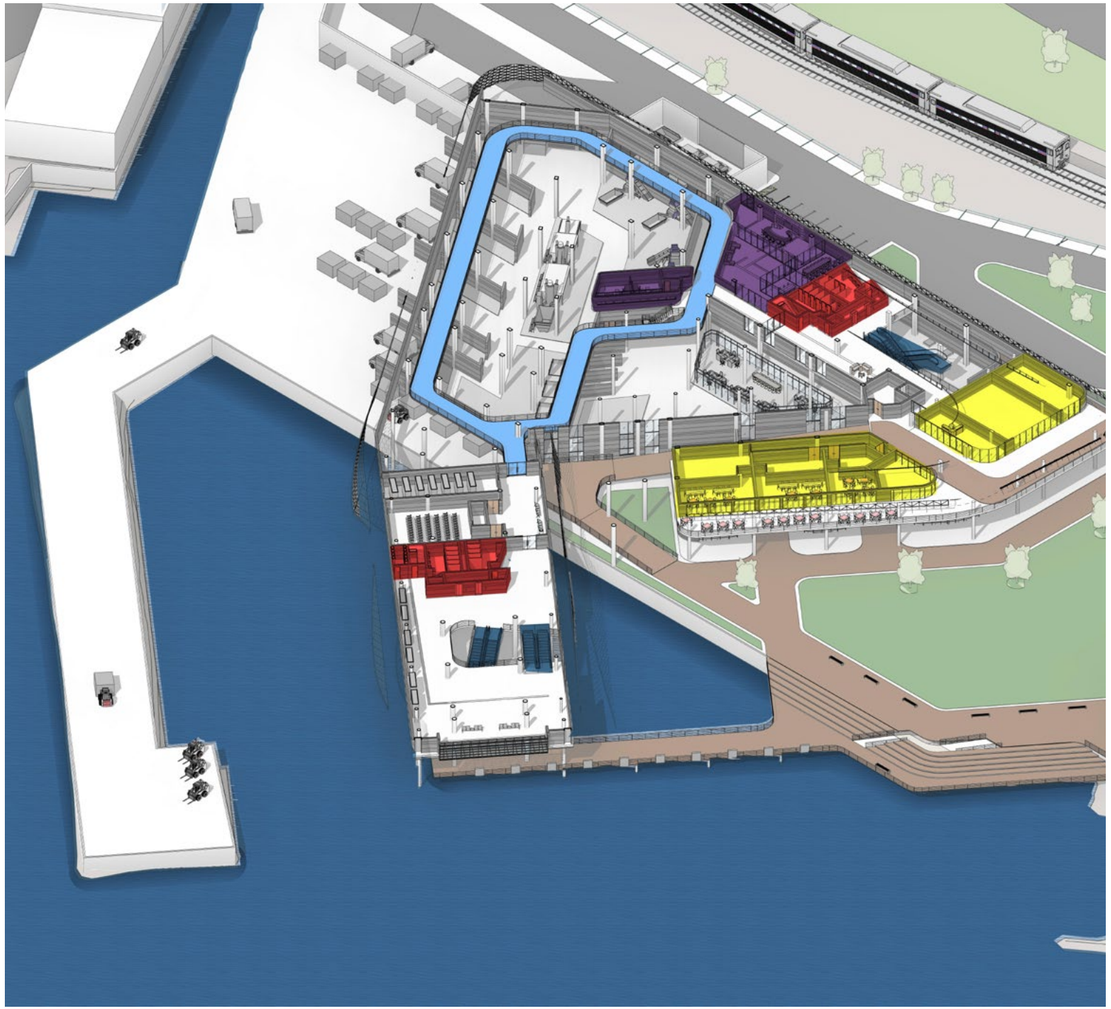
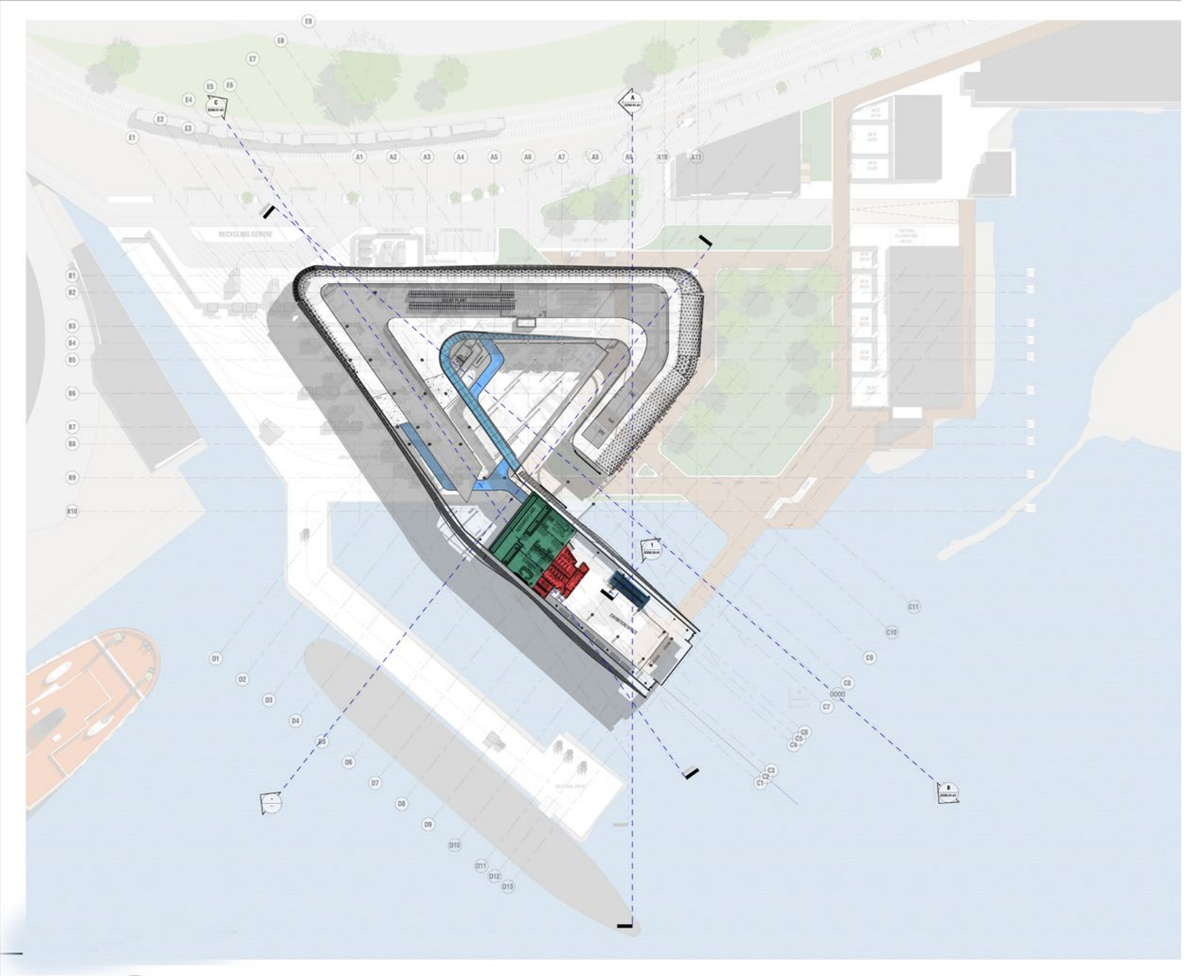


Figure 13 - 6: First Axo [Graphic]



SECOND FLOOR
NOT DRAWN TO SCALE

Figure 13 - 7: Second Floor [Graphic]

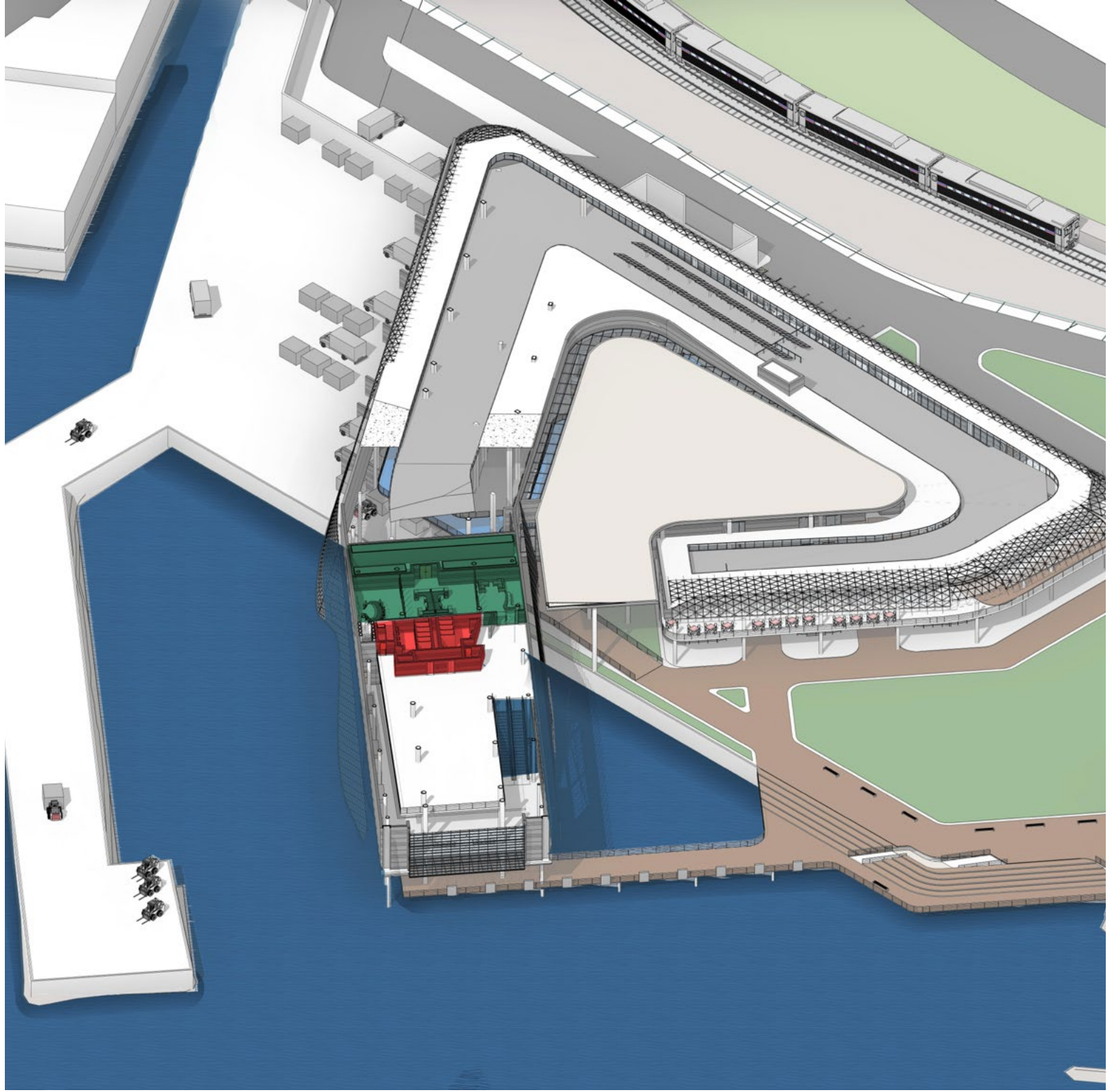


Figure 13 - 8: Second Axo [Graphic]

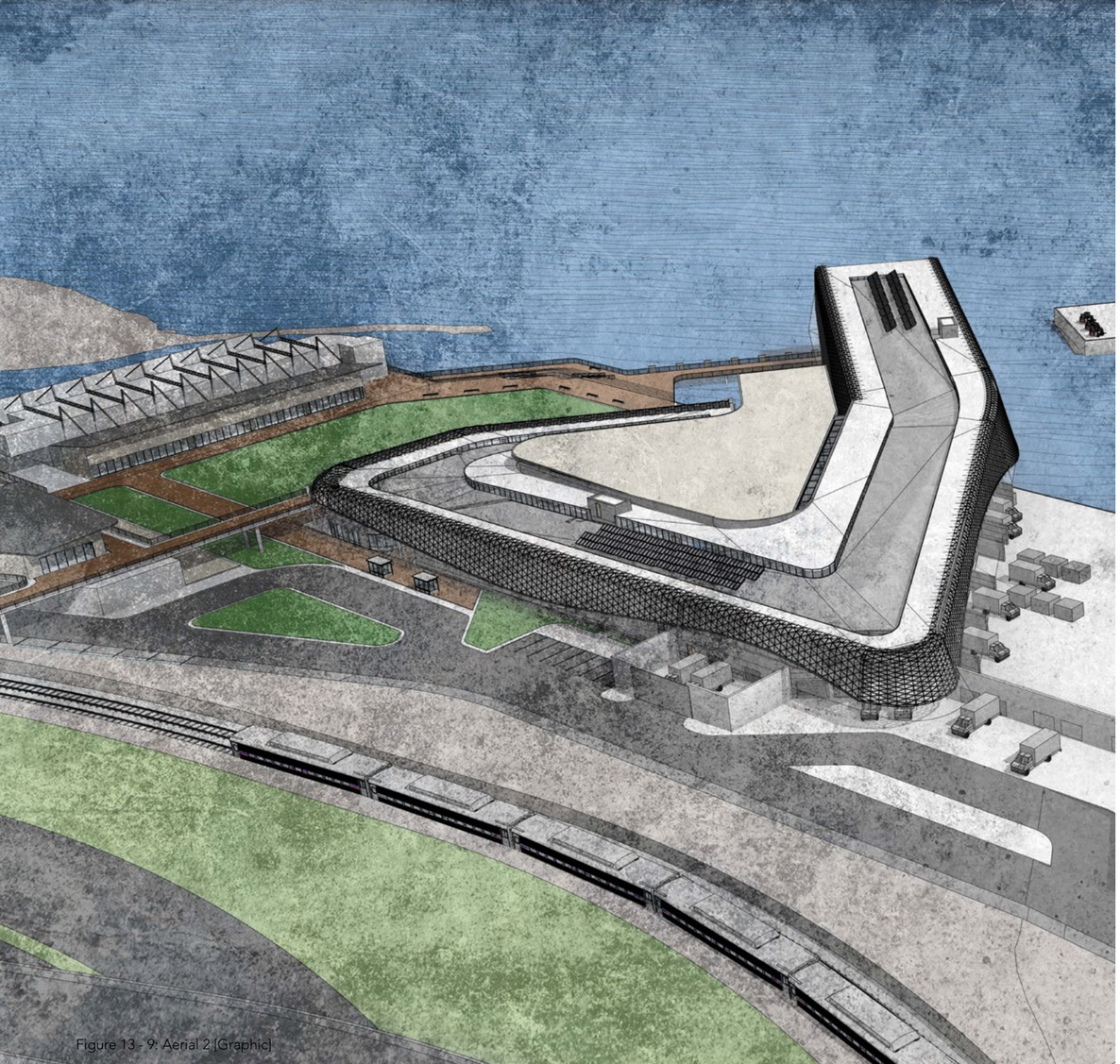
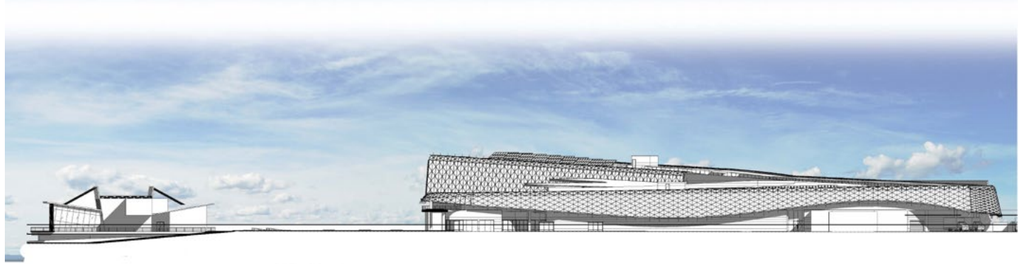


Figure 13 - 9: Aerial 2 [Graphic]



NORTH ELEVATION

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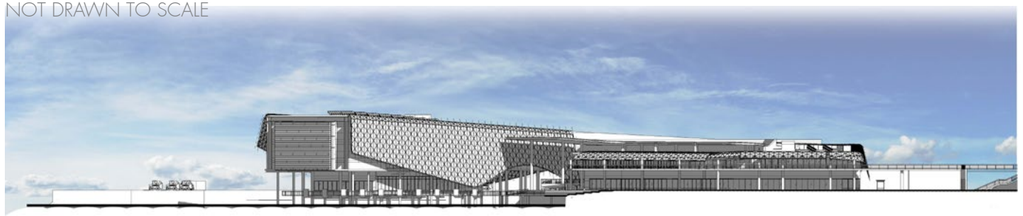

EAST ELEVATION

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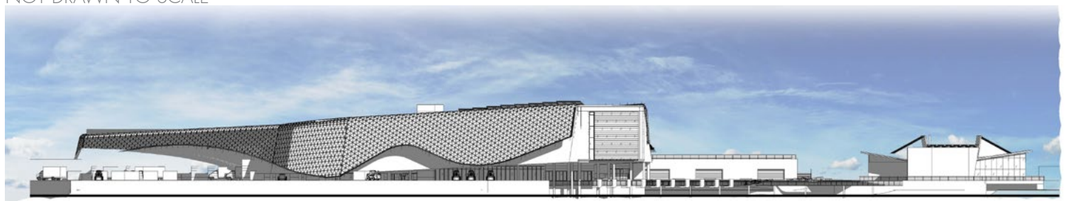

SOUTH ELEVATION

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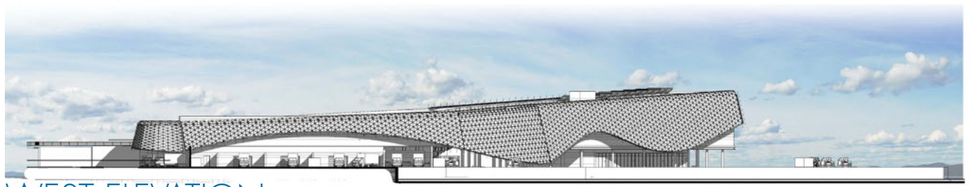

WEST ELEVATION

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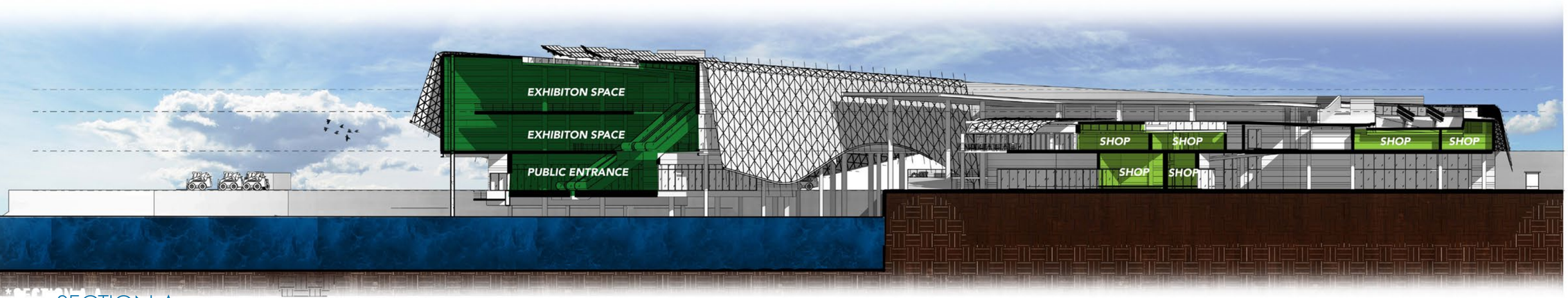
Figure 13 - 10: Elevations [Graphic]



SECTION A

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Figure 13 - 11: Section A [Graphic]



SECTION B

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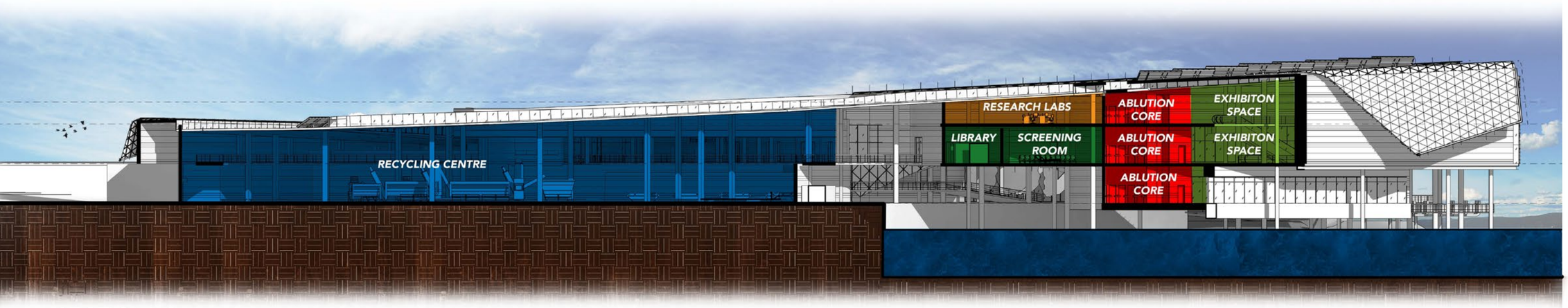
Figure 13 - 12: Section B [Graphic]



SECTION C

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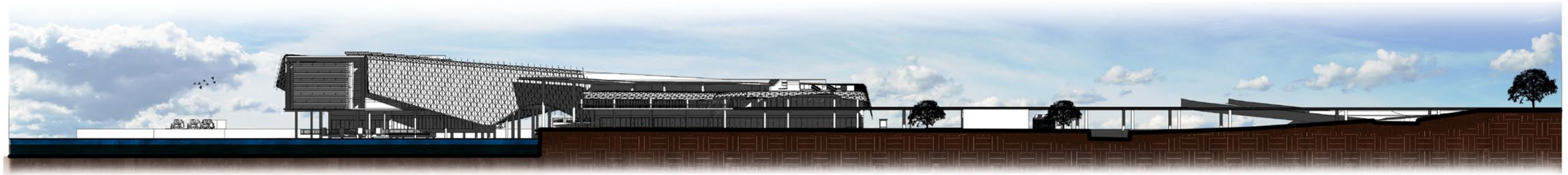
Figure 13 - 13: Section C [Graphic]



SITE SECTION

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Figure 13 - 14: Site Section[Graphic]

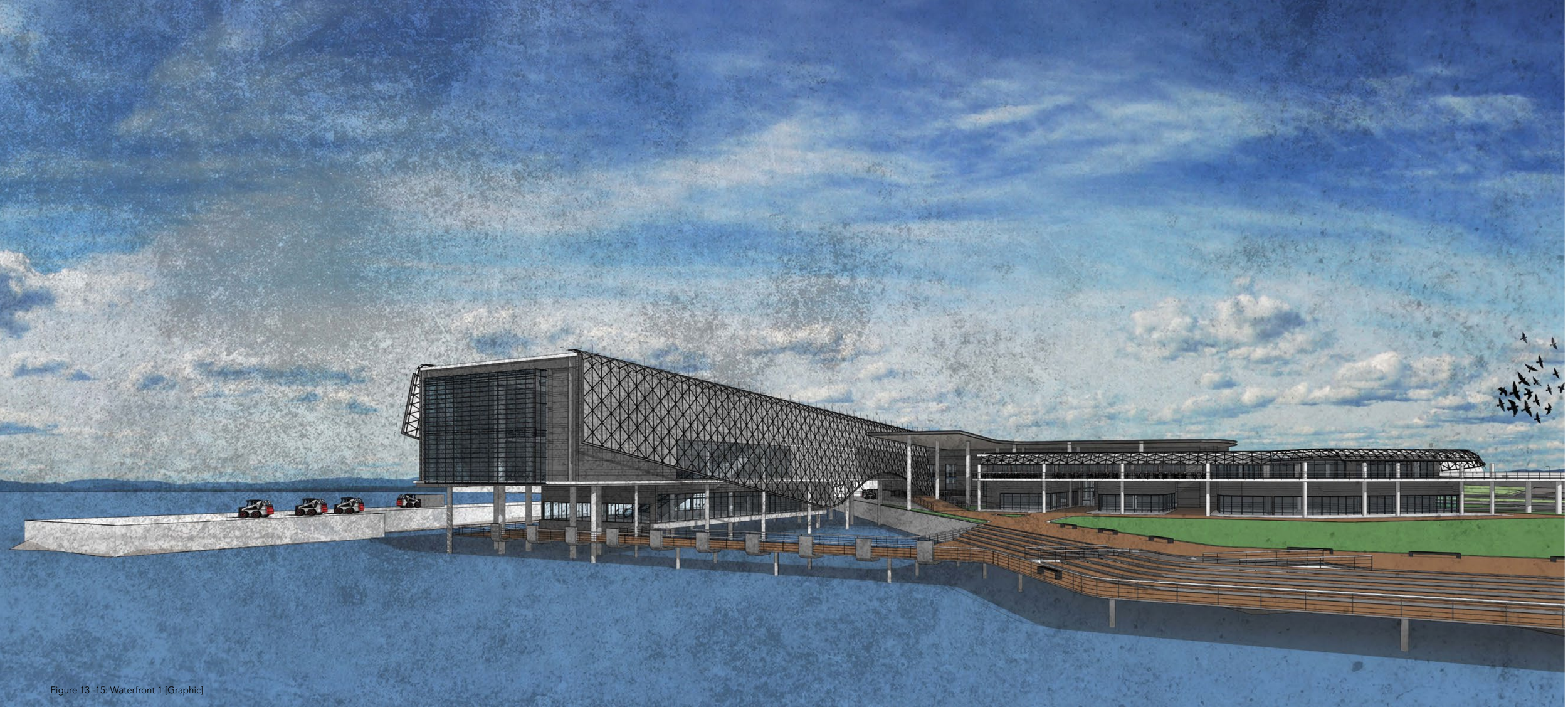

Figure 13 -15: Waterfront 1 [Graphic]

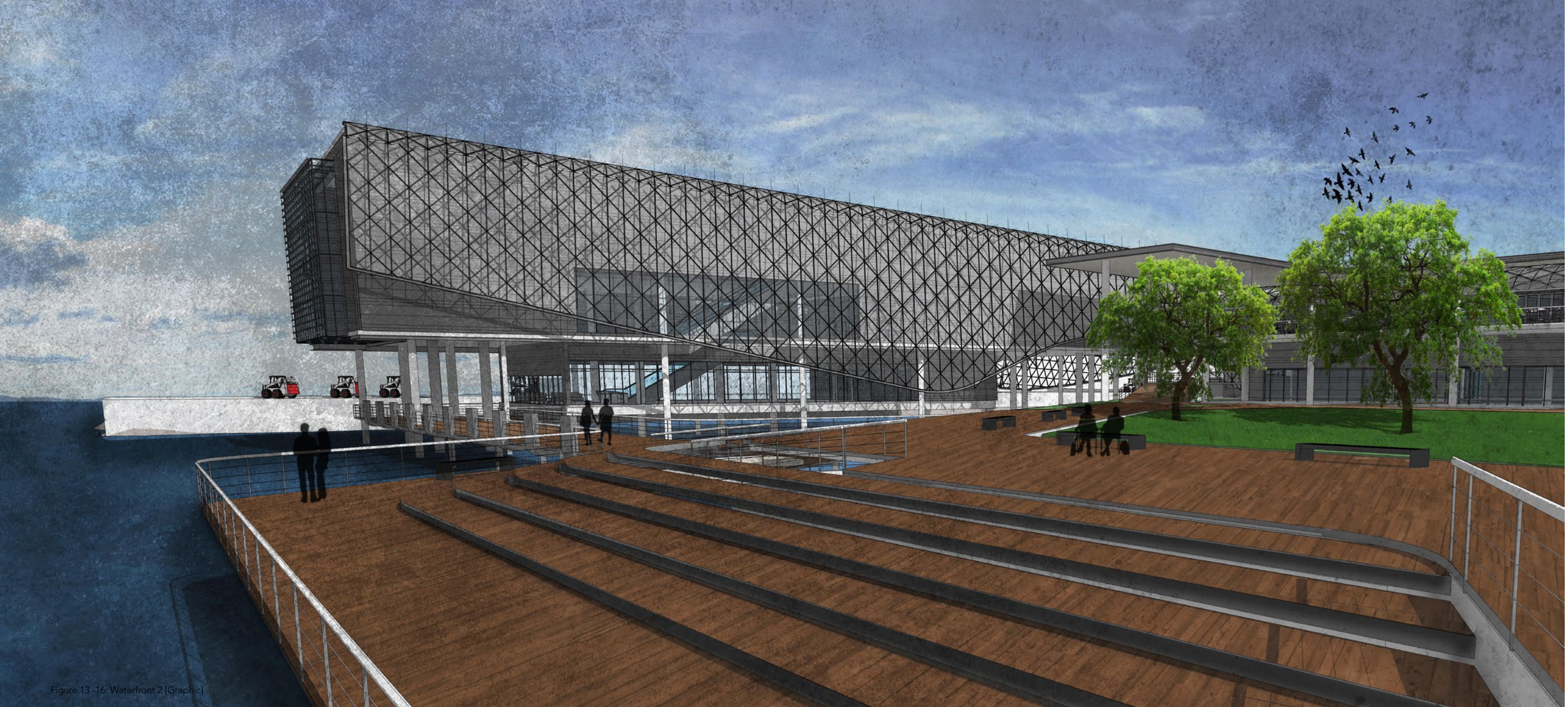

Figure 13 -16: Waterfront 2 [Graphic]

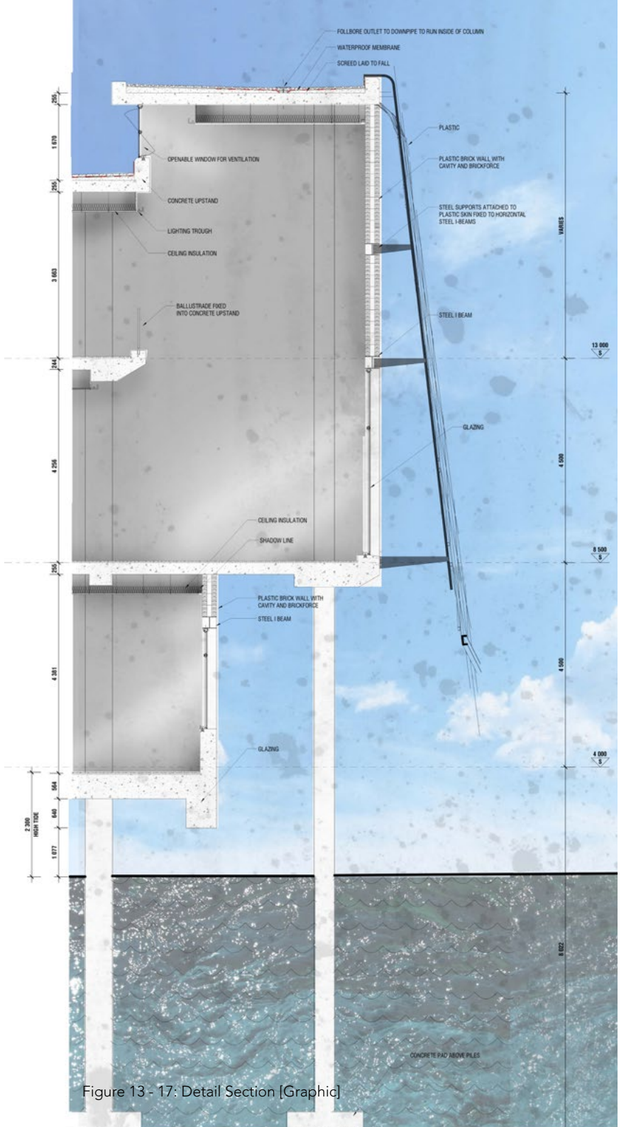

Figure 13 - 17: Detail Section [Graphic]

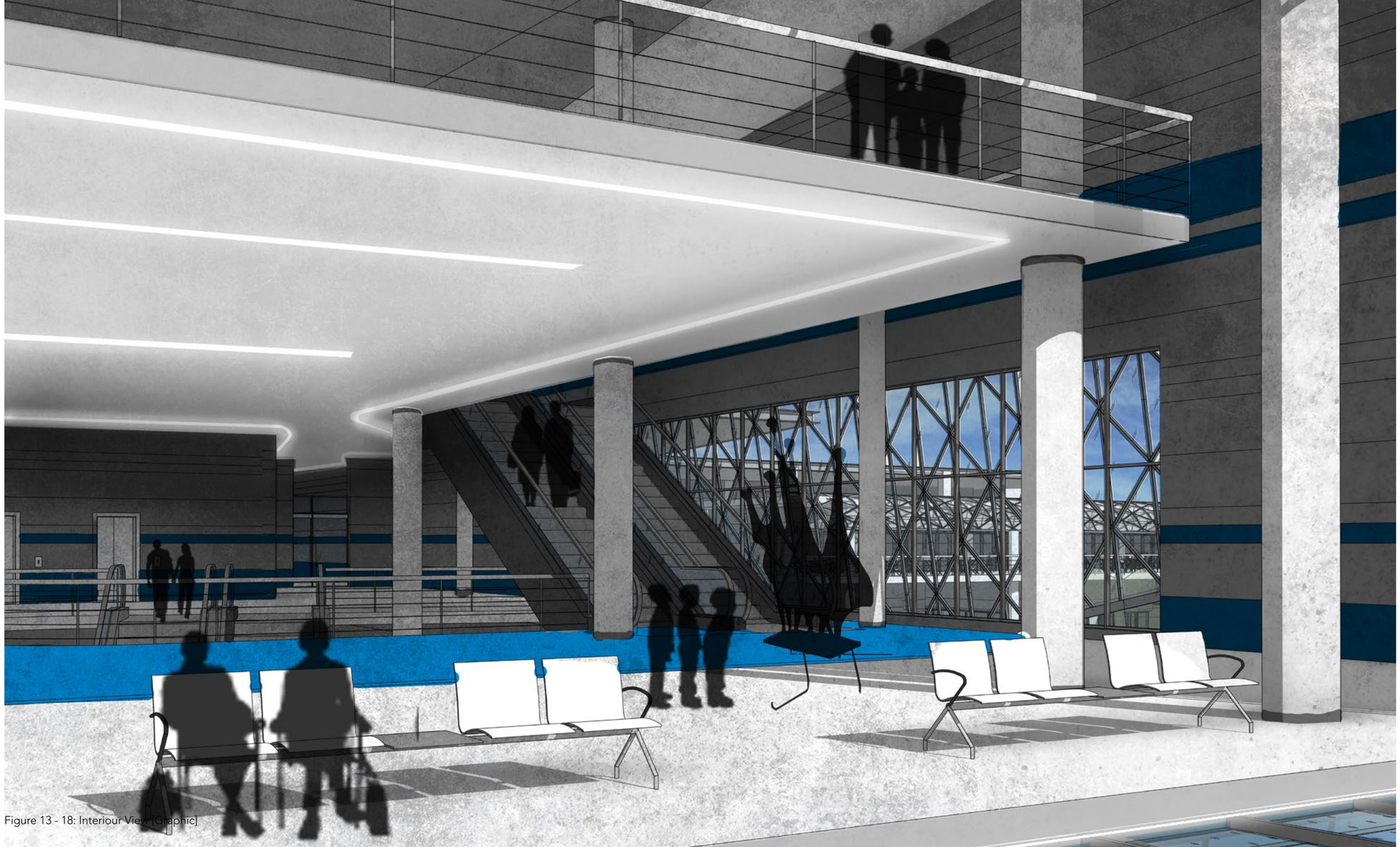

Figure 13 - 18: Interiour View [Graphic]

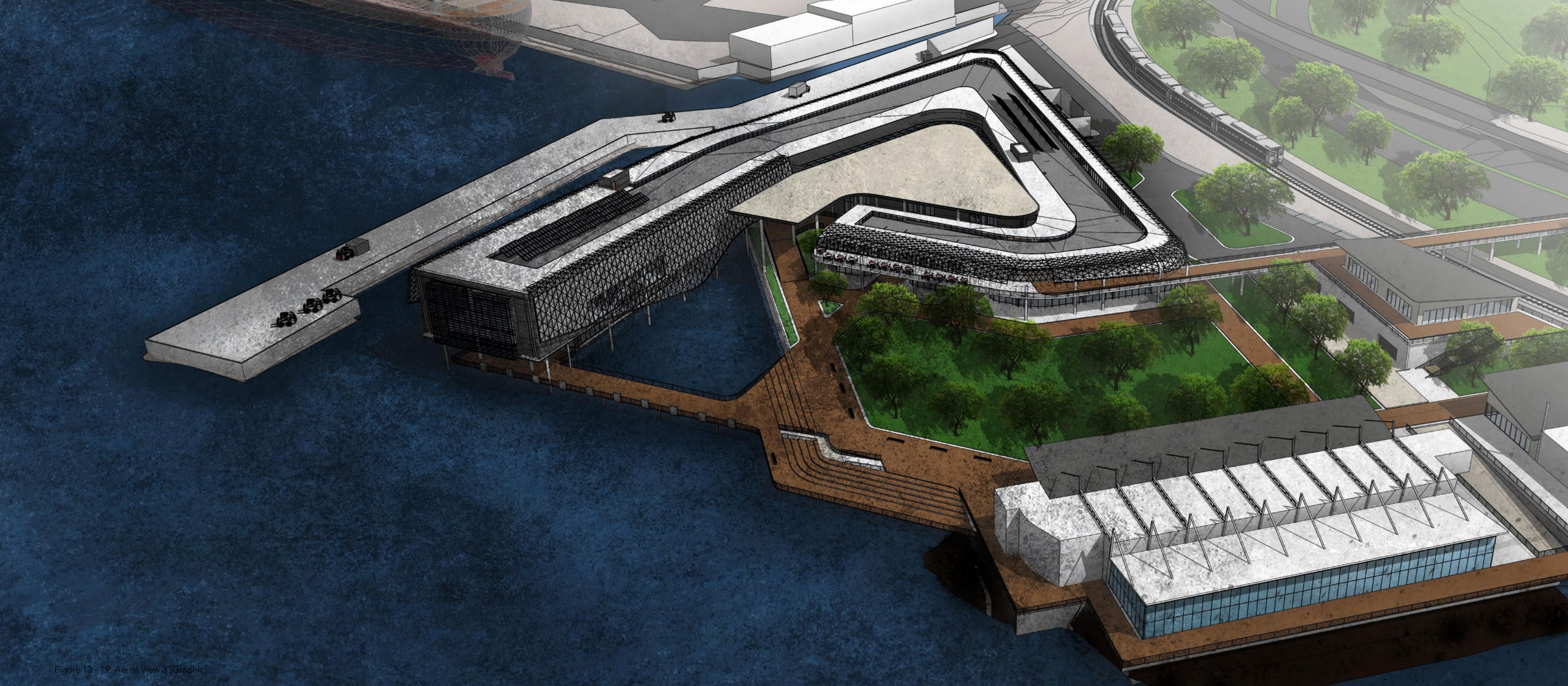

Figure 13 - 19: Aerial View 3 [Graphic]

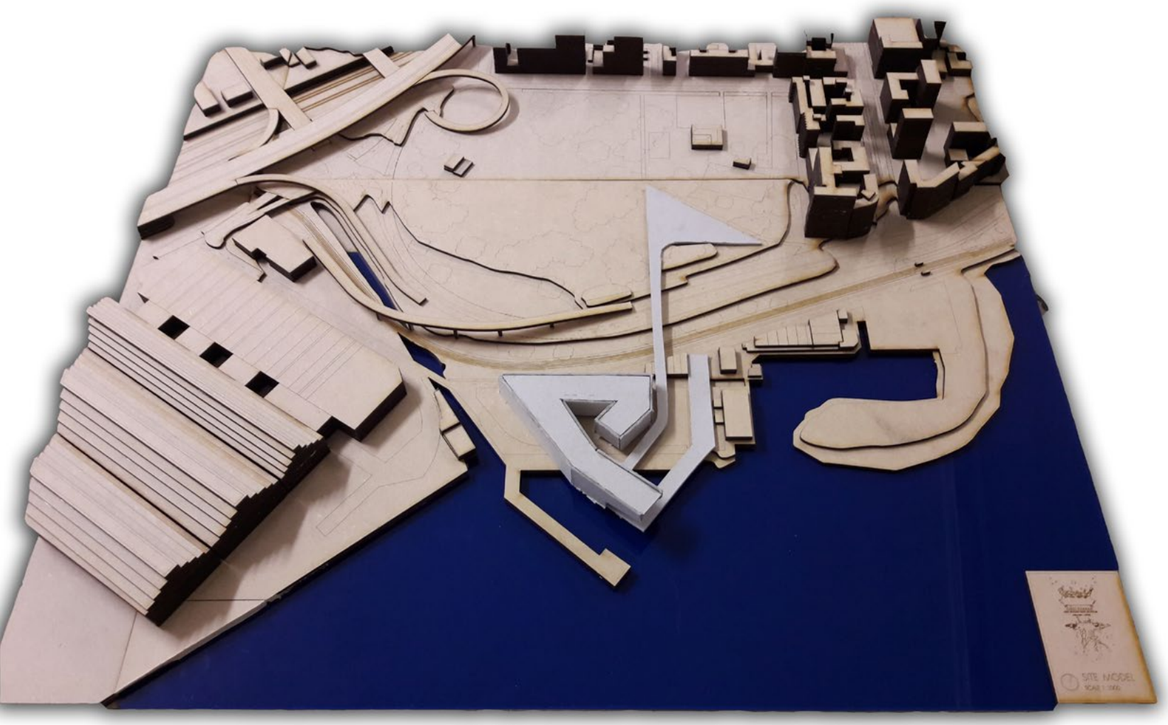

Figure 13 - 20: Site Model [Photograph]

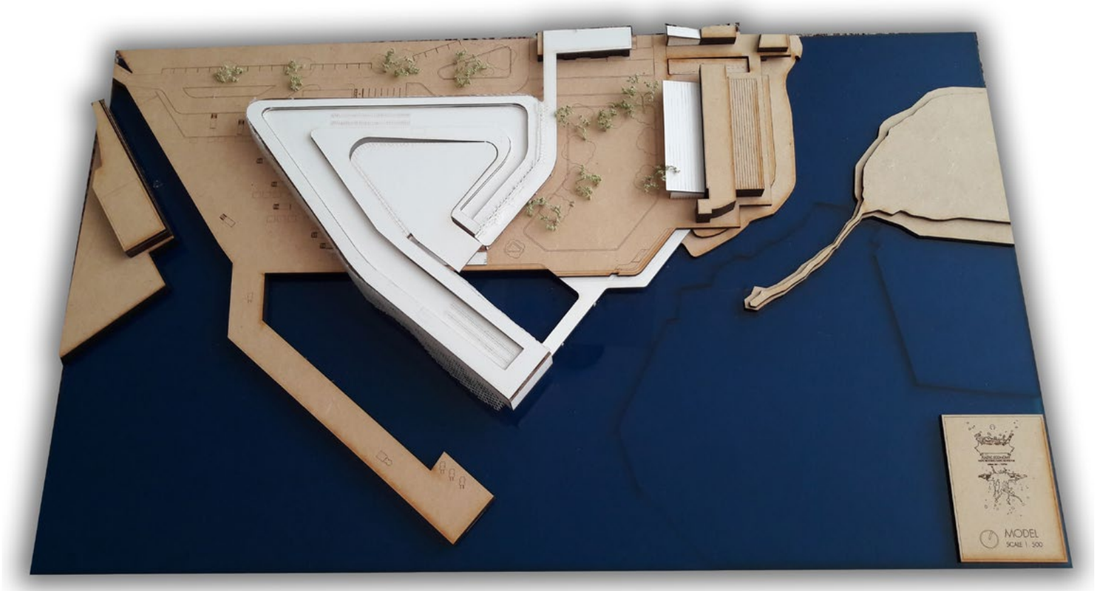

Figure 13 - 21: Model [Photograph]

REFERENCES

156 IMAGE REFERENCES

162 BIBLIOGRAPHY

Figure 14 - 1: References Image [Graphic]

LIST OF FIGURES

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Environmental issues are becoming increasingly common topics in the news and posts on social media. On social media it is common to see posts reporting on issues ranging from global warming to endangered animals and occasionally the people who are dedicating themselves to correct humanity's mistakes. One of these environmental concerns has been the increasing amount of plastics collecting in our oceans.

This issue is caused by plastic being discarded improperly and eventually finding its way into our oceans where it breaks down and causes devastating harm to sea life. This serious issue needs to be corrected before the effect become irreversible and their are a number of organisations already taking on the challenge. However the scale of this issue is simply too large, this is a global issue and it needs a global involvement in order for it to be handled and their are economic opportunities to be gained from the situation.

By using the discarded plastic as a raw material for the production of new products, the process is manipulated from one born of consumerist society to a more sustainable option that the modern world strives for. In a world striving for continuous technological advancement, what innovative processes can be utilized to take advantage of this global problem and turn it into opportunity?

This research essay will suggest how the construction of a **PLASTIC RECYCLING AND RESEARCH CENTRE** located in the city of **DURBAN** could act as a catalyst for South Africa to begin to play a serious role in tackling this global issue. Could South Africa capitalise on this opportunity and how could emerging technologies be utilized for the benefit of the country, the oceans, the global community and a sustainable future.