Jason Di Bon

2019

LIVING WITH CARBON CO_2

Re-defining spatial experiences that rejuvenate ones body, mind and soul through the biophilic integration with man transforming the industrial wasteland of Pretoria West.

Therefore restoring power to the natural environment and those who dwell within.

Living with Carbon

by

Jason Di Bon

Study Leader:
Jan Hugo

Year Co-ordinator:
Arthur Barker

Research Field:
Environmental Potential (EP)

Submitted in fulfilment of part of the
requirements for the degree
Master of Architecture (Professional)
in the Faculty of Engineering, Built Environment
and Information Technology
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2019

Figure 1: ***Pretoria West Power Station - View of Cooling Towers***
Right, (Photograph taken by Author, 2019)

PROJECT SUMMARY

Site location:
Pretoria West Power Station, Tshwane, Gauteng

GPS Co-ordinates:
25°45'3.2"S 28°08'45.9"E

Address:
Delfos Rd & Charlotte Maxeke St, Proclamation Hill, Pretoria, 0183

Site Description:
Coal power Station, which currently supplies the City of Tshwane with limited power

Program:
Core Programs: Carbon Sequestration through:
Spriulina & Biofuel Production
Supplementary Programs: Wood Craft Workshop & Exhibition Hall, Training Facilities & Nutritional Cafe

Client:
The City of Tshwane and with possible commercial investors or sponsorship

Theoretical Premise:
Biophilia, Regenerative design and Environmental psychology

Architectural Approach:
Regeneration of an existing typology, urban layering

LIFE STYLE

"...the enjoyment of scenery employs the mind without fatigue and yet exercises it, tranquilizes it and yet enlivens it; and thus, through the influence of the mind over the body, gives the effect of refreshing rest and reinvigoration to the whole system."

Frederick Law Olmsted, 1865

Figure 2: Healthy Lifestyle - 1
(Getty Images, 2017)

ABSTRACT

This Living with Carbon project seeks to deal with the global systemic risk that climate change presents to society. It threatens the basic elements of life for all people which include access to potable water, food production, health, use of land, and physical and natural resources. Inadequate attention given to addressing the effects of climate change could result in increased social consequences for human well-being, hampered economic growth and intensified large scale changes to ecological systems. As man's needs are constantly increasing, so is the demand and pressure on industry to deliver and meet man's expectations. This in turn increases the amount of CO_2 emissions that both industry and buildings generate. Investigations into the effects of greenhouse emissions, on man and nature, has resulted in a program in which architecture will respond to the distress caused by climate change. This will be done through the introduction of biophilic and sustainable design principles. These principles will be added into the solution to improve man's health, restore damaged ecosystems and rejuvenate the connection between man and nature. From the investigations, the project considered the effects within the local context of Pretoria and drew its conclusions with an applied methodology. The field of design and development was established at the Pretoria West Power Station. This was because of the Station's industrial nature. The site, as a result of its contribution to the increase in CO_2 emissions has had a profound impact on the ecology, river systems, air and water quality and social conditions within its local context.

Due to the complexities of these issues, multi-functional programs will need to be introduced. The intervention's primary building program will initiate two systems. The first is the production of Spirulina, which will be introduced as a key nutritional food source, high in protein. The second system will produce Biofuels as a clean energy source. These systems will operate as a closed loop system. The architectural program will contribute to the alleviation of both the root cause of the CO_2 emissions and the symptoms of natural degradation. The aim is to improve air and water quality, in and around the site. It will assist with the creation of jobs whilst producing nutritional food for the local community. The core focus will promote and support a paradigm shift. This shift will address a new industrialism approach, which not only is about production and energy efficiency, but will also seek to change processes, which were once harmful to the environment, to processes that rejuvenate and uplift the local community. At the same time, this will serve to improve quality of life for the local inhabitants through reconnection with nature.

Declaration

In accordance with Regulation 4(c) of the General Regulations (G.57) for dissertations and theses, I delare that this thesis, which I hereby submit for the degree Master of Architecture (Professional) at the University of Pretoria, is my own work and has not previously been submitted by me for a degree at this or any other tertiary institution.

I further state that no part of my thesis has already been, or is currently being, submitted for any such degree, diploma or other qualification.

I further declare that this thesis is substantially my own work. Where reference is made to the works of others, the extent to which that work has been used is indicated and fully acknowledged in the text and list of references.

Jason Di Bon

ACKNOWLEDGMENTS

- This dissertation is dedicated to “The Grand Master of the Universe” who has been My inspiration, My Strength and My Guide. Thank you for allowing me to be a part of your creation, giving back to You, God.

- To my pride and joy, my wife Desire, thank you for your constant support and motivation and for helping me put my visions into creations and my thoughts into actions.

- Special thanks to my parents for their continual encouragement and confidence they have in my ability to succeed. Thank you for always being there when I needed you most, for the financial support provided and for the loving, nurturing and supportive environment. Without you I would not have been able to accomplish so much.

- To Jan Hugo, my mentor and guide, thank you for your valuable insight throughout the year. Thank you for always pushing me to explore further and to push the boundaries of my thinking and approaches. The lessons learnt have been priceless and will be a firm foundation that will carry me throughout my career.

- Thanks to the Engineer, who provided me with such insight and knowledge of the Pretoria West Power Station, without this valuable expertise and knowledge I would not have fully understood the context of the site.

THANK YOU...

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CHAPTER 01

INTRODUCTION

1.1 The Degenerating and Toxic Environment

Kellert, (2016), suggested that **environmental degradation** is not caused by modern life, but rather by the failure of mankind to make informed decisions, through the course of progress. Decisions of the past should have considered the possible impacts and effects that various decisions could have on the planet. These decision makers should also have taken social and economic effects into consideration and applied a proactive rather than a reactive approach to growth. Although there has always been this unfortunate struggle in finding a balance between architecture, man and nature (Gendall, 2009), it has become important that the decisions that are made today prioritise the **well-being** of both man and nature before growth and development.

As Janine Benys, (2013), co-founder of the Biomimicry Institute, expressed that the challenge for the 21st century lies in correcting the hard lessons of overpopulation which have had catastrophic degenerative impact on our planet. Benys, (2013) goes on to say that despite the efforts of some to address these issues, it will not be enough if we also do not regenerate and revitalise our ecosystem's functions and create conditions where all of life can thrive.

The benefits of connecting with nature will depend on repeated experience and interaction. Mankind may possess an inherent inclination to affiliate with nature, but like much of what makes us human, this biological tendency needs to be nurtured and developed to become functional (Wilson 1986, Kellert 2012).

1.2 Project Intension

This dissertation's intention will seek to address the impact climate change has had on the state of well-being of man and nature, within the context of Pretoria West, by considering one of the root causes of climate change, which is high levels of CO_2 and greenhouse emissions in our atmosphere. The expectation is that the intervention will mitigate some of the impact that harmful conditions, caused by CO_2 emissions, have on man's health and the degradation of the ecology. The building programme will respond to the local and global challenges identified, to bring about transformation of a derelict industrial site, whilst promoting health and well-being.

1.3 Issues

Some 21st century challenges that overwhelm societies include global warming, depletion of natural resources, disappearance of ecosystems, lack of organic production, wasteful global consumption and increased waste lands, (Pilon, 2014). Figure 3 illustrates the availability of natural resources and, given our current usage rate, shows at which point the various natural resources will be depleted. It clearly indicates how important it is for mankind to change our destructive and selfish behaviours should we intend to continue our lives here on Earth.

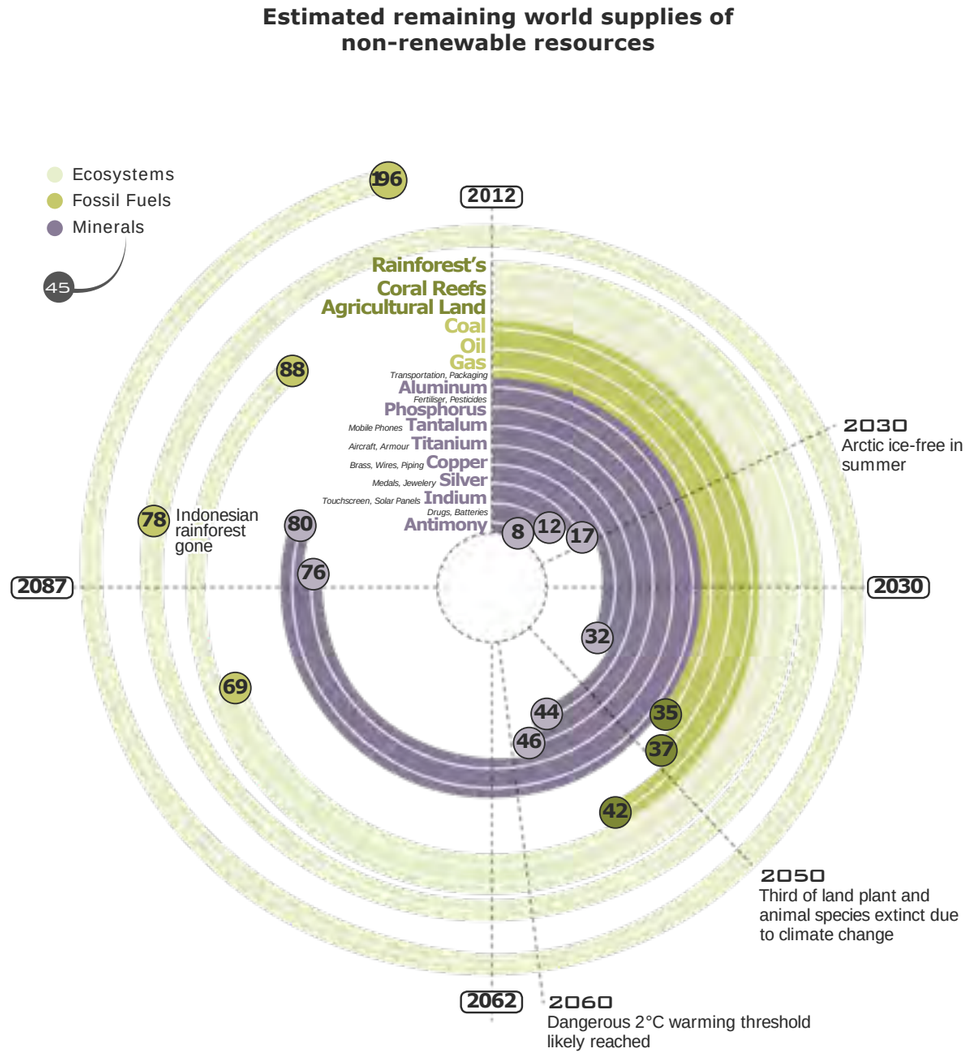


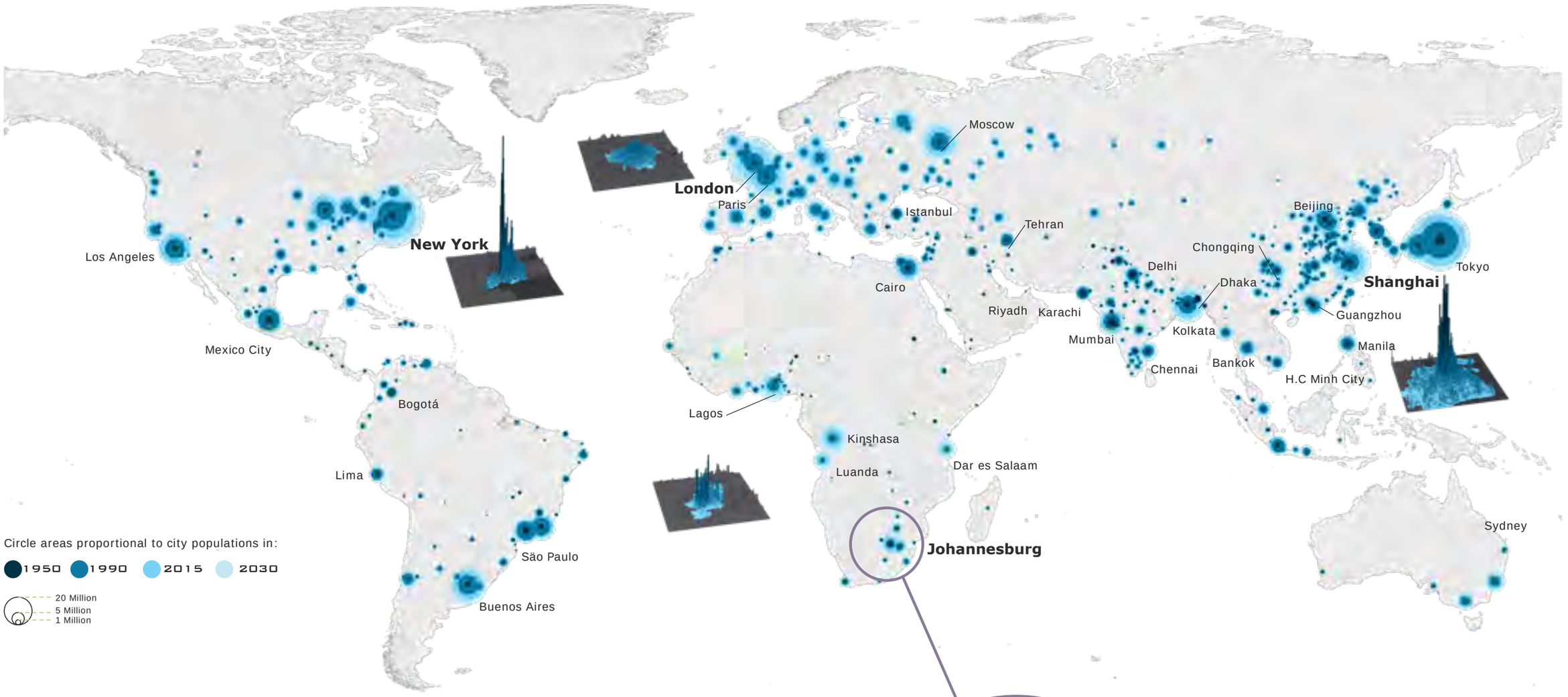
Figure 3: Estimated remaining world supplies of non-renewable resources

Source: UN TEEB, US Geological Survey, BP, Worm et al [2006], London Metal Exchange. Figures are worldwide. Living natural resources dates are worst-case based on published estimates. Minerals and fossil fuel data based on known reserves currently economical to extract, assuming fixed % increase in usage per year. No provision made for changes in demand caused by new technologies, discoveries of new resources or market forces. Agricultural land means land suitable for rain-fed cultivation net of other land usage. Thirty Year historic agricultural expansion rates are applied.

World City Populations, *1950-2030*

Figure 4: World City Populations, 1950-2030

Data: United Nations World Urbanization Prospectus 2014. Minimum city population threshold: 300k.
Cartography: D. A. Smith, CASA UCL



Impacts of Climate Change


Air


Land


Water


Wild Life

1.4 General Issue

The challenge of this thesis stems from the way man has dealt with industrialism without a care to the effects that it has had and still has on its environments. Since the onset of the 1st industrial revolution in the 1800's (Vyas, 2018), many changes to technological, socio-economical, cultural and political aspects have risen. As per Figure 4 it is evident that the population will continue to escalate at a rapid rate. The United Nations, (2019) has projected that the current world population of 8 million people will rise by an additional 2 million by the year 2050, with Southern Africa expected to nearly double its population. This will lead to extreme pressure on an already constrained environment. Our planet will become more overcrowded, while demand to consume more and

World Annual CO_2 emissions, *1751-2016*
- Measured in tonnes per year

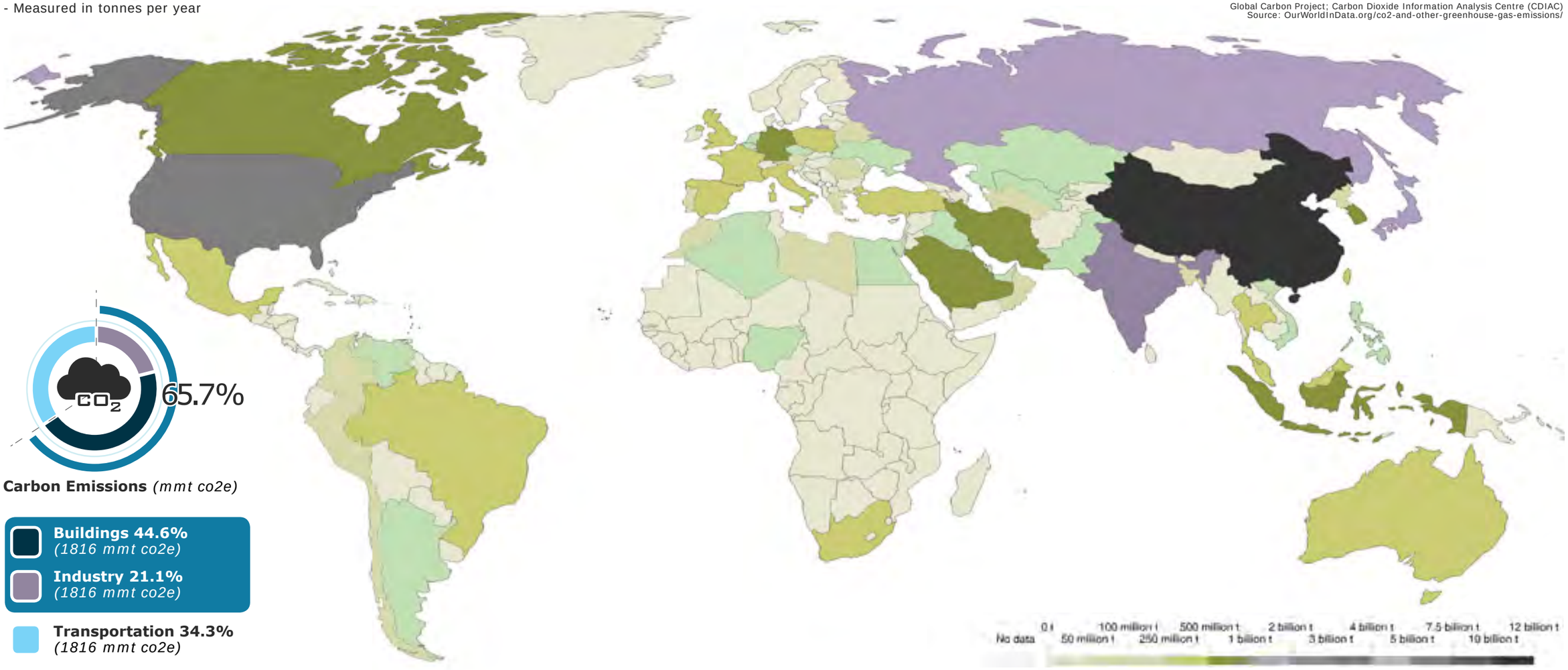


Figure 5: World annual CO_2 emissions map, 1751-2016

Global Carbon Project; Carbon Dioxide Information Analysis Centre (CDIAC)
Source: OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/

Carbon Emissions *(mmt co2e)*

Buildings 44.6%
(1816 mmt co2e)

Industry 21.1%
(1816 mmt co2e)

Transportation 34.3%
(1816 mmt co2e)

produce more will sky rocket. Figure 5 indicates that current carbon emissions, which according to The World's Research Institute, (2018), have since grown by 4.1% over the past two years. All this negatively impacts our quality of air, use of land and its natural resources, quality and availability of water and natural environments. Technology led to the use of new material, the use of new energy sources, development in transportation and design of new production methodologies such as mass production and the beginning of the assembly line. In the 19th and 20th centuries a second industrial (Vyas, 2018) revolution began which has exploited many more natural and synthetic resources. These developments have led to rapid urban expansion and growth as well as rapid formation of cities and large metropolitans.

According to Rockström, (2015), "as the human enterprise becomes more encompassing and independent the prospect of achieving human well-being is becoming more and more dim". Man continues to become the dominant force of change on the planet. He further goes on to explain that over the past 50 years "The Great Acceleration" of human pressure on the planet has intensified and can be seen through the collapse of marine fisheries, accelerated melting of ice sheets, uprising of warm ocean waters, methane release from thawing Siberian sea beds, climate volatility and extreme droughts, shifts in ecological regimes in lakes caused by nutrient runoffs from fertilizers and other sources and the collapse of tropical coral reef systems.

This carefree attitude of man over the centuries has intensified, leaving society with the challenges which they are faced with today. In the endeavour to address these challenges "An Eco-systemic approach to live better in a Better World" (Pilon, 2014) is crucial. The design of built environments must move towards a more sustainable future in order to sustain life and evade environmental collapse. James Martin warns us in "The meaning of the 21st century" (2006), that we are at an extraordinary crossroads of human history, and that the fate of Earth rests in our ability to act or in our failure to act, over the next 20 years. The fifth assessment report of Intergovernmental Panel of Climate Change (IPCC), (2014) indicates that greenhouse gases are at their highest level ever recorded. The panel also confirmed in their report in 2019, that the increased levels of greenhouse emission are predominately a result of human activity. Planetary warming has thus led to global climatic changes. These changes are evident as the average global temperature rises and average rainfall patterns change. This amount of CO_2 that each country contributes, is indicated in Figure 5 of all the CO_2 emissions, both industry and buildings contribute to 65.7% of it.

South Africa is not exempt from the effects of climate change. The Department of Environmental Affairs (2015) has observed that the rate of warming increases by 2°C per century, which is twice the rate of global temperature increases. The impact of these changes in South Africa has in recent years been experienced through extreme weather conditions. An El Nino phenomena related drought was recorded in the late 2014-2016 period, as being the worst meteorological drought since 1904. Since 2017-2018, the Western and Northern Cape, as well as Gauteng and Free State, have experienced extreme drought with most of the water supply running dry, causing extreme water restrictions, widespread crop failure, wildfires and substantial stock losses. From late 2016, intense storms along the coastal regions of KwaZulu-Natal and the Cape, have resulted in flooding and loss of lives and homes. The Gauteng region has also been hit by intense storms, mini tornadoes, high winds and large hails storms, leading to damage and loss of property. All this is as a result of climate change. (Documented by Sustainable Energy Africa, 2015).

Africa Annual CO_2 emissions, *2016*
- Measured in tonnes per year

1.5 CO_2 Emissions

South Africa is the 13th largest CO_2 contributor as per the Carbon Dioxide Information analysis Centre (CDIAC), 2016. As seen in Figure 7 South Africa is responsible for 250 to 500 million tons of CO_2 emissions. It is also the largest emitting country on the continent of Africa. Boden, (et, al. 2011) reported that the country has experienced a 7-fold increase since 1950, with 80-92% of the emissions coming from coal. In 2008, 85% of South Africa's fossil fuel CO_2 emissions (119 million metric tons of carbon), were generated from coal, 11.6% from oil consumption, and the remainder from cement manufacture and natural gases. As a direct result of climate change, it is predicted that the net effect for South Africa will be a reduction in water availability. This effect is expected to be unevenly distributed with the interior and western regions leading to more intense and prolonged periods of drought. (Department of Water Affairs, 2016)

1.6 Water Scarcity

The growing population and economic development in South Africa is placing an increasing load on the limited water resources of the country. Water plays a crucial role in the national planning initiatives, such as agriculture, mining, energy, municipal supply, tourism and recreation. As indicated by FAO Aquastat, (2016) in Figure 6, the renewal of water resources is diminishing year on year, with 2013-2017 being the lowest at 972.4m³ (per capita). This puts the country below the water stressed line of 1000m³/inhabitant/yr, and makes it more difficult to meet the growing country's demand of water. South Africa was identified as having medium to high water stress on its resources. The World Resource Institute (WRI, 2000), confirms that South Africa is one of the worlds most deprived countries with regards to water resources, with less than 500m³ of water available annually, per capita. In addition, WRI suggests that the future of the country's water projections will become scarcer and it is estimated that by 2030 there will be a gap of 17% between supply and demand. However, in 2018 the Western Cape was hit by severe water depletion, with dams running dry and residents reduced to 500Ml (mega litre) consumption per day, bringing the severity of climate change to our own back door. (Tonisi, 2018)

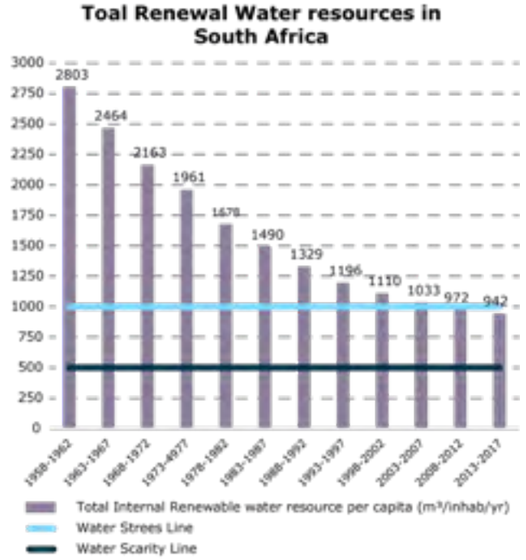


Figure 6: Total Renewal Water Resource in South Africa

(Data source:FAO2016, 2016)

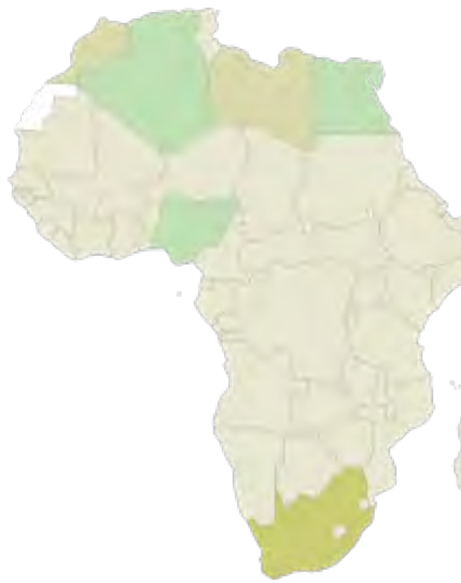
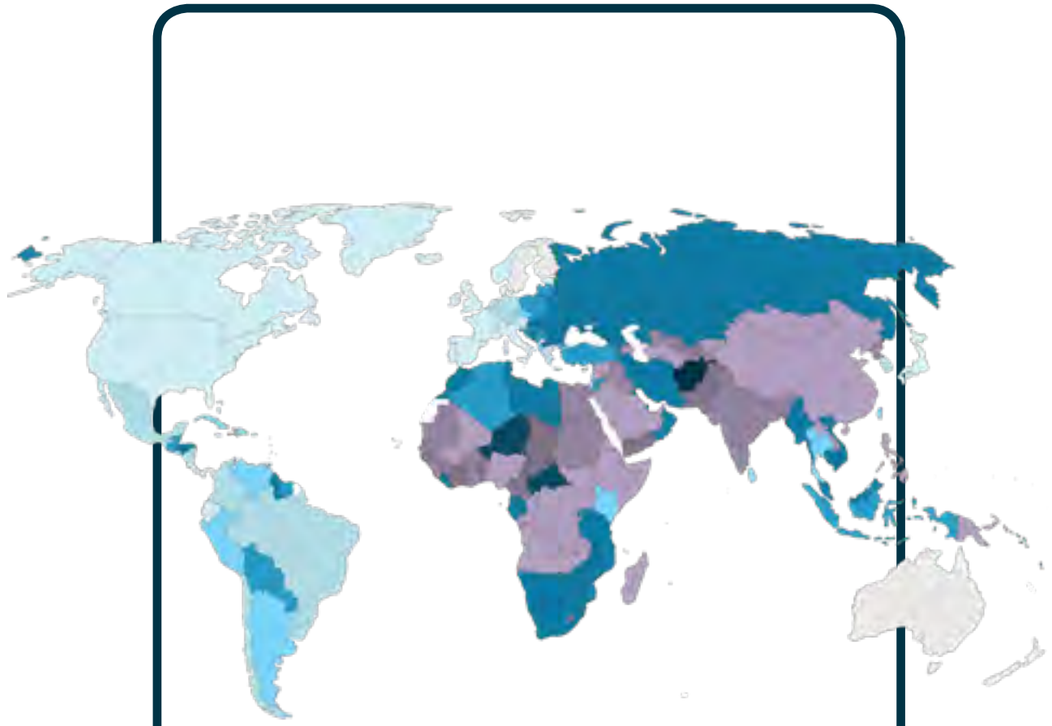


Figure 7: Africa annual CO_2 emissions map, 2016

Source: Global Carbon Project; Carbon Dioxide Information Analysis Centre (CDIAC)
OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/

Death Rate from Ambient Particulate Air Pollution, *2016*
- Measured as the number of deaths per 100 000 individuals



1.7 Deaths Related to CO_2 Emissions

The supply of electricity accounts for 42% of national Emission (Worthington, 2019). It is reported that air pollution can cause adverse health impacts (Matooane et al. 2004). A study conducted in South Africa indicated that amongst the negative impacts that CO_2 emissions have on health are: problems in respiratory health (Epidemiological) and increased lifetime cancer effects. Amongst children the impact of CO_2 has caused an increase in hypertension, ADHD, asthma (Department of Environmental Affairs 2007), mental health and mortality. The number of deaths related to CO_2 emissions is illustrated in Figure 8 above.

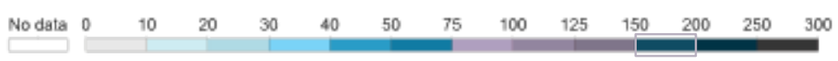


Figure 8: Death Rate caused by ambient Particulate Air Pollution

Source: HME, Global Burdeb of Disease, (OurWorldInData.orh/air-pollution, Date)

PRETORIA WEST

Figure 9: 1952 Power Station
(Photograph By Author, 2019)

1.8 Local Issue

The global symptoms spill over into the local context of Pretoria West. Pretoria West is a region which lies directly west of the Inner City of Tshwane. The area was established shortly after the first settlers arrived in Pretoria in the 1800's. Maré, (1998) This region is one of the oldest in the City of Tshwane, which was established in 1892. It was initially established as a residential suburb. The expansion to the west was an indication of the wealth of Pretoria during the 1890's, which followed on from the development of the gold rush on the Witwatersrand. By 1910 the region was still largely middle class residential, with the railway line extended to the north cutting Pretoria West in two. Industries in the 1920's and the 1930's picked up as the 1st power plant in Pretoria West was erected during 1924 and the development of the iron and steel industries bloomed in the 1930's. During 1952 a complete new power plant was built. Over the years of the period, 1950's to 2000's, the characteristics of the region changed to more of a mono-functional industrial development (predominately automotive related). Businesses, manufacture, flats and single residential areas also expanded. Much of this has been neglected and isolated from the rest of the urban fabric. So in just a few short years Pretoria West was transformed from a flourishing region and ideal living environment into one with its focus on infrastructure, including rail, energy and manufacturing. This has created a harsh and sterile environment. Like many cities, Pretoria, with its rapid growth and densification expanded in all directions from the CBD. This has led to large scale urban decay, which is attributed to its urban sprawl and decentralization. The Pretoria West Power plant has decreased its production and it has become uneconomical to run the industrial plant. (Pretoria News, 2019)

With Industrialism and the need for energy, power stations were erected on the outskirts of the city. In addition, the continued population growth and man's own desire for growth and advancement caused various other industries to take root here in Pretoria West, further contributing to the destruction of our home planet. The various issues caused in Pretoria West are listed below and represented in Figure 10 and Figure 11.

- Rivers no longer flow through the site and have been dammed up,
- Current dams are over grown with Water Hyacinth and evasive species
- Exploitation of the land,
- Mining waste left discarded,
- Increase in carbon emissions,
- Derelict buildings and unused land and buildings
- Lack of public connection,
- Site being cut off by railway line and harsh boundary lines
- Power station no longer runs at optimal capacity due to out dated technology.

The eventual decommissioning of the Pretoria West Power Station will leave behind a large disconnected urban framework. It will also result in the further decline of a site that is already under dereliction and decay. At the same time it will result in an economical gap, which once contributed significantly to the Tshwane industrial sector.

Figure 10: Site Boundaries & Issues
(By Author, 2019)

Figure 11: Site Carbon Emissions
(By Author, 2019)

Figure 12: Pretoria West Power stations Cooling Towers
(Photograph By Author, 2019)

1.9 Architectural Issue

Much of Gauteng's industrial architecture heritage has been neglected and is rapidly diminishing. This is impacted by their stigma that industrial sites are ugly and intrude on the urban landscapes, which aim to present an "aesthetically pleasing "architecture to visitors. Industrial heritage should be seen to have much more cultural value and significance, in Gauteng. According to the National Heritage Resources Act (NHRA) of 1999 the measure of cultural significance relates to; aesthetic, architectural, historical, scientific, social, spiritual, linguistic or technological value or significance. At least five of these measures relate to industrial buildings in Context to Pretoria West Power Station.

The Pretoria West Power Station is destined to be decommission in the next 2 to 5 years. Operating as a power station, it has become uneconomical, failing to even run at its full potential and capacity. (Pretoria News, 2019). To refurbish the coal fired power station will be more expensive than to build a new station. With global pressures, to do away with the coal fired power station and to generate new technology to implement and provide clean power, which is not harmful to our natural environments and our health, would mean the death of these heritage sites.

Despite the massive extent to which the Pretoria West Power Station may have added to the exploitation of raw materials and the generation of carbon emissions in South Africa in its plight to provide the region with a source of power, its existence has profoundly modified the landscape and life-styles of its community. Mc Clelland (2018), poses the question, as times change and as the business of power generation transforms to a new tomorrow, what remanence will remain, of these once prominent buildings and will the cultural value of these abandoned industrial heritage sites disappear? In Europe some of these industrial heritage sites have not been lost. In London the HQ of Apple is based at the former Battersea Power Station; at the Bankside Power Station also in London, the world renowned Tate Modern gallery has been built above the old subterranean oil tanks and in Portugal, the former Tejo Power Station has been re-purposed, as the "Museum Art, Architectural and Technology", its prime campus for EDP Foundation.

Industrial heritage is one of the best ways to reflect the contrast of the South African Landscape over the last 2 centuries. The Pretoria West Power Station has been classified as a heritage site, as its building structure and other parts are older than 60 years (SAHRA; 1994:4) It is thus important to conserve this heritage site as a new productive site which not only acts as a reminder of the damage industry has caused but as a beacon of hope to man, that indeed man can change his behaviour. In so doing he finds solutions to past mistakes and seeks new opportunities to promote health, well-being and restoration on a planet that is rapidly dying.

1.10 Research Problem

Built environments have contributed to more than 60% of the world's carbon emissions, which have far fetching effects on health, environments and community.

1.11 Project statement

The dissertation will explore the potential of architecture as a catalyst to create spatial experiences, through various programs integrating with nature, which promote healing through various stages within the healing process of body, mind and soul.

1.12 Research Question

How can architecture address the effects of climate change through the transformation of derelict industrial spaces, whilst promoting healthy living?

1.13 Sub Questions

- How can architecture deal with carbon sequestration and promote sustainable living?
- How can architecture incorporate water as a mechanism to stimulate transformation by facilitating healing of, body, mind and soul?
- How can architecture be designed to include systems that extract productive potential from the environment, whilst activating restoration of the natural environment?

1.14 Research Intention

The intention of this dissertation is to re-address how the architectural environment responds to the impact it has previously had on its environment through its contribution to climate change. It will further explore how by creating stimuli, which harness positive behaviour changes and promotes healing and restoration of both natural and human environments, we can rectify some of the harmful effects that CO_2 emissions have previously had on its environment and its users. It will explore how the application of water in design can induce activation of healing to the ecosystems, body, mind and soul, thereby addressing climate anxiety. This will be applied on multiple levels, bringing about a paradigm shift that helps us to live better and become responsible stewards of our environments.

1.15 Research Methodologies

The research methodologies will aim at generating a platform for exploration and investigation, in order to answer the thesis statement, questions and sub questions, previously posed. To address the issues and intention of this dissertation, the following research methodologies will be adopted and utilised to support the dissertation's question and develop and form an appropriate architectural response.

1.16 Theoretical Exploration

A theoretical study will be performed to gain an understanding of the causes of the issues. It will also look at identifying strategies to alleviate the problem. Literature reviews will be carried out to theoretically analyse the impact architecture design has on the environment. In collaboration with regenerative design theory and environmental psychology, this dissertation will explore the impact that the physical and built environment has on man's senses, emotional integration, interaction with community life and general well-being both physical and mental. It will also examine the overlaying benefits of using Biophilia to establish a mutually beneficial co-existence and evolution of man and natural systems, in a partnership, (Cole, 2012).These design theories will investigate sustainable principles as a basis to inform spatial quality and to form generation and responsive design. The responsive design will assist in reduction and elimination of negative influences on nature and will bring about a harmonious connection of man and nature.

1.17 Contextual Analysis

A thorough exploration and critical analysis of the existing context and urban fabric of Pretoria West will be conducted, to be able to attain a well-informed architectural resolution. The investigation will include a collection of historical aerial photographs, maps and documentation to assist in understanding changes and challenges that the built environment and ecosystems are faced with. The analysis will also include physical mapping of networks and infrastructure, as well as site visitations and observation to be able to gain a deeper insight of the influences to development within the study area.

1.18 Precedent and Case Study

An extensive comparative analysis will be discussed and used to determine fundamental architecture design principals which demonstrate:

- Responsive architecture design with the goal of realising an Eco-systemic lifestyle that restores and brings about harmony between man and nature.
- Exploration of the intrinsic and trinsic characteristics of an environment which are most beneficial to the promotion of good mental health, which has been caused through climate anxiety.

1.19 Assumptions and Delimitations

For the sake of this dissertation, the assumption is made that the Pretoria West Power Station, has been decommission and that the site will undergo rehabilitation and restoration. It will also be assumed that "The City of Tshwane", the current owners, will choose to reinvest in the upliftment and restoration of the site. Although there will be a whole master plan for the proposed site, the dissertation will only focus on the area adjacent to the previously demolished cooling tower. It will not address solutions to mental well-being, but will rather explore the opportunity to act as a catalyst through which the built environment facilitates multi-functional spaces promoting a sense of comfort, safety, connection, purpose and healing.

1.20 Limitations

The global complex issue is vast, and it will take more than just a handful of people to bring about change and restore the damage that has been inflicted on the planet. This dissertation will focus on those issues that directly impact the site selected such as dereliction, urban sprawl, decentralisation, decrease in productivity and social and economic loss.

1.21 The Site

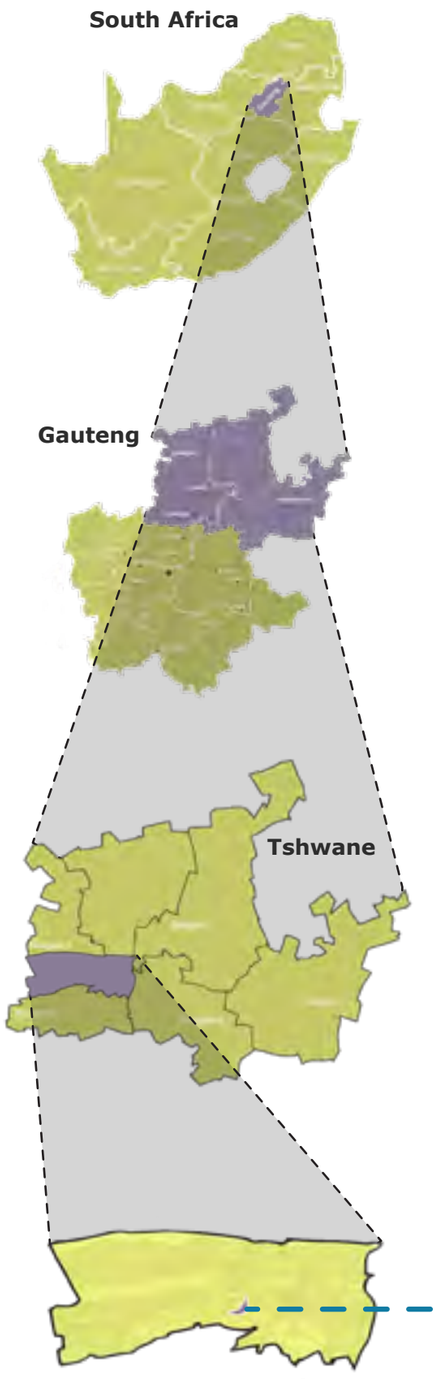
The study area of Pretoria West Power Station falls in Tshwane, the heart of the country's largest metropolitian (Stats SA, 2019). The site lies to the west of the CBD, on the outskirts of the city in the Pretoria West Region. It is bordered by the Magaliesburg mountain range to the North and the N4 highway, to the east. D.F. Malan Drive and the south is defined by the metro railway line. With its population of only 500 to 600 thousand people, of the 2.9 million (Statistics SA Census 2011) of the whole of Tshwane, the region is one of the least densely populated area of the whole metropole.

The site is characterised with its heavy to light industry. A large portion of it is focused on energy generation, steel works and the motor industry. There is, however, also a small area of low-income housing.

1.22 Conclusion

In conclusion, how can we formulate eco-systemic living, discussed above, which promotes an all-inclusive well-being. Although architecture has come a long way and interventions have slowed down the rate of degradation of our natural environments, design efficiency and performance alone are still not enough to mitigate the negative impacts of our history. Craft, (2012) reiterates the importance of going beyond reactive design and move towards a transitional regenerative design approach. Beatley and Newman (2013), support this by presenting the many benefits a Biophilic approach will contribute to the restoration and regeneration of ecosystems. This is done through the integration and reconnection of humanity's aspirations and activities with nature. The creation of this symbiotic relationship will be mutually beneficial. Keetley (2016) best describes our choice in the following words: "We have designed ourselves into this predicament, we can design ourselves out of it". Du Plessis and Brandon (2015) remind us that Einstein warned us against the trap of attempting to find solutions within the same thinking, tools and methods that got us into the predicament in the first place. The first step towards a shift in our world-view is not in changing technologies but in instilling a new mind-set which will bring about a new era of regenerative design. This regenerative design encourages harmony, co-existence and positive relationships between mankind and nature.

CONTEXT



2.1 Pretoria West, Tshwane

The background research, investigations, and current normative position, of sustainability and well-being, provided strategies to enable and establish an appropriate site, which address the issues previously mentioned. The City of Tshwane region, was identified, as it contained many of the symptoms contextualized within the global and local issues.

Fisher, & Maré, (1998), describes how the early settlers in the 1855's strategically established Pretoria, between the two river systems which provide water to the city. The Magaliesburg Mountain range lies on the Northern boundary of Pretoria, which falls within a critically endangered ecosystem, according to National Biodiversity Institute (2012).

During the period of 1930-1960 the inner CBD developed rapidly, and is continuously evolving as the need for industry and energy increases. Due to the continuous need of man the earth is exploited for it's natural resources. The extraction and processing of these raw materials results in more CO_2 being expelled into the atmosphere and contribute to climate change and climate anxiety.

From further analysis, it is evident that Pretoria West falls within an already highly sensitive ecological area. There is also a high presence of industries and mines such as Vibro Aggregate Mine, which cause huge ecological damage to a critical endangered area. Due to these factors and that the area contributes to a large amount of CO_2 emissions, Pretoria West was identified as the most appropriate location, in order to address the challenges already discussed.

Furthermore, the Pretoria West Power Station has been classified as a heritage site, (SAHRA;1994:4), and becomes important to preserve the heritage of this site. It will act as a reminder as to what effects the power station has had on the local environment. With the activation of the site to promote health and well-being, it will stand as a beacon of hope, that change is possible.

2.2 Location

Pretoria West Power Station is located within this sensitive ecological environment and has a significant historic industrial identity. The power station within the urban framework was identified as the site which would have the best potential to yield the greatest impact within its context shown in Figure 13.

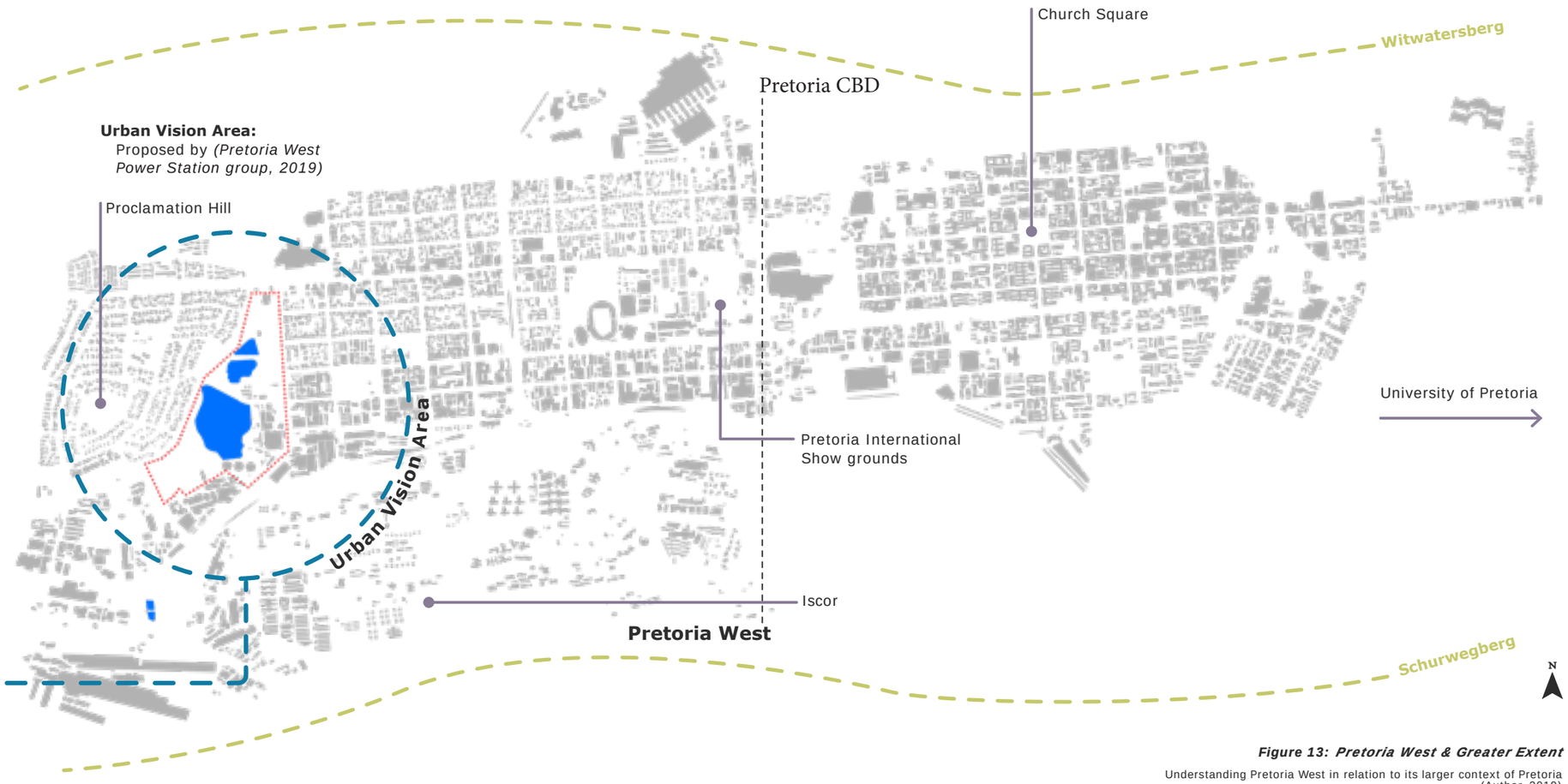


Figure 13: Pretoria West & Greater Extent

Understanding Pretoria West in relation to its larger context of Pretoria (Author, 2019)

2.3 Threatened Ecosystems

Based on the studies and data generated by the South African National Biodiversity Institute, (2012) and the Department of Environmental Affairs, (2016); Pretoria West Power Station falls within both a vulnerable and endangered ecosystem with high biodiversity importance as indicated in Figure 14. Due to the industrial nature of the site and its current projected trajectory, further damage is anticipated to this already sensitive area. The Department of Environmental Affairs, (2014) suggest that though protection of endangered ecosystems, and bringing about healthy ecosystems, this can increase resilience's to the impacts of climate change. It then becomes important to transform an area, like Pretoria West Power station, which has been at the forefront of decay of the ecosystem, by its very nature of creating air pollutants, but has an opportunity to adapt and bring about change and restoration.

Figure 14: Threatened ecosystem status

(Right) (Data Source: SANBI (South African National Biodiversity Institute)(Author, 2018)

Legend

- Critically Endangered
- Endangered
- Vulnerable
- Least Threatened

ECOLOGY

Pretoria, Tshwane

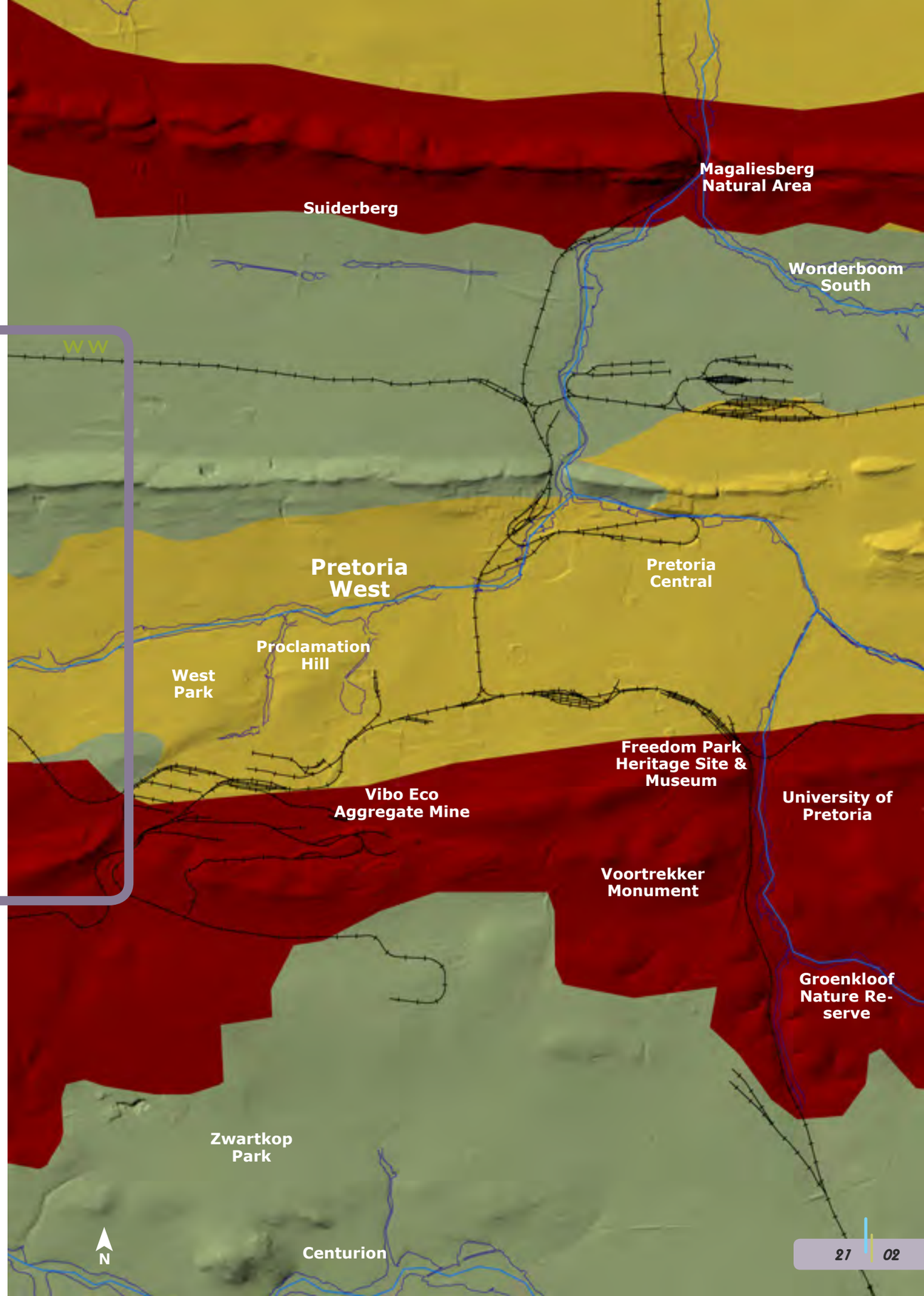


Figure 15: Pretoria West - Access & Movement

Understanding a larger movement network of Pretoria (Author, 2019)

2.4 Infrastructure

The current transport infrastructure into Pretoria West is illustrated in Figure 15. The infrastructure provides a high degree of accessibility through the public transport network. As shown above a 5min and 10min walking radius indicate the proximity and walk-ability of pedestrian access supplied by the current railway infrastructure.

There are two bus services, the Tshwane Bus Service and the A-Re-Yeng Bus Services, which have bus stops at regular intervals providing residents and workers access into the Industrial area. The two main routes follow along Mitchell and Souter street, both being one-way traffic and the second route follows along Von Hagen and Church Street and DF Malan Street. It is envisaged that these routes will be extended across and through the site, to create more accessibility into the site and to introduce connectivity of commuters with the site.

The Metro rail line extends along the southern boundary of the site, approaching from the CBD, with numerous stations, positioned along the line. The railway line provides access into the industrial area for services, industry, manufacture and residential commuters. Important linkages will also be established with the rest of the city when the proposed new Ring Rail project comes into play. The proximity of the railway to the industrial area is critical to the success of the manufacturing and industrial hub of Pretoria West.

The road system runs parallel to the current city grid, moving out from of the CBD. It provides an adequate system, allowing a thoroughfare for vehicular movement, for: taxis, individual motorist or logistic providers for industry. The infrastructure supports the CBD with its direct link to the city.

Figure 16: ***Public transportation - Rebecca Train Station***

Adequate train stations positioned across Pretoria West, providing substantial access of public transportation. (Author, 2019)

Figure 17: ***Vehicular and Pedestrian access***

Vehicular and pedestrian access, along Delfos Road. High utilization of private vehicles, while pedestrian side walks are narrow and not paved, creating spaces of discomfort. (Author, 2019)

Figure 18: ***Public transportation - Taxi & Buses***

Strong presences of taxis and buses along Delfos Road, providing transportation for workers and local inhabitants into the surrounding industrial and residential area. Along the bus route are many bus stops, providing ease of access into the area. Additionally a rapid feeder route is proposed to link into the existing bus routes of the area. (Author, 2019)

Figure 19: ***Main entry point from Charolotte Maxeke St***

Main entry point into the site, from Charlotte Maxeke Street, controlled by security. Limited access available to the site. (Author, 2019)

Figure 20: ***Old railway entry from Delfos Rd***

Old railway track and entry from Delfos Road, which has been abandoned. Not easily accessible with its high walls, overgrown vegetation, and state of dereliction. (Author, 2019)

Figure 21: ***Entry point from Quagga Rd***

Entry point from Quagga Road, is currently redundant and not used. This entrance, is barred by a gate which is situated in the vicinity of the coal bunkers, which have now been discarded and are lying to waste. (Author, 2019)

INDUSTRIAL VS RESIDENTIAL PRESENCE

Figure 22: Pretoria West - Industrial Vs Residential Presence
Understanding the impact and significance of industry on local residence of Pretoria (Author, 2019)

2.5 Proximity

The current industrial presence in and surrounding Pretoria West is shown in Figure 22. In additional it shows the juxtaposition of the industry to the residential area in Pretoria West. The proximity of the residential area to the power station, alerts society to the critical and alarming impact that the industrialism could have on the health of the local residence.

The key industries which are currently operating in this area are: metal and steel production, aggregate, asphalt and bitumen mining, energy and power production, brick manufacturer, polyurethane manufacturer, animal feed production, chemical and cleaning material manufacturing, manufacture of foam insulation, production of gas and food and beverage canning. In addition to the heavy industrial presence there is also light weight industry which includes, many used car dealerships and scrap-yards, panel beaters and various service industries.

The Pretoria West Power Station stands out as being one of the most prevalent Industrial sites, which provides the region with its power. Coal is brought onto the site through the railway infrastructure and deposited in the coal bunker. It is however destined to be decommissioned or revived within the next 2 years (City of Tshwane, 2017 and Montse, 2019). Through observation and investigation, it is evident that parts of the surrounding area are already experiencing urban dereliction. A once thriving industrial production area, as documented in archived articles, producing for both local and global requirements, is now not so prolific, (City of Tshwane Report, 2016). Some of the area is filled with low economic housing and informal settlements. Many manufacturers are struggling to survive, and are closed off by walls or fences, and they are subsequently disconnected with the street edge.

Figure 23: Aggregate mining activity

Eco Aggregate Mining, situated within the critical endangered ecosystem, as reported by the Biodiversity Institute. (Author, 2019)

Figure 24: Aggregate mining activity

Pretoria West Power Station, with its three cooling towers in the forefront, which has become part of Pretoria's West architectural features. (Author, 2019)

Figure 25: Oil Refinery - Watt Rd

RCL Foods Epol, along Staal and Watt Road. Producer of animal feed, by utilising by-products from the milling, oil and fishing industries. This is one of RCL's milling divisions. (Author, 2019)

Figure 26: 1942 Power Station (A)

Has fallen into dereliction and decay, due to insufficient funding and non-use. (Author, 2019)

Figure 27: SGB_Smit Power Malta

SGB-Smit Power Malta, along Buitenkant Street, manufactures and supplies a full range of transformers, from generator step-up to transmission and distribution transformers. (Author, 2019)

NATURAL ENVIRONMENT

***Figure 28:** Pretoria West - Natural Environment*

Understanding the natural environment of the larger context of Pretoria (Author, 2019)

2.6 Open Spaces

The Pretoria West region, has a significant amount of sensitive open spaces, as previously indicated by Figure 14 on page 21. These open spaces are represented mostly to the southern part of the south-western part of the area, shown in Figure 28 (City of Tshwane, 2005). Much of the green open spaces have been damaged. It is evident that the more our cities grow the more our natural envi-ronments suffer. If future development is uncon-trolled, it may result is further ecological damage and significant loss of non-renewable resources.

2.7 Water Systems

Water is a valuable natural resource in which we often take for granted. Climate change has impacted on our natural weather patterns, which has resulted in many droughts occurring within South Africa in the past few years, Department of Labour (2017). Within the Pretoria West region a significant water and wetland systems runs through the region, most notably the Skinner and Nooitgedag Spruit, together with their tributaries. These river systems also fall within an ecologically sensitive region.

The Pretoria West Power Station has contributed to the alteration of the river systems which runs through the region. Water for the cooling of steam is received directly from Daspoort sewerage works. The water is treated before it is pumped 4km, and is deemed to be semi refined effluent, which is safe for recreational activities, Muir, (2019). Any excess is pumped into the holding dam, which was created on the existing water system. This effects the natural flow of the river system, causing it to flow slower and run dry, negatively impacting on the biodiversity within the region.

It is important for man and nature to work together for mutual benefit in order for us to preserve our way of life here on this planet. We need to rethink the way in which we produce and consume should we wish to survive.

Figure 29: Damaged River System - Nooitgedag Spruit

Existing river system has been altered. (Author, 2019)

Figure 30: Damaged River System - Nooitgedag Spruit

Existing river system had been damaged due to portions being redirected and channeled. (Author, 2019)

Figure 31: Retention Dam - From Corner of Quagga Rd & Charlotte Maxeke St

Existing water storage supplied by Daspoort with overflow feeding back into the natural river system. Excess water held within the dam flows back into the existing river system. (Author, 2019)

Figure 32: Water Supply to Cooling Towers

Treated sewage water from Daspoort is pumped to site. After water has been used for cooling purposes in the power station it contains some impurities from ash particles. (Author, 2019)

Figure 33: Water Infrastructure - View form existing CW. Pump Room

Warm water from the turbine is pumped into the cooling towers, where the water is cooled and is sent to the condenser. The excess water is fed back into the main retention water dam. (Author, 2019)

Figure 34: Coal Storage on Site

A large area of coal has been stored on the site for a sister power plant. Nature has began to reclaim this natural resource. (Author, 2019)

LOCATION

Pretoria West Power Station

2.8 Site Context

The Pretoria Power Station forms a boundary within the urban fabric, separating adjacent communities from the CBD, with little or no access across it. The study site lies between Church St Quagga Rd, Roger Dyason Rd, the railway line and Buitenkant Street. This Urban cell, is strategically situated, as it is in close proximity of the CBD. It is advantageously placed, with a functional transport infrastructure, which links it to the CBD. From this, it would suggests that the site could be able to support the growth outward from the CBD.

Figure 35: Site Map
(Left), (Arc GIS, 2015)

Figure 36: Existing Uses in Pretoria West
(Author, 2019)

1 - Dam
2 - Cooling Towers
3 - 1937 Power station (A)
4 - 1924 Power Station (B)
5 - Bantu Residence
6 - Some plastic PTY LTD
7 - Nooitgedag River system
8 - Coal storage for sister-plant
9 - Ash ponds
10 - Power station training facilities
11 - Coal Bunker
12 - Sports facilities
13 - Quagga shopping centre
14 - Residential and Mixed-use
15 - City Park
16 - SGB-Smit Power Matla
17 - Police Training Facility
18 - Iscor Industrial Park
19 - Residential (proclamation Hill)
20 - Frederick Theron Park
21 - Golf Course

2.9 Site History

The original Pretoria West Power Plant was first built in 1924 (Masut, 2019). With the increasing capacity requirement of power, it became necessary to erect a new plant, in 1952.

The original cooling tower was demolished due to its poor structural integrity. The new power station was erected alongside the old station as it would have been too expensive to demolish the old buildings. Some of the old buildings were left to stand vacant, leaving the building in disrepair and a state of dereliction.

The power station is still operational, today, although at one stage it was temporarily decommissioned and put back online when the Eskom crisis in 2007 occurred, as Eskom was unable to delivery power. It is currently running, but at a reduced capacity and efficiency. The plant and its surrounding land are currently owned by the Tshwane Electricity Department. The plant with its outdated technology and the high costs of repair and maintenance has now become financially non-viable to operate (City of Tshwane, 2017). It will be more cost efficient to build a new plant than to refit the old plant with modern power generating technology, which is able to emit less pollutants and greenhouse gases (Masut, 2019).

It is the intention of the City of Tshwane to decommission the entire plant, leaving the plant to suffer the same fate as the original plant built in 1924 (Masut, 2019) did. It will take all stakeholders of Pretoria West to join forces and together find creative interventions that will preserve and regenerate this industrial heritage site.

Figure 37: Aerial Photograph of Pretoria West (2015)
Right, (Arc GIS, 2015)

Figure 38: Aerial Photograph of Pretoria West (1948)
Left, (Van Der Waal, 1948)

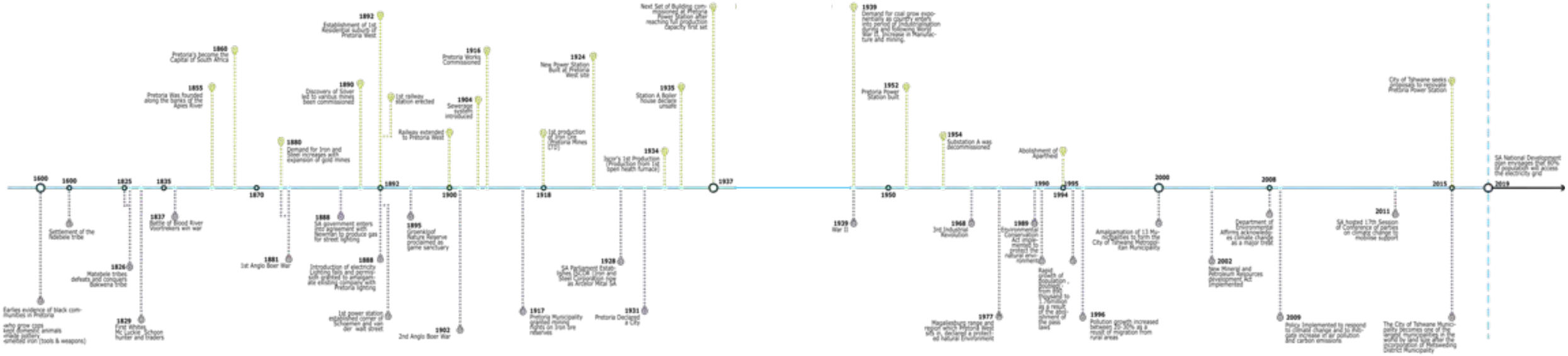


Figure 39: ***Historic Time-line of Pretoria West***
(Author, 2019)

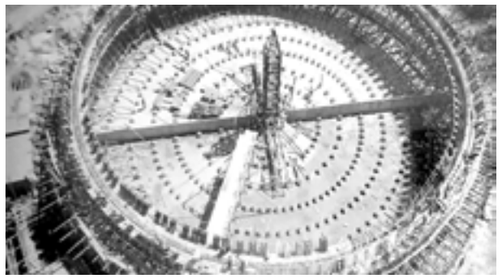


Figure 40: ***Construction of Cooling Tower***
(Unknown, 1924)

Figure 41: ***Completion of Cooling Tower***
(Unknown, 1998)

Figure 44: ***Demolition of Cooling Tower***

This Cooling Tower was demolished due to its poor structural integrity which was too dangerous to leave standing due to the risk of collapsing. (Unknown, 2000)

Figure 45: ***Current State of Cooling Tower***

Currently the cooling towers are still functioning, however only one is in operation due to the power station not functioning at its full capacity. This is due to outdated technology and lack of staff. (Author, 2019)

Figure 42: ***Retention Dam***
(Unknown, 1932)

Figure 43: ***Retention Dam***
(Unknown, 2004)

Figure 46: ***Retention Dam***

This water storage dam has been invaded by a parasitic plant known as a Hyacinth Plant which consumes much of the oxygen and sunlight entering the water body thus killing off the aquatic life. (Author, 21 February 2019)

Figure 47: ***Retention Dam***

It is evident how fast growing the invasive plant species is. It has now reached the point where the dam is fully covered by this plant resulting in the loss of a beautiful water view as well as damage to the aquatic life within. (Author, 8 April 2019)

MAPPING

Pretoria West Land Uses, *2019*

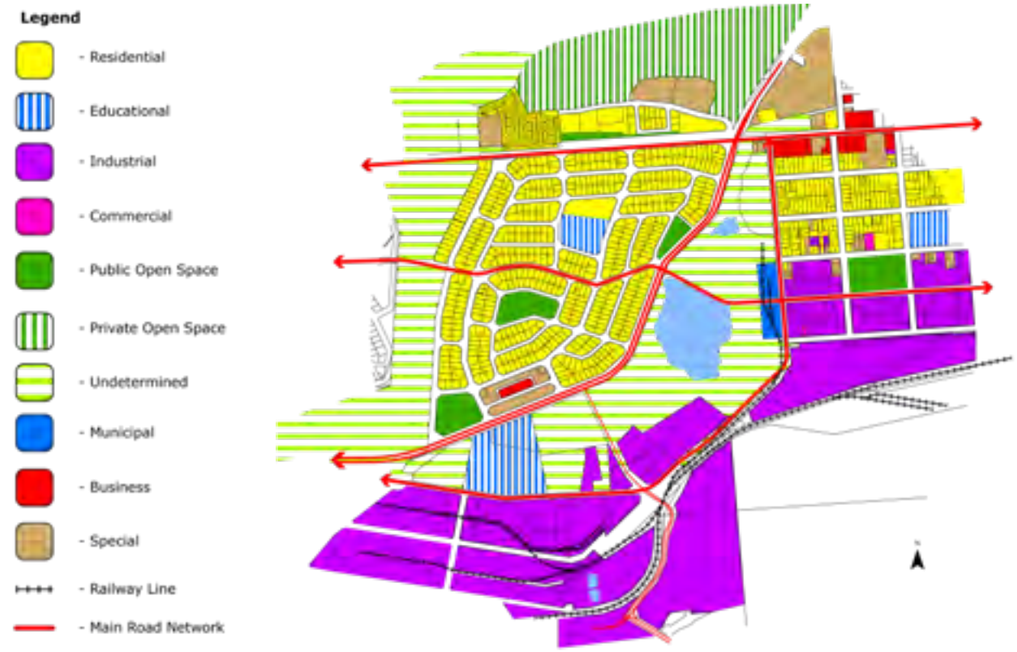


Figure 48: Pretoria West - Land Use
(Author, 2019)

Pretoria West Green Systems, *2019*

Figure 50: 1952 Power Station (Left)
(Photograph taken by Author, 2019)

Figure 49: Pretoria West - Green Systems
(Author, 2019)

BUILDING TYPOLOGIES

Existing typologies, are mostly low density, single storey buildings, with an occasional high rise mix-use typology, with a maximum of four stories. Most of the building typologies on the front edge, have wide walkways on the street edge, while the buildings share yard space on the back side of the buildings. The typologies range from medium income housing to small retail typologies.

Typology 1
- View from Buitenkant St

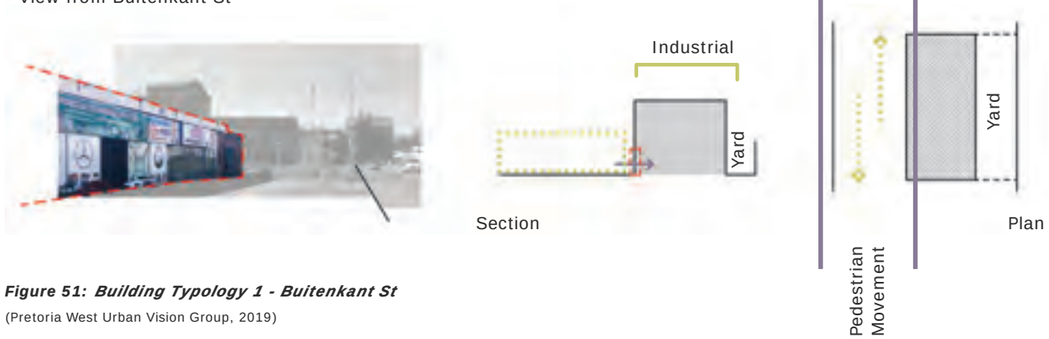


Figure 51: Building Typology 1 - Buitenkant St
(Pretoria West Urban Vision Group, 2019)

Typology 2
- View from Charlotte Maxeke St

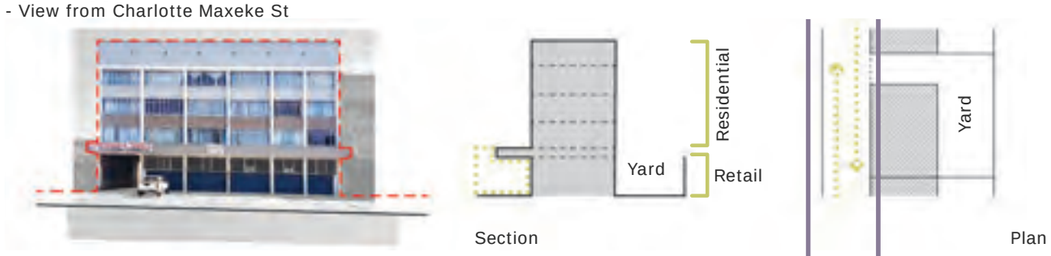


Figure 52: Building Typology 2 - Charlotte Maxeke St
(Pretoria West Urban Vision Group, 2019)

Typology 3
- View from Nikkel St

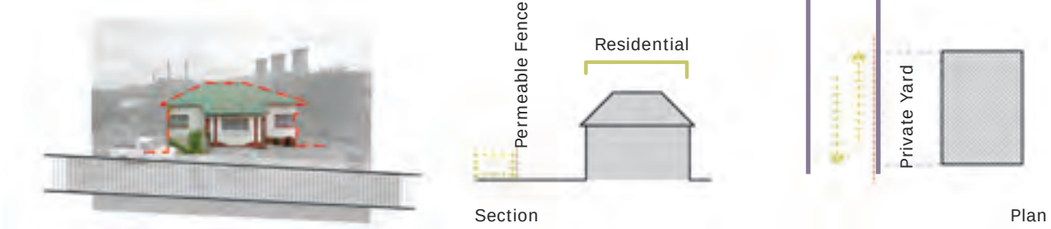


Figure 53: Building Typology 3 - Nikkel St
(Pretoria West Urban Vision Group, 2019)

Typology 4
- View from Charlotte Maxeke St

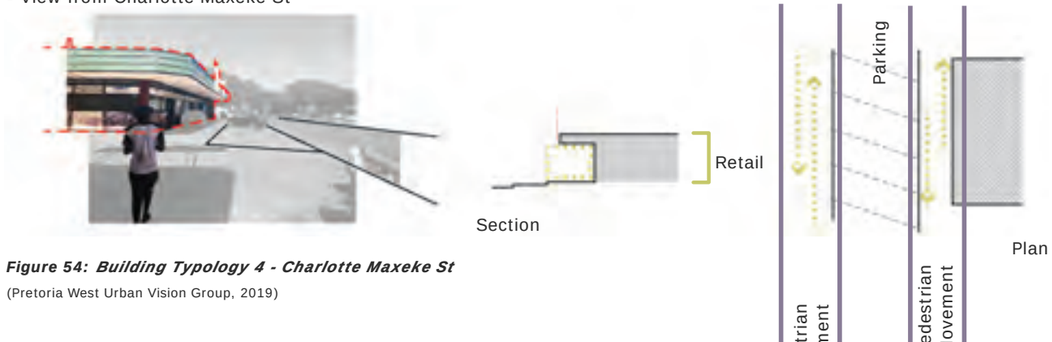


Figure 54: Building Typology 4 - Charlotte Maxeke St
(Pretoria West Urban Vision Group, 2019)

Typology 5
- View from Quagga Rd

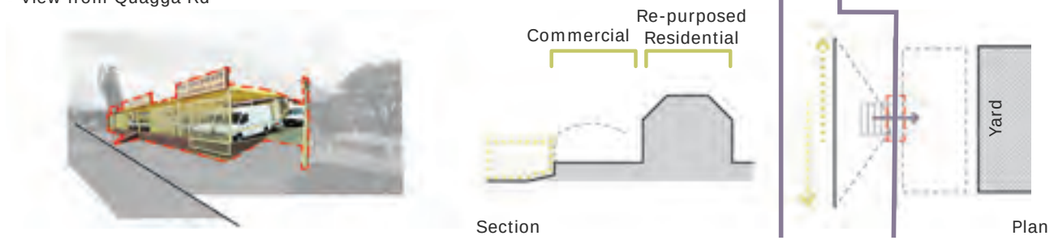


Figure 55: Building Typology 5 - Quagga Rd
(Pretoria West Urban Vision Group, 2019)

STREET TYPOLOGIES

The street typologies indicate which streets are high vehicular and pedestrian movement areas. They also indicate the comfort or discomfort the user / passer-byers will experience in terms of the amount of shading available which will impact in thermal comfort. In addition they also indicates the boundary conditions of the various street edges, whether they are soft and open or harsh and closed off. This all impacts on the users experience within each of theses various different conditions. In order to promote more activity and comfort it is important for the Urban Vision to address these edges which in term would lead to a far more successful project intervention as it would better relate to it's surroundings.

Figure 56: ***Street Typology Views Key Plan***
(Pretoria West Urban Vision Group, 2019)

1

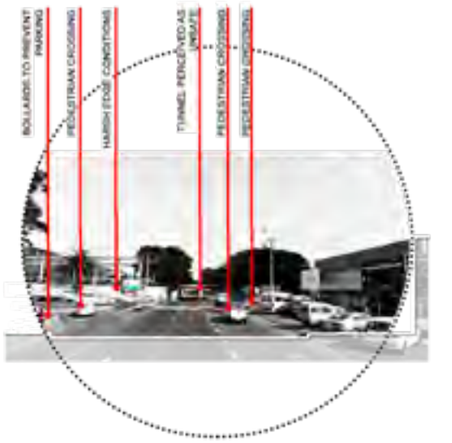


Figure 57: ***Street Typology - Charlotte Maxeke St - View West***
(Pretoria West Urban Vision Group, 2019)

2

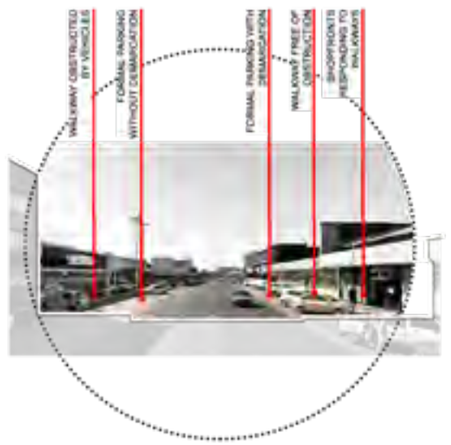


Figure 58: ***Street Typology - Charlotte Maxeke St - View East***
(Pretoria West Urban Vision Group, 2019)

3

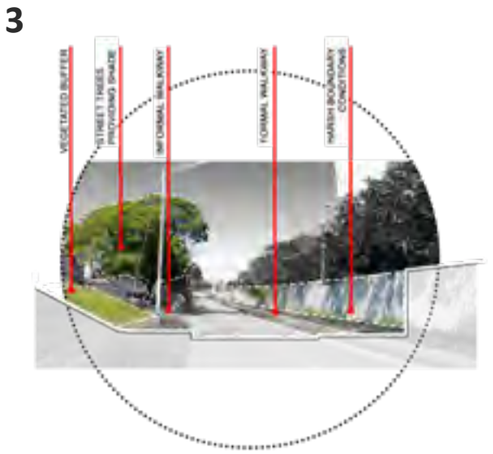


Figure 59: ***Street Typology - Delfos Rd - View South***
(Pretoria West Urban Vision Group, 2019)

4

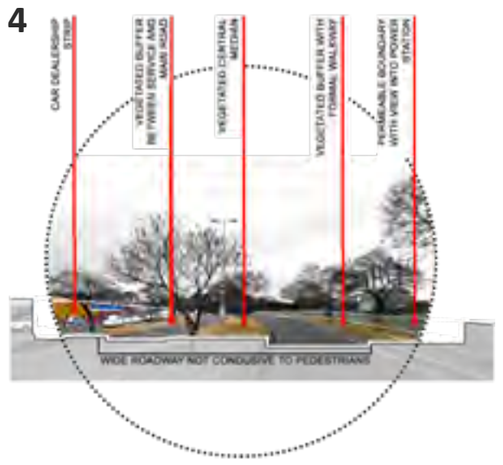


Figure 60: ***Street Typology - Quagga Rd - View North***
(Pretoria West Urban Vision Group, 2019)

5

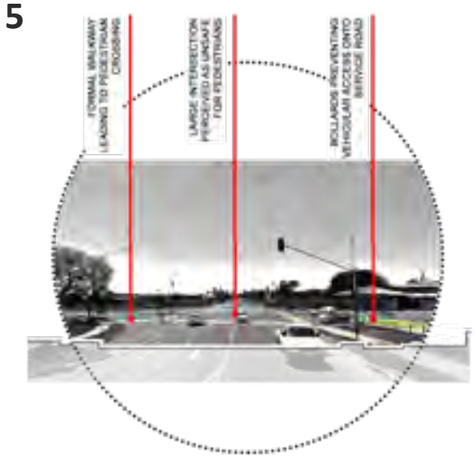


Figure 61: ***Street Typology - Church St - View East***
(Pretoria West Urban Vision Group, 2019)

6

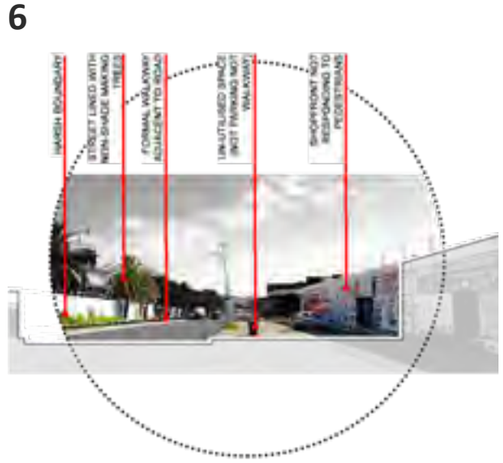


Figure 62: ***Street Typology - Buitenkant St - View North***
(Pretoria West Urban Vision Group, 2019)

VISION STATEMENT

The vision for Pretoria West is not to become a post-industrial landscape, but rather for the industrial area to be altered in such a way as transform the landscape to promote an eco-systemic lifestyle aligning man's ideals with that of nature.

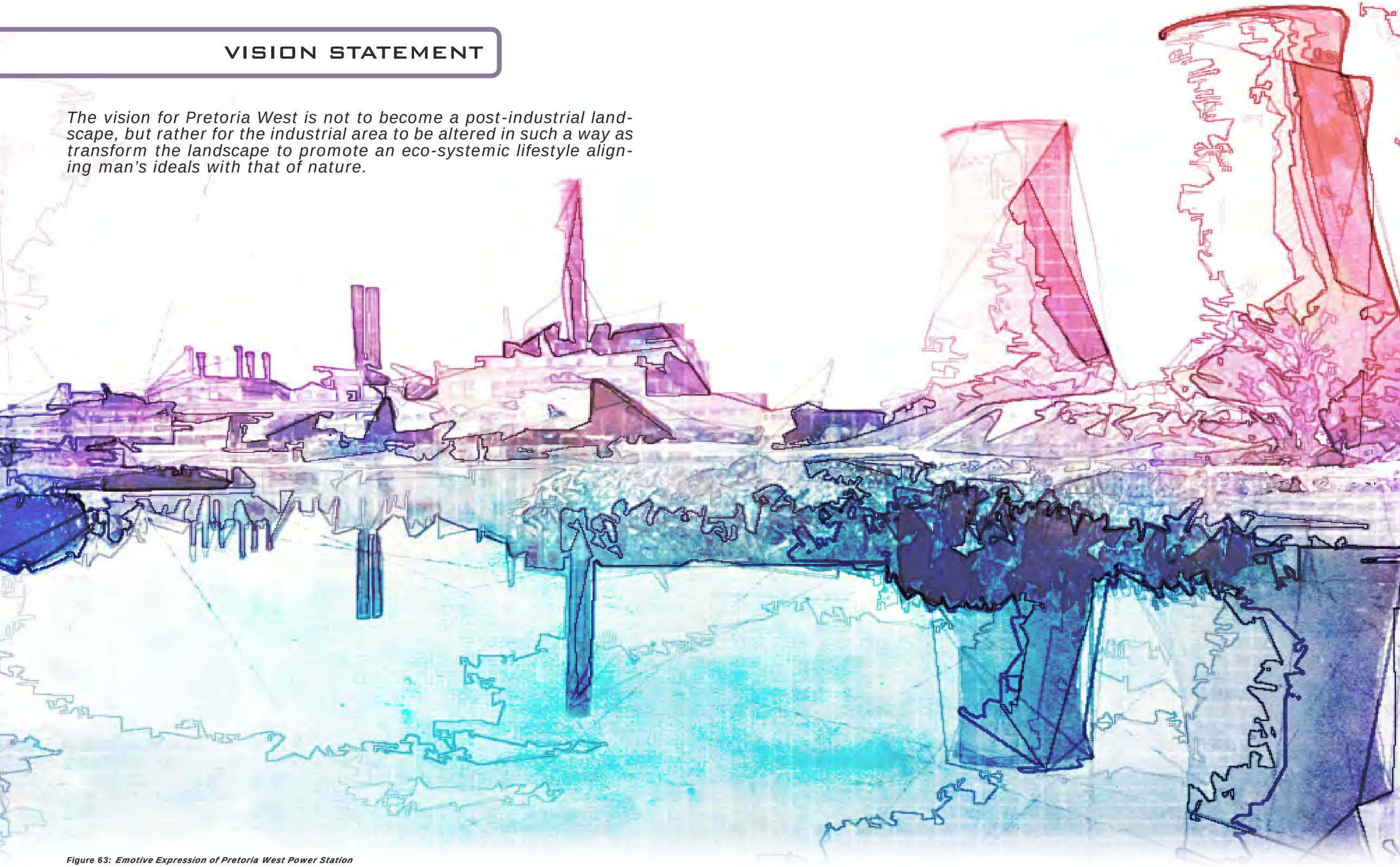


Figure 63: ***Emotive Expression of Pretoria West Power Station***
(Author, 2019)

2.10 Ecological Preservation & Regeneration

The study area is situated in a currently vulnerable ecosystem as recorded by SANBI (2013). It predominantly lies within the Grassland Biome (Rutherford & Westfall 1986), which does not fall with in the 2.85% of land in Pretoria that has been proclaimed as nature conservation. This leaves the rest vulnerable to development and the land use can severely impact available habitat. The plant lies between the three splits of the Skinnerspruit River, which feeds the Apies River. The first boundary formed by the river lies to the north. The second split in the river forms the eastern boundary and the third runs through the power plant station site. These are known as the old river system. This system has minimal flow to the south as a direct result of the damming up on the river. The City of Tshwane in their state of environment report, (2011) has identified some of the following areas of concern:

- Diminishing Aquatic biodiversity, as the river systems have been classified as poor.
- 79% of Wetlands are under pressure and are in a state of ruin.
- Poor quality of water, with an increase of bacteria in river systems.
- Sustained increase in levels of nitrate nitrogen and chemical oxygen in the rivers (indicating pollution).
- Declining Local air quality as a result of the increase per capita or electrical consumption and the increase of private motor vehicles.

The urban vision will explore methodologies to treat the water systems and regenerate the health of these water bodies which will be utilised by industrial, residential and social interaction. It will also introduce forestry for carbon emission absorption and a reintroduction of plant, fauna, and aquatic biodiversity, including those that are endangered.

2.11 Connectivity

The existing movement from the CBD into Pretoria West is currently along Church Street and Charlotte Maxeke Street. The access into the site is hindered by the only operational entrance.

The Pretoria Power Plant node, merges the CBD and the Western Urban sprawl, acting as an intersection and possible catalyst for Urban renewal and revival. It is envisaged to extend the existing pedestrian, vehicular and public routes, penetrating through the site, in effect stitching the urban fabric together. It will also break down the harsh boundaries whilst simultaneously feeding and activating connectivity through the formation of industrial and ecological opportunity, which will contribute to increased diversity and densification within the area. One way in which connection will be established will be through the introduction of green corridors.

2.12 Integration

Pretoria has been at the center of the “apartheid era” which according to Fioramonti (2017) was designed as a” growth machine”, exploited both the natural and socio-economic environments, stopping at nothing to achieve economic success. The urban vision will seek to integrate the “Western Hub” to the CBD, introducing programs to restore and rebuild the environmental destruction in the urban study area. It will search for common denominators between local industries and communities, including the greater Pretoria district. Through adaptive reuse and regeneration, a unity between users will be reinstated, bringing about a balance between industry, communities and ecology. The integration of shared open spaces will activate the connectivity network links. A new iconic image will be molded, establishing a community in which one can work, play and live in a health and friendly environment for the common well-being of all. Integration can be addressed through awareness programs and interventions that require buy in from all.

2.13 Activation

In addition to the main themes of connectivity, integration, ecological preservation and regeneration, the vision for the site is to establish a non-hostile environment. It will activate a negatively perceived environment, bringing about a paradigm shift, towards rejuvenation, promotion of sustainable clean power and support restorative healing.

The activation will focus from the core of the power station, outwardly, activating the plant which in the past, had played a role in poor site conditions and health. It will move towards the unresponsive street facades and street edges, and will stimulate public engagement and permeability through the site. The street edges will be generating comfort and safety through the shaded areas which serve as a vegetative buffer from vehicular movement and pedestrian friendly paths and crossings.

2.14 Industrial Heritage

The Pretoria West Power Station is a large Iconic structure rising above the Tshwane skyline and has become a landmark, to be preserved. With the decommissioning of the plant it becomes essential to adopt an approach of maintaining and preserving the current industrial heritage to prevent further future dereliction. From the onset of closure, a process of revival and energy will be fostered.

2.15 Production vs Consumption

There will always be the argument over production vs consumption but if we continue to look for solution with the same mindset that created the problem in the first place then we are doomed (Einstein, A., 1879-1955). Mcdonough and Braungant, (2003) confirm that “doing more with less” is not the answer, despite the role this philosophy played in the 20th century, by slowing down ecological destruction. It is therefore necessary to adopt a new paradigm to find the balance between production and consumption. Some processes that will be explored will included the production of CO_2 and how these emissions can be absorbed through natural process. In nature nothing is wasted, and the vision will hopefully mimic the methodologies that nature uses to keep the balance.

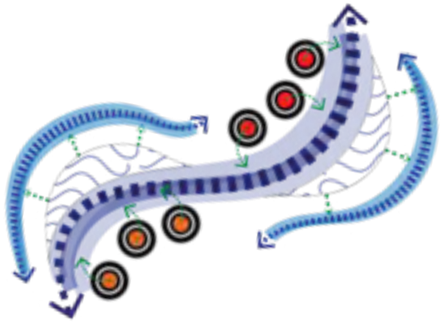


Figure 64: Urban Vision Principle Diagram - Connectivity

(Pretoria West Urban Vision Group, 2019)

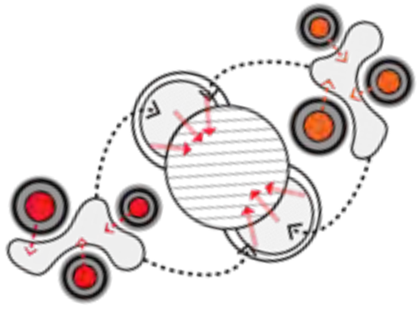


Figure 65: Urban Vision Principle Diagram - Ecological Preservation & Regeneration

(Pretoria West Urban Vision Group, 2019)

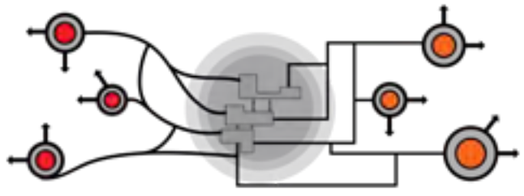


Figure 66: Urban Vision Principle Diagram - Integration

(Pretoria West Urban Vision Group, 2019)

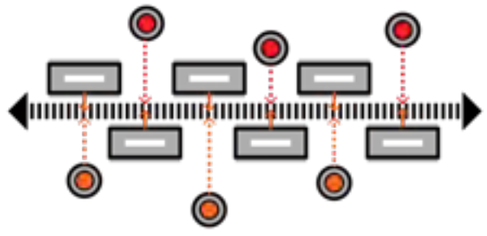


Figure 67: Urban Vision Principle Diagram - Activation

(Pretoria West Urban Vision Group, 2019)

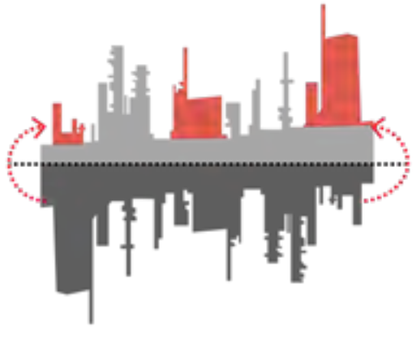


Figure 68: Urban Vision Principle Diagram - Industrial Heritage

(Pretoria West Urban Vision Group, 2019)

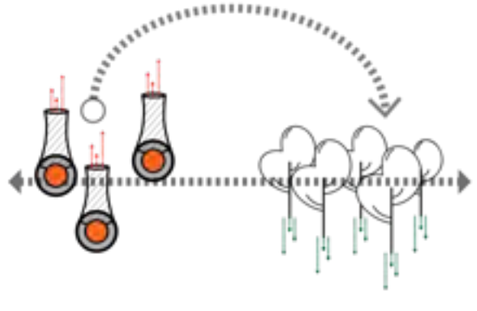


Figure 69: Urban Vision Principle Diagram - Production VS Consumption

(Pretoria West Urban Vision Group, 2019)

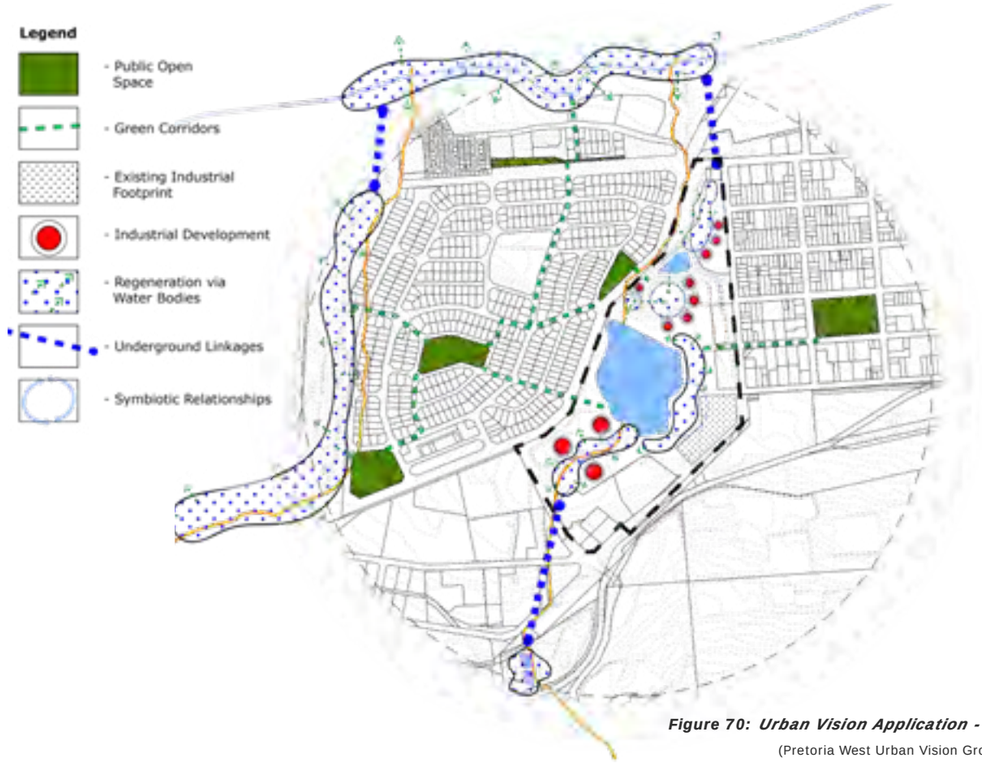


Figure 70: ***Urban Vision Application - Ecology***
(Pretoria West Urban Vision Group, 2019)

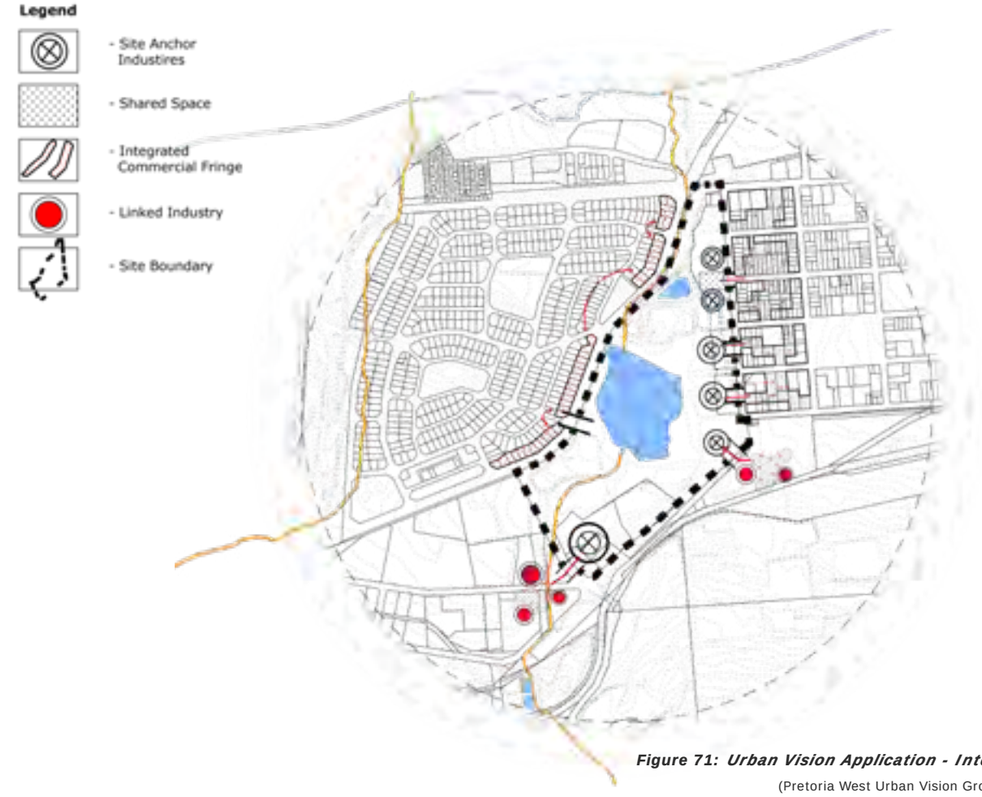


Figure 71: ***Urban Vision Application - Integration***
(Pretoria West Urban Vision Group, 2019)

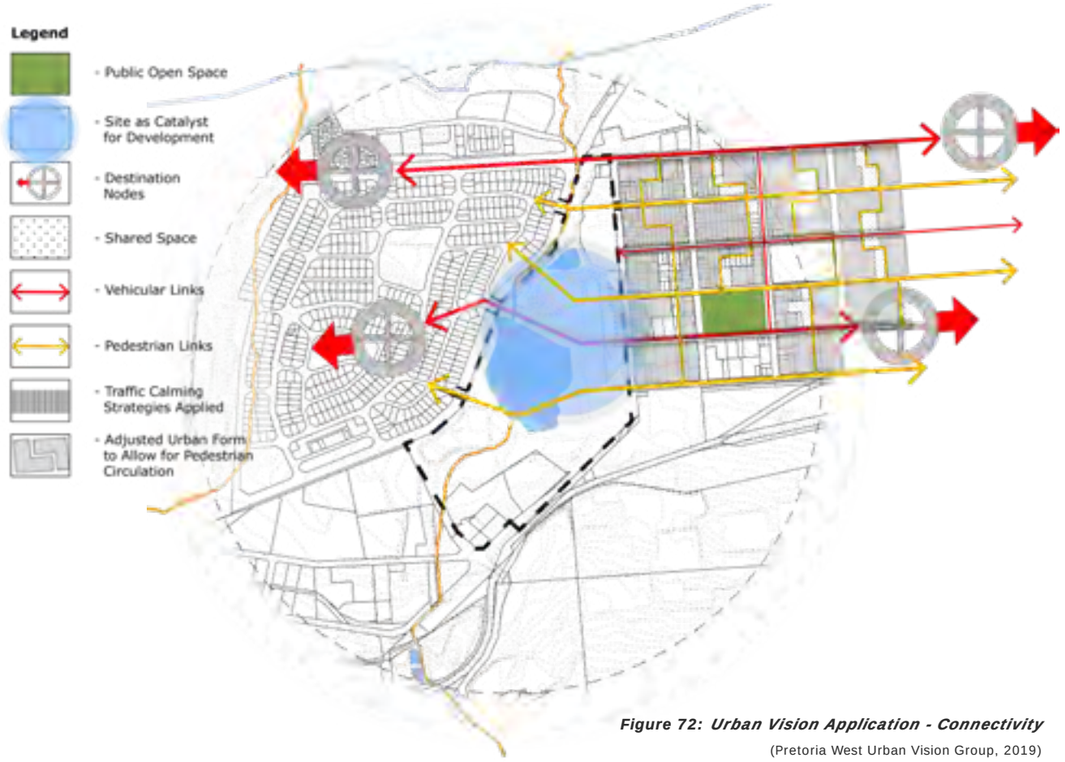


Figure 72: ***Urban Vision Application - Connectivity***
(Pretoria West Urban Vision Group, 2019)

Master Plan Zoning Diagram

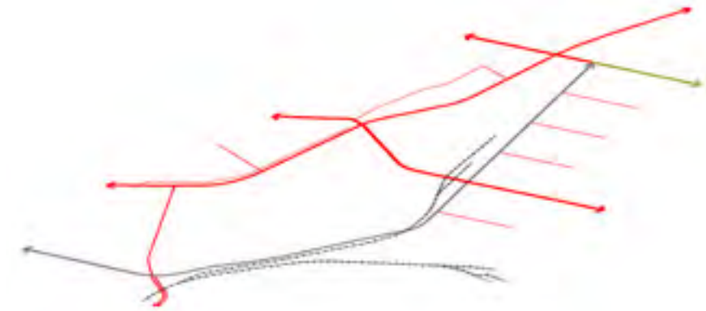
Figure 73: Master Plan Zoning Diagram

(Author, 2019)

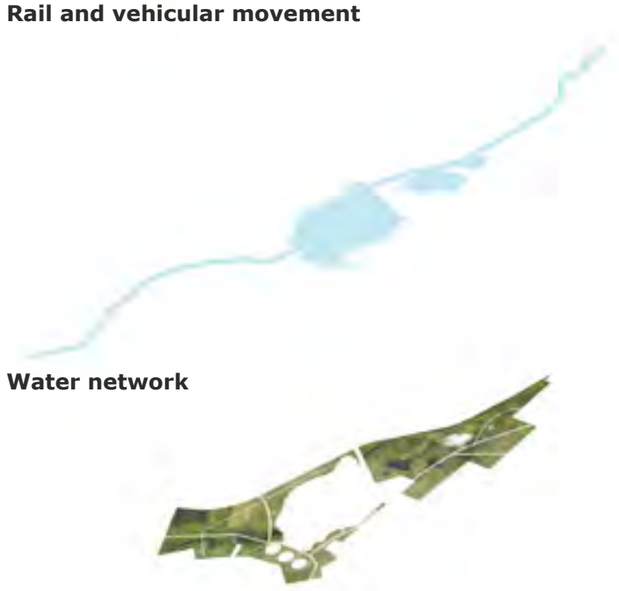
Master Plan Zoning Diagram - Exploded

Legend

- Proposed Waterfront
- Sustainable Forest 0-5 years
- Sustainable Forest 5-10 years
- Sustainable Forest 10 years and older
- Sports Ground
- Hydroponic Farming
- Biochar & Energy Production Plant
- Timber processing plant
- Retail
- Timber Storage
- Training Facility
- Restoration of ash ponds
- Retention Dam
- Restored wetland
- Primary Access Points
- Pedestrian Access
- Bicycle depot



Rail and vehicular movement



Water network

Green Space

Access and walkway

Site

Figure 74: Master Plan Zoning Diagram - Exploded

(Author, 2019)

Master Plan Program Diagram

Figure 75: Master Plan Program Diagram

(Author, 2019)

Figure 76: Cycle & Running Track

(Ref, Date)

Figure 77: Waterfront

(Ref, Date)

Figure 78: Rock Climbing

(Ref, Date)

Figure 79: Forrest Walkway

(Ref, Date)

Figure 80: Forrest

(Ref, Date)

Legend

Sports Ground
Existing sports ground to be fixed up and upgraded. A link within the site to be established to the greater extent of the site.

Training Facility
Existing training Facility on site currently only used for the power station, to act as a local training facility for the Pretoria West context.

Agriculture
A previously proposed hydroponics project to produce healthy local food products within the area to supply the functions proposed on site.

Timber Processing Plant
Timber grown on site will be cut, debarked and manufactured into various wooden products.

Biochar & Energy Production
Existing decommissioned power station to be converted to a Biochar and energy production plant where organic waste material from the timber production plant and any other organic waste will be burnt. The heat energy will be used as a sustainable power source and the resulting byproduct turned into a Biochar material. The fumes will be captured and sequestrated through other means. Existing rooftops fitted with PV panels for Eco-friendly electricity production.

Rock Climbing & Viewing Platform
A rock wall and viewing deck will be installed onto the side of the cooling tower.

Water Sports
Water Retention Dam utilised for many different water sports such as: Water Skiing, Canoeing Speed Boating, Swimming, Fishing etc...

Docks
Servers as a boat yard, viewing deck and fishing point.

Bird Hides
Allow people to immerse themselves within nature, providing beautifully views, resting points as and allowing people to view wildlife.

Forrest Trails
Temporary walkways to be installed in forest during the growing process.

By re-imagining the way the industrial buildings function - Pretoria West can become a revitalised hub of industrial activity which acts as a sub support system to the Pretoria CBD.

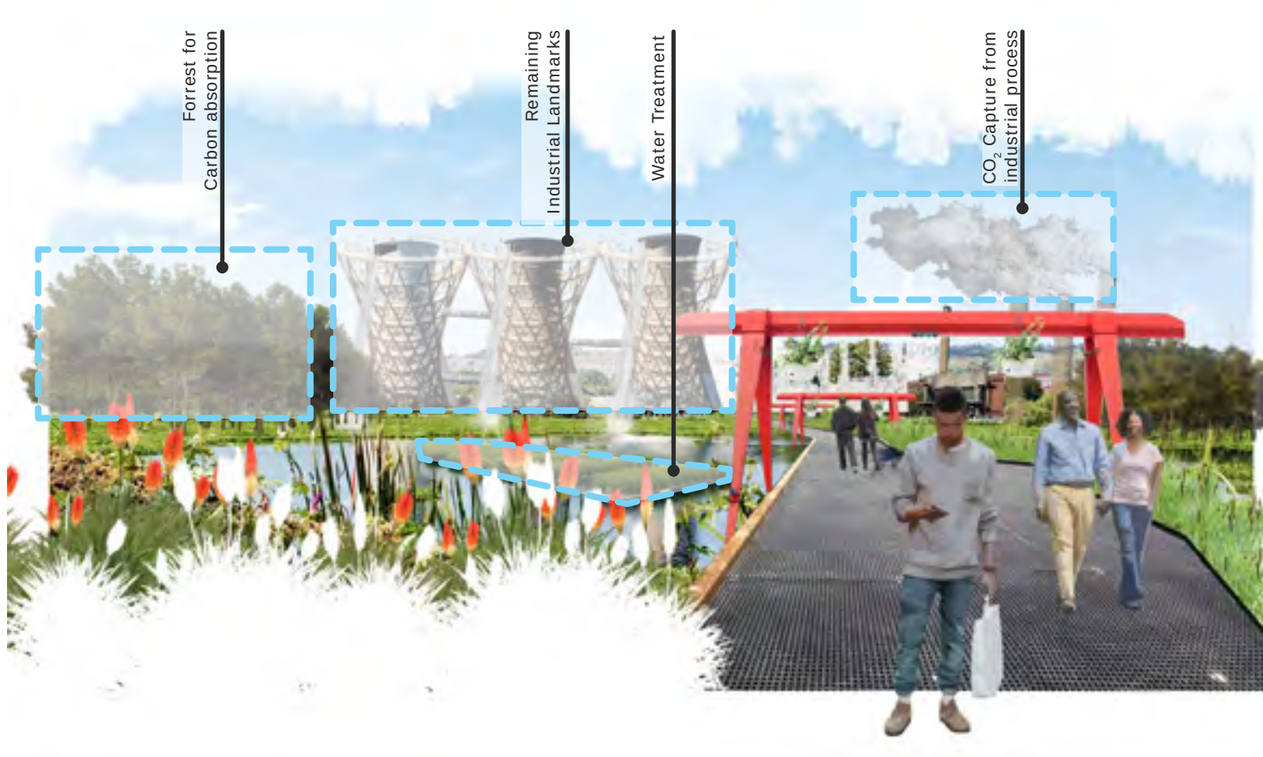


Figure 81: ***Urban Vision Montage 1***
Pretoria West Urban Vision Group, 2019)

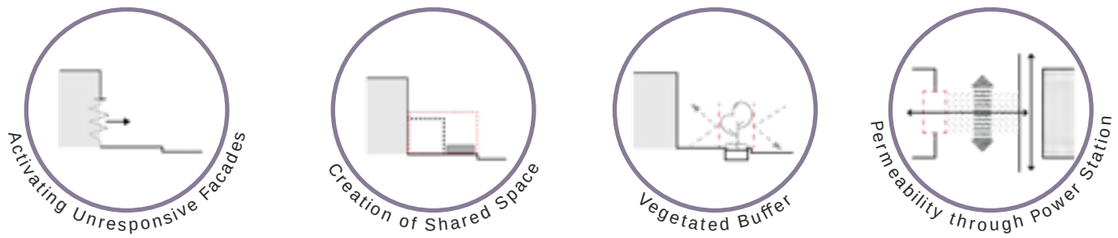
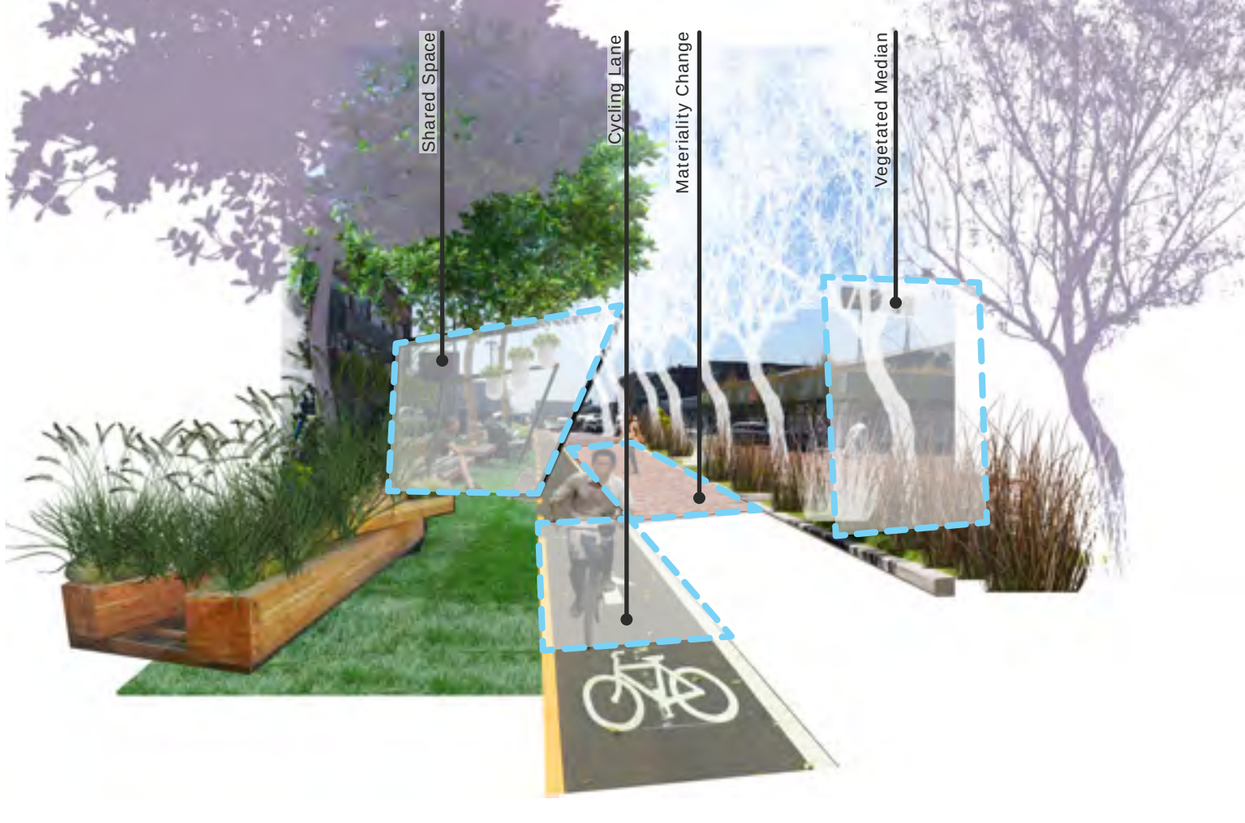


Figure 82: ***Urban Vision Montage 2***
Pretoria West Urban Vision Group, 2019)



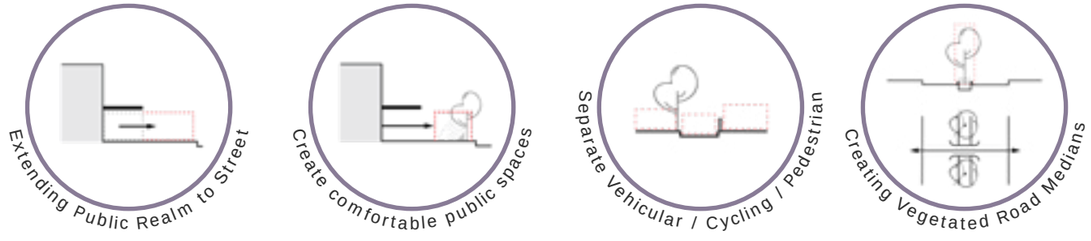
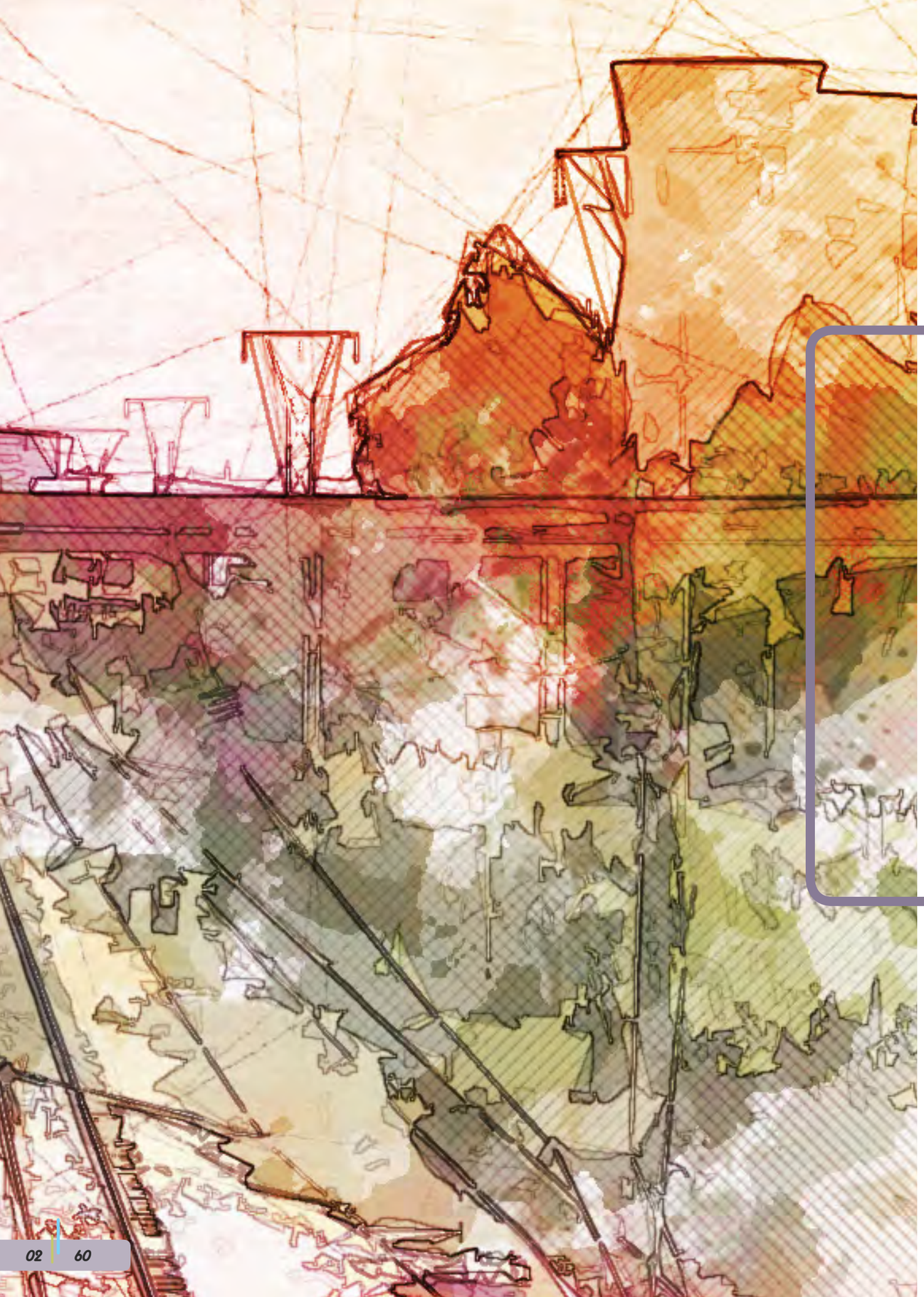


Figure 83: ***Urban Vision Montage 3***
Pretoria West Urban Vision Group, 2019)



2.16 Conclusion

The overall intention and vision for Pretoria West is to mirror the vision that the City of Tshwane has for 2055, in that we establish a livable and resilient environment, in which its inhabitants can enjoy:

- High quality of living experiences.
- Transformation of and access to social and economic infrastructure.
- Interventions should be transformative and bold, in order to meet the challenges of the 21st century and beyond.
- Creating a new identity

Through the urban renewal processes, the re-imagination and re-conceptualisation will transform the industrial landscape. The vision is therefore not arguing for the “West to become a post-industrial landscape but rather for the industry to be altered in such a way as to become more sustainable in terms of environmental as well as social issues.”

The proposed program will offer a means to transition from a place of dereliction and decay, to a productive, life sustaining outcome.

Figure 84: ***Abstract Expression of Pretoria West Power Station***
(Left), (Author, 2019)

CHAPTER 03

PROGRAM

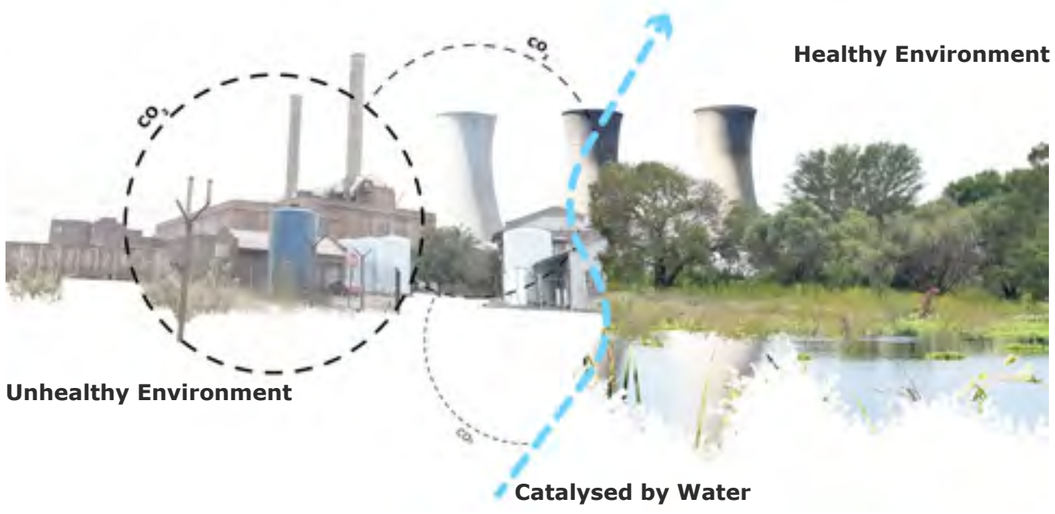


Figure 85: Water acting as a Catalysis to Transform the Nature of Industry
(Author, 2019)

3.1 Programmatic Intentions

The aim of this dissertation's program is to present a case for a paradigm shift regarding the role and responsibility which industry plays within our local and global context. A new perspective will be explored and proposed to transform an industrial site. A once negative contributor of climate change and CO_2 emissions will provide for the use of sustainable methodologies and processes whilst moving towards becoming carbon positive.

This means that industry would remove more CO_2 from the air than it emits. ((www.madeofair.com), (2018)). The programmatic approach will address one main root cause of climate change and seek to address some of the symptoms triggered by climatic change. In the hope to bring about healing of both natural and human environments, its aim will be to generate a healthier environment which promotes the healing of nature and her inhabitants and ultimately that of man.

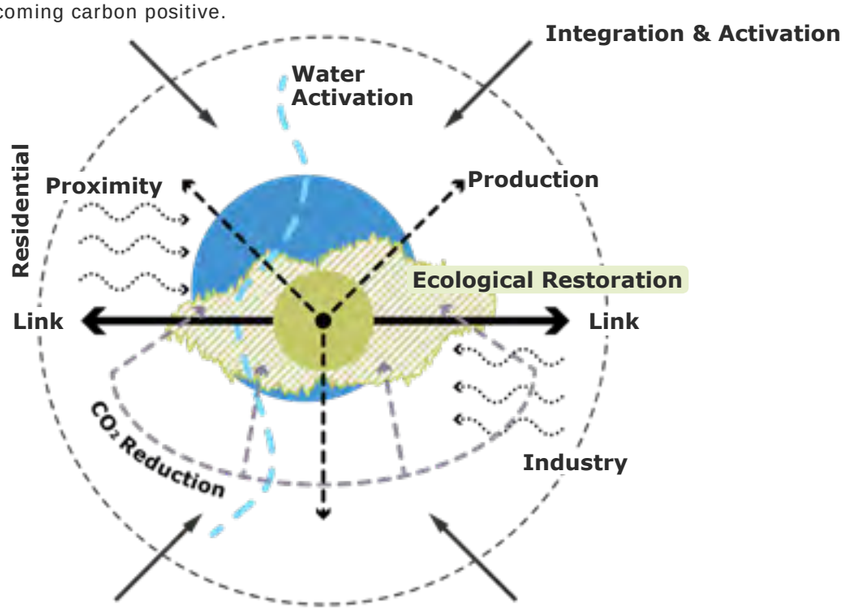


Figure 86: Programmatic Intension Diagram
(Author, 2019)

3.2 Response to Current Paradigm

In response to the core issue of CO_2 emissions, the proposed programme is further developed, to support the health of body mind and soul, within its natural environment. In so doing it is evident that through a theoretical exploration, mentioned in a previous chapter, it is insufficient to merely address the human state of body mind and soul. It is also necessary to incorporate man's natural environments, in order to influence human behaviour and state of well-being.

The core addresses only four identified symptoms, caused by climate change and CO_2 emissions. Figure 87 on page 67 indicates that these symptoms are related to physical health and include conditions such as asthma, allergies, cardiovascular and lung disease and problems in one's state of mental well-being. These problems are split into depression, climate anxiety and the provision of nutritional value of food (IPCC, 2018).

The first layer of the program intends to address the process of healing, bringing restoration to mental and physical well-being. Society has often overlooked the impact physical and architectural environments have, on man's senses, emotions, integration and interaction with community life and general well-being. The program assists to promote an environment that considers the factors that stimulate creativity, sense of worth and tranquility. These support a rapid recovery from illness and increase the success of restoration.

The urban vision and background identified that, within the decaying infrastructure of Pretoria West, there is a need to restore connectivity between the residential and industrial areas. Therefore, layer 2 of the program development and master plan, will introduce a mechanism to trigger social activities and encounters. These spatial experiences will promote community connectivity, a sense of belonging and improved self-worth.

To fully reap the benefits of nature, it is important to integrate the natural elements. The intention is to activate suitable ways which complement and merge an architectural environment with its natural environment. Through daily interaction and integration with nature, it will be beneficial, to a more productive, happier and meaningful life (Beatley, 2013). Therefore, establishing ideal spaces and corridors for connection and encounters with nature, specifically the natural element of water, will generate positive emotional responses. This 3rd layer will introduce the supplementary programmes which implement activities that create spatial experiences and promotes well-being. This layer of peace and tranquility will introduce programs that provide for:

- Support
- Job creation
- Healing
- Relaxation
- Reflection
- Restoration
- Skill development

3.3 Primary Programme

The primary programme will introduce two systems which use algae as a source of food and energy. The first is the production of Spirulina, which will be introduced as a key nutritional food source, high in protein. The second system will produce Biofuels as a clean energy source. Both the systems provide a natural process by which carbon dioxide is removed from the atmosphere and is utilised in the two production processes of the primary programme. Biofuel production is an innovative biotechnology, which produces cost-efficient renewable clean energy from plant and algae matter. This process of generating energy, reduces its dependence on natural resources, by extracting the excess co2 emissions from the cultivation of Spirulina.

3.4 Secondary Programme

The secondary building programs are linked to the main issue and deal with climate anxiety. These programs include training and educational facilities, which can be used to: better inform the community on global and local issues; provide workshops in which local communities work together with government to come up with solutions in dealing with the challenges; provide upliftment and new skills sets to the members of the local community, in order that they can support their families. These facilities also have multipurpose use, which can also be utilised for events and conferences. The facility provides a timber craft workshop, which connects to both the larger timber manufacturing plant on the site and to a small exhibition space in the building which can display pieces the craftsmanship of the local timber craft workshop. The timber craft workshop adds to the "value of work", which has been lost over the years. Additionally, the timber craft brings a social artistic element into the context. This helps to bring about a sense of worth to one, which helps to deal with climate anxiety. This will help regain personal and professional loss of identity which is often felt with climate anxiety (American Psychological Association, (2019)).

Core

The programmatic core is based on the principle of carbon sequestration.

Layer One

The first layer will focus on the restoration of mental, physical & spiritual health aspects

Layer Two

The second layer will introduce with social stimulants to promote social interaction

Layer Three

The third layer will deal with the integration of natural elements

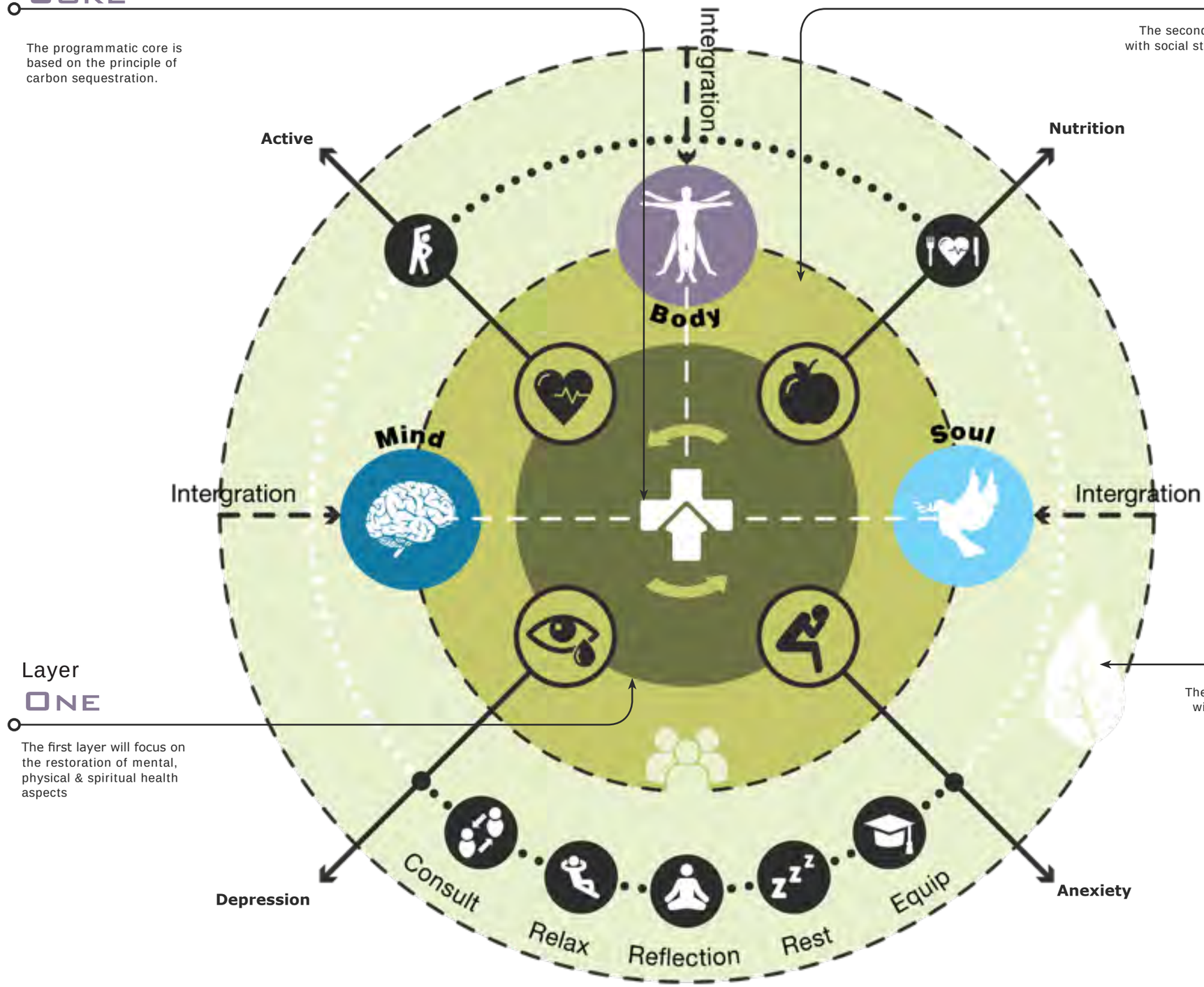


Figure 87: Layered Programmatic Diagram

Diagram illustrating the various layers the building program or space articulation strives to achieve or address (Author, 2019)

ALGAE

3.5 Understanding Algae

Algae are tiny single celled fast-growing organisms that grow in aquatic environments. They use sunlight, carbon dioxide (CO_2) and wastewater to create biomass. There are many various species of algae and they are classified into two main types: macroalgae and microalgae. Macroalgae are measured in inches, and are mainly found in ponds or in large bodies of water. The largest is known as seaweed, for example the giant kelp plant, which can be more than 30m long. Microalgae, on the other hand, are measured in micrometers and are tiny, normally growing in suspension within a body of water. (Zerrouki, 2019)

Figure 88: Algae
(Left), (www.norvento.com/biocombustibles)

3.6 Spirulina

The advantage of using micro-algae to produce Biofuel is because of their relatively high oil content and rapid rate of biomass production. Micro-algae grow far quicker than conventional crop, requiring only a small amount of land. The algae cultivation can also be performed on non-arable lands, using non-potable and wastewater. It then becomes a good alternative to other Biodiesel sources.

New technologies have opened doors, to a wide range of applications of algae cultivation. One such technology, is the production of Spirulina which is used in the health food industry as a protein and a vitamin supplement, and is used in many other ways, such as aquaculture and poultry diets. Spirulina is a complete protein, containing all essential amino acids. Compared to standard proteins, such as egg, milk or meat (Phang et al., 2000), it contains twice as much protein and is high in Omega 3 (which has become a scarce commodity, due to the declining fishery industry). It also contains many vitamins such as B1, B2, B3, B6, B9, B12, C, D, E. It also contains minerals such as potassium, calcium, copper, iron, magnesium, zinc, etc. It is said that the production of Spirulina could overcome the huge levels of malnutrition in the world (Trent, 2018) and has been classified as a “super food”.

Spirulina can transform our food production process through creating a more meaningful and sustainable way of living. The production can help end deforestation, as it can replace soy protein extracted to feed livestock and poultry. Some scientist have even declared that Spirulina assists with the reduction of inflammation and heart diseases, (Space 10, (2017)) Eating micro-algae, dates back to the Aztecs who scooped the Spirulina (called Tecuitlatl), out of the lakes in Mexico, molding it into flat cakes. (Spaceio, 2017)

3.7 Application

Spirulina has been used to make various different food products as listed below:

- Powder is used in smoothies, milkshakes, and as a spice
- Chips
- Adding it to dough to make breads or rolls
- Vitamin tablets

Figure 90, Figure 91 & Figure 92 show some of these applications.

3.8 Why Biofuel?

As energy demand increases so does the production of power. Along with the rising demand for energy, comes the pressure of the depletion of natural resources and concerns about climate change. It therefore becomes essential to seek new methodologies and sources that provide for renewable and clean energy, ensuring environmental protection and quality of life.

There have been many production processes explored to establish the most effective ways to both extract and develop unconventional energy sources. Biofuels could be the solution for replacing natural resources currently in use, as they emit less CO_2 emissions (Duan, 2014).

Research done by NASA, investigated various crops which can produce Biofuels. Their results are shown in Figure 89. Some of these crops are, soybeans, sunflower, canola, and palm oil. However the production of micro-algae is the most successful, producing 19 cubic meters of algae per half a hector as opposed to soybean and sunflowers which only produce 0.19 to 0.4 cubic meter per half a hector. (Trent, 2012)

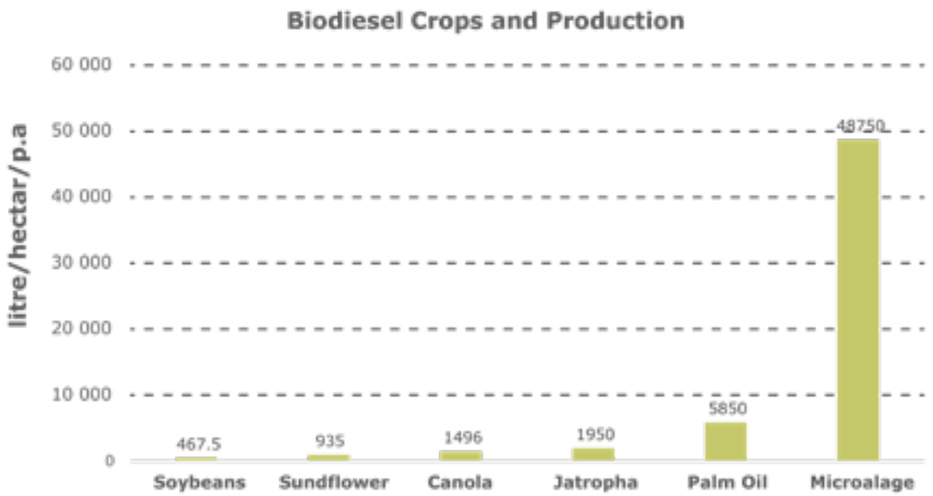


Figure 89: Biodiesel Crops & Production

NASA Omega Project (https://everwideningcircles.com/2018/03/04/sustainable-energy-from-algae/)

Figure 90: Sprulina Powder

(Kunevski, S., 2006)

Figure 91: Sprulina Chips

(Vindelev, N. A., 2017)

Figure 92: Sprulina Bread

(Vindelev, N. A., 2017)

ALGAE CULTIVATION

3.9 Algae Cultivation

The cultivation of algae today, not only is a source of high protein food, but also produces oxygen. This is another reason that “our lives” will be every changed by the process. There are many different process and methodologies used in the cultivation of algae.

Figure 93: Algae Tubes
(Left), (IGV Biotech, 2013)

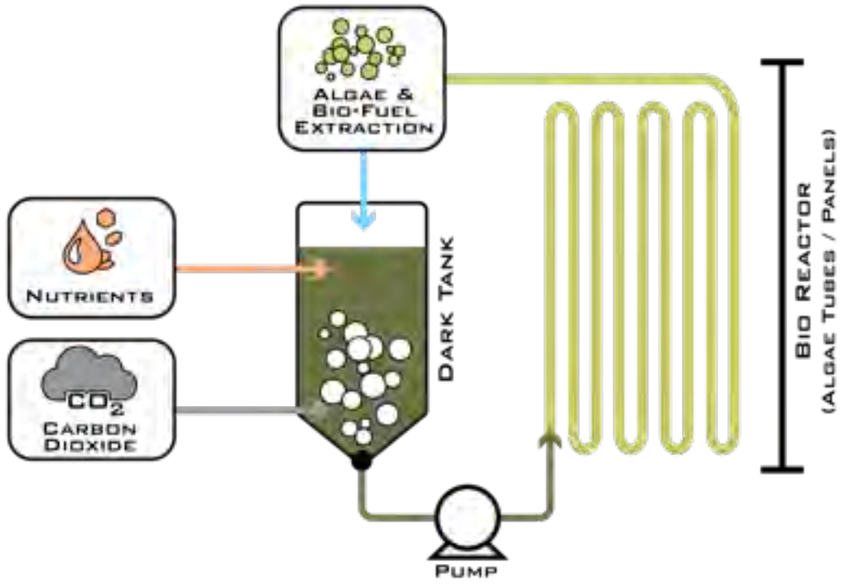


***Figure 94:** Bio-reactor Systems Diagram*

(Author, 2019)

3.10 Algae Cultivation Methods

Algae reproduces rapidly and only require sunlight (or another form of energy) water, carbon dioxide and a few inorganic nutrients to grow. A number of algae production technologies are currently been used, but the two main ones are open ponds and closed Photo-Bioreactors. Other researchers and companies are pursuing alternative approaches to growing algae like fermentation tanks or hybrid systems are also used. All the systems use CO_2 which the algae needs in order to grow. The CO_2 comes in the form of flue gases from power plants (into a dark tank) or other industries using fossil fuel combustion. This process helps remove harmful carbon emissions when the biomass is converted into Biofuel. As the algae grows it consumes CO_2 and releases oxygen back into the atmosphere and recycles the water back. The algae are harvested, and oil is extracted. Any excess is recycled ore used in the production of other products such as Spirulina. (Duan, 2014)

3.11 Open Systems

Open pond systems use shallow pools of water, about one acre to several acres in size. Herein the algae are exposed to natural sunlight, which is converted into biomass. Typically, the ponds are called raceway ponds because their shape resembles a racetrack. Paddle wheels are frequently used or other water moving devices, to keep the algae circulating. There are various different types of open ponds as indicated by Figure 95, Figure 96 and Figure 97.

3.12 Closed Systems

A Photo-Bioreactor (PBR) differs from an open pond in that the algae is enclosed in transparent tubes, bag-type or panel design. These shapes are usually oriented vertically or horizontally. Several advantages that PBR's have over open ponds, are that the growth conditions can be better maintained and controlled, smaller area is required for similar production and the invasion of weed algae, which could contaminate the cultivation (Zerrouki, 2019), is possible. Figure 98 is an example of one such closed loop system.

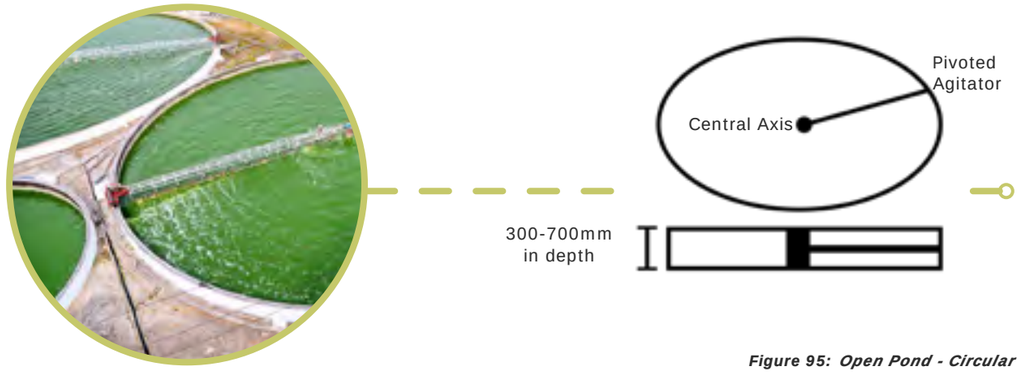


***Figure 95:** Open Pond - Circular*

(Ref, Date)

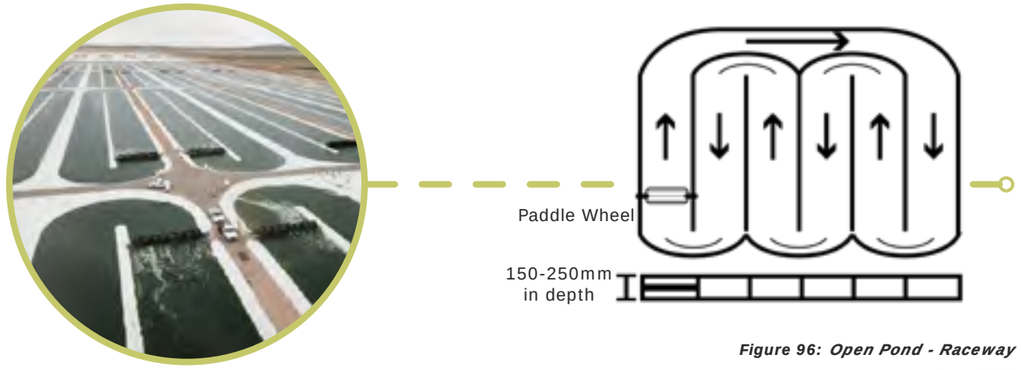


***Figure 96:** Open Pond - Raceway*

(Duan, 2014)

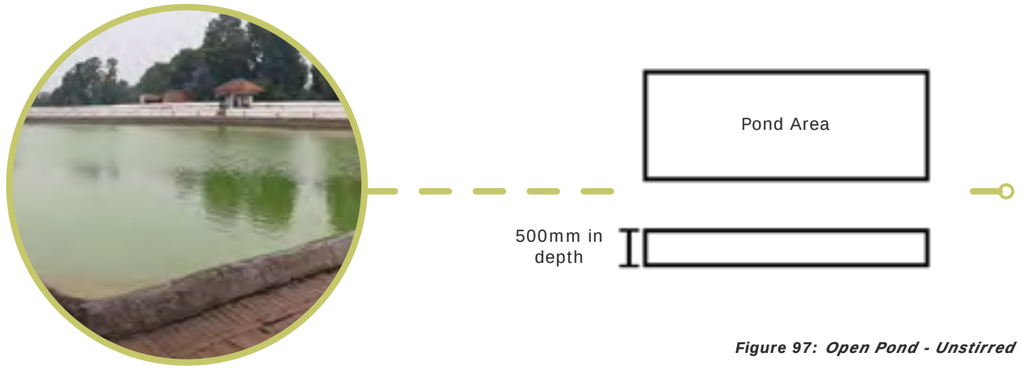


***Figure 97:** Open Pond - Unstirred*

(Duan, 2014)

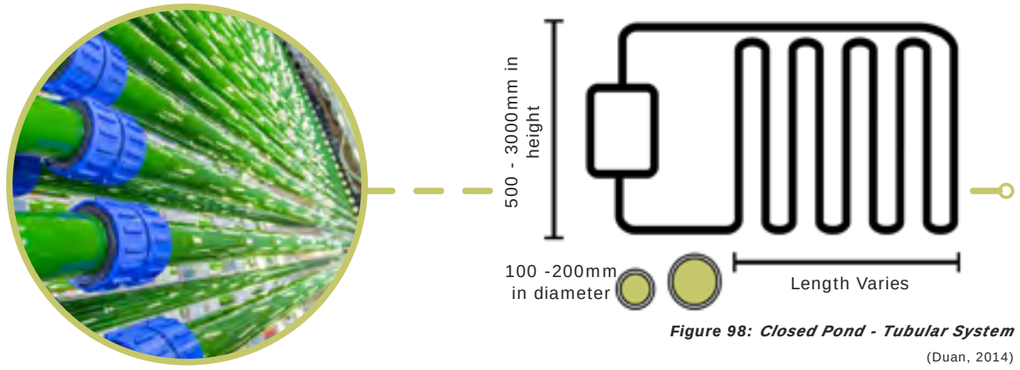


***Figure 98:** Closed Pond - Tubular System*

(Duan, 2014)

CRITERIA FOR SITE SELECTION

In order to achieve the programmatic intentions, discussed above, a criteria for selection was set out to establish suitable sites for the application of the architectural intention. This assists in the narrowing down of appropriate sites, to ensure that the site with the best potential and opportunity is selected. To meet the requirements of the program, the following elements would need to be present at the proposed sites.

3.13 Alignment to Urban Vision

It is necessary to align the proposed intention to the Urban Vision formulated for the Pretoria West area. This site requires activation, ecological preservation and regeneration of a currently damaged ecosystem. The site needs to connect the residential area and the industrial area, equipping both residents, local authorities and industries to adopt a stewardship role over their natural environments, while mutually benefiting all.

Adopting the themes of connectivity, integration and ecological preservation discussed in prior chapters, the site needs to be able to transform a once hostile environment into one that encourages engagement and permeability though the site.

3.14 Accessibility

It is essential that the site has ease of access for the users and the local community to enter into the site, as well as the necessary infrastructure to provide for service delivery and facilities.

3.15 Proximity to Water

From the research, it has been established that water is one of the most important natural elements of life. Water is also critical to the creation of healing environments, as the flow of water, its sound, movement and perceptions provide a tranquil and calming effect. In the program water is necessary to stimulate healing and to grow algae for the Spirulina and Biofuel production. This requires the site to be in close proximity to a water supply. This will minimise unnecessary cost implications and provide ease of access to water supplies for the implementation of the programme.

3.16 Site Orientation

To achieve the programmatic intention, the site will need to be orientated in such a manner that sufficient daylight is available for the cultivation of Spirulina. To integrate the natural element of the sites surrounding, there needs to be adequate open spaces which can be used to increase biodiversity and enhance the natural environment.

Figure 99: ***Pretoria West Power Station Water System*** (Left), (Author, 2019)

3.17 Site Possibilities

Figure 100 indicates four possible sites, which were identified, through the application of the site criteria, within the Pretoria West region. As illustrated in the figure, the four selected sites are found along the main, large industrial infrastructure, to the south of the Pretoria West Power station.

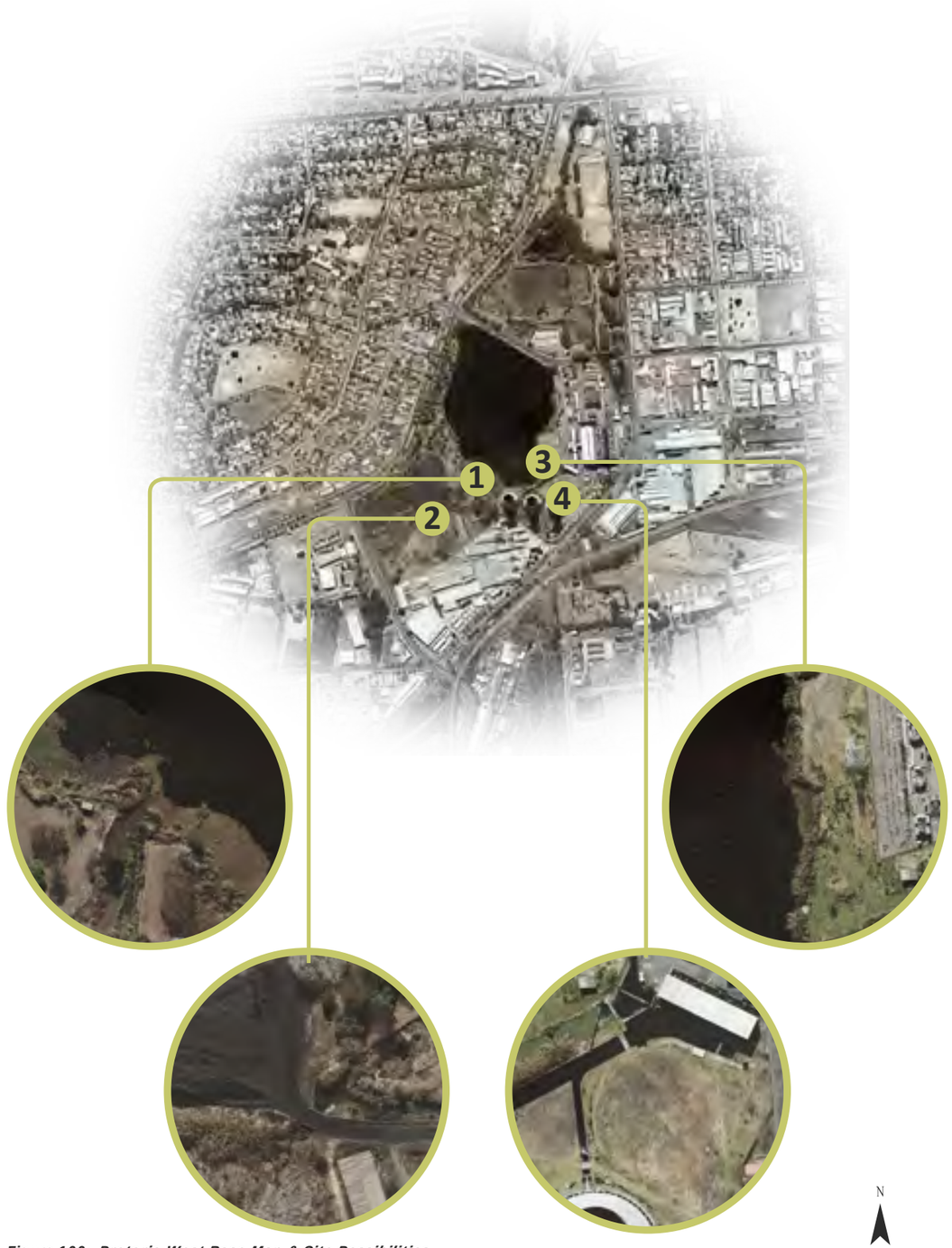


Figure 100: Pretoria West Base Map & Site Possibilities

(Author, 2019)

3.18 Site Selection

Out of the four sites, site 4 was chosen for the proposed architectural intervention. The site not only meets the site selection criteria but offers current and future opportunities to support existing structures, expansion and activation from other users. It is also not as isolated as some of the other site options and also has more existing water infrastructure as shown in Figure 103.

Locality Map

Figure 101: Locality Map of Pretoria West Power Station

Indicating chosen site (Author, 2019)

Topography

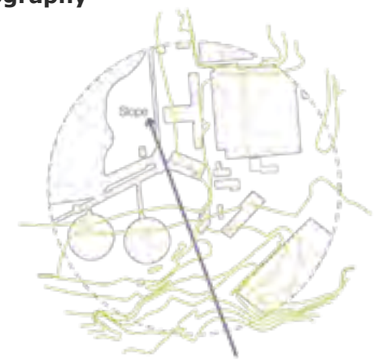


Figure 102: Site Observations - Topography

(Author, 2019)

Water Network

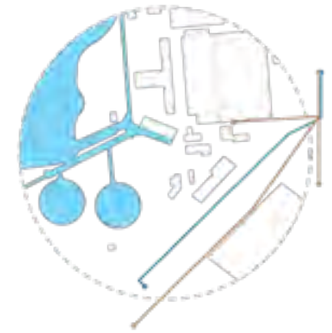


Figure 103: Site Observations - Water Network

(Author, 2019)

Infrastructure

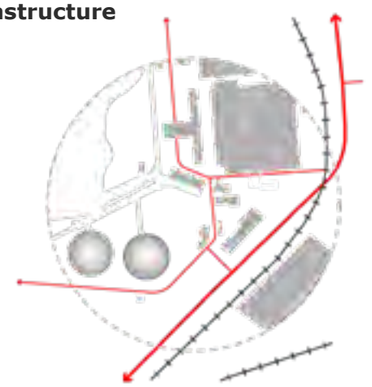


Figure 104: Site Observations - Infrastructure, Access & Proximity

(Author, 2019)

Site Features

Figure 105: MSite Observations - Site Features

(Author, 2019)

CHAPTER 04

THEORY

INTRODUCTION

4.1 Theoretical Premise

In the previous chapters the dissertation outlined the current global, local and architectural issues, which forms the basis of the study. In the endeavour to combat the rapid rate of climate change, societies are faced with the stress of surviving extreme weather conditions and the effects of climate change, in what feels like the end of days (Joubert.l, 2019). It is for this reason, that it is important to understand the relationship between man, nature and well-being. Positioned within the theoretical context of regenerative, biophilic design and environmental psychology theories, the relationship between the natural and human environments will be explored. These theories will furthermore pursue synergies between the environments to establish a mutually beneficial, co-existence and partnership, that establishes both physical and mental well-being. (Cole, 2012)

The theoretical premise mentioned above, will be discussed, considering the architectural application and the way in which it will respond to the physical environment. Through an analysis of these theories, the findings will inform the design principals which act as a catalyst to promote positive physical and mental well-being. The design principals will form the departure point to establish an architectural intervention which responds to the distress of climate anxiety, which has been caused by climatic changes, through a series of spatial experiences. The chapter will conclude the importance of creating natural and human environments, that not only promote physical and mental well-being, but restoration of environments and connection of man with nature.

4.2 Introduction

“Sometime during this current century, the Earth system will pass a threshold beyond which its committed to irreversible and mostly adverse change. Once we pass this threshold set by the level of carbon dioxide in the air of something between 400 and 500 parts per million, nothing the nations of the world can do will alter the outcome. We are in a sense like passengers on a small pleasure boat sailing down the river toward the Niagara Falls, not knowing that the engines are about to fail.” James Lovelock, (2019).

Man’s pursuit for growth, prosperity and success, has seen to “The Great Acceleration of human pressures of the planet, as deliberated by Rockström, (2015). This acceleration can be seen through the increasing consumption of natural resources and fossil fuels. Other impacts are experienced through the effects of climatic changes, increase of air pollution, contamination of ecosystems, loss of biodiversity and breakdown in societies. All this leaves a lasting detrimental impact on our natural environments. (Fioramonti, 2017 and Kawamura, 2005). Martin, (2016) exclaims, that humanity is at the crossroads of history. The fate of the planet depends on our ability to act or failure thereof, in the course of the next 20 years. Everything will rest in our capability to regenerate vital ecosystems, creating flourishing environments, (Wahl, 2017).

4.3 Climate Change – A Changing World

In earlier chapters, climate change was identified as one of the biggest challenges our planet is faced with today. In a United Nations’ report, (2009), climate change and global warming are recognised as a major concern to sustainable development. The report has further identified that the building sector is the largest source of all greenhouse gas emissions, contributing to 50% of global emissions. Graph A and B in Figure 106 initially indicates that the building sector only contributes to a fraction of global emissions represented by 8% of greenhouse emissions. However in the fifth assessment report of the intergovernmental for Climate Change (IPCC), (Mayer, 1999; Nabuurs et al., 2007; Rogner et al., 2007), states and is indicated in graph C ,that building’s contribution includes both direct and indirect influences. When both direct and indirect influences are combined the total emissions attributed from buildings, are 50%. Projections show that continued increase in CO_2 emissions, will continue to give rise to increasing global temperatures during the 21st century and that further changes to the climate system will continue to be observed, with the extent of changes depending on the global trends in greenhouse gas emissions (IPCC, 2013).

4.4 Climate change impacts

Climate change impacts are increasing in intensity and frequency on both a global and local scale. Scientific evidence illustrates the disturbance of the natural systems created by the increased greenhouse gases, which are a result of human activities and lifestyles. According to the World Health Organisation (WHO) and Wold Bank (2017), air pollution from rapid industrialisation and use of energy has been recognised to be a cause of serious health problems. WHO, (2017) further explains that there are two main sources of emissions and pollutants. The first comes from the burning of fossil fuels (i.e. combustion emission) and the second source comes from non-combustion processes (i.e. Process emissions). These processes have a profound impact on our environments.

The conditions of the natural environments have both direct and indirect effects which jeopardies human health and well-being. WHO, (2017) (World Health Organisation), defines well-being as not merely physical, but a complete physical, mental and social state of comfort and happiness, which is more than just the absence of disease or infirmity. Figure 107 best illustrates the numerous direct and indirect impacts that climate change has on mental, physical and social well-being. The toll on our mental health have far reaching effects. They induce stress, depression, and anxiety. It puts strain on social and community relationships and has even been linked to increases in aggression, violence, and crime (USGCRP, U.S. Global Change Research Program), (2016).

The direct impact of climate change will influence individuals across all cultural lines and does not isolate anyone specifically. Everyone is at risk to climate change, causing changes to body, mind and soul. In turn these effects influence changes in social dynamics, creates economic pressures to deal with dramatic changes as a result of climate change and the devastating effect it has on our environment. The indirect effects of climate change then result in physical incapacitation though injuries, increased cardiovascular disease, etc. While mental stability challenges are exacerbated through climate anxiety, a recent study (Greco & Roger, 2003) shows that it causes depression, grief, and other mental instabilities. When mental well-being and physical well-being is impaired, the knock-on effect is exhibited through increased behaviour changes which cause pressure and conflict within the social community.

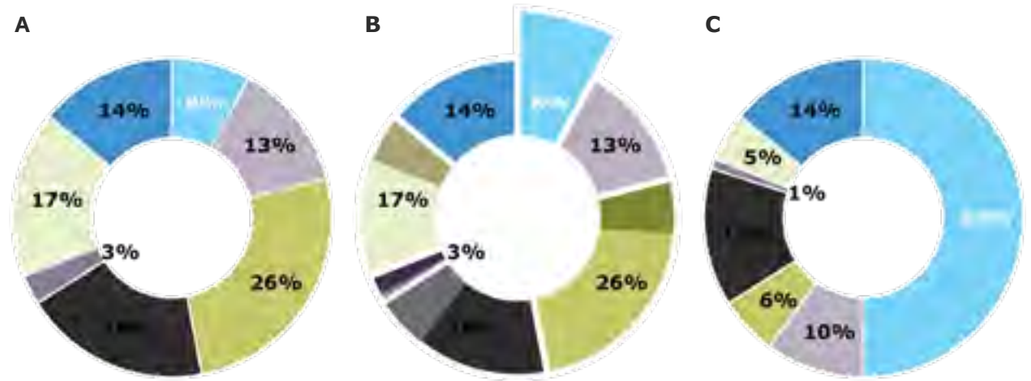


Figure 106: Percentage of Global Emissions Generated per sector

Recorded by IPCC (Mayer,1999;Nabuurs et al., 2007;Rogner et al., 2007)

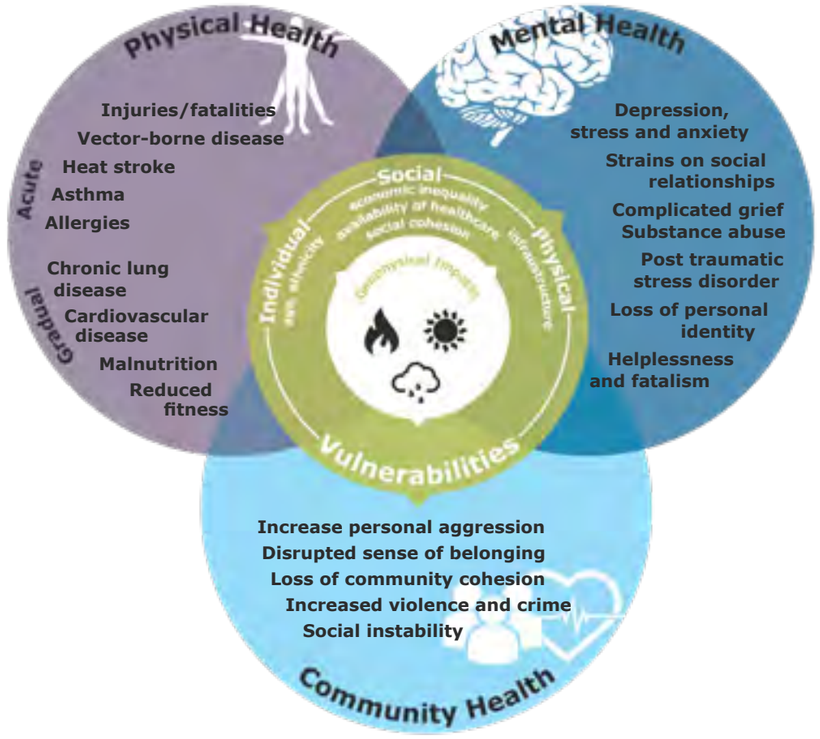


Figure 107: Climate change VS Mental health

Indicates the far reaching impacts Climate Change causes on mental health (Mental Health our changing climate Impacts, Implications and guidance), Eco-America (2017)

4.5 Climate Anxiety is Real

As climate changes continues to effect and alter the way we live as a result of devastating disasters, concerns and fears are exacerbated with the onslaught of poverty, disease, famine, drought and conflict. The negative impacts of climate change on humanity will only increase alongside the ever-increasing concentrations of CO_2 emissions. The "sixth extinction" is upon us as Ovary, (2019). This is evident as we see: oceans acidifying, insects that pollinate our plants are dying, biodiversity loss is accelerating, ice caps are diminishing, desertification is spreading, water supply is being contaminated and depleted and heat waves and fires are the norm.

Since early 2015-2016, Dr Paul De Pompo, a clinical psychologist in California, has seen that many psychiatric patients have been talking more and more about "the impending doom and gloom of our planet" and about how their physical and sociological environments are changing. The sense of growing fears increase along with "what if's and buts", anger, feelings of total helplessness to the plight of climate change, fatalism, exhaustion as sleepless nights pass worrying about what's next, depression and grief for the loss of our world as we know it, and even avoidance and denial. This is the psychological response to catastrophic that is on our door steps ,Ratcliffe,G., (2018).

Recent research scientists Kastner, (2019), who has been interested with the interaction between ecology and human health, has climate change as a contributing factor to mental health disorder which is referred to as "Eco-anxiety" or ''Climate Anxiety". Australian environmental philosopher, Glenn Albrecht (2003), defines eco-anxiety as "the generalised sense that the ecological foundations of existence are in the process of collapse". Furthermore, research reveals that eco-anxiety affects us in many ways. This is all dependent on how much control we think we have over our lives, what we understand about the risks, and how we process questions of responsibility.

A major report by the American Psychological Association (APA) released in 2017 identifies three specific forms of climate anxiety which affect mental health as a result of climate change:

- "The Grief" or "Trauma" which you may experience first-hand, due to a natural disaster and direct ecological loss.
- "The anxiety" from loss of environmental knowledge which leads to loss of identity.
- "The fear" around climate change and how this will impact the world on a global scale, including future losses.

Rebecca Fearn, (2019) has reported that the symptoms of climate-related anxiety, are similar to other types of anxiety, which can include insomnia, depression, and panic attacks. In turn these symptoms have other far reaching side effects according to American Psychological Association and Eco-America (2017). Studies conducted by Albrecht (2003), indicate that people can experience anything from altruism, a sense of personal growth, strong sense of community to post traumatic stress disorder, panic, anxiety, PTSD, mental illness, suicidal thoughts, and effects on pre-existing mental health conditions. While another study also found that climate anxiety exacerbated obsessive-compulsive disorder. The more familiar impacts of climate change are known as worsening asthma, allergies, heat related stress, food-borne and waterborne and vector-borne diseases, illnesses and injury.

Mental disorders in South Africa have been stated by Dan Stein of the Medical Research Council (2014) to be 30% of a population of 55 million. It is hence important to find architectural programs that will assist with the improvement of mental well-being. Glenn, A. (2004), states that further studies and exploration from eco-anxiety offer an expansion on "psychoterratic" and "solastalgia" which deals with the health relationship between the psyche and the biophysical environment. Some may call this stance "holistic", although Glenn, A. (2004) prefers to think of it as "a new intellectual discipline" involving "the systematic study of humans living together with the totality of life," as embodied in "life-supporting relationships between man, ecosystems and biophysical systems, incorporating both local and global perspectives.

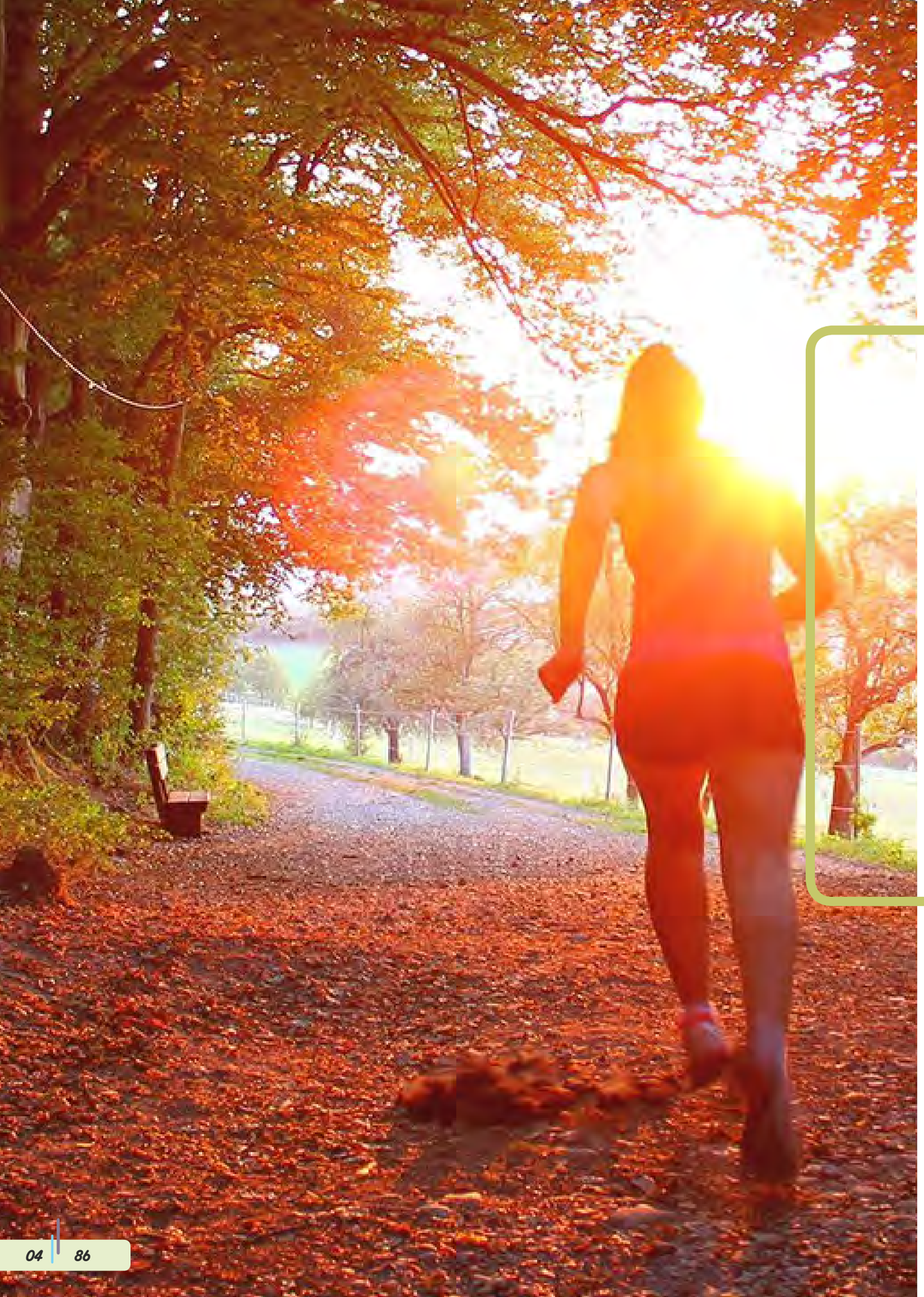


Figure 108: Woman Running in the Forest
Left, (Mottet; N. D. 2017.)

4.6 Lost Connectivity

Despite man's inherent need to be connected to nature (Wilson, 1984 Kellert, et.al, 2008), modern cities have developed with a view that nature was seen separate to that of man and his environment (Baker and Du Plessis, 2013). Furthermore, Howe (1993) highlights that in man's quest to gain dominance over nature through technical advancement, man is now in disharmony with nature. The natural world has been treated as a commodity rather than a symbiotic environment embodying both man and nature.

4.7 Where have we come from?

Early environmental response to the built environment was first evident in the 1970s. The "Willis, Faber & Dumas" Headquarters, built in 1977, is an example of this (Gissen, 2002). Subsequently, much has changed through environmentally sensitive architecture, such as:

- Prefabricated energy efficient wall systems, pioneered by Herzog (2001 cited in Energy efficiency in Thomas Herzog Architecture: From Interdisciplinary Research to Performance Form, 2016).
- Sky gardens and water reclamation systems incorporated by Yeang, 2008 (Ken Yeang Eco Skyscapes, Bullivant, 2011).
- More sustainable construction practices and material use, proposed by Braugart, 2010
- Cradle to Cradle: Remaking the way we make things, social sustainability investigated (Serlin, 1992).
- Ecological Design (Van Der Ryan and Cowan, 1996).

In view of the transformation of sustainable architecture Yeang (2017) describes that designing for sustainability needs to start with changing society's ideologies towards design. These ideologies in turn determine the norm of society's socio-economic and political systems which influence architectural design, having detrimental or positive consequences on nature and man.

4.8 Where to from now?

Whilst much has changed in sustainable development as represented in Figure 109, Du Plessis (2015), highlights Reed's (2007:676) viewpoint. He suggests that a shift towards a new paradigm, needs to go beyond increasing resource efficiency and eliminating negative impact on our environment while meeting mankind's needs. Reed, (2007) states that "it is a recalibration of human intentions to coincide with the way the biophysical world works". It is based on a complete living system whose purpose is to sustain life-enhancing conditions in a complete closed-loop cycle.

It is necessary to look towards outcomes that not merely reduce environmental impact but seek to reverse negative environmental impact, which will not only slow the rate of degradation but regenerate ecological systems and communities. The emphases of regeneration through architecture is one that gives back more than it receives, (Cole, 2012) Regenerative designs starts by accepting "Place"as it's initial point for design, while connecting people back to "the spirit of the place" in a manner which stirs and rejuvenates them to become stewards of its well-being, Mag, (2009). However, exploring and understanding ecological and other systems are equally as important for design.

4.9 Integration

An integrated system-based approach is vital to regeneration. Built environments are not standalone units, but rather become incorporated into larger systems, which promote interactions between architecture, nature and its inhabitants. These interactions happen in such a way, that all parties mutually benefit. Through integration of man and nature, it becomes possible to repair and restore ecosystems to once again function without man's intervention. In turn, these integrated and participative design methodologies, promote significantly to both individual and community health and well-being. Zair, (2010)

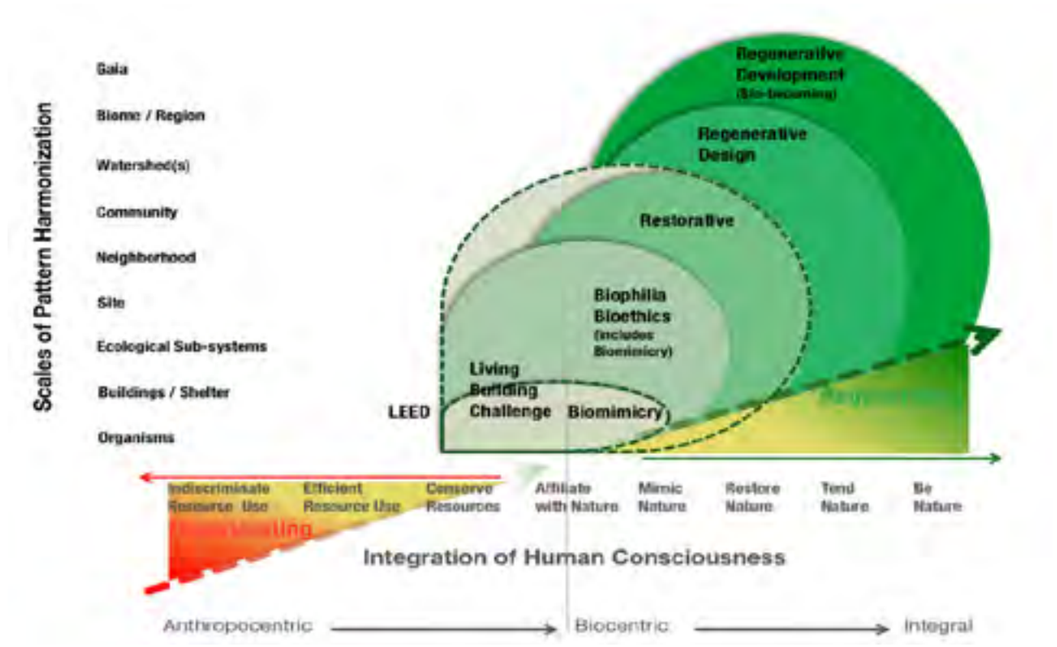


Figure 109: Integration of Human Consciousness
(Developed from Bill Reed 2007 [10]

4.10 Introduction

Society has often overlooked the impact that the physical and built environment has on man's, senses, emotions, integration and interaction with community life and general well-being both physical and mental.

Winston Churchill, (1943) mused, ***"we shape our building and afterwards our buildings shape us. They regulate the course of our lives"***

Studies in the past have mainly focused on the physiological aspect of well-being of man. Little attention to the physiological aspect of well-being of man, was being considered (Abkari, 2016). Recent theories on "Environmental Psychology" now explore the connectivity and relationships between the environments in which man lives, together with its influence and impact on human well-being, Stock et al (1987) and De Young, (2013).

The psychology of the environment first emerged after a publication on *"person-place interactions"*, by Proshansky, (1958) was published. Environmental psychology is entrenched in the belief and theories that nature plays a significant role in shaping man's growth and behaviour and draws from varied factors like psychology, sociology, ecology, environmental sciences, socio-architecture and environmental designs. This is because these factors influence human behaviour.

This field of study has increased in importance due to the increase in global issues in the environment, such as population explosion, pollution and pressure on natural resources. The study is problem-orientated, by first identifying the disconnection of man and nature and finding a solution-focused outcome.

4.11 A Sense of Place

"Genius Loci" a Latin term referring to *"spirit of place"* emphases that each place is unique, and the idea of "place" relates to each individual's perception which is expressed in different dimensions of human life. This includes emotions, biographies, imagination, stories, personal experiences, social interactions and identities, (Basso, 1996).

Through environmental psychology, sense of place also includes the attachment and meaning one has of the place Kudryavtsev, et al, (2012), which further reflects the bond between people and place. The way we perceive places will influence human well-being. It directly links one psychologically to the way individuals feel and interpret an environment. This can be either positive or negative. It is through this lens which one experiences and connects with a place Adams, (2013), and the combination of architecture elements and collective environmental settings, give*a space balance between design and nature.

4.12 Nature & Psychological Psychology

Researchers have focused their studies on the physiological, cognitive, and healing components of human interaction with nature. In Richard's Louv's book Last Child in the Woods: Saving our Children from Nature-Deficit Disorder, (2016) he emphasizes that staying close to nature improves physical, mental and spiritual well-being. Cultures around the world have adopted practices, which have been recorded to improve health conditions. Forest bathing, practiced in Japan, indicates the many therapeutic effects on health. People participating in this practice have: optimum nervous system functions; balanced heat condition; reduced bowel disorder; increased production of anti-cancer and an increased ability to fight terminal diseases. Research done by Yoshifumi Miyazaki, also revealed that this activity resulted in a reduction of 16% in the stress hormone cortisol, 2% drop in blood pressure and 4% drop in heart rate.

Further studies noted by Shern et,al; (2014), specified that "nature walks" provide relief and improvement for people suffering from depression, along with providing mood upliftment. In addition, they have been more motivated, energised and experienced a more speedy recovery, (Berman, Kross, Kaplan, (2012)). A survey launched by Health Parks Healthy people, concluded that:

- Being near to greeneries such as parks, farms, and fields increases outdoor activities and improves mental health and physical fitness.
- Natural urban settings promote social connections and interpersonal communication.

Additional experiments and research have also revealed:

- "Nature connectivity" is linked to stress recovery, Ulrich (1984) and enhances emotional well-being, alleviates feelings of social disconnection, helps mental conditions like attention problems, Kaplan, (1980) and mood disorders, and anxiety including climate anxiety.
- Reduces fatigue (Kaplan 1980).
- Improves conditions such as hypertension, cardiac Illness and chronic pain (Ulrich, 2008).
- Staying close to nature, improves a sense of value towards, more environmentally responsible, better interpersonal relationships and appreciation (Dutcher, et al., 2007).

Miyazaki's experiment on the island of Yakushima in 1990 reveals that immersing oneself into our natural habitat causes healing qualities to be experienced and is a catalyst to well-being.

4.13 Why Nature in Psychology

"In every walk with nature one receives far more than one seeks." - John Muir, 19 July 1877

There has been a growing acknowledgment that daily interaction and integration with nature are beneficial to a more productive, happier and meaningful life, Beatley, (2013). However, Kellert (cited Padayschee, 2014) suggests that despite the development in sustainability and improved design strategies, we still miss the interaction with nature which is critical to human well-being and development. To address the current ecological crises, the intertwining and interdependency of all must be considered, Voigt and Drury, (1997). As Nelson, (1993) explains, the intricate weaving together of nature and culture is like the exchange between living cells and their surroundings which are vital to their existence. Thus, man and nature cannot be seen in isolation to each other.

Figure 110: Walking Through the Forrest
(EFFEKT, 2018)

4.14 Introduction

Wilson, (1984) summed up the key problem that humanity faces, by considering how we are to bring about a better quality of life to 8 billion people, without wrecking the environment entirely in the attempt. Though his hypothesis of Biophilia, Wilson, (1984) suggests that man has a great need for affiliation with nature which promotes emotional contentment and well-being. Subsequent research, (Keller, 2008 and Beattely, 2013) suggests that the creation of built environments which promote psychological and physiological recovery of health can be achieved through the connection architecture has with its natural environment.

An excellent example of the Biophilic design approach can be seen in "Khoo Tech Puat Hospital", in Yishun, Singapore, which opened in 2010. It was planned as a "hospital in a garden and a garden in a hospital" (Alexander Health systems, (2013), cited in Du Plessis and Brandon, (2015), shown in Figure 111.

4.15 Appreciation of Nature

Furthermore, from an environmental paradigm the incorporation of Biophilic design features into architecture inspires interest and appreciation of nature. In turn, shifting their current ideology from one of vain disinterest, to one that stimulates and motivates people to adopt a stewardship role, thus focusing on the protection and perseveration of their natural habitat. In addition Forman, (2012), a professor of landscape ecology, emphasizes that biophilic design also creates benefits to nature, which restores habitats for rare and endangered flora and fauna, enhancing the natural ecosystems.

4.16 Parallel Dimension of Nature to Well-Being

There is a direct correlation between the physical and mental well-being of man and their surroundings, including natural and built environments. Smithson, (1962) confirms this, stating that man first creates his environment that he lives in, which in turns influences him both mentally and physically. MuCurry, (2009) is of the opinion that wellness considerations such as the psychological effects and environmental aesthetics are often ignored or neglected in the design process. Considering the above, Du Plessis, (2000), presents a compelling case for a prerequisite to a sustainable paradigm, in order to address the *"dysfunctional human/nature relationship"* through an interactive partnership aiming to restore and regenerate social-ecological systems incorporating local design and engineering practices.

Figure 111: Brining nature into buildings through Biophilic design
(Alexander Health systems, 2013, cited in Du Plessis and Brandon, 2015)

Figure 112: Teenagers Jumping in the Air at the Beach
(Wang, T. 2016)

4.17 The Presence of Water

The Presence of water is one of the design principals of Biophilia. It has evolved from research on health and well-being benefits, associated with the access and presence of water. The experience of place is enhanced through sight, hearing and touch of water, Browning, (2014). The research identified positive emotional stimuli with environments which contain clean natural water elements, causing improved health as a result of reduced stress, lower heart rate and blood pressure, increased feelings of tranquility and improvement in concentration and memory restoration. Andrews, (2014). It is the bubbling sound of flowing waters and trickling water fountains, a glimpse of a flowing creak or an open expanse of water and the ability to touch, that stimulates ones senses, which, in turn, elicits a desired health response. This is apparent if water is incorporated into design in a deliberate way and is not too powerful.

4.18 What does water mean to us?

Water is an essential element of nature, which all living organisms are dependent on. Without it there would be no life and thereby water becomes an immense symbol of life. The concept of water as a natural element of healing is nothing new. The ancient Greeks viewed water as the highest element with the greatest potential of healing, Ryrie, (1998:20). They had one of the first networks of healing spaces, called Epidaurus, which used water from natural springs in cleaning rituals.

Humanity from the time of creation has surrounded themselves near water, never questioning the health-giving water properties of flowing streams, refreshing waterfalls or welcome down pours of rain. They accepted, respected and treasured the life-giving properties of water, unlike modern society, which has moved away from water and has limited contact to water in their everyday life.

4.19 Water an element of healing

Huelat, (2003) emphasizes that water is not only vital to life but represents the key of healing architecture. Many studies have been carried out to observe the relationship between nature and human well-being by introducing water into the natural setting (Völker and Kistermann, 2011). Ullrich, (1981) was amongst the first to consider water in his studies. His studies indicate that natural surroundings* bring about restorative stress recovery, more than urban ones. However water did not make a significant difference to the results. More recent studies have revealed that water has a more significant effect on restoration than that of green spaces, Korpela, et al., (2010); Völker and Kistemann,(2011), White(2010); Wilkie & Stravridou, (2013). White's (2010) research, indicates that there is a positive and direct correlation between the greater proportion of water in natural environment and perceived restorativeness. This study took into consideration people and objects which previous studies had not. Later studs have further revealed that water has more positive influences on mental wellbeing as opposed to other environments, which was confirmed by, Ulrich, (1981). In addition further studies by Kaplan, (1998), reveals that where water is found, people experience a heightened sense of fascination and mysticism which draws them into these environments.

4.20 Conclusion

Although architecture has come a long way and interventions have slowed down the rate of degradation of our natural environments, design efficiency and performance alone is still not enough to mitigate the negative impacts of our history. Craft, (2012) reiterates the importance of going beyond reactive design and moving towards a transitional regenerative design approach. Beatley and Newman, (2013), support this by presenting the many benefits that a Biophilic approach will contribute to the restoration and regeneration of ecosystems. This is done through the integration and connection of humanity's aspirations and activities with nature. The creation of this symbiotic relationship will be mutually beneficial. Keetley (2016) best describes our choice in the following words: "We have designed ourselves into this predicament, we can design ourselves out of it". Du Plessis and Brandon (2015) remind us that Einstein warned us against the trap of attempting to find solutions within the same thinking, tools and methods that got us into the predicament in the first place. The first step towards a shift in our world view is not in changing technologies but in instilling a new mindset which will bring about a new era of regenerative design. This regenerative design encourages harmony, co-existence and positive relationships between mankind and nature. Consider that "a walk in the park "can elicit a restorative response and the fact that both locally and globally, governments and companies squander millions of Rands on lost productivity due to stress and anxiety related illness. Designing with nature, in particular water, through regenerative design, environmental physiology and Biophilia, is essential to life, work and play in an environment in which its co-existence is dependent on the survival of the natural habitat.

CHAPTER 05

PRECEDENTS

1

The Algae House

Architect: Splitterwerk
Location: Hamburg, Germany
Project Size: 1600m^2
Building Type: Residential
Project Completion: 2013

Figure 113: The Algae House
(Colt, 2013)

2

Khoo Teck Puat Hospital(KTPH)

Architect: Studio 505 in association with CPG Consultants
Location: Yishun Singapore
Project Size: 105 000m^2
Building Type: Hospital
Project Completion: 2010

Figure 114: Khoo Tek Puat Hospital - View from Water
(RMJM, 2011)

3

Manuel Gea Gonzalez Hospital

Architect: Manuel Villagran & Elegant Embellishments
Location: Mexico City, Mexico
Project Size:35 000m^2
Building Type: Hospital
Project Completion: 2013

Figure 115: Smog Eating Hospital Facade
(Elegant Embellishments, 2016)

4

Omega Centre for Sustainable Living

Architect: Bnim Architects
Location: Rheinbeck, New York
Project Size:575m^2
Building Type: Waste Water Treatment
Project Completion: 2009

Figure 116: Omega Centre
(BNIM, 2009)

1 - THE ALGAE HOUSE

5.1 Project Overview

The Algae house is one of the world's first algae powered buildings, which was initially designed for the International building Exhibition hosted in Hamburg in 2013. It consists of 120 integrated Photo-Bioreactors (PBR's) and glass facade mounted panels, which generate renewable energy from algae biomass and solar thermal heat. The 200m²algae facade panel system supplies all the buildings energy needs, while reducing carbon emissions by 6 tons a year (POE).

5.2 Bioreactors

The glass PBR's are installed on the south-east and south-west sides of the building, as illustrated in the plan of Figure 118. This maximises the micro-algae absorption of sunlight, for the cultivation of the algae. The innovative facade integrates additional functionalities, such as dynamic shading and thermal installation. The flat Photo-Bioreactors (PBR's), displayed in Figure 121, according to Arup (2013) are highly efficient for the growth of algae and require very little maintenance. The PBR's consist of four glass layers: a pair double-glazed units (DGU's), which creates a cavity which has a capacity of holding 24l of grow medium. Argon is put into the cavity to minimise heat lost. The outer pane is a white anti-reflective glass, while the inner pane is used as a decorative feature. The PBR's are assembled by a steel U-section frame, which can withstand the static pressure from the water within the cavity. Figure 119 communicates how this Bioreactor system works. Figure 120, illustrates the effectiveness of the PBR's, based on the urban context of Munich. The diagram further shows the effectiveness of the panels and indicates that 40% (200kWh/m²) of the annual heat energy is utilised in the building, through a hydronic heating system, while biomass, is 10% (50 kWh/m² p.a) and is converted into biogas. All the components; heat, biomass and biogas have a combined effect of reducing CO_2 emissions by 0.069 t/m² per annum. According to Arup (2013), the building has an energy efficiency of 27%, which stands in contrast to traditional PV systems which only yield 12% efficiency.

Figure 117: The Algae House - Render
(Arup, 2013)

Findings

- Thermal Comfort
- Energy Production
- Waste Water Treatment
- Biophilia
- Carbon Sequestration
- Technology

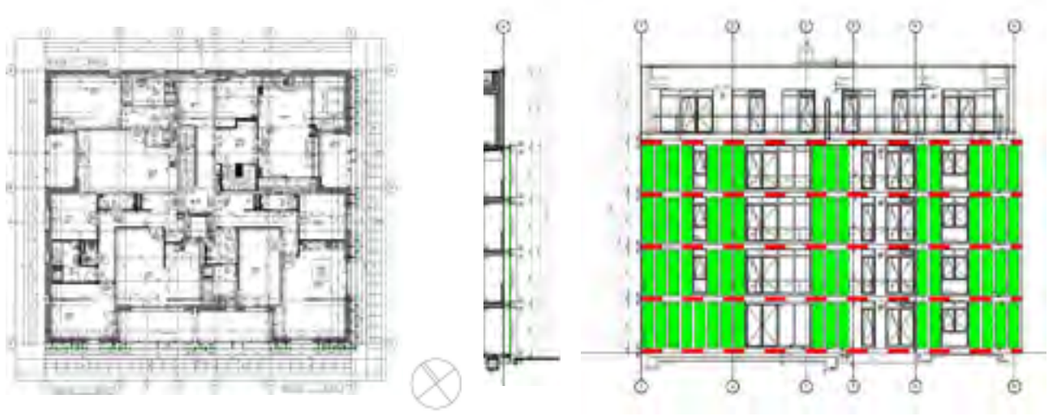
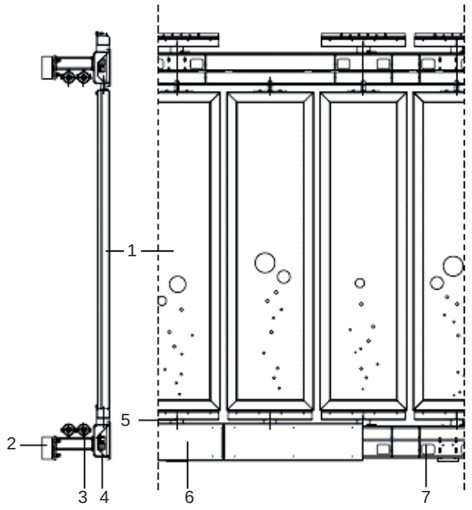


Figure 118: The Algae House - Plan, Section & Elevation
(Arup, 2013)



Key

1. SolarLeaf external louvers
2. Brackets with thermal breaks for the transfer of loads to the primary structure
3. Pipework for the medium to enter and leave
4. Sub-frame and rolled steel U section
5. Pivot fixing allowing rotation
6. Metal cladding
7. Supply of pressurised air controlled by magnetic valves.

Figure 121: Biofacade Panel Section, Elevation & 3D View
(Arup, 2014)

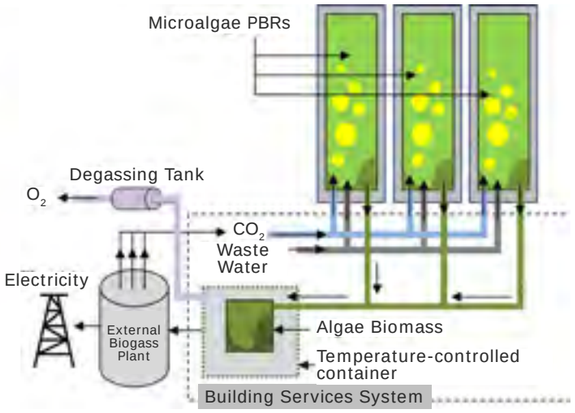
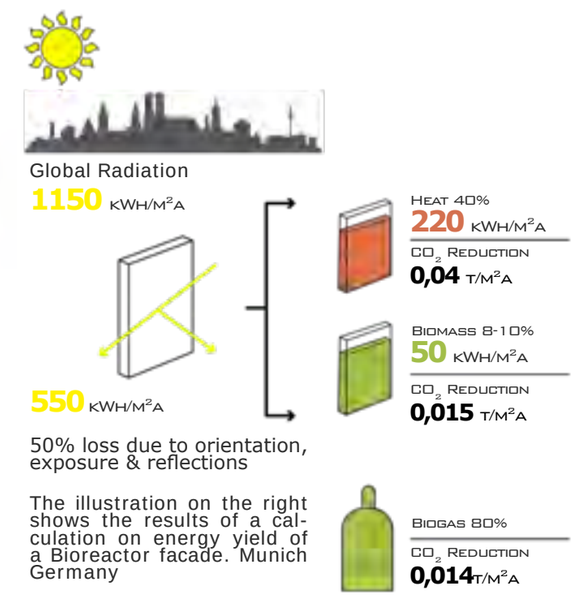


Figure 119: Bio-reactor System Diagram
(Arup, 2014)



The illustration on the right shows the results of a calculation on energy yield of a Bioreactor facade. Munich Germany

Figure 120: Bio-reactor Energy Yeild Results
(Arup, 2014)

5.3 Conclusion

The Algae house, has paved the way for innovative technologies to be adopted that can be used to lower building related emissions. Should this technology be adopted on a large scale, it has the potential to contribute to reducing the Urban Heat Island effect, (Wilkinson, 2016).

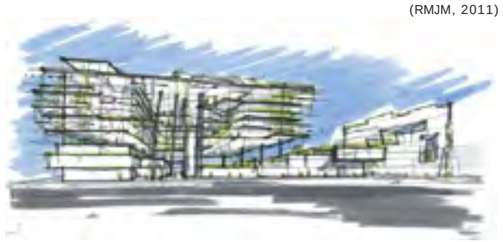
2 - KHOO TECK PUAT HOSPITAL

5.4 Project Overview

The hospital was designed so that a “healing environment” would be created, stimulating the lowering of “one’s blood pressure when one enters the grounds” and enhancing a state of well-being. This was achieved through the application of Biophilia and Environmental Psychology theories. KTPH illustrates the importance of connecting man with nature in a healthcare setting, through its integration of natural elements. The architecture therefore forms positive experiences of tranquility and calmness. It is “forest-like“ and water features are found both indoors and outdoors; along corridors, in open courtyards, and on balconies leading off the patient’s rooms. The “hospital in a garden and a garden in a hospital” is the home of a wide diversity of plants which attract many birds and butterfly species.

Throughout the building, there is the continual connection of man to nature, both visually and audibly, encouraging the occupants to engage with the spatial experiences formed by the gardens as shown in Figure 123. The building’s facade was designed to allow for both natural daylighting and natural ventilation as indicated by Figure 124 and Figure 125. To maximise the natural ventilation and increase thermal comfort, the building is orientated to capture the light cooling breezes from the prevailing Northern and Southern winds. Passive shading strategies with sunshades over the windows, control glare and heat gains. All this reduces the need for mechanical ventilation and reduces energy consumption. In addition this building also brings in the presence and sound of water into the building which adds tranquility and a sense of calm into the interior spaces as well as aiding in the healing process of the patients as shown in Figure 126.

Figure 122: Yishun Community Hospital
(RMJM, 2011)



Findings

Thermal Comfort

Biophilia

Presence of water

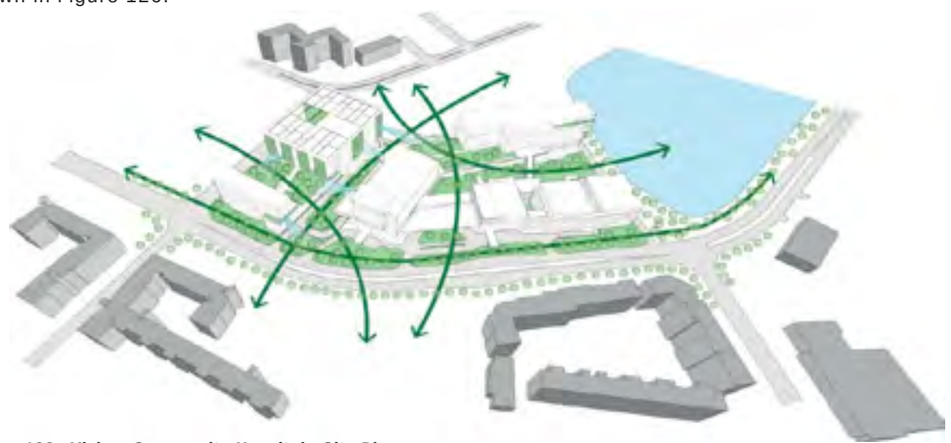


Figure 123: Yishun Community Hospital - Site Plan
Diagram illustrates the green corridors and it’s relationship to water. (Studio 505, 2010)

Figure 124: Facade Shading & Ventilation Diagram
(Studio 505, 2010)

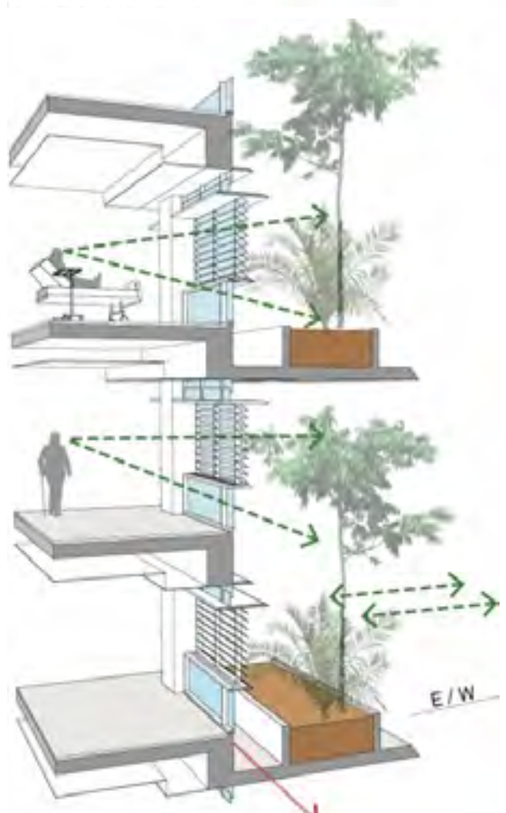


Figure 125: Biophilic Relationship Diagram (Visual Connection)
(Studio 505, 2010)

Figure 126: Waterfall in KTP Hospital
(Unknown, 2011)

5.5 Conclusion

Implementing natural elements, particular water into design, improves psychological and physical behaviour and well-being. Nature and natural elements integrated with spatial experiences can stimulate increased health recovery.

3 - MANUEL GEA GONZALEZ HOSPITAL

5.6 Project Overview

The original Manuel Gea González Hospital was completed in 1942 and was designed by Manuel Villagrán. In 2013 a new medical specialties tower was built with its aim to consider environmental needs of both patient and community. The hospital with its advanced technology, focuses on surgery. A double skin, smog eating facade, made up of pieces of lightweight ABS plastic material, called Pro-solve 370e, covers over 100 meters of the building. The pieces are covered with a thin layer of titanium dioxide (TiO2), and the installation is easy, as it does not require heavy duty machinery to erect the pieces. This material acts as a photo catalyst which causes a chemical reaction when it comes into contact with ultraviolet rays.

This chemical reaction aids in the neutralization of harmful CO_2 emissions as illustrated in Figure 129 and Figure 130. This facade is approximately 250m^2 and is able to sequestrate pollution emitted by 1000 cars per day, therefore significantly improving the air quality in its vicinity. The modularity of these panels allows for complexity in design whilst still being cost effective. The systems clean the air that goes into the hospital and its surrounding areas. The Pro-solve facade panels also acts as a shading device to help reduce the internal heat gains entering the building.

5.7 Material & Technology

Pro-solve in association with Elegant Embellishments has been developing a new building material which is made of carbon that has been extracted from the air. This is done through the uses of biomass which has absorbed CO_2 during its lifetime. Figure 131 indicates a facade panel system which has been produced by this carbon.

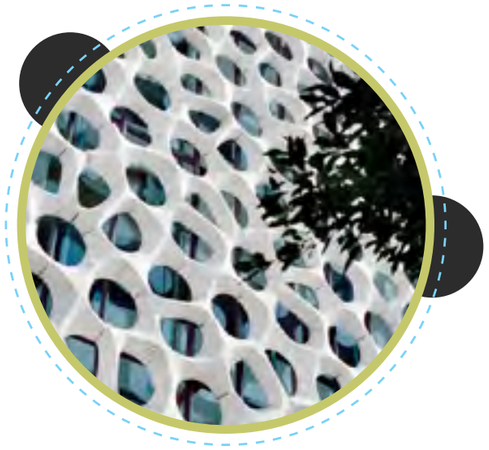
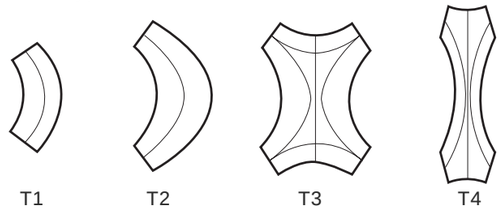


Figure 127: Manuel Gea Gonzalez Hospital

(Elegant Embellishments, 2016)

Panel Types



Findings

Technology

Materiality

CO_2 Sequestration

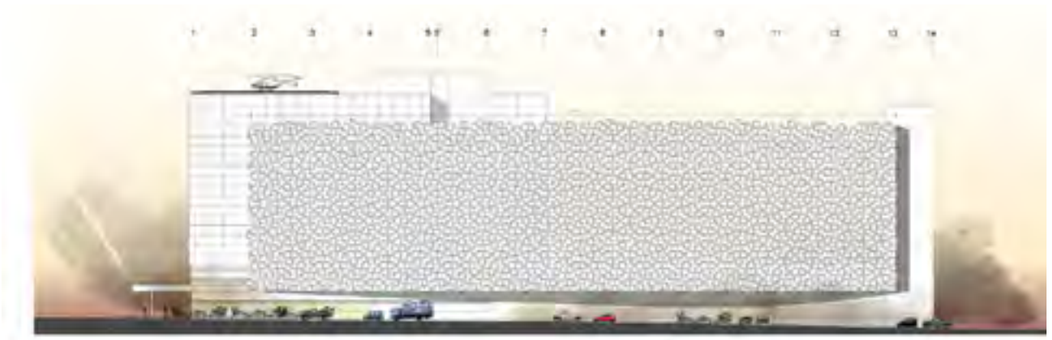


Figure 128: Manuel Gea Gonzalez Hospital - Elevation & Partial Plan

(Pro-solve, 2011)

Figure 129: Smog Eating Facade Diagram

(Elegant Embellishments, 2013)

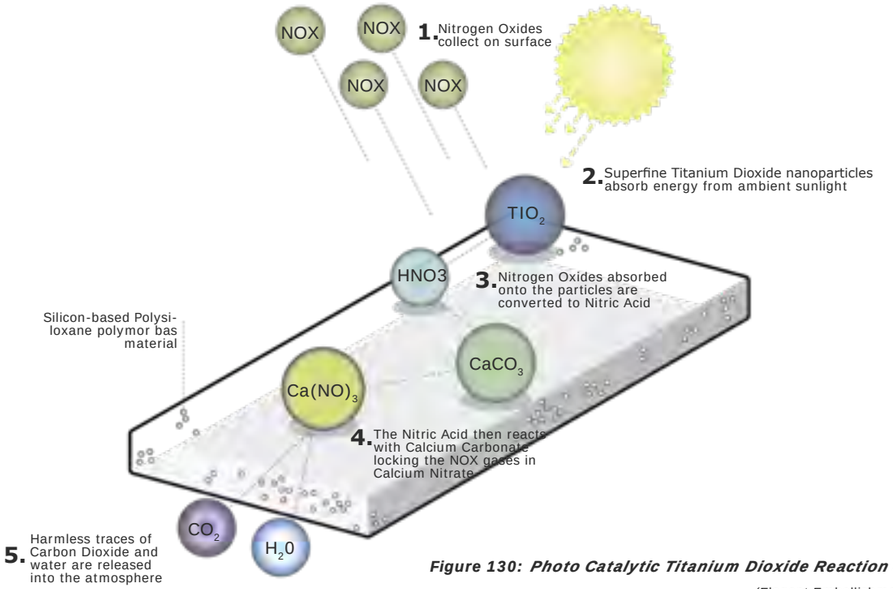


Figure 130: Photo Catalytic Titanium Dioxide Reaction Diagram

(Elegant Embellishments, 2013)

Figure 131: Carbon Negative Material Facade Panel

(Made of Air, 2018)

5.8 Conclusion

The construction and building materials, contribute to around 50% of global emissions, as discussed in prior chapters. The high level of CO_2 emitted from the construction industry is unsustainable, especially since the population trajectory is estimated to increase by 2 billion people over the next 3 decades. Made of Air has developed a Biochar based material, which sequestrates CO_2 directly form the atmosphere and uses organic waste to produce a carbon-negative material facade panel. An additional feature of the facade is that at the end of its life-span, the panels can be shredded and then sequestrated into soil.

A paradigm shift from producing products that generate CO_2 to those that capture and consume CO_2, will certainly go a long way to restoring balance within our ecosystems. It will assist with the reduction of CO_2 in the atmosphere and will restore damage and effects caused through CO_2.

4 - OMEGA INSTITUTE

5.9 Project Overview

To achieve the client's vision and goals for the project, the design team first sought to reduce energy and water requirements throughout the basic design of the building and then to embrace appropriate technologies in an effort to reduce or eliminate negative environmental impact from the required loads.

5.10 Building Form / Design

The building form largely evolves from the practical need to serve the plants that do the work of wastewater treatment in the Eco-Machine as well as to provide an inviting and comfortable place for those who use or visit the building. Early research revealed that typical greenhouse design, attempts simply to maximize the sunlight to the plants. The Omega Centre for Sustainable Living (OCSL) design was informed by the removal of its wastewater disposal system. The 1,371.6m^2 glass greenhouse which houses the water filtration system achieves it's goal by utilizing plants, bacteria, algae, snails and fungi to recycle wastewater into clean water.

Figure 132: Omega Institute
(Ref, Date)

EUI (kbtu/SF/yr)

Energy use compared to average building of it's type

Findings

Thermal Comfort

Energy Production

Waste Water Treatment

Biophilia

Key

1. Septic Tanks
2. Anoxoc Tank
3. Constructed Wetland
4. Aerated Lagoons
5. Sand Filter
6. Surface Dispersal
7. Rain Gardens
8. Rain Cistern
9. Waste water Lagoon
10. Entry Vestibule
11. Learning Lab
12. Pv Collectors
13. Metal Roof
14. Green Roof
15. Wood Rain-screen
16. Automated Ventilation Windows
17. Interior Finishes

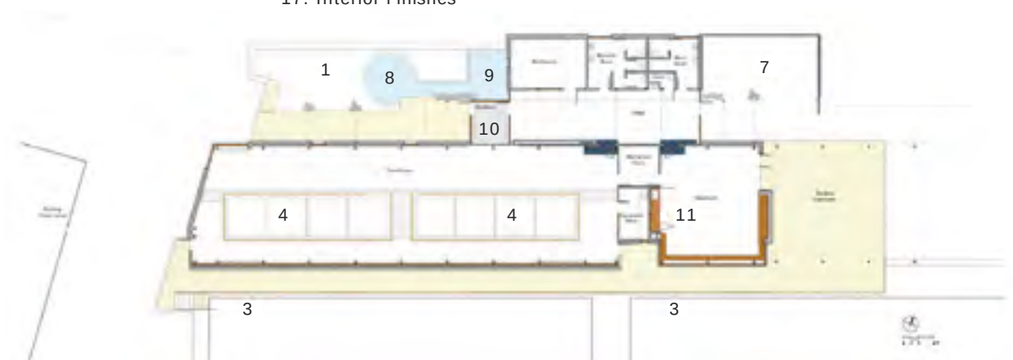
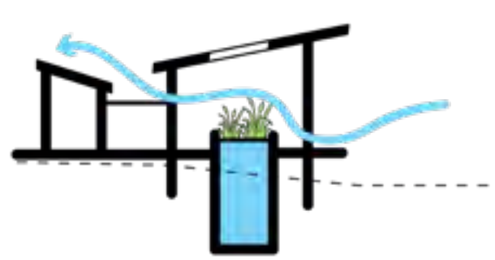
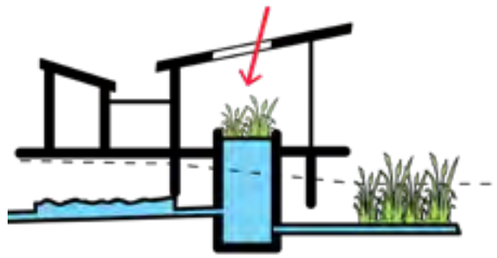


Figure 133: Omega Institute Ground Floor Plan
(BNIM Architects, 2008)



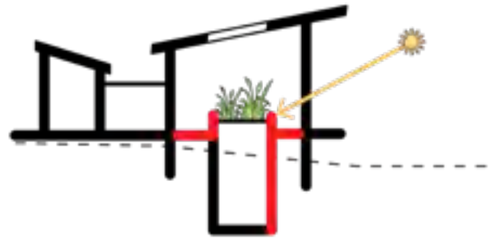
Natural Ventilation



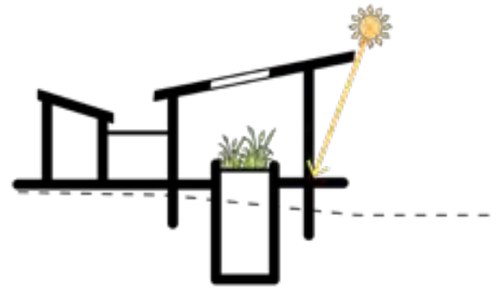
Water Cleaning

Passive Cooling

Daylighting



Passive Heating



Shading

Figure 134: Omega Institute System Diagrams
(BNIM Architects, 2008)

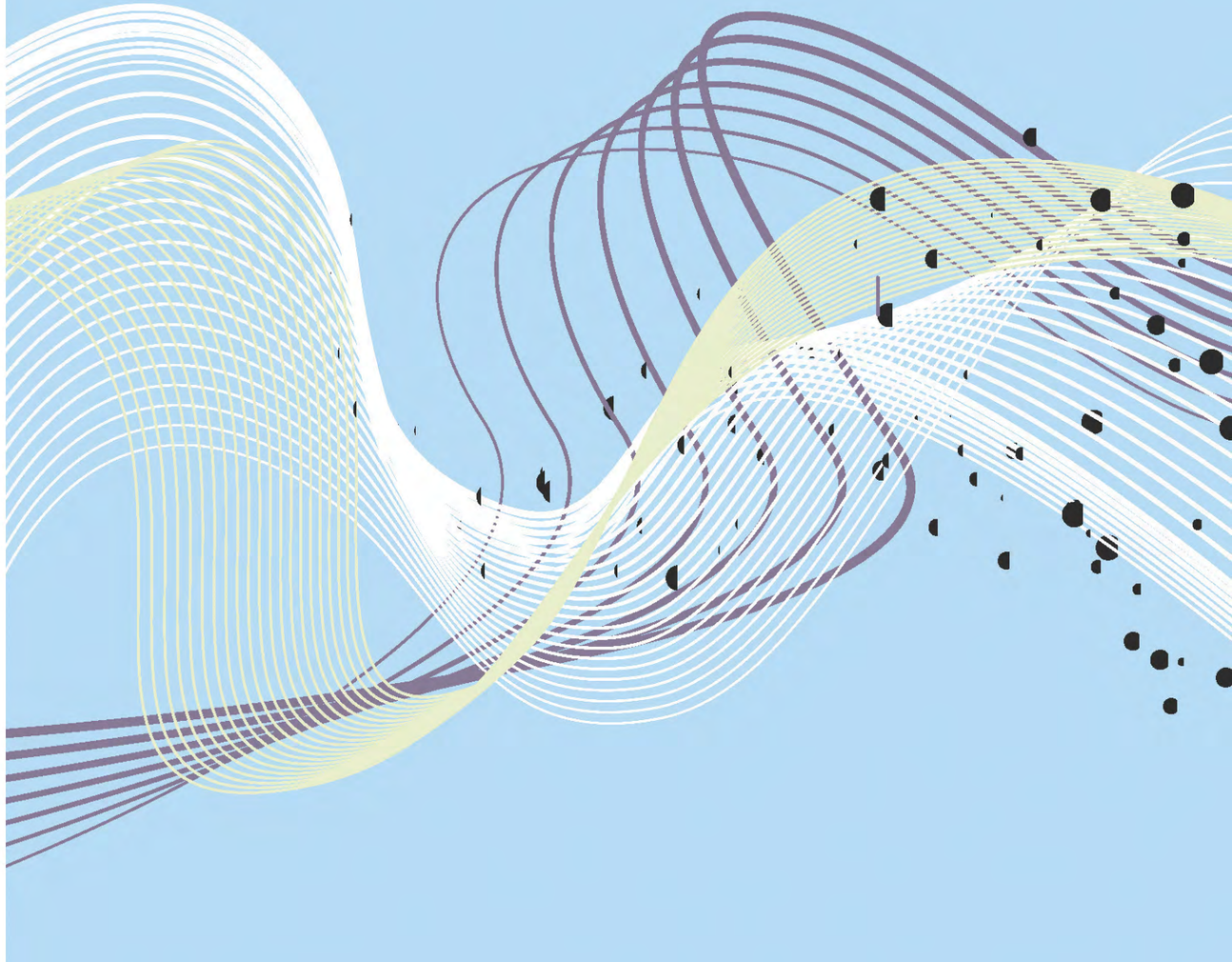
Figure 135: Omega Institute 3D Axo
(BNIM Architects, 2008)

5.11 Conclusion

This project made use of various design principles as per Figure 134 which enabled this project to be successful and achieve a low energy use index (EUI). These basic design principles can be applied to any project in order to achieve a well preforming building.

CHAPTER 06

CONCEPT



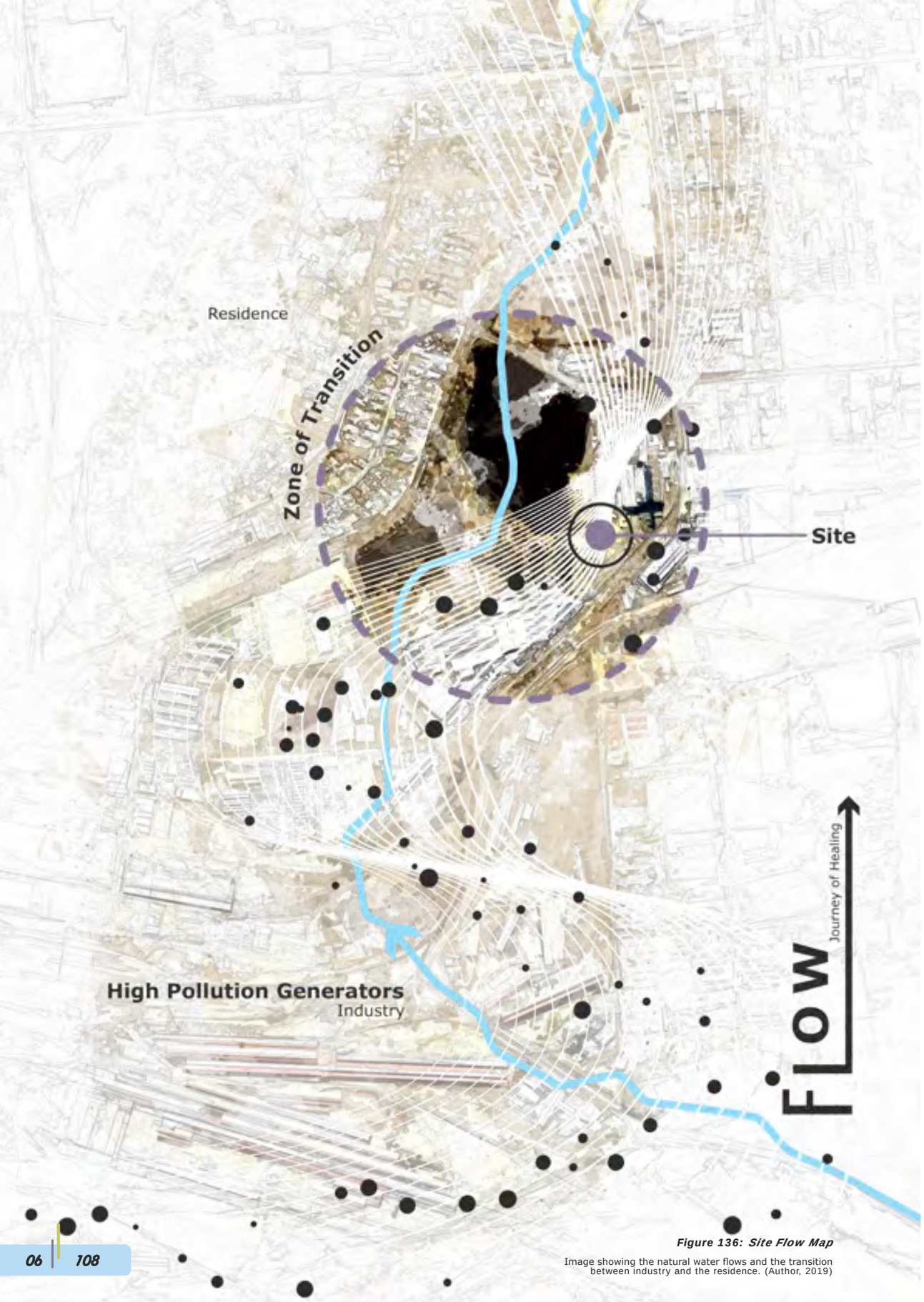


Figure 136: Site Flow Map

Image showing the natural water flows and the transition between industry and the residence. (Author, 2019)

INTRODUCTION

This section of the dissertation deals with the development of an architectural response to the distress caused by climate anxiety, which has been set out in prior chapters. This phenomenon of climate anxiety has been caused through the increasing contribution that human development and its urbanisation activities have had on escalation of greenhouse emissions, decline in natural resources, degradation of ecosystems and health. The aim is to influence our perceptions of industry and ultimately impact previous methods and approaches adopted and applied to industry functions. This in-turn would reduce the negative impacts on the natural environment and address "**Climate Anxiety**".

6.1 Conceptual Driver

The main conceptual driver is in response to the necessary "healing", that both the environment and mankind so desperately needs. **Water**, the fundamental building Block of Life, is the key component required for our revival. It will be utilised to begin about a **"Journey of Healing"**. The natural flow of water is pure and offers far more than just a mere resource. Therefore, an architectural response to utilise water to evoke a user experience, whilst allowing for transition to occur, will be adopted. It is fundamental to incorporate the sound, sight, flow, transition and sheer presence of water, integrated with nature to bring about a cleansing effect. Therefore, neutralising the impact of **CO_2 emissions** and bringing us closer to a state of well-being.

The Pretoria West Power Station and its surrounding context contain many different flows both natural and artificial as shown in Figure 136 and Figure 137. It is believed that the Power Station (despite its prior negative impact) with its abundance of natural resources such as its large water supply, is key to bring about a transformative transition. This transition is both tangible & intangible in nature, in a sense that it becomes the link between the industry and the residence whilst allowing one's mental state to transition from a place of desperation, despair and anxiety to one of relief, peace and rest.

The culmination of productive activities and experiential spaces for healing which is catalysed by water design leads to an economic & social sustainability whilst restorative processes are in effect. This address both the root cause of climate change and the symptoms generated thereof. The design of the proposed architectural intervention will respond to informants which relate to the nature of the industrial site and physical conditions which have resulted from its industrial activities. These informants include:

- The southern industrial belt - which has exacerbated the conditions of climate change through its intensity of its activities which produce carbon emissions.
- The existing water system which comprises of four components: Municipal Water, Natural River Systems, Cooling Tower Water, Sewer and storm water systems

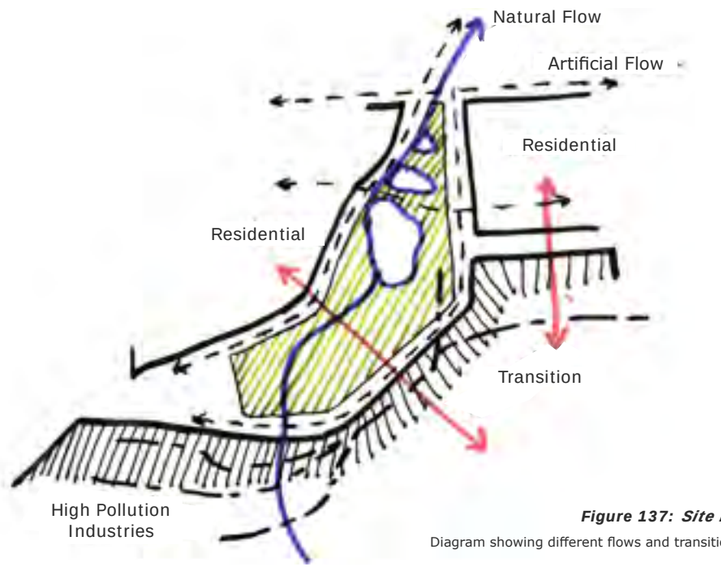


Figure 137: Site Flow Diagram

Diagram showing different flows and transition (Author, 2019)

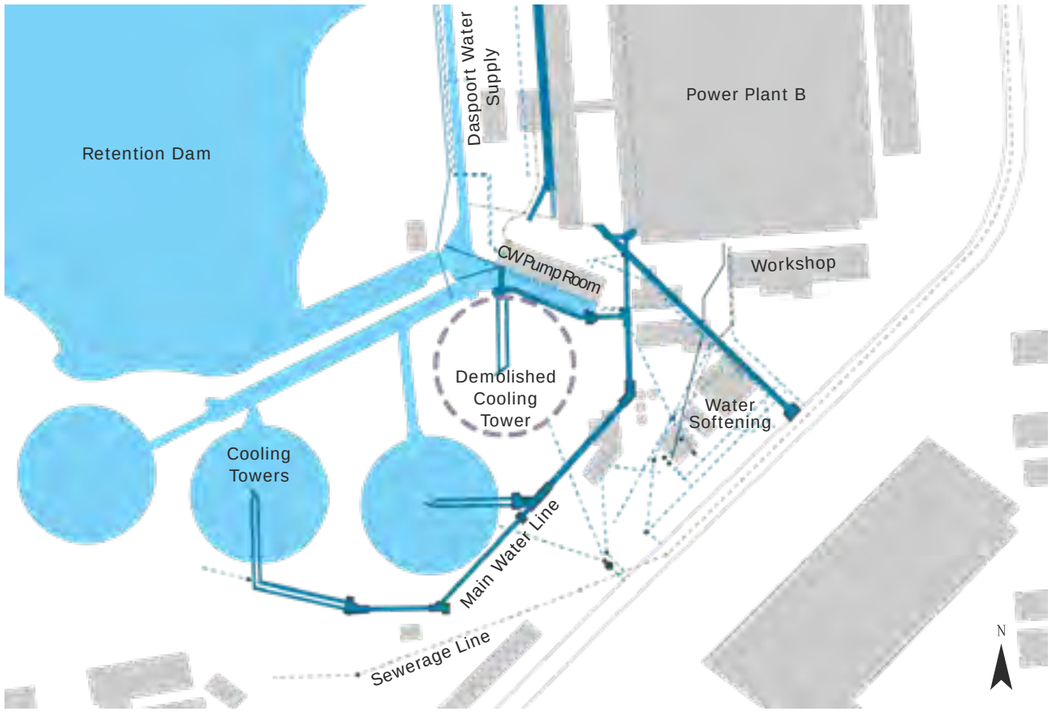


Figure 138: Existing Water Network Diagram

Diagram showing the existing water networks (Author, 2019)

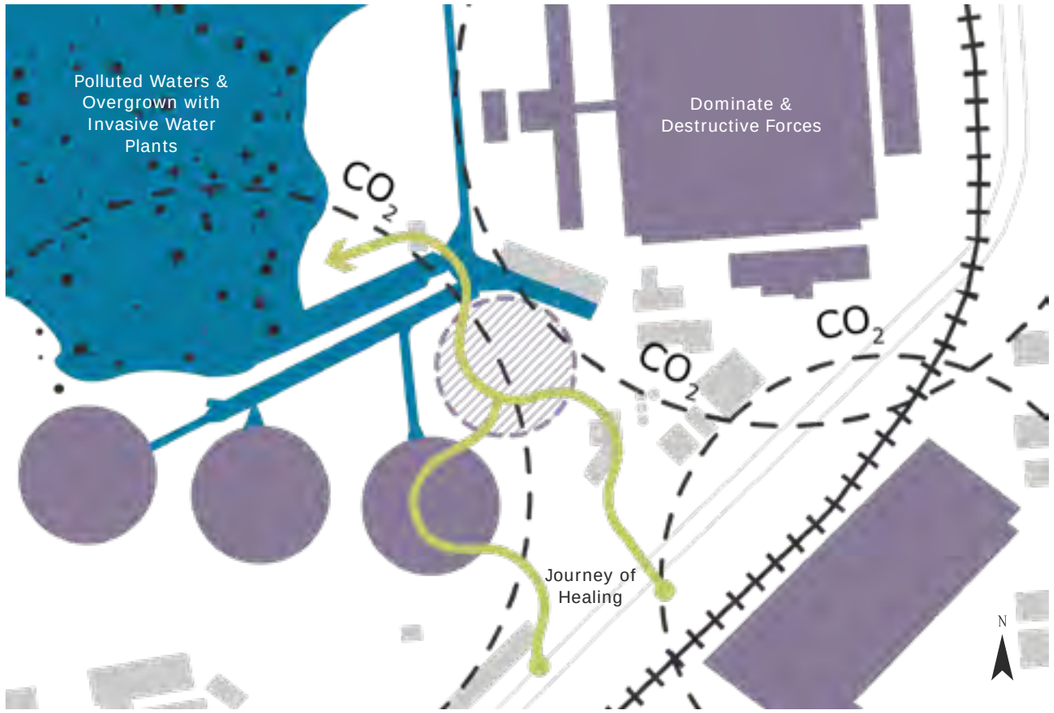


Figure 139: Mechanised Narrative Diagram

(Author, 2019)

6.2 Existing Water Network

The proposed architectural intervention will be situated between the retention dam and the street edge where a cooling tower once stood. This location is ideally situated as it best expresses the transition of decay and destruction to rejuvenation and cleansing. In addition, this position is home to many existing water networks above and below ground as shown in Figure 138, which connects the site to the surrounding urban fabric. In the same way that the old cooling tower became weak and was no longer structurally sound due to its own circumstances, we too have become weak and need repair in order to prevent the inevitability of our own extinction.

6.3 Mechanised representation narrative

The very nature of **industry** is destructive, consuming the planets resources for its own selfish gains. How does the “machine” which is industry repay **Mother Nature**? By polluting her waters, turning the skies black with CO_2, destroying ecosystems and poisoning the earth. That is how industry shows its gratitude. The presence of industry belittles those in its proximity, with its large chimneys and cooling towers standing in dominance over nature. Therefore, the architectural approach is to be in contradiction with the sheer vertical scale of these elements and respond horizontally which speaks to the notion of a **“Journey of Healing”**. In addition, remembering where one has come from gives one purpose and direction to know where we need to be and the achievements necessary to bring about change to making the planet a better place to live in. Figure 139 indicates these dominate forces and areas of destruction on the site.

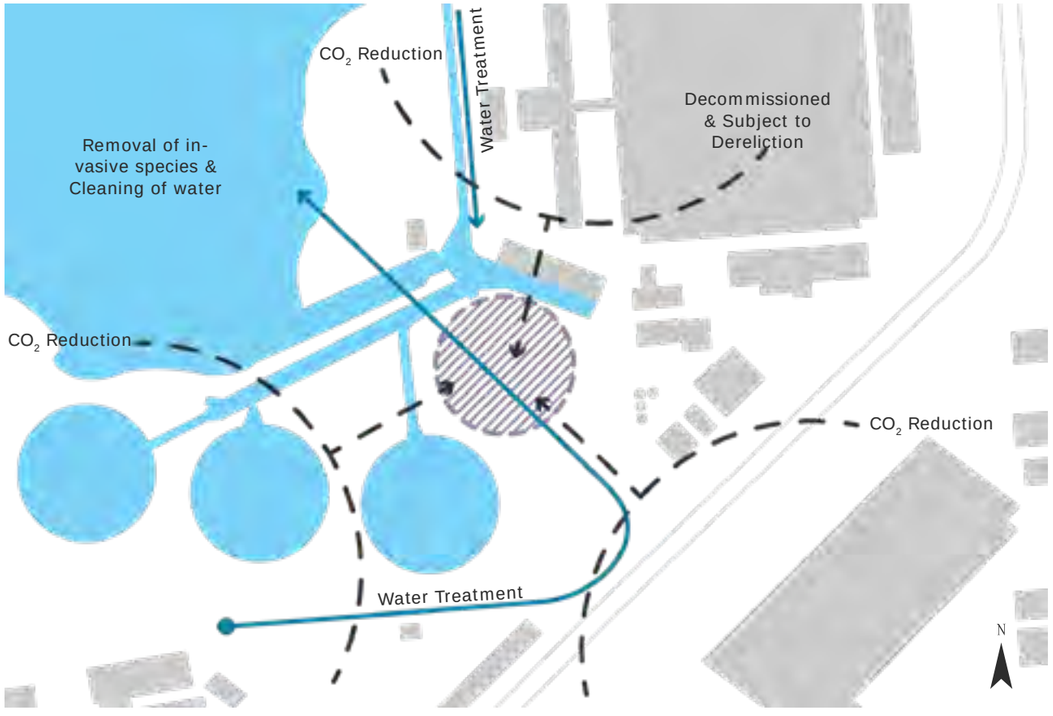


Figure 140: Restoration Narrative Diagram

(Author, 2019)

Figure 141: Awareness Narrative Diagram

(Author, 2019)

6.4 Restoration Narrative

The intervention will encompass the concept of including and blending of natural and non-natural elements, which mimic and simulates natural processes. The aim is to integrate design with natural elements which articulates a shift to a newfound relationship between man and nature. One that within the contexts preserves and replenishes the existing ecological structure. These spaces will be the focus of the architectural intervention as it addresses limiting carbon emissions through the carbon sequestration process, which is facilitated through forestry and through the capturing of carbon for **Spirulina production** and energy production. These spaces will introduce a technological mechanism that is both decorative and functional as it helps to soak up carbon emissions, thereby creating improved air quality and a healthier life. The process for remediation and restoration encompasses the activation of natural water processes to cleanse and treat water and to enhance and improve current aquatic infrastructure.

Water is vital to humanity's very existence. Without water most systems would cease to function. Presenting water as a key component to the design will articulate the relationship of improving some of man's sensory experiences such as touch, sight and hearing. This relationship between nature and humanity's state of mental and physical well-being will be exhibited through the healing characteristics of water. The intervention will deal with three levels of water which will be articulated as followers:

- Above the water – These spaces will reveal the dominant role which man has had over its environments, binging about dereliction and decay to our planet
- The transitional space between above and below- These spaces represents the journey of healing as one move from above to below water levels, to achieve restoration and meaning of life
- Below Water – The below water experience will create spaces of awareness and realisation to the places where we have come from, inability one to transition to a space of restoration and healing.

Studies have suggested the presence of water, though its characteristics of freshness, reflectiveness and clarity, can provide considerable mental health benefits and improve social behaviour. It represents a state of peace, tranquility and calm. As man is drawn to the enigmatic rippling flow of water, the power of the water affects humanity's mind body and soul. The interventions will incorporate spatial experiences where the inhabitants and users can be drawn into this mysteries of water as soothing and rejuvenated environments are created though the bodies and flow of water in and around the site. This intervention will strive to incorporate all the senses of touch, sight, hearing of the rippling water, and will bring about healing though the soothing relaxing and rejuvenating experiences which revitalise and wash away stress, invigorating our life's energies.

The activation of water will be present throughout the intervention and will act as a medium to treat and cleanse water, to assist in the production of food and energy, to improve the health of ecosystems and to improve mental well-being.

6.5 Awareness Narrative

The awareness narrative will present a structure to express an awareness of the interdependency of nature and man. It will express the need to address the symptoms and causes, generated by man's carefree attitude towards nature and its state of well-being. It will provide the opportunity of our generation who are feeling the effects of climate change and anxiety, to do something about it, while there is still a chance. This will further be expressed though the facilities that address health, facilitate training and connect the industrialised process into a holistic approach to restoring and benefiting both mankind and nature.

CONCEPT

This project seeks to create a journey of healing through a series of different spatial experiences. These spatial experiences are based on the stages which one would go through for both physical or emotional grief. These stages are integrated with the restorative healing and cleansing proper ties of different water experiences which are illustrated in Figure 143 & Figure 144.

This Journey of Healing can be interpreted into two main conceptual ideas. These are Transition and Flow. Each of these have their own sub categories. For flow there are direct flows and indirect flows and for transition there are seamless/direct transitions and indirect ones which is represented in Figure 142.

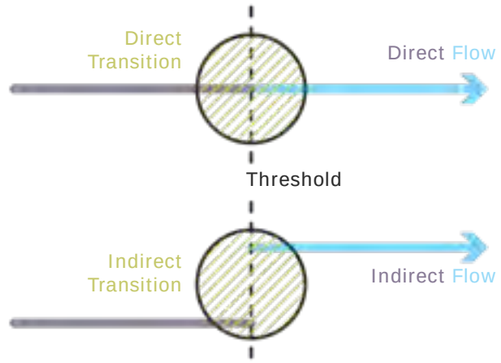


Figure 142: Flow & Transition Concept Diagram

Diagram showing the different transitions and flows (Author, 2019)

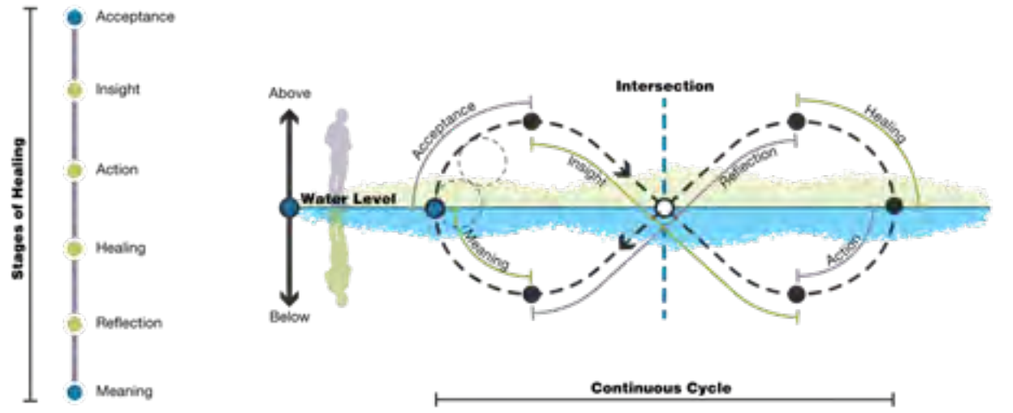


Figure 143: Journey of healing

Diagram the stages of healing and the water relationship (Author, 2019)

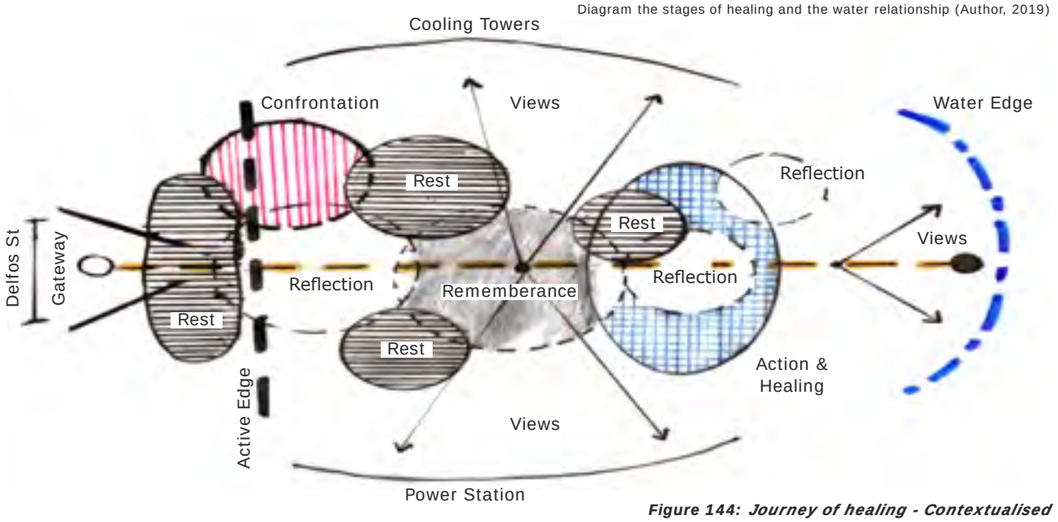


Figure 144: Journey of healing - Contextualised

(Author, 2019)

6.6 Flow & Transition

Flow and Transition are aimed at communicating the process of change from the point of departure, through a series of exchanges which lead to renewal and enlightenment. The state of departure represents the negative impact and harsh realities of the mechanised representation of industries. Although, through a process of water rehabilitation and activation, the state of departure allows for a paradigm shift towards portraying industrialism as an Eco-mechanised representation which not only provides for economic growth and stability but is the catalyst of restoration. Transition therefore represents the stages of transformation from a mechanised representation to an Eco-systemic one. The overlaying themes and journeys will be represented through the flow of water.

The current state of climate change is on a downward path and therefore, if we wish to change our circumstances, we need to alter our current trajectory. This is what is refered to as the apparent transition which results in an indirect flow. On the other hand it is imperative that humanity and nature become one entity and not two separate independent entities. This is the seamless transition which requires a direct flow. Water is the device in which these flows and transitions are expressed.

6.7 Tangible Transition

The intervention will articulate the tangible or the physical transition of dereliction (as indicated in Figure 139 on page 110) to one of rebirth and renewal (as indicated in Figure 140 and Figure 141 on page 112. It will transform a once resource hungry industry to a industry that gives backs to the environments it once took advantage of. It introduces a sustainable productive process which neutralises future risks, eliminating threats posed on the ecological environments, health of our economy and social and individual well-being.

The aim is to utilise the water flow, as the key activation to production, which re-establishes a connection between man and nature by forming a platform where man's reliance is dependent on the success of natural systems. This will assist to minimise threats of potential job losses, stress and anxiety, destruction of ecosystems and increased impacts on climate change. The intervention will introduce a sustainable closed-loop system.

The architectural form will articulate the cultivation and harvesting of Spirulina as a source of food and energy production. Spirulina is a natural algae which is high in protein and a good source of antioxidants, B-vitamins, Omega 3 and other nutrients Phang et al. (2000). Algae are organisms which grow in aquatic environments, using light and carbon dioxide captured on the site to create biomass. The algae tubes will be incorporated on the northern facade and roof. Biofuels are also able to be extracted from the algae which supplies the Biochar and energy production plant.

Not only will the algae cultivated be a source of food but will abate CO_2 emissions in the atmosphere. The intervention herefore generates a better quality of air as it extracts the CO_2 emissions for the production of algae. Additional vegetation will be used as screen walls or for plated rooftop which also aid in the sequestration of CO_2.

The aim of production is thus to integrate design as an extension of nature binding all processes and functions into one element, infusing man and nature as one.

6.8 Intangible transition

The architectural intervention express the "intangible", that which is not seen but felt, that considers the ideas and creates a desire for further exploration. It will ponder on man's newfound awareness and sense of responsibility for nurturing instead of destruction. This process will flow through the water which activates a cleaning mechanism, moving from dirt and destruction to, clean state of body, mind, and soul bringing about a state of well-being as represented in Figure 143 and Figure 144.

Spaces of cleansing are articulated to exhibit the ecological systems at work through the natural wastewater treatment system. This system utilises the network of adjacent wetlands to purify water, which is used in the building and pumped back into the local natural water system networks. The structure will provide for active water reticulation, through the collection of rain and storm water. This will assist in the replenishment of water to the site and local surroundings.

The aim of cleaning as a intangible transition is symbolic of what man must go through to be able to create a living system, which is self-cleansing, self-healing and self-restorative.

The intervention will represent transition through a series of experiences that happen on multiple levels and spaces, be it physical, psychological or metaphorical. The architecture allows the presence of water to convey these experiences, which represents the very need for man's dependency on nature. As the transition and flow of water changes, so does the user's experience, allowing the user to have their own journey.

Today it is clear with the pollution of our atmosphere, dereliction of our ecosystems and depletion of our natural resources, that the Biophilic connection has been lost. The need for regenerative design is imperative, to bring about change and restoration of our natural environments which supports an integrated system-based approach, promoting well-being, rectifying the lost connection between man and its natural environment. The three main drives of the concept, has taken the mechanised approach, to create restoration and awareness, in the hope to re-establish an eco-systemic lifestyle.

6.9 Presence of Water

- Slow moving water creates feeling of tranquility *(lower heart rate, blood pressure and reduces stress).*
- Therapeutic and aesthetically stimulates healing of mind, body and soul.
- Natural fluctuation produces visual stimuli.
- Water sounds create a soothing atmosphere for our minds.

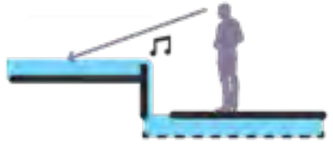


Figure 145: Presence of Water Diagram
(Author, 2019)

6.10 Environmental Connection

- Improves air quality.
- Reduces stress and aggression.
- Visual connection with nature lowers blood
- pressure and heart rate and creates well-being.
- Improves mental engagement and attentiveness *(impacting positively on mental and physical health).*

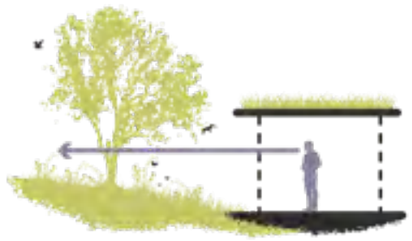


Figure 146: Environmental Connection Diagram
(Author, 2019)

6.11 Levels

- Encourages increased physical activity.
- Creates attractive interactive experiences along circulation routes.
- Provides opportunity for spatial variation and encounters.
- Generates wider perspective.

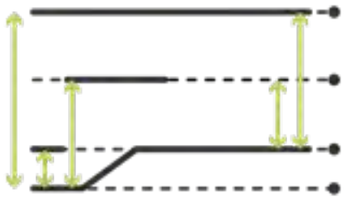


Figure 147: Levels Diagram
(Author, 2019)

6.12 Integration

- Proximity of programs & activities.
- Increase in number of programs.
- Blurs boundaries between various programs.
- Brings about integration of programs, people, heritage, environment & sustainability.

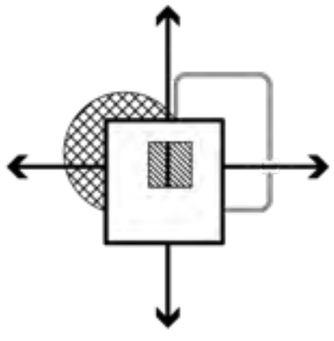


Figure 148: Integration Diagram
(Author, 2019)

6.13 Openness & Volume

- Higher volumes create a sense of freedom.
- Studies show increased mindfulness *(which reduces symptoms of stress, anxiety and depression).*
- Clear line of sight- creates sense of security, connectivity with others and openness to connect.
- Limits social barriers.
- Increases mobility and accessibility.

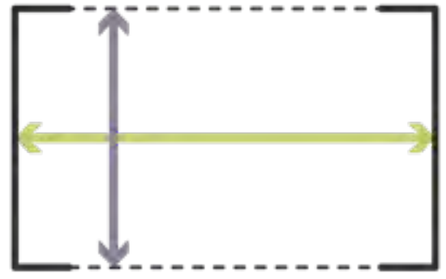


Figure 149: Openness & Volume Diagram
(Author, 2019)

6.14 Natural Lighting

- Provides a sense of comfort and safeness.
- Impacts on performance, mood and well-being.
- Increases visual comfort.
- Creates energy efficiency.
- Creates natural views.
- Creates awareness of and a link to outdoor conditions.

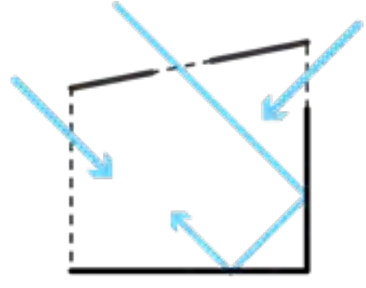


Figure 150: Natural Lighting Diagram
(Author, 2019)

6.15 Colour and Texture

- Increased observation, stimulation and creativity.
- Impacts on behaviour, enhancing performance.
- Articulates connection between spatial experiences.
- Enhances cognitive performance.

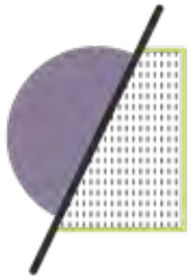


Figure 151: Colour & Texture Diagram
(Author, 2019)

6.16 Concept Summary

The architectural design intention is summed up as: The transforming of an industrial mechanised representation through a series of transitional processes which are achieved by the activation of water to accomplish a state of eco-systemic well-being.

The images shown in Figure 152 - Figure 157, are a set of spacial and form exploration models incorporating the various design principles mentioned.

Figure 152: Spacial Model Exploration 1
(Author, 2019)

Figure 153: Spacial Model Exploration 2
(Author, 2019)

Figure 154: Spacial Model Exploration 3
(Author, 2019)

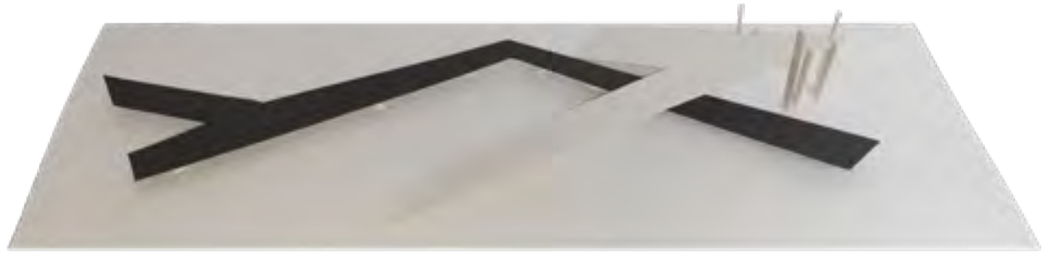


Figure 155: Spacial Model Exploration 4
(Author, 2019)

Figure 156: Spacial Model Exploration 5
(Author, 2019)

Figure 157: Spacial Model Exploration 6
(Author, 2019)

CHAPTER 07

DESIGN DEVELOPMENT

DESIGN BY WATER

7.1 Introduction

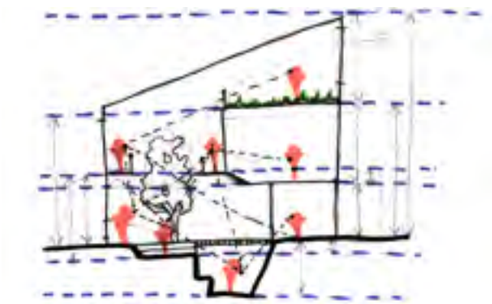
"Water is a natural material with an unchanging identity, wherever it appears in architecture or nature. If we can effectively incorporate water's symbolism, history, and physical nature, then our water and architecture can have a potential for wonder unmatched by any other material that we can include in our environments." (Moore, 1994: 199)

In this section, the development of an architectural response set out in Chapter 3 and explored through the theories in chapter 4, will be outlined. The aim of the architectural response is to incorporate the "healing process" into the design of both internal and external spaces, to create spatial experiences that promote healing and well-being.

This chapter will further develop on the concept stipulated in the previous chapter. Three Main design iterations will be illustrated and critically evaluated, demonstrating the transformation of the design from concept to final realisation. In summary the design's main driver is that of water. This is due not only to the abundance of water on their site but also due to the healing and therapeutic.

Figure 158: Sun Set View Over the Water
Left, (Burns,L. M., 2017)

INITIAL CONCEPT EXPLORATION



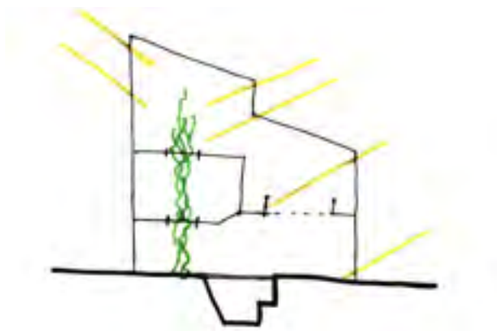


Figure 160: ***Spatial Sketch Design 2***
(Author, 2019)

Figure 159: ***Spatial Sketch Design 1***
(Author, 2019)

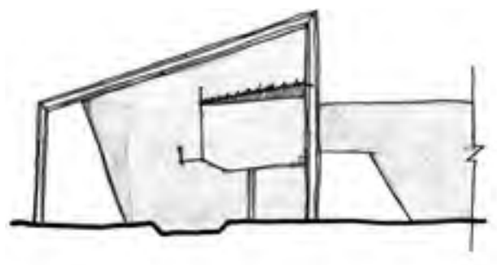


Figure 161: ***Spatial Sketch Design 3***
(Author, 2019)

Figure 162: ***Spacial Model Exploration 1***
(Author, 2019)

Figure 163: ***Spacial Model Exploration 2***
(Author, 2019)

Figure 164: ***Spacial Model Exploration 3***
(Author, 2019)

ITERATION 1

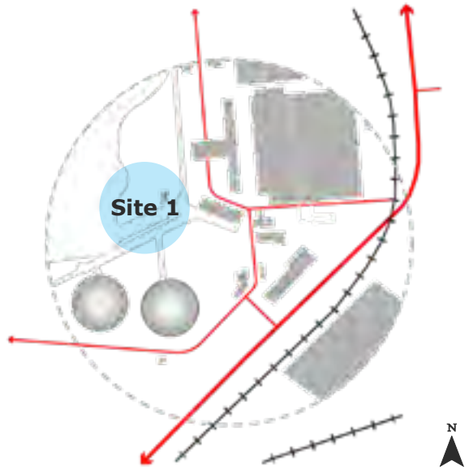


Figure 165: Iteration 1 - Locality Plan
(Author, 2019)

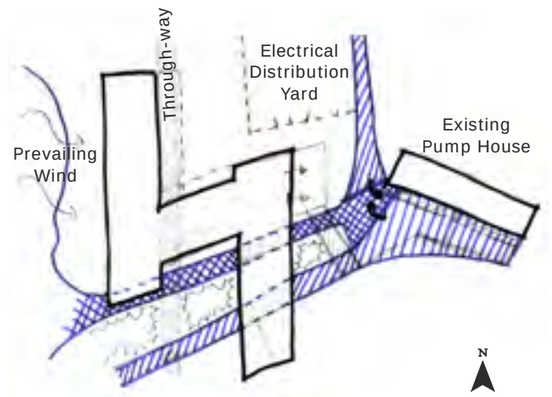


Figure 166: Iteration 1 - Plan
(Author, 2019)

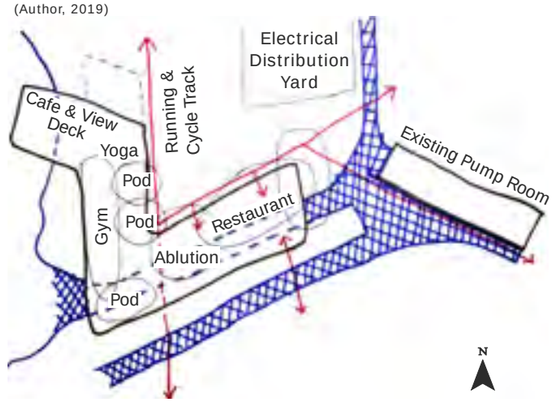


Figure 167: Iteration 1 - Plan
(Author, 2019)

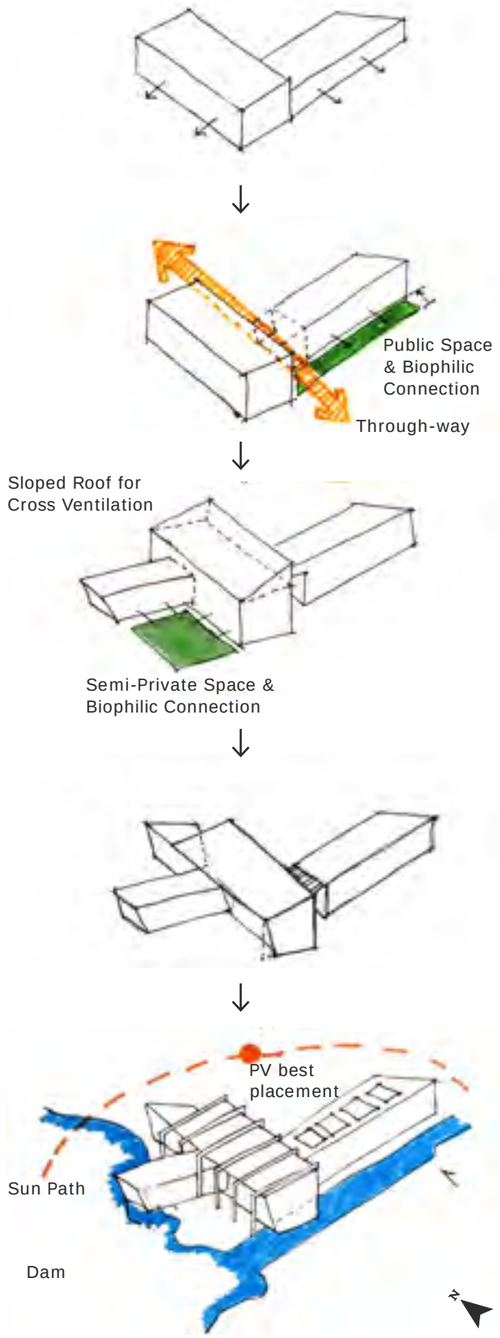


Figure 168: Iteration 1 - 3D Development Diagram
(Author, 2019)

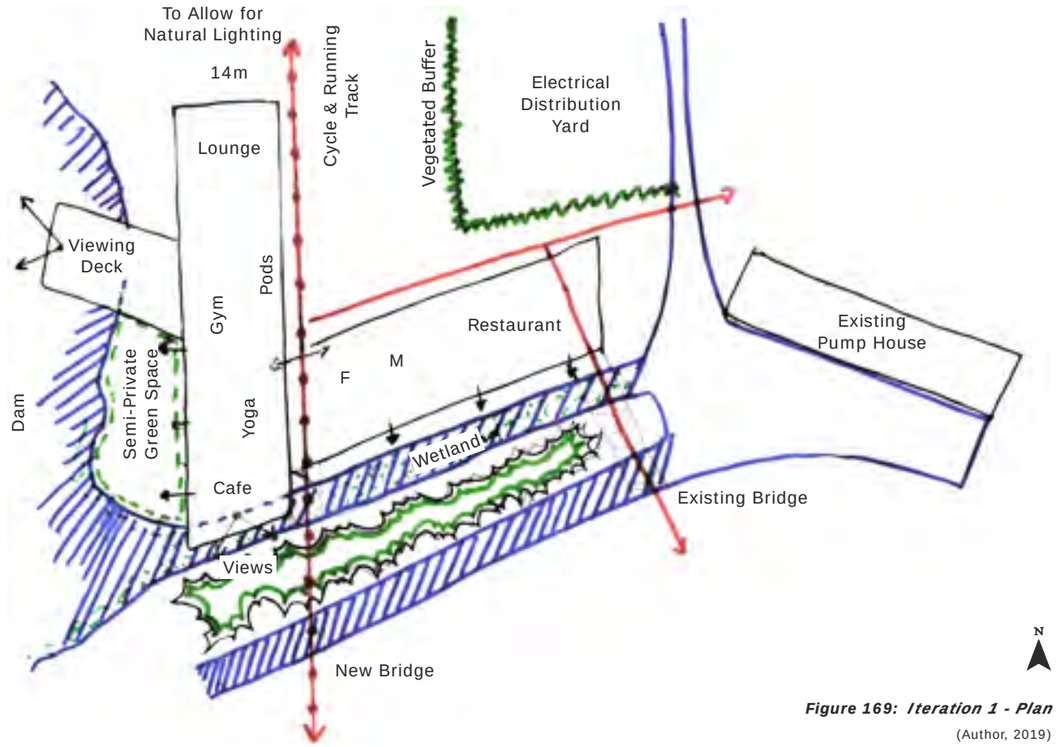


Figure 169: Iteration 1 - Plan
(Author, 2019)

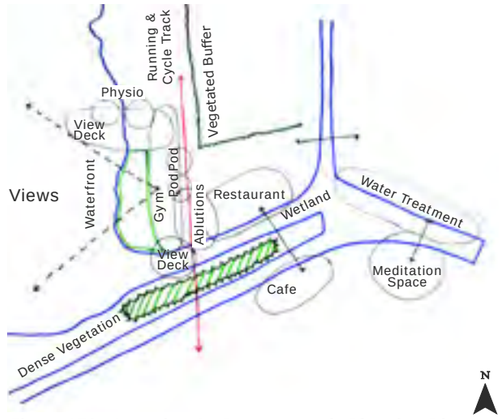


Figure 170: Iteration 1 - Programmatic Planning Diagram
(Author, 2019)

7.2 Evaluation

The design proposed responded to those aspects of regenerative design, Biophilia and environmental psychology, which consider the surroundings and its environment. This influences one's behaviour and emotional response to the environment. The various aspects which promote healing and well-being were considered during the design process and are as follows

- The "presence of water", for its characteristics of power and brain stimuli, and tranquility and calming effects.
- Connection to nature through a series of spaces, creating public and semi-private spaces for rest and reflection.
- Introduction of activities which encourage engagement, connection and awareness.
- Feeling of safety and comfort.
- Promotion of physical stimuli though various level changes.

The initial site was chosen due to its proximity to the large body of water, which would allow for more natural views. In addition, it had a good connection to the existing water infrastructure. It also responded to some climatic factors, specifically that of the wind. The prevailing winds come from a North Western direction which blows across a large body of water. This is important as it forms part of the summer cooling strategy and promotes good natural ventilation.

The building's form responded to the surrounding infrastructures. The aim was also to create both public spaces and more private spaces to allow for resting and reflection to occur as part of the healing process. The one disadvantage with the buildings orientation & placement was that it did not benefit as much from the sun in winter. Despite the various advantages this site proposed, it ultimately was too isolated from its surrounding context The design program changed, making it necessary to move the site to one having better access and connection to the existing water infrastructure and to the urban framework.

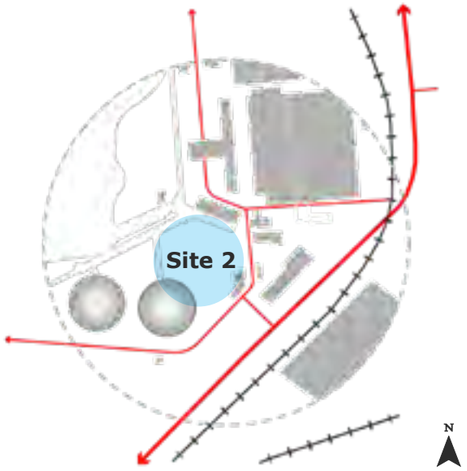


Figure 171: ***Iteration 2 - Locality Plan***
(Author, 2019)

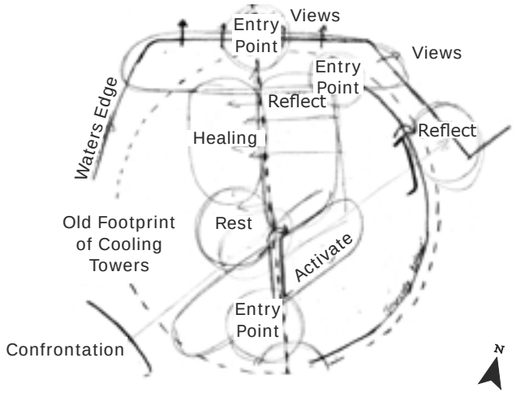


Figure 172: ***Iteration 2 - Space Planning Plan Diagram***
(Author, 2019)

Figure 173: ***Iteration 01 - Plan Layout 1***
(Author, 2019)

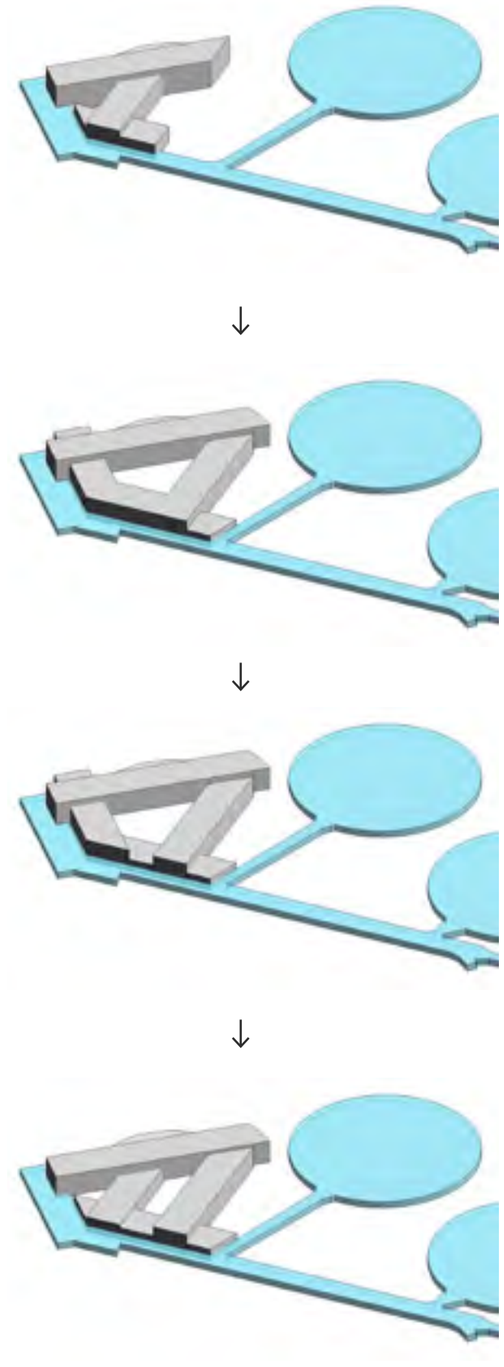


Figure 174: ***Iteration 2 - 3D Development Diagram***
(Author, 2019)

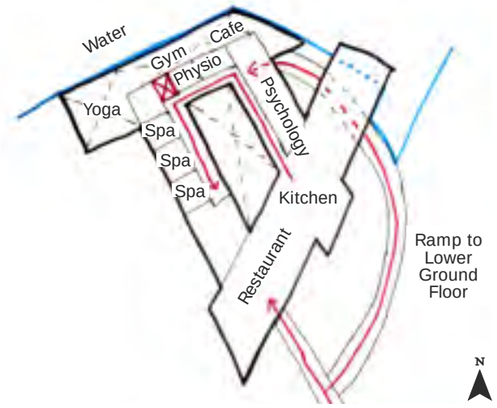


Figure 175: ***Iteration 2 - Programmatic Plan Layout 2***
(Author, 2019)

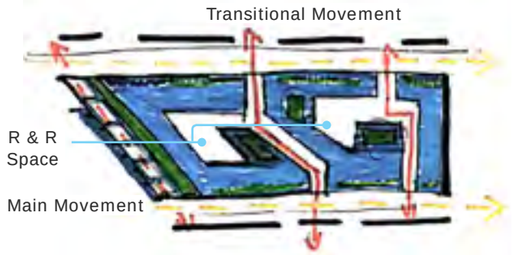


Figure 176: ***Iteration 2 - Resting/Reflection/Transition Space***
(Author, 2019)

7.3 Evaluation

This site location is not as isolated as the previous one, but still has proximity to the existing water infrastructure. It is located between the existing pump house and the cooling towers as indicated by Figure 171. It is also situated where the old cooling tower once stood. This tower was demolished due to its poor structural integrity.

This iteration better relates to project intentions as it explores the journey of healing through a series of different spatial experiences. It also utilises the symbolism of the old cooling tower which represents the negative impacts that industry has had on its environment. The project therefore flips this around, taking something, which is overpowering and above nature and sinking it below or within nature, taking the user on a journey of healing from being above water, transitioning through it, being below it and then emerging having been “healed”.

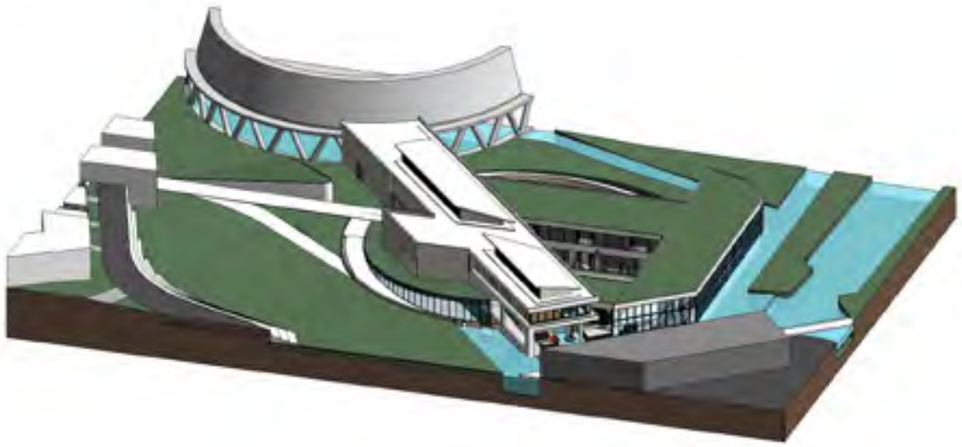


Figure 177: Iteration 2 - 3D Axo View 1
(Author, 2019)

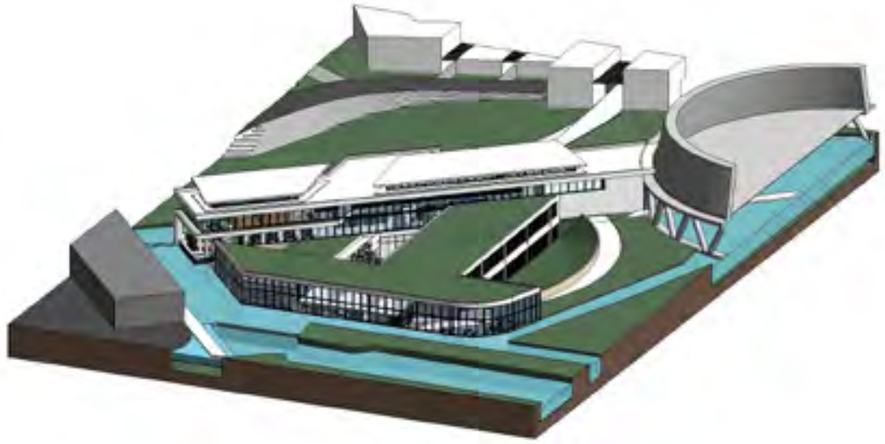


Figure 178: Iteration 2 - 3D Axo View 2
(Author, 2019)

Iteration 2 - Section
(Author, 2019)

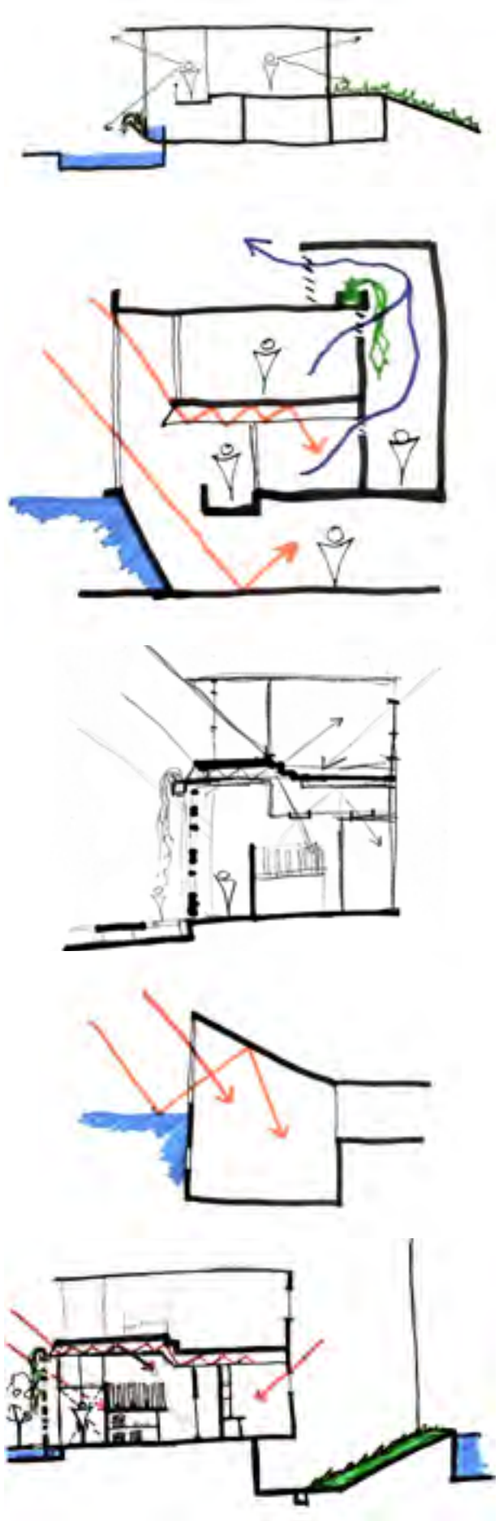


Figure 179: Iteration 2 - Sketch Design Section
(Author, 2019)

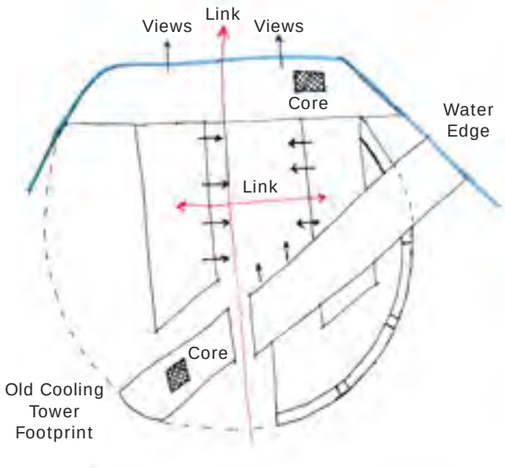


Figure 180: Iteration 2 - Plan
(Author, 2019)

Figure 181: Iteration 2 - Section Diagram
(Author, 2019)

Although this iteration may have been successful in some respects, in terms of program, it did not relate to its surrounding context. The building program directly related to the issue of climate anxiety by using the following:

- Gym & Physio Therapy - to address the impacts on physical health,
- Psychology consultation rooms - to address the impacts on mental health,
- Restaurant and Nutritional consultants - to address the impacts on both physical health and mental health in terms of the social aspects.
- Spa & Yoga - to address the impacts on all three aspects being body, mind and soul.

The Pretoria West region remains an important manufacturing industry, to the City of Tshwane and is a significant driver of the City's economics, City of Tshwane, (2016). This region will remain a key contributor to the high levels of CO_2 emissions. It was therefore necessary to change the programme, as the initial programme had failed to address the root cause of CO_2 emissions and find appropriate solutions to the reduction of the Carbon footprint in Pretoria West.

INITIAL DESIGN - FLOOR PLANS

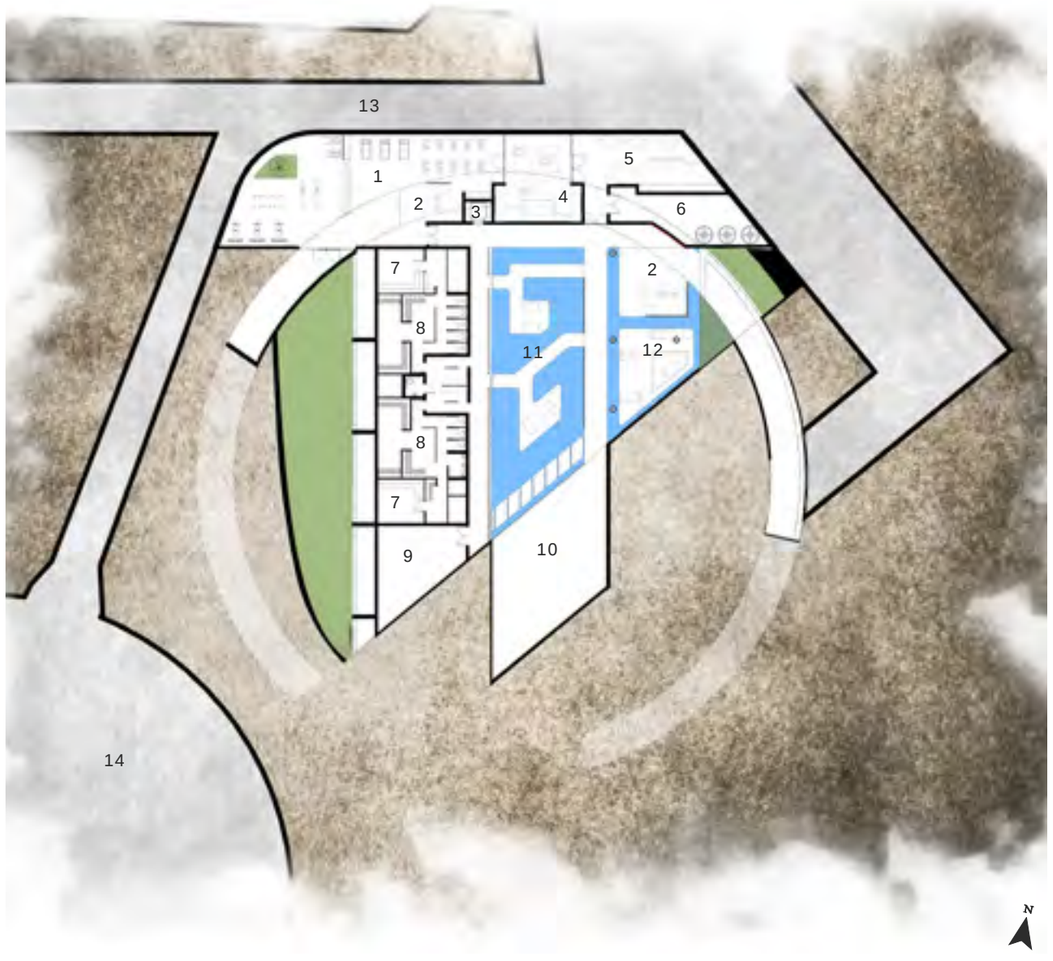


Figure 182: Initial Design - Lower Ground Floor Plan
(Author, 2019)

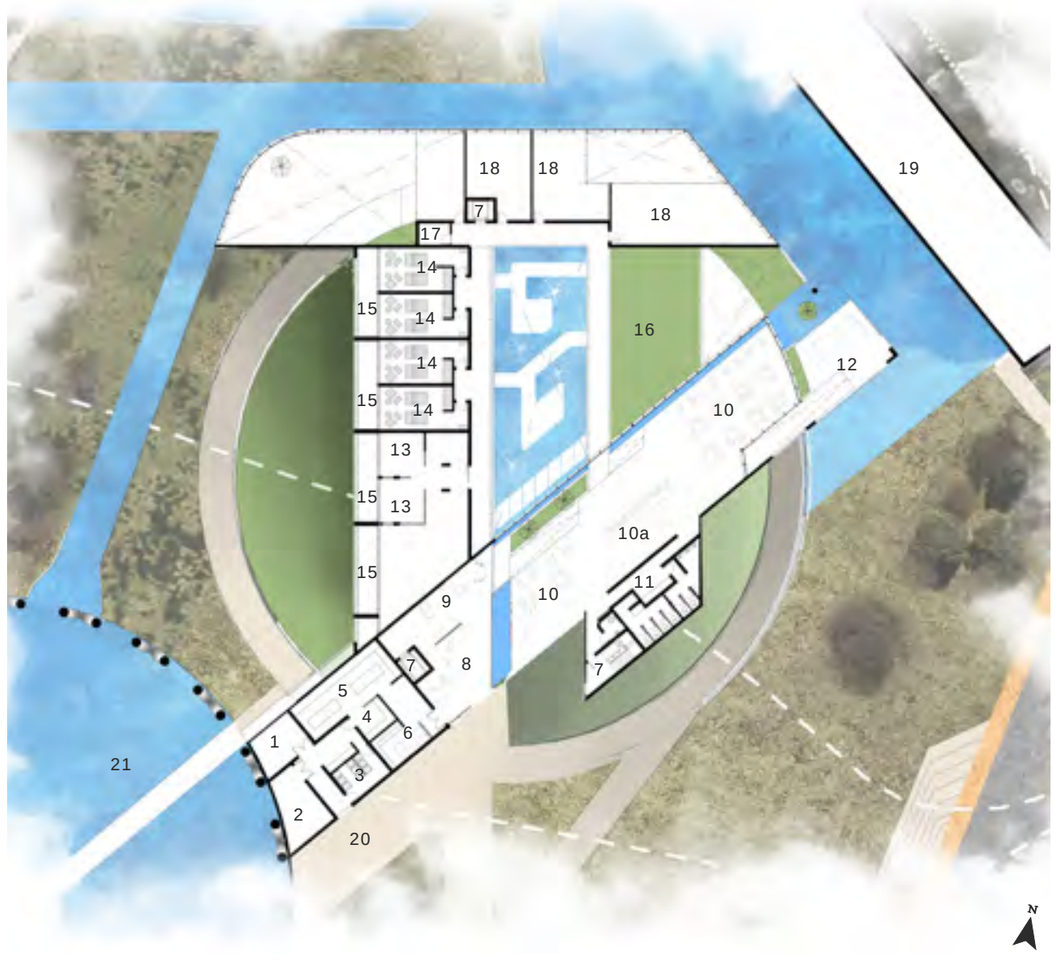


Figure 183: Initial Design - Ground Floor Plan
(Author, 2019)

Key

1 - Gymnasium
2 - Reception
3 - Vertical Access
4 - Yoga Room
5 - Cafe
6 - Pump Room
7 - Sauna
8 - Ablutions
9 - Store
10 - Dance Hall / Studio
11 - Rest & Reflection Space
12 - Waiting Area
13 - Existing Water Channel
14 - Existing Cooling Tower

Key

1 - Dry Store
2 - Cold Store
3 - Refuse
4 - Wash Area
5 - Kitchen
6 - Break-out Area
7 - Vertical Access
8 - Reception
9 - Waiting Area
10 - Eating Area
11 - Ablutions
12 - Rest & Reflection Space
13 - Relax Area
14 - Massage Room
15 - Balcony
16 - Planted Roof Top
17 - Store
18 - Psyio-theorpy Room
19 - Existing CW Pump Room
20 - Service Yard
21 - Existing Cooling Tower

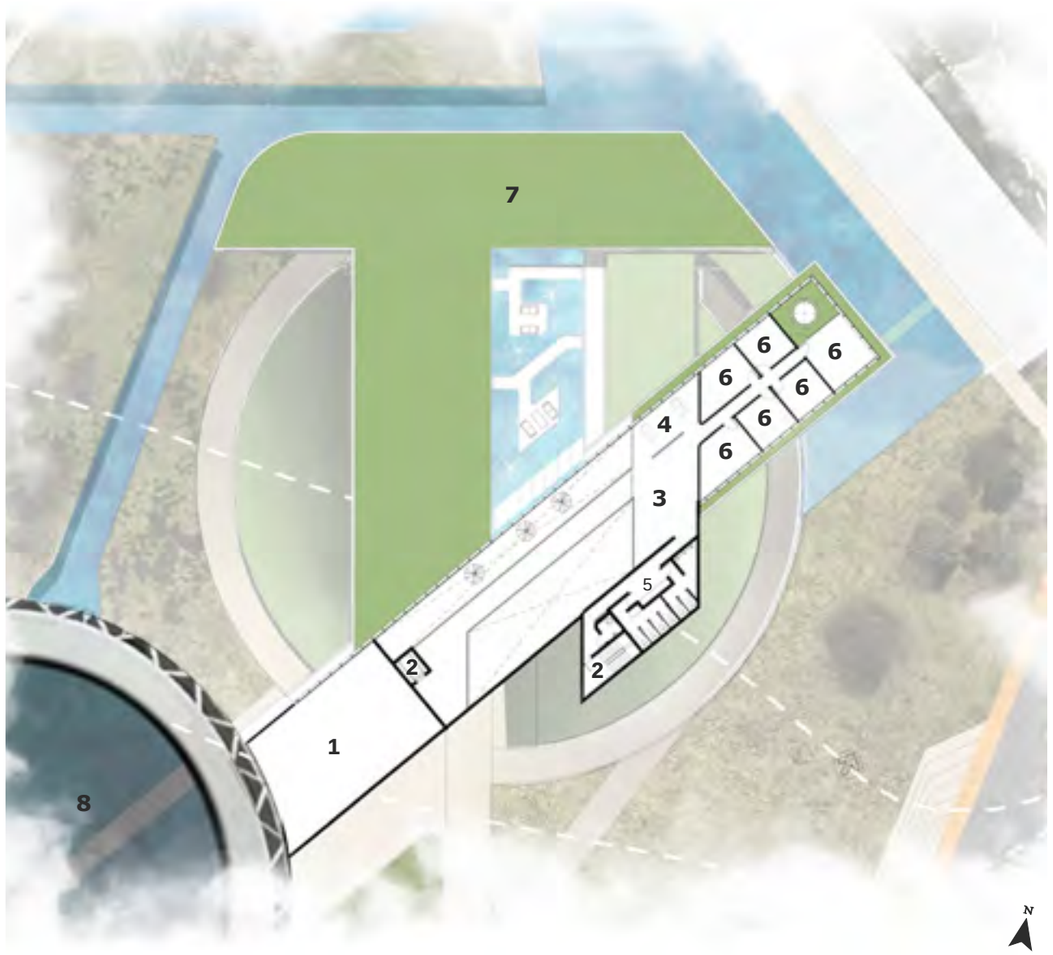


Figure 184: ***Initial Design - First Floor Plan***
(Author, 2019)

Figure 185: ***Initial Design - Roof Plan***
(Author, 2019)

Key

1 - Kitchen
2 - Vertical Access
3 - Reception
4 - Waiting Area
5 - Ablutions
6 - Psychology Room
7 - Planted Roof Top
8 - Existing Cooling Tower

INITIAL DESIGN - SECTIONS

Section A-A

Key

1 - Rest & Reflection Space
2 - Passage
3 - Psychology Consultation Room
4 - Reception
5 - Eating Area
6 - Dance Hall / Studio
7 - Reception
8 - Break-out Space
9 - Dry Store
10 -
11 - Cooling Tower

***Figure 186:** Initial Design - Section A-A*
(Author, 2019)

Section B-B

Key

1 - Reception & Waiting Area
2 - Planted Roof
3 - Rest & Reflection Space
4 - Ablutions
5 - Spa Room
6 - Balcony

***Figure 187:** Initial Design - Section B-B*
(Author, 2019)

Section C-C

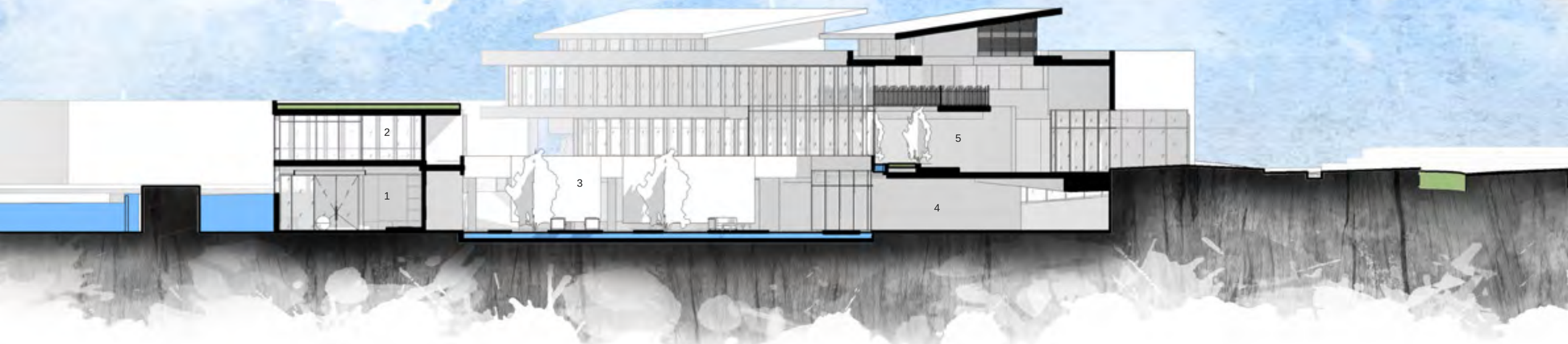
Key

1 - Gymnasium
2 - Psyio-thearapy Room
3 - Yoga Room
4 - Cafe

Figure 188: ***Initial Design - Section C-C***
(Author, 2019)

Perspective 1

Section D-D



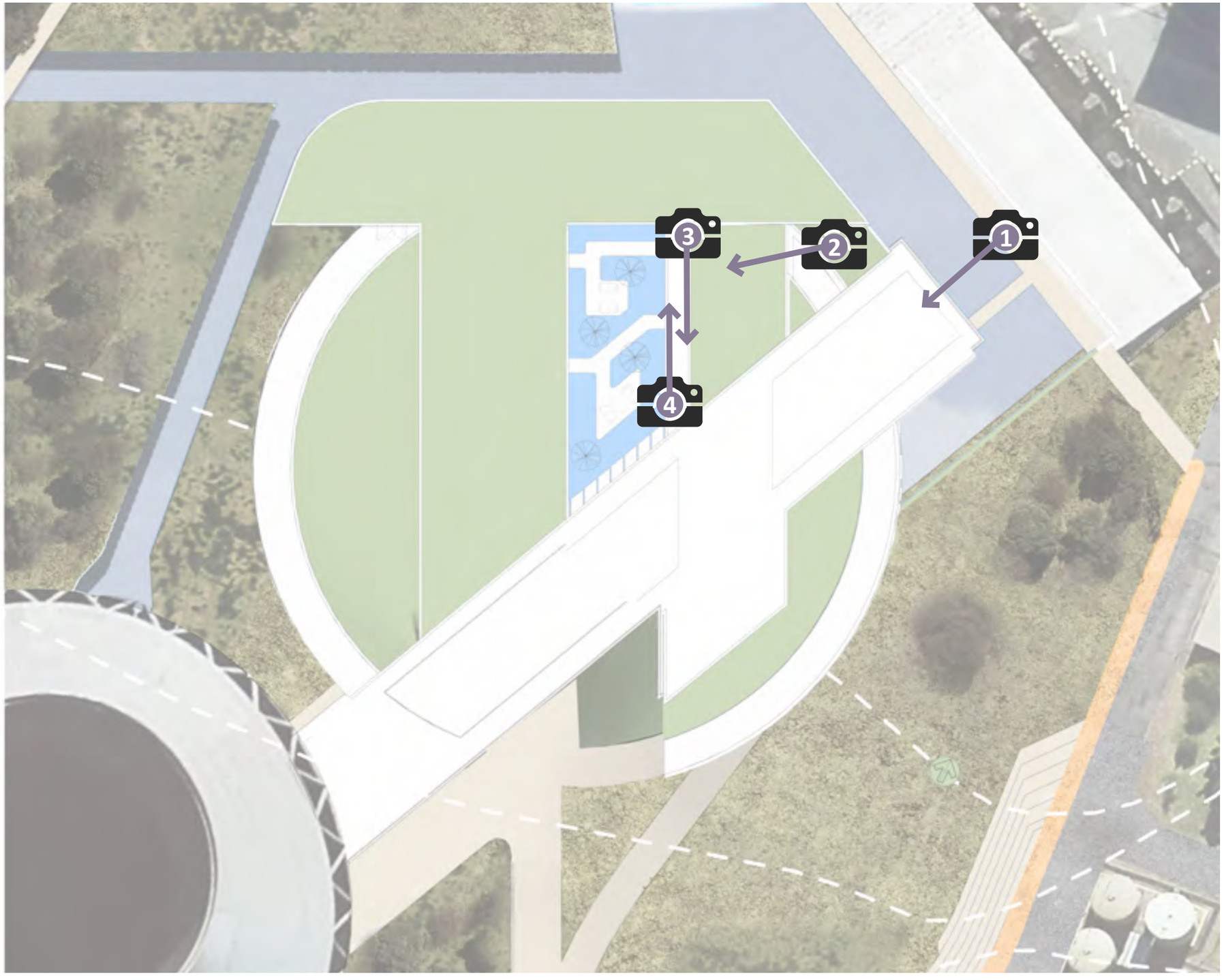
Key

1 - Yoga Room
2 - Psyio-thearapy Room
3 - Rest & Reflection Space
4 - Dance Hall / Studio
5 - Eating Area

***Figure 189:** Initial Design - Section D-D*
(Author, 2019)

INITIAL DESIGN - PERSPECTIVES

Figure 190: ***Initial Design - Site Plan - Indicating Perspective View Points***
(Author, 2019)



Perspective 1

Figure 191: ***Initial Design - Exterior Perspective 1***
(Author, 2019)

Perspective 2

Figure 192: ***Initial Design - Exterior / Interior Perspective 2***
(Author, 2019)

Perspective 3

Figure 193: ***Initial Design - Exterior / Interior Perspective 3***
(Author, 2019)

Perspective 4

Figure 194: ***Initial Design - Exterior / Interior Perspective 4***
(Author, 2019)

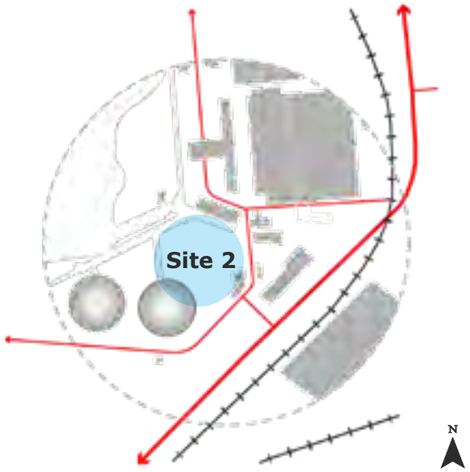


***Figure 195:** Iteration 3 - Locality Plan*
(Author, 2019)

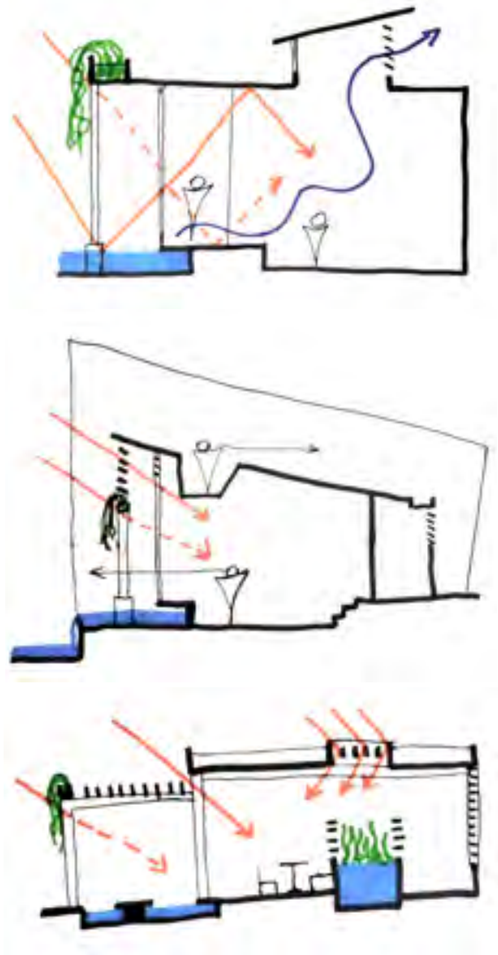


***Figure 197:** Iteration 3 - Sketch Design*
(Author, 2019)

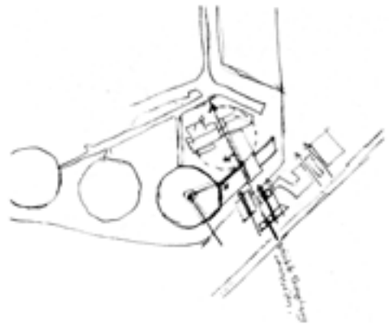


***Figure 196:** Iteration 3 - Context Plan*
(Author, 2019)

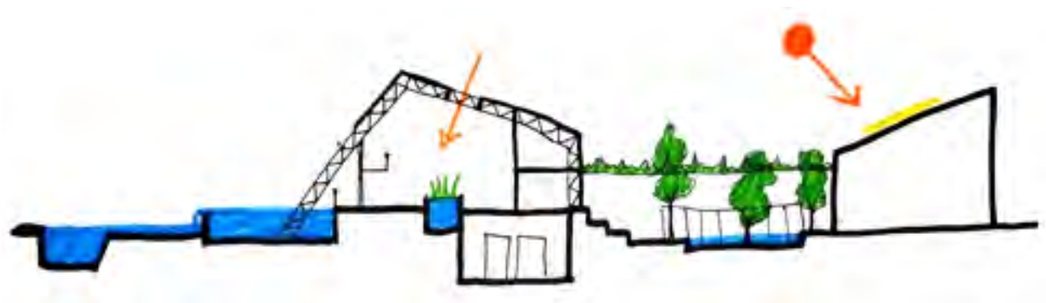


***Figure 198:** Iteration 3 - Section*
(Author, 2019)

***Figure 199:** Iteration 3 - Building Placement Plan*
(Author, 2019)

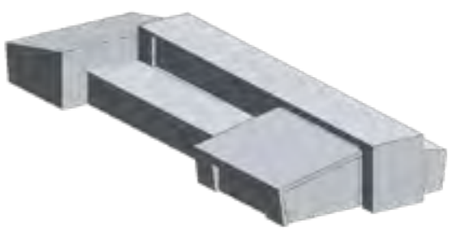


***Figure 200:** Iteration 3 - 3D Massing Development Diagram*
(Author, 2019) Building A

7.4 Evaluation

This iteration addresses the root cause of climate change (being CO_2 emissions) whilst also ddressing various aspects of climate anxiety. The building utilises water as a medium by which to bring about change and restoration. Through the introduction of the building's primary programs, which are Spirulina and Biofuel production, harmful CO_2 emissions are absorbed and the impact of climate change is reduced.

This iteration aims to address climate anxiety through two methods. The first deals with the root cause which is CO_2 emissions. The second creates a journey for healing to occur through spatial experiences, which allows for confrontation, reflection, resting and relaxation. A series of private, semi-private and public spaces are used. In all types of spaces, water is used as the catalyst for healing. These spaces incorporate a visible and audible connection to water and include spaces which are above water, spaces transitioning through water and spaces below water.

As per the design principles set out previously, this

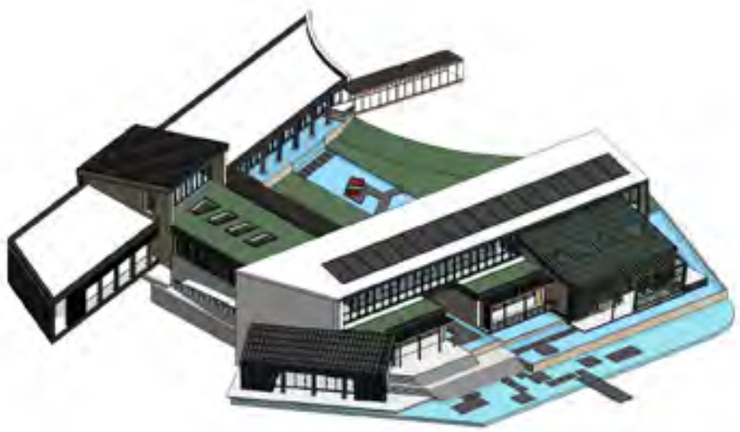


Figure 201: Iteration 3 - 3D Axo View 1
(Author, 2019)

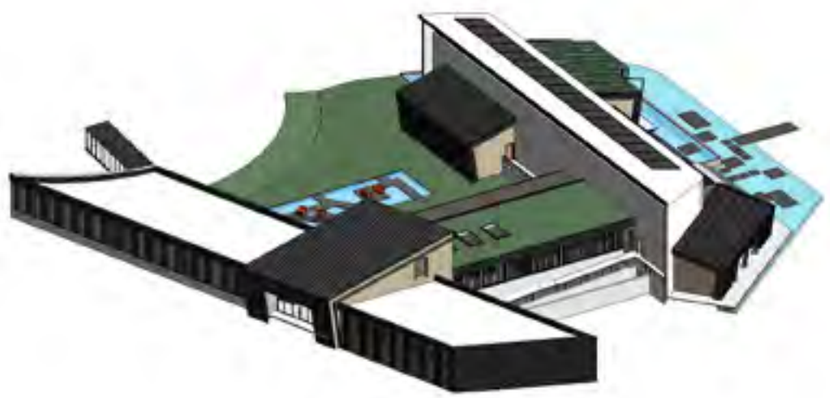
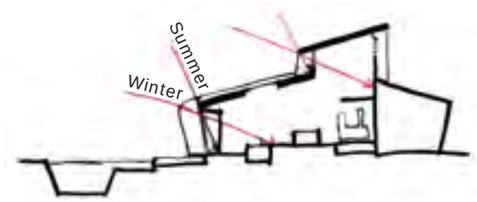
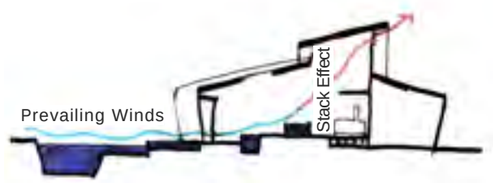


Figure 202: Iteration 3 - 3D Axo View 2
(Author, 2019)



Sun Angles & Heating

Daylighting



Natural Ventilation & Cooling

Energy

Carbon Sequestration & Algae Cultivation

Figure 203: Iteration 3 - Sustainable Design Diagrams
(Author, 2019)

iteration better responds to natural lighting, presence of water, levels etc. As per Figure 217 and Figure 197, the relationship to water and nature, whilst incorporating level changes and natural lighting, is explored in various ways.

Figure 203 illustrates the various strategies utilised in order for this iteration to perform well in terms of energy, lighting, heating, cooling and systems used to sequestrate CO_2. It is for all these various reasons that this iteration best responds to the needs of the area and the global issues of climate change and climate anxiety.

FINAL DESIGN - MASTER PLAN

Figure 204: Final Design - Master Plan
(Author, 2019)

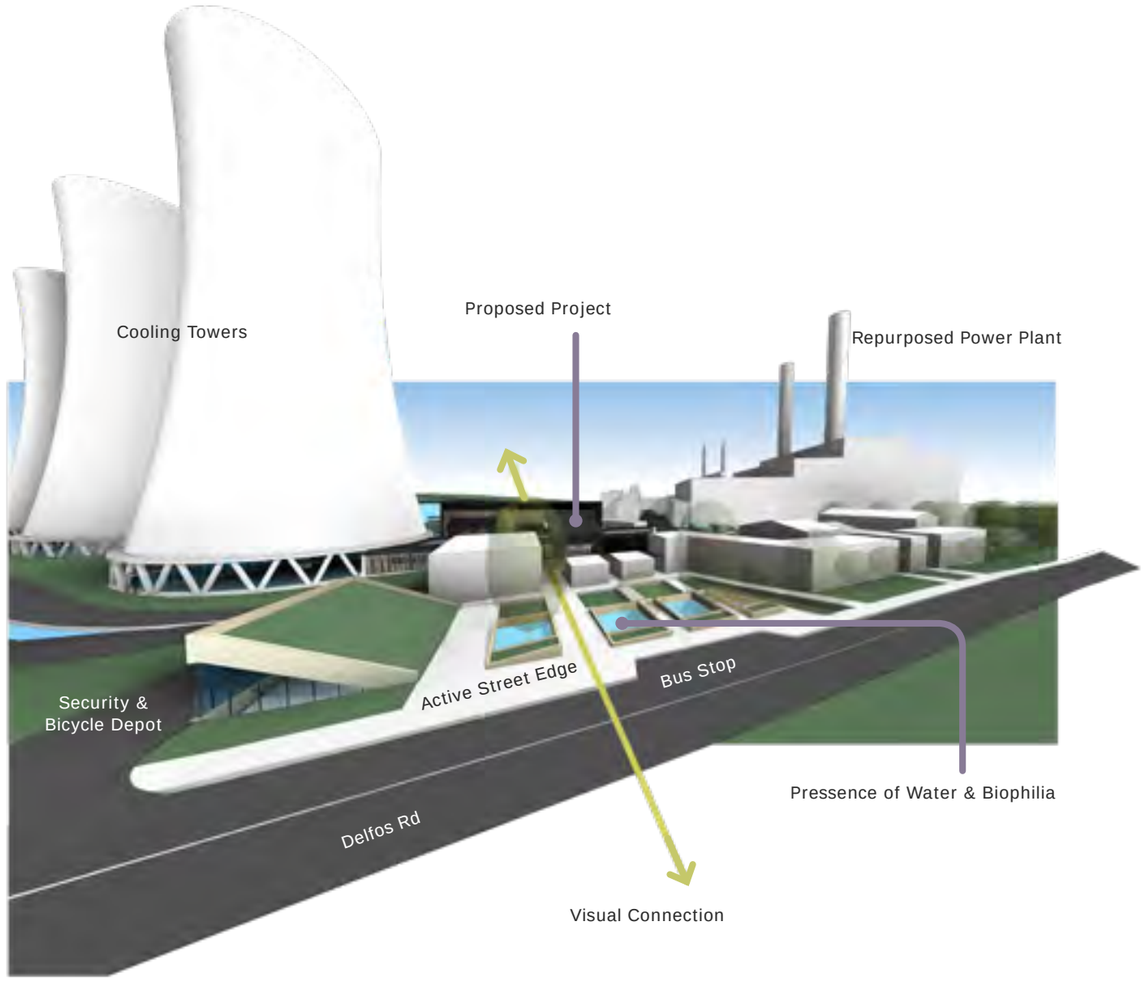


Figure 205: Master Plan perspective View 1
(Author, 2019)

1 — Pedestrian Entrance
2 — Security Checkpoint
3 — Retail & Craft Markets
4 — Bicycle & Running Track
5 — Bicycle Depot
6 — Retail
7 — Public parking
8 — Wetland
9 — Waste water treatment (Biogas & Septic tanks)
10 — Cooling Towers
11 — Forestry
12 — View Deck
13 — Rock Climbing
14 — CW Pump Room
15 — Waterfront
16 — Boat Yard
17 — Fishing Point
18 — Switch-yard
19 — Pv Panels
20 — Bio-char & Energy Production Plant
21 — Staff Parking
22 — Timber & Organic Waste\ Storage
23 — Small Cafe & Restaurants
24 — Goods Delivery Railway Line
25 — SGB-Smit Power Matla
26 — Service Yard
27 — **Timber Craft Workshop**
28 — **Training & Conference Rooms**
29 — **Spriulina & Biofuel Production**

Project Proposal

FINAL DESIGN - FLOOR PLAN

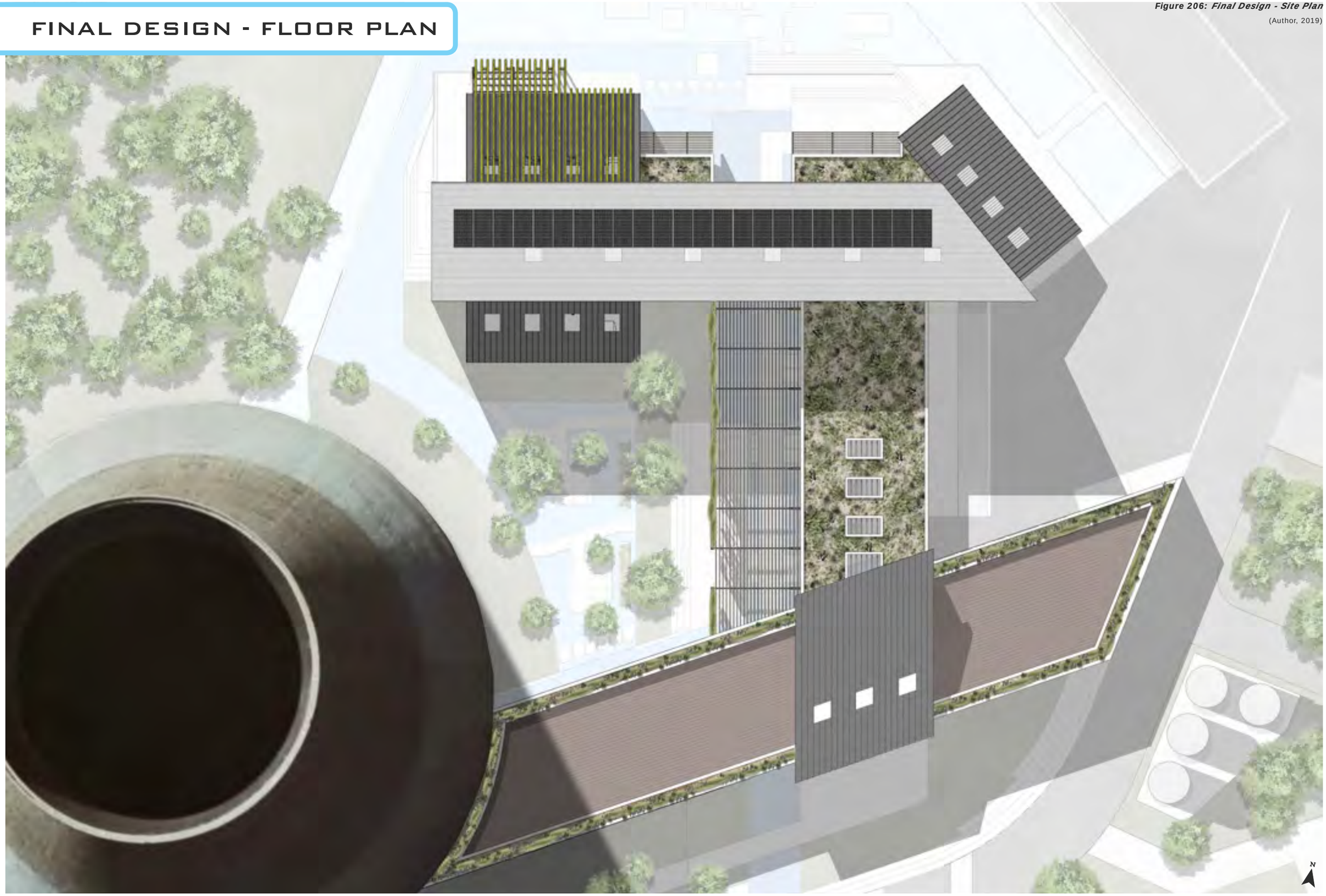


Figure 206: Final Design - Site Plan
(Author, 2019)

Figure 207: ***Final Design - Ground Floor Plan***

(Author, 2019)

Figure 208: ***Final Design - First Floor Plan***

(Author, 2019)

Key

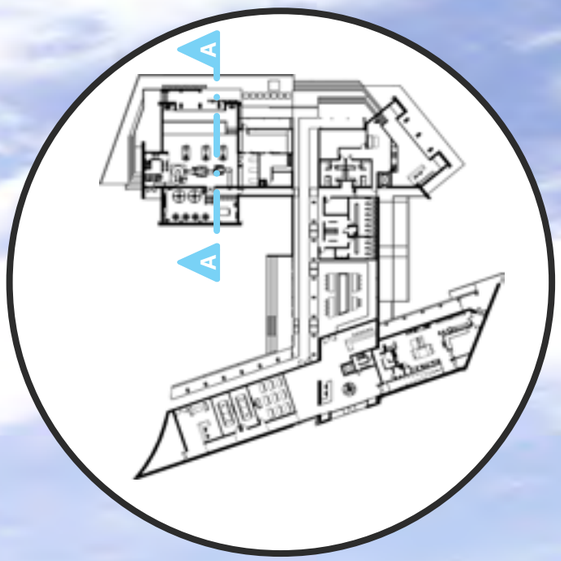
1 - Algae Cultivation & Extraction Space
2 - Pump Room
3 - Lab - Dry
4 - Mudroom & store
5 - Lab - Wet
6 - Down Waiter
7 - Change Room
8 - Vertical Access
9 - Waiting Area
10 - Reception
11 - Store
12 - Ablution
13 - Eating Area
14 - Cafe & Bar
15 - Exhibition Space
16 - Training, Conference or Consultation Room
17 - Timber Craft Workshop
18 - Refuse
19 - Service Yard
20 - Cooling Tower
21 - Confrontation, Reflection & Exhibition Space
22 - Rest & Reflection Space
23 - Existing CW Pump Room
24 - Admin Office

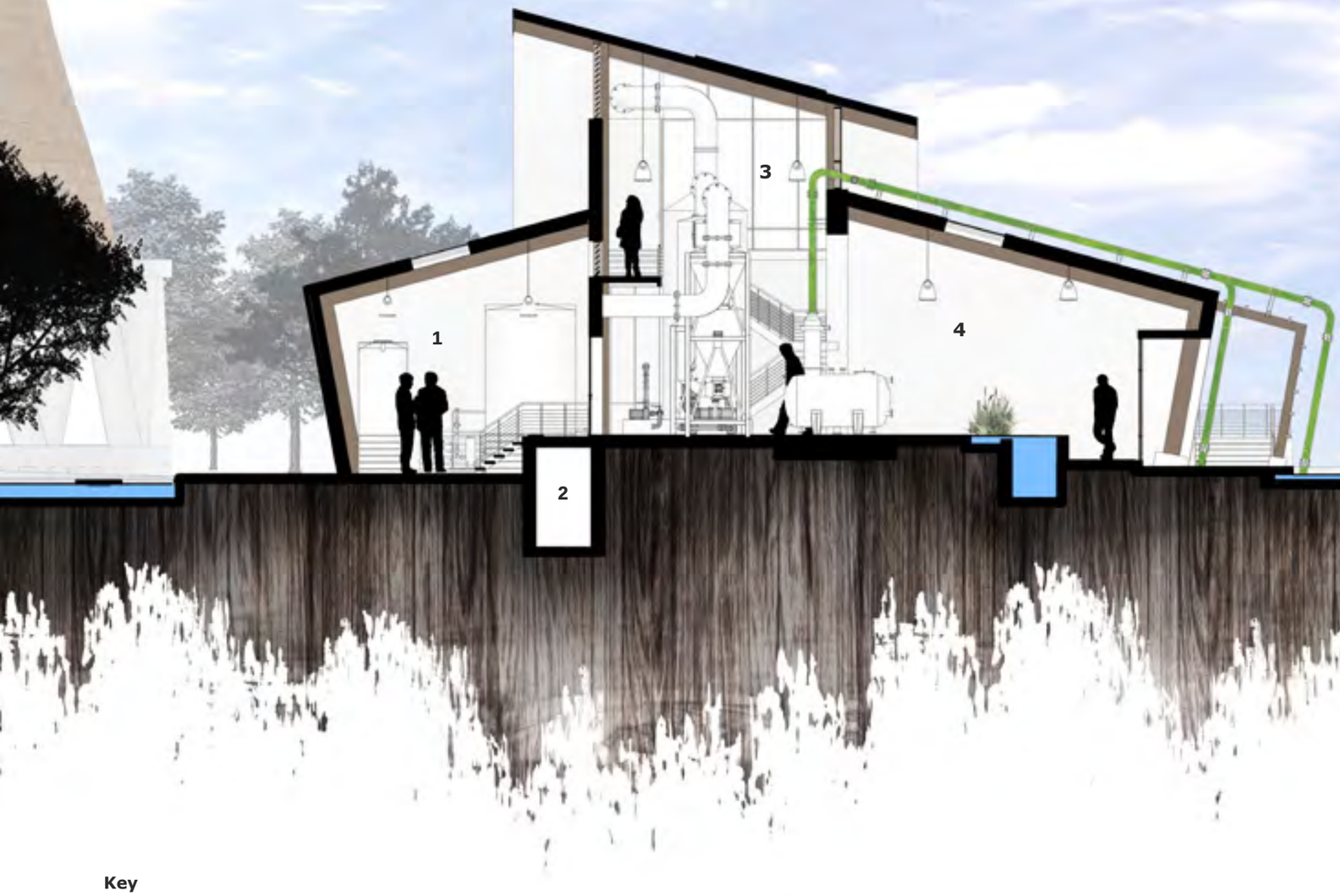
Key

1 - Office
2 - Passage
3 - Mudroom& Store
4 - Lab - Clean
5 - Vertical Access
6 - Down Waiter
7 - Planted Roof
8 - Exhibition Space
9 - Roof Top Deck & Sky-bar

SECTIONS

Section A-A



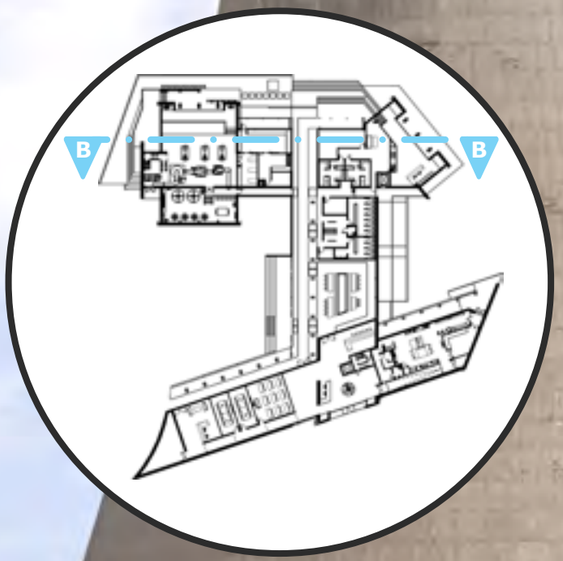


Key

1 - Pump Room
2 - Service Zone
3 - Office
4 - Algae Cultivation & Extraction

Figure 209: Final Design - Short Section A-A
(Author, 2019)

Section B-B

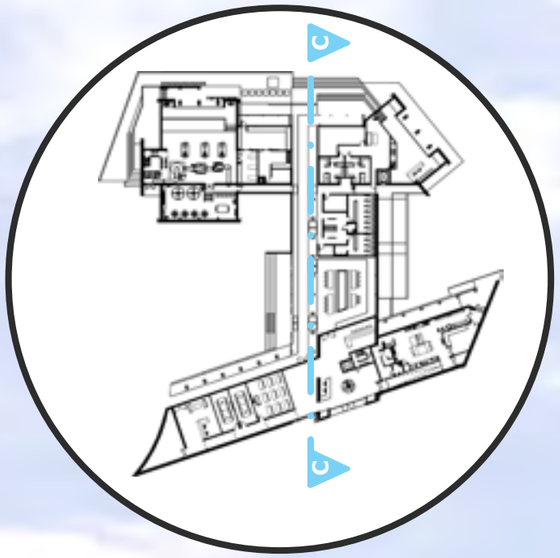


Key

1 - Reception
2 - Walk-In Cooler / Freezer
3 - Lab - Dry
4 - Planted Roof
5 - Through-way
6 - Lab - Wet
7 - Mudroom / Storage
8 - Algae Cultivation & Extraction Room

***Figure 210:** Final Design - Section B-B*
(Author, 2019)

Section C-C

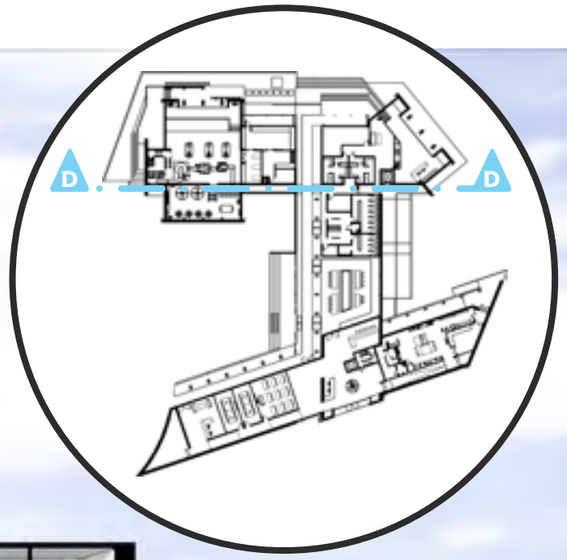


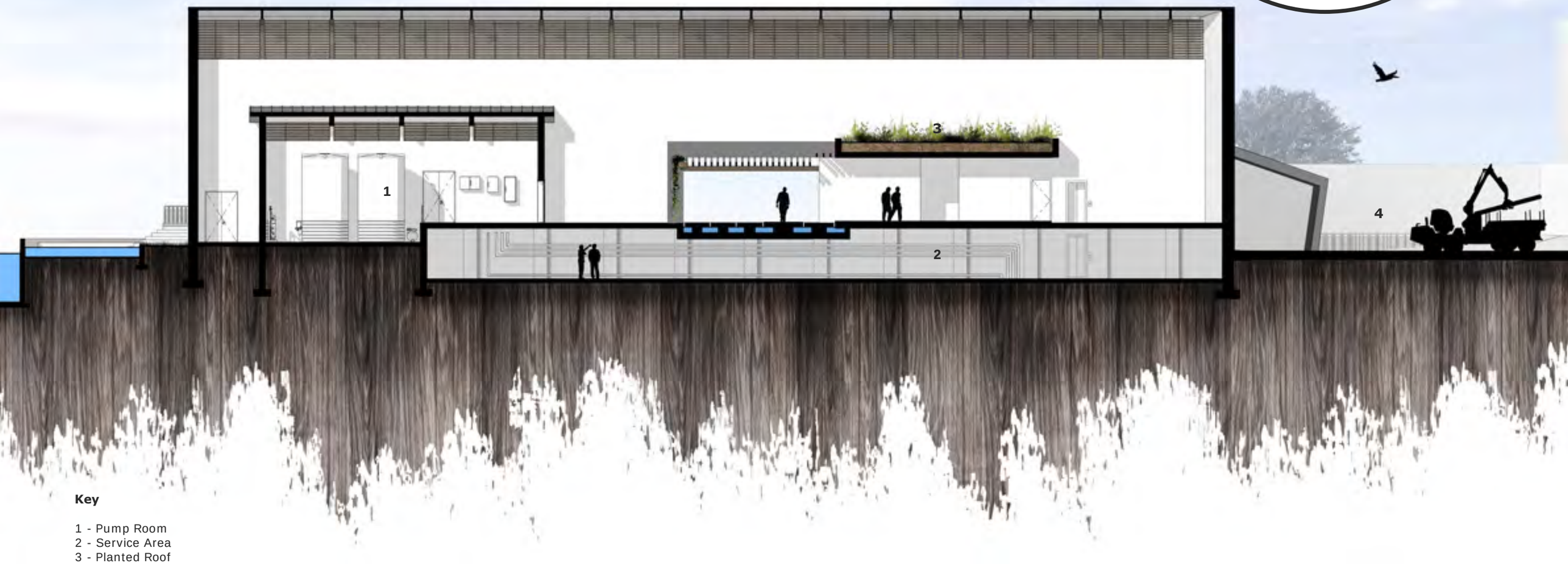
Key

1 - Rest & Reflection Space
2 - Lab - Dry
3 - Service Lab
4 - Exhibition Space
5 - Planted Roof

Figure 211: Final Design - Section C-C
(Author, 2019)

Section D-D



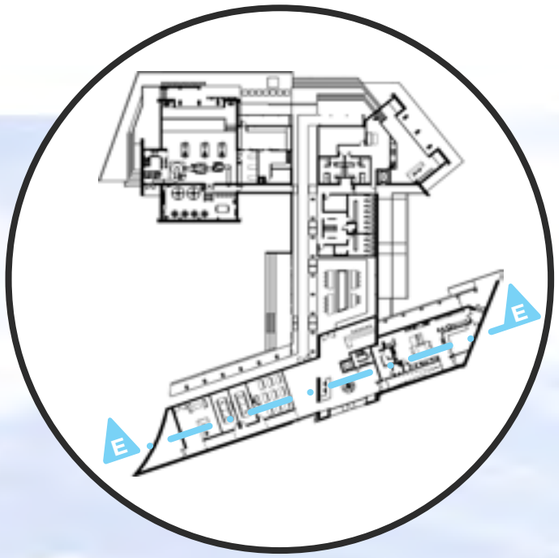


Key

1 - Pump Room
2 - Service Area
3 - Planted Roof
4 - Service Yard

Figure 212: Final Design - Section D-D
(Author, 2019)

Section E-E

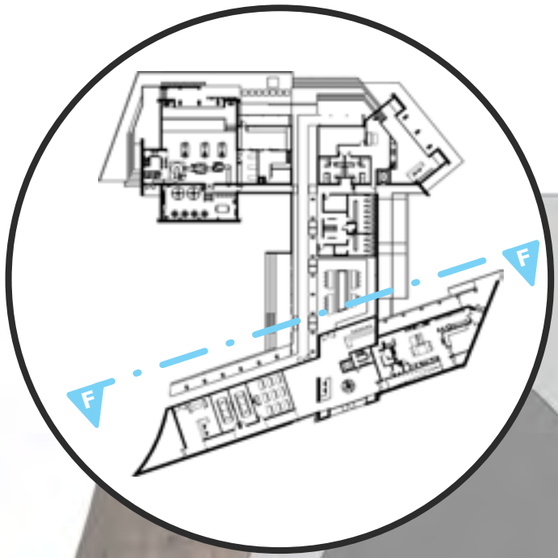


Key

1 - Existing Cooling Tower
2 - Uni-sex Ablutions
3 - Reception
4 - Training / Conference Room
5 - Exhibition Space
6 - Accessile Roof Deck
7 - Ablution
8 - Wood-working Workshop
9 - Store

***Figure 213:** Final Design - Section E-E*
(Author, 2019)

Section F-F



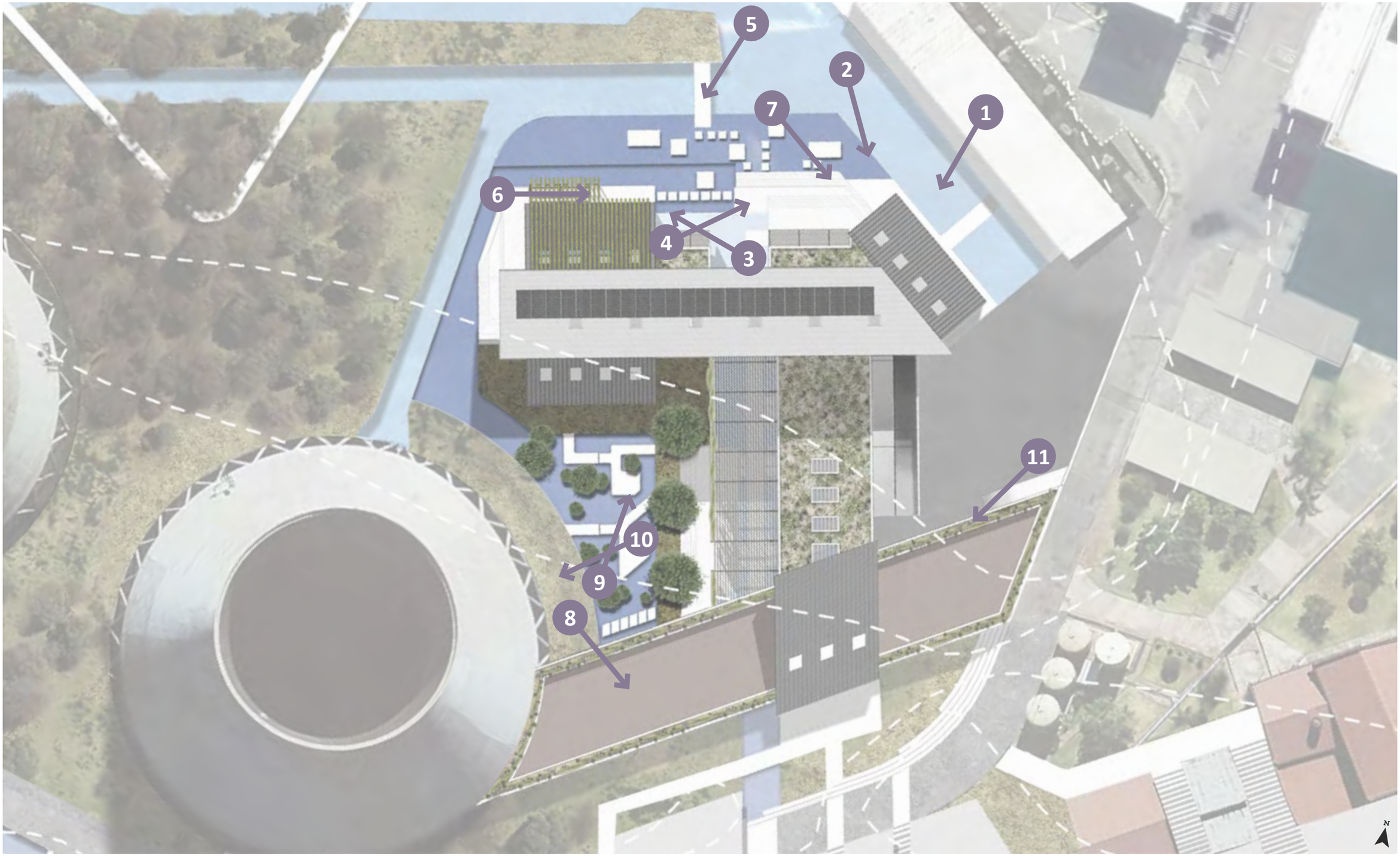
Key

1 - Existing Pump Room
2 - Service Yard
3 - Eating Area
4 - Planted Roof
5 - Pond of Reflection
6 - Existing Cooling Tower

Figure 214: Final Design - Section F-F
(Author, 2019)

FINAL DESIGN PERSPECTIVES

Figure 215: ***Final Design - Site Plan 1 - Indicating Perspective View Points***
(Author, 2019)



Perspective 1

Figure 216: ***Final Design - Exterior Perspective 1***
(Author, 2019)

Perspective 2

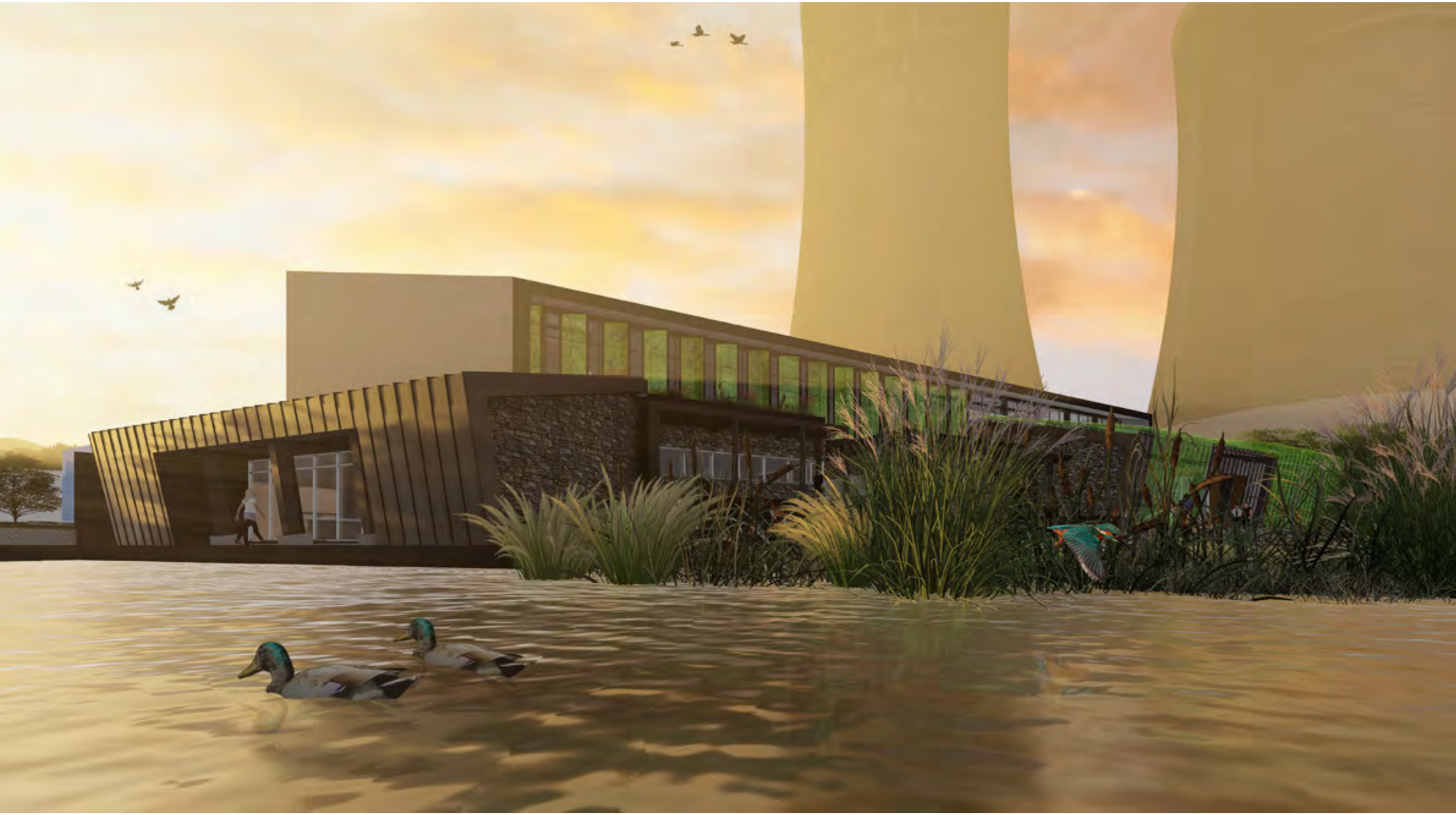


Figure 217: ***Final Design - Exterior Perspective 2***
(Author, 2019)

Perspective 3

Figure 218: ***Final Design - Exterior Perspective 3***
(Author, 2019)

Perspective 4

Figure 219: ***Final Design - Exterior Perspective 4***
(Author, 2019)

Perspective 5

Figure 220: ***Final Design - Exterior Perspective 5***
(Author, 2019)

Perspective 6

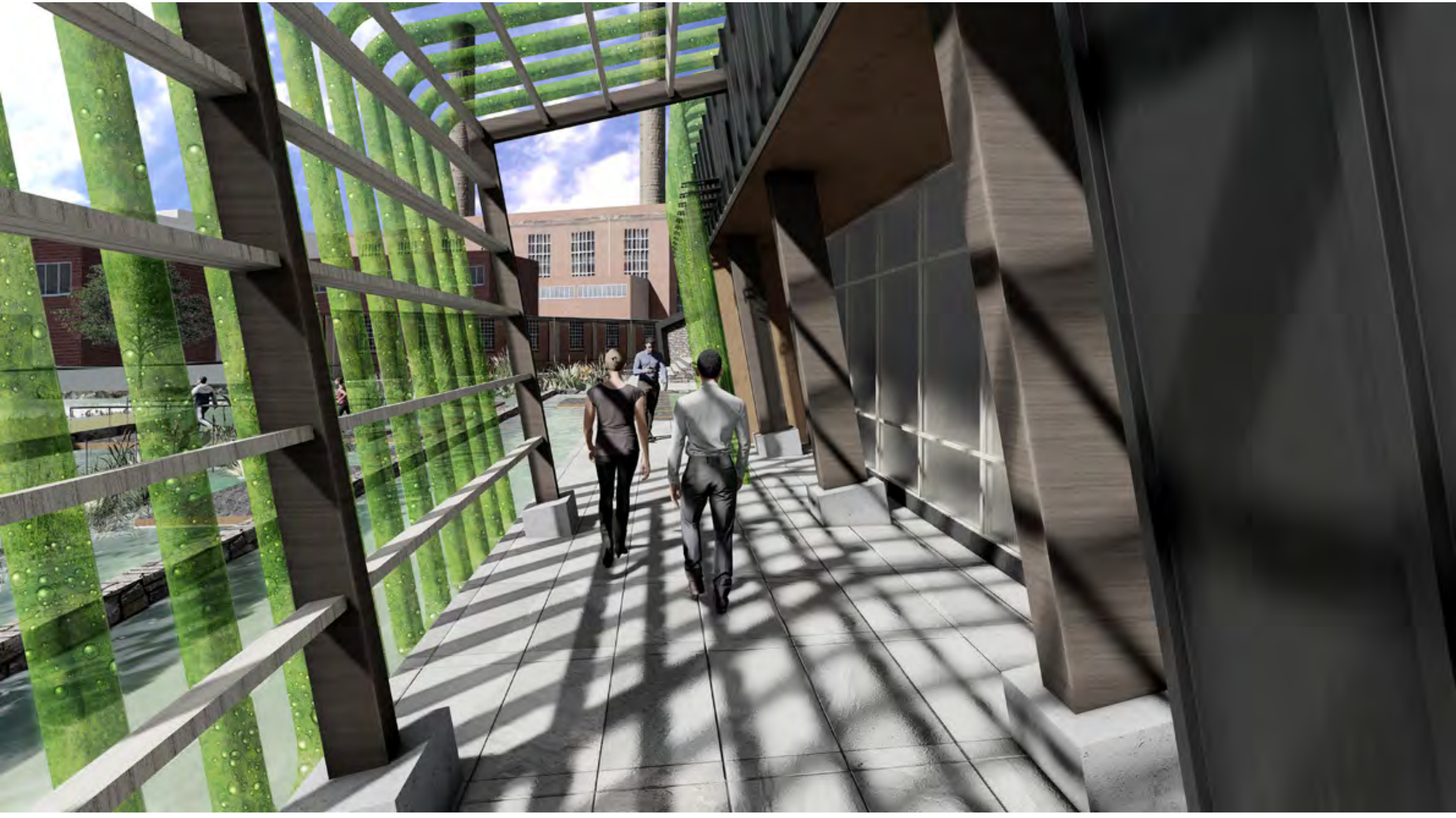


Figure 221: ***Final Design - Exterior Perspective 6***
(Author, 2019)

Perspective 7

Figure 222: ***Final Design - Exterior Perspective 7***
(Author, 2019)

Perspective 8

Figure 223: ***Final Design - Exterior Perspective 8***
(Author, 2019)

Perspective 9

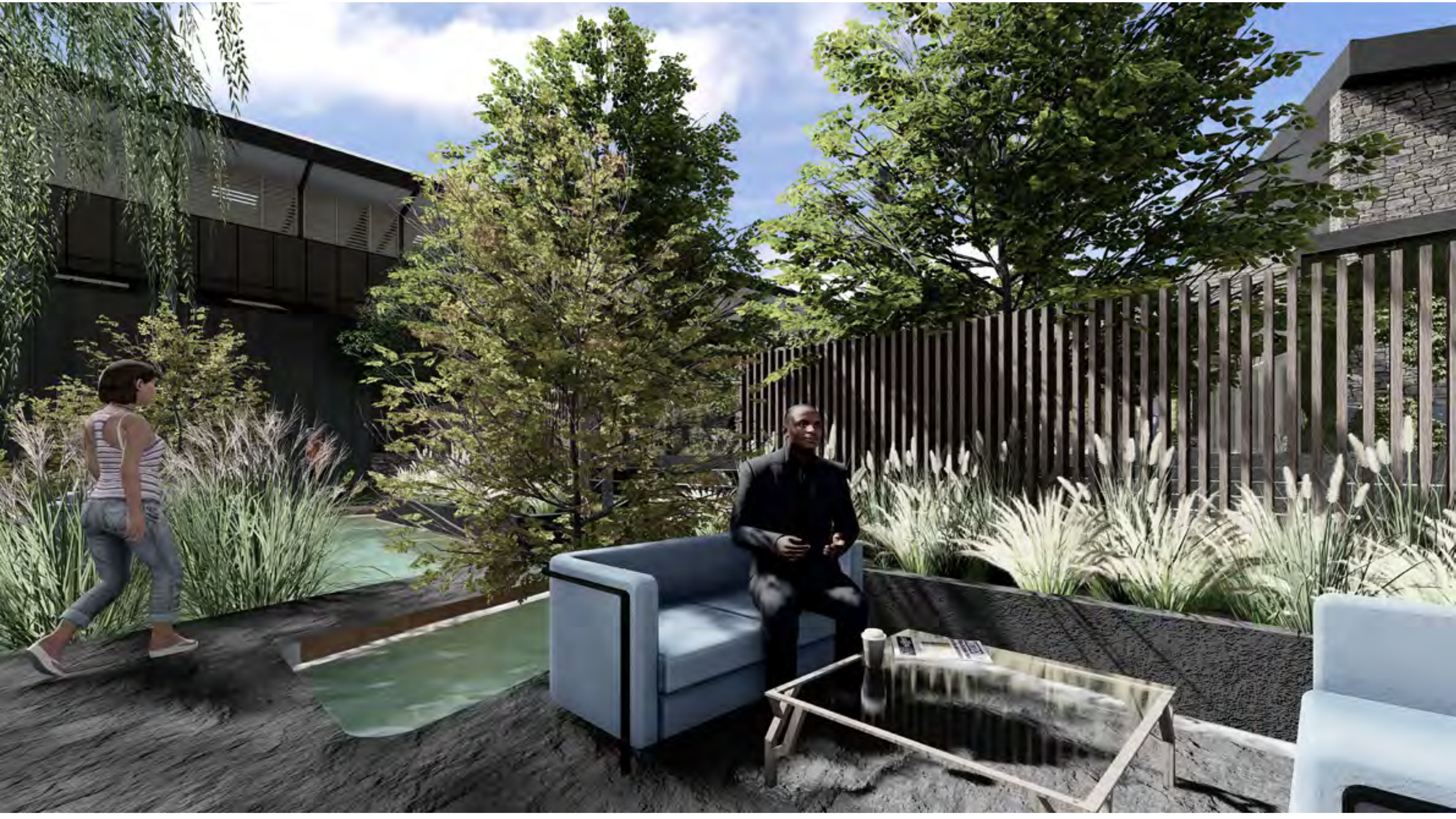


Figure 224: ***Final Design - Exterior Perspective 9***
(Author, 2019)

Perspective 10

Figure 225: ***Final Design - Exterior Perspective 10***
(Author, 2019)

Perspective 11

Figure 226: ***Final Design - Exterior Perspective 11***
(Author, 2019)

Figure 227: ***Final Design - Site Plan 2 - Indicating Perspective View Points***
(Author, 2019)

Perspective 12

Figure 228: ***Final Design - Exterior Perspective 12***
(Author, 2019)

Perspective 13

Figure 229: ***Final Design - Exterior Perspective 13***
(Author, 2019)

Perspective 14

Figure 230: ***Final Design - Exterior Perspective 14***
(Author, 2019)

Perspective 15

Figure 231: ***Final Design - Interior/Exterior Perspective 15***
(Author, 2019)

Perspective 16

Figure 232: ***Final Design - Interior Perspective 16***
(Author, 2019)

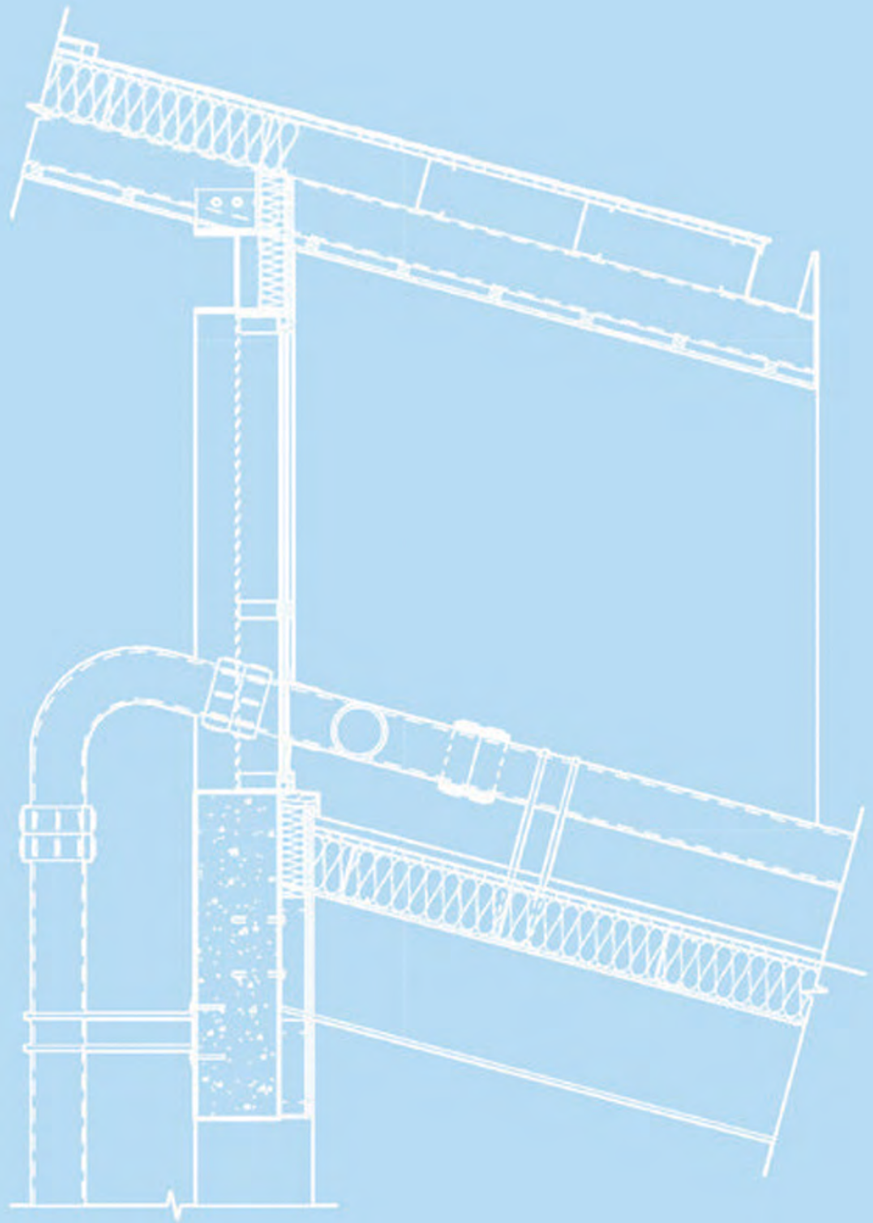
Perspective 17

Figure 233: ***Final Design - Interior Perspective 17***
(Author, 2019)

Figure 234: ***Final Design - Interior Perspective 18***
(Author, 2019)

CHAPTER 08

TECHNIFICATION



Transition

8.1 Introduction

The architectural design intention is to address climate change and its resulting impacts of climate anxiety on the users of Pretoria West. This industrial area contributes to a large amount of CO_2 and destruction of our natural ecosystems. The project aims to utilise the natural flows of nature specifically that of water for its healing and restorative properties to bring about a transition from a state of decay into a living system.

Therefore the project uses water in the production of Bio-fuels and Spriulina which is a high protein and omega 3 food source whilst simultaneously sequestrating CO_2.

8.2 Technical Translation

The project makes use of various level changes and facilitates the flow of water, which is treated and cleansed along its journey. In order for the healing process of body, mind and soul, one needs to go through a series of stages or “Thresholds”. Therefore, the technical concept is expressed through this journey of transition. The water flow passes through a series of different thresholds at which point the architectural intervention will articulate and technically express the moments of transition moving forward on the journey of healing.

The technical concept is therefore represented by moments of transition and will be illustrated through the application of various material choices which will also consider texture, shape and patterns, different structural forms or junction connecting elements as well as environmental systems and strategies.

Therefore along these thresholds it is important to express the transition in the way materials connect. In addition the choice of materials not only needs to be conscious of its impact on climate change but also aids in expressing change along these points of intersection.

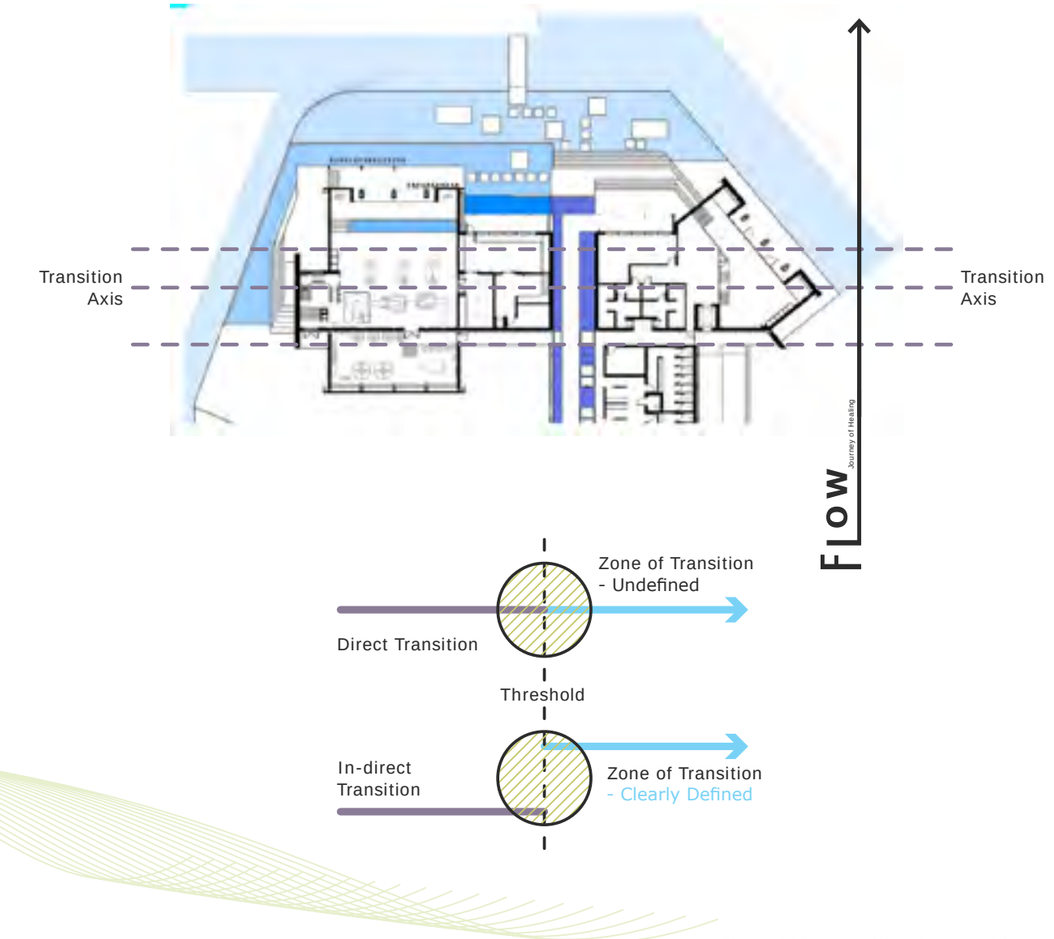
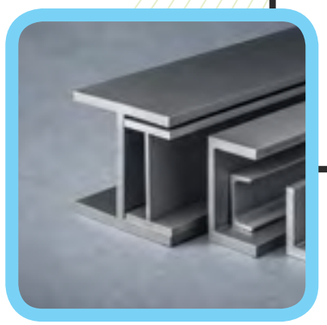
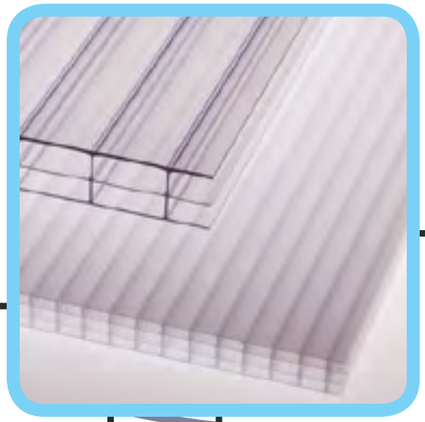


***Figure 235:** Transition Concept Diagram*

(Author, 2019)

MATERIALS





8.3 Introduction

Selecting buildings materials, can contribute to a higher use of CO_2 emissions and influence the health and well-being of its occupants and the natural environments. In line with The City of Tshwane Vision for 2055, one of its responses is the call to become a “Low carbon economy”. This gives rise for the architectural intention to adopt an approach in alignment, towards contributing to the lowering of its carbon footprint. The selection of materials for the architectural intention is focused on recycling of existing materials, the minimising of depletion of natural resources and moving to a state of carbon positive, as previously discussed.

8.4 Hydraform Blocks

This project requires a lot of excavation of soil in order to create the new wetland water systems proposed for the site. Moving the soil off site would add to the carbon footprint of the project. Therefore it is more advantageous to utilise the excavated soil on site as a building material. Hydraform blocks can be produced from the compression of this soil with the addition of a bonding agent. The blocks are made with an interlocking profile, which will reduce the need for mortar joints and makes the erection of the building quicker and easier. Additionally, the use of Hydraform blocks provides more work for local laborers. The Hydraform block will be used as infill for the walls of the project.

Material	Net carbon emissions (kg C/t)[a,b]	Near-term net carbon emissions including carbon storage within material (kg C/t)[c,d]
Framing lumber	33	–457
Medium-density fiberboard (virgin fiber)	60	–382
Brick	88	88
Glass	154	154
Recycled steel (100% from scrap)	220	220
Concrete	265	265
Concrete[e]	291	291
Recycled aluminum (100% recycled content)	309	309
Steel (virgin)	694	694
Plastic	2,502	2,502
Aluminum (virgin)	4,532	4,532

[a]Values are based on life-cycle assessment and include gathering and processing of raw materials, primary and secondary processing, and transportation.
[b]Source: EPA (2006).
[c]From Bowyer and others (2008); a carbon content of 49% is assumed for wood.
[d]The carbon stored within wood will eventually be emitted back to the atmosphere at the end of the useful life of the wood product.
[e]Derived based on EPA value for concrete and consideration of additional steps involved in making blocks.

***Figure 236:** Net carbon emissions in producing a tonne of various materials*

(Wood Handbook, 2010)

8.5 Stone

From all the excavations on site and from the adjacent, aggregate mine, there is a large supply of locally sourced natural stone which can be used as a building material. The varying textures, colours and shapes, provide for a wide range of applications. Natural stone is not harmful to the environment as there are no chemicals and toxins in the material. Extracting the stone and using it in the architectural intervention as aggregate or for the stone walls, will result in a lower carbon footprint.

8.6 Polycarbonate

Polycarbonates are pliable and durable material which can transmit light. It is also commonly used in eyewear as it possesses a nature UV filter whilst being much lighter than glass. It is easy to work with and can be thermoformed into the desired shape or application. As per Figure 236 it is evident that polycarbonate, as opposed to glass has higher net carbon emissions. However, polycarbonate material can also be recycled from recycled materials, which would have a greater impact on reducing embodied energy, whilst reducing non bio-degradable plastic waste. A twin-wall polycarbonate sheet has a better R-value than that of glass which would improve thermal envelope of the building. It therefore proves to be more energy efficient then glass. It is therefore for this reason that polycarbonate was chosen for all glazed areas in the building.

8.7 Concrete

Concrete has higher net carbon emissions, as indicated by Figure 236, than other building materials such as brick and framing lumber however is less than steel. Therefore, this material will be utilised as little as possible. It will mainly be used for foundations, plinth walls, surface beds, screeds and a few transfer beams. It will also be used as part of a bondek slab for flat roofs. These construction methods substantially reduce the amount of concrete required as the sub structure deals with most of the structural loads.

8.8 Steel

Initially, steel was chosen to be utilised for the main structure of the building. There were two main reasons this material was chosen. Firstly, there is an abundance of steel production and steelwork related industries within the local context of Pretoria West. Secondly, with the abundance of water in and around the proposed project, concerns around the lifespan of the materials were considered. It is evident that as per Figure 236 that steel has a very high net carbon emission in comparison to framing lumber. Therefore, timber better aligns with the projects intension’s to reduce carbon footprint. It is also necessary to minimise the amount of steel which would be utilised within the building and to consider using recycled steel where possible. This would enable the project to greatly reduce the embodied energy of the project on a whole. The only steel that will be used in the project will be for fasteners (such as screws, bolts, base plates etc.), roof sheeting and for re-bar used to strengthen concrete floors, walls and beams.

8.9 Timber

Timber has a low environmental impact on its production and life cycle. Its many advantages over other industrial building materials such as concrete and steel is expressed in Figure 236. By maintaining sustainable forestry plantations, the trees sequestrate CO_2 as they grow. As per the Urban framework, there is a portion of land which has been allocated for a sustainable timber plantation. This is advantageous as it brings in a source of income to the site, sequestrate CO_2 within the area and it is a close source of building material. This reduces the carbon footprint as there is very little transportation of the material required. In addition, the methodology of transforming timber into usable products is far less energy-intensive than that of most other materials. A concern arose around whether timber would be durable in the context of the surrounding “presence of water. The challenges arise around the moisture content of the wood and the application there of. The saturation point of wood is averaged at 30% considering the relative humidity in the area where the wood is been applied. Skaar, (1988), as cited in the Wood Handbook, (2010) It is therefore important that the wood is not submerged in water as this would structurally impair its structural integrity. Timber will be used in the construction of the primary, secondary & tertiary structure of this project. The timber will also be used for the floor finishes, ceilings, cladding, railings and door paneling will also be made from this material.

8.10 Biochar

A new Biochar-based material has been designed by Made of Air, in order to combat climate change. It is a carbon-negative material, which uses waste biomass, which absorbs CO_2 emissions from the atmosphere during its lifespan. The Urban Framework proposed a sustainable timber forestry, a timber manufacturing plant in the existing power station A and a Biochar and energy plant in existing power station B. The resulting waste material from the forestry and the timber processing plant and any organic waste from the surrounding context will be combusted to produce energy and the Biochar material. The biomass is baked into a solid char as the CO_2 is converted into energy and a stable form of carbon is formed. The material can then be used for tiling and facade cladding.

8.11 Insulation

In the endeavour to design and build more energy efficient and more comfortable buildings, it is necessary to create a thermal envelope around the building in which there is very little or no thermal bridging. This refers to the transfer of energy (specially heat) between the interior and exterior. Therefore, it is necessary to insulate all exterior walls, roofs, and ground plane floors. It is also important to source local supplies and to consider the distance that the materials need to travel to site in order to reduce its carbon footprint.

Primary Structure

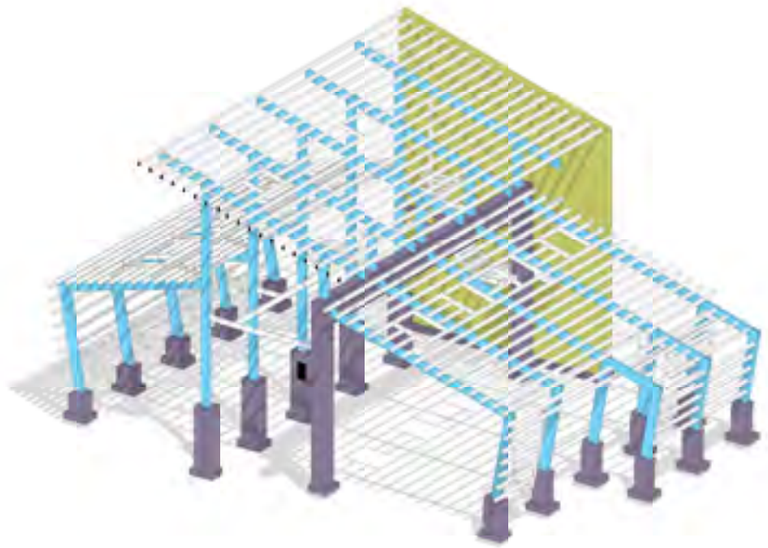


Figure 237: Primary Structure
(Author, 2019)

Secondary Structure

Figure 238: Secondary Structure
(Author, 2019)

Tertiary Structure

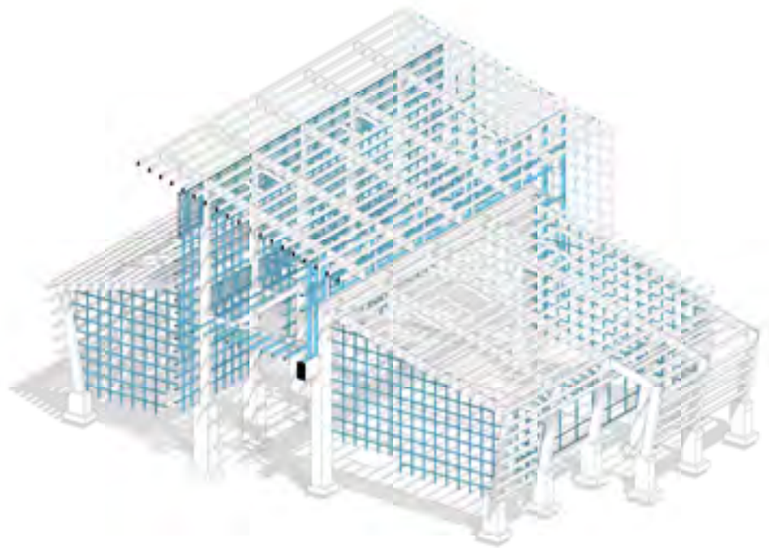


Figure 239: Tertiary Structure
(Author, 2019)

8.12 Primary structure

As discussed previously the use of sustainable and low embodied energy/ low carbon footprint materials are key in order for this project to reach its desired goal of reducing the impact of buildings in the fight against climate change. For this reason, the primary structure of the building consists mainly of load-bearing timber columns and rafters with exception to concrete transfer beams, plinth walls and footings as shown in Figure 237. The timber used originates from a sustainable forest on site. Due to external weather conditions and the nature of the material it is important that this material is treated and maintained regularly. In addition the structure must not be subject to water for prolonged periods of time and therefore needs to be elevated above the water plane. A timber structure strays away from the traditional methods of construction of the Pretoria West context which is steel construction. However, should we wish to change our current circumstances it is important for one to evoke change and look to more economical and sustainable ways of thinking.

8.13 Secondary structure

In continuation of this notion of sustainability, timber beams and purlins will be utilised as indicated in Figure 238. The method of the joinery will be done in such a way as to limit the amount of steel fixings necessary. The use of timber also promotes the use of local labourers and use of local material.

8.14 Tertiary structure

Thermal comfort and the buildings energy efficiency is also a crucial part of the design, which is why a tertiary timber framed insulated cavity structure will be used for all exterior walls. This sub-structure will be fixed to the infill Hydraform walls. Timber slatted screen walls are also utilised to separate spaces adding a degree of privacy whilst still providing a visual connection to the surroundings. It also adds a texture and creates interesting shadows which helps to create unique experiences. These elements also include timber pergola structures, timber railing supports, operable timber louvers and glazing frame elements which are not load bearing.

SYSTEM DIAGRAMS

Daylighting

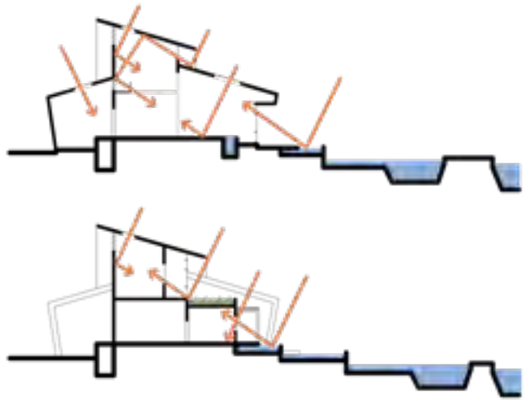


***Figure 240:** Daylighting System Diagram*
(Author, 2019)

Passive Heating

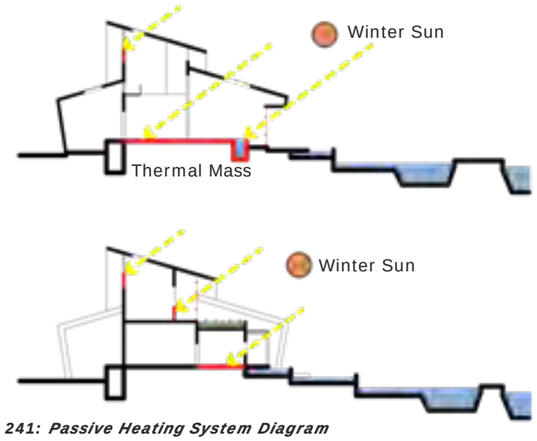


***Figure 241:** Passive Heating System Diagram*
(Author, 2019)

Energy

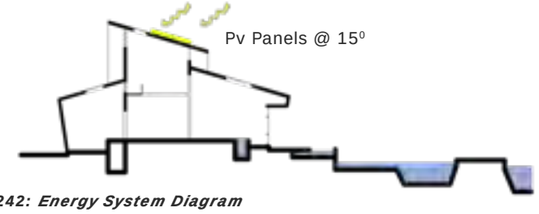


***Figure 242:** Energy System Diagram*
(Author, 2019)

Spirulina & Biofuel Production

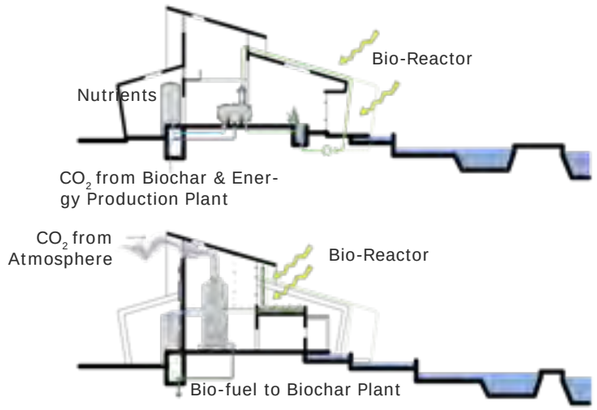


***Figure 243:** Spirulina & Biofuel Production System Diagram*
(Author, 2019)

Shading

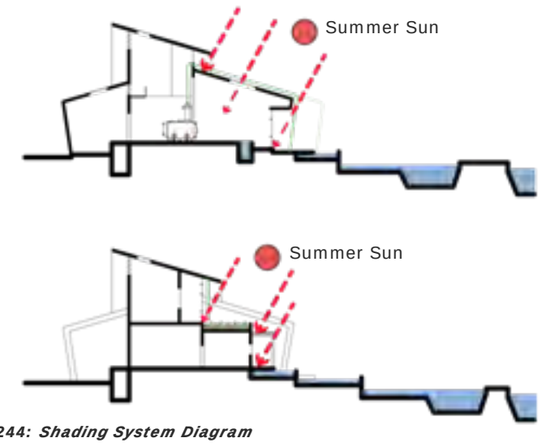


***Figure 244:** Shading System Diagram*
(Author, 2019)

Rainwater Harvesting

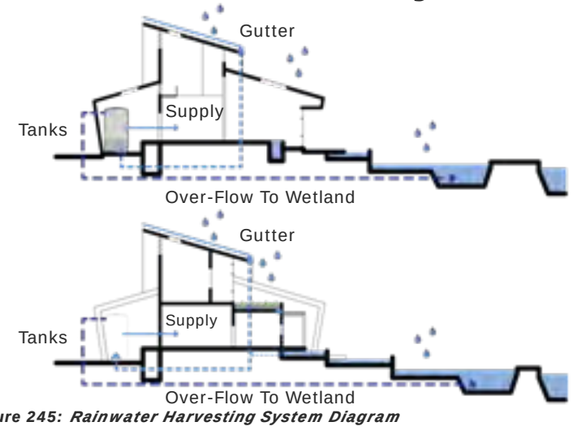


***Figure 245:** Rainwater Harvesting System Diagram*
(Author, 2019)

Natural Ventilation & Passive Cooling

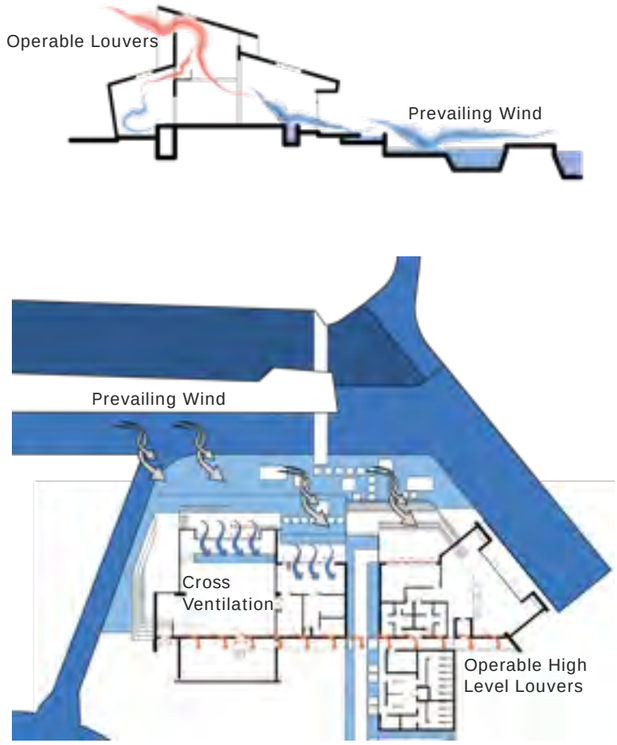


Figure 246: Natural Ventilation & Passive Cooling

(Author, 2019)

Bio-Fuel & CO2 Network

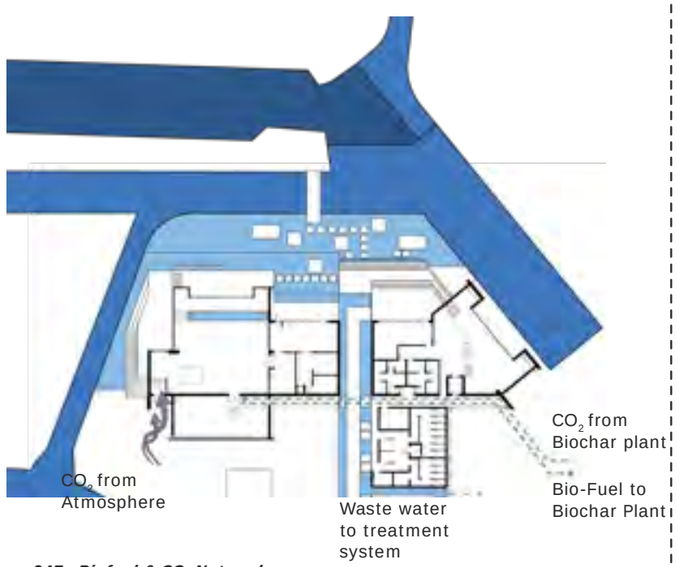


Figure 247: Biofuel & CO_2 Network

(Author, 2019)

Movement

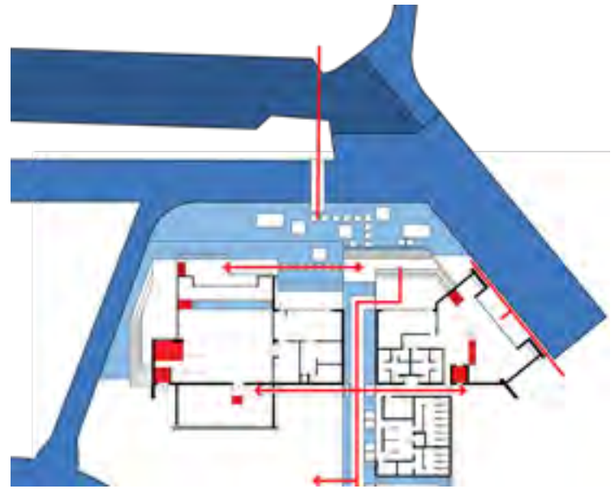
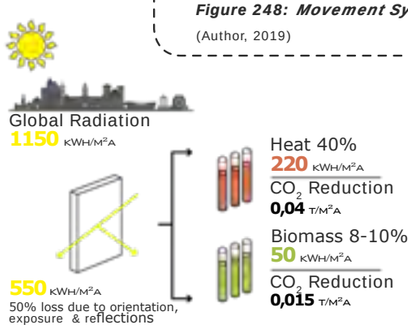


Figure 248: Movement System Diagram (Plan)

(Author, 2019)



The illustration on the right shows the results of a calculation on energy yield of a bio-reactor facade. Munich Germany

Figure 249: Bio-reactor Panels

Adapted by Author, (Arup, 2014)

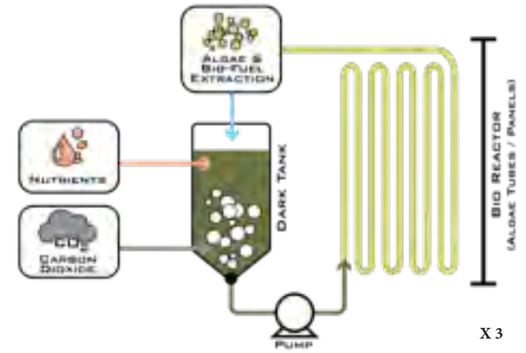


Figure 250: Bio-reactor System Diagram

(Author, 2019)

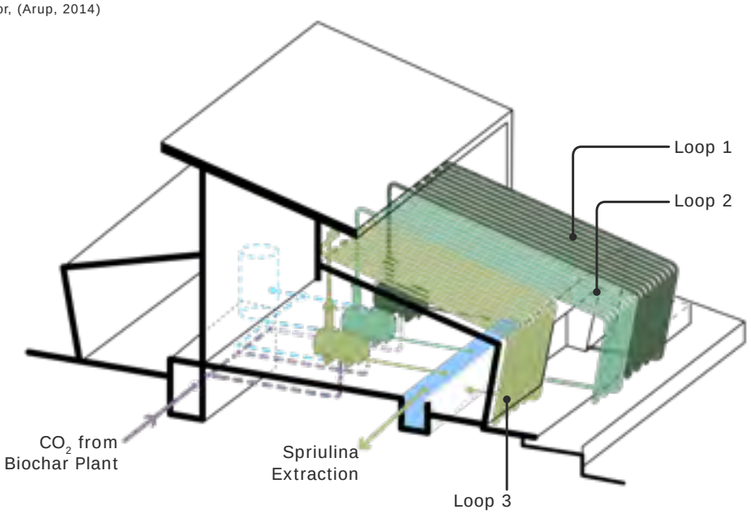


Figure 251: Bio-reactor 3D System Diagram

(Author, 2019)

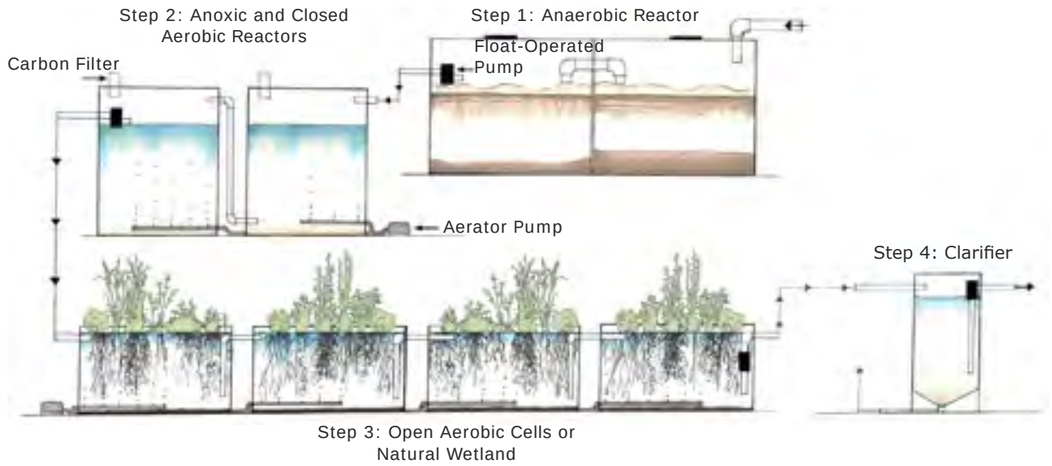


Figure 252: Eco-machine

(Shann. A. and Frisch. J., 2007)

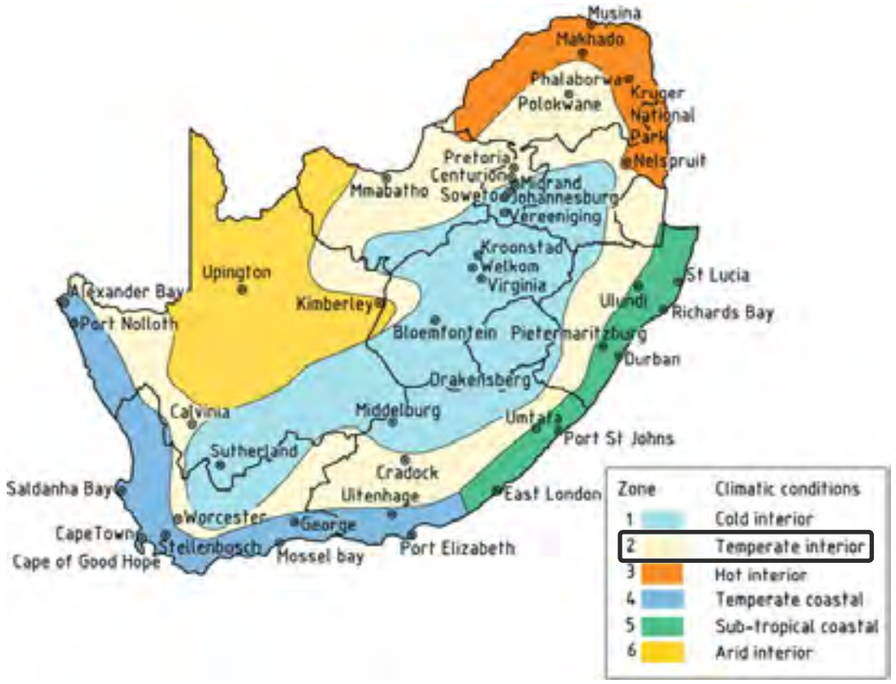


Figure 253: South Africa Climatic Zones

(South African Bureau of Standards (2005)

8.15 Climatic Conditions

It is important, when designing, to first consider the climate conditions within the local context. It is a very good design informant for the building design to best respond to its context enabling it to be as energy efficient as possible. Pretoria West falls within Zone Two which according to the climatic zones mentioned in the SANS 204 (Schmidt et al 2013:104) is known as a Temperate Interior. This means that this region experiences long, hot and rainy summers and short dry winters. According to (Windfinder, 2019) this area receives most of its wind from a North Westerly direction as indicated in Figure 258 and Figure 260. Its speeds range between 1-61 km/h. The average annual temperature for Pretoria West is 23°C. The hottest months are in September to March as per Figure 254. According to the climatic data (Meteoblue 2018) and plotted temperatures on the psychometric chart in Figure 256, it is evident that the majority of the climate falls within a range in which one would feel comfortable. However, there is a portion of the climate data which requires a heating and internal heat gains strategy in the colder months and natural ventilation and high-mass cooling in the warmer months. Figure 255 shows the sun's path over the course of the year for the Pretoria West region.

It is important to understand this as it allows us to provide shading where necessary and to use sun angles to determine the size of window openings. This ultimately impacts on the building's performance and the level of comfort the user experiences.

With consideration to the climatic conditions of Pretoria West, the design will respond to the various climatic factors and apply the various strategies discussed above.

Climate *(Pretoria)*

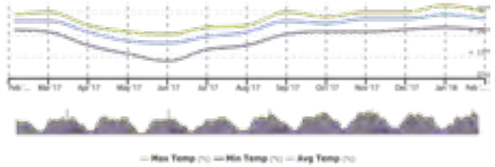


Figure 254: Climate (Pretoria)

WorldWeatherOnline.com (Edited by Author, 2019)

Sun Diagram *(Pretoria West)*

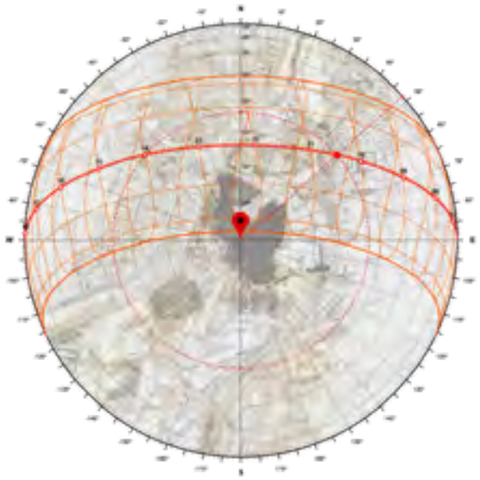


Figure 255: Sun Diagrams

(Author, 2019)

Psychometric chart (Pretoria)

- Comfort Zone

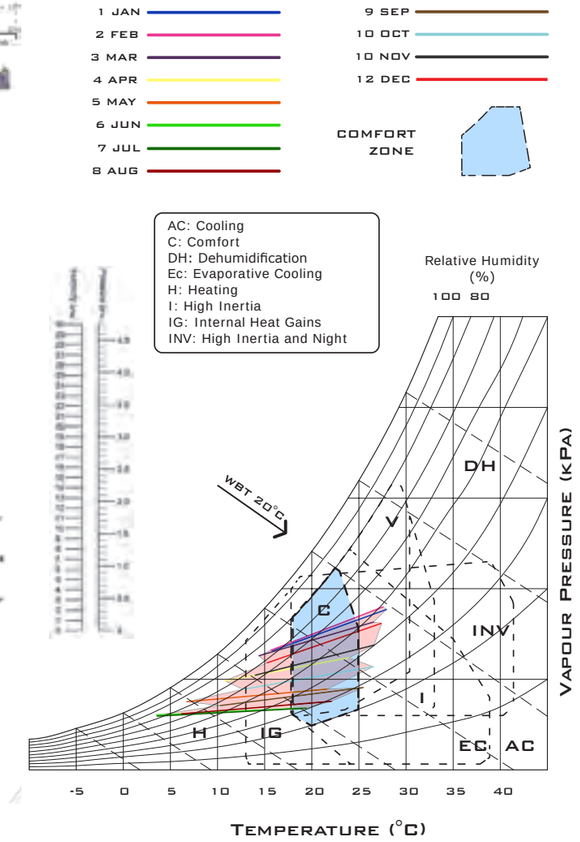


Figure 256: Psychometric Chart (Pretoria)

(Author, 2018)

Average and Max Wind Speed and Gust

(km/h)

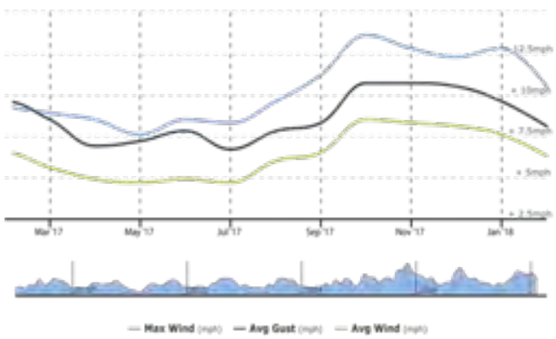


Figure 257: Average Wind Speeds

WorldWeatherOnline.com (Edited by Author, 2019)

Annual Wind Distribution *(Pretoria)*

- Wind direction distribution in (%)

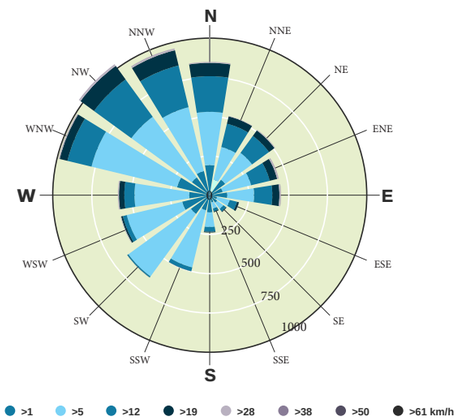


Figure 258: Annual Wind Distribution (Pretoria)

windfinder.com (Edited by Author, 2019)

Average Rainfall amount (mm) and Rainy Days (Pretoria)

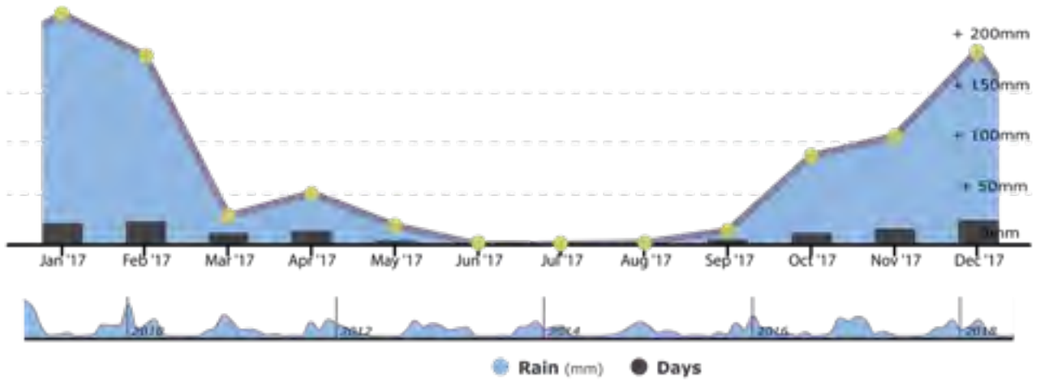


Figure 259: Average Rainfall Distribution (Pretoria)

WorldWeatherOnline.com (Edited by Author, 2019)

Monthly Wind Distribution (Pretoria)

- Wind direction distribution in (%)

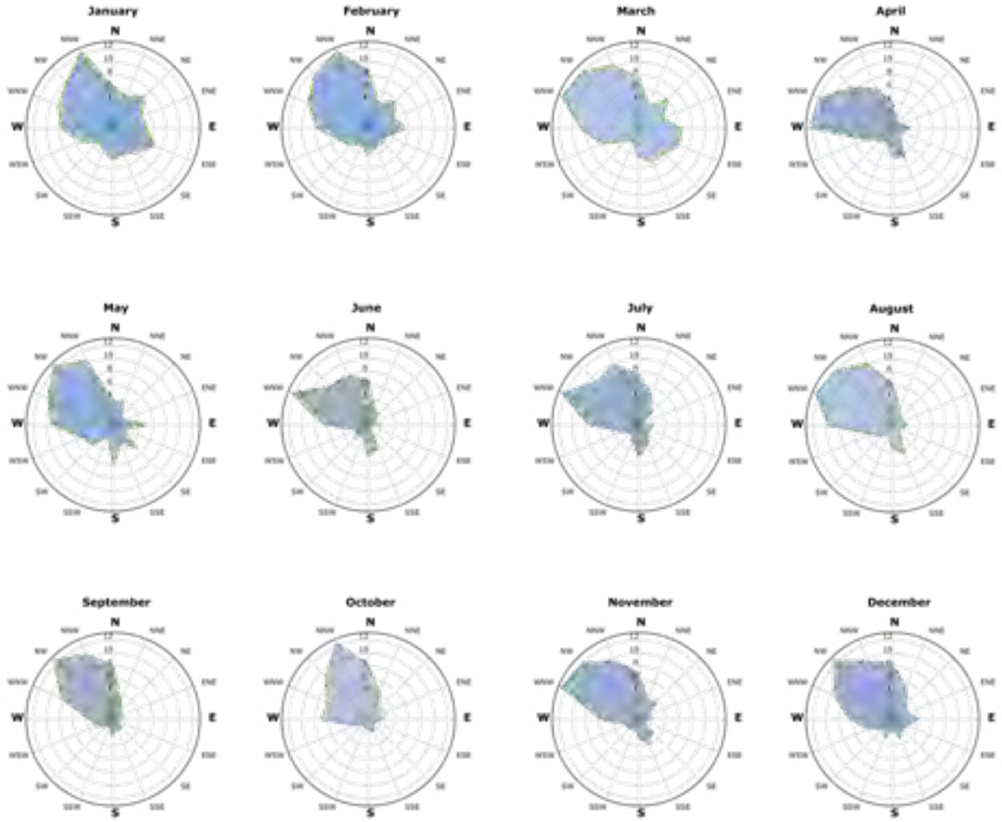


Figure 260: Monthly Wind Distribution (Pretoria)

windfinder.com (Edited by Author, 2019)

ENERGY ANALYSIS

8.16 Energy Analysis Introduction

"Be a yardstick of quality. Some people aren't used to an environment where excellence is expected." (Steve Jobs, 2010) With the ever increasing demand for energy and the declining availability of resources, it is imperative that we design more energy efficient and comfortable buildings. With the use of energy analysis software, the design is tested and altered in order to maximise its efficiency and level of comfort for its users.

Figure 261: Reaching for the Sun
(Left), (Unknown, 2016)

SEFAIRA - ENERGY ANALYSIS

8.17 Iteration 1 *- Base Model*

Total Floor Area: **881 m²**

Model 1:
Poor Insulation *(with Single Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :		25049
Cooling :		18121
Lighting :		1830
Equipment :		3660
Fans :		12008
Pump :		248

• Daylighting

Under Lit :		**42**
Well Lit :		36
Over Lit :		22

Model 2:
Excellent Insulation *(with Double Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :		6935
Cooling :		19167
Lighting :		1830
Equipment :		3660
Fans :		12373
Pump :		42

• Energy Use Index (EUI)

2030 Challenge:		65
Actual :		50

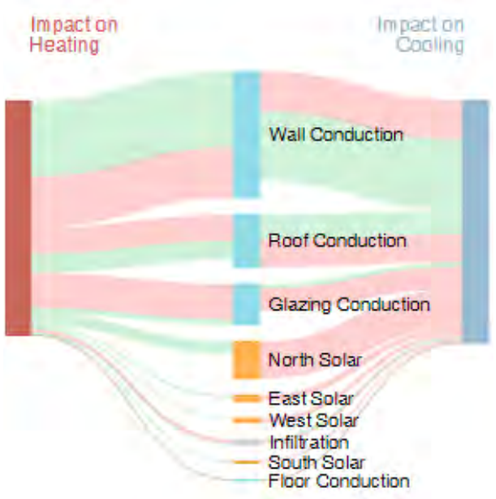


Figure 262: Heating & Cooling Poorly insulated - 1
(Generated by Sefaria, 2019)

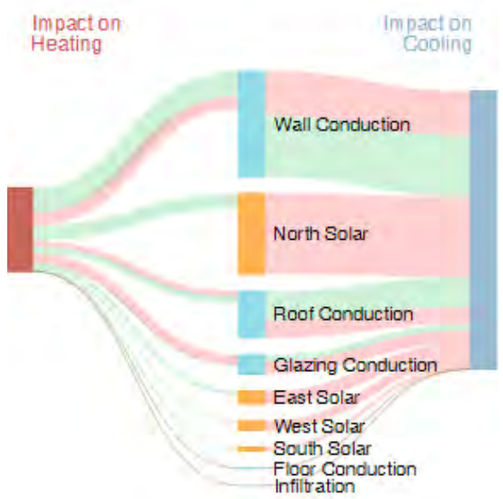


Figure 263: Heating & Cooling Well Insulated - 1
(Generated by Sefaria, 2019)

Key

Exterior Walls	Glazing
Floors	Shading
Roofs	Interior Walls

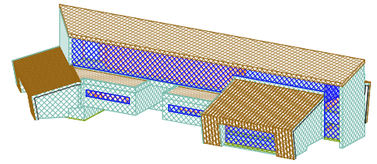
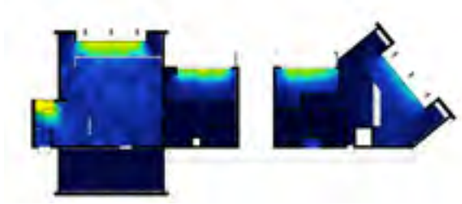
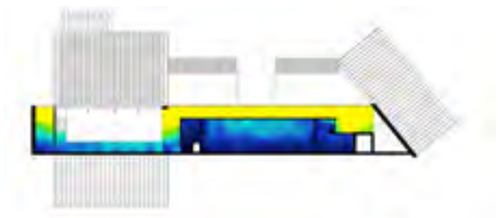


Figure 264: Iteration 1 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



Ground Floor



First Floor

Under-Lit VS Over-Lit *(%)*

Ground Floor

First Floor

Figure 265: Iteration 1 - Daylight Factor Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Figure 266: Iteration 1 - Over & Underlit Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Daylighting

42% Under-Lit

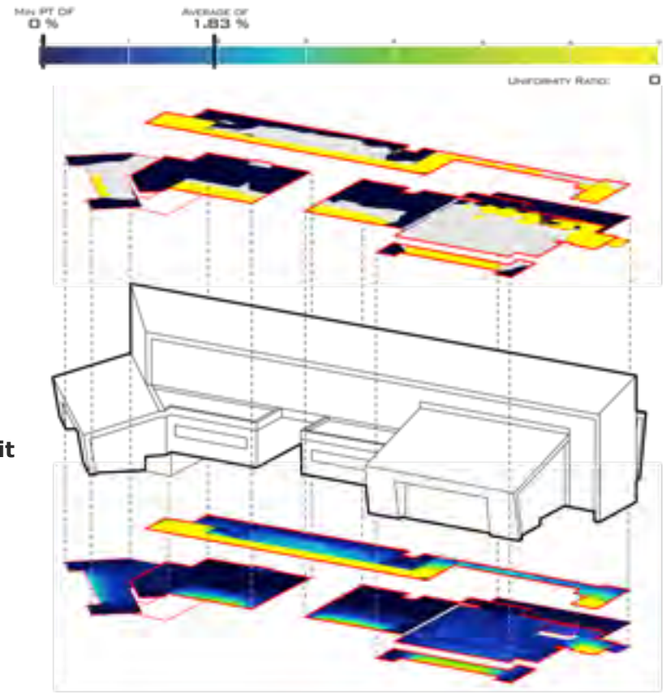


Figure 267: Iteration 1 - 3D Exploded Axo with Daylight Factor + Over & Underlit
(Data Generated by Sefaria, Drawn by Author, 2019)

8.18 Iteration 2 *- Window Adjustment (Larger & Additional Windows Interior & Exterior)*

Total Floor Area: **881 m²**

Model 1:
Poor Insulation *(with Single Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

	Heating :	24719
	Cooling :	18529
	Lighting :	1830
	Equipment :	3660
	Fans :	12221
	Pump :	242

• Daylighting

	Under-Lit :	**36**
	Well-Lit :	35
	Over-Lit :	29

Model 2:
Excellent Insulation *(with Double Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

	Heating :	6875
	Cooling :	19202
	Lighting :	1830
	Equipment :	3660
	Fans :	12922
	Pump :	39

• Energy Use Index (EUI)

	2030 Challenge:	65
	Actual :	51

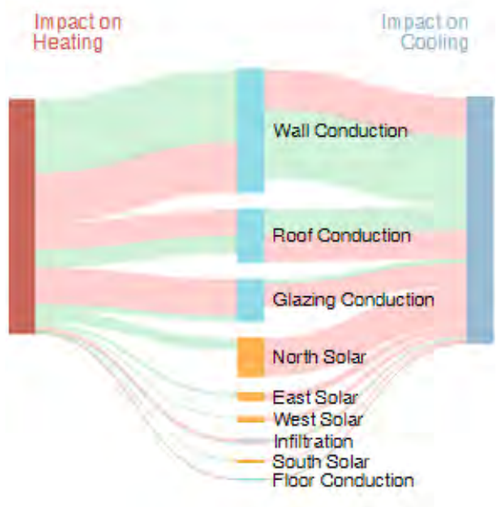


Figure 268: Heating & Cooling Poorly Non-insulated - 2
(Generated by Sefaria, 2019)

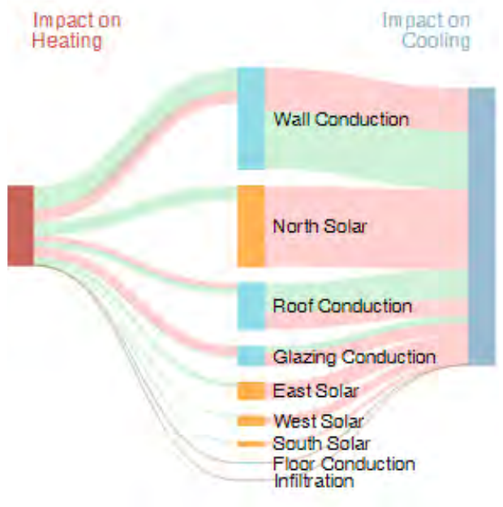


Figure 269: Heating & Cooling Well Insulated - 2
(Generated by Sefaria, 2019)

8.19 Findings

The addition of internal windows and the size increase in a few of the external windows has reduced the amount of under lit area by 6%. Although there is more natural daylighting there is also an increase in the thermal heat gains. It is therefore necessary to ensure that the exterior windows have sufficient shading to prevent excess heat gains in summer whilst allowing for an increased amount of heat gains in winter.

Key

- Exterior Walls
- Floors
- Roofs
- Glazing
- Shading
- Interior Walls

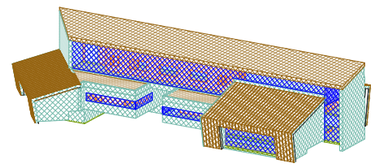
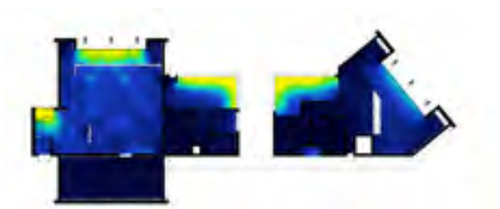


Figure 270: Iteration 2 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



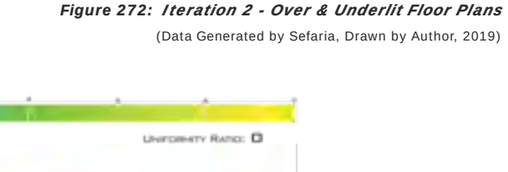
Ground Floor

First Floor

Figure 271: Iteration 2 - Daylight Factor Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Under-Lit VS Over-Lit *(%)*

Ground Floor



First Floor

Figure 272: Iteration 2 - Over & Underlit Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Daylighting

36 % Under-Lit

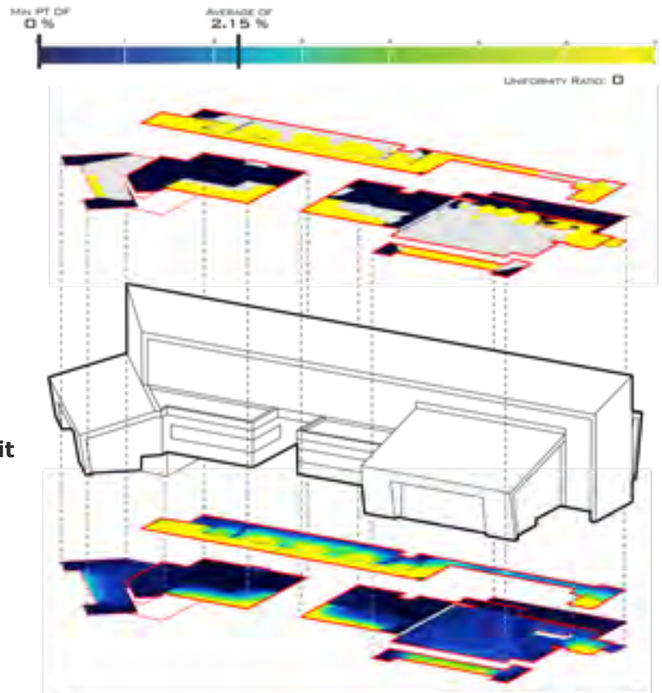


Figure 273: Iteration 2 - 3D Exploded Axo with Daylight Factor + Over & Underlit
(Data Generated by Sefaria, Drawn by Author, 2019)

8.20 Iteration 3 *- Addition of Skylights*

Total Floor Area: **881 m²**

Model 1:
Poor Insulation *(with Single Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :		25094
Cooling :		18135
Lighting :		1830
Equipment :		3660
Fans :		12025
Pump :		248

• Daylighting

Under-Lit :	20
Well-Lit :	17
Over-Lit :	**63**

Model 2:
Excellent Insulation *(with Double Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :		6979
Cooling :		18417
Lighting :		1830
Equipment :		3660
Fans :		12366
Pump :		41

• Energy Use Index (EUI)

2030 Challenge:	65
Actual :	49

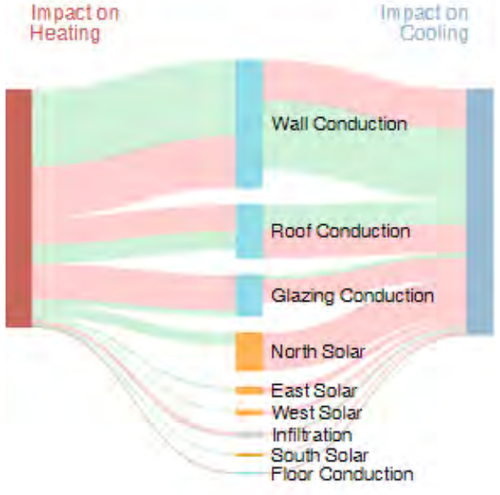


Figure 274: Heating & Cooling Poorly Non-insulated - 3
(Generated by Safaria, 2019)

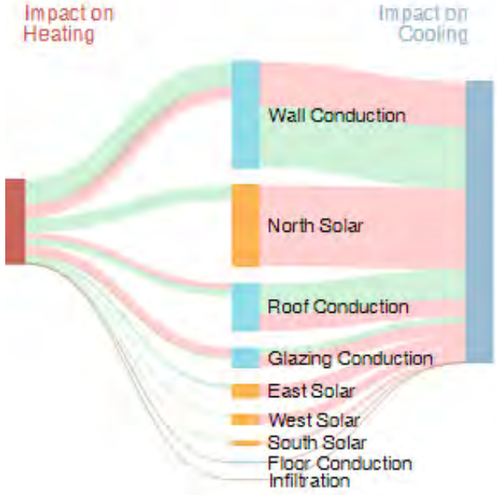


Figure 275: Heating & Cooling Well Insulated - 3
(Generated by Safaria, 2019)

8.21 Findings

The addition of the skylights has reduced the amount of under lit area by 16%.However it has also resulted in a huge increase of over lit areas. By reducing the size of the skylights and the uses of shading devices where necessary, it will be possible to achieve a balance between over-lit and under-lit areas, resulting in a more well-lit internal environment. This iteration also managed to reduce its overall energy use index (EUI) as compared to the base iteration.

Key

- Exterior Walls
- Floors
- Roofs
- Glazing
- Shading
- Interior Walls

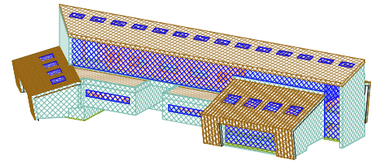
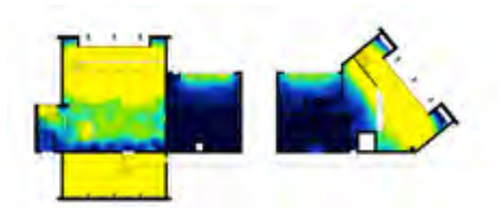
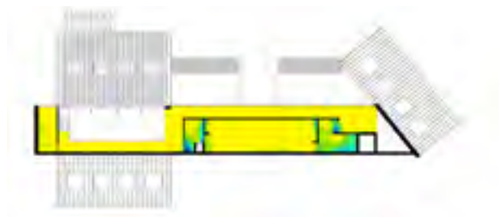


Figure 276: Iteration 3 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



Ground Floor



First Floor

Figure 277: Iteration 3 - Daylight Factor Floor Plans
(Data Generated by Safaria, Drawn by Author, 2019)

Under-Lit VS Over-Lit *(%)*

Ground Floor

First Floor

Figure 278: Iteration 3 - Over & Under-lit Floor Plans
(Data Generated by Safaria, Drawn by Author, 2019)

Daylighting

63 % Over-Lit

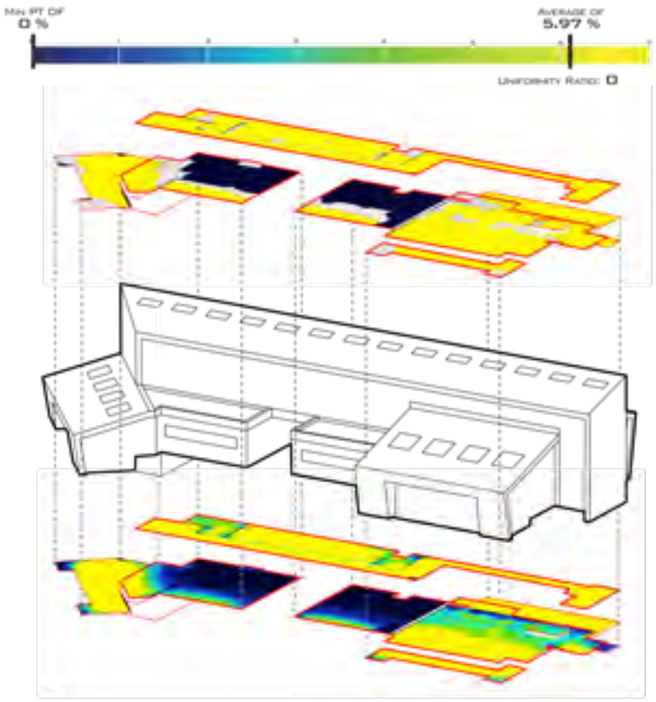


Figure 279: Iteration 3 - 3D Exploded Axo with Daylight Factor + Over & Under-lit
(Data Generated by Safaria, Drawn by Author, 2019)

8.22 Iteration 4 *- Addition of Skylights with Shading*

Total Floor Area: **881 m²**

Model 1:
Poor Insulation *(with Single Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :	24685
Cooling :	17660
Lighting :	1830
Equipment :	3660
Fans :	111739
Pump :	241

• Daylighting

Under-Lit :	27
Well-Lit :	**38**
Over-Lit :	35

Model 2:
Excellent Insulation *(with Double Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :	6825
Cooling :	13573
Lighting :	1830
Equipment :	3660
Fans :	8684
Pump :	47

• Energy Use Index (EUI)

2030 Challenge:	65
Actual :	39

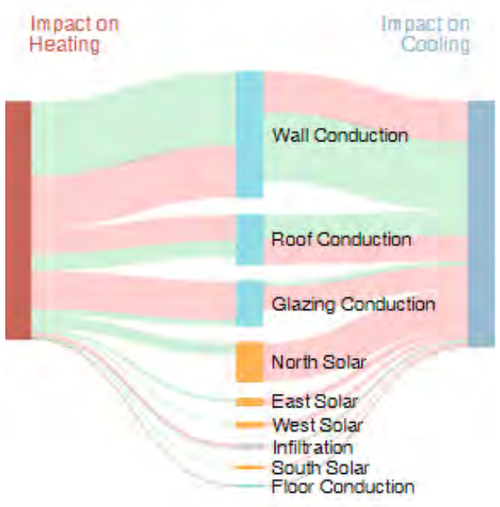


Figure 280: Heating & Cooling Poorly Non-insulated - 4
(Generated by Sefaria, 2019)

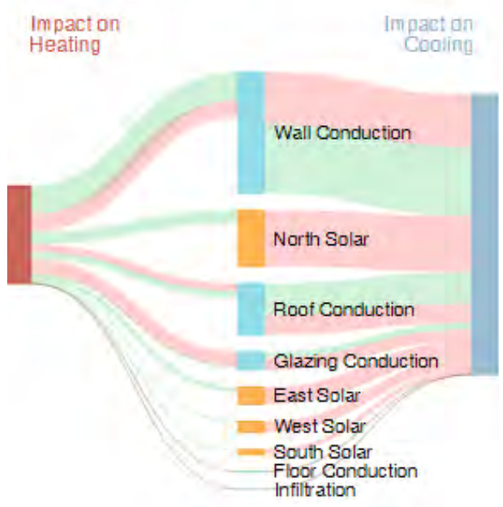


Figure 281: Heating & Cooling Well Insulated - 4
(Generated by Sefaria, 2019)

8.23 Findings

This iteration is mostly well-lit and also has reduced its overall energy use index (EUI) from 50-39 as compared to the base iteration. Most of the under-lit areas are spaces (such as cold rooms, stores and ablutions) that do not require natural daylight. However, there are still many areas that have a high daylight factor as highlighted in yellow in Figure 283.

Key

- Exterior Walls
- Floors
- Roofs
- Glazing
- Shading
- Interior Walls

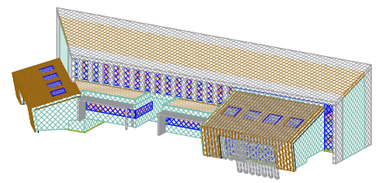
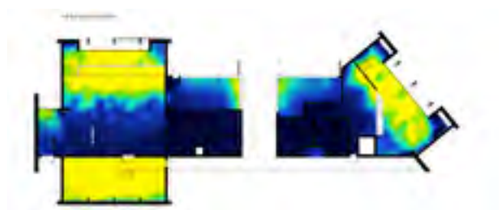
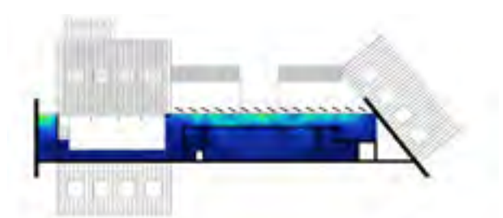


Figure 282: Iteration 4 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



Ground Floor



First Floor

Figure 283: Iteration 4 - Daylight Factor Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Under-Lit VS Over-Lit *(%)*

Ground Floor

First Floor

Figure 284: Iteration 4 - Over & Under-lit Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Daylighting

38 % Well-Lit

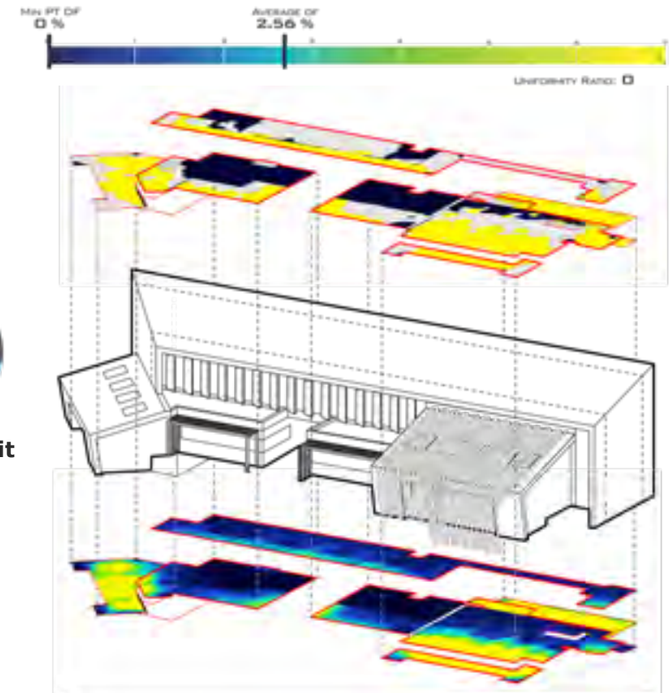


Figure 285: Iteration 4 - 3D Exploded Axo with Daylight Factor + Over & Under-lit
(Data Generated by Sefaria, Drawn by Author, 2019)

8.24 Iteration 5 *- (Hybrid)*

Total Floor Area: **881 m²**

Model 1:
Poor Insulation *(with Single Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :	24232
Cooling :	15159
Lighting :	1830
Equipment :	3660
Fans :	10146
Pump :	259

• Daylighting

Under-Lit :	29
Well-Lit :	**46**
Over-Lit :	28

Model 2:
Excellent Insulation *(with Double Glazing)*

EUI

kWh/m²/yr

Energy Segments

• Energy segments

Heating :	6825
Cooling :	13946
Lighting :	1830
Equipment :	3660
Fans :	8938
Pump :	47

• Energy Use Index (EUI)

2030 Challenge:	65
Actual :	39

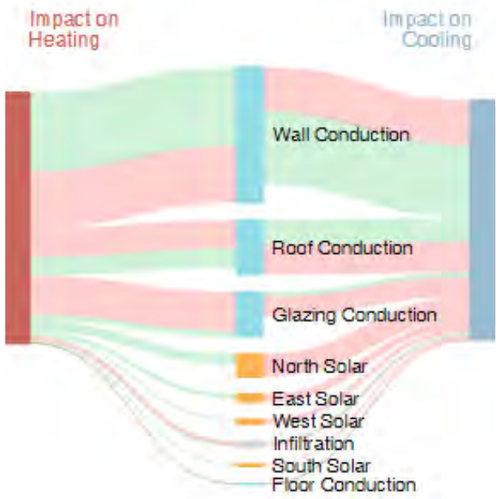


Figure 286: Heating & Cooling Poorly Non-insulated - 5
(Generated by Sefaria, 2019)

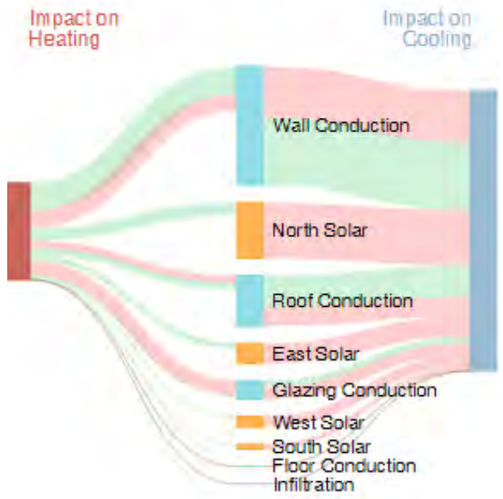


Figure 287: Heating & Cooling Well Insulated - 5
(Generated by Sefaria, 2019)

8.25 Findings

This iteration has applied all the findings from the previous iterations. It has increased the amount of well-lit area by 8%. It has also managed to bring the EUI of model 1 (single glazing) below the desired target of 65. The high daylight factor areas have been almost completely reduced as shown by Figure 289.

Key

- Exterior Walls
- Floors
- Roofs
- Glazing
- Shading
- Interior Walls

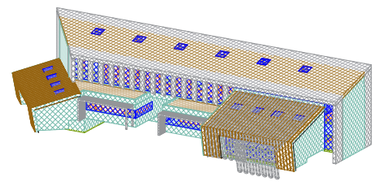
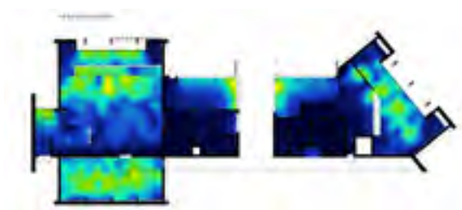


Figure 288: Iteration 5 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



Under-Lit VS Over-Lit *(%)*

Figure 289: Iteration 5 - Daylight Factor Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Figure 290: Iteration 5 - Over & Under-lit Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

Daylighting

46 % Well-Lit

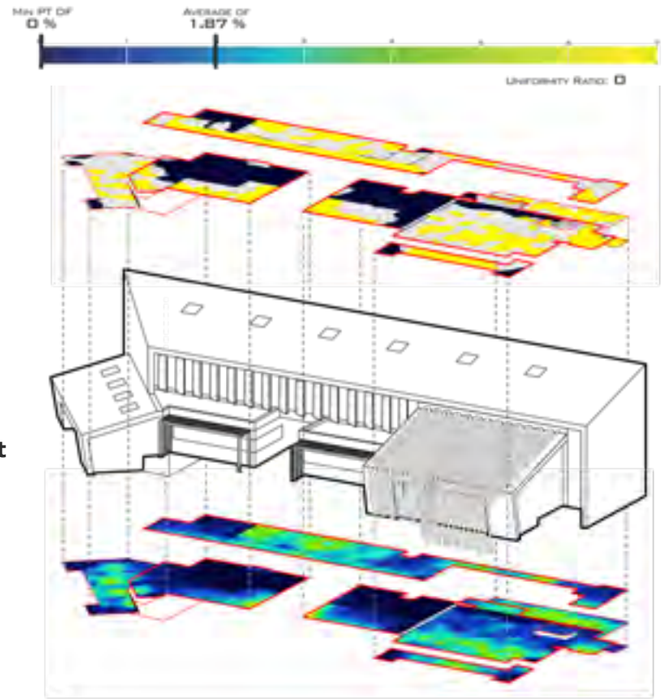


Figure 291: Iteration 5 - 3D Exploded Axo with Daylight Factor + Over & Under-lit
(Data Generated by Sefaria, Drawn by Author, 2019)

8.26 Iteration 6 *- Hybrid with Wider Through-way*

Total Floor Area: 853 m²

Model 1:
Poor Insulation *(with Single Glazing)*

kWh/m²/yr

- Energy segments

Heating :	24232
Cooling :	15159
Lighting :	1830
Equipment :	3660
Fans :	10146
Pump :	259

- Daylighting

Under-Lit :	24
Well-Lit :	**47**
Over-Lit :	29

Model 2:
Excellent Insulation *(with Polycarbonate)*

kWh/m²/yr

- Energy segments

Heating :	3394
Cooling :	10955
Lighting :	1771
Equipment :	3543
Fans :	6995
Pump :	23

- Energy Use Index (EUI)

2030 Challenge:	65
Actual :	31

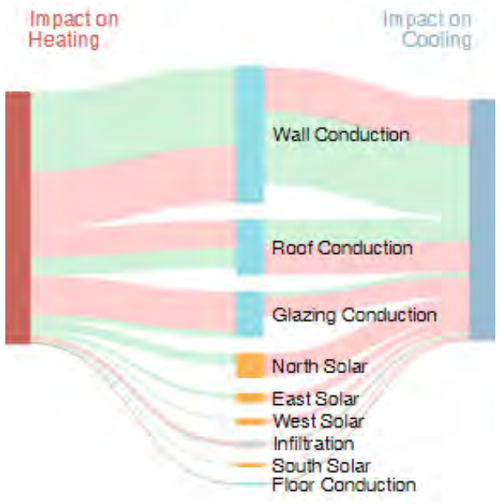


Figure 292: Heating & Cooling Poorly Non-insulated - 6
(Generated by Sefaria, 2019)

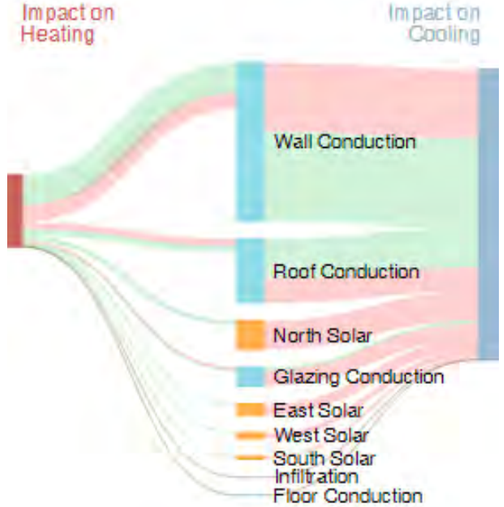


Figure 293: Heating & Cooling Well Insulated - 6
(Generated by Sefaria, 2019)

8.27 Findings

This iteration shows that polycarbonate sheeting has a better R-value than double glazing. In addition, design change was made by widening the through-way which also slightly reduced the building area. This iteration increased the well-lit area by 1% and has reduced its EUI down to 31. Therefore, as per all the reasons discussed, this iteration has achieved the best overall results.

Key

- Exterior Walls
- Floors
- Roofs
- Glazing
- Shading
- Interior Walls

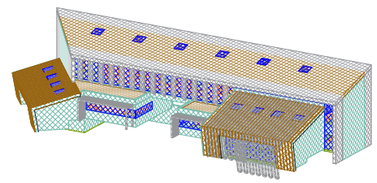
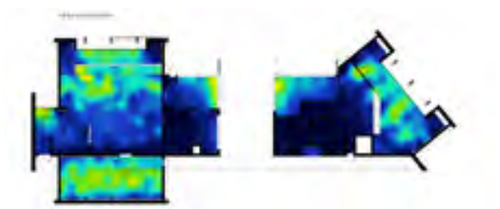
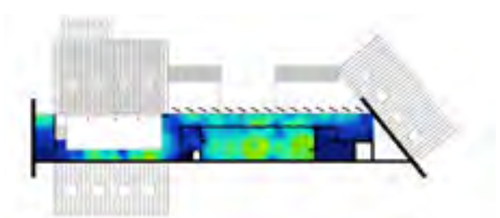


Figure 294: Iteration 6 - 3D View
Right, (Author, 2019)

Daylight Factor *(%)*



Ground Floor

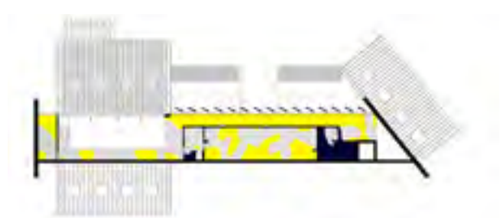


First Floor

Figure 295: Iteration 6 - Daylight Factor Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)

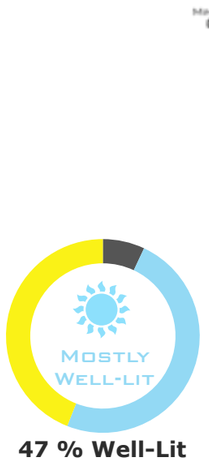
Under-Lit VS Over-Lit *(%)*

Ground Floor



First Floor

Figure 296: Iteration 6 - Over & Under-lit Floor Plans
(Data Generated by Sefaria, Drawn by Author, 2019)



47 % Well-Lit

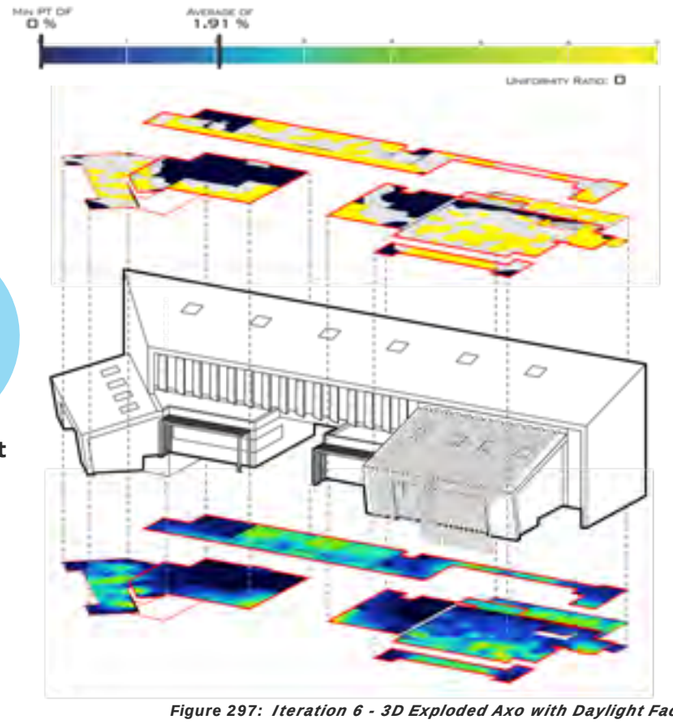


Figure 297: Iteration 6 - 3D Exploded Axo with Daylight Factor + Over & Under-lit
(Data Generated by Sefaria, Drawn by Author, 2019)

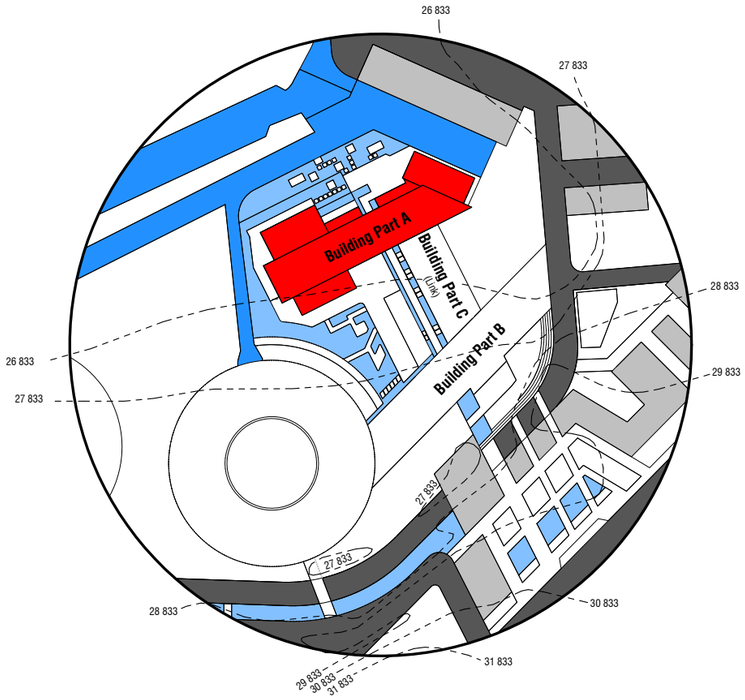


Figure 298: Locality Plan
(Author, 2019)

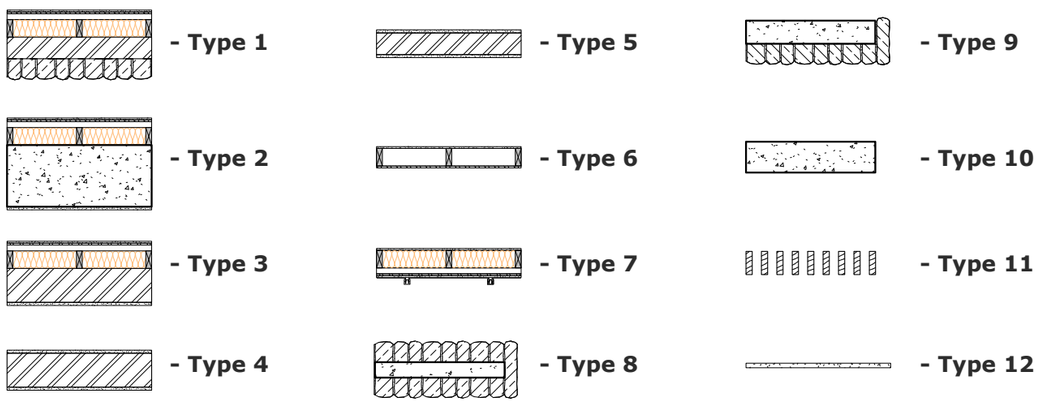


Figure 299: Wall Type Keyy Plans
(Author, 2019)

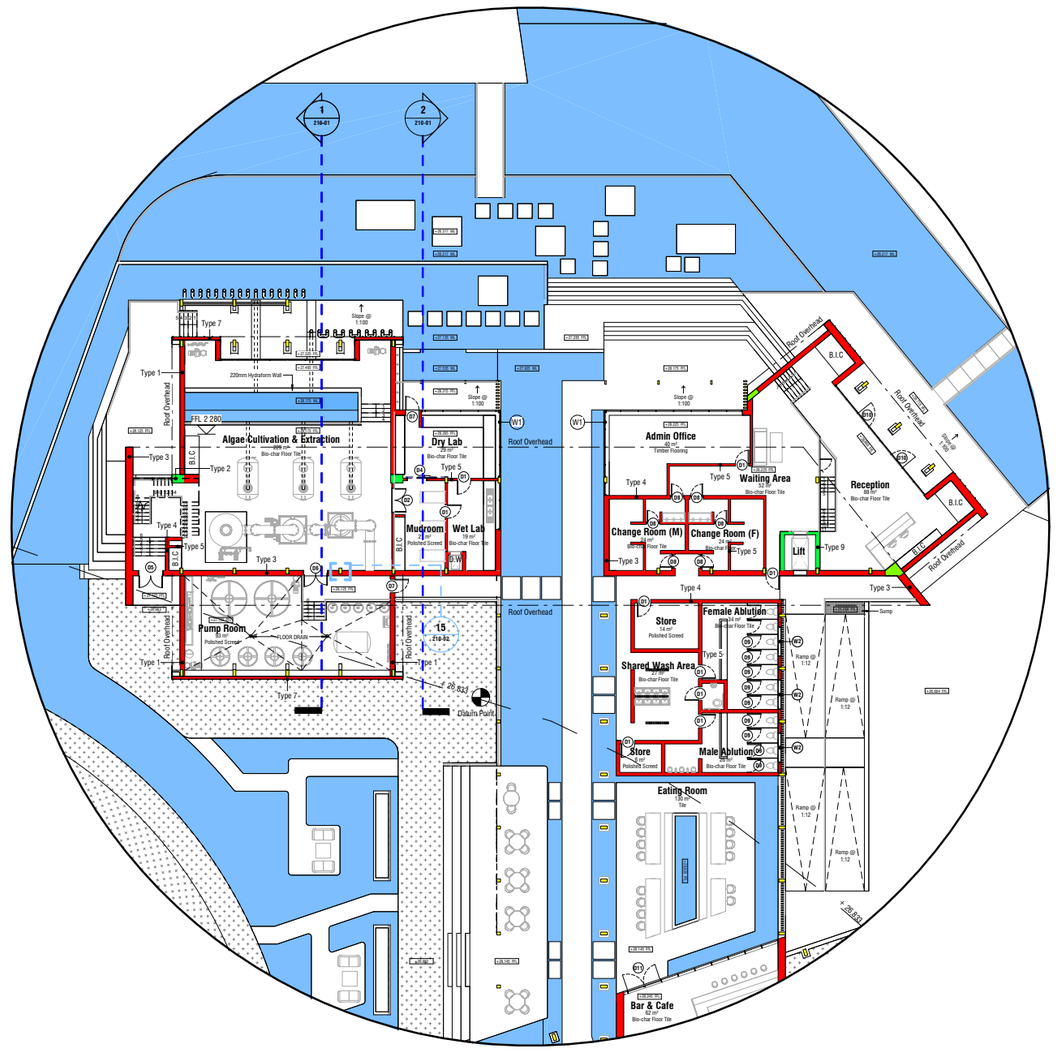


Figure 300: Ground Floor Plan
(Author, 2019)

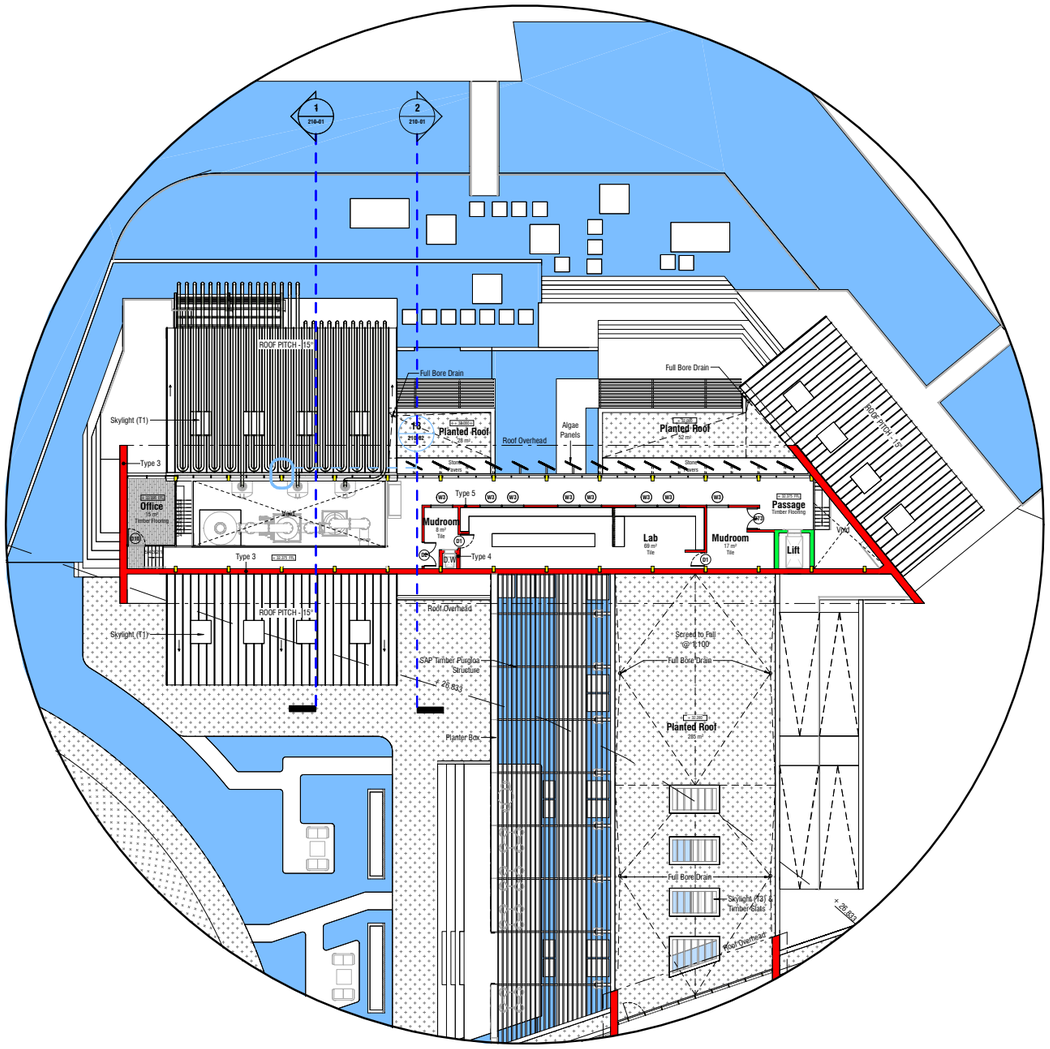


Figure 301: ***First Floor Plan***
(Author, 2019)

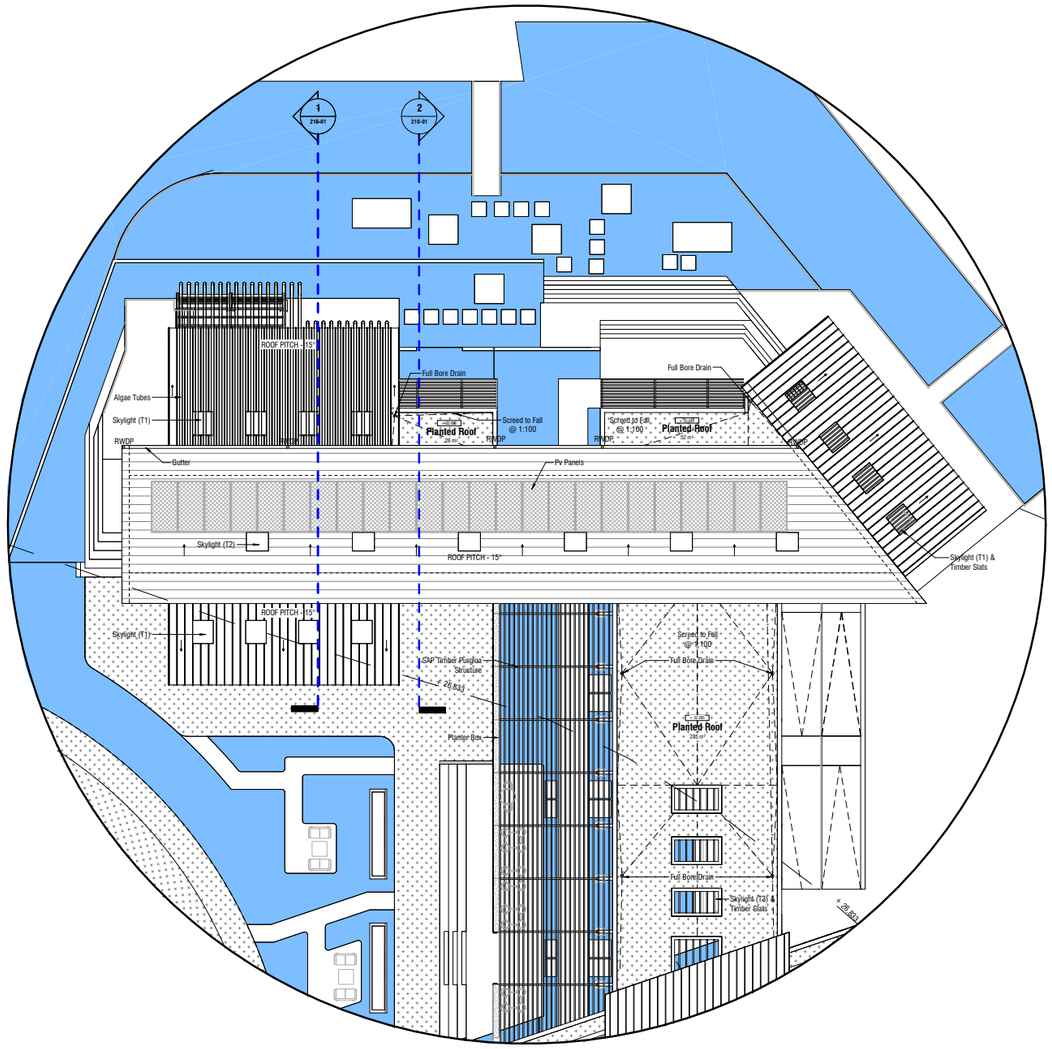


Figure 302: ***Roof Plan***
(Author, 2019)

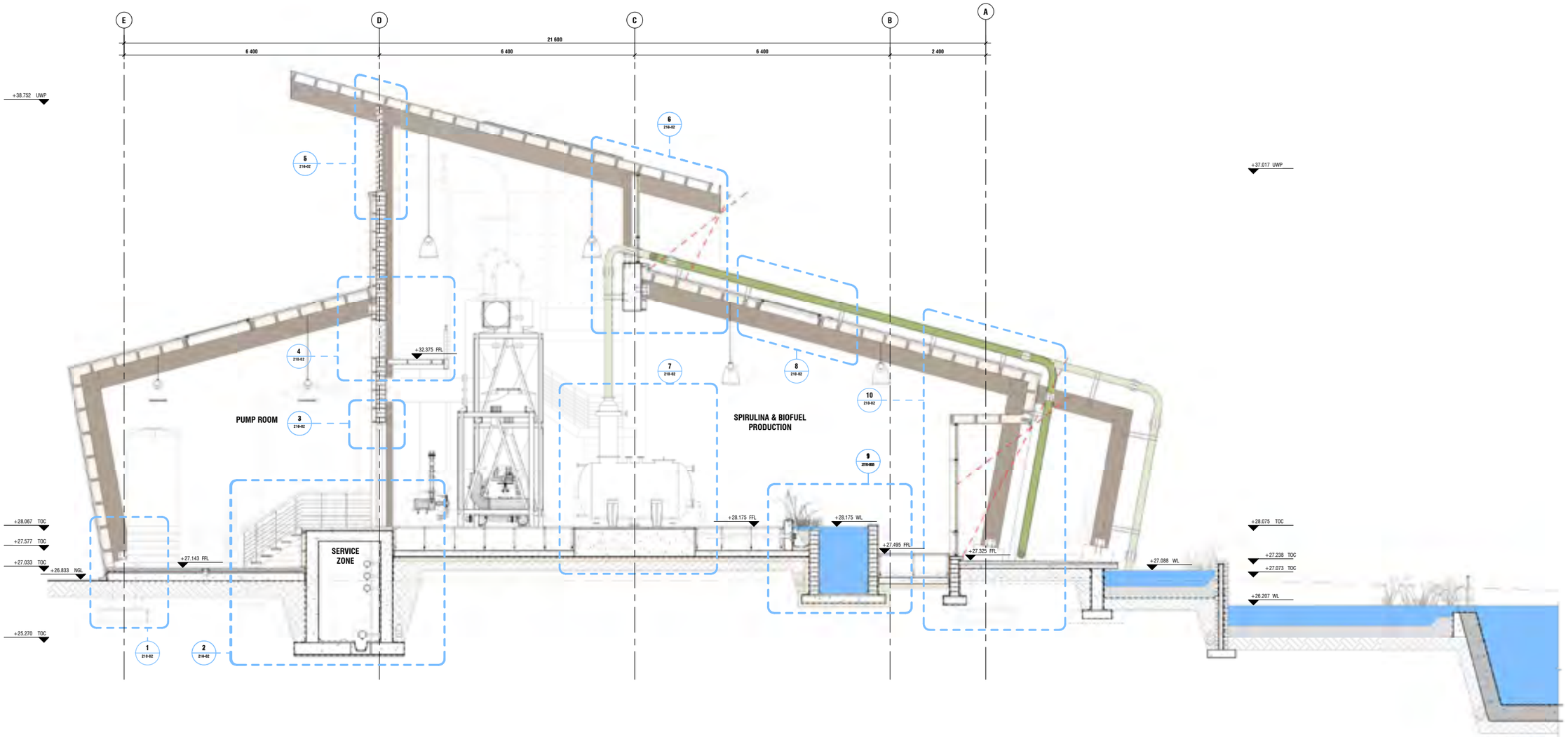


Figure 303: Section 1
(Author, 2019)

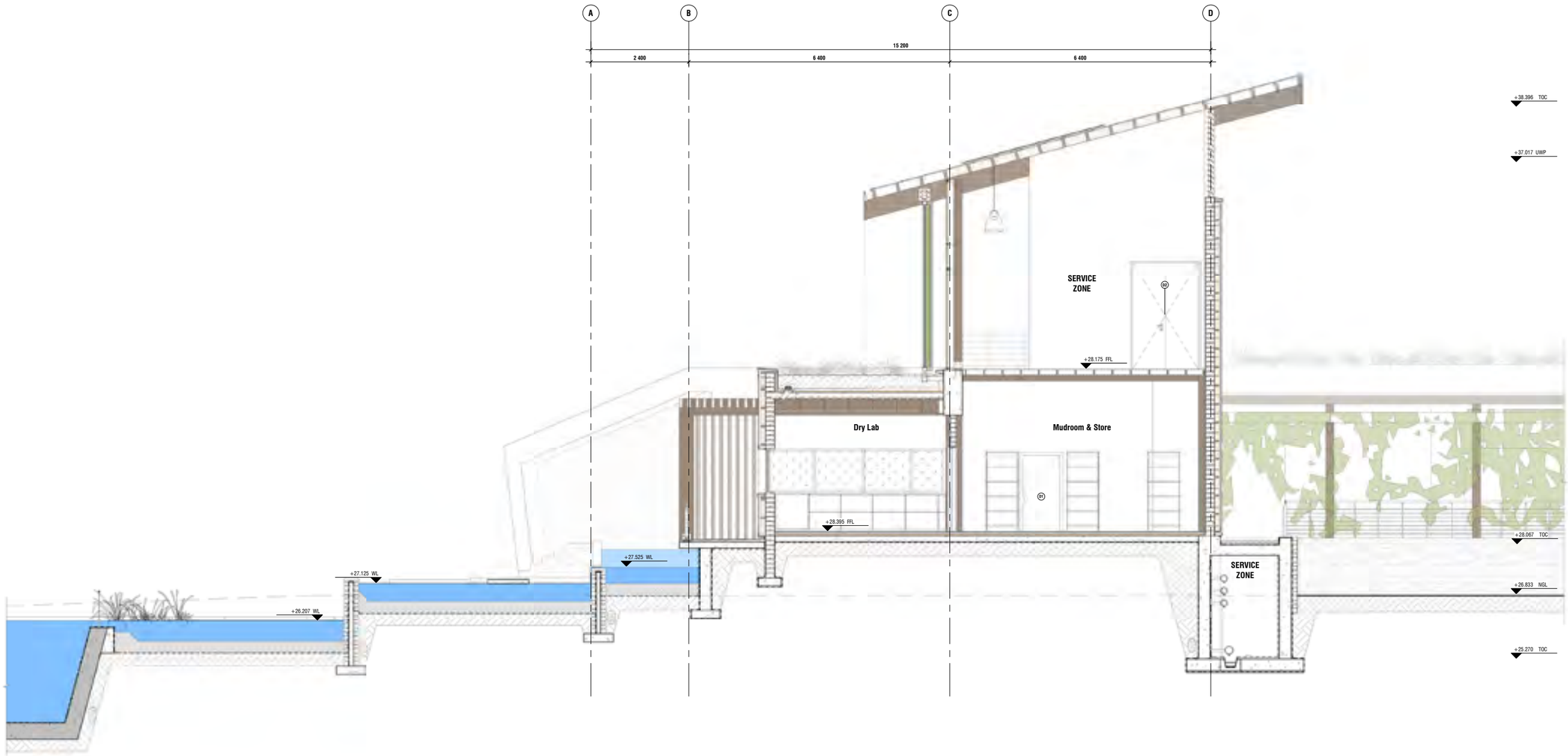


Figure 304: Section 2
(Author, 2019)

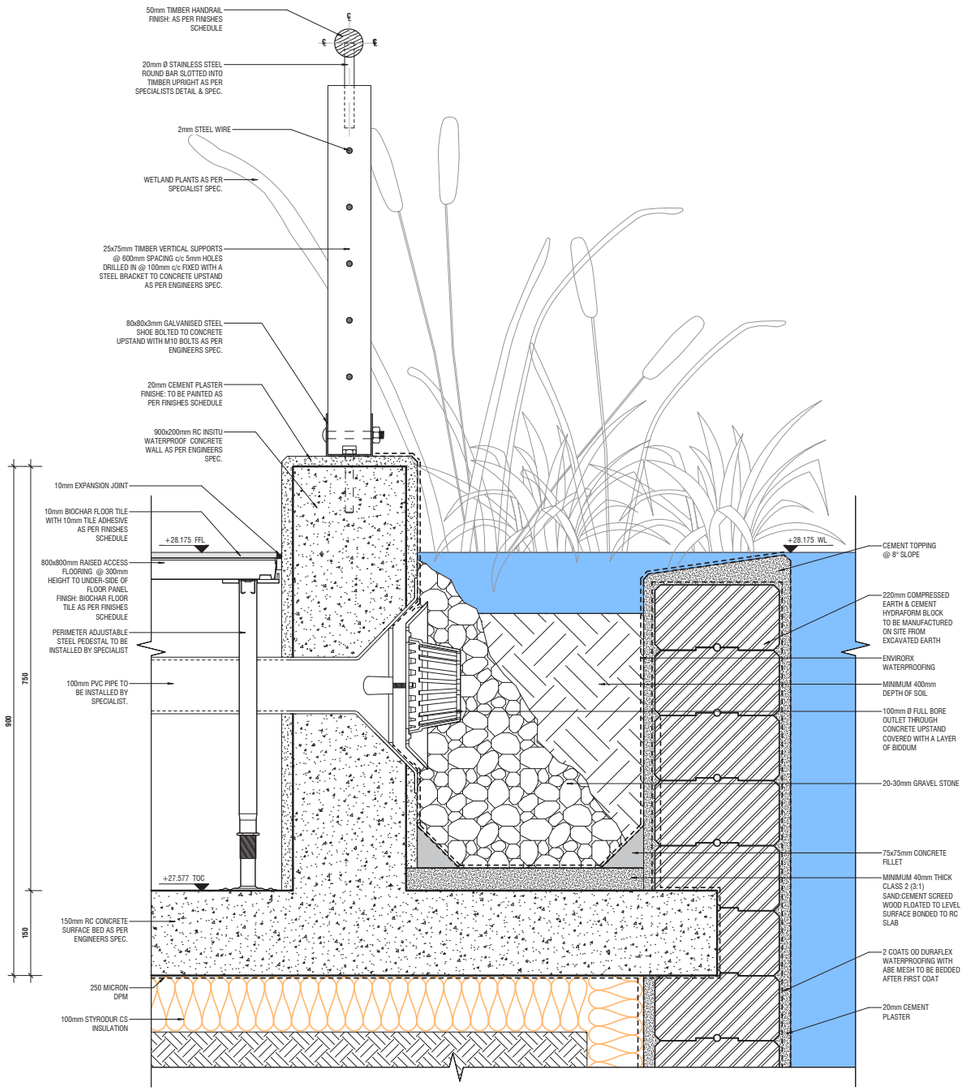


Figure 305: Algae Extraction Pond Junction Detail (#14)

(Author, 2019)

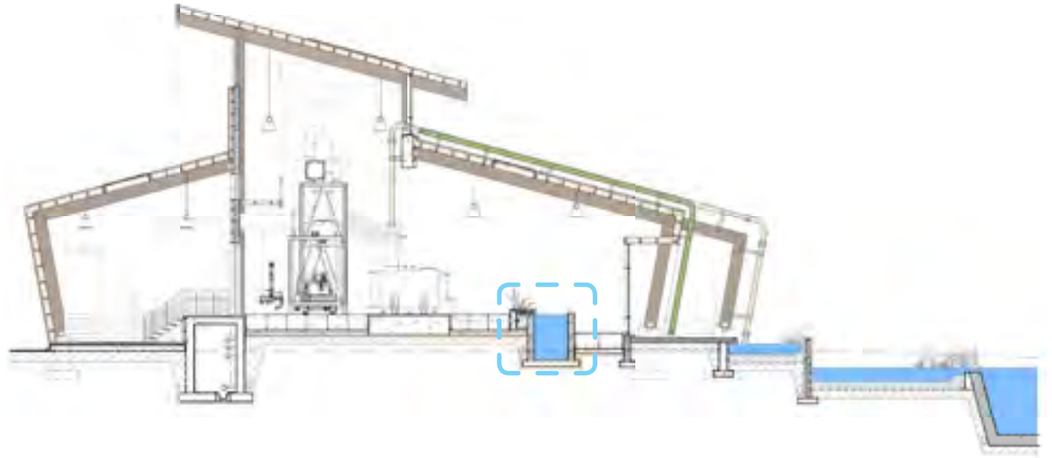


Figure 306: Reference Section A-A

(Author, 2019)

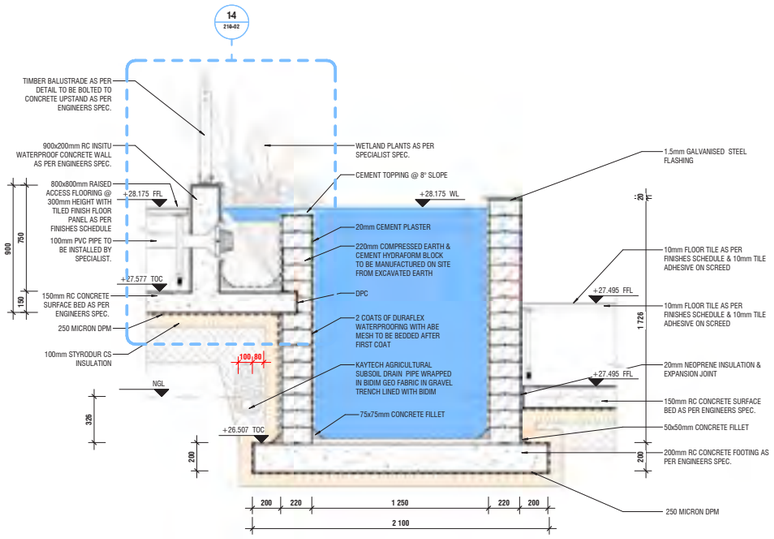


Figure 307: Algae Extraction Pond Detail (#9)

(Author, 2019)

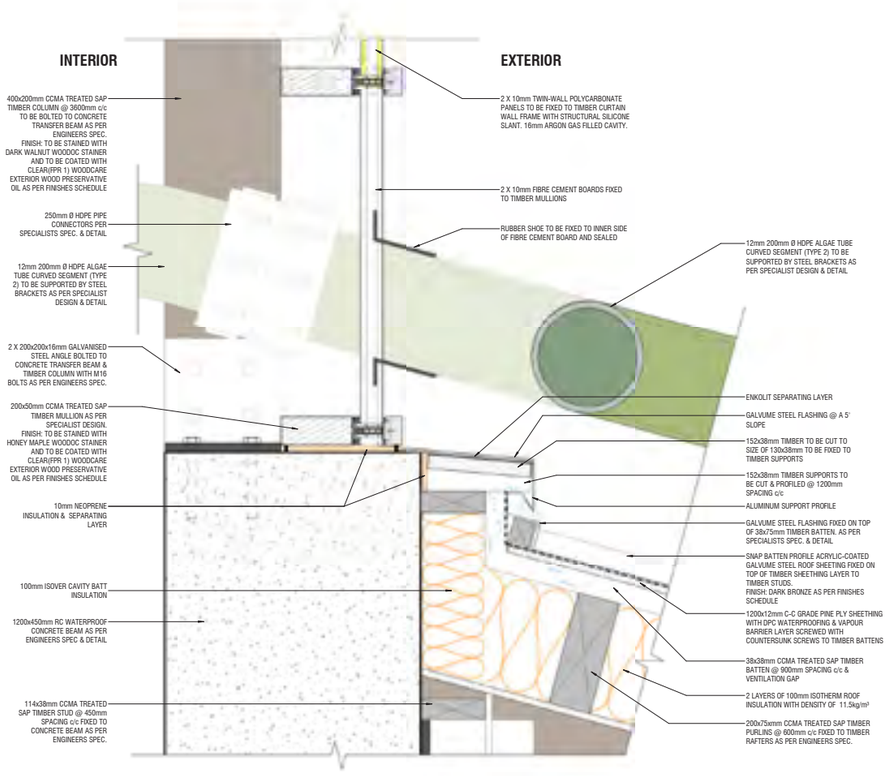


Figure 308: Curtain Wall Cill Detail (#12)

(Author, 2019)

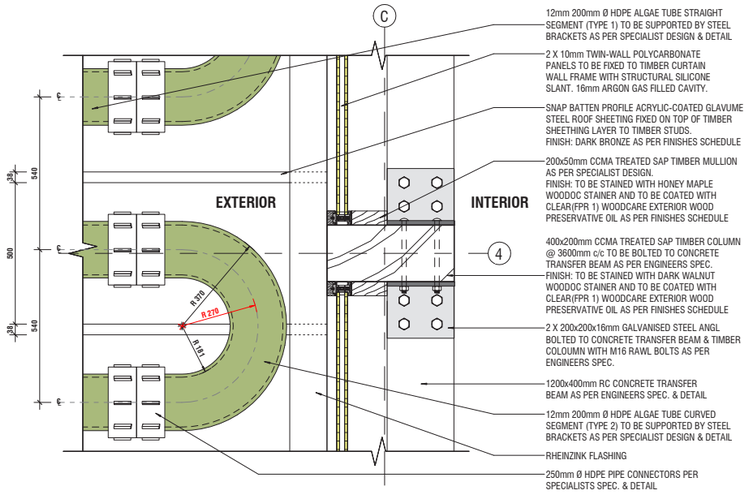


Figure 309: Curtain Wall Jamb Detail (#13)

(Author, 2019)

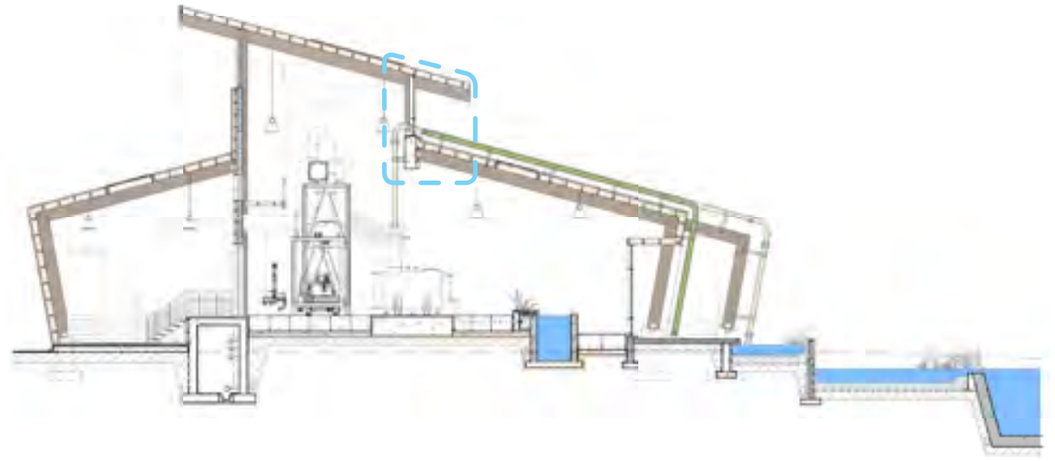


Figure 310: Reference Section A-A

(Author, 2019)

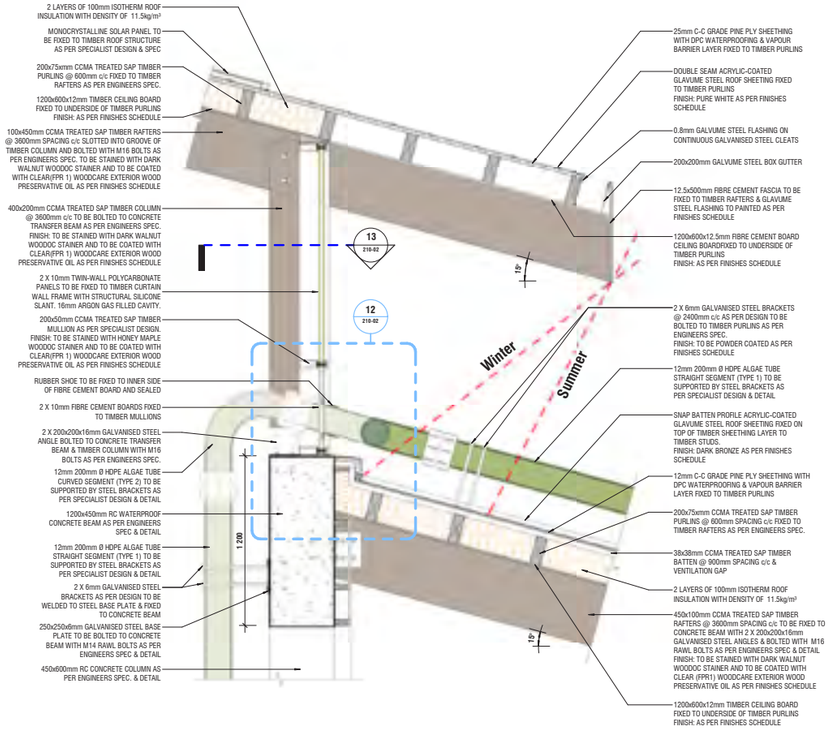
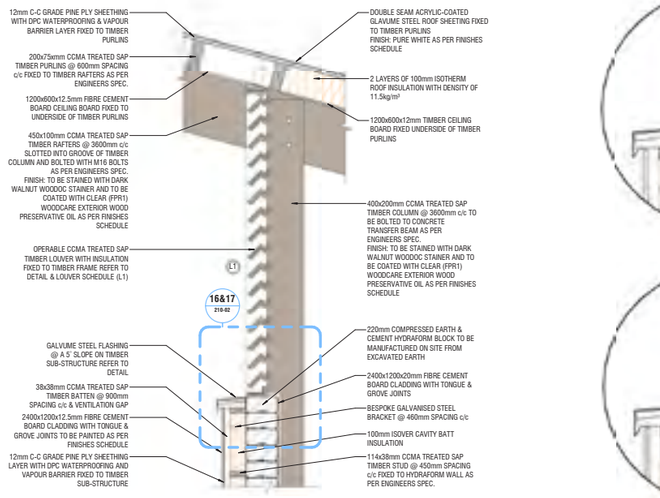


Figure 311: Algae Tubes & Roof Junction Detail (#6)

(Author, 2019)



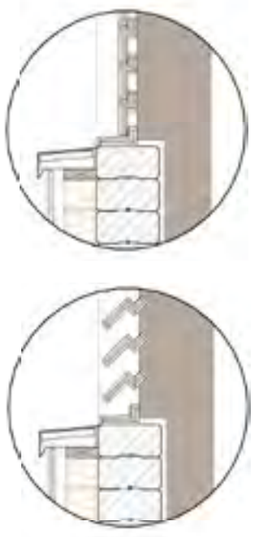


Figure 312: Louver & Roof Junction Detail (#5)

(Author, 2019)

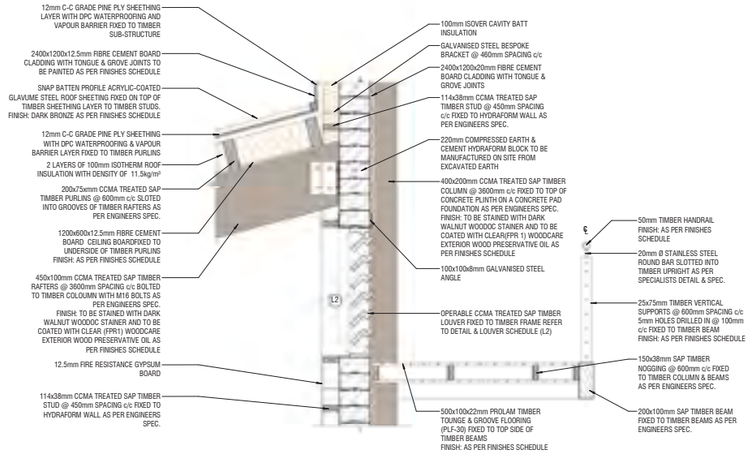


Figure 313: Suspended Floor & Roof Junction Detail (#4)

(Author, 2019)

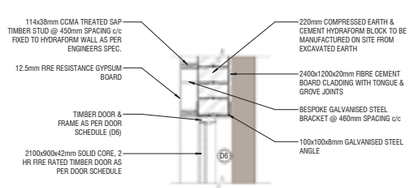


Figure 314: Door Lintel Detail (#3)

(Author, 2019)

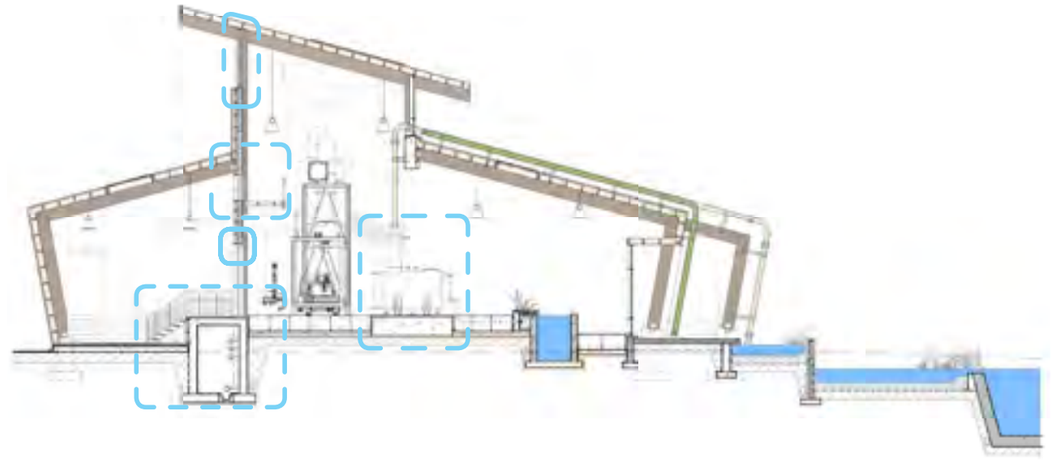


Figure 315: Reference Section A-A

(Author, 2019)

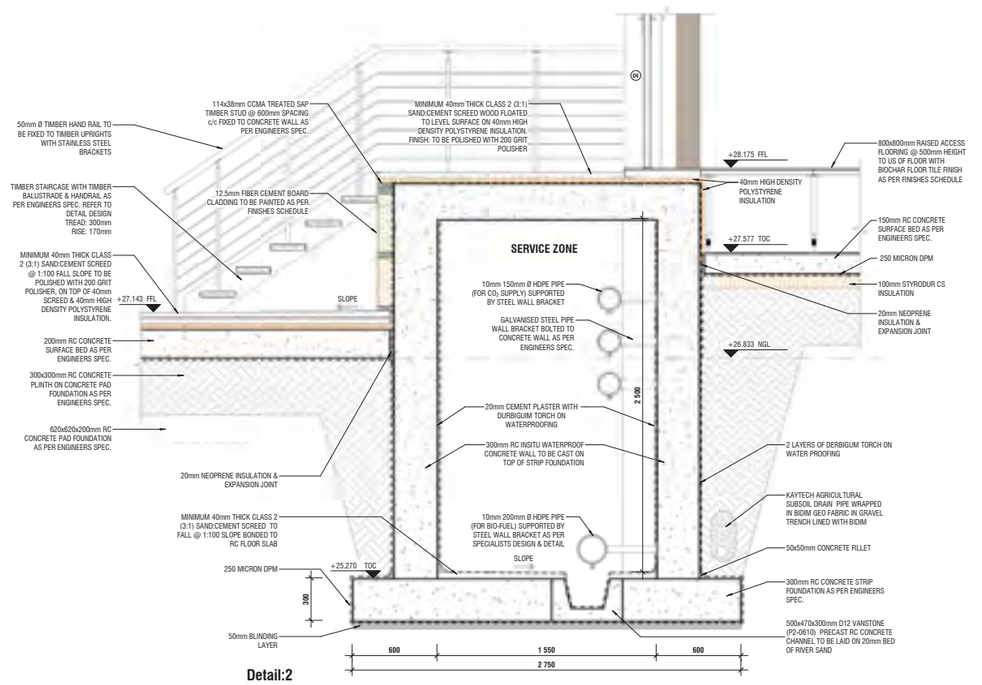


Figure 316: Service Zone Detail (#2)

(Author, 2019)

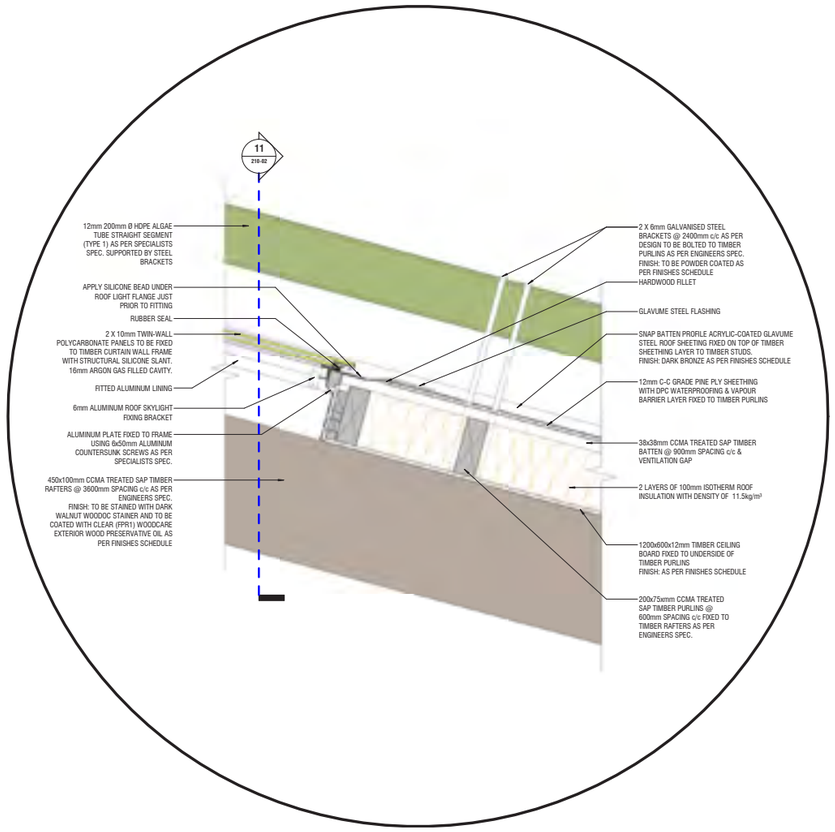


Figure 317: Skylight Detail - Bottom Junction (#8a)

(Author, 2019)

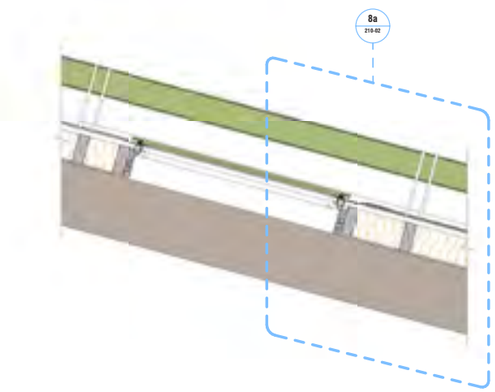


Figure 318: Skylight Detail (#8)

(Author, 2019)

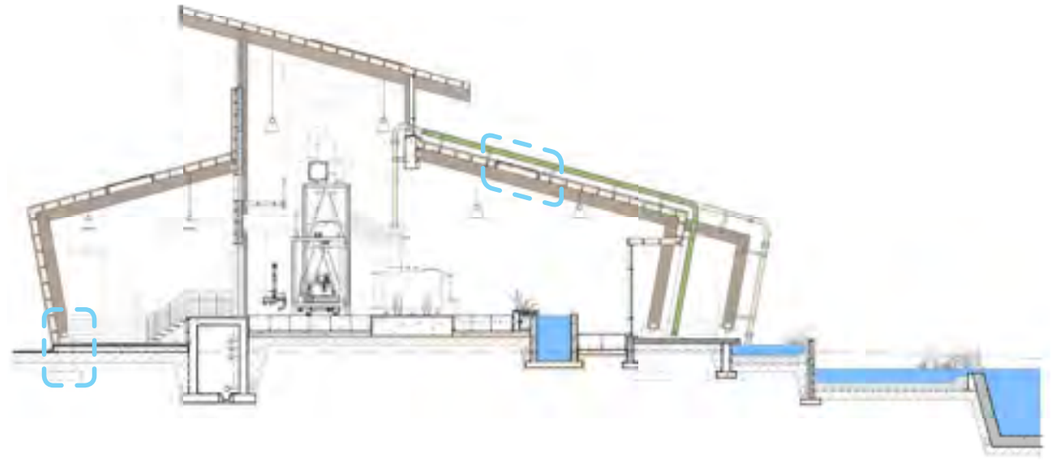


Figure 319: Reference Section A-A

(Author, 2019)

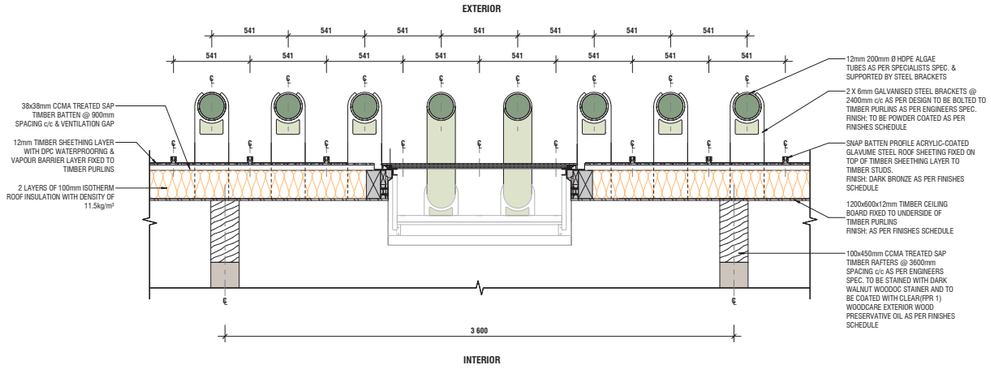


Figure 320: Roof Cross Section Detail (#11)

(Author, 2019)

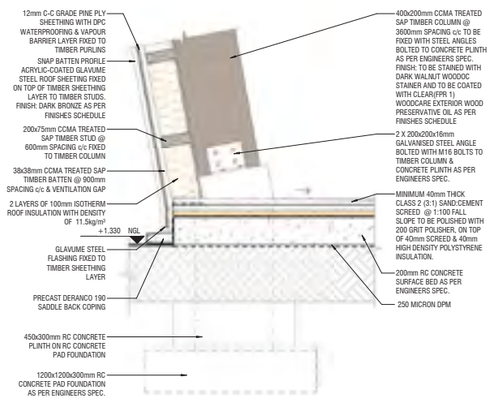
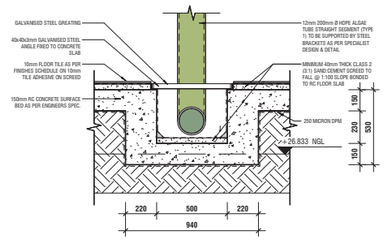


Figure 321: Southern Facade Base Junction Detail (#1)

(Author, 2019)

Figure 322: Algae Tube Chanel Detail (#16)
(Author, 2019)



Algae Tube - Channel Detal
SCALE: 1 : 20

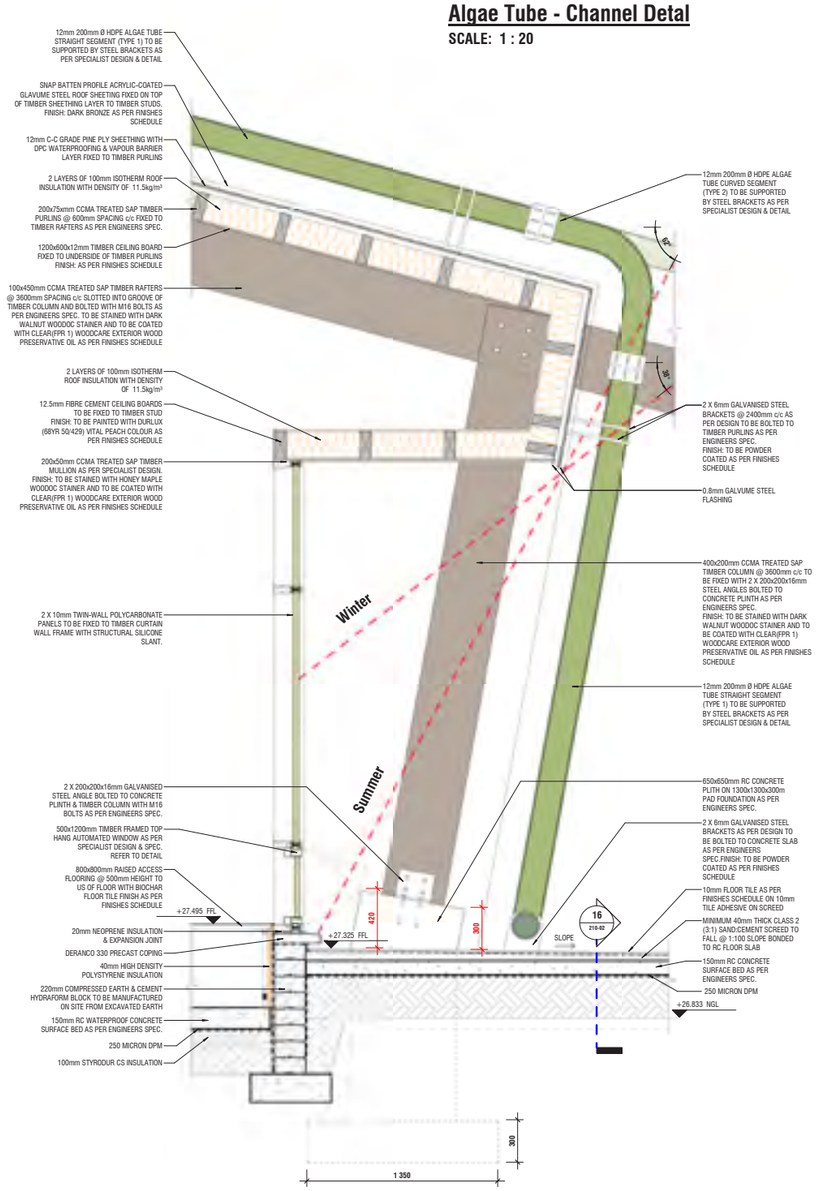


Figure 323: Northern Facade & Roof Junction Detail (#10)
(Author, 2019)

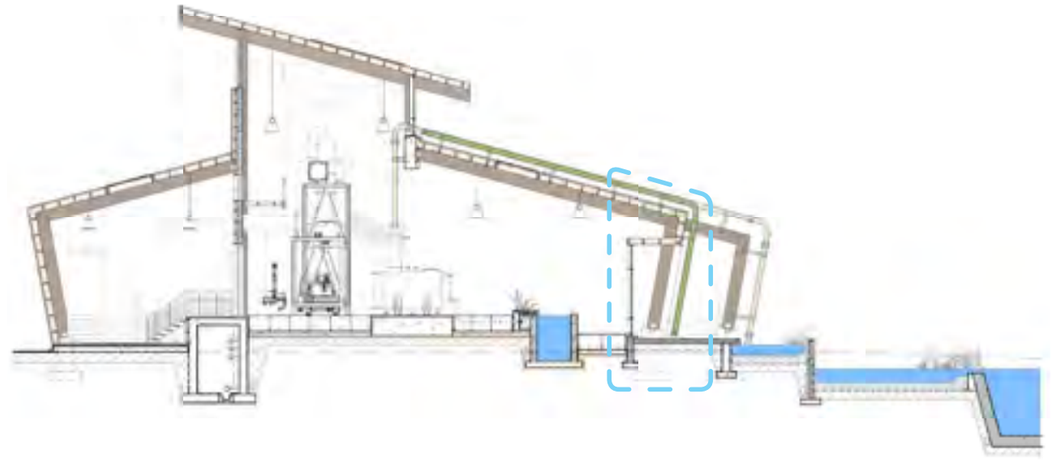


Figure 324: Reference Section A-A
(Author, 2019)

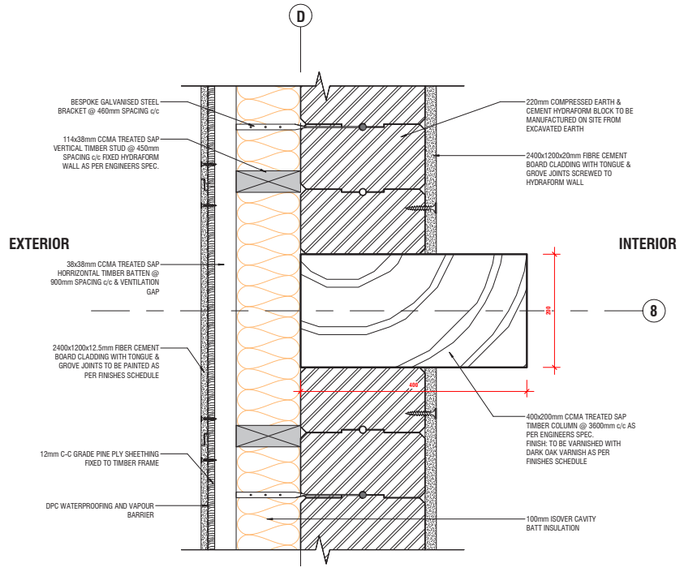


Figure 325: Column Wall Jamb Detail - Plan (#15)
(Author, 2019)

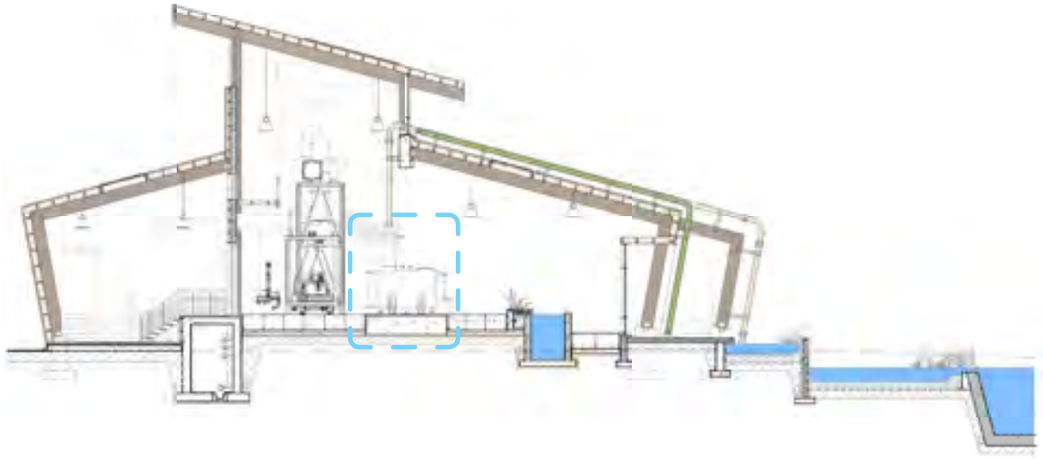


Figure 326: Reference Section A-A
(Author, 2019)

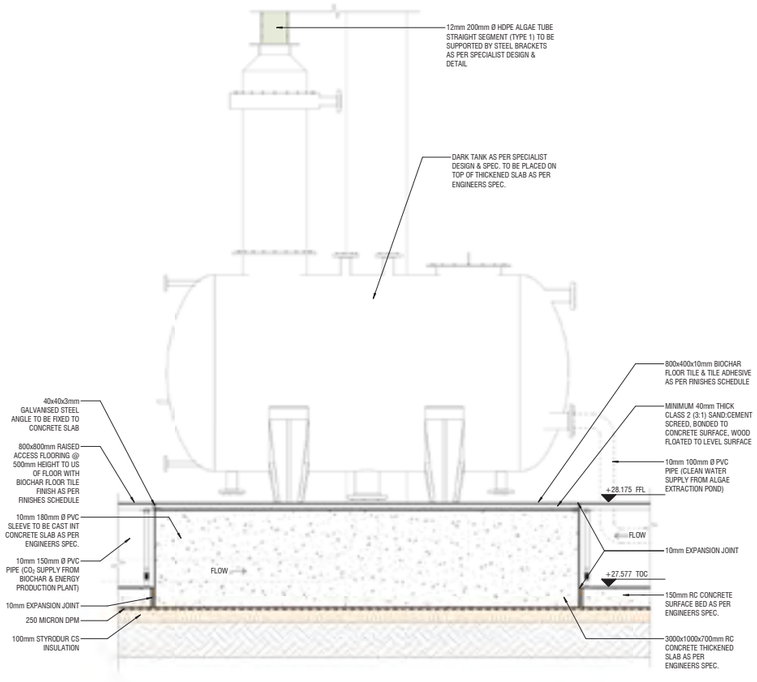
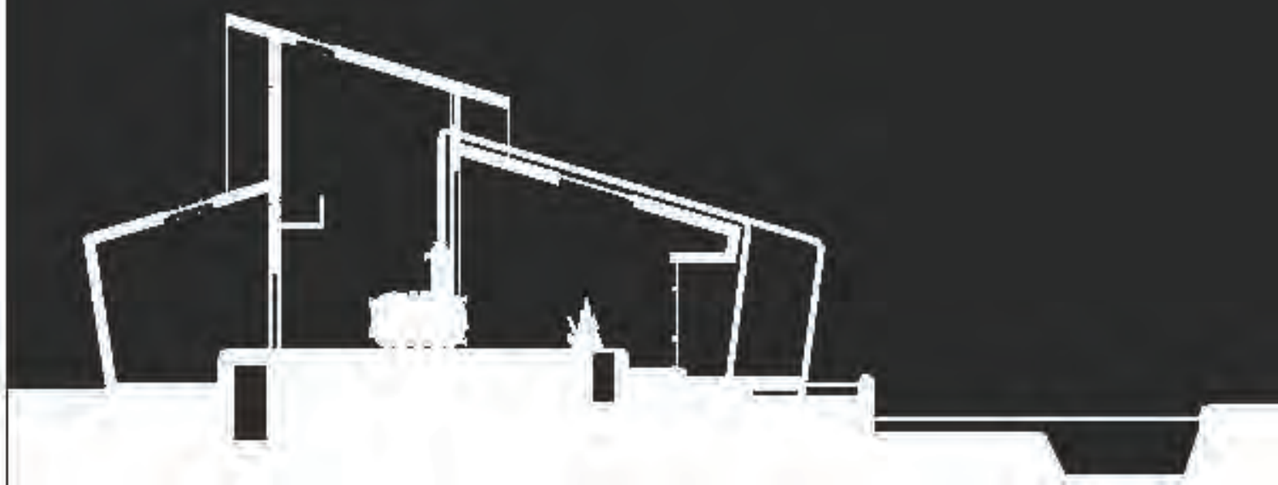


Figure 327: Dark Tank Base Detail (#7)
(Author, 2019)

CHAPTER 09

CONCLUSION



CONCLUSION

"Design is a healing art that provides the opportunity to enhance people's lives using elements of nature as a gift"

- Clodagh
(Kettler, GHeerwagen, Mador. 200:341)

Throughout the test of time, man has continued to define the natural and architectural environments that we live in. As discussed in this dissertation, it has been man's dominance over nature that has put us in the predicament we are experiencing in the 21st century. This dissertation explored the potential ways in which architecture can act as a catalyst to the creation of spatial experiences which integrate man with nature. Through transformation within architecture, a possible solution was sought to create a healing environment which would bring about restoration of body mind and soul, thus creating a healthy environment.

This dissertation was able to offer a way forward, showing how architecture can mitigate the causes and effects of climate change on our health and environments. This was achieved by suggesting that architecture should be part of the solution to diminish CO_2 emissions and to cause a paradigm shift in the way man approaches development and growth with the applied response to live better and become responsible stewards of our environments.

There is a native American Proverb ***"We do not inherit the earth from our ancestors, we borrow it from our children."*** For the future, there still lies many challenges in designing in such a manner that minimises or eliminates negative impacts that architecture has on our environmental and physical well-being. It is therefore critically important that continued exploration into new technologies and methodologies exacerbated, if we are to have a planet that can provide for the future of 12 million people.

Figure 328: Healthy Lifestyle - 2
(Getty Images, 2017)

CHAPTER 10

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CHAPTER 11

APPENDICES

Figure 329: ***Final Presentation - Image 1***
(Author, 2019)

***Figure 330:** Final Presentation - Image 2*
(Author, 2019)

Figure 331: ***Final Presentation - Image 3***
(Author, 2019)

Figure 332: Final Presentation - Image 4
(Author, 2019)

Figure 333: ***Final Presentation - Image 5***
(Author, 2019)

Figure 334: ***Final Presentation - Image 6***
(Author, 2019)

Figure 335: ***Final Presentation - Image 7***
(Author, 2019)

Figure 336: ***Final Presentation - Image 8***
(Author, 2019)

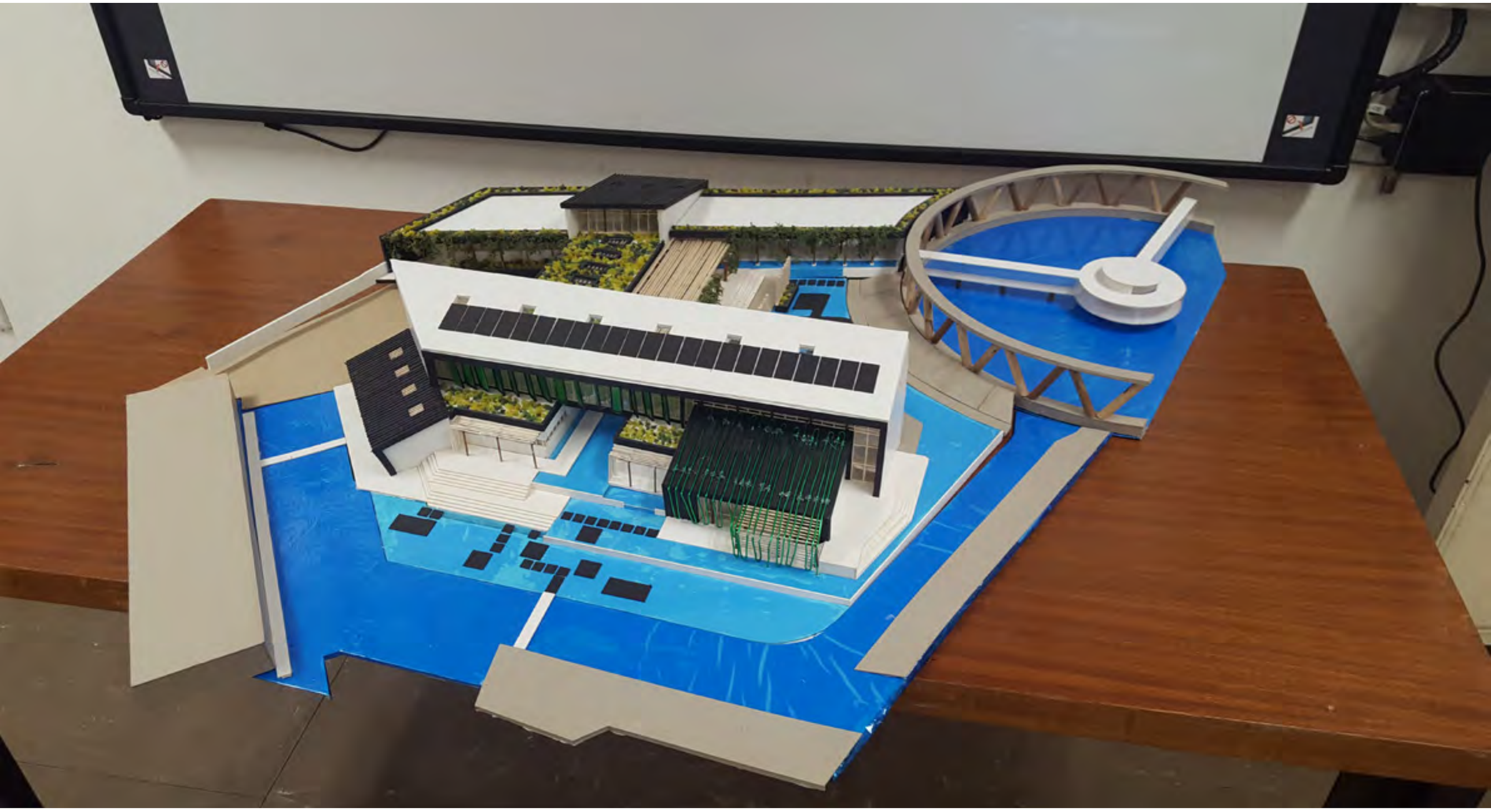

Figure 337: Final Presentation - Image 9
(Author, 2019)

Figure 338: ***Final Presentation - Image 10***
(Author, 2019)

Jason Di Bon

AN ARCHITECTURAL OASIS OF HEALING

Design by water as an approach to create a state of well-being within the built environment

Fig. 01. Above; The Current State of Pretoria West Water Retention Pond (Author, 2019)

Introduction

In the endeavour to combat the rapid rate of climate change, societies are faced with the stress of surviving extreme weather conditions in what "feels like the end of days" (Joubert L., 2019). According to Rockström, (2015), the prospect of achieving a state of well-being, is becoming more and more dim. Man has become the dominant influential force on the earth, taking little or no consideration to the degradation of the earth. He further goes on to explain that over the past 50 years "The Great Acceleration" of human pressure on the planet has intensified and continues to contribute to climate change.

Our global climatic systems are being affected by the increasing contribution that human development and its urbanization activities have had on the escalation of greenhouse emissions, and more significantly, Carbon Dioxide. These emissions have recently been recorded by the Intergovernmental Panel on Climate Change (IPCC, (2017)), and they make up more than a third of all global emissions. We are slowly heading towards a state of climatic collapse due to the current greenhouse emissions amounting to 53.5GtCO_2 per annum. This is greater than it has been in 3 million years. It is alarming to note that it is projected that we have just 12 years to bring our carbon emissions down to zero. (IPCC, (2018.) Should we continue our current trajectory we would cross an irreversible threshold bringing us into a new climatic era. This Trajectory has been out of balance from the origin of modern society. Reed, (2007.) This puts man at risk, with increasing health issues and also puts our planet at risk, as it heads for the "sixth extinction", Overy, (2019).

Despite the negative effects of climate change, man continues to build and develop, growing our cities whilst devouring our natural resources. According to Abdinor, (2019), advised that the Climate Action Tracker, a European group, has declared South Africa's national plan of 2007 as "highly ineffective", and its already relaxed 2007 budget for reducing carbon emission will be difficult to achieve. If every country adopts this approach, it is expected that the world temperatures would rise by 4°c, double to what the United Nation's Intergovernmental Panel on Climate Change considers to be safe.

In turn these effects of climate change have resulted in many negative impacts on humanity's physical and mental health which has caused a phenomenon known as Climate Anxiety. This is "the distress" that is produced by environmental change impacting on people while they are directly connected to their home environment as explained by Prof Petersen Boring, (2016). This disorder is becoming a major concern, and the American Psychological Association, has documented a climate change guide to assist mental care practitioners to deal with this condition.

In the hope of addressing these challenges "An Eco-systemic approach to Live better in a Better World" Pilon, (2014), is crucial. The design of built environments must move towards a more sustainable future to sustain life and evade environmental collapse. James Martin, (2006) warns us in "The meaning of the 21st century", that we are at an extraordinary crossroads of human history, and that the fate of Earth rests in our ability to act or in our failure to act, over the next 20 years.

The aim of this article is to investigate how architecture can respond to distress caused by climate anxiety, by exploring the introduction of water as a mechanism to bring about healing. The article structure is outlined below. This article will first consider what climate anxiety is and what its impact on humanity is. Furthermore, a theoretical premise of Biophilia, regenerative design and environmental psychology will be discussed. It will only take into consideration the impact that water has and how through the theoretical premise water can be incorporated into architecture to address some of the challenges caused by climate anxiety. This will be done in order to gain insight of its application within architecture and the impact on our impending future. A series of selected precedent studies are investigated in order to identify important design criteria, construction methodologies and innovative technologies which align with the theoretical premise defined. The findings will be discussed and applied to the local context of South Africa. The findings will be utilised to generate design principals which should be applied in order to respond to our current dilemma in which humanity finds themselves as a species. The intention of these principles is to address and act as a catalyst on the road to recovery for climate anxiety and more importantly in the fight against climate change. The article will then conclude on the impact both architecture and industry have on our daily lifestyles and ultimately on the livelihood of our one and only planet.

Climate Anxiety is Real

As climate changes continue to affect and alter the way we live, concerns and fears exacerbated with the onslaught of poverty, disease, famine, drought and conflict. The negative impact on humanity will only increase alongside the ever-increasing concentrations of CO_2 emissions. The sixth extinction is upon us; as the oceans are acidifying, insects that pollinate our

Fig. 02. Impact of Climate Change on human health (Clayton et al. 2014

plants are dying, biodiversity loss is accelerating, the ice caps are diminishing, desertification is spreading, water supply is being contaminated and depleted, heat waves and fires are the norm. (Overy, (2019).

Since early 2015 - 2016, Dr Paul De Pompo, a clinical psychologist in California, has seen that many psychiatric patients have been talking more and more about "the impending doom and gloom of our planet", Maverick, (2018.), and how their physical and sociological environments are changing. There is a sense of:

- Growing fear,
- "What if's and buts",
- Anger and feelings of total helplessness to the plight of climate change,
- Fatalism,
- Exhausted as sleepless nights pass wondering what's next,
- Depression and grief for the loss of our world as we know it,
- Avoidance and denial.

This is the psychological response to the catastrophic state of our home. Ratcliffe, (2018.)

Recent research scientists who have been interested in the interaction between ecology and human health, have attributed the above issues to climate change saying that it is a contributing factor to a mental health disorder which is referred to as "Eco-anxiety" or "Climate Anxiety". An Australian environmental philosopher, Glenn Albrecht, (2019.), defines eco-anxiety as "the generalised sense that the ecological foundations of existence are in the process of collapse." Furthermore, research reveals that eco-anxiety affects us in many ways. This is all dependent on how much control we think we have over our lives, what we understand about the risk, and how we process the question of responsibility Stern, (1992.)

A major report by the American Psychological Association (APA) released in 2017, identifies three specific forms of climate anxiety which affects mental health as a result of climate change. The first is the "Grief" or the "Trauma" which you may experience first-hand due to a natural disaster and direct ecological loss. The second is the "anxiety" from the loss of environmental knowledge which leads to a loss of identity. Lastly, the "fear" around climate change and concerns over how this may impact the world on a global scale, including future losses. Fearn, (2019), has reported that the symptoms of climate-related anxiety, are similar to other types of anxiety, which can include insomnia, depression, and panic attacks. In turn these symptoms have other far reaching side effects according to American Psychological Association and Eco-America (2017), in their report on mental health and our changing climate. This is illustrated in Fig. 2 which defines the three areas where climate change impacts on human health. These areas included: physical health, mental health and the health of the community.

South Africa has taken few steps in response to the risks and threats to human health problems that are the result of climate change. Garland, (2014) explains, that The White paper on the National response to climate change, has identified vector-and water -borne diseases and heat stress as potential challenges. It goes on to say that other related challenges include socio-economic risk factors, such as problems regarding housing and settlements. Furthermore, it indicates the need to address the social inequalities and poverty in SA, as the paper suggests that the largest health risks are possibly amongst the communities already most vulnerable. Garland believes that little is known about extent and magnitude of health risks in South Africa. The White paper did suggest that quantitative vulnerability and risk assessments should be carried out to identify the most important climatic impacts on health. The responses on data collection, however, are slow and community involvement is limited. These reactions are holding back South Africa from properly addressing the core causes of, and solutions to challenges regarding changing climate. These reactions are also keeping us from adopting new principles for design to address the problem and support psychological resiliency.

Localised climatic change

Department of Environmental
airs, (DEA) (2015) has observed the
eased rate of warming which is 2°C
century. That is twice the global rate
emperature increase of the western
ld. The impacts of these changes in
uth Africa have in recent years been
erienced through extreme weather
ditions. An El Nino phenomenon
ted drought was recorded in the
2014-2016 period, as being the
st meteorological drought since
4. Since 2017-2018, the Western
Northern Cape, Gauteng and
e State, have experienced extreme
ught with most of the water supply
ning dry, causing extreme water
rictions, widespread crop failure,
lfires and substantial stock losses.
A) (2015). From the late 2016,
nse storms along the coastal
ions of KwaZulu-Natal and the
e, have resulted in flooding and
s of lives and homes. The Gauteng
ion has also been hit by intense
ms, mini tornadoes, high winds and
e hails storms, leading to damage
loss of property. All this is as a
ult of climate change. Sustainable
rgy Africa, (2015).

**w South Africans Experience
matic Anxiety**

uth Africans are already experiencing
effects of climate change as
cribed above, with the rising
peratures and water vulnerabilities.
evidence of extreme weather
ditions in South Africa is increasing,
eat waves are more frequent. The changes in climate affects climatic zones, ecosystems and landscapes, which in turn impact on health.

The more familiar impacts of climate change on health are recorded in South Africa, and known as: diarrhoeal diseases, respiratory diseases, cardiovascular health, vector-borne infectious diseases such as malaria worsening asthma, allergies, heat related stress, food-borne and water-borne diseases, illnesses and injury. Very little consideration and connection has in the past considered mental health. Ziervogel, (2014) and American Psychological Association, (2017)

Mental disorders in South Africa are recorded by the Department of Health (2018), and are estimated to be 30% of a population of 55 million. It is hence important to find architectural programs that will assist with the improvement of mental well-being. In so doing, the intention is to decrease the high-risk factor that mental disorders have on other health conditions and diseases such as, cardiovascular disease and diabetes, an increased risk of suicides, along with climatic anxiety and mental disorders, and altered human behaviour patterns.

When individuals experience conditions of mental breakdown and disorder, there is a ripple effect within our society and on the overall health of the community. Climberg, (2018). These effects may include: greater social isolation; increased personal aggression; lack or loss of a sense of belonging; loss of community cohesion, increased violence and crime; substance abuse epidemics and social instability. The changes of climate have a direct impact on one's physical and mental health which effects the state of the community.

What does this mean?

The realization that our state of "contentment or health" has a direct impact on our community' well-being, has been established through studies on environmental psychology and theories such as Biophilia. This presents opportunities, despite the current negative consequences of climate change. It provides us a chance to really unite and work together as a community to introduce new strategies and find solutions to overcome our adversities. It also can help us to grow by changing social and economic patterns that have led us to our dilemmas of the past, affording us an appreciation of our natural environments that will support and sustain us.

What does water mean to us?

Water is an essential element of nature, which all living organisms are dependent on. Without it there would be no life and thereby water becomes an immense symbol of life. The concept of water as a natural element of healing is nothing new. The ancient Greeks viewed water as the highest element having the greatest potential of healing Ryrie, (1998:20). They had one of the

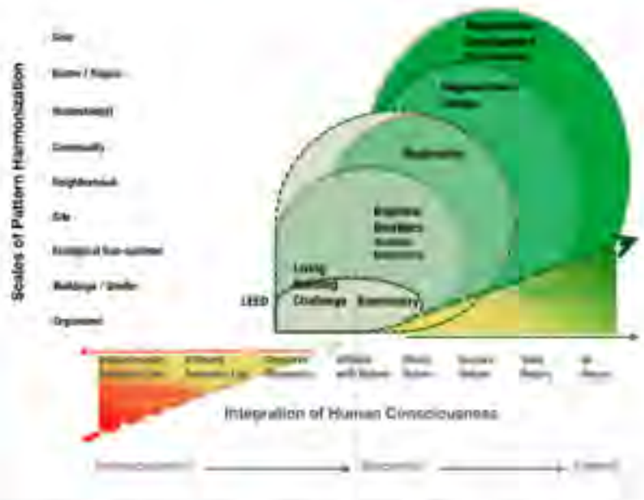

Fig. 03. Left: Range of sustainability approaches (Developed from Bill Reed 2007)

first network of healing spaces, called Epidaurus, which used water from natural springs in cleaning rituals.

Humanity from the time of creation has situated themselves near water, never questioning the health-giving water properties of flowing streams, refreshing waterfalls or a welcome downpour of rain. They accepted, respected and treasured the life-giving properties of water. Yet through time and expansion, man has moved further away from the presence of water and surrounded himself with the harshness of concrete buildings and machines whilst creating for himself, a fast pace lifestyle.

Water, an element of healing

Huelat, (2003), emphasizes that water is not only vital to life but also represents the key to healing architecture. Many studies have been carried out to observe the relationship between nature and human well-being by introducing water into the natural setting. Völker & Kistermann, (2011). Ulirich, (1981) was amongst the first to consider greenery and nature in his studies. From some of the data and medical records collected of surgical patients in a Pennsylvania hospital, during the period 1972 to 1981, Ulrich, (1981) noted that patients with a view of natural environments showed a more significant restorative recovery than those that were not exposed to nature. The impact of water, however, did not indicate a significant difference to healing. More recent studies have revealed that water has a greater and more significant effect on restoration than that of green spaces (Korpela, et al., 2010; Völker and Kistemann, 2011. White (2010) Wilkie and Stravridou, 2013). White's, (2010) research indicates that there is a positive and direct correlation between the amount of water in a natural environment and perceived restoration. This study took into consideration people and objects which previous studies had not.

Later studies have further revealed that water has more positive influences on mental well-being than any other environments. This was confirmed by, Ulrich, 1981. In addition further studies by Kaplan, (1998), revealed that where water is found, people experience a heightened sense of fascination and mysticism which draws them into these environments. The results of these research projects contribute to defining the concept of "presence of water " as a means to bring about greater restorative healing and therapeutic practices, through architectural interventions.

Why is water important in South Africa?

According to the World Resource Institute (WRI, 2000), South Africa has less than 500m³ of water available annually, per capita. It is one of the worlds most deprived countries with regards to water resources. In addition, WRI, (2000) suggests that the future of the country's water projections, will become scarcer and is estimated that by 2030 there will be a gap of 17% between supply and demand. Furthermore, according to SAICE, (2009) the limited water supply is exacerbated by low rainfall, inadequate underground aquifers, insufficient maintenance and inadequate freshwater management and by the high inefficiencies of an aging bulk water infrastructure in South Africa. This then presents a crisis to the South African government both economically and socially. Businesses in South Africa (CDP South Africa Water Report 2014) have become more aware of the challenges identified regarding water risk, which is associated with climate change, declining water quality, inadequate infrastructure during drought, increased water scarcity and stress. Despite this, it is necessary for local stakeholders to partner and initiate appropriate response measures in order to better conserve and manage our water resources and to find innovative solutions to combat the effect of climate change on our stressed water environment.

Psychological connection to water

According to Brown, (2017), water not only provides man with physiological benefits like reduced muscle tension and joint stress, good hydration and moisturised skin, but also contributes to psychological well-being. Moore,(1994) suggests that water embodies youthful health and beauty through its characteristics of freshness, reflectiveness and clarity. It represents a state of peace, tranquility and calm.

man is drawn to the enigmatic
ding flow of water, the power of the
er affects humanities mind body
soul. As the mind is drawn by the
sations of touching, seeing and
ring the rippling water, its healing
ilities are experienced which
ome highly soothing, relaxing and
venating, having the ability to wash
y stress and invigorate our life's
rgies.

ne scientists suggests that:

The rhythm and movement of water can affect the neuronal waves in man's brain, encouraging more peaceful thoughts.
The sense of awe when surrounded by water has a profound effect on how we feel and can lead to pro-social behaviobehaviours such as, loving kindness, magnanimity and fostering greater life satisfaction
Being by the sea has a positive impact on mental health. The minerals that are in the sea air reduce stress.
Negative ions that are present near the sea and waterfalls, increase the flow of oxygen to the brain, improving alertness and mental energy. And salt in the water preserves tryptamine, serotonin.

the still the expanse of waters,
s and rivers that is the essence of
quillity. The slower and calmer the
er, the more it induces moods of
n, awe, and energy Day, (2002:38),
moting contemplation and
loration from mental fatigue.

**ension for the future through
ign**

– Raymond Williams
89)

spite the feelings of hopelessness
powerlessness, which have
n brought about through our own
ligence and carefree attitude, much
changed. Du Plessis (2014), who
rs to Reed (2007:676) as indicated
'ig. 3 suggests that a new paradigm
s beyond increasing resource
ciency and eliminating negative
act on our environment while
eting mankind's needs. It is based
designing with a new mindset and
on to accomplish the formation of a complete living system which purpose is to sustain life-enhancing conditions in a complete closed-loop cycle.

Regenerative Design - Moving forward

Surely, we have a responsibility to leave for future generations a planet that is healthy and habitable by all species - David Attenbourough, (2015) Although "sustainable development" is an improvement on conventional design, it continues to support development based on economic growth through resource consumption, resulting in negative environmental impact. Du Plessiss, (2014). This will still leave us at the mercy of climate change, which will cause social and ecological collapse. It is therefore necessary to look to outcomes that not merely reduce environmental impact but seek to reverse negative environmental impact, which will not only slow the rate of degradation but regenerate ecological systems and communities. The emphasis of regeneration through architecture is one that gives back more than it receives. (Cole, 2012). Success of regenerative built environments will be measured by the improvements of health and the well-being of man and nature.

"Water-Wise" Design

The International Water Association, (2018), has adopted regenerative development principles which use the built environment to become the conduit, to overcome increased water scarcities. This has been brought about by climate change and results in the increase of demand as the population continues to expand. It adopts a four level approach to ensure the safety of public health, whilst meeting their needs and protecting the quality and quantity of water resources. The four level approach includes:

- Regenerative Water Services
- Water Sensitive Urban Design
- Basin Connected Cities and
- Water Wise Communities.

Regenerative Water Services seek ways in which to replenish water bodies and their connected ecosystems through: reducing consumption of water; looks at ways to reuse, recycle and recover water; and use an integrated approach to link to other services.

Water Sensitive Urban design principles activate regenerative water services, while enhancing liveability with the presence of water, integrate urban planning with water preservation. Basin Connected Cities puts a plan into action to secure and protect water by mitigating the impacts of drought and protecting the quality of water. Water Wise Communities seeks to encourage collaborative action of all stakeholders, including government, urban professionals, and other individuals, while generating awareness, empowerment and unity to find solutions.

Cities around the world have begun to adopt water-wise strategies that strengthen urban water resilience. This is a step in the right direction towards restoration and management of the sacred water resource and to bringing about balance in order for humanity to have an excess of supply over demand.

Biophilia - our innate need for affiliation

John Muir, (1877)

There has been a growing acknowledgment that daily interaction and integration with nature is beneficial to a more productive, happier and meaningful life. Beatley, (2013). However, Kelert (cited Padayachee, 2014) suggests that despite the development in sustainability and improved design strategies, we still miss the interaction with nature which is critical to human well-being and development. To address the current ecological crises, the intertwining and interdependency of all must be considered (Voigt and Drury, 1997). As Nelson, (1993) explains, the intricate weaving together of nature and culture is like the exchange between living cells and their surroundings which are vital to their existence. Thus, man and nature cannot be seen in isolation to each other.

It is possible to move from a narrative of fear to one of love through the conscious re-integration of man and nature and acceptance of our innate need for connection, as proposed

by the Biophilia hypothesis. It is accepted that we are "inherently affiliated to nature's forces, systems and processes", as stated by Edward O. Wilson, (1984). He further acknowledges that "[illegible]". This relationship which bonds humanity is essential because exploring the human connection to nature has provn to impact on our physical, emotional and mental well-being. Stephen Kellert, (2011) is of the same opinion that "people's physical and mental well-being remains highly dependant on contact with natural environments". Biophilic design through tapping into natural processes, patterns and integration of place into nature can: reduce stress and anxiety; enhance creativity and clarity of thoughts; improve well-being and expedite healing.

The presence of water

As this article deals with the incorporation of water into design, only one of the Biophilic design principles - "the *presence of water*" - is explored. The pattern of water enhances the experience of a place throughseeing, hearing, and touching water. Browning, (2014). It is intrinsically calming, especially when incorporated within urban environments.

The "presence of water" is a Biophilic design pattern which has evolved from research on health and well-being benefits associated to access of water, which enhances one's experience of place through sight, hearing and touch of water. Andrews, (2014). The research identified positive emotional stimuli to environments containing clean natural water elements. There were indications of improved health as a result of reduction of stress levels, lower heart rate and blood pressure, increased feelings of tranquility, improvement in concentration and memory restoration.

It is the bubbling sound of flowing waters and trickling water fountains, a glimpse of a flowing creak or open expanse of water and the ability to touch, that stimulates ones senses, eliciting a desired health response. As long water is incorporated into design in a deliberate way and is not too

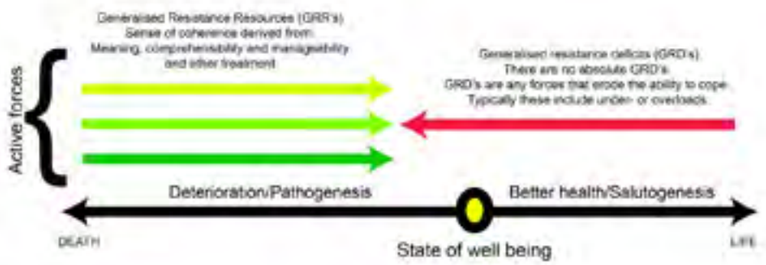

Fig. 04. Right Top; The salutogenic effect (Golembiewski 2017:4))
Fig. 05. Right Bottom; Biophillic relationship in the Khoo Tech Puat Hospital (Unknown Author, 2010)

Fig. 06. Left; Eco-machine diagram (Shann, A. and Frisch, J. 2007.)

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ciety has often overlooked the
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ng both physical and mental. It
Winston Churchill, (1943) who
sed that, "we shape our building
afterwards our buildings shape us.
y regulate the course of our lives"
a long time, studies have focused
he psychological well-being of man
little attention to the psychological
l-being of man. Abkari, (2016) .
cent theories on
have explored the
nectivity and relationship between
environments in which man
s and it's influence and impact to
nanity's well-being, (Stock et al,
7) and (De Young, 2013).
psychology of the environment,
emerged after a publication
'person-place interactions", by
sharisky, (1958). Environmental
chology is entrenched in the belief
theories that nature plays a
tificant role in shaping man's growth
behaviour and it draws from varied
ors like psychology, sociology,
logy, environmental sciences,
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igns. This is because these factors
uence human behaviour. Ackerman,
18).

Application of water in architecture for sustainable design

Water plays an important role in the formation of life. It is a key element of humanity's existence. Architectural response to water needs to go beyond the pure elements of necessities and services. It needs to provide for spatial experiences which encourage engagement through amplifying the humans sensors. At the same time, it is important for architecture to respond to the emerging sustainability challenges in building design, and offer possible solutions and model strategies, which can be adopted, built and further developed on. The precedent study of Khoo Tech Puat Hospital, is evidence of one such solution, which has brought water into its design, creating spatial experiences that promote restorative recovery and bring healing and well-being to both staff and patients.

Responding to the effects of climate change on health

The Khoo Tech Puat Hospital Singapore, which was designed as a "Hospital in a garden and "a garden in a hospital." Beatley, (2010), is a prime example of creating a healing environment, which incorporates the healing powers of nature to stimulate recovery and wellness to all who visit the hospital. It's site was chosen for its proximity to the Yishun pond, which brings cool air into the hospital as the winds pass over the water. The hospital adopted an approach to a sustainable hospital design which combines the concepts of clinical treatment, pathogenic treatment and the emerging recognition of the psychological benefits of Saultogenic" effects, indicated in Fig. 4, which focuses on the promotion of health and well-being.

Studies, (Kishnani and Cossu-Ramboll, 2016) suggest that the environment plays an important role to a more rapid recovery of patients. The hospital was designed to produce a healing environment through gardens and water features and to engage and stimulate the senses including; sight of natural elements of fauna, flora and water, sound through falling water, scent through a selection of scented plants and touch, for the patients, visitors and staff of the hospital.

In the first basement of the hospital there is a waterfall, which cascades into a deep pond. The overflow from the waterfall pond is channelled into a stream that flows the length of the basement before the water enters a filtration system. The views of the pond and basement garden serves as healing elements for patients, creating a tranquil calming environment. The Yishun Pond was once a barren storm water collection pond which has been restored and transformed into a lush health promoting environment. The hospital is designed to embrace the pond, thereby drawing in the natural elements of water, flora and fauna which create an integrated entity of wholeness. Beatley, (2010).

The Khoo Tech Puat Hospital, has gone

beyond creating an environment which enhances stimuli for well-being. It has collaborated with local communities and government, in order to serve multi groups, including its surrounding neighbours, providing access to the blue and green spaces to all those that visit.

Managing the environmental effects- Restoring water balance in the environment

Water management through architecture interventions can also be investigated through regenerative programs, in order to re-establish a lost balance within our existing environments and to reduce the negative impacts of urbanisation. A significant case study illustrating responsible stewardship, through water management, is illustrated, through the Omega Institute of sustainable Living, Rhinebeck, New York, Bachus, (2009). The building not only influences the water quality of its own site but also that of its immediate surroundings, and even the waterways within the Hudson watershed.

Water supply of Omega comes directly from the groundwater via the aquifer on site. Prior to the replacement of their ageing wastewater system, water was taken from the aquifer used for multiple actives and then piped back to a Septic Tank. They decided to adopt a new approach with the new waste system which would handle water not as "waste" but as a "precious resource." It now utilises a natural system for water purification and reclamation, returning a high-water quality back into the ground aquifer and lakes. Potable water comes from the aquifer, while water harvested from rainwater is used to flush the toilets. For all other uses, black and grey water is sent to the "Eco machine lagoons and wetlands where it is purified by microscopic algae, fungi, plants and snails, without the use of chemicals. In addition, low flow plumbing fixtures were installed to minimise consumption, including waterless urinals and uses landscapes threat would thrive without supplemented irrigation. BNIM, (2009).

The Omega Centre provides an overall complete cycle utilising natural systems to restore and regenerate water sources, providing for cleaner water and reintroduction to groundwater supply and the Hudson watershed.

Findings

The main aim of the article was to investigate how architecture can respond to distress caused by climate anxiety which is in turn caused by climate change. It explored integrating the "presence of water", into design, to bring about healing" to the user and their natural environment. The main findings revealed that the natural environments of water, incorporated in the built environment, can have a greater contribution to restorative and rapid recovery as well as to health, stress and anxiety.

Environmental psychology, a relatively new approach to understanding human behaviour within architectural design, indicates that there is still much to learn. Before Donald Patterson's, (1960), first inspired article

, people would look to medication or therapy for solutions to their health. His research, along with other studies into the interrelationship between humanities behaviour and their environment, suggest that the built environment has an important role in creating health conditions and facilitating rapid recovery. The living spaces created through architecture can thus be a catalyst to reducing stress and restoring body, mind and soul.

The case study presented of Khoo Tech Puat Hospital, revealed that including water in and around us, is more likely to bring about psychological restoration and well-being. Körpela, (2010), findings are consistent with the investigation that reveals that water or blue spaces in the built environment have more restorative qualities than both green and urban spaces.

Regenerative and restorative buildings, as explored in the case study of Omega Institute. The centre goes beyond moving toward a sustainable building, by also improving the surrounding environment. These improvements include restoration of the site and surrounding water systems, through natural hydrology, which in turn improves the quality and quantity of water. BNIM, (2009).

ter in architecture

ough the exploration of water as a alyst for "healing "a people-centered roach "linked to environmental chology, to design is necessary to considered, in order to understand the built environment, influences nan behaviour and their experiences rder to optimize healing in hitectural design it is important to ximise one's multi-sensory water erience to achieve an optimal eficial outcome. In so doing, it is ommended that design incorporates erent levels of water fluctuation rder to provide a sense of the xpected and a sense of intrigue. flow volumes should not be too ulent as this could create a feeling nsecurity and discomfort, whilst reasing acoustic qualities. In lition, shading water elements within ign can minimize loss of water ugh evaporation, and possibly will enhance the Biophilic and wellness erience.

clear, that in environments where er is present, there is a greater ential and likihood of psychological loration. Architecture design, with er, thus creates the opportunities to pond to distress caused by climate iety and to bring about connection ween man and nature. It is important we create spaces that allow an vidual to physically, psychologically emotionally flourish. All three areas d to be fostered, because each t should be present to achieve rall well-being. The key commitment is to ensure that design promotes connection between man and nature, maintains a sense of ommunity and exposes the users to the healing powers of water and nature.

Designing for the future

In conclusion, the application of water in architectural design is nothing new and is well recorded throughout history. In a post-industrial era, the use of water for aesthetic pleasure in urban planning is still present, although within the expanding cities, man seems to have lost the need to incorporate water into his living spaces. The integration of water allows for cohesive strategies to be incorporated into large and small scale urban and built environments. These strategies will enable an approach to environmental sustainability issues which will work against the impact of climatic change and the depletion of natural resources in order to re-establish a balance with nature, restoring the health of natural environments as well as the wellbeing of man.

Researchers are still focusing their attention on a deeper understanding of humanity's environments and the spaces we dwell in. As we seek to explore these environments and the impacts they have on how we feel, respond and cope with everyday life, designers need to continually be moving towards the concept of environmental modification which is viable to a more sustainable solution for humanity's physical, psychological and emotional well-being.

In overcoming the 21st century challenges of climate change, Du Plessis and Brandon, (2015) remind us that, Einstein warned us against the trap of attempting to find solutions within the same thinking, tools and methods that got us into the predicament in the first place. The first step towards a shift in our world-view is not in changing technologies but in instilling a new mind-set which will bring about a new era of design sensitivity. This design approach should include a regenerative design which encourages harmony, co-existence and positive relationships between mankind and nature, restoring health to both man and nature.

Endnotes

1. Saultogenesis , as described by Antonovsky, (1979)in his book titled Health , Stress and Coping refers to the life experiences that shape ones sense of purpose bringing about a state of mental well-being

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Faculty of Engineering, Built Environment and Information Technology

Fakulteit Ingenieurswese, Bou-omgewing en Inligtingtegnologie / Lefapha la Boetšenere, Tikologo ya Kago le Theknolotši ya Tshedimošo

Reference number: EBIT/E11/2019 25 April 2019

Prof A Barker, Mr JN Prinsloo & Ms C Karusseit
Department Architecture
University of Pretoria
Pretoria
0028

Dear All

FACULTY COMMITTEE FOR RESEARCH ETHICS AND INTEGRITY

Your recent application to the EBIT Research Ethics Committee refers.

Approval is granted for the application with reference number that appears above.

1. This means that the research project entitled "*Masters professional dissertation in architecture, landscape architecture and interior architecture*" has been approved as submitted. It is important to note what approval implies. This is expanded on in the points that follow.

2. This approval does not imply that the researcher, student or lecturer is relieved of any accountability in terms of the Code of Ethics for Scholarly Activities of the University of Pretoria, or the Policy and Procedures for Responsible Research of the University of Pretoria. These documents are available on the website of the EBIT Research Ethics Committee.

3. If action is taken beyond the approved application, approval is withdrawn automatically.

4. According to the regulations, any relevant problem arising from the study or research methodology as well as any amendments or changes, must be brought to the attention of the EBIT Research Ethics Office.

5. The Committee must be notified on completion of the project.

The Committee wishes you every success with the research project.

Prof JJ Hanekom
Chair: Faculty Committee for Research Ethics and Integrity
FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND INFORMATION TECHNOLOGY