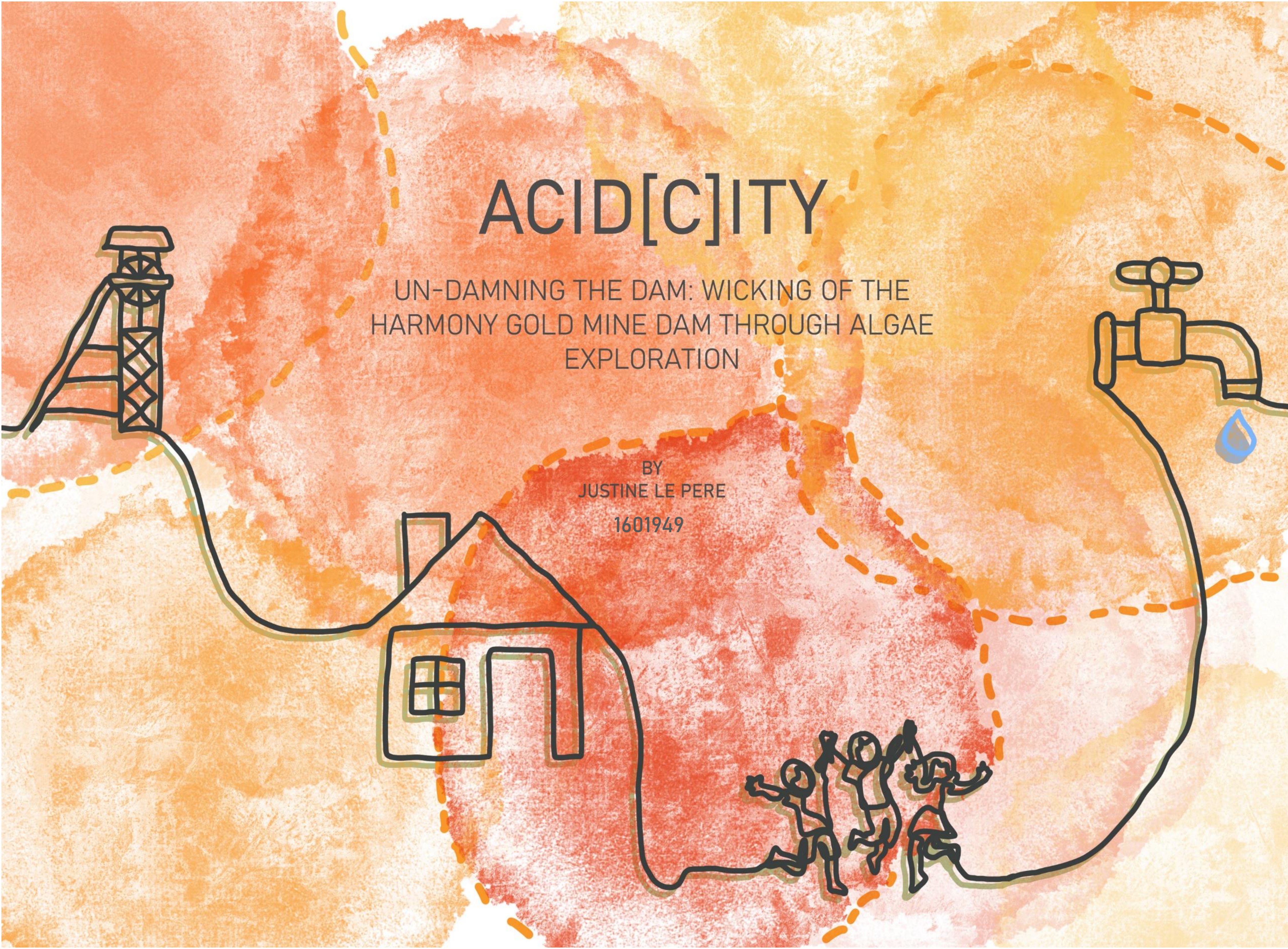

ACID[C]ITY

UN-DAMNING THE DAM: WICKING OF THE HARMONY GOLD MINE DAM THROUGH ALGAE EXPLORATION

BY
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ACID[C]ITY

Un-damning the Dam: Wicking of the Harmony Gold Mine Dam Through Algae Exploration

Supervisor: Christos Daskalakos

A research report submitted to the Faculty of Engineering and the Built Environment, University of the Witwatersrand, in partial fulfillment of the requirements for the degree of Masters in Architecture (Professional).

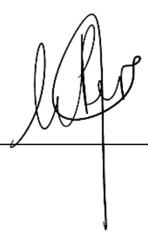
Justine Le Pere_1601949

DECLARATION

I, Justine Le Pere (1601949) am a student registered for the course ARPL7003A in the year 2023. I hereby declare the following:

I am aware that plagiarism (i.e., the use of someone else's work without permission and/or without acknowledging the original sources) is wrong. I confirm that the work submitted for assessment for the above course is my own unaided work except where I have stated explicitly otherwise. I have followed the required conventions in referencing thoughts, ideas, and visual materials of others. I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my own work.

Justine Le Pere, 15 February 2024



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II.

ABSTRACT

This project discusses the need to help fight against the effects of mining on water, and to help the surrounding environment and community. A large emphasis is placed on the use of algae to treat the water from the Harmony Gold Mines' tailings dams, and the facility plays host to this natural water treatment method. The facility provides the space for water resource management and water treatment education to take place.

The community of Tshepisong Phase 2 lies north of the facility and acts as the activator of the facility. Without the community needing to collect water for use at home, the facility would not have a strong sense of integration into the township.

The layout of the facility allows the layers of privacy to help aid the program, and the program allows the facility to be transparent to its visitors and the neighbouring township.

CHAPTER
01

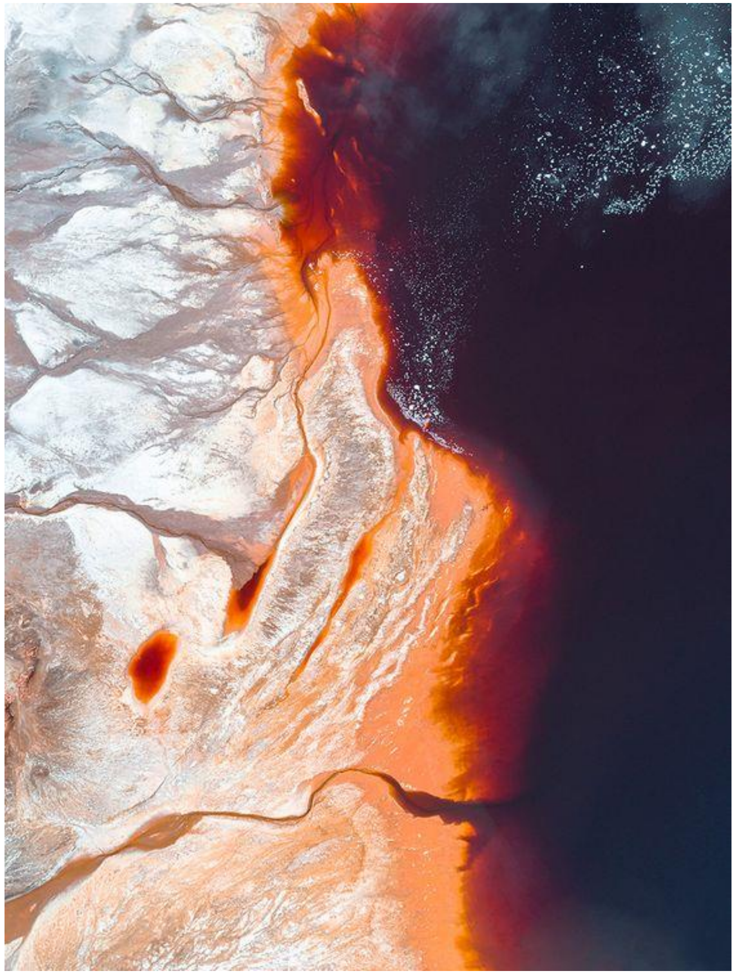


Figure 1.1 Acid Mine Drainage Aerial Photograph by Behance, 2019

01 INTRODUCTION

In my report, I will address the issue of toxicity in tailings dams at the Harmony Gold Mines in Doornfontein. With mining being at the forefront of my issue, I aim to treat the water that sits unused in these tailings dams by making it useful again. The implementation of algae as a method of water treatment is not one that is widely known, especially not in South Africa. Algae, especially spirulina, is not readily available in South Africa, and by introducing a facility like this in South Africa, algae can be readily available for other mining facilities to use.

While tailings dams in South Africa are not that many, the impact that they have on other economic factors due to acid rain is extensive. The acid rain which affects crops and forests is a large reason why such research is fundamental in helping an already failing economy, and especially an economy where food scarcity is a problem.

The method of water treatment is a simple process using algae as a wicking device to remove toxins and heavy metals from the water. The algae absorb these toxins and heavy metals, and once this absorption has taken place, the algae is simply skimmed off of the water and reused as biofuel. The now non-toxic water will then be purified further to create grey water which can be used on-site for services and farming, and then further purified to create potable water. Algae will form part of the shading for the building in the form of louvre panels on the building facades, and the algae through fermentation will be a form of biofuel which can then power the building on site.

My research is worth looking at because it forms the basis for a circular economy to be created. This circular economy thought process can then be implemented in other societies or mining facilities where it can be necessary. Hopefully, this type of water treatment can be implemented in mining facilities with tailings dams as a necessary measure to curb global warming.

Specific problems I am tackling are water treatment, algae growth, and biofuel creation. All these problems feed off and into each other and create my whole facility. The facility aims to be the spine that allows the water to perform its natural function – to nourish people, animals, and plants. The building will resemble a long spine with circular elements that protrude and hold the water. The specific design strategies such as shading from the sun and a green grid to service the building all integrate into one collection of buildings. These design strategies not only help fuel the building; they also provide an aesthetic that links directly to the theme of my research – water as the backbone of society.

The shading panels are made up of algae in a nutrient-rich solution which gets fed carbon dioxide to assist in the algae's growth. When the algae are in bloom in the summer seasons, the shading becomes more intense as there is less room for light to shine through the algae on the facades.

The algae produced on-site in the panels and for water treatment then get collected and are allowed to ferment to form the basis for a biofuel. A biofuel is any fuel generated using natural or organic matter which is then turned into a gas through fermentation to form the fuel. Once this biofuel is generated, it can be used to heat the building in the winter months and cool the building in the summer. The biofuel generated will also be used to generate electricity and can then be used alongside solar panels to power the building fully.

Figure 1.2: Facade panels sketch by Author.

The scientific approach to this project was driven by the nature of the ingredients to make the project. Nature is the scientific basis which life is derived from. There are processes to be followed and a structure to create the perfect organism. The link to architecture is thus simple to understand.

In architecture, there are processes to follow to achieve the best outcome for a building. All the details (little cells) that work together start to form the building (the organism). My love for science and its details paired with my love for architecture and its opportunities allowed the culmination of both worlds as presented in this thesis.

CHAPTER 02

02

METHODOLOGIES

In this research, my objective is not to state that algae is the only way to help mines with toxic tailings dams, but rather to explore the narrative that this organic material which seems so banal, can be such an influential factor in not only treating water but generating energy too.

My methodologies encompass a systematic exploration of optimal architectural forms for the containment of water bodies, emphasizing their resonance with the overarching natural and organic theme of the facility. The primary mode of documentation will be through meticulously curated photographs, sourced either directly by myself or from accredited online repositories. In addition, I have conducted interviews with subject matter experts within the pertinent fields of study. The insights garnered from these interviews have significantly enriched my comprehension of each respective field, thereby enhancing the contextual relevance of my research endeavours. In this research, I will be aiming to address how architecture has an influence on enhancing strategies to better

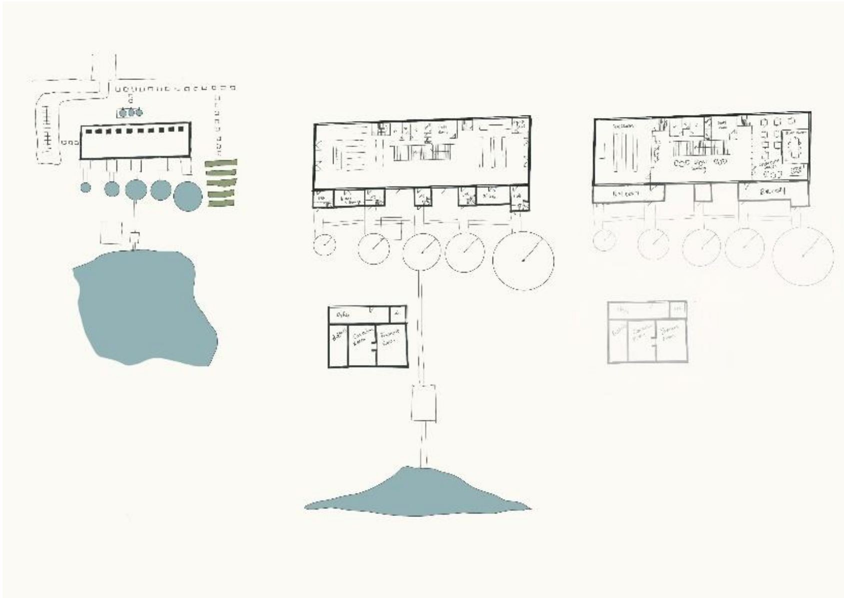


Figure 2.1: Sketch design by Author.

the environment, and how architecture can provide an adequate place for such interventions to occur without destroying the environment even more.

Part of the methods of gathering information was to find a site where an intervention was needed. I have chosen the Harmony Gold Mines (HGM) in Doornfontein, Soweto because there are three tailings dams on site. Each of these dams poses the issue of toxic water sitting and causing seepage into the groundwater tables and acid rains during the summer months. This site has the perfect amount of space for such a facility and is a perfect location in terms of townships nearby as they may also benefit from extra water to use.

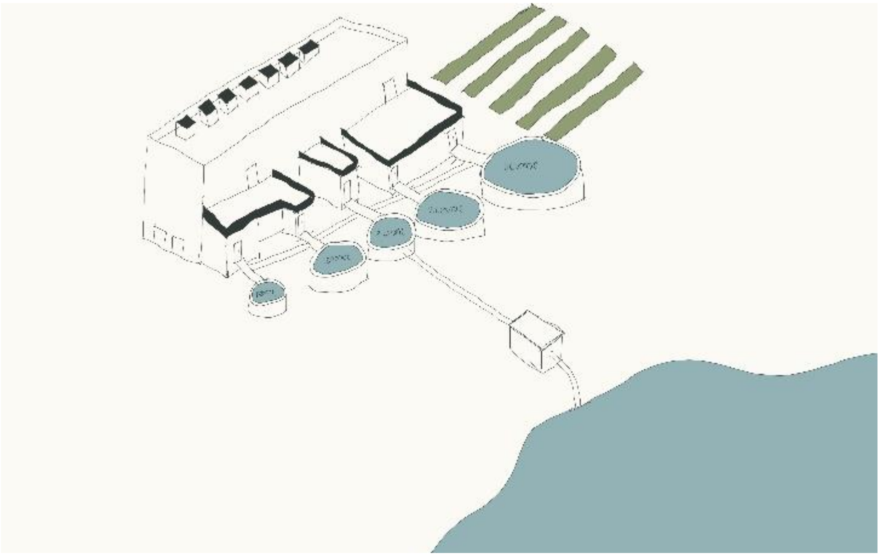


Figure 2.2: 3D sketch of facility by Author.

Analysis of the rural and semi-urban context will aid me in understanding my site better and letting me make informed decisions in my research. Architectural and scientific research will be conducted through precedent studies as well as case studies and expert research papers to better understand what my facility needs to accommodate. All the abovementioned information will inform my design outcome and the methods used to get to the outcomes seem necessary in achieving such.

The main scientific element aims to bring a framework from which ideas and concepts can be derived from. It is useful for architects in this context to know about science and the black-and-white it entails. The architect’s job is to know about the black and white, but then reinvent the colours to different shades of grey. There are new possibilities for speculative responses due to the nature of science and architecture, and especially the two in combination. A closer look at the science might give a different perspective to an architect's eye, which then drives the need to want to go into microscopic details to achieve the perfect design organism.

CHAPTER 03

03

WATER BODIES IN CRISIS

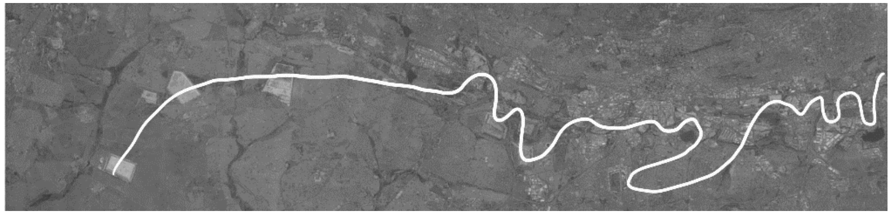


Figure 3.1.1: Aerial View of Gauteng Mining Belt edited by Author.

3.1 HISTORY OF MINING

The gold rush in 1886 was the start of gold mining in Johannesburg and the start of transformations across the landscape as we know it today. Once grasslands were then transformed into a bustling city which was responsible for over 40% of the world's gold production (Tang and Watkins, 'Ecologies of Gold'.). The 80-kilometre mining belt which stretches from west to east has been built up and the ground excavated so much that "these operations have weakened geological strata, disrupted natural drainage patterns and altered ecological habitat" (Tang and Watkins, 'Ecologies of Gold'.). With these weakened systems, mines continue to dig deeper and even re-mine the tailings created, which increases their carbon footprint and their mark on global warming. "Tailings are the major wastes produced from gold extraction and they contain high amounts of heavy metals (HM). These metals leach out in an uncontrolled manner into surrounding environments on exposure to water or through dispersal by wind. The presence of elevated concentrations of HM in the environment is a serious health issue worldwide due to their non-degradative nature which makes them persistent and thereby exert long-term effects on the ecosystem". (Fashola MO, Ngole-Jeme VM, Babalola OO. Heavy Metal Pollution from Gold Mines: Environmental Effects and Bacterial Strategies for Resistance.) With gold being one of the largest commodities on the market, the mining industries that produce them are going to be in operation for the foreseeable future. The surrounding communities that reside along the mining belt, which are over 400,000 residents, are faced with the issue of overpopulation of land caused by the gold rush. With issues such as water, electricity and sanitation lacking in these communities due to the rush, it sparks a need for something to be done to solved these issues. It is therefore necessary for mines and communities to find solutions to help curb global warming and the mark that mining has on it.

In terms of providing places of disposal for mining waste, mines have used tailings dams as their solution. Tailings dams are bodies of water which are meant to hold the tailings which are produced during the gold mining process. Tailings are any minerals or toxins which come from the process of mining which need to be removed from the system and disposed of effectively. HGM prides itself on being a sustainable company, however, on their website, it makes no mention of what happens to the water in their tailings dams once they have deposited their waste into them. Effectively, tailings dams should be dug out and lined with a non-permeable lining to ensure that there is no transfer of toxins into the ground. Should there be no lining, the water tables and site ecologies risk becoming affected by these toxins which in turn damage the environment in the long run. HGM manages these tailings dams through specialised teams of experts in water management, whose data is then audited to assure the validity and authenticity of their findings. While this method is effective to hit the goals of sustainability, it does not provide a solution to the issue which needs addressing.

In acid mine drainage (AMD) particularly, the high concentration of heavy metals is cause for concern due to their seeping capacity and damage caused in ecosystems. (Chetty 2017). When ecosystems become damaged, it takes many years for them to repair themselves, and in that time, it is likely that more damage can occur which would make an ecosystem irreparable.

3.2 INTERVENTIONS FOR SOLUTIONS

There are many ways to tackle an issue, however, only a few work effectively. I aim to explore methods of water treatment which use mostly natural methods and to see how we can use things that are abundant can help benefit the environment.

Boiling and sediment filters are one of the first methods thought of to treat water, but which would be the most effective out of both methods on acid mine water? If you were to boil the water, you would be killing any live organisms or bacteria in the water, without removing any toxins. Toxins might evaporate; however, you are not achieving the goal of getting rid of them. If you were to use a sediment filter, the filter will pass through various layers of porous rock, sand and even clay when filtered. This will remove particles of certain sizes and minerals that will be encapsulated by the clay particles. Both methods are helpful if one uses a source of water that is not stagnant and an amount of water that is not over one litre of liquid. With this basic knowledge, it starts to make sense that a body of water with the scale of a tailings dam and the toxicity of it cannot simply be boiled or filtered, rather it needs to be handled in such a way that toxins can be removed at a large scale and disposed of effectively. The main method I am exploring is a process called wicking and it is the act of collecting particles in an absorbent material which can then be removed from the source and disposed of if necessary. The material I am going to explore is not a fabric material, but rather a natural plant – algae.

An article, by Hydrogeologist Shane McDonald, highlights his exploration of wicking water through wicking wells and reclaiming dissolved solids from groundwater. “Dissolved contaminants, such as arsenic, boron, lithium and selenium, may be found in groundwater near mining, manufacturing, and coal-fired power generation sites.” (McDonald 2023). These harmful elements need to

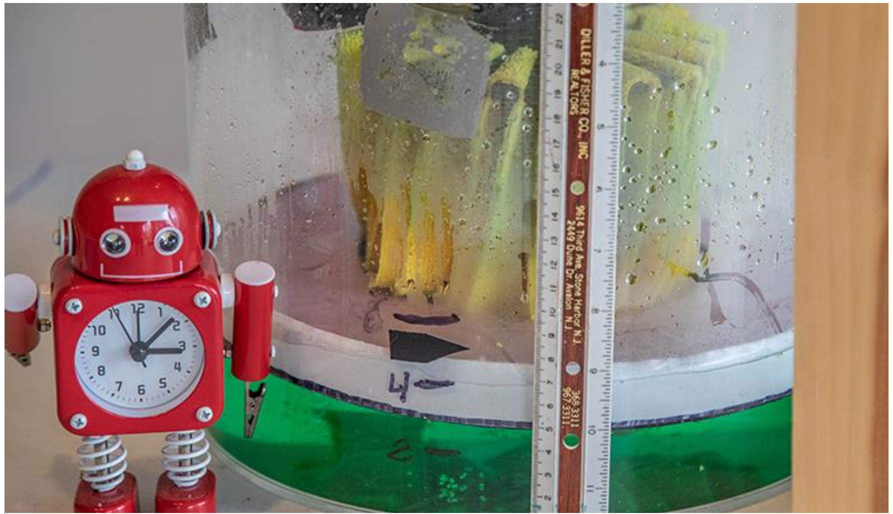


Figure 3.2.1: An early bench-scale test of Shane McDonald's fellowship project

be disposed of properly and not be left to contaminate the environment further. The theory behind this method is that the material he uses will capture and hold onto these mineral elements. These elements will then be collected and separated for their individual reuse. The aim of this process is not only to remove the elements from the water but to use a cheap and effective method to do so. The aim in using algae as a wicking system is for it to be a cheap and abundant material to use while also being natural and reusable.

Algae is an effective method of wicking acid mine water because “They act as “hyper-accumulators” and “hyper-adsorbents” with a high selectivity for different elements.” (Chetty 2017). The readiness for a natural material to absorb and remove a toxic element from water is why algae is a super plant for this process. Algae is a sustainable and suitable method for removing heavy metals from water as it is self-renewing. The term self-renewing refers to the algae’s ability to continuously reproduce without any help. It is for this reason that algae is one of the best candidates for the removal of heavy metals in water. “The presence of various variety of algae coupled with their multilayer cell walls make them suitable as a cheap source of adsorbent for heavy metals”. (Bilal 2013)

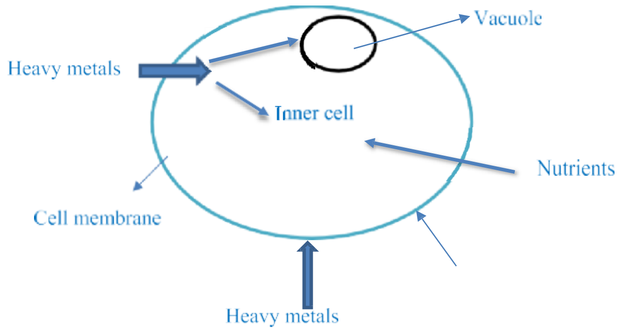


Figure 3.2.2: Absorption and adsorption scheme mechanism from a microalgae cell. Adapted from Kaplan (2013).

3.3 WHAT ELSE CAN BE DONE WITH THE ALGAE?

Algae can not only absorb heavy metals from AMD but also generate biofuel and provide shading. The facility will be using algae in most of its processes, so what can happen if the algae is in excess or already used? Algae will be used to create a biofuel which will power the building through a process of fermentation to create gas. This process of fermentation will occur in a controlled environment where the gas produced from fermentation can be contained and collected. This gas will then be used to power the buildings on site and to heat and cool the building when necessary. The process of burning the biofuel releases carbon dioxide which will be used in the panels that surround the buildings to help the algae grow to form part of the façade features.

The algae in the façade panels will be fed a nutrient-rich solution and be fed a constant supply of carbon dioxide which will come from the biofuel combustion process. The algae in the panels are plants which need sunlight to bloom and carbon dioxide to breathe, so that photosynthesis can occur. This means that in the summer months, the algae will be more in bloom which will create more shade from the sun than in the winter months where the combination of less sunlight and heat allows more sun into the building. The algae-filled panels will have a tube coming from the top to feed carbon dioxide into the solution, while a valve at the bottom will be there for drainage of the solution to replace any dead algae. According to an article on the use of algae in the treatment of AMD, dead algae cells are more absorbent of heavy metals, and this can be used in the filtration process of the water system as an extra step of purification. (Chetty 2017).

The whole process of treating the water in these dams is so that the water can be used by the facility and the community. The land which surrounds the facility is ideal for a farming intervention to take place as there is adequate space available. The space around the facility will be used to grow fruits and vegetables for community consumption and the nutrient-rich algae that will be collected from the algae panels that surround the buildings will act as a superfood

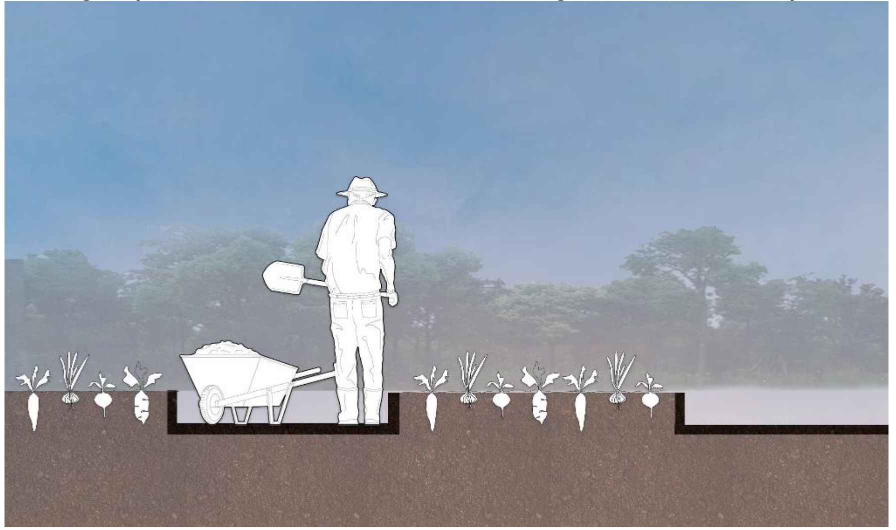


Figure 3.3.1: Farming image created by Author.

to help the produce thrive. The water which is treated at the facility will be used to water the produce grown on-site and this eliminates the cost of water used for farming as the facility already produces the water. Bottled water will be sold to the community and visitors at the facility's kiosk, and the price of the water will be less than market value due to the water being treated on-site. The drinking water tank will be fed directly into taps for the community to come to the facility and collect. This act of collection will encourage more social interaction while performing an everyday task, and it will make the event of water collection more enjoyable rather than a chore.

3.3.1 ALGAE TYPES

Figure 3.3.2: Spirulina algae plant

Spirulina algae is the algae that will be growing at this water treatment facility. Its singular shape is a spiral which has the best surface area to attract and retain heavy metals.

Figure 3.3.3: Laminaria algae plant

Laminaria is a genus of 30 brown algae species found in cold salt water.

Figure 3.3.4: Chlorella algae plant

Chlorella is a genus of 13 species of green algae and has a temperature tolerance of between 15-40 degrees Celsius.

3.4 HOW CAN ARCHITECTURE HELP TO SOLVE THIS PROBLEM?

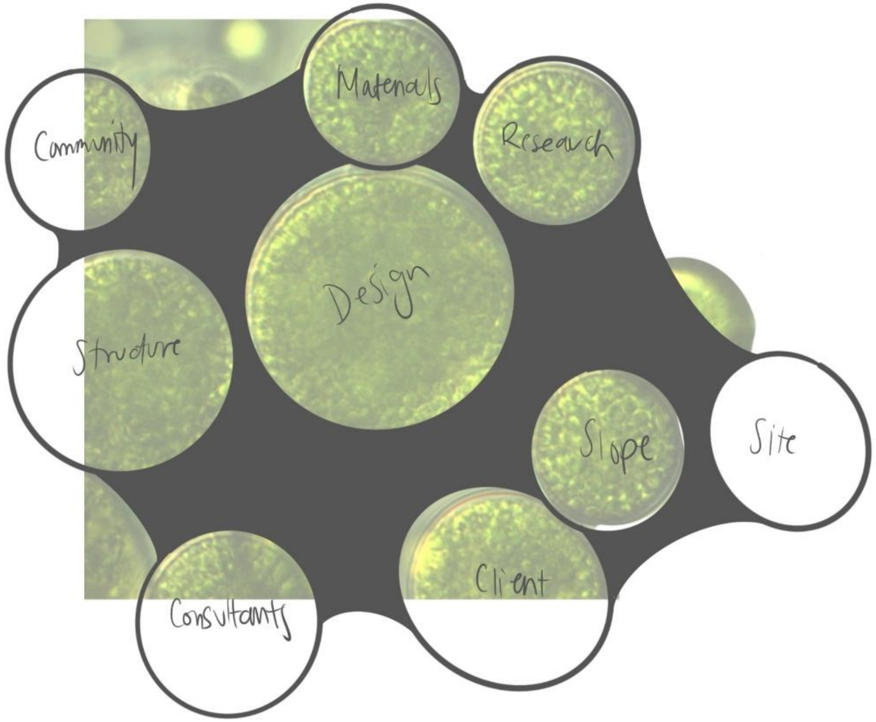


Figure 3.4.1.: Cells in Architecture Diagram by Author.

In the realm of science, we often encounter concepts like hypotheses, variables, and controlled environments. But what if we were to transplant this scientific methodology into the field of architecture? How might this approach manifest in a specific scenario? Let's consider an intriguing hypothesis: if we harness the potential of algae to mitigate toxins in Acid Mine Drainage (AMD) water, then the establishment of a dedicated facility for cultivating and nurturing this algae becomes imperative. Such a facility could serve as the catalyst for a global initiative aimed at alleviating the enduring repercussions of AMD, all while boasting an aesthetically pleasing design.

In this architectural context, the variables at play would revolve around the diverse forms and functions of the spaces within the facility. These variations could encompass everything from the spatial layout to the overall architectural design. Yet, amidst this array of variables, there remains a crucial constant—the algae itself, unwavering in its identity and purpose as the key agent for toxin remediation. Thus, within this architectural experiment, the controlled element firmly remains the algae, steadfast in its role as the driving force behind the realization of our hypothesis.

A facility such as this will need to host labs and spaces where equipment for these processes can be held. The spaces are going to be designed to host the programmes designed for the spaces and this will be influenced by the types and number of space occupants.

The concept of a central spine within a building design draws inspiration from the fundamental idea that, much like the human body relies on a well-functioning spine for support and mobility, every architectural structure benefits from a robust central core or spine to optimize its functionality and performance. Much like a spine, humans, animals, and plants need water to function not only internally, but nutritionally as well. Water is a basic right of all living creatures and the need for a facility to treat water is necessary in this environment.

Circular shapes act as protrusions out onto the site which house the water and the algae process. The circular shape is most effective in holding water due to there being no edges for the water to get stuck against. The shape also allows whirlpools to be created which will push the water to the outer edges of the tanks, forcing them into the next tank for the next process to occur. The tanks will also be tiered in levels to allow gravity to help carry the water, minimising the use of pumps on site.

CHAPTER 04

Figure 4.1.1: BIQ - The World´s first Solar Leaf-Building in Hamburg, Germany perspective view

04

PRECEDENTS

4.1 World's First Algae Bioreactor Façade

Collaboration between: Splitterwerk Architects, ARUP Engineers, Colt International, Strategic Science Consult

Year: 2013

Country: Germany

BIQ is the world's first algae-powered building. It was completed in 2013 by Splitterwerk Architects and ARUP in collaboration with Colt International and Strategic Science Consult. The building is a zero-carbon apartment complex and has a façade which is essentially an algae farm.

Microalgae, which are similar in size to bacteria, can produce more biofuel per hectare of land than alternative farming crops. The algae which float around in the panels of 2.5x0.7m in size, basks in the sun which hits the façades and then also gets fed carbon dioxide and nutrients through pipes that feed into the panels. The panels allow the algae to photosynthesise and grow at the same time, which then prepares it to be periodically harvested for fermentation which then generates biogas. The panels not only provide heat and sound insulation but the "heat from excess sunlight, not needed by the algae, is collected and can be stored in brine-filled boreholes, to be used for space and water heating" (Rackard 2013).

FIGURE 4.1.2: BIQ Airlift-System bubbles rising in the Solar Leaf Louvers

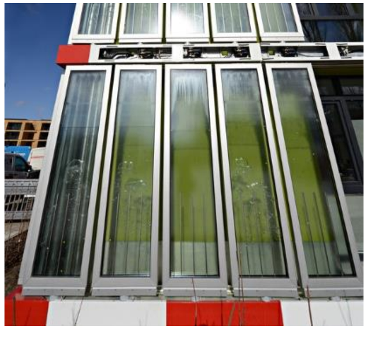


FIGURE 4.1.3: BIQ Solar Leaf-Louver Detail

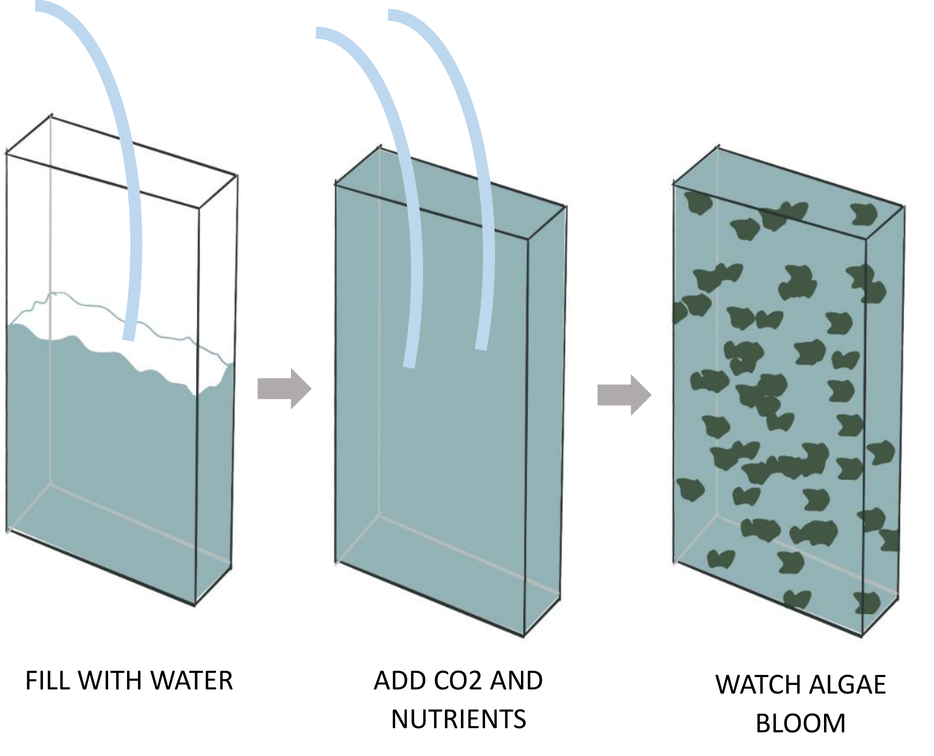


Figure 4.1.4. Algae Panels diagram by Author

Algae is a fast-rising form of biofuel with major fuel companies such as BP investing in algae fuel initiatives and bio-architecture is using it to its advantage. This sustainable solution for powering buildings also has the power to detect and absorb pollution, absorb carbon dioxide, and produce oxygen all in one.

This building is extremely relevant to my design because it validates that I needed to work with algae in a building. The panels of the building not only power the building, but they are a feature which makes it unique. I aim to use the properties of algae to my advantage and to use algae in every way I can in the building. The only place that will be unable to use algae is the actual building materials themselves, but the algae water in the panels will be classified as a material of use to the building.

FIGURE 4.2.1: Marina City Algae Green Loop

4.2 Marina City Algae Green Loop

Architects: Influx Studio

Year: 2011

Country: United States

Algae emerge as a remarkable source of food, energy, and a natural CO2 absorber. We need to start thinking of the spatial consequences of the use of algae and how we can bring the use of it into the built environment. Influx Studio believes in using existing structures as their most sustainable option and incorporating algae in cities and urban spaces where carbon dioxide is a problem.

The problem of supporting economic growth while still trying to create a sustainable future is one that many cities across the world are trying to solve. In Chicago, the Chicago Central Area Action Plan aim to expand and maintain its downtown area's role as it is the driving force behind its economy. However, if they want to enhance their office spaces, they need to add additional space to what is already existing, and this just adds to the CO2 emissions as buildings contribute about 70% of greenhouse gas emissions (Furuto 2011).

This building aims to provide closed loops in terms of energy production by absorbing any CO2 emissions it produces and thus creating sustainable economic growth. The use of algae is by retrofitting the Marina City Towers with algae technology which in turn cleans the environment around it provides biofuel as well as brings greenery into the concrete buildings of downtown Chicago.

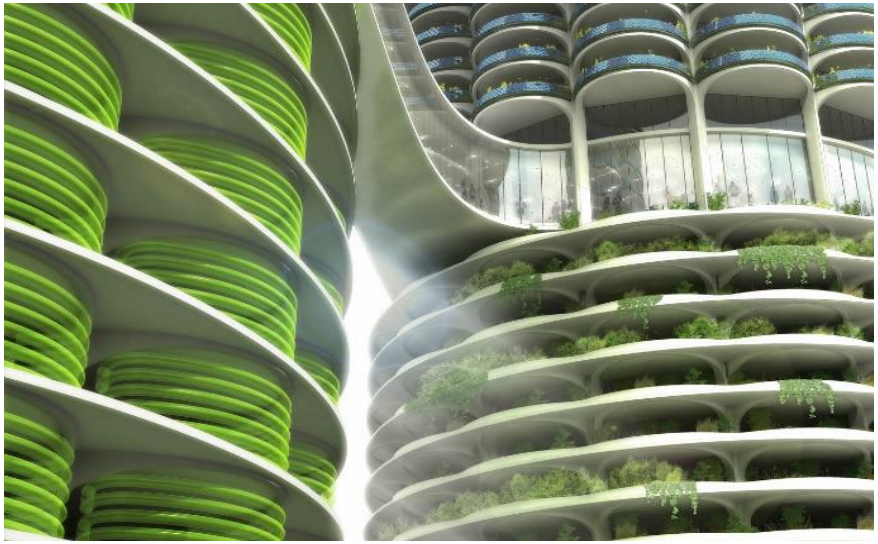


FIGURE 4.2.2: Algae loops at Marina City Green Loop

The use of this precedent is to see how I can incorporate algae into my building that not only helps the environment, but also the economy surrounding my site, and eventually the country. The use of the looped system could be translated into a circular economy in which one thing creates another which then helps another to sustain something else. Algae in building technology is bound to become extremely successful in this country if we can get it to work for us. As a country that still uses coal to produce electricity, greenhouse gasses and CO2 emissions are very high. Coupled with being a

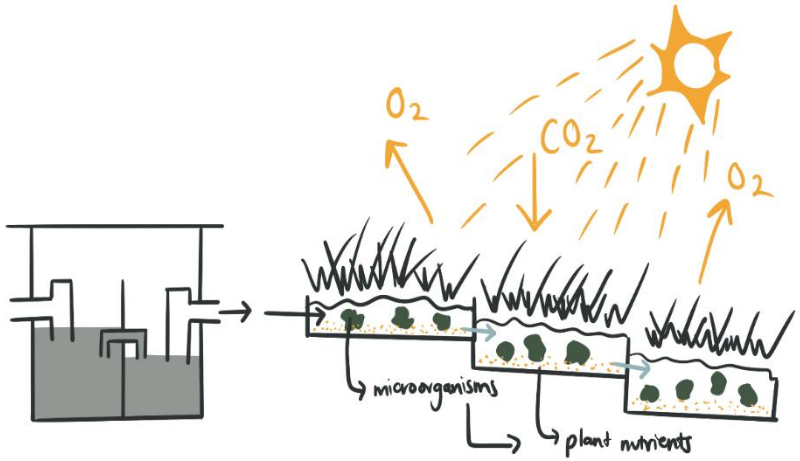


Figure 4.2.3. Phytoremediation Garden Diagram by Author.

bustling city, we do not have a reason not to try algae as a solution to fighting toxins and pollutants.

4.3 Water Hyacinth on Hartbeespoort Dam

Year: 2023 (Shree Bega for Mail & Guardian)

Country: South Africa

A precedent study is necessary, not in terms of only buildings, but of plants too. Water hyacinths have been an invasive alien plant species all around the world and a homegrown problem on the Hartbeespoort Dam in the North West province. The plant which covers the top layer of the water, takes up all the sunlight which would penetrate the water and sustain the ecosystems in the water. Once no sunlight reaches the underwater ecosystems, the plants in the water begin dying as well as the fish due to the high nitrate levels in the water.

Although the alien plant is invasive to ecosystems, it also has properties like algae in that it can remove heavy metals, and pollutants in water. Water hyacinth is an effective and cost-effective method of treating polluted water bodies, but due to its uncontrollable reproductive rate, it is not a feasible solution.

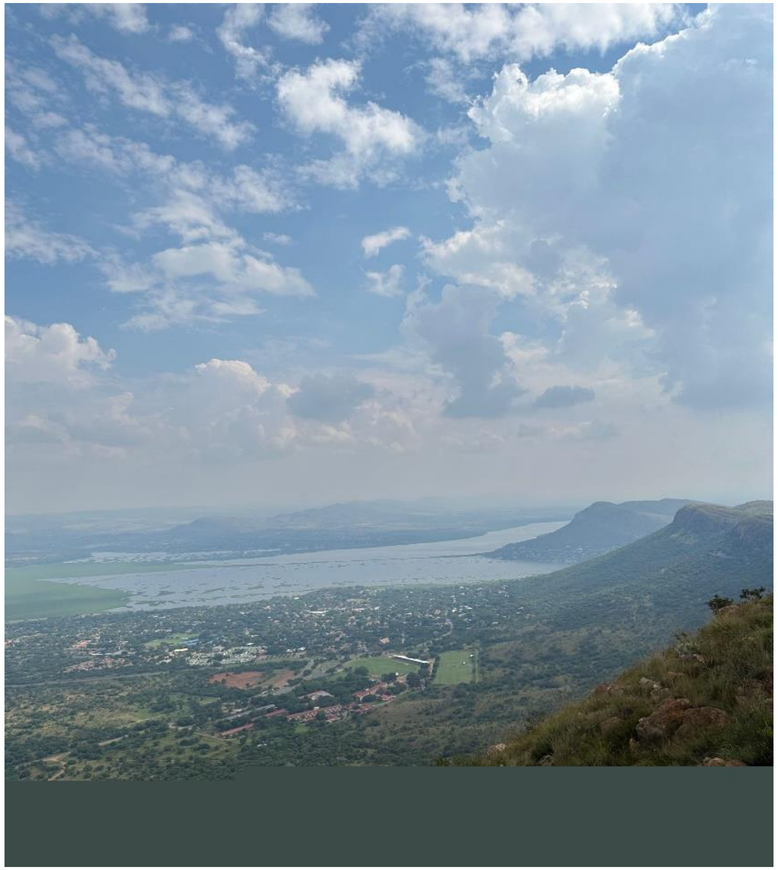


Figure 4.3.1: Water Hyacinth over Hartbeespoort Dam

4.4 The Planning Exhibition Centre of Liangjiang

Architects: Tanghua Architect & Associates

Year: 2022

Country: Chongqing, China

Figure 4.4.1: The Planning Exhibition Centre of Liangjiang Collaborative Innovation Zone Façade view

The research done on buildings of circular forms led to the notion of something organic influencing the building. In Chongqing, China, The Planning Exhibition Centre of Liangjiang Collaborative Zone uses the river as an inspiration for the form of the building, and the circular shape of the building encompasses that form (Shuangyu 2022). The building's form is "avoiding the fate of being a monotonous envelope architecture", and this has influenced the desire for me to use a

Figure 4.4.3: The Planning Exhibition Centre of Liangjiang Collaborative Innovation Zone river diagram

Figure 4.4.2: The Planning Exhibition Centre of Liangjiang Collaborative Innovation Zone Aerial view

circular form which will help deviate from the monotonous narrative of a rectangular or rigid-edged building. In using this form, the algae panels around it will give the outsider a quick glance at what the facility is about, and this can then be seen from any angle in which you look at the facility.

The architecture of the facility is meant to create a sense of community through water collection. Water collection in rural communities has been a daily activity in many women's and children's lives and the aim is to create a facility that makes that experience less banal and more social and interactive. Users of the facility should not be intimidated by the facility, but rather able to see through the transparent façades and be able to appreciate what is happening in their community.

4.5 Advanced Water Purification Facility

Architects: Mainstreet Architects + Planners

Year: 2013

Country: United States

This facility located in Southern California aims to treat stressed water sources by helping wetlands and groundwater sources. The facility makes use of the manmade wetlands around the building to test the water conditions as well as demonstrate to the public the impacts and solutions to water problems. The facility is a transition between the facility and the public to educate the public about water treatments and how to manage them.

The bridges over the wetlands allow the public to interact with them and become immersed in the function of the facility. Passive cooling and lighting systems all add to the sustainability of the facility which further emphasises the need to start creating a greener future.

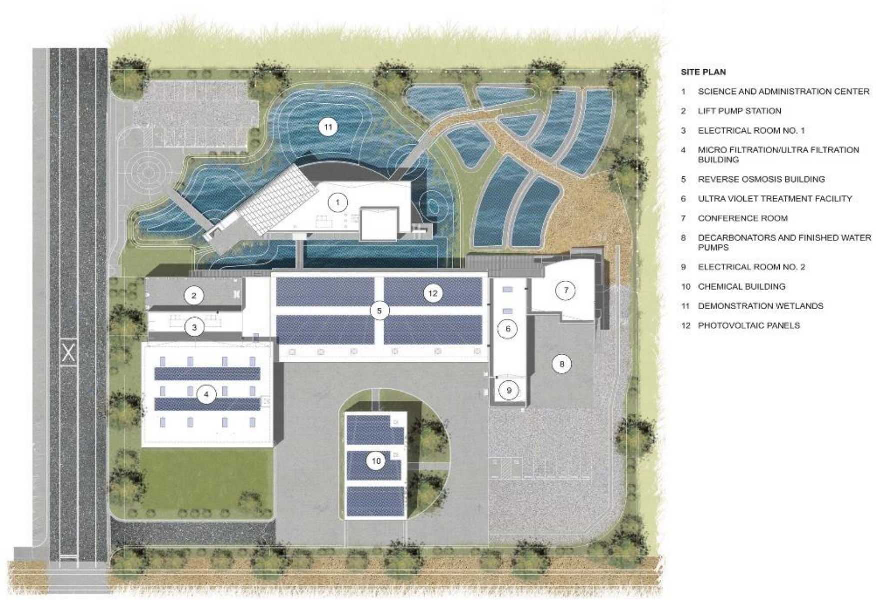


Figure 4.5.1: Advanced Water Purification Facility Site Plan

4.6 Columbia Boulevard Wastewater Treatment Support Facility

Architects: Skylab Architecture

Year: 2012

Country: United States

This is a facility where the earth seems to erupt creating this space where water treatment takes place. The facility in Portland Oregon which treats wastewater has taken the idea of Genius Loci very seriously. The building is located radially along the path of the sun allowing maximum usage of the sun. The sawtooth pattern of the roof imitates the teeth of a saw used to cut wood, which is symbolic of the state's woodlands. The downward folds in the landscape provide runoff into a berm and bioswales return stormwater into a slough. The plant efficiently makes use of the water system to heat and cool the building and uses as much natural light and ventilation as possible, which also allows for night flush cooling throughout the building.

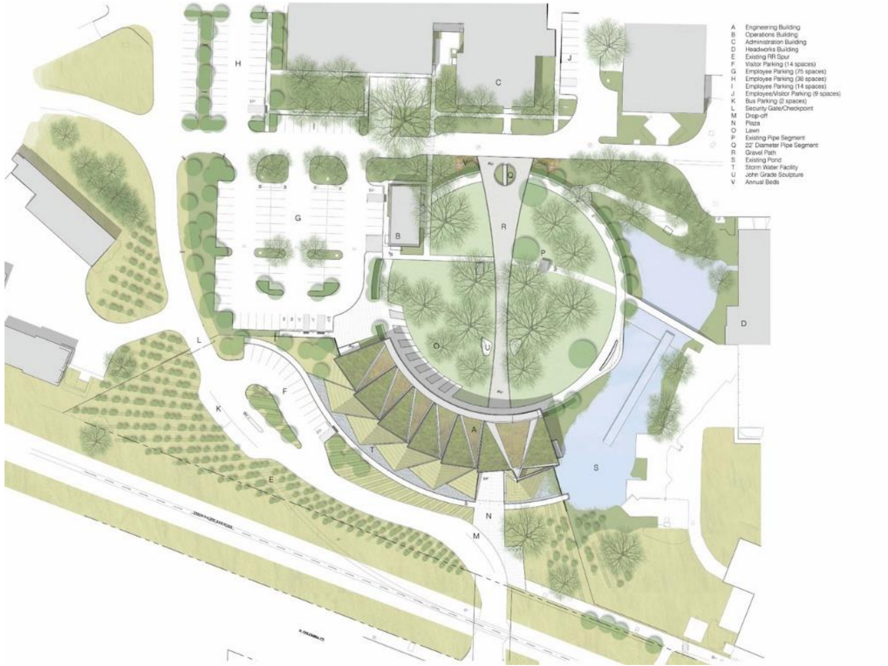


Figure 4.6.1.: Columbia Boulevard Wastewater Treatment Support Facility Site Plan

Precedent Conclusion:

This project aims to be a catalyst for mining communities to be able to harness what they have access to and make use of simple and natural methods for the removal of pollutants. Gold mines will never cease to exist due to the demand for gold and the byproducts of mining will always come with the mining process. Biomining, which is the use of bacteria for gold mining, is one of the only natural methods of mining this precious metal and does not entail any byproducts. This method could soon be a solution to eliminate tailings dams, however, the use of algae is most effective due to its multiple uses. These uses not only include the removal of heavy metals in water but also as a shading device as well as a method for creating a biofuel to sustain the facility.

It is noted that as in Precedent 4.5, the facility has its electrical power building separate from the facility to not have water interacting with the electricity. The labs and facilities indicated are factors to consider when designing the facility.

A dive into the overview of layout and design brings to the forefront how natural shapes influence the designs. Almost all of the studies show an organic shape, whether it be the water bodies or the building. It is an important element to note because it shows that water and its natural forcing shape influences the designs.

CHAPTER 05

05 THE SITE

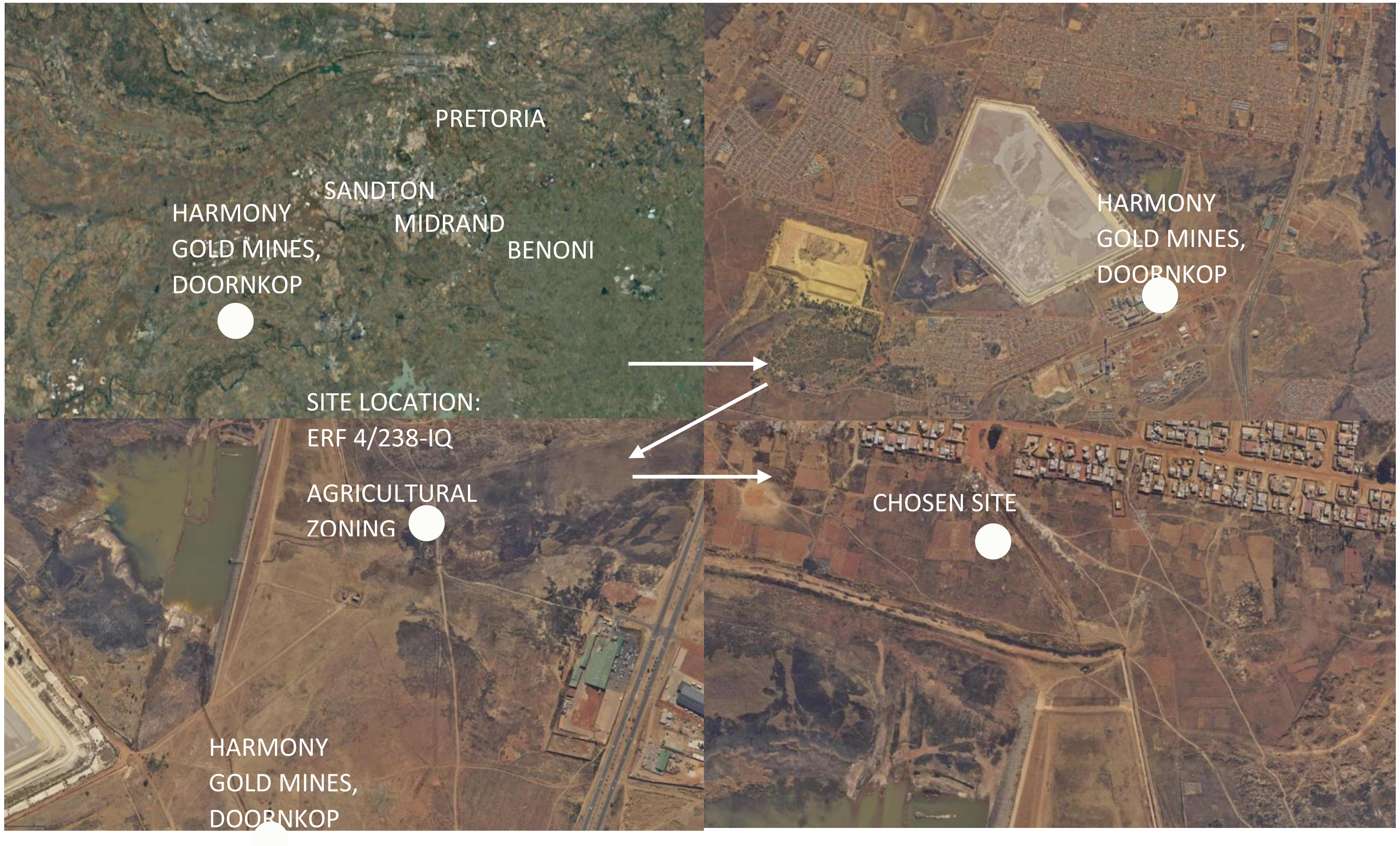


Figure 5.1.1: GIS imaging of site and surroundings.

5.1 SITE SELECTION

Johannesburg's business-friendly environment has effectively attracted investment, which has contributed to its success. However, challenges persist in deconcentrating the economy. Johannesburg's dominance in trade and finance is rooted in its central geographic location in South Africa, among other factors. This contrasts with the lower concentration in agriculture and mining, driven by the scarcity of natural resources. To address this, Johannesburg must focus on improving manufacturing production, emphasize higher value-added processes, and expand into emerging neighboring markets. Over the past decade, the city's economy exhibited solid growth, becoming one of the fastest-growing regions in the country at an average rate of 6% annually. After recovering from a negative 1.7% in 2008, GDP is expected to sustain growth at an average of 3-5% in the short to medium term (Group Strategy, Policy Coordination and Relations, December 2016).

This site which is located at the Harmony Gold Mines in Doornfontein, Soweto has a rich historical and cultural background. With Soweto being one of the most historical and cultural areas in our country, it forms part of the backdrop to my facility which aims to give back to the community. Harmony Gold Mines tailings dams were chosen as they form the beginning of the mining belt of Gauteng.

The backdrop for my facility, coupled with Soweto, is also a mining landscape with neutral colours and vast open spaces. The space on site allows for a water treatment facility to fit in perfectly, while not taking up too much land. As this facility is meant to be giving back to the community and cast a good light on the work done by algae, it was necessary to situate the facility in the middle of the Harmony Gold Mine mining facility and the Tshepisong Phase 1 community of Soweto.

The site is surrounded by communities, namely Tshepisong Phase 1 and Harmony Gold Mine. These entities will need to have physical infrastructure built to connect to my facility in the form of a road. The main road will need a new road joining onto it for access to the site, and this is necessary for the delivery and picking up of algae, water, and produce harvested on-site.

The history of the township was established in 1998 with around 13000 people to start off with. The area was underdeveloped and was in need of infrastructure and adequate services. The reliability of water sources was never one to count on due to infrastructure and the lack of enthusiasm from the mine to help the community was never there.

As the township became more developed, more households were erected and were in need of electricity and water. The facility which I am proposing is there to educate and help the community with water management and sustainability practises. Many people of that area walk to get water daily from tanks that are far away from their homes, i.e. the tanks are not central to the community. On top of the commute to the tanks, the journey is often unpleasant and the destination even more so.

With no community gardens or gathering spaces, a facility like the one proposed would benefit the community and especially the youth. The facility aims to draw in school children, parents, researchers as well as people from the community. The large soccer pitch is where many young children can play and become stars on the field while their parents socialise and collect water.

The facility aims to take a chore and make it more enjoyable, which is the reasoning for the proximity to the township. The ever-increasing population and demand for basic needs is never going to end, and our job as architects are to maximise opportunities in communities to not only better what is already there, but also educate the communities on sustainable development practises and basic need management.

5.2 SITE ANALYSIS

Figure 5.2.1: Toxicity areas map by Author.

This map shows the areas for concern on site due to toxicity. HGM is next door to the site and their tailings dams are dispersed in and around the site. This gives access to water sources but also highlights potentially hazardous zones.

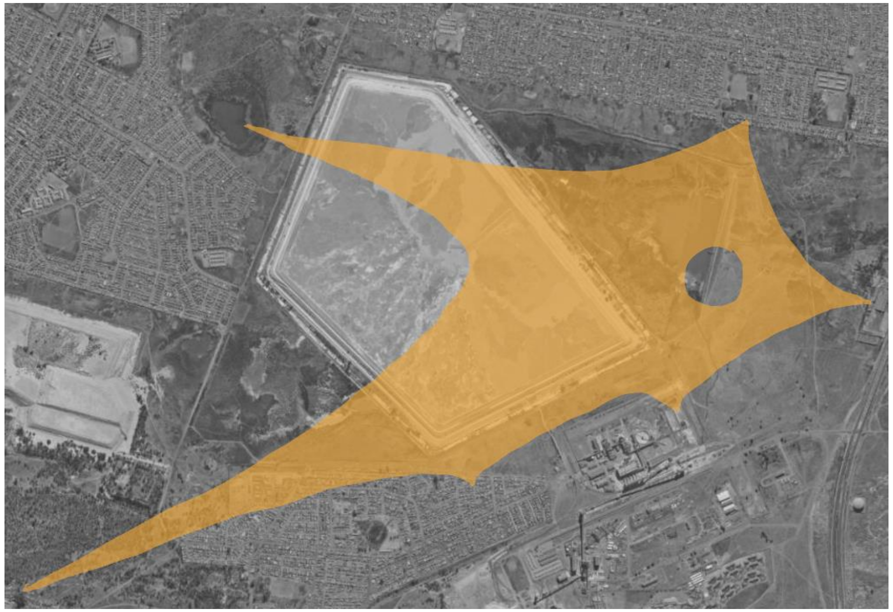


Figure 5.2.2: Distribution into communities' map by Author.

This map is aimed at highlighting the corners of dispersion and reaches that the facility will have on its surrounding community and nearby mine. The distribution is meant to visualise the impact that the facility will have once fully completed and running.

Figure 5.2.3: Site ecologies map by Author.

The ecological factors on site are sparse due to the toxic nature of the site. Any plant life is dried grass patches or weeds that thrive off little to no water, and the insect ecosystems do not stretch far due to the dry landscape. There are no vertebrates or invertebrates living in the water that are known, and should there be any life in the water, it is likely to be bacteria or even spores.

Figure 5.2.4: Tailings dams on site map by Author.

Dams are the main source of material for the facility as the facility needs the dam water for its function. With four dams at ground level, one would not know of the three that sit on top of the mining hill. These water bodies can also become treated, as their travel to the facility can be made possible by gravity and a pumping system.

5.3 NATURAL CONDITIONS

Climatic conditions

The site has many natural conditions which range from dry to very damp and fully submerged in water. The two contrasts are what give the site its character and make it a good challenge to work on. The weather patterns are typical to Gauteng in that in the summer months there is heavy rainfall and humid conditions, but in the winter months, there are few scattered thundershowers with little to no humidity. Temperatures in summer peak at around 25-35°C while the winter temperatures peak at between 12-20°C.

Ground conditions

The ground surrounding the site is comprised of red sand and rocks typical of this area and in a mining community. The sand is hard and dry on the top layer but gets colder, darker in colour and wetter the deeper you go. The site does not have any major influences or need for special construction of foundations as it is not a wetland or a desert.

With the dam being a man-made structure, the risk of flooding is minimal and the need for flood lines does not exist in this context. The site slopes downwards away from the community towards the mine, and this mitigates the risk of flooding in the community should it ever occur.

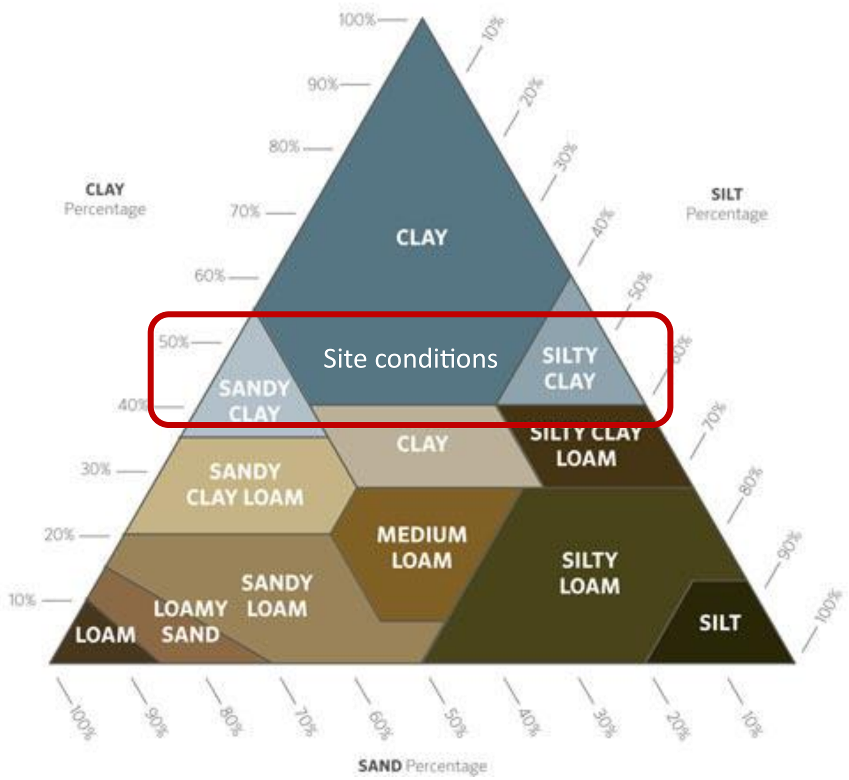


Figure 5.3.1: Best Soil Conditions for Foundations.

CHAPTER 06

06 THE BRIEF

6.1 PROGRAMME

The design of a building comes from many trial and error-tests and explorations. Once a workable model is reached, it is moulded and used to create the final design.

In my building design, the focus is on creating transparency throughout the facility, allowing the visitors to be able to engage and explore the functions and tasks of the facility. The interaction comes from the transparency created and the level of fluidity created in the spine of the facility.

The three main elements are water treatment, community, and education, which are all interchangeable, yet separated by function. In water treatment facilities, it is necessary to have some levels of privacy, and this is achieved with the change in levels which indicates a change in privacy. The first floor of the facility houses more private labs and offices, while the ground floor is where the semi-public and public spaces occur. The tanks that house the water were determined their sizes through discussion with a farming expert on how much water is needed for a crop per day. (Calculations included in Revision 2 Concept figure 7.2.9)

Due to the dam being over 350m away from the community, the aim of bringing the facility nearer to the community was to help eliminate walking distances on an already tedious task.

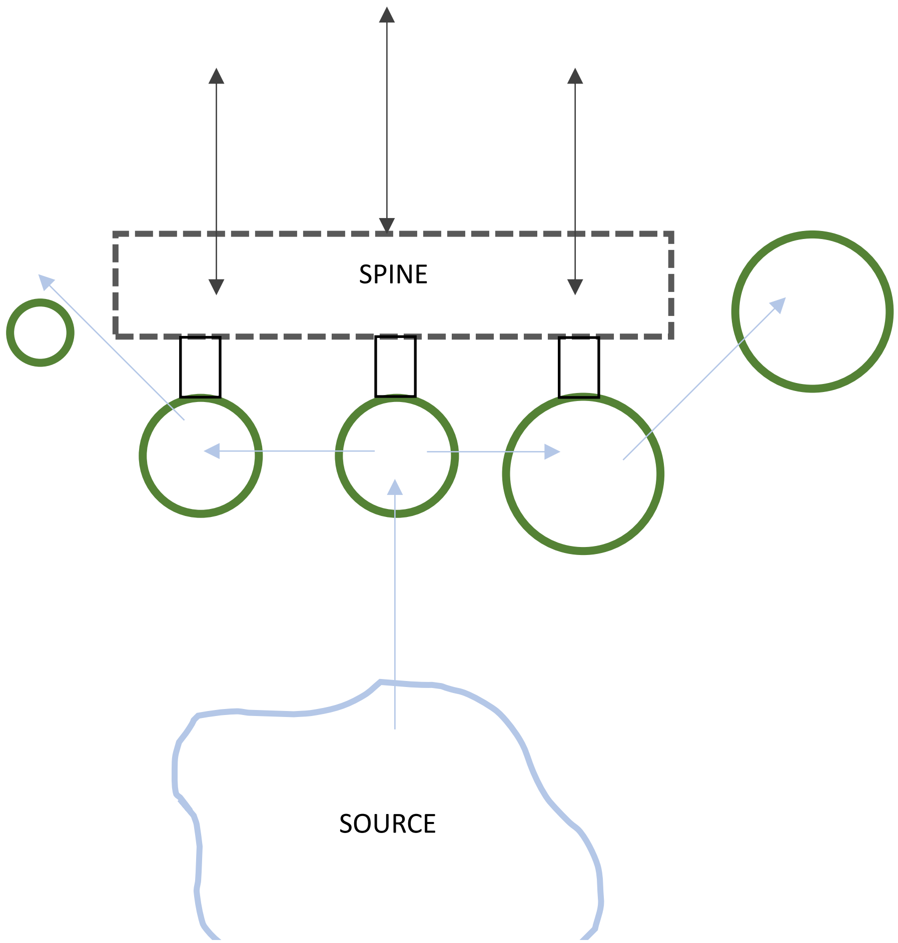


Figure 6.1.1: Diagrammatic layout of facility by Author.

DESIGN PROGRAMME

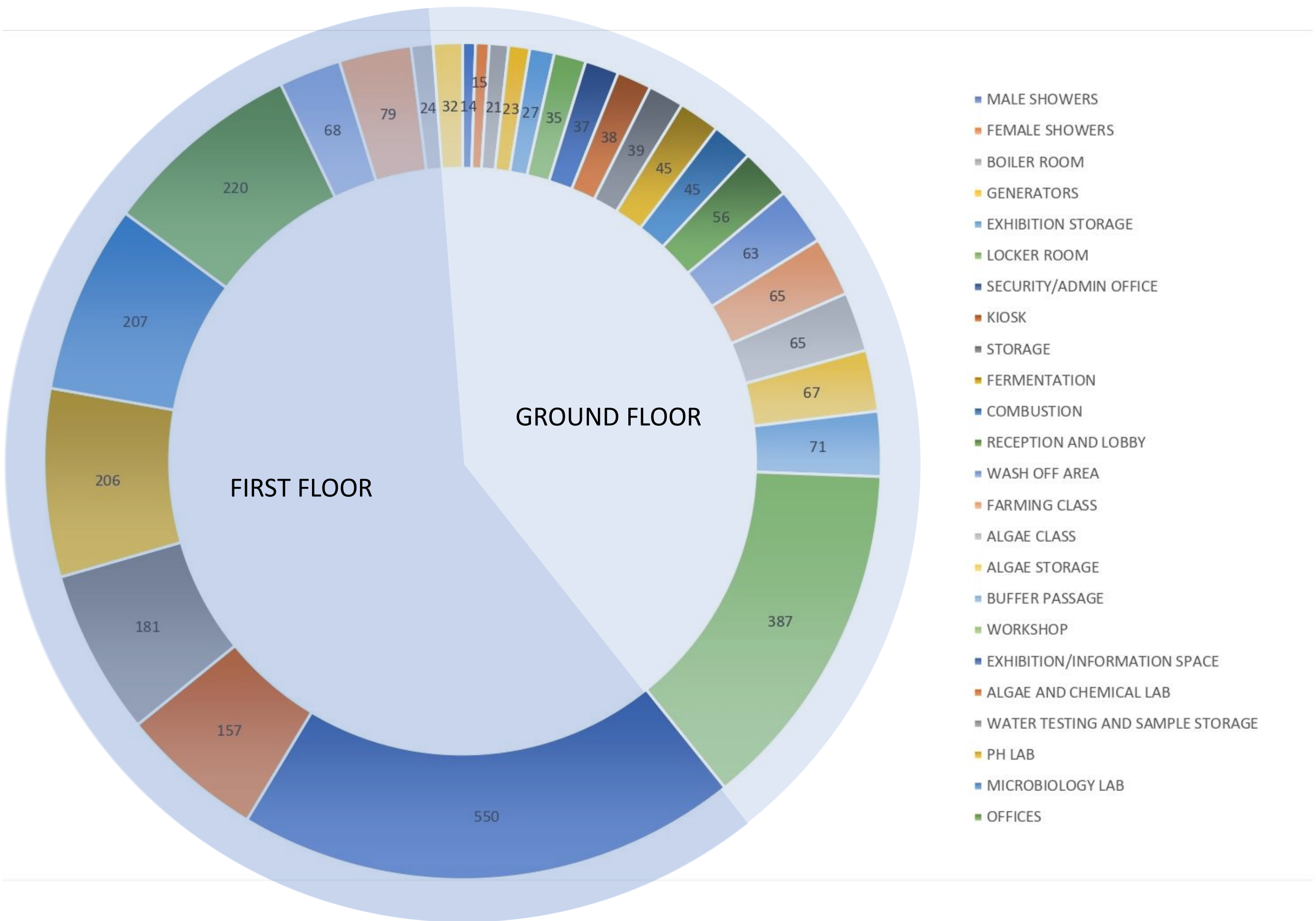


Figure 6.1.2: Programme layout in square meters by Author.

6.2 TECHNICAL SYSTEMS

The algae panels are an important part of my facility as they are the face of my facility. These panels are created from a specialised glass which is essentially a rectangular box with a lid. The edges are bonded together to form a watertight seal, and this allows for the panel to hold water. As carbon dioxide and nutrients will need to be fed into the panel, and the panels cleaned, the top face will need to be removable with holes cut into the glass to allow access to these tubes. A hole will also need to be made in the bottom face to allow for the draining of the water and algae. While this glass panel could stand on its own, it needs to be raised off the ground for maintenance reasons as well as wear and tear of the panels. Holes for fixings will need to be made in these panels, with water seals at the fixing points to allow for a closed envelope.

These panels are beneficial to my project as they are a means of growing algae as well as providing shade and biomass. The innovative use of algae in these panels can be used as a template for other building façades where shading or biomass is needed. There is special maintenance which is required for these panels and a team will need to be trained for this task. Onsite maintenance will be necessary to achieve the smooth running of the facility, and should something happen to the panels, the onsite team can assess the situation and create a way forward without having to call in an outside team which will incur extra costs. Unfortunately, the cost implication of these panels is a significant portion of the budget, however, the benefits, in the long run, outweigh the negative impact the cost has on the budget, and the circular economy that the facility is aiming to become will allow a return on its investment, making the cost worth the portion of the budget.

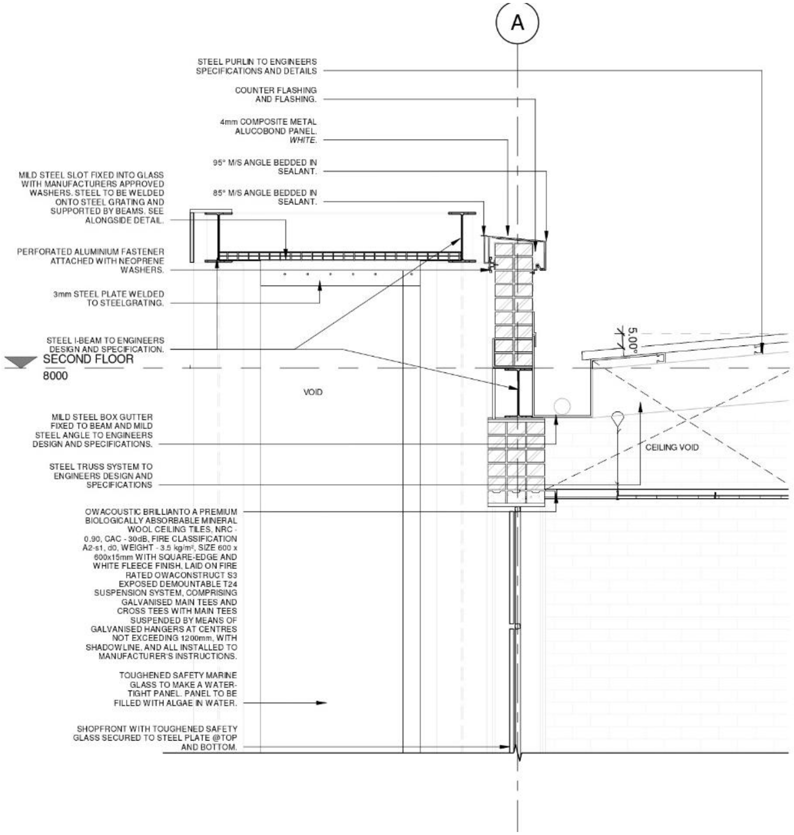


Figure 6.2.1.: Building technical section by Author.

6.3 VIABILITY

Figure 6.3.1: Site Aerial View Found at https://ags.joburg.org.za/cgismobi/

Town Planning Aspects

My site, located on land next to Harmony Gold Mines in Doornfontein has the ERF number of 4/238- IQ and is stated to be unproclaimed land or a farm. The land will have to be converted to proclaimed land which can take up to four years after all the necessary procedures have taken place. My hopes for this issue to be easily resolvable lie in the fact that the site is near to existing infrastructure. While there is existing infrastructure, it will also be a costly but necessary exercise to achieve a facility that will benefit the greater community.

To change the zoning from a farm to a research facility, the below aspects are required:

- Prepare and apply for the establishment of a township.
- Circulate the township application to external departments and internal departments of the Council for their input and comments.
- Advertise the application according to the regulations specified in the Municipal By-Laws.
- Receive positive comments from all relevant departments, and the City Planning Department takes steps to obtain approval for the township.
- Engage a land surveyor to create the General Plan for the approved township at the SG's office.
- Hire civil and electrical engineers to compile necessary service reports for submission to the Council, seeking approval and installation of engineering services.
- Obtain a Land Surveyor Certificate.
- Acquire a Geological Report.
- Obtain an Environmental Report.
- Obtain a Conveyancers' Certificate (from an attorney).
- Prepare Outline Scheme Reports (concise reports from civil and electrical engineers, detailing the availability of services and how they will be integrated into the area, etc.).

▪ Conduct a Traffic Impact Assessment.

With the above points in mind for rezoning, the site is also noted to not have an SG diagram at the surveyor general's office. This requires a land surveyor to inspect the site and provide the relevant information for a title deed to then be registered at the deeds office when the building has approval and ownership. A Site Development Plan (SDP) will need to be done for the site to include all the relevant information stating what will be happening on the site and where it will be located on the site.

According to the National Environmental Management Act, any interventions occurring in wetlands, near water sources, or in protected areas of nature require an environmental impact assessment. This assessment aims to determine the project's effects on the site and its compliance with maintaining environmental integrity. In the case of my intended building location, an Environmental Impact Assessment is necessary since there is a water body directly in front of it. It is, therefore, crucial to avoid any negative impact on the environment caused by the building and avoid any further damage caused by mining.

Once all the above requirements are fulfilled, the building plan can be submitted to the council for approval, and construction can commence. These procedures, including the environmental impact assessment and the conversion of unproclaimed land to a research facility, significantly impact the development costs.

Technical Aspects

The chosen materials for my site will be local to South Africa, and possibly some materials can be sourced 25km or closer to the site which helps with the green building element. I aim to use concrete, steel, and brick for my structure, with glass and steel for features added to my structure. These materials are mostly available with no waiting periods for delivery to the site, however with the steel and glass, it might take a bit longer as these pieces would need to be custom-made, increasing the cost of the project.

Logistical aspects such as material storage – due to the location of the site – will need to be thought of, as site security is needed to watch these materials during the construction period. Delivery times for the chosen materials as well as the access to the site to deliver the materials will also need to be planned effectively, especially for the installation of the algae panels. The labour on site would need to be efficient in concrete shuttering, as well as waterproofing for the structure to have a long life span. The labourers will need to be trained by specialists in the installation of the algae panels on the façades, as these panels need a carbon dioxide gas supply and a sturdy fixing to the structure. Staff that occupy the building will need to be trained in the maintenance of these algae panels as the technology is not widely known in South Africa. These algae panels are there to provide shading as well as a source of biomass energy and this adds to the sustainable technologies implemented in my facility.

The income generated from the facility will be able to sustain the algae water treatment portion of the site where water is collected in tanks for community use, and for use on the
farming portion of the site where fruits and vegetables will be grown for community consumption. The income generated by the selling of useable water and vegetables can then sustain the maintenance of the facility creating a circular economy.

When planning the project, it is essential to consider weather conditions such as rain and potential sandstorms. The objective is to initiate the project at the beginning of the year when rainfall is minimal or has ceased completely. This approach aims to prevent rain-related delay claims by the contractor, thus saving time and costs.

During the construction phase, the site must be properly arranged to help the workers get the job done properly. This includes allocating spaces for the workers and establishing a site office for the foreman and project manager. It may also be necessary to consider setting up food stalls for the convenience of the workers to obtain their meals for the duration of the project and have designated lunch break areas.

Financial Aspects

There are several methods that can be employed to determine the costs associated with establishing a water treatment facility. A common approach would be the detailed cost estimation method, which involves conducting a comprehensive analysis of all the components and activities involved in the construction and operation of the facility. This method entails assessing factors such as land acquisition, equipment and machinery procurement, labour costs, construction materials, engineering and design expenses, permits and regulatory compliance, and ongoing operational expenses.

A comparative cost analysis, which involves evaluating similar existing water treatment facilities to estimate the costs of constructing a new facility, will be done in order to determine what the facility should be achieving at different stages during its lifespan. By examining the costs and specifications of comparable projects, adjustments can be made to account for specific site conditions, technological advancements, and other relevant factors.

Life cycle costing is a comprehensive method that considers not only the initial capital expenditure but also the operational and maintenance costs over the facility's entire lifespan. This approach involves analysing the costs associated with equipment maintenance, energy consumption, algae production, labour, and any necessary upgrades or replacements throughout the facility's operational years.

A method used to assess the financial feasibility of the water treatment facility by weighing the projected costs against the anticipated benefits can be done using a cost-benefit analysis. This analysis considers factors such as improved water quality, public health benefits, environmental impacts, and potential economic gains resulting from the facility's operation.

Additionally, engaging experts such as engineers, consultants, and contractors can provide valuable insights and expertise in estimating costs based on their experience with similar projects. By combining these various methods and expert input, a comprehensive and accurate cost estimation for a water treatment facility can be achieved, enabling effective budgeting and financial planning for the project.

Crucial elements when planning for the water treatment facility will include:

1. Budgeting: Develop a comprehensive budget that includes both capital expenses (initial construction, equipment, and infrastructure) and operational expenses (maintenance, staff salaries, utilities, chemical supplies, etc.). Regularly review and update the budget as needed to ensure financial stability.
2. Cost Control: Implement strategies to monitor and control costs throughout the facility's lifecycle. This involves careful monitoring of expenditures, seeking competitive bids for procurement, optimizing biomass energy and algae usage, and identifying cost-saving opportunities without compromising the quality and effectiveness of the treatment processes.
3. Revenue Generation: Explore various revenue streams to offset operational costs. This can include fees charged for water treatment services provided to municipalities, industrial clients, or residential users.
4. Asset Management: Implement an asset management system to effectively track and maintain the facility's equipment, infrastructure, and other assets. Regular maintenance of the algae panels and timely repairs where needed can extend the lifespan of assets, minimizing the need for costly replacements and improving overall operational efficiency.
5. Financial Reporting: Maintain accurate and up-to-date financial records to facilitate informed decision-making. Regularly analyse and report financial performance, including income, expenses, cash flow, and key performance indicators. These reports will help to identify trends, assess the facility's financial health, and adjust where necessary.
6. Risk Management: Identify and manage financial risks associated with the water treatment facility. This includes assessing potential risks such as regulatory changes and unforeseen events. The facility would require contingency plans and insurance strategies to mitigate financial risks and protect the facility's financial stability in its circular economy.
7. Funding and Grants: Explore funding opportunities and grants specific to the water treatment industry. Research would need to be done in the governmental or private sector to find companies that support environmental projects or sustainable infrastructure development. These funding sources can provide additional financial support for the facility's operations and initial costing.

8. Continuous Improvement: Continuously evaluate and improve financial management practices by staying updated on industry best practices, adopting new technologies, and incorporating feedback from stakeholders. Regularly reassess financial goals and objectives to ensure long-term financial sustainability.

Development Plan

To assess the economic feasibility of my project, I need to delve into several key aspects. Firstly, it is important to define the scope of work, particularly considering the use of advanced technologies on the site. Conducting a market analysis specific to the Doornfontein area will help identify the target market and estimate potential sales revenue. Additionally, I must consider the potential risks associated with the project and develop risk management strategies to mitigate them if they arise.

In terms of financing the project, it is necessary to evaluate different financial options to secure the necessary funds. This evaluation process also involves identifying potential investors who are interested in supporting a green energy system powered by algae, such as BP.

The establishment costs for this project will be significant, as the site needs to be developed from scratch. This includes the installation of essential infrastructure such as electricity cables, sewer connections, and water mains before any construction can commence or goods can be delivered to the site.

Furthermore, the holding costs of the property will be zero due to the land being owned by the . Given the technical aspects involved, which may require the involvement of specialists from outside the country, the construction timeline is likely to span over a year. It is therefore essential to take out insurance to cover the specialized equipment and implement on-site security measures to safeguard the project's assets.

Marketing of the project will be implemented with social media campaigns as this is the best method for reaching a wide audience in a short amount of time. Architects and any other professionals will be invited to the site for viewing of this technology and this will then spread the word of the project to other professionals to hopefully spark a greater interest in the use of algae in building technologies.

The building will be part of a self-sustaining circular economy which generates its own income. Investors will be allowed to get a return on their investment should they be interested in this algae technology, and shares can also be made available, should they be willing to contribute more to a green building.
The architect will need to arrange with the land surveyor to set out cadastral points on site and generate a surveyor's general diagram before anything can happen on-site. A civil engineer will need to arrange drainage on site as well as contact a structural engineer to assess soil conditions in the wet region my site is on. An electrical engineer is also needed to arrange electricity lines to feed into the site for construction to start. The civil and electrical engineer needs to contact the municipality to create sewer connections and electrical connections on site. A town planner might be needed to

create roadways; however, this will be determined once the design is finalised.

6.4 SITE CONDITIONS

Site Access and Security Points

The site has four access points which allow entry onto the property. The main entrance off of the street is where most people will enter from and will need to get through security checkpoints at the facility's entrance doors. This vast site has access points to the farm on the north, west and southern sides, which will also have security stationed at each point.

Figure 6.4.1: Site Access by Author.

Site Falls

With the many little mounds of sand and grass patches, the site has many contours. These contours are not recognisable on a larger-scaled drawing; however, they do add to the site's undulations. The facility is positioned at the foot of a contour with a fall of 1000m from the top to the bottom.

The water from the dam will need to be pumped up to the site and distributed from the central tank. The central tank is at a higher level than the outer tanks to allow gravity to help in the process. The outer tanks are set lower in the ground to achieve this.

Figure 6.4.2: Site Falls by Author.

Softscapes and Hardscapes

The two textured patterns help differentiate between the types of landscapes on site. Noticing how the softscape envelopes the hardscape, it is easy to note which is of more importance. The site entrances as well as the path around the soccer pitches are all hardscapes which lead onto the softness of planting and greenery around the facility.

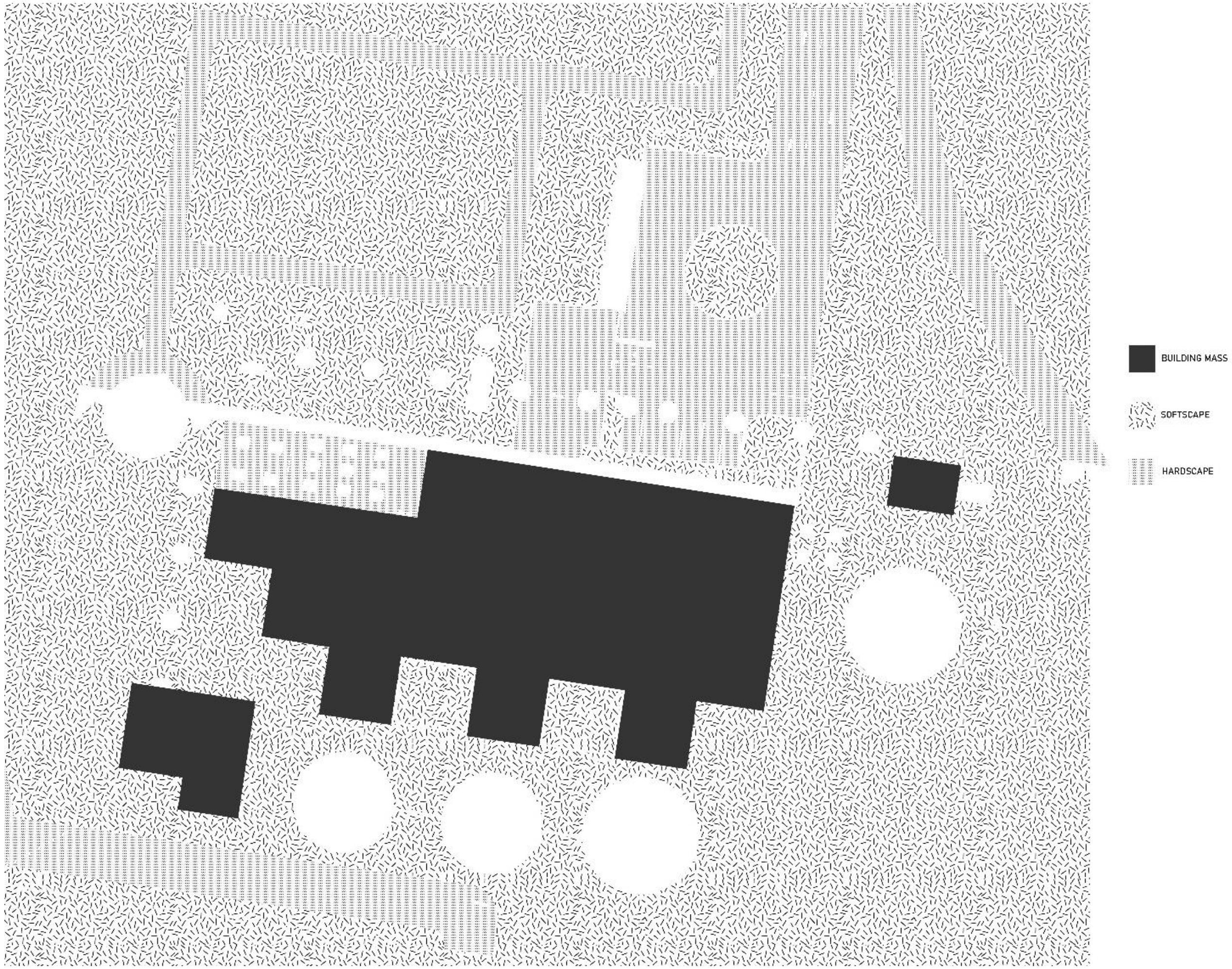


Figure 6.4.3: Hard and Softscapes by Author.

CHAPTER 07

07

DESIGN DEVELOPMENT

7.1 CHARETTE WORK

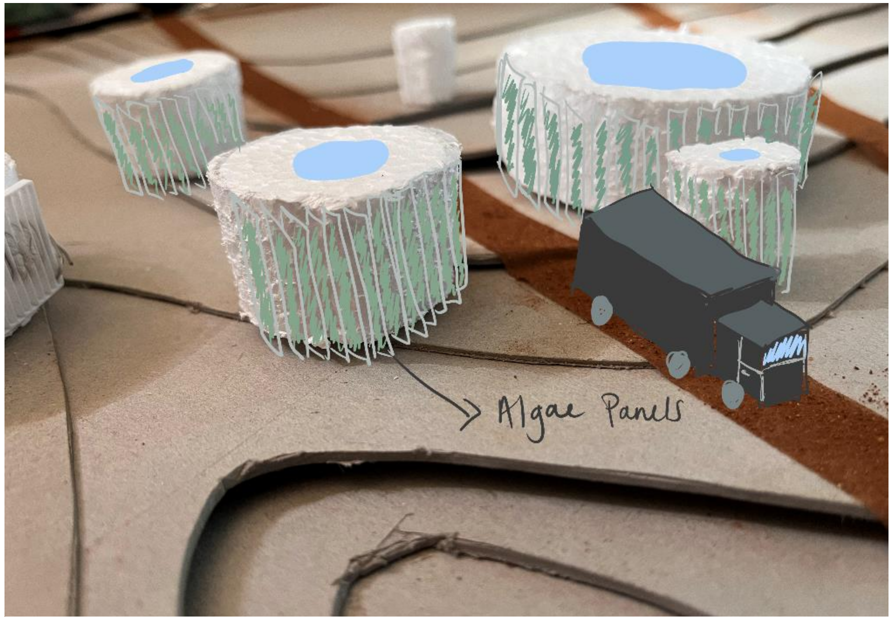


Figure 7.1.1: 3D explorations by Author.

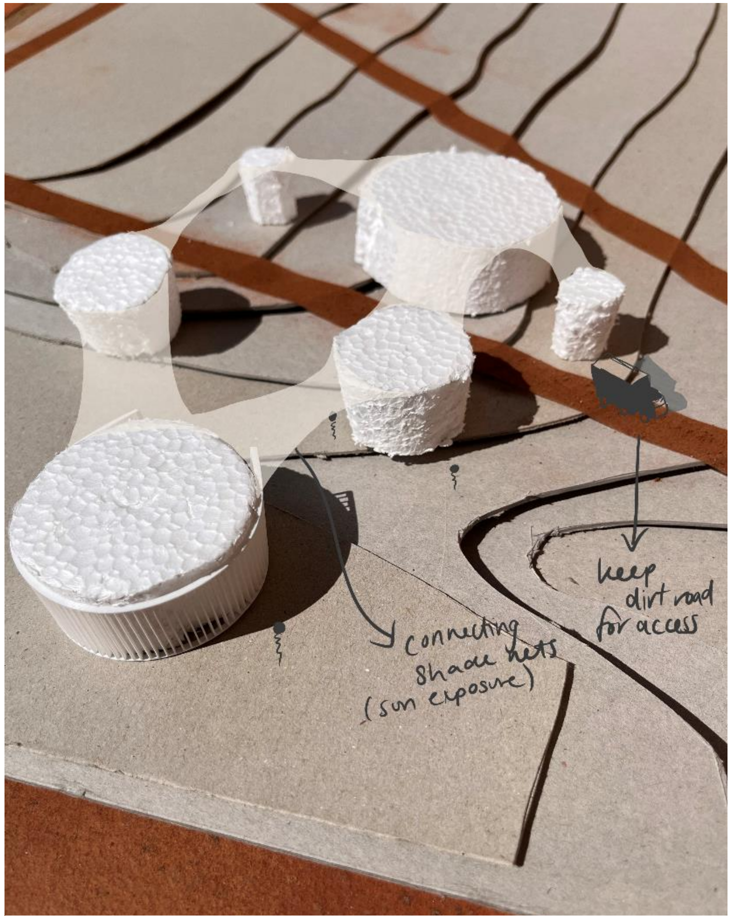


Figure 7.1.2: 3D explorations by Author.

In this first attempt at a design, my aim was to determine if the shapes on site were functional and efficient in performing their task. The initial design was circular single-storey buildings which housed the water and the processes internally. This revision also did not consider the community in its design as it was over 400m away from the community edge, which would render the facility useless to the community that it is meant to help. The error in this revision was not thinking about who the building was for, and just focusing on the facility's need for water.

The learning outcomes from this revision were to focus on how the community can use the building, how to orientate the different buildings and how much water is needed per building.

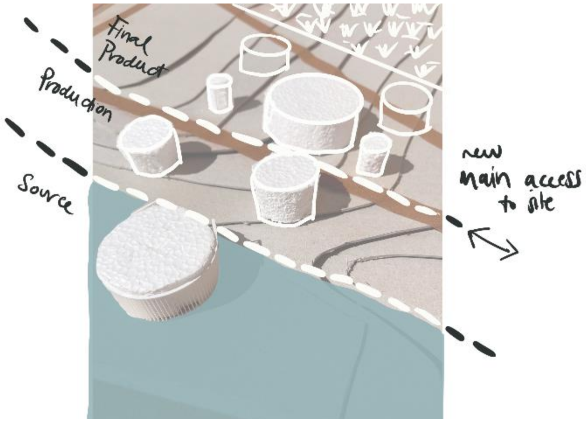


Figure 7.1.3: 3D diagram by Author.

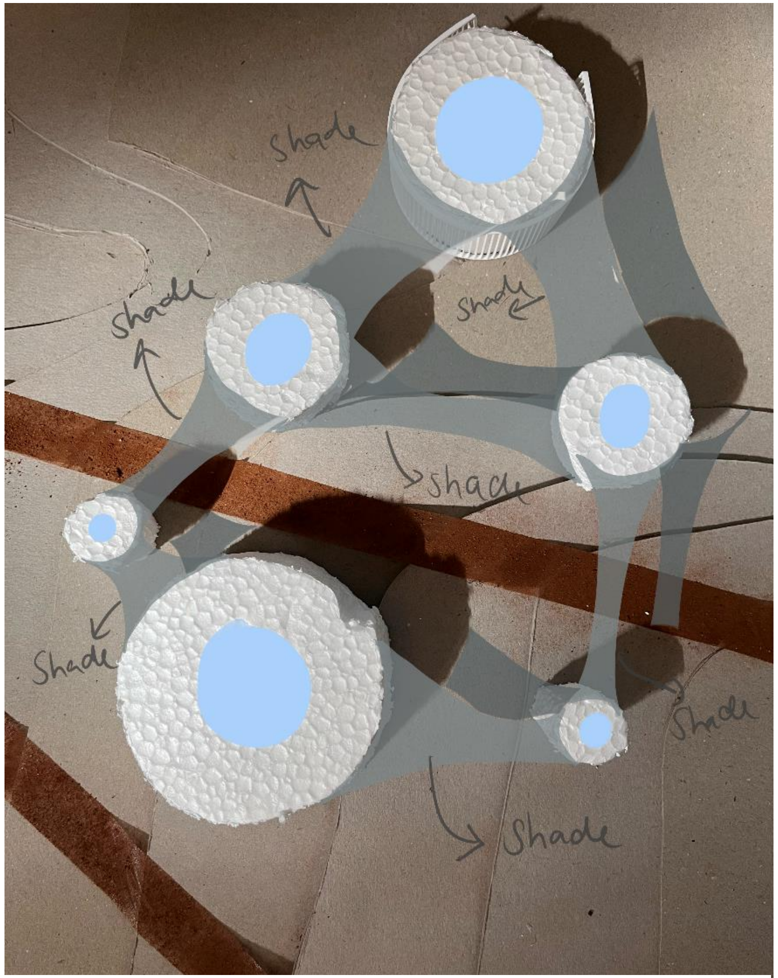


Figure 7.1.4: Shade diagram by Author.

7.2 CONCEPTUAL EXPLORATION

The conceptual process started off with the cells of an algae plant and its naturally organic shape. The exploration took off into an even further exploration of how the organic shape can be expanded and diversified to create a feeling within a space. The exploration of such feelings and forms led to a spine-like structure which plays with light and form. The circular forms are kept by the water tanks of the facility, while the spine is the building which houses function.

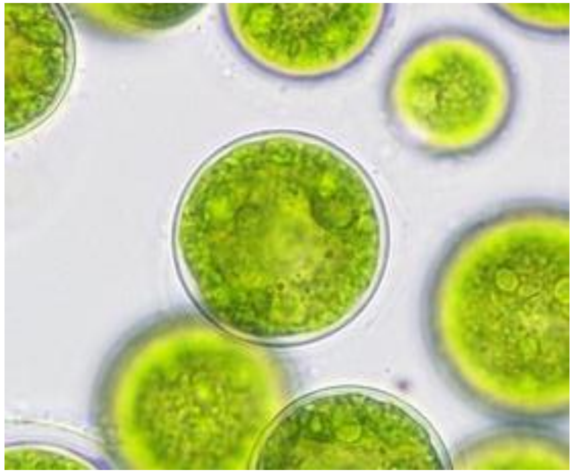


Figure 7.2.1: Algae cells found at https://www.nutraingredients-usa.com/Article/2016/04/21/Algal-omega-3-future-still-bright

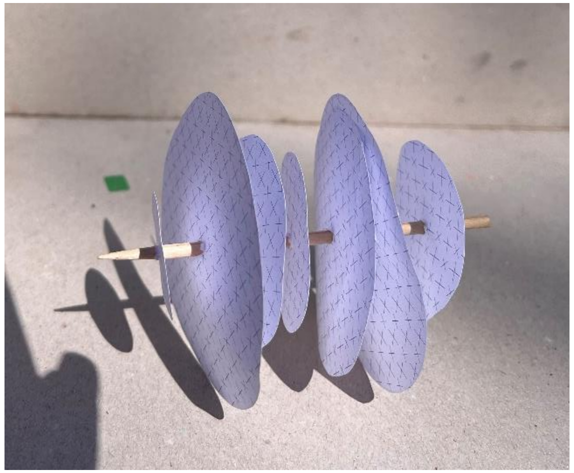


Figure 7.2.2: Conceptual exploration A by Author.

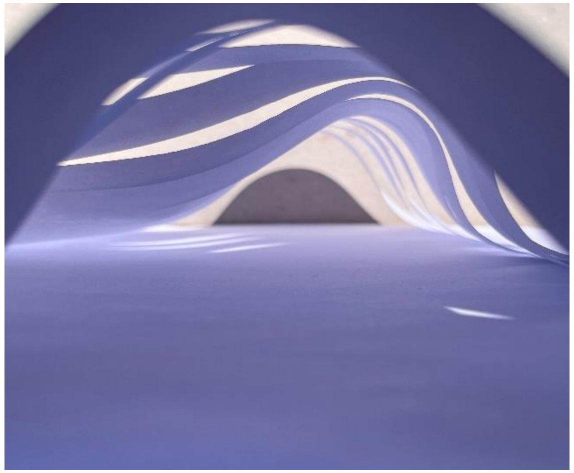


Figure 7.2.3: Conceptual exploration B by Author.

Beginning of exploration

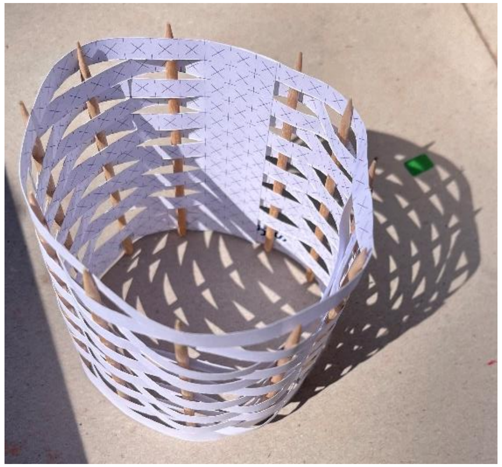


Figure 7.2.4: Conceptual exploration C by Author.

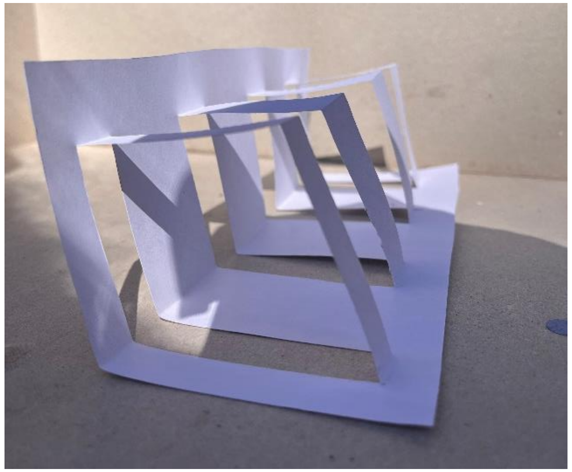


Figure 7.2.5: Conceptual exploration D by Author.

Figure 7.2.6: Conceptual exploration E by Author.

Middle of exploration

REVISION 1 CONCEPT

The concept for this revision moved the intervention closer to the community edge where there could be more interaction between the facility and the people. The buildings were organised on site according to the process of the facility and the proximity of buildings to each other.

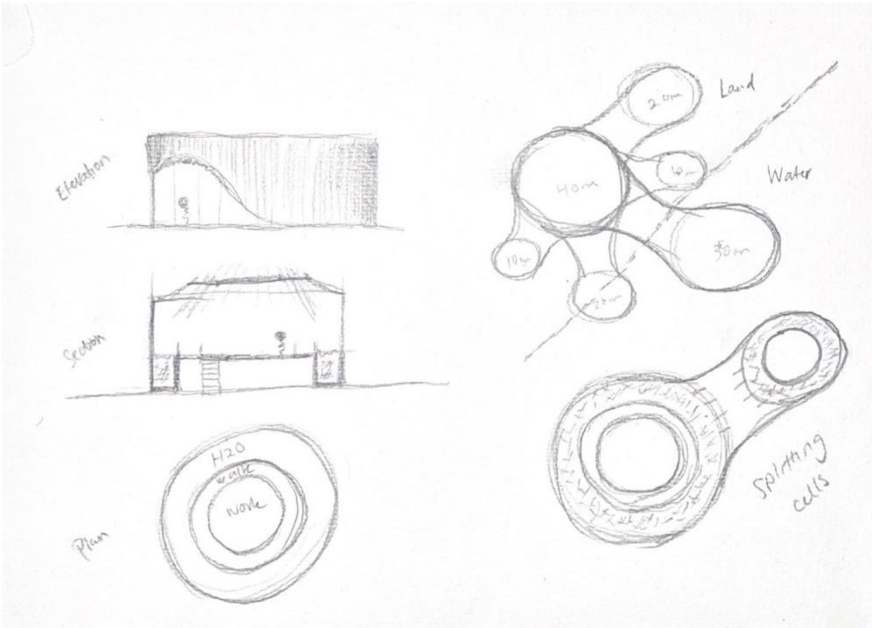


Figure 7.2.7: Concept sketches revision 1 by Author.

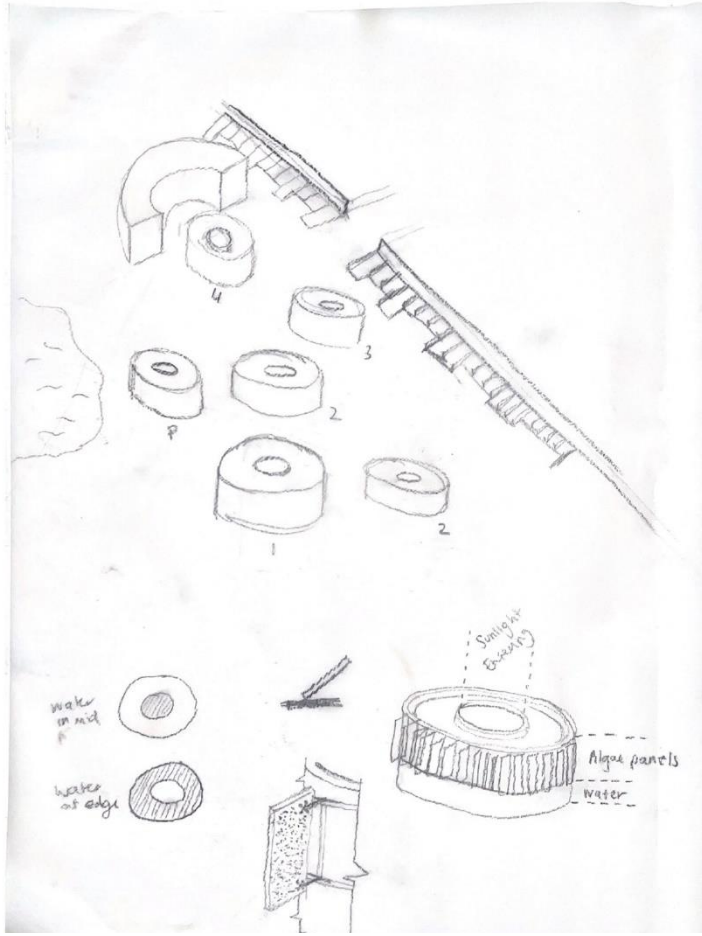


Figure 7.2.8: Concept sketches revision 1 by Author.

REVISION 2 CONCEPT

This revision is a more well-thought-out and organised execution of what the facility should be. The water tanks are now open to the elements and allow natural sunlight to help the process along. The main building acts as the spine that lets the extremities perform their functions.

The initial idea for this revision came about due to the haphazard placements of the previous revision, and a solution was needed to bring everything into one cohesive facility.

The need to change my design was driven by my scientific approach to architecture. When the initial design was not working, I sat down and looked at the building from the scientific aspect of my research. I needed a central organism to power the rest of the spaces, that being the water.

The lead on from the water then jumped to how do I link the water to a facility without it seeming random, because in science everything has its place. The structural grid system helped me arrange the tanks to relate to the building and then also design the spaces within the facility so that the facility would do what I needed it to do.

A sun analysis will be performed to ensure that the façade is designed to its maximum function as a feature and a light source. The algae panels will provide shading; therefore, the main focus will be the building's glazing performance.

Figure 7.2.9: Concept sketches revision 2 by Author.

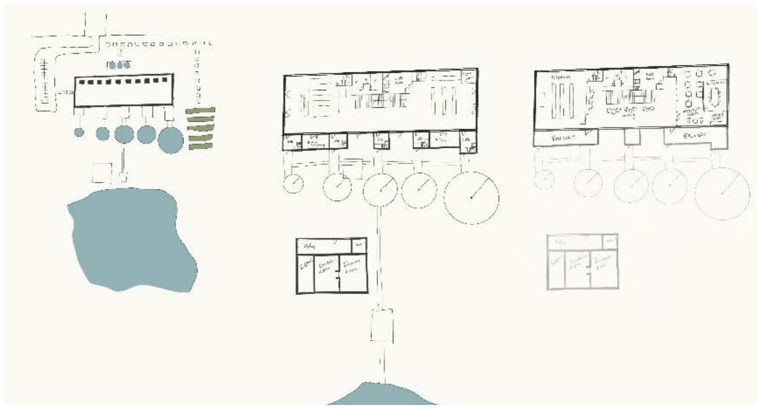


Figure 7.2.10: Concept sketches revision 2 by Author.

REASONS FOR FURTHER DEVELOPMENT

The reasoning behind the further development was to make use of what I had and think of how to maximise my ideas. I knew that I wanted to keep the circular forms to relate to the idea of cells, but I needed a better way to communicate that.

In my design, I wanted to achieve a pattern, with uniformity and organic shape combined. The first revision was not convincing enough as the round forms were too scattered and random. With no sense of uniformity or central branch, this idea needed refining. A further investigation into what I needed led me towards revision two which now has a uniform pattern of the round and organic forms, a central uniform structure, and a pattern to follow in terms of the tank layouts.

All of the above intentional moves played in favour of the facility and helped me bridge the rigid method of science with the planning out of spaces in architecture.

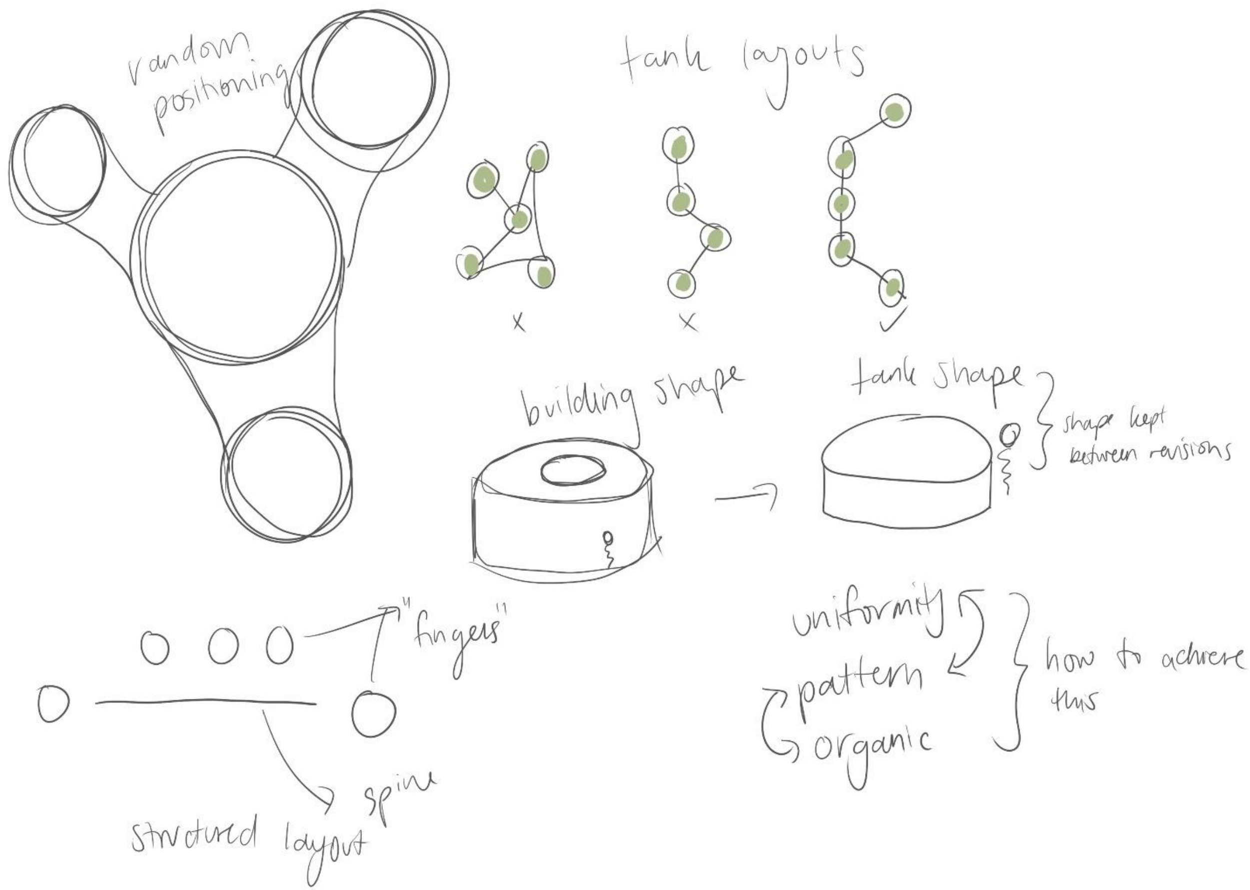


Figure 7.2.11: Design Development Sketches by Author.

7.3 MATERIALITY

Figure 7.3.1: Steel mass by Author.

Figure 7.3.2: Concrete form by Author.

Figure 7.3.3: Algae panel by Author.

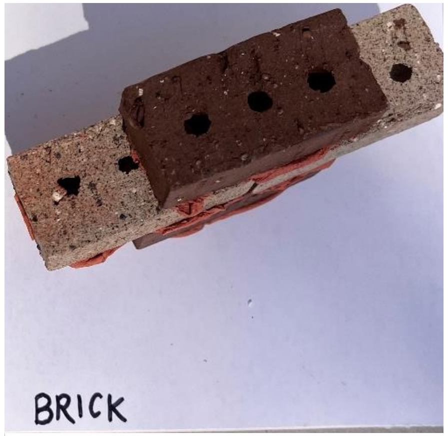


Figure 7.3.4: Brick layout by Author.

The materiality explored in the research suggests the best materials to use for such a water treatment facility. The concrete will form part of the slabs of the building, while steel holds up the structure. Bricks will be used non structurally as infill panels and the algae will form part of the façade as shading devices. The steel frame structure also allows for the panels to be fixed to the steel which then ties the loads back into the building.

7.4 SKETCH DESIGN

REVISION 1

During the sketch design phase of this revision, many design issues and details were found to be lacking. The main cause for concern is the emptiness and randomness of the buildings placed on site. The technical building seems to have been the best functioning part to this revision, yet it was the most out of place.

Once the fault was recognised, a better use for the tanks was needed and a better facility had to be designed.

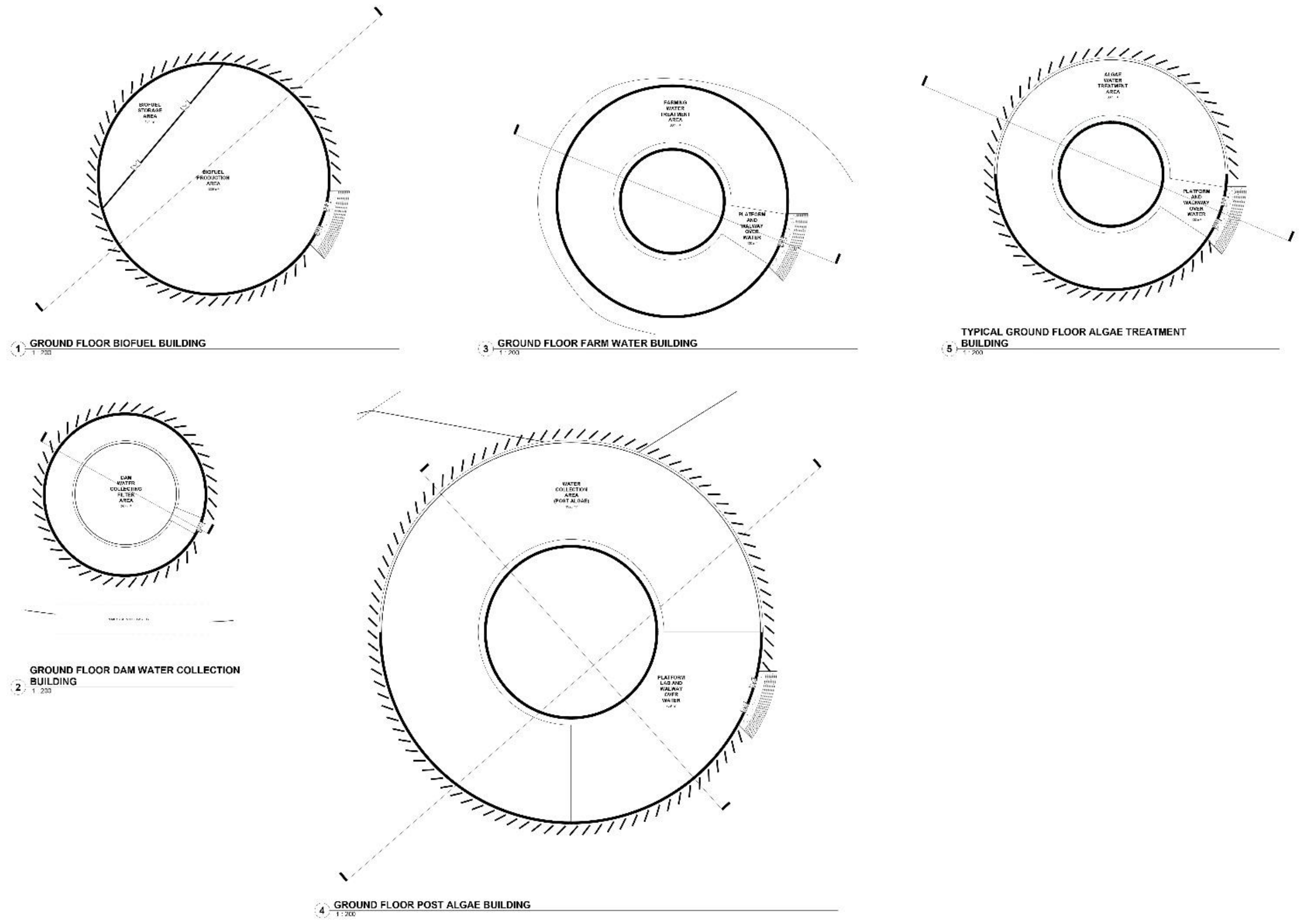
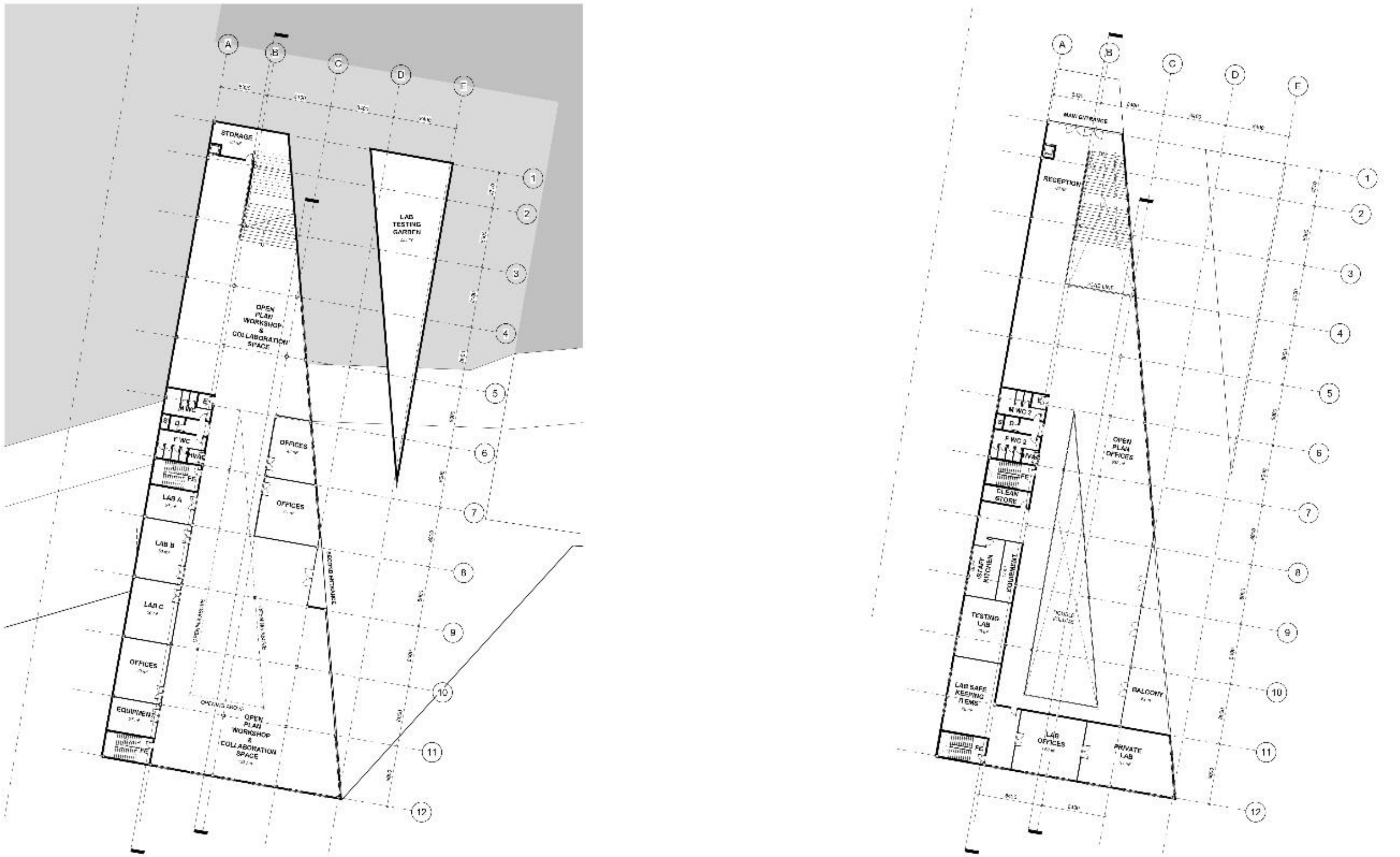


Figure 7.4.1: Revision 1 floor plans by Author at 1:1600.



1 GROUND FLOOR
1 : 200

2 FIRST FLOOR
1 : 200

Figure 7.4.2: Revision 1 floor plans by Author at 1:1600.

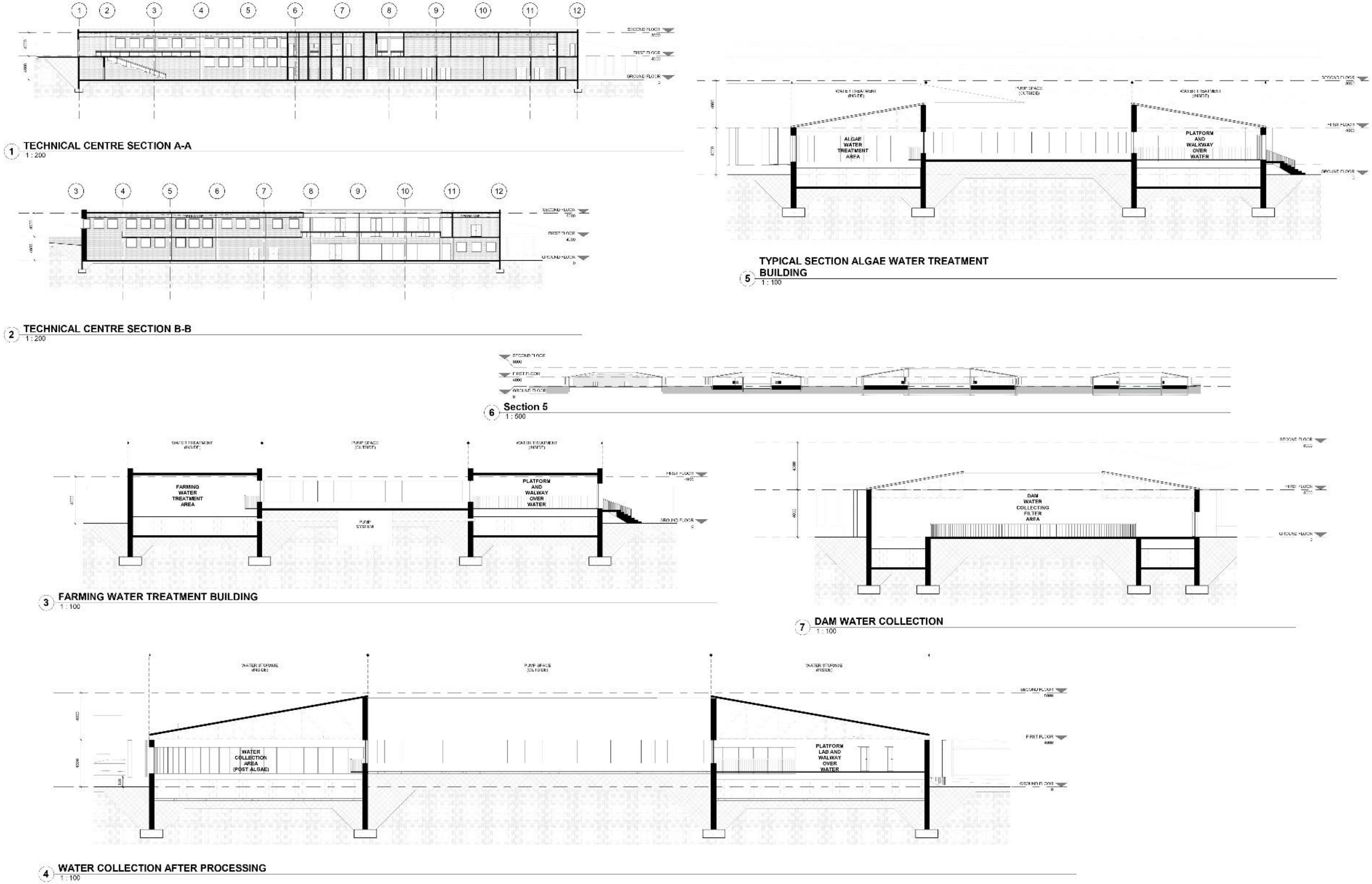


Figure 7.4.3: Revision 1 sections and elevations by Author at 1:1600.

REVISION 2

This revision is the chosen sketch design that works best on-site to allow the facility to perform its function. The facility sits on the edge of the Tshepisong township which gives the community direct access to the facility. A road leading towards the facility is made available to users of the farming portion as well as visitors to the building and delivery trucks.

The two tanks at each end of the building are where the algae process ends, and the water's purposeful journey begins. As the two end processes are used by the community, they need to be visible to the community and not tucked away.

The paths that lead down into the facility from the township are going to be filled with chatter and laughter as a then boring task is now made to be a social activity.

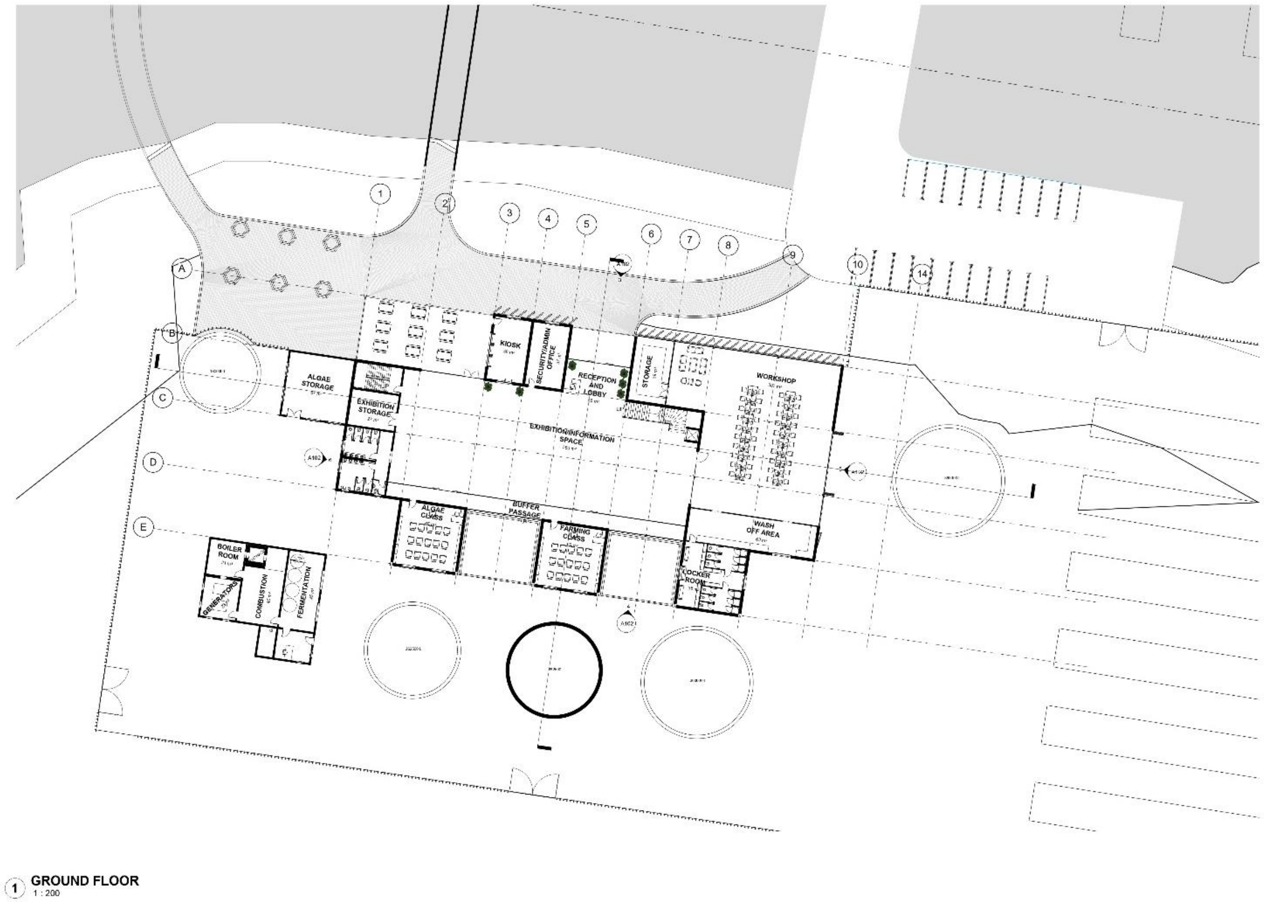


Figure 7.4.4: Revision 2 floor plans by Author at 1:1600.

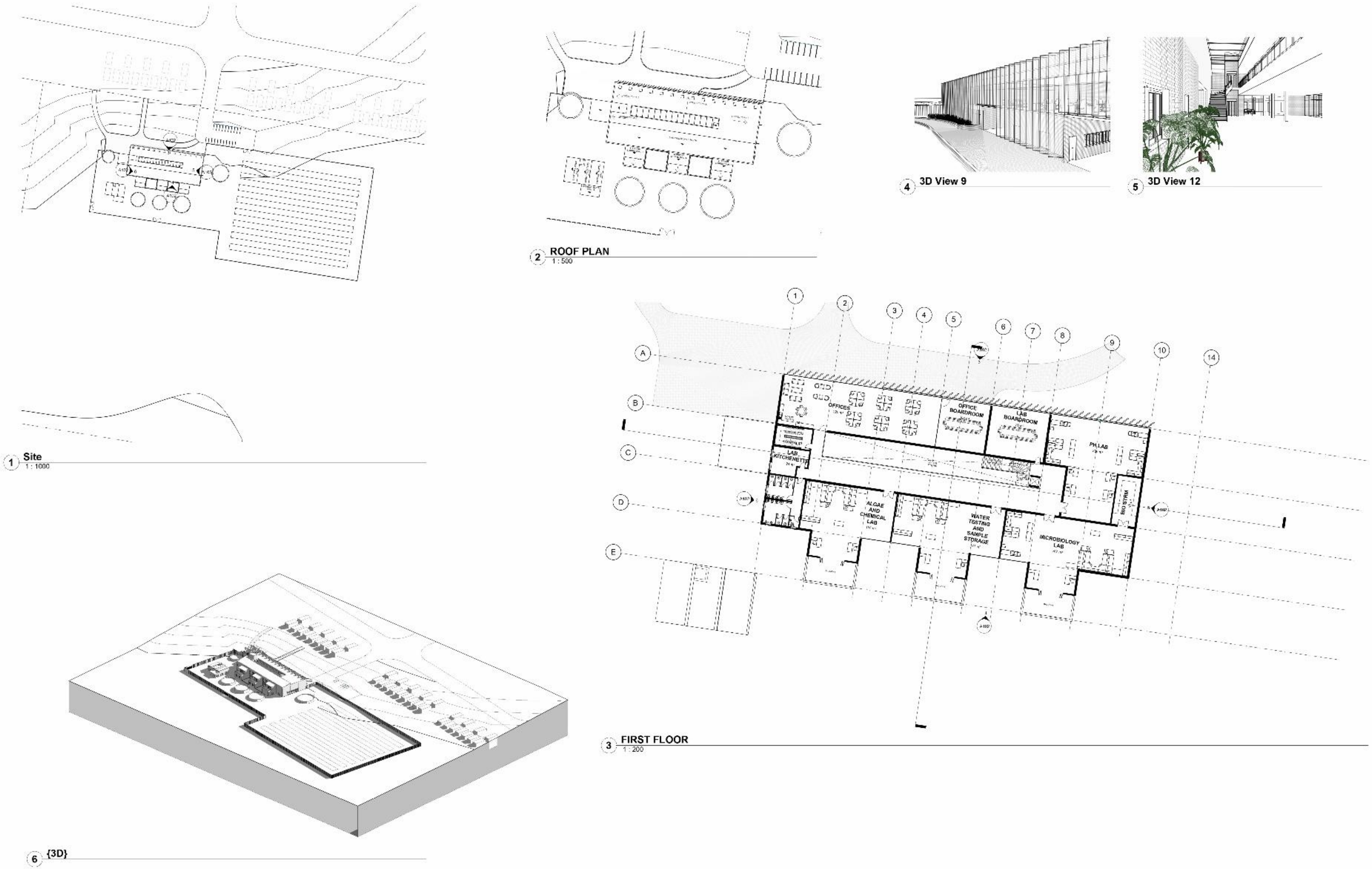


Figure 7.4.5: Revision 2 3D's and plans by Author at 1:1600.

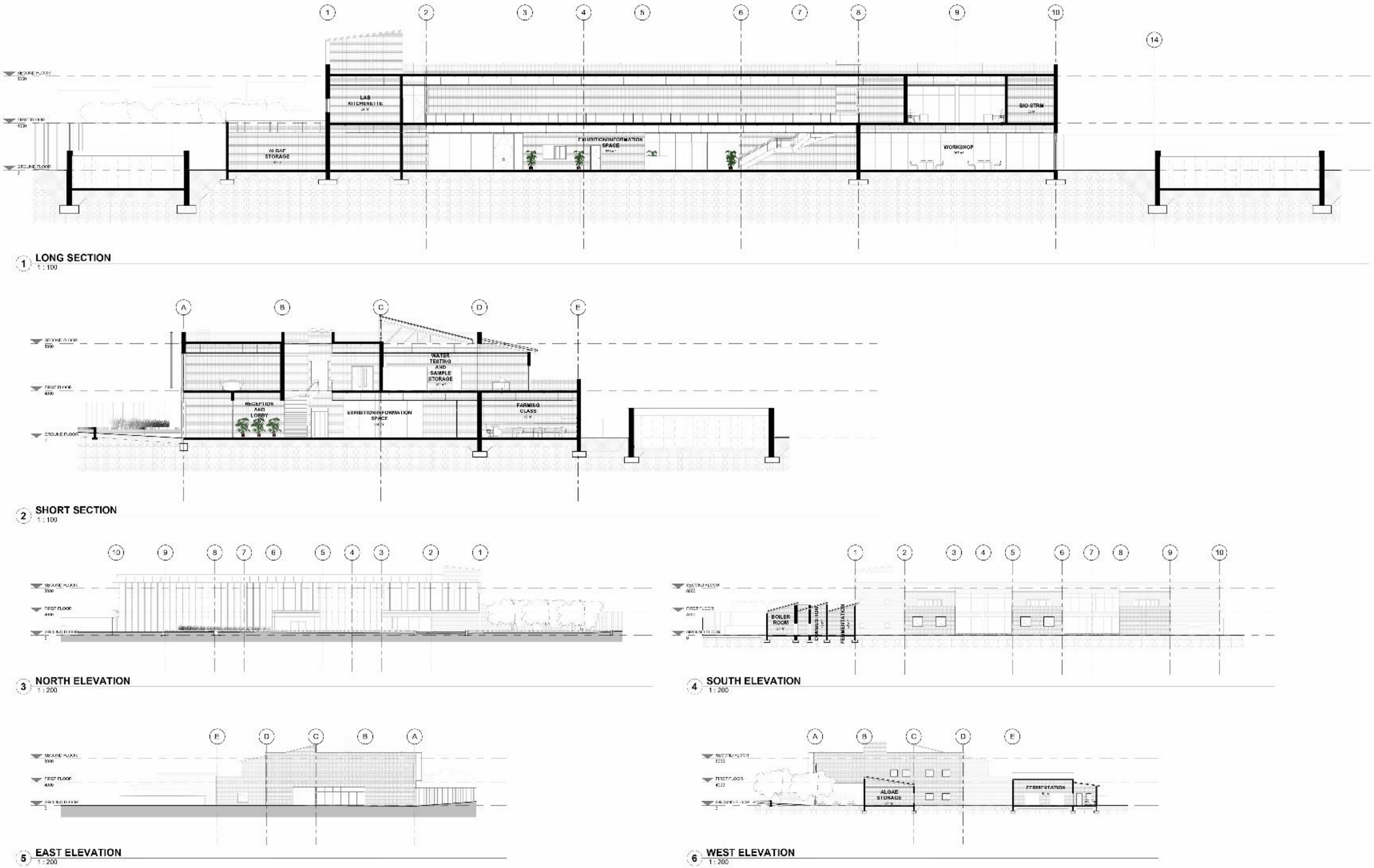
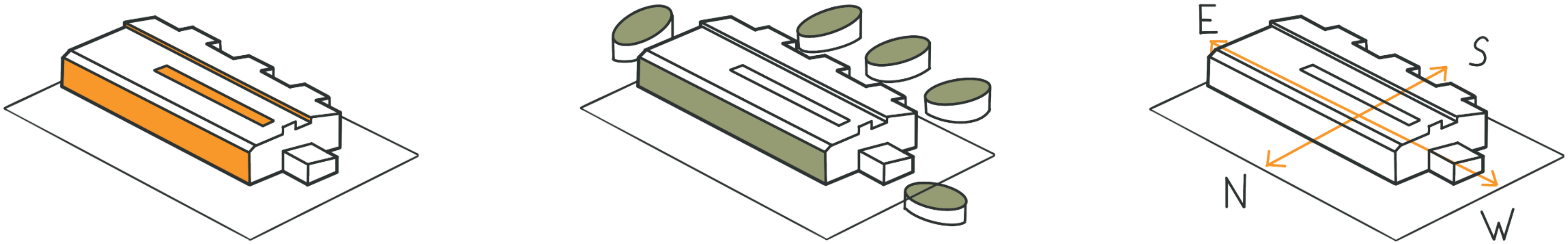


Figure 7.4.6: Revision 2 sections and elevations by Author at 1:1600.

7.5 DIAGRAMMING EXPLORATIONS

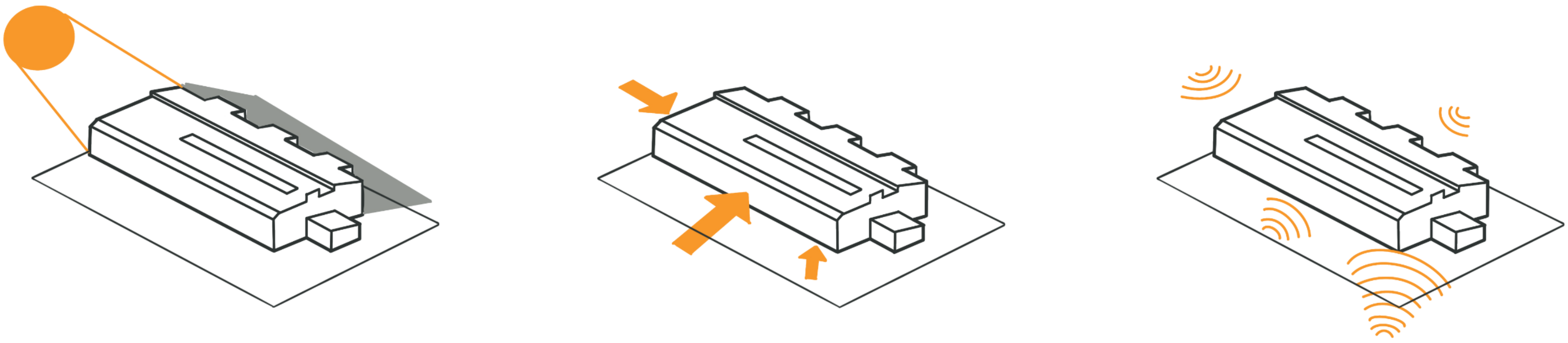


Light-penetrable surfaces

Algae in action

Orientation

Figure 7.5.1.: Diagramming set 1 by Author.

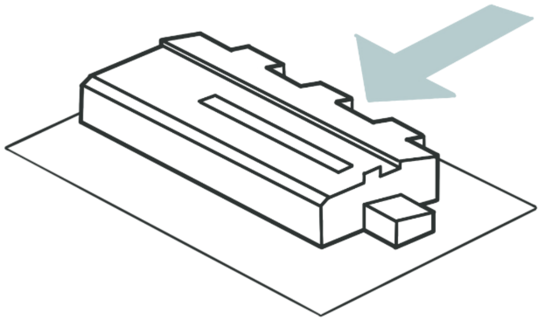


Sunny facade

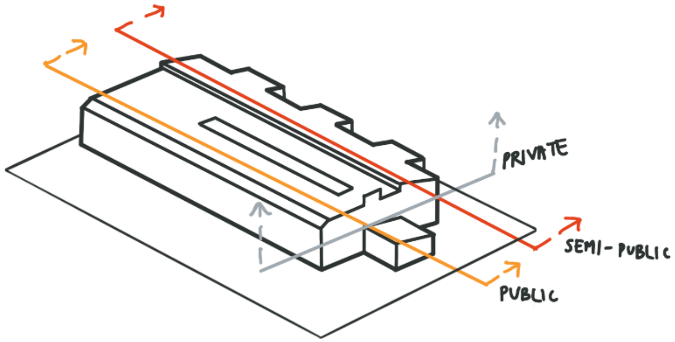
Building entrances

Sound hubs around the building

Figure 7.5.2.: Diagramming set 2 by Author.



Incoming water direction



Programming in terms of access

Figure 7.5.3.: Diagramming set 3 by Author.

CHAPTER 08

ACID[C]ITY

Figure 8.1: Large Scale Area Map by Author.

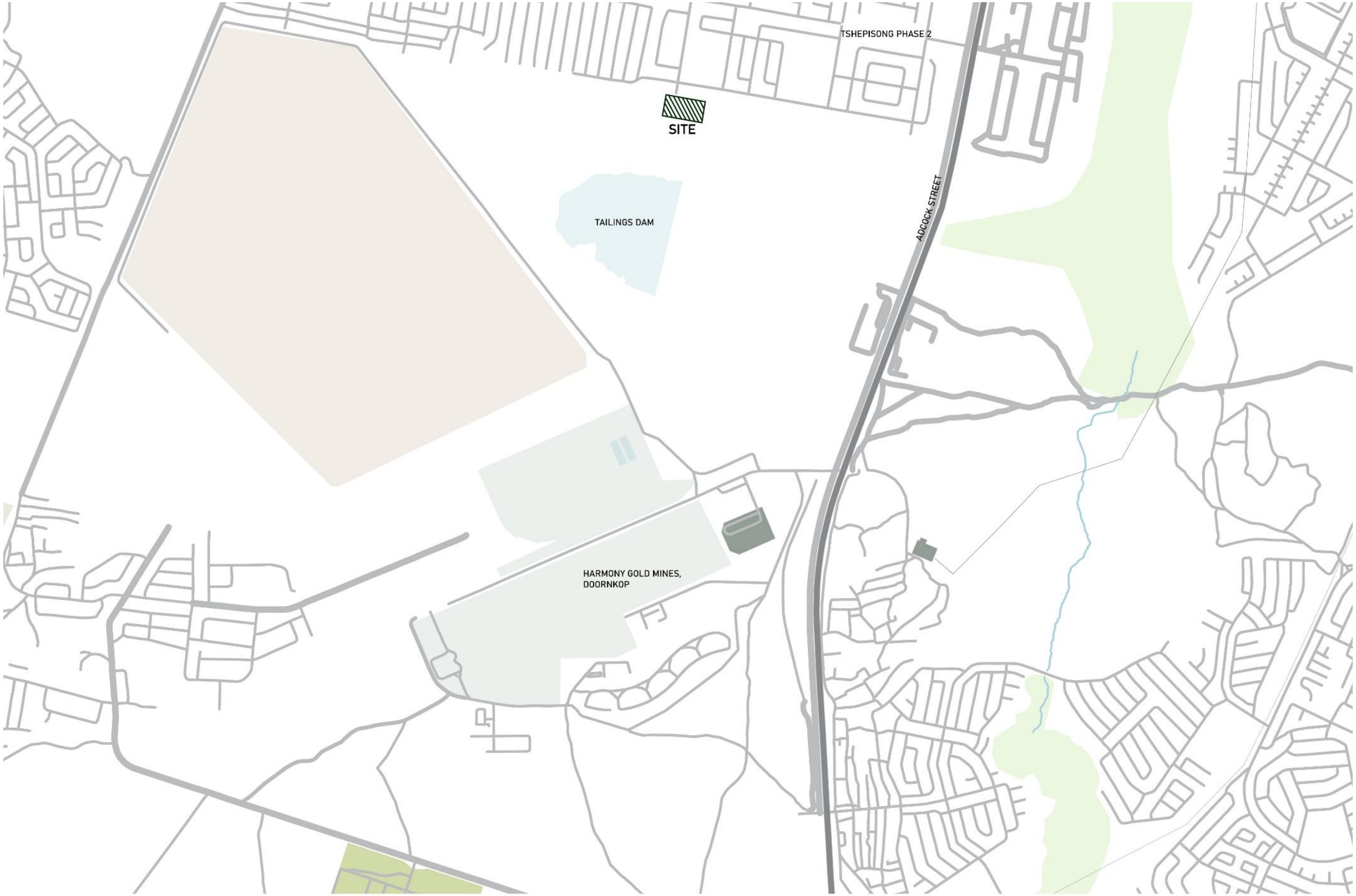


Figure 8.1.1: Macro Map by Author.

Figure 8.1.2: Site Plan by Author at 1:4000.

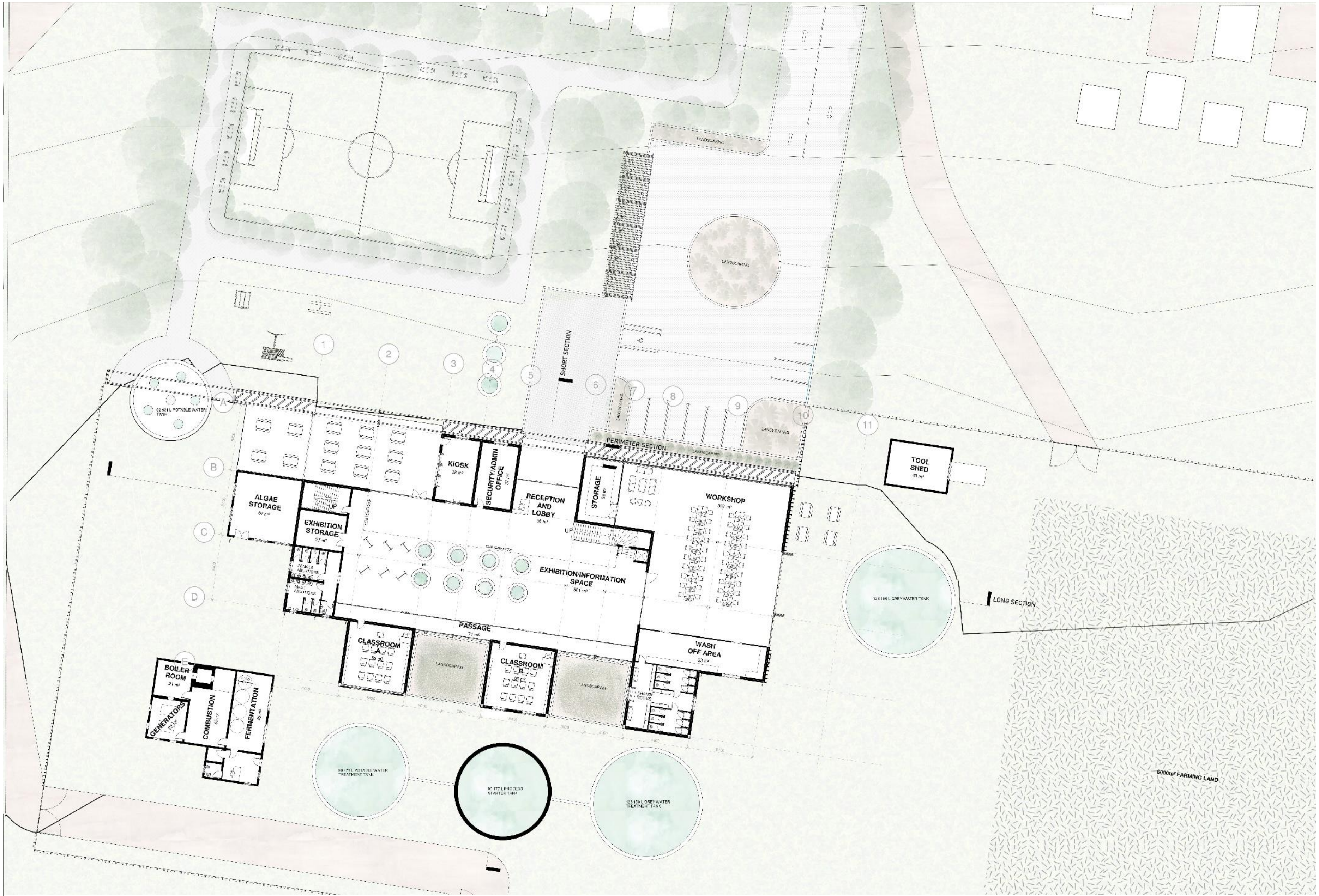


Figure 8.1.3: Ground Floor Plan by Author at 1:1600.

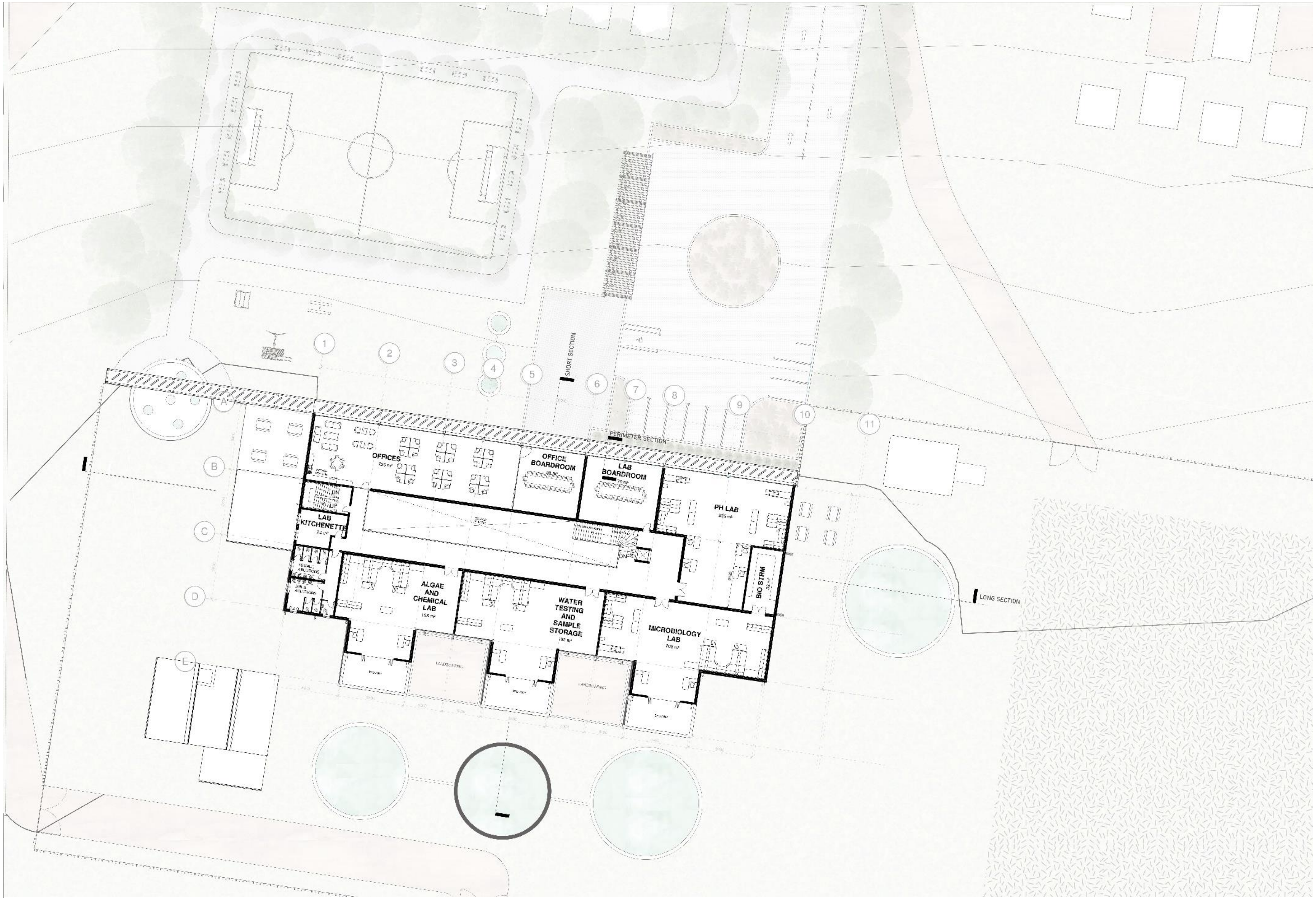


Figure 8.1.4: First Floor Plan by Author at 1:1600.

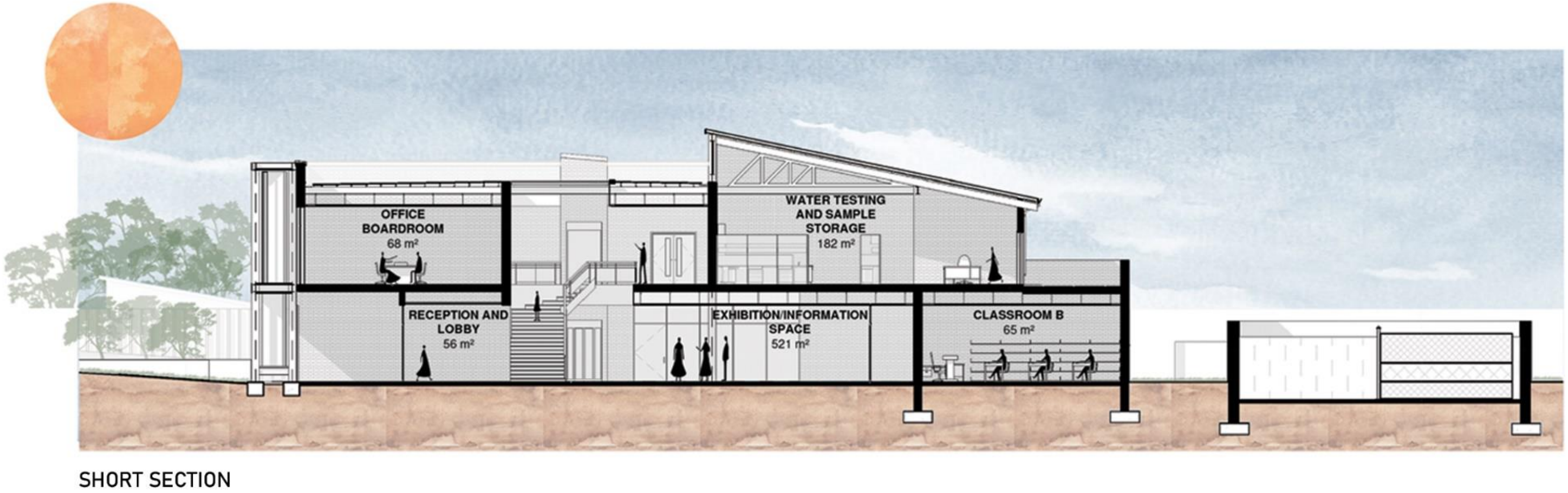


Figure 8.1.5: Short Section Through Building by Author at 1:1600.

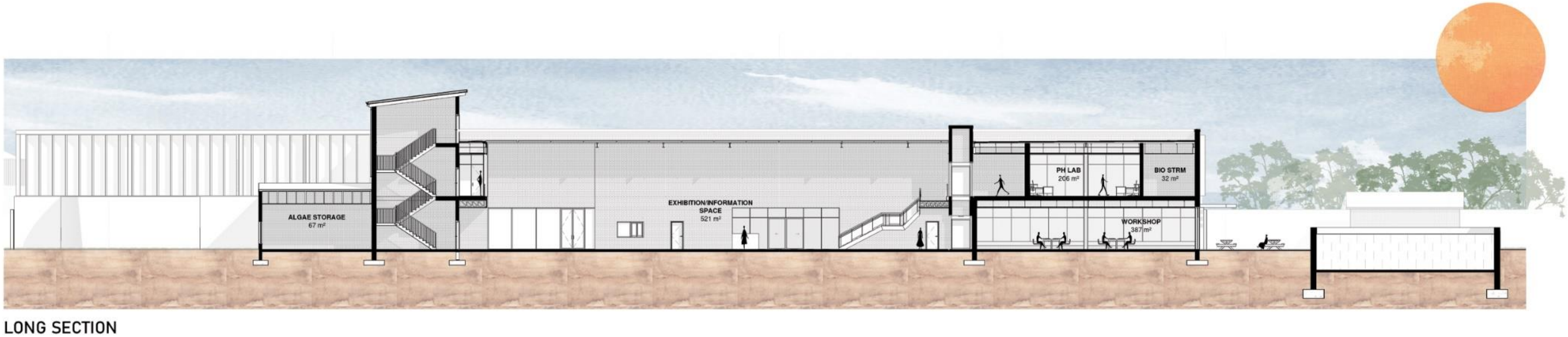
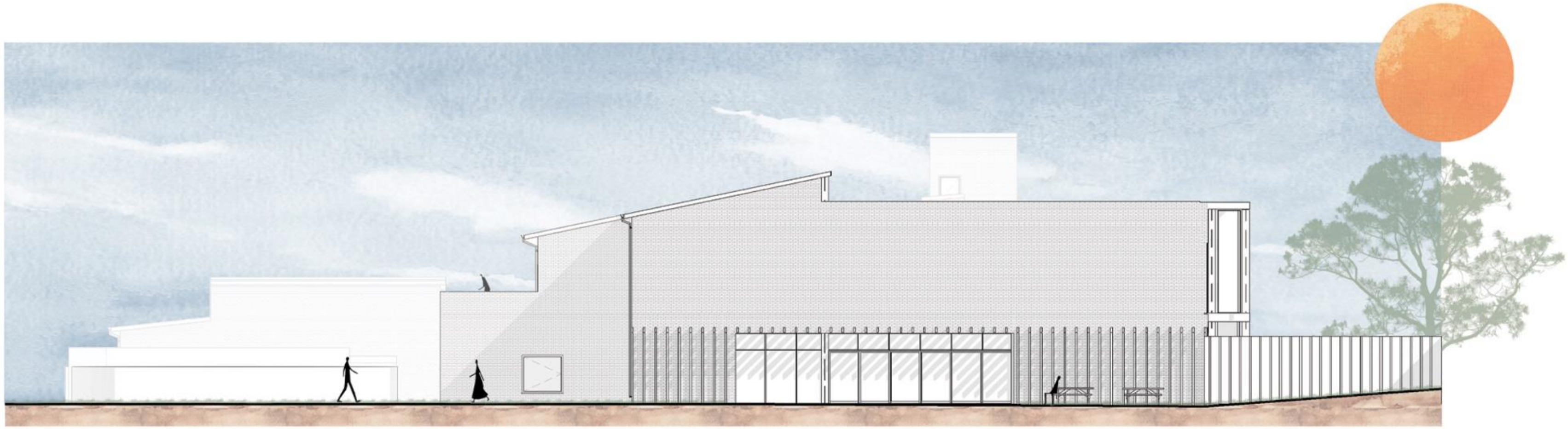


Figure 8.1.6: Long Section Through Building by Author at 1:1600.



EAST ELEVATION

Figure 8.1.7: East Elevation by Author at 1:1600.

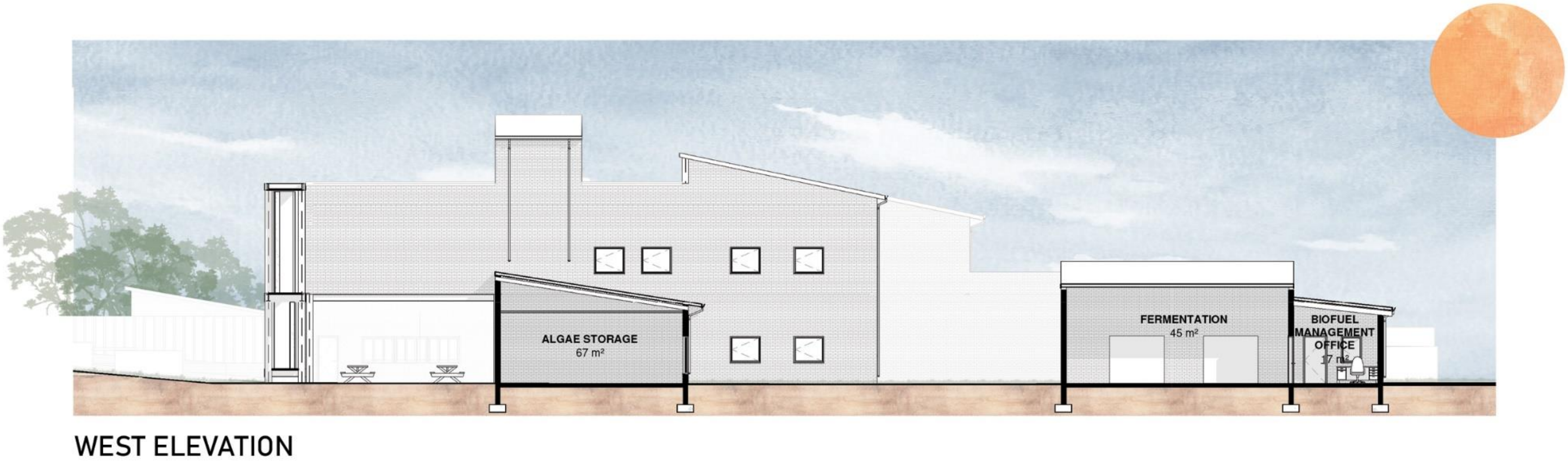


Figure 8.1.8: West Elevation by Author at 1:1600.

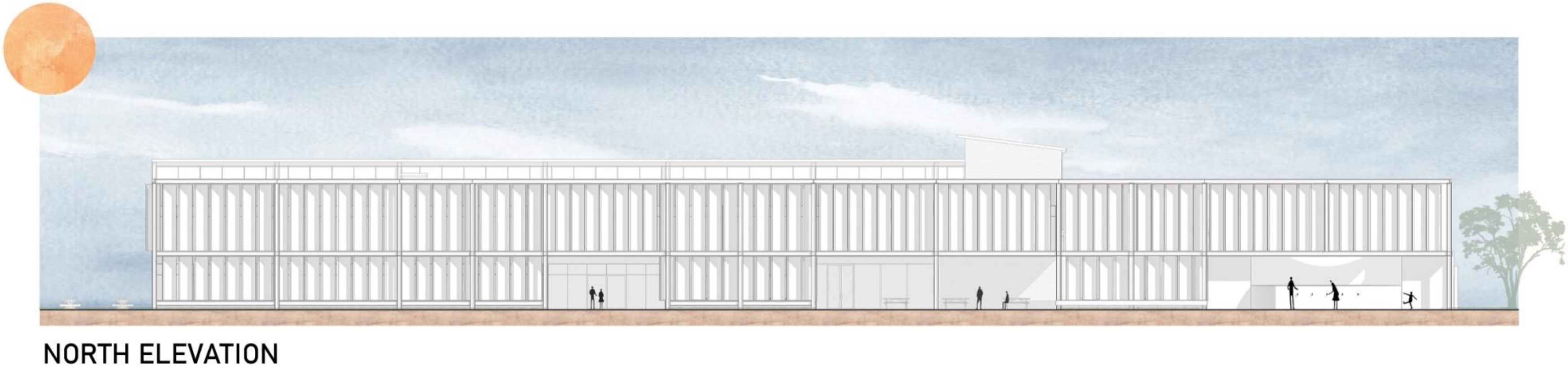


Figure 8.1.9: North Elevation by Author at 1:1600.

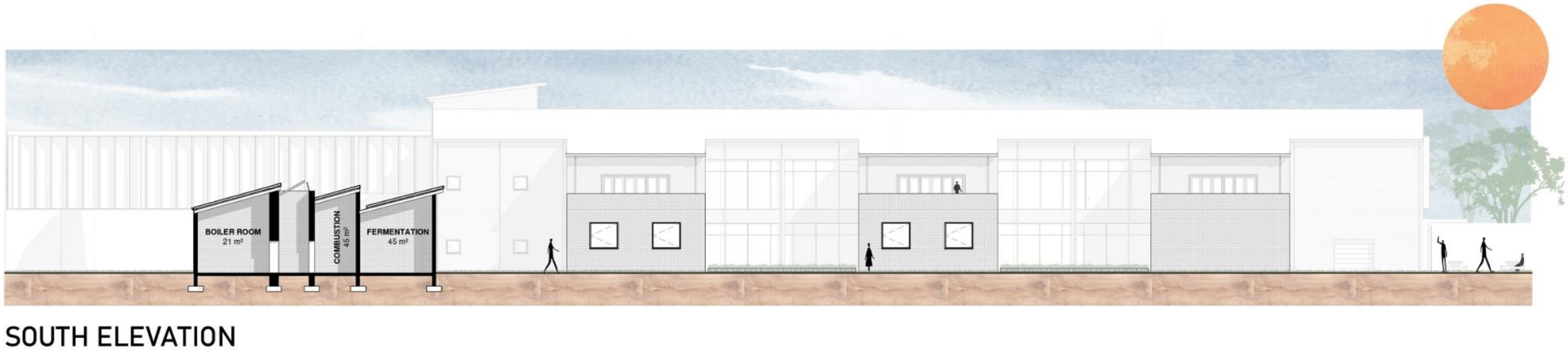
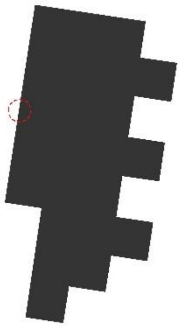
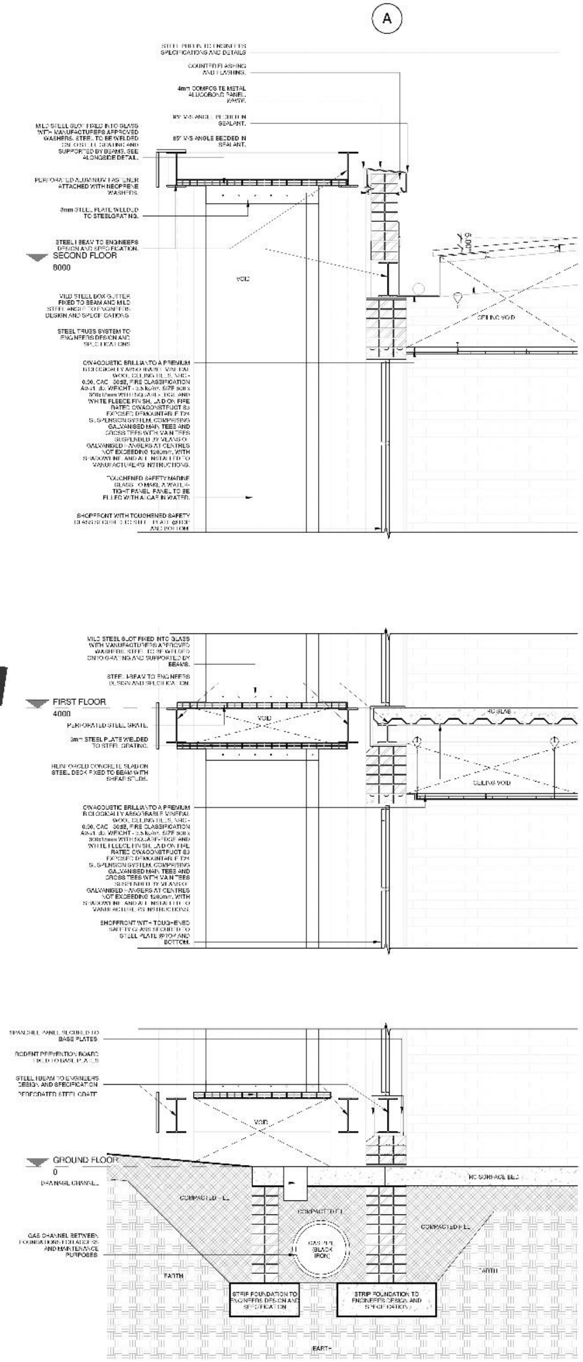


Figure 8.1.10: South Elevation by Author at 1:1600.



Section location

FACADE PANELS 1:20

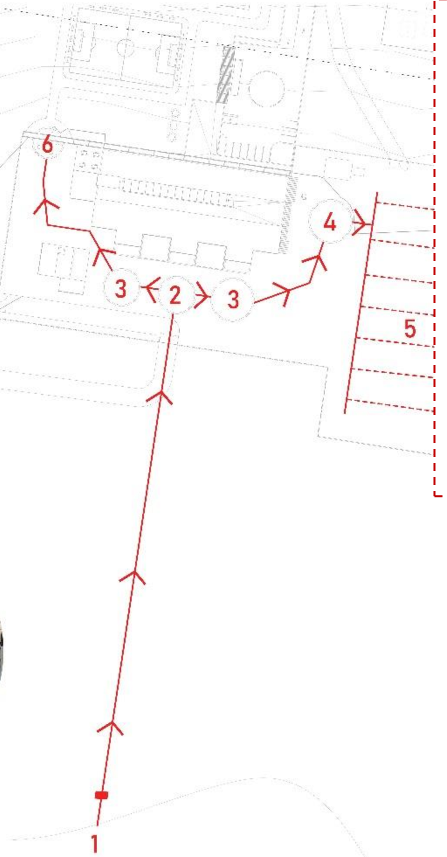


ROOF DETAIL

FIRST FLOOR SLAB DETAIL

GROUND FLOOR DETAIL

WATER PROCESSING 1:20



1: tailings dam

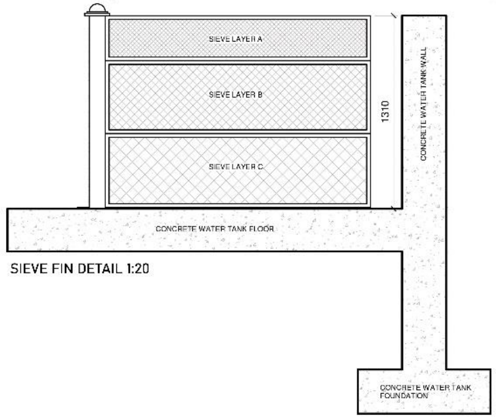
2: collection tank

3: left is the potable water treatment tank; right is the grey water treatment tank

4: grey water storage tank

5: farming irrigation system

6: potable water storage tank



SIEVE FIN DETAIL 1:20

Figure 8.1.11: Technical Details by Author at 1:160.

This structural investigation begins to interrogate the bones behind the facility. With a steel frame structure as bones, the building makes use of brickwork panels to fill the column and beam spaces. With the beams running in both directions, the structure becomes sturdier. The structure holding up the panels sits independently of the rest of the building structure due to the load it bears. This design choice was made methodically during the process to give the algae panels independence.

The lightweight structure makes construction time shorter and the whole frame lighter in weight. Both factors are suitable to argue that this construction works best for facilities of this type.

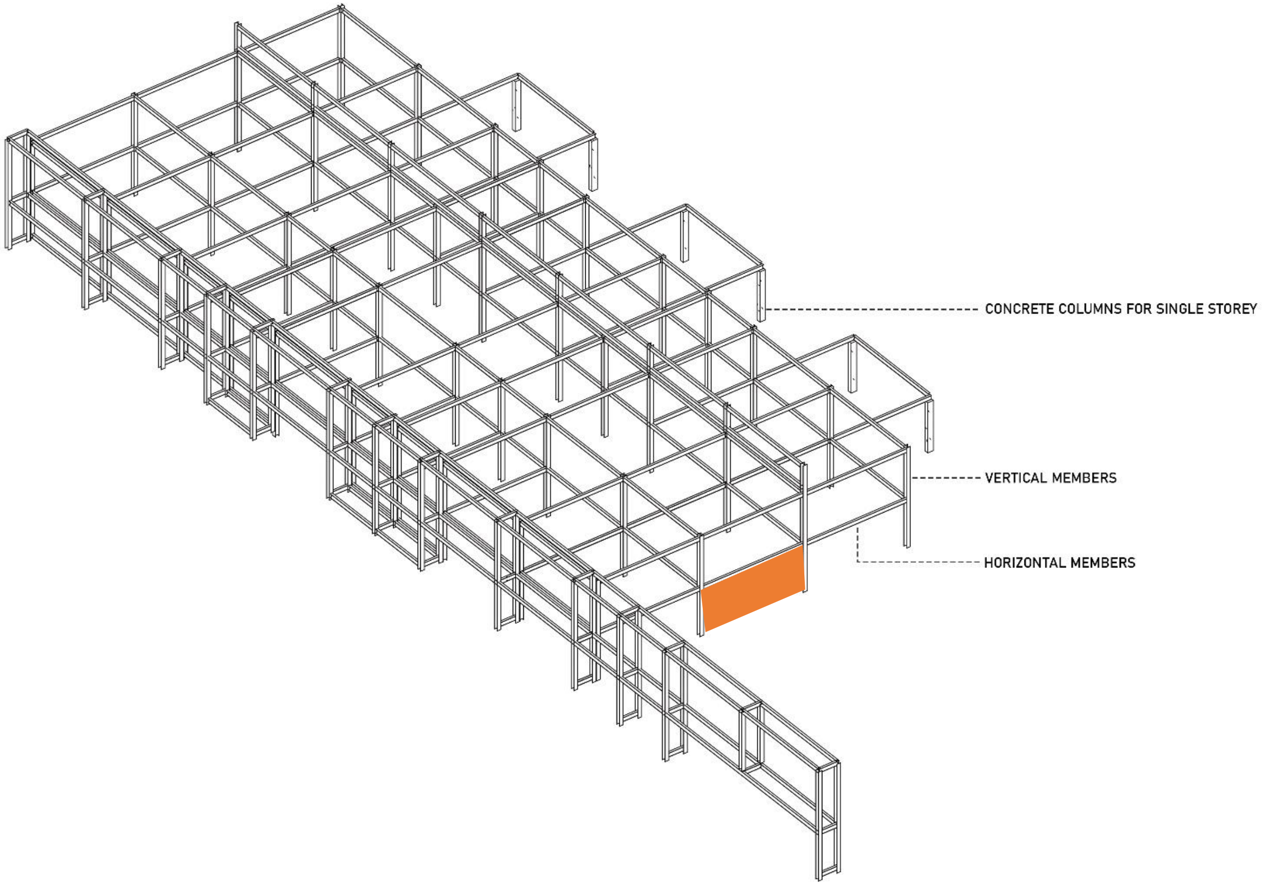


Figure 8.1.12: Structural Skeleton by Author.

Figure 8.1.13: Overall Panel View from Outside by Author.

Figure 8.1.14: Close-up Panel View From Outside by Author.

Figure 8.1.15: Parking Lot View by Author.

Figure 8.1.16: Social Space and Soccer Pitch View by Author.

Figure 8.1.17: Back of Facility and Tanks View by Author.

Figure 8.1.18: Atrium View by Author.

Figure 8.1.19: Canteen View from Atrium by Author.

Figure 8.1.20: Panel View 1 from Inside by Author.

Figure 8.1.21: Panel View 2 from Inside by Author.

Figure 8.1.22: Panel View 3 from Inside by Author.

CHAPTER 09

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03 October 2023

Dear Justine Le Pere (1601949)

This letter confirms that your clearance/waiver application has been approved. Your protocol/clearance number is: SOAP013/04/2023

Yours sincerely

lerato nkosi

Lerato Nkosi

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