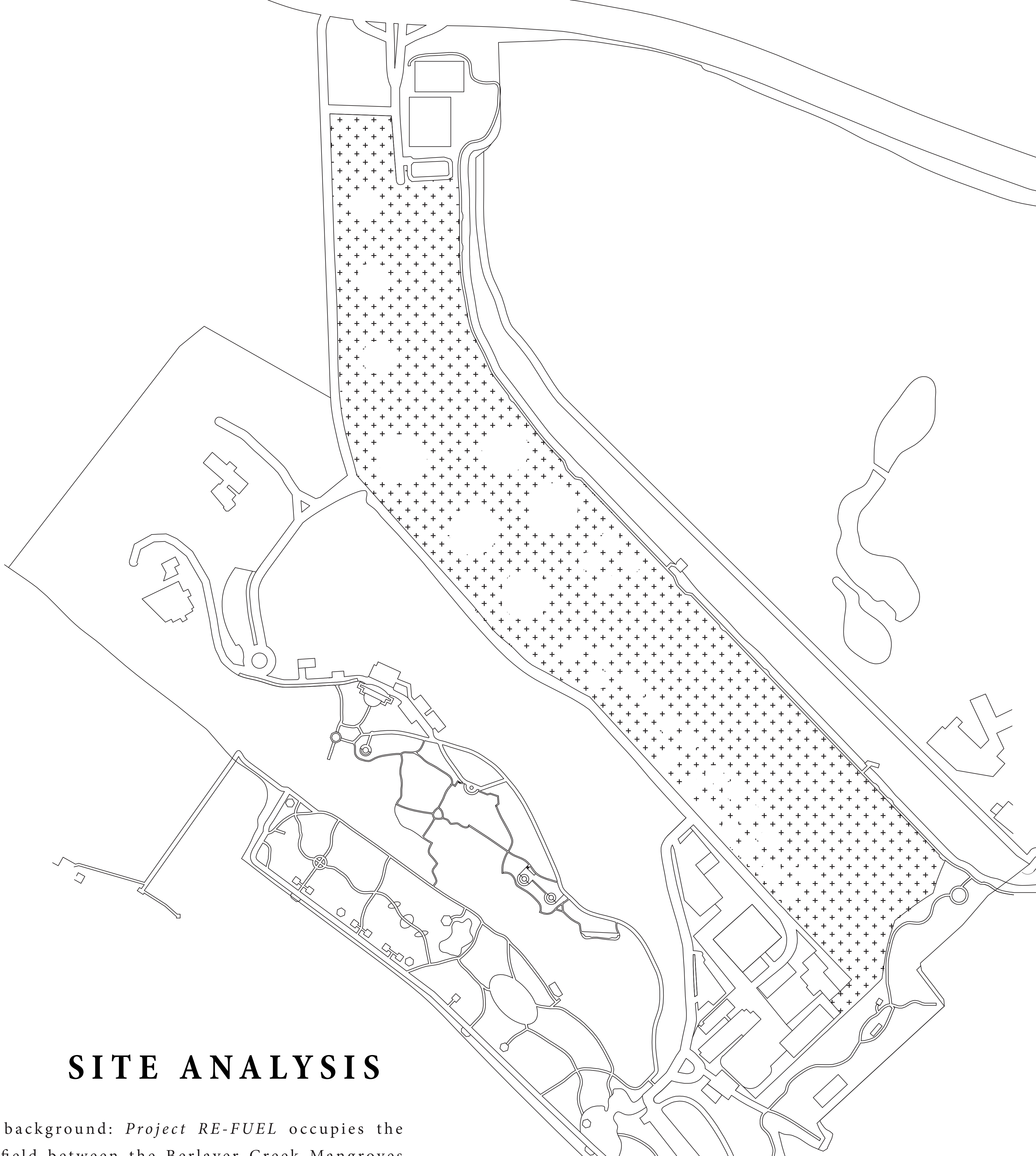
ASSIGNMENT 03

TROPICAL TECHTONICS



Site plan showing where oil barrels were placed.

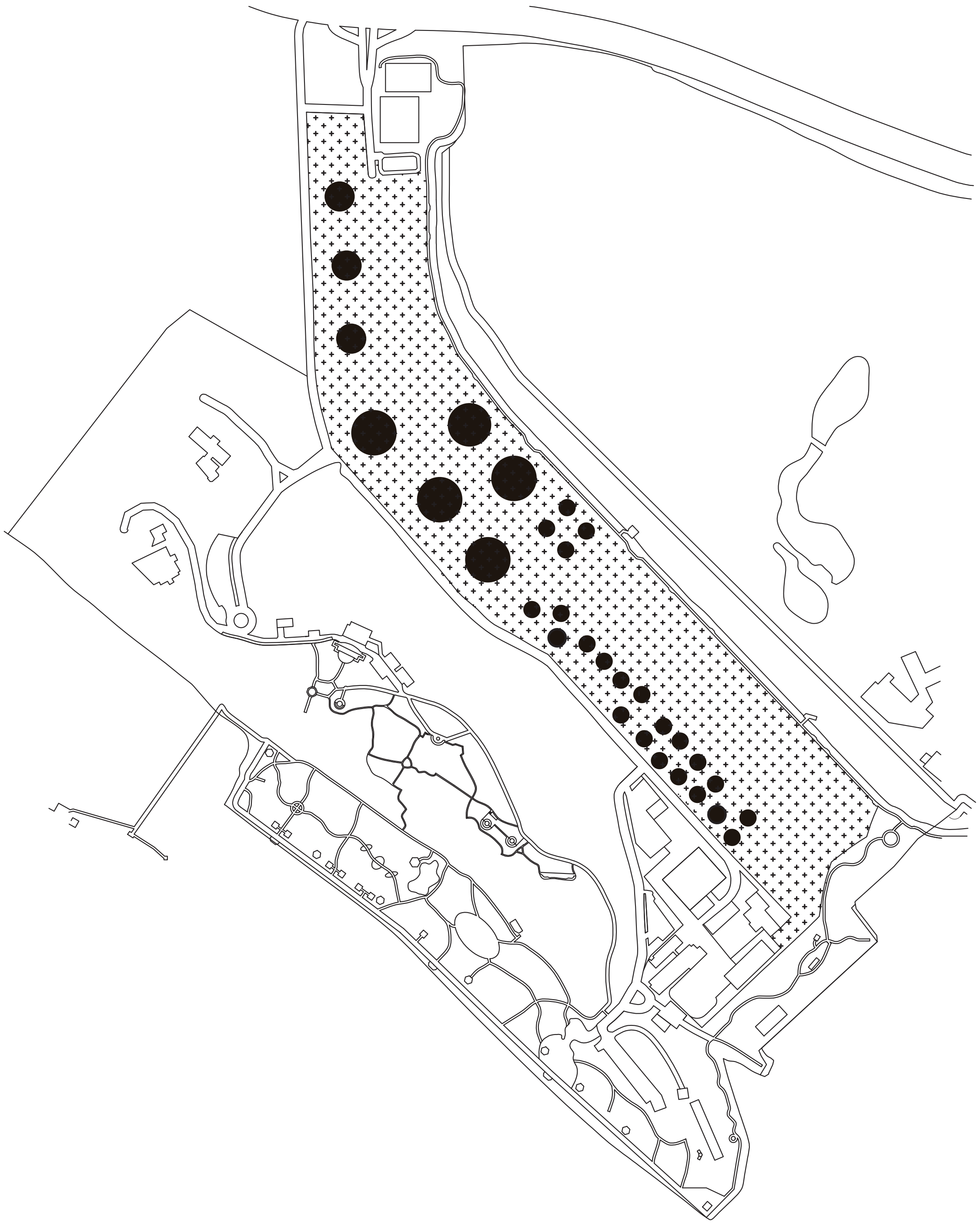
01 SITE ANALYSIS

Brief background: *Project RE-FUEL* occupies the open field between the Berlayer Creek Mangroves and Labrador Villa Road, approaching Labrador Nature Reserve. With a field size of 95300m2, the field is provisionally used for Radio-Controlled model aeroplanes and drones for the hobbyist club, Radio Modellers Singapore. The club was granted a two-year lease with SLA in 2017.

Prior to this, cylindrical oil tanks used to occupy the field. They belong to the Japanese Oil refinery company, Maruzen Toyo which supplied fuel to Pasir Panjang Power Station, located on the other side of Labrador Villa Road. By June of 1964, the refinery was sold to British Petroleum (BP). Following this, there was a redesignation of land use which marked the end of BP's land lease, BP subsequently ended operations in 1995. The land was used as an oil tank storage space before returning it to the state in 1998. It has been vacant ever since.

BRIEF HISTORY OF SITE

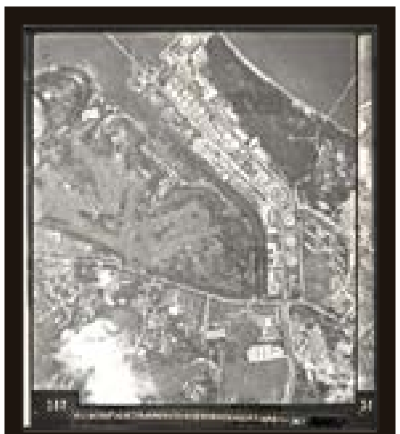
OLD OIL REFINERY
the field beside port road



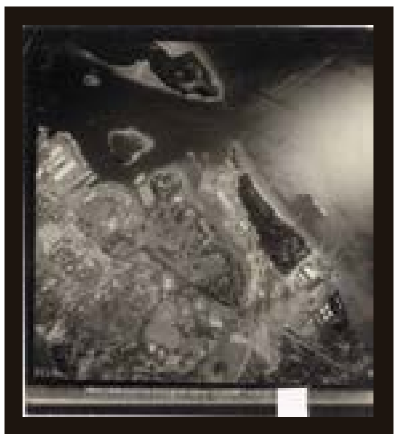
1950

1962

maruzen toyo refinery at its opening

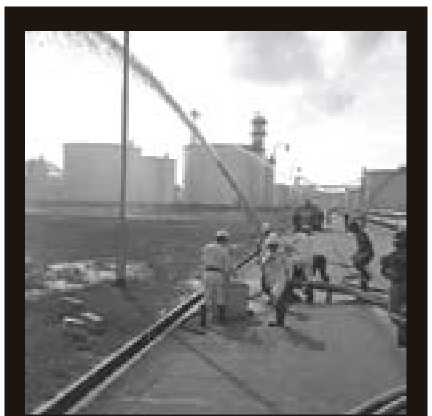


1963



1966

aaerial view of tanjong berlayer area showing BP refinery



1968

fire-fighting excercise at BP refinery

1962 — Opening of 28,000 bpd refinery at Tanjong Berlayer, operated by Maruzen Toyo, supplying fuel to nearby Pasir Panjang Power Station.

1963

1964 — Refinery was sold to British Petroleum (BP) in June 1964

1995 — Operations at the refinery stopped due to redesignation of the land use, preventing BP from extending its lease in the longer term

1998 — BP used site as storage facility before returning it to the state in 1998.

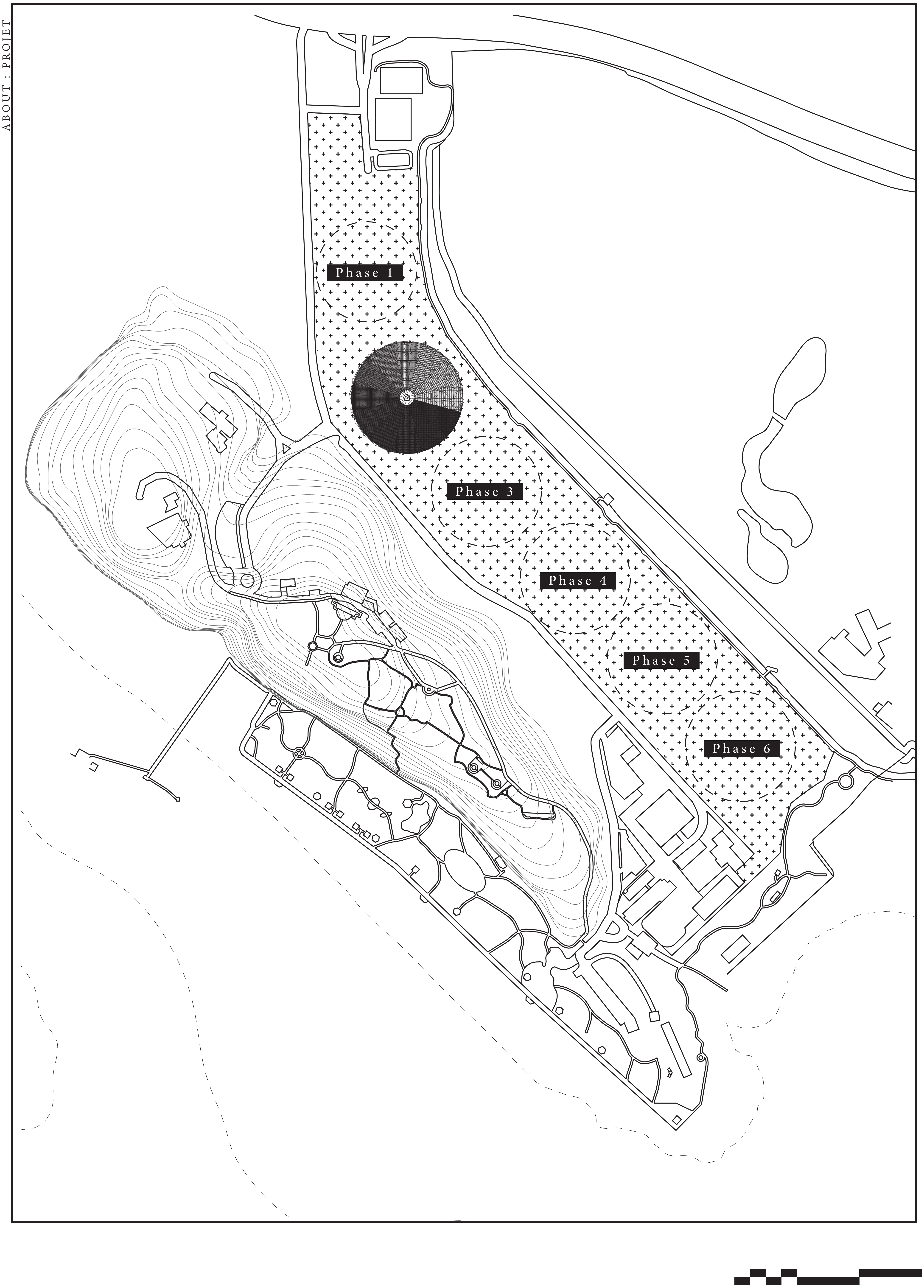
current — Master Plan 2019 land for residential use


PASIR PANJANG
LABRADOR PARK
TELOK BLANGAH
HARBOURFRONT
PASIR PANJANG TERMINAL
HARBOURFRONT CENTRE
EXISTING ROADS AND TRANSPORT NODES
CAT 1 EXPRESSWAY
CAT 3 MINOR ARTERIAL
CAT 4 PRIMARY ACCESS
CAT 5 LOCAL ACCESS
TRAFFIC
SCALE 1:5000
BUS STOP
MRT STATION
CARPARK
FERRY TERMINAL
LABRADOR PARK
SHIPPING ROUTES
5MIN WALKING RADIUS


LABRADOR PARK MRT STATION
TELOK BLANGAH MRT STATION
MOUNT FABER PARK
PASIR PANJANG TERMINAL
LABRADOR PARK
KEPPEL ISLAND
SENTOSA

MICRO SITE 1:3000


NORTH
SOUTH


Phase 1
Phase 3
Phase 4
Phase 5
Phase 6

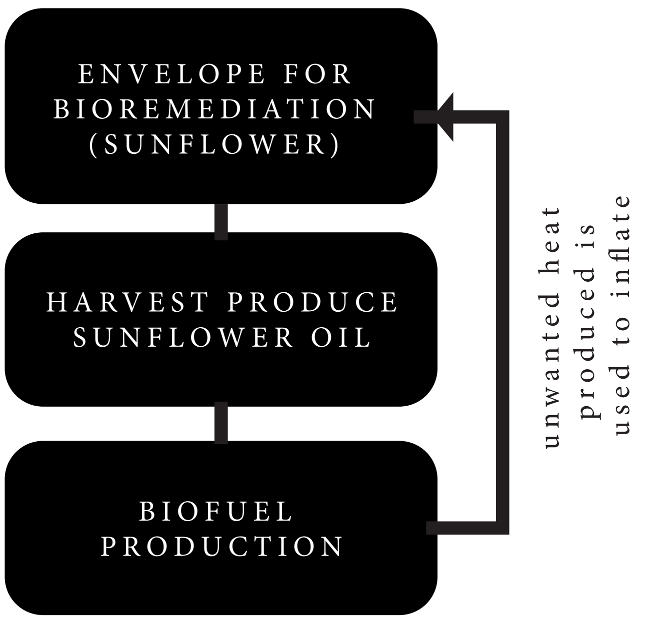
02 PROJECT

As Singapore's growing urban fabric is put to higher intensity use, brownfield lands become potential sites that can be made usable again. Such fields include landfills and old gas-work sites which includes this vacant field at Labrador Park.

Project RE-FUEL is a temporary, multi-phase bioremediation research laboratory that comes with a test-bed on site. While the program aims to research on accelerating the process of the decontamination of gasoline-contaminated-soil that contains harmful petroleum hydrocarbon particles within the soil, through plantation of sunflower plants. The resultant, non-consumable harvest of sunflower seed is then converted into biofuel through the chemical reaction of transersteriterification and esterification. In turn, the heat generated from this production of biofuel is used to inflate the pneumatic structure which serves as the primary envelope for the architecture.

Hence, while finding an alternative way of remediating land that poses fewer health and environmental hazards and educate the public, the second important objective in this project is to harness unwanted heat energy, such that the elements of the project becomes reciprocal, to minimise the loss of potentially useful energy.

With these fundamental design objectives, the architecture seeks to include the following spaces: The main plantation grounds to have optimal sunlight for various stages of growth, a sheltered, a well-lit space for the research laboratories (Bioremediation lab and Biofuel lab), an outdoor space with maximum sunlight to speed up the process of drying of Sunflowers to obtain sunflower seeds, an outdoor space with good airflow and sunlight for the biofuel workshop space, and a space with optimal daylighting for the 30 pax classroom space that also house a flower market.



Briefly on : Bioremediation (Sunflower)

Some main methods of remediating contaminated soil includes Phytoremediation, Mycoremediation, Microbial remediation, Thermal Methods and Soil Washing. (Angela Hartsock)

Phytoremediation through Sunflower plants (Helianthus annuus) was chosen to be the main crop of the project due to its potential in reaping greater benefits to the overall scheme.

Phytoremediation is the method of using plants to 'bind, extract and clean up pollutants such as pesticides, petroleum hydrocarbons, metals and chlorinated solvents' (Aftermath) Despite various research done worldwide, Singapore has yet to adopt such methods of bioremediation. Rather, the more common method used locally is the decontaminating of soil through thermal methods and soil washing.

Such remediation works had been carried out on the site of Kallang Gasworks site on 19 April 2018, in preparation for the upcoming residential precinct in Kallang. (Au-yong, 2018) This method requires the soil to be treated ex-situ by digging up the soil and putting in a reagent to allow for the oil particles to be removed. In addition, it requires the site to be covered to prevent vapours from escaping and to prevent rainwater from flushing the contaminated soil to the river.

On the other hand, the rationale for the choice of sunflower is in its inherent capability in adapting in the tropics, among other crops. It has been observed to grow wildly in contaminated lands.

A research by Ali Daryabeigi Zand and Hassan Hoveidi from the Graduate Faculty of Environment, University of Tehran, Teran, Iran found the sunflower to be tolerant to hydrocarbon contamination of soil, with minimal influence on the sunflower in the presence of 500, 1000 and 2500 mg/kg gasoline ($P>0.05$). In the presence of 5000mg/kg gasoline in the soil, a there was an obvious reduction in seedling germination compared to the control clean soil.(fig. 3) (Zand & Ali 2016) In addition, Sunflowers are fast growing species which is suitable for the intentions of bioremediation.

Next, another important factor to consider for the architecture to keep off pollinators such as bees and butterflies from entering the plantation area. The reason is due to the harmful toxins that the sunflowers contain after being planted within the contaminated soil. The negligence of this would cause these pollinators to die. Therefore, this gives extra grounds for the use of commercial agricultural netting.

Briefly on : Biofuel production

At the same time, this process of bioremediation through plantation of crops - Phytoremediation creates an abundance of non-consumable harvest due to the toxic soil. Therefore, the creation of biofuel can harness these unwanted crops.

PETROLEUM HYDROCARBON

*raw petroleum composition. Petroleum composition varies widely depending where and how the petroleum was formed

01 Environmental Impacts

Changes composition and structure of soil organic matter and impact the C/N, C/P, salinity, pH, EH and conductivity of soil

Impedes the normal growth of crops such as reduce the germination rate and fertility and decline the resistance to pests and diseases.

Oil pollutants impact the pedosphere, atmosphere and watersphere. The low boiling point and lightweight hydrocarbons can enter into the atmosphere by evaporation easily; then through runoff and infiltration into the surface water and osmosis into the groundwater system; and finally through the food chain enter into the human's bodies.

Changes microbial population, the composition of the community structure and the enzyme system in the soil

02 Health Impacts

Benzene

Has been shown to cause cancer (leukemia)

High exposure could lead to death

Xylene

Affects human central nervous system

High exposure could lead to death

Toluene

Breathing tolune at concentrations greater than 100ppm for more than several hours can cause fatique, headache. nausea and drowsiness.

Long period of exposure can cause peripheral neuropathy, a permanent damage to the nervous system.

High exposure could lead to death

Others

Compounds in some TPH fractions can also affect the blood, immune system, liver, spleen, kidneys, developing fetus, and lungs.

Certain TPH compounds can be irritating to the skin and eyes.

03 Methods of decontamination

PHYTOREMEDIATION

Using plants to bind, extract and clean up pollutants including petroleum hydrocarbons.

Phytovolatilisation
Plants take up volatile compounds through their roots and transpire the same compounds through the leaves.

Phytodegradation
Contaminants are taken up into the plant tissues where they are metabolized, or biotransformed. Transformation can occur in roots, stems, or leaves depending on the plant

Phytoseqestration
Absorption by roots, production of biochemicals by the plant that are released into the soil or groundwater in the immediate vicinity of the roots and can sequester, precipitate or immobilise nearby contaminants.

Phytoextraction
Plants hyperaccumulate contaminants through their roots and store them in the tissues of the stems or leaves. Substance can be recovered for reuse by incinerating the plants in phytomining in some cases.

Phytohydraulics
Use of deep-rooted trees to contain, sequester, or degrade groundwater contaminants that come into contact with their roots.

Rhizodegradation
Takes place in the soil or groundwater surrounding the plant roots. Exudates from plants stimulate rhizosphere bacteria to enhance biodegradation of soil contaminants.

MYCROREMEDIATION

Uses fungi's digestive enzymes to breakdown contaminants such as pesticides, hydrocarbons and heavy metals.

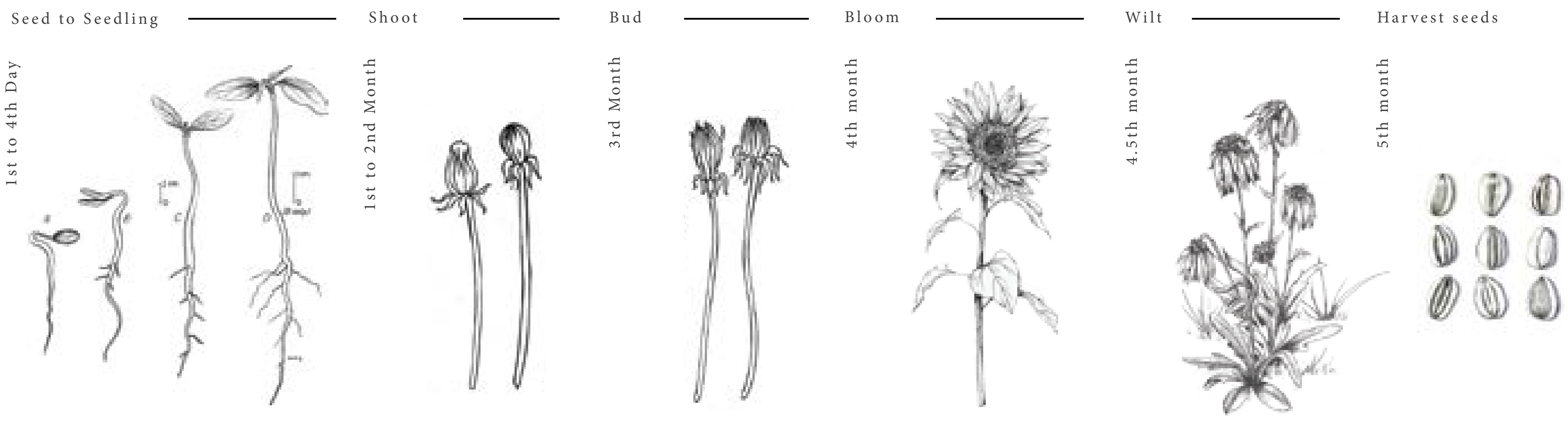
MICROBIAL BIOREMEDIATION

Bioremediation emerged as a response to this threat. In bioremediation, bacterium that feed on hydrocarbons and transform them into carbon dioxide may be applied to an affected area.

THERMAL METHODS AND SOIL WASHING

Requires all soil to be dug up and put in a reagent to remove oil elements. Undergoing in Kallang Gasworks site

SUNFLOWERS



Life cycle of a Sunflower

03

Sowing:
Seed 2.5cm into the soil and tamp soil around the seed. Tamping helps to firm up the soil around the growing seedling.

Water:
First inch of soil to be moist.

Sun condition:
Semi-shade condition with good airflow, avoid direct sunlight at this stage.

04

Sunflower roots spread widely and can withstand some drought.

Water:
Water them regularly 20 days before and after flowering. Deep, regular watering helps encourage root growth, which is especially helpful with taller sunflower varieties bearing top-heavy blooms

Sun condition:
Direct sunlight with at least 6-8hours of sunlight per day.

05

To harvest the seeds ahead cut off the seed heads with a foot or so of stem attached and hang them in a warm, dry place that is well-ventilated.

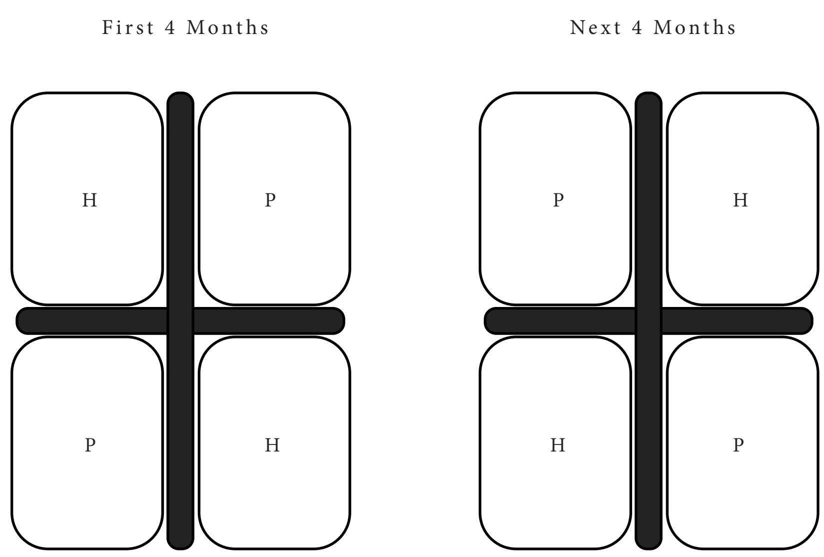
Keep the harvested seed heads out of humidity to prevent spoilage from molds and let them cure for several weeks.

When the seeds are thoroughly dried, dislodge them. Allow the seeds to dry for a few more days then store in airtight glass jars in the refrigerator to retain flavor.

06 properties

Botanical name:	*Helianthus annuus*
Category:	Hardy Annual plants. They are germinated, come into flower, set seed and die during one season or year. Hardy annual seeds are sown in the site where they will flower
Climate:	Cultivated in tropical and temperate climates
Height:	up to 300cm
Width:	20cm, place seeds 60cm apart
For Bioremediation:	Sunflower has been observed to grow wildly in contaminated lands around the Oil Refinery of Tehran. The ability to tolerate harsh conditions under environmental stress is an important required characteristic for a plant to be selected for remediation purposes has a deep root system.

07 PARTI DIAGRAM



■ permanent
□ movable / temporary

P Plant | Transparent shelter to prevent
H Harvest | Shaded shelter for

03 CLIMATIC STUDY

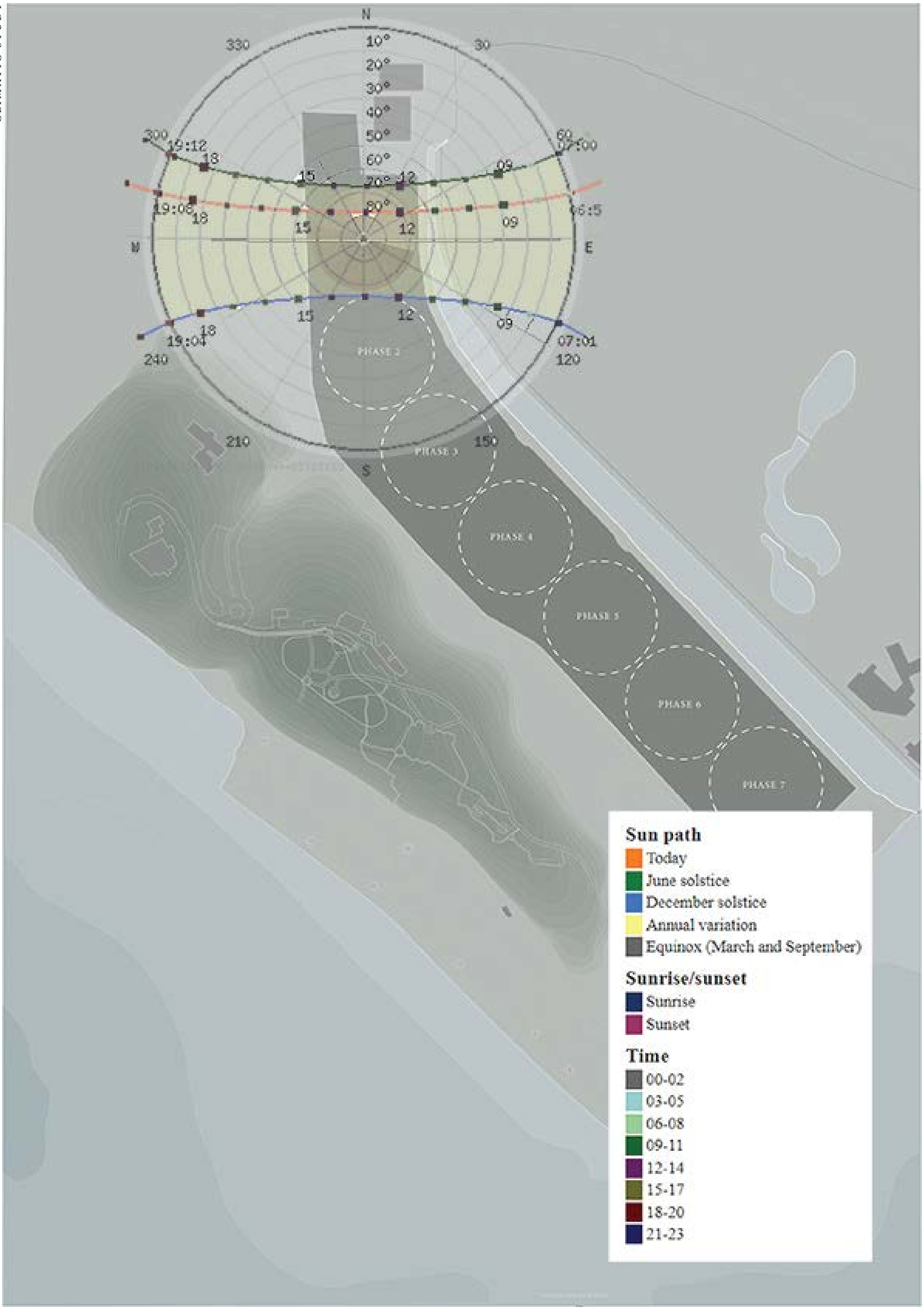
The Singapore climate has two main monsoon seasons, namely the Northeast Monsoon Season which occurs between December to March, the Southwest Monsoon Season from June to September. There is also the Inter-Monsoon Period which occurs twice between late March to May and October to November, (MSS 2010)

SUN

As Singapore is located along the equator it has a typical tropical climate, the length of its day and sunlight hours are relatively constant throughout the year.

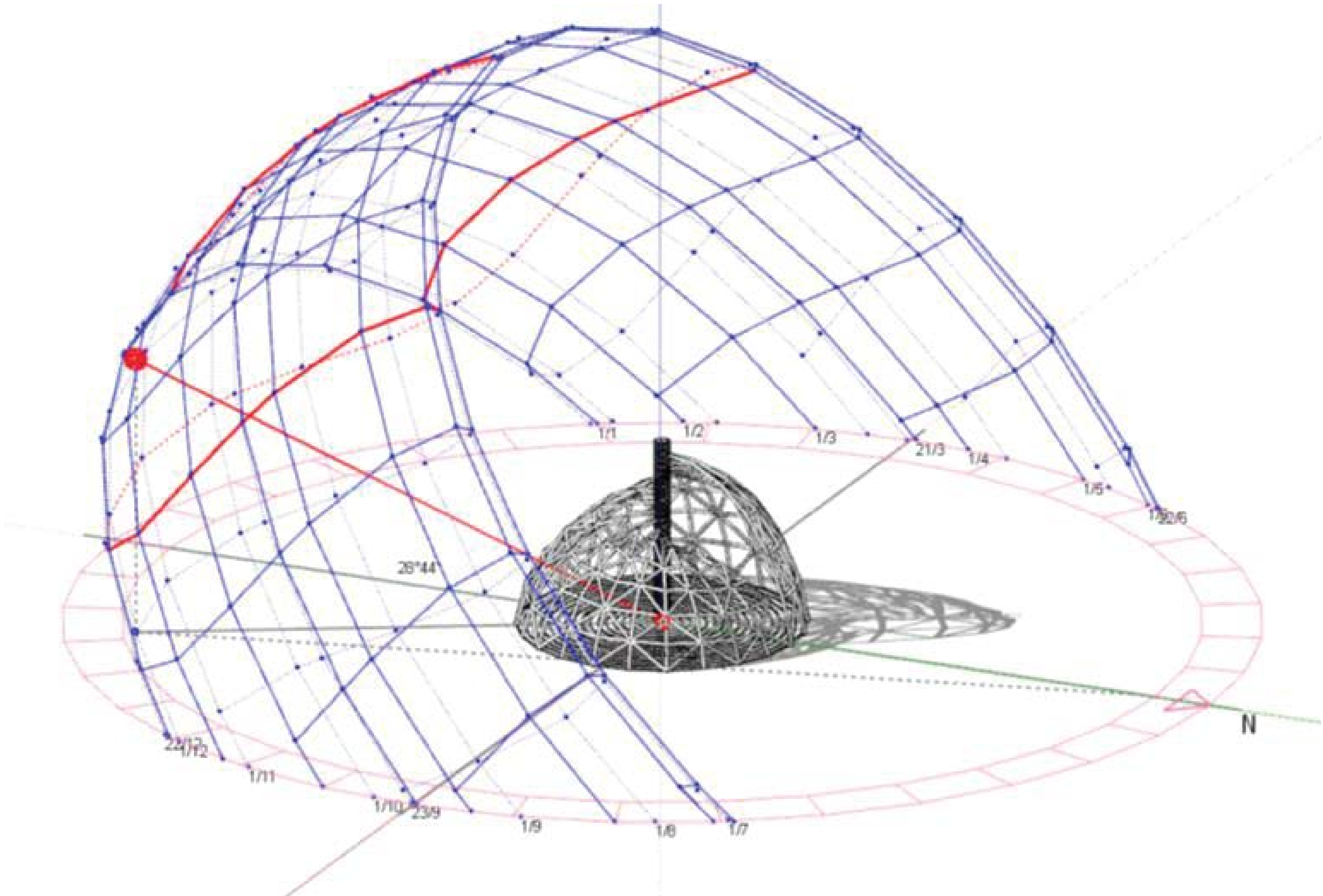
WIND

The prevailing wind direction comes from the **northeast and south**, reflecting the monsoon seasons in Singapore.Winds generally follow the prevailing monsoon winds except when affected by terrains, showers, thunderstorms, and land or sea breezes. (MSS 2010)

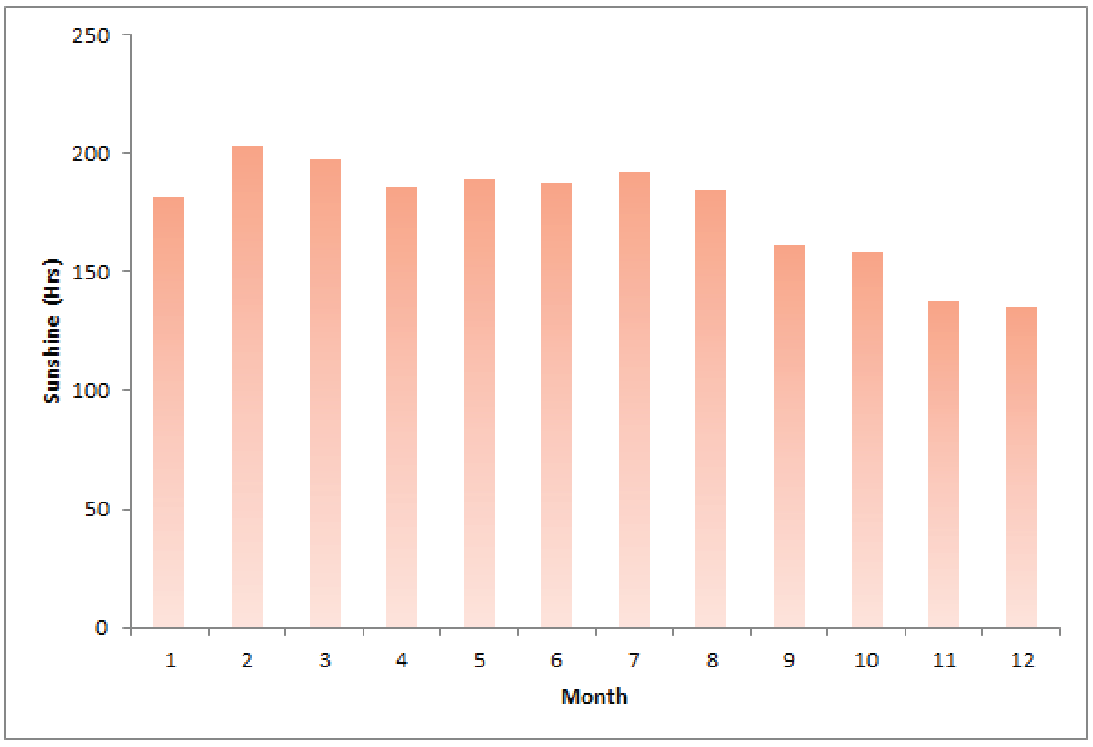


Sunpath diagram (Gaisma)

Windrose for Singapore(Windfinder)



site is located within the field, thus maximum sunlight is received. Therefore, the consideration for sun shading is needed to reduce solar heat gain, to reach the optimal conditions for both the plantation grounds and the human space.



Since Singapore is located along the equator and has a typical tropical climate, the length of its day is relatively constant throughout the year, thus the amount of sunshine is constant as well. The amount of sunshine hours average from four to five hours during the wettest months (November and December), to eight to nine hours during the drier months (February and March).

Southwest Monsoon

June - September

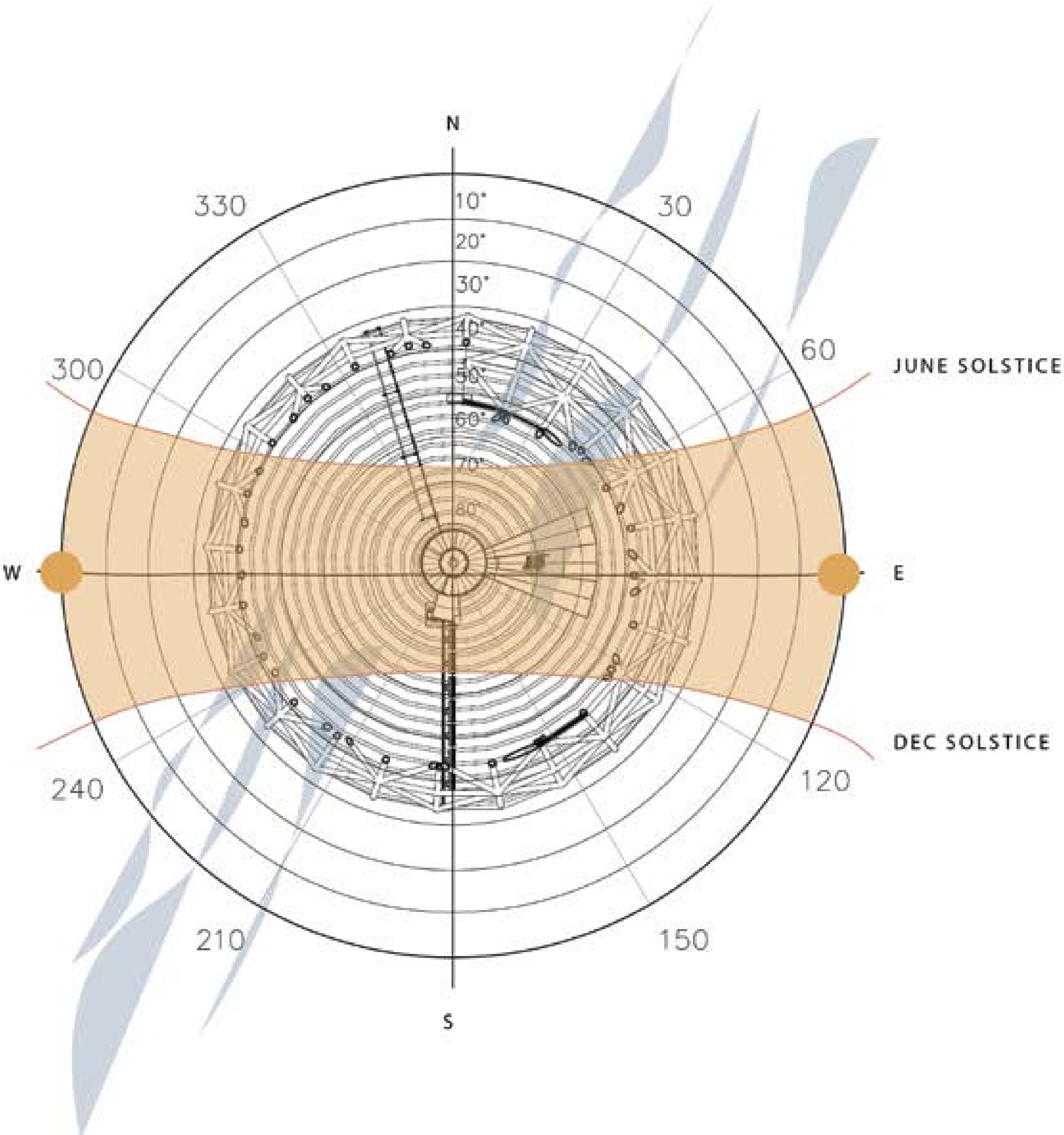
Prevailing winds come from South-east and south. The absence of surrounding buildings and tall vegetation reduces obstruction of wind. Wind is less strong during Southwest Monsoon season than when in Northeast monsoon season

Northeast Monsoon

December to Early March

Prevailing winds come from North and north-east. First half of the season(December to early January) has higher precipitation, that comes with 25.35km/h winds. The later half of the season (January to early March) is generally windy with lesser precipitation

The terrain beside the open field in which the architecture will be situated, obstructs the prevailing airflow coming from the south.



Climatic Response

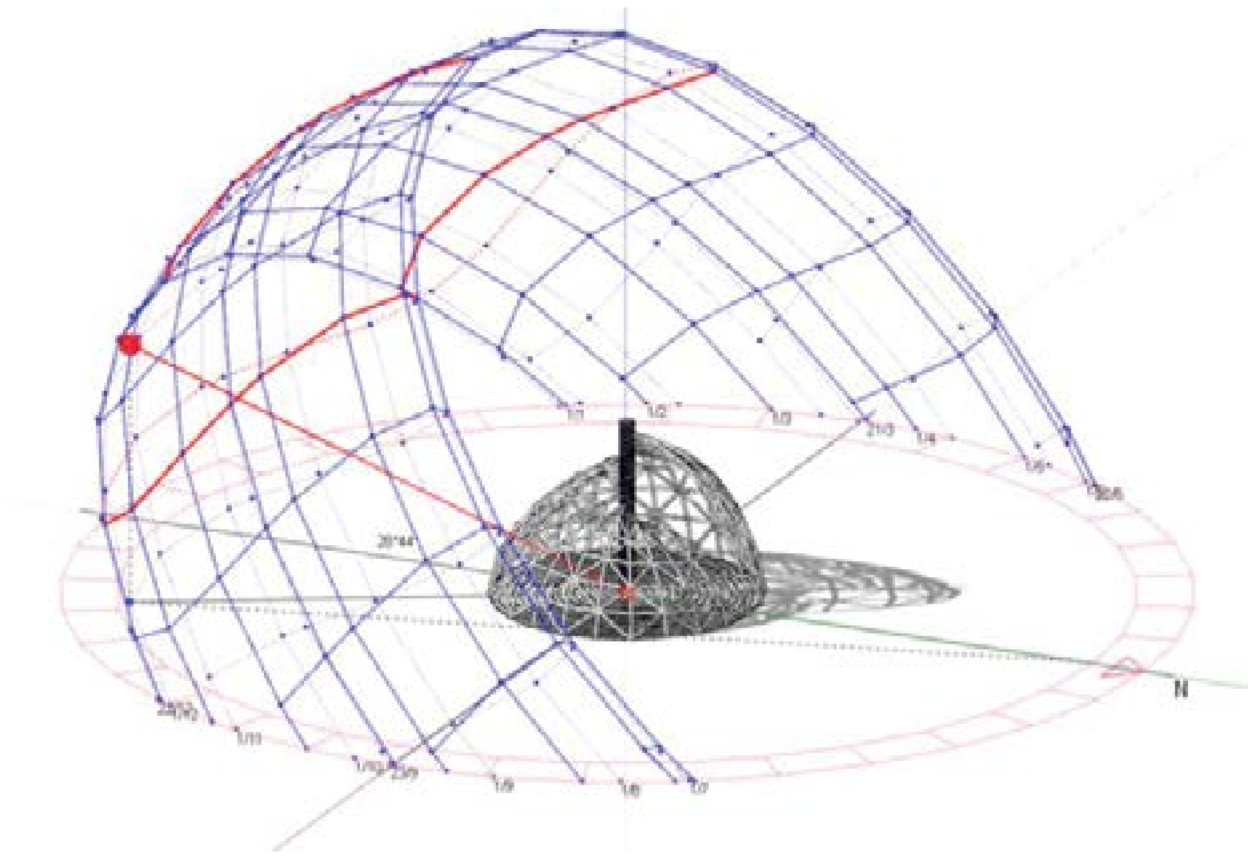
01 Orientation

Sun

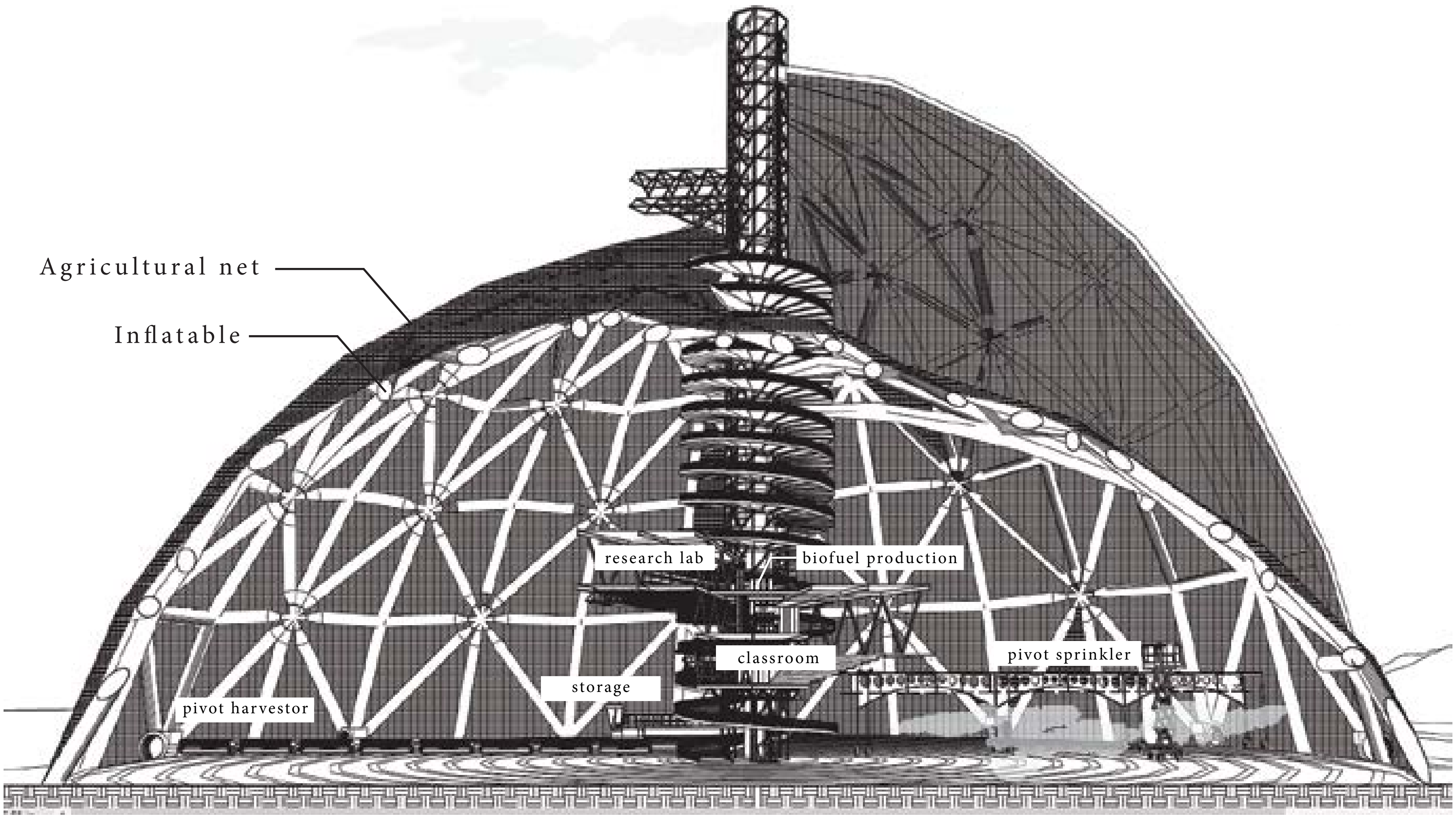
The building is strategically oriented with the long side facing the north-south which would receive less harsh morning and evening sunlight, while the short side would face the east-west to reduce solar heat gain within the building. In addition, this orientation allows for the prevailing wind to enter the habitable spaces.

Wind

Although the terrain has blocked prevailing wind coming from the south, the large field allows for wind to channel from other directions easily. Good airflow is optimal for the growth of sunflower. (Baker 2013) (Npark, 2013) The overall envelope by the agricultural netting is relatively porous which allows for wind to pass through easily.



03 CLIMATIC RESPONSE + STRUCTURAL STRATEGY



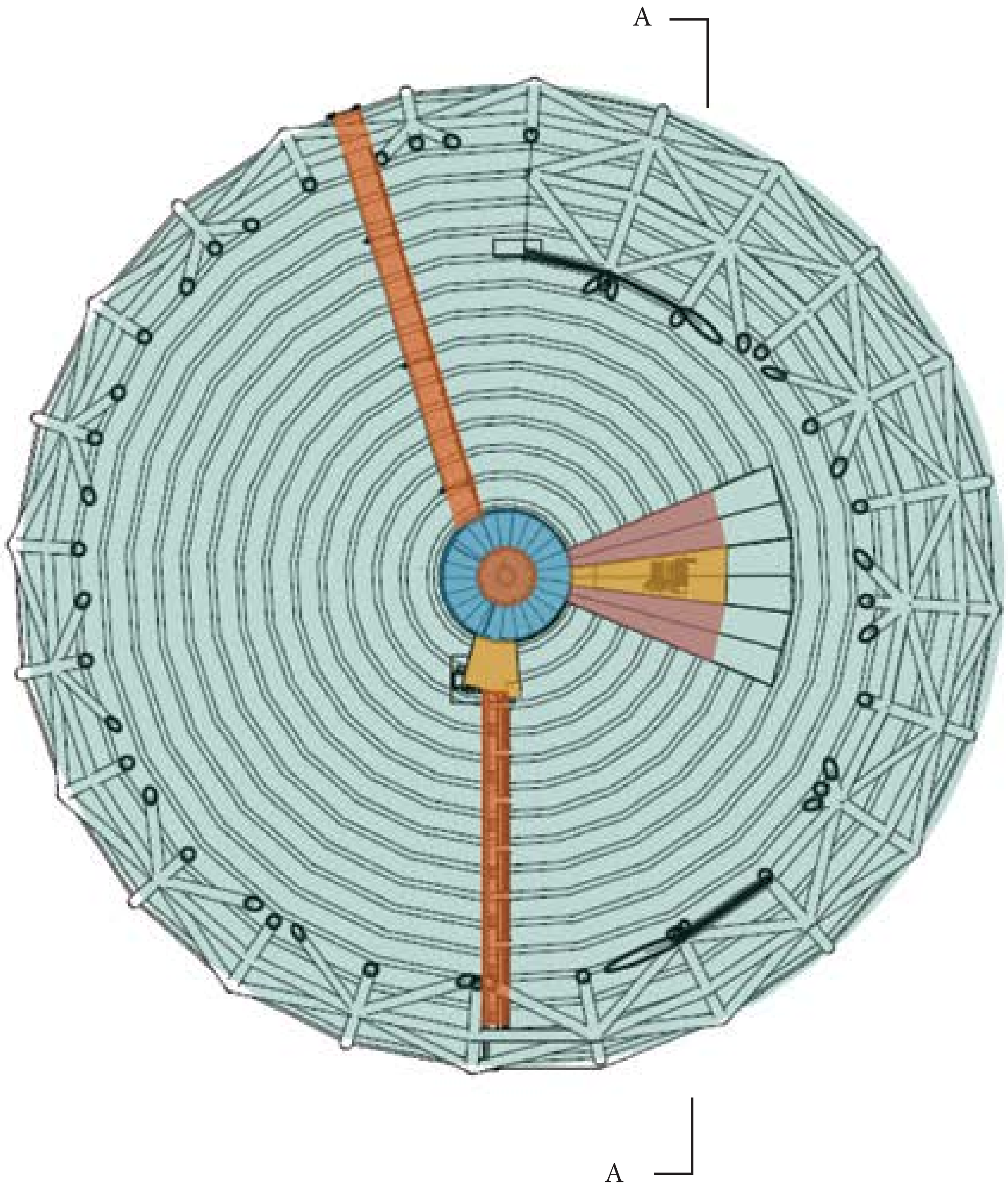
Sectional perspective A-A

02 Massing

As the plot is required mainly for sunflower plantation, minimuml footprint is required to maximise the area of plantation for bioremediation to take place effectively and efficiently. In addition, users should be kept away from the ground as much as possible due to the presence of petroleum hydrocarbons in the soil of the field, the contact with this soil could pose a health hazard. Therefore, the need for an architecture with small footprint is cruicial. Moreover, this allows for minimal impact on its site, while maximising green open spaces. Hence, the building is designed vertically upwards with smaller footprint.

03 Structure

With the intent of minimising the built elements within the grounds, the choice of steel scaffolding around the chimney that takes away the heat from the biofuel production process by distributing the heat into the respective "inflatable tubes". These inflatable tubes are anchored minimally on the ground with a fan blowing air in to keep it inflated during times when production of biofuel is not in operation. These inflatable tubes make up an envelope that has qualities of a lightweight structure. At the same time, it provides a controlled environment for sunflower growth which will be further elaborated under 4.4.



3rd Storey Plan (Zoning)

- Service core
- Industrial non habitable space
- Industrial habitable space
- Lab and Classroom spaces
- Plantation zone

03 Programmatic planning

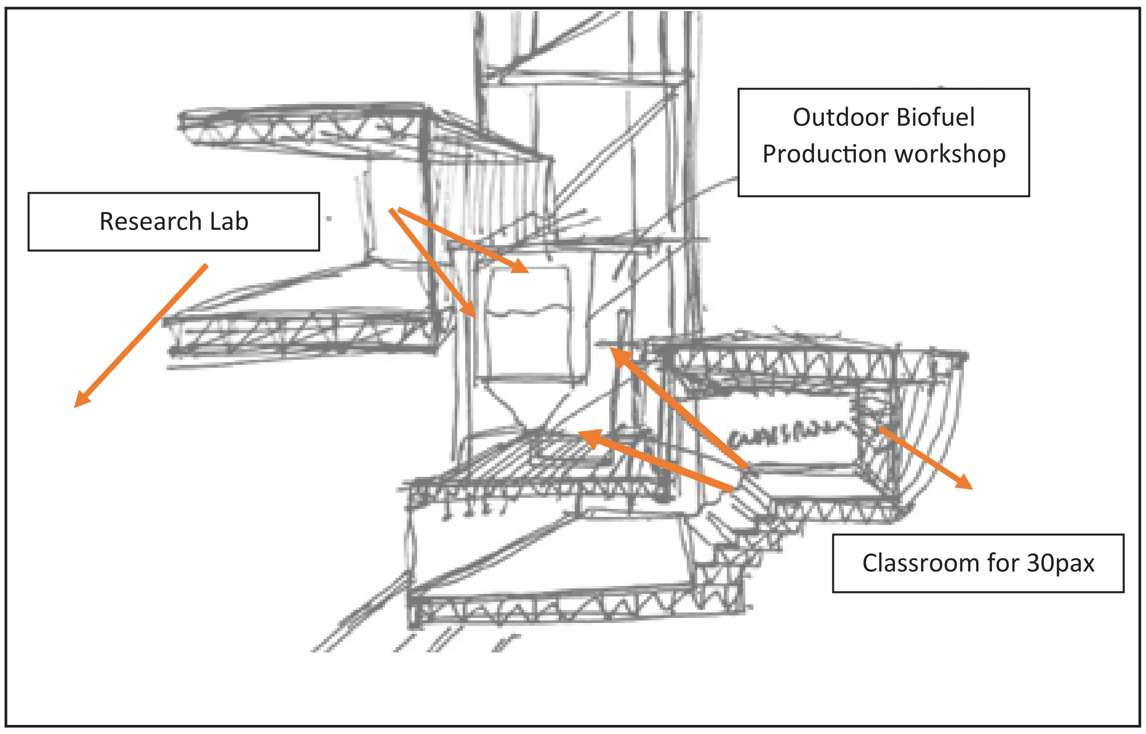
The production workshop is designed to be placed at the core of the programmed spaces. This is to allow for visual connectivity from the classroom and lab to the biofuel workshop while keeping a physical distance. At the same time, to allow for vistas to the sunflower plantations.

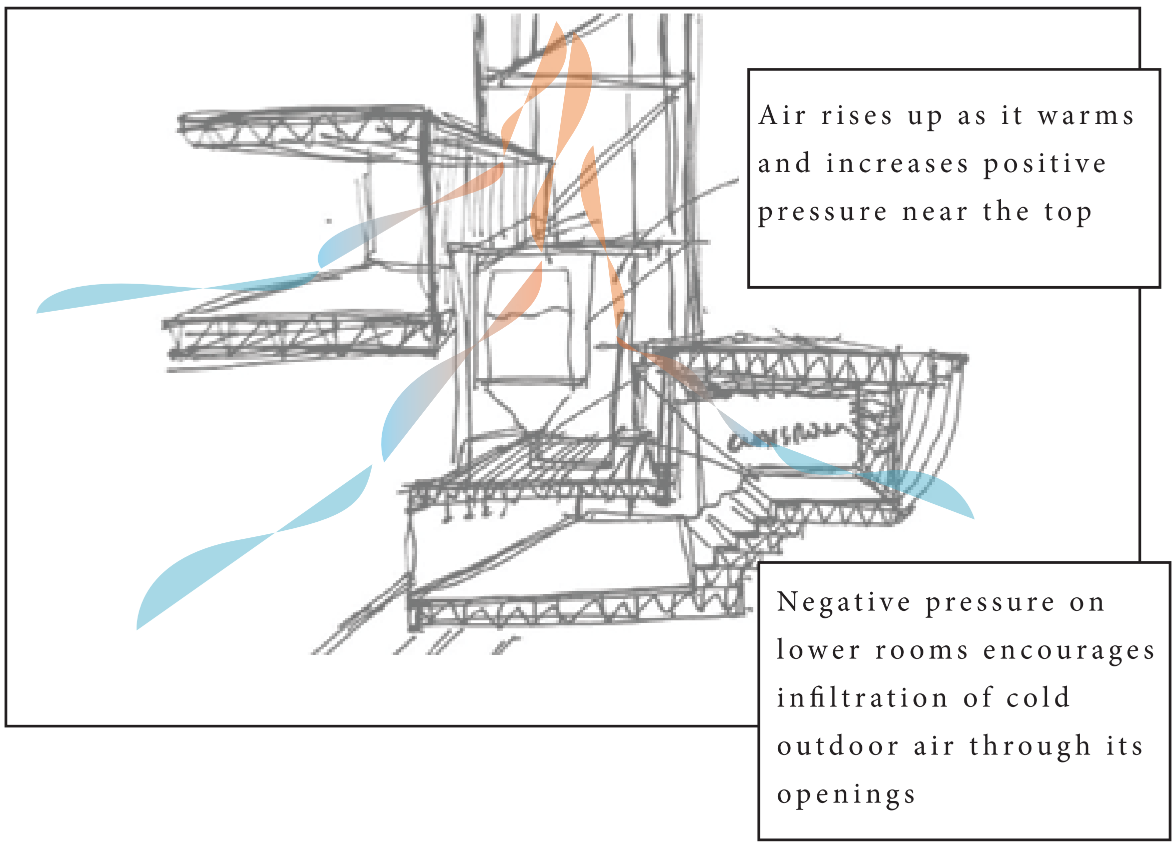
SUN

However, this loses the opportunity for these regularly occupied spaces (research lab and classroom) to be buffered from the sun by the less occupied workshop space. Therefore, an envelope that shades the space while allowing for visual porosity to the outside is needed.

WIND

The staggering of spaces creates an air well in the middle. The temperature and pressure difference in the research lab & classroom (cooler) versus the production workshop (warmer) creates a heat stack effect, further cooling down the research lab and classroom



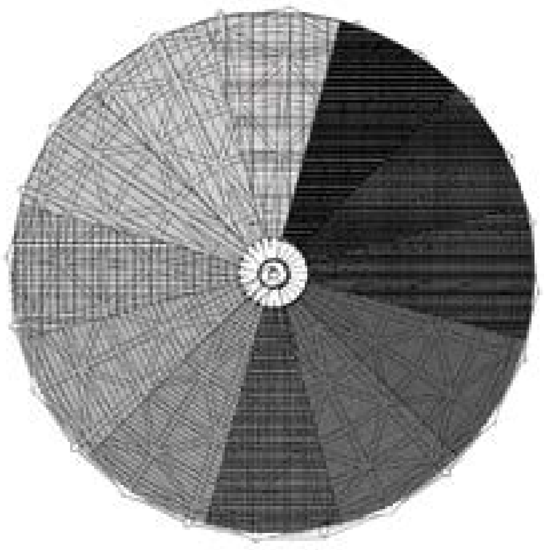


04 Envelope - shading (sunflower)

For optimal growth of sunflowers, the control of sunlight is crucial. The shading device used by this "microenvironment" is a form of agricultural netting at different porosities for different stages of growth of the sunflower.

The agricultural netting is attached to the inflatable at where the joints of the inflatables meet. (refer to Detail A) The duration from seed to seedling requires at least 4 days. The shoot appears after the first to second month. By the third month, the bud of the sunflower starts to grow. The sun condition required up till this point is semi-shade condition. Direct sunlight is not optimal at this stage. Next, by the fourth month, the sunflower would start to bloom. At this point, the sunflower roots spread widely and can withstand some drought. Direct sunlight with at least 8-8 of full sunlight per day is optimal at this stage. (Baker 2013) (Npark, 2013)

Therefore, in designing the envelope, the placement of plantation, and the time taken for manual seed sowing needs to be considered and calibrated in order to have a systematic approach to increase in efficiency. Hence, within the circular plot marked out for plantation, a sector will start to be sown with seeds by batches in a radial order. Hence, when one sector has been sown, this batch of seeds will start to germinate while the second batch of seed at the next sector is being planted, and so on. Therefore, such organisation would require a change in porosity of the netting at every radial interval to create a controlled environment in terms of sunlight. This netting is held up by the inflatable tube structures that form the dome-like shape. Fundamentally, the material of the structure is air itself. Hence, the lightweight qualities allow for the entire dome to rotate easily to cater for different conditions required by the sunflower. Therefore, this is the strategy taken to provide an optimal environment for good sunflower growth.



Roof plan of *Project RE-FUEL*

Pneumatic structure case studies by Graham Stevens

05 Envelope - shading (human occupants)

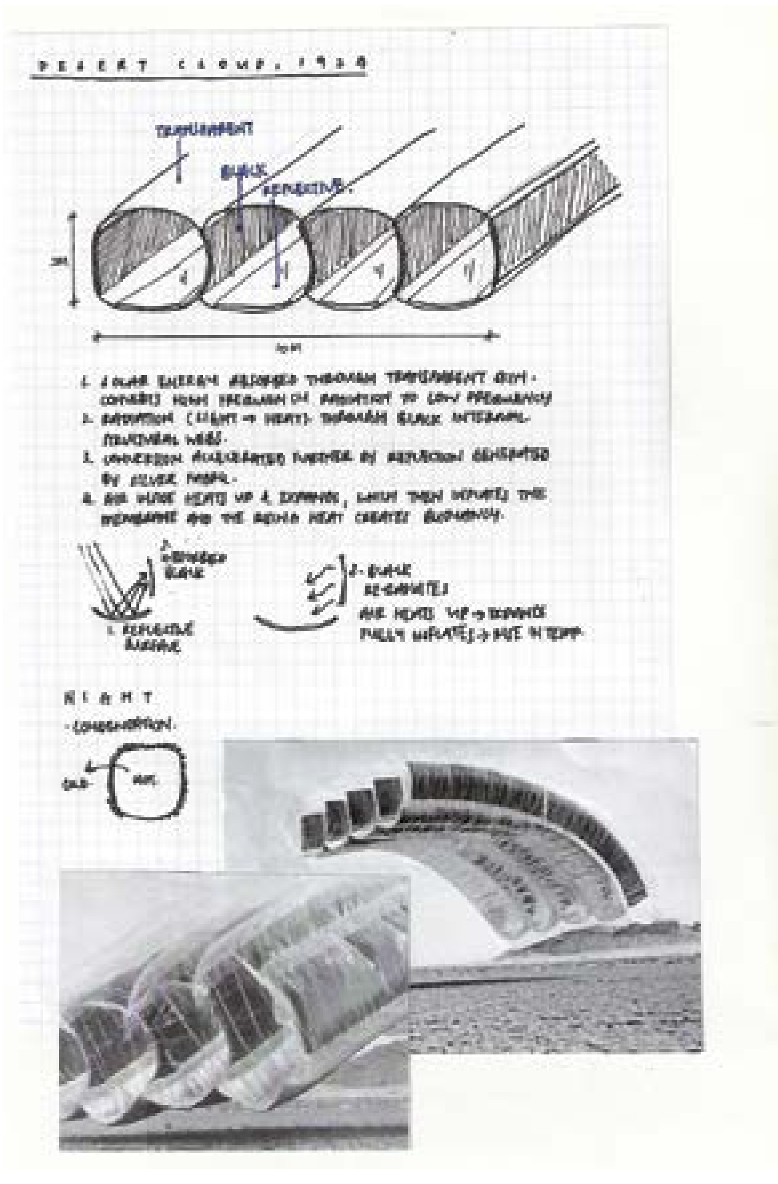
On the other hand, within the built areas, the manicuring of sunlight to reach the plantation remains a priority for this project.

Therefore, steel grating has been used as the floor at the upper stories which house the laboratories, workshop space, classrooms etc. to allow for sunlight that has been filtered through the inflatable envelope with agricultural netting to be equally effective even under the built areas.

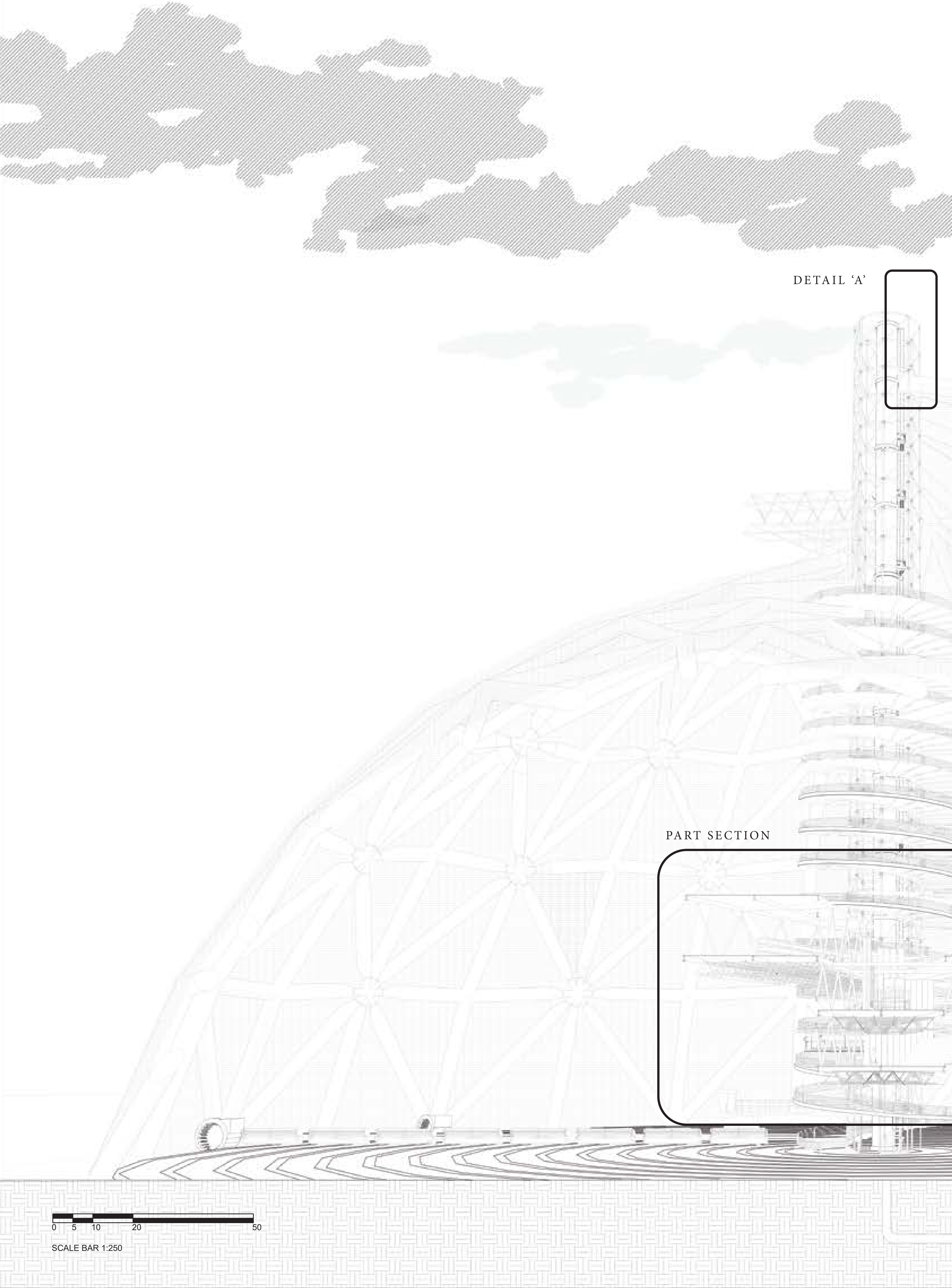
Due the before mentioned strategies that are intended for creating the optimal environment for sunflower plantations, while the built spaces are meant for succinct and temporary use, the shortfall of the project would be that it has inevitably created an unpleasant environment for the human occupants of this architecture, due to the ever changing degrees of sunlight (changed based on the different stages of sunflower growth requirements) coming from top down into the spaces. With no feasible solution directing it at this point, it is however, possible to shade the sun through the façade, to minimise heat gain into the spaces as much as possible.

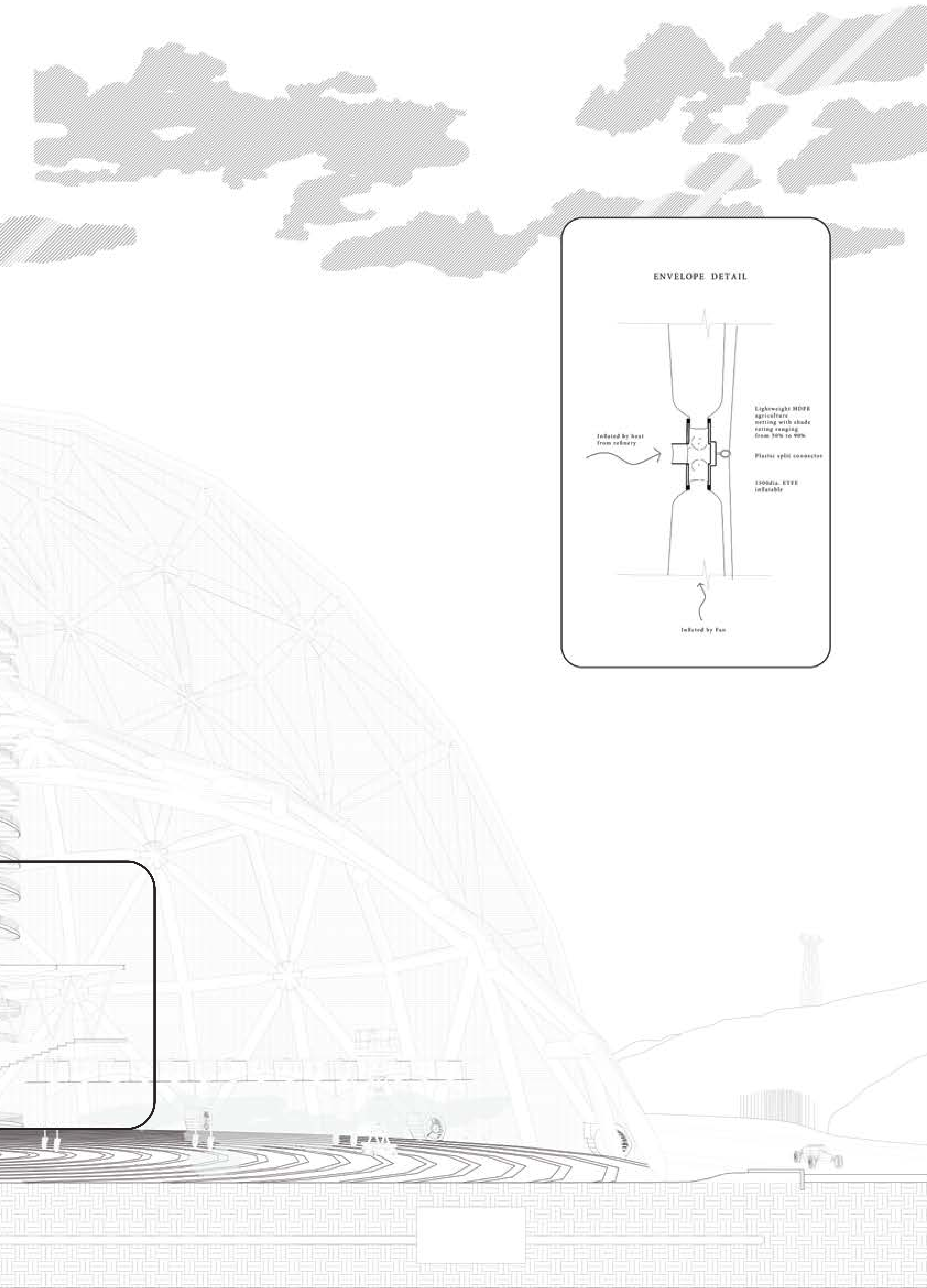
An attempt has been made to shade the harsh morning and evening sun at the east-west façade with transparent/translucent inflatable tubes of 50cm diameter through the technology of the "desert cloud" by Graham Stevens. (Westminster 2013) This technology by Graham is completely passive. As seen in the scanned notes on the right, The desert cloud consists of tubes of inflatables, that are internally lined with black material at the sides of each tube, and a reflective material at the bottom, facing the sun above. Solar energy is being absorbed through the transparent inflatable skin, which converts high frequency radiation to low frequency radiation (Light to heat energy) Through the black internal structural webs. This conversion of energy is further accelerated by reflection generated by the reflective silver fabric. Therefore, air inside heats up and expands, which then inflates the membrane and the rising heat creates buoyancy. Therefore, lifting the pneumatic/inflatable structure.

However, this technology was tested in a desert with sunlight of temperature between 43.5 – 49 degree Celsius. Hence, despite the architecture being in an open field the amount of buoyancy would be lesser in the Singapore climate with maximum temperatures of 2018 34.8 Degree Celsius in February 2019 (MSS 2010). Nevertheless, the use of this pneumatic structure as a façade merely requires for it to inflate to hold its shape. This inflated tube creates a literal air gap that acts as a buffer between the interior and exterior, to reduce heat gain from the harsh east-west sun, all while allowing for maximum visual porosity.



Scanned precedent study on
'Desert Cloud' by Graham Stevens


DETAIL 'A'
PART SECTION
0 5 10 20 50
SCALE BAR 1:250


ENVELOPE DETAIL
Lightweight HDPE agriculture netting with shade rating ranging from 50% to 90%
Inflated by heat from refinery
Plastic split connector
1500dia. ETFE inflatable
Inflated by Fan

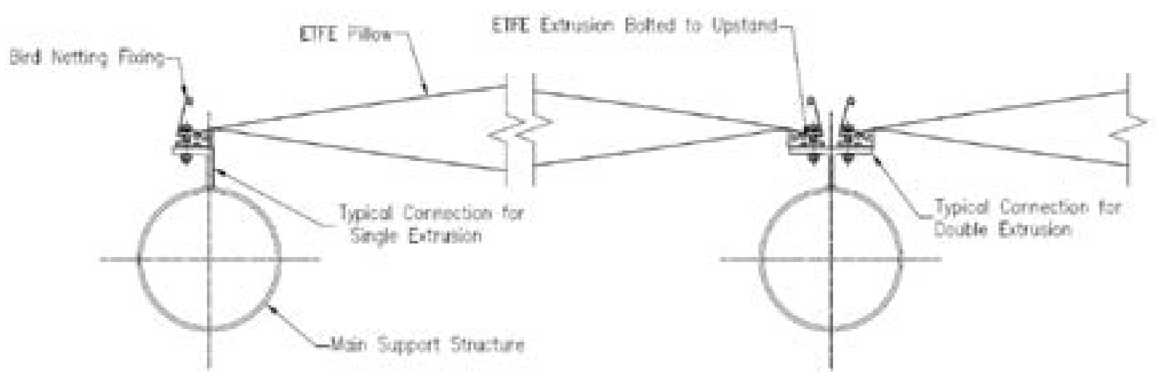
Construction & structural strategy

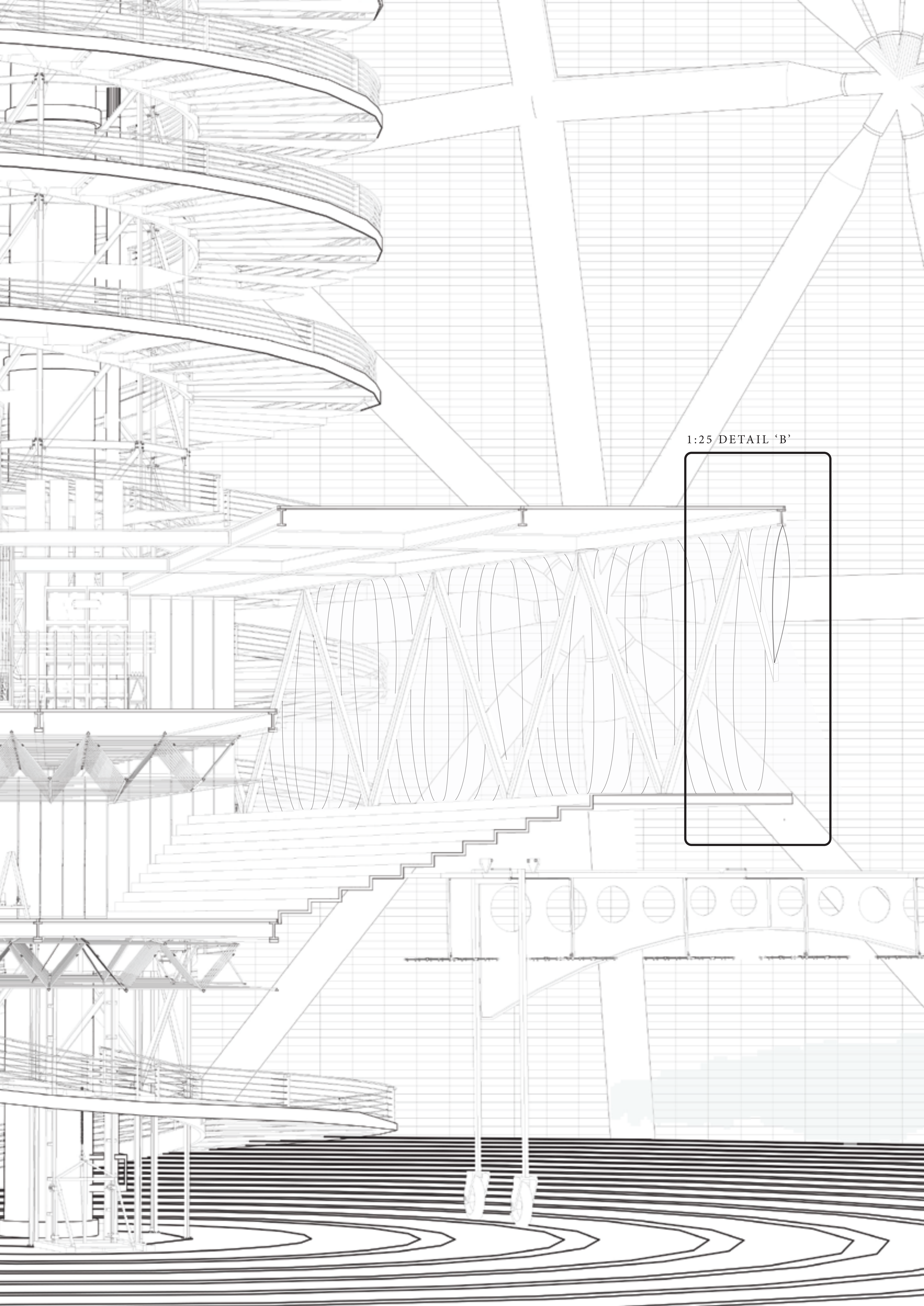
Facade structure comprises of the diagrid structure and ETFE Foil Pillows.

Diagrid
Diagonal members eliminate vertical columns.

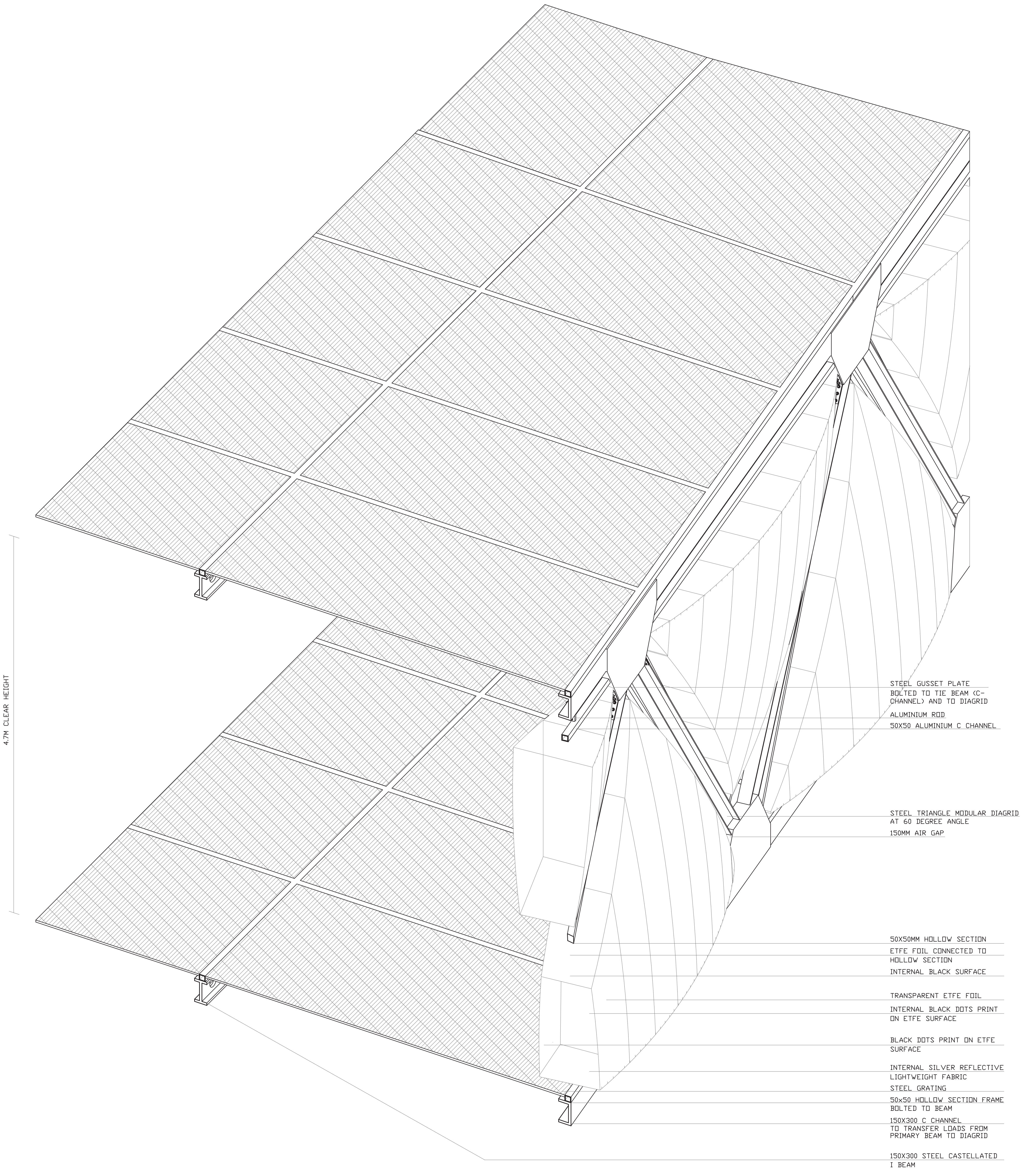
ETFE Foil Pillows
ETFE Foil cushins are exremely lightweight weighing 2-3.5kg/m3

Typical EFTE detail section by Architen Landrell




1:25 DETAIL ‘B’

EXTERNAL FACADE LIGHTWEIGHT SYSTEM



DETAIL B

1:25 ISOMETRIC CUTAWAY

Construction & structural strategy

Diagrid Components

1. Nodes
   Intersection between diagonal perimeter members and tie beam

   Formed by bolting or welding ends of members to a gusset plate.

2. Perimeter Diagonal Members
   Eliminates the use of columns

   Transfers both lateral and gravity loads through axial force

3. Tie Beams
   Transfers Load from RC Core to Diagrid

4. Ring Beam
   Connects diagonal and edge beam

4. Core
   Vertical core to resistst gravity load

06
PHOTOGRAPHS

EXPERIMENTAL MODELS


01

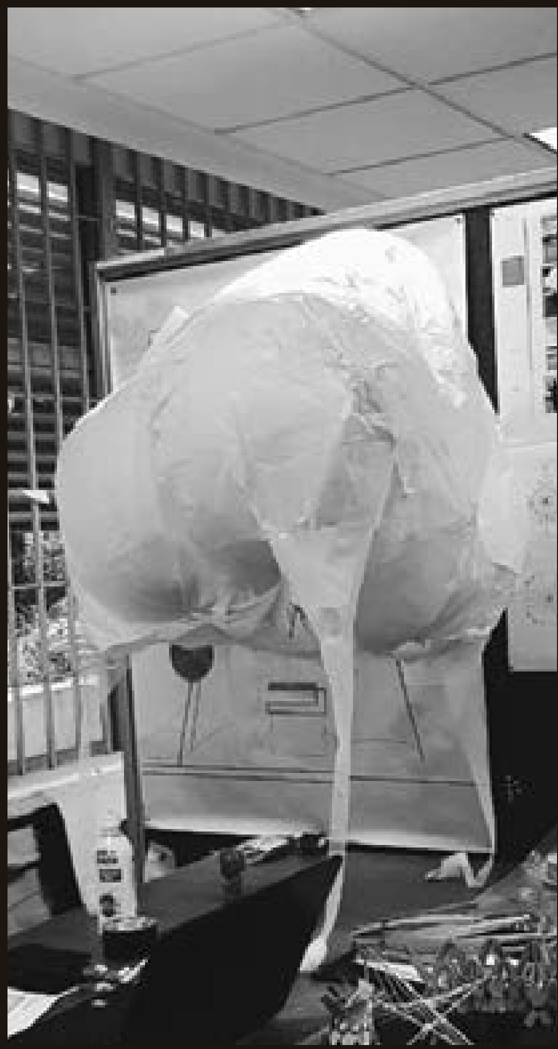

02


03


04


05


06


07

The initial idea of a creating a personal floating shelter through harnessing excess heat given off by the Barbeque pit, has led to further explorations of air as an envelope and structure. In capitalising on the advantages of pneumatic structures, including its limitless span and lightweightedness, the possibilities of air as a an envelope and structural element is further studied through existing Lighter-than-air inventions including Hot air balloons, Rozier balloons, Blimps, Graham Stevens' Desert Cloud, Sky-ballet, etc. The personal enclosure is then translated into a larger scale. Explorations of spatial and formal qualities through inflatables has driven the final architure into a micro-environment that house sunflower plantations for bio-remediation of Labrador Park's contaminated soil while housing research labs for biofuel production that is heat generating, gives the inflatable envelope its firmness.

The
Personal
Enclosure

The

Envelope