Interior Educators 2021 National Writing Award.

Course Director/Programme leader's overview.

Candidate: 181.W.CS.2021b.pdf

Due to the Covid19 implications to teaching and university guidelines, students on this programme of study have an amended submission deadline of June 24th 2021. As such, this work is not considered fully complete, and will be marked upon submission of the physically crafted submission.

This work is an extensive illustrated research and analysis report, which presents specific knowledge, understanding and arguments, based upon critical analysis of primary and secondary sources to inform an individually negotiated Design Project.

Beneath the Crops

As our world population and life expectancy continues to rise, our nation has become increasingly aware of the lack of food security. This has been further highlighted by Brexit border turmoil, Covid restrictions, the environmental impact of global food miles and the environmental impact of dietary choices.

World Trade Organisations have long reported predicted food shortages, making it clear that we should readdress how our food is produced. This design report explores and evaluates options available to our farmers to generate resources in rural and urban environments, which can capitalise on our changing eating habits.

The farmers of Bridlington will use the Bempton Bunker as a prototype hydroponics facility and research hub to kick start a modern method of farming that can be adapted in varied landscapes and within varied disused buildings. Through this project, farmers will collaborate with the organisation '*Farm Urban'* with a vision to create food for the future, for everyone.

Bempton bunker, an underground Second World War Radar Station has a functional architecture which revisits a time when our country was urged to 'Dig for victory', and moving food production underground allows for natural life and growth to occur above the earth.

Beneath the Crops

Maya Gribby

RAF Bempton
1941
CHL Station
R1 CEW Station
Bempton, Bridlington, East Riding of Yorkshire

Introduction

01


Fig.4


Fig.5


Fig.6

Personal Manifesto:

'Quietly confident' is a phrase I've often been described as and have realised it is also a trait reflected in my visual language and ideologies too. 'Local differences can have global impacts' is one of such ideologies I want to embody in this project; the idea that your individual action won't change the world but your collective contribution might.

Be quietly confident.

This concept piece illustrates the forementioned concepts, whilst also containing materials and symbols of key themes that influence my work. The piece has been photographed in fuchsia lighting reflecting the LEDs used in hydroponics.


Fig.7

Fig.8


LOCAL
DIFFERENCES
CAN
HAVE
GLOBAL
IMPACTS
BE
QUIETLY
CONFIDENT

Fig.9

Abandoned and almost forgotten, RAF Bempton was once a crucial part of the British radar defence system between 1939 to 1972. Originally located at Flamborough Head, the chain home (CH) station was relocated to Bempton a few months later due to its poor performance. Sitting at 360ft above sea level, Bempton Cliffs provided the perfect height for aircrafts to be detected at low altitude. This led to its further three upgrades, the final being its upgrade to a rotor 2 centimetric early warning (R2 CEW) station by 1955, before being disbanded in 1972.

All that remains of RAF Bempton now are the empty, weathered shells of the surface buildings scattering the hillside, which previously supported the radar heads and acted as decoys for enemy bombers to the bunker that safely housed the essential operations equipment underground. Aside from a plaque placed by the RAF reunion group, there is little to no indication of it being hidden below. A lot of mystery and intrigue surrounds the site, and as a result it has been the destination for many urban explorers. Unfortunately, this has also contributed to its deterioration, with many acts of vandalism leaving the station in a state of disrepair.

With security being at the forefront of the site's original purpose, 'Beneath the Crops' aims to keep it at the heart of the project but this time by placing food security at its core. Surrounded by farmland and recognised as a Site of Special Scientific Interest (SSSI) and a Special Protection Area (SPA), the site already has existing interest evolving around agriculture and conservation (The RSPB, 2020.) Therefore, the area presents an opportunity to design a collaborative scheme that involves local communities as, according to the Liverpool Knowledge Quarter Sustainability Network, existing businesses/ventures that were additionally supported by sustainable schemes to create collaborations were proven to be more successful than schemes that were created as individual entities within existing communities (Stenton, I. and Hanmer-Dwight, R., 2019.)

Already with an existing portfolio of projects, Farm Urban is constantly adapting and developing new ideas that put community at the heart. Having already explored multiple urban-based schemes, this new venture will allow them to explore hydroponics from a different angle. Originally designed to grow in unconventional environments, hydroponics are able to grow without sunlight or soil, making the underground nature of the bunker ideal conditions for growing hydroponic crops all year round, whilst also decreasing reliance on external factors and farming's impact on the landscape. Having lost the majority of its natural landscape since farming first began centuries ago, a transferable, underground agricultural scheme also presents the UK opportunity to restore or preserve some of its landscapes and biodiversity once lost to farming, which also feeds into The RSPB's efforts at Bempton cliffs.

Fig.10

RAF Bempton will be re-envisaged as an underground hydroponics farm, recycling lab, exhibition and market, as part of Farm Urban's portfolio expansion. Although modern hydroponics are generally located in urban environments, this project aims to tackle local food security from an alternative angle; the project aims to create a transferable scheme that will enable traditional, rural farms to increase their efficiency and output by expanding their skill set and land use to incorporate modern farming techniques, whilst also educating and inspiring its visitors.

The closed-loop scheme will bring local communities together with the aim to:
- Produce healthy crops locally and hydroponically.
- Increase local sustainability by reducing waste and using renewable energy sources.
- Educate about the importance of food security and how hydroponics work.

Surrounded by farmland and recognised as an SSSI and SPA, the site already has existing interest evolving around agriculture and conservation (The RSPB, 2020.) As hydroponics are designed to grow in unconventional environments, the underground nature of the bunker is ideal for growing hydroponic crops all year round. Considering the dilapidated nature of the station, an intervention-based approach will be adopted with few restrictions in its preservation.

As recognised by Biohm, and countless other sources, communities should have equilibrium and be able to regenerate themselves like natural ecosystems do, in order to truly be sustainable (Sayed, E. 2020.) Similarly, Dr Despommier wrote 'we have the ability to create a "cradle to cradle" waste-free economy, an urban equivalent of a natural ecosystem' (Dr. Despommier, D. 2010.) By using agricultural waste from neighbouring farms to create fertilisers and biogas to grow hydroponic crops, this project aims to create its own mini 'ecosystem', or 'close-loop' scheme.

'Beneath the Crops' will explore the journey from traditional to modern farming, spatially following this close-loop format by connecting one space to the next. These spaces will include:

'The Field Observatory' – A 360° observatory taking in the surrounding landscape and drawing attention to its traditional farmlands.

'The Switching Station' – A science laboratory for recycling local agricultural waste into fertilisers and biogas for use in the hydroponic farm.

'The Security Study' – An educational exhibition about food security that highlights its importance.

'The Fuchsia Garden' – An underground hydroponic farm that will take up the majority of the bunker in order to produce its optimal output. Plant choices will be based on their calorie content in order to be competitive.

'The Green Market' – A small, multi-functional farmer's market that will also act as a backdrop for the green illusion.

By providing such facilities, both resources and money are circulated locally, whilst also providing a centre for local pride, education, and research.

‘60% OF LEAFY GREENS END UP AS WASTE’

Food Security:

The United Nations predicts that by 2050 global populations will have reached almost 10billion with food demand increasing by 70% (FAO, 2009.) However, agricultural production is also set to fall by 20-40%, as a result of natural disasters increasing in severity and the number of occurrences due to climate change, which in itself has been accelerated by factors like population growth (Lim, C. and Liu, E., 2019.) Consequently, increase in demand and reduction in supply will force food prices up and make trading internationally more challenging.

The UK currently imports 45% of its food supply, therefore heavily relying on external food sources and heavily lacking in national food security (Gov.uk, 2019) The biggest commodity the UK imports is fruit and vegetables, spending £11.5billion in 2019 alone (Gov.uk, 2019.) Yet, 60% of leafy greens end up as waste (Myers, P., 2016.)

Agricultural Waste:

A biproduct of the increase in agriculture is the increase in waste. Although figures on global food loss pre-harvest are hard to estimate, in 2011 it was estimated that 1/3 of all food produced was either lost or wasted, with agricultural waste between post-harvest and retail estimated to be as high as 14% in 2019 (FAO, 2019.) The UK currently wastes 7.2% (3.6million tonnes per annum) of all food harvested, with horticulture and cereal waste making up 84% of that figure (WRAP, 2019.)

An increase in waste can also lead to an increase in disease, which can lead to an increase in potential pandemics that, again, can lead to a reduction in international trade, as observed with COVID-19. In a recent journal publication addressing the impacts of Covid-19 on trade, it was recognised that military conflicts and climate change aren’t the only threats to food supply and distribution, but the consequences of pandemics are too, such as border closures, quarantining, and supply chain disruptions (Erokhin, V. and Gao, T., 2020.)

Existing Schemes:

All of these issues surrounding food security and waste have led to the need for modernisation, innovation, and localisation in agriculture. It has been argued by multiple sources that there’s a disassociation between producer and product, and producer and consumer, resulting in a lack of consumer awareness (Lim, C. and Liu, E., 2019.) Therefore, the movement towards urban agricultural schemes involving practices such as vertical farming, close loop systems and hydroponics have been trialled in cities across the globe, in attempt to increase sustainability and awareness. For example, in the UK, community allotment schemes have been established, such as ‘The Allotment’ in Kensington, London, with the aim to educate and involve locals encouraging long-term personal investment (Tran, H., 2020.)

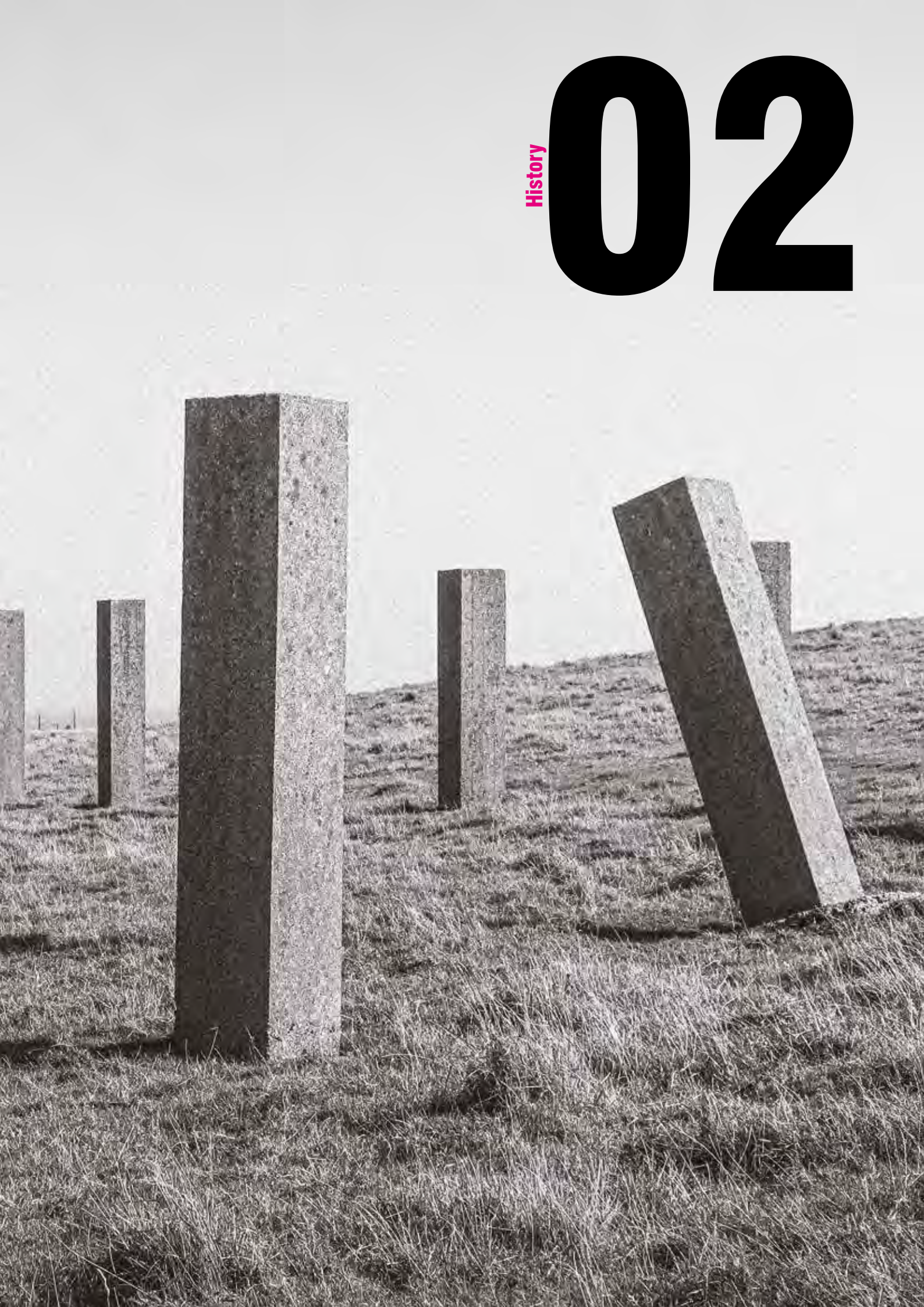
Why would Bempton/East Riding of Yorkshire benefit from a modern agricultural scheme?

Disconnected geographically and socially, the rural areas of the UK are miles behind cities in its economic core. With an ageing population, consequence of youths moving away for university and employment opportunities, innovation is needed to encourage investment to reinvigorate these areas and encourage younger populations to stay (East Riding of Yorkshire Council, 2019.)

In order for a system like this to be successful, it requires community pride. Although this project is on a smaller scale, when considering smart cities, other projects have realised the need to maintain a location's identity rather than restart a fresh, as this builds on existing community pride promoting interest and in turn involvement within the scheme (Lim, C. and Liu, E., 2019.) 'Traditionally the character & industry of a place arose from geographical uniqueness of the earth' (Lim, C. and Liu, E., 2019.) As 90% of land in East Riding of Yorkshire is dedicated to agriculture, a result of its arable land, there is already the foundations to adapt to a modern agricultural scheme (East Riding of Yorkshire Council, u.d.) Furthermore, Bempton cliffs were chosen as a location for the RAF Station due to being 360ft above sea level, giving Bempton historically political significance as well. Bempton's heritage and identity is agriculture, security and now, due to the RSPB's intervention, conservation. All of which are the foundations of the proposed scheme to reenvisage RAF Bempton as a close loop hydroponic farm.

History

02



CH Stations:
(1940)

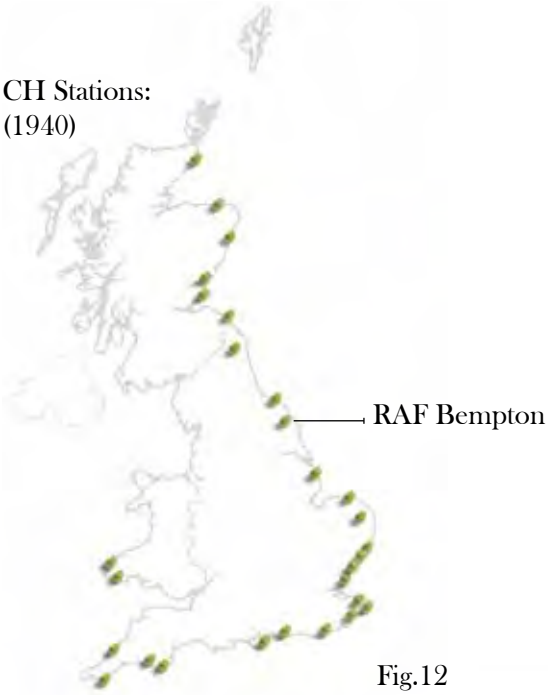


Fig.12

CHL Stations:

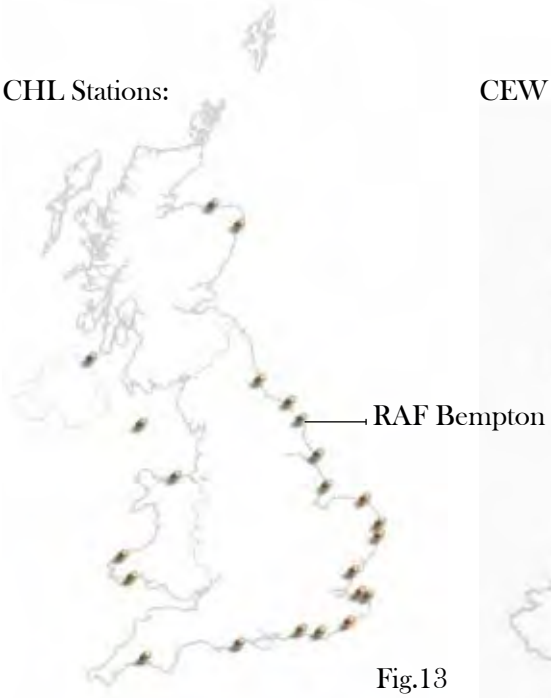


Fig.13

CEW Stations:

Fig.14

RAF Station Locations:
As a crucial part of the defence against Germany in WWII, RAF stations were assembled all along the south and east coast of the UK.

RAF Bempton:

A CH station was initially erected in 1940 at Flamborough Head, East Riding of Yorkshire, but was relocated several miles north to Bempton a few months later, as a result of its poor performance 130ft above sea level; Bempton being over twice the height sitting at 360ft (Higton, J. 2020.) This height was ideal for detecting aircrafts at low altitude as well as the odd ship. At first, RAF Bempton was positioned 1/4mile inland but a year later was moved again closer to the cliff edge as a CHL station. In the 1950s, this station adapted to become 1/8 CEW bunkers and is the site that the project will be situated at (Higton, J. 2020.)

Fig.15

The Domestic Site:

Erected in 1953, the domestic site consisted of RAF personnel billets & an administration office. This is the site where the men would eat, sleep, and enjoy leisure activities with the locals; Bempton welcomed the extension to their community, benefitting from the economic investment and social facilities that came along with the camp, such as a small cinema (Singer, A., 2001.) The site has since been converted into a caravan park.

Fig.16

The original site plan drawn up in 1951 retrieved from the archives of the RAF Museum, London.

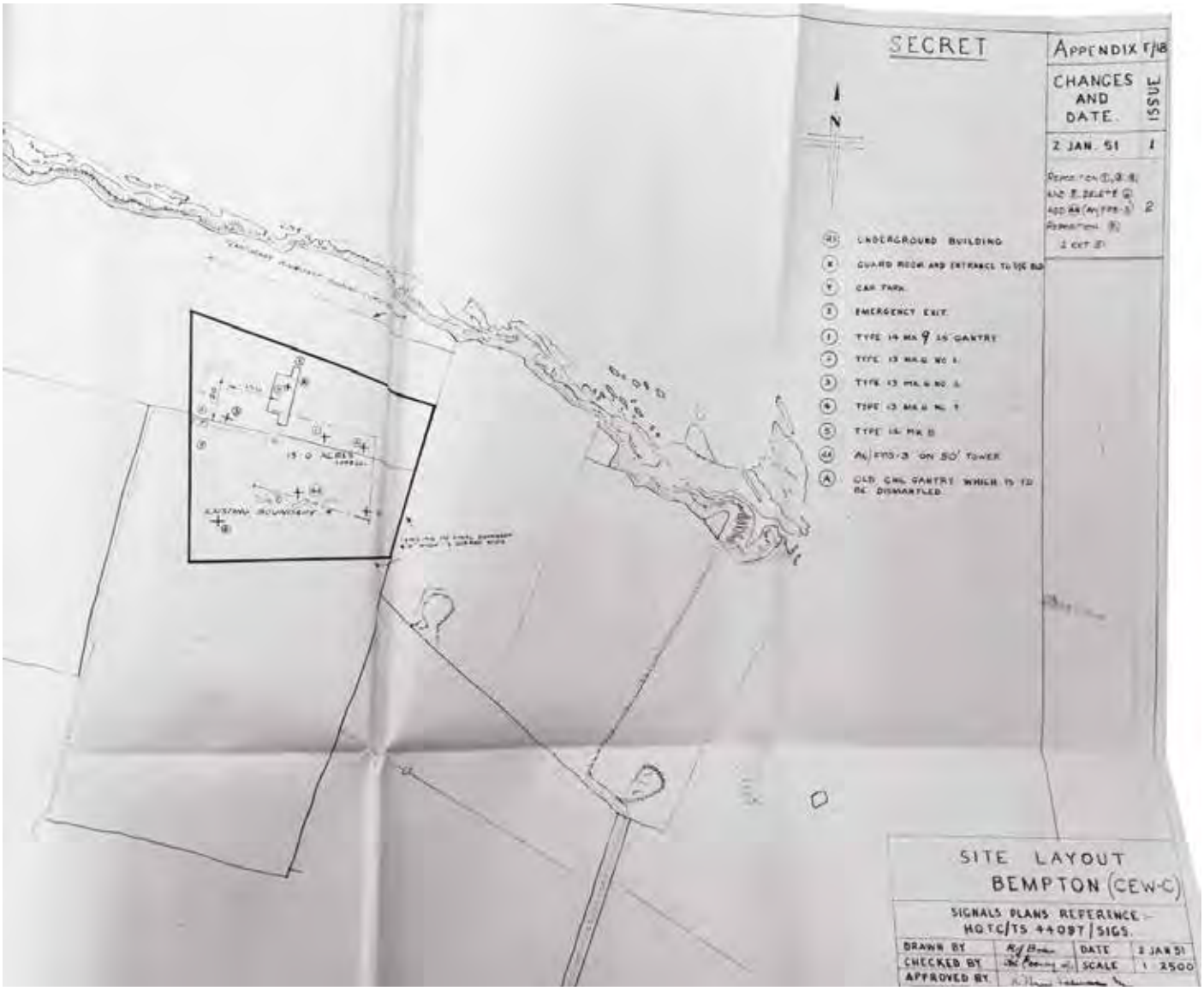


Fig.17

A Timeline of RAF Bempton:

1939 – A CH station was erected at Flamborough Head in January but was relocated to Bempton by April.

1941 – The new CHL site was moved 1/4mile closer to the cliff.

1950 – The station became an R1 CEW station, and the decision to build a bunker following successful German bombings of other stations was made.

1952 – The station came under RAF command.

1953 – Construction of the bunker was complete, and the domestic site was built.

1954/55 – The new, revolutionary type 80 head was installed and it became an R2 station.

1961 – The 146-signal unit was disbanded, and RAF Bempton became a satellite station for RAF Patrington.

1972 – The station closed for good.

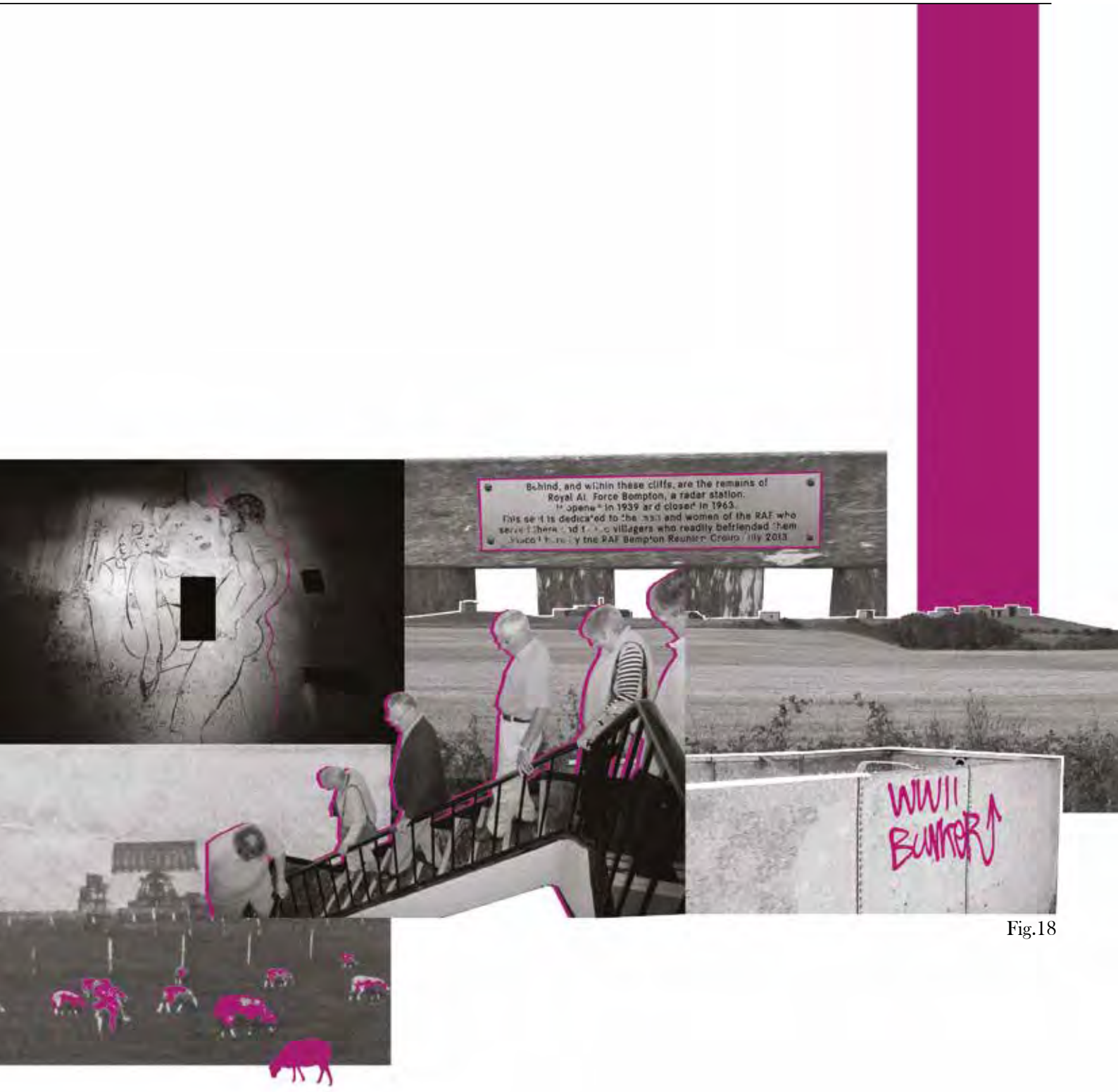


Fig.18

1970/80s – Rumours of a cult occupying the abandoned bunker (The Order of Nine Angles) and their potential associations with mysterious disappearances. The bunker was also subject to vandalism and the interior was gutted as a result of fires.

1980/81 - The land was sold to the Walkers, who already owned the neighbouring farm, The Grange, for decades.

2002 – A reunion of RAF personnel was held for its 50th anniversary.

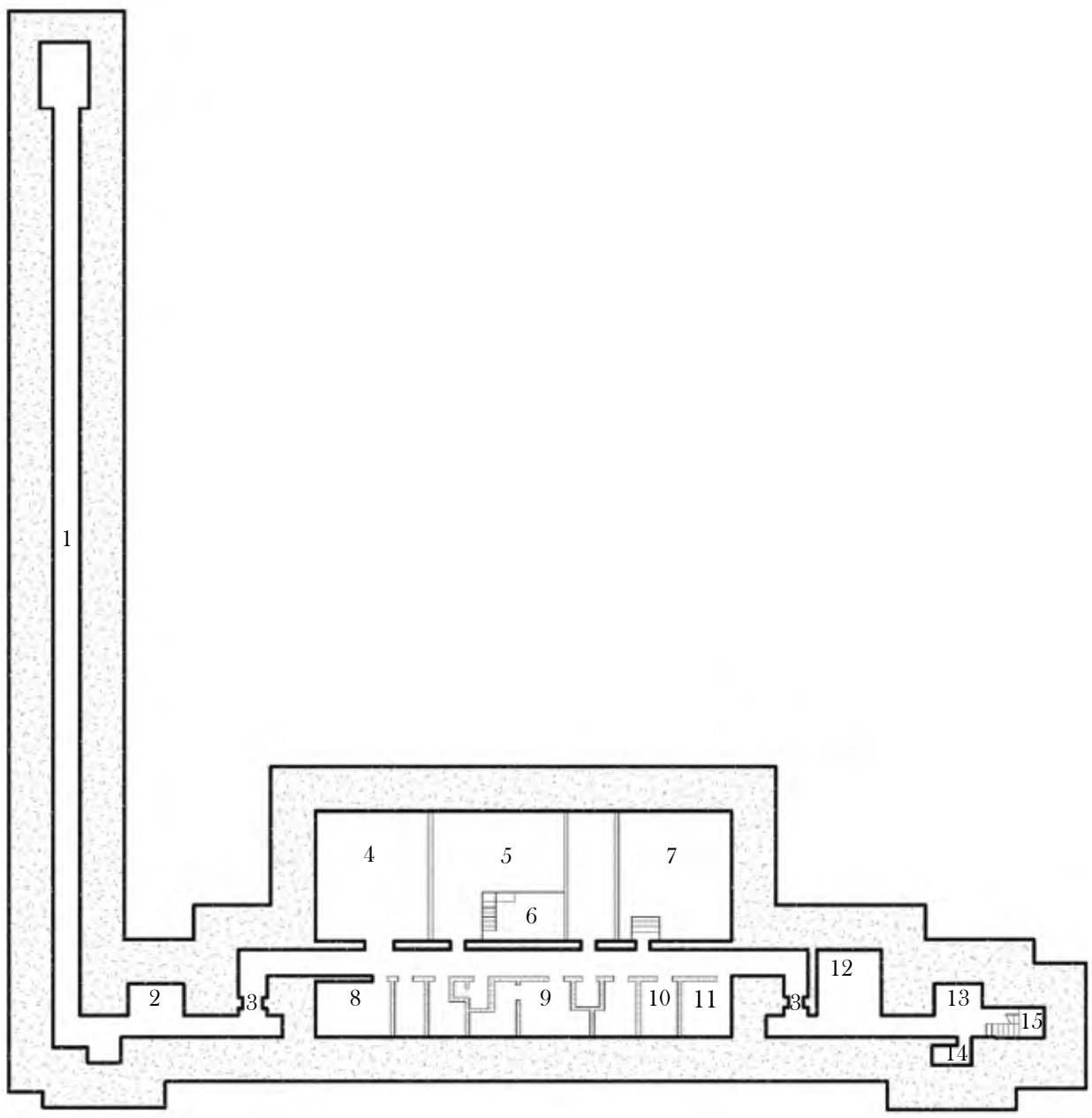
2010 – The entrances to the bunker were sealed off with concrete, and covered with an iron gate and large trough.

2013 - A bench was placed by the RAF reunion group in fond memory of the station and in memory of three RAF personnel, who lost their lives off the cliff (Hepworth, G., 2020.)

Today – The disused RAF Station sits on private farmland still owned by the Walkers.

(Higton, J. 2020, and McCamley, N., 2013.)

Previous Functions:



Plan 1:500@A4 Fig.19

1. Entrance Tunnel
2. Transformer Location
3. Blast Doors
4. Radar Office
5. Track Telling Room
6. PDS Image Processing Room
7. Plant Room
8. Intercept Cabin
9. Rest Rooms
10. Switching Room
11. Machine Room
12. Cooling Tower
13. Air Filters
14. Sump Room
15. Emergency Exit

The transformer cage.

Fig.20

Location of the nuclear blast doors.

Fig.21

The switch room and machine room.

Fig.22

Fig.23

The sump room had an air compressor and receiver to power a large pneumatic sewage ejector.

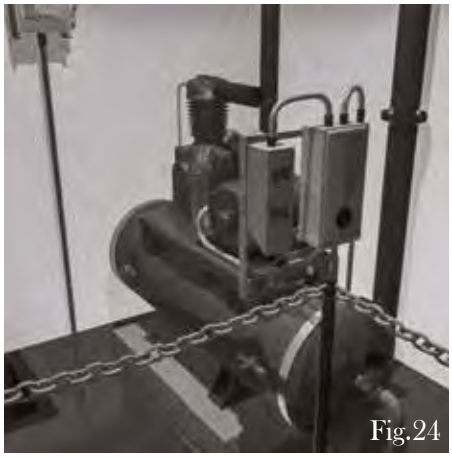
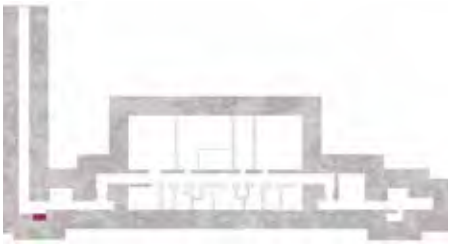


Fig.24

Fig.25

Air Cooling and Ventilation:

Air cooling and conditioning was vital to operate the station effectively. At the end of the long passage down to the bunker, contaminated air was extracted via foul air ducts and, at opposite end, the emergency exit doubled up as an air passage allowing cool air from outside to travel down through the cowl (Higton, J., 2020.) The atmosphere of the interior connected to the exit was a direct consequence of external conditions. Additionally, there were two air & gas filters powered by two centrifugal fans in a room adjacent to the exit, along with extensive apparatus cooling and conditioning located in the plant room (Higton, J., 2020.)



Exit to the surface for the foul air and cable ducts.

Fig.26

The plant room provided the air cooling and conditioning essential to the station:

-Cooling fan.

-Refridgeration plant: twin cylinder compressers, a water cool condenser, valves, pipework, pumps and an evaporator tank for chilling water.

-Centrifugal water pumps for distributing chilled water to the apparatus cooling and conditioning plant.

-Apparatus air filter room: filters, cooling unit and large fans that circulate the air to the rest of the bunker via a complex duct system.

-Cabinets of plant room control equipment.

Fig.27

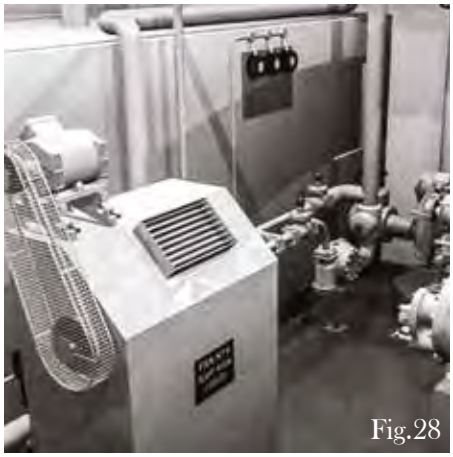


Fig.28

Fig.29

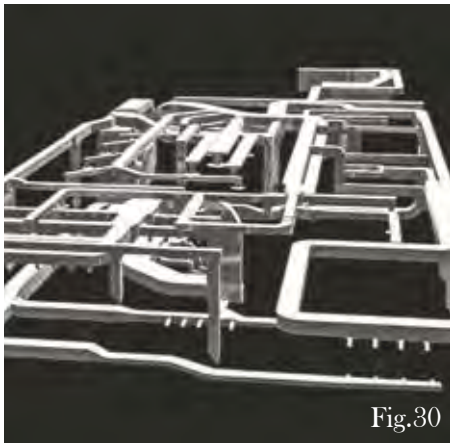


Fig.30

Water cool condenser and cooling tower for the air conditioning plant.

Fig.31

Air and gas filters powered by two centrifugal fans. The conditioned air is then directed to the plant room via ducts.

Fig.32

Fig.33

Location of one of the centrifugal fans removing contaminated air.

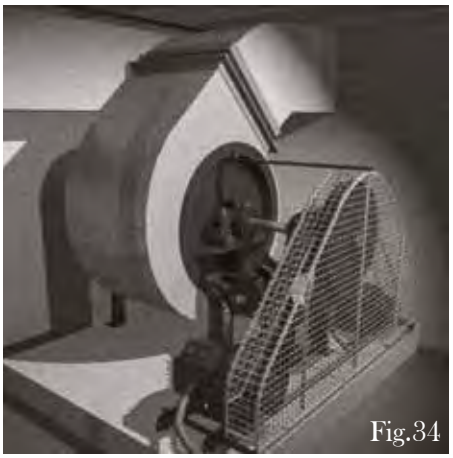


Fig.34

Fig.35

A cowl vent provided fresh air down the stairway of the emergency exit.

Fig.36

Fig.37

Radar Operations:

The track telling room.

Fig.38

Fig.39

The intercept cabin.

Fig.40

Fig.41

Fig.42

Type-60A:
PPI displays.

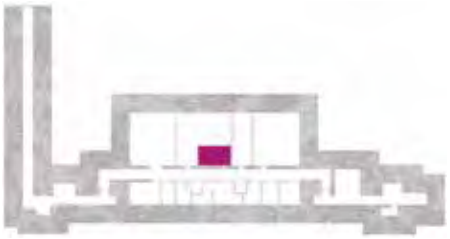
Fig.43

Type-61:
Height range displays.

Fig.44

Type-64:
The console for the Type-80 radar.

The PDS Room/'The Udder':



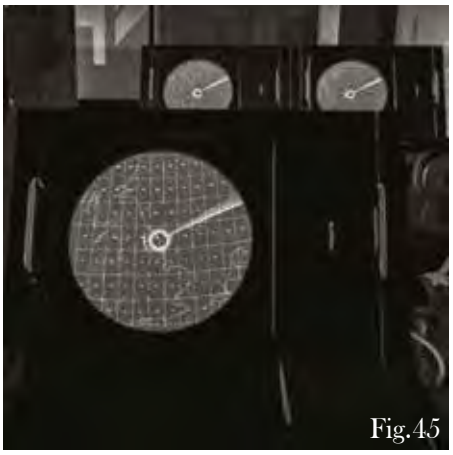


Fig.45


Fig.46


Fig.47


Fig.48

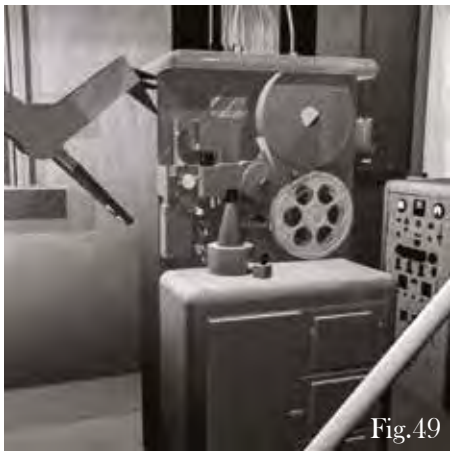


Fig.49


Fig.50


Fig.51


Fig.52

Beneath the bunker was a small room dedicated to taking photographs of the radar screens onto 35mm film and projecting the images above onto a 7ft2 table in the track-telling room. The images provided a continuous radar picture allowing locations of aircrafts to be plotted (Higton, J. 2020.)

RAF personnel referred to the PDS room as 'the udder', as it was located beneath the bunker. Not only is this a humorous reference to a key component of the project proposal (cows), but also the use of film, projections and light could be interesting elements to reintroduce into the new design.

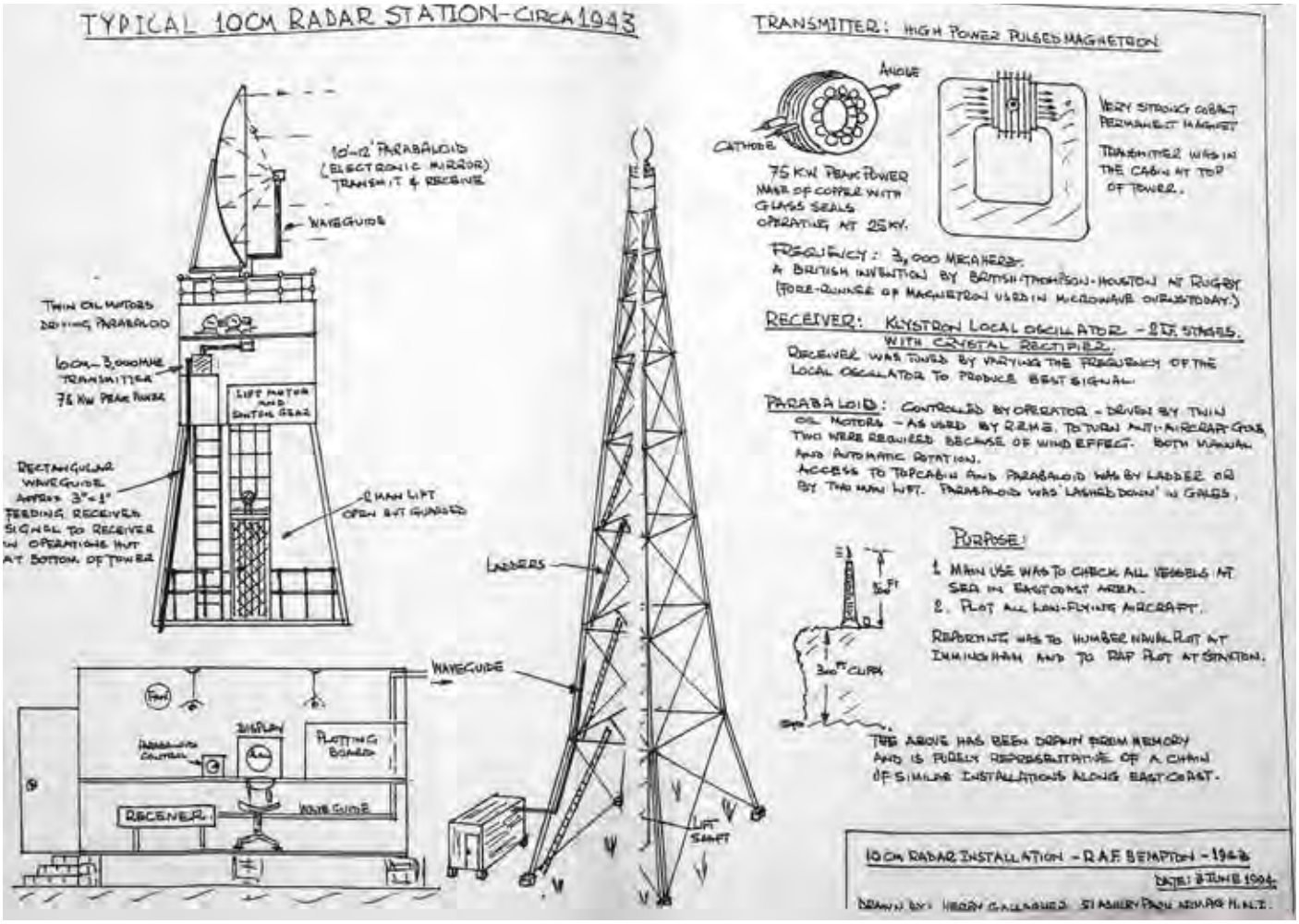


Fig.53

Original drawing by Herby Gallagher in 1994 from Jeff Wardlow's personal collection.

The Radars:

Fig.54

Type-14:
Scanned horizontally for aircrafts with a range of up to 100miles. It was this model that the Type-80 was developed from.

Fig.55

Type-13:
Remote controlled, this radar head would nod vertically 6 times per minute to detect an aircraft's height.

Fig.56

AN/FPS-3:
Imported from America, these radar heads were mounted on 50ft towers and covered a radius of 200miles but experienced multiple technical faults.

Fig.57

Type-80:
Code-named 'Green Garlic', the type 80 revolutionised radar stations in the 1950s, as they were able to get 360° readings with a 240mile coverage.

(Higton, J., 2020.)

Fig.58

George Hepworth,

Retired Corporal, who worked at RAF Bempton between 1953-1955.

The following extracts were taken from a telephone interview with him.

What would a day in the life of yourself working at RAF Bempton look like?

8am: We'd assemble outside the station, where the military police would raise a flag, before marching up to the cliffs, if there was no transport to take us there. By 9am, we would be down in the bunker starting the radars and plotting coordinates. Sometimes time would be allocated for morning exercise.

12:30: We were transported back to the domestic site for lunch.

2pm: Operations were restarted again until 5pm, when we would return again to the domestic site for dinner.

Evening: Some would relax at the domestic site, and some would go to the local pub. In the pub there was a piano, & one of the RAF personnel were an amazing pianist. The pub would close at 22:30, so some would continue drinking on the church wall. (Regular personnel at the station took their job more seriously than the temps.)

How many days a week did you work, and how long were you stationed there for?

We would usually work 5 days a week and have Saturdays off. If you managed to get a 36hr pass, you would be able to leave for home over the weekends; sometimes you could even get 72hr pass. Time off was staggered with other stations though.

I was stationed at RAF Bempton from August 1953 - December 1955, before moving to Germany with the Type-80 radar head.

How secret was the bunker kept?

Very. (Referring to the guardhouse) villagers questioned how so many men could fit into such a small building!

Years later, I spoke to people at Bridlington library and they had no idea about there even being a station at Bempton, it was that secret.

What did your role involve at RAF Bempton?

I was incharge of the operations of things, such as giving lectures, organising the watch, allocating positions, keeping other personnel informed etc.

I earned my position of Corporal after showing interest in working abroad in Hong Kong; the commanding officer told me I was too good to do so, and told me I wouldn't be able to work my way up the ranks if I left, so I took a course and earned the title.

What was the atmosphere like working in the bunker?

Fantastic; it was the best station I worked in my whole career and I have lots of fond memories from there.

Fig.59

Jeff Wardlow,

Local historian and carp farmer.

The following extract was taken from a telephone interview with him.

What was the space itself like?

The station was brand new so it was clean, spacious, had central heating and was overall a good, social environment to work in. At the domestic site, the bunkbeds were comfy and we were given fresh bedding every week too; we felt very pampered working for the RAF vs the army!

Do you have any personal stories you would like to add?

It was such an interesting life that I look back so fondly on. I have many stories and memories, but there's a funny one that sticks out. Grange farm had a bull as tame as a dog at the time. One night, one of the RAF personnel got really drunk, took the bull and tied it to a post outside his window on the domestic site. When he woke up the next morning, he was sober and had completely forgotten about the bull coming face to face with it at his window. He was terrified! Higher personnel made him take it back to the farm himself too!

Growing up in Bempton, do you have any recollections of the RAF Station and/or the personnel?

Living next to The White Horse inn, I would often see the RAF men around. In the evenings, they would often go there for a few pints but, as the pub closed at 22:30, many of them would carry on drinking after on the church wall. As a kid, I would go round collecting the bottles the next morning and return them back to the pub for 3p a bottle to make some pocket money.

Photographs of RAF Bempton's Personnel:
Kindly provided by Jeff Wardlow from his personal collection.

George Hepworth

Fig.60

Sport was often played for leisure at the domestic site.

Fig.61

In the evenings, at The White Horse inn.

Fig.62

A group photo of some of the RAF personnel stationed at RAF Bempton.

Fig.63

Duties also included keeping the site clean.

Fig.64

The uniform that RAF personnel were required to wear.

Fig.65

Fig.66

The Climmers:

Climmers were teams of professional climbers in the 1800s/early 1900s, who would rent a section of the cliff in teams and abseil down to collect the eggs from bird nests, often harvesting 5-6 dozen a day (Singer, A., 2001.) Hundreds would travel from miles around to watch them farm the cliffs and purchase eggs themselves, particularly on Whitsun Bank-Holiday Monday in spring (Singer, A., 2001.) Egg-collecting was banned in 1954.

Fig.70

Fig.67

Fig.68

Fig.69

Fig.71

Shipwrecks: (A further 170 were lost around the headland between 1770-1806.)

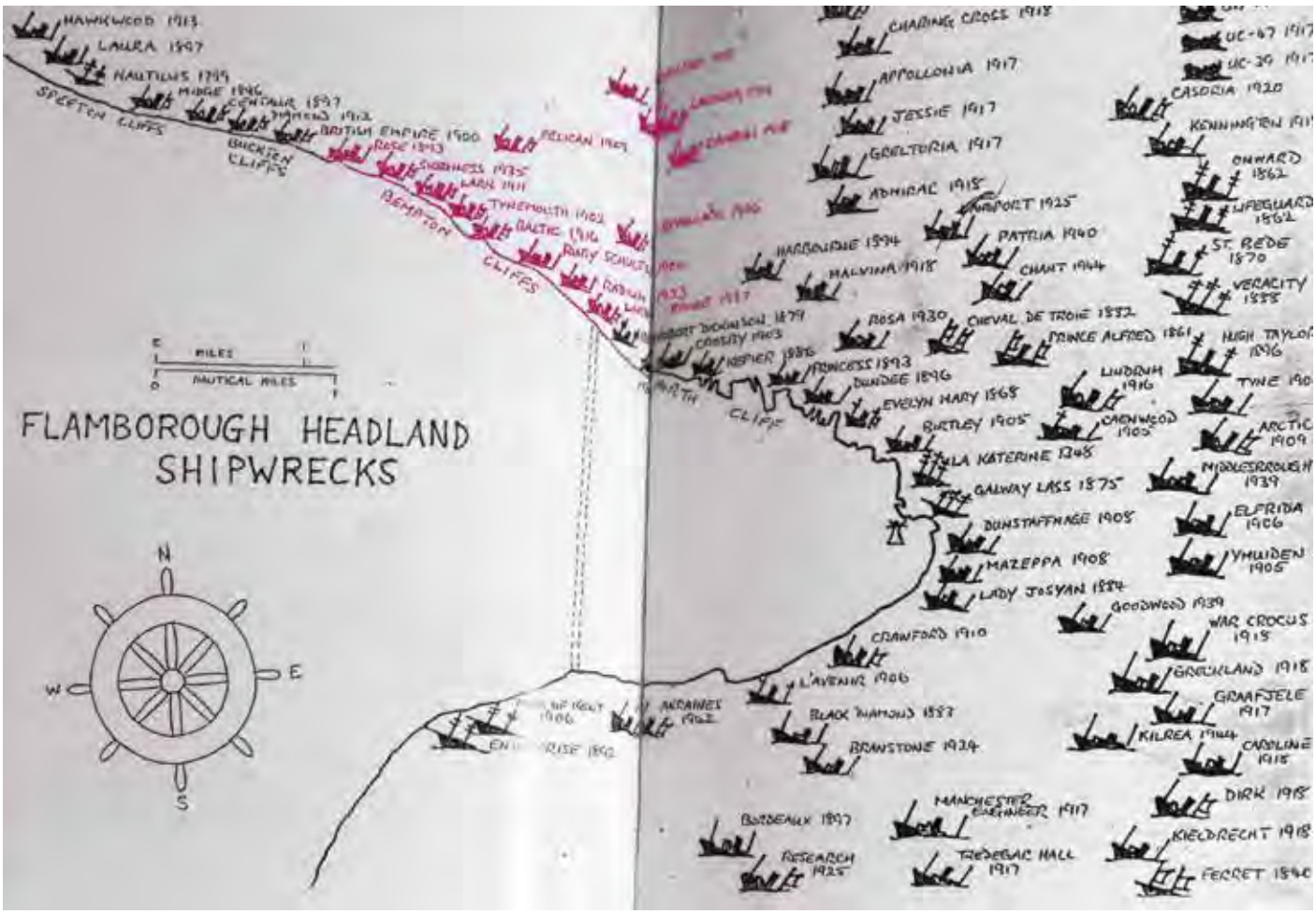


Fig.72

Fig.73

The Water Pump:
The water pump is a symbolic feature of Bempton, and was restored in 2003.

Fig.74

The Village Pond:
Playing a big role in Bempton's agricultural history, the village pond was previously utilised as a watering station for the animals, and was somewhat seen as the heart of the community. A spring is located beneath the pond, where a well was fitted during the 1700s (Wardlow, J., 2020.)

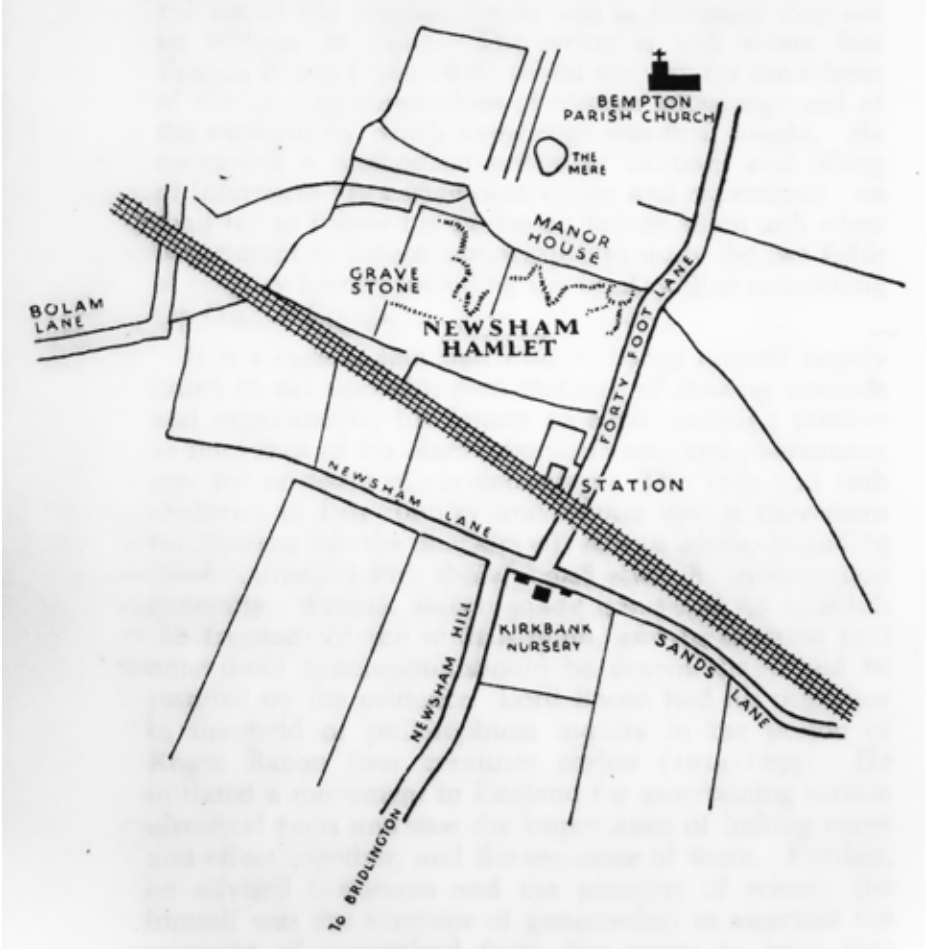


Fig.75

The Lost Village of Newsham:

The biggest mystery evolving around Bempton is the lost village of Newsham thought to date back to the early Middle Ages. As no local authority was responsible for preserving its heritage at the time, there is no solid record of Newsham, only clues to its existence.

Signs of buildings that once existed along the perimeter of an open field suggest a village once stood there. However, claims advise excavation wouldn't be worth while, as the locally-quarried chalk used to build cottages is thought to have been burnt to make lime for the land, so now only a few of the original cottages remain (Rudkin, E., 1948.) Furthermore, the land is now protected.

Another clue to the village's existence is the lonely grave that lies in an open field dating back to 1721 to a Henry Jarratt. It was believed he was an eccentric soldier, in order to have a grave on its own. Although he likely did fight in some battles, research has since revealed he was infact the Churchwarden (Wardlow, J., 2020.)

Fig.76

Grange Farm:

The Walkers have owned The Grange (a dairy farm) for decades and are also the landowners of the now disused RAF site (Wardlow, J., 2020.) Harry Walker ran the farm when the RAF Station was in operation, Brian Walker then took over but has since retired leaving it to his son, Steven (Wardlow, J., 2020.)

Fig.77

The highest point of their private land is Standard Hill, where the original CH Station was situated (Singer, A., 2001.)

Fig.78

Fig.79

A Timeline of Local Agriculture:

Early 20th century:

Most residents of Bempton were farmers; the streets were always dirty with the cows wandering freely, and there was a real sense of community (Singer, A., 2001.)

Fig.80

1939-1950:
The women's land army (WAAF) occupied Bempton (Singer, A., 2004.)

2001:
A national outbreak of foot and mouth disease hit Bempton's main industry of farming hard forcing farmers to choose between persevering, diversifying, or changing profession (Singer, A., 2004.)

Fig.80

Today:
90% of land in East Riding of Yorkshire is still dedicated to agriculture (East Riding of Yorkshire Council, 2019.) With an ageing population and industry in decline, the need for modernisation is vital for Bempton to maintain its heritage whilst boosting its local economy. With an existing farm sitting atop a disused RAF bunker, the site poses the perfect opportunity to combine traditional and modern farming techniques.

Fig.81

Site Analysis

03

Bempton Demographics:
According to East Riding of Yorkshire Council 2011 census and 2019 estimates.

Population: 1,062
Dwellings: 527
(Small parish.)

Average ages:
- 10.92% 0-15
- 46.7% 16-64
- 42.37% 64+
(Ageing population.)

Ethnicities:
- Less than 0.5% non-white.
(Lack of diversity.)

Health:
- 1/3 reported 'very good' health.

Occupation:
- 16.3% in skilled trades.
(Note: 36.7% are retired and economically inactive.)

Deprivation Index:
- 40-50%
(One of the least deprived.)

Cities within 100mile radius of Bempton and local towns within East Riding of Yorkshire, where the greens produced in the bunker could potentially be distributed to.

Until 1954, RAF Bempton received rations from Driffield (Hepworth, G., 2020.) The proposed scheme can give back.

Fig.83

Man-Made Landmarks:

1. Bempton Station
2. Village Water Pump
3. St. Michael's Church
4. Bempton Post Office
5. The White Horse Inn
6. Bempton Primary School
7. Community Village Hall
8. Jaw Bones Corner
9. Bempton Chalet Park
10. The Lonely Grave of Henry Jarrett
11. Grange Farm
12. Original RAF CH Station Site
13. The RSPB Centre
14. RAF Bempton

11

12

13

14

Fig.84


Key:
= Public Footpath
= Main Roads + Car Park
= Railway + Station
= Private Footpath
= Private Road
RAF Bempton
N
M
L
RSPB Centre
+ Car Park
K
J
I
Grange Farm
H
Cliff Lane
G
F
D
E
C
B
A
Bempton Station

Fig.85

Journey from Bempton Station to RAF Bempton.

(30min. walk)

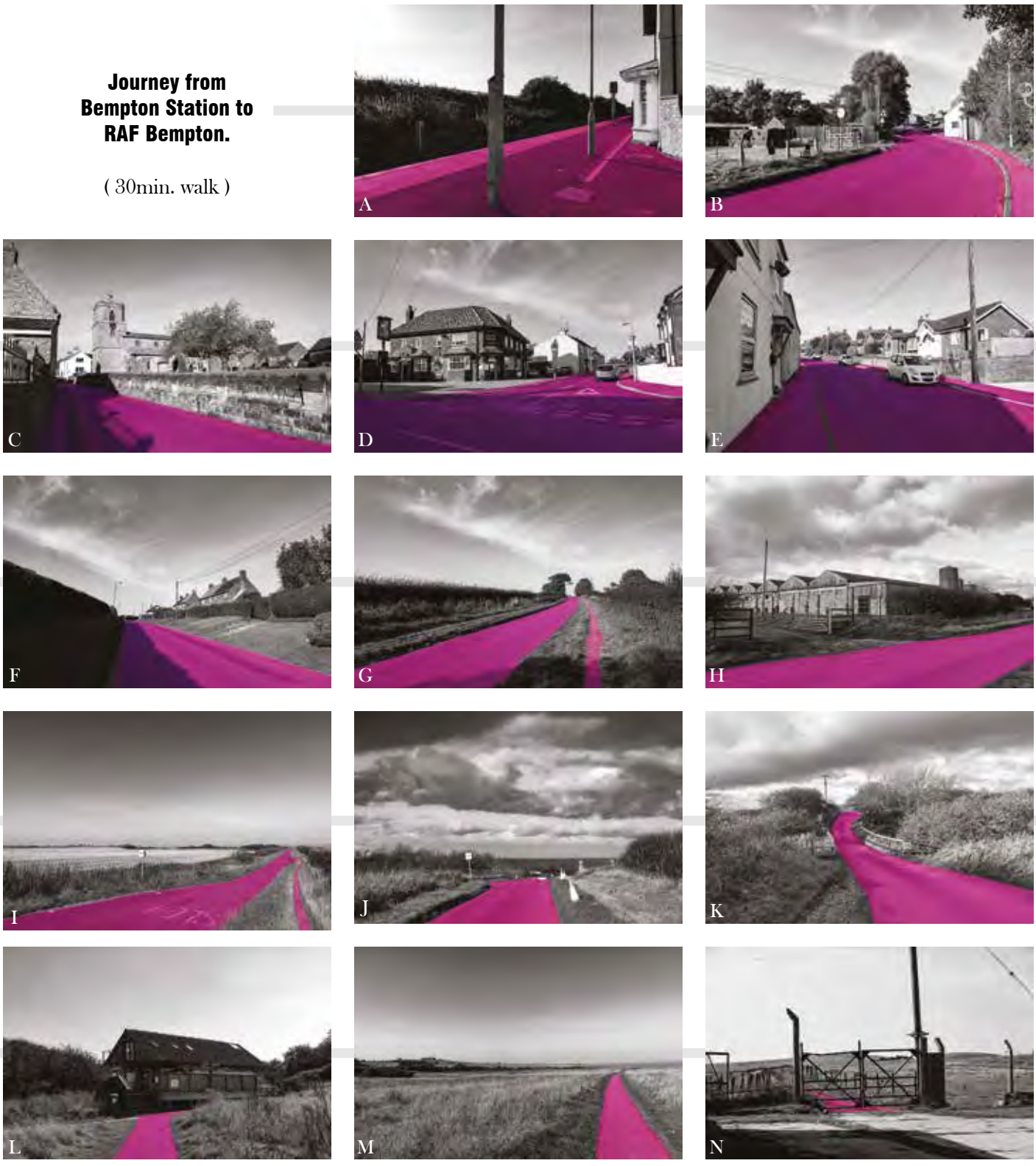


Fig.86

Whether a resident of Bempton, from a neighbouring town or a tourist, everyone ends up on the same direct route to Bempton Cliffs, whether it by car or foot, via Cliff Lane. Once off the road, there are two paths: one leading through Grange Farm on private land past the original RAF site, and one accessible via the RSPB centre. Both loop around the field that RAF Bempton is situated in allowing potential accessibility from almost every angle depending on the restrictions placed by the current landowner.

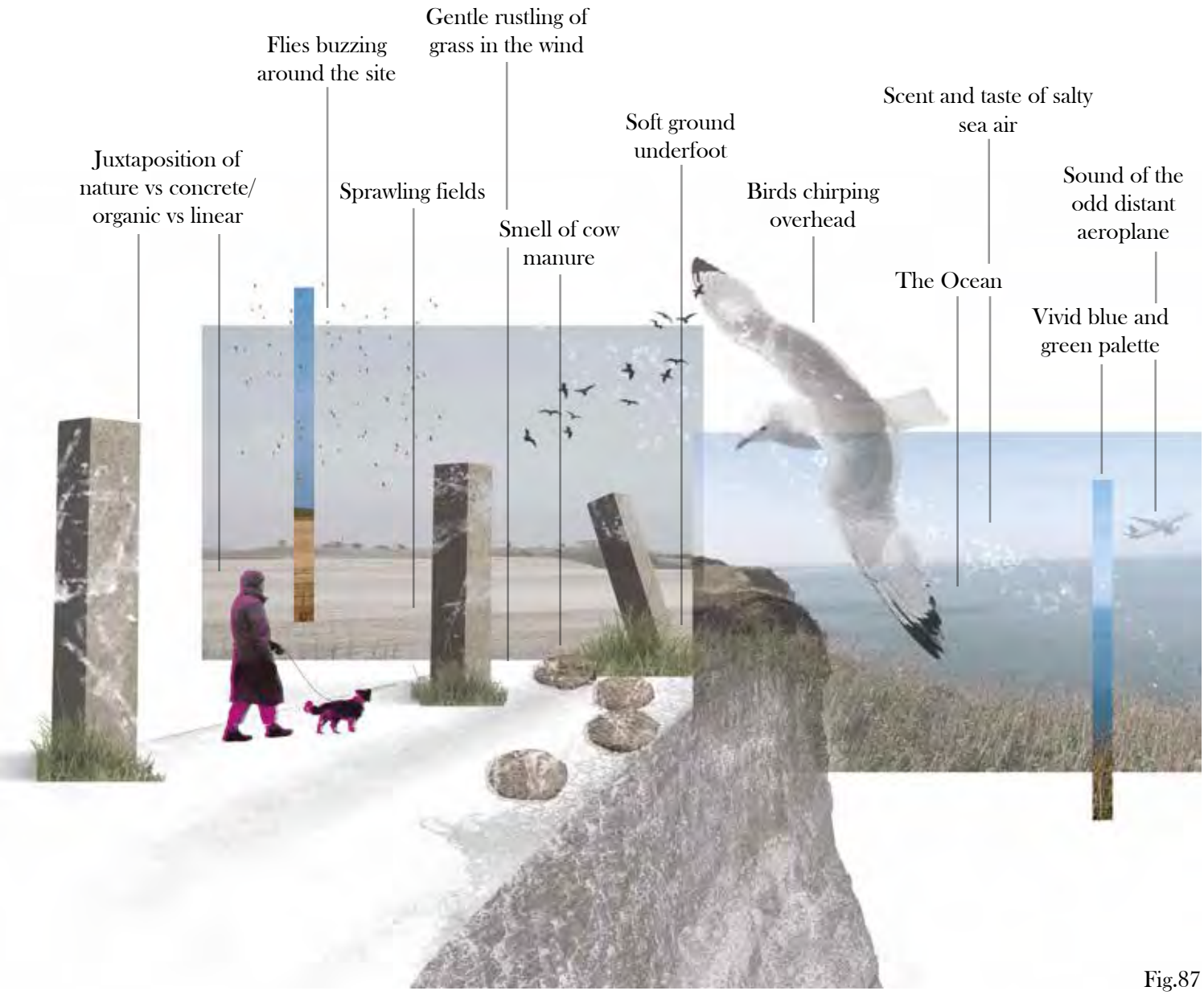


Fig.87

Immediate Reactions:

Although the weather changes the atmosphere of the surrounding site upon each visit, the remnants of the RAF station's surface buildings still carry an underlying darkness. Their weathered, empty shells combined with the association of war is somewhat haunting even on a sunny day. Each solid, concrete block stands strong on the hilltop holding their ground like soldiers holding their posts. In isolation and surrounded by nature, the site feels almost post-apocalyptic, as though nature has regained control over the abandoned, man-made infrastructure. However, the bunker doesn't sit completely alone. Neighbouring is an RSPB centre, where keen birdwatchers (primarily of the Caucasian, elderly demographic) wander around the perimeter of the cliff edge, whilst birds swoop and chirp with the wind overhead. The ground is soft underfoot, and the grass gently rustles in the sea breeze. Apart from the odd passing smell of cow manure, the landscape is truly stunning and picturesque; its natural yet vivid colour palette is particularly charming.

The RSPB:

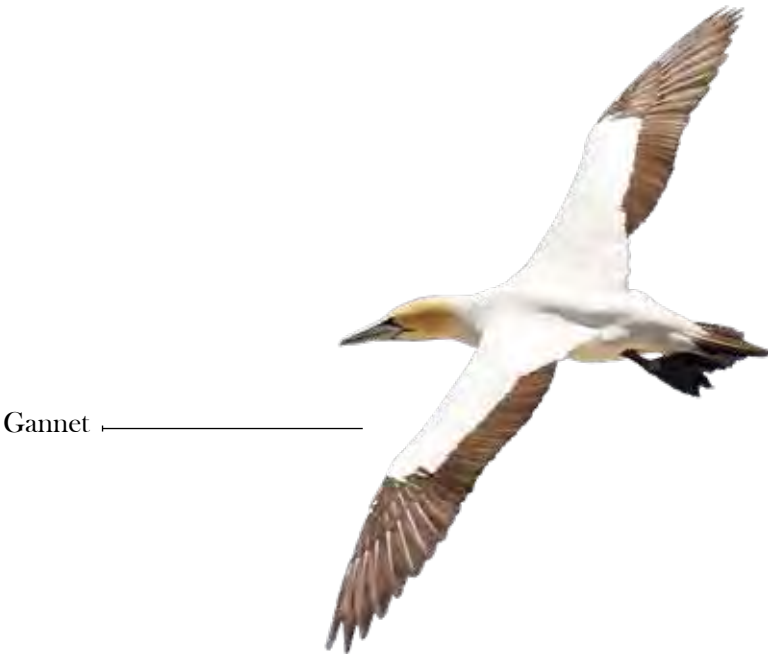
The RSPB purchased 3 1/2miles of cliff top and opened a seabird centre in 1992 (Singer,A., 2001.) The sanctuary was redeveloped in 2015, with funding from Heritage Lottery Fund, Coastal Communities Fund, and Biffa Award. They also receive funding from the European Agricultural Fund for Rural Development to provide educational services (RSPB, 2020.) The sanctuary hopes to increase its protection status in the future and continue to educate the public.

Birds:

- Kittiwakes; considered to be the best indication of the health of the North Sea (Singer, A., 2001.)

- Gannets; Bempton has the largest mainland gannetry in England (RSPB, 2020.)

- Also, puffins, guillemots, barn owls and tree sparrows are commonly seen (RSPB, 2020.)



Gannet

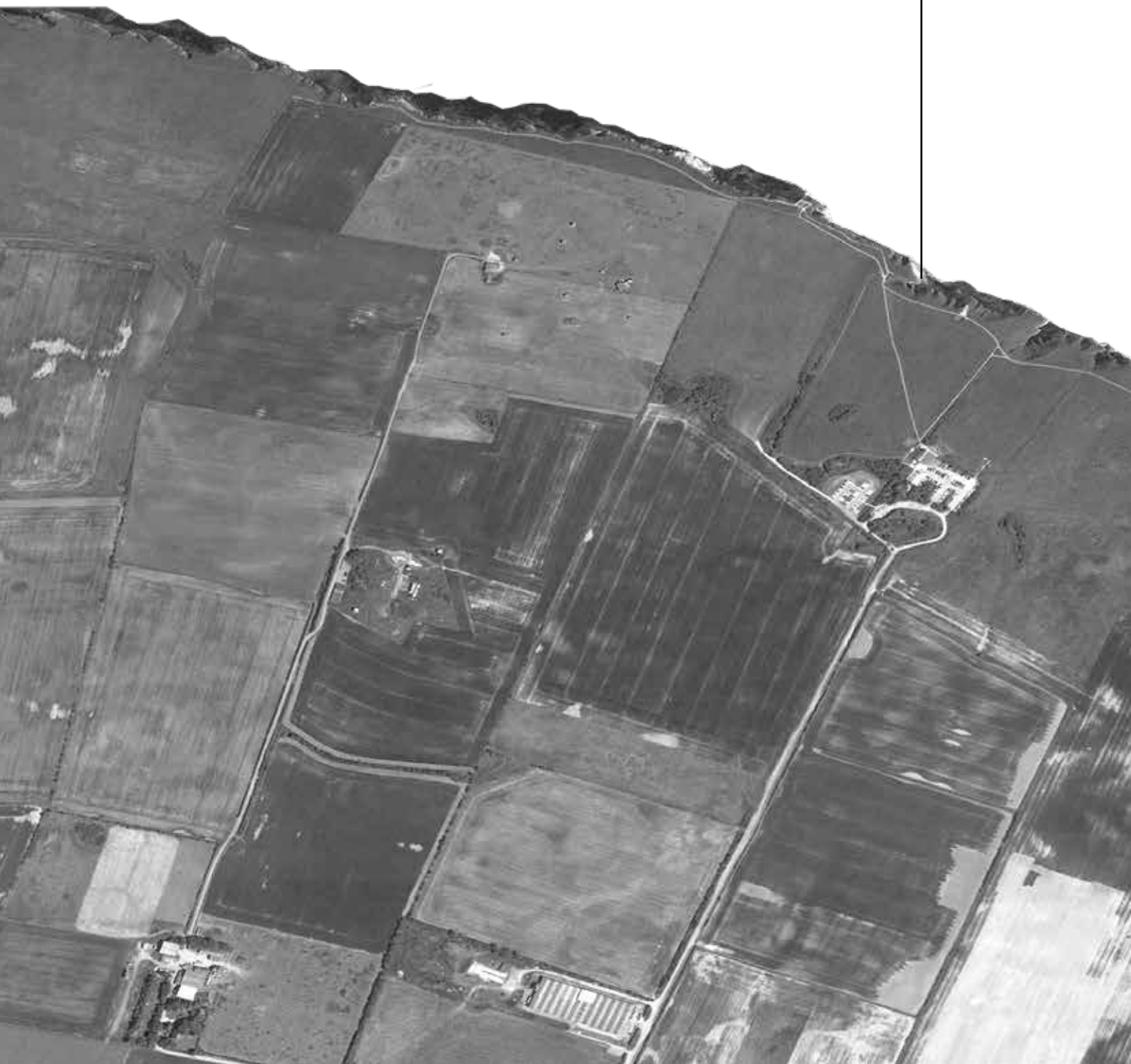
Kittiwake

Fig.91

Natural Landmarks:

1. Mosey Down Gate. Site of a geo.
2. Staple Newk. Site of the arch known as 'the elephant'.

1



2

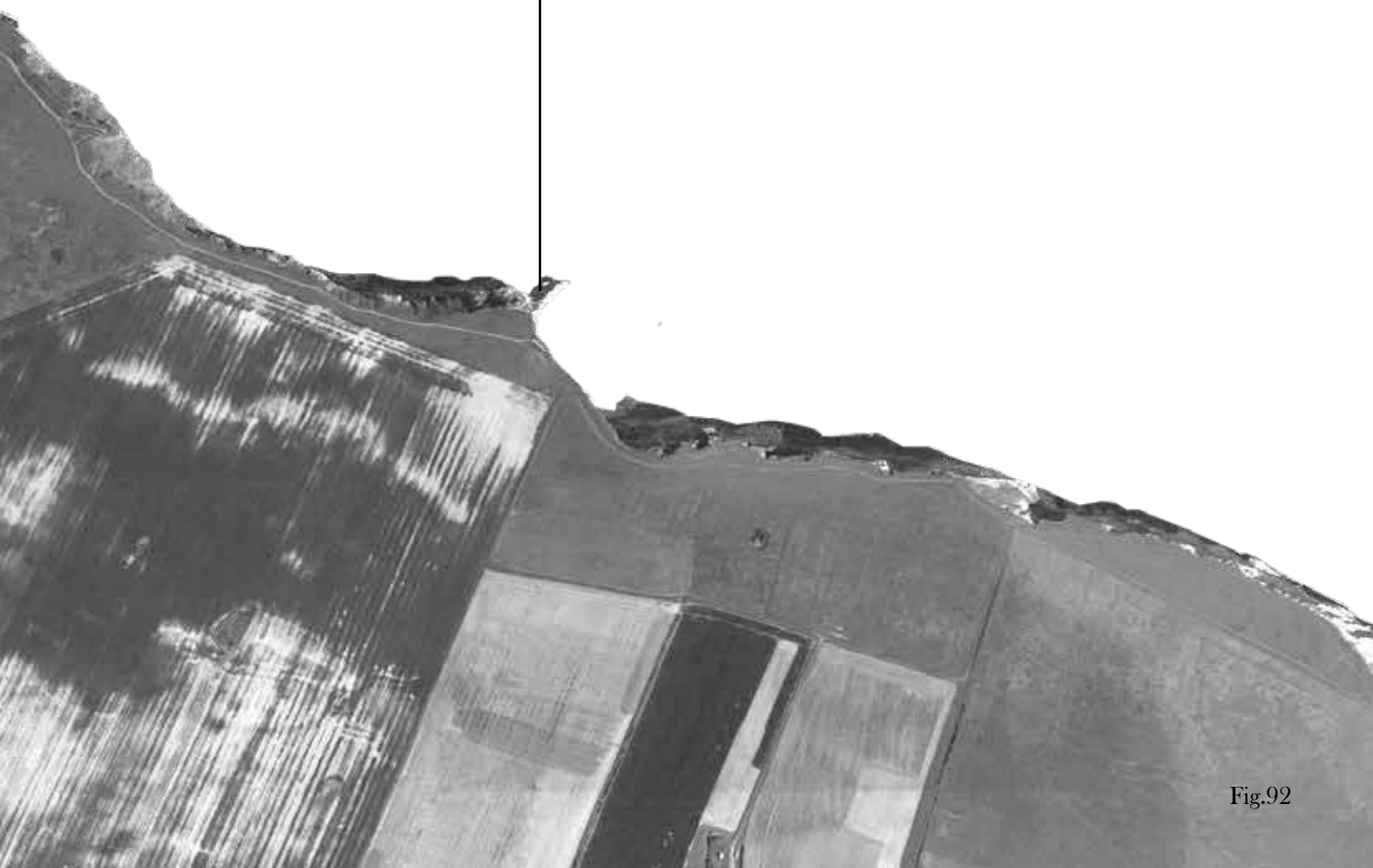


Fig.92

Water:

Naturally, the closest/largest water source is the North sea but there are also a number of other local drains, ponds and springs around the site too. As water is essential in hydroponic farming, local water supplies could potentially be of value to the project.

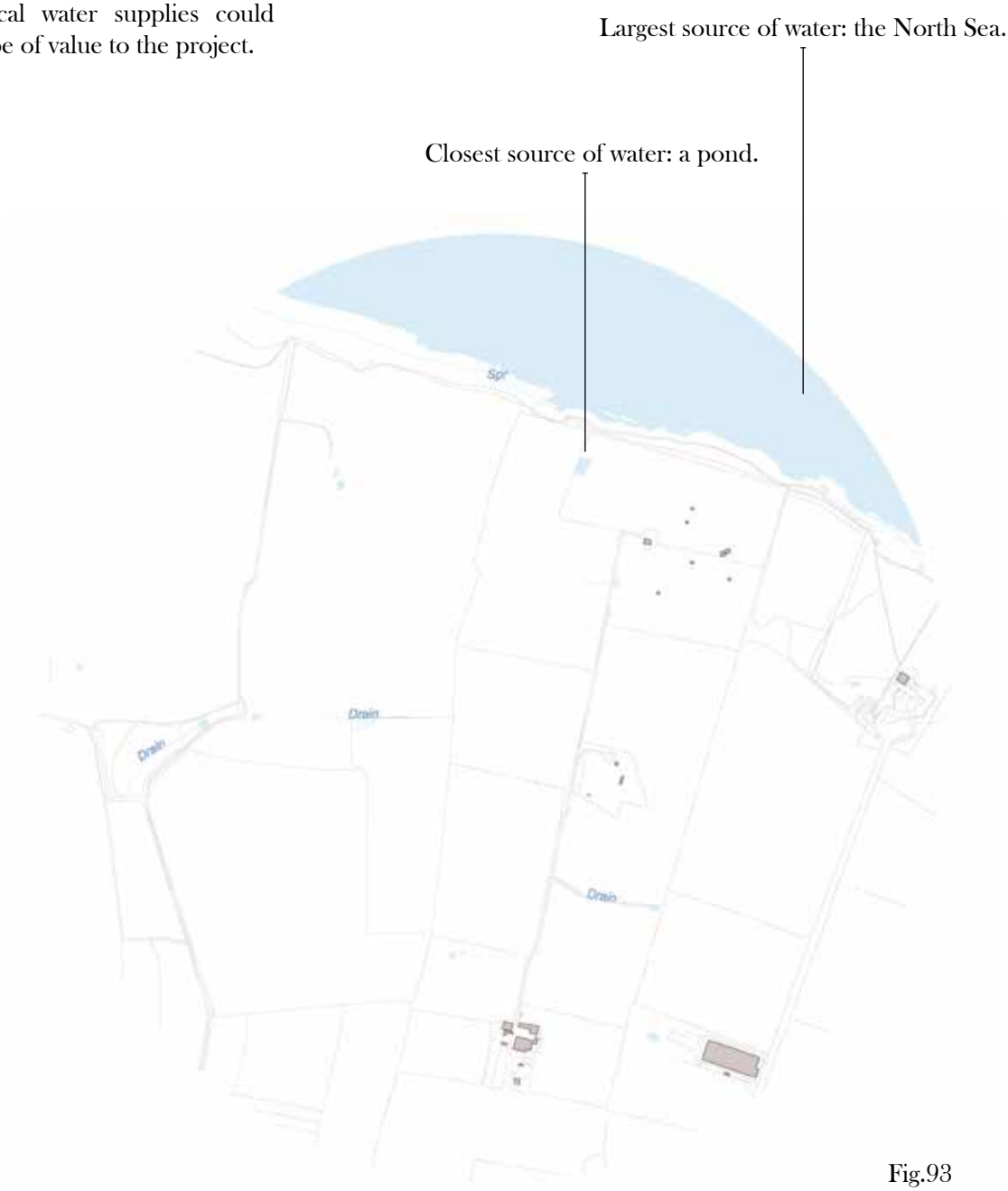


Fig.93

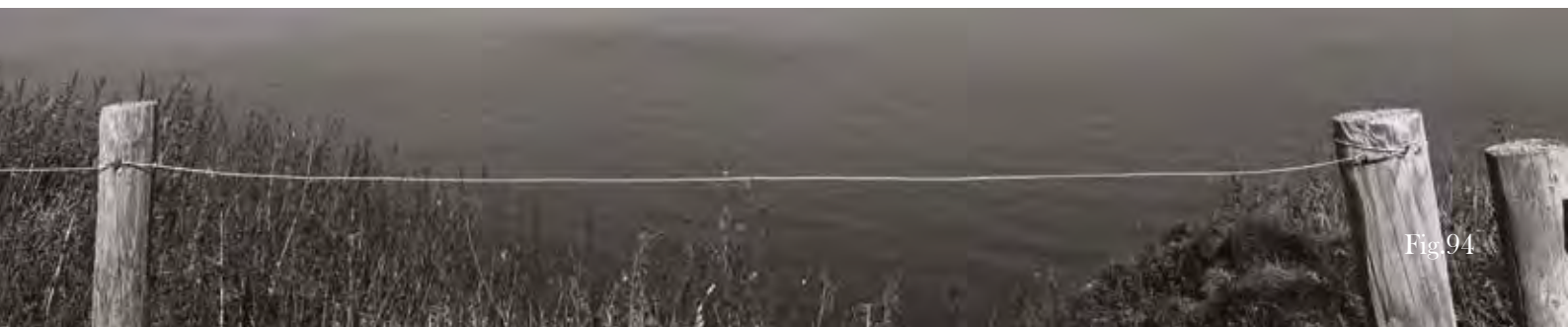


Fig.94

Foliage:

Despite being in the middle of the countryside, there is somewhat a lack of foliage. As the land has been dedicated to farming for decades, only fields surround the site; the site lacks natural forms of shelter. The main area of foliage around the site is a cluster of trees and shrubs on the eastern perimeter.

Fig.95

Fig.96

Wind Analysis: Summer

During the summer, the prevailing wind direction is south easterly. Located on the coast and in a very exposed location, the site generally experiences strong winds all year round, but during the summer doesn't reach any higher than 40mph.

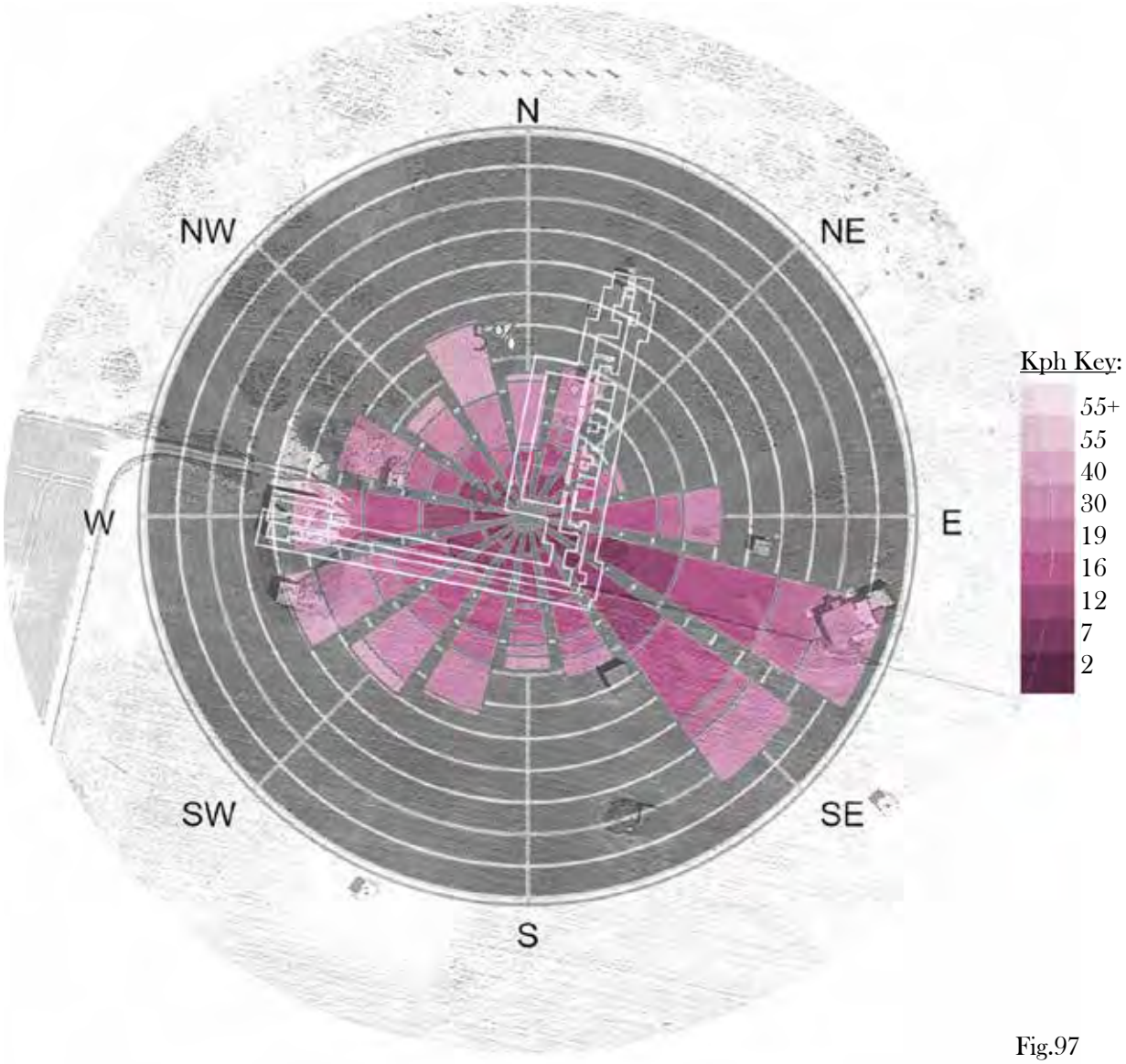


Fig.97

Wind Analysis: Winter

During the winter, the wind speed is much worse often reaching above 55+ kph. The prevailing wind direction in winter months is south and south westerly.

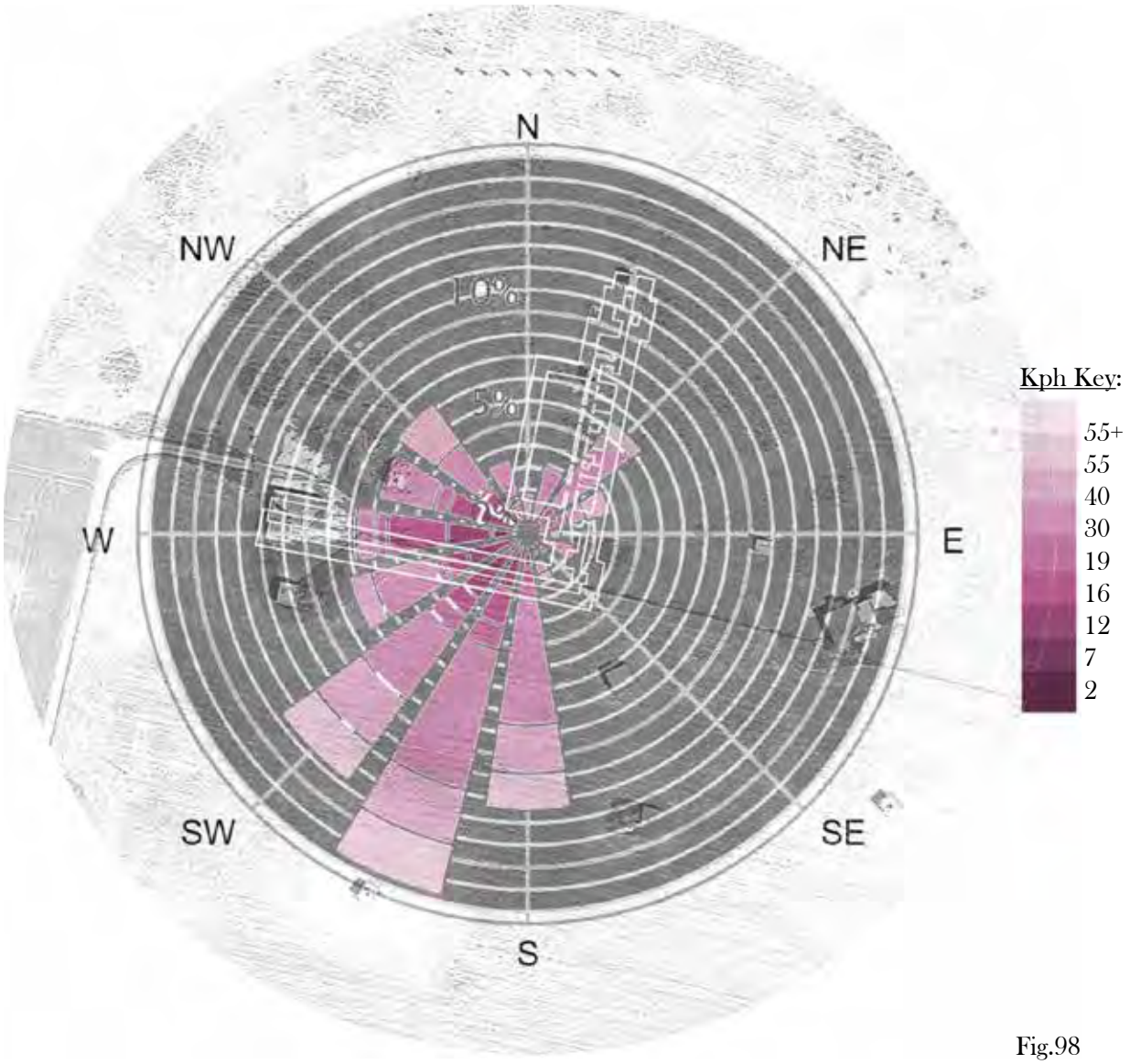
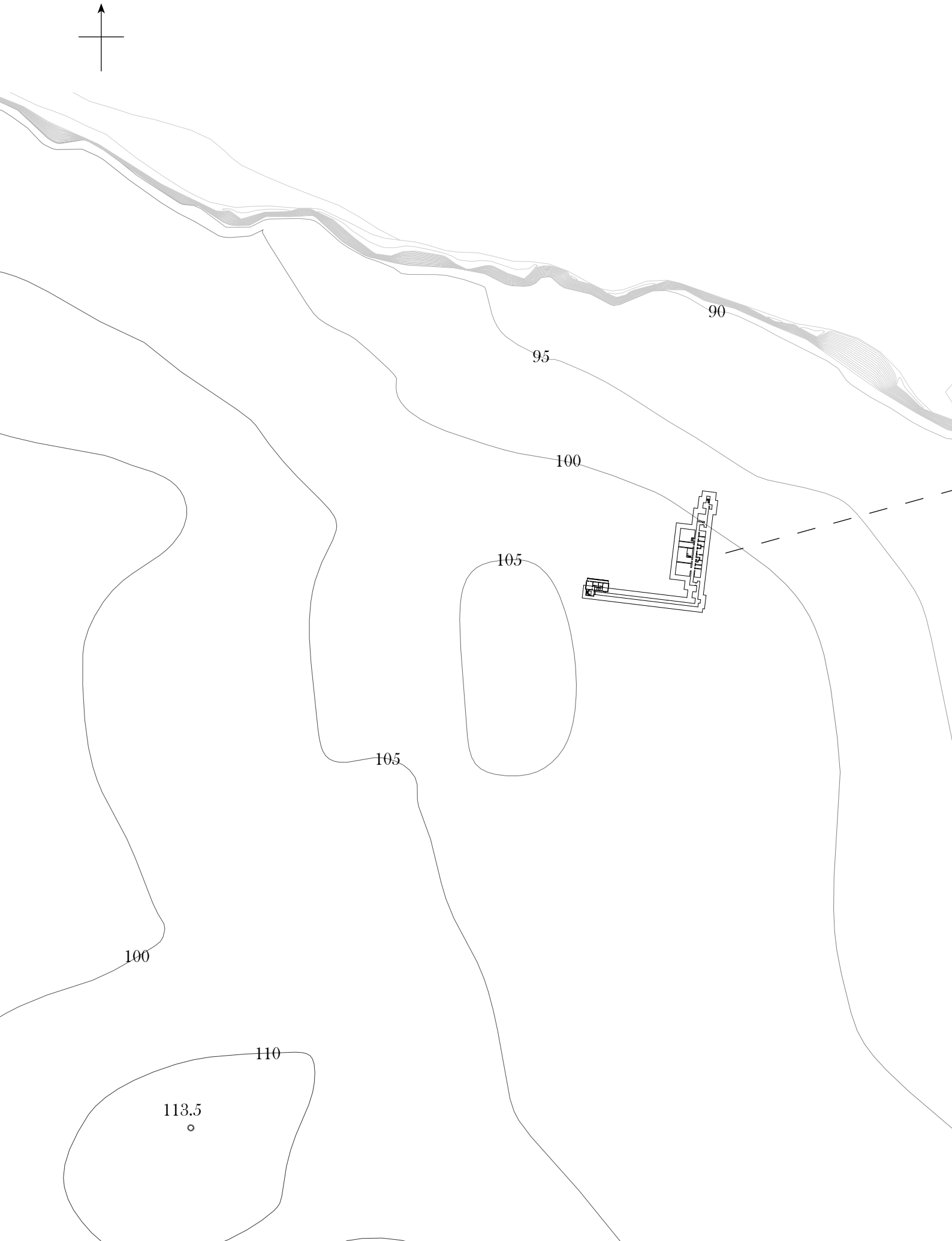
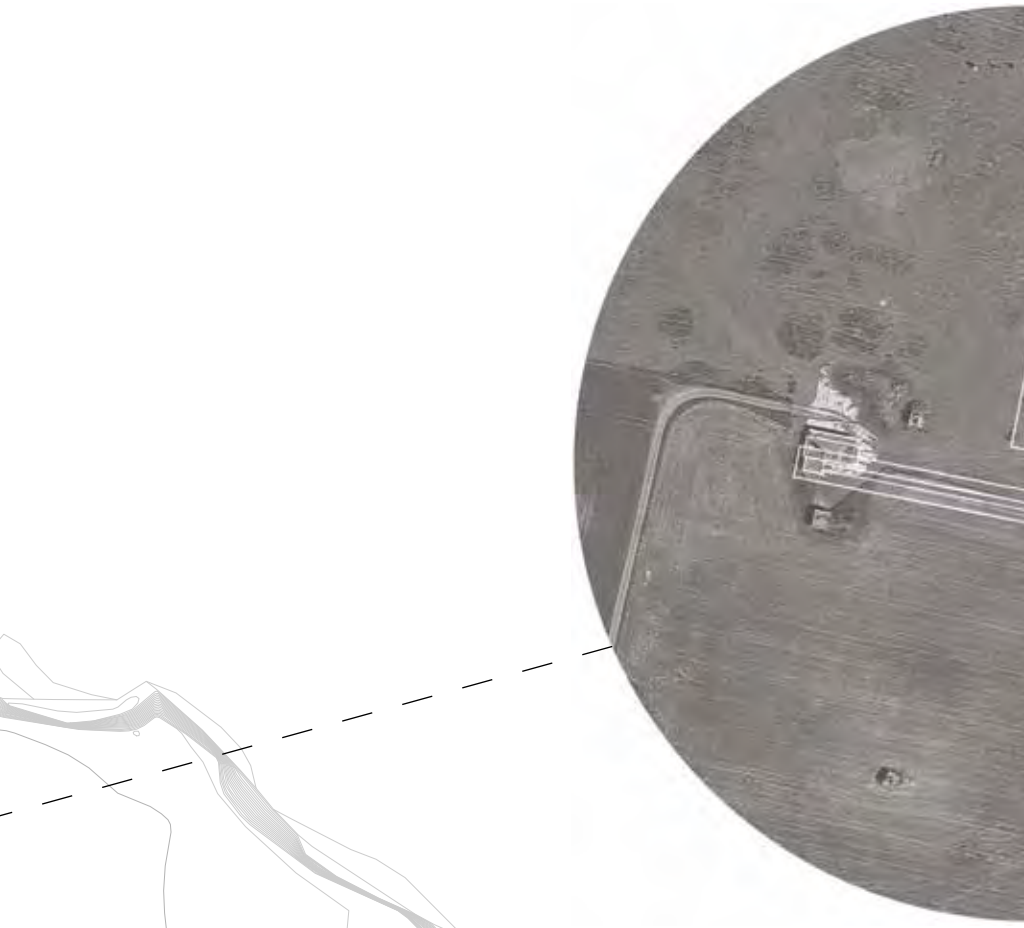
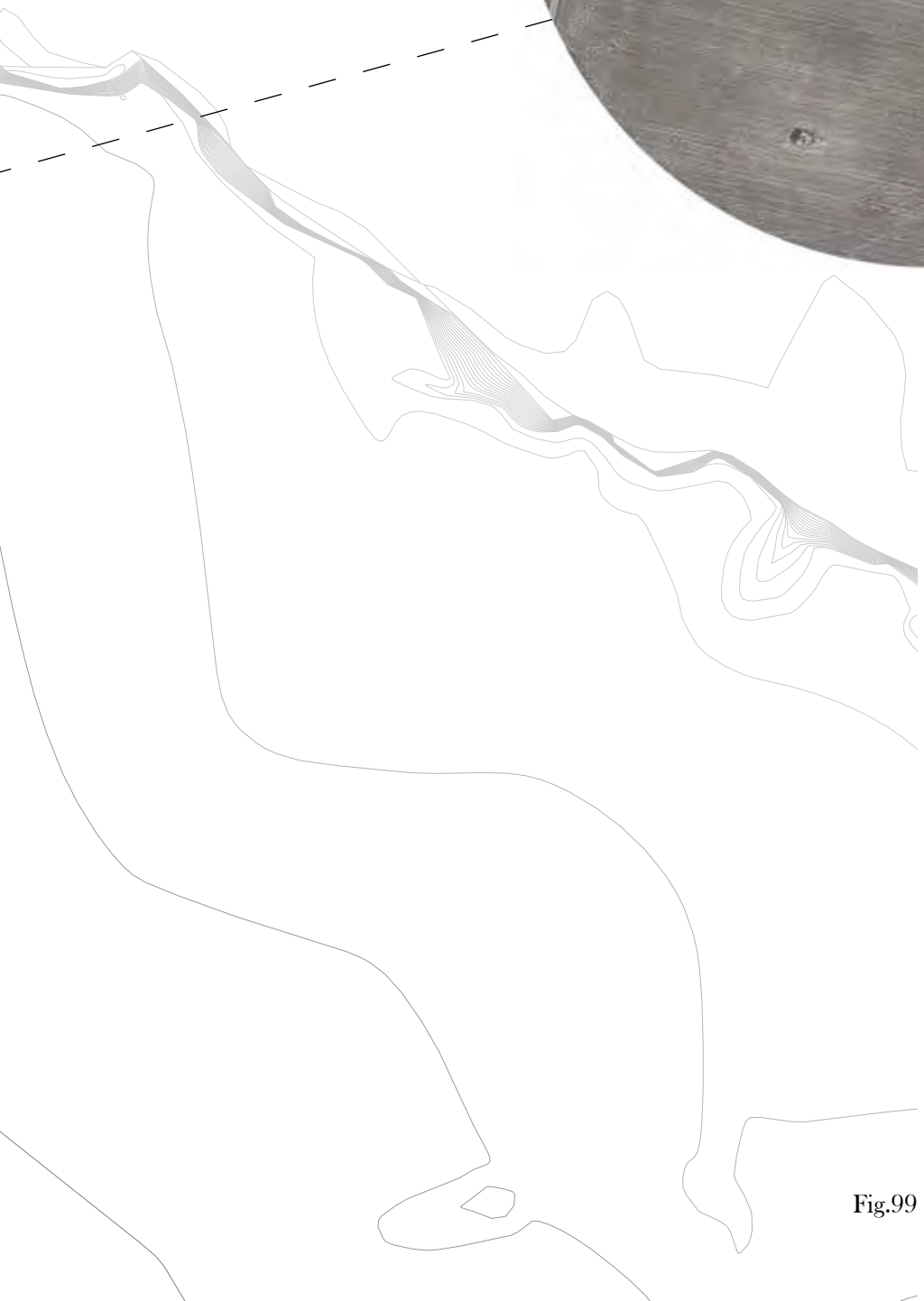


Fig.98

Although the bunker is sheltered from the winds underground, consideration should be made to the audial impacts via ventilation holes and thresholds.


90
95
100
105
105
100
110
113.5





Topography:

Having been placed at one of the highest points of the cliffs (the highest being Standard Hill), RAF Bempton has both the advantages and disadvantages of being located at the top of a hill.

With few obstacles both visually and physically, there's a lot of room for manipulation of the landscape and freedom with the design. However, high exposure to the elements above ground requires materials and structures with strength and longevity to withstand the harsher coastal conditions.

Fig.99

Fig.100

Geology: Bempton Cliffs are formed of chalk from the Cretaceous age (RSPB, 2019.) Eroded by the sea, as a result of having horizontal planes and vertical/diagonal cuts of weakness, ledges are formed by protruding flint and used by the birds as nesting sites (RSPB, 2019.)

Mosey Down Gate is the site of a geo, which was formed when compressed air in the chalk was forced out by the sea (RSPB, 2019.) The top of this geo has also collapsed.

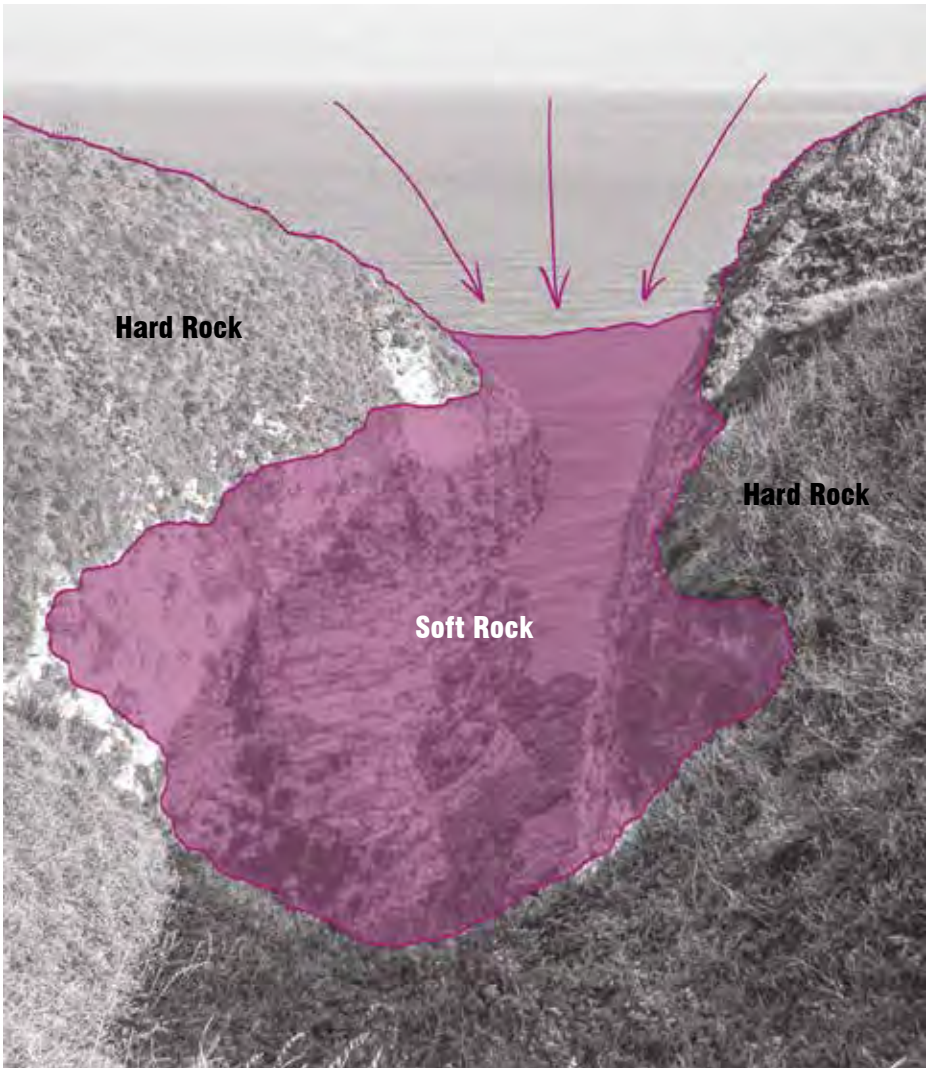


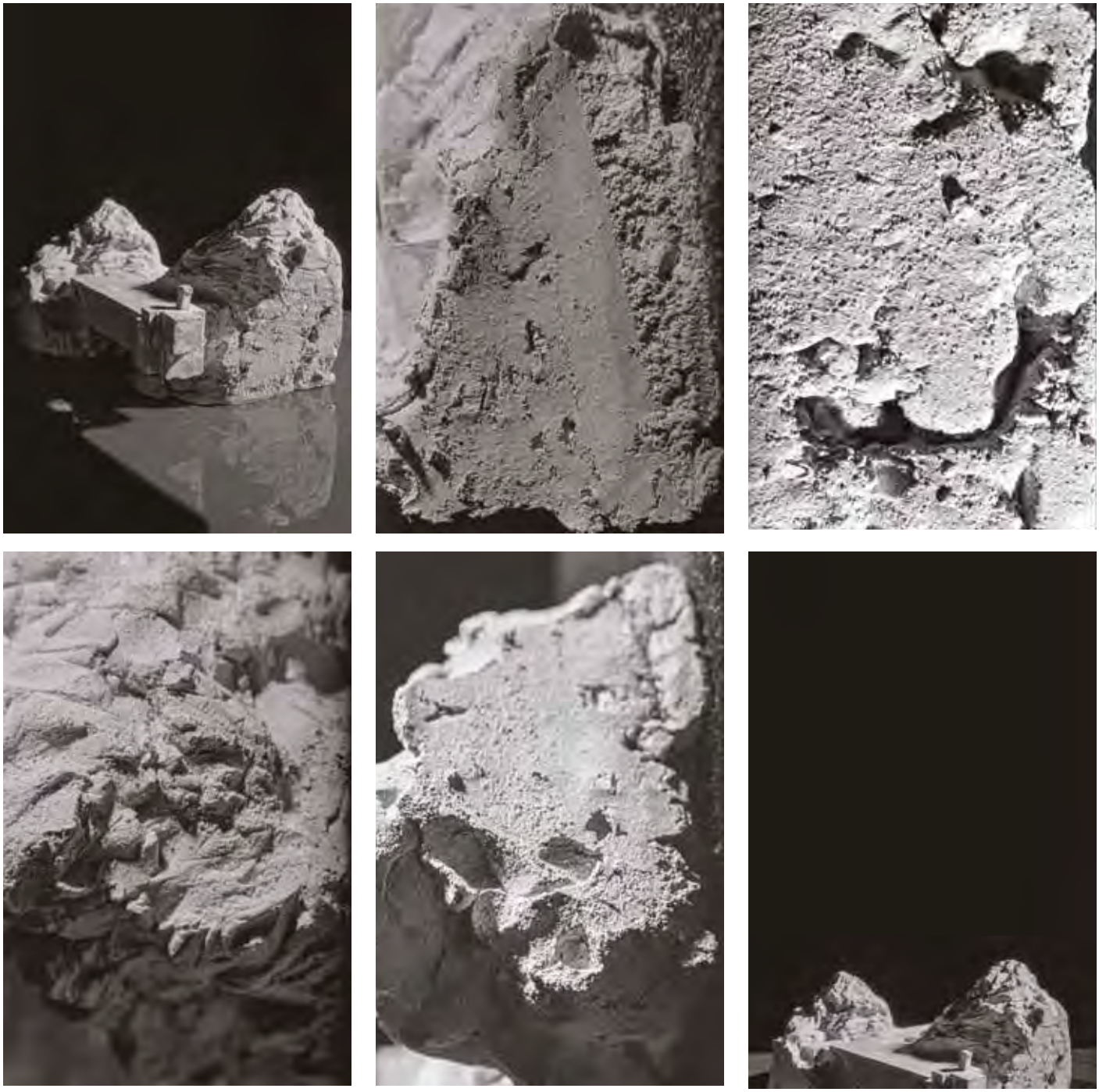
Fig.101

Fig.102

Fig.103

Fig.104

Site Combine: An exploration into some of the site and landscape's materials (clay, sand, gravel, chalk, concrete, and water), whilst also unearthing the bunker's form. The piece was photographed with 35mm film, as the radar screens had been in the RAF station from the 1950s onwards.



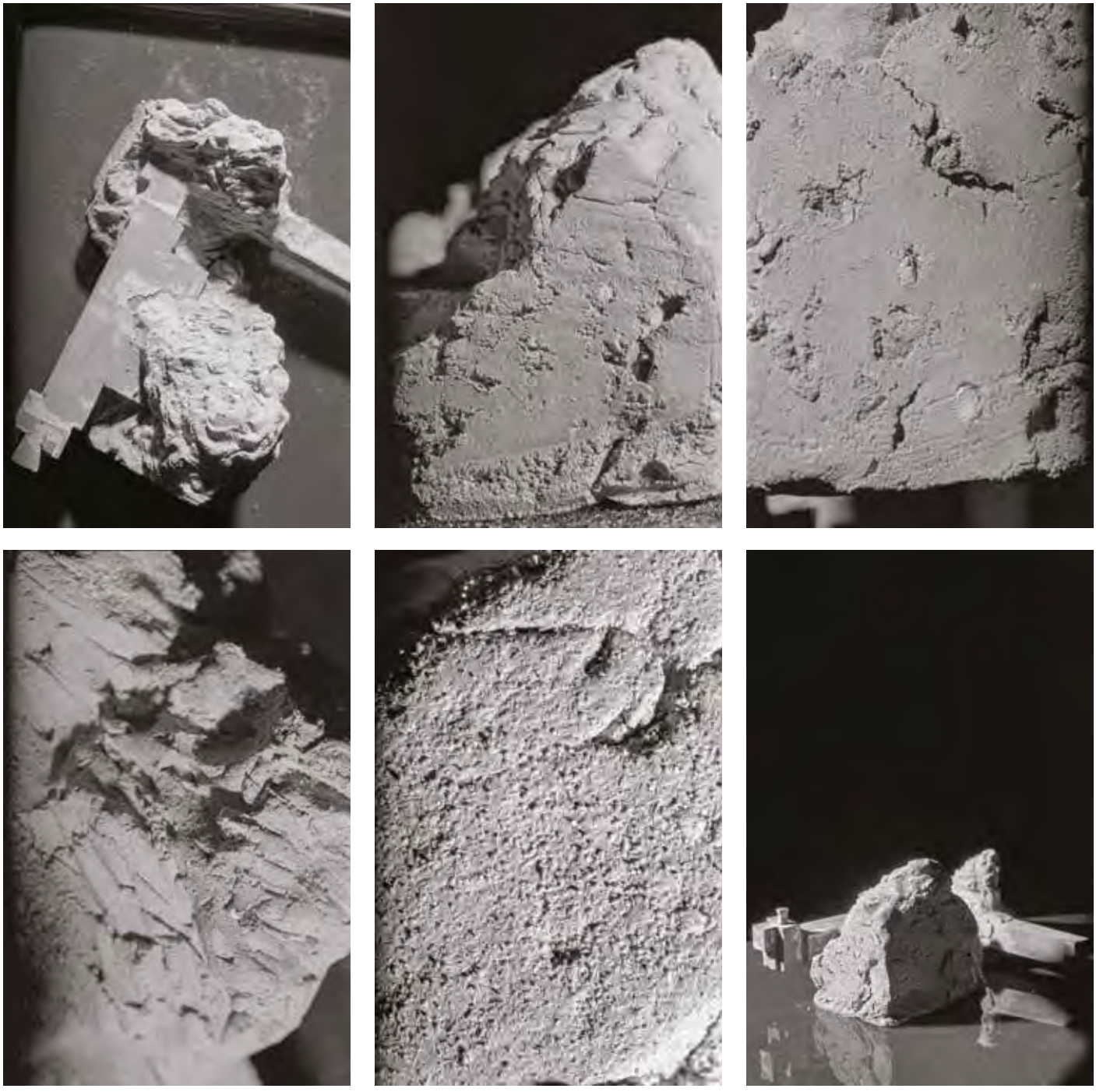


Fig.105

Fig.106

Fig.107

Wildflowers:

Chickweed

A common weed attracted to fertile soil (RHS, u.d.)

Fig.108

Red Campion

Flowering during the summer, their distinctive pink colour is reflective of the LED colours used in hydroponics. They're also indicators of ancient woodlands and hold importance to pollinating insects (Woodland Trust, u.d.)

Fig.109

White-Flowered Scurvy Weed

Before citrus fruits were imported, the grass was used in herbal medicines for its Vitamin C (Singer, A., 2001.)

Fig.110

Views: With the ocean sweeping round from the north to the north-east and sprawling fields in every other direction, every viewpoint from above ground is scenic with virtually no visual pollution. The only side without a completely uninterrupted view is the east, where the RSPB centre can be seen, but even that wouldn't be considered an eyesore.

W

S

N

E

Fig.111

04

Building Analysis


Fig.113

Wehrmacht Communications Centre.


Fig.114

RAF Holmpton - How RAF Bempton used to look.

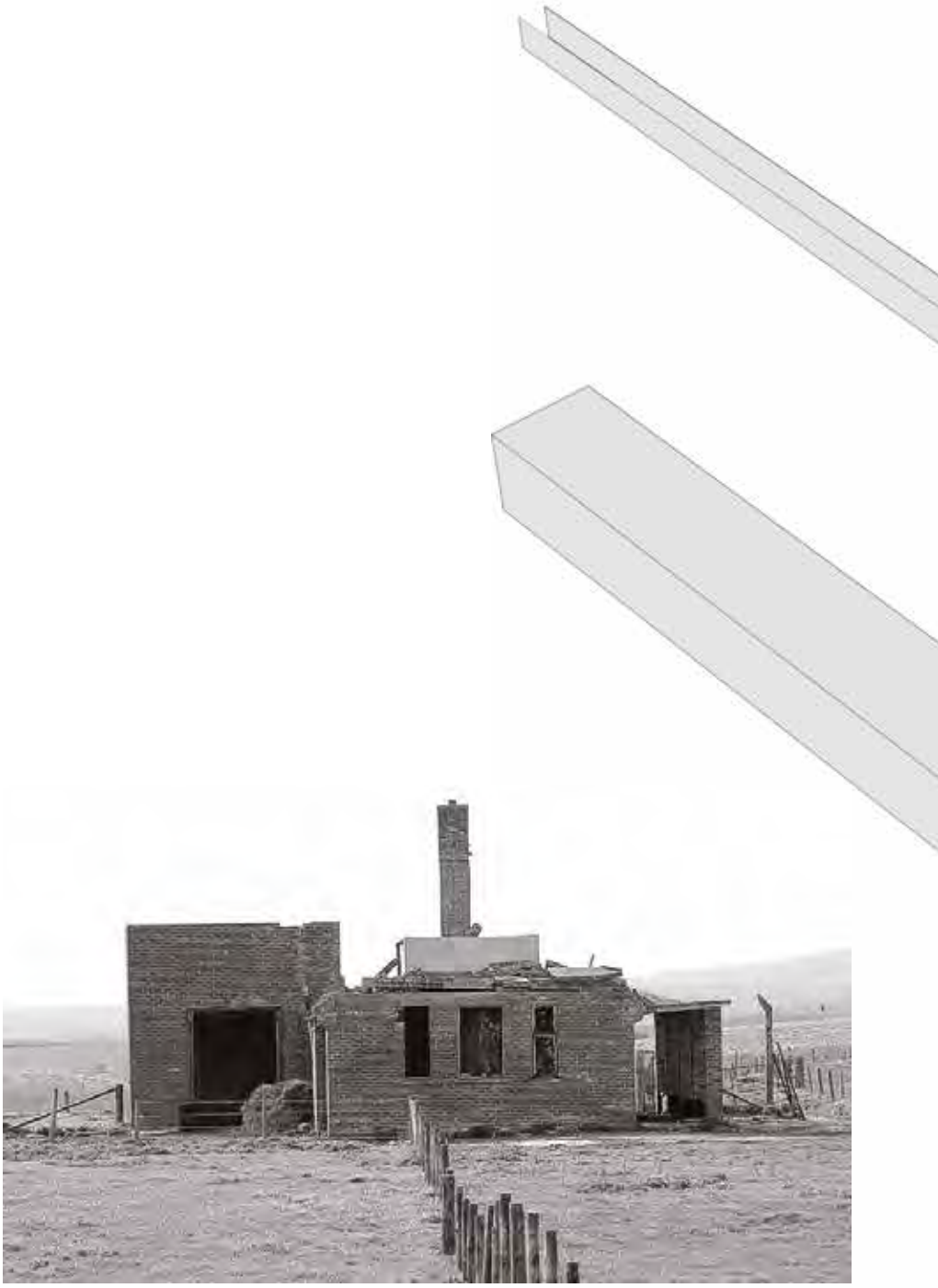
"The bunker was such a well kept secret that the locals were baffled at how so many men could fit into such a small building!"

(Wardlow, J., 2020.)

Architectural Style: The architectural language of the guardroom is considered to be heavily influenced by late 1930s German architecture, such as the Wehrmacht Communications Centre at Zossen Wünsdorf near Berlin (Cocroft, W., Thomas, R. and Barnwell, P., 2004.) Prior to the installation of larger radar heads, the aim had been to minimise visual pollution on the landscape, which had been a concern expressed by organisations like the Royal Fine Art Commission (Cocroft, W., Thomas, R. and Barnwell, P., 2004.)

To begin with, the RAF stations only consisted of a two-storey brick house to fit in with the local vernacular style as a form of camouflage to hide the rotor station from enemy aircrafts. However, from the 1950s onwards, they also became a cover for a secret stairway leading to a bunker.

The bunker was an underground, monolithic, concrete structure reinforced with steel rods at 6inch intervals (Cocroft, W., Thomas, R. and Barnwell, P., 2004.) Built during the cold war, the bunker was designed to withstand a nuclear attack.



RAF Bempton

Fig.115

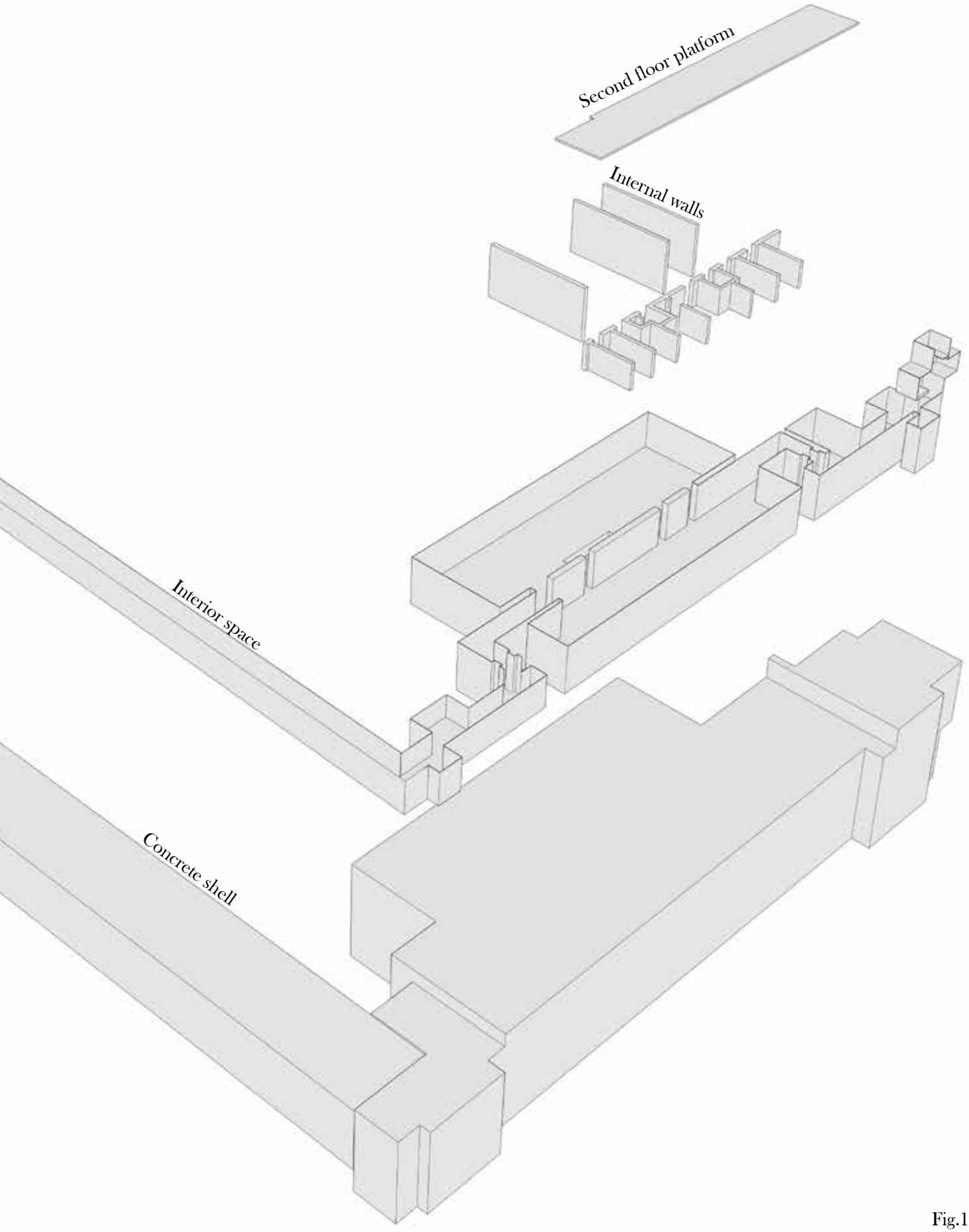
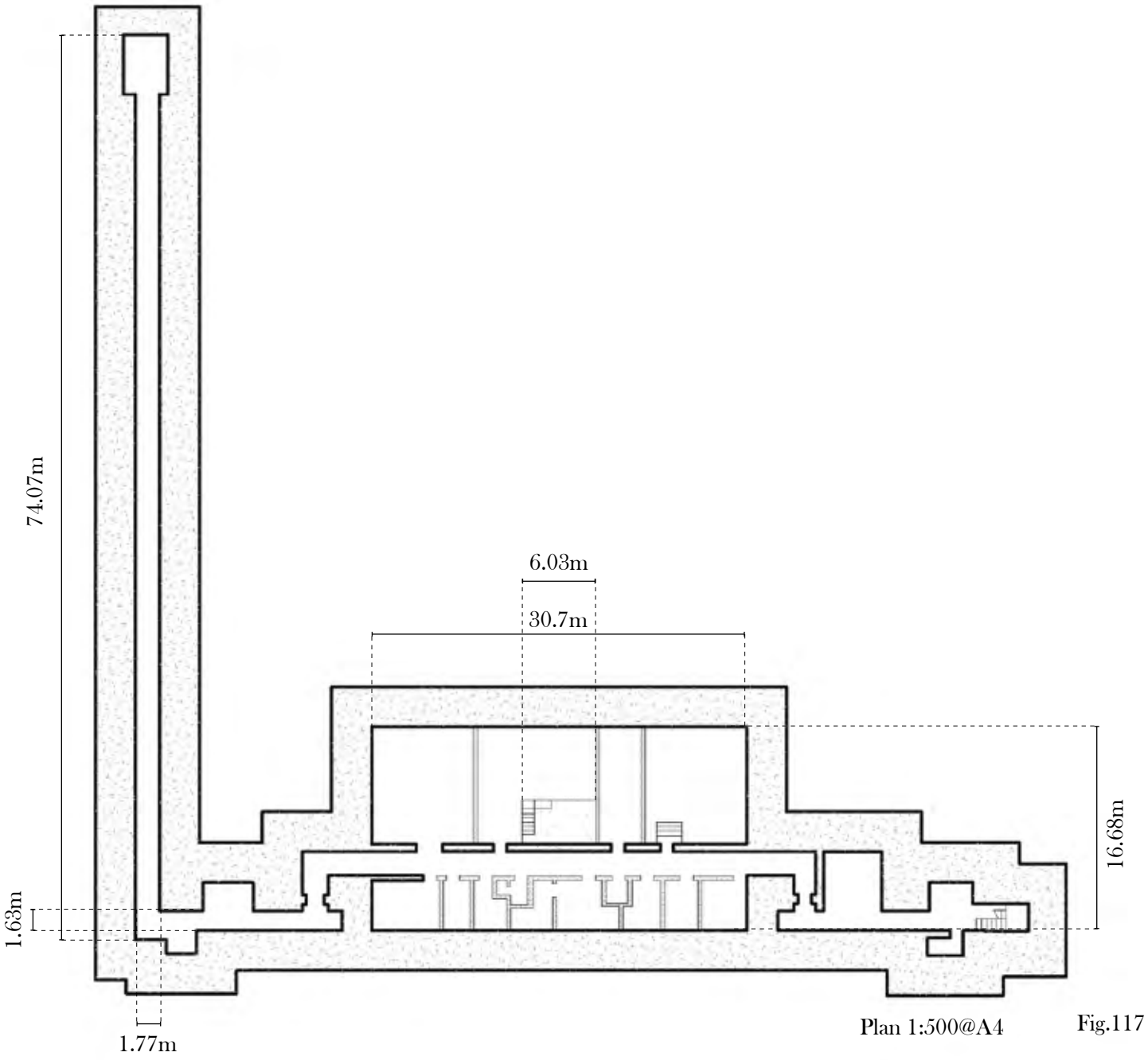

Second floor platform
Internal walls
Interior space
Concrete shell

Fig.116

The Bunker:

Originally designed during the cold war to withstand a nuclear attack, the bunker was buried in a hole 400ft across and 60ft deep (Higton, J., 2020.) Made from reinforced concrete, its shell is 10ft thick with another 10ft of earth covering it.



Plan 1:500@A4

Fig.117

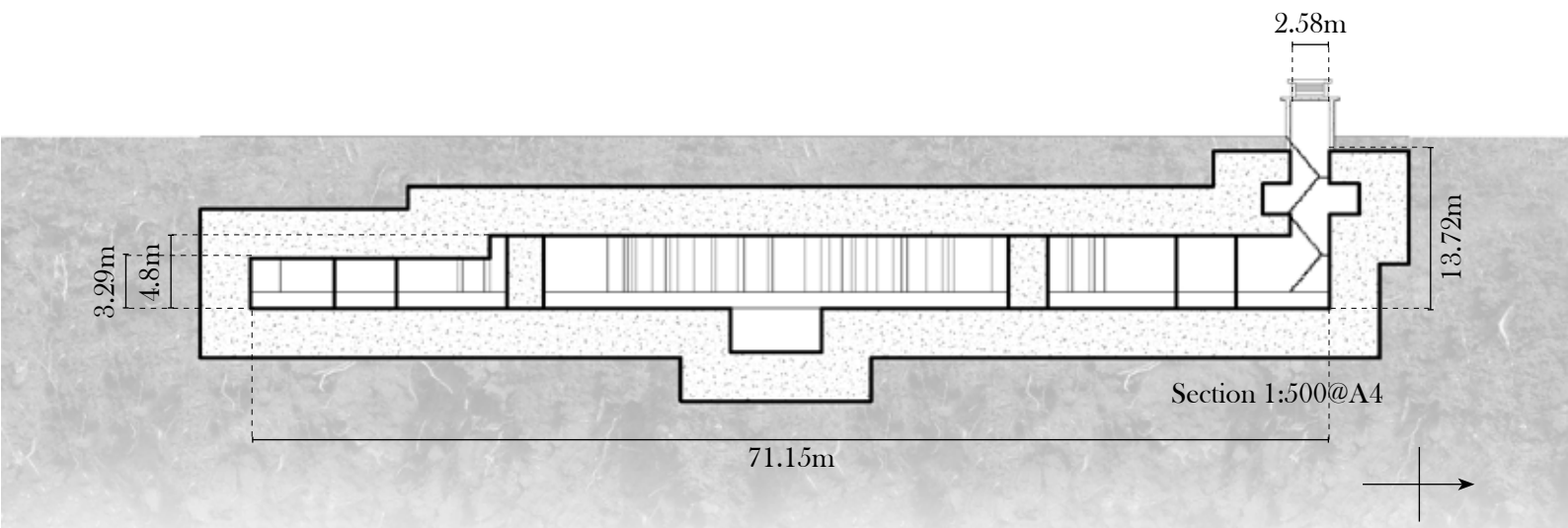
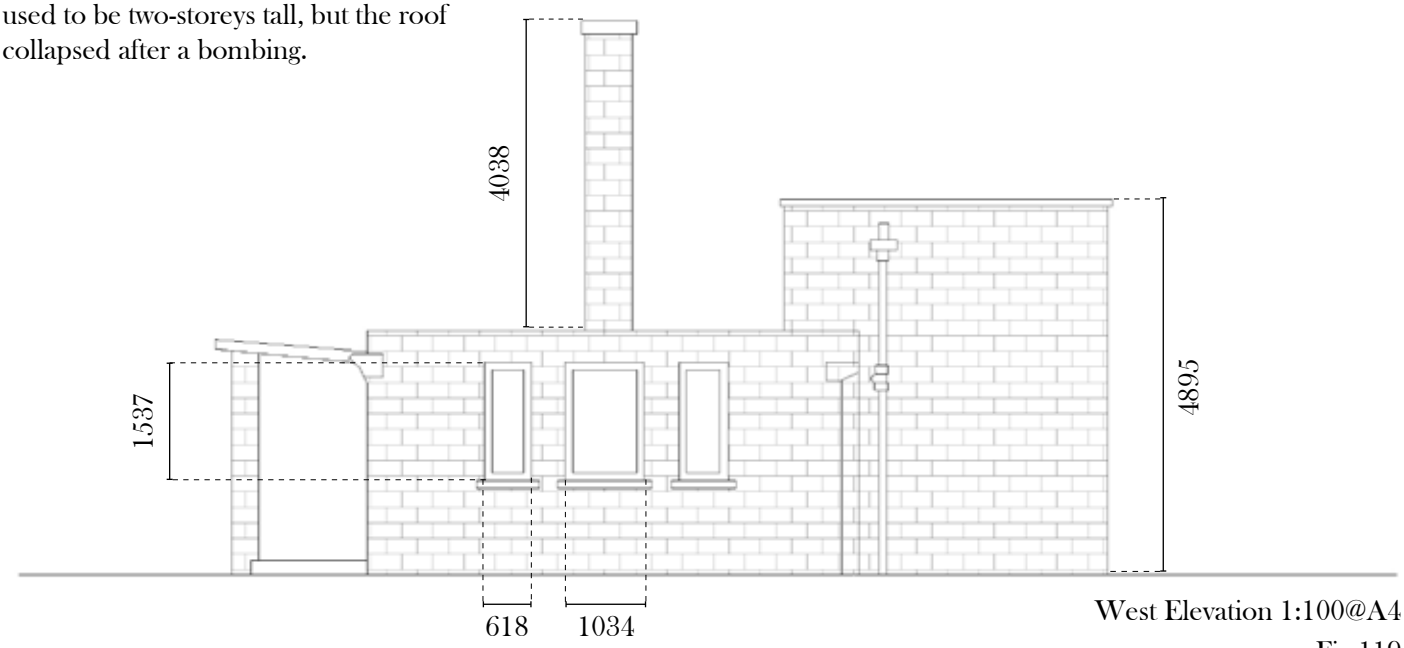


Fig.118

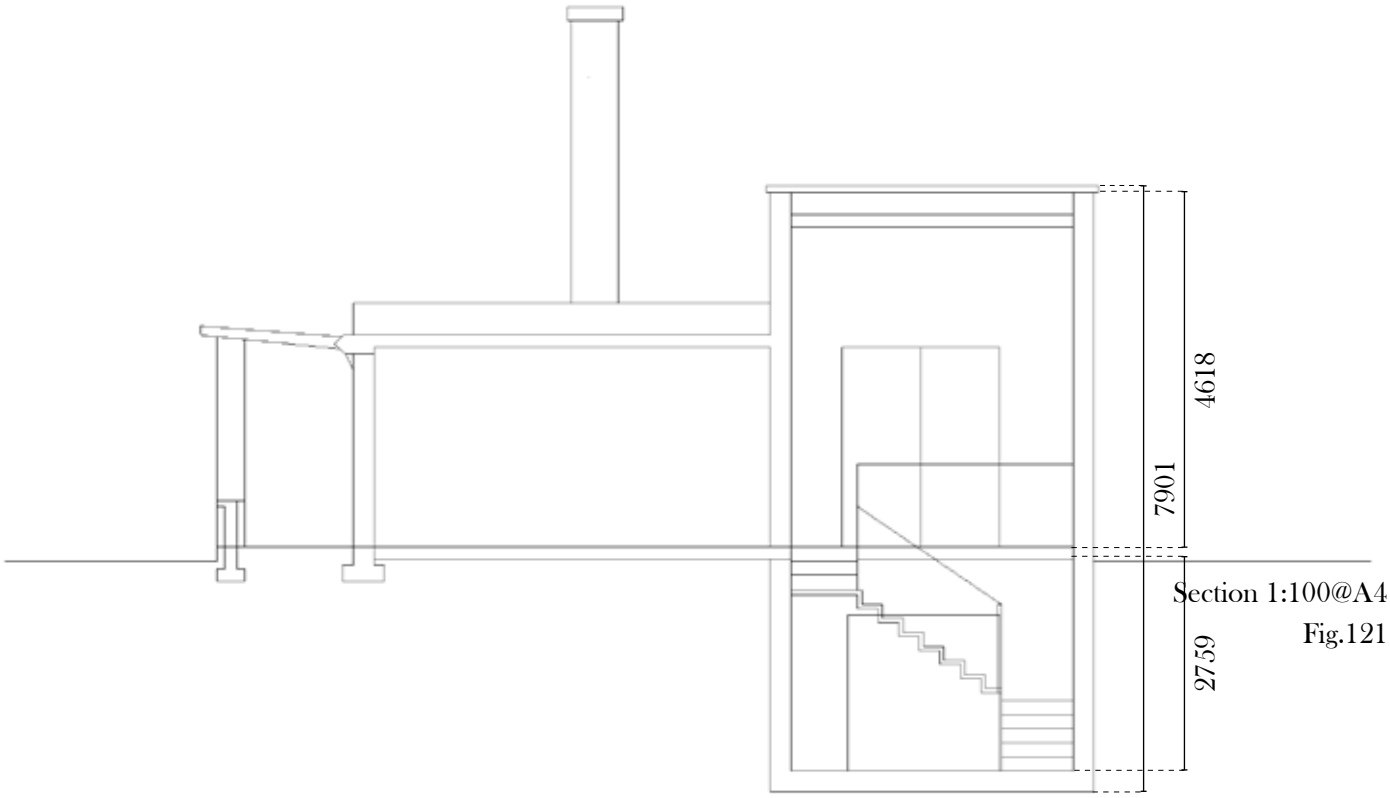
The Guardhouse:

Location for the stairway down to the bunker, the guardhouse was designed to be a decoy to enemy aircrafts. Currently a bungalow, the building used to be two-storeys tall, but the roof collapsed after a bombing.



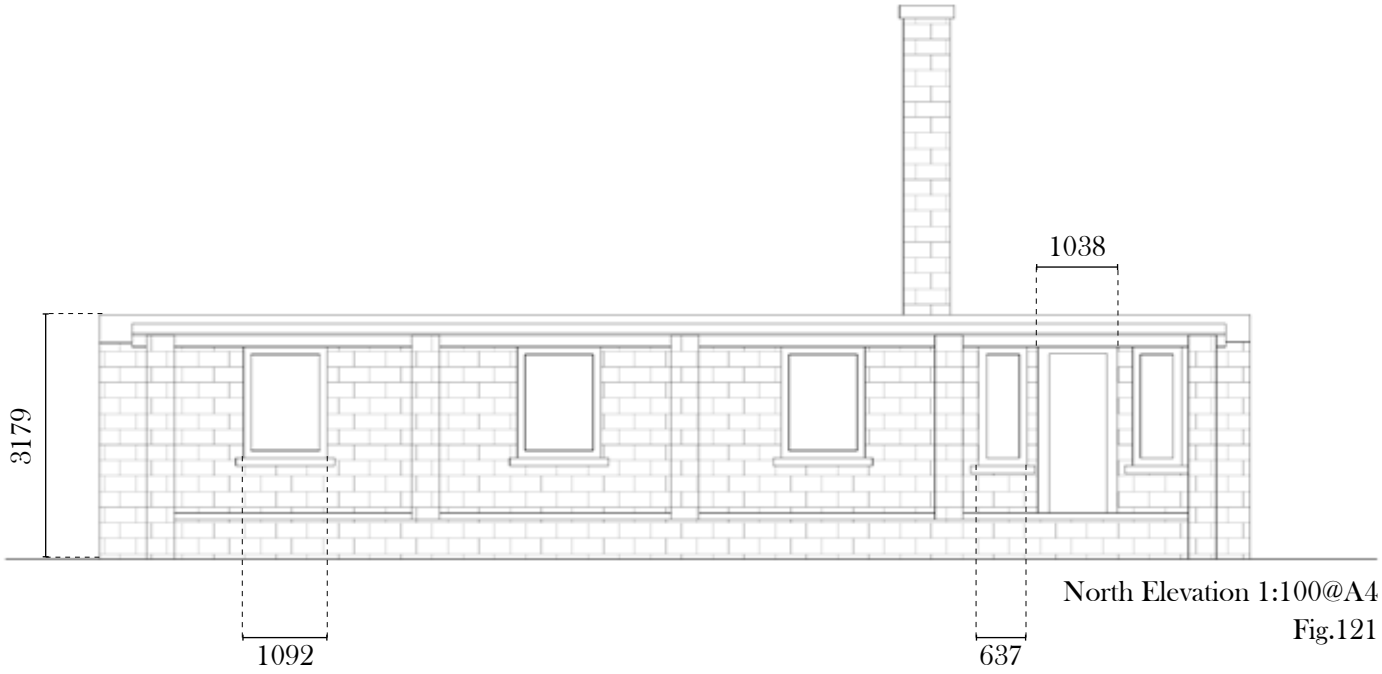
West Elevation 1:100@A4

Fig.119



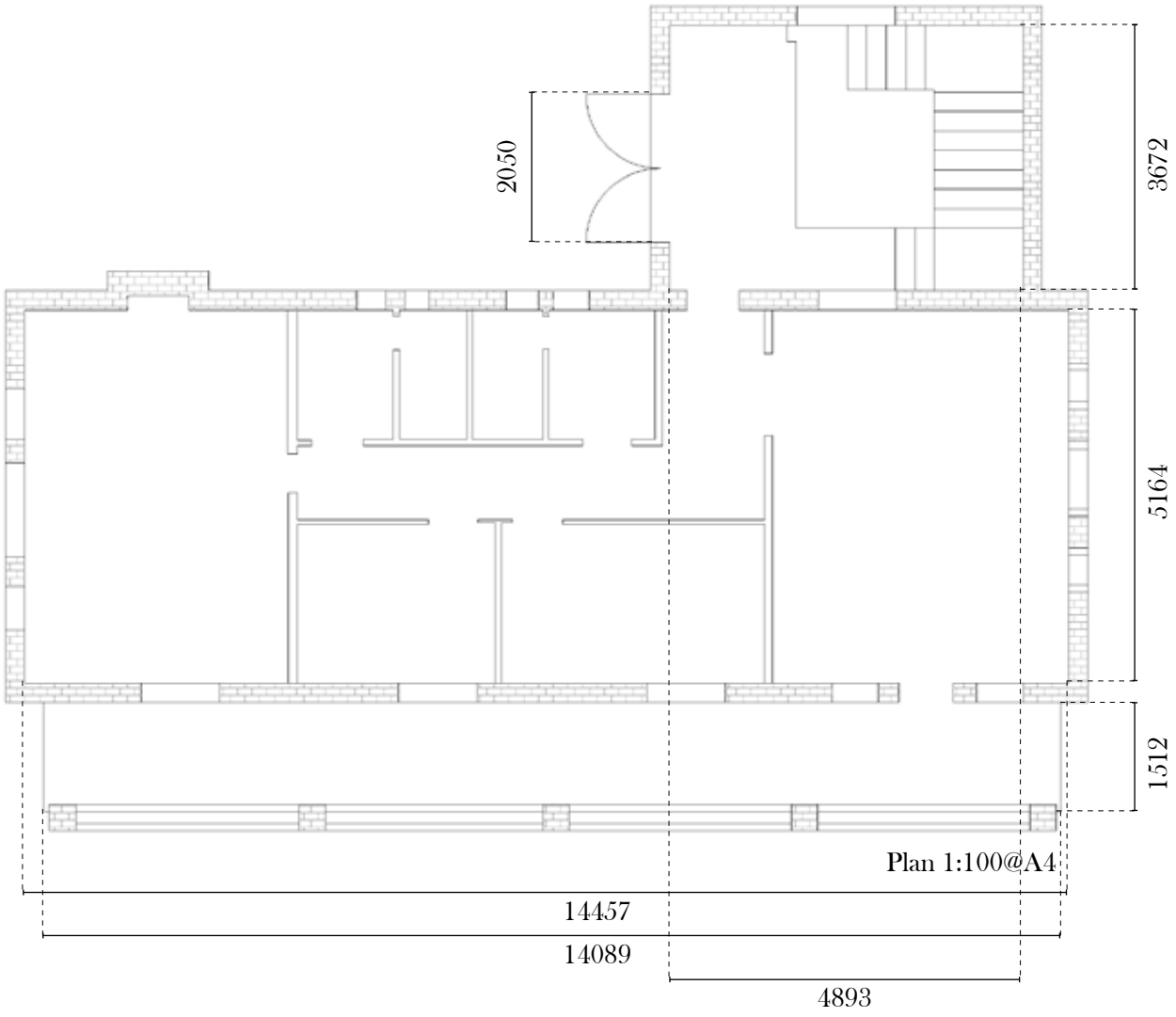
Section 1:100@A4

Fig.121



North Elevation 1:100@A4

Fig.121



Plan 1:100@A4

Fig.122

Current Condition: The station has been heavily subjected to weathering, vandalism, fires and an overall lack of maintenance leaving it in an extremely poor condition. The following images were sourced online, as the bunker is now inaccessible.


Fig.123

The remnants of the original stairway/ access to the bunker.

Some weathering has occurred due to exposure from above.

Lots of debris.

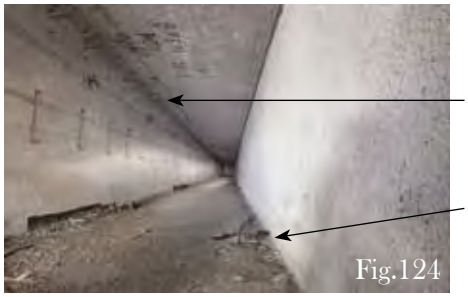


Fig.124

The tunnel leading to the bunker.

Remains of metal light fixtures line the length of the tunnel.

Gravel and rubble litter the floor making it feel dirty, and the painted concrete is no longer white.

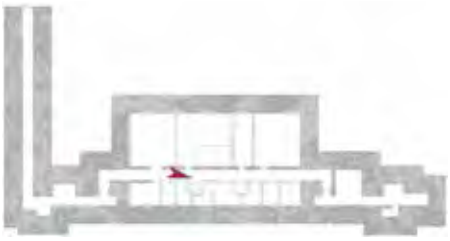



Fig.125

A view of the main corridor.

The remains of metal ducts and fencing have rusted badly.

Doors are missing from the doorways.

Paint has peeled away.


Fig.126

The radar office through to the plant room.

The flooring, wall divides and ceilings have fallen through exposing the brick wall supports, pipes and electrics, which were once concealed.

Signs there's been a fire e.g. charring.


Fig.127

Remains of the machinery in the plant room.

The metalwork has rusted badly.

Like the other spaces, lots of debris and hazardous materials.

Fig.128

Looking out from the plant room into the corridor.

An example of the crude vandalism that can be found throughout.

The stairway down to the plant room is still in tact.

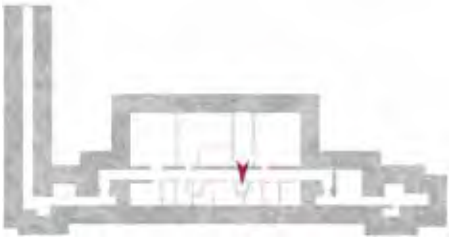


Fig.129

The small kitchen space.

The remnants of cupboards and shelving.

Signs of mould.

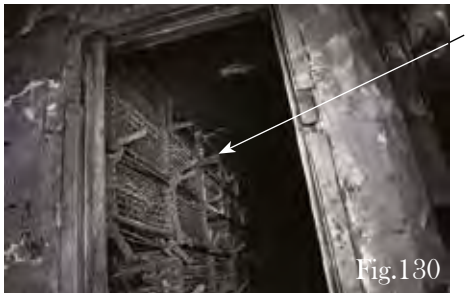


Fig.130

Most of the electric switchboxes still line the wall of the machine room, but without their covers.

Fig.131

The water cool condenser and blast doors.

Less debris in this area but still in poor condition.

The water cool condenser appears to be heavily rusted and unlikely to be functional again.

Fig.132

The remnants of the original emergency exit stairway.

Signs of weathering and mould from exposure via the cowl ducts above.

A ramp appears to have replaced the stairway.

Lots of debris piled up.

Current Condition: Above ground there are countless examples of the impacts of weathering and lack of maintenance.

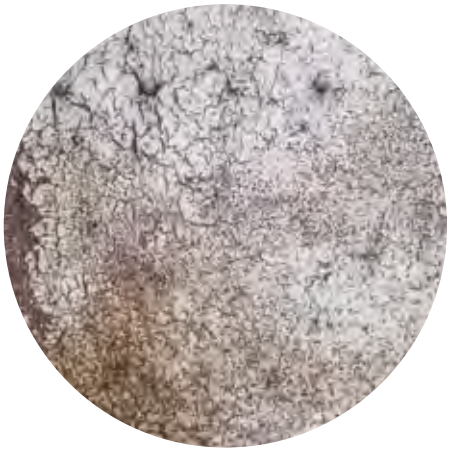
Paint peeling.

Signs of mould and bleaching.

Charring from fires.

Bird droppings, mould and rusting.

Cracks in the plasterwork.

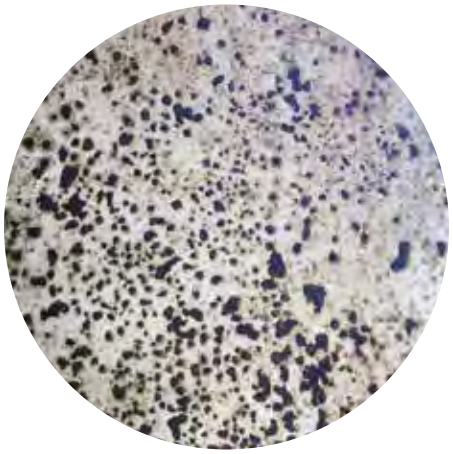


Cracked plaster and paintwork.

Strong impacts of weathering; plaster worn down to the iron reinforcement.

Heavy weathering and paint peeling.

Bubbling paintwork due to excess moisture and/or heat.

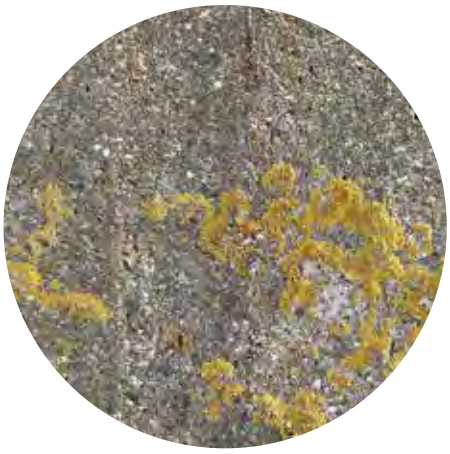


Weathered paint and rusted metal.

Grimey surfaces.

Exposed iron reinforcements.

Fungus growing due to damp conditions.



Cracks in the concrete.

Bubbling paint due to moisture and/or heat, and mould growing.

Mould and cracked plaster due to weathering.

Fig.133

Fig.134

Fig.135

Fig.136

Fig.137

Fig.138

Fig.139

Materiality Palette: the existing combination of textures and colours above ground. Fig.140

Red Brick

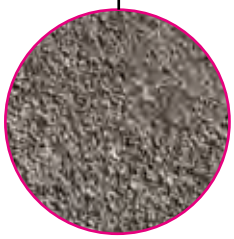
Guardhouse/Bungalow

Concrete

Wooden Frames

Fig.141

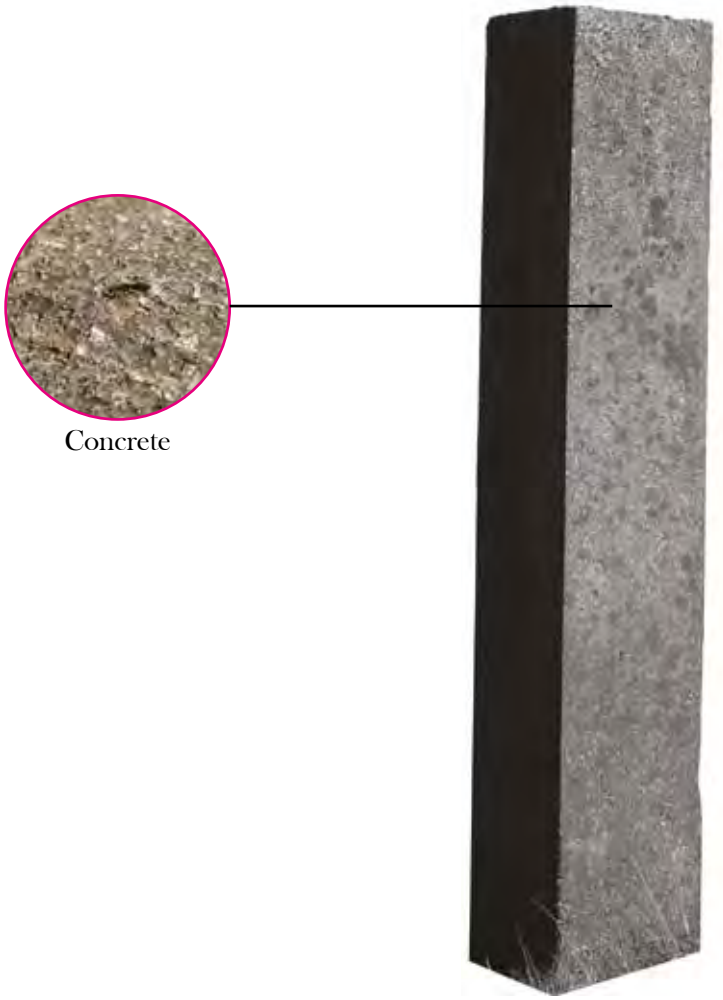
Steel



Concrete

Iron

Fig.142



Radar Pillars Fig.143

Radar Head Buildings

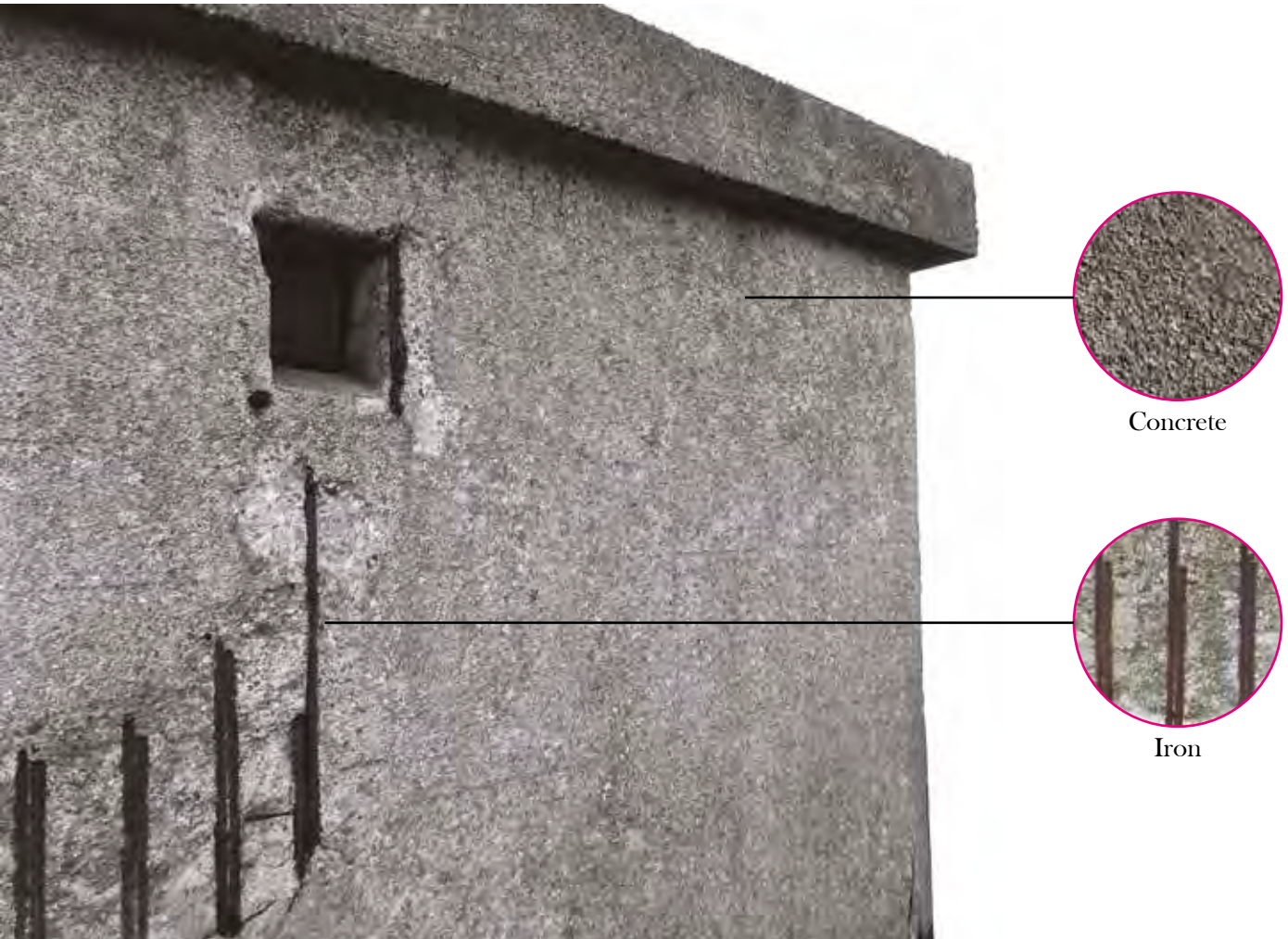


Fig.144

Details and Relics: Inaccessible, any remnants of the station underground are left unknown. However, there are still a few points of interest above ground, including parts of rusted metal relics in the interior spaces, the remains of a fireplace, and the concrete posts from the previous barbed-wire fence piled up outside. Although in poor condition, upcycling or restoring some of these could be a potential way of honouring the building's past, whilst keeping to the sustainable aspect of the brief.

Fig.145-161

Interior Photos:

(Unedited, in order to get a true feel of the space.)

Interior photographs of the guardhouse (location of 'The Switching Room'.)

The interior is currently divided up but, as the walls aren't structural supports, could be removed.

Interior photographs of the Type-80 building.

The largest of the surface buildings, this will be the location of the reception space.

Interior photograph of one of the Type-13 and Type-14 buildings (there are 8 in total scattered across the field.)

Fig.162-176

Exterior Photos:

(Unedited, in order to get a true feel of the space.)

The concrete plinths with an unconfirmed previous purpose Thought to have been for early radar heads that could detect from an 8mile radius (Wardlow, J. 2021.)

View of some of the surface buildings, including the one that housed the Type-80.

Type-80 building (location of 'The Field Observatory'.)

The exterior of the emergency exit.

Views of the guardhouse from the exterior.

Fig.177-186

N

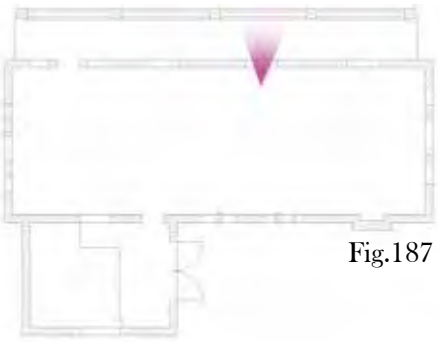


Fig.187

SE

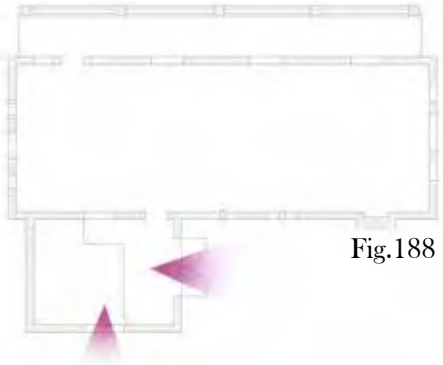


Fig.188

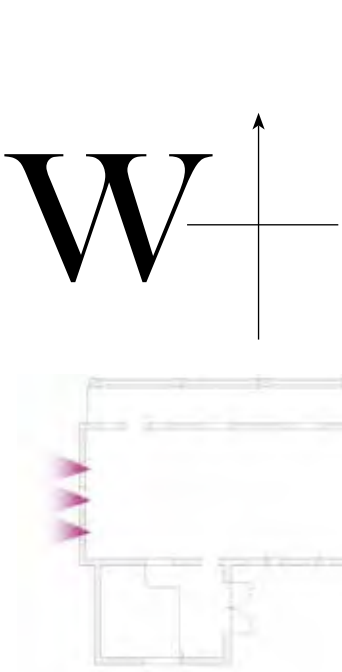


Fig.189

Views from the Guardhouse:
The north windows have a view of the site and the sea, the east have a view of the rest of the site, and the south and the west have views of the fields.

All of the views are picturesque with no real visual pollution.

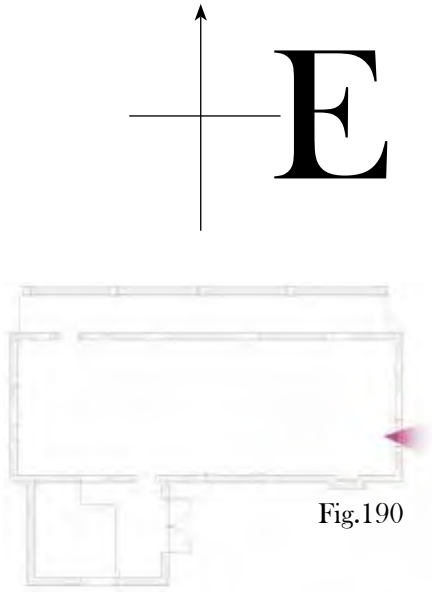


Fig.190

Sun Path: Summer

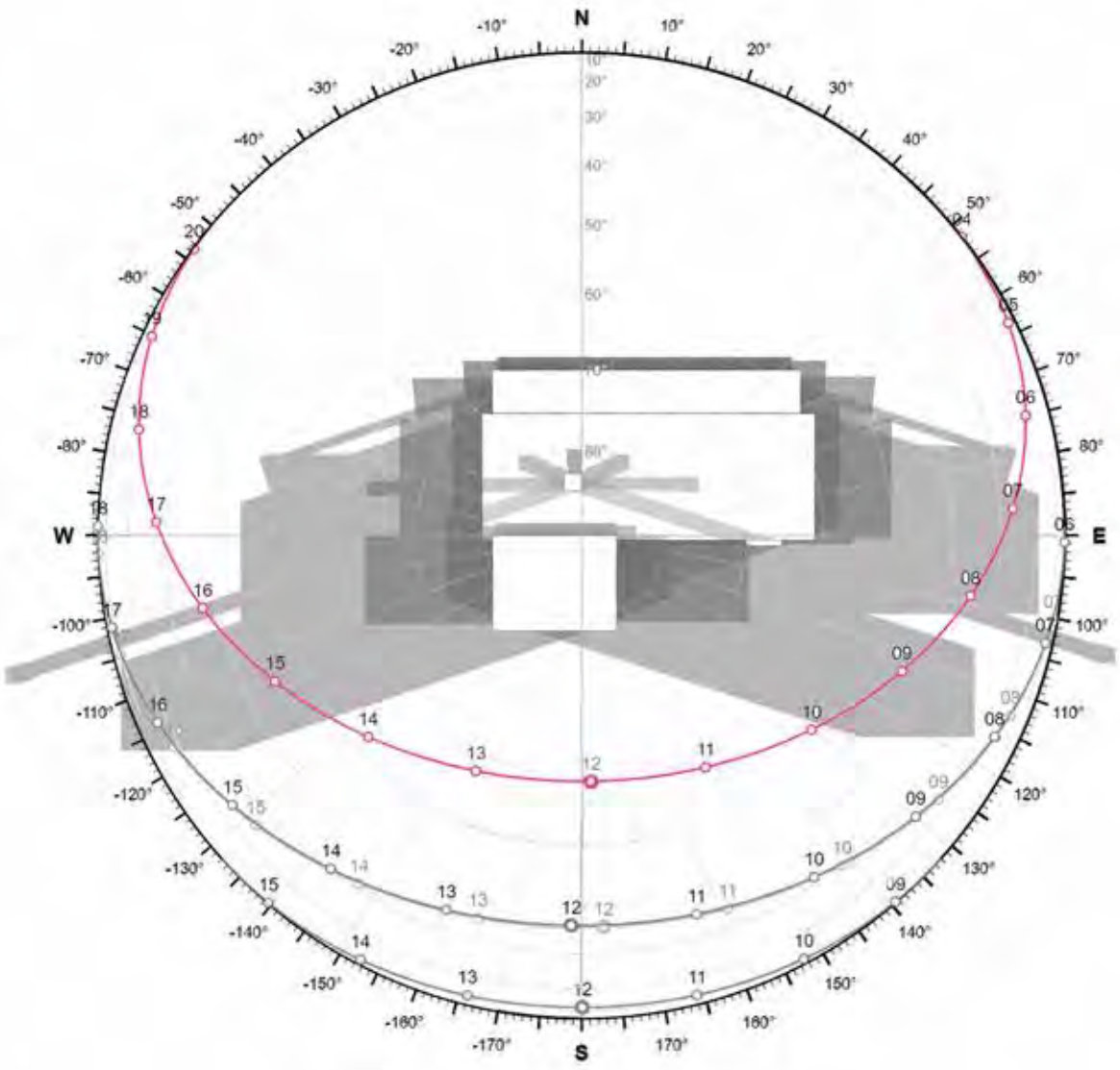


Fig.191

Fig.192

Fig.193

Fig.194

Sun Path: Winter

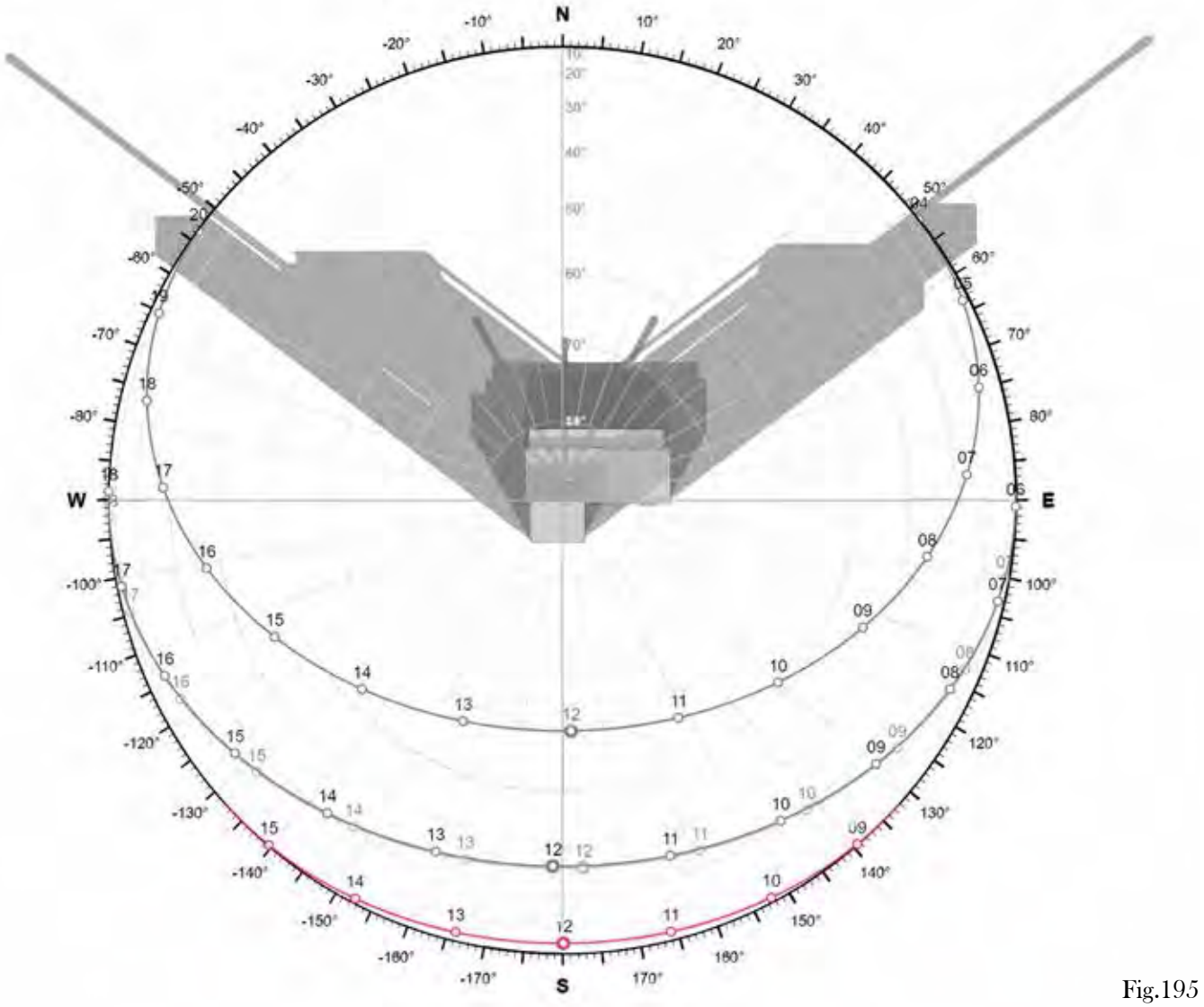


Fig.195

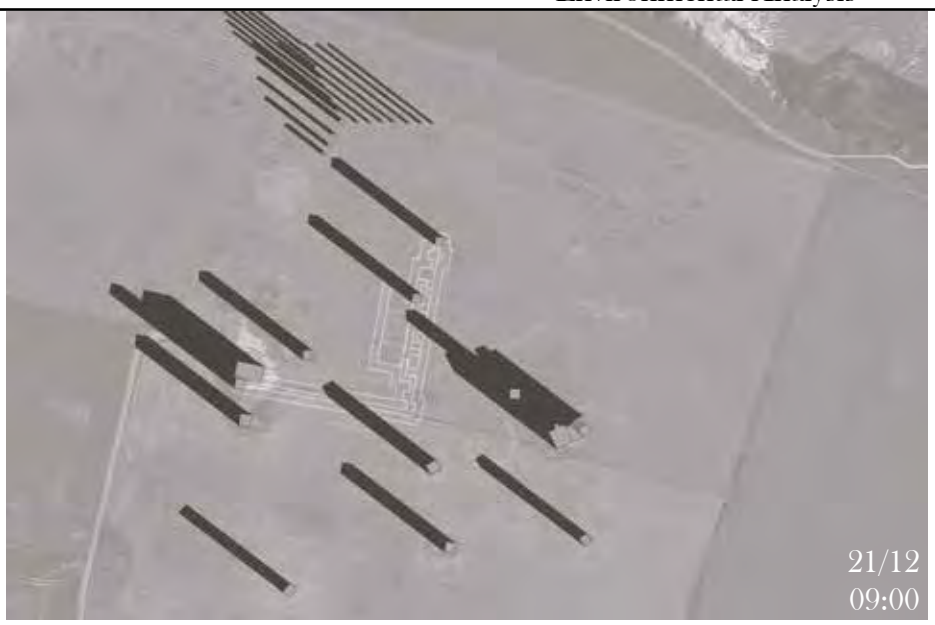


Fig.196

Fig.197

Fig.198

Circulation:

Whilst the circulation route of the RAF station was routine and somewhat rigid, the movement of people never follows the exact same path. This expressive diagram aims to show the flow of people along the original circulation route.

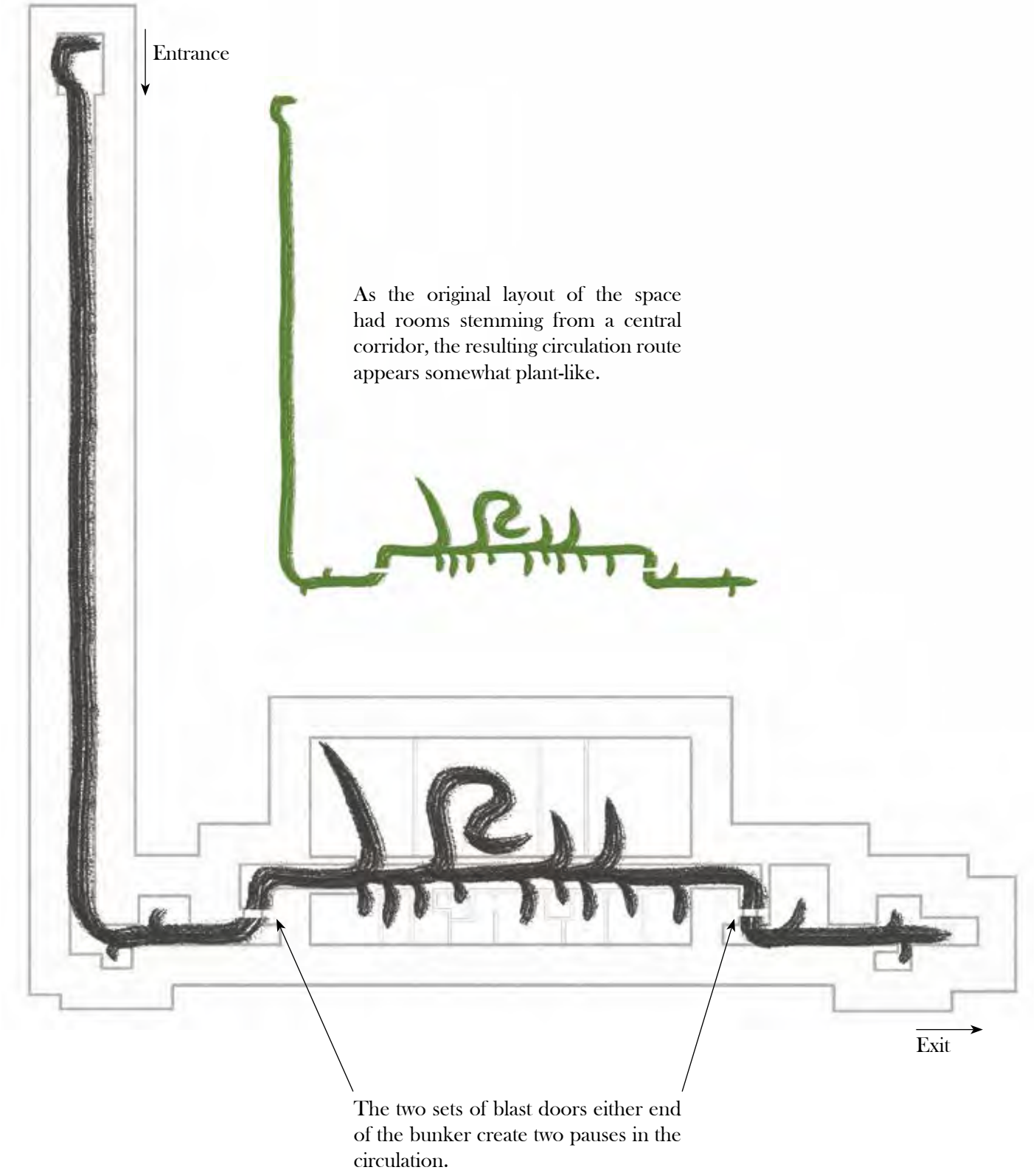


Fig.199

Thresholds:
The main two thresholds between above and below ground are indentifiable via the guardhouse and emergency exit on the surface. However, there are also some underground thresholds, including the two sets of blast doors at either end of the bunker and the level change between the track telling room and 'the udder'.

The dividing walls between operations rooms would also be considered thresholds, but wouldn't be consistant with the new brief as the interior will be stripped back.

1. Guardhouse Entrance
2. Blast Doors
3. Stairway to 'The Udder'
4. Emergency Exit

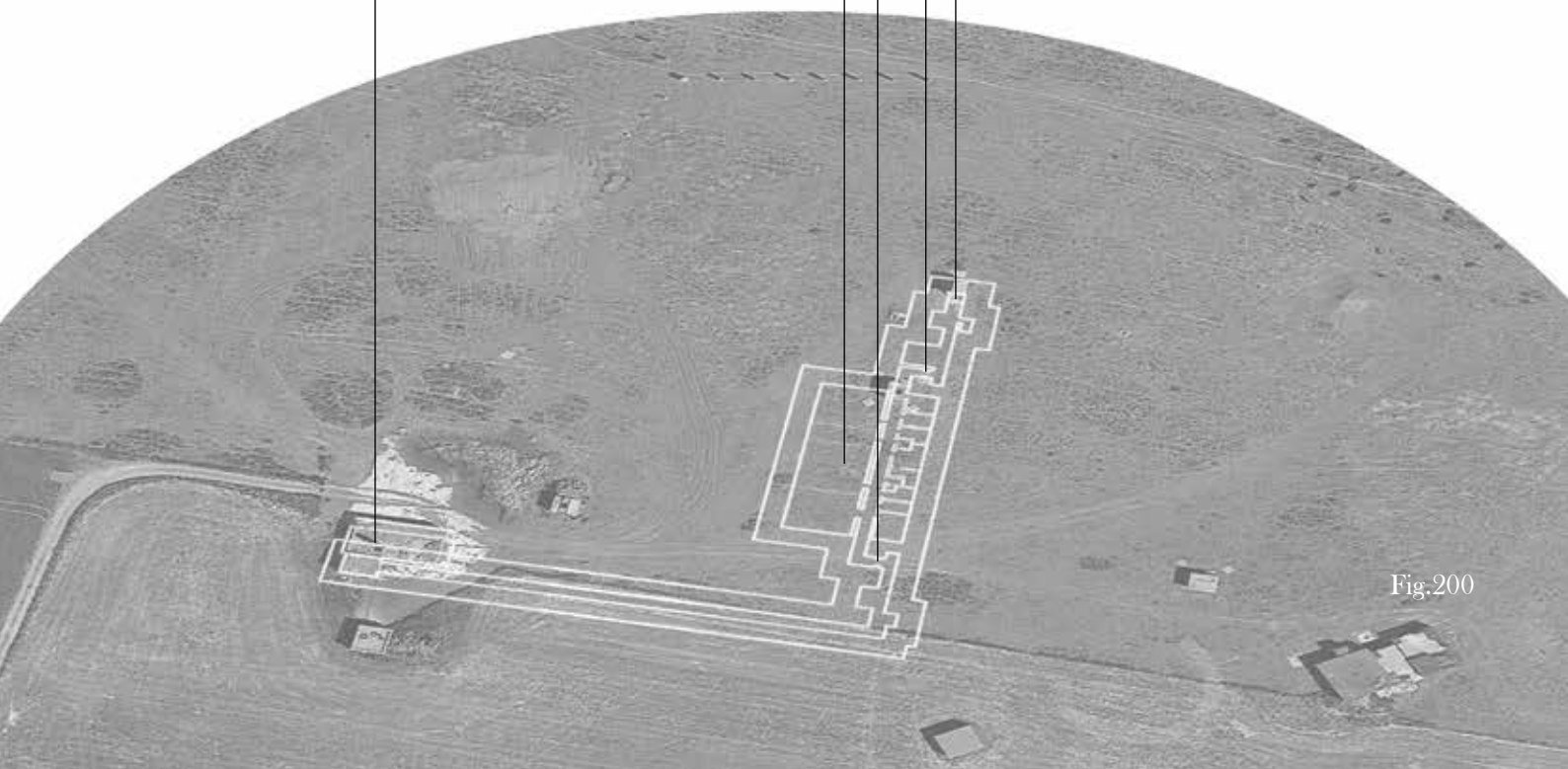
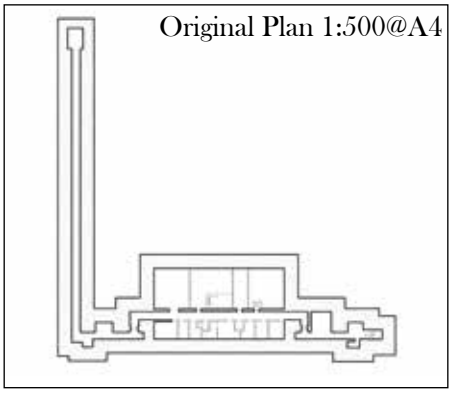


Fig.200

The Bunker: Retain or Remove?



Due to being heavily vandalised, the state of the bunker is in complete disrepair with the current condition extremely hazardous. The interior will need to be completely stripped back to its concrete shell leaving lots of room for creativity.

The original circulation route: entering via the tunnel and exiting via the emergency exit, will be retained.

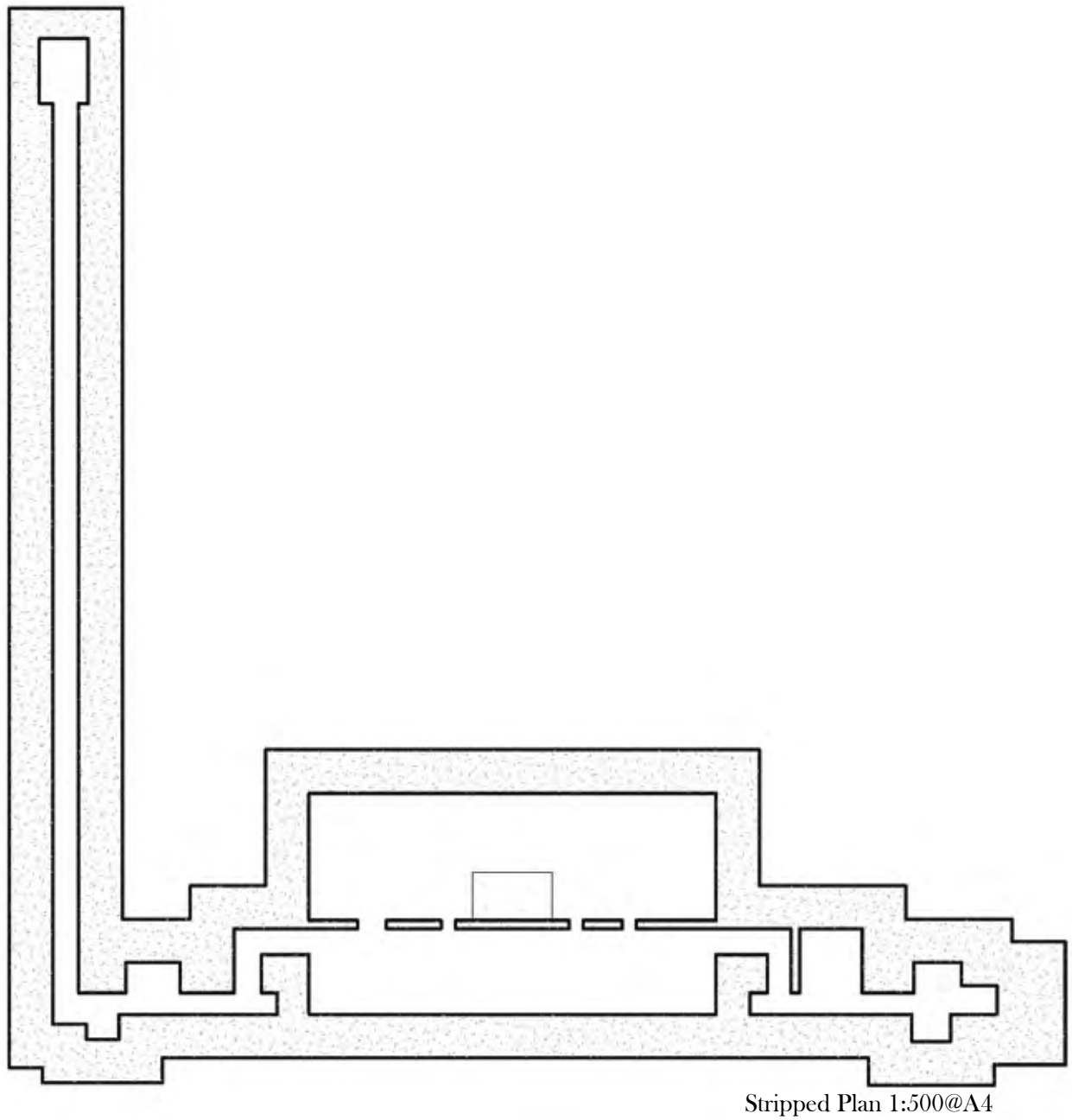
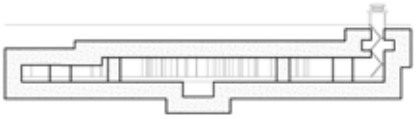


Fig.201

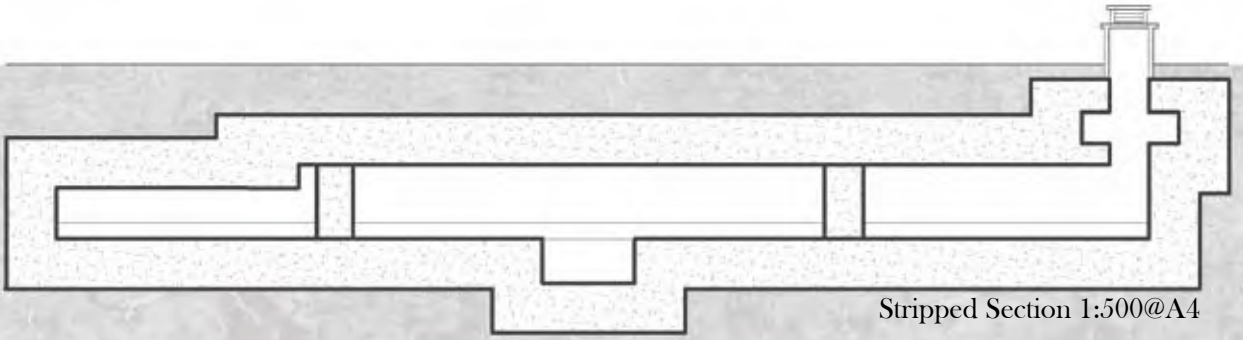
Original Section 1:500@A4



With the ambition to create multiple skylights, parts of the earth and concrete structure nearest the surface will have to be removed. As the concrete shell is so thick, extra support will have to be considered.

It would also be beneficial to have a quick access route to the underground farm and market, which doesn't interfere with the opposite flow of circulation from the walk-through exhibition. Similarly to the previous point, the structural support of removing so much earth and concrete will have to be considered in the design.

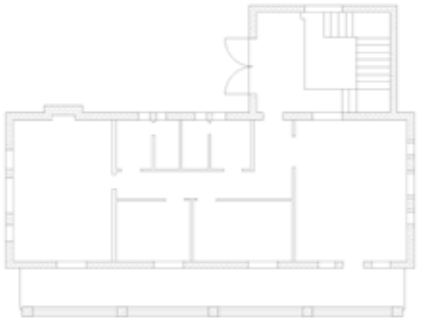
Wanting the keep the same circulation route as when it was an RAF station, stair of lift access to the surface will be restored via the emergency exit.



Stripped Section 1:500@A4

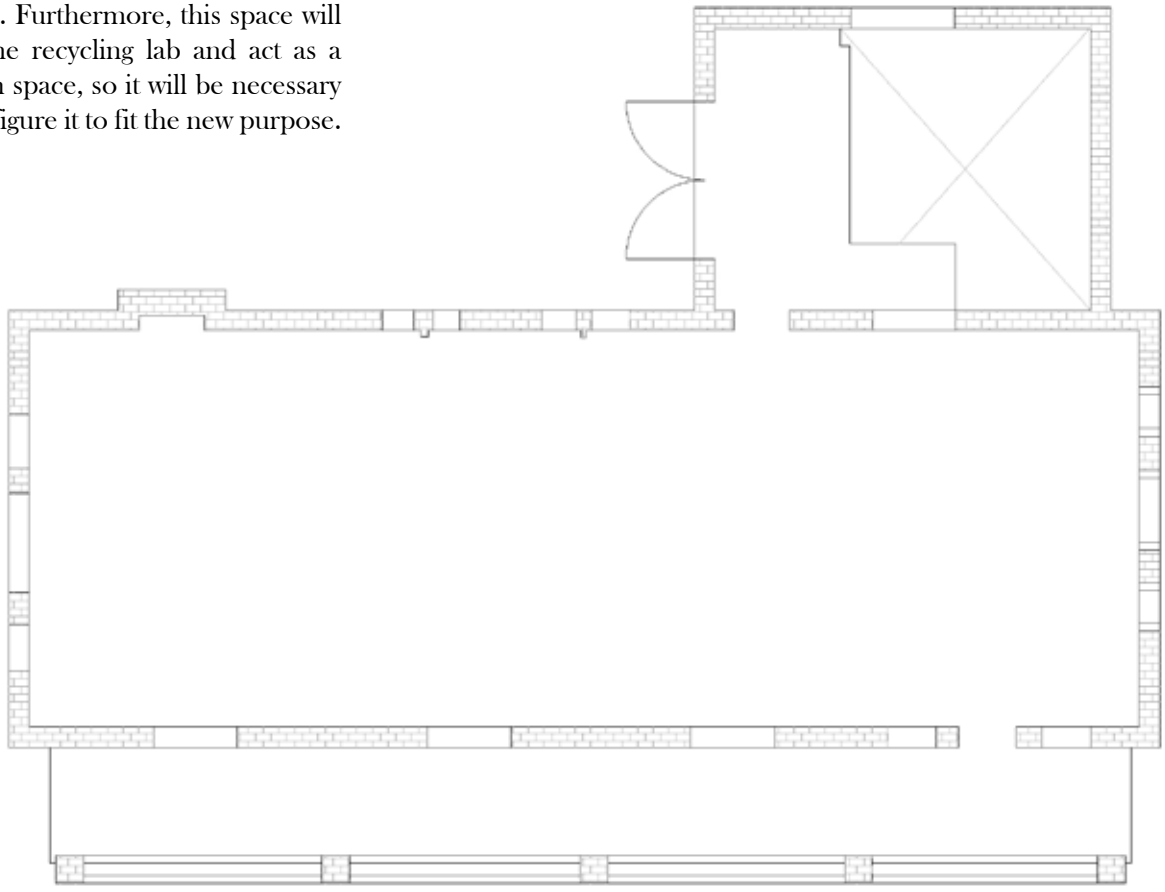
Fig.202

The Guardhouse: Retain or Remove?



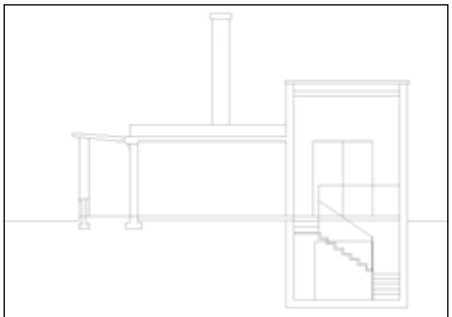
Original Plan 1:100@A4

Being in such poor condition as a result of weathering and lack of maintenance, the interior walls will be removed. Furthermore, this space will be for the recycling lab and act as a transition space, so it will be necessary to reconfigure it to fit the new purpose.



Stripped Plan 1:100@A4

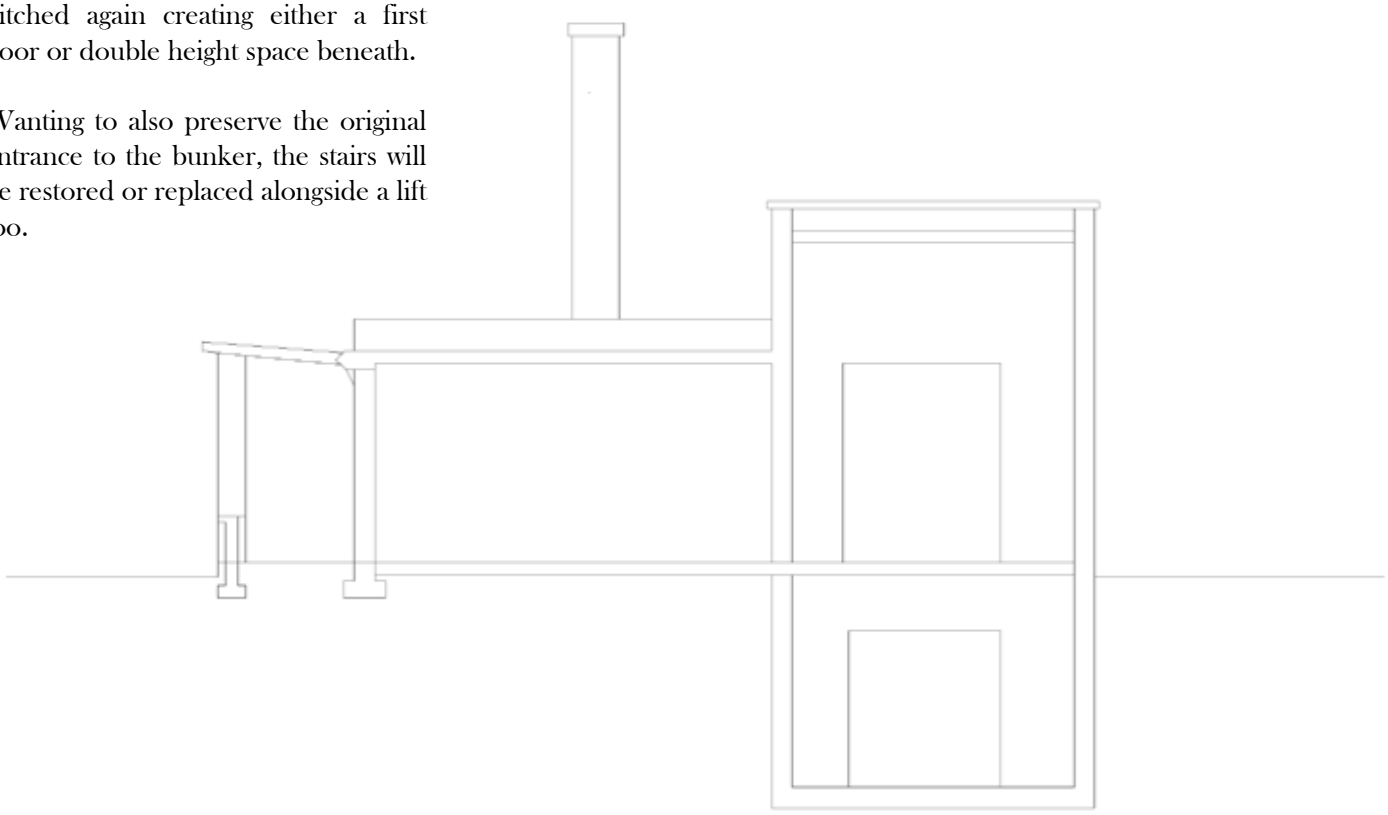
Fig.203



Original Section 1:100@A4

As one of the last remaining landmarks of RAF Bempton, the project should preserve this aspect of its heritage by restoring the exterior of the guardhouse to its former glory; the roof will be pitched again creating either a first floor or double height space beneath.

Wanting to also preserve the original entrance to the bunker, the stairs will be restored or replaced alongside a lift too.



Stripped Section 1:100@A4

Fig.204

Study of Hydroponics

05

'The technology for growing plants in nutrient solutions (water and fertilisers), with or without the use of an artificial medium to provide mechanical support.'
(Jenson, M., 1991.)

Fig.206

Fig.207

Fig.208

A Brief History:

Although hydroponics can be traced as far back as the ancient Egyptians (and probably beyond), modern hydroponics were only established in 1934, when a professor at the University of California successfully applied the technique to crops other than rice (Kenyon, S., 1992.) With the ability to grow crops in abnormal environments, the technique has since been used to tackle multiple modern challenges. For example, in WWII hydroponics were used in air and naval bases in the South Pacific to feed soldiers (Kenyon, S., 1992.) Having been continuously developed since, a notable improvement was the introduction of LEDs by NASA in the late 1980s (Herridge, L., 2012.) Followed by their first use on a commercial scale in Japan in 2000 (Hernández, R., 2016.) Currently, the potential hydroponics have for combating poor food security in urban environments, in response to population and environmental challenges, is being heavily explored.

Plant Processes:

In order to understand the requirements for a hydroponic system, the requirements for plants need to be understood first. The two key processes that plants go through are photosynthesis and aerobic respiration.

Photosynthesis:

Light is absorbed by the chlorophyll in leaves, which is then used in an endothermic reaction to turn carbon dioxide and water into glucose and oxygen (BBC, u.d.) The plant needs glucose for energy for growth, and oxygen is a bi-product of the reaction.

Aerobic Respiration:

To use the energy stored in glucose, the oxygen is needed. This exothermic reaction releases carbon dioxide and water as bi-products (BBC, u.d.)

Photosynthesis:

Carbon Dioxide + Water $\xrightarrow{\text{Light}}$ **Glucose + Oxygen**

Respiration:

Glucose + Oxygen $\longrightarrow$ **Carbon Dioxide + Water**

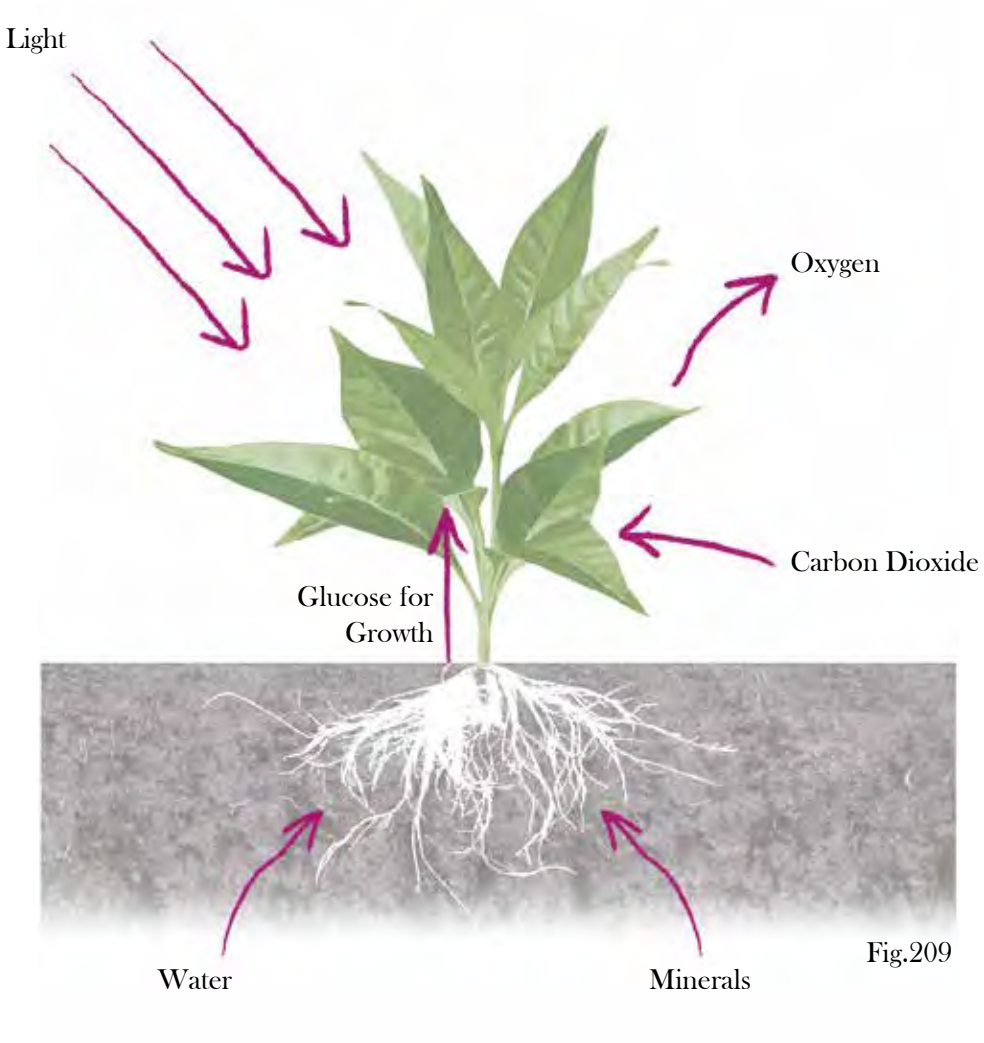


Fig.209

Light:

LEDs are used as a substitute for sunlight as they can be used in any location and left on for 24hrs a day, unlike the sun. This provides more reliable farming conditions. Furthermore, LEDs use less heat/ energy making them more efficient for plant growth. However, too much light can cause plants to become saturated leading to photoinhibition, and ultimately damaging the plant or stunting its growth (AlboPepper, 2017.) Balance is key.

Fig.210

A combination of red and blue LEDs have proven to be the most effective and efficient sources of light for plant growth.

Fig.211

White:

White light is the type of light plants receive from the sun; white is comprised of the entire colour spectrum, primarily red, blue and green. However, white is an inefficient use of light for plant growth as plants don't use the colour green (Baessler, L., 2020.) Studies have therefore shown the combination of red and blue LEDs are the most effective and efficient.

Red:

Red light is associated with flowering and blooming. It also helps with the early stages of plant growth, such as seed germination, root growth, and bulb development (Baessler, L., 2020.)

Blue:

Blue light is associated with creating strong, leafy greens, as it helps chlorophyll production (Baessler, L., 2020.)

Green:

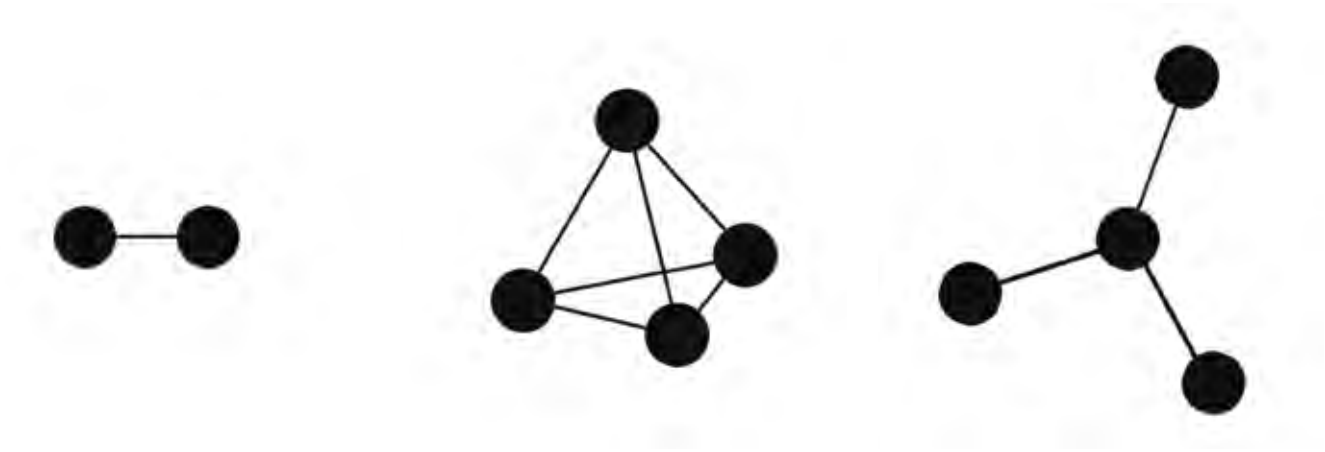
The biology department at the University of Leeds reported that working in a space with red and blue LEDs for an extended amount of time distorted their vision somewhat, as they saw everything filtered in green once leaving the room (Penketh, L., 2018.)

Nutrients:

Applying nutrients to the water are essential for replacing those that would ordinarily be found in soil. N-P-K values hold the most importance when considering fertilisers to do so, and can be found in that format (N-P-K) on fertiliser packaging.

Multiple micronutrients are also required in fertilisers, such as copper and iron, but the three mentioned above should make up the highest percentages. However, if the concentration of nutrients are too high, the plants will give out water rather than take it in, consequently becoming dehydrated due to a high salt to water ratio (Kenyon, S., 1992.)

Fig.212



Nitrogen (N) = growth and greenness

Phosphorus (P) = bloom and reproduction

Potassium (K) = photosynthesis, CO2 intake, activating enzymes, regulating water intake, building healthy stems, and producing seeds

(ZipGrow, 2017.)

Fig.213

NPK Values of Cattle Manure:

Dairy Cattle: N - 0.5
P - 0.2
K - 0.4

Beef Cattle: N - 0.5
P - 0.3
K - 0.5

(Pennsylvania State University, u.d.)

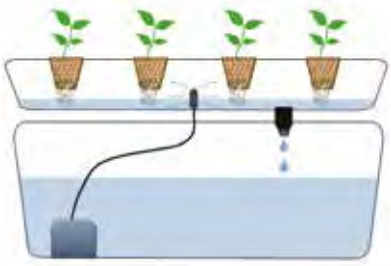
Drainage:

Drainage is essential for aeration and preventing algae, and qualities of the plant, medium and aggregates should be considered when choosing which method (Kenyon, S., 1992.) Furthermore, when using a new nutrient solution, the system should be completely cleaned of any old solution in order to avoid unbalance and contamination. However, the way system drainage is tackled is important in order to not pollute the surrounding environment, which is already a massive issue with irrigation and surface runoff in traditional farming (Choi, E., Seo, S., Choi, K. and Lee, Y., 2014.)

Fig.214

Drip Method:

The most commonly used system and good on a commercial scale. Plants are able to regulate their nutrient intake, as excess solution can be drained into the separate water reservoir (Off-Grid Gorilla, u.d.) However, the mediums can suffer from algae build-up slowing plant growth, due to surface moisture (Kenyon, S., 1992.).

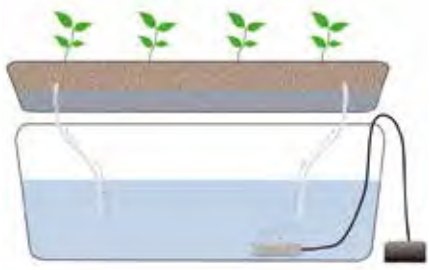


Flood and Drain:

As a less complex system and one that delivers solution to all plants in the same tray, this method is perfect for growing one type of plant (Off-Grid Gorilla, u.d.) The disadvantage is plants can't be treated individually, and may react poorly to extreme changes when flooding and draining (Kenyon, S., 1992.)

Nutrient Film Technique:

Very similar to the flood and drain method, however the plant tray is tilted at an angle and water is pumped constantly, resulting in good aeration of water solution, a steady supply of nutrients and immediate drainage (Kenyon, S., 1992.) However, this technique uses more power and is more vulnerable to failures (Off-Grid Gorilla, u.d.)



Wick Method:

This method is a cheaper, more power-saving way of delivering nutrients to plants (Off-Grid Gorilla, u.d.) The drawback is its simplicity reduces human control, reducing the system's efficiency. Furthermore, stagnant water has a lack of aeration and leads to algae and foul odours, so an air stone is essential.

Deep Water Culture:

Submerged in the solution 24/7, this method is cost-effective and requires less equipment, but is only suitable for water- rich plants (Off-Grid Gorilla, u.d.) The lack of circulation also would require an air stone for aeration.

Fig.215

Ventilation:

Adequate air flow helps with temperature, humidity, and disease control, keeping the air fresh from odours, and supplying the plants with enough CO_2 to carry out the necessary processes they need to survive (Vents, 2014.) The aim of a ventilation system is to remove hot 'waste' air and replace it with cool, fresh air (Vents, 2014.)

Fig.216

Fresh air can naturally flow in

Fig.217

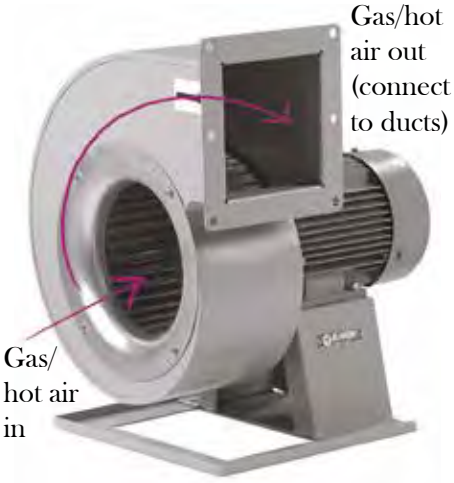


Fig.218

Vent-holes:

Creating openings between the interior and exterior is a natural way of allowing fresh air to circulate, but the process is somewhat slower than using alternative electrical options (Vents, 2014.) However, an advantage of this method is having more freedom of space and creativity in designing exterior walls. An example of this method can be identified on site via the cowl vents on the roof of the emergency exit.

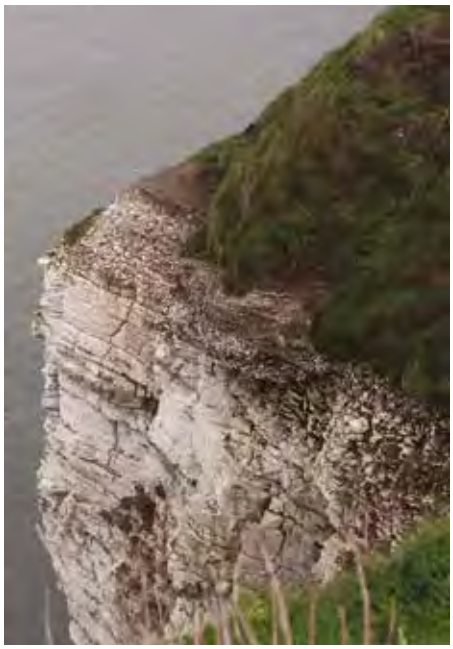
Centrifugal fans:

These fans are a quicker way of circulating fresh air by removing the hot, waste air (Vents, 2014.) These are more advantageous in large spaces or commercial scales. Centrifugal fans were used to power the air and gas filters in the bunker, and were vital parts of the cooling and conditioning of the RAF Station (Higton, J., 2020.)

Aggregates:

Aggregates can be any material but must create support for the plants' roots and allow aeration. Other factors that should be considered when making a material choice include sharp edges that could damage the roots, whether the material will affect the water's pH level, and the size of the aggregate pieces to allow adequate circulation of water and air (Kenyon, S., 1992.)

Fig.219



Material from Bempton Cliffs:

+ Locally sourced.

- Could be lime-based and therefore have a negative effect on the pH balance.
- Potentially too sharp.

Fig.220

Discarded remnants of the RAF Station:

+ Upcycling discarded material.
+ A connection to the bunker's previous use.

- Potentially too sharp.

Fig.221

Local clay:

+ Locally sourced.
+ Won't damage the roots.
+ Good aeration.

- If not treated properly, dust can effect the pH and cause system issues.

Fig.222

Primary Study:

Due to national lockdown restrictions, I was unable to get a first hand experience of a hydroponic farm. Therefore, I bought a small, personal hydroponic system to see what I could learn from attempting to grow herbs hydroponically myself. (Note, the experiment was conducted before I had gathered enough information in order to have a more successful outcome. All the data was collected via experimentation and observation, and wasn't a controlled experiment.)

Observational Diary:

08/12/20

Planted coriander (left) and basil (right) in a growing medium and left submerged in water (deep water culture method) at room temperature with white LEDs to help germinate the seeds.

12/12/20

The basil shoots started to emerge (x4).

13/12/20

Another 6 basil shoots started to emerge, but no sign of the coriander.

15/12/20

Small leaves started to sprout on the basil shoots.

17/12/20

Some of the basil shoots reached 1cm.

19/12/20
A lot more basil shoots had emerged (15 in total.)


22/12/20
Some more of the basil shoots reached 1cm, but still no sign of the coriander.


02/01/21
Despite the coriander still not growing, I decided to start adding the fertiliser to the water, so the basil shoots had the nutrients they needed for stem and leaf growth (the fertiliser I chose was 7-3-5.) The basil shoots almost immediately appeared greener and taller.


08/01/21
Some of the basil shoots reached 2cm. Unfortunately, due to a change in location, the controlled environment was compromised; the system had to be drained in order to be moved, and the new location differed in temperature. The system was refilled with water and 1/4 cup of fertiliser, and the light was changed from white to the red and blue LEDs.


18/01/21
The basil suddenly took a turn for the worse and had died. Mould was growing on the surface of the growing medium.


Conclusions:

- The 'deep water culture' drainage method was unsuccessful for growing herbs.

- A controlled environment is essential for a successful harvest.

- Different plants have different requirements.

Fig.223

Plant Choices for Bempton Bunker:

More greens have to be consumed to reach a sufficient number of calories in a meal; the following choices of plant were based on their higher calorie content in order to be competitive with traditional farms, and to encourage consumers to buy the produce or to grow their own. By covering a spectrum of plants (e.g. from a fruit to a herb) the farm should be equipped to cater for a variety of other plants in the future too.

Fig.224

Saffron (flower/spice)

Calories per 100g: 314

Harvest Time: Every 45day cycle.

Environmental Requirements: - pH value between 6.0 - 6.25.
(Native to Western Asia.) - Plant in 2inch mesh pots with an inert substrate.
- Warm temp.
- Dry climate.
- Fragile nature requires delicate nurturing.
- Well - drained.

Other Notes: - Saffron is labour - intensive, but maintenance can be reduced via controlled system.
- Its high value would be beneficial to the local economy.
- Previously grown by Farm Urban.

Avocado (fruit)

Calories per 100g: 160

Harvest Time: From seed it would take approx. 4years for the tree to grow and even longer to fruit.

Environmental Requirements: - Warm temp.
(Native to South America.) - Full 'sunlight'.
- Humidity/moisture.
- Restrict growing space, water and nutrients in order to dwarf the tree (can grow to 80ft, if not controlled.)
- pH value between 6.0-6.5.

Other Notes: - Due to long growing times, the farm could either sell the trees once matured to a certain height, or not grow them from the seed in order to produce the fruits faster.

Fig.225

Fig.226

Kale (vegetable)
Calories per 100g: 54

Harvest Time: Young = 20-30days, mature = 3-4months.

Environmental Requirements: (Native to the Mediterranean.)
- pH value of 6.0 to 6.5.
- Full 'sunlight'.
- Nitrogen rich fertiliser.
- Cool temp. (7-30°C.)
- Fairly humid.

Other Notes:
- Previously grown by Farm Urban.
- As a leafy green, nutrients don't have to be changed over the growing season.

Red Batavia (vegetable/salad leaf)
Calories per 100g: 25

Harvest Time: Young = 3 weeks, mature = 45-85days.

Environmental Requirements: (Native to East Asia.)
- Doesn't require full sun; 10-14hrs moderate to low light intensity.
- Can grow in lower temp.(20-23°C ideally.)
- pH value of 5.5 - 6.0.
- Fertiliser high in nitrogen, but not potassium.
- Low maintenance.

Fig.227

Other Notes:
- Currently grown by Farm Urban.
- As a leafy green, nutrients don't have to be changed over the growing seasons.
- Although not the highest calorie-count, it's rich in vitamins and minerals.

Fig.228

Dill (herb)
Calories per 100g: 43

Harvest Time: 90 days.

Environmental Requirements: (Native to South-West Asia and South-East Europe.)
- pH value 5.5 - 6.5.
- Full 'sunlight' to part shade.
- Well-drained.
- Around 20°C.
- Cool, less humid.

Other Notes:
- As a leafy green, nutrients don't have to be changed over the growing seasons.

Creating Fertilisers from Agricultural Waste:

The private farmland, where the site is located, is arable and grows grains for cattle grazing (Wardlow, J., 2020.) Agricultural waste and cow manure can be recycled to produce organic fertilisers because they are already rich in nutrients.

Cow Manure Tea:

A smaller-scale, more labour-intensive method of producing liquid fertiliser.

Method:

1. Sun-dry the cow manure.
2. Break into pieces and place into a net bag with other organic waste.
3. Place bag in a sealed container of water for around 3 weeks (1/3 cow manure, 2/3 water.)
4. Stir every 3 days.
5. Extract the liquid once the smell has dissipated.
6. Apply very diluted to plants once a week, or less diluted once every 2 or 3 weeks.

(Tetlow, S., 2014.)

Fig.229

Fertiliser Production Line:

A larger-scale, less labour intensive method of producing fertiliser pellets. (Although this system won't be included in the farm, it's useful to see the process.)

- Collect the cow manure & dewater it (dewatering machine takes the water content down to 30%)

- Mix the dried cow manure with other organic wastes (mixing machine)

- Composting & aerobic fermentation (composting machine turns the waste to speed up the composting process & allow air to circulate)

- Crushing the composted material (crushing machine)

- Granulating (granulating equipment)

- Drying the granules for easy packaging

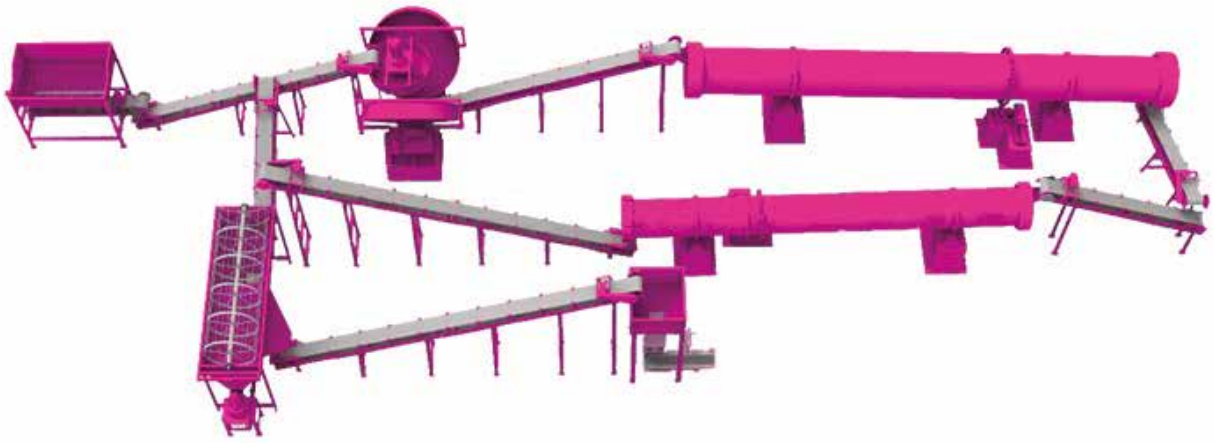


Fig.230

Creating Biogas (and Fertiliser) from Agricultural Waste:

As the underground hydroponic farm requires a sufficient amount of electricity/ heat, another way of reducing and recycling agricultural waste is to use it to create biogas. Biogas is the production of methane and slurry from agricultural waste to produce renewable energy and organic fertiliser. A biogas reactor is the technology to carry out this process via anaerobic reaction (Gill, B., 2021.)

A Small-Scale Biogas Reactor:

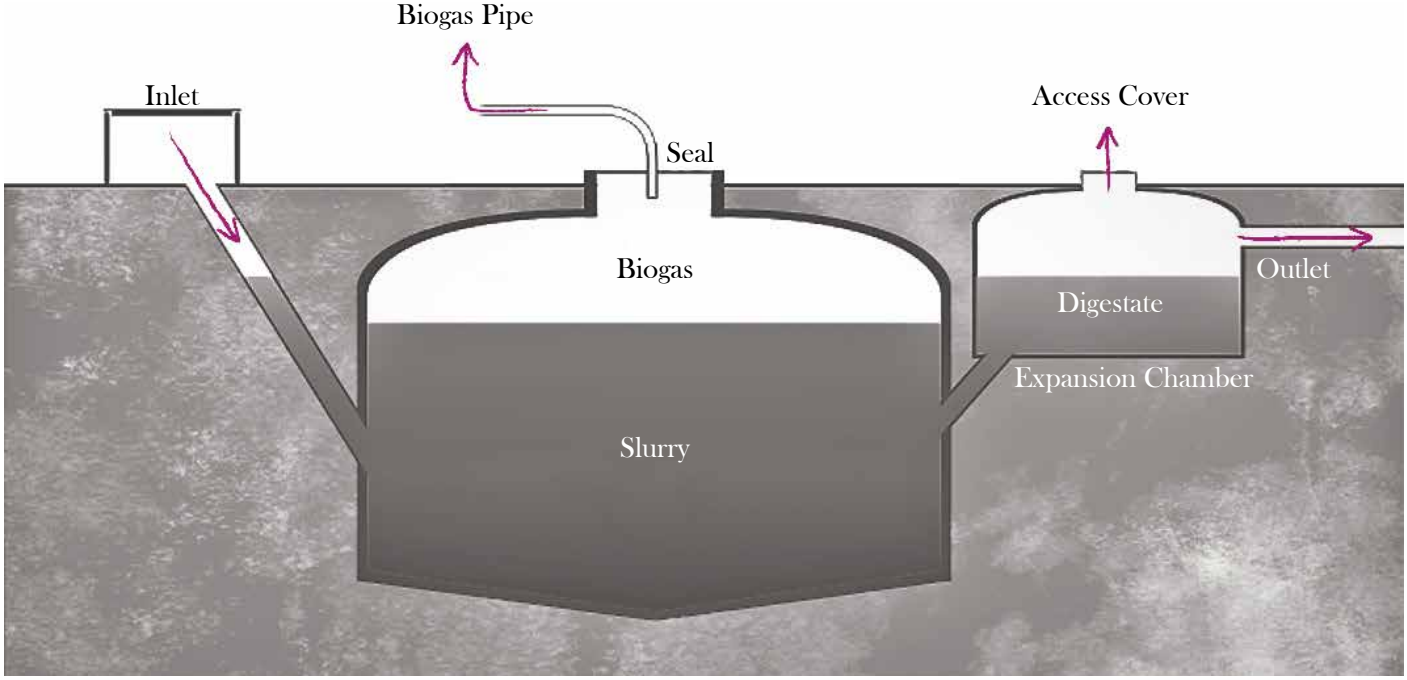


Fig.231

Process:

1. Agricultural waste is mixed together and enters at the inlet.

2. An airtight chamber facilitates the anaerobic reaction; biogas (methane and carbon dioxide) gathers at the top of the container mixing the slurry in the process.

3. The biogas is forced out via the pipe connected to another container or transported directly to the power source.

4. The slurry rises and falls with the biogas production. When rising, it's forced into the expansion chamber.

5. The digestate exits from the outlet as organic fertiliser.

(SSWM, u.d.)

Small-scale:
- 2m^3 to 3m^3
- 800litres
- 15-20kg of waste per day.
- Would suite a household of 3-5 people.

(NBP, u.d.)

Fig.232

Larger-scale:
- 4m^3 to 15m^3
- 4000litres
- 20-100kg of waste per day.
- Would suit a household of 5-15 people.

(NBP, u.d.)

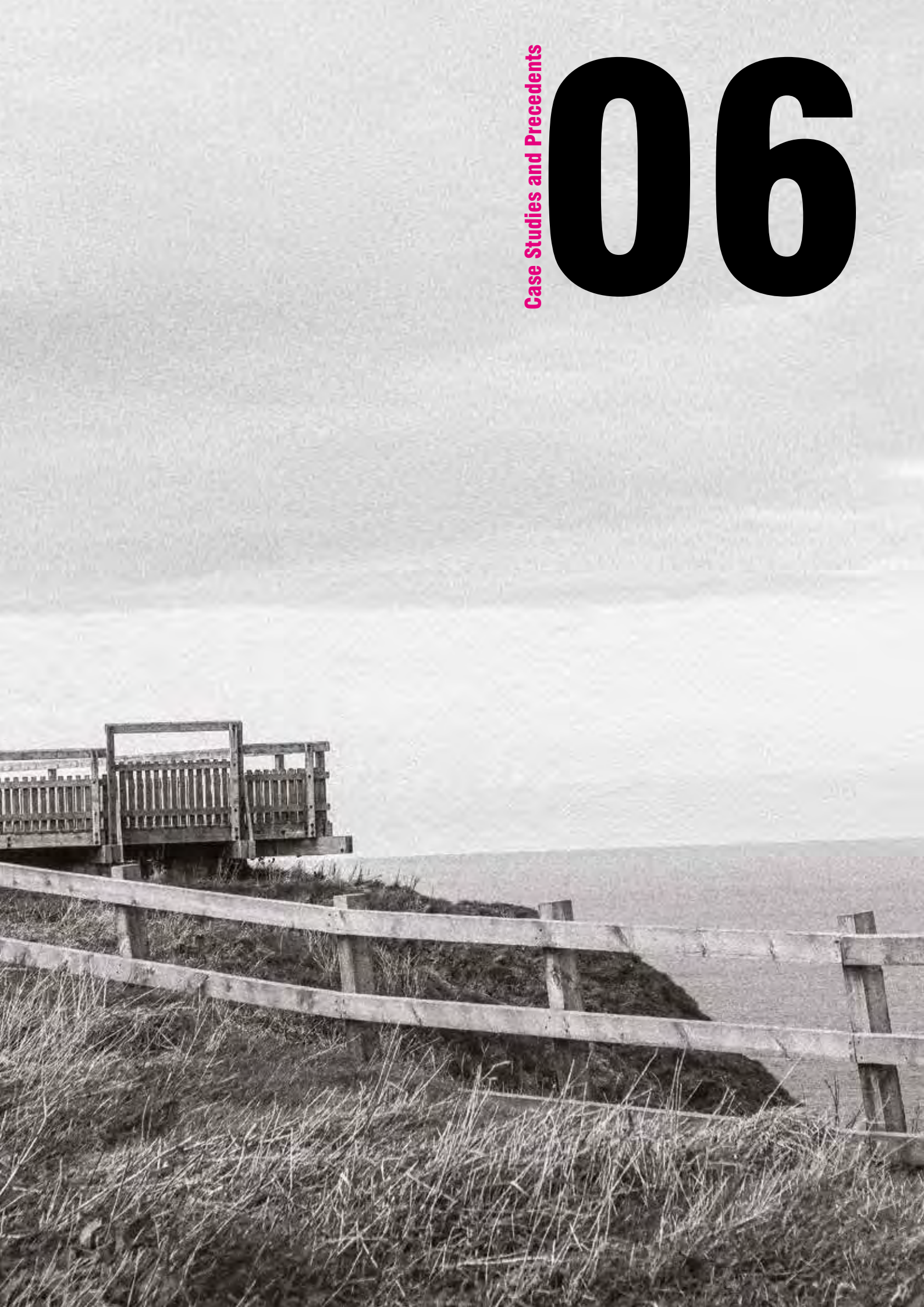
Fig.233

Small-scale biogas reactors can be located above or below ground, and are generally made from brick (SSWM, u.d.)

Fig.234

06

Case Studies and Precedents



Farm Urban

Project: Farm Urban

Founders: Dr Paul Myers, Dr Jens Thomas
Opened: 2014
Location: Liverpool, United Kingdom

Farm Urban, Liverpool, was founded by Dr Paul Myers and Dr Jens Thomas in 2014 as a result of their aspiration to find solutions to the global food crisis. By designing integrated urban farming systems that put communities at the heart of their projects, an engagement with food was formed. With the aim to change people's dietary choices and attitudes towards food, they believe consumer-involvement is vital in making the shift from damaging, meat-led diets fuelled by financial gain and reliant on fossil fuels, to local close-loop systems fuelled by taste, and maintained by an increase in consumer knowledge and desire for a healthier lifestyle (Myers, P. 2016.) Taking a 'bottom-up' approach, rather than 'top-down', Farm Urban's projects have been situated in local schools and hospitals, where children and young adults can be educated. The project this case study will focus on is the aquaponic farm located beneath Liverpool Life Science UTC. The following information was primarily gathered through an interview with Dr Jens Thomas.

Fig.236

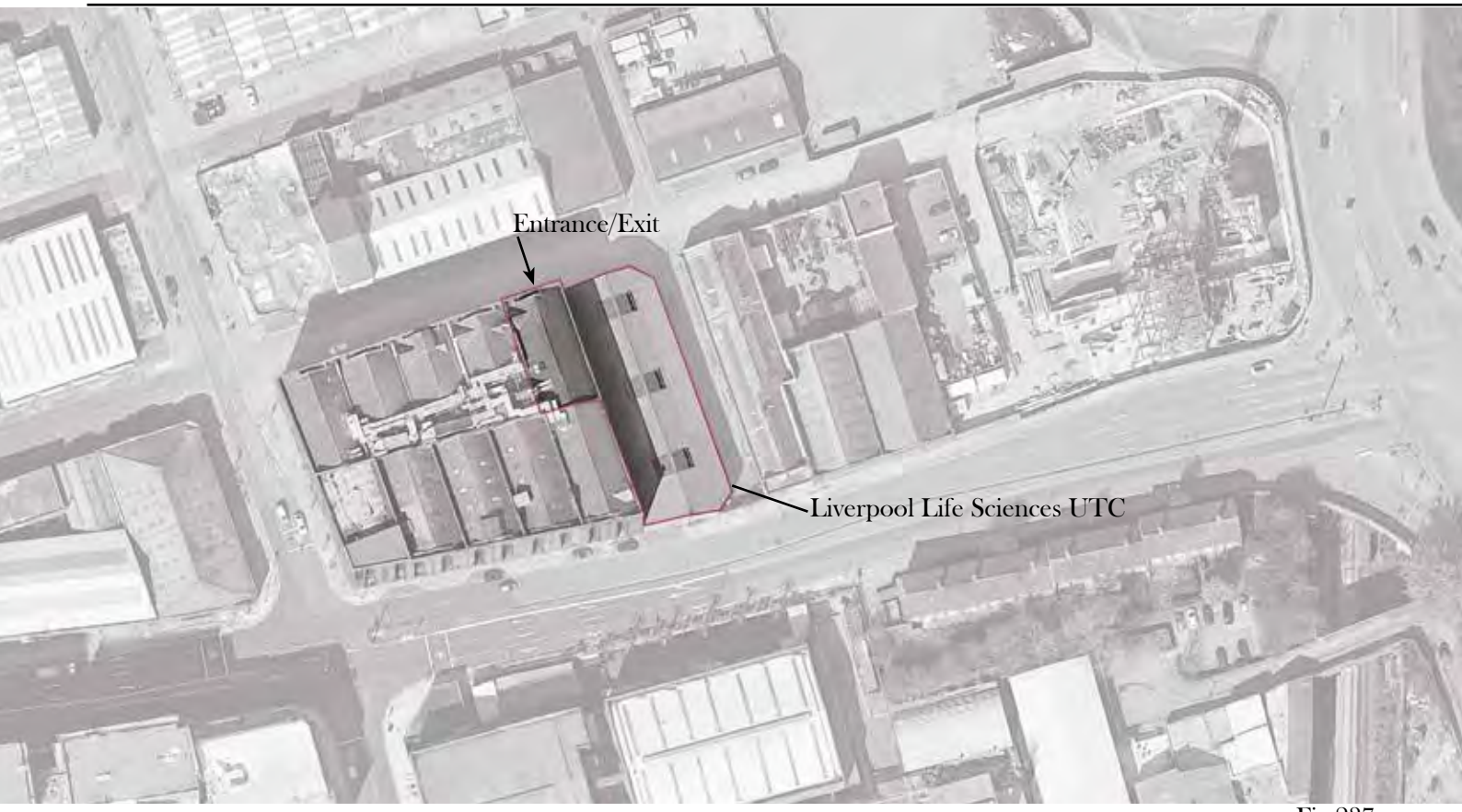


Fig.237

Location:

Located in some disused Victorian tunnels beneath Liverpool Life Science UTC, the vertical farm is run by 2 full-time staff members along with some volunteers. Accessible via an entrance off Greenland Street, the site sits in Liverpool's Baltic Triangle positioning the project in the heart of a vibrant community of independent start-ups. The project connects with the local community by providing on-site educational talks to local schools and colleges, as well as selling the harvested produce to individuals and companies living within a 4-mile radius. However, with no exterior sign indicating the farm occupies the tunnels beneath, the project appears to be lacking street presence; a pedestrian passing by wouldn't know of its existence, consequently missing an opportunity to further spread awareness.

Fig.238

Liverpool Life Sciences UTC entrance, and access to Farm Urban in the tunnels beneath.

A few visual indications and signs its a science college, but no street presence for Farm Urban; a missed opportunity to further spread awareness?

Quieter backstreet in Liverpool.

Fig.239

Equipment/Facilities:

- ZipGrow systems that use 8ft towers growing the main bulk of produce.

- 5ft edible walls x4

- Packaging area

- Storage for packaging

- Storage for daily consumables

- Propagation area

- Sinks x2 (one clean and one dirty)

- Extract

- Vents x4

- Sump

LED lights:

- The main farm (large-scale) uses both Intravision SB-785-1251B-L09 and Intertek ZPGLW-075 lights.

- The edible walls (small-scale) use Valyoa LEDs.

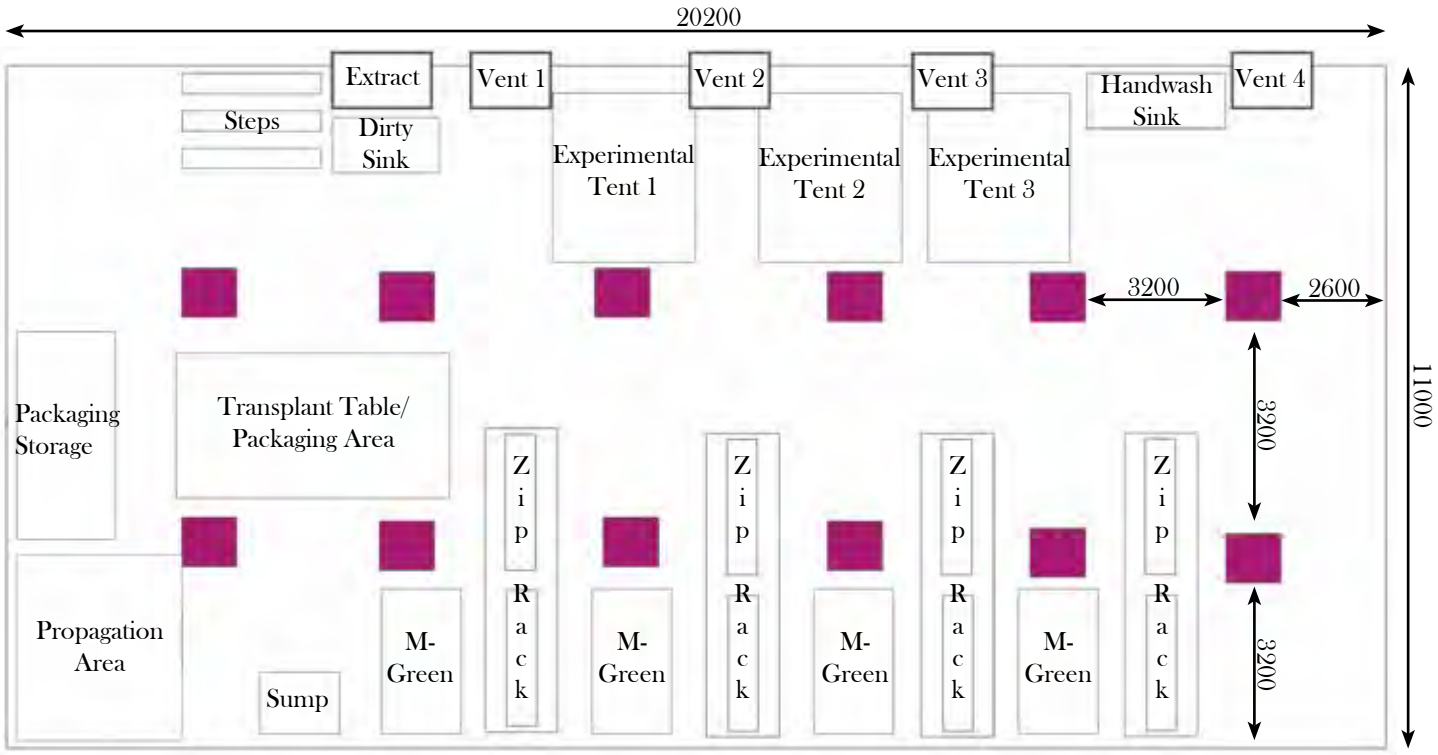


Fig.240

Circulation:

With a singular entrance/exit leading onto a main 'corridor' with different areas stemming off it, the layout and circulation of the farm is somewhat like a small-scale version of the bunker.

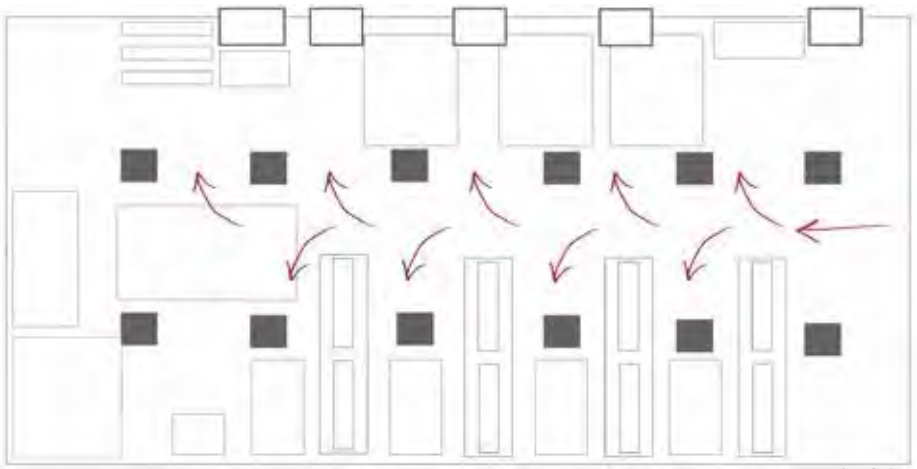


Fig.241

Main farming area:

System electrics and pipework runs along the ceiling to reduce trip hazards.

Vertical, 8ft ZipGrow towers.

Red and blue LED lighting surrounding the towers.

The farms are on wheels for easy mobility, if conditions need altering etc.

Concrete flooring for practicality.

Fig.242

Eight 8ft towers on either side of each system.

Fig.243

Company ethos sets the tone for the educational tours.

Keeping the original Victorian tunnel brickwork contributes towards the farm's sustainability ethos.

Entrance to the farm:

Storage and propagation facilities stored away at the back of the tunnel.

Vertical farming systems tucked away into each alcove.

An example of one of their produce pods.

Fig.244

Experimentation tents:

Fig.245

Use of produce pods for small-scale experiments.

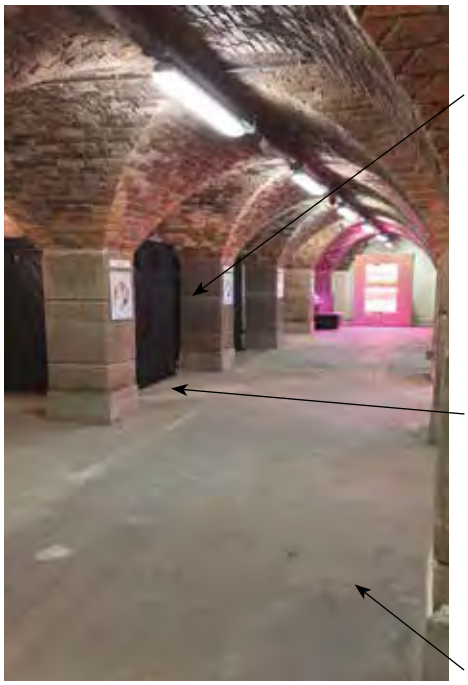


Fig.246

Foil interior for insulation and temperature control.

Tents tucked away in tunnel alcoves to leave clear paths for the walk-through tours.

Tents allow Farm Urban to create very controlled environments.

A wide central tunnel space allows large class sizes to attend the educational talks.

Propagation area:

Propagation is required to breed plants from their parent stock.

Metal table for practicality and easy-to-clean surfaces.

A young plant ready for the vertical farming systems.

Fig.247

Fig.248

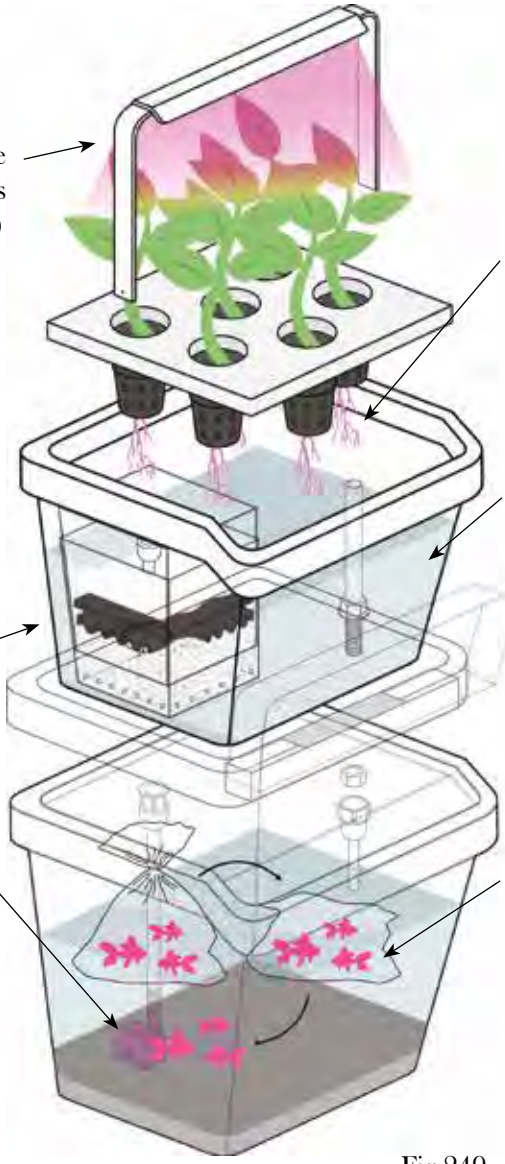
Aquaponics:

Aquaculture: raising fish in a controlled environment.

Hydroponics: growing plants in nutrient-rich water (without soil.)

Aquaponics: the combination of the above two processes. The fish provide the plants with nutrients; the plants provide the fish with fresh water.

LED lighting when there's an absence of sunlight. (Farm Urban uses LEDs for their transportable Produce Pods.)



Nitrates/nutrients are taken up by the roots of the plant.

Bacteria oxidises the ammonia into nitrites, then a second process oxidises the nitrites into nitrates with the help of another bacteria present.

Waste water rich in ammonia is transported to a grow bed above.

Clean water free from ammonia is delivered back to the fish tank.

Ammonia produced by fish via their respiratory system.

Fig.249

Produce:
As 60% of packaged leaves are wasted in the food system, Farm Urban focuses on growing such perishables locally (Myers, P. 2016.)

Currently the farm produces 450 lettuces per week, growing 5 types each taking 6-7weeks until harvestable:

- Oak Leaf Cornouai (16 cal. per 100g)
- Salanova Seurat (14 cal. per 100g)
- Salanova Hawking (14 cal. per 100g)
- Salanova Expertise (14 cal. per 100g)
- **Red Batavia (25 cal. per 100g)**

In addition, herbs that can be harvested multiple times in a 40day span, producing 200 per week, include:

- Basil (Sweet Genovese, Lemon, Red Shiraz) (22 cal. per 100g)
- Coriander (23 cal. per 100g)
- **Parsley (36 cal. per 100g)**

In the past, the farm has also grown:

- **Kale (54 cal. per 100g)**
- Chard (19 cal. per 100g)
- **Saffron (314 cal. 100g)**

Fig.250

Fig.251

Greens for Good Scheme:

Funded by grants they have been awarded, Greens for Good is an extension of this specific Farm Urban project and focuses on the community by helping it support itself. For example, when someone buys a box of greens, they support a box being donated to a local school too. The scheme also helps businesses incorporate vertical farms within their own buildings, as well as selling 'produce pods' (small-scale, aquaponic farms) to individuals. Selling locally allows capital to be raised and reinvested into the local community by expanding projects through infrastructure and teaching.

Fig.252

Buy or subscribe to a box of freshly grown greens.

Fig.253

←Box of greens includes various leafy greens and a small jar of edible flowers.

Fig.254

←Local schools getting involved.

Fig.255

←Educating students of different ages about hydroponic farming, and the importance of sustainable food.

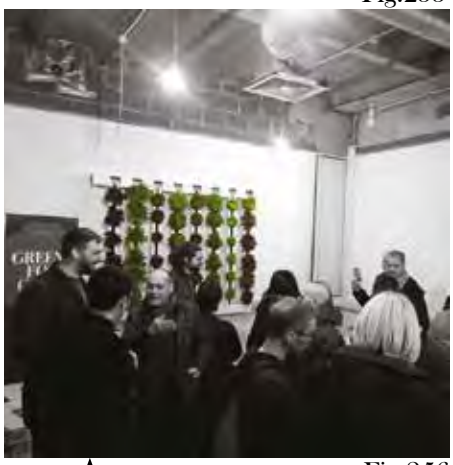


Fig.256

Events/presentations showing potential clients how they can incorporate their own vertical farms in the office.

Sellable Produce Pod.

Fig.257

When asked 'what would your ideal urban farm be like?' Dr Thomas replied:

"Ideally an urban farm would be situated within the community that it was growing food for, so that it would also be providing jobs to the local population as well. It would take advantage of otherwise unused urban space, thereby reducing costs and bringing value to something that is currently unvalued. It would take advantage of as many 'waste streams' within the local area to reduce its ecological footprint and would use renewable energy wherever possible." (Dr Thomas, J. 2020.)

Fig.258

Community-feel; positive working atmosphere.

Successes:

- Located where their consumers are, so food mileage is reduced and education is easily accessible to local schools.

- Being underground, the project is shielded from the external environment i.e. pests and unpredictable weather.

- The building is already heated by the school, so the farm can take advantage of the waste heat for growing.

- The space was otherwise unused so it's an economically viable project.

- The visual and interactive learning aspect of the project gives greens a form of narrative, which generally results in human investment. (For example, unhealthy foods sell much better on the market due to the sheer amount of investment in the branding of each product giving them more of a 'narrative', unlike the fruit and vegetables also on the shelves of supermarkets. Myers, P. 2016.)

Drawbacks:

- Due to being located within a school, there are a lot of health and safety requirements, and the scheme has to work around the school's timetable.

- More greens have to be consumed to reach a sufficient number of calories; plants with the highest-calorie content should be prioritised to be competitive with traditional farms.

- The financial cost to set up and run an urban farm is notably high, which is often a deterrent when trying to get consumers to shift to growing their own produce.

- Aquaponic systems often have nutrient imbalances that are hard to track and rectify; hydroponic systems are a lot simpler to maintain.

Eleanor Palmer Science Lab

Project: Eleanor Palmer Science Lab
Architect: Ay Architects
Completion: 2004
Location: London, United Kingdom

Completed in May 2018, the Eleanor Palmer Science Lab's architecture was designed by AY Architects with the aim to reflect the function within: learning. Built entirely from exposed timber, the structure also became a teaching point, encouraging children aged 3-11 to not just question what's in their textbooks, but also the structural and environmental qualities of the space around them (Architects Journal, 2019.) Described as 'a cabinet of curiosities', the array of shelving lining the walls leaves room for the space to grow with its users, as it has the capacity to hold more artefacts donated over time (AY Architects, 2018.) The aim of the project was to promote discoveries and excitement for learning amongst children, whilst also remaining functional as a practical science classroom.

'Foster enquiring minds, curiosity and wonder in the world.'
(AY Architects, 2018.)

Fig.259

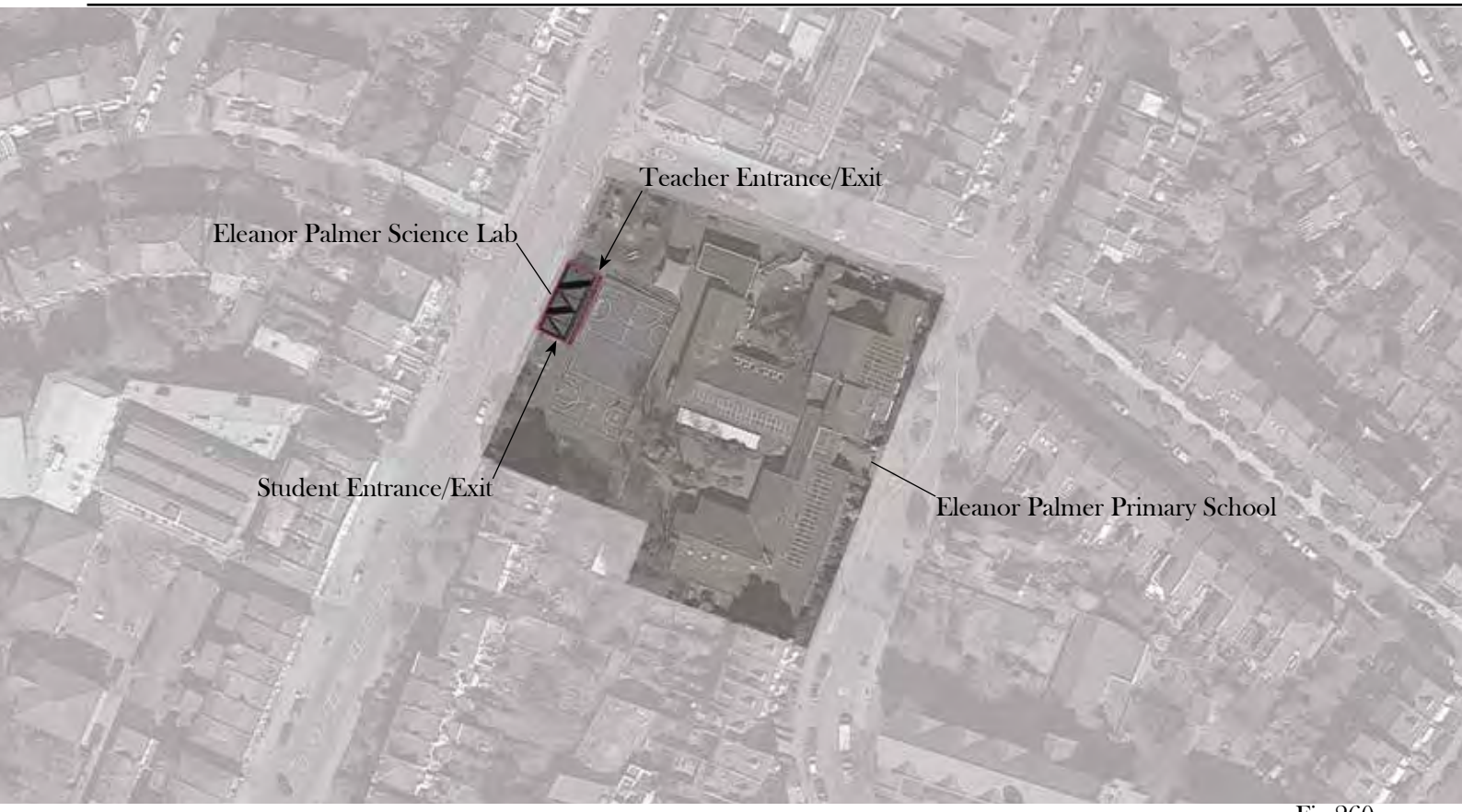


Fig.260

Location:

Located on a busy road in Camden, London, the project became a hub for the local community of primary schools. Visually linked by a square window in the Victorian wall separating the street from the lab, the architecture is a sensitively considered addition to its urban surroundings (RIBA Architects, 2019.) Giving pedestrians just a hint of what lies beyond the wall, again, plays on the idea of curiosity.

Fig.261

Sound and ventilation were key challenges for the project, as the site is adjacent to a busy main road.

Small square window through to the science lab follows the concept for curiosity into the architecture.

The tops of the triangular roofs can be seen peaking above the Victorian wall from the street.

Fig.262

Equipment/Facilities:
- Chairs x30
- Tables x15
- Sinks x5 (one lower for disabled access)
- Vents x4
- Hanging plug sockets x2
- Teaching board
- Oven
- Storage shelves of various heights and sizes
- Closed storage cupboards
- Private storage room
- Coat pegs
- Toilet with disabled access

Materiality:
- Safety vinyl flooring was chosen for slip resistance as well as being wipe clean for easy maintenance and hygiene (Architects Journal, 2019.)

- Timber was chosen to mimic the feel of a garden shed, whilst also teaching children of sustainable building technologies (AY Architects, 2018.)

Fig.263

Open shelving at windows maximises storage whilst not blocking natural light.

Ventilation flaps for allowing fresh air into the space.

Multiple sinks to avoid a concentration of students and potential hazards.

Simple, 3D handles for easy access.

Exposed materials and structures encourage students to questions the space around them.

Hanging plug sockets to reduce trip hazards.

Moveable chairs and tables to adjust classroom configuration.

Practical surfaces easy to clean.

Lots of storage both cupboards and open shelving; open shelving or cupboards with clear doors containing science-related artefacts on them encourages student interaction and inquisitiveness.

Circulation:

Varying in lessons and activities, the main space is flexible allowing the classroom to be reconfigured accordingly. Although fitted with an adequate number of facilities to capacitate for 30 pupils and 1 teacher, the space isn't huge (Arch Daily, 2019.) Therefore, the pupils file in from the south-facing double-doors, collecting a lab coat on the inside of the entrance, before making their way to their seats via the outskirts of the classroom to avoid chaos in the transition. Meanwhile, the teacher can enter via the north-facing entrance adjacent to the teaching board, in order to be able to prepare for the lesson at the opposite end of the classroom to the children. Key facilities, such as sinks, are distributed evenly along the length of the space to avoid a concentration of pupils in one area, reducing the risk of accidents as well as waiting times that could hold up the lessons.

Fig.264

Plenty of floor space in order to be able to reconfigure the space, and also to avoid collisions and potential hazards.

Thresholds are located at opposite ends of the room for orderly circulation.

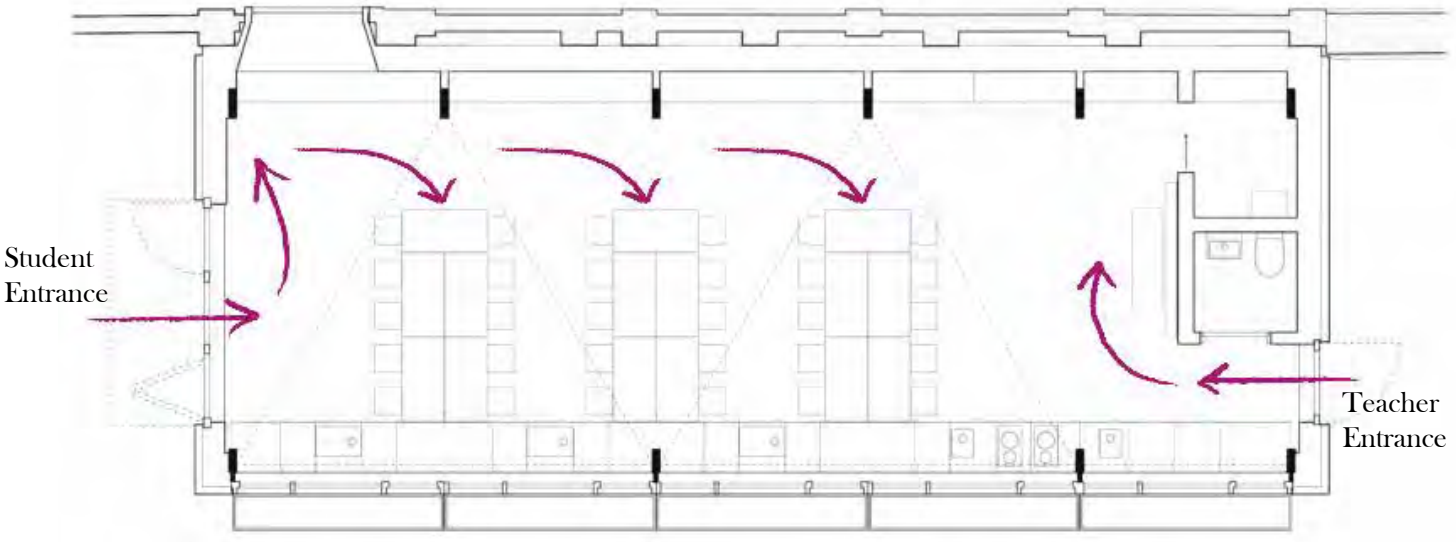


Fig.265

Ventilation:

Ventilation can be difficult because when air is allowed in so is noise pollution. AY Architects tackled this problem by placing the vents along the east elevation to reduce noise caused by the traffic (Architects Journal, 2019.) The timber flaps allow the outside to be closed off at any time giving teachers the ability to control the classroom environment. Furthermore, the doors at either end and the windows along the east elevation can be left open on a clear day too to maximise air flow.

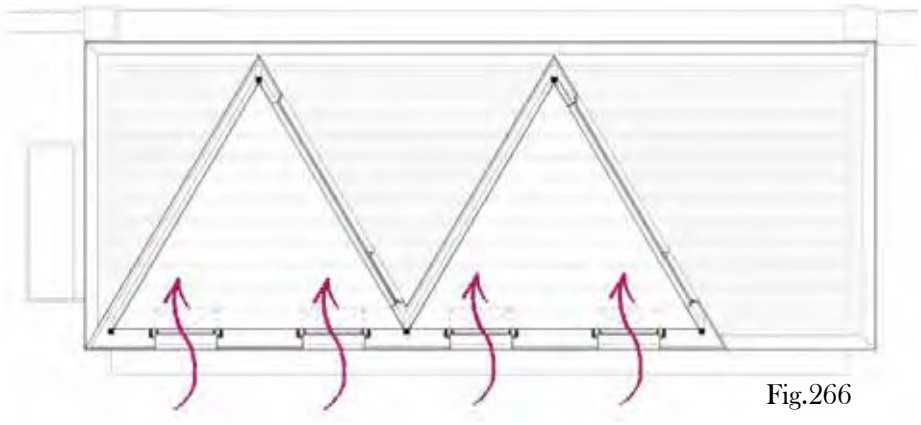


Fig.266

Evenly distributed to evenly circulate fresh air through the interior.

Located alomg the east elevation to reduce traffic noise.

Use of beams enables artefacts to spill out from the display shelving and be hung from the ceiling.

Strong use of geometrics also adds to the mathematical statements used within the structure intended to add to the educational nature of the space.

Ventilation flaps can be opened or closed by the teachers in order to adapt the space to their needs.

Fig.267

Natural Light:

Not only was natural light important for creating an inviting atmosphere, but functionally was also needed to achieve the best teaching environment too, such as demonstrating and carrying out the experiments. Windows line the length of the east elevation, whilst two raised triangular roofs allow light through their northern faces. Northern light is considered to be the best working light, as it stays the most consistent throughout the day. The doors are also glass to maximise the space's natural lighting opportunities, but is withheld from the west elevation to avoid the risk of distractions from the street.

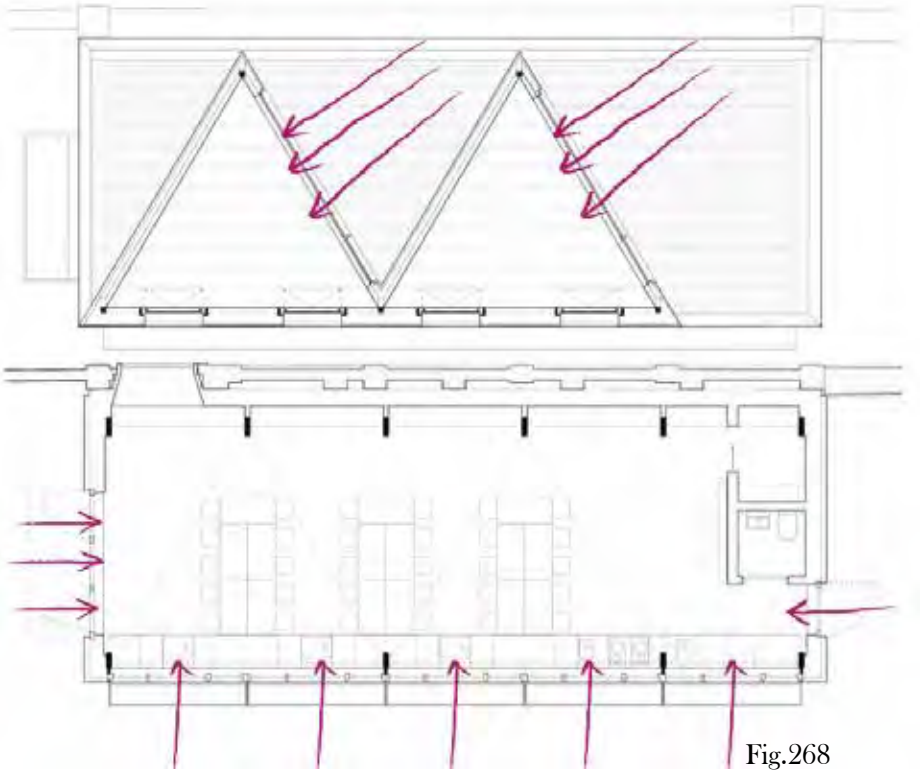


Fig.268

North-facing skylights for best working light conditions.

Glass doors also maximise lighting.

Windows along the entire eastern elevation to maximise natural light but minimise potential distractions.

Fig.269

Successes:
- Using the concept of curiosity and learning to develop architectural choices throughout the scheme.

- The circulation of students and air flow around the space.

- As the users are both students and teachers, the design had to consider how these two contrasting roles would work together within the space; as the proposed project will have two contrasting roles of private and public, inspiration can be taken from this scheme's circulation, storage etc.

- The vast amount of storage space and shelving incorporated into the structure.

Drawbacks:
- The space could be considered too distracting for a classroom environment.

- Although the positioning of air vents reduced noise pollution, it didn't cancel it out. Located on a busy steet in London, an air ventilation system may have proven a better option.

- Circulation flow would be somewhat easy to disrupt, when the classroom's layout is reconfigured.

- Natural timbers aren't easy-to-clean surfaces.

Chichu Art Museum

Project: Chichu Art Museum
Architect: Tadao Ando
Completion: 2004
Location: Naoshima Island, Japan

'Chichu' translates from Japanese to 'beneath the earth' (Pollock, N. R., 2005.) Ando's brief was to design environments specifically to showcase the works of Claude Monet (impressionist painting), Walter De Maria (land works and installations) and James Turrell (light and movement installations). Consequently, the challenge of manipulating natural light in an underground space was essential to the design. Wanting nature, light and art to be the central focuses for the project, Ando used his signature style of brutalist architecture, concrete and minimalism to act as a blank canvas, whilst also using it as a tool to manipulate the senses.

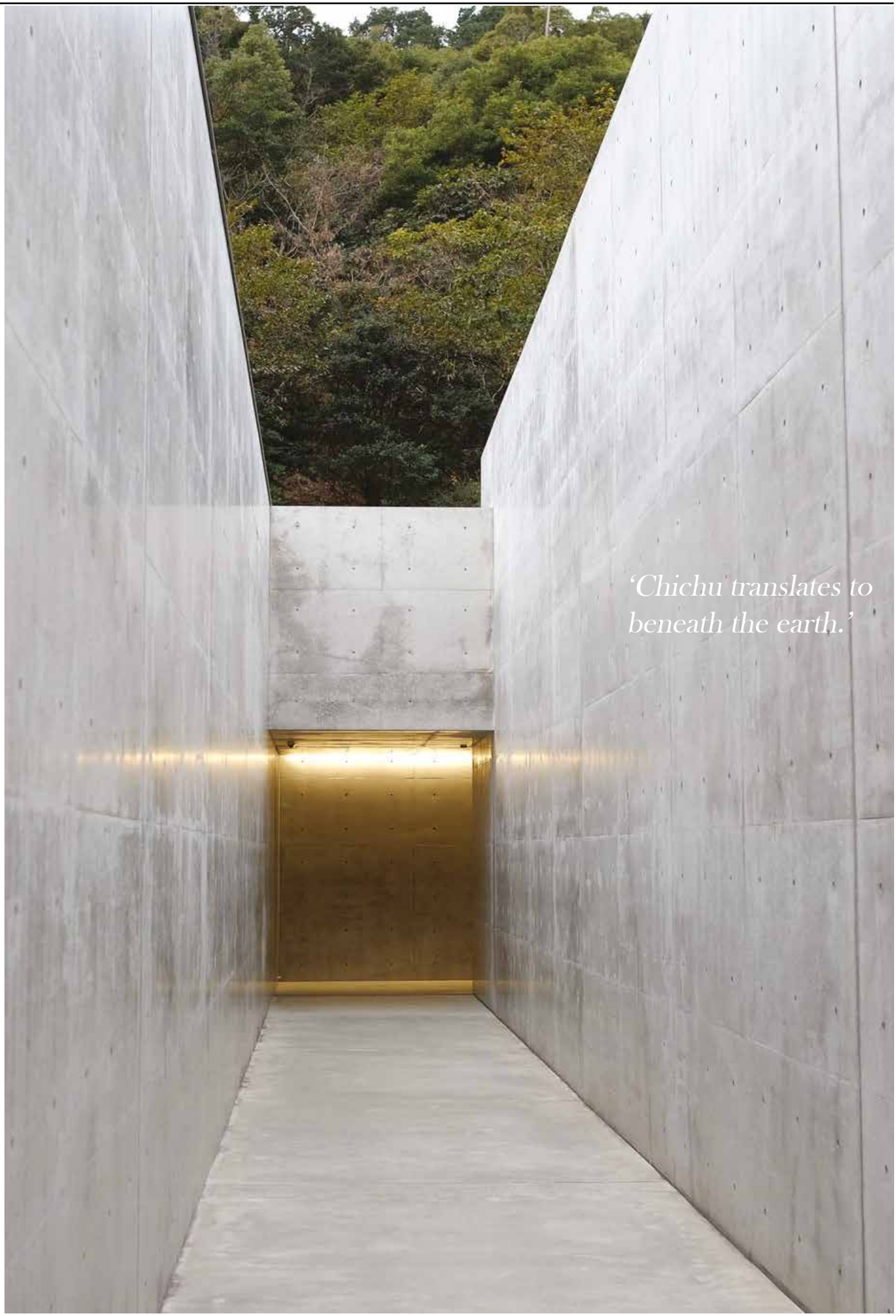


Fig.270

Relationship with Nature:

In order to preserve the location's natural salt pans, Ando chose to bury the architecture within the hillside becoming part of its topography (Architects' Journal, 2005.) Being within nature takes 'being at one with nature' to a whole new level. Users are grounded within the heavy structure, whilst its emptiness combined with natural light and materials make it feel lightweight and somewhat meditative. The two elements are contrasting yet harmonious. The inspiration for involving nature was taken from the subject matter of Monet's paintings; there is also a garden containing plants and flora identifiable in Monet's work. Turrell and De Maria also have strong interests in nature with their work.

Fig.271

Aerial view showing the voids cut into the landscape; the thresholds between above ground and below ground, and nature and architecture.

Fig.272

Garden constructed by Monet's landscape paintings.

Fig.273

Empty Space and Transitions:
The term 'ma' in Japanese means to place more value on empty space over physical matter. Keeping the same minimalist language throughout allowed the spaces to be free from visual pollution giving Ando more control over the users' senses and the phenomenology created within each space. The idea of championing empty space can be best seen in the use of the transition spaces. Cutting courtyards out of the landscape enclosing both grass, stone and sky, Ando achieves a pause in a moment of movement. Furthermore, the voids carved out give a hint of what lies within from the exterior purely from the outlines of the empty spaces being so distinctively geometric in comparison to the natural landscape, and therefore clearly of human intervention.

Fig.274

Framing sky and grass, the concrete architecture merely acts as a tool to manipulate the users experience of their natural surroundings.

Fig.275

The circulation wraps around the inner walls, creating a moment of pause in a moment of movement.

The minimalist language feels meditative allowing users to focus on a singular surface or texture at a time.

Fig.276

Overlapping levels of circulation utilise the same transition space.

Openings in the walls through to the next space show glimpses of how the spaces connect.

Fig.277

The height of the architecture drawing attention to the depth of the earth and height of the sky draws attention tp the vastness of nature.

Framing a sky and stone similarly to the first courtyard a pause in a transition space is created.

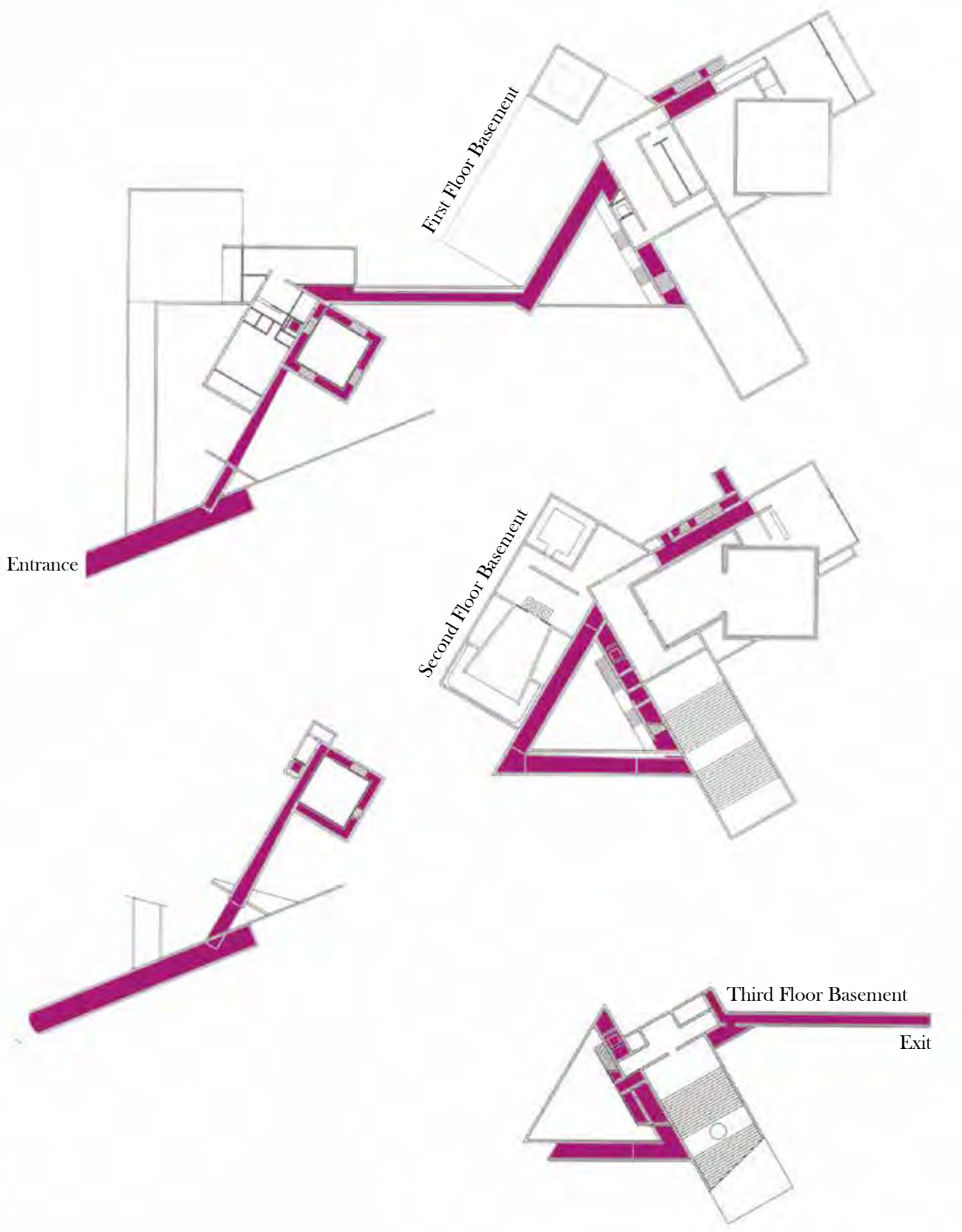

First Floor Basement
Entrance
Second Floor Basement
Third Floor Basement
Exit

Fig.278

Circulation:

The project is laid out like a journey, which starts with visitors switching their shoes for slippers giving the intimate feel of entering a private home (Pollock, N. R., 2005.)

Fig.279

The circulation of the building starts at one end and slowly builds up towards the galleries at the other, controlling in what order visitors view the spaces. Consisting of a series of paths, corridors and stairways connecting together geometrically shaped spaces, the structuring of circulation is very linear with any changes in levels occurring in the courtyard transition spaces. This touches on a previous note about creating a pause within the transitions; although the user is moving to another level, they aren't progressing along the linear route causing a pause in their journey toward the galleries.

Fig.280

Natural Light:

The scheme solely utilises natural light and manipulates it to best showcase individual artworks.

Fig.281

Claude Monet:

With a soft yet striking colour palette, the light for this space was paired back to let the paintings do the talking. By only letting light filter down from the edges of ceiling, the paintings are illuminated in soft, natural light without being glaring in the eyes of the users or reflecting off the glass frames they sit in. The mosaic floor combined with this type of lighting give a soft, dappled effect, like the brushstrokes straight out of Monet's impressionist painting.

Tadao Ando:

As tribute to his own work, Ando created a seated space and moment of reflection centred around a square framing the sky. The skylight floods the room with light whilst creating that ever present connection with nature.

Fig.282

Fig.283

Fig.284

Walter De Maria:
Of all the gallery spaces, this one has the strongest input of natural light. De Maria's work explores art's interaction with space. This concept is emphasised by the usage of light, which falls across different parts of his work at different times of the day giving a sense of surface, texture and scale.

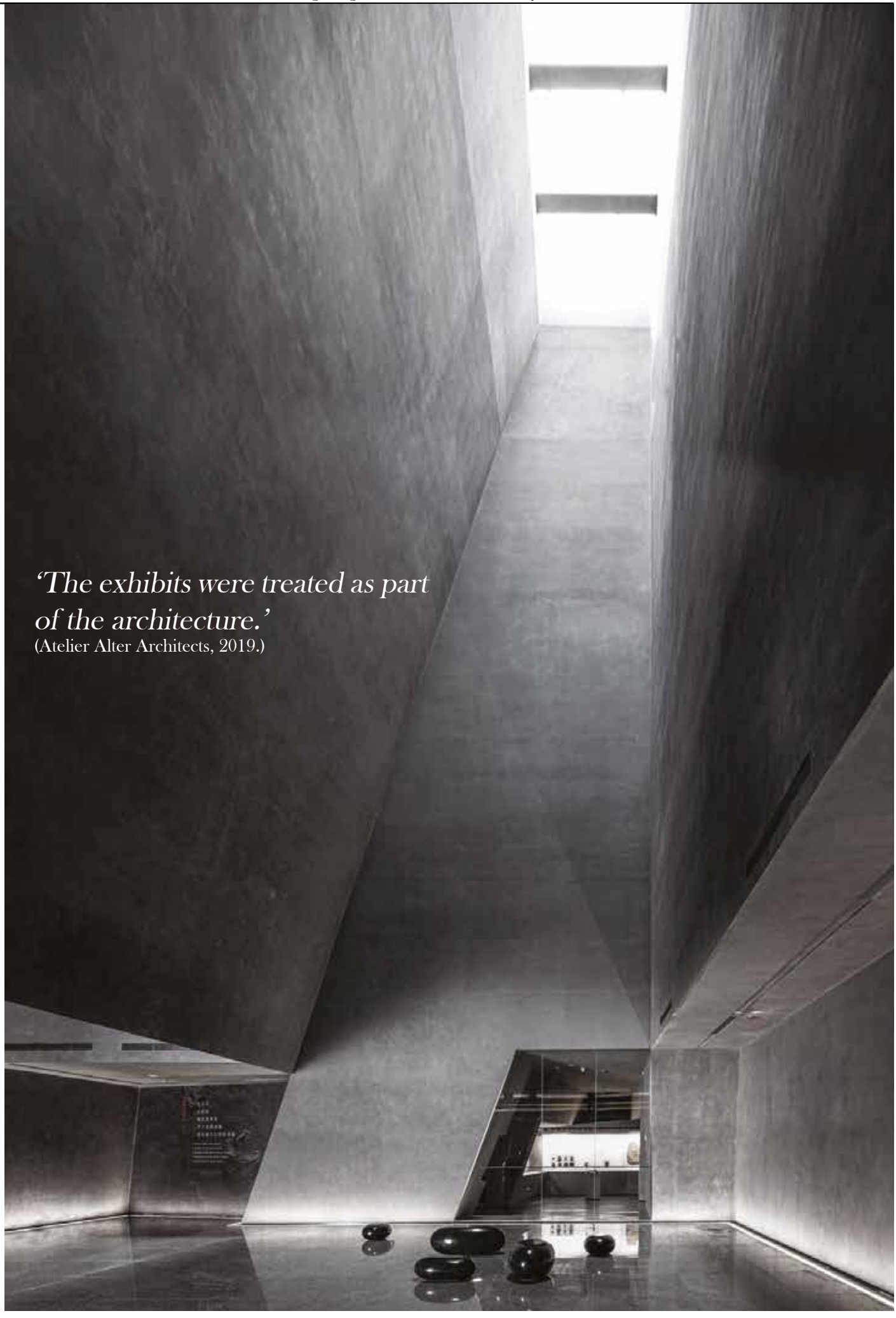
James Turrell:
As Turrell's installations evolve around light, natural light has been restricted in this space. Ando created an opening for light similarly to the other spaces but, instead of natural light pouring through it, artificial coloured light from the installation is contained by it, creating a clear boundary between Ando's architecture and Turrell's installation piece.

Fig.285

Yingliang Stone Natural History Museum

Project: Yingliang Stone Natural History Museum
Architect: Atelier Alter Architects
Completion: 2019
Location: Xiamen, China

Built into the office of a stone company, this project was about expanding a brand by incorporating a museum into their existing premises to exhibit the company's collection of stones and fossils. The brief emphasised cohesion yet separation between private and public spaces to encourage both public and corporate interest, and 'bridge the gap between industry and culture' (The Plan, 2019.) The architecture was designed as though the exhibits were a part of it, by basing the structural design on the geometry of a crystal. The biggest challenge was how to get light into the space, as the building was five-storeys tall with the fossil museum required to be on the ground and first floor in order to be accessible to the public.



'The exhibits were treated as part of the architecture.'
(Atelier Alter Architects, 2019.)

Fig.286

The central 'crystalloid' acts as both structural support and a divide for the light wells to direct the light towards different levels of the building.

Textured concrete softens the intensity of the light and gives the concrete a stone-like feel.

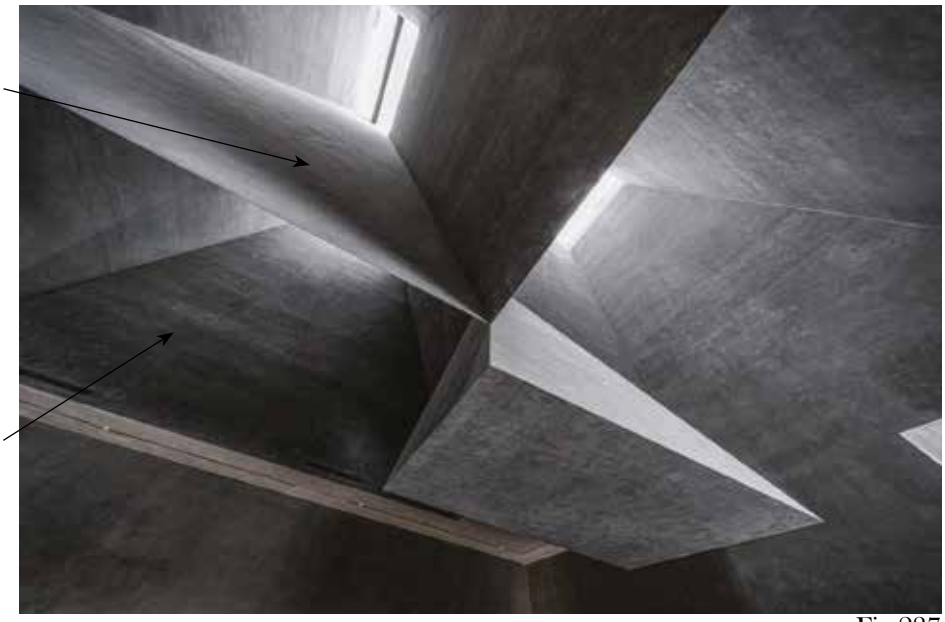


Fig.287

Light:

With the challenge of getting natural light to reach every level of a five-storey building, Atelier Alter created a void straight through its centre acting as a light well. The arrangement of vast concrete surfaces stemming from it reflect each skylight towards different areas of the space. The result is dramatic yet softened by the textured concrete walls and thick concrete beams, which filter the flood of light reducing its intensity from overhead. For the darker corners of the ground floor, where the natural light doesn't quite reach, the perimeter is lined with warm-white LEDs.

Fig.288

The ground floor receives the least light and feels as though you're inside a cave. Warm LEDs bring light to the darker corners.

Concrete beams create support whilst also filtering the light intensity.

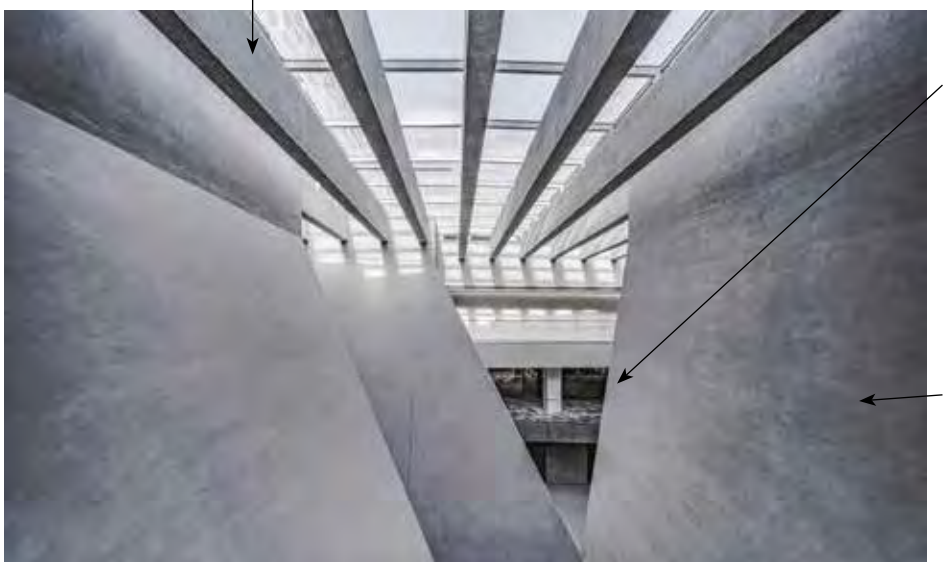
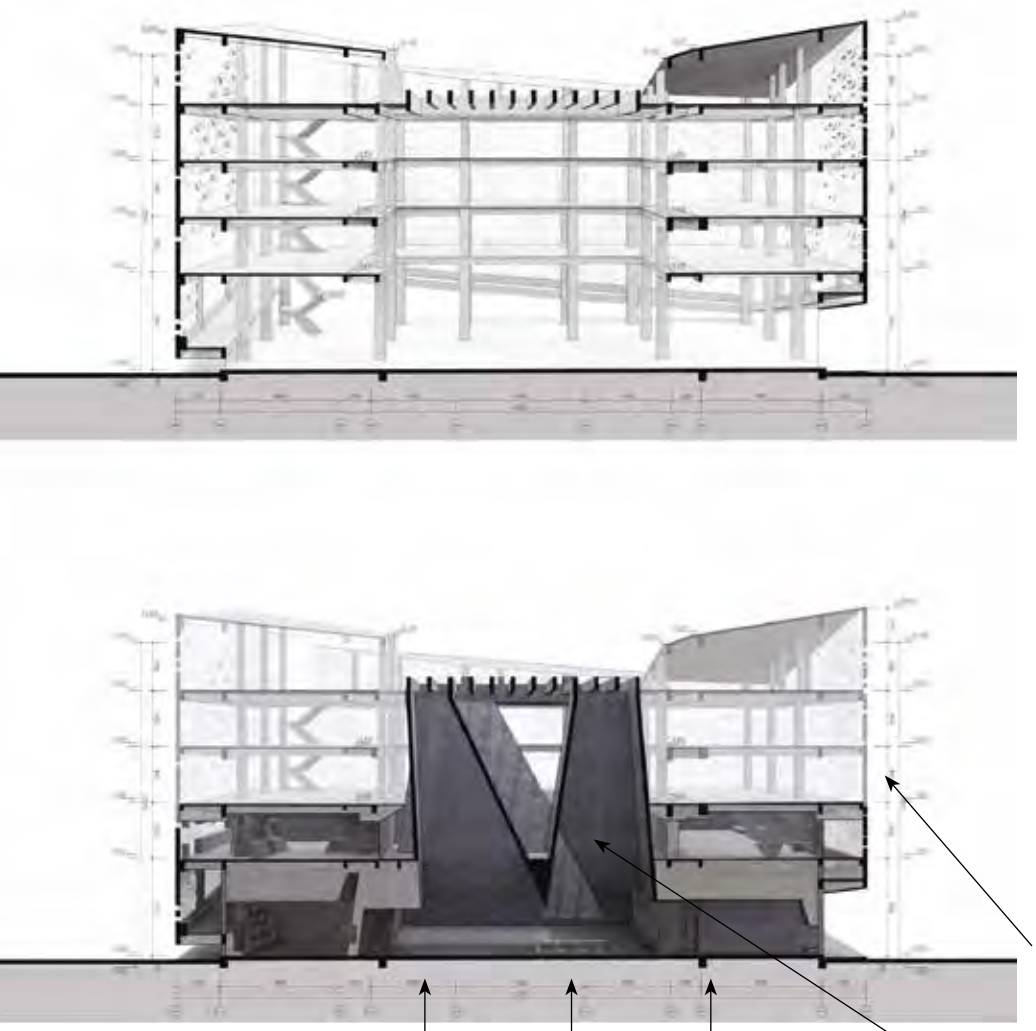


Fig.289

The offices receive the most light for working conditions.

The irregularly layered walls feel reminiscent of a mountainous landscape.



Private vs Public:

One of the main parts of the project requirements within the brief was for private and public spaces to be cohesive yet separate creating a connection between industry and culture (The Plan, 2019.) Cohesion was primarily achieved via the central void, connecting all the spaces by natural light, alongside the mutual visual connection to the central, concrete structures. The museum is located on the ground and first floors in order for it to be accessible to the public from the street, whilst the offices are located on the third, fourth and fifth floors to keep them isolated and private.

The three top floors are dedicated to the private office spaces for the stone company.

Fig.290

Inspiration can be taken from the approach to natural light as the challenge of getting natural light to reach the ground floor from a five storey tall building is comparable to the thickness of earth and concrete above the bunker.

Insertion within the existing office building.

First two floors are dedicated to the fossil museum and have easy public access via the street.

Central void creates cohesion between private and public spaces.

The divide between the spaces in the interior can also be distinguishable from the exterior architecture.

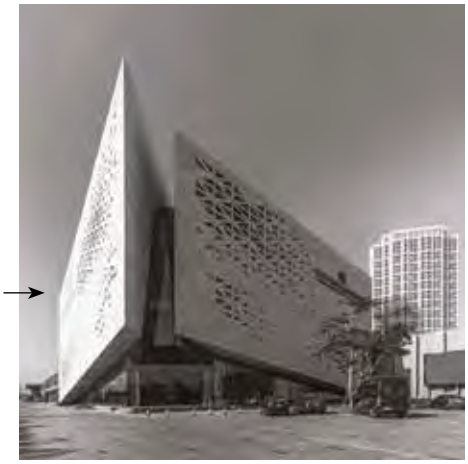
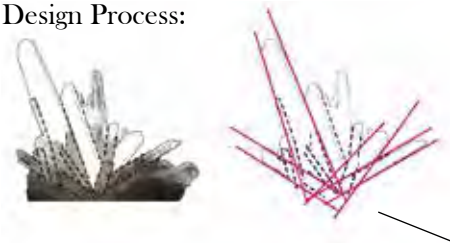
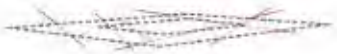


Fig.291

Design Process:



Initially inspired by the intersecting nature of a crystal formation.



Used the intersecting lines to help design a floor plan layout.

Took repeated patterns from the crystal geometry.

Used the repeated patterns to create 3D volumes in the space.

An initial sketch working out how to divide the exhibition space.

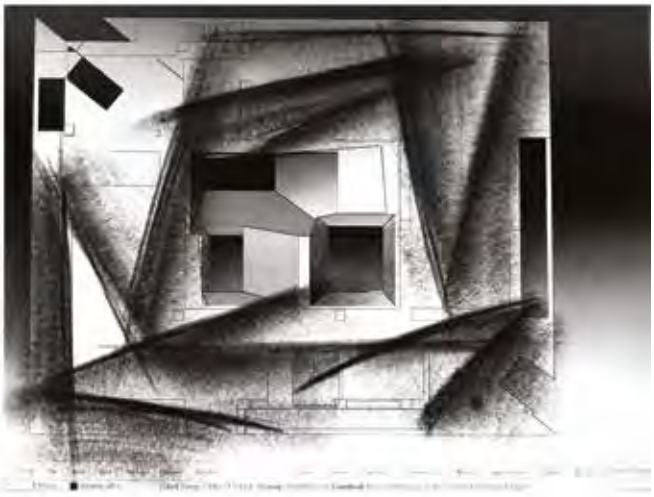


Fig.293

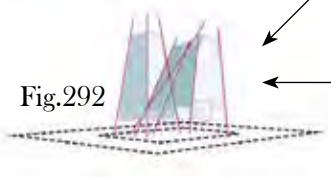


Fig.292

The complete concept combining the two initial concepts.

Design Approach:

Wanting the architectural language to reflect the museum's exhibits, the main design was developed from the geometry of a crystal. Slicing through the centre of the building, the final design can be linked to the volumes and negative spaces created by that of a crystal. The result is minimal yet powerful and feels somewhat cave-like: a strong spatial association to fossils and archaeology. The low ceilings in the exhibition spaces combined with irregular concrete forms and winding circulation gives the user a similar feeling to finding the artefacts displayed for the first time.

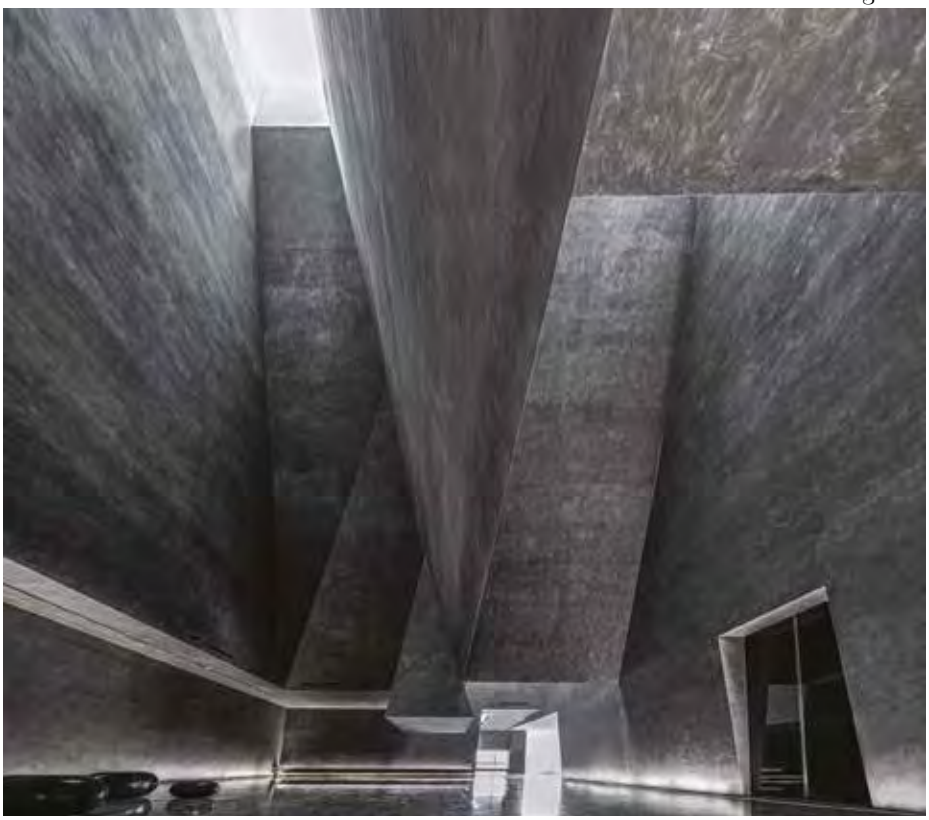


Fig.294

Dynamic volumes carried through from the atrium design.

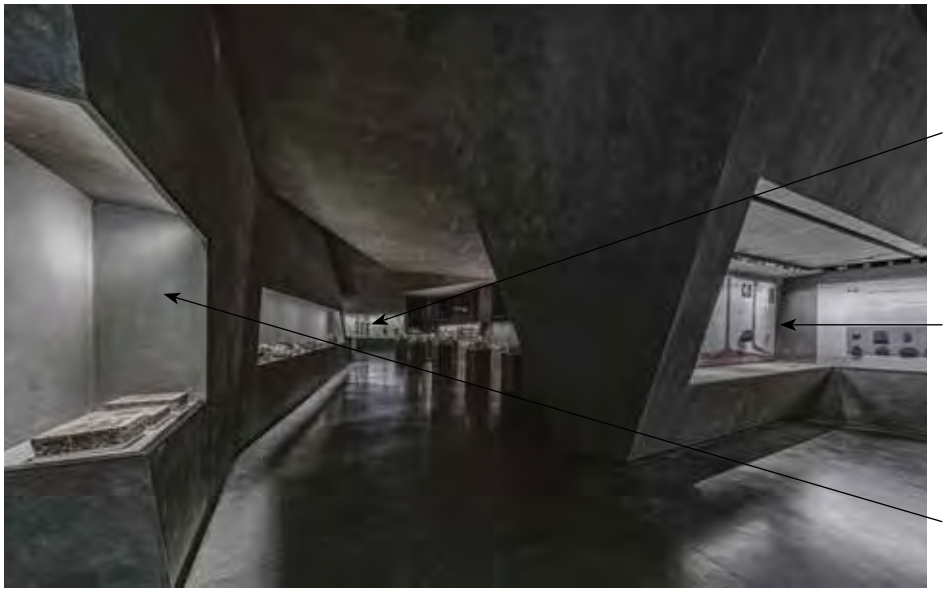
Varied types of exhibition spaces, stands and cases in order to protect the more valuable or delicate artefacts, whilst creating interest through variety.

Fig.295

Low ceilings add to the atmosphere of it feeling like your inside a cave.

Practical, concrete flooring to cope with the mas amount of visitors walking through on a daily basis.

Fig.296



Twists in circulation create a sense of intrigue and curiosity to see what's around each corner.

Exhibit spaces intergrated into the architectural structure.

Soft lighting illuminates the exhibits without causing any glare.

Fig.297

IKEA Urban Farming Installation

Project: IKEA Urban Farming Installation

Designer: Tom Dixon

Completion: 2019

Location: London, United Kingdom

Exhibiting the installation at the world's biggest horticulture show, *The Chelsea Flower Show*, IKEA wanted to demonstrate to consumers a vision for urban gardens of the future. With Tom Dixon leading the project, they designed a productive landscape installation with the aim to raise awareness of existing technologies and encourage people to consider home gardening on any scale themselves. The installation had two levels: the ground level housed an 'underground' hydroponic lab, whilst the first level created a bridge garden of traditionally grown plants; a slightly abstract concept of home gardening, whilst addressing both indoor and outdoor, and above and below.

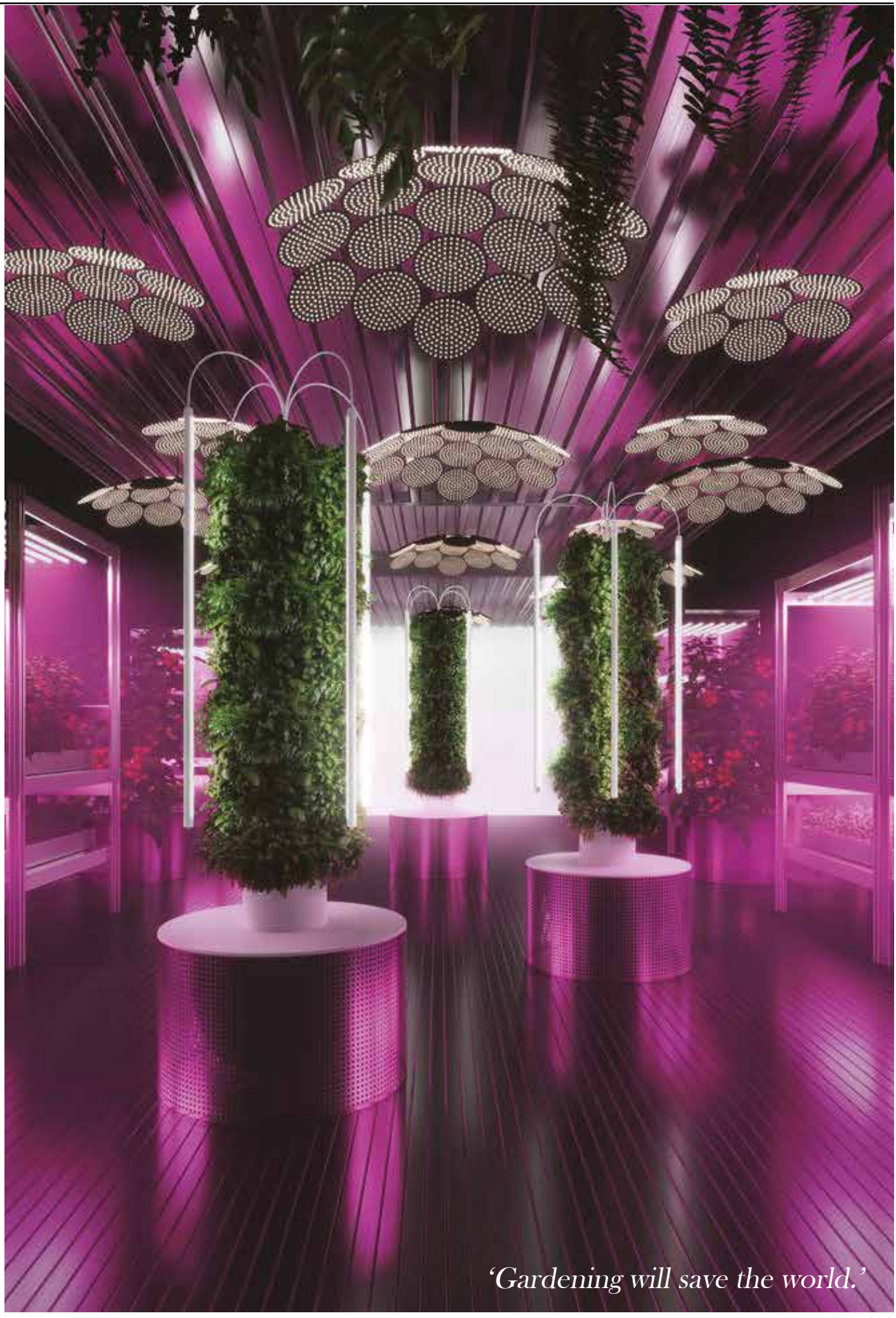


Fig.298

Fig.299

4,000 plants with varieties of both edible and medicinal species to show a range of possibilities (IKEA, 2019.)

Fig.300

Use of robot technologies to help maintained controlled environments and reduce human labour.

Some creatively shaped hydroponic setups to further entice curiosity.

Open-plan with large openings for maximum ventilation.

Adjustable shelving units to adapt to different plant heights.

Sanitary, practical, wipe-clean surfaces.

Shorter plants on lower shelves, medium plants on higher shelves, tall plants given their own space.

Adjustable lighting to adapt to different plants' light requirements.

Fig.301

Metal units for helping conduct temperature.

Individual hydroponic units to show users smaller scale versions of what can be acheived at home.

Plenty of walkway space between each hydroponic unit to be able to tend to the plants by hand.

Main fertiliser tanks stored underneath the plants.

Empty space under stairways utilised for storage of equipment.

Fig.302

Imperial War Museum North

Project: IWM North
Architect: Daniel Libeskind
Completion: 2002
Location: Manchester, United Kingdom

Libeskind designs architecture that feels uncomfortable and focuses on the phenomenology, with the desire to create expressions of our own existences. Often comparing architecture to music, Libeskind believes the physical building is just the instrument with the derived atmosphere being the architecture (LibeskindxTalks, 2009.) As part of the Salford Regeneration project, the IWM North was built on a key bomb site from the Manchester Blitz. As the site's history evokes such an emotional response, it was only right the museum's architecture did so too; deconstructivism was used as a tool in reaching the resulting genius loci.

‘Architecture is an emotional experience just as music is.’
(Libeskind, D., 2014.)

Fig.303

Design Approach:

Wanting to capture the way the bomb had shattered the landscape during the Manchester Blitz, Libeskind used deconstructivism to physically articulate such. Scaling up the idea in reference to how the war had affected the world entirely, Libeskind took a teapot to represent the globe and dropped it from a window for the initial design concept (Libeskind, D., 2001.) Three of the resulting fragments became the structural concept for the building representing the landscape reformed both physically and metaphorically. The shards represented war at air, land and sea with different functions being allocated to each in its interior. Imposing and theatrical, the way the museum punctures Manchester's skyline emits a feeling before anyone has even entered it. Associations with machines and weaponry are formed via materiality: steel structuring and aluminium cladding (Studio International, 2002.) Furthermore, both metal's durability and aluminium's malleability symbolise strength and adaptability.

Fig.304

Fig.305

Imposing and powerful, 'shards' of architecture puncture the skyline. Despite its irregularities, its form is strong.

Fig.306

Steel structure and alluminium cladding.

Fig.307

Exhibition Space:

Located in the 'earth shard', the exhibition space opens out into a large room and is filled with so much visual and audial stimulus it's overwhelming, without any particular focal point. The floor slopes by 8ft with all columns placed 4o off the perpendicular plane to account for the curved floor created by the earth shard's form (Tully, L., 2017.) This along with the chaotically arranged lighting and irregularly divided space provides for a highly disorientating experience. Unable to see what's around each corner also contributes to emotions of uneasiness of the unexpected. Libeskind derives the essences of war through these emotional responses.

One of the key features of the museum exhibition are the projections. Using the surfaces created by the interior dividers, large videos of war footage are projected onto multiple walls at a time criss-crossing over each other adding to the overwhelming atmosphere by introducing movement. However, every hour, other visual and audial stimuli are muted for the projections to become the only focus. This moment of pause allows time for reflection and understanding.

Fig.308

Chaotic positioning of lighting gives the space a dynamism and movement, despite the lighting itself being fixed in place.

Exhibit placements encourage you to look up and take in your surroundings.

Some areas feel more claustrophobic than others, as you move from open plan spaces to smaller spaces, where the towering walls feel like they're closing in on you.

Fig.309

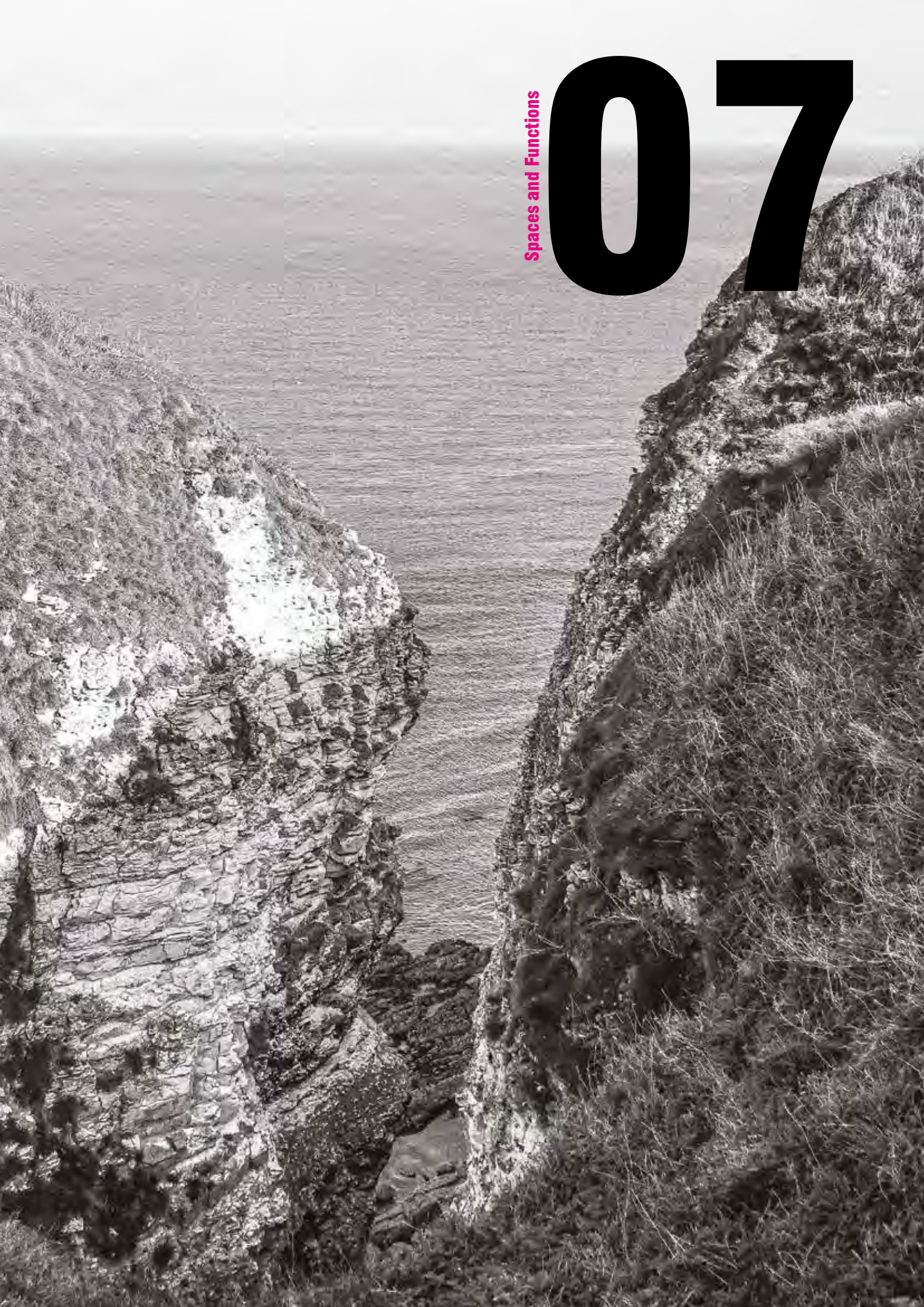
Projections placed everywhere create their own visual language and atmosphere.

Overwhelming amount of visual and audial information.

Projector placements are well out of reach of the public and aren't obscured by passing people.

Wall heights/projection screens feel imposing.

Fig.310



07

Spaces and Functions

Historic Process: A collage exploring the functions that were carried out above and below ground and how they were linked in a linear fashion.

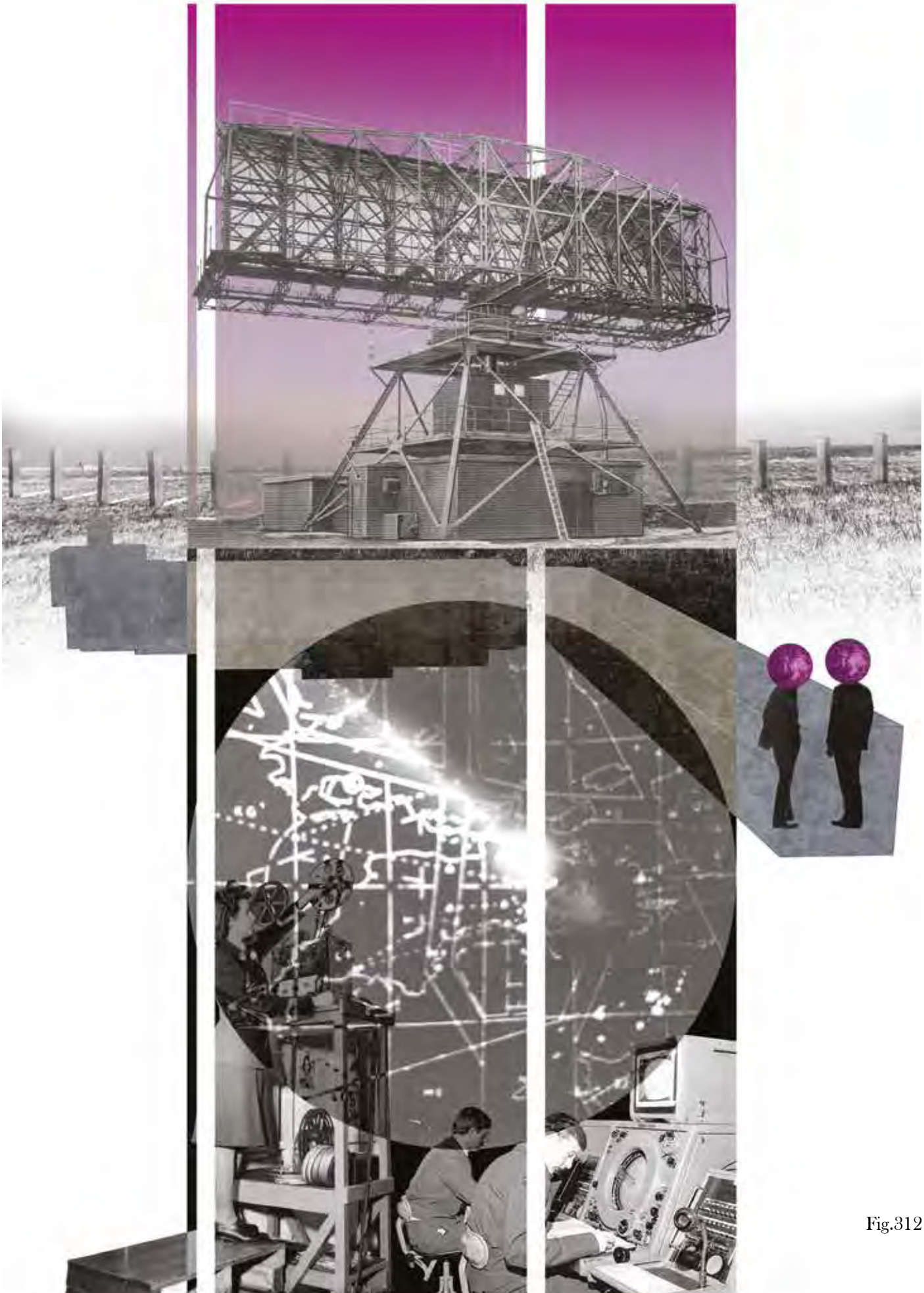


Fig.312

Fig.313

Proposed Process: A collage exploring the placement of proposed functions above and below ground and how they could link in a circular fashion.

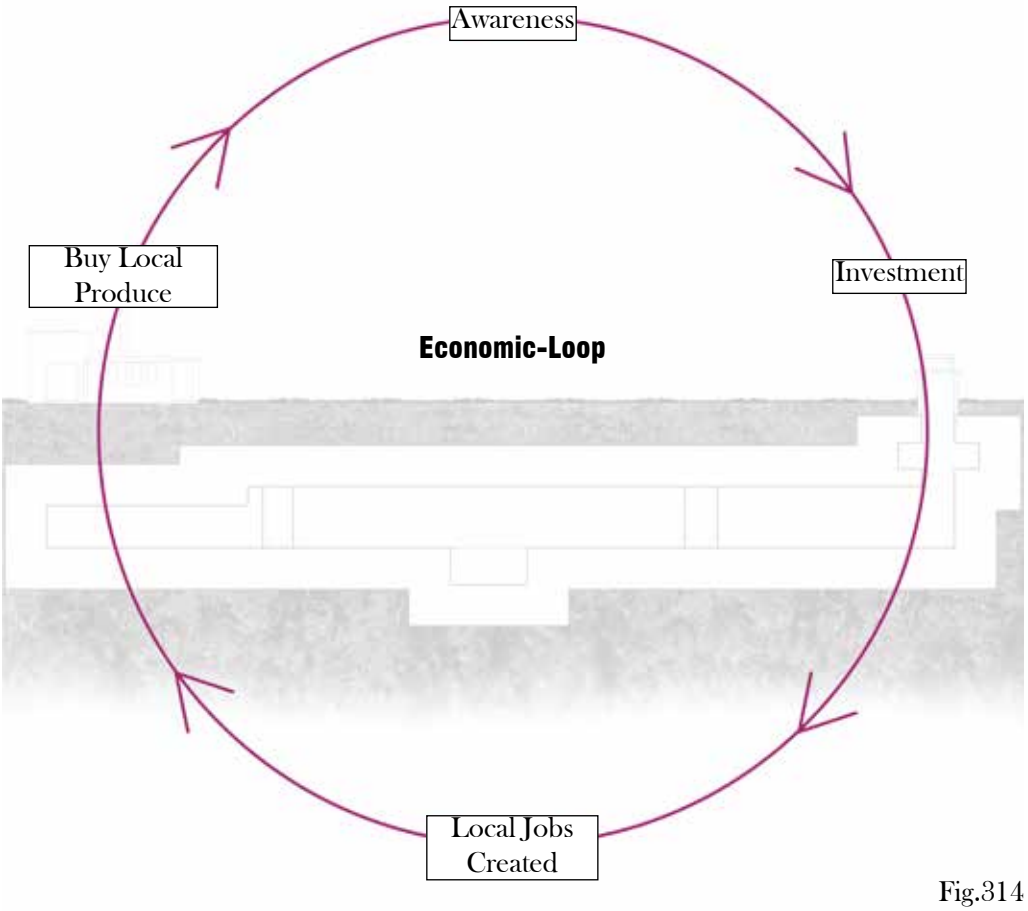


Fig.314

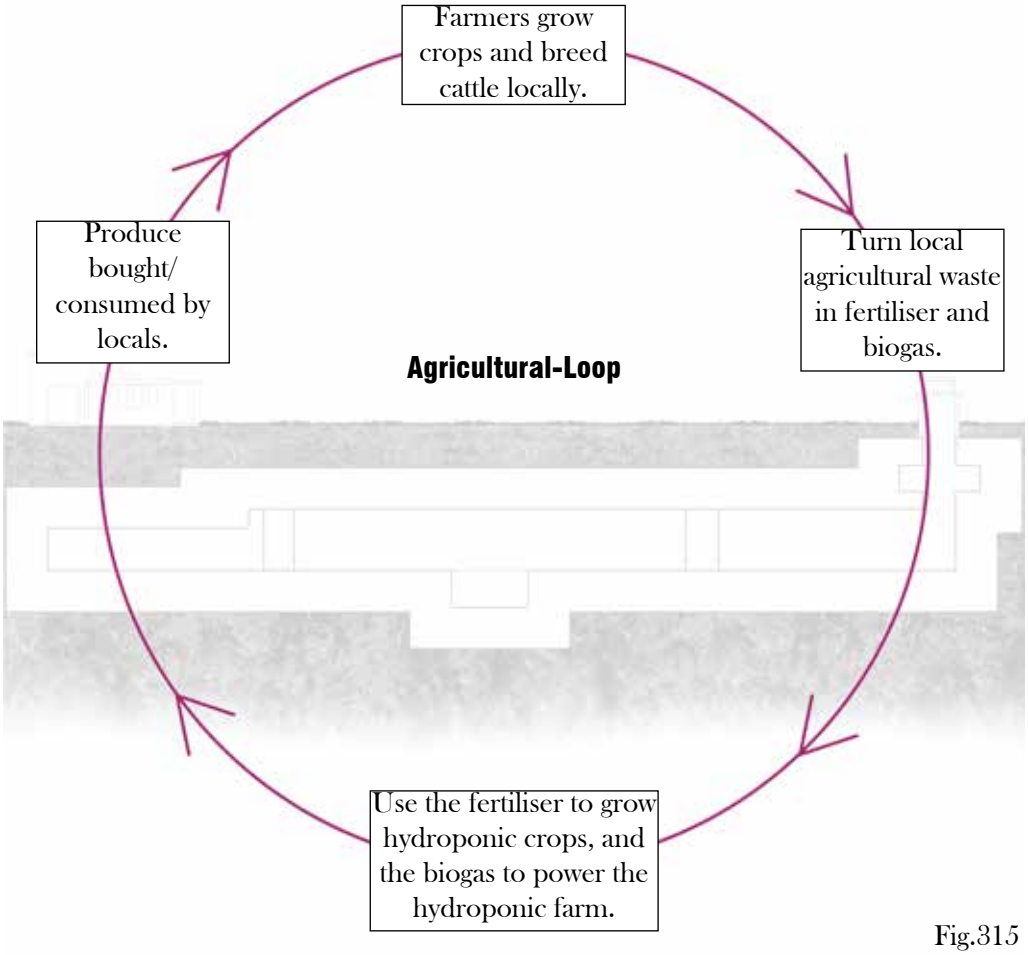


Fig.315

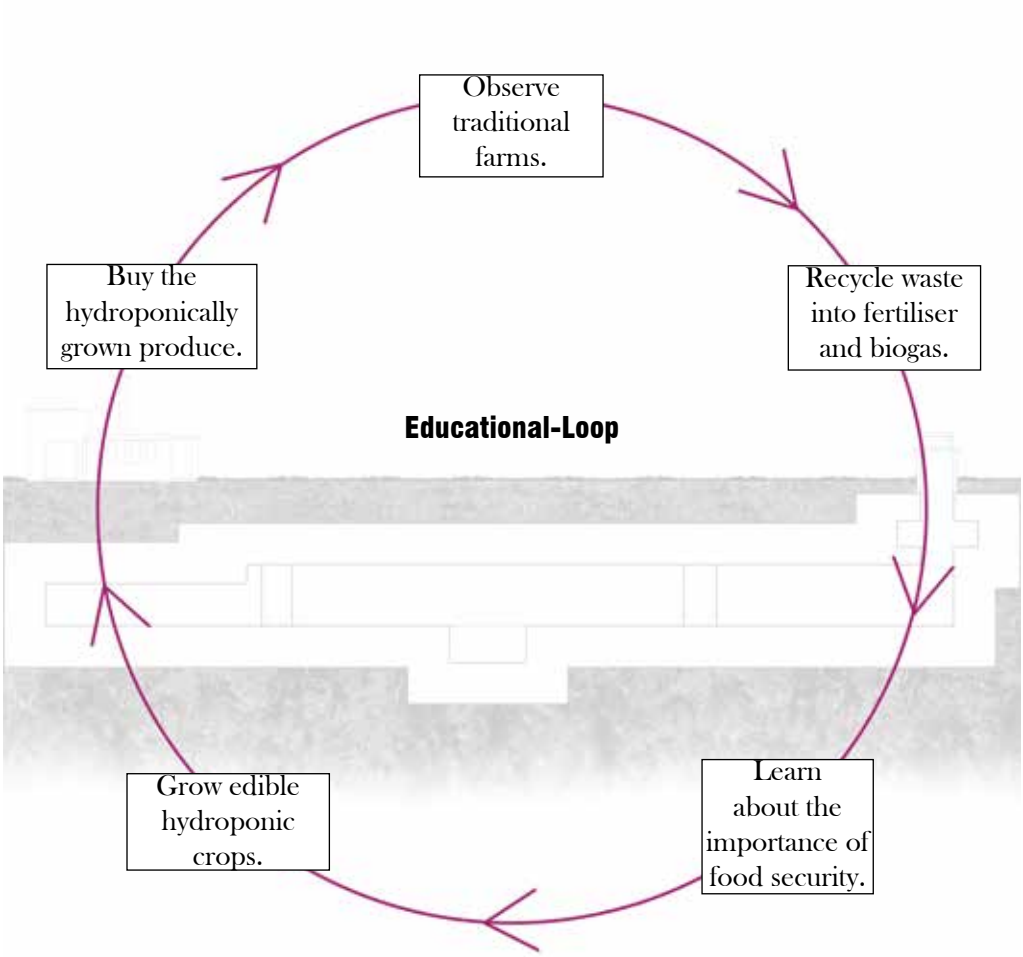


Fig.316

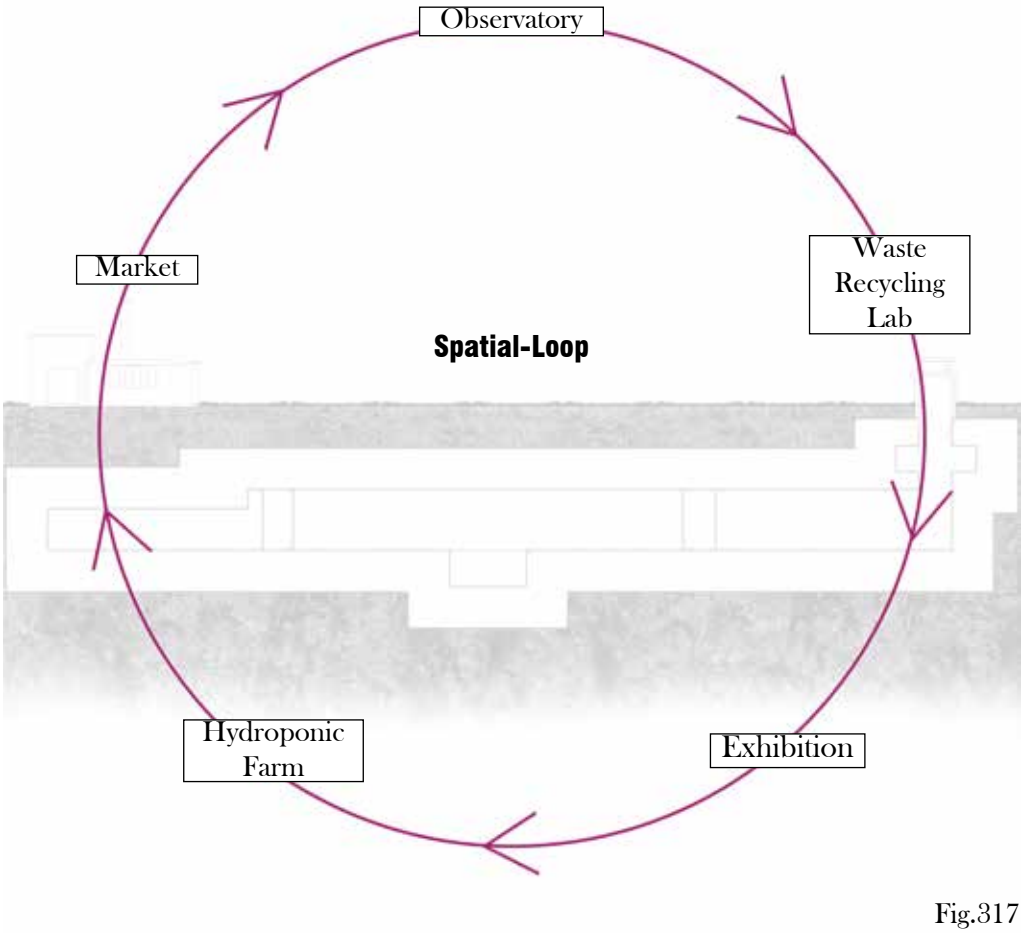


Fig.317

Site Plan:

Fig.318

5. The Green Market
(Small farmer's market.)

4. The Fuchsia Garden
(Hydroponic farm.)

2. The Switching Station
(Waste recycling lab.)

3. The Security Study
(Educational exhibition.)

1. The Field Observatory
(Reception and observatory.)

The Field Observatory

Observe existing traditional farms surrounding the site.

Original location of the type-80 radar head.

Fig.320

Fig.321

An architectural extension of what will already have been experienced by users approaching the site. 'The Field Observatory' will be fairly minimal, purely acting as a tool to frame and draw attention to the existing, traditional farmland surrounding. With picturesque, sweeping landscapes from all angles, the windows will sweep around covering 360º; a subtle reference to the revolutionary, type-80 radar head that once took its place.

The windows should be anti-glare and somewhat easy to clean in order to get the clearest of views; keeping the interior dark and free from visual pollution should also help with this. Both stair and lift access will be required to reach the vantage point, as well as a level pathway leading to it across the uneven terrain. This will also be the location of the reception, as it is the starting point of the walk-through exhibition.

Requirements:

Reception:
- Reception desk
- Waiting area
- Toilets

Observatory:
- Large, anti-glare viewing windows
- Seating
- Stair access
- Lift access

Reception Desk:
- There should be at least two different desk levels for both seated and standing use.
- For the seated receptionist or wheelchair user, leg room should be accounted for.
- If the receptionist is seated at a pc, an adjustable chair is required for arms to be positioned at 90° and for the pc to be eye-level.

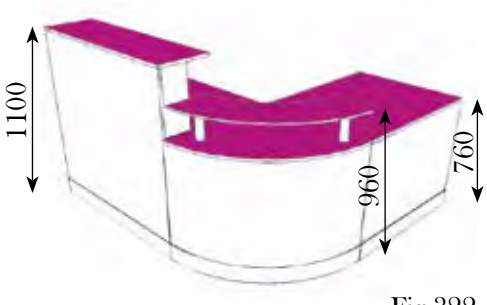


Fig.322

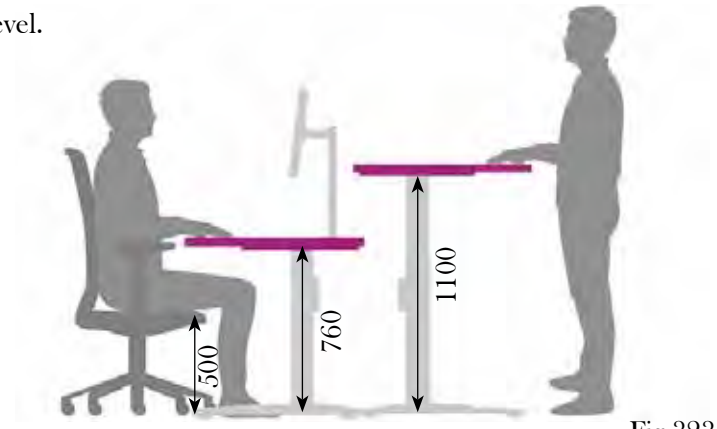


Fig.323

Public Toilet:
- If there is only space for 1 toilet, it will have to have disabled access and be unisex.
- If there is space for men and women WCs, the building will require a minimum of 1 for men and 2 for women.

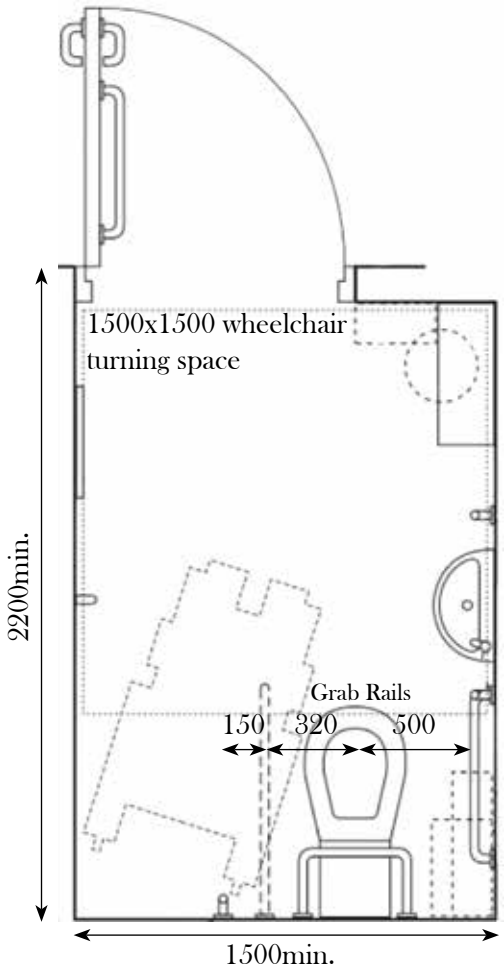


Fig.324

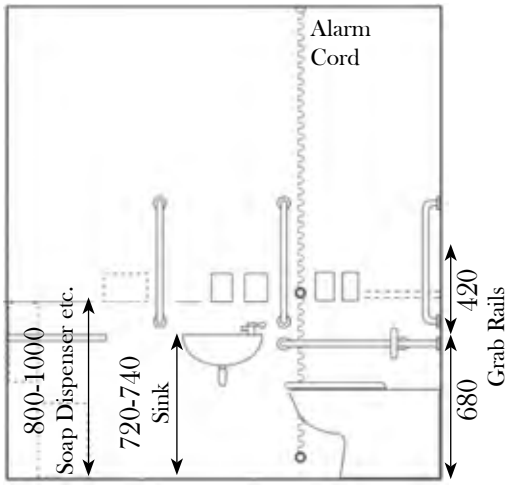
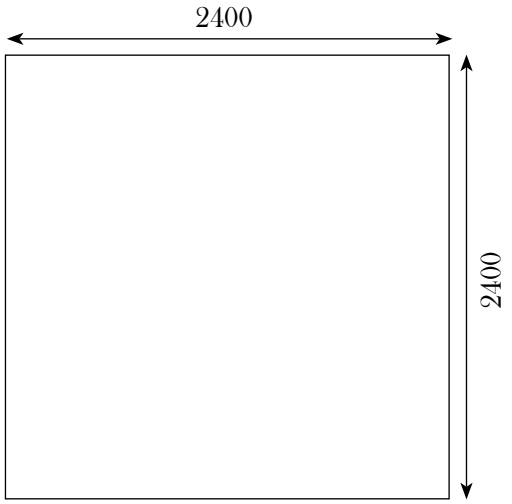


Fig.325

Windows:
- As the windows of the obersatory will cover 360°, it will need to be broken up by muliple glass panels.
- Being on a large scale, they would potentially have to be custom made; the largest 'picture window' size sourced online was as drawn (see diagram.)



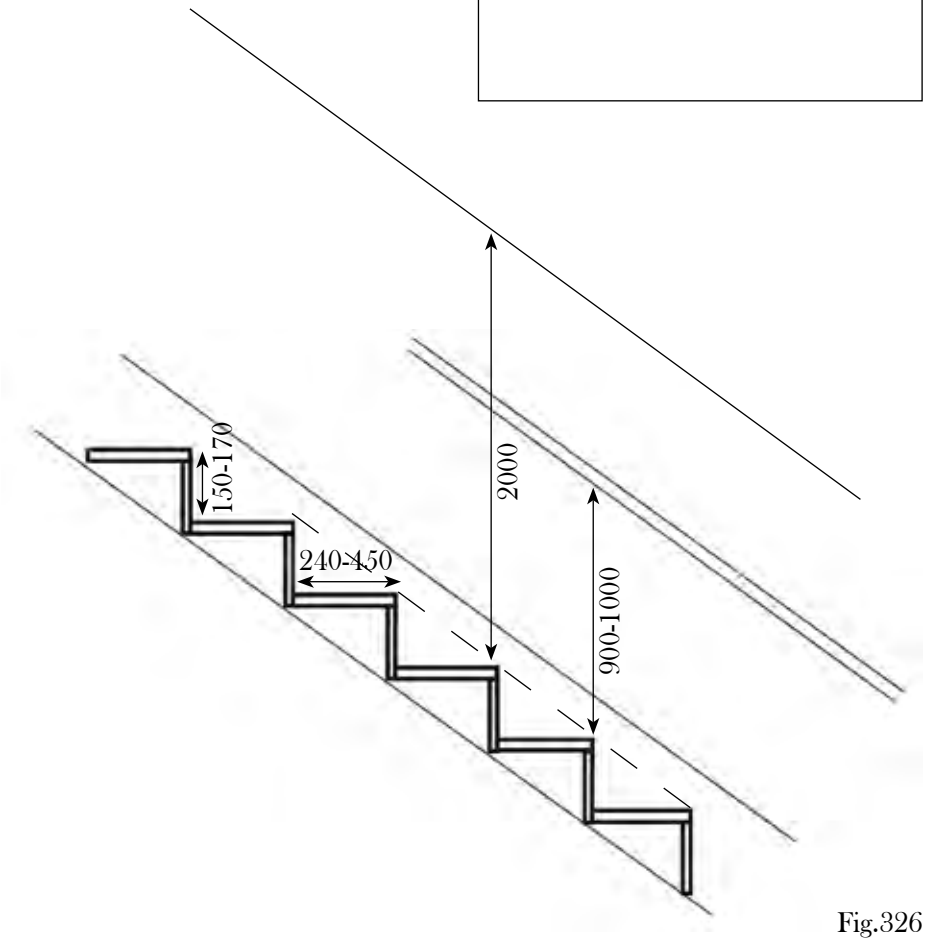


Fig.326

Access:
- Both stair and lift access will both be required to reach the observatory.
- Stairs should be without nosing to avoid trip hazards and be a maximum of 16 risers before a landing.
- Handrails for stairs should be both sides and, if the stair width exceeds 1800, another should be placed.
- The lift should consider outside of the lift as well as within it, in order for there to be enough space for a wheelchair to turn.
- (Note: lift sizes are the minimum requirements for wheelchair access.)

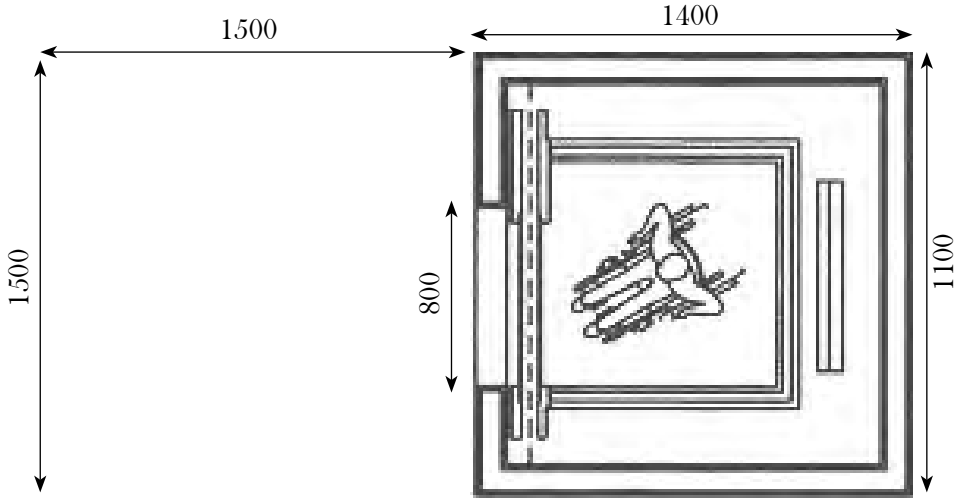


Fig.327

The Switching Station

Recycle local agricultural waste into liquid fertiliser and biogas.

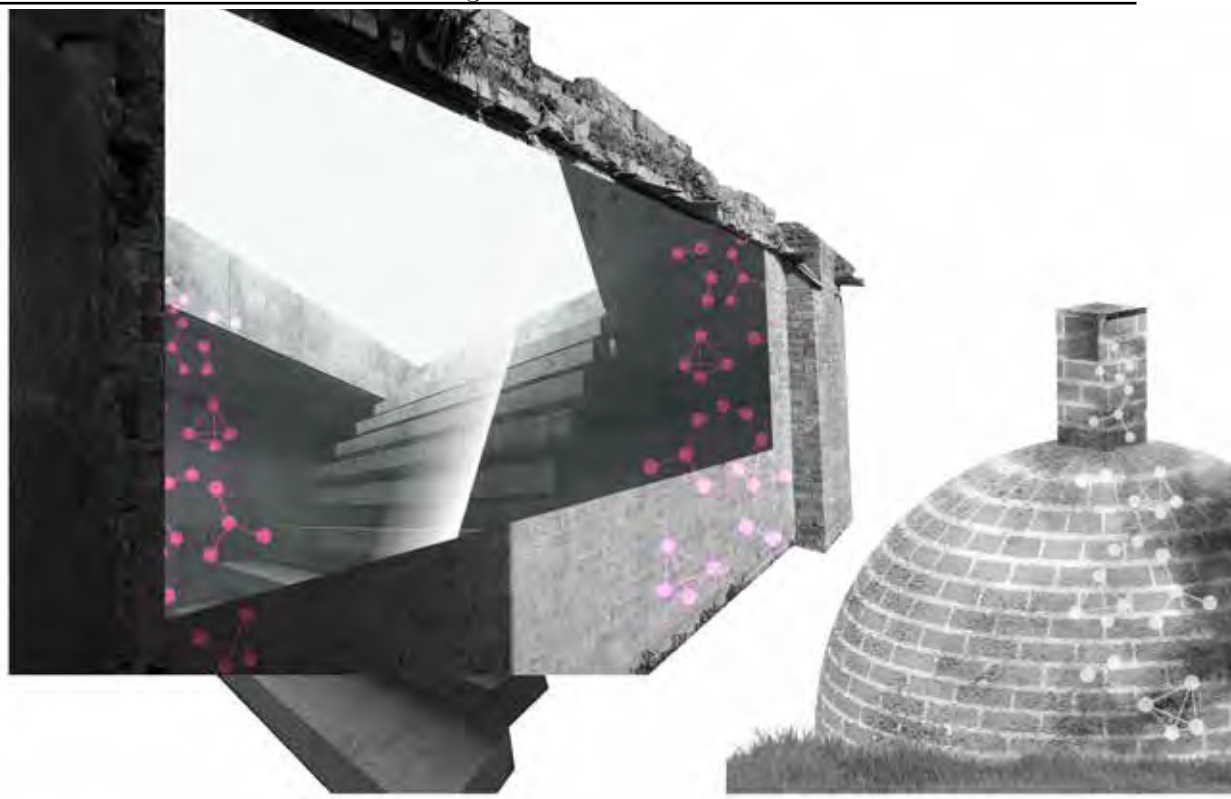
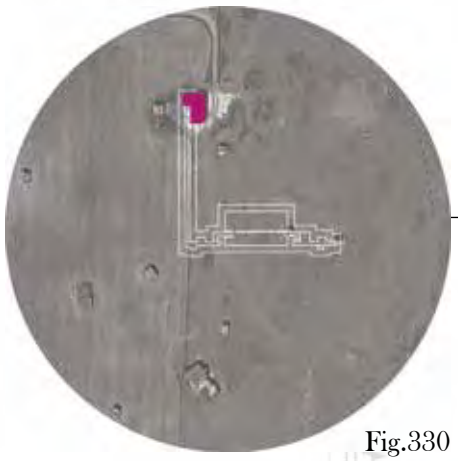


Fig.329

Located in the previous guardhouse, 'The Switching Station' will be a transition space in multiple respects, transitioning users from above ground to below ground, whilst also transitioning agricultural wastes into organic fertiliser and biogas. This will be a primarily functional space with both areas of private and public access; however, the majority of the space will be taken up by the necessary equipment to carry out the reactions.



—Original location of the guardhouse.

Fig.330

The design for this space should be the most sensitive to the existing architecture as many view the guardhouse as a landmark, and one of the last distinctive remains of RAF Bempton's heritage having previously been a decoy to the entrance of the bunker.

Requirements:

Public Walk-Through/Transition:
- Partition between public and private access
- Stair access to the bunker (see pg.177.)
- Lift access to the bunker (see pg.177.)

Waste Recycling Lab:
- Small-scale biogas digestor
- Storage for fertiliser
- Storage for science lab equipment
- Ventiliation
- Sinks (clean x1, dirty x1)
- Hanging plug sockets
- Standing tables (see pg.176.)
- Practical flooring

Liquid Fertiliser Tank:
- Sizes vary depending on the size of the biogas digestor.
- Designed to contain the liquid fertiliser between exiting the biogas digestor and entering the hydroponic plant system.
- Option to connect the biogas outlet straight to the farm.

Fig.331

Sinks:
- Two sinks should be provided: one clean and one dirty (the diagram shows an industrial-style double sink.)
- Sink heights are slightly lower than standing desk heights, but one should also be accessible at a lower height (refer to disabled toilet ergonomics on pg.164.)

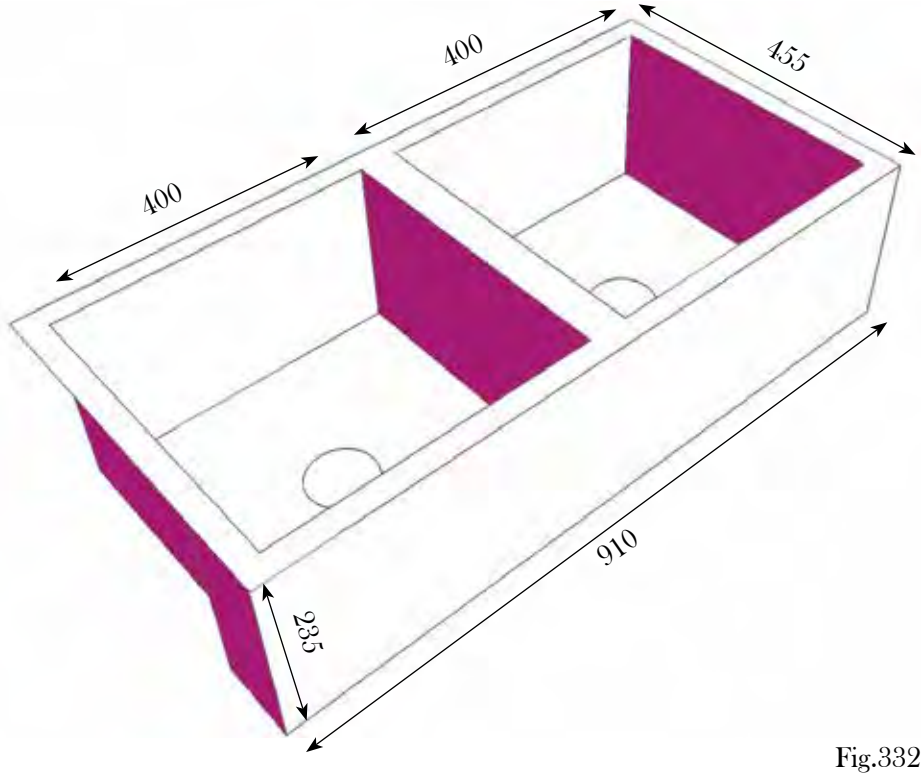


Fig.332

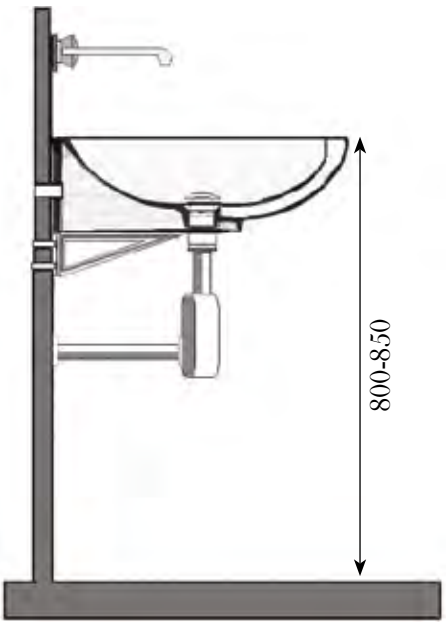


Fig.333

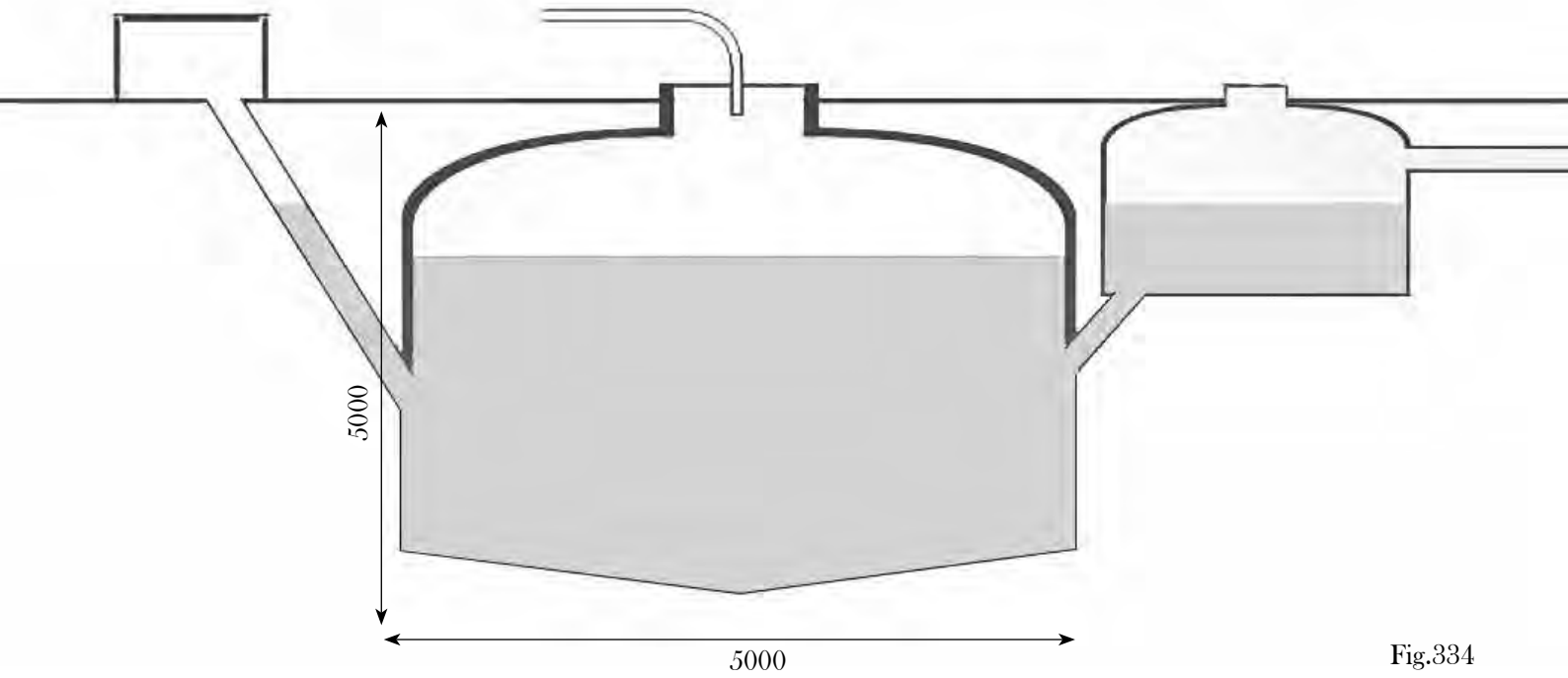


Fig.334

Biogas Digestor:

- Sizes vary depending on the amount of agricultural waste that will be processed, but the minimum recommended is at least $5m^3$, but are generally 8-$10m^3$.
- To take up less space, the digestor could be mostly placed underground.

The Security Study

Educate people about food security and growing greens from home.

Location of the tunnel leading to the bunker.

Fig.336

The most uncomfortable of all the spaces, 'The Security Study' will aim to draw a light on the global situation regarding food security. Users should feel uneasy as though a weight has just been placed upon their shoulders. The heavy contrast between this space and the next is vital in order for the hydroponic farm to have the required impact on visitors.

Located in the dark tunnel of the bunker, the passage isn't just a physical connection between the traditional farm above and the modern farm below, but an educational one too in learning why the way in which we produce food must evolve. Taking one of the RAF station's previous functions of projections, The Security Study will educate the public via projecting informative video clips onto the walls as they navigate through the space. Attention to the placement of the projectors should be strongly considered in order for the visuals to not be blocked by passing people. Furthermore, the acoustics will have to be addressed to avoid the sound system echoing.

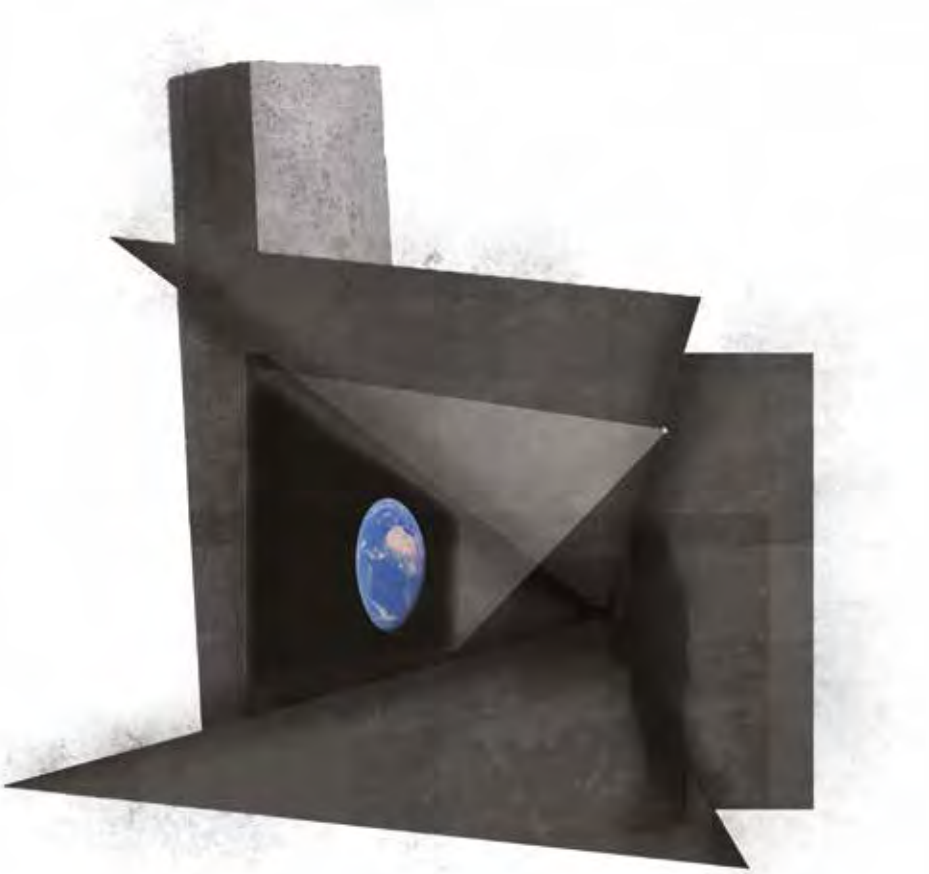


Fig.337

Requirements:
Exhibition:
- Dim lighting
- Bare wall space/projector screen
- Projectors
- Sound system
- Acoustics

Sound System:
- As the location for the exhibition is currently a long and narrow space, multiple smaller-scale speakers evenly distributed would work better than using one big speaker to reduce echo and create surround sound.
- The speakers can be placed in the walls/ceilings to reduce visual pollution on the walls that might interfere with the projections.

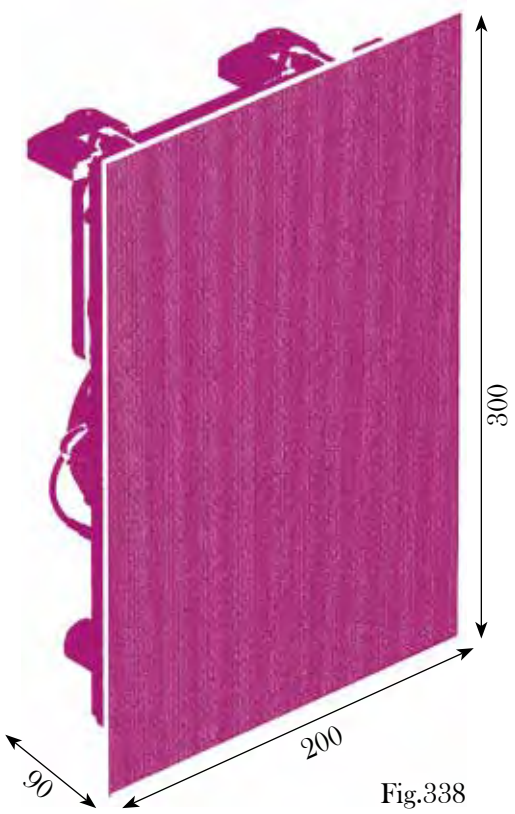


Fig.338

Projectors/Screen Space:
- Screen sizing depends on the distance between the projector and the wall it's projecting onto.
- Fixtures, such as projector lifts, could be considered to adapt projection heights and/or store away the projector into the ceiling when not in use.

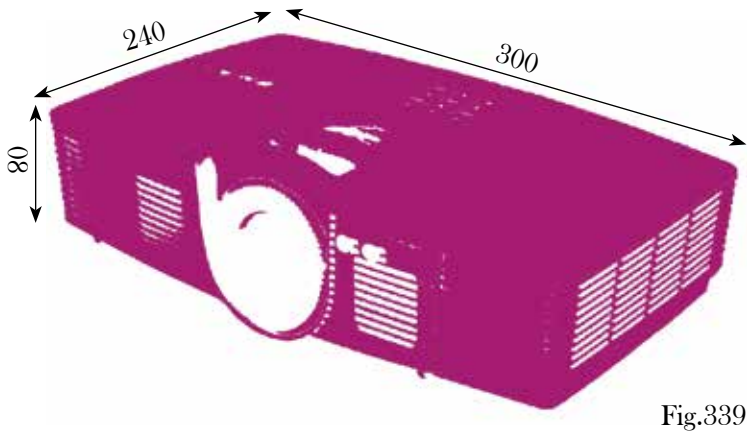


Fig.339

Width of projector screen/wall space x 2 = minimum distance between the projector and the screen

Width of projector screen/wall space x 5 = maximum distance between the projector and the screen

The Fuchsia Garden

Grow edible hydroponic plants underground using the recycled fertiliser and biogas.

Fig.341

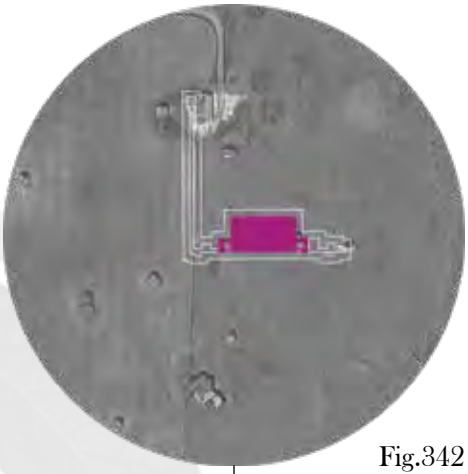


Fig.342

Location of the bunker's main space.

Exiting from the narrow passage, visitors will be given a moment of pause, where the blast doors used to be located, to reflect on what they have just learnt. The space then opens out into the main bunker, the location for the hydroponic farm aka 'The Fuchsia Garden'. The weight should feel as though it has been somewhat lifted from the visitors' shoulders, as they are faced with a solution to the problem they were just given. Just as the radar screens had once lit up the dark, track telling rooms of the RAF station, the red and blue LEDs of the new scheme will illuminate pink (or *fuchsia*) from openings, enticing curiosity.

A strong distinction between private and public spaces will need to be distinguished here; requiring a lot of equipment and machinery for functions such as ventilation, the public cannot have access to these, but staff members will need to be able to easily. Furthermore, a controlled environment is vital for successful plant growth and cannot be put at risk from public interaction. The main 'user' to consider for this space first and foremost is the plants and their individual requirements. Although the scheme will begin with a decided number of plants, the space should be somewhat flexible for the farm to have adaptability for trying new ones.

Fig.343

Requirements:
- Toilets (see pg.164)
- Sinks x2 (one clean and one dirty - see pg.180)
- Ventilation
- Centrifugal fans
- Extraction fans
- ZipGrow systems
- Adjustable shelving units
- Adjustable mixed LED lighting
- Sump linked by drain pipes
- Storage for gardening tools
- Propagation area
- Practical flooring

Adjustable Mixed LED Lighting:
- The plant lighting needs to be height adjustable in order to adapt to the individual plants' requirements and heights.(If a lighting is too weak, growth will be slow, but if lighting is too strong, it could damage the plant.)

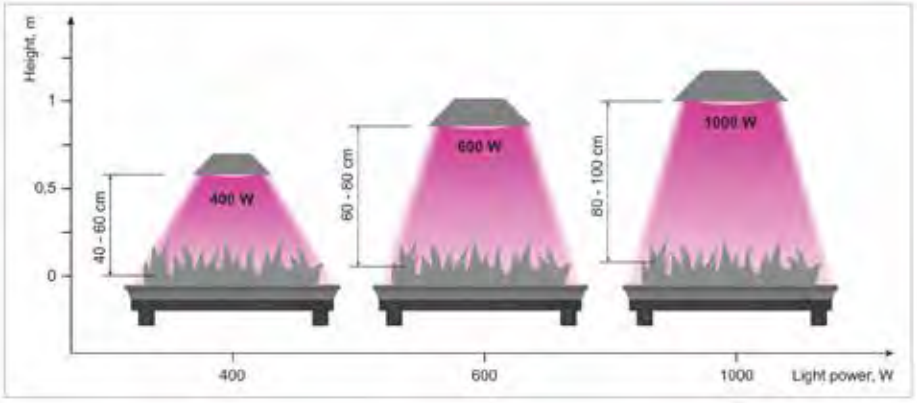


Fig.344

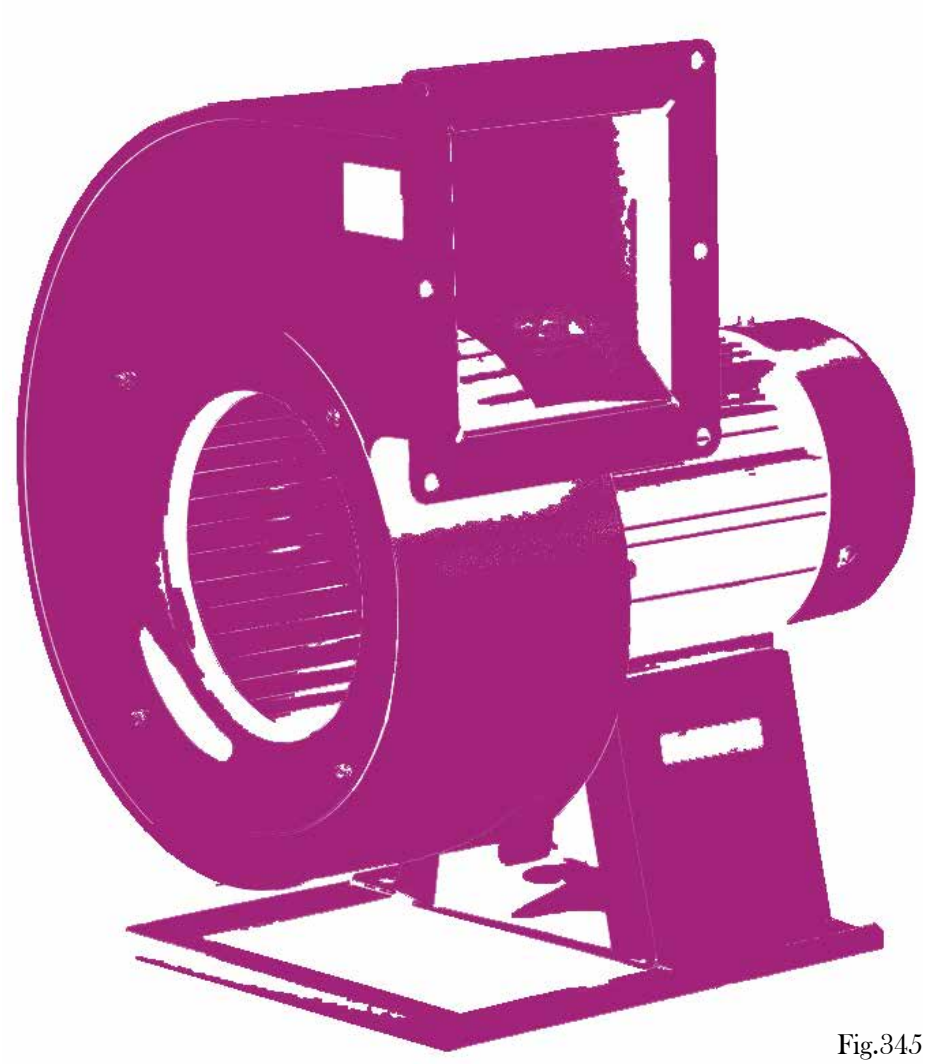


Fig.345

Centrifugal Fans:
- Previously used in the RAF's ventiliation system, centrifugal fans are required to increase the rate of ventilation in the space. As the bunker is so large and deep within the earth, purely using vent-holes wouldn't be adequate enough to ventilate the entire space.
- The RAF station had required at least four fans.

ZipGrow Systems:
- Currently adopted by Farm Urban, these vertical farming systems will be used for the leafy green produce, such as kale.
- The towers can be 5 ‘ or 8’ tall and 8 towers can be fitted to 1 system.

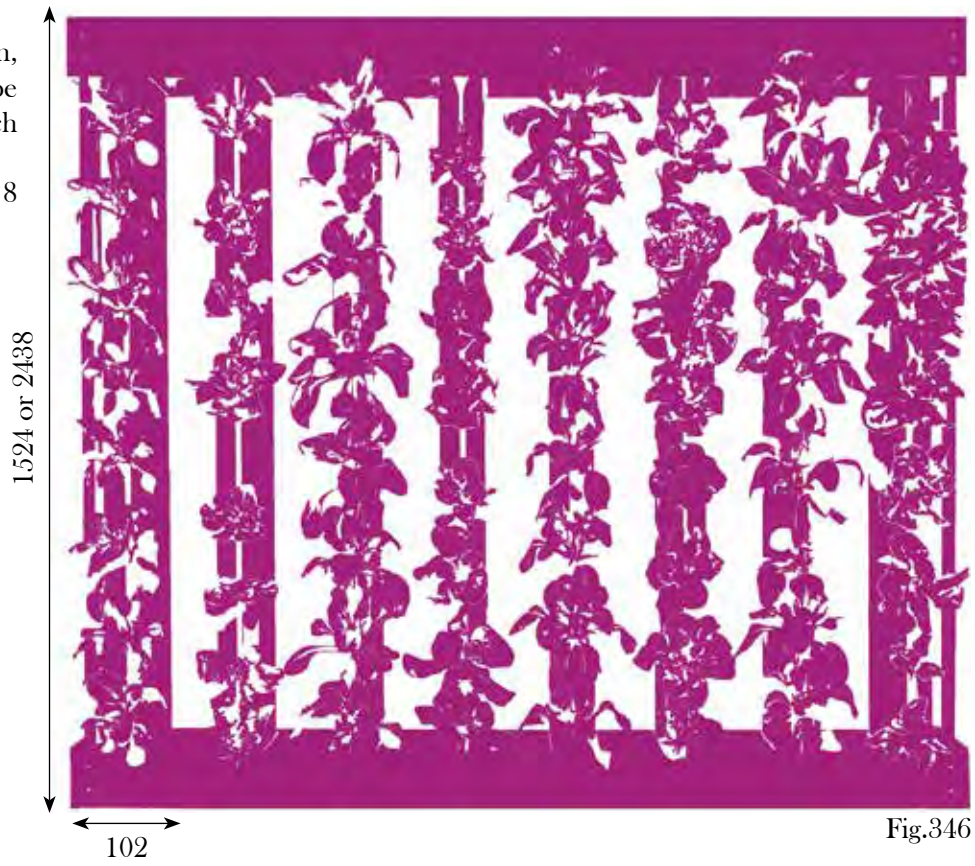


Fig.346

Sump Tank:
- A sump tank is an essential part of system drainage, as it collects all of the waste water via drainage pipes linked to the systems. Waste water can then be filtered and put back into the system, used as a renewable energy source or drained elsewhere, but this can be harmful to the environment.

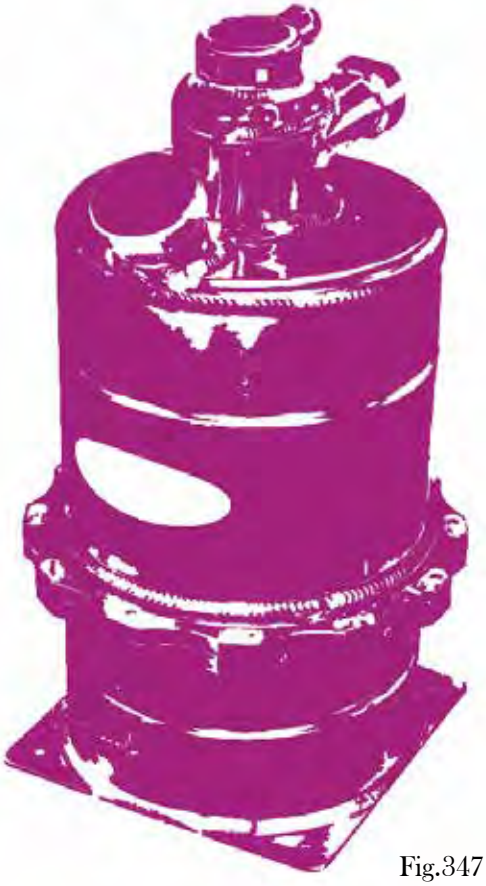


Fig.347

The Green Market

Sell the plants locally to reduce food miles and spread awareness.

In regard to the University of Leeds' claim about visual distortion, The Green Market will not only sell the green produce harvested from the bunker, but it will also initially *appear* green to users too, who will have just left the hydroponic farm. Although fresh produce won't be sold here daily, the architecture should still act as a backdrop for this visual illusion.

Storage will be integrated/hidden to store the fresh produce, and for the space to become multifunctional. With many recent designers responding to COVID-19, it would be advantageous to make the space as hands-free as possible, which also contributes to the idea of modernised, futuristic farming.

The journey ends where it first started: by exiting back out onto the open fields, but this time users should have an altered perception. The exit will be located via the previously used emergency exit following the same circulation route RAF personnel would have previously used too. However, a second entrance/exit should also be considered for members of Farm Urban or those just wanting to access the food market without taking the entire walk-through tour.

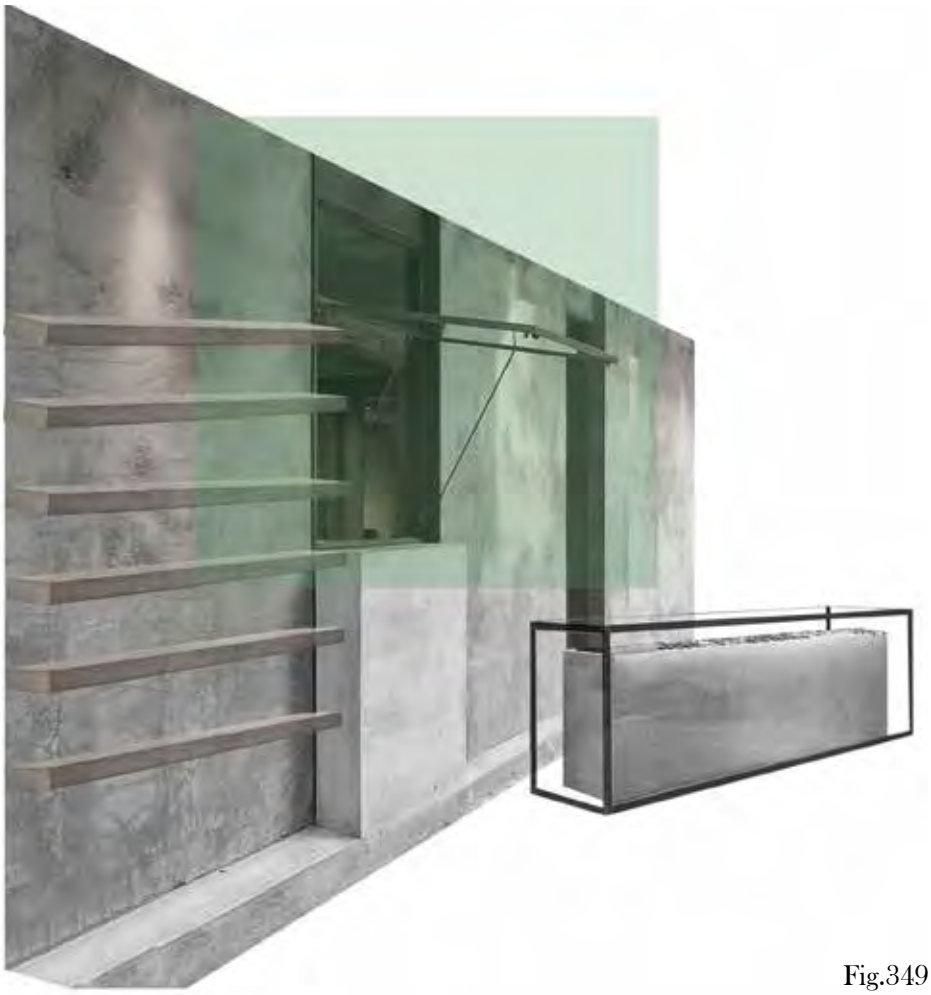


Fig.349

Fig.350

Requirements:
Market:
- Storage for fresh produce
- Display shelving
- Shop counter (see pg.176)

Display Shelving:
- Although the market won't be selling fresh greens daily, it will need to be able to store and sell them on the appropriate height shelving and kept at cool temperatures.
- Recently a lot of design has considered its response to COVID-19, so perhaps the shelving could be covered to be as sanitary as possible.

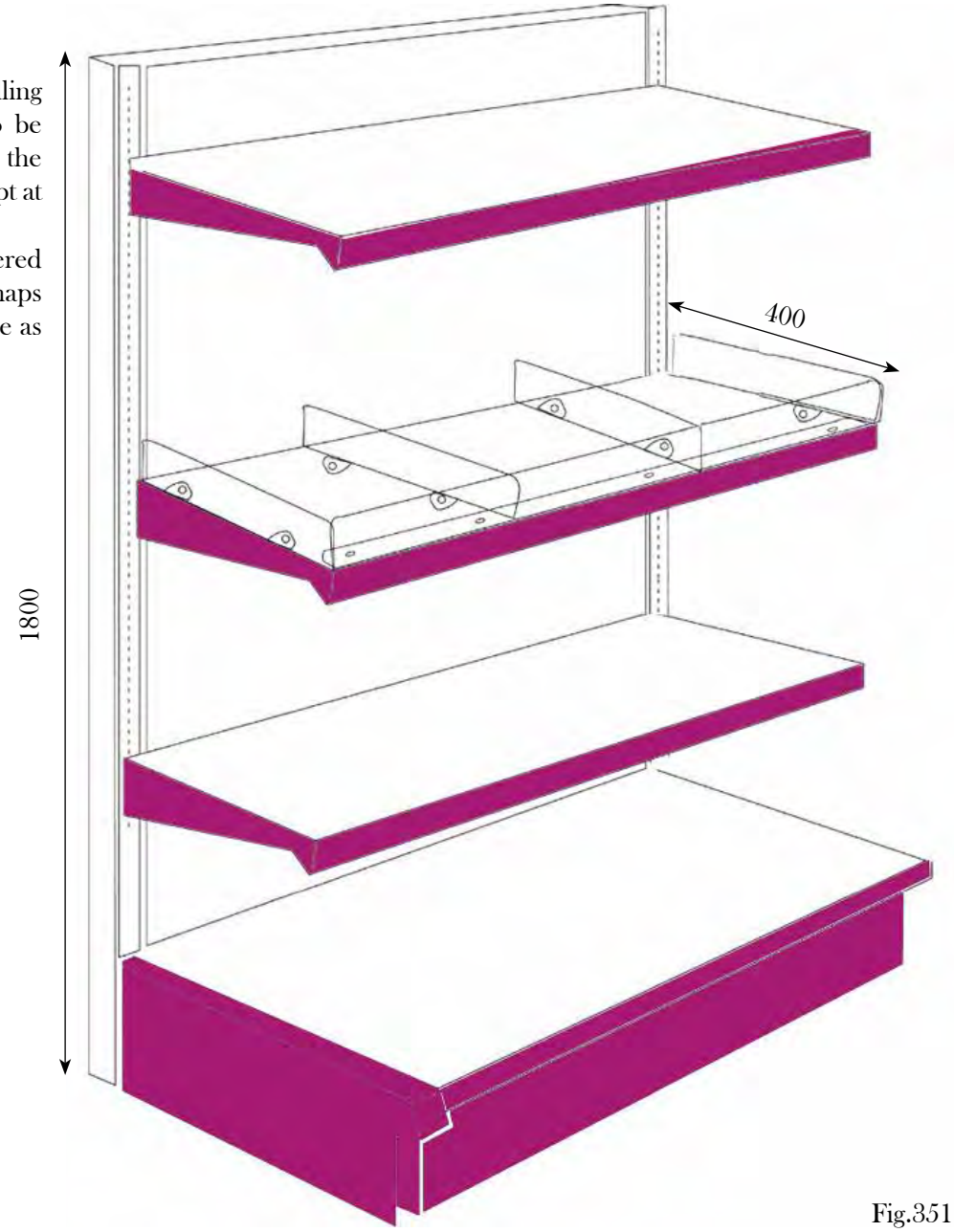


Fig.351

Concepts and Inspiration

08

'Rock Steady' - Photography by Jumbo Tsui for Kinfolk Magazine

Fig.354

"The conflict between science and the appeal of the 'natural' is centuries old... It's possible, in fact, for science and nature to work together as two disctinct forces." (Kinsella, A., 2020.)

Fig.355

‘The Farmer’

(Published 1950)

Written by Patricia Battey, a resident of Bempton.

When work is done and the hour is late
Oft times he leans on garden gate,
And view with love his own domain
Of moonlit Sunripe, golden grain
Then turns he homeward with a sigh
Of mute appeal to the sky - kissed sky
And magical harvest moon.

Then the wind and rain on his window seep
To wake him from his restless sleep.
At dawn once more at his rustic gate
His spirit quails at the tricks of fate
As he sees the havoc all around
His fields now flattened to the ground
Perhaps his harvest doomed.

So let us praise these men of worth
Who slave, and toil, and till the earth.
Whom nature rules with iron rod
Their fortunes in the hands of God.
Backbone of England in war or need,
An honest, proud, and noble breed,
These staunch and stalwart men.

'The Martian' (2015)

Fig.356

Fig.357

Wearable Concept:

With both radar station and hydroponic farm, security and technology are consistent themes of its past and proposed uses, with users operating the equipment whilst silmultaneously being protected by its function.

Applying the concept to site, a network of geometric forms are constructed around the user making them a vital component of the piece whilst also being protected at its centre.

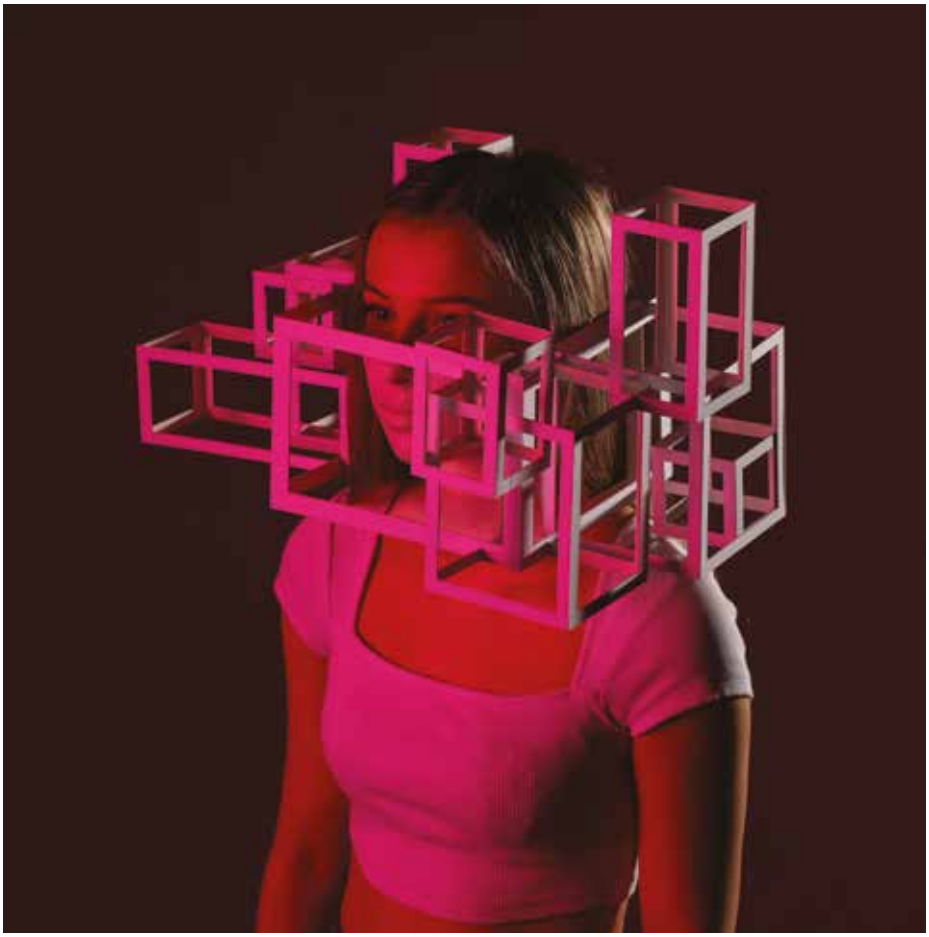


Fig.358

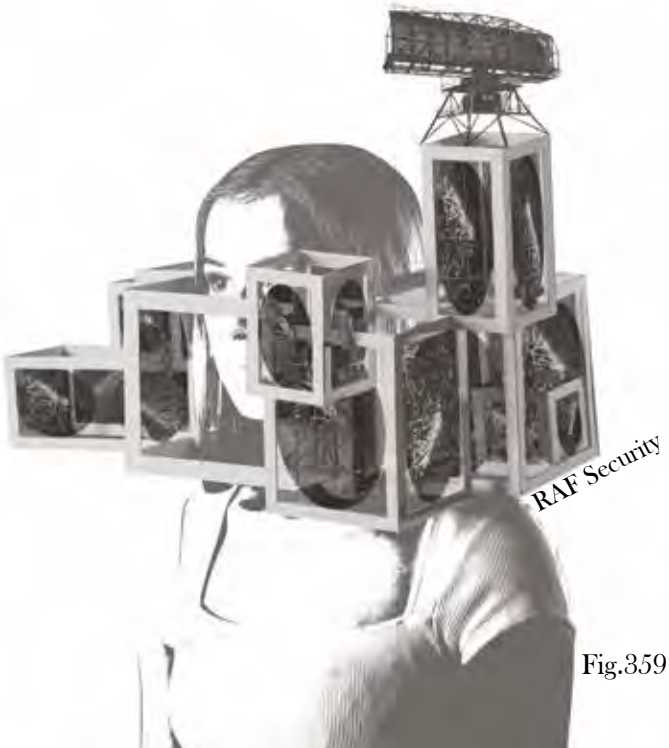


Fig.359

Fig.360

Fig.361

Chalk Piece:

This concept piece was inspired by Mosey Down Gate and the process of a geo cliff formation (see pg.062).

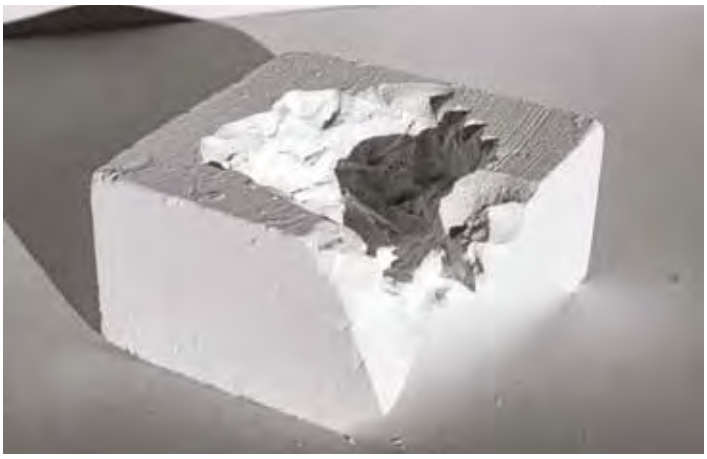


Fig.362

Fig.363

Fig.364

Fig.365

Fig.366

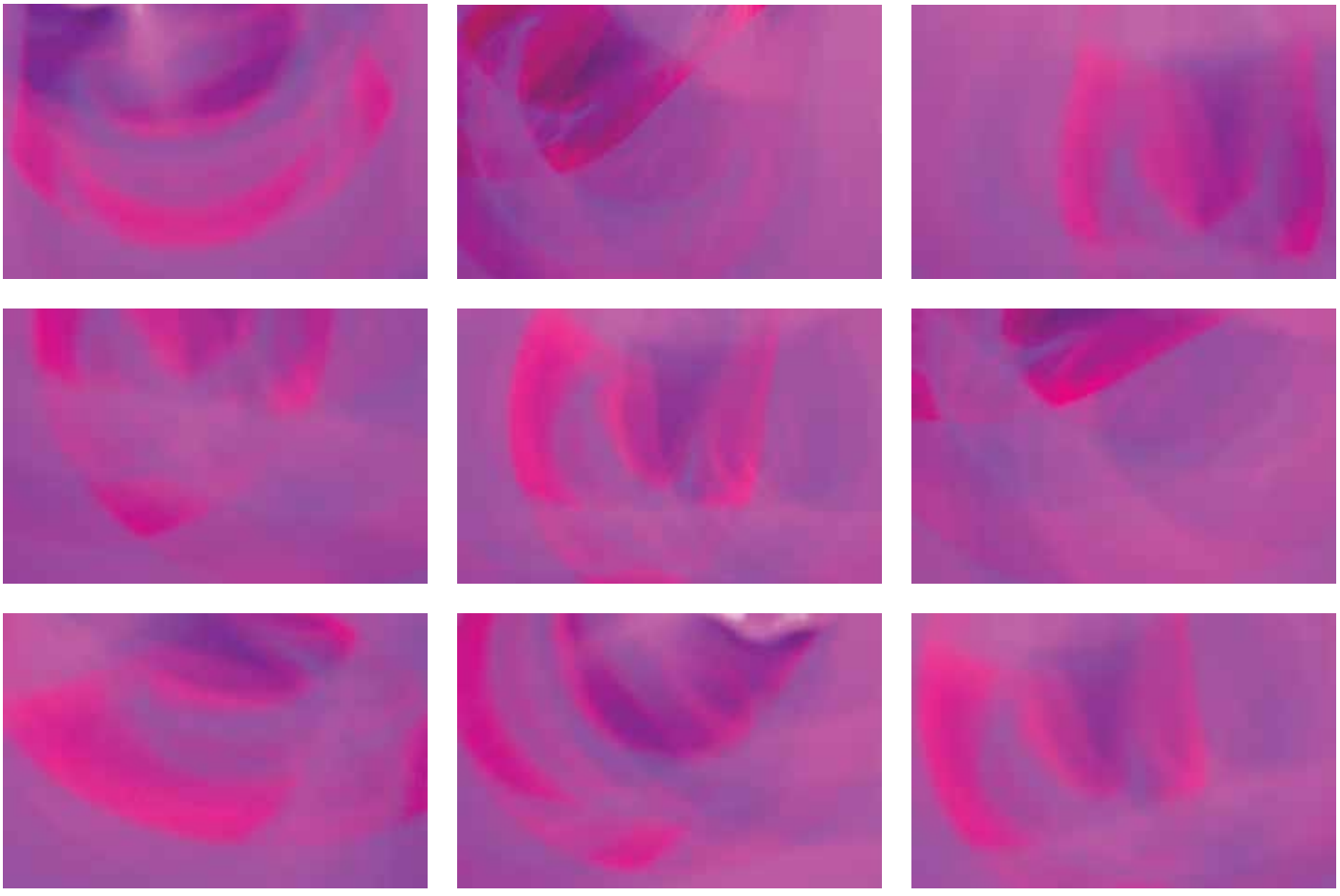


Fig.367

Fig.368

Exploring how red and blue LEDs react with water:

(Images depict the diffraction of the light but not the luminosity of the LEDs or the actual tone of the colours.)

Credits

09

AJ Contributor, 2019. *Eleanor Palmer Science Lab by AY Architects.* [online] The Architects' Journal. Available at: <https://www.architectsjournal.co.uk/buildings/eleanor-palmer-science-lab-by-ay-architects> [Accessed 6 February 2021].

AlboPepper - Drought Proof Urban Gardening, 2017. *Experiment: Red Light vs Blue Light -How Spectrums Affect Plant Growth- LED vs CFL.* [video] Available at: <https://www.youtube.com/watch?v=sfihE4IuFuU> [Accessed 9 February 2021].

ArchDaily. 2019. *Eleanor Palmer Science Lab / AY Architects.* [online] Available at: <https://www.archdaily.com/914703/eleanor-palmer-science-lab-ay-architects> [Accessed 6 February 2021].

AY Architects. 2018. *Eleanor Palmer Science Lab | AY Architects.* [online] Available at: <http://ayarchitects.com/project/eleanor-palmer-science-lab/> [Accessed 6 February 2021].

Baessler, L., 2020. *Red Light vs. Blue Light: Which Light Color Is Better for Plant Growth.* [online] Gardening Know How. Available at: <https://www.gardeningknowhow.com/garden-how-to/design/lighting/red-light-vs-blue-light.htm#:~:text=The%20three%20major%20colors%20of,red%2C%20blue%2C%20and%20green.&text=The%20effect%20of%20blue%20light,plants%20flower%20and%20produce%20fruit.> [Accessed 10 February 2021].

BBC Bitesize, n.d. *Photosynthesis.* [video] Available at: <https://www.bbc.co.uk/bitesize/guides/zg8nrwx/video> [Accessed 10 February 2021].

BBC Bitesize. n.d. *Respiration.* [online] Available at: <https://www.bbc.co.uk/bitesize/guides/zcjy97h/revision/1> [Accessed 10 February 2021].

Choi, E., Seo, S., Choi, K. and Lee, Y., 2014. *Development of a Non-Drainage Hydroponic System with a Coconut Coir Substrate by a Frequency Domain Reflectometry Sensor for Tomato Cultivation.* Journal of Plant Nutrition, [online] 37(5), pp.748, 749. Available at: <https://www-tandfonline-com.ezproxy.leedsbeckett.ac.uk/doi/pdf/10.1080/01904167.2013.868479?needAccess=true>.

Chow, P. (2005) *'Art Bunker: Art Museum, Naoshima Island, Japan'*, Architectural review, 218(1302). Available at: http://search.ebscohost.com.ezproxy.leedsbeckett.ac.uk/login.aspx?direct=true&db=bvh&AN=574979&site=eds-live&scope=site [Accessed: 7 December 2020].

Cocroft, W., Thomas, R. and Barnwell, P., 2004. *Cold War: Building for Nuclear Confrontation 1946-1989.* Swindon: English Heritage, p.92.

Despommier, D., 2010. *The Vertical Farm.* 1st ed. New York: St. Martin's, p.2 & 3.

East Riding of Yorkshire Council. 2019. *East Riding – Population.* [online] Available at: <https://intel-hub.eastriding.gov.uk/population/> [Accessed 11 December 2020].

East Riding of Yorkshire Council. n.d. *Farming and Land Use.* [online] Available at: <https://www.eastriding.gov.uk/living/rural-life/food-and-farming/farming-and-land-use/> [Accessed 10 December 2020].

Erokhin, V. and Gao, T., 2020. *Impacts of COVID-19 on Trade and Economic Aspects of Food Security: Evidence from 45 Developing Countries.* International Journal of Environmental Research and Public Health, [online] 17(16). Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7459461/> [Accessed 11 December 2020].

Farm Urban, 2019. *Greens for Good: Vertical Farming with A Social Mission.* [online] Kickstarter. Available at: <https://www.kickstarter.com/projects/greens-for-good/greens-for-good-vertical-farming-with-a-social-mission/> [Accessed 12 December 2020].

Farm Urban. 2020. *Projects – Farm Urban.* [online] Available at: <https://farmurban.co.uk/projects/> [Accessed 10 October 2020].

Food and Agriculture Organization of the United Nations, 2009. *How To Feed The World In 2050.* [online] United Nations, p.2. Available at: <http://www.fao.org/fileadmin/templates/wsfs/docs/expert_paper/How_to_Feed_the_World_in_2050.pdf> [Accessed 10 December 2020].

Food and Agriculture Organisation of the United Nations, 2019. *The State of Food and Agriculture. The State of the World.* [online] Rome: FAO, p.v, 8. Available at: <http://www.fao.org/3/ca6030en/ca6030en.pdf> [Accessed 11 December 2020].

Gill, B., 2021. *Knowledge of Hydroponics and Biogas.*

Hernández, R., 2016. *The Evolution of LEDs.* [online] Greenhouse Management. Available at: <https://www.greenhousemag.com/article/the-evolution-of-leds/> [Accessed 9 December 2020].

Herridge, L., 2012. *NASA - LED Lights Used in Plant Growth Experiments for Deep Space Missions.* [online] Nasa.gov. Available at: <https://www.nasa.gov/centers/kennedy/home/plant_growth.html> [Accessed 9 December 2020].

Higton, J., 2020. *RAF Bempton 1940-1964 * Part One *.* [video] Available at: <https://www.youtube.com/watch?v=jS9SMoc4Auw> [Accessed 13 October 2020].

Higton, J., 2020. *RAF Bempton 1940-1964 * Part 2 *.* [video] Available at: <https://www.youtube.com/watch?v=kbXN_kAnd0s> [Accessed 26 November 2020].

Jensen, M., 1991. *Hydroponic Culture for The Tropics.* Taipei City: Asian and Pacific Council. Food Technology Center, p.1.

Kenyon, S., 1992. *Hydroponics for The Home Gardener.* Toronto: Key Porter Books, p.2, 12, 13, 30, 31, 32.

Libeskind, D. (2001). *Daniel Libeskind: The Space of Encounter.* London: Thames & Hudson, pp.62, 63.

LibeskindxTed, (2009). *Daniel Libeskind's 17 words of architectural inspiration.* [video] Available at: https://www.youtube.com/watch?v=G8w4UQL6aI0 [Accessed 1 Dec. 2019].

Lee, D., 2020. *Food Statistics in Your Pocket: Global and UK Supply.* [online] GOV.UK. Available at: <https://www.gov.uk/government/publications/food-statistics-pocketbook/food-statistics-in-your-pocket-global-and-uk-supply> [Accessed 10 December 2020].

Lim, C. and Liu, E., 2019. *Smartcities, Resilient Landscapes and Eco-Warriors.* 2nd ed. New York and Oxon: Routledge, p.1.

McCamley, N., 2013. *Cold War Secret Nuclear Bunker.* Havertown: Pen and Sword, p.98.
RHS. n.d. Chickweed. [online] Available at: <https://www.rhs.org.uk/advice/profile?PID=1011> [Accessed 26 January 2021].

Myers, P., 2016. *Urban Farming: Fixing the Broken Food System & Improving Health* | Paul Myers | Tedxliverpool. [video] Available at: <https://www.youtube.com/watch?v=5AcjM5BKfRQ&feature=emb_logo> [Accessed 5 December 2020].

Open Journal. n.d. *Chichu Art Museum: Japaneseism at its Best.* [online] Available at: <http://openjournal.com.au/chichu-art-museum-japanese-brutalism-at-its-best/> [Accessed 7 December 2020].

Pollock, N. R. (2005) *'Chichu art museum'*, Architectural Record, 1 October. Available at: http://search.ebscohost.com.ezproxy.leedsbeckett.ac.uk/login.aspx?direct=true&db=edsbig&AN=edsbig.A139241171&site=eds-live&scope=site [Accessed: 7 December 2020].

Rand, L., 2019. *The underground farm in a Victorian tunnel beneath Liverpool.* Liverpool Echo, [online] Available at: <https://www.liverpoolecho.co.uk/news/liverpool-news/underground-farm-victorian-tunnel-beneath-17273804> [Accessed 28 October 2020].

Rudkin, E., 1948. Concerning some historical remains and a lonely grave in the parish of Bempton-cum-Newsholme-cum-Buckton. York: Herald Printing Works, pp.5, 6, 7, 8.

The RSPB. 2020. *Bempton Cliffs Nature Reserve, East Riding of Yorkshire - The RSPB.* [online] Available at: <https://www.rspb.org.uk/reserves-and-events/reserves-a-z/bempton-cliffs/> [Accessed 27 October 2020].

The RSPB, 2019. *The Geology of RSPB Bempton Cliffs.* [pdf] pp.1,2. Available at: <https://static1.squarespace.com/static/5ebc647c0446723b32229119/t/5ee1fc9b13476845630b8b99/1591868575055/bemptoncliffsgeology.pdf> [Accessed 27 October 2020].

Tran, H., 2020. *What benefits can urban agriculture bring to people within cities?* Undergraduate. University of Reading.

Tully, L. (2017). *8 Things You Didn't Know About The IWM North Building.* [online] Imperial War Museums. Available at: https://www.iwm.org.uk/history/8-things-you-didnt-know-about-the-iwm-north-building [Accessed 4 Nov. 2019].

Sayed, E., 2020. *Biohm.*

Singer, A., 2001. *History of Bempton and Buckton.* United Kingdom: Capenita Publishing, p.13, 26, 30, 31, 35, 40, 41.

Singer, A., 2004. *A Wider History of Bempton and Buckton.* United Kingdom: Capenita Publishing, p.1, 15, 19, 20, 50.

Stenton, I. and Hanmer-Dwight, R. (2019) *'Liverpool knowledge quarter sustainability network: case study',* International Journal of Sustainability in Higher Education, 20(8), pp. 1393–1408. doi: 10.1108/IJSHE-01-2019-0049

Sustainable Sanitation and Water Management Toolbox. n.d. *Anaerobic Digestion (Small-scale).* [online] Available at: <https://sswm.info/arctic-wash/module-4-technology/further-resources-wastewater-treatment/anaerobic-digestion-%28small-scale%29> [Accessed 11 February 2021].

Tetlow, S., 2014. *Making Liquid Manure Tea – Muck Tea.* [video] Available at: <https://video.allotment-garden.org/110/making-liquid-manure-muck-tea/> [Accessed 4 January 2021].

Thomas, J., 2020. *Case Study: Farm Urban, Liverpool.*

United Nations, 1974. *Report of The World Food Conference.* [online] Rome: United Nations, pp.2, 3. Available at: <http://undocs.org/en/E/CONF.65/20> [Accessed 28 October 2020].

Vents World, 2014. *Hydroponics Ventilation Basics.* [ebook] Vents World, p.1. Available at: <https://ventsworld.com/wp-content/uploads/2014/03/HYDROPONICS_booklet_10_2013_eng.pdf> [Accessed 5 February 2021].

Wardlow, J., 2020. *History and Knowledge of Bempton.*

Woodland Trust. n.d. *Red Campion.* [online] Available at: <https://www.woodlandtrust.org.uk/trees-woods-and-wildlife/plants/wild-flowers/red-campion/> [Accessed 26 January 2021].

World Food Summit, 1996. *Rome Declaration on World Food Security.* [online] Rome: UN Food and Agriculture Organization. Available at: <http://www.fao.org/3/w3613e/w3613e00.htm> [Accessed 10 December 2020].

WRAP. 2019. *Food Waste in Primary Production in The UK | WRAP UK.* [online] Available at: <https://www.wrap.org.uk/content/food-waste-primary-production-uk> [Accessed 10 December 2020].

ZipGrow, 2017. *A Beginners Guide: NPK In Hydroponics.* [video] Available at: <https://www.youtube.com/watch?v=-gtFvhEjA3o> [Accessed 9 December 2020].


WW!!
BUNKER