CHAPTER 8

Technical Investigation

This chapter provides insight to the technical expression of the overall scheme.

Technical concept

The primary (sub) structure comprises of thick, heavy, stereotomic concrete and stone walls; structures and masses that fit in and emerge from the landscape. This heaviness is representative of the large scale and grandeur of elephants. The night stalls will be built into the earth, with thick retaining walls, to effectively use thermal mass for heating and cooling. The design and placement of these stalls is to connect the elephants to the earth, being more familiar to them than actual buildings, and to create dramatic entrances and thresholds when the elephants emerge from them. The thickness of all walls forming the sub-structure of the building have been determined to withstand great forces of 15 tonnes exerted by a 6 ton elephant. The lightweight (super) structure in spaces either occupied by people or beyond reach of elephants, consists of concrete columns with either brick or glass infill.

All architectural decisions were informed by elephant proportions and dimensions – referred to as the modular elephant. Elements that are specifically designed according to these dimensions and specifications include all curved walls (both on plan and elevation), materials and finishes, floor surfaces, ceiling heights, services, doors and thresholds, and use of water in keeping with the urban vision set by the Apies River framework group.

In-situ cast concrete is more conducive in building a protective environment for the elephants and for allowing creative opportunities in the design, with its free flowing forms, and variability in the shuttering finishes and play on textures - such as sand blasting and timber formwork. The curved corners of larger spaces indicated on plan were based on the turning radius of a fully grown male elephant's proportions. Steel formwork will be designed to cast this curved wall and will be reused throughout the building. Different timber shuttering panels can then be fixed inside this steel formwork to create a variation in concrete finishes as per the design concept.

Systems & Sustainability introduction

Passive systems will be integrated into the design to maximise the use of naturally available elements. Geothermal pipes will be used for both under floor heating and cooling; materials with high thermal mass, green roofs and earth sheltering will be incorporated to create thermally stable and comfortable internal environments for the elephants – to help reduce electricity demands and the need for additional heating and cooling. Water from the river, as well as rainwater from all roof surfaces, will be harvested, filtered and purified for elephant use such as drinking, swimming, spraying and staff use for general cleaning. Greywater will be filtered and reused in public and staff ablutions as well as for irrigation purposes in the outdoor elephant gardens.

Technical resolution

Elephant habitable spaces

Primary Elephant Spaces

Night Quarters
Migration corridor
Day Area
Storerooms

Environmental strategies & calculations
SANS 10400
SBAT rating

Elephant Waste Management

Introduction

The effective management of elephant waste is essential to minimise the elephants' exposure to damp, unhygienic conditions for prolonged periods of time which result from the build-up of urine and manure (Clubb & Mason 2002: 190). This management is required to minimise risk of infection, unwanted foul odours, and nuisances such as rodents and insects, while promoting good hygiene and aesthetic of the building.

Most of the waste produced indoors will occur in the night quarters, day area enclosures and migration passage. Although not indoors, a waste water strategy for all the swimming pools will be discussed. Uncomfortable and unsanitary conditions can often lead to irritation and ammonia related burns if elephants in captivity are exposed to their own waste frequently. Chronically damp and filthy environments are ideal for bacterial growth which can cause foot rot. Continued exposure to manure is a further source of pathogens which are also considered to being a primary cause of foot rot and abscesses. For these reasons, most reputable facilities scrub the elephants' legs and feet daily to promote foot health. This is considered an alternative to wild elephants walking long distances and visiting waterholes daily, to maintain clean and healthy feet (Clubb & Mason 2002: 190).

For reasons stated above, elephants in the proposed scheme have the freedom to move to any space as they please, particularly if that reason entails moving to an area free of manure at night before the staff are able to remove it. The night quarters are also provided with insulated concrete floor slabs which can be heated to ensure rapid drying of the floors, in order to reduce foot problems. Having heated and sloping floors to drains helps to minimise risks of foot rot as well as potential slipping in any excrement. The outdoor yards have a variation of natural substrates, such as that of grassland and woodland terrains, to effectively clean and wear down their feet.

Outdoor yards will likewise be exposed to elephant manure, which will need to be removed daily and sent to the compost heap and digesters, where it will be used as an alternative energy source.

Figure 8.1 Rubber flooring in the elephant sleeping stalls at the Smithsonian Zoo, sloped to drain. Floors are routinely hosed down and disinfected to ensure a healthier environment (Author, 2016).

Figure 8.2 & 8.3 Right above and below: 'MnD Floors' Equine and Zoo range rubber flooring shown in the Giraffe and Elephant barn at the Hogle Zoo, Utah.

Rubber Flooring

Night Quarters

Rubber flooring is utilised in the sleeping areas to alleviate the possible discomfort caused by concrete floors. Since elephants in captivity are prone to foot pathologies and arthritis, rubber flooring is a suitable alternative and shock-absorbent substrate proven to have positive impacts on their wellbeing (Boyle et al, 2015).

Female African elephants on average can weigh 5 tonnes, and male elephants 6 tonnes. Due to their large weight and the pressure exerted on their joints, they can experience several issues regarding foot health, arthritis and degenerative bone ailments.

Seamless rubber flooring, made from recycled rubber, will be used in conjunction with insulated and heated concrete floor slabs to provide warm, dry floors for the elephants. The rubber floor helps to reduce joint stress and provides a slip and wear resistant surface. The rubber material is likewise a more sanitary solution being 99,9% bacteria free, making it easier to clean and disinfect.

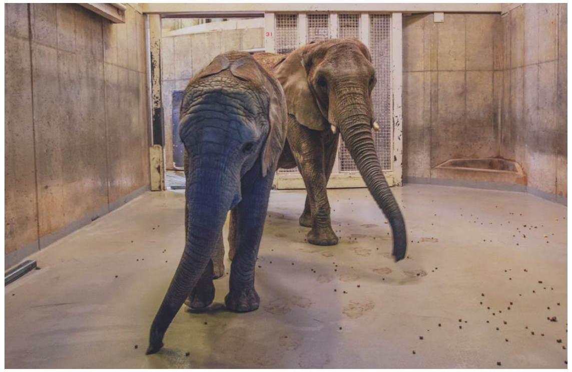
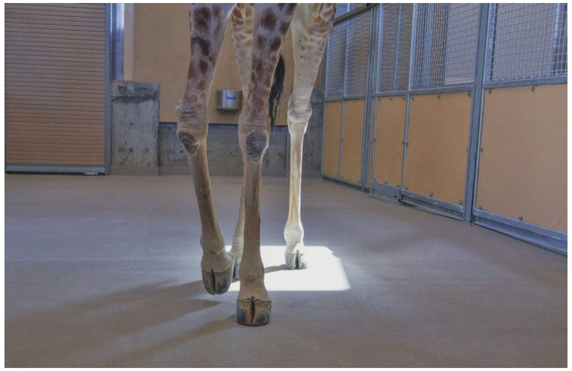
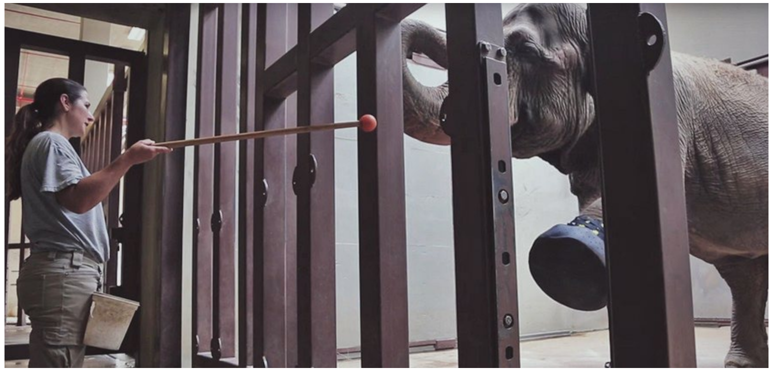


Figure 8.4 Left and 8. 5 Below: Asian elephant with chronic arthritis at the Smithsonian Zoo receives specialised sized 20 Teva boots designed for her front feet. The boots also help keep debris out of the fissures in her feet (Gunaratna, 2016).

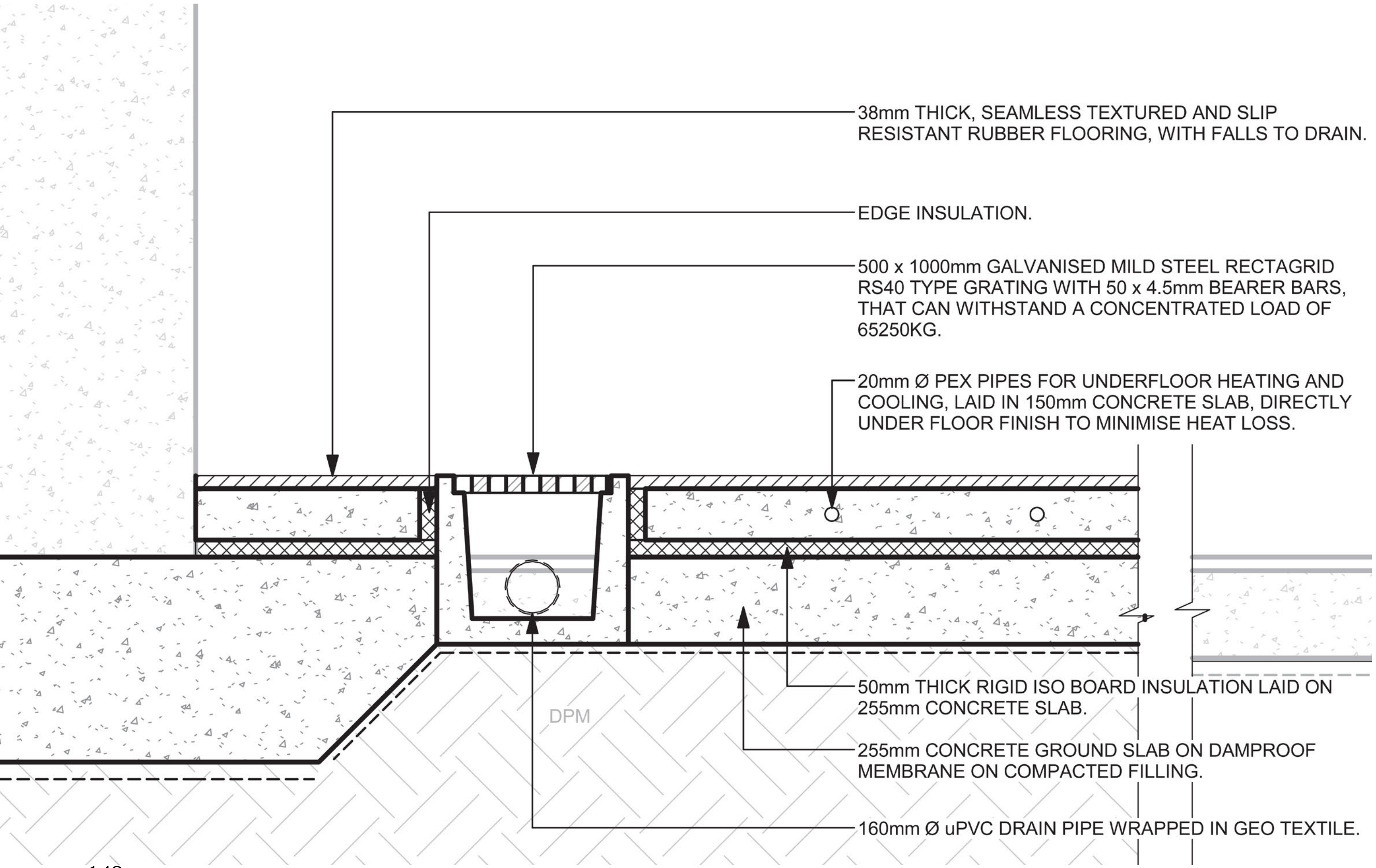




Thermal & Sound Insulation
Night Quarters

Excavating and placing the night quarters 3m deep into the earth creates a niche for elephants in the landscape. By doing this, peaceful sleeping areas away from pedestrian and traffic noise are provided. The 600mm thickness of the concrete walls, the surrounding soil behind, and the living green roof above provide thermal mass as well as a sound insulated space ideal for resting and sleeping. The 3m depth below natural ground level provides reasonably stable, constant internal temperatures, in comparison to the daily and seasonal temperature fluctu-ations occuring outside above ground level. These internal temperatures are stabilised due to the insulating effect of the ground and surrounding soil.

Hot or cool water can be fed through 20mm diameter pex pipes for passive underfloor heating or cooling. Having heated floors is especially important to ensure the rapid drying of the floors ,after routine cleaning, to reduce ele-phants' exposure to moisture.



Elephant Harness
Night Quarters

A harness connected to a push beam girder trolley, running along a steel beam, is needed in the event that an elephant is down and it is nec-essary to keep it upright or elevated to prevent injuries or complications.

Figure 8. 6 Left: Floor drain detail in Night Quarter, with 600mm thick concrete wall stepped 3m deep into the earth (Autho, 2016).

Figure 8. 7 Block and tackle running along steel beam used to raise elephants in emergencies, at the Smithso-nian Zoo (Author, 2016).

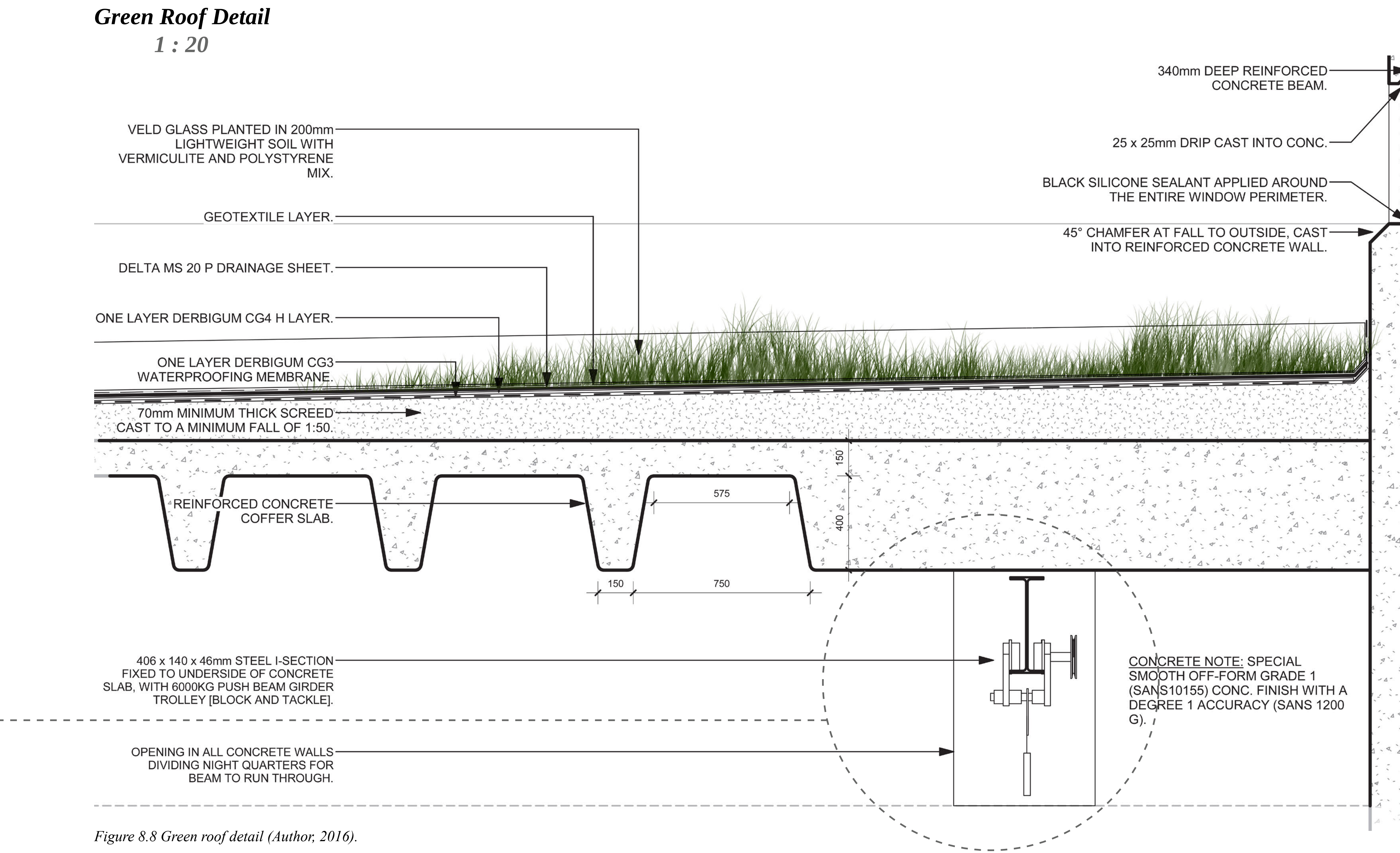


Figure 8.8 Green roof detail (Author, 2016).

Staff-Elephant barrier

Migration Corridor

The Transfer Hall, as it is known in elephant management practice, is referred to in this project as the 'Migration Corridor'. This corridor forms the primary means of circulation for the elephants, which connects their various habitable spaces and the different conditions (areas containing soil, sand, vegetation and water) together.

The migration corridor creates a prominent, continuous feature in the design, allowing the architectural intervention to be integrated into the sloping landscape. It helps to re-establish the condition of migratory patterns which exist in the wild to a smaller scale for the purposes of the project. It allows for free roaming and meandering of the elephants and their freedom of choice to occupy any space whether indoors or outdoors. It is not about captivity; it is about the freedom of movement.

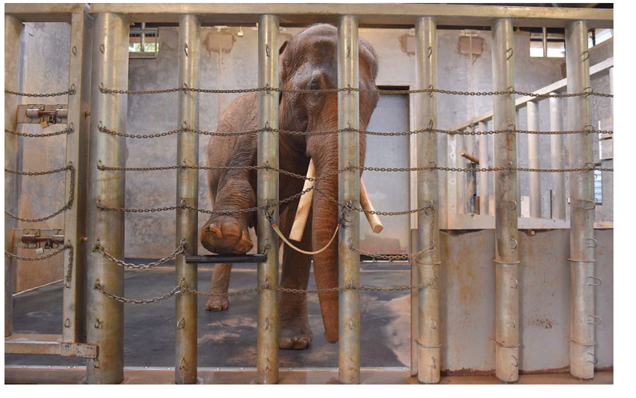
The corridor also assists the staff in the management and transitioning of elephants. Due to the open barrier design, elephants are able to walk alongside their handlers while receiving positive reinforcement, an important ritual that aids in developing trust between the two parties.

Migration corridor steel barrier design

As specified by SANS regulations regarding shelter design requirements for animals, where steel pole construction is utilised for indoor barriers or perimeter fencing, members should always be positioned vertically and not horizontally. This is to reduce the danger of elephants breaking their tusks into the members, which is a far greater risk if the barrier design contains more horizontal members (SABS, 2004).

While circular steel members placed either vertically or diagonally have been used at other elephant facilities worldwide, vertically placed square steel members have been chosen for this project. The welding and assembly of circular members firstly is far more difficult. With the standard of welding in South Africa, the project prefers to not compromise the original structural function of the barrier design or choose a challenging and unnecessary assembly method.

Furthermore, a barrier containing square steel members provides elephants with a flat surface and area to lean on, in comparison to circular members. Because of their scale, the square members turn into a plane to provide greater support and comfort, rather than circular ones. The vertical placement of members also offers the staff members fast and easy access to transition between spaces safely, while also being able to practically perform general tasks of maintenance and cleaning of spaces, as well as examining and treating elephants.

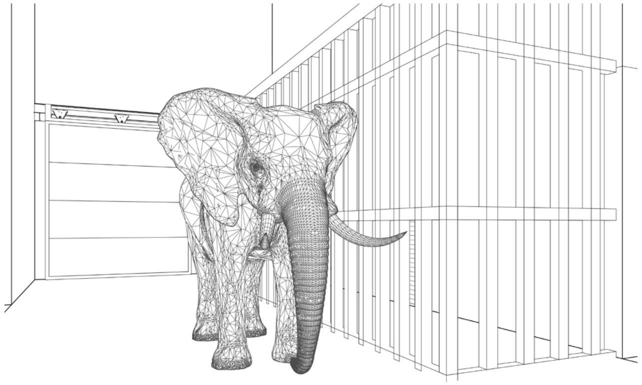


Steel Column Detail

1 : 20

Figure 8.9 Left above: Circular steel members positioned diagonally, at the Elephant House in the Copenhagen Zoo. Figure 8.10 Left below: Circular steel members at the elephant enclosure at the Melbourne Zoo.

Figure 8.11 Above: Steel barriers at the Smithsonian Zoo (Author, 2016). 8. 12 Below: Square Steel members used in design, which provide a supportive flat plane for the elephants (Author, 2016).



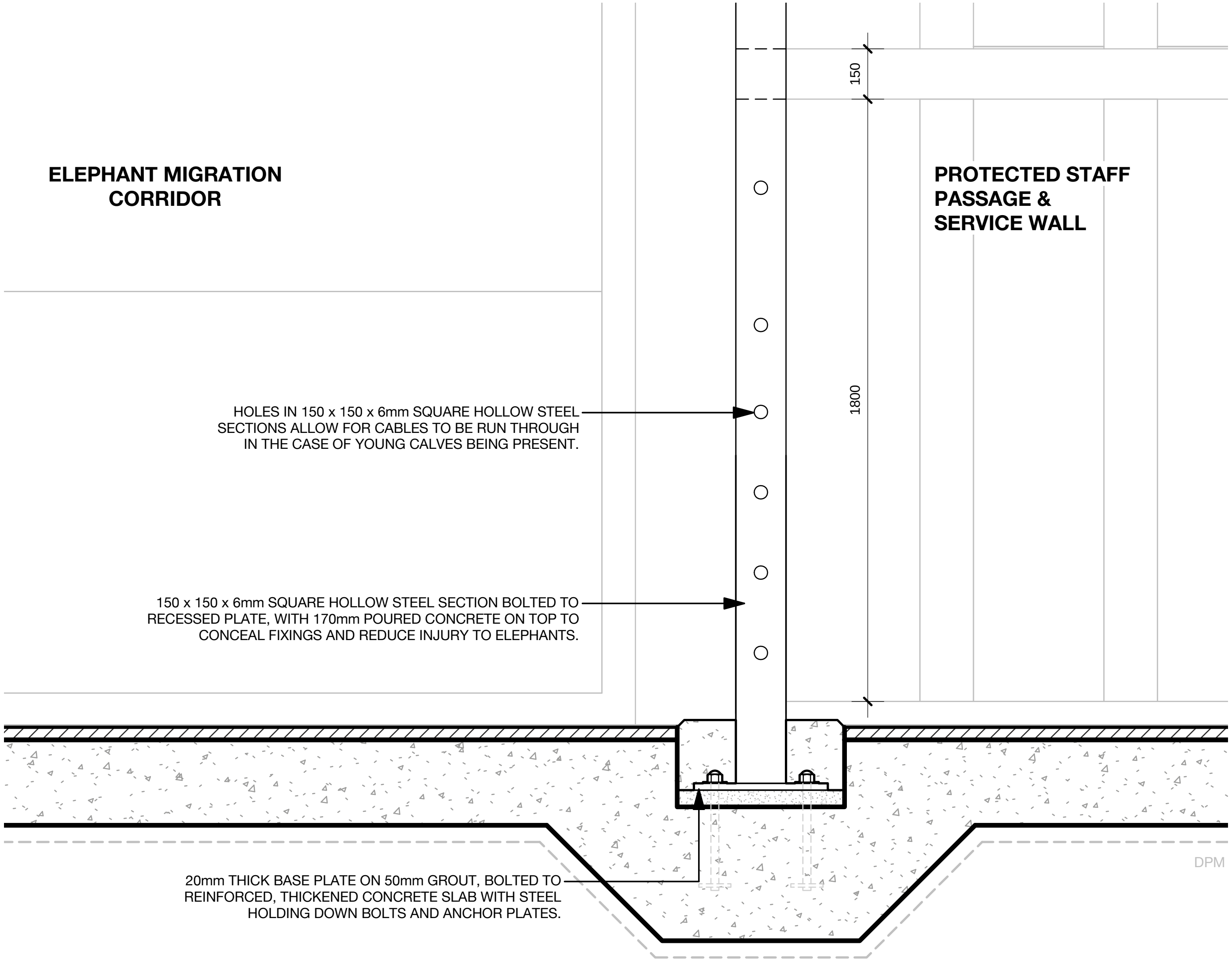
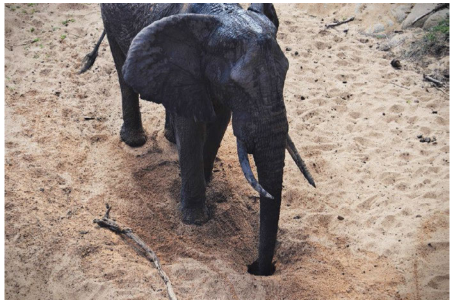


Figure 8.13 Steel column detail (Author, 2016).

Sub-surface drainage
Day Area



Seeing that the Day Area has only 30% roof cover, there is need to integrate a drainage system to prevent the space becoming waterlogged by removing excess water during rainfalls.

Elephants are accustomed to digging holes in the wild with their feet, tusks and trunks in search of water for survival. Provided they are able to dig up to 750mm deep, the sand substrate floor layer needs to be of substantial depth to prevent the elephants exposing the pipes underneath. Elephants will want to access any pipes with flowing water, therefore the drains and water pipes will need to be protected.

A concrete floor bed will be cast to slope to southern wall of the Day Area with a single concrete drain trench running adjacent the entire 600mm thick concrete wall.

Similar to the gratings used in the night quarters, 500 x 1000mm galvanised mild steel Rectagrid RS40 type gratings with 50 x 4.5mm bearer bars will be used to cover the concrete trench. These gratings can withstand a concentrated load of 65250kg, more than the weight of an adult male elephant. Welded steel lugs will help anchor the gratings into the concrete, which need to be locked in place on either side with padlocks as a precautionary measure in the event that an elephant reaches the trench. The padlocks can be opened if maintenance is required in the trench.

The concrete trench will be sloped South East, where at the lowest point a pipe will run out towards to road. The shortest section of this pipe will need to intersect the elephant yard before reaching the public road. The water collected will be gravity fed down the slope and into the river.

Figure 8.14 Photographs of an elephant digging a waterhole with its trunk and feet, at the Kruger National Park.

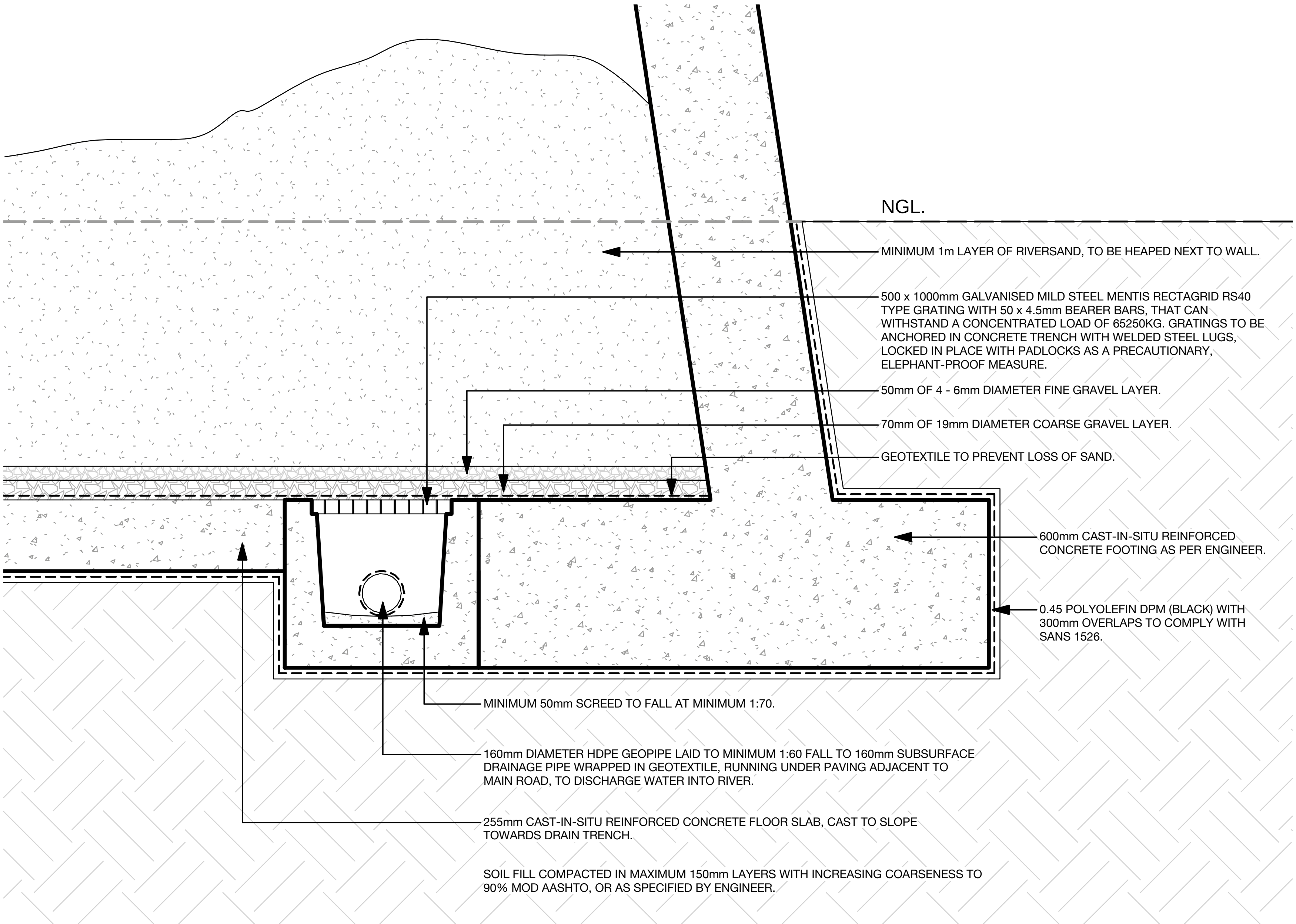


Figure 8.15 Detail of drain in Day Area

Ventilation strategy

Storerooms at ground level

The centrally located storerooms and service wall on ground level assist the staff in servicing and cleaning all the elephant habitable spaces in the building. Ventilating these spaces on the southern side is not possible as any windows or gratings punctured into the 600mm thick concrete wall are within reaching height of the elephants and would be damaged.

Air inlets to supply fresh air would be needed outside on ground level, preferably positioned in the shade to draw in the coolest and cleanest possible air that is free from dust. These inlets are connected to geothermal pipes running under the building that then feed clean, fresh air into each storage space. However, as the southern part of the building is completely elephant accessible, any inlets would be damaged or exposed to dust.

Service ducts in the corners of each storage unit will contain vertical pipes with fans that draw in fresh air from the highest point on southern wall, but still below the roof level, to direct the fresh, cool air to geothermal pipes laid underneath the floor slabs as an alternative ventilation solution. The geothermal pipes will run at an angle to allow any water build-up from condensation to run down and be extracted via a manhole. The pipes will be sloped so the lowest angle will fall in the manhole which will be accessible outside the building.

The pipes will be laid in trenches with concrete covers, compacted with soil, underneath the concrete flooring in the migration corridor. Two wall vents will be built in each store storeroom to supply fresh air. The pipe length will run between 40 and 65 metres at a maximum.

Material Palette

Proposed materials

Figure 8.16 Material palette collage

Concrete walls

Elephants

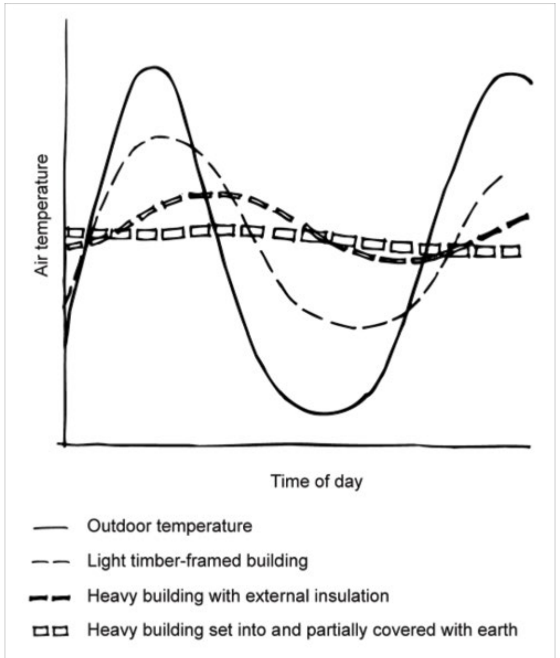
The thickness of the reinforced concrete walls, in order to be structurally resilient to elephants, wass estimated based on the wall thickness calculated for the Elephant House in Copenhagen Zoo, designed by Foster + Partners.

Copenhagen Elephant House:	5,5T Asian elephant	:	15T force	:	300mm Wall	
Garden of Captives project:	6T African elephant	:	16,4T Force	:	327mm Wall	(Average maximum weight of a male)
Graden of Captives project:	7T African elephant	:	19,1T Force	:	381,8mm Wall	(Rare maximum weight of a male)

The above calculation was based on the average maximum weights of both Asian and African male elephants. In rare cases, African male elephants are able to reach a weight of 7 tons, which needs to be taken into consideration even if the likelihood of a 7 ton male being brought to the zoo is very small.

Therefore, the chosen thickness of concrete walls exposed to elephants’ bodies needs to be 400mm, up to their head height. Past this height (4m), the concrete walls can taper to 300mm - where only their trunks can reach.

Material	***Density***	***Specific heat***	***Volumetric heat capacity***
	(Kg/m3)	*(kJ/kg.K)*	*Thermal mass (kJ/m3.K)*
Water	1000	4.186	4186
Concrete	2240	0.920	2060
AAC	500	1.100	550
Brick	1700	0.920	1360
Stone (Sandstone)	2000	0.900	1800
FC Sheet (compressed)	1700	0.900	1530
Earth Wall (Adobe)	1550	0.837	1300
Rammed Earth	2000	0.837	1673
Compressed Earth Blocks	2080	0.837	1740



Time lag figures for various materials	
Material thickness (mm)	***Time lag (hours)***
Double brick (220)	6.2
Concrete (250)	6.9
Autoclaved aerated concrete (200)	7.0
Mud brick/adobe (250)	9.2
Rammed earth (250)	10.3
Compressed earth blocks (250)	10.5
Sandy loam (1000)	30 days

Figure 8.17 Table 1:

Figure 8.18 Table 2:

Figure 8.19 Top right:

Environmental strategy:
Elephant manure as energy source

Due to elephants being able to produce up to 50kg of manure per day, the potential of using their manure as an alternative energy source was investigated. A study with conclusive results conducted on 'Energy production from zoo wastes' at the Knoxville Zoo in the U.S. was consulted.

Elephant manure is a source of biomass, as elephants consume a diet of mostly grass and hay. As elephants are inefficient digesters, their manure has a higher energy content and calorific value, with indigestible plant fibre, which results in a high energy fuel. Due to the substantial amount of waste produced daily in zoos, the disposal of their manure can be both problematic and costly (Klasson & Nghiem, 2003). The Knoxville Zoo spends $5475 per year to dispose of the manure, while other zoos such as The Rosamond Gifford Zoo spend closer to $10 000 annually.

The results of the tests conducted in the study indicated that the digestion of elephant and rhino manure achieved better results (largest amount of gas produced) when incubated at 37°C, and enhanced by the addition of ammonium nitrogen (Refer to Appendix for all the test results).

As the project is designed to accommodate a minimum of six elephants, the calculations were based on the waste produced by six elephants and the two rhinoceroses (a black and white rhinoceros) currently as the NZG, who each produce 23kg of waste daily (Animal Answers, 2015).

Energy Calculations

[6 Elephants x 50kg per day] + [2 Rhinos x 23kg]
= 346kg of manure per day
= 126 290kg per year

1kg of manure = 33L of Biogas
1kg of manure = 20L of Methane
(Biogas is used as fuel for a gas water heater)

Therefore:
346kg manure = 11 418L Biogas
346kg manure = 6 920 L Methane

1m³ of Biogas is equivalent to 6kWh of calorific energy
Specific heat of water at 20°C is 4,182kJ/kg.K
Volume of pool water @ 18° slope = 183 kL

4,182kJ/kg.K = 1,1616667Wh/L.°C

1,1616 x 183kL = 212,6kWh/ °C = 68,508kWh

@ R0,9804/kWh: 68,508 x 0,9804 = R67,14 savings per day on electricity; equivalent to a 8,56kW heater running for 8 hours per day.
68,508kWh / 212,6 kWh/ °C = 0,32 °C temperature increase per day.

Covered outdoor pool:

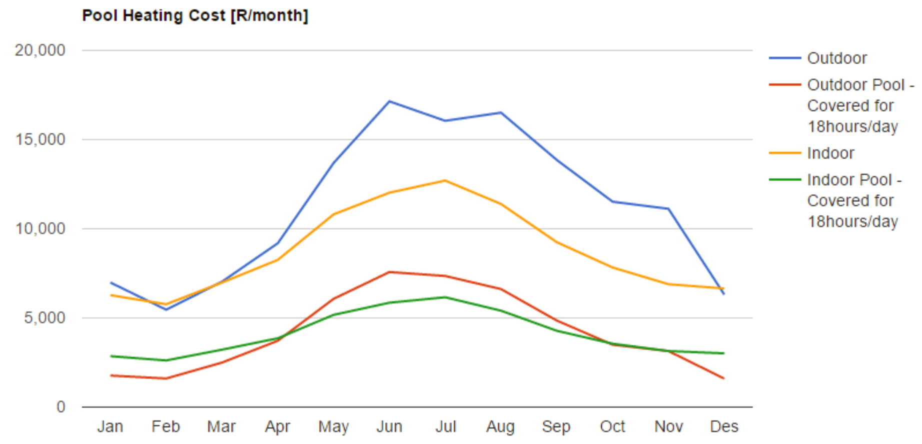
87,4kW is needed for a 12 month cycle

[87,4 / 100] x 20,1kW = 17,5kW of Electricity

32,4kW is needed for October to April (7 of 12 months)

[32,4 / 33,7] x 6,59kW = 6,34kW of Electricity

Energy produced used to heat pool
results



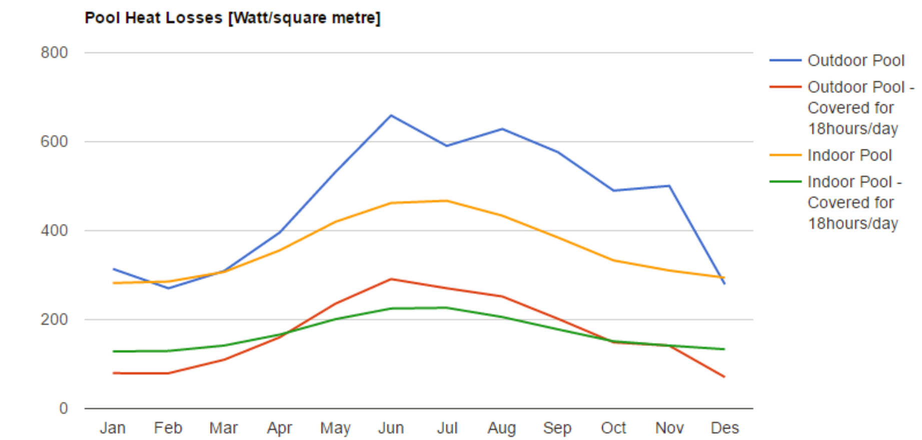


Figure 8.17 Test results

From the results produced it is evident that having an efficient pool cover is crucial to minimise heat losses.

Of the total energy needed to heat the water from 20°C to 30°C over a two to three week period, using energy produced from manure only accounts for approximately 6,75% of what is needed.

Using a pool heatpump would provide a better alternative with superior hearing efficiency than digesting animal manure for biogas or using solar geyser energy. One of the major benefits from using this system is the cool air byproduct produced which can then be used to cool interior spaces for the public.

PROPERTY	OUTDOOR POOL	OUTDOOR POOL COVERED FOR 18H/DAY	INDOOR POOL	INDOOR POOL COVERED FOR 18H/DAY
Max Heat Loss [W/m^2]	658.9	291.1	467.2	226.6
Heat Pump Size [kW]	197.7	87.4	143.0	69.3
Heat Pump Model Requirement	Enerflow EIP720MTC model.	Enerflow EIP330MTC model.	Enerflow EIP500MTC model.	Enerflow EIP230MTC model.
Electricity Cost [R/year]	134866	50300	104825	49139
Mean COP of Heat Pump During Period	4.1			

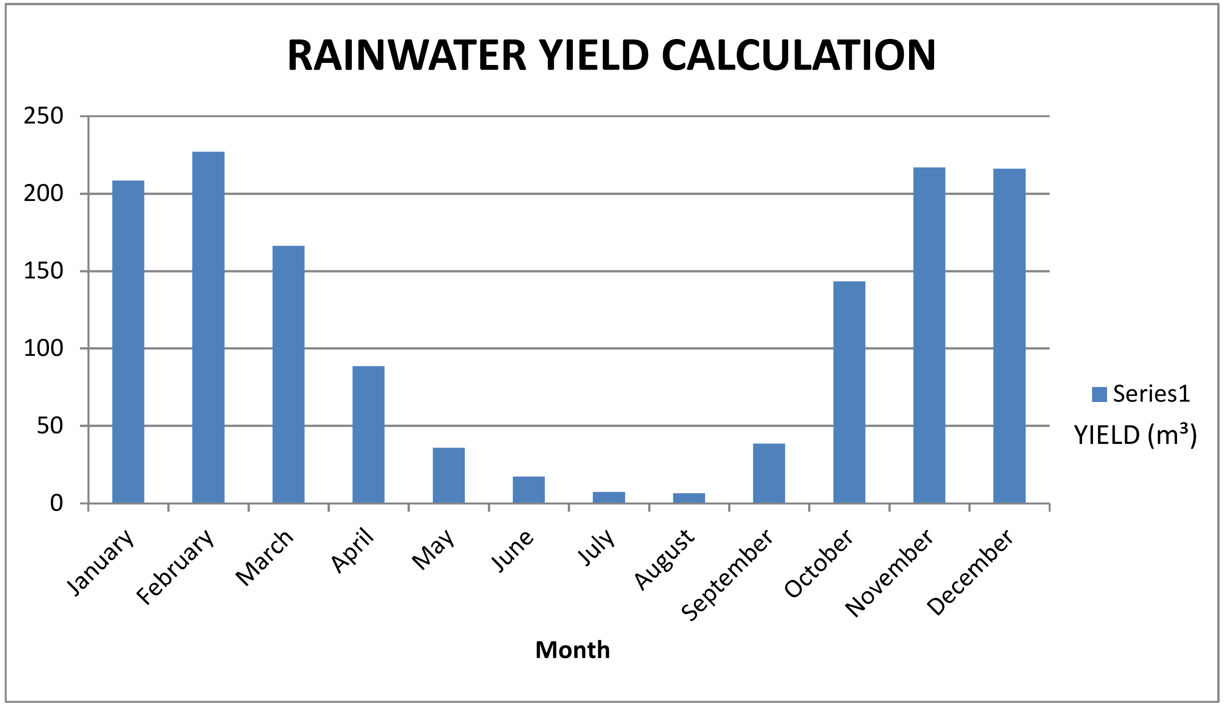
PROPERTY	OUTDOOR POOL	OUTDOOR POOL COVERED FOR 18H/DAY	INDOOR POOL	INDOOR POOL COVERED FOR 18H/DAY
Max Heat Loss [W/m^2]	500.7	141.5	310.3	141.7
Heat Pump Size [kW]	114.6	32.4	71.0	31.9
Heat Pump Model Requirement	Enerflow EIP500MTC model.	Enerflow EIP15MT3 model.	Enerflow EIP330MTC model.	Enerflow EIP15MT3 model.
Electricity Cost [R/year]	36911	10611	32574	14853
Mean COP of Heat Pump During Period	4.4			

Calculations

Precipitation in Pretoria

Temperature (°C				Perecipitation		
Month	Average Daily Maximum	Average Daily Minimum	Lowest Recorded	Average Monthly (mm)	Average Number of Days with > =1mm	Highest 24 hour rainfall (mm)
January	30	18		138	10	160
February	30	18		75	8	95
March	28	16		83	6	84
April	26	13		30	4	72
May	24	9		6	1	40
June	21	5		9	1	32
July	21	5		3	0	18
August	24	8		3	1	15
September	28	12		21	2	43
October	29	15		54	5	108
November	29	16		90	8	67
December	30	17		108	8	50
ANNUAL AVE.	320/12	151/12		674	87	160

Figure 8.18 Rainwater Calculations.


RAINWATER YIELD CALCULATION
250
200
150
100
50
0
January
February
March
April
May
June
July
August
September
October
November
December
Month
Series1
YIELD (m³)

Calculations

Rainwater harvesting

RAINWATE									
Month	**Ave. monthly precipitation, P (m)**	**Area of catchment roof 1 (m²) - GREEN ROOF [NIGHT QUARTERS]**	**Runoff coefficient**	**Yield (m³)**	**Area of catchment roof 2 (m²) - PLEXIGLAS ROOF [MIGRATION CORRIDOR]**	**Runoff coefficient**	**Yield (m³)**	**Area of catchment roof 3 (m²) - CONCRETE ROOF [STAFF]**	**Runoff coefficient**
January	0,1038	627,4	0,4	26	795,7	0,8	66	101,8	0,9
February	0,1131	627,4	0,4	28	795,7	0,8	72	101,8	0,9
March	0,0828	627,4	0,4	21	795,7	0,8	53	101,8	0,9
April	0,0441	627,4	0,4	11	795,7	0,8	28	101,8	0,9
May	0,0178	627,4	0,4	4	795,7	0,8	11	101,8	0,9
June	0,0086	627,4	0,4	2	795,7	0,8	5	101,8	0,9
July	0,0036	627,4	0,4	1	795,7	0,8	2	101,8	0,9
August	0,0032	627,4	0,4	1	795,7	0,8	2	101,8	0,9
September	0,0205	627,4	0,4	6	795,7	0,8	4	101,8	0,9
October	0,0714	627,4	0,4	18	795,7	0,8	45	101,8	0,9
November	0,1081	627,4	0,4	27	795,7	0,8	69	101,8	0,9
December	0,1077	627,4	0,4	27	795,7	0,8	69	101,8	0,9
ANNUAL AVE.	0,674			14			36		

Figure 8.19 Rainwater Calculations.

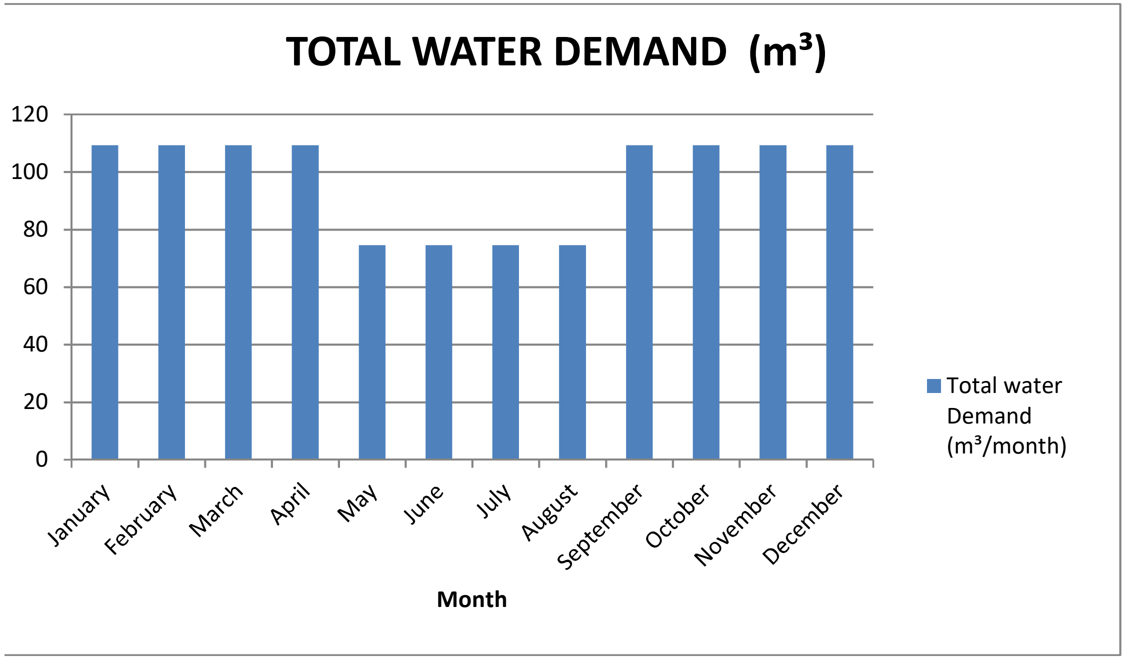
R YIELD CALCULATION

Yield (m^3)	Area of catchment roof 4 (m^2) - CONCRETE ROOF [PUBLIC 1]	Runoff coefficient	Yield (m^3)	Area of catchment roof 5 (m^2) CONCRETE ROOF [PUBLIC 2]	Runoff coefficient	Yield (m^3)	Area of catchment roof 6 (m^2) CONCRETE ROOF [CLINIC]	Runoff coefficient	Yield (m^3)	Area of catchment roof 7 (m^2) GREEN ROOF [CLINIC]	Runoff coefficient	Yield (m^3)	Yield (m^3) TOTAL
10	252,3	0,9	24	498,7	0,9	47	332,5	0,9	31	131,5	0,4	5	208
10	252,3	0,9	26	498,7	0,9	51	332,5	0,9	34	131,5	0,4	6	227
8	252,3	0,9	19	498,7	0,9	37	332,5	0,9	25	131,5	0,4	4	166
4	252,3	0,9	10	498,7	0,9	20	332,5	0,9	13	131,5	0,4	2	89
2	252,3	0,9	4	498,7	0,9	8	332,5	0,9	5	131,5	0,4	1	36
1	252,3	0,9	2	498,7	0,9	4	332,5	0,9	3	131,5	0,4	0	17
0	252,3	0,9	1	498,7	0,9	2	332,5	0,9	1	131,5	0,4	0	7
0	252,3	0,9	1	498,7	0,9	1	332,5	0,9	1	131,5	0,4	0	6
6	252,3	0,9	6	498,7	0,9	9	332,5	0,9	6	131,5	0,4	1	38
7	252,3	0,9	16	498,7	0,9	32	332,5	0,9	21	131,5	0,4	4	143
10	252,3	0,9	25	498,7	0,9	49	332,5	0,9	32	131,5	0,4	6	217
10	252,3	0,9	24	498,7	0,9	48	332,5	0,9	32	131,5	0,4	6	216
6			13			26			17			3	1371

USER DEMAND: DRINKING				
Month	Elephant	Water / Elephant /day (L)	Water / day (L)	Water / Elephant /month (L)
January	6	200	1200	36500
February	6	200	1200	36500
March	6	200	1200	36500
April	6	200	1200	36500
May	6	200	1200	36500
June	6	200	1200	36500
July	6	200	1200	36500
August	6	200	1200	36500
September	6	200	1200	36500
October	6	200	1200	36500
November	6	200	1200	36500
December	6	200	1200	36500

USER DEMAND: SHOWERING					
Month	ELEPHANTS	Water / capita /day (L)	Water / capita /month (L)	Domestic Demand (L/month)	
January	3	175	4900	14700	14,7
February	3	175	4900	14700	14,7
March	3	175	4900	14700	14,7
April	3	175	4900	14700	14,7
May	3	175	4900	14700	14,7
June	3	175	4900	14700	14,7
July	3	175	4900	14700	14,7
August	3	175	4900	14700	14,7
September	3	175	4900	14700	14,7
October	3	175	4900	14700	14,7
November	3	175	4900	14700	14,7
December	3	175	4900	14700	14,7
					176,4

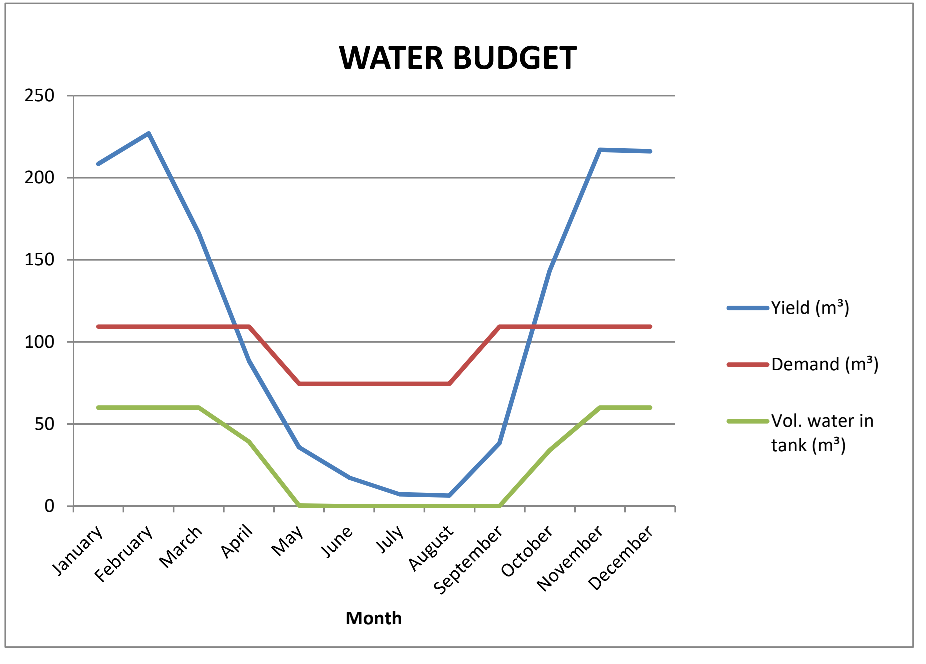
TOTAL WATER DEMAND CALCULATION						
Month	Staff Demand (m³/month)	Visitors Demand (m³/month)	Elephant Drink Demand (m³/month)	Elephant Washing Demand (m3/month	Evap Losses	Total water Demand (m³/month)
January	6,33	16,99	36,5	14,7	34,8	109
February	6,33	16,99	36,5	14,7	34,8	109
March	6,33	16,99	36,5	14,7	34,8	109
April	6,33	16,99	36,5	14,7	34,8	109
May	6,33	16,99	36,5	14,7	0	75
June	6,33	16,99	36,5	14,7	0	75
July	6,33	16,99	36,5	14,7	0	75
August	6,33	16,99	36,5	14,7	0	75
September	6,33	16,99	36,5	14,7	34,8	109
October	6,33	16,99	36,5	14,7	34,8	109
November	6,33	16,99	36,5	14,7	34,8	109
December	6,33	16,99	36,5	14,7	34,8	109
TOTAL	76	204	438	176,4	278,4	718



WATER BUDGET with tank						
Month	Yield (m³)	Demand (m³)	Monthly balance	Vol. water in tank (m³)	Municipal water required	Rain water used
January	208	109	99	60,0	0	109
February	227	109	118	60,0	0	109
March	166	109	57	60,0	0	109
April	89	109	-21	39,2	0	109
May	36	75	-39	0,4	-38	36
June	17	75	-57	0,0	-57	17
July	7	75	-67	0,0	-67	7
August	6	75	-68	0,0	-68	6
September	38	109	-71	0,0	-71	38
October	143	109	34	34,0	0	109
November	217	109	108	60,0	0	109
December	216	109	107	60,0	0	109
			199		-302	870,669179

TANK SIZE (m	SAFETY FACTOR	FINAL TANK m³		Tank Size Selected		Saving of
60	1,333333333	80		60		74,25%

EVAPORATIVE LOSSES				
Month	Area	mm loss per week	m3 loss per week	Water / Month (L)
January	290	0,03	8,7	34,8
February	290	0,03	8,7	34,8
March	290	0,03	8,7	34,8
April	290	0,03	8,7	34,8
May	290	0,03		0
June	290	0,03		0
July	290	0,03		0
August	290	0,03		0
September	290	0,03	8,7	34,8
October	290	0,03	8,7	34,8
November	290	0,03	8,7	34,8
December	290	0,03	8,7	34,8
				278,4



SANS 10400

The SANS 10400 was referred to regularly to ensure that the building conforms to the national building standards and regulations.

Part A: Administration

The classification of occupancy of the building:
Due to the non-standard function and programme of the building, it has been categorised as both A1 and C1 in terms of the public functions.

A1: Entertainment and public assembly (Table 1 & 2)
1 person per m² (No fixed seats)
C1: Exhibition hall
1 person per 10m²

Climatic Zone of Pretoria: Zone 2 Temperate interior

Part O: Ventilation

Minimum air requirements:

Public Assembly Halls = 3,5 L/s per person (non-smoking)
Offices: General spaces and Boardroom (staff) = 5,0 L/s per person (non-smoking)

Part P: Ablutions

Required for both categories:

Personnel - Male ablutions:
1 Water closet
1 Urinal
1 Wash hand basin

Personnel - Female ablutions:
1 Water closet
1 Wash hand basin

Public – Male ablutions:
2 Water closets
3 Urinals
3 Wash hand basins

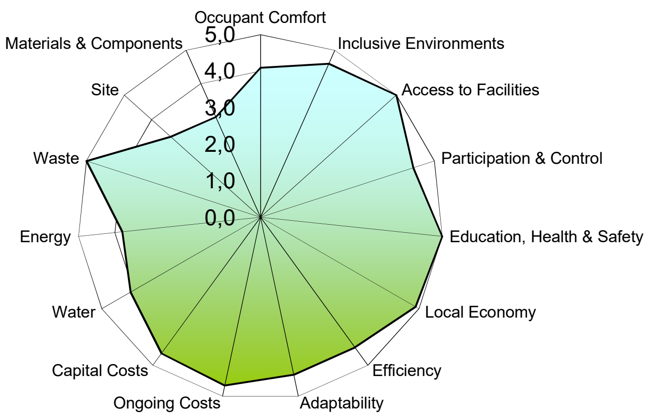
Public – Female ablutions:
5 Water closets
3 Wash hand basins

2 Disabled bathroom facilities are provided on ground floor for each gender.

SBAT Rating

SUSTAINABLE BUILDING ASSESSMENT TOOL (SBAT- P) V1

PROJECT		ASSESSMENT	
Project title:	Urban Rehabilitation Sanctuary for Elephants	Date:	17/10/2016
Location:	National Zoological Gardens of South Africa on Boom Street, Pretoria	Undertaken by:	Chrysanthe Nicolaides
Building type (specify):	Animal enclosure	Company / organisation:	Student, University of Pretoria
Internal area (m2):	2464,6	Telephone:	Fax:
Number of users:	10 Elephants; 50 People (Staff & Public)	Email:	
Building life cycle stage (specify):	Design		



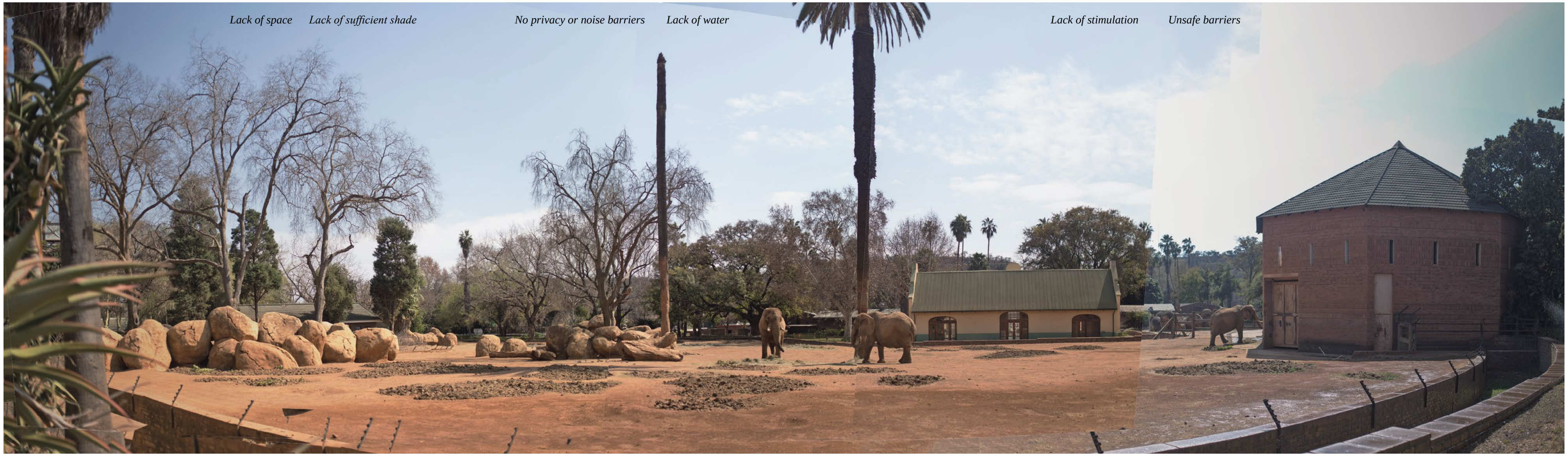
Social	4,6	Economic	4,6	Environmental	3,8
		Overall	4,4		

Figure 8.19 SBAT Rating based on design as it was in mid-October.

EXHIBITION DRAWINGS & MODELS
23 · 11 · 2016

CREATING A PLACE OF SANCTUARY, FOR OUR GENTLE GIANTS

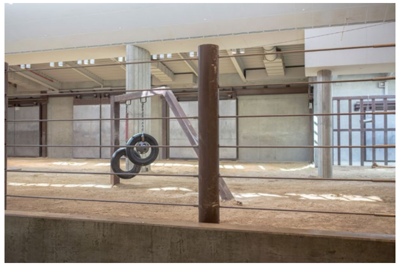
EXISTING **ELEPHANT ENCLOSURE**

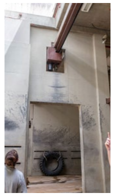


PRECEDENT **SMITHSONIAN NATIONAL ZOO**

*Architects: pja architects + landscape archi-
tects
Location: Washington D.C., United States
Area: 8 943 m²
Project completion year: 2012
Client: Smithsonian National Zoo*

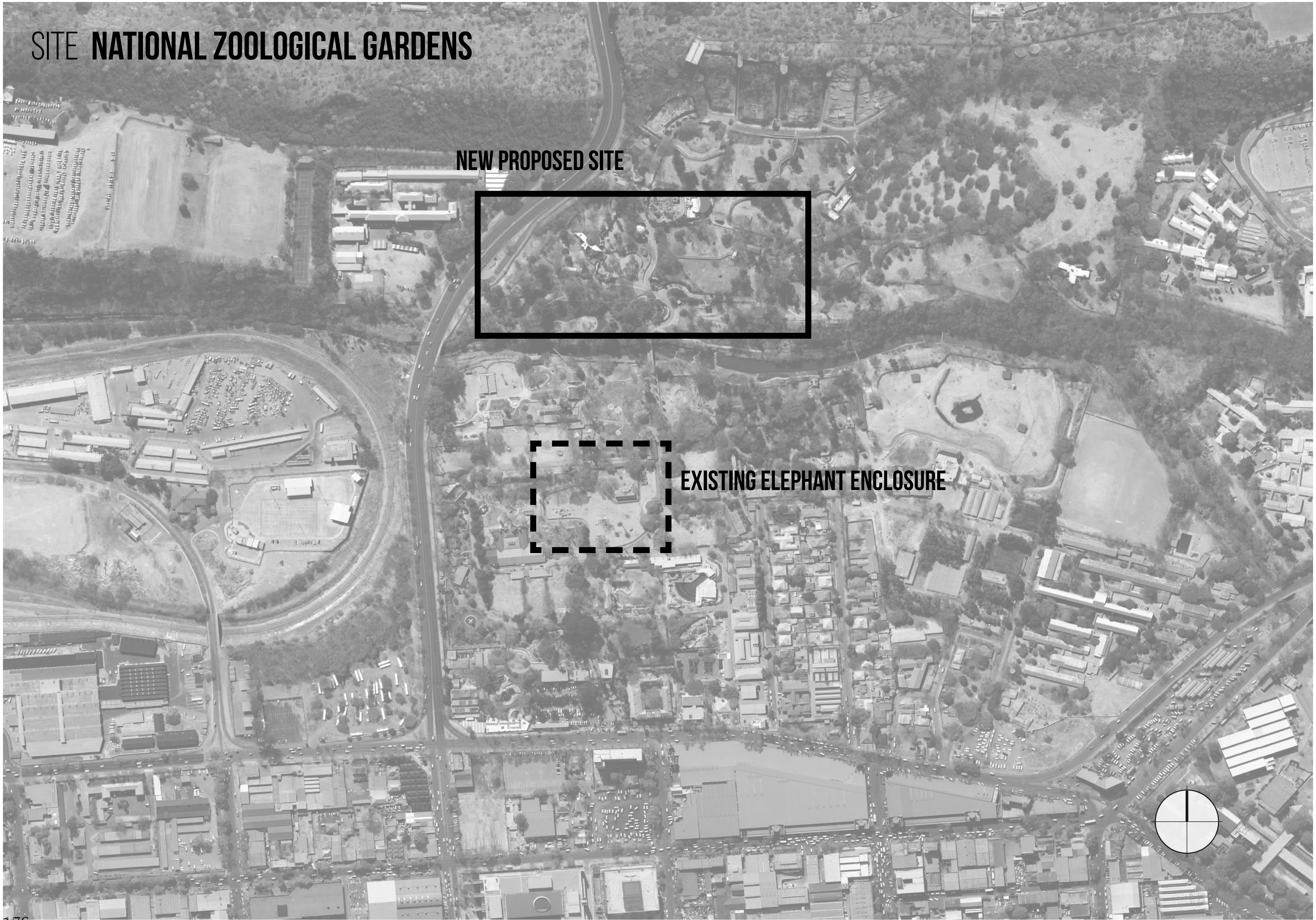




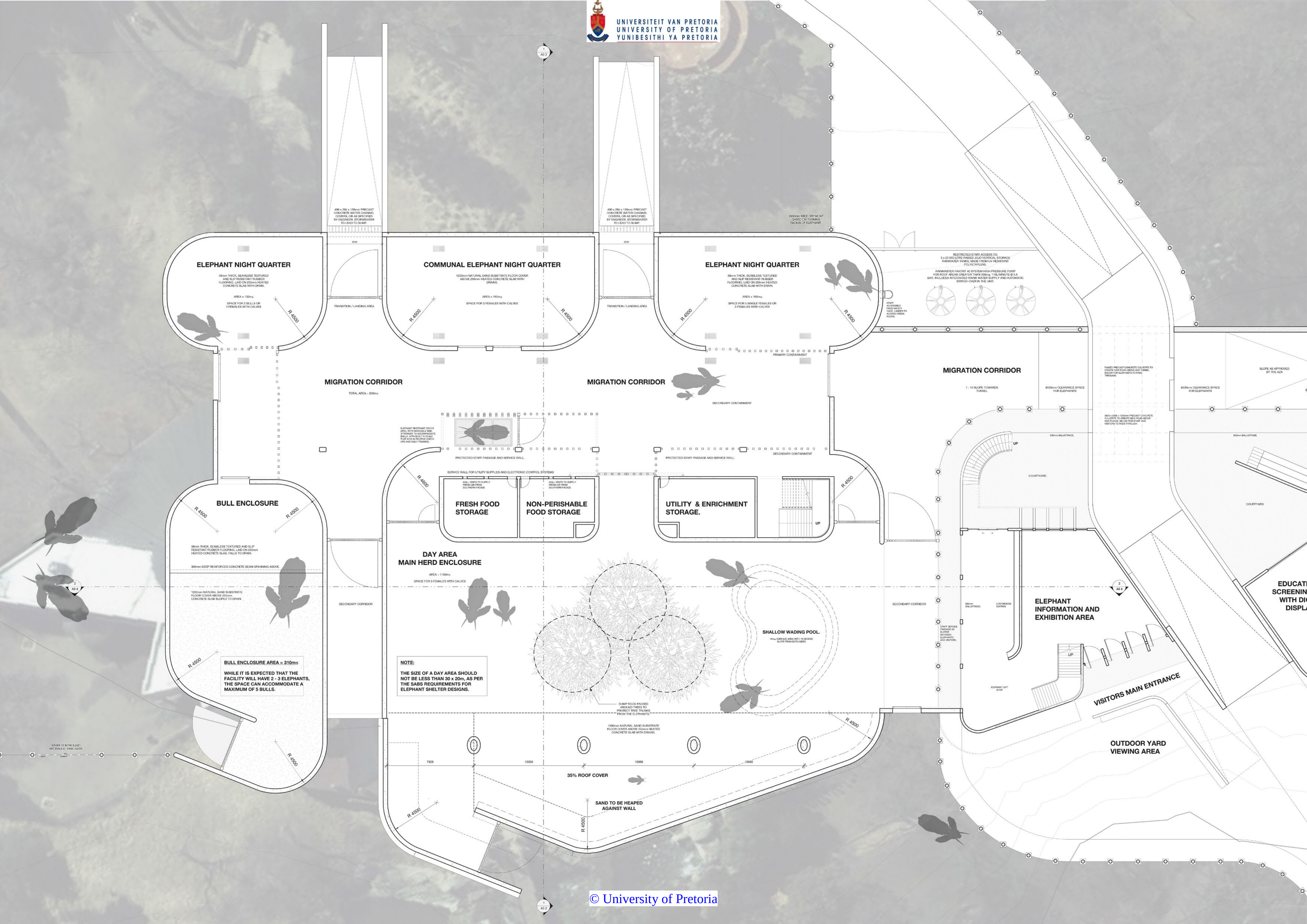







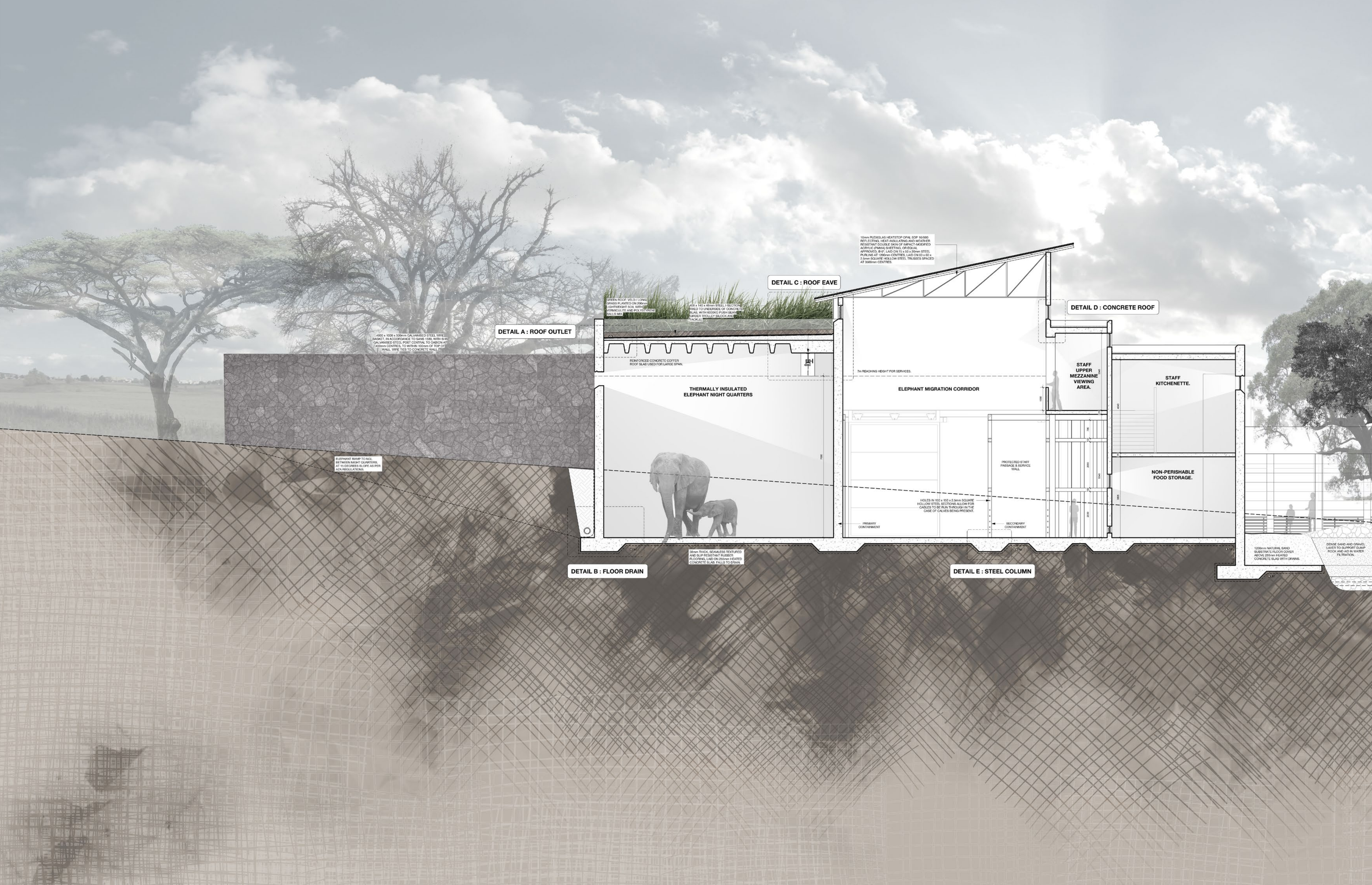


SITE NATIONAL ZOOLOGICAL GARDENS
NEW PROPOSED SITE
EXISTING ELEPHANT ENCLOSURE


ELEPHANT SANCTUARY
ELEPHANT WALKING TRAILS
SHARED GARDEN
SITE PLAN

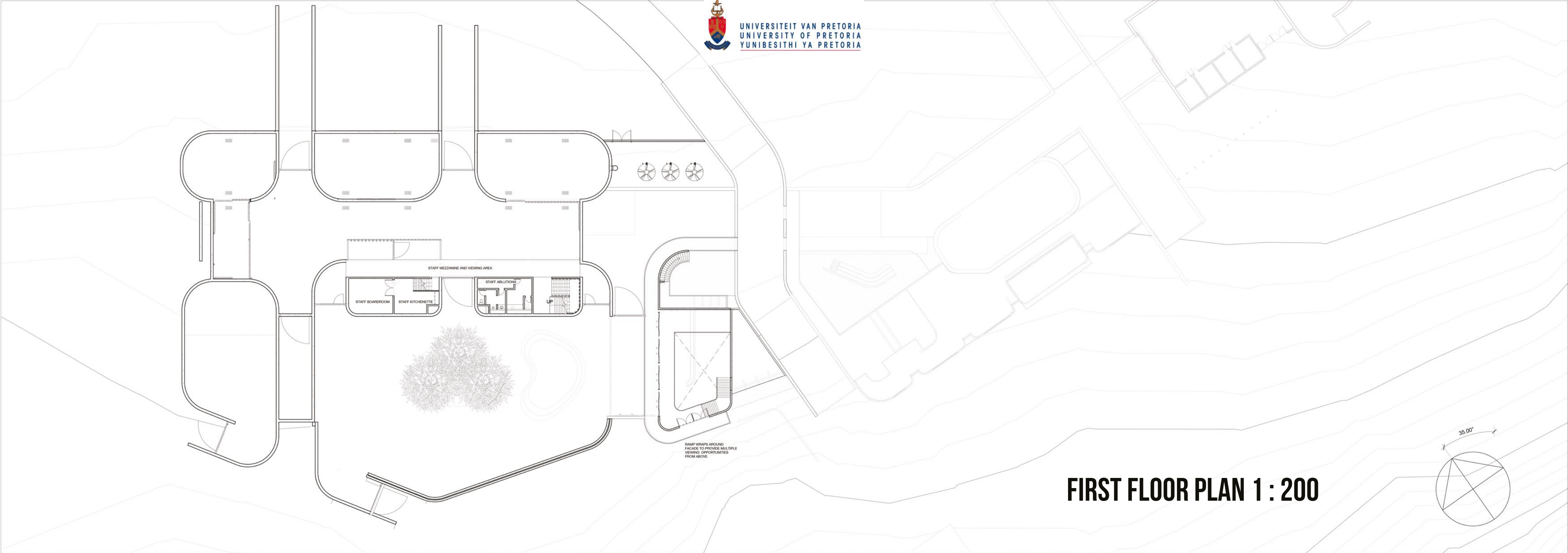

ELEPHANT NIGHT QUARTER
COMMUNAL ELEPHANT NIGHT QUARTER
ELEPHANT NIGHT QUARTER
MIGRATION CORRIDOR
MIGRATION CORRIDOR
MIGRATION CORRIDOR
BULL ENCLOSURE
FRESH FOOD STORAGE
NON-PERISHABLE FOOD STORAGE
UTILITY & ENRICHMENT STORAGE.
DAY AREA
MAIN HERD ENCLOSURE
SHALLOW WADING POOL.
BULL ENCLOSURE AREA = 310m²
WHILE IT IS EXPECTED THAT THE FACILITY WILL HAVE 2 - 3 ELEPHANTS, THE SPACE CAN ACCOMMODATE A MAXIMUM OF 5 BULLS.
NOTE:
THE SIZE OF A DAY AREA SHOULD NOT BE LESS THAN 30 x 20m, AS PER THE SABS REQUIREMENTS FOR ELEPHANT SHELTER DESIGNS.
35% ROOF COVER
SAND TO BE HEAPED AGAINST WALL
ELEPHANT INFORMATION AND EXHIBITION AREA
VISITORS MAIN ENTRANCE
OUTDOOR YARD VIEWING AREA
R 4500

GROUND FLOOR PLAN 1:100

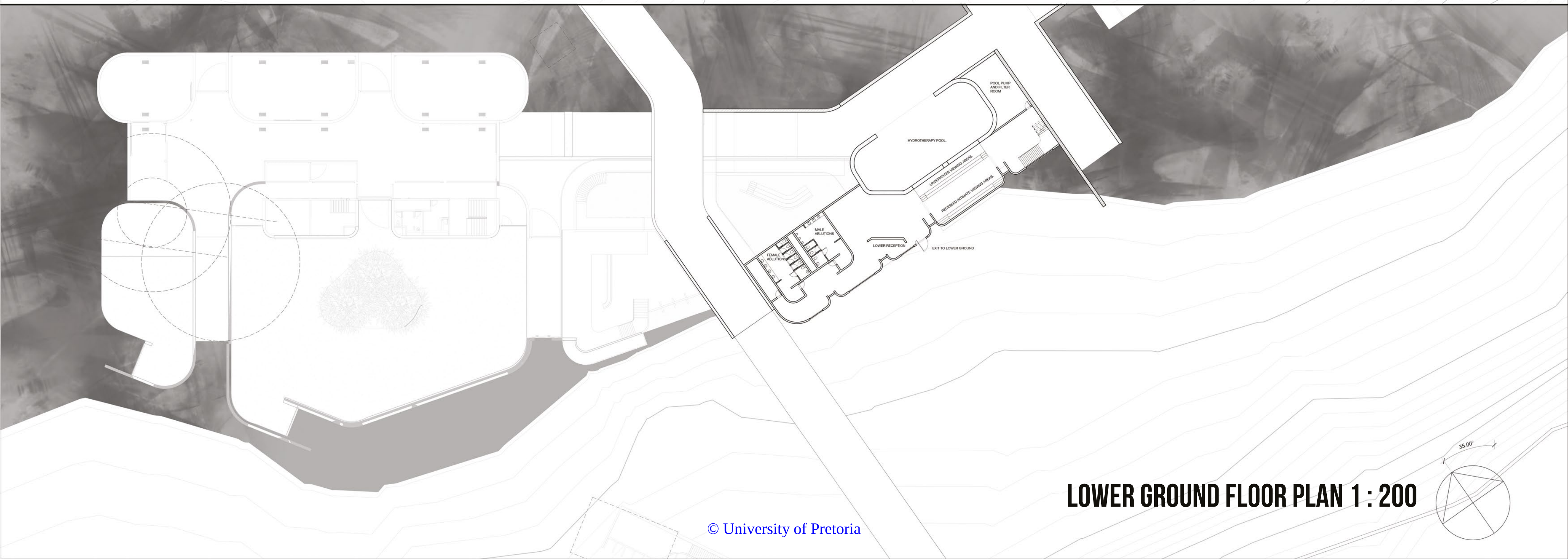
UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA



SECTION A-A 1:50

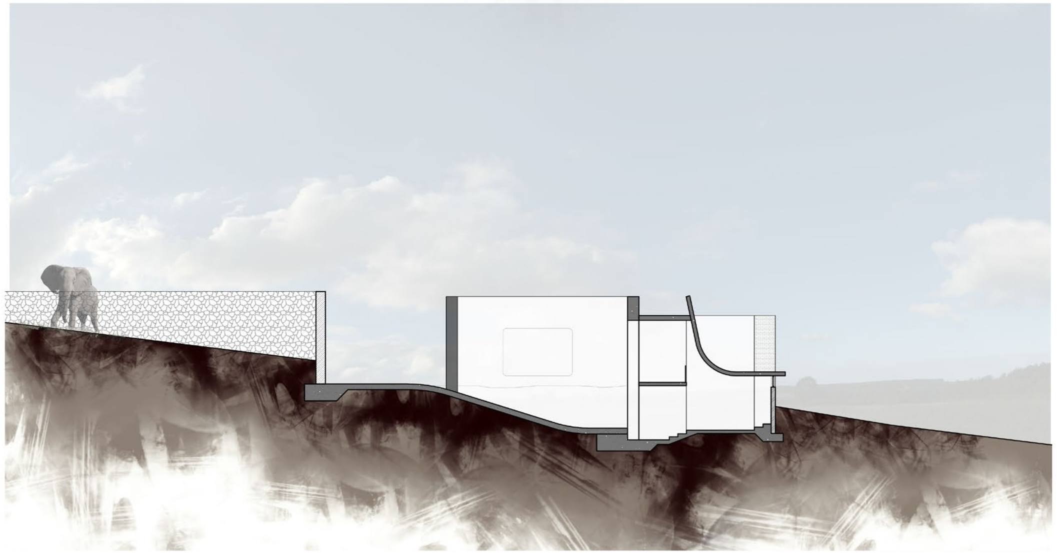


FIRST FLOOR PLAN 1 : 200



LOWER GROUND FLOOR PLAN 1 : 200

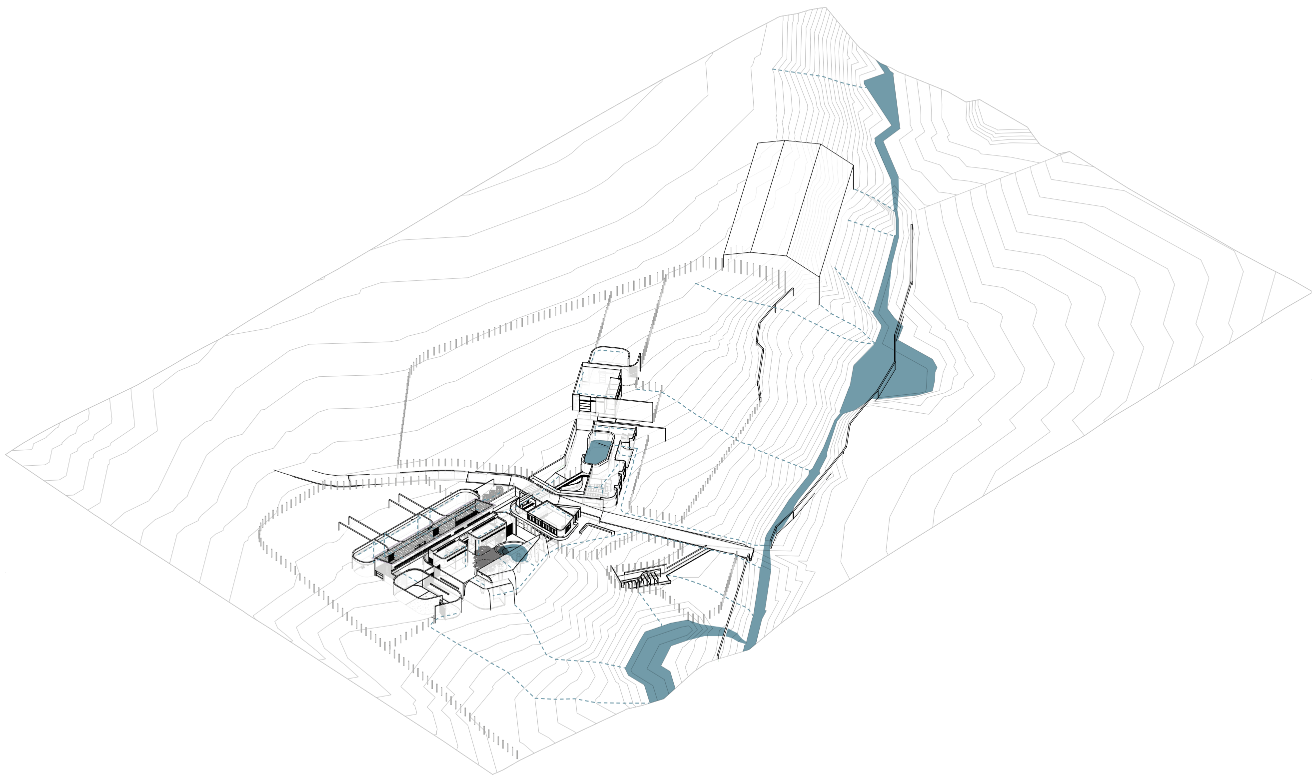
SECTION B-B 1: 100

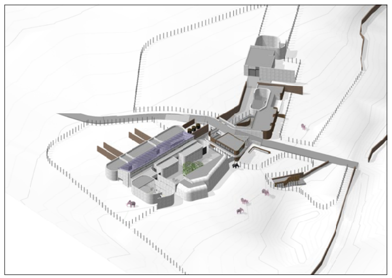


SECTION C-C 1: 100

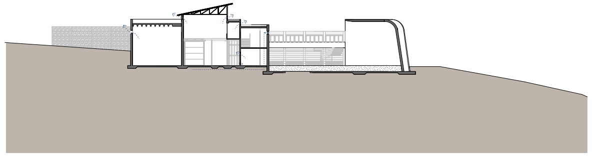
ENVIRONMENTAL STRATEGIES

WATER STRATEGY

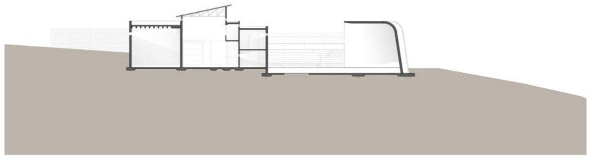




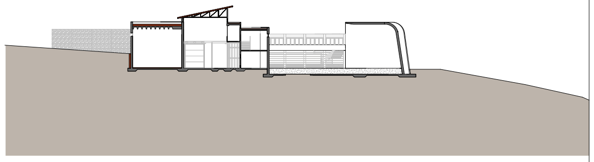
VENTILATION



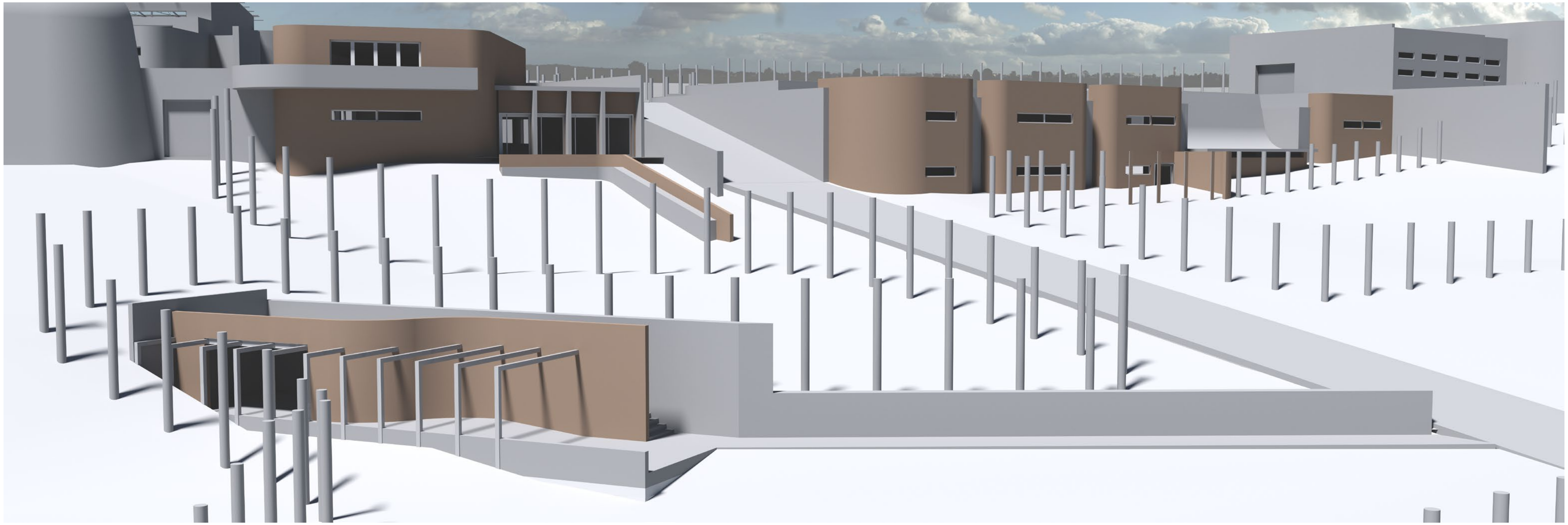
NATURAL DAYLIGHTING



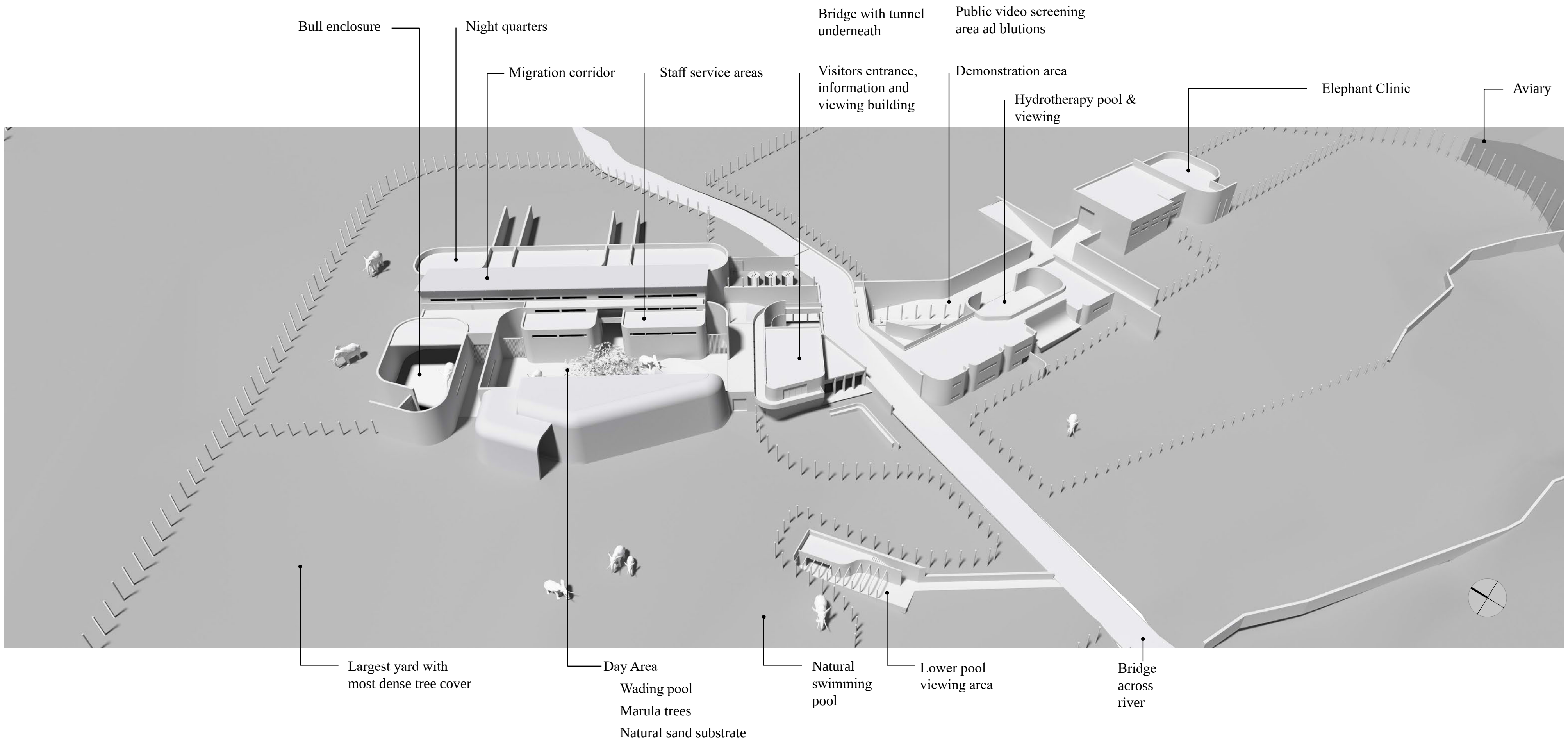
INSULATION AND THERMAL MASSING



SOUTH FACADE AND PUBLIC ENTRANCE



AERIAL PERSPECTIVE

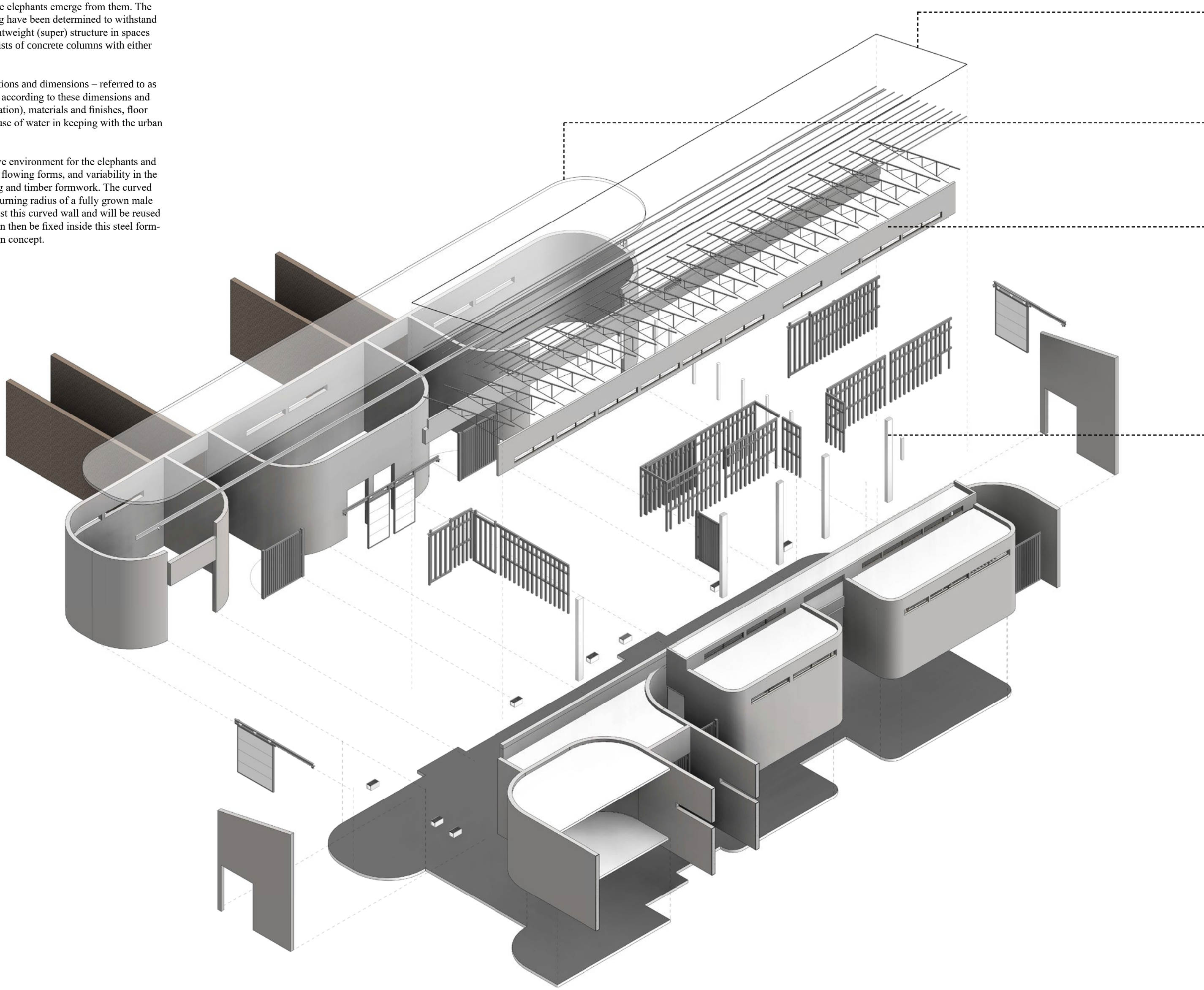


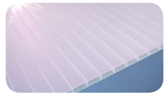
STRUCTURAL AND TECTONIC INTENTIONS

The primary (sub) structure comprises of thick, heavy, stereotomic concrete and gabion stone walls; structures and masses that fit in and emerge from the landscape. This heaviness is representative of the large scale and grandeur of elephants. The night stalls will be built into the earth, with thick retaining walls, to effectively use thermal mass for heating and cooling. The design and placement of these stalls is to connect the elephants to the earth, being more familiar to them than actual buildings, and to create dramatic entrances and thresholds when the elephants emerge from them. The thickness of all walls forming the sub-structure of the building have been determined to withstand great forces of 15 tonnes exerted by a 6 ton elephant. The lightweight (super) structure in spaces either occupied by people or beyond reach of elephants, consists of concrete columns with either brick or glass infill.

All architectural decisions were informed by elephant proportions and dimensions – referred to as the modular elephant. Elements that are specifically designed according to these dimensions and specifications include all curved walls (both on plan and elevation), materials and finishes, floor surfaces, ceiling heights, services, doors and thresholds, and use of water in keeping with the urban vision set by the Apies River framework group.

In-situ cast concrete is more conducive in building a protective environment for the elephants and for allowing creative opportunities in the design, with its free flowing forms, and variability in the shuttering finishes and play on textures - such as sand blasting and timber formwork. The curved corners of larger spaces indicated on plan were based on the turning radius of a fully grown male elephant's proportions. Steel formwork will be designed to cast this curved wall and will be reused throughout the building. Different timber shuttering panels can then be fixed inside this steel formwork to create a variation in concrete finishes as per the design concept.





Plexiglas Heatstop Opsl SDP 16. It is an infrared-reflecting, heat-insulating PMMA (polymethyl methacrylate) double skin

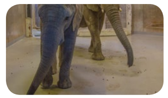
500mm deep in situ cast reinforced coffered concrete roof slab to span 10m

Thick plywood-shuttered cast in situ concrete walls

150 x 150 x 2,5mm hot rolled structural hollow steel sections. 1 coat metal primer, 2 coats final structural steel paint (colour - grey)

400 x 600mm high strength, 35mPa, reinforced in situ cast concrete columns

Secondary wall material, clay facebrick



Rubber flooring

Power floated concrete screed

ROOF STRUCTURE

- Plexiglas roof sheeting
- Galvanised steel lipped channels
- Galvanised steel tube trusses
- Reinforced concrete beams
- Reinforced concrete columns

PRIMARY CONTAINMENT STRUCTURE

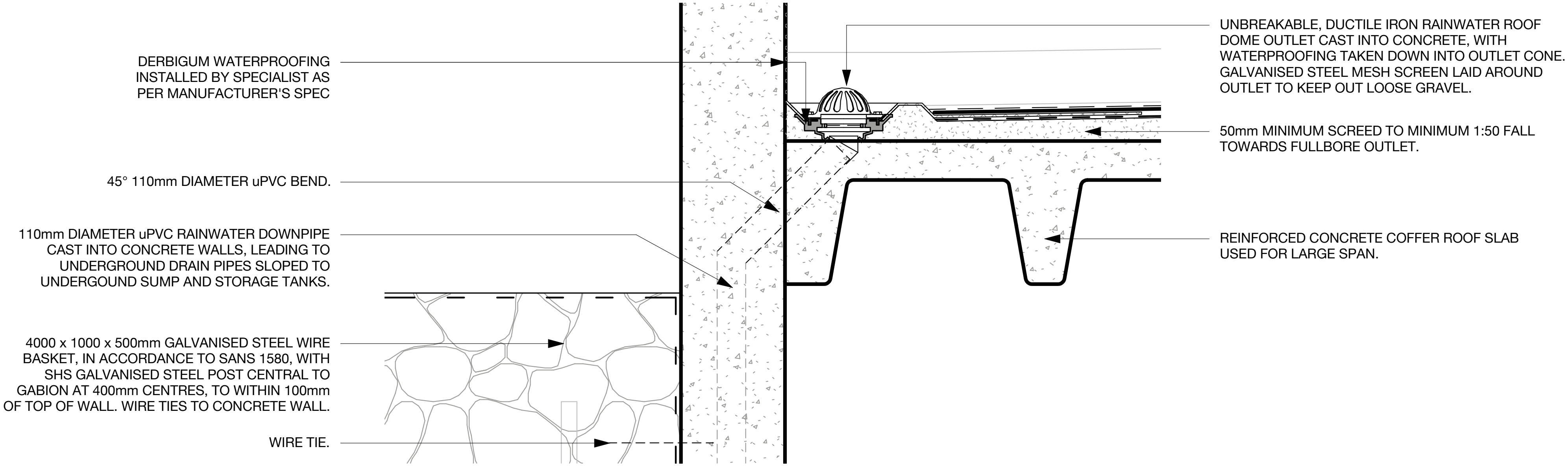
- Reinforced concrete walls

SECONDARY CONTAINMENT STRUCTURE

- Square hollow steel sections
- Reinforced concrete doors
- Square hollow steel section gates

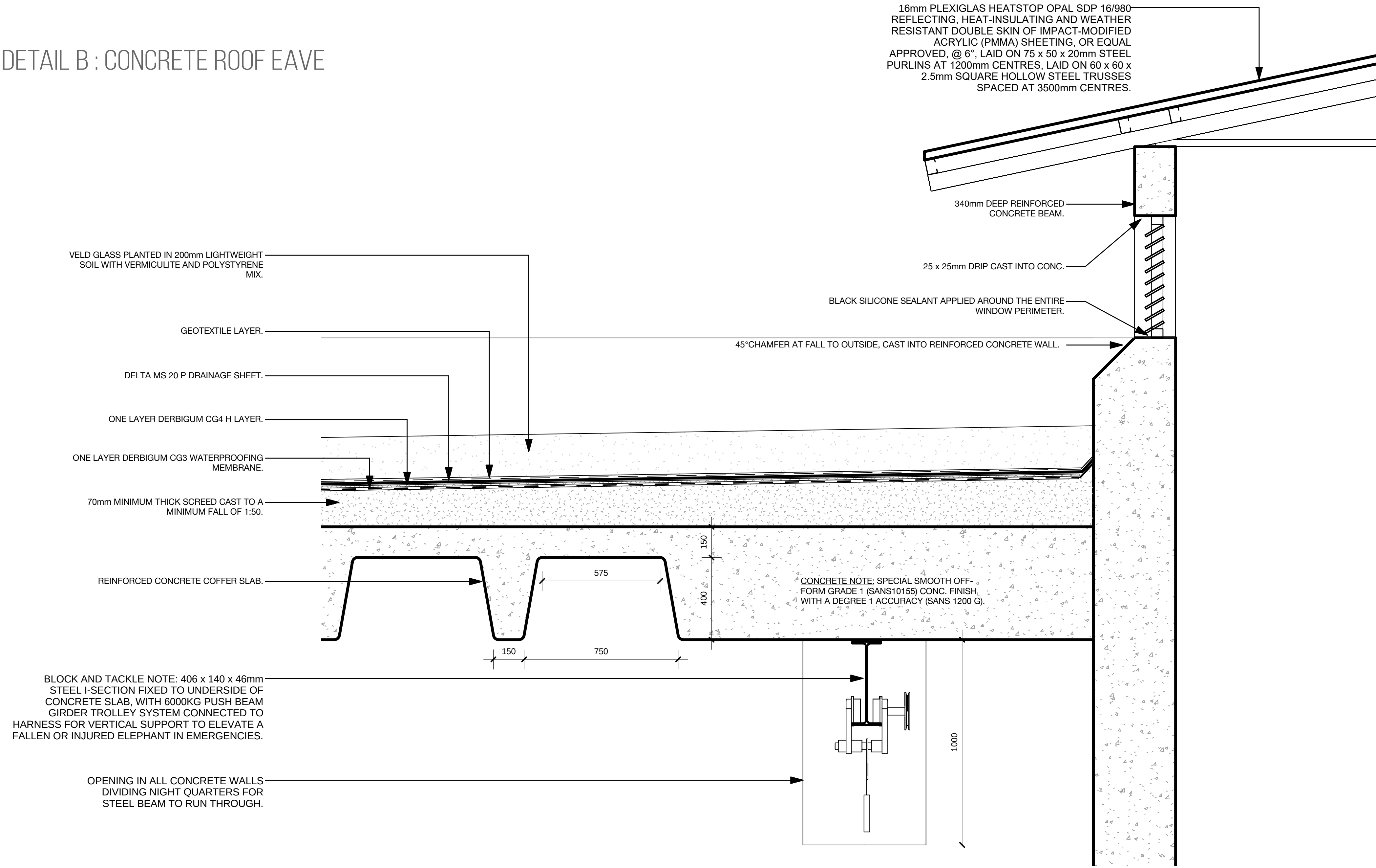
DETAIL RESOLUTION

DETAIL A : FLAT ROOF RAINWATER OUTLET TO DOWNPIPE



(Detail not to scale).

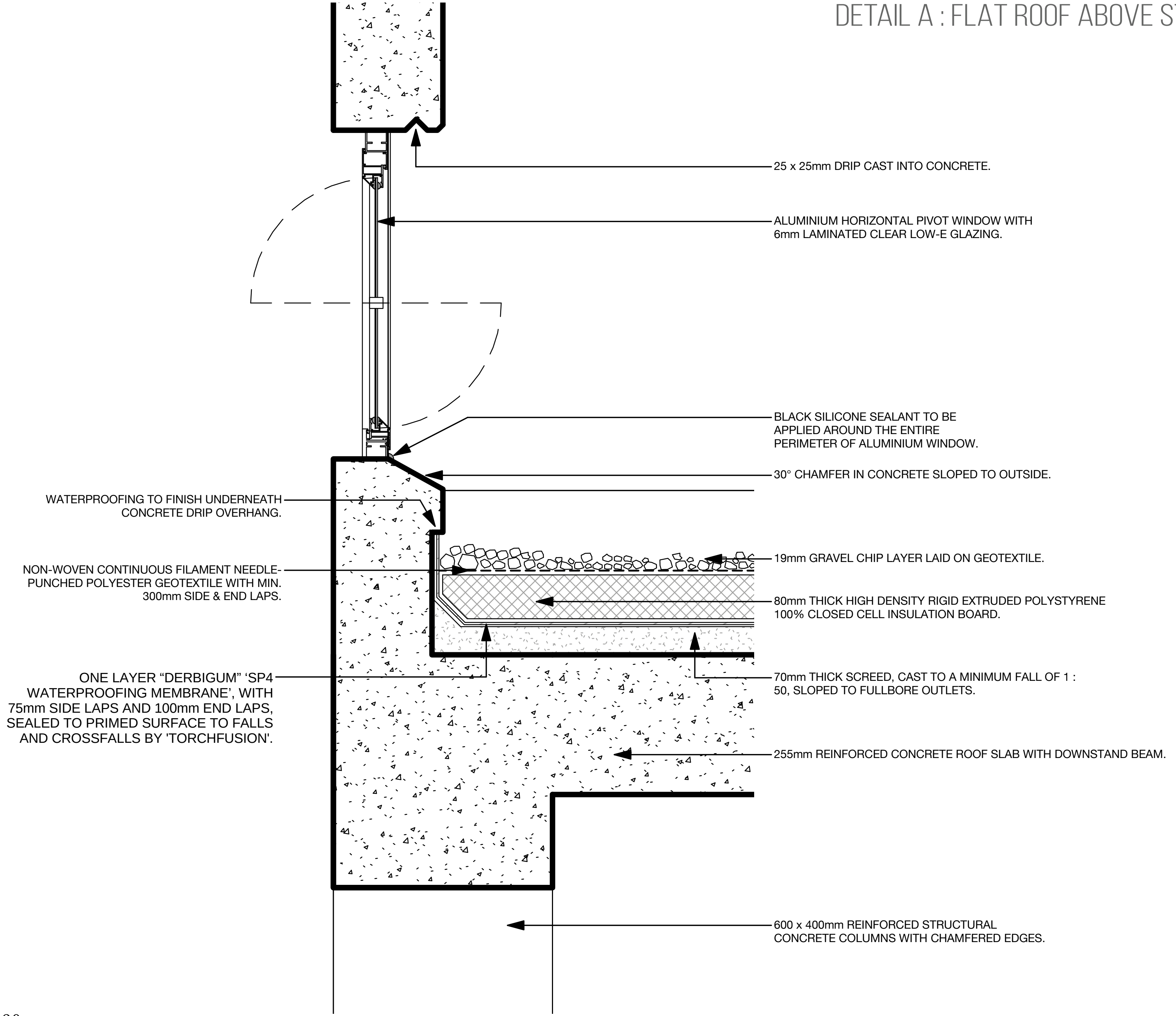
DETAIL B : CONCRETE ROOF EAVE



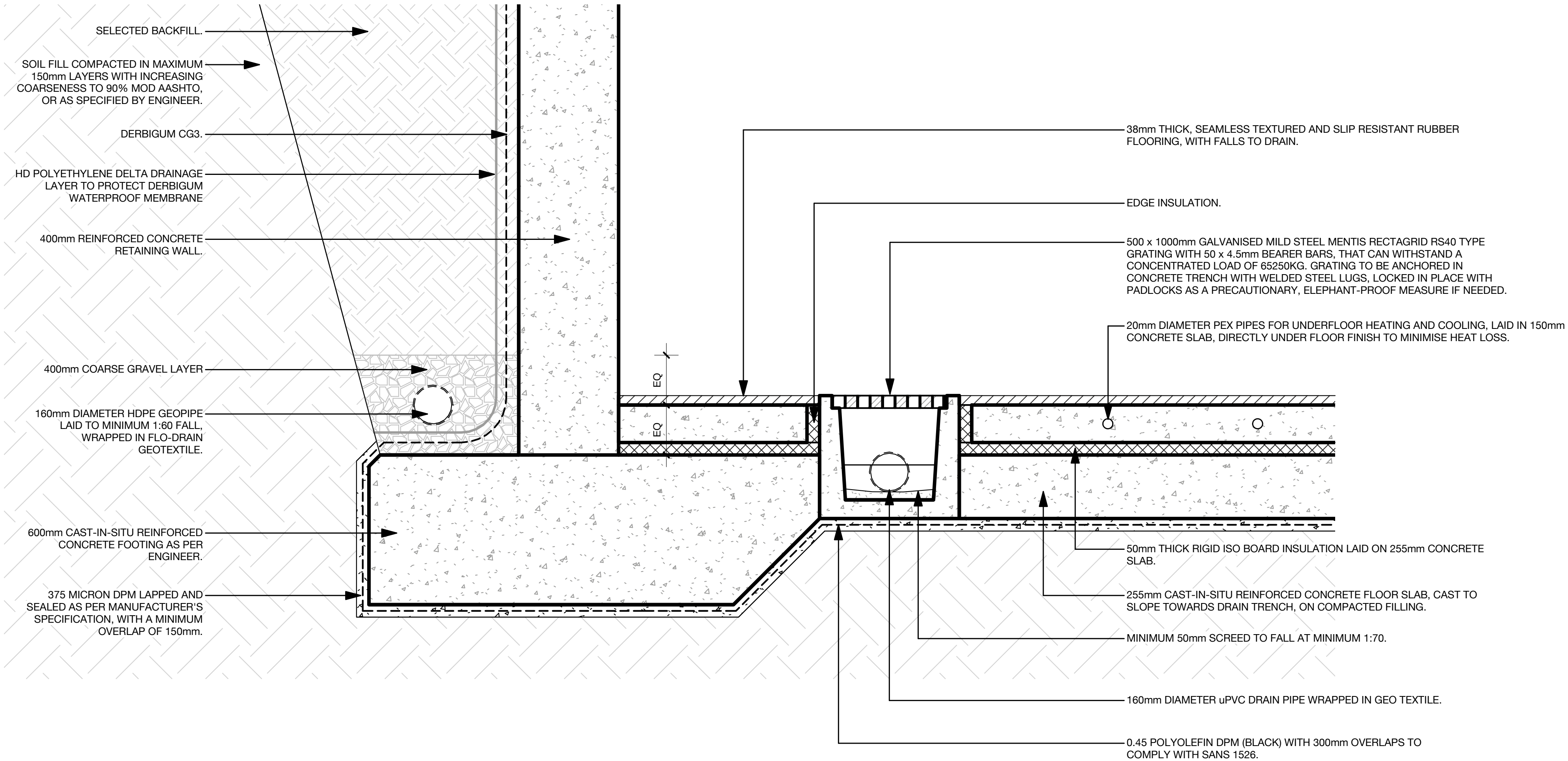
(Detail not to scale).

DETAIL A : FLAT ROOF ABOVE STAFF MEZZANINE LEVEL

1 : 10



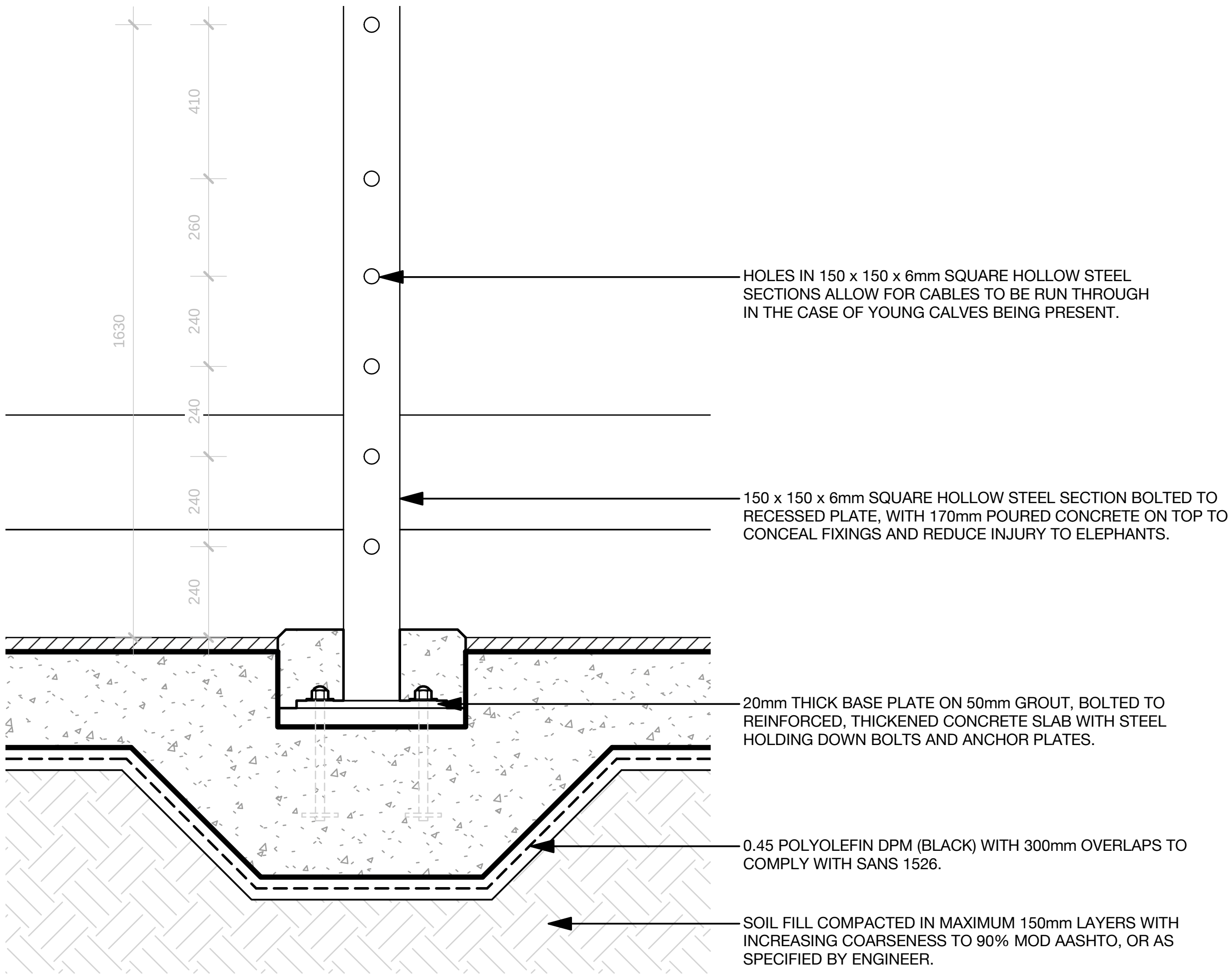
DETAIL D : RUBBER FLOORING WITH DRAIN



(Detail not to scale).

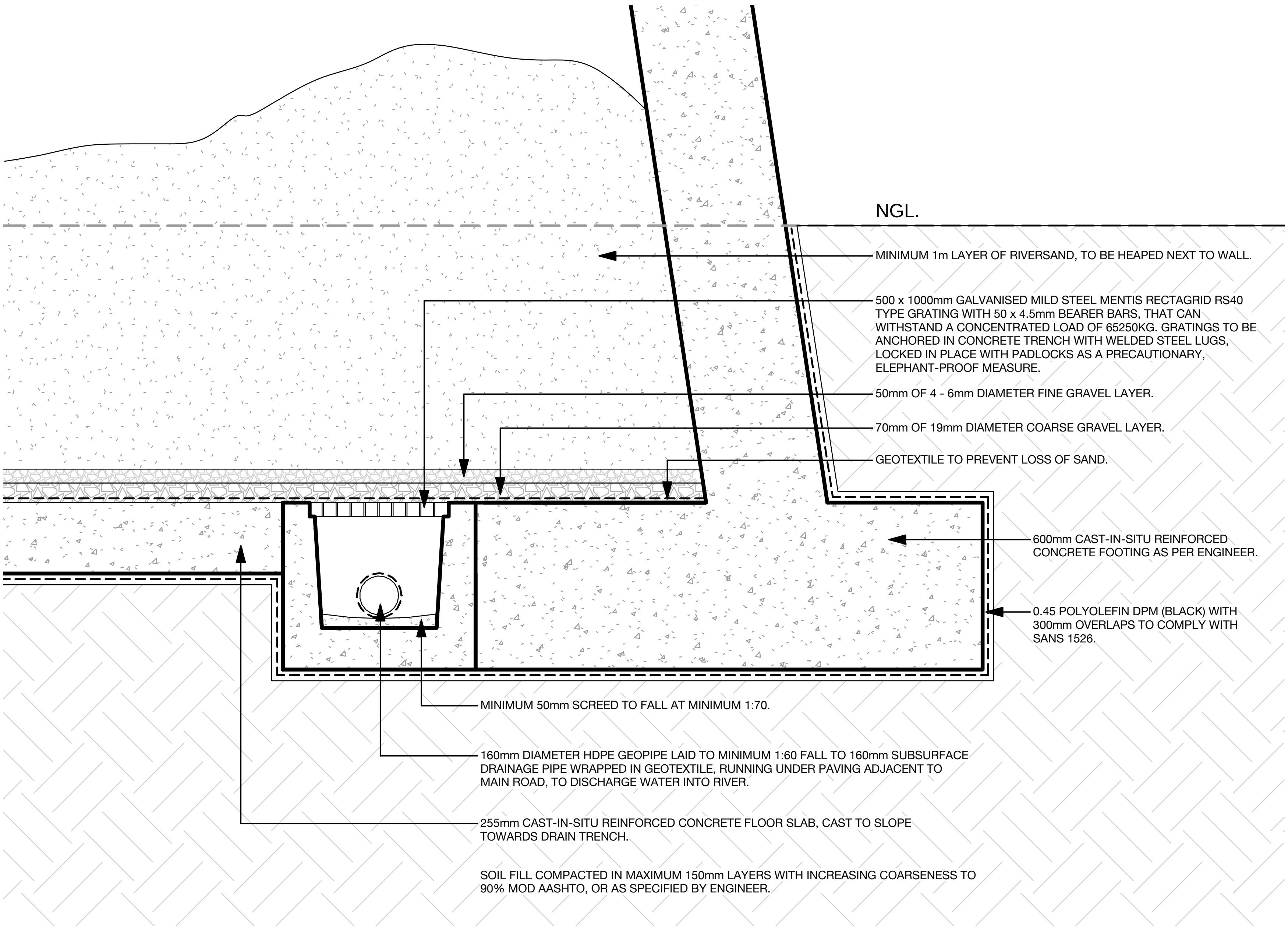
DETAIL E : HOLLOW STEEL SECTION BARRIER

1 : 20

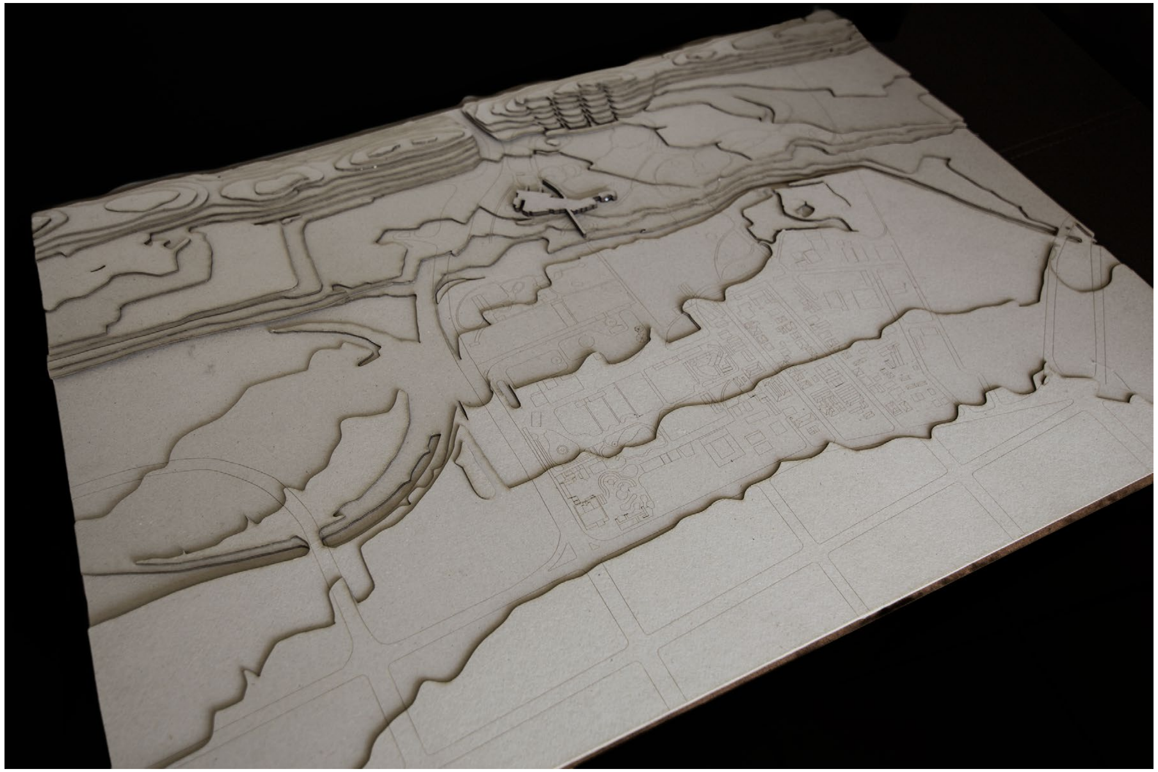


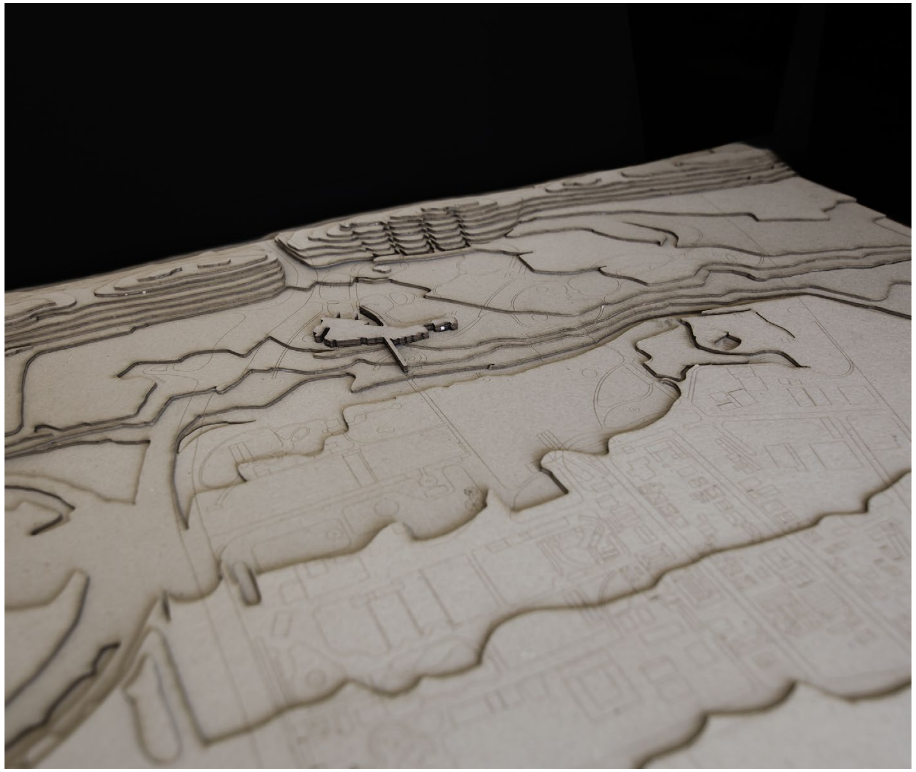
DETAIL F : DAY AREA FLOOR DRAIN

1 : 20

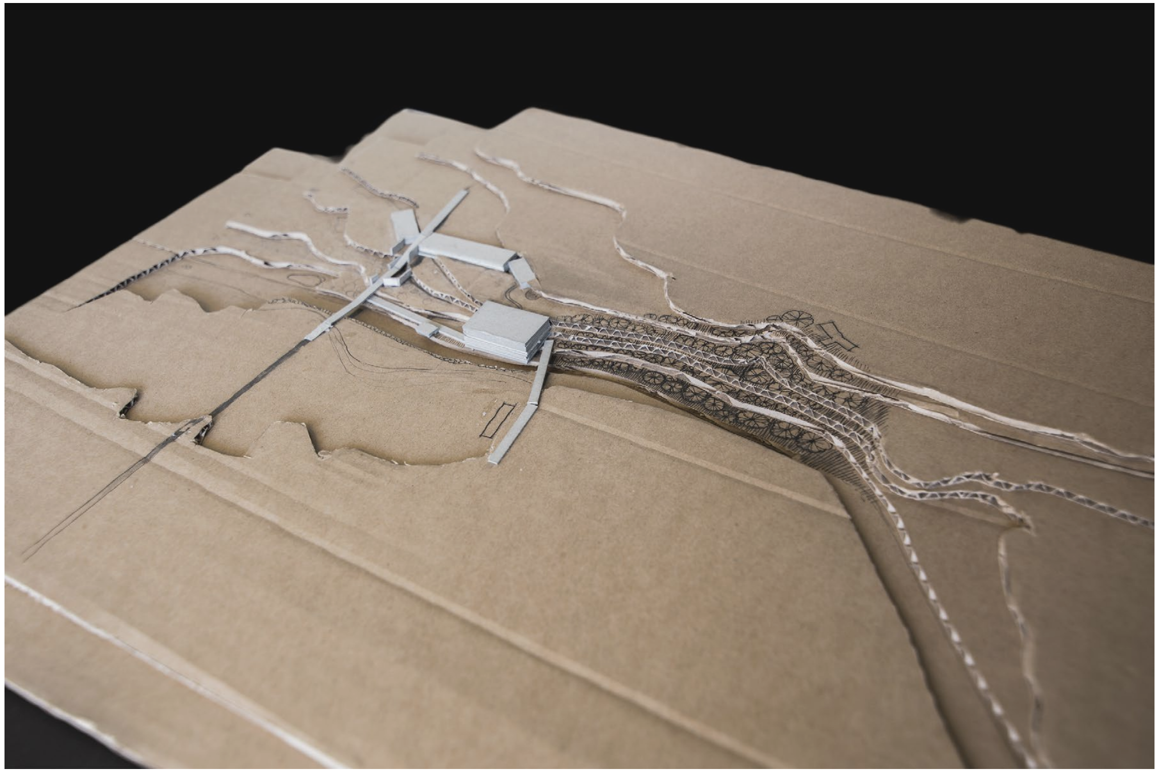


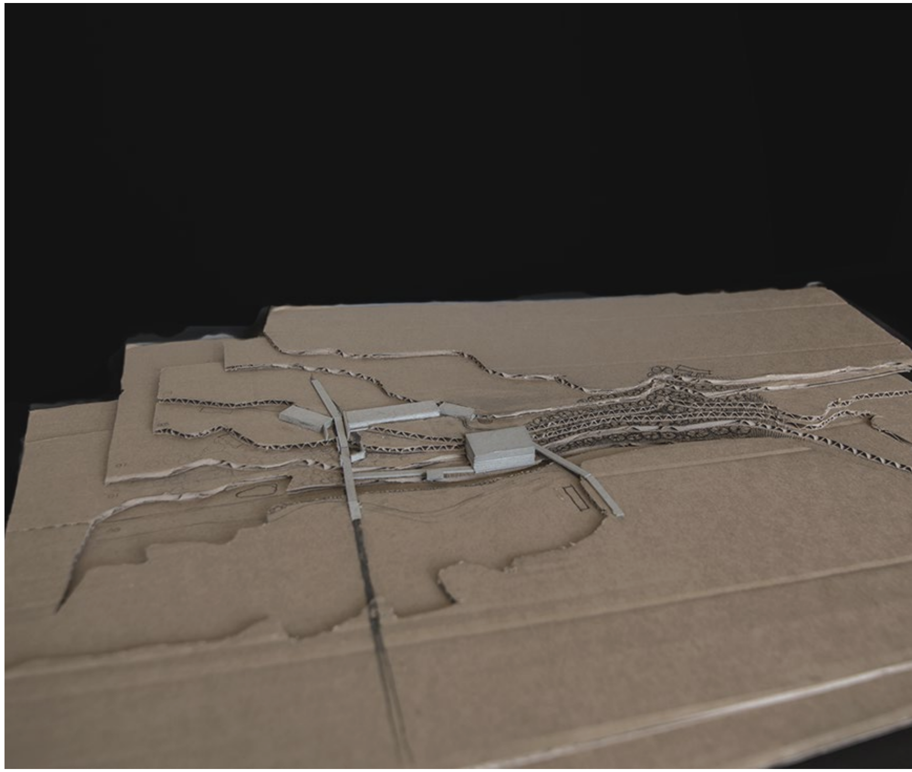
1 : 2000 SITE MODEL



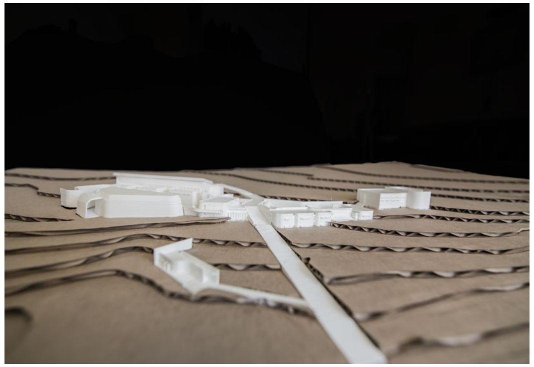


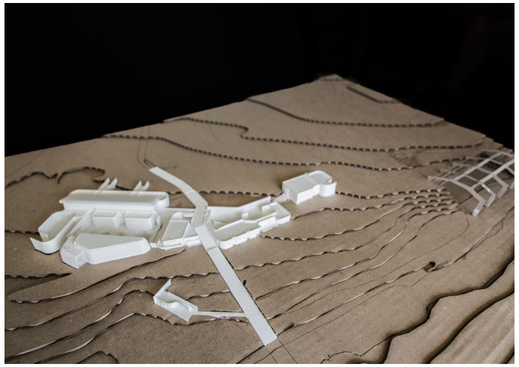
1:2000 **CONCEPT MODEL**

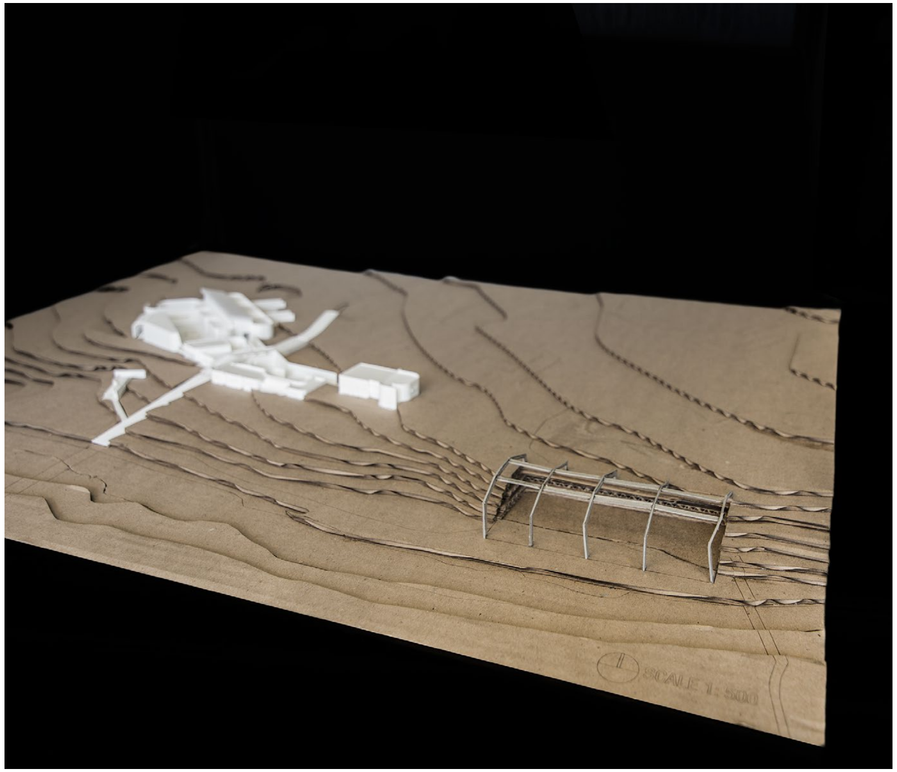


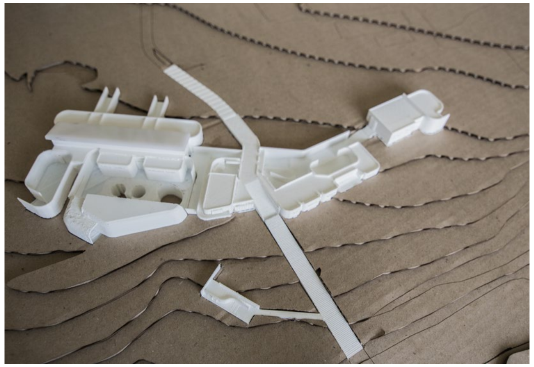


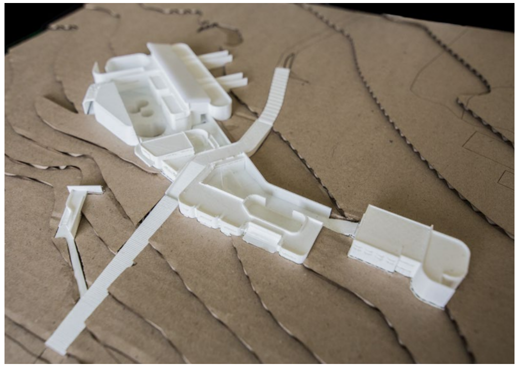
1:500 FINAL MODEL



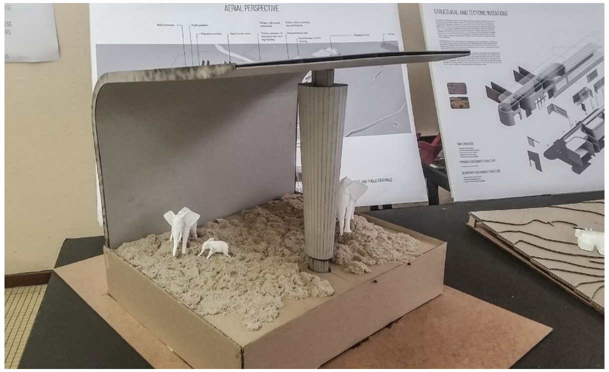








1:25 SECTION DETAIL MODEL



FINAL **EXAM PRESENTATION**


1. FREEDOM FROM
HUNGER OR THIRST
2. FREEDOM FROM
DISCOMFORT
3. FREEDOM FROM
PAIN, INJURY OR DISEASE
4. FREEDOM TO EXPRESS
NORMAL BEHAVIOURS
5. FREEDOM FROM
FEAR OR DISTRESS
AERIAL PERSPECTIVE

THE **FIVE FREEDOMS**

The core concept of the five freedoms states that animals under human control and in their care should have their primary welfare needs met (Wentzel, 2015), by referencing and safeguarding the following points:

1. FREEDOM FROM
   HUNGER OR THIRST

2. FREEDOM FROM
   DISCOMFORT

3. FREEDOM FROM
   PAIN, INJURY OR DISEASE

4. FREEDOM TO EXPRESS
   NORMAL BEHAVIOURS

5. FREEDOM FROM
   FEAR OR DISTRESS

Conclusion

The success of the design was therefore determined by ensuring that these 'five freedoms' relating to animal welfare were met and accounted for.

The intention of the project and facility is to not prolong elephants staying in the zoo, but to rather act as a threshold for rehabilitation and assist in the future release of rehabilitated elephants, all in attempt to aid in the survival of elephants.

This project is therefore of great benefit to elephants, but of equal importance and benefit to the public in terms of unique experience, understanding and education. The design will enhance a far greater dissemination of information regarding elephants and their intense struggle for survival.

The design, while necessitating the correct management and care of elephants to be fully rehabilitated, also incorporated natural conditions and elements such as sand, water and vegetation, to provide as natural environment as possible for the elephants. It must be stressed that this is not a petting zoo situation; the public will experience and view the elephants as unobtrusively as possible, so that the elephants will not be disturbed or agitated.

While it is of vital importance to allow the visitors to witness the elephants engaging in various natural behaviours and conditions, this significant opportunity for the public must never cause unnecessary trauma to the animals.

List of Figures

CHAPTER 1

fig. 1.1 http://manuelvandenberg.deviantart.com/art/Low-Poly-Elephant-485720133

fig. 1.2 Map of the Pretoria National Zoological Garden's extensions and Lion enclosures by W. Mollison. Department of Public works, n. d.

fig. 1.3 https://rdaily2.wordpress.com/2011/03/29/strictly-no-elephants/

fig. 1.4 http://www.poachingfacts.com/faces-of-the-poachers/buyers-of-elephant-ivory/

fig. 1.5 http://www.poachingfacts.com/faces-of-the-poachers/buyers-of-elephant-ivory/

fig. 1.6 http://www.poachingfacts.com/faces-of-the-poachers/buyers-of-elephant-ivory/

fig. 1.7 Illegal ivory trafficking routes

fig. 1.8 http://www.bioag.novozymes.com/en/products/unitedstates/PublishingImages/Peanuts.jpg

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Appendix A

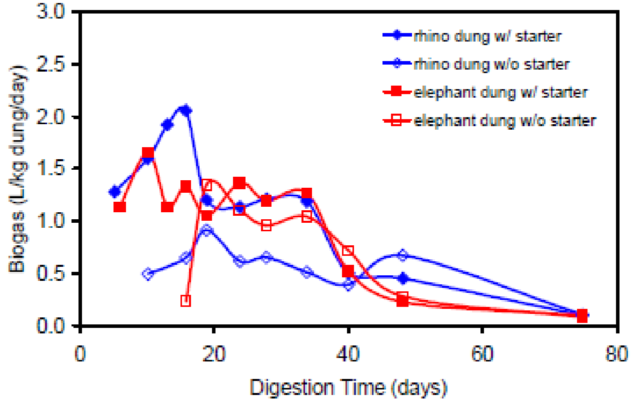


Fig. 7. Biogas production rate for digesters with or without starters.

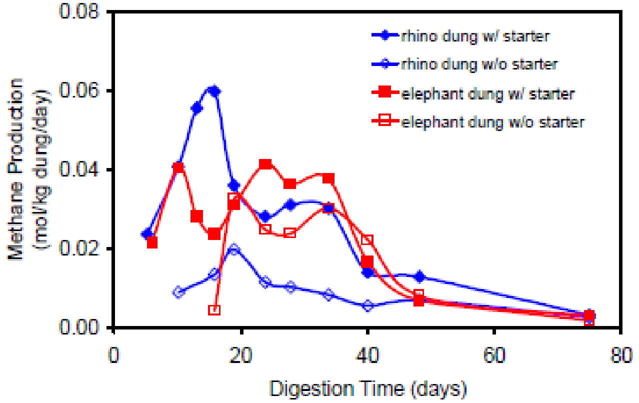


Fig. 8. Methane production rate for digesters with or without starters.

The biogas and methane yields are shown in Table 2. The benefit of using a starter is clearly seen in the yields. Both types of dung resulted in similar results a biogas yield on dung of 0.051–0.057 L/g. This compares favorably with the results obtained by Mandal and Mandal, who obtained 2.4–3.3 L gas from 150 g of "dense" animal dung, such as camel and horse dung.[3] The yield of methane on TVS of 0.2 L CH_4/g TVS follows well those reported by Gunaseelan for average grasses in his review article.[2] The final pH of the digesters at the end of the incubation period was 6.95–7.39. The control digester containing just starter did not produce significant biogas.

Table 2. Biogas and methane yields in digesters with and without starters

Digester	Dung (g)	TVS (g)	Biogas (L_{STP})*	CH_4 (L_{STP})	Yields (L biogas/g dung)	(L CH_4/g dung)	(L CH_4/g TVS)
Rhinoceros dung w/ starter	37.5	6.1	2.12	1.24	0.057	0.033	0.20
Rhinoceros dung w/o starter	37.5	6.1	1.16	0.44	0.031	0.012	0.072
Elephant dung w/ starter	37.5	5.7	1.90	1.13	0.051	0.030	0.20
Elephant dung w/o starter	37.5	5.7	1.21	0.68	0.032	0.018	0.12

*STP = standard temperature (0°C) and pressure (1 atm).

In order to potentially increase the biogas and methane yield on rhinoceros and elephant dung, nitrogen was supplemented to some of the digesters in the subsequent experiment. Elephant dung has been found to contain lower than optimal nitrogen content for methane generation.[6] Nitrogen was added in the form of ammonia to achieve a carbon-to-nitrogen ratio of 25 g/g, which is considered in the optimal range.[6] The effect of nitrogen addition and incubation at 37°C or 50°C may be seen in Fig. 9 and Fig. 10. As in the previous study, there was a high initial methane production rate, followed by a much slower rate. The digester with elephant dung was incubated at 50°C with supplemental nitrogen initially produced a small amount of biogas and the production halted for several weeks; then suddenly, gas was generated again.

The biogas and methane yields are shown in Table 3. The largest amount of gas was produced in the elephant dung digester supplemented with nitrogen and incubated at 37°C. It is interesting to note that the amount of gas produced in this digester was less than the amount of gas produced in the digester with elephant dung and cow starter, incubated at 37°C (see Table 2). The digestion of rhinoceros dung did not appear affected by supplemented nitrogen, and the rhinoceros dung digester in the second set of experiments produced less biogas than the digester with rhinoceros dung and cow starter, incubated at 37°C (see Table 2). This indicates that the use of a blend of cow manure and zoo dung would yield more biogas and methane. The final pH of the digesters at the end of the incubation period was pH 8.3.

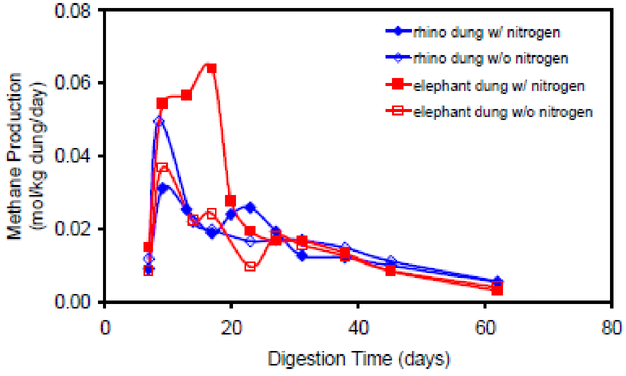


Fig. 9. Biogas production in second set of digesters incubated at 37°C.

Results from study on 'Energy production from zoo wastes' conducted at the Knoxville Zoo in the U.S (Klasson & Nghiem, 2003).

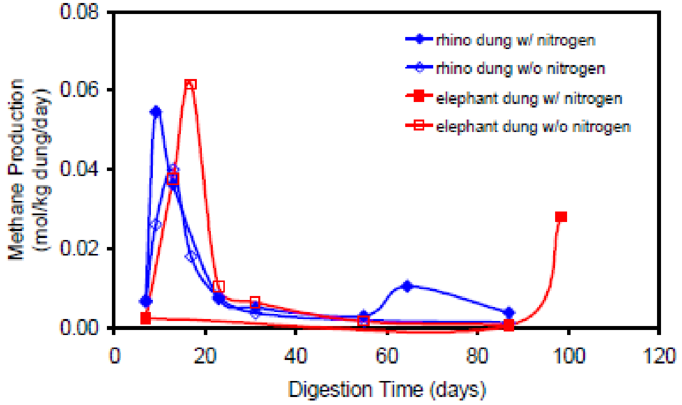


Fig. 10. Methane production in the second set of digesters incubated at 50°C.

The biogas methane content for the digesters incubated at 37 and 50°C is shown in Fig. 11 and Fig. 12. As noted, the methane concentration in digesters incubated at 37°C was fairly constant, around 60%. The methane concentration was higher at the elevated temperature (50°C) during the initial part of the incubation, but it dropped toward the end of the incubation period.

Table 3. Biogas and methane yields in digesters with and without nitrogen supplement at two different incubation temperatures

Digester	Dung (g)	TVS (g)	Biogas (L_{STP})*	CH_4 (L_{STP})	Yields (L biogas/g dung)	(L CH_4/g dung)	(L CH_4/g TVS)
Rhinoceros dung w/ nitrogen at 37°C	37.5	6.1	1.17	0.69	0.031	0.019	0.11
Rhinoceros dung at 37°C	37.5	6.1	1.23	0.72	0.033	0.019	0.12
Elephant dung w/ nitrogen at 37°C	37.5	5.7	1.59	0.99	0.042	0.026	0.17
Elephant dung at 37°C	37.5	5.7	0.98	0.61	0.026	0.016	0.11
Rhinoceros dung w/ nitrogen at 50°C	37.5	6.1	1.02	0.57	0.027	0.015	0.093
Rhinoceros dung at 50°C"	37.5	6.1	0.74	0.41	0.020	0.011	0.068
Elephant dung w/ nitrogen at 50°C	37.5	5.7	0.57	0.32	0.015	0.009	0.060
Elephant dung at 50°C	37.5	5.7	1.21	0.56	0.032	0.015	0.097

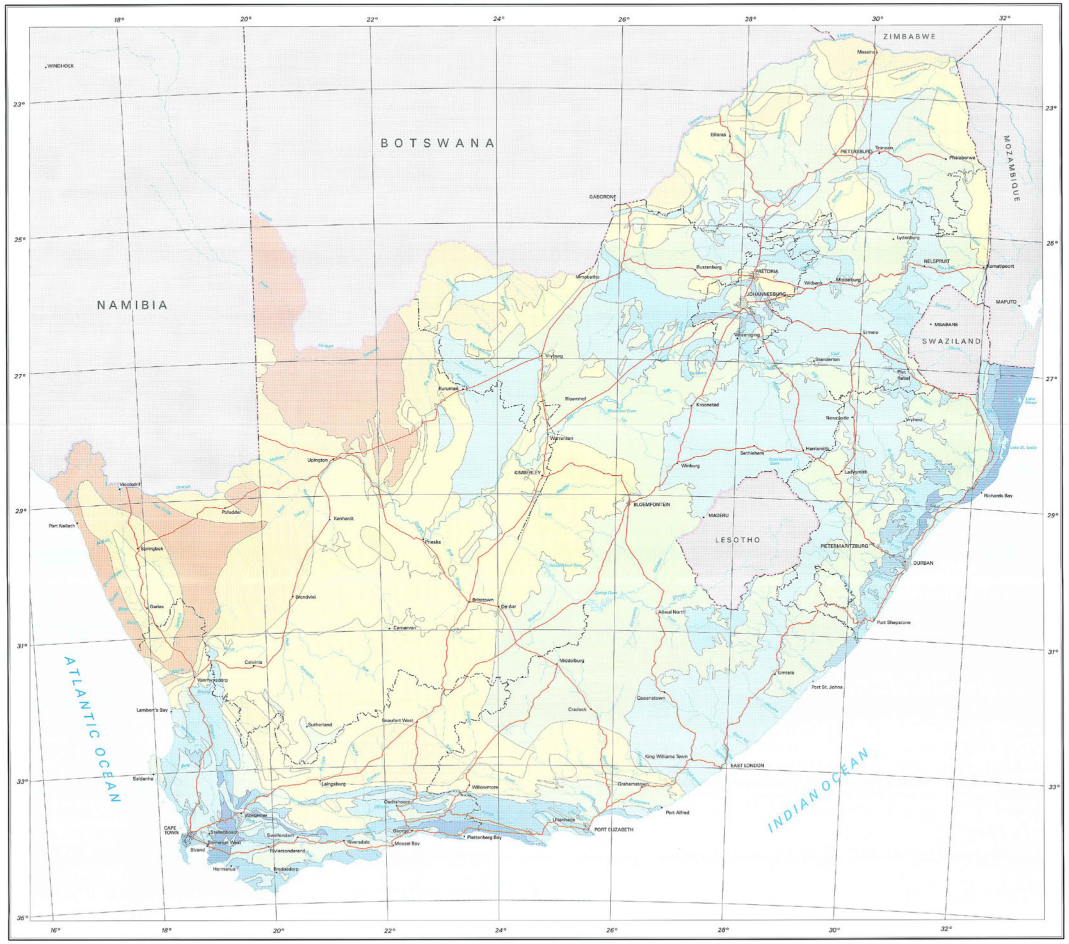
GROUNDWATER HARVEST POTENTIAL OF THE REPUBLIC OF SOUTH AFRICA

Map Authors - Alan Seymour and Paul Seward
Cartography and GIS Support - Elretha Louw

In a water-scarce country such as South Africa it is imperative that every drop of water be used judiciously. To aid the wise use of groundwater a National Groundwater Harvest Potential Map has been compiled. This map gives the first nationwide, quantitative depiction of sustainable rates of groundwater potentially available for abstraction.

The aim of this map is to provide a very general picture of Harvest Potential to guide national and regional planning of groundwater development, and to create an awareness of sustainable yield issues. The map is not suitable for local planning, development and management of groundwater.

This first attempt at a quantitative national picture relies heavily on a limited borehole data set, and computerized statistical procedures. Thus there are obviously local cases where better data, more advanced procedures, or local expertise, would provide a more accurate picture. Any additional groundwater-related data received by the Directorate: Geohydrology will improve the accuracy of further generations of this map.



< 2 500	2 500 - 4 000
4 000 - 6 000	6 000 - 10 000
10 000 - 15 000	15 000 - 25 000
25 000 - 50 000	50 000 - 100 000
> 100 000	

Maximum volumes of groundwater (m³/km²/annum) that may annually be abstracted per surface area of an aquifer system to preserve a sustained abstraction

100 0 100 200 300 400 km

1:3 000 000

Albers' Equal Area Projection
Standard parallels 24° and 33° south

HARVEST POTENTIAL

Harvest Potential is the maximum volume of groundwater that may be abstracted per square kilometre per annum without depleting the aquifers. In other words it is the maximum rate at which groundwater can be abstracted sustainably if socio-economic factors are not an issue. Socio-economic factors include, inter alia, the cost of bringing the water to the point of demand, the value of the water, and legal and environmental issues. Groundwater Harvest Potential is determined from two parameters: groundwater recharge and groundwater storage. Since Harvest Potential was determined using historical rainfall data it is closer to the surface water concept of historical reservoir yield, rather than assessed yield for defined levels of assurance, calculated from stochastic rainfall sequences.

HARVEST POTENTIAL VERSUS EXPLOITATION POTENTIAL

When socio-economic factors are incorporated into the Harvest Potential evaluation an Exploitation Potential map is produced. For example if cost was not an issue it would theoretically be possible to abstract all the Harvest Potential. However if, for certain users, the abstraction of groundwater was only economic below say R2/kl, and in certain areas it cost more than this, then the Exploitation Potential - for that user - would be zero, even though the Harvest Potential might be high.

In addition to the economic considerations of the groundwater user, Exploitation Potential must also take into account environmental issues. Groundwater must be viewed holistically in terms of its role in the hydrological cycle. For example, groundwater's contribution to springflow, river base flow, wetlands, riparian vegetation, stabilizing fresh/saline water interfaces (inland water bodies and along the coast) must be considered.

It is important to note that Harvest Potential cannot simply be added to surface water availability to obtain a number for total water resources. In many parts of the country, particularly in the eastern half, an increase in groundwater utilization will mean a reduction in surface water supplies because groundwater's contribution to river flow will be reduced.

The subtle interplay of groundwater conditions with socio-economic and environmental factors will be unique to a given area, and so local planning of groundwater schemes can only be based on a local evaluation of all the relevant factors and not read from a national map. However accurate a future second or third generation Harvest Potential map might be, it can never replace the need for local assessments of Exploitation Potential.

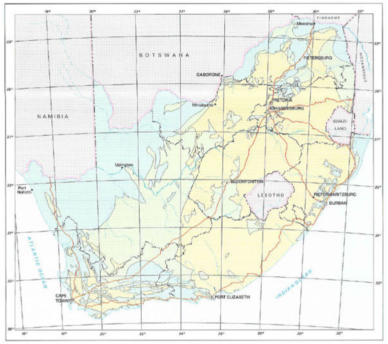
METHODOLOGY

The country was divided into regions. For each region the mean annual recharge and the groundwater storage limitation to sustainable abstraction were determined. Recharge was determined principally from the results of base-flow studies in the eastern half of the country, and from extrapolation of the findings of local recharge studies in the western part of the country.

Groundwater storage was determined by multiplying an aquifer storage coefficient by the aquifer dimensions. The aquifer storage coefficient was assigned to each region from an understanding of the geology, and from an understanding of typical storage coefficients associated with that geology. Aquifer dimensions were determined from borehole logs and extrapolated according to geology.

Groundwater storage was then divided by the mean annual recharge to give a "storage time" (ST), which thus equals the time it will take to deplete the aquifer if pumped at a rate equal to the mean annual recharge. An indication of recharge variability (MR), and hence drought length, was introduced by multiplying mean annual recharge by a precipitation variability factor i.e. (20th percentile precipitation) / (50th percentile precipitation). The safe abstraction as limited by storage was then taken as: ST*MR. The lesser of safe abstraction or mean annual recharge was taken as the Harvest Potential for a given region. Results from each region were then "blended" to produce the Harvest Potential Map.

A fuller explanation of this methodology, and it's merits and shortcomings, will be discussed in a report on Harvest Potential.



FACTORS RESTRICTING HARVEST POTENTIAL

- volume of average annual recharge
- variability of annual recharge
- volume of effective storage

FACTORS RESTRICTING HARVEST POTENTIAL

1. Volume of average annual recharge. In this case the size of the aquifer considerably exceeds the annual recharge volume so that abstracting or harvesting at the average annual recharge does not present a problem. There are some aquifers where the storage so excessively exceeds the recharge that even if the aquifer was harvested at twice the annual recharge it would take several decades to completely deplete the aquifer. The Harvest Potential of Coastal primary aquifers is typically determined by mean annual recharge.

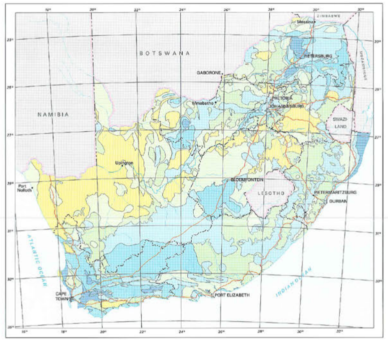
2. Variability of annual recharge. When variability of annual recharge is the limiting factor many years will have negligible recharge, and the number of years between major recharge episodes will vary considerably. If an area with very variable annual recharge is coupled with limited aquifer storage then the Harvest Potential is limited by the storage capacity to bridge droughts. Karoo aquifers in the arid western half of the country typically follow this pattern.

3. Volume of effective storage. Recharge occurs regularly most years but cannot all be absorbed into the aquifer because of low storage. The limiting factor is how much groundwater can be stored during the wet season to bridge abstraction during the drier season. Most of the aquifers in the eastern half of the country with its high and more regular rainfall fall into the Harvest Potential case where volume of effective storage is a limiting factor.

100 0 300 km

1: 8 500 000

Albers' Equal Area Projection
Standard parallels 24° and 33° south



AVERAGE BOREHOLE YIELD

Geometric mean of blown yield (l/sec)

- < 0.4
- 0.4 - 0.6
- 0.6 - 0.8
- 0.8 - 1.5
- 1.5 - 3.0
- > 3.0

AVERAGE BOREHOLE YIELD

This map depicts the average yield of water boreholes according to an analysis of data downloaded from the National Groundwater Data Base in 1993. Optimally sited boreholes may yield in excess of the average value. The average refers to the average immediate (e.g. "blown-test") borehole yield for an area, rather than an average over time. The long-term yield is controlled by the Harvest Potential. The short-term production borehole yield is controlled by the transmissivity of the aquifer.

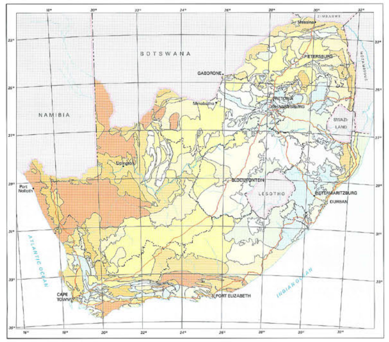
Average production borehole yields influence costs and therefore Exploitation Potential. Low yields means more production boreholes are needed and therefore costs are higher, and exploitation potential is lower.

However, so many other factors also influence Exploitation Potential besides average production borehole yields. For example in some areas every borehole drilled might be able to be used as a production borehole. In other areas the majority of the boreholes drilled might be dry and/or unsuitable for production boreholes.

100 0 300 km

1: 8 500 000

Albers' Equal Area Projection
Standard parallels 24° and 33° south



GROUNDWATER QUALITY

Geometric mean concentration of TDS (mg/l)

- < 200
- 200-300
- 300-400
- 400-500
- 500-750
- 750-1 000
- 1 000-1 500
- 1 500-2 000
- > 2 000

GROUNDWATER QUALITY

Groundwater quality, like borehole yields, does not determine the Harvest Potential but it does affect the Exploitation Potential. Harvest Potential simply says so much groundwater is potentially available for harvesting irrespective of quality. However, if this water is unfit for its intended use, and/or it is uneconomic to desalinate, then its Exploitation Potential becomes zero.

100 0 300 km

1: 8 500 000

Albers' Equal Area Projection
Standard parallels 24° and 33° south

- Perennial River
- Non-perennial River
- National Road
- International Boundary
- Provincial Boundary
- Dam
- City
- Town

Map and digital data are obtainable from:
Department of Water Affairs and Forestry
Private Bag X16
Sanlamhof
7532

National GIS maps used to compile the National Groundwater Harvest Potential Map include the following:

a) Saturated Interstices (Groundwater Resources of South Africa 1995. Vegter and Seymour).
Groundwater storage volume is estimated from
i) Storage coefficients of specific rock type and
ii) Estimated aquifer thickness calculated from vertical strike frequency analyses.

b) Mean Annual Groundwater Recharge (Groundwater Resources of South Africa 1995. Vegter).

c) Groundwater Quality (Groundwater Resources of South Africa 1995. Vegter, Simonic and Seymour).
Geometric mean concentration of total dissolved solids.

d) Annual Percentile Precipitation (CCWR). Groundwater recharge variability directly correlated from precipitation variability.

e) Borehole Yield (Point Data of borehole yield 1993. NGDB). Ninety two percent of the borehole yield data were determined from blown yield results and eight percent of the borehole yield data were determined from pumping tests.

f) Road, river and town data were obtained from the Chief Director: Surveys and Land Information, Department of Land Affairs.

This map was produced on Arc/Info GIS.

Provincial Boundaries
July 1995

Authors assisted by:
The Mapping Management Team: P. Seward, P.S. Meyer, J.R. Baron, F. Jonck and A. Conley and the Editorial Board: E. Braune, W.R.G. Orpen, Z.M. Dziembowski and F. Coetzee.

This map has been approved by the Director-General of the Department of Water Affairs and Forestry.

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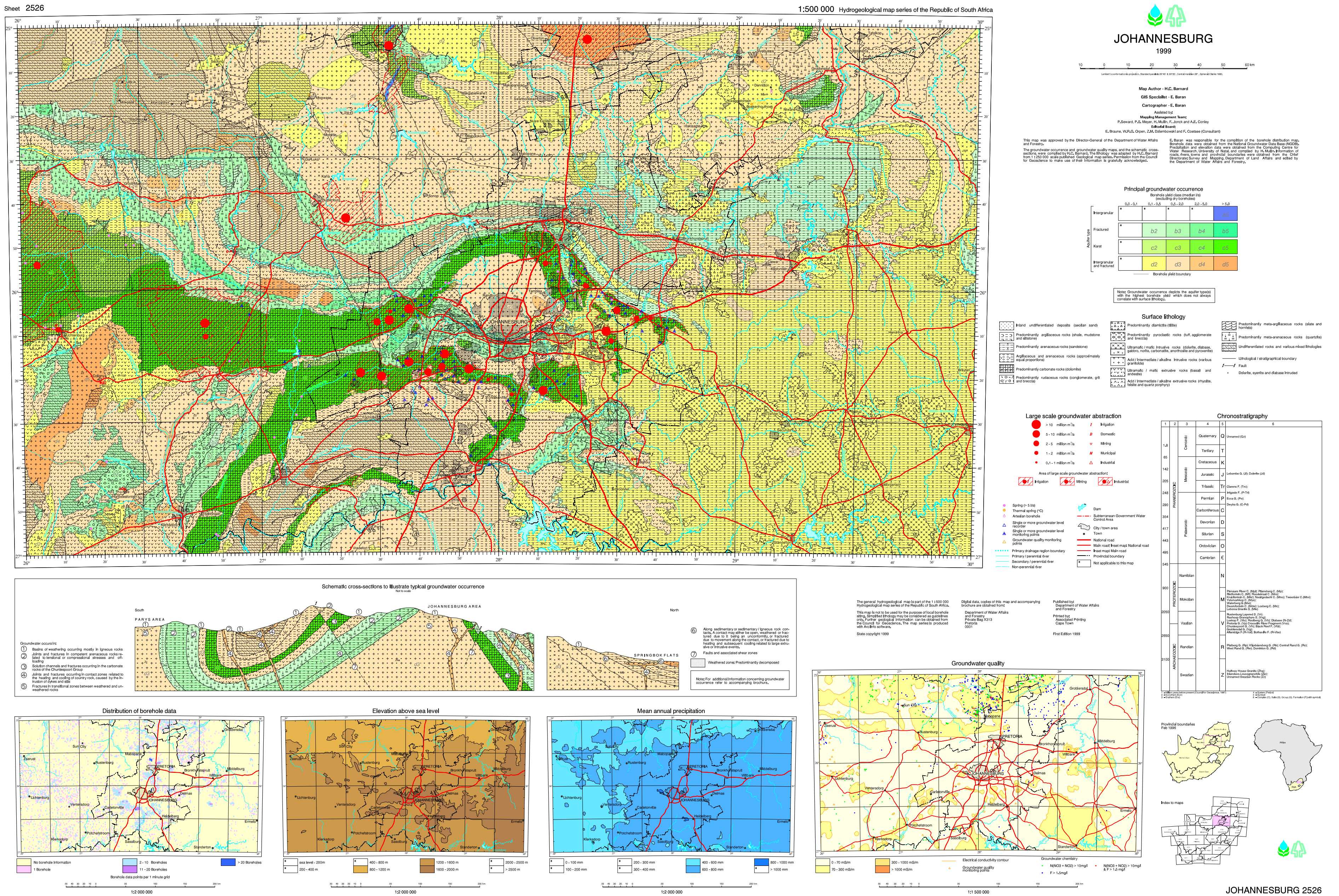

Maps from the Department of Water and Sanitation, showing the groundwater harvest potential of South Africa, specifically Pretoria.

The welfare stastus of elephants in captivity in South Africa

Once free to roam most of the African continent, elephant populations and their habitats have been drastically reduced. In South Africa, both the Kruger National Park and the Addo Elephant Park are devoted to protecting large elephant herds from poachers. Due to severe conservation measures taken, the elephant population in South Africa is estimated to have grown to 10 000 elephants in 40 locations today, a tremendous growth improvement from the 120 elephants that existed in 1920 (Kruger Park, 2016).

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DETAILS OF INDIVIDUAL CAPTIVE / MANAGED ELEPHANTS - JULY 2015 (Wentzel, 2015).

Facility	Elephant	DOB	Age	Gender	Origin	Captive born	Wild born	Unknown	Comments	Inspected by NSPCA
GAUTENG										
Pretoria Zoo/NZG	Charley	1982	32	M	Zimbabwe to Boswell Circus to NZG 2001		X			Jan 2015
	Thandi	1981	33	F	Zim to Boswell Circus (1984) to NZG (2001)		X		Killed handler at Glen Afric reserve during filming for Boswell (2001)	
	Londa	1982	32	F	Kruger to Boswell to NZG 1996		X			
Johannesburg Zoo	Kinkel	1983	31	M	Kruger 2000		X		Injury on trunk,	March 2015
	Lammie	1979	35	F	Captive born at zoo	X			Has injured zoo staff member	
Plumari/Askari Lodge	Damara	1997	17	M	Elephants for Africa Forever (EFAF)		X			Jun 2015
	Nzeve	1996	18	M	EFAF		X			
KZN										
Natal Zoo/Brian Boswell Circus	Lola (African)			F				X	African elephant	
	Daisy (African)			F				X	African elephant	
	Emma (African)			F				X	African elephant	
	Thembi (African)	1982	32	F	Hwange Nat Park 1985		X		African elephant/Used in circus	
	Wanki (African)	1982	32	F	Hwange Nat Park 1985		X		African elephant/Used in circus	
	Minoti (Asian)	1970	44	F	Chipperfield Circus to Brian Boswell		X		Asian elephant born in India	

REPORTED DEATHS OF CAPTIVE / MANAGED ELEPHANTS (Wentzel, 2015).

Elephant	Age	Gender	Captive born	Wild caught	Facility	Year & Cause of death
Sarah	?	F		X	Johannesburg Zoo	1914 - Unknown
Mary	?	F		X	Pretoria Zoo	1942 – old age
Dorothy	?	F		X	Tygerberg Zoo/Brian Boswell Circus	1984 - Unknown
Sophie	3	F		X	Hwange Nat Park/Brian Boswell Circus	1985 - Unknown
Unknown	0	M	X		Johannesburg Zoo	1986 - Stillborn
Manju (Asian)	19	F		X	Chipperfield Circus/Brian Boswell Circus	1989 - Unknown
Safari	?	M		X	Knysna Elephant Park	1996 - Poison from fungal spores in food
Jumbo	29	M		X	Johannesburg Zoo	1999 - Unknown
Mohini (Asian)	29	F		X	Chipperfield Circus/Brian Boswell Circus	1999 - Unknown
Dolly	37	F		X	Johannesburg Zoo	2000 - Unknown
Satara	?	M		X	Knysna Elephant Park	2001 – Nutritional Myopathy
Mopani	11	F		x	Kwantu	2006 - Pneumonia
Kwantu	4	M		x	Kwantu	2007 - Gored by stable mate
Bobby	38	M		X	Brian Boswell Circus	2008 – Euthanased – Tetanus from wound on foot
Bibi	2 months	F	X		Knysna Elephant Park	2009 - Pneumonia
Joe	24	M		X	Camp Jabulani, Kapama	2011- Euthanased after killing handler
Dineo	1 month	F	X		Pretoria Zoo	2011 - Pneumonia
Pumbi	27	F		X	Pretoria Zoo	2012 - TB
Bandula	30	M		X	Brian Boswell Circus	2012 – Euthanased – Spleen cancer
Mopani	19	F		X	The Crags Elephant Sanctuary	2012 - Died after bad fall
None	0		X		Knysna Elephant Park	Stillborn
Kiribun	26	F		X	Garden Route Game Lodge	2013 – Died day after birth of calf
Lunar	2 months	M	X		Garden Route Game Lodge	2013 – Orphaned Calf – hand raised
Fiela	3 months	F	X		Knysna Elephant Park	2013 - Unknown

CAPTIVE / MANAGED ELEPHANTS IN SOUTH AFRICA – JULY 2015 (Wentzel, 2015).

No	Facility	Province	No of elephant	Sex ratio M:F
	Captive elephants			
1	Pretoria Zoo /NZG	Gauteng	3	1.2
2	Johannesburg Zoo	Gauteng	2	1.1
	Captive/Managed elephants			
3	Natal Zoo/Brian Boswell (Pietermaritzburg) - African Elephants	Kwa Zulu Natal	5	1.4
4	Natal Zoo/Brian Boswell (Pietermaritzburg) - Asian Elephants	Kwa Zulu Natal	4	0.4
	Managed elephants			
5	Plumari /Askari game lodge (Magaliesberg)	Gauteng	2	2.0
6	Bayete Zulu Game Lodge (Mkuze)	Kwa Zulu Natal	3	1.2
7	Elephant Whispers (Hazyview)	Mpumalanga	6	4.2
8	Kwa Madwala Private Game Reserve (Hectorspruit)	Mpumalanga	2	1.1
9	Elephant Sanctuary, (Hazyview)	Mpumalanga	2	2.0
10	Kapama Game Reserve (Hoedspruit)	Limpopo	14	6.8
11	Shambala Private Reserve/ Waterberg Safaris (Vaalwater)	Limpopo	10	4.6
12	Adventures with elephants – Zebula (Bela Bela)	Limpopo	5	2.3
13	Pilanesberg Elephant Back Safaris (Sun City)	North West Province	7	4.3
14	Elephant Sanctuary, (Hartbeespoort)	North West Province	4	2.2
15	Glen Afric Country Lodge – (Broederstroom)	North West Province	3	0.3
16	Knysna Elephant Park – (Knysna)	Western Cape	18	8.10
17	Indalu Elephant safaris (Mossel bay)	Western Cape	6	3.3
18	The Elephant Sanctuary (The Crags, Plettenberg Bay)	Western Cape	5	1.4
19	Botlierskop Private Game Reserve, (Mossel Bay/Klein Brak)	Western Cape	4	2.2
20	Buffelsdrift Game Lodge, (Oudtshoorn)	Western Cape	3	2.1
21	Garden Route Game Lodge (Albertinia)	Western Cape	2	2.0
22	Fairy Glen Game Reserve (Worcester)	Western Cape	2	2.0
23	Aquila Safari (Touws River)	Western Cape	2	2.0
27	Inverdoorn Game Reserve (Touwsriver)	Western Cape	2	2.0
24	Kwantu Game Reserve (Paterson)	Eastern Cape	4	0.4
25	Addo Elephant Back Safaris (Addo/Paterson)	Eastern Cape	3	3.0
26	Inkwenkwezi Private Game Reserve (East Coast, East London)	Eastern Cape	3	2.1
		Total	**126**	**60.66**