

# GARDEN OF CAPTIVES

## Creating a place for Sanctuary

*An architectural investigation that aims to facilitate healing and rehabilitation of both man and animal, as well as the surrounding ecology in the natural setting of a zoological garden, in order to restore the proper relationship between man and beast.*



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MProf (Arch) 2016  
University of Pretoria*

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## *Project Summary*

***Programme:*** *An Urban Rescue and Rehabilitation Sanctuary for Elephants*

***Location:*** *National Zoological Gardens of South Africa.*

*232 Boom Street, Pretoria, South Africa.*

***GPS Coordinators:*** *S 25 °44.39' E 28 °11.329'.*

***Research Field:*** *Environmental Potential.*

***By Chrysanthe Nicolaides***

*Submitted in fulfilment of part of the requirements for the  
Degree Masters in Architecture (Professional).*

*Department of Architecture, Faculty of Engineering, the Built Environment  
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*Pretoria, South Africa.*

*Study leader: Nico Botes  
Course coordinator: Arthur Barker*

*Editor: Irene Downer*

## *Dedication*

*To my father. A man beyond his years, taken before his time. This is for you.*

*You taught me to always strive for excellence, and that hard work always pays off.  
May your memory forever live on.*

*2 August 1953 – 9 October 2009*

## *Acknowledgements*

*To my fiancé and best friend, Mike, who helped make all this possible. Thank you for your unwavering and constant support, and patience, throughout this year. For your love, advice and encouragement; for those late night motivational talks.*

*Thank you for helping me reach my dream.*

*Nico Botes, I am thankful for your meticulous guidance throughout the year and for being a tremendous source of inspiration. Thank you for believing in me. Thank you for your insightful comments and advice that contributed immensely to the clarity of the final project.*

*Thank you to both my family and future family, for your love and support.*

*My friends, for the motivation, laughs and tears. We did it.*

## ***Declaration***

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

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

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

.....  
*Chrysanthe Nicolaides*

## *Prologue*

*Eleven elephants. One plane. Hurling together across the sky. The scene sounds like a dream conjured by Dali. And yet there it was, playing out high above the Atlantic. Inside the belly of a Boeing 747, eleven young elephants were several hours into a marathon flight from South Africa to the United States. Nothing could have prepared them for what they were experiencing. These were not circus animals, accustomed to captivity. All of these animals were wild, extracted at great expense and through staggering logistics from their herds inside game reserves in Swaziland. All were headed for zoos in San Diego and Tampa.*

*He [their trainer and owner of the game reserve] has heard the protests from the animal-rights groups, insisting that for elephants any fate would*

*be preferable to a zoo, that it would be better for them to die free than live as captives. As far as he could tell, nature cared about survival, not ideology. And on this plane, the elephants had been given a chance.*

*Wild elephants are accustomed to ranging through the bush for miles a day. They are intelligent, self-aware, emotional animals. They bond. They rage and grieve. True to their reputation, they remember.*

*– French (2010:1-3).*

## *Abstract*

*Previously, people elsewhere in the world laboured under the misconception that animals in Africa wandered freely across the vast open spaces of the African plains. However, in reality, as humans (elephants' greatest contenders of space) have encroached upon large areas of their natural habitats, countless animals are now forced to live within the confines of the controlled spaces of zoos and nature reserves. Despite many of these reserves being quite large, the movement and freedom of these animals are still restricted by 'human boundaries, human considerations and human priorities'. The concept of the circle of life, as described in the Lion King and explained by French (2010:5), and the endless African landscape and bushveld enjoyed by many species in the wild, is in truth continuously shrinking.*

*Humans have always embraced a strong sense of biophilia which drives them to seek diverse life forms when their own immediate spaces become too anthropocentrically homogenous and monotonous. Wild animals fascinate people; they reveal unknown worlds occupied by these diverse beings. They pose timeless questions of identity, confronting or strengthening life's beliefs (Acampora, 2010).*

*The initial formation of zoos represented the age-old belief that humans were granted power over other creatures on earth. Zoos represent living catalogues of our own fears, fixations and presumptions of supremacy. They reflect the manner in which we perceive animals as well as ourselves; our longing for both pleasure and diversion for our own desires, no matter the cost to or implications on the animals themselves. They show our longing for the wildness we have*

*lost within ourselves; our instinct to both respect nature and control it; our deepest wish to care for and protect species even as we destroy and pollute their habitats, forcing them into oblivion. All of this is on display in the garden of captives (French 2010:24).*

*The few elephants in the National Zoological Gardens in Pretoria were once wild animals from Zimbabwe and the Kruger National Park. These are now forced to live in a confined space with no interaction with other wildlife, and the vast landscape of this once great circle of life.*

*It is therefore of imperative importance that an environment be created as close as possible to their natural habitat. This would be of benefit to both elephants and humans, where safety and security from poaching and human conflict would be provided to preserve these remarkable creatures.*



## Ekserp

*In die verlede het mense in ander gedeeltes van die wêreld vooropgestelde idees gehad dat diere in Afrika vry was om rond te wandel in die wye ope spasies van die horison en verder. Die realiteit is egter dat mense, olifante se grootste mededingers vir spasie, so 'n groot deel van die kontinent ingeneem het en bewoon dat 'n onbepaalde aantal diere gedwing word om te woon in die beperkte, beheerde spasies van natuurreservate en dieretuine. Alhoewel 'n aantal van hierdie natuurreservate dikwels groot spasies beslaan, word die diere se beweging en vryheid steeds beperk deur 'menslike grense, menslike oorweginge, en menslike prioriteite'. Die konsep van die sirkel van die lewe, soos wat dit in die rolprent "The Lion King" beskryf word, en deur French (2010: 5) verduidelik word, en die eindelose bosveld wat deur alle spesies in die wildernis, is inderwaarheid voortdurend besig om te krimp.*

*Die mensdom se historiese omhelsing van biofilie dien as motivering om diverse lewensvorme uit te soek wanneer mense se eie onmiddellike spasies te antroposentrië homogeen, staties en eentonig begin raak. Wilde diere fassineer mense; hulle openbaar ongekende wêreld wat deur hierdie divêrse wesens bewoon word. Hulle stel tydlose identiteitsvrae wat lewensooruiginge kan bevestig of uitdaag (Acampora, 2010).*

*Die aanvanklike vorming van dieretuine verteenwoordig die eeue-oue oortuiging dat mense mag oor ander wesens op aarde gegun is. Dieretuine verteenwoordige lewendige katalogusse van ons vrese, fiksasies en aannames van meerderwaardigheid. Hulle reflekteer die wyse waarop ons diere, sowels as onself, sien; ons verlange na beide plesier en afleiding vir ons eie begeertes, maak nie saak wat die koste of implikasies vir die diere self is nie. Hulle wys hulle ver-*

*lange na die wildernis wat ons binne onself verloor het; ons instink om die natuur beide te respekteer en beheer; ons diepste wens om spesies lief te hê en beheer terwyl ons terselfdertyd hulle habitat vernietig en besoedel en die inwoners daarvan in die vergetelheid in dwing. Dit is wat ten toon gestel word in die tuin van gevangenes (French 2010: 24).*

*Die paar olifante wat tans woon in die Nasionale Dieretuin in Pretoria, eens wilde diere oorspronklik afkomstig van Zimbabwe en die Kruger Nasionale Park, word nou gedwing om te woon in 'n klein beperkte spasie by die dieretuin, met geen interaksie met die ander wild en die wye landskap van hierdie eens grootse sirkel van die lewe nie.*





# CHAPTER 1

## Introduction

*This chapter provides insight into the conceptual and theoretical direction of the dissertation and the primary intentions to be investigated.*

## General issue

### *Elephant Poaching in Africa*

African elephants are divided into two distinct species, the African bush elephant and the smaller African forest elephant. The African bush elephant, the world's largest living land animal species, has modified incisors (tusks) which are used for a variety of essential purposes and tasks in their daily lives. Unfortunately, these tusks are a significant source of ivory to be used in ivory ornaments and jewellery (Poaching Facts, 2016).

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), which listed African elephants under Appendix I, restricted the international trade of elephant parts in 1989. However, the high demand for ivory has continued to stimulate illegal trafficking and poaching of elephants (Poaching Facts, 2016).

CITES reports showed that during the period of 2003 – 2014, estimated levels of illegal killings in Africa occurred at unsustainable levels relative to their natural population growth. This clearly indicates that their death rate exceeds their reproduction rate.

#### *South Africa*

The previous practice of culling elephants for various reasons was ended in 1994. It has been estimated that a population of nearly 8000 elephants existed at the time, with 7325 elephants culled between 1980 and 1994. During this same period, 1259 elephants were translocated out of the Kruger National Park to protected areas, zoos and other regions within the country or neighbouring countries such as Namibia.

#### *Elephant Ivory*

Ivory tusks and worked, ornamental ivory trophies reflected an indication of wealth for hundreds of years, possibly dating back 4000 years to the ivory carving industry in India. Nowadays male and female African elephants' tusks are still being illegally trafficked as trophies to consumers worldwide. As previously mentioned, African elephants were listed by CITES under Appendix I in 1989, to provide the utmost level of protection for elephants and to prohibit international commercial trade in any parts or live specimen. During the decade prior to this listing, the African elephant population is estimated to have declined from approximately 1, 3 million to near 600 000 elephants; more than a 50% total decline (Poaching Facts, 2016).



Figure 1.4  
An ivory flask for  
black powder.



Figure 1.5  
Ivory stockpile in  
Tanzania, 1988.

Figure 1.6  
Newspaper clipping  
of the biggest trophy  
haul found by police  
in 1978 in Nairobi,  
including elephant  
tusks, rhino horns,  
lion claws & skins.

ABC MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS No. 5491, Saturday, June 10, 1978 Kenya 1/20 Tanzania 1/40

Box 48997 Nairobi Tel 20961/337097

# POLICE SEIZE BIGGEST EVER TROPHY HAUL

By NATION Reporter

POLICE have seized game trophies worth Sh. 2 million in three raids on houses and a shop in Nairobi.

Some of the trophies were due to be exported last night.

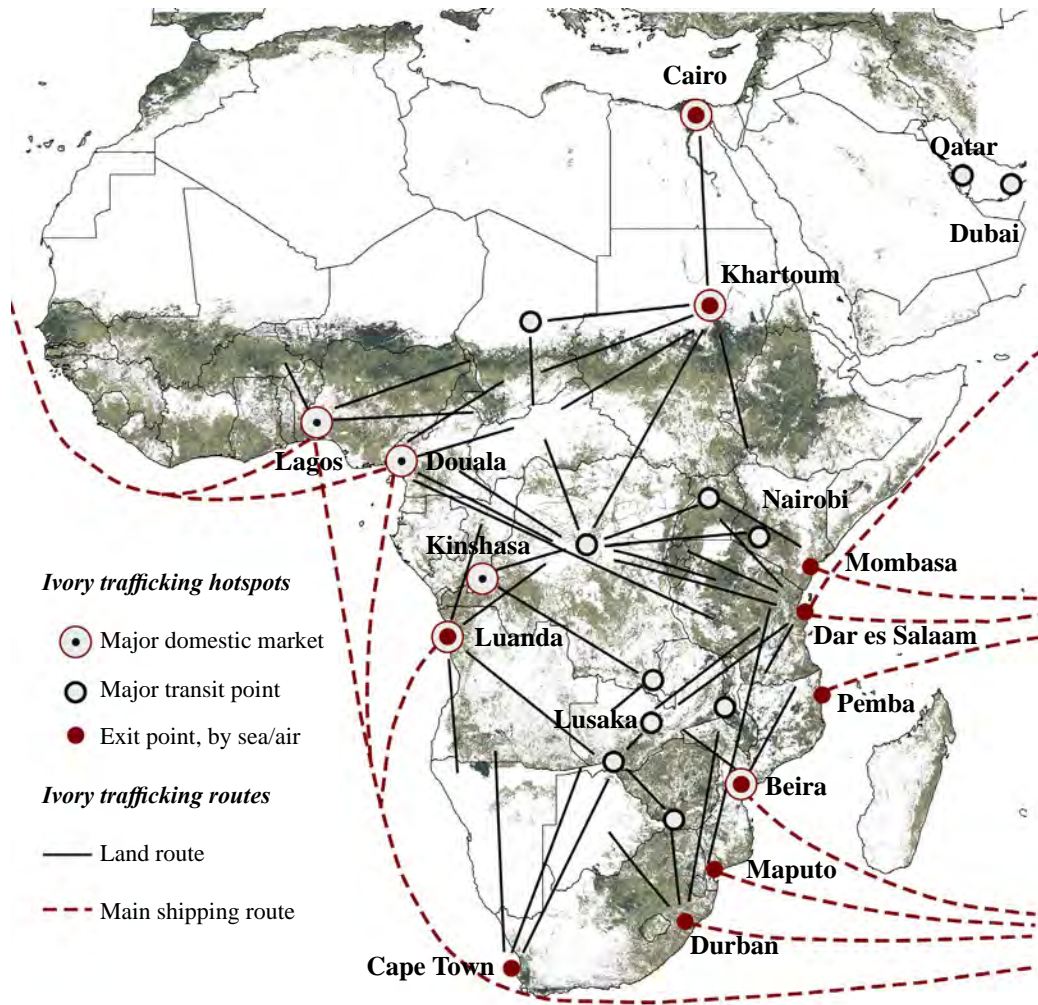
Items seized included tusks, rhino horns, lion skins and claws, leopard skins, zebra skins, ostrich eggs and skins, python skins, ivory carvings, watch straps and impala skins and pieces of various animal bones and skins.

They were seized at Pangani, Highridge and in a shop in city centre, and taken to the Ministry of Tourism and Wildlife Conservation Department at the National Museum under heavy guard.

According to a senior police officer, the trophies were seized after police received information. "We went straight to a house in Pangani at dawn. The house had been turned into a factory by the owner," the police

THE ivory and some of the ostrich eggs found in the police raids. More pictures on Back Page.

# Illegal ivory trafficking



## Ivory in disguise



*Mombasa  
8 July 2013*

*Three tons of ivory were seized in Mombasa, Kenya. The haul had been disguised as peanuts in attempts to avoid detection. One week prior, 1,5 tons were discovered disguised as dried fish.*

*Hong Kong  
18 July 2013*

*Authorities in Hong Kong seized 1,148 trafficked ivory tusks which were hidden in containers and declared as timber from the Togo. Hong Kong is known as one of the major transit points for illegal ivory.*

*Zanzibar  
13 Nov 2013*

*Officials at Zanzibar's main port, just off the coast of Tanzania, seized 1000 ivory items destined for the Philippines. The ivory had been hidden in sacks containing shells and other articles.*

Figure 1.7 Illegal ivory trafficking routes (Author, 2016).

*“This much is certain: the richest wildlife communities in Africa are found neither in pure woodlands nor in pure savannas, but in areas where the two general types of habitat meet and become interspersed with each other. Elephants are one of the most important agents influencing the dynamics of that mixture, and their activities generally increase the overall biological diversity of a region. Conserving elephants, then, becomes much more than an issue about how to protect a single great species. It is about protecting one of the forces that shapes ecosystems and helps sustain the wealth of wildlife found across much of the continent. It is about saving the creative power of nature.”*

*- Douglas Chadwick.*

## Urban issue

### *The Urban Animal*

Clear and defined rational consideration is required regarding the protection and welfare of animals in an urban environment. Urban context issues are usually focused on the idea of a city as only a human habitat, not an animal habitat. Therefore, the numerous aspects of urban development within a city have overshadowed our perception of 'non-humans'. Ethical considerations, as well as ecological, political and economic ones, have been left for the attention of conservation experts and those involved with the protection of endangered fauna and flora. Such a divide between the responsibility of these considerations causes the lives and living spaces of these urban animals to be ignored. The everyday animal in the city should matter (Acampora 2010:223).

### *The Human-Animal Divide*

The Human-Animal divide, as put by Acampora (2010:223), results in both humans and animals social-

ly constructing their own worlds and deeply impacting on each other's worlds. While these animal constructs may differ greatly from ours, they are in fact no less real and should not be ignored. Animals have their own realities, their own views and fears, and are therefore *subjects* and not objects. Most forms of progressive environmentalism have objectified animals to avoid the question of animal subjectivity.

Reclaiming this subjectivity implies an ethical and political commitment to reconsider the problematic urban strategies and praxis from the viewpoints of animals. Allowing animals subjectivity from a theoretical stance is a first step. A far more difficult step would include the revalorisation of animal subjectivity to become meaningful in terms of daily practice (Acampora 2010:224).



### *Re-enchanting the City*

The elephant sanctuary will embody healing landscapes which will allow humans and animals to engage with the environment and restored ecology in the proposed Garden. The design aims to facilitate this healing of both humans and animals in attempts to encourage dialogue and interaction between the two.

To reaffirm an ethical stance for politics and practices in the city that considers the well-being of animals, we need to renaturalise the city, creating inviting spaces for animals, and thus in the process re-enchant the city. This accessible reintegration of animals will provide city dwellers with the local, relevant knowledge and understanding of animal life resulting in their respect for animals including their viewpoints and place in the city. Such awareness would inspire a rethinking of our wide range of daily urban activities and practices that

impact on nature and animals.

An interspecific ethical stance, once it has replaced man's assumed dominion over nature, will encourage designs of urban spaces where animals are not incarcerated, killed, culled or displaced in confined 'concrete prisons'. Instead, animals and city dwellers can become valued neighbours trying to survive the city (Acampora 2010:227). A place-specific dualism of both nature and culture in Pretoria is needed that does not exclude these animals. This radical exclusion of most animals from daily urban life can hinder the development of human identity and consciousness, and the simple matter of concern for wild life.

## Urban vision Water group, 2016

### *Ecological restoration of the Apies*

Previously, early settlers had a respectful, mutualistic relationship with nature. This relationship became parasitic over time as a result of the channelisation of the river and urbanisation of the city.

The aim for the proposed urban group vision is to remove the artificial disturbance from the Apies River, both in and around it, in order to restore and maintain the integrity of the river's ecosystem. This restoration of the river's ecology and the integration of retention ponds into its fabric will restore the low water channel to guarantee the self-purifying capacity of the water as well as the ecological habitats for both plant and animal species. This will create water-friendly features and green spaces for the public, particularly in the zoo itself.

Intervention measures to achieve this will include the planting of seeds of indigenous grasses, the removal of alien species, the dredging of contaminated sediments,

the construction of wetlands and retention ponds to slowly release, filter and improve water quality. This will allow river biota to survive and thrive.

#### *Green space*

Pretoria's most successful open green space was, and is still, Church Square. This is largely due to the layout of the public square, where all neighbouring buildings face the open space, creating activity along the edges that filter into the open space.

As the city started developing, the Apies River was not recognised as an open space that needed to be taken into careful consideration and was therefore overlooked. The resulting lack of interaction between the buildings along the river as well as the fast moving traffic and roadways, caused open spaces adjacent to the river to become derelict spaces for unwanted, illegal activities. To resolve this, a successful green space is

proposed to be expanded to the green space along the river, with new buildings to face towards the river. This establishment of new edges and green spaces will create an identity of humans in symbiosis with nature and the reclamation of lost space.

#### *Movement*

Historically, the main routes leading into the city centre were far away from the river. Currently, Nelson Mandela drive intersects the city, creating an East West divide. Several existing spaces running along the river do not allow for any interaction with the water. The proposal looks at the addition of more spaces to bridge the river, to reduce the scale of Nelson Mandela drive and to cater to pedestrians.

### *Rituals*

As Pretoria developed, various rituals that took place along the river changed during the course of history. From a previous recreationally focused, romantic river condition, the Apies has changed to a channelised stream, drawing city dwellers to its banks for washing and cleaning clothes, providing shelter, supporting church groups and providing space for city recyclers.

These rituals form an important factor of city life and cannot be disregarded. The framework therefore proposes a space where rituals are celebrated and formalised through architecture. Public spaces for these rituals help to expose the result of non-ownership to establish a new river identity in the city and for the individual: an everyday river for everyone.



Figure 1.11 1947 Map of Tshwane, showing the zoo's relation to Church Square and the Apies River (Author & Water Group, 2016).

## Architectural vision

### *Architectural vision*

The Garden of Captives aspires to create spaces that initiate programmes of outreach, conservation, preservation and restoration of the environment. It questions contemporary urbanisation methods from the perspective of animals as well as those of humans, who, together with animals, suffer from habitat degradation and urban pollution. It addresses those who are denied the experience of animal interaction, an integral contributant to our well-being. The project seeks to create spaces where nature and animals are no longer incarcerated in small, confined areas but are free to roam - re-enchanting the city by this animal kingdom (Acapora 2010:238).

If certain species are found harmoniously co-existing in the wild, why are they isolated and separated from each other in zoos? This notion will need to be investigated and engaged with in order to create an informed architectural response that best serves the captive animals.

This can be realised by modernising the concept of the waterhole in an urban context, to recreate a condition that exists in the lives of wild animals.

The rehabilitated and purified water of the Apies River, a scheme proposed by the framework and urban vision, can be used to create this urbanised concept of the waterhole that certain species will have access to. The purpose here is to recreate a more realistic and natural condition of how animals actually live in the wild. This simulation of the wildlife experience and exhibition of animals can be achieved through an architectural and landscape solution. Taking an analogy of ecology, a successful architectural design depends on adaptation, and the avoidance of unnatural juxtapositions of wild animals in an urban context. The zoo should, to some extent, be reorganised around the central 'Garden' – to be highlighted it as a landmark and as a strong element in the design. Viewing spaces, towers, bridges and

other structures surrounding it that enable visitors to view the animals, have the potential to be characteristic architectural elements in the broader site plan design and are essential to the educational experience and enjoyment of the zoo. The design should protest against typical ideologies of any zoological exhibition that places animals on display as passive objects to be viewed, with humans as mere spectators unable to participate in the encounter. Free-ranging animals should have the freedom to avoid or engage with humans – a condition quite contrary to the standard zoo protocol.

## *Programme*

The sanctuary will provide visitors with insight into the conservation, medical treatment and rehabilitation of elephants, to focus on educating the public through maximised, varied interaction. Rescued elephants that cannot be released back into the wild (as they would be unable to survive), are given permanent residence in the shared Garden. Responsible and enlightening interactions between the elephants and humans will allow for the appreciation of these remarkable creatures, whilst simultaneously providing freedom for the animals to roam the landscape. Although there will be no traditional fences or electrical barriers to hinder any close encounters, safety will still be maintained. The Garden will encourage elephants and other wildlife to exhibit more natural behaviours.

While several elephant specific sanctuaries are located around the country, including Knysna, Plettenburg Bay and the Kruger National Park, none of these pro-

grammes are either easily accessible or affordable to most urban children and city dwellers living in Pretoria. These educational programmes are paramount in educating the public of issues regarding conservation and protecting ecosystems and endangered species, and to build a culture of resilience through science and education.

Elephants will act as a catalyst in facilitating human-animal interaction which is currently severely lacking at the National Zoological Gardens for normal, everyday visits - due to visual and physical barriers. As they are highly intelligent, empathetic, emotionally-responsive and social creatures, they are far more accessible than most animals. They will thus provide humans the opportunities to interact with them through responsible and educational programmes – always on elephant terms. Elephants should be allowed the freedom to choose where they want to travel, what they want to eat

and who they want to interact with (Knysna Elephant Park, 2016).

The programme will also incorporate a captive breeding facility that aims at safeguarding the earth's rich genetic heritage and re-diversifying genetic pools of endangered species. The necessity of this is to prevent “in-breeding” which is typical of most captive breeding situations, in order to prevent breeding weaker species susceptible to illness, deformities and sterility (Koebner, 1994).



# CHAPTER 2

## Zoo Metamorphoses

*This chapter explores the nature and development of zoological gardens, and the various processes involved in the display of captured animals as well as the social and cultural reactions of these displays. A background to the National Zoological Gardens of South Africa will also be investigated as the chosen site.*

## A passion for controlling

Throughout history, terms such as ‘animal collections’, ‘menageries’ and ‘zoological gardens’, have been coined to reflect mankind’s curiosity regarding the animal world and our dominion thereof (Koebner 1994:13).

Since wild animals were first held in captivity, zoological gardens have undergone many transformations based on our changing understanding. Unfortunately, countless zoos still exist today that resemble the menageries and collections of the Middle Ages, where animals live in inhumanely conditions in confined cages and enclosures with little to no regard for their wellbeing

(Koebner 1994:19). In the Twenty-First Century, these zoos are a disgrace and should no longer be in existence.

Looking further than simply the manner in which zoos exhibit animals, the greatest indication of a zoo’s quality is through how the animals are cared for and treated, how the zoo effectively contributes to conservation, and equally important, what it teaches the public about wildlife and conservation thereof. The best zoos are centres of learning for researchers, biologists, geneticists, veterinarians, as well as the public (Koebner 1994:19).

Becoming ‘conservation centres’ is the next evolutionary stage for zoos. Recently, several international zoos have been renamed as “Wildlife Conservation Centres” with the purpose of providing good care, meeting their missions of conservation, educating the public about the necessity of protecting ecosystems and wildlife and providing homes for animals that are extinct in the wild and unable to survive without positive human intervention (Koebner 1994:19). Zoos should be designed as sanctuaries for wildlife, putting the needs of animals always first, and second for viewers visiting.

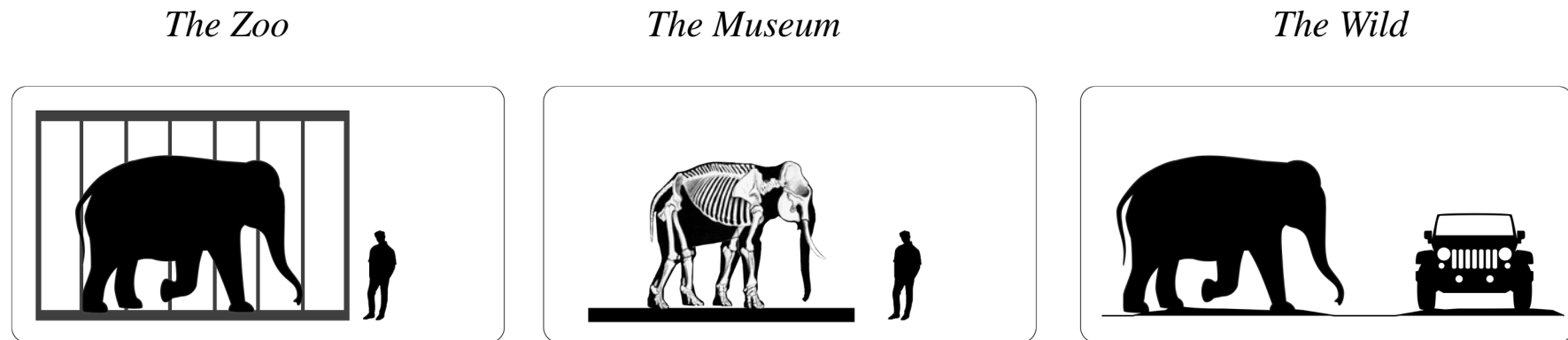
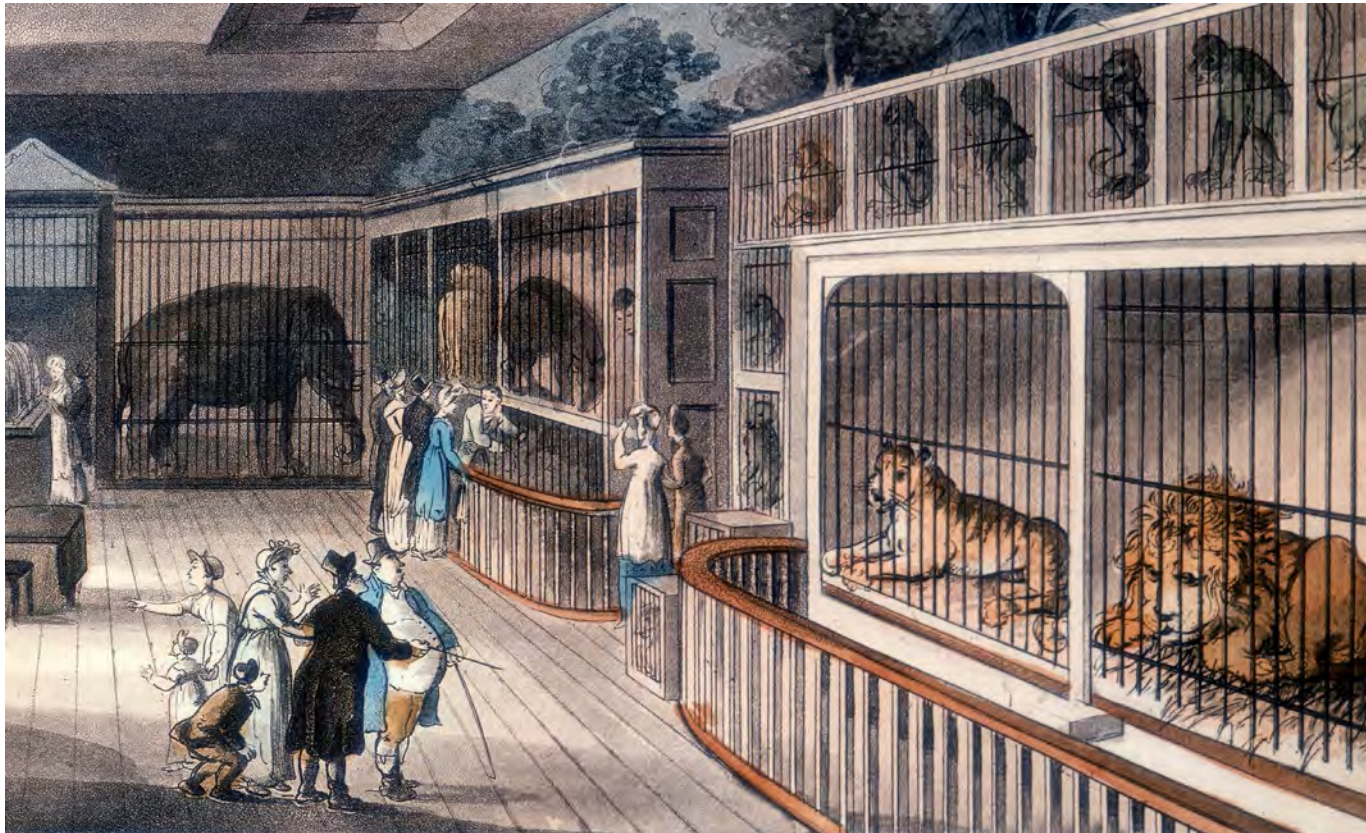


Figure 2.1

A graphical representation of how animals are viewed by humans today (Author 2016).





*Figure 2.2*  
*The Royal Menagerie: An illustration of the zoo*  
*within the Tower in 1816, England.*

## Earliest collections

Human beings, and animals such as elephants, rhinoceros and whales, have all evolved over millions of years to occupy their special niches and roles on earth. The story and evolution of zoos has been re-adapted over time by history, philosophy, anthropology, and of course, architecture scholars. History reveals that all great civilisations held animals in captivity for display in wealthy cities. Initially, collecting animals was a privilege only of kings and potentates, who desired exotic creatures as treasures for their personal enjoyment. These ‘collections’ became more organised over time. However little thought or consideration was bestowed upon the animals and their needs. Animals were confined in cages designed for viewing rather than comfort (Koebner 1994:55).

The earliest known animal collection recorded belonged to Queen Hatshepsut, around 1500 B.C in Egypt (Koebner 1994:55). The collection was discovered during excavations near Hierakonpolis, one of Egypt’s greatest urban centres. Remains of elephants, baboons, hippos and wildcats were discovered in the ancient city’s elite cemetery (Doc Zone, 2016).

### *Garden of Intelligence*

Wen Wang, Emperor of the earliest Chinese Dynasty (Zhou Dynasty, 1027 - 221 B.C.) named his animal collection the “Garden of Intelligence”. This garden was used as a place to both study and learn the remarkable and unknown marvels of nature and the animal kingdom at the time (Koebner 1994:56).

These types of early animal collections represented great wealth and power of rulers, as exotic and dangerous animals were kept under their dominion. These collections also provided study and research opportunities to better understand nature and discover if domestication of animals for the benefit of humans was possible (Koebner 1994:55).

### *The Colosseum*

During Roman times, 27 B.C. - 476 A.D., the captivity and display of animals for pure human entertainment and embellishment had fully peaked. Through the power and control of wild animals, Roman leaders were able to demonstrate their supremacy. In the Colosseum, a great deal of animals died fighting either each other or gladiators. Unarmed, defenceless people were often thrown to the lions as punishment. Many of these animals used in combat were either bred in

captivity or captured from the wild, to be used as a constant supply for these bloody spectacles (Koebner 1994:56). The Colosseum was equipped with cages to house the wild beasts which were starved before any fights. These spectacles were finally banned in the fifth century.



Figure 2.3 Animals being forced to fight each other and against gladiators in the Colosseum.



Figure 2.4 Akbar the Great's menagerie of exotic animals in India.

## Menageries

Until the eighteenth century, animals kept on display were only to be seen and enjoyed by nobility and those in power. However as the nobility lost control, animal collections become accessible to the public as well. These more organised collections were renamed as 'menageries', defined as collections of wild animals in cages.

Animals in menageries were still viewed as mere curiosities, with little regard to their health and needs (Koebner 1994:58). These cages provided the animals with no privacy or space to escape being observed.

Henry III continued his grandfather's tradition of collecting animals when he became king of England (1216-1272) and relocated the royal residence to the Tower of London. He erected what is now known as the "Royal Menagerie", which housed animals in cages to be displayed outside the Tower. In 1254, he received an elephant as a gift from Louis IX of France, the first of its kind to be transported to England.

A special elephant house was built under his commission; in keeping with the tradition of small cages of menageries, the house was just big enough for the elephant to fit into.

During the Renaissance period in the late 1400s, a large menagerie was established in Florence. At the time, animals were considered as creatures of nobility and beauty. Lions and wolves appeared on family emblem designs and used as models for paintings. Leonardo da Vinci kept many animals used as models which appeared in his works of art (Koebner 1994:59).

One of the finest considered menageries belonged to Akbar the Great (1542-1605), the third Mogul emperor of India. Before his passing, he had five thousand elephants and one thousand camels in his possession. Animal fights were strictly forbidden under his rule, as he had great admiration for the exotic animals kept under his protection (Koebner 1994:59).

# Zoological Gardens

## Origins

At the start of the nineteenth century, the development of large urban areas initiated the preservation of natural, green spaces for recreational parks. Protecting natural areas became a growing concern and the thirst for scientific knowledge and understanding of wildlife advanced (Koebner 1994:60).

The origin of the word “zoo” originated from the Ancient Greek word “zoion”, translates to “living being”. “Zoology”, the study of living things developed thereafter, including the evolution of the zoological park and garden (Koebner, 1994).

Animal collections, menageries and zoological gardens, being various displays of animals in captivity, have evolved and changed significantly over the years to reflect current culture and society worldwide. Today, zoological gardens continue to evolve into ‘conservation centres’ in order to meet the requirements and standards of current times acceptable in the twenty first century (Koebner, 1994).

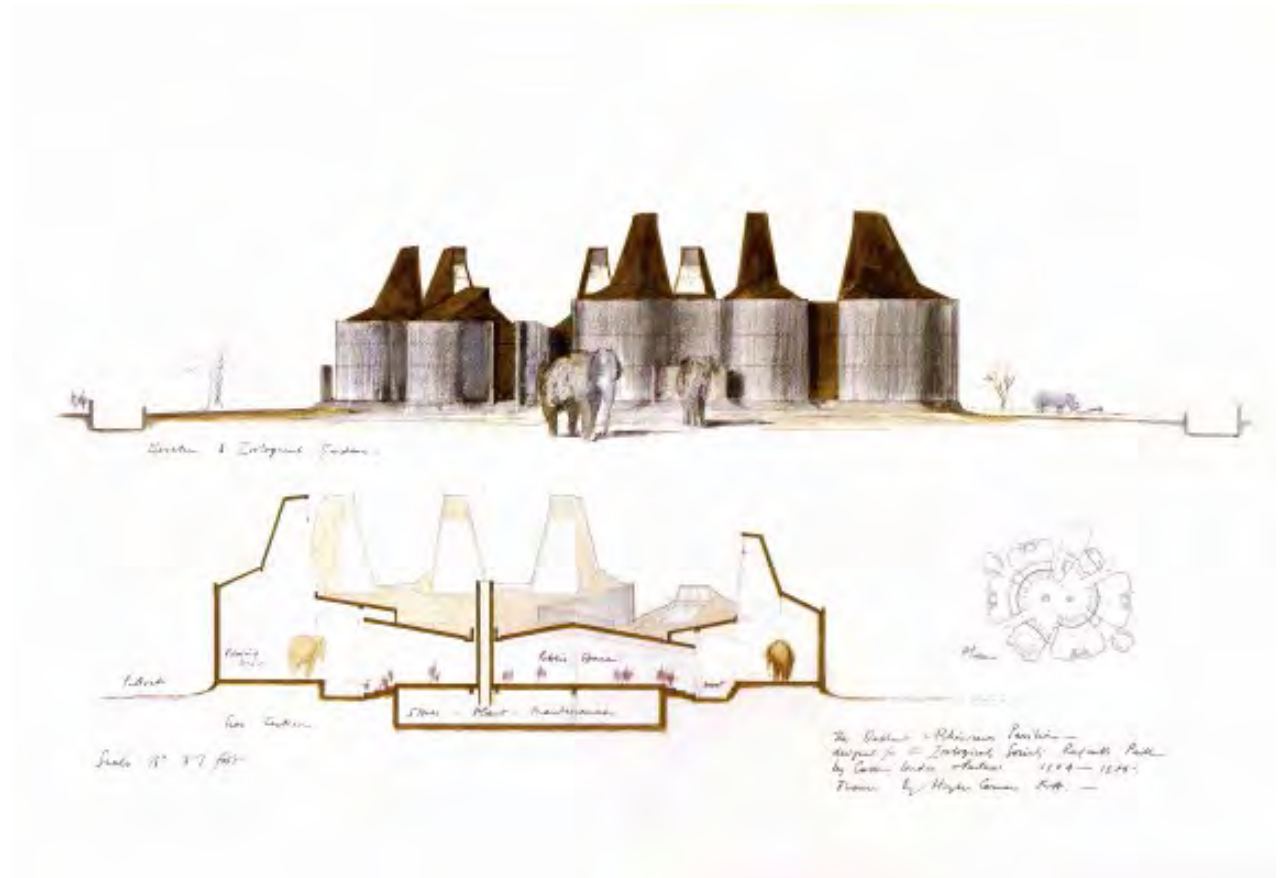
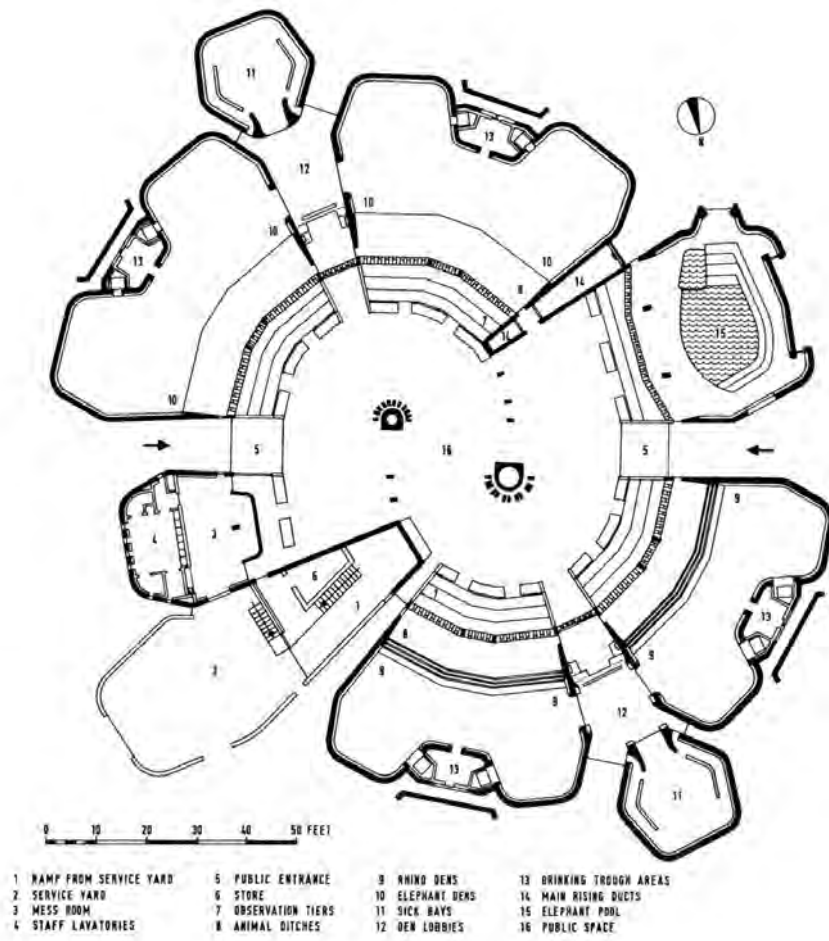


Figure 2.5 The Elephant and Rhino House drawings by Hugh Casson, London Zoo, 1965.

Figure 2.6 Next page Left to Right: Floor plan of the Elephant and Rhino House, London Zoo. Figure 2.7 Photograph of the Elephant and Rhino House.



# Conservation Centres

## *The next evolutionary step for Zoological Gardens*

### *Introduction*

With their origins founded in royal collections, menageries and circuses, zoological gardens need to evolve once more in order to effectively meet the needs of animals and the critical state of the earth today. Many zoos across the world have progressed towards what is now termed as “conservation centres” (Koebner 1994: 61).

Previously, status, recreation and economics were the primary drivers for these animal collections. However, today most zoos seek international accreditation from the Association of Zoos and Aquariums (AZA) and assign resources towards research, conservation, protecting biodiversity and ecosystems.

As conservation centres, a zoo’s primary objective should be the wellbeing and welfare of all the creatures in its care, as well as the improvement of their lives and natural surroundings. This necessary evolution is still

far from being realised unfortunately (Ludlum & Hill, 2015).

Zoos are valuable as they contain an overview of various animals and ecosystems found on earth. A necessary provision needed to be made by zoo professionals for the future is protecting ‘keystone’ species. Most of these large animals, including mammals, carnivores and herbivores, are seriously threatened with extinction in the possible future.

Animals such as elephants, rhinos and tigers require large volumes of space and habitats to thrive. As a result of this, they help support other animal and plant life. If elephants were to be hunted and poached entirely to extinction, consequences will arise that impact upon other animals that have evolved to live alongside elephants. The elephants become the representatives for their habitats; the “keystone” (Koebner 1994:123).

*“In the end, we will conserve only what we love. We will love only what we understand. We will understand only what we are taught.”*

*– Baba Dioum, Senegalese conservationist.*

# ENDANGERED SPECIES WORLDWIDE

The IUCN Red List  
Extinctions & Critically Endangered  
Species in Numbers

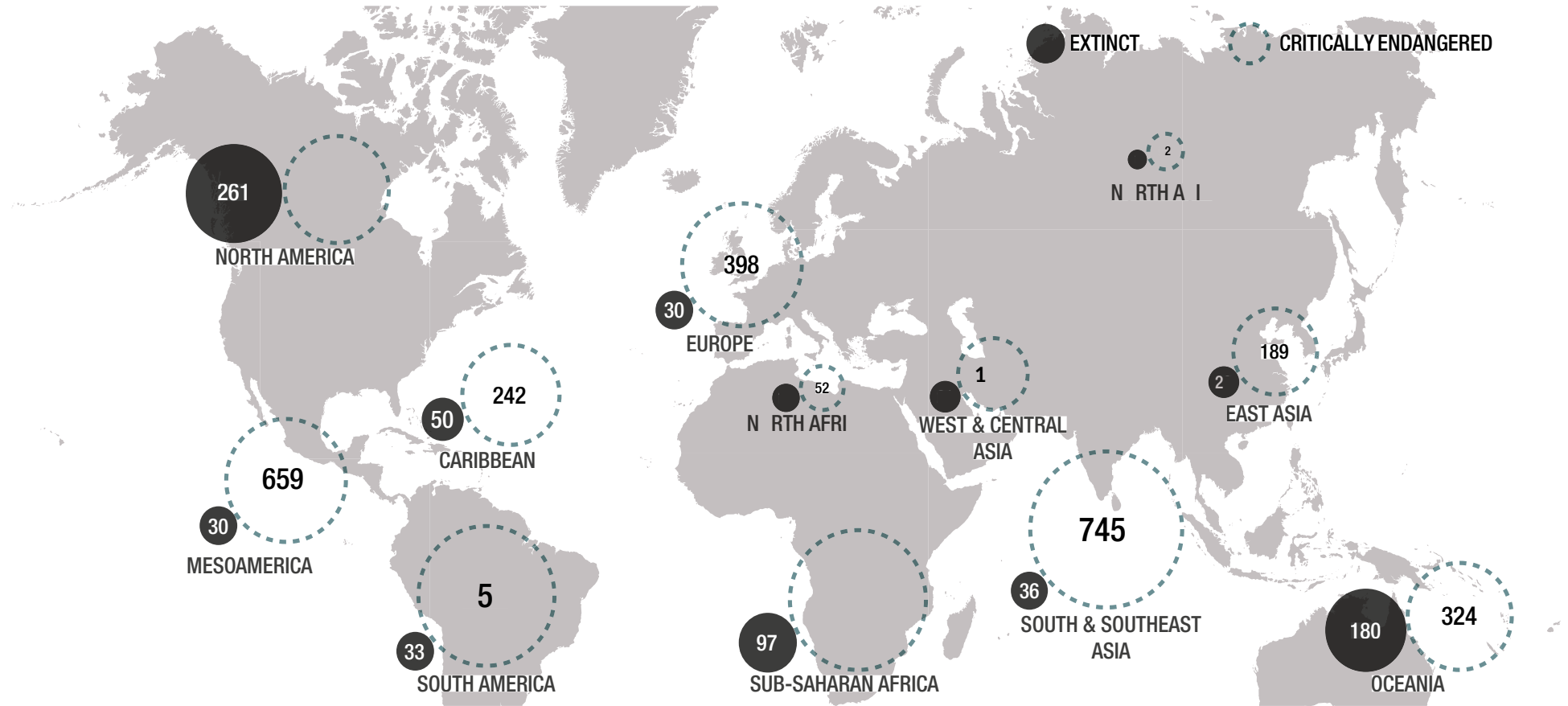


Figure 2.8 Image representing Endangered Species Worldwide as per the IUCN Red List (Author, 2016).



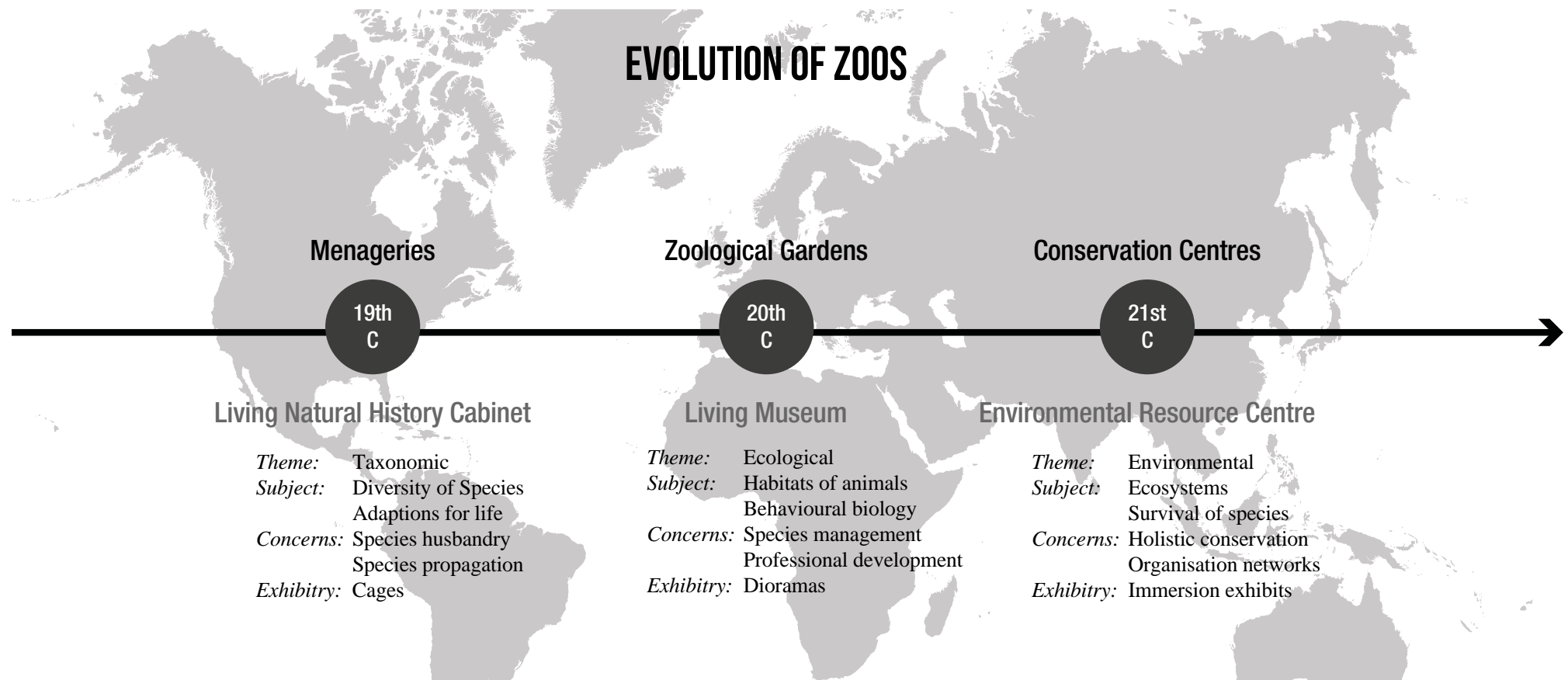


Figure 2.9 Diagram representing Rabb's concept of the linear evolution of zoos (Author, 2016).

## “Evolution of Zoo Concept”

The evolution of zoos concept was put forward by George Rabb, the former head of Brookfield Zoo. This concept involved the future of zoos, with an anticipated greater focus and devotion to wildlife conservation. In many ways, several institutions United States specifically, are already achieving these goals. Most AZA accredited zoos are primarily focused on core issues of wildlife conservation, safeguarding ecosystems and biodiversity and contributing to research (Hill, 2014).

Conservation is becoming the central focus for several zoos. As conservation centres, zoos need to address sustainable relationships of people, animals and nature, communicate the values and importance of preserving biodiversity and ecosystems, and practice conservation ethic with all operations. These operations should be linked to the survival and management of species populations in the wild threatened with extinction. Zoos should adopt immersion exhibits to actively involve visitors to understand the environmental predicaments of wild animals. These experiences are conducive in creating awareness and strong conservation messages which relate to issues of poaching and habitat destruction (IUDZG & CBSG, 1993).

Zoos, while seeking accreditation, need to actively cooperate with the world zoo network and other conservation institutions working in conjunction with “The

World Zoo Conservation Strategy”, published Fund for Nature (WWF) in 1980. The World Zoo Conservation Strategy encapsulates the present viewpoints of zoos as being a “living document” that has the potential to evolve and change over time as research, knowledge and philosophies concerning conservation are further defined (IUDZG & CBSG, 1993).

### “The future of Zoos: Blurring the boundaries”

The evolution of zoos over the past hundred years up to now has undergone a paramount transformation with the changing of cultural beliefs and knowledge. Zoos as we know evolved from royal collections, menagerie and circuses. In the twenty-first Century however, it is curious to contemplate what the next phase for zoos will be.

When considering what the next evolutionary state or transformation of zoos may be, many people and zoo critics firmly believe that zoos should cease to exist indefinitely; that keeping animals in captivity, and the ethical concerns thereof, surpass any other concerns. Furthermore, they believe these concerns far outweigh other moral dilemmas associated with protecting species and safeguarding the earth’s rich genetic heritage. The author disagrees.

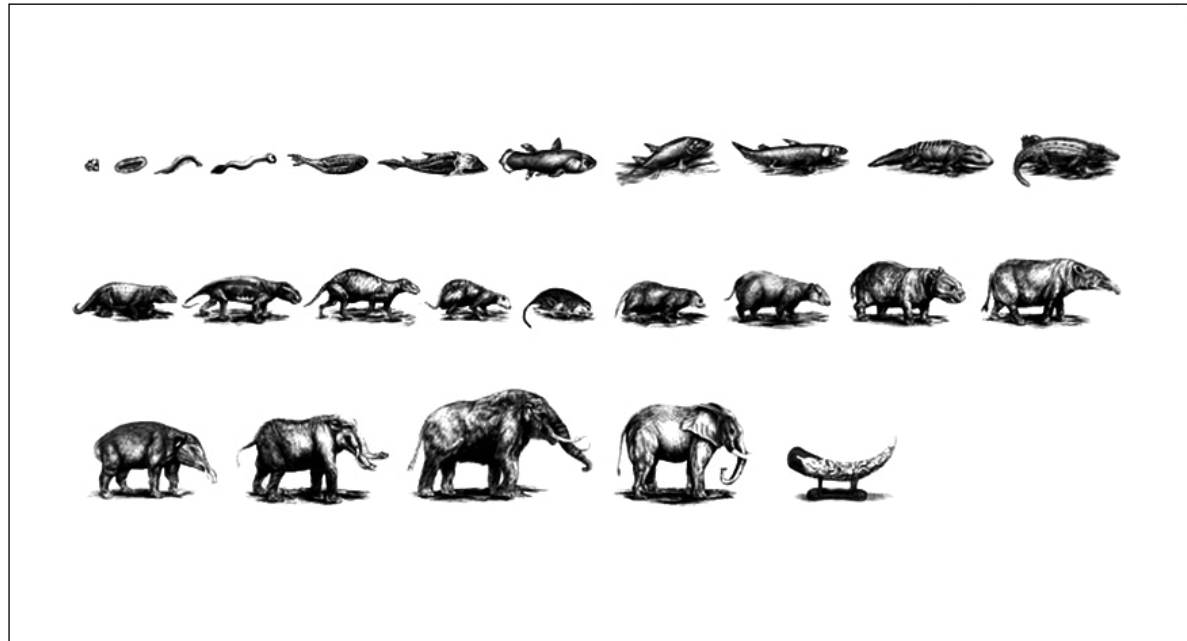
Today, animal populations in the wild are currently

and will continue facing unimaginable crises and life-threatening challenges brought about by significant human changes to their environments. For this reason, zoos should continue to exist to bring these severe issues to light. Zoos should therefore “exist as a moral imperative” and provide refuge and a resting place for animals against a gathering storm (Hill, 2014). This forms the crux of the project’s intentions.

Wildlife rehabilitation centres are devoted to treating injured, sick or orphaned wild species to recovery, in order to increase their chance of survival when returned to the wild. In the past, these centres disregarded visitors, considering them as nuisances. Accommodating visitors was associated with the so thought less important of the four goals – being that of recreation and entertainment. Now however, these centres are realising their potential for providing unique public education and awareness to the importance of wildlife conservation. These wildlife rehabilitation centres are committed to the care and management of wildlife and population numbers thereof. Today’s AZA accredited zoos focus on four goals of ‘recreation, education, conservation and research’ which distinguishes them from other zoos and institutions (Hill, 2014).

Figure 2.10 During the Middle Ages, artists had known of the existence of elephants having heard stories and descriptions from other travellers. Various paintings and illustrations were done based on these descriptions, despite the artists having never actually seen an elephant (Sunny Skyz, 2016).





# CHAPTER 3

## The War on Elephants

*This chapter provides insight into the current crisis concerning African elephants and the various issues threatening their very existence. A comparison study between elephants in the wild and those in captivity, as well as reviewing elephant handling regulations, will be conducted to further inform the design.*

*A keeper at the Phoenix Zoo noticed Ruby, a nine-year-old Asian elephant, would use a stick or grasses to make patterns in the sand. The keeper gave Ruby big rods of coloured chalk and paper to see what she would do. Ruby seemed to love it. In her big trunk she carefully held the chalk – she chose the colours – and drew on the paper. She was careful to keep the paper from moving by gently placing her foot on the corner. If the paper ripped, she'd smooth it down with her trunk.*

*To have an elephant draw may not be exactly what a zoo is about, but it shows that keepers can be perceptive and provide the animals with new experiences. This kind of activity also helps to educate the zoo visitors, making them more interested and appreciative of the animals' abilities. – Koebner, 1994.*



*Figure 3.2 Ruby the painting elephant, Phoenix Zoo*

## The War on Elephants

‘A bleak future for our living dinosaurs’

### *Significance of Elephants*

Elephants are some of the most intelligent animals, with the capability of experiencing a range of complex emotions and consciousnesses. For centuries they have demanded respect from humans and other creatures who occupy the same African landscape, instilling their cultural significance. They are also keystone species who play a vital role in maintaining the biodiversity of the ecosystems in which they live.

They are able to survive during dry seasons and droughts by digging for water with their tusks, furthermore providing water for other animals living in similar harsh predicaments (Save the Elephants, 2016).

### *Introduction: The Ivory Trade*

Research conducted by Save the Elephant (STE) predicted that during the period of 2010 and 2012, nearly

100 000 elephants in Africa were slaughtered for their ivory. The ivory trade is driving organised crime and poor security as tusks are illegally smuggled through the same networks as other high profile illegal goods. This trade is unfortunately driven by demand for ivory, mostly from consumer countries in the East, where possession is considered an investment and symbol of status (Save the Elephants, 2016).

Approximately 30 000 to 40 000 African elephants are poached every year leaving only around 400 000 elephants remaining on the continent. Taking new-borns into account as well, this current rate of killing questions whether these creatures will still be around in the next fifteen to twenty years – especially as human populations are constantly increasing in Africa thus reducing their habitat space (Leithead, 2016).

Organised crime runs the ivory industry. Esmond Bradley Martin, having spent decades interviewing

traders and traffickers and investigating smuggling routes across the world, states that “corruption is probably the biggest cause of the increase in elephant poaching”. The majority of the poached ivory exits Africa through Dar es Salaam and Mombasa, establishing corruption in those parts. From there, the corruption continues as the ivory is shipped to Asia, most commonly China and Vietnam (Leithead, 2016).

The Kenya Wildlife Service (KWS) headquarters in Nairobi contains a basement strong-room housing mountainous heaps of tusks reaching the ceiling. This stockpile confirms the success of the Kenyan government’s attempts in prohibiting the illegal ivory trade. Each individual tusk has been labelled and registered, accompanied by a team of armed rangers to be destroyed at the biggest single ivory burn in history (Leithead, 2016).

*“Slaughtered for their ivory, the elephants are left to rot, their carcasses dotting the dry riverbed; in just two days, we counted the remains of more than 20 elephants in a small area.”*

- David McKenzie, CNN.



*Figure 3.3 Burning of illegal ivory stockpile*



## *Great Elephant Census (GEC)*

### *The latest tally*

#### *African Savannah Elephants*

The GEC is a project devoted to taking count of all savannah elephants living in the wild throughout Africa, via survey planes. Together with EWB (Elephants Without Borders), a team tracks the movements of elephants in Africa using satellite collars with transmit real-time data (McKenzie & Formanek, 2016).

Before this project, calculating elephant population numbers was left mostly to speculation. However, during the last two years of this project, 286 crew members with 90 scientists have flown over 18 African countries to tally all remaining elephants.

Scientists estimate that Africa was home to as many as 20 million elephants at the start of the 20th Century. This total dropped to 1.3 million by 1979. A recent census reveals a devastating number of only 352, 271 African elephants remaining – a number far lower and more disturbing than previous estimations (McKenzie & Formanek, 2016). In a span of seven years, between 2007 and 2014, elephant numbers dropped by approximately 30 % - or 144, 000 elephants to be exact.

A recent survey in specific cases including the Niassa Reserve in Mozambique and the Selous Game Reserve in Tanzania, revealed that elephant population numbers dropped by more than 75% in the last decade alone due to poachers attacking family herds (McKenzie & Formanek, 2016).

*“When you think of how many elephants occurred in areas 10 or 20 years ago, it is incredibly disheartening”* – Mike Chase, Elephant ecologist and founder of Elephants Without Borders (EWB) and lead scientist of the Great Elephant Census (GEC).

The present rate of elephant population decline is 8%, which could result in the current census halving to 160, 000 elephants in 9 years. If poaching continues at this alarming rate, extinction of African elephants is almost definite. Elephants have reached a critical tipping point, where more are killed than are born (McKenzie & Formanek, 2016).

#### *African forest elephants*

African forest elephants, the smaller of the two subspecies of African elephants, have experienced a 65% drop since 2002 due to illegal poaching and habitat

loss. These species take longer to recover and repopulate after poaching due to a much slower birth rate, a result of challenging living conditions in forests – where new plant growth and high canopies are inaccessible to these ground-dwelling species (Pandey, 2016).

A recent study was published in the Journal of Applied Ecology on 31 August 2016, titled ‘Slow intrinsic growth rate in forest elephants indicates recovery from poaching will require decades’, by authors Andrea K. Turkalo, Peter H. Wrege and George Wittemyer. This study discusses scientists’ prediction that forest elephants will require at least 90 years to regain previous population levels, due to the extreme loss in numbers from the high ivory demand fuelling poaching. This estimate is primarily because of their significant low birth rates (Pandey, 2016). In contrast to savannah, or bush elephants normally start breeding from ages of 12, forest elephants only begin to breed at ages of 23 – a relatively late maturity age in comparison to other mammals. Female forest elephants only produce calves once every five to six years, whereas savannah elephants are able to give birth every three to four years (Pandey, 2016).



## A bleak future for Africa's elephants

New research shows the shocking decline of elephants over the past 100 years – and a worrying trend for the future.

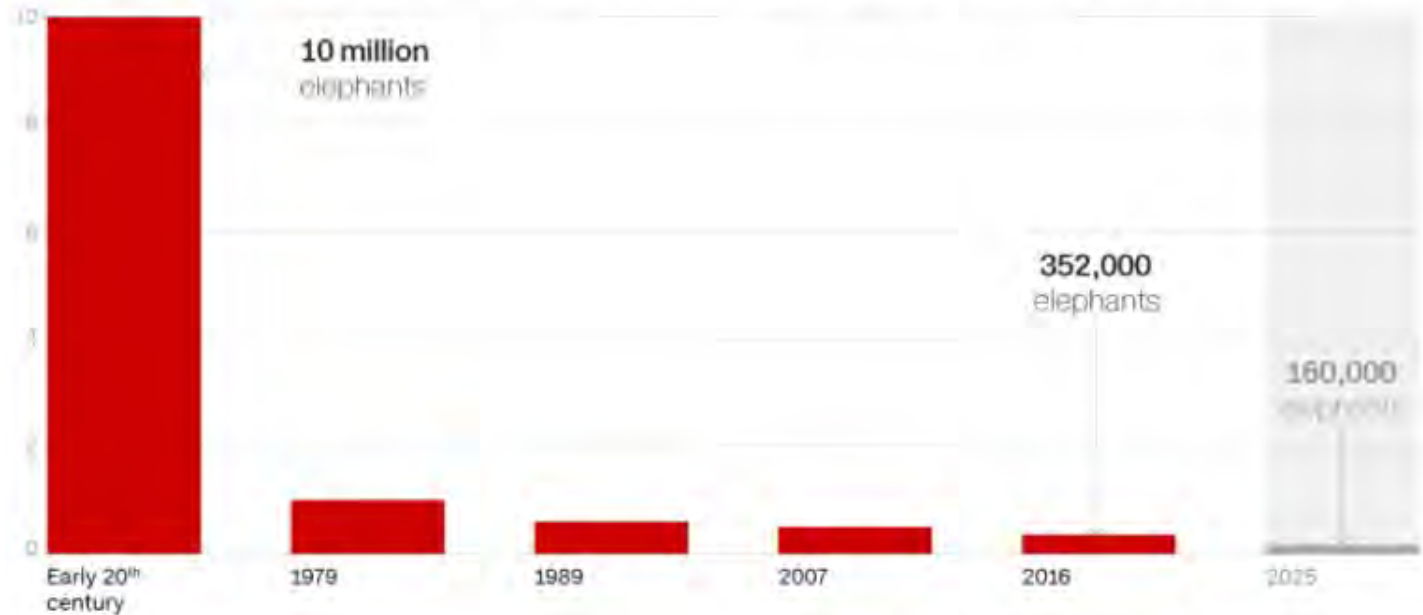


Figure 3.4 & 3.5 Above: Survey planes used for counting elephants for the GEC.

Figure 3.6 Right: Data revealed after the latest elephant census in 2016.

\*All figures are rough estimates except for 1979 and 2016.

## *“An extraordinary intelligence”*

*“Their corpses rot in the dry river grass down below.  
One bull’s trunk had been hacked off and placed nearby  
– the poacher’s signature.”*

The work of the GEC and EWB have revealed proof of the extraordinary intelligence of elephants, including their awareness of human conflict and threats, and will travel across country borders to flee any conflict. Northern Botswana is a renowned elephant corridor for migrating herds moving between the forests and savannahs of Angola and Zambia, and Botswana’s Central Kalahari (McKenzie & Formanek, 2016).

Elephants avoided travelling to Angola during the country’s prolonged civil war. When the country declared peace, the elephants travelled back. Now, however, with the peak in poaching and the ivory trade market demand, the elephants are avoiding the country again. In fear of poaching, the elephants no longer journey across eastern Namibia into Angola and Zambia. This has led to their home ranges being severely limited to the safety of Northern Botswana (McKenzie & Formanek, 2016).

*“An unconventional war”*

One of the few strongholds remaining of savannah elephants is Botswana. Together with Zimbabwe and

South Africa, Botswana is accredited for over 60% of all the elephants that were tallied in the Great Elephant Census. Elephants are faced with incalculable odds. Besides poaching threatening their existence, habitat loss and destruction, human-elephant conflict and climate change are all issues representative of their continued struggle for existence (McKenzie & Formanek, 2016).

### *Elephant Empathy*

The grief of losing a member of their herd is an indication of these social creatures’ remarkable, extraordinary intelligence and empathy.

With scientists having only recently commenced examination of the neural architecture in an elephant’s cranium, unique characteristics have already been revealed. Professor Paul Manger from the School of Anatomical Sciences at Wits, relocated from the United States to South Africa in 2002 with the sole purpose of studying the elephant brain. In an article published in Scientific American on the 23 February 2014, he stated that elephants have neural networks

which are highly specialised for their extraordinary senses and unique kinetic movements and abilities (Dugmore, 2015).

## *Elephants in Captivity*

It is well known that animals in captivity often display abnormal behaviour patterns in comparison to their wild counterparts, largely due to their restriction of space. Other factors such as lack of physical and mental stimulation, hunting and foraging for their own food, needing to survive, protecting their territories and raising their young, also contribute to these abnormal behaviours. In the wild, animals are confronted with these problems and needs on a daily basis whereas captive animals have their food, shelter and mates provided. Zoo keepers and designers therefore need to provide activities and enriching environments that can provide such stimulation, especially for highly intelligent and social animals such as elephants and chimpanzees (Koebner 1994:88).

Respectable, successful zoos today ought to implement social enrichment programmes; social animals for example should live in groups, as should herd animals live in herds. Elephants especially are social beings who need to live with the same members of their species. It is crucial for calves to have role models as they grow and learn skills from their mothers and aunts, such as what to eat, how to care for their own young and behaving with other dominant animals. Without learning from their elders, they may not become successful members of their species (Koebner

1994:90).

The vast difference in space available in the wild and that offered in captivity is indeed substantial and supports the argument against zoos. It validates the concern of large animals which suffer a significantly bigger space restriction in captivity than they would in the wild in comparison to other smaller animals.

Elephants in particular, being the largest land mammals on earth, have incredibly complex needs and requirements that no zoo, circus or other public-focused attraction can really offer. Due to their size and needs, they are also the most appropriate example of animals in captivity which suffer the most and exhibit more welfare problems when living in captivity. Studies of elephants kept in captivity conducted in 2002 by Clubb & Mason, have shown that many of the welfare problems elephants experience in captivity include abnormal behaviour, low breeding, high mortality and numerous illnesses. The authors conclude that the primary reason for these problems are caused from the restriction of space for captive elephants (Casamitjana, 2005).

### *Enclosure sizes and requirements*

Elephants in the wild roam considerably vast distances, the minimum being between 60 and 100 times larger than EAZA (European Association of Zoos and Aquaria) recommended enclosure sizes. Their results proved that enclosure sizes in the UK were in fact an average of 1000 times smaller as opposed to the recommended size (Casamitjana, 2005). The EAZA outdoor enclosure size recommendation is 400m<sup>2</sup> for three elephants, with an additional 100m<sup>2</sup> for any new elephant introduced into the zoo. In contrast to this, 167.2m<sup>2</sup> is recommended by the AZA per elephant, with an additional 83.6m<sup>2</sup> for each newly added elephant. These recommendations are not based on any proven results or hard data, but rather from the standpoint of providing optimal welfare and what is physically feasible in zoos (Casamitjana, 2005).

## *Elephant social systems*

The social groupings and environments of elephants in captivity affect their welfare considerably. Reviewing naturally formed social structures of both sexes in the wild can provide insight into correcting social groups forced upon them in zoos. Factors needed to be taken into consideration include elephant size, age and sex ratio of groups, as well as the degree of relatedness between members. Secondary factors such as movement and transfer of elephants between zoos and facilities also impact upon the formation of social groups (Clubb & Mason, 2002).

The degree of sociality differs between female and male elephants. Female elephants tend to be more sociable than males, and have proven to have the largest social network of any mammal studied, other than humans. Adult females and their off-spring live in close, family groups with social bonds ‘extending from mother-offspring bonds to families, bond groups and clans’. Families are the basic social group in which females stay throughout their lives, if undisturbed. Therefore, these families typically contain an older, experienced female known as the matriarch. The Matriarch is responsible for leading the group, her own offspring, and other adult daughters raising their own immature offspring – including prepubescent male elephants before they separate from the group. Family

units usually include between four to twelve members in African savanna herds (Clubb & Mason, 2002).

Female elephants therefore remain in their family unit throughout their lifetimes and form extremely strong and long-lasting social bonds, between family and bond group members. These bonds usually manifest in the group’s efforts to protect their young for example, defend against predators, frequent social interactions and allomothering behaviour.

Female elephants, known as ‘aunts’, have also been found to show nurturing, affectionate mother-like behaviour to calves that are not their own and may assist them during times of distress. This behaviour is known as allomothering. Similarly, female elephants in captivity have adopted unrelated, orphaned calves and are capable of forming similar special bonds and relationships with other non-relatives (Clubb & Mason, 2002).

### *Group sizes in Captivity*

*“Animals of social species should normally be maintained in compatible social groups. They should only be kept isolated for the benefit of conservation and*

*welfare needs of the group, and where this is not detrimental to the individual specimen.” – Secretary of State’s Standards of Modern Zoo Practice (DETR 2000).*

The AZA suggests zoos and other facilities should contain a minimum of three female elephants whenever possible, and stipulate that any new elephant enclosures built adhere to this. Roocroft & Zoll (1994) recommend that elephant herd sizes of at least six females is necessary to meet the social requirements of elephants. On the contrary, the AZA accept that male elephants may need to be separated and housed singly if displaying signs of aggression or conflict towards other members. However, they should still be allowed to hear, smell and see other elephants if kept isolated (Clubb & Mason, 2002).



***The Giant Panda: no longer an endangered species***

*The World Wildlife Fund (WWF) announced at the start of September this year that the Giant Panda is no longer an endangered species (Gajanan, 2016).*

*With a 17% rise in their population numbers in the last ten years, the giant pandas have officially been demoted to being ‘vulnerable’.*

*“The successful recovery of the panda shows that when science, political will and engagement of local communities come together, we can save wildlife and also improve biodiversity,” – Marco Lambertini, WWF Director General. September 2016.*

*While these pandas still remain under threat, this achievement calls for celebration. The WWF has been developing reserves to help recover panda populations for several decades. They have succeeded in establishing sustainable livelihoods with local communities and reducing impacts on forests, the pandas’ natural habitats, previously due to ill-conceived infrastructure projects. To date, there are 67 panda reserves devoted to protecting approximately two-thirds of all 1,864 pandas living in the wild (Gajanan, 2016).*







# CHAPTER 4

## Context

*This chapter provides a background study of the history of the National Zoological Gardens of South Africa, while critiquing the overall site and the current elephant enclosure according to zoo theory.*

## Locality Plan of Pretoria indicating the Zoo

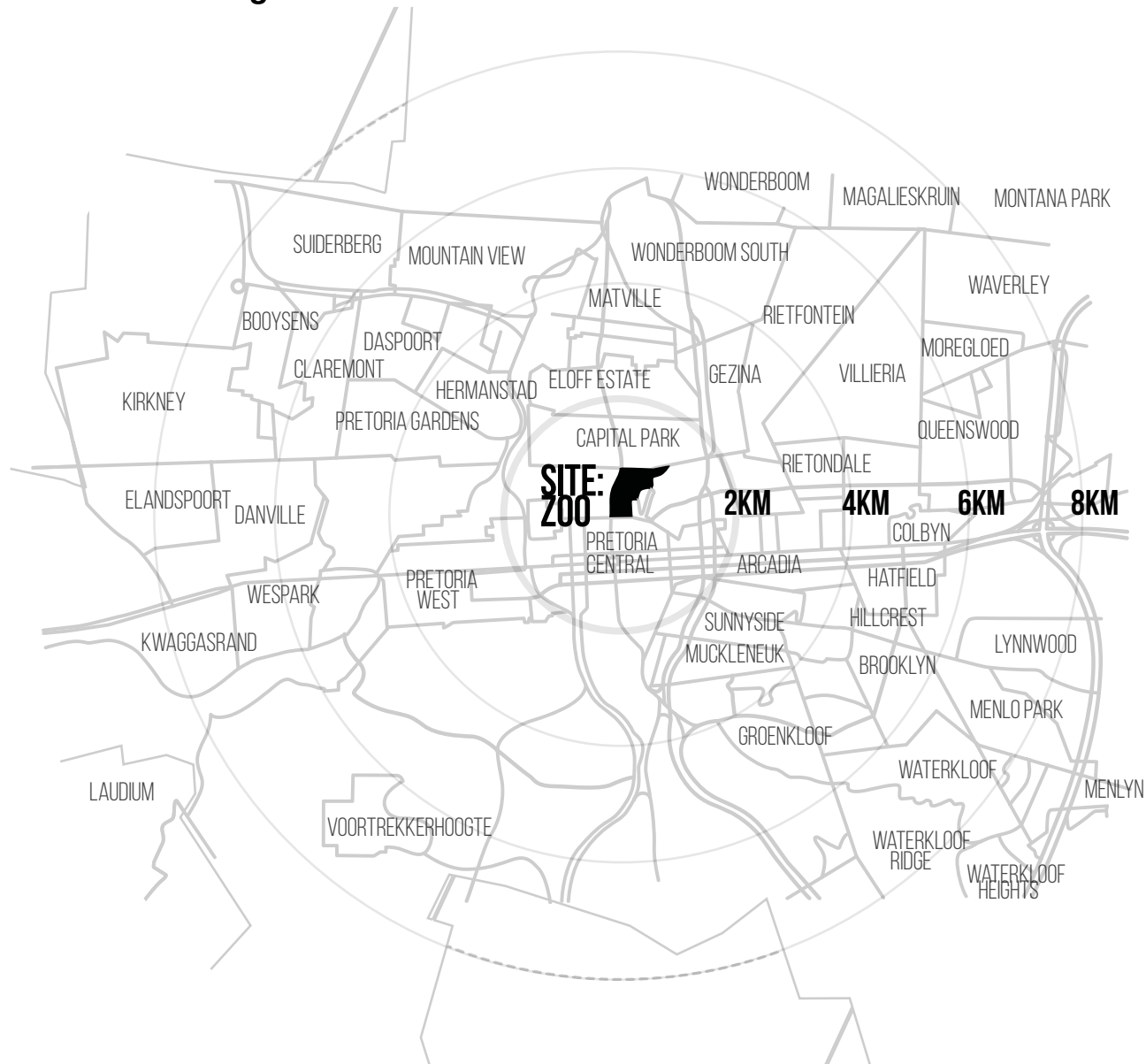


Figure 4.2 Locality map of Pretoria, adapted by Author.

## Nolli Map of Pretoria indicating the Zoo



Figure 4.3 Nolli map of Pretoria and the NZG, adapted by Author.

# Contextual study

## *Site Analysis*

1. Historical background of the National Zoological Gardens of South Africa
2. Zoo analysis & Master Plan
3. Elephant enclosure critique

## *Location*

The focus area for this dissertation, being the National Zoological Gardens of South Africa (hereafter referred to as NZG) is located on the northern periphery of the Central Business District (CBD) of Pretoria. The following chapter investigates the historical background of the NZG and contextually analyses the current conditions of the site to inform the design.

## *Research Methodology*

### *Field research*

The current elephant enclosure, and the NZG as a whole, will be critically analysed in relation to theory, literature review, international precedents and case studies, as well as design regulations and guidelines predominantly set by the AZA for the care and handling of elephants in captivity.

### *Literature review*

1. Draft minimum standards for the management of captive elephants – National Environmental Management: Biodiversity Act, 2004 (Act No. 10 of 2004), Department of Environmental Affairs and Tourism, South Africa.
2. AZA Standards for Elephant Management and Care, 2012.
3. CAZA Elephant Care Manual, 2008.
4. A Review of the Welfare of Zoo Elephants in Europe, Animal Behaviour Research Group, Department of Zoology, University of Oxford.

## *Case study of elephant in captivity:*

The Inokashira Park Zoo, in Japan.

## *Delimitations*

The intention for this project is not to propose a new general design for the entire zoo precinct, but to rather focus on a selected group of animals to accommodate to their unique needs and requirements.

Elephants, being the largest land animals, suffer the most when kept in captivity in appalling conditions. For this reason they have been selected for the investigation to overcome challenges of designing for wild animals.

## Aerial photograph of the NZG

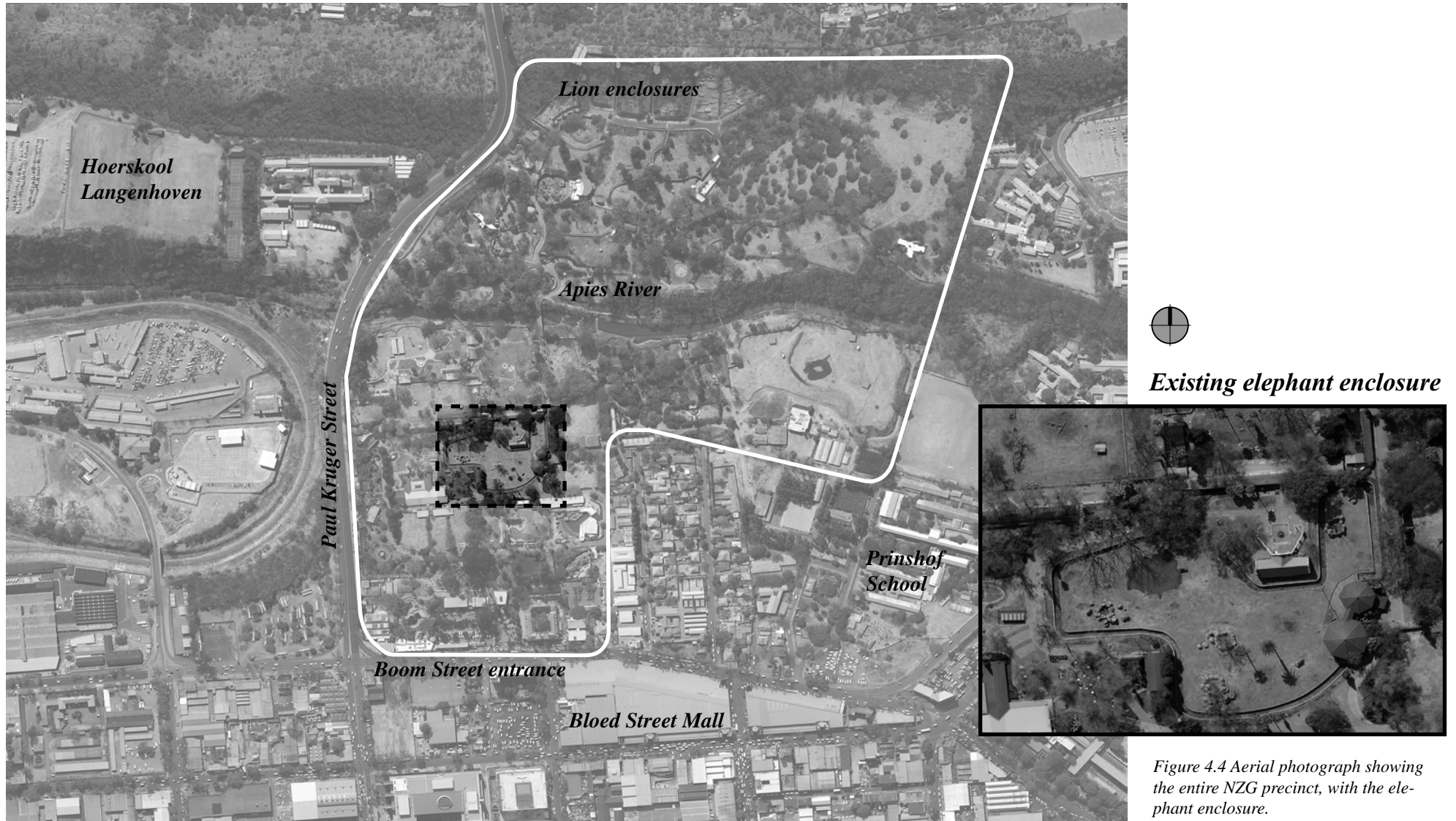
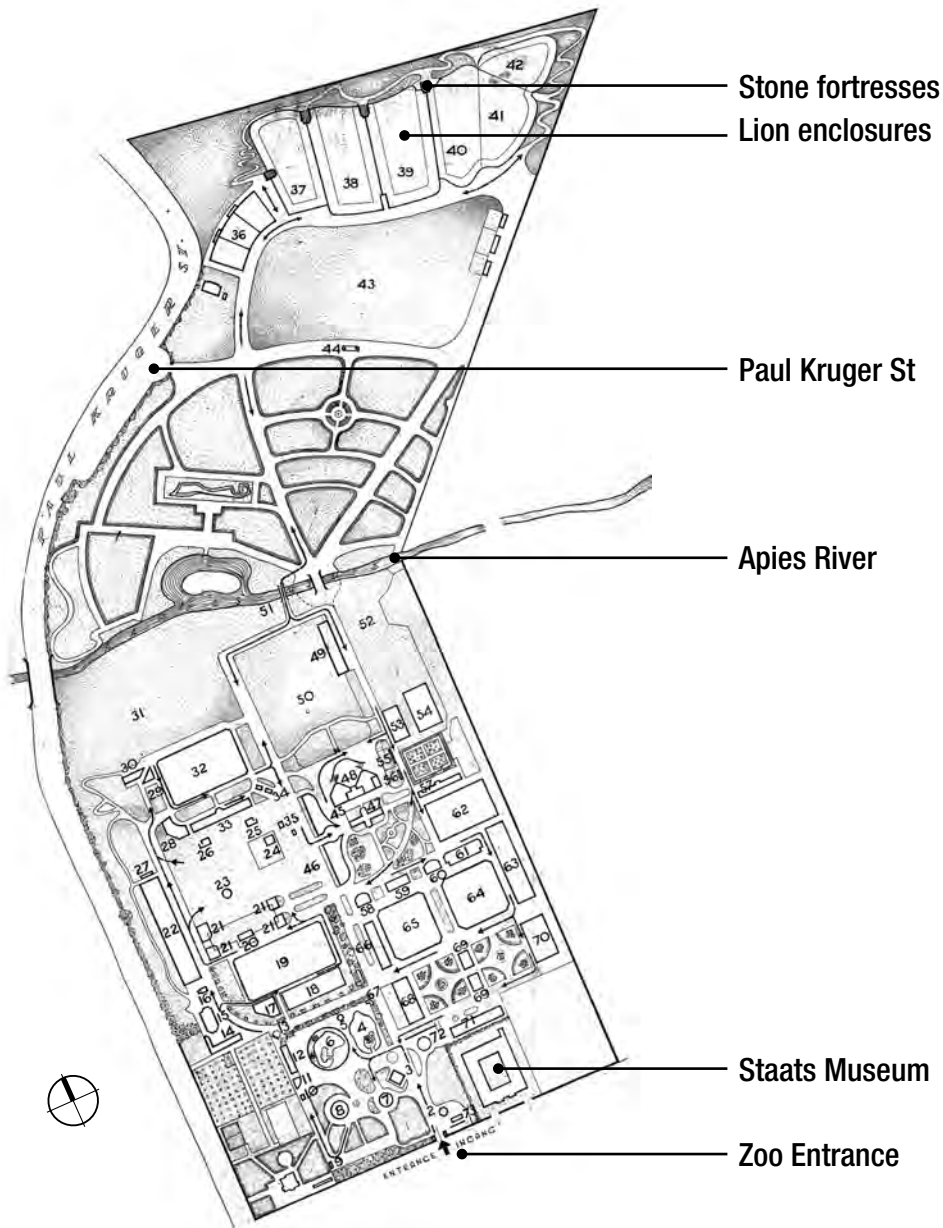


Figure 4.4 Aerial photograph showing the entire NZG precinct, with the elephant enclosure.

## The National Zoological Gardens of South Africa



### Historical Background

The National Zoological Gardens of South Africa was established in 1899 when the Transvaal Republican Government purchased the farm 'Rus in Urbe' with the intention of creating a zoo. Until the year 1913, the zoo was linked directly to the Transvaal Museum, previously known as the "Staatsmuseum der Zuid-Afrikaansche Republiek". The establishment and existence of the zoo is entirely due to the persisted efforts of the late Dr. J. W. B. Gunning, who was the Director of both the Transvaal museum and the zoo during the period of 1900 to 1913. The first animals brought to the zoo in 1899 were temporarily housed in the garden behind the museum, and then later relocated to the farm. During this time, the zoo was referred to as the Transvaal Zoological Gardens, with the name later changed to the National Zoological Gardens (NZG) in 1916.

During this early period, the zoo depended mostly on donations and entrance fees to run operations. However, with its growing animal collection, these conditions were not conducive for its survival. In October 1933, the zoo was declared a State Funded Institution with Act 23 of 1931.

The zoo was eventually declared a Cultural Institution by 1969, later falling under the Department of Arts, Culture, Science and Technology's responsibility in 1994. After the division of this department, the NZG was de-proclaimed in 2004 as being a cultural institute due to its heavy emphasis on conservation. The NZG was then moved to the Department of Science and Technology, which declared it a National Facility under the administration of the National Research Foundation (NRF) (Dry & Joubert Architects, 1991).

Figure 4.5 Map of the NZG illustrating the northern extension beyond the Apies River

*Present status*

As the zoo is closely affiliated with international associations, such as the World Association of Zoos and Aquariums (WAZA), most developments undertaken aim to be in accordance with international practices.

The NZG is regarded as a leading zoological institution with international recognition. With nearly 643 species and 9000 specimens, the NZG has one of the largest and most remarkable animal collections in the world. Having developed three unique Game Breeding Centres, the zoo is ideally suited to make a significant contribution to the conservation of

biodiversity in Africa. Over 70 species, categorised as ‘threatened’, have been successfully bred. This thriving record makes the zoo the most successful ‘ex-situ’ conservation agency in South Africa.

The NZG is also closely associated with other zoos and agencies devoted to conservation in numerous African countries, including Algeria, Angola, Botswana, the Democratic Republic of the Congo, Ivory Coast, Mozambique, Malawi and Nigeria (NRF, 2006).

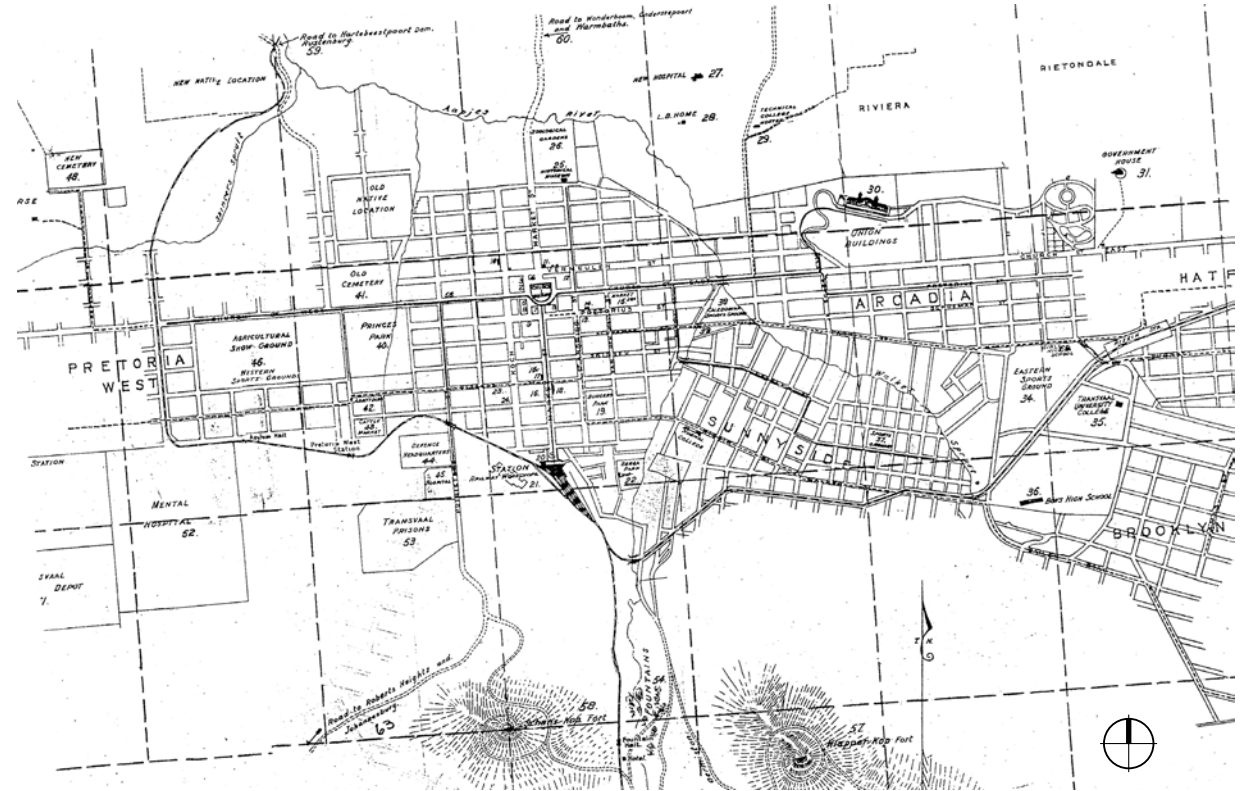


Figure 4.6 Map of Pretoria showing the NZG, 1928.

# National Zoological Gardens Masterplan

## *Introduction*

## *Services Analysis*

## *Ecology Analysis*

## *Zoo Analysis*

## *Masterplan*

### *Introduction*

The Department of Public Works and Land Affairs commissioned the firm Dry & Joubert Architects on 24 August 1989 to develop a masterplan for the National Zoological Gardens of South Africa (Hereafter referred to as the NZG or the zoo). The absence of a masterplan was placing severe pressure on the zoo regarding any future projects and developments. The masterplan therefore provides a detailed guideline for future development and operations.

The provisional masterplan consists of two volumes:

1. Volume 1 includes a masterplan for the NZG of South Africa.
2. Volume 2 includes a complete animal inventory of the NZG of South Africa.

The original document was then expanded by the firm Dry Mokoena & Partners in June 1996, as instructed by the Department of Public Works.

For the purpose of this project, Volume 1 was acquired for its information regarding site conditions, geological and geotechnical aspects.

“By exhibiting, caring for, acquiring and multiplying indigenous and exotic animals, a national and educational service is rendered to the community and thereby to foster concept, knowledge, research, maintenance of appreciation for our wild life.” - Dry & Joubert Architects, 1991.

### *Limitations*

As the only available geological and geotechnical survey and analysis of the NZG was completed in 1991, variations may be expected. For the purpose of this dissertation and the relevant analyses, such as soil conditions, the data in question is assumed valid.



## *Services Analysis*

### *Water*

The NZG currently consumes water from four different sources, including the Municipal supply, bore holes, purified sewerage from Daspoort Water Care Works and water from the Apies River (Dry & Joubert Architects, 1991).

#### *Municipal Water*

Metered water supply from the Municipality is supplied to the NZG via a 100mm Ø connection located on Boom Street, adjacent to the Aquarium building. This water is then utilised for human consumption, drinking water for animals, fire water throughout the zoo and a limited amount used for irrigation purposes, via 50mm Ø connections (Dry & Joubert Architects, 1991).

This water is stored in five different elevated tanks located in various points within the zoo, including: the main entrance, elephant enclosure, restaurant, farmyard and the composting area.

### *Bore holes*

There are seven serviced bore holes within the NZG. Water from these bore holes is used to supply the aquarium, water features, including drinking and irrigation water for animals and gardens which are located north of the river respectively.

Bore holes 1 and 3 are situated within the new elephant site precinct. Bore hole 1, situated north of the river close to the western boundary of the zoo, supplies water through a 50mm Ø GMS pipe to elevated water storage tanks in the Aquarium building (Dry & Joubert Architects, 1991).

Bore hole 3 however, also situated north of the river, dispenses water through a 100mm Ø GMS pipe to a ground level reservoir. This reservoir then supplies water to the farmyard, to the pond and water feature with a water wheel which specifically circulates water, via a 75m Ø gravitational feeder. This reservoir also supplies drinking water to the two game enclosures east of the reservoir.

### *Purified water*

Purified sewerage, extracted from the Daspoort Water Care Works, is only utilised for irrigation purposes south of the river. This purified water, supplied to the south western corner of the zoo, is of a high biochemical standard suitable for irrigation only. Under an agreement entered into by the Government of the Union of South Africa and the City Council of Pretoria on 21 February 1957, the government is allowed to extract water from the river in lieu of the 500kl of effluent supplied 8 hours per day to the zoo from Daspoort.

Previous tests of this water supply indicated that effluent treated with lime and alum, while being fully chlorinated, will be in accordance with the Water Act (Dry & Joubert Architects, 1991).

### *Water from the Apies River*

The hippo pool just north of the river, soon to be an elephant pool, only utilises water from the Apies which is pumped directly into the pool. The pool is flushed twice a week, with the effluent water led gravitationally back to the river.

Water from the river is also used to irrigate gardens closely surrounding the pool itself, being the site chosen for the project.

When testing was carried out of all effluent water being released back into the river from various pools, ponds and dams in the zoo, these tests revealed that all water, excluding that from the hippo pool, met the requirements. It was recommended that water from the hippo pool be passed through a fine sieve in order for the water and effluent quality to be acceptable (Dry & Joubert Architects, 1991).

### *Storm Water*

The present, somewhat improvised, storm water system in the zoo gravitates naturally towards the Apies River, which itself functions as a primary storm water collector for the CBD of Pretoria.

The system installed south of the river has longer, underground lines discharging storm water directly in the river. The system north of the river is less formal, with storm water lines discharging into open channels.

Due to the location of the farmyard, it is predicted that in the event of an extreme storm it will be flooded by 0,5m of water, which can be seen in the 1 : 50 year flood line drawing (Dry & Joubert Architects, 1991).

## Services Analysis Plans

### Sewerage (Not to scale)

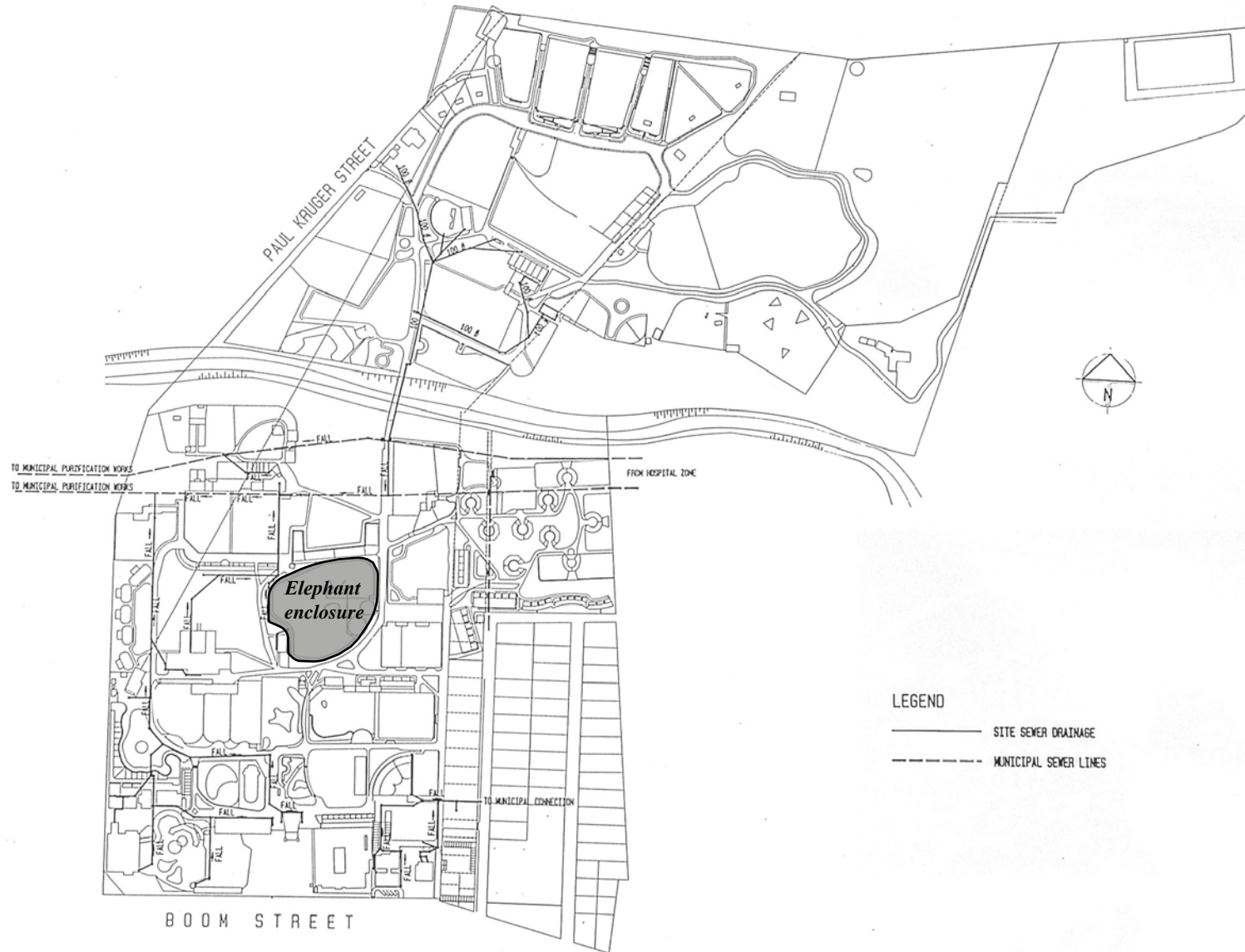


Figure 4.7 Sewerage map

*Municipal Water Supply*  
(Not to scale)

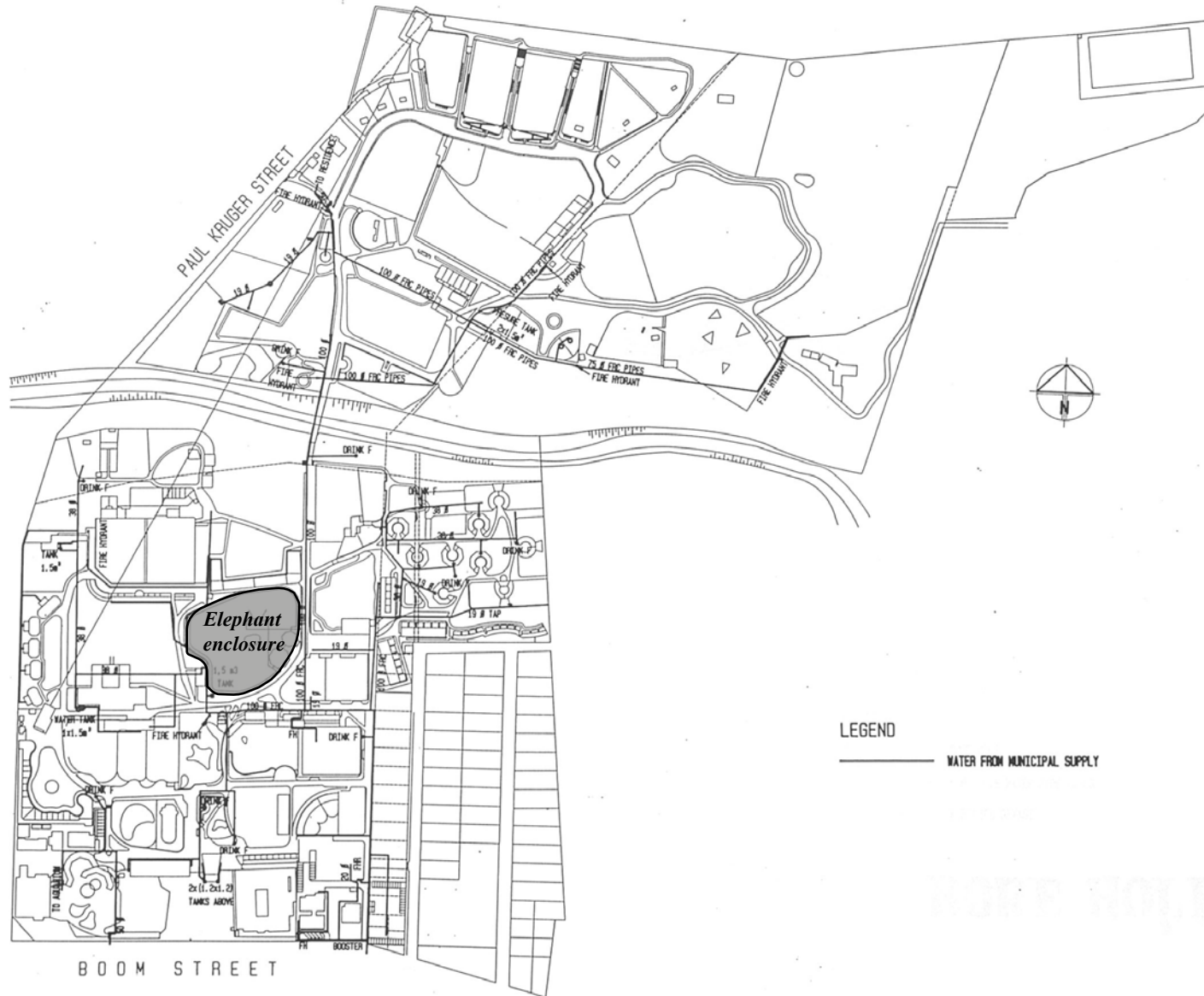


Figure 4.8 Municipal water supply map

*Bore Holes & Purified Sewage*  
 (Not to scale)

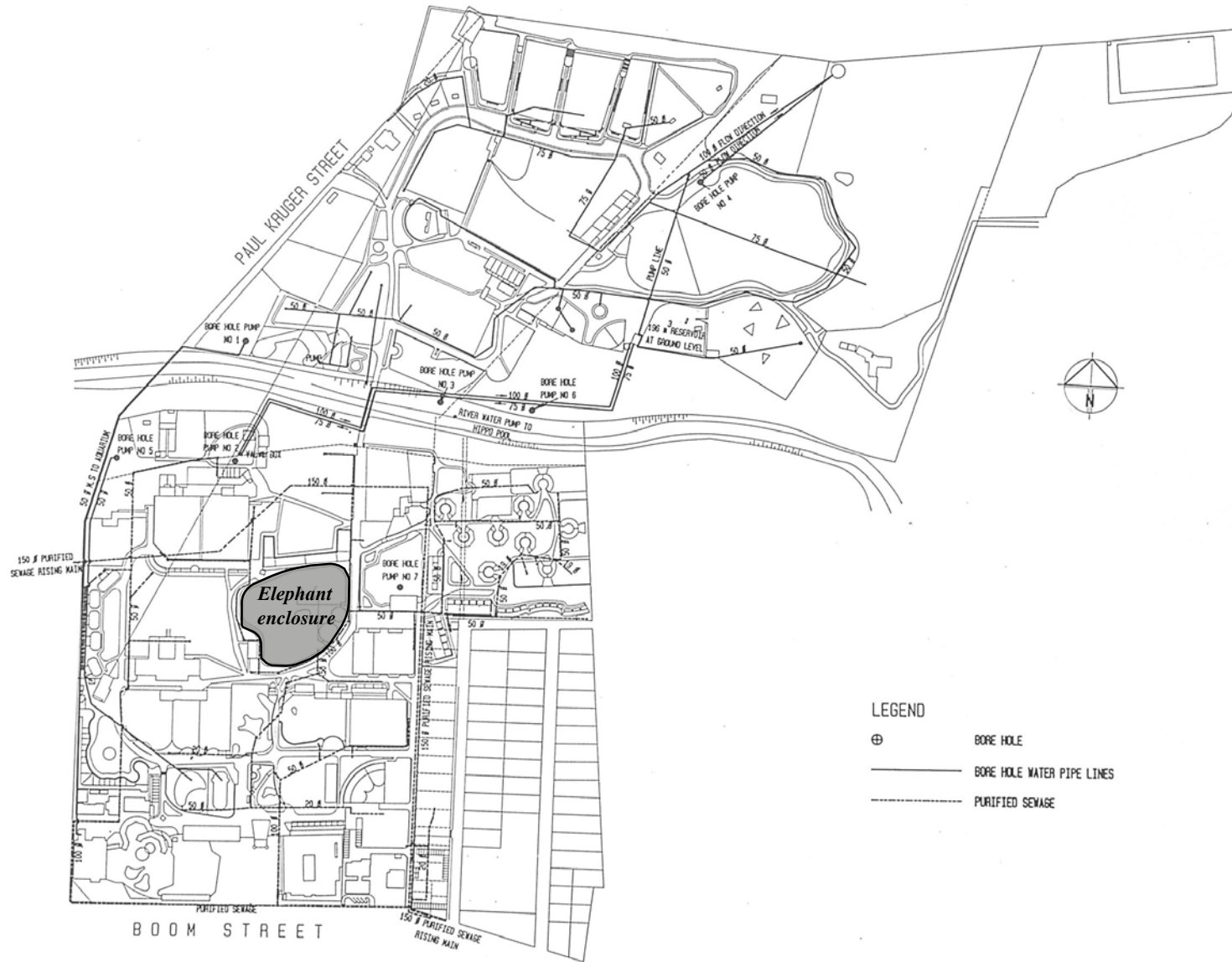


Figure 4.9 Bore Hole map

*Storm Water  
(Not to scale)*

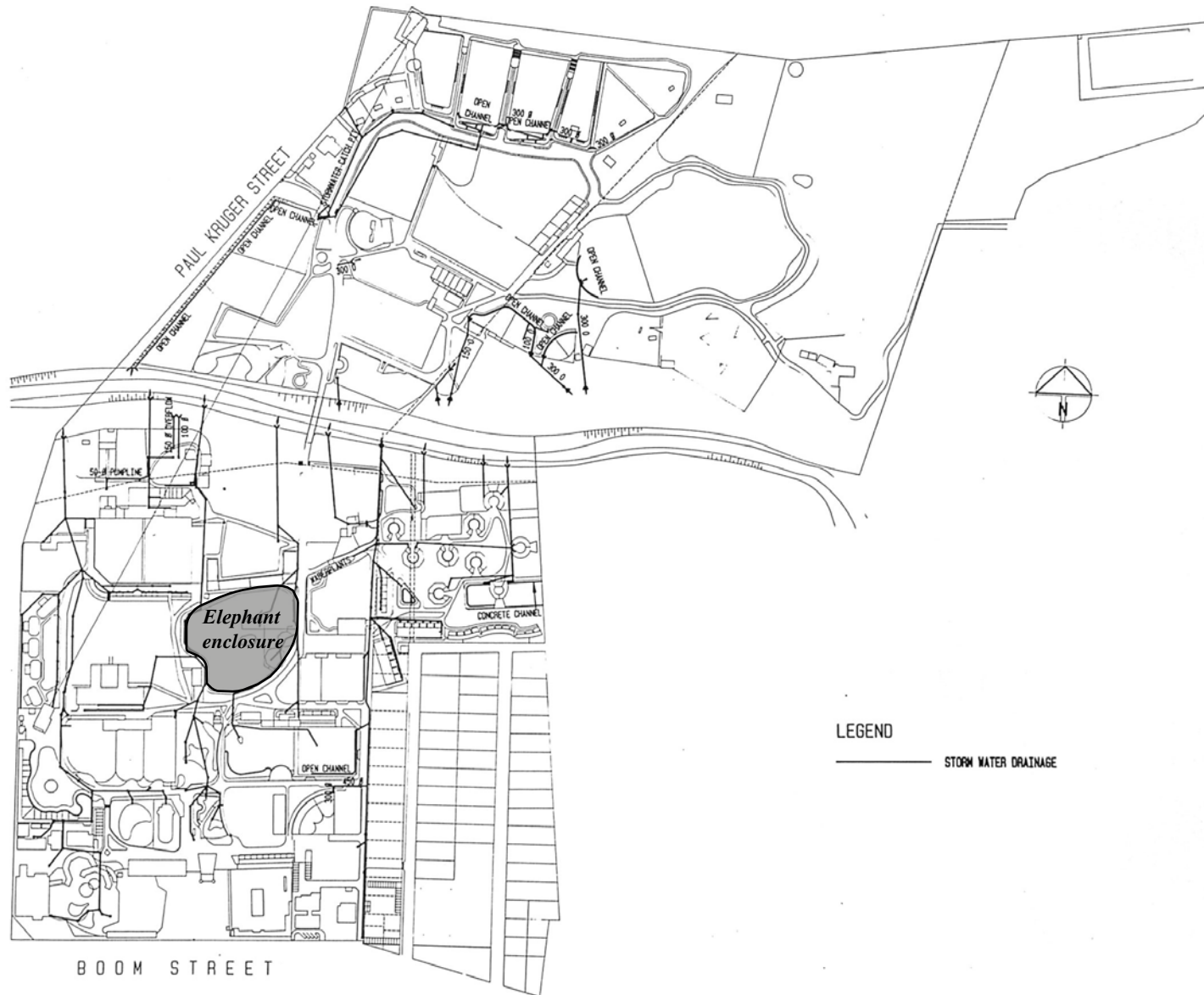


Figure 4.10 Municipal water supply map

*Electrical Supply*  
(Not to scale)

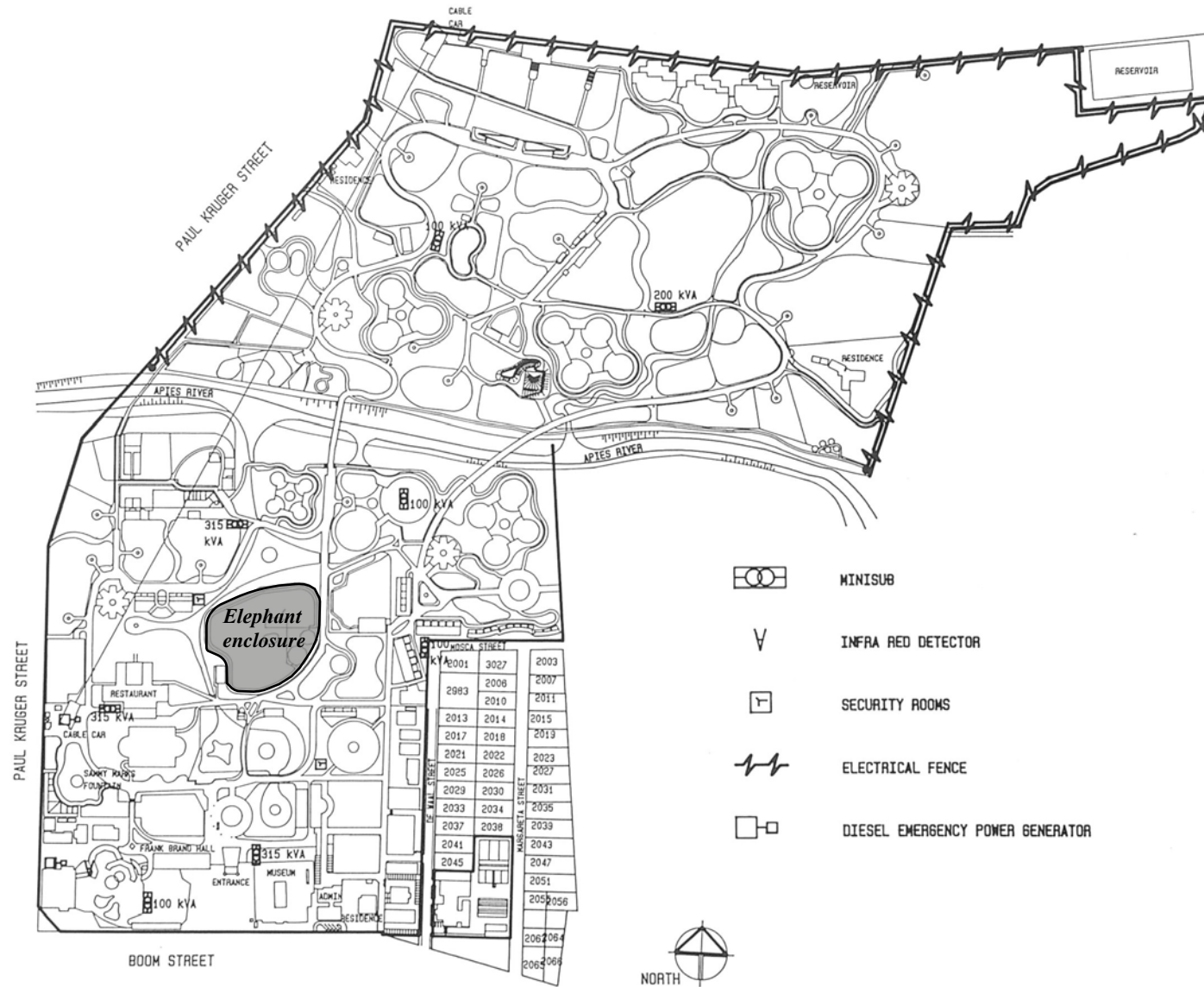


Figure 4.11 Bore Hole map

## *Ecological Analysis*

### *Soil Survey*

The soil survey was undertaken to characterise the soil and other related terrain structures, to be understood in terms of suitability for future landscaping developments.

Soil was classified according to the binomial system for South Africa, and described morphologically. Eighteen soil profiles were specifically chosen and investigated throughout the NZG to derive a detailed soil survey. These eighteen open test pits were excavated by means of a tractor mounted backactor (TLB), and entered by an engineer. The soil profiles were described according to the visual and tactile procedures, including: moisture condition, colour, soil consistency, soil structure, soil type and origin (MCCSSO) (Dry & Joubert Architects, 1991).

### *Regional Geology*

The NZG is situated on recent alluvial and colluvial sands, clays, gravels and residual soils, with quartzite, shale and andesite bedrock underlying at a depth. A diabase sill, spread across east-west in the northern portion of the zoo, is intruded into the sediments.

### *Bedrock*

Outcrop of quartzite bedrock expands along the northern portion of the NZG, with shale and andesite bedrock to the south of the river (Dry & Joubert Architects, 1991).

### *Soils*

Most of the site is covered by transported and residual soils. A thick horizon of made-ground is present along the northern and southern banks of the river. The transported soils are underlain by a well-developed pebble

marker horizon which separates them from the underlying residual soils and bedrock (Dry & Joubert Architects, 1991).

### *Ground Water*

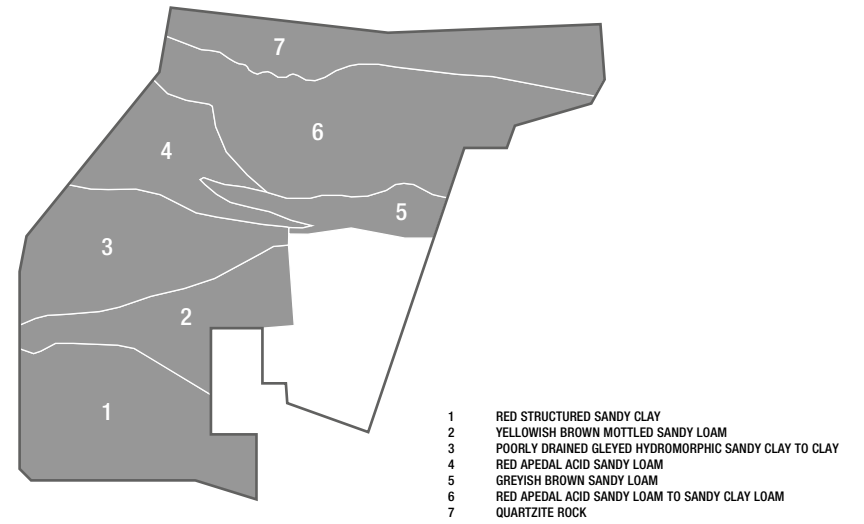
The water table was only encountered at depths of between 1,6 and 2,5m in test pits situated along the southern alluvial floodplain of the Apies River.

### *Collapsible Soils*

Areas situated near the north-western boundary of the site may encounter potential collapsible soils. Foundations for any structures built in this region should be excavated to a depth of 1,5B, where B is the width of the foundation footing. The excavated material should then be replaced in well-compacted layers, up to the desired foundation depth (Dry & Joubert Architects, 1991).



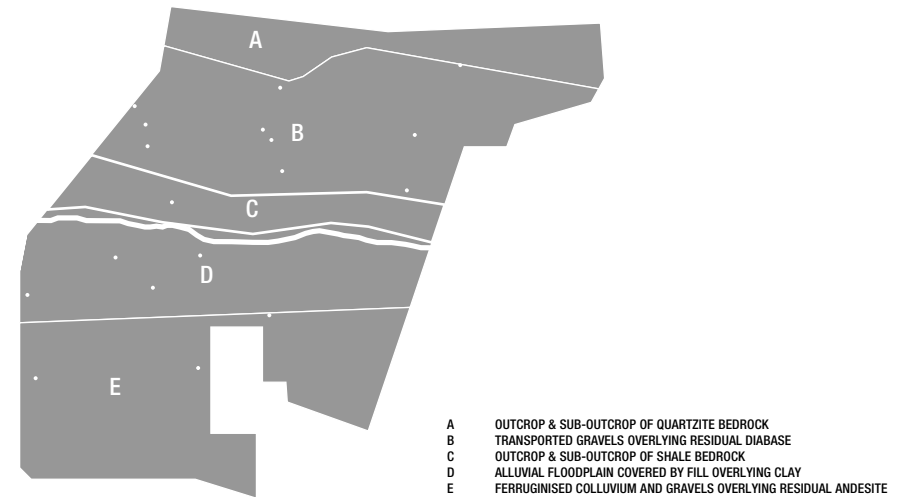
# Ecological Analysis Maps



Detail Soil Survey  
National Zoological Gardens



Geological Plan  
National Zoological Gardens



Geotechnical Plan  
National Zoological Gardens

Figure 4.12 Map summaries of various ecological conditions

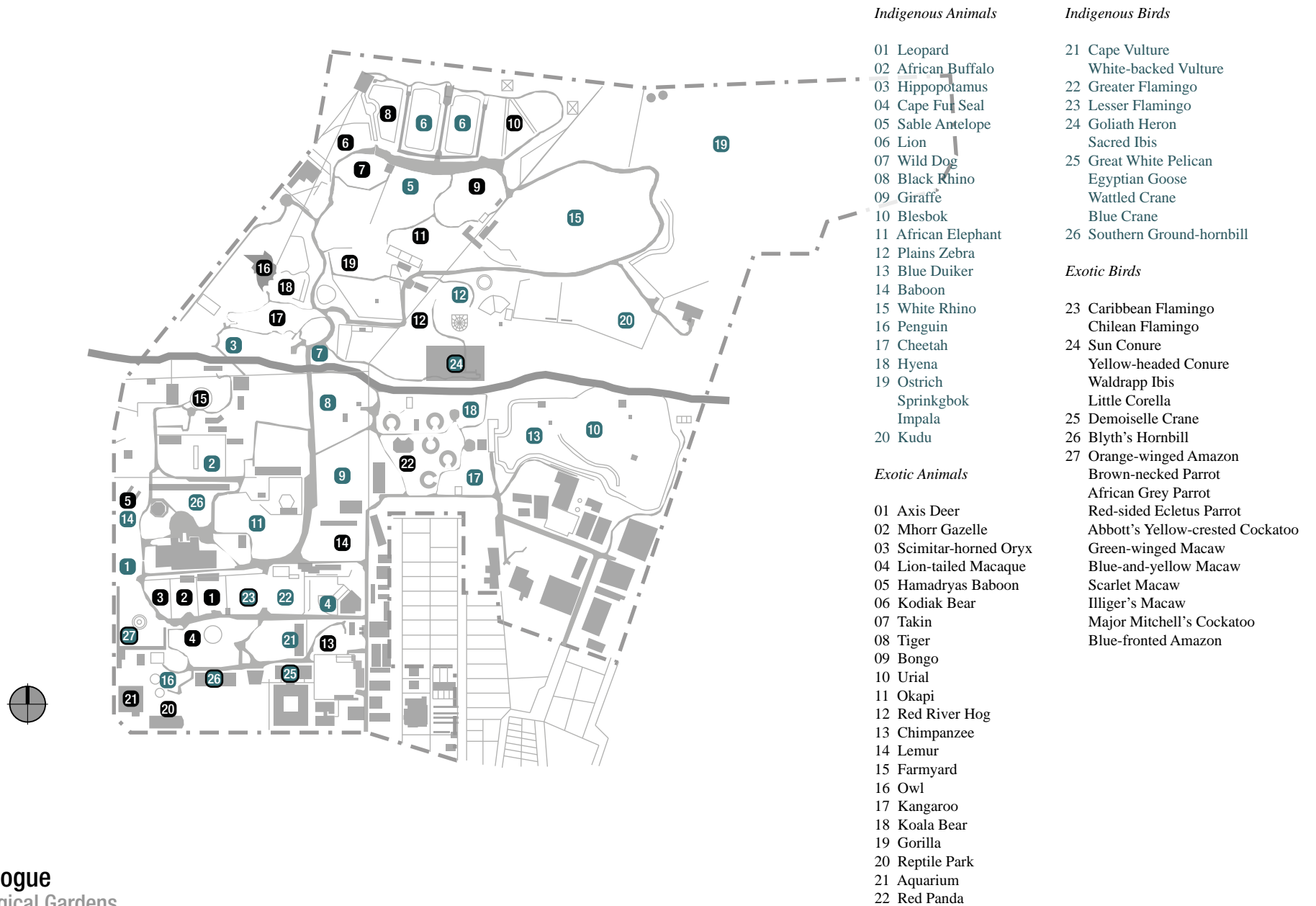
## Zoo Analysis

*Base condition map*  
*Barrier Analysis*  
*Material Analysis*



## Latest Enclosure Map National Zoological Gardens

Figure 4.13 Map summaries of various ecological conditions  
56



**Animal Catalogue**  
National Zoological Gardens

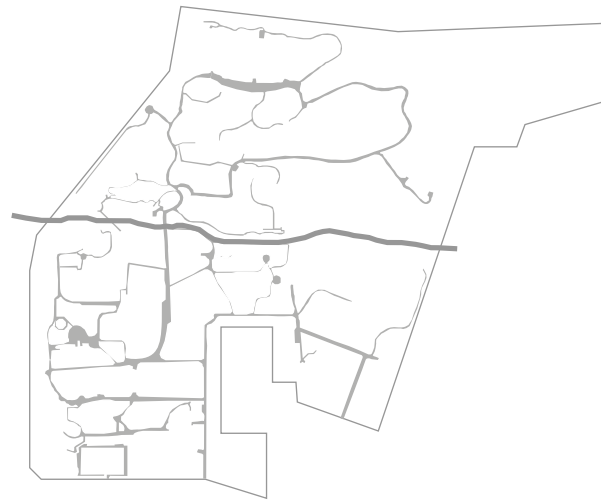
Figure 4.14 Map summaries of various ecological conditions



**Animal Enclosures**  
National Zoological Gardens



**Accommodation**  
National Zoological Gardens



**Circulation**  
National Zoological Gardens

Figure 4.15 Map summaries of various spatial conditions  
58

# Masterplan

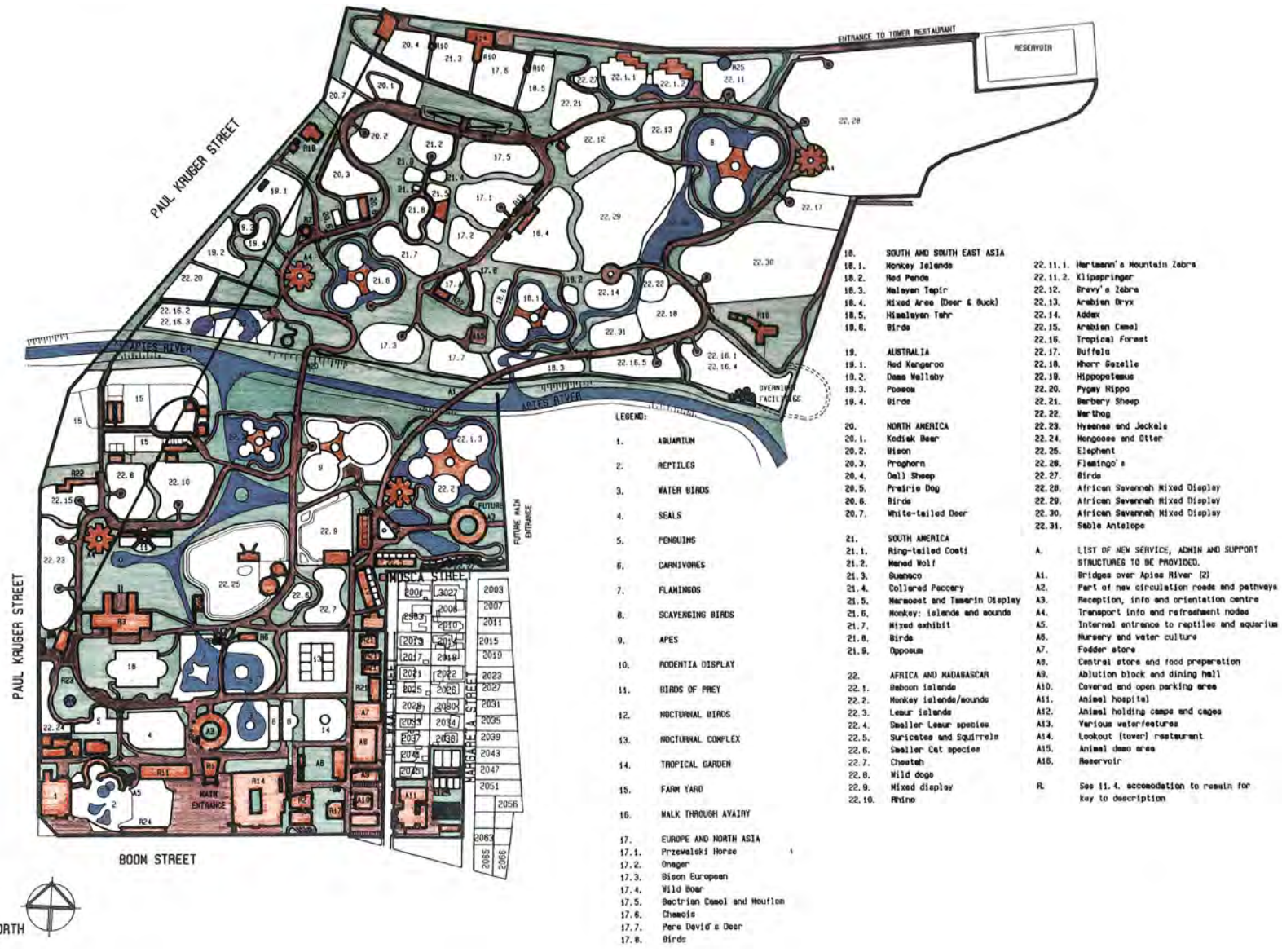


Figure 4.16 Masterplan proposal

## Photographic Analysis

### *Barriers in NZG*

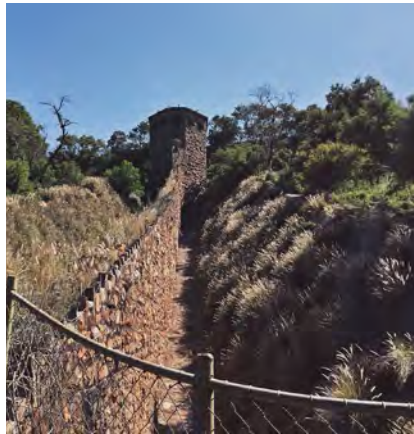


*Figure 4.17 Photographic collage of various barrier methods in the NZG (Author, 2016).*



## Photographic Analysis

### *Material Palette in NZG*



*Figure 4.18 Photographic collage of different materials and textures found in the NZG (Author, 2016).*



### Current hippo pool

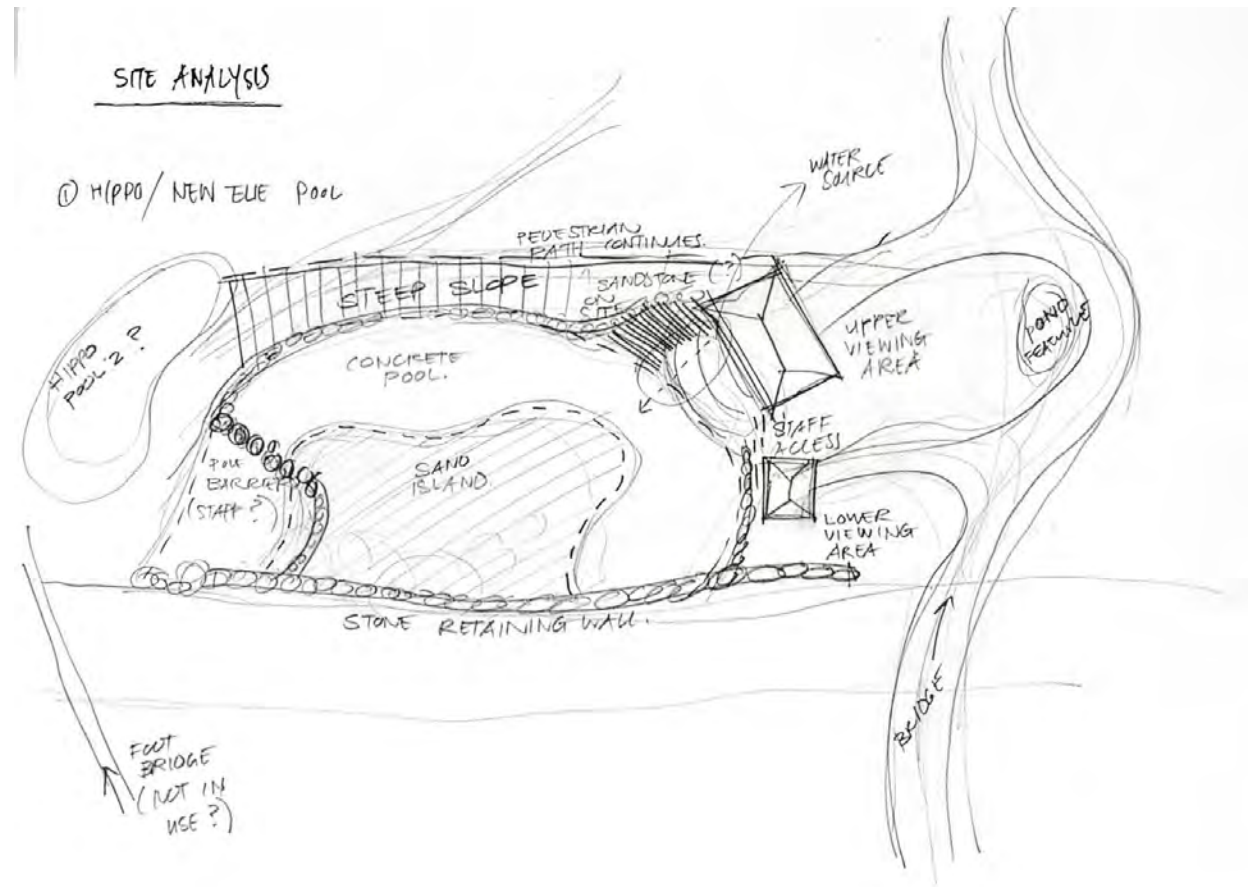


Figure 4.19 Site analysis sketch of current hippo pool to be converted for elephants (Author, 2016).

## Existing elephant enclosure critique

### *Lack of Space*

The current enclosure is not compatible for elephants due to the lack of space. The three elephants residing at the zoo do not have the freedom to roam and meander beyond the small confines of their enclosure, despite plenty of wasted and unused space in the zoo. Companionship of other elephants and allowing for a larger herd to live together is also unattainable due to the limited space of the enclosure. Elephants in the wild are typically active for 18 hours a day, most of which is spent roaming vast distances, socialising with their herd, and expressing their natural behaviours such as foraging for fresh food and vegetation, playing, bathing and spraying themselves with water from rivers and waterholes and traveling as far as 50 kilometres (PETA, 2016) – all of which are currently-impossible within their small and unvaried enclosure. Therefore the boundaries of their enclosure need to be expanded drastically while simultaneously giving them the opportunity to explore the varied terrain that the zoo has to offer, with plenty of water sources, ponds, pools, mud wallows, trees and hills, for the sake of their physical and psychological health and well-being (PETA, 2016).

Most elephants living in captivity are deprived of their most basic needs – being able to live in natural, matriarchal herds with extended social relationships, and the freedom to roam long distances, both of which occur naturally in the wild (PETA, 2016). Lack of sufficient exercise and long hours spent each day standing on dry, hard surfaces contribute to their many foot and arthritis problems, the leading causes of their significantly short lifespans as opposed to their wild counterparts. The enclosure consists of only dry, hard compacted earth with no other variation in substrate, contributing to their poor foot health.

### *Lack of water*

Elephants depend greatly on water for drinking, cooling down and for general skin health and hygiene. The apparent waterhole is far too shallow to be used effectively for bathing and cooling; and the actual water itself is dirty and polluted.

The only other water source visible in the outdoor space is a sprinkler on far edge of the enclosure, closer to the building, and does not reach far enough into the enclosure to be of any use to the elephants. Grass growing in the barrier trench is greener and unfortunately out of reach to the elephants.

Mud baths, an option not currently provided, serve as a critical prerequisite for elephants to protect them from the harsh African sun, heat and UV radiation. Aside from cooling them down, mud helps to form a protective barrier from harmful sun rays as their skin is surprisingly sensitive and susceptible to getting sun burnt. In the wild, elephants are used to coating themselves in plenty of mud and dust whilst seeking shade (Witvrouwen, 2012).

### *Lack of Shade*

As neither mud nor loose sand or dust is provided for the elephants to coat themselves, it is intolerable that they do not have ample tree shade or artificial cover either. The only trees found in their enclosure are palm trees which do not provide any shade - despite the abundance of diverse trees found in the zoo, particularly north of the river. To add to the elephants' distress, the large doors to their night houses are closed during the day to force the elephants to remain outdoors for public viewing and amusement – despite their own needs being so blatantly ignored. The extent of the damage from the lack of natural and artificial shade protecting them from direct sunlight, is evident in the severity of their poor skin health.

### *Lack of stimulation*

No attempt of mental or physical enrichment is evident, leaving the elephants looking severely bored and unstimulated. This profound deprivation and lack of stimuli is evident in their repetitive swaying back and forth, an abnormal behaviour indicative of poor welfare and health (San Rafael, 2015).

Elephants feed from hay on the ground. There have been no visible attempts from the staff to design any innovative methods of feeding or devices used that encourage natural foraging behaviours and actions. This is especially unforgiveable as many elephants bred and living in captivity never learn to fully use all the muscles in their trunks, as wild elephants would when searching for food. This may result in them never being able to lift their trunks above their heads and being able to use them to their full potential.

### *Unsafe Barriers*

The current barrier design is dangerous and can lead to potential injuries if an elephant attempted to escape. The barrier trench is built from brick wall construction with electrical fencing along the perimeter; this is problematic due to the small width of the trench,

the vertical brick walls and no slope within the trench. Requirements state that any dry moat design should ensure that the trench be wide enough to allow an elephant to turn around and comfortably walk back up the slope without any difficulties or risks of injuries.

### *Architecture*

The only positive feature in the outdoor enclosure is the artificial rocks. Due to their grouping, large size and colouring, they easily resemble the African elephants themselves and help camouflage them as they move through or behind them – but only when viewed from the southern edge of the enclosure. These rocks attempt to function as visual barriers but do not sufficiently provide enough privacy for the elephants to shy away from the public's glare.

### *Privacy & Noise*

The enclosure does little to protect the elephants from any disturbing noises. Elephants have sensitive hearing and can detect sounds as low as 14 to 16 Hz (human low range is 20 Hz); therefore low frequency noise needs to be minimised due to their sensitivity to these sounds.

## Photographic Analysis



*Current elephant enclosure & barriers*



*Figure 4.20 Photographic collage of existing elephant enclosure at the NZG (Author, 2016).*

*Figure 3.1 During the Middle Ages, artists had known of the existence of elephants having heard stories and descriptions from other travellers. Various paintings and illustrations were done based on these descriptions, despite the artists having never actually seen an elephant (Sunny Skyz, 2016).*





Figure 4.21 Panorama of the existing elephant enclosure



*Figure 4.22 Panorama of the existing elephant enclosure*



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*“At a time of greater awareness of the plight of elephants in the wild, who are dying for the illegal ivory trade, it is shocking that captive elephants continue to suffer and die prematurely at the very zoos that are claiming to help save these species”*

*-Toni Frohoff, Ph.D.,  
Elephant and Cetacean Scientist for IDA.*

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*Figure 4.23 Photo of new site for proposed elephant enclosure  
(Author, 2016).*



# CHAPTER 5

## Precedents

*Elephant Trails of the Smithsonian Zoological Park in Washington D.C., visited by the author, forms the primary influence for creating architecture for elephants and people. Spatial planning to ensure optimal elephant care and management, elephant enrichment, sustainable design, energy efficient technologies and of course, suitable materials were all investigated.*

# Elephant House, Zoo Zürich | Markus Schietsch Architekten

*Location: Zürichbergstrasse 221*

*Area: 8 440.0 m<sup>2</sup>*

*Project completion year: 2014*

*Client: 57.0 Mio SFr*

The most striking feature of the new elephant building is the large wooden roof, with ETFE plastic skylights, that encloses a large space, terminating and merging into the landscape. Despite it being an enclosed indoors space, there are plenty of trees and natural substrate, with selective views to the sky to allow sunlight to filter through, generating changing light patterns and atmospheres. These atmosphere effects are representative of light filtering through tree canopies. The iconographic organic shape of the roof conveys a sense of “Nature-Construction” a symbiosis between architecture and the natural landscape (Archdaily, 2015). Apart from adhering to the unique building requirements for elephants, allowing them to experience a space based on their natural habitats was an important design informant and consid-

eration, for both the elephants and visitors.

The new enclosure provides the ten Asian elephants with six times as much space as they previously had, to roam between changing indoor and outdoor environments. The site was chosen for its open, slightly sloping landscape and thick vegetation for the new elephant building. The overall 11 000 m<sup>2</sup> enclosure contains numerous watering holes for the elephants to fully submerge themselves in and bathe. Visitors are also able to view the elephants swimming from an underwater vantage point (Frearson, 2015).

In accordance with new AZA requirements, the elephants are cared for in protected contact only within

the new building. The elephants and their handlers therefore are separated from each other and will never cross paths or be in a same space at any given time. This not only establishes better safety for the handlers and staff, but it enables elephants the freedom to develop their own natural social behaviours and bonds with one another (Swiss-Architects Review, 2015).



## Elephant House, Copenhagen Zoo | Foster + Partners

*Location: Copenhagen Zoo, Denmark*

*Area: 3 500 m<sup>2</sup>*

*Project completion year: 2008*

*Client: Foundation Realdania for Copenhagen Zoo*

Copenhagen Zoo, located within a historic royal park, commissioned a new Elephant House to celebrate these noble, magnificent creatures and provide them with a more natural, healthy and enriching environment. Visitors experiencing the enclosure were also considered from the start of the design process, to create easily accessible spaces, both physical and visual, from which the public can observe the elephants in a naturalised habitat.

An extensive research investigation was conducted regarding elephant social patterns and networks, and other behaviours expressed in the wild, to design a specialised enclosure that addresses all their needs. As male elephants are inclined to separate from their mothers and the matriarchal herd when they reach sexual maturity, the architects structured their design around two separate enclosures for the female and male herds. This formed the primary design informant that influenced the rest of the decisions that followed.

These enclosures provide the benefit of passive thermal mass and heating as they are embedded into the sloping landscape, while also minimising the building's impact on the earth. These enclosed day areas are covered with glazed domes that offer the elephants strong visual connections to the surrounding sky and varying light patterns during the course of the day. Visitors are provided with viewing spaces along these internal enclosures, which then direct them to the various paddocks and yard spaces outside. Discreet barriers are put in place to protect both the elephants and visitors alike (Foster and Partners, 2008).

This new building contributes to new zoological standards concerning elephant management and their mental and physical wellbeing. The larger of the two internal enclosures allows the six female elephants and their calves to socialise and sleep together, a first for elephants in captivity, as they would in the wild. The enclosures are filled with sand with heated slabs



underneath to maintain healthy foot care for the elephants.

Additional elements, as a result of research of elephants' natural habitat, include the surrounding paddocks and yard spaces. The paddocks reinvent a dry riverbed condition, as found at the edges of rainforests (Foster and Partners, 2008). The concrete walls have a warm terracotta-colouring, and the yellow beach-like sand naturally existing on the site, was reused to create the paddocks. These textures and colours are symbolic of the dry riverbed found in the natural habitats of Asian elephants (Fairs, 2008).



### *Special Features*

As a fully grown male Asian elephant weighing 5, 5 tonnes may be prone to aggressive behaviour, and can exert a force of 15 tonnes on a wall, all enclosing walls were constructed from reinforced concrete, 300mm thick. Precast concrete panels were used in the stable walls, with an exposed aggregate finish to allow the elephants to rub and exfoliate their skin against the textured surface.

To prevent direct sunlight and glare entering the large day areas, a 'fritting' pattern on the glazed dome roofs was computer scripted by varying, overlapping leaf designs to provide

naturalistic, dappled light entering the space – similar to that of tree canopies. These glazed sections in the domes have operable windows to optimise natural ventilation, and together with a heat recovery system, fully enhances the energy efficiency of the overall building (Fairs, 2008).

# Elephant Trails | Smithsonian National Zoological Park, Washington D.C.

Architects: *pja architects + landscape architects*

Location: *Washington D.C., United States*

Area: *8 943 m<sup>2</sup>*

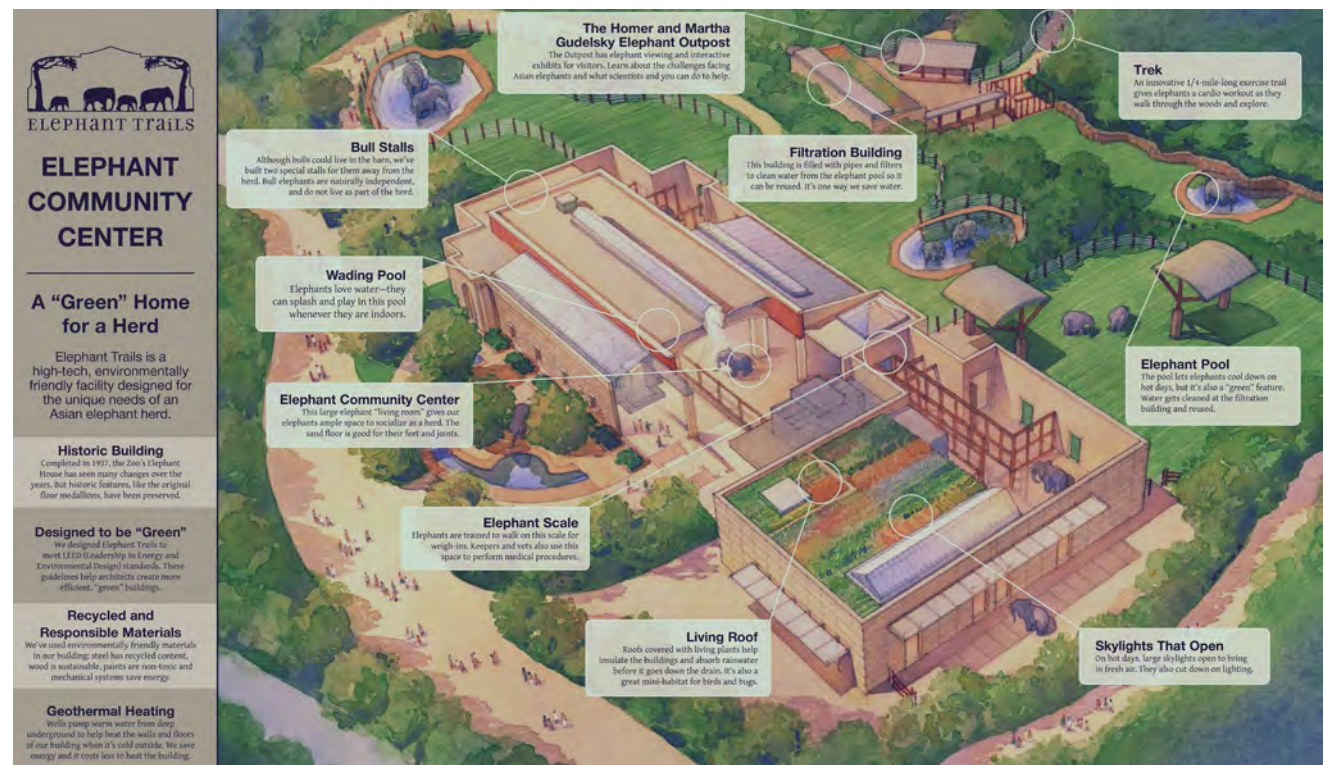
Project completion year: *2012*

Client: *Smithsonian National Zoo*

## Introduction

The Elephant Trails facility at the Smithsonian National Zoological Park in Washington D.C was recently renovated and expanded in 2013, now covering a total area of 8, 943 square metres. The site is divided into an indoor exhibit of 1,232 square metres and an outdoor one of 7,711 square metres.

The facility is large enough to be able to accommodate between eight and ten fully grown Asian elephants as well as their young; however the handlers have decided on rather catering to six Asian female elephants, including a small matriarchal herd which they hope will expand (Smithsonian National Zoological Park, n. d). It will require a long time to have a multi-generational herd at the zoo due to long breeding time and limited space. Besides a mother and daughter currently residing at the facility, all the other elephants are unrelated.



## History

The large mammal house was completely reconfigured and renovated in 2013, since the opening of the original stone building in 1937. Initially, the large mammal house had smaller enclosures along the periphery with a large, central viewing area for visitors. It now has a large space for the elephants and a much smaller space for the people – prioritising the elephants over the visitors.

Previously, the large mammal house consisted of various species, including giraffes, Asian and African elephants, rhinoceros and hippopotamuses. The decision was made to then only focus on Asian elephants (due to their loss of habitat) and redesign a new facility to cater entirely to them alone.

Recently until six years ago, the handlers worked with the elephants in free contact. The decision was then made to convert to protected contact in keeping with AZA (Association of Zoos and Aquariums) regulations. The facility opted instead for open barriers, as barriers were still needed –

even inside, between handlers and the elephants. Due to an unfortunate event where

an elephant accidentally killed a handler in another zoo, a re-evaluation was prompted and the shift to protected contact. They currently do have their accreditation with the AZA which is evaluated every five years.

After every incident that takes place within the zoo or any cases across the country, the safety and security of the zoo is re-evaluated. The zoo is currently preparing to put in a 4 metre barrier as an additional safety measure (Flinkman, 2016).





### *Experiencing Elephant Trails*

A better, detailed understanding of the facility and the management and care of elephants was achieved through a two hour discussion and private tour on the 8th of July 2016 with one of the senior elephant handlers, Deborah Flinkman. Deborah, who has been working with the elephants for twenty-six years, generously welcomed all questions while showing and explaining each of the rooms and spaces within the elephant building where public access is strictly forbidden.

### *Features*

The objective of the facility is to provide the elephants the freedom to move between various indoor and outdoor spaces on a daily basis, particularly in the evenings when all handlers leave the zoo premises. The new building includes an Elephant Community Centre (which the public are allowed to experience from a safe distance) and an Elephant Barn containing nine indoor living spaces for shared or single use depending on the elephants. The outdoor exhibit consists of seven enclosures, including four exhibit yards and two paddocks. There is also a half kilometre fenced Elephant Trek, unique to the National Zoo, which provides a walking trail for the elephants to encourage outdoor exercise through the elevated terrain and wooded vegetation. Visitors are able to view the elephants on their daily walks from selective raised viewpoints.

The six female elephants have access to several varied

outdoor enclosures containing features such as pools, sand piles and mental and physical stimulation and enrichment devices that aid in stimulating natural behaviours. These outdoor enclosures or yards provide almost a hectare of varied terrain, elevations and opportunities for foraging, exploring, exercising and socialising, and provide the handlers with optimal herd management (Smithsonian National Zoological Park, n. d).

Although not fully functional and efficient, there are a several open structures with roofs in the yards meant to provide protection from the sun during the summer, and provide heat in winter. In reality, they provide very little sun protection due to placement height and small roof areas.

The Elephant Community Centre, a large indoor exhibit with enrichment for the elephants, also provides public viewing of the elephants and an exhibition and information point for educational purposes. This centre exhibits first-class animal husbandry, state-of-the-art elephant care facilities and medical care, while also contributing to the Smithsonian elephant research committed to elephant conservation. This centre provides abundant space for the elephants to socialise, exercise and play. It includes a wading pool with overhead shower sprays that can be activated by the elephants themselves with a foot press. This centre provides visitors with incredible opportunities to view these creatures and learn about elephant physiology and behaviours, both social and cognitive, as well as animal care given to them.

The building also has a separate facility adjacent to the Community Centre which is strong enough to house an adult bull if one were to be brought to the zoo in the future (Flinkman, 2016).

The entire elephant facility is approximately two acres of space. Currently, the facility consists of 6 female Asian elephants – the largest number the zoo has ever had. The young male calf born in the zoo previously was moved to another zoo with a breeding facility when he ‘came of age’. There is only one female elephant at the moment who is suitable for breeding. There is debate as to whether a male elephant will be brought to the zoo for this purpose or if artificial insemination would be an easier and more affordable option. On the other hand, it is not certain if the female elephant will accept the training for the artificial insemination – which is a time-consuming process.

The facility has what is called a restraint device (ERD, also called a ‘squeeze cage’) which allows the elephants to be reinforced positively into this device, which is not a harness. They are given treats and made comfortable while inside. It is used for examinations and minor procedures. The sides of the device are slowly closed in on the elephant in a much smaller space. Training is required to allow elephants to gradually become accustomed to this device as a form of reinforcement. At first they are taught to just walk through it, and slowly they are fed inside it to ultimately allow them to be comfortable being inside. The training thereof becomes part of their daily rituals. The device also has a scale for handlers and veterinarians to monitor the weight of the elephants (Flinkman, 2016).

The facility has never had an adult bull residing at the zoo. Before the renovation in 2013, the facility was not able to house any adult males since only male Asian elephants have tusks which can be problematic and dangerous. Now the prospect is welcomed to contribute to public education, allow for breeding and to provide sanctuary to any bulls in need.

The elephants receive a lot of enrichment, both physically and mentally, throughout the day. The elephant handlers also provide a daily demonstration to the public – if the elephants are willing to be present and respond to simple commands. Food is placed in different containers at different heights to encourage ‘foraging’.





## Challenges

- Enormous expense (renovation)
- Geothermal heating is an interesting element in the facility.
- Having multiple and adequate spaces for all the equipment for the handlers' needs – for example a hydraulic lift, connected to a cross beam running through all the barns, to lift an elephant that is down to keep it upright or elevated to prevent injuries or complications. This proves to be a challenge in itself in order to be gentle and yet strong enough to support an elephant. This hydraulic lift is able to lift up to 5, 5 tonnes, the size of an adult Asian elephant.
- Due to the extreme cold in winter (half a metre of snow at the worst), elephants have to be housed indoors for the majority of the time. Therefore it was necessary for reinforced steel and concrete doors. Otherwise, the elephants are free to move between indoors and outdoors as they please. Ice is a bigger concern where elephants will need to be housed permanently for safety reasons.
- Sun protection – adequate coverage is a concern. Several of the single roofed structures scattered throughout the outdoor spaces do not provide the sufficient shade in summer as they were hoping for. Elephants do, however, cover themselves with sand and mud for cooling and skin protection purposes from the sun, yet ample shade is still something that should be present. Indoor spaces need to be kept cool in summer for elephants wishing to remain inside.
- Due to leakage issues, three of the four pools are currently empty, including the biggest pool that is visually accessible to the public. Due to the size, it is the only pool where partial to full submerging of elephants is possible depending on their size. The other pools are merely splash pools. Due to lack of funds, the main pool could not be renovated as hoped and remained as is since being built in 1937.
- On one of the roofs they have solar panels as well as growing plants on the green roof.
- Being an interstate zoo, there is no space for expansion and designers and handlers have to use the limited amount of space provided as best as possible, which is always a challenge.

## Education & awareness



# Sustainable design

## *Green Building*

The elephant building is LEED (Leadership in Energy & Environmental Design) gold certified for its sustainable and environmentally friendly design (Smithsonian National Zoological Park, n. d).

The building includes several green features including:

- Forty geothermal wells with radiant floor heating and heat pumps are used for heating the barn's floors and walls during winter, and cooling them down during summer months. These wells offer an energy-efficient, renewable source for cooling and heating the building for the elephants.
- Operable skylights run the length of the barn, permitting natural daylight, essential to elephants, while reducing electricity costs. Shade cloths were specifically designed to allow heat the exit through the roof, with fresh air entering through the many doors in the building.
- A green roof with vegetation helps absorb rainwater, reduces storm water runoff, provides insulation to maintain indoor air temperatures, and creates a habitat for wildlife including local birds and other fauna.
- Natural ventilation strategies help improve the building's overall energy performance, which include – operable skylights with retractable shades, and elephant

containment doors with large openings.

- The building's envelope is super-insulated, including the large reinforced steel and concrete elephant doors.
- All elephant pool water is filtered and reused to decrease the amount of wastewater on site.
- Recycled materials were used to meet LEED standards, including stone, sand, wood and demolished concrete.
- The HVAC system was designed to reduce energy use.

## *Safety and access control*

Hydraulic gates are used to separate certain yards to control elephant movement when general maintenance and cleaning needs to be done. As part of Flinkman's suggestion, the operable section of the steel gate was painted yellow to be easily identifiable from a distance as it contrasts the rest of the brown gates and fencing used throughout. This was purposefully done to ensure the handlers' safety while they are working in specific yards, as they can easily identify if the gate is open or closed.

Inside the building, a 'training wall' runs throughout all the barns, parallel to the staff's service wall, that allows the handlers and specialists safe, protected access to the elephants during daily training rituals and

medical procedures.

Between the staff passageway and storage areas, and the elephant barn spaces, runs a 'transfer hall' in which elephants can move between the Elephant Community Centre and the night barns. This transfer hall is comprised of square steel sections with gaps small enough for humans to pass through while securing elephants from escaping into the staff passage. This is what is called the primary containment.

## Flooring



To ensure healthy feet and nails, a recurring problem with elephants in captivity, the floor surfaces used contain various substrates. Sand is excellent for drainage but also provides a more comfortable flooring material for the elephants, causing less strain on their feet and legs.

In the Community Centre and one of the barns, 1,2m of sand above a heated concrete slab works well in terms of drainage and maximum comfort. The rest of the barns, used for sleeping, include rubberised floor material above a heated concrete slab which serves a similar purpose.

The outdoor yards offer a variety of natural substrates, including grass, soft sand, earth and pavement.

## Elephant Care & Management

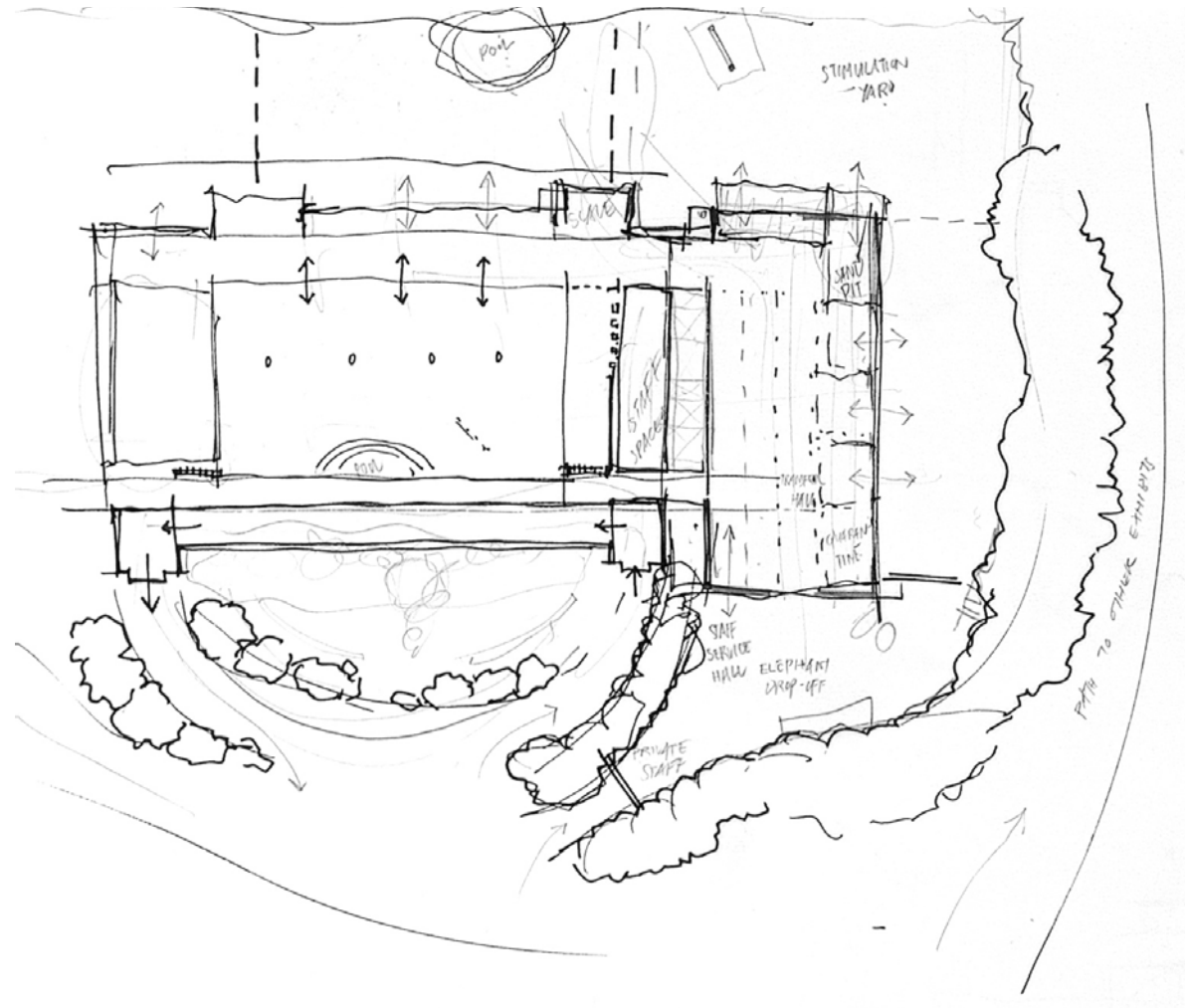
### *Enrichment*

The National Zoo strives to provide mentally and physically stimulating environments and challenges for the elephants in its care. The stimulation provides various opportunities for the elephants to embrace their natural tendencies and abilities, while being in control over their own decisions in the many different enclosures and environments provided.

The handlers document all enrichment challenges and activities they offer their elephants, to continually improve and expand their research contributions to elephant conservation. The type of enrichment activities they provide aim to encourage thinking, problem solving, curiosity, enhance gross body movements and fine manipulation skills. These active behaviours attempt to fulfil husbandry needs and actions, those typically displayed by elephants living in the wild.







*Author's experiential drawing of the building during the visit.*

# Night Quarters





## Health

The handlers incorporate challenging and stimulating training sessions into the daily routines of the elephants. This routine training allows for daily health inspections and treatment, which can be challenging as elephants are only dealt with through protected contact to ensure the staff's safety.

All of the veterinarians available on site have been trained and experienced in providing elephants with medicine, diagnostics and treatment. Handlers and scientists are involved and contribute to field research of elephants, topics which include 'elephant anaesthesia, wound management, infectious disease investigation, pharmacokinetic studies and reproduction' (Smithsonian National Zoological Park, n. d).



## Nutrition

Food is a daily source of nutritional enrichment, with a variety of food given to the elephants daily and scattered throughout their enclosures. Food is also placed in specifically designed nooks throughout Elephant Trails, and hung in suspended feeders to encourage trunk use. Grass grows in 2 of the four outdoor yards to allow elephants to graze naturally.

*Storage spaces accessed via the service wall are used to store perishable and non perishable foods for the elephants.*

The National Zoo's Department of Nutrition, comprising of clinical nutritionists, commissary manager, laboratory manager and food service specialists, have carefully devised individualised diet plans for elephants together with the handlers.

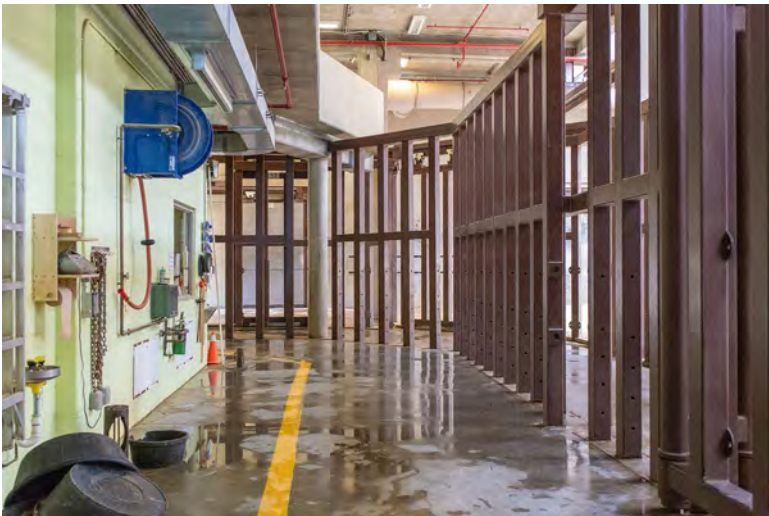




## Service spaces and functions



*The service wall next to the elephant transfer hall allows staff to service, clean and maintain all surrounding elephant occupied spaces on a daily basis.*



*Utility storage and service wall*

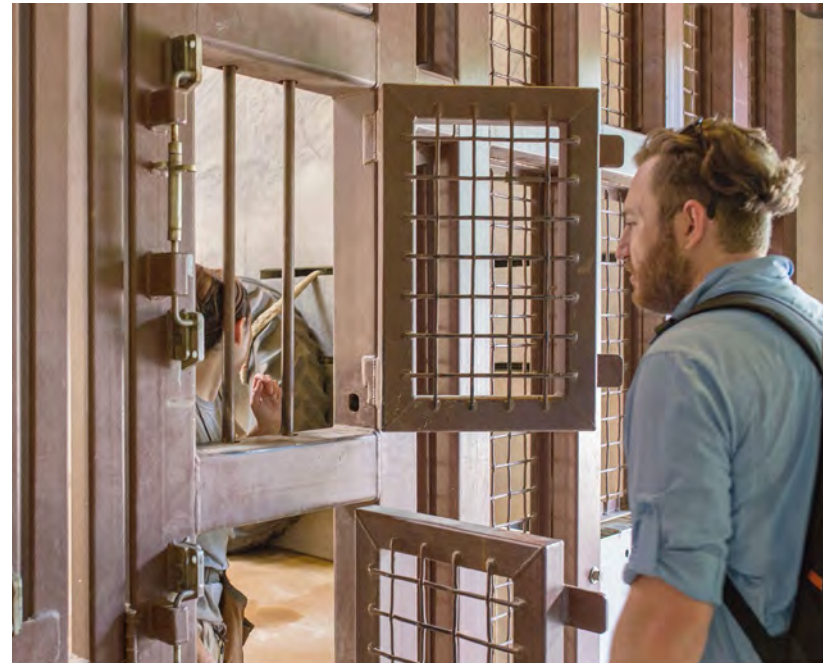


*Steel elements comprising the elephant transfer hall allow the staff to pass through, while still containing the elephants for their safety.*

*Holes in the steel columns allow for cables to be run through when young calves are in the building.*



*The training wall of the quarantine area allows handlers to safely access the elephant in need of treatment. The wall includes various openings at various heights for their convenience to reach all parts of the sick or injured elephant.*









# CHAPTER 6

## Programme

*This chapter provides a comparative study of international and local zoo practices and regulations regarding the care and management of handling elephants in captivity, with a focus on elephant rehabilitation to assist in sustaining population numbers of compromised elephants.*

# AZA Standards for elephant management and care

*The intention for these standards are to provide the safest possible work environment for both elephants and their care givers.*

## ***Programmatic requirements***

The point of departure for this dissertation included designing a place of sanctuary for these magnificent creatures that provides a healthy and mentally enriching environment that prioritises their needs over visitors. The project aims to establish new zoological standards for elephants in captivity within South Africa and Africa alike, in keeping and succeeding international examples.

The project is informed by extensive research investigating behavioural patterns of elephants in the wild, and the lack of concern shown to those in captivity that hinder their natural behaviours.

## ***Spatial requirements***

Understanding the natural social patterns and behaviours of elephant herds in the wild should inform all spatial decisions when designing shelters for them in captivity.

As male elephants living in the wild tend to separate from their mothers and the matriarchal herd when they

reach a certain age, they either choose to roam on their own or join the bull herd. This tendency to separate needs to be addressed by including two separate day areas and night quarters for females and males (Foster and Partners, 2008).

These enclosures are set into the sloping site to optimise the use of thermal mass in the night quarters and the use of geothermal pipes for heating and cooling, to regulate stable internal environments and passive thermal performance.

The elephant community centre, being the large day area that allows for a sheltered and stimulating indoors environment, needs to be either covered with a glazed roof or left open to allow a strong visual connection with the sky and allow plenty of natural light into the space. This sense of light and openness inside a traditionally closed type of space is more characteristic of their habitats in the wild. If elephants are kept or choose to remain indoors during the day, it is important for them to be aware of the changing daylight patterns as the day progresses (Fairs, 2008).

This community centre needs to incorporate a public viewing and exhibition component to further increase elephant conservation awareness, while also allowing for general public and school children to ask the handlers questions concerning elephants. The public can then follow the elephants and the staff, who always act as the buffer between the elephants and the public, to the pre-cleanse area. Here they can witness elephants being cleaned and groomed, an important daily ritual for their health and hygiene.

The path leads to a final ‘surprise’ where visitors encounter elephants swimming in the hydrotherapy pool, from underwater and above-water viewing points.

The community centre and the night quarters enable elephants, particularly mothers and their calves, to congregate and sleep together in larger or smaller groups, as they would in the wild. The smaller night quarters also allow them to sleep alone if they prefer while still being in hearing and smelling range of their fellow herd members in adjacent quarters. These spaces will have heated rubberised flooring to keep elephants dry and comfortable, maintaining their foot health.

#### *Flooring surfaces*

As part of the National Environmental Management: Biodiversity Act 2004 (Act No. 10 Of 2004) of South Africa, the 'Draft Minimum Standards for the Management of Captive Elephants' states all artificial floors should be made of non-slip materials to reduce the risk of slipping. Artificial flooring should therefore comprise of either natural substrate or rubberised material providing a degree of 'flexibility, elasticity and thickness comparable to natural substrate'.

*"Hard floor surfaces must be relatively smooth to*

*prevent excessive pad wear, but not so smooth that they become slippery when wet". – AZA standards for elephant management and care, 2012.*

Ensuring that elephants in captivity have healthy feet and nails, a variety of different substrates used is essential – both indoors and outdoors. Sand is a great, natural substrate to use as a floor cover, in place of only using concrete; it has less impact on their feet and helps lessen the elephants developing foot problems.

Sand also provides elephants with additional exercise and helps strengthen their leg muscles as it proves more difficult to walk on, a necessity as they do not have the space to walk as much as they would in the wild. Sand piles located both indoors and outdoors help stimulate natural behaviours and opportunities for them to explore. Handlers can also hide objects in the layers of sand for elephants to find to stimulate and develop their curiosity and cognitive abilities (Fairs, 2008). Providing the elephants with ample amounts of natural substrate enables them to dust themselves after baths in order to protect their sensitive skin.

The flooring in the indoor enclosures will be heated for the elephants' benefit, and will comprise of either sand or rubber flooring depending on the space. In the community centre, 1,2m of sand flooring above a heated concrete slab with adequate floor drains will be used. In the transfer halls and night quarters, rubberised flooring will be placed on a heated concrete slab, to effectively keep them warm and dry while allowing for easy maintenance and cleaning.

The outdoor yards should be maintained to allow sufficient grass to grow, unlike the current enclosure. Spaces should have a variation of substrate to maintain foot health and muscle development.



Elephant Prosthetics

*Figure 6.1 'Friends of the Asian Elephant' (FAE) have built a new prosthesis factory on site for their injured rescued elephants.*

## Elephant shelter specifications set by the SABS and EMOA (Elephant Management and Owners Association)

Elephants are highly social creatures and should not, as far as possible, be confined in isolation. Elephant numbers should be compatible for formation of adequate size herds, which is no smaller than ten adult African savanna elephants according to the National Environmental Management: Biodiversity Act regarding the minimum standards for the management of captive elephants, 2009.

The minimum size of a shared day area for the elephants should not be less than 30 x 20m, as per the SABS requirements for elephant shelter designs. 1m<sup>2</sup> per 25kg of live body mass can also be used as a guideline. The size of night quarters provided for shared or single use should be equal to 25% of the minimum space of the day area. The day area should either be covered by artificial means, such as the use of 80% shading cloth being the minimum requirement, or have large tree with thick canopies to provide

ample shade.

Covered night quarters and interior spaces should provide the elephants a dry, comfortable space for them to lie down and rest – especially during extreme weather conditions. These night quarters should be of robust construction and draught-proof – as elephants, especially calves, react poorly to cold draughts.

Any window openings should be out of reach of elephants' trunks to prevent any damage and harm. Double enclosures, both indoors and outdoors, are required to move elephants when cleaning and maintenance is necessary. Each night quarter needs to be equipped with an adequately sized water trough raised above the ground (2000 x 750 x 400mm deep). Adult elephants drink 100 litres of water on average per day. Outdoor day yards should have additional water supplies, pools or mud wallows for drinking, bathing and

spraying purposes.

Scratching posts, designed as either columns, tree trunks or suitably shaped and sized rocks should be provided within the enclosure, as it is necessary for them to exfoliate their skin.

Open barriers built of steel pole construction should always have the steel sections placed vertically, not horizontally, to reduce the risk of elephants breaking their tusks in them. The circular steel sections, with steel cables running through, should be filled with concrete and have pile foundations to the necessary depth.

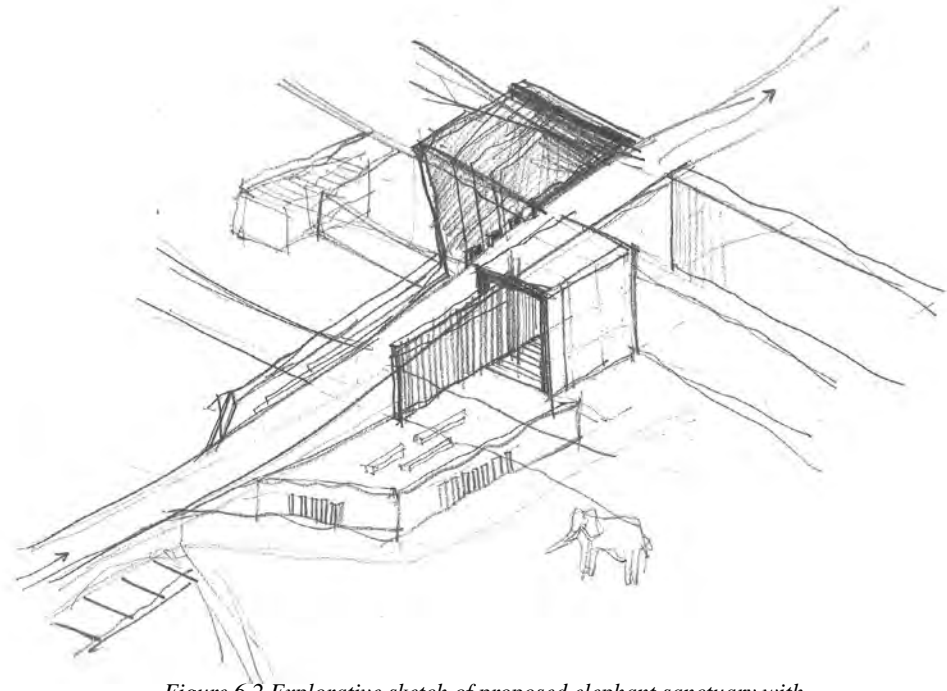
*Creating awareness: conservation, research and education*

The elephant facility needs to institute educational programs for visitors to promote an improved knowledge and understanding of elephants and the issues regarding conservation.

The facility managing a herd is entitled to contribute to elephant conservation efforts through public education, school programs and scientific research. Through these efforts, the facility should support conservation projects on a global scale.

*Nutrition*

Sufficient, enriching food that meets dietary needs should be provided daily in correct amounts formulated to ensure elephant health and appropriate weight.



*Figure 6.2 Explorative sketch of proposed elephant sanctuary with selective views to elephant spaces (Author, 2016).*



# Programme Exploration

## A SANCTUARY FOR THE WORLD'S GENTLE GIANTS, THE ELEPHANTS

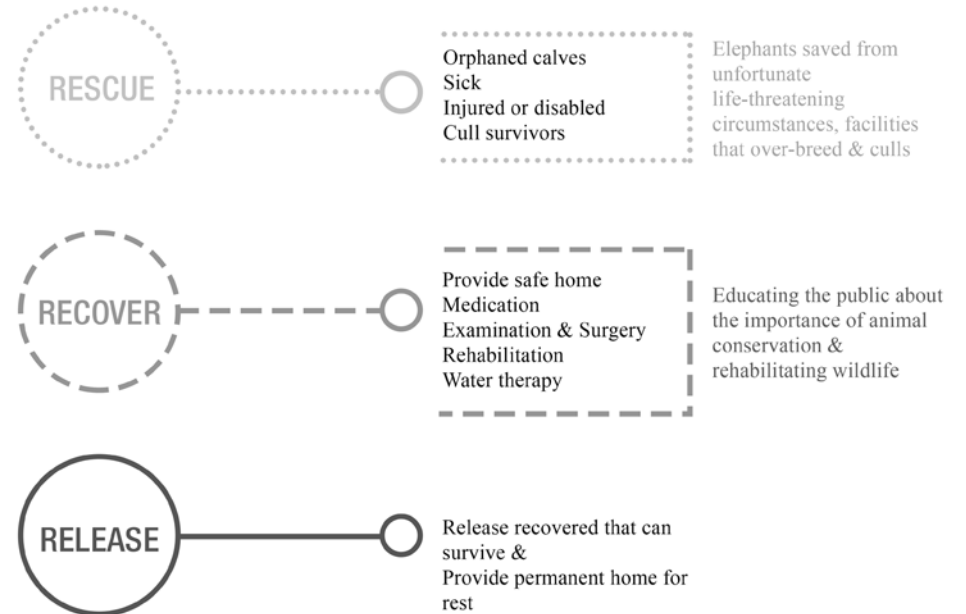


Figure 6.3 Left: Diagram indicating programme and accommodation requirements, ranging from public to private (Author, 2016).

Figure 6.4 Above: Diagram of Programmatic concept of elephant rehabilitation (Author, 2016).

# Elephant Rehabilitation

## *Rescue · Rehabilitate · Release*

These three principles form the essence of the design scheme and program, and will assist in the design development of the elephant enclosure to accommodate different spaces that aid in the elephants' recovery.

The sanctuary provides safe refuge for these vulnerable creatures, providing them ample walking trails and spaces to roam, mud pits, swimming channels and hydrotherapy pools for their rehabilitation and well-being. A variation of hard and soft spaces will give them the freedom to alternate between various spatial conditions in attempts to recreate their wild habitats.

Creating stimulating and enriching living environments for the elephants is essential for both their physical and mental development - a factor that is not currently being met by the existing enclosure.

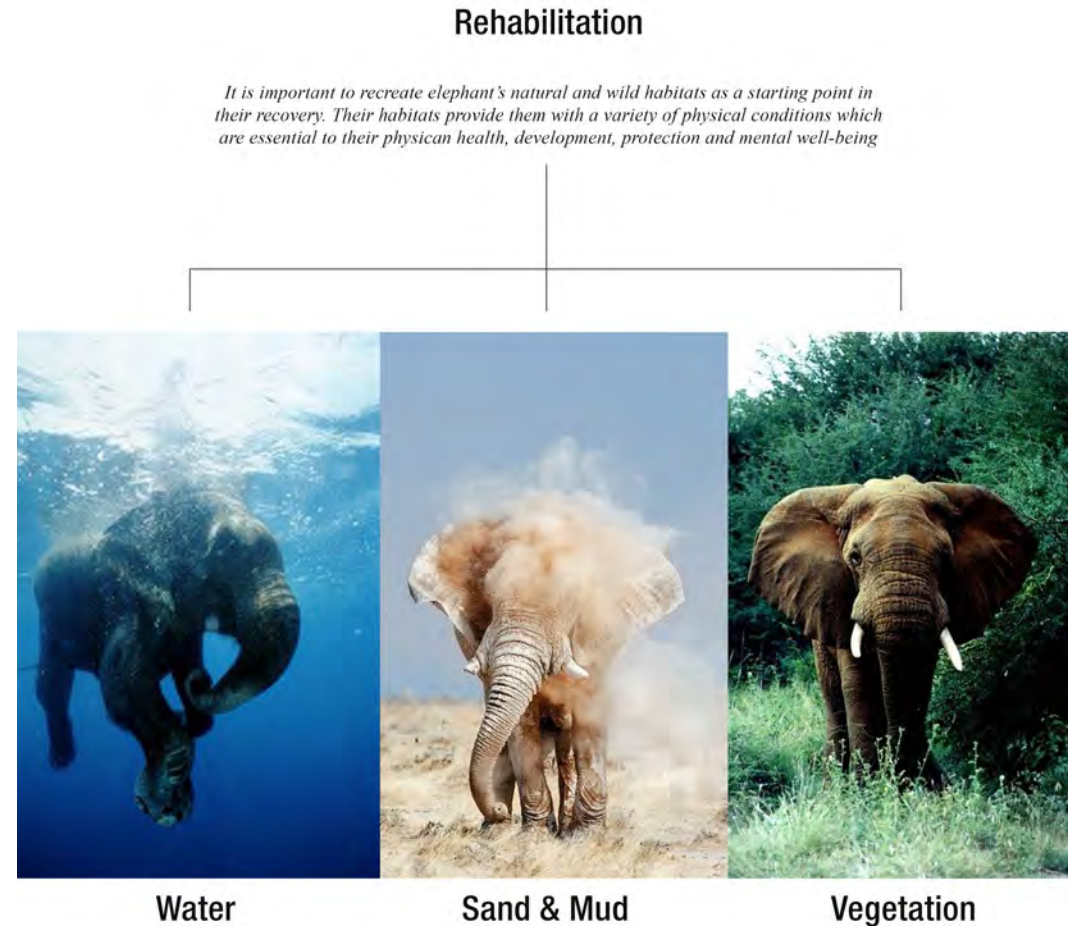
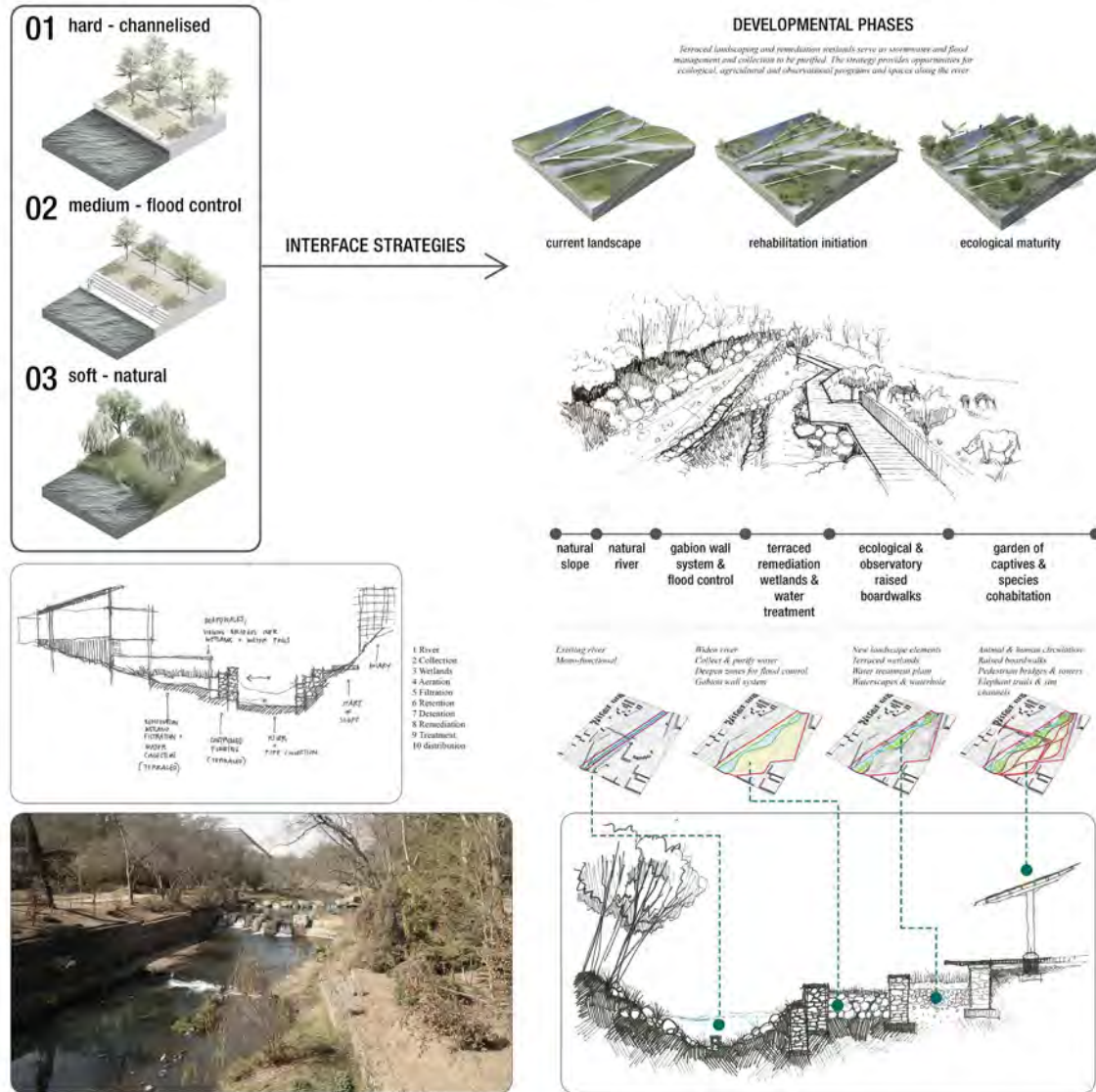


Figure 6.5 Above: Three natural conditions which facilitate elephant rehabilitation (Author, 2016).

Figure 6.6 Left: River rehabilitation strategy (Author, 2016).

# River Rehabilitation

## RIVER REHABILITATION STRATEGY



### Apies River purification

One of the largest problems that zoos situated in cities experience is not having adequate amounts of water to provide their animals. Elephants in particular drink on average 200 litres of water per day. Water from the Apies River will therefore need to be collected, together with rainwater, to satisfy this demand as well as other requirements such as cleaning, swimming and bathing for thermoregulation.

Due to this high demand, it would be far too expensive to provide elephants with only potable water from the municipal supply. It would be highly feasible to feed elephants filtered and purified water from the river. The water would need to be passed through a trash trap (for debris), an oil trap, a biofilter and lastly a UV filter to sterilise and bring the water to a potable water level safe for elephant consumption. This potable water will then be pumped and stored in large underground tanks or subsurface reservoir in a restricted area near the building. This will form the primary storage area.

There are 5 categories of water pollutants to remove:

1. Floating debris
2. Lighter than water
3. Heavier than water
4. Dissolved in water
5. Pathogens



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*Figure 6.7 Hanako, the world's saddest elephant alone in her cell.*

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***“The world’s saddest elephant dies after 60 years alone in her cell.”***

*The world’s loneliest elephant, Hanako, passed away after spending sixty years alone in her cell at the Inokashira Park Zoo in Japan. Her small, barren, concrete enclosure, where she spent more than 6 decades in solitude, contained no trees or vegetation. For most of her life she had never felt or been exposed to grass or earth, or the companionship of another elephant or animal (Schelling, 2016).*

*Elephants are highly complex and social animals who naturally live in herds with extended family networks, accentuating the cruelty in isolating these creatures (San Rafael, 2015). As a result of her unforgiving isolation, she lived a life devoid of any social or emotional connections, and any form of enrichment.*

*Hanako, an Asian elephant that resided at the Inokashira Park Zoo in Japan, spent sixty years living in a small, concrete enclosure with no trees or vegetation. Elephants, who are highly sociable animals, build lifelong relationships with other elephants – with both family and friends. Hanako, who had not seen or interacted with another elephant in decades lived a life devoid of any social or emotional connections, and any form of enrichment. In the barren, treeless cell where she spent six long decades, she never felt grass, soil or the closeness of another elephant, yet alone another animal.*



# CHAPTER 7

## Elephant in the Garden

*This chapter focuses on conceptual exploration and design development that took place in response to various design informants relating to site, programme, and of course, the elephants.*

*The design aims at creating a place of sanctuary for displaced elephants. A place for healing and refuge.*

---

*Experiential journey*

*As visitors walk across the bridge over the natural river and approach the building, they are directed towards a funnelling public entrance. The monumental, monolithic concrete walls wrapping the elephant enclosure come to view, providing a glimpse into the building. Inside, elephants are frolicking about in the sand, spraying themselves with water, while enjoying the fruits of the Marula trees.*

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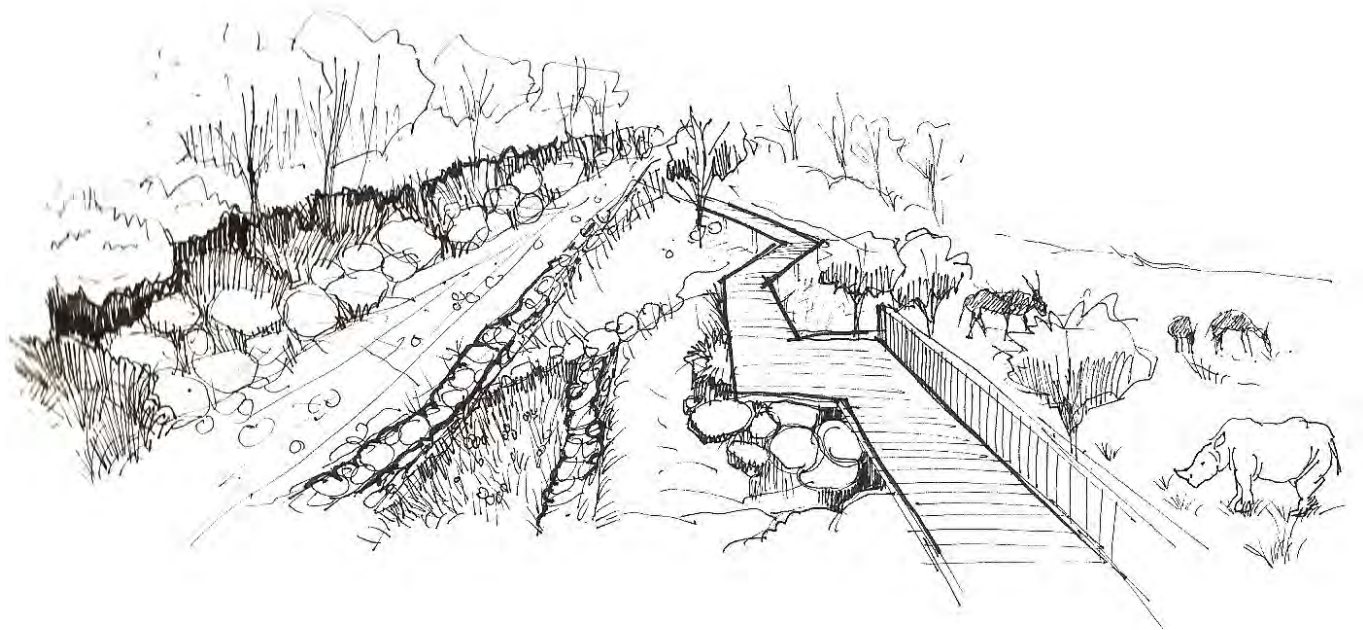
## Design Review Introduction

*The design aesthetic of the project is determined by three factors.*

Firstly. The design is a response to the natural and environmentally aware stigma associated with designing for wild animals.

Secondly. The design adheres to the functional requirements and regulations stipulated by international as well as local standards, when dealing with elephants in captivity. Issues such as materiality, access, flooring, safety and protection were considered.

Thirdly. The architecture is meant to symbolise the ethereal nature of these magnificent creatures; our living dinosaurs. The spaces where humans and elephants encounter are meant to make visitors aware of being in a presence greater than themselves; A space where the extraordinary intelligence and presence of elephants is showcased.



*Figure 7.1 Initial sketch of proposed Garden of Captives (Author, 2016).*

# The Elephant in the Room

## Design informants

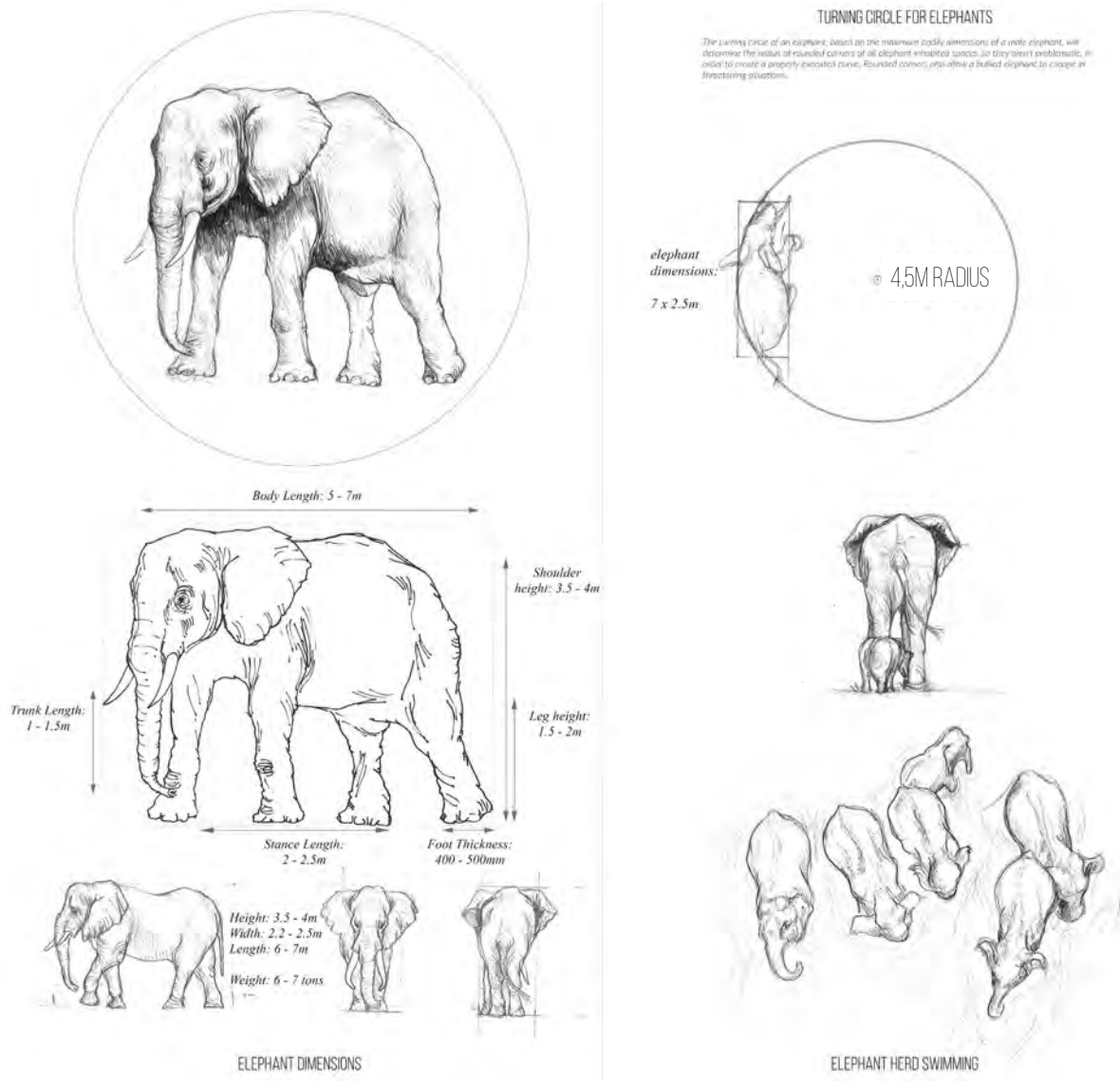
### The Modular Elephant

The Modular Elephant was developed by establishing the bodily dimensions of a fully grown, 6 ton male elephant. The body length, shoulder height, stance length and width were used to determine dimensions of circulation passages, doorways, ramps, swimming pool slope and steps, reaching heights and ceiling heights.

### Turning Circle for elephants

The turning circle of an elephant, also based on the maximum bodily length and width of a fully grown bull, will determine the radius of rounded corners of all elephant inhabited spaces, to ensure that the corners are not problematic or wasted space – due to the large size of elephants. The turning radius is therefore used to create a properly executed curve to be repeated throughout the ground floor plan. Rounded corners also allow a smaller, bullied elephant to escape in any threatening situations before staff can intervene.

Figure 7.2 Modular elephant (Author, 2016).



## Primary users

### African Elephants (*Loxodonta Africana*)



#### Weight

males 4,700 - 6,048 kg  
females 2,160 - 3,232 kg



#### Height

males 3.2 - 4m  
females 2.2 - 2.6m



#### Habitats

Tropical and Subtropical Moist Broadleaf Forests, Flooded Grasslands and Savannahs, Miombo woodlands, Acacia savannahs



#### Status

Vulnerable



#### Water

200 litres per day



#### Food

100 - 270 kg per day

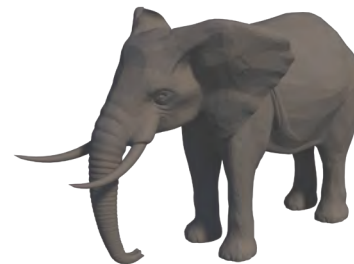
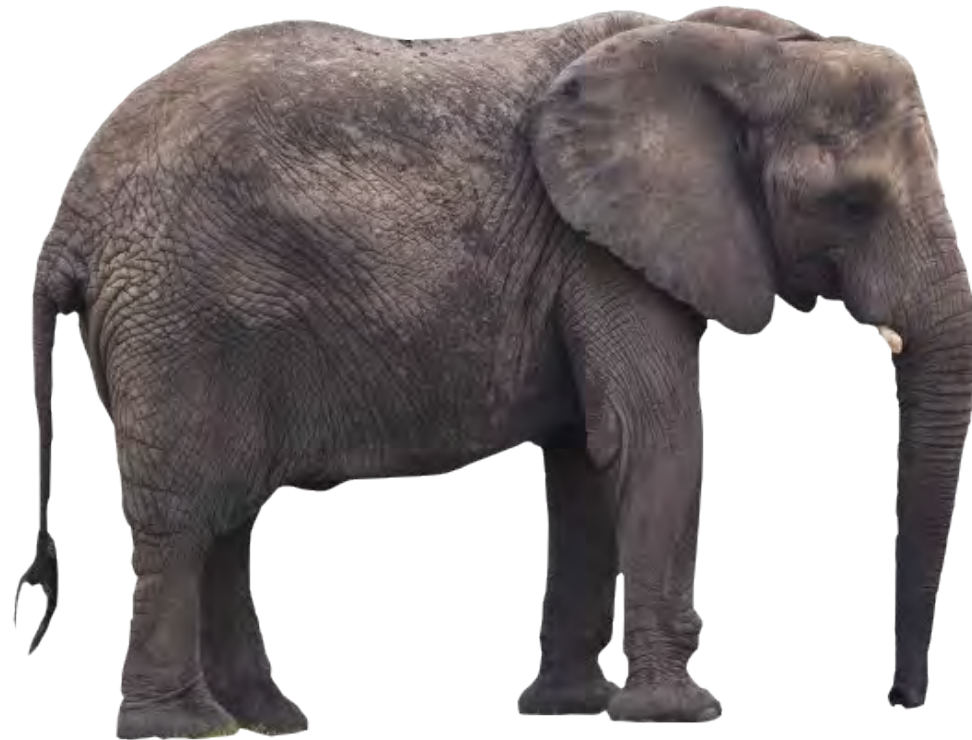


Figure 7.3 African elephant analysis (Author, 2016).

## Celebrating elephants in various natural conditions which aid in rehabilitation





*Figure 7.4 Elephants in natural conditions photograph collage (Author, 2016).*

# CONCEPT DESIGN EXPLORATION

## SITE PLAN



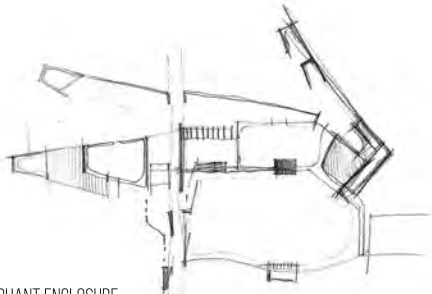
### 01 SERIES OF SENSUAL GEOMETRIES TO CREATE FORM

The thin, long building and structure is seen as a journey and an experience, that includes gradual disclosure and sudden surprise. The user is taken through a process of rehabilitation and recovery while being exposed to distant views of the river, the landscape and surrounding animals occupying the shared Garden.



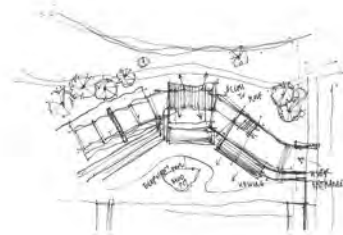
### 02 SEPARATE PATHS

Using levels and difference in height, scale and volumes to separate paths of elephants, visitors and staff members



### 03 ELEPHANT ENCLOSURE

Permanent residence is given to elephants that can not be released back into the wild. Night and day spaces are built in the landscape around the natural elephant pool and island.



## GROUND PLAN



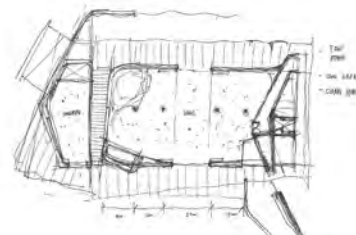
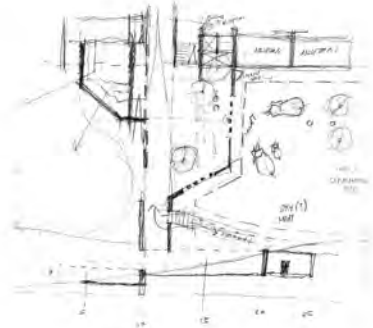
### 01 REHABILITATION

Water forms an important component in the design and rehabilitation programme, that is used to tie both indoor and outdoor rehabilitation spaces for the elephants. The theme of water also ties into the river and water purification and rehabilitation framework set by the urban vision.

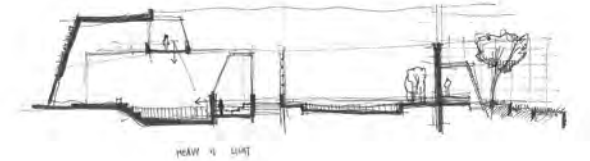


### 02 ELEPHANT HOSPITAL

The elephant hospital will contain isolated sick rooms which are the furthest away from the public. A main operating space allows the staff to examine, treat and operate if necessary on the elephants. The hospital is supplied with a pharmacy, bio bank, food store, equipment store and gun safe.

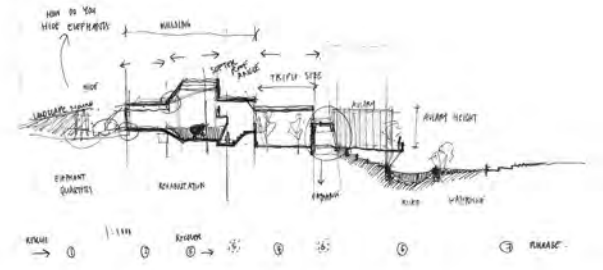


## SECTION



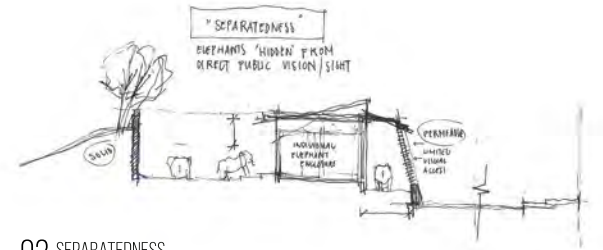
### 01 MATERIALITY: HEAVY VS LIGHT

Aspects of GRAVITY and HEAVINESS represent the significantly greater scale and weight of elephants in comparison to humans, which is also shown in the volume of spaces.



### 02 SECTION TO TELL A STORY

Elephants are brought in and kept in isolation while they recover. The recovery process involves examination, treatment, medical procedures, indoor play and water therapy (rehabilitation), outdoor play and engagement with humans and the landscape, before being introduced to the rest of the elephant herd and into the Garden.



### 03 SEPARATEDNESS

Rescued elephants first brought to the sanctuary are kept in isolated recovery units hidden from public access. The connection of the building to the landscape is important.

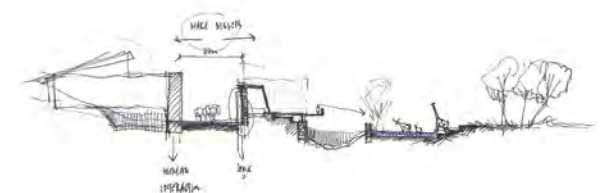


Figure 7.5 Concept design exploration (Author, 2016).

## *Site Plan functions*

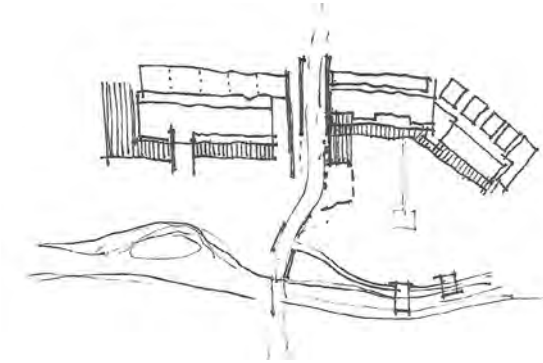


Figure 7.6 Site plan exploration (Author, 2016).

### *Series of sensual geometries to create form*

The building is seen as a series of different spaces and structures nestled into the landscape, reconnecting the elephants to the earth. The separation and placement of the separate 'buildings' making up a whole contributes to the journey and experience of visitors as they move through the different spaces. Each space includes a unique experience and intake of information, contributing to the journey of gradual disclosure and revealing. The visitor is taken through a process of elephant rehabilitation and recovery while being exposed to views of the river, the landscape and elephants in the Garden.

### *Separate Paths*

Optimum safety and security considerations are of utmost importance to ensure the protection of both animals and people. When dealing with elephants, this importance is escalated due to their supreme scale and strength. Therefore, maximising the slope of the site to create levels and height differences, as well as difference in scale and volumes of space, can assist in establishing separate paths of elephants, staff and the visitors. These changes in levels allow varied interaction and vantage points of the elephants from underwater, ground level and higher levels to further contribute to the user experience.

### *'Separatedness'*

Rescued elephants brought to the sanctuary need to be first kept in quarantine, to receive necessary treatment while recovering. This isolated recovery ward is hidden from public access, situated on the furthest and most private edge of the site.

## *Ground Plan functions*

### *Elephant enclosure facilities*

Permanent residence is given to elephants that cannot be released back into the wild due to injury, disease or circumstance. Therefore, sufficient indoor space needs to be provided for elephants to move around and rest without restriction. The design challenges traditional approaches in zoological enclosure designs, particularly in designing shelter for elephants.

### *Standard and measurement*

Enclosure sizes recommended by the AZA, include providing 37m<sup>2</sup> per single elephant indoors (56m<sup>2</sup> for an adult elephant with calves) and 500m<sup>2</sup> per elephant outdoors (AZA, 2012). These sizes form the minimum suggested stall areas for circumstances such as extreme weather conditions that require elephants to remain indoors for extended periods of time. Therefore, these spaces need to be adequate enough for elephants to exhibit natural behaviours, social interac-

tions and allow for better movement.

A large, mostly open day area of 1320m<sup>2</sup> is provided with a 1200mm layer of sand substrate, Marula trees and a small wading pool for drinking and cooling purposes. According to AZA requirements, the space is large enough to accommodate 23 adult elephants with calves, as 56m<sup>2</sup> per elephant and calf is stipulated. This space allows elephants to congregate together as a herd. The space, with only 30% roof cover, is purposefully left opened for elephants to be aware of changing daylight patterns. This also provides for full natural ventilation, an important and necessary design measure for animal shelter design, as well as for effective drying of the sand substrate after routine cleaning.

Three sleeping quarters with insulated rubber flooring, built into the landscape to optimise the use of thermal mass, are each 90m<sup>2</sup> in size. As elephants in the wild tend to sleep together in groups or pairs, the floor areas of each night quarter are large enough to accom-

modate more than one elephant, as well as mothers sleeping with their calves. A fourth, larger sleeping quarter, with a sand substrate floor, is 140m<sup>2</sup> in size – large enough to accommodate 4 adult elephants.

In order to accommodate bulls' natural tendencies to separate from the matriarchal herd when reaching sexual maturity, a separate bull enclosure is provided. This space, with an area of 315m<sup>2</sup>, can accommodate five bulls as per the AZA minimum requirements.



### *Rescue Elephant Clinic*

In accordance with the AZA and similar elephant regulations, the project will include an elephant clinic. This clinic, located at the furthest and most private point of the immediate site, will accommodate sick, recovering elephants and new elephants brought to the zoo that need to be kept in quarantine before being allowed to join the rest of the herd.

The clinic will also contain an Elephant Restrain Device (ERD) with an elephant scale, built into the transfer hall leading to the isolated, quarantine area. This allows for handlers and veterinarians to examine, treat and perform both minor and complex procedures to elephants safely.

An appropriately stocked pharmacy, or drug store, and temporary bio bank storage areas are included in the clinic for handlers and veterinarians.

### *Elephant Transfer Hall*

The elephant transfer hall is the primary circulation passage for elephants that directs them and connects different spaces such as the day area, night quarters, hydrotherapy pool and the clinic – all spaces nestled along the topography of the site. The transfer hall is wide enough to accommodate 2 elephants walking side by side (such as a mother and calf), as well as providing enough room for an elephant to turn around. The thick, reinforced concrete walls on the one side and rows of square steel columns on the opposite side of the hall form the primary and secondary containment – to ensure staff safety.

## *Water & Rehabilitation*

### *Rehabilitation & water therapy*

The process of bathing and cleansing is an important ritual for the physical health and mental wellbeing of elephants during their daily rehabilitation and recovery process.

Elephants are highly dependent on water and should be bathed or showered daily in captivity. Hydrotherapy pools will aid in their recovery as heated water provides therapeutic advantages, and allow for stronger muscle development through play. Water channels or swimming pools intersect with the human spaces. Visitors are then able to view the elephants from different viewpoints, levels and heights, with varying degrees of physical and visual interaction.

### *Water & remediation wetlands*

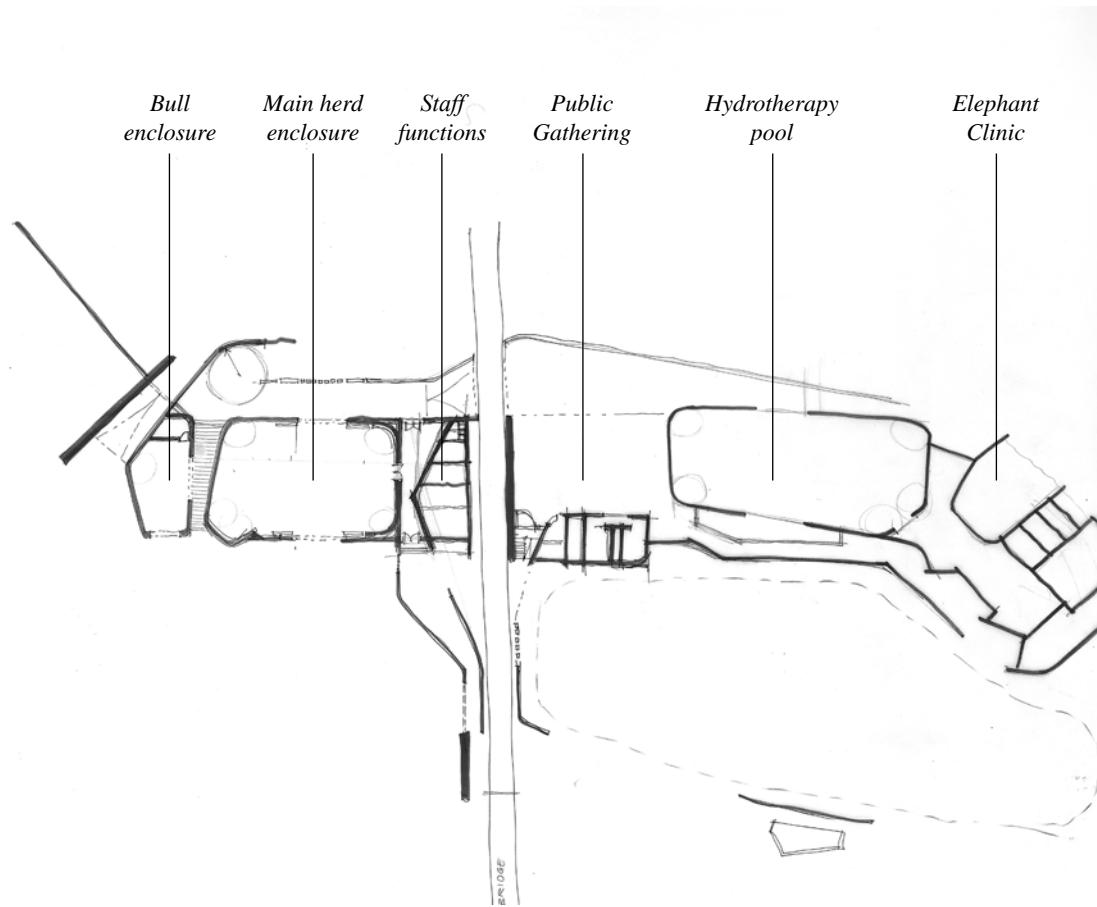
Water is a critical component in the overall design scheme; it facilitates interaction between humans, elephants and nature. Rehabilitating the Apies River, and in turn the zoo, can be achieved through different devices such as terraced wetlands and water filtration and treatment systems. Observational walkways or boardwalks will allow visitors to celebrate water and nature and be made aware of the water purification process.

Through a series of water collection pipes and pumps, gabion wall systems and flood control, various wetlands and retention pools, traps, bio filters and UV filters, the water from the Apies can be purified and stored, and directed to various waterscapes and pools in the overall scheme.

### *Journey of the visitor & viewing opportunities*

The design layout allows for an experiential journey for visitors, with a gradual unfolding of information as they walk along the route. Small glimpses of elephants are revealed through the dense placement of trees, as visitors walk towards the building. These glimpses slowly build anticipation until visitors are able to view elephants in their entirety – whether playing in the sand, foraging fruits from the Marula trees or swimming gloriously in the deep pool.

## Design iterations Plan



*Figure 7. 7 Parti Diagram indicating main functions*

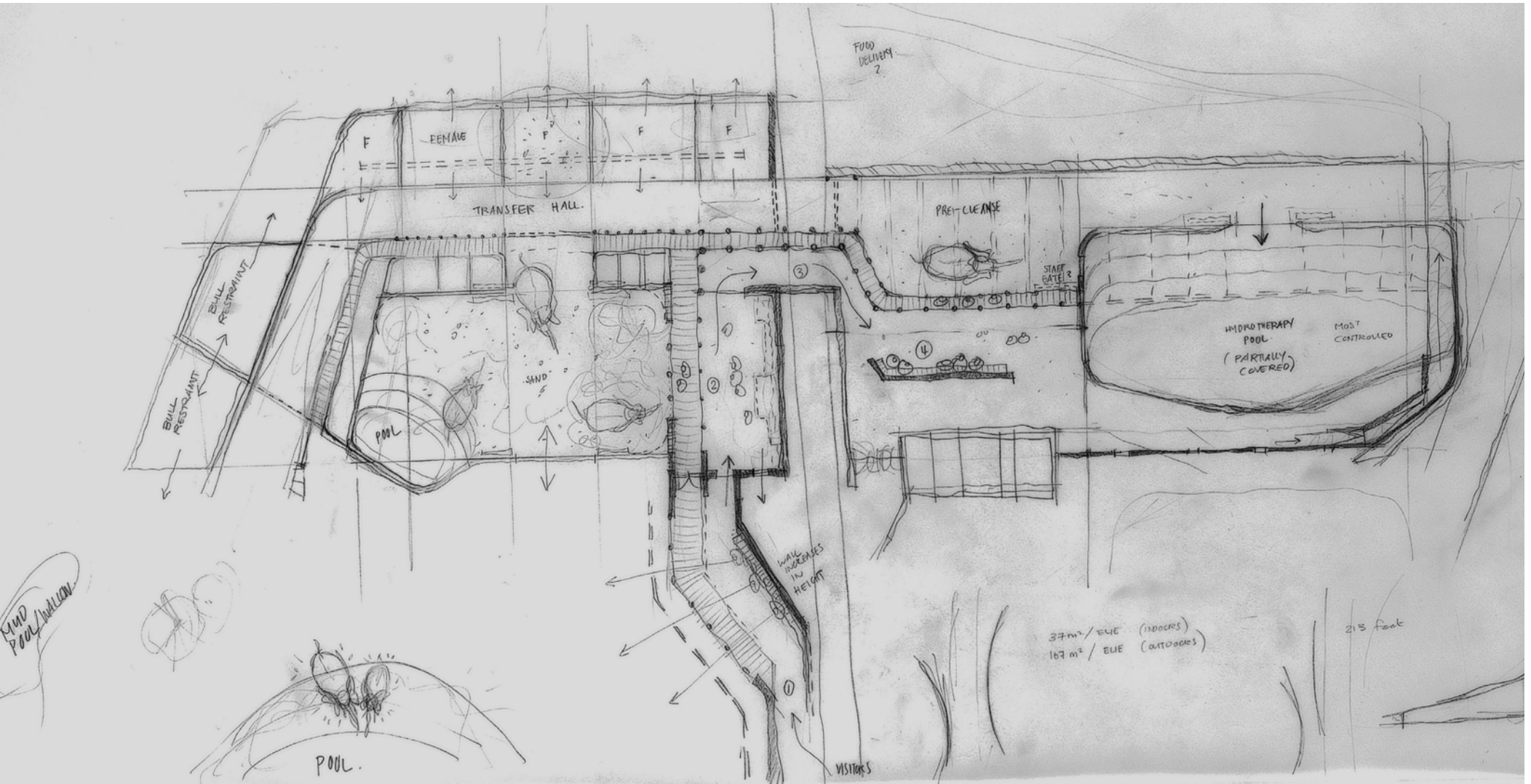
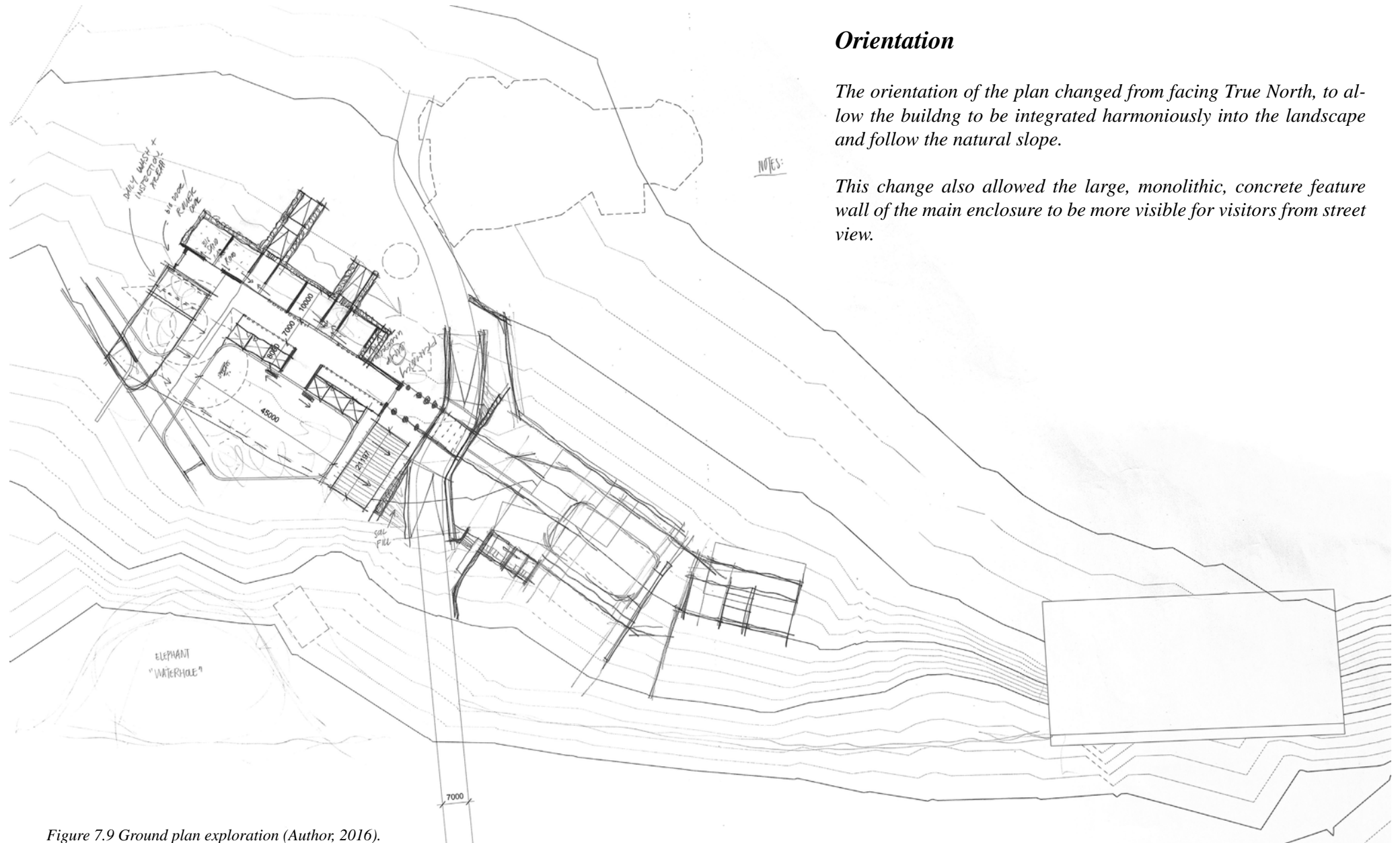


Figure 7.8 Ground plan exploration (Author, 2016).



## Orientation

*The orientation of the plan changed from facing True North, to allow the building to be integrated harmoniously into the landscape and follow the natural slope.*

*This change also allowed the large, monolithic, concrete feature wall of the main enclosure to be more visible for visitors from street view.*

Figure 7.9 Ground plan exploration (Author, 2016).

*Exploration of public spaces adjacent to the main road, connecting to the two primary elephant viewing spaces.*

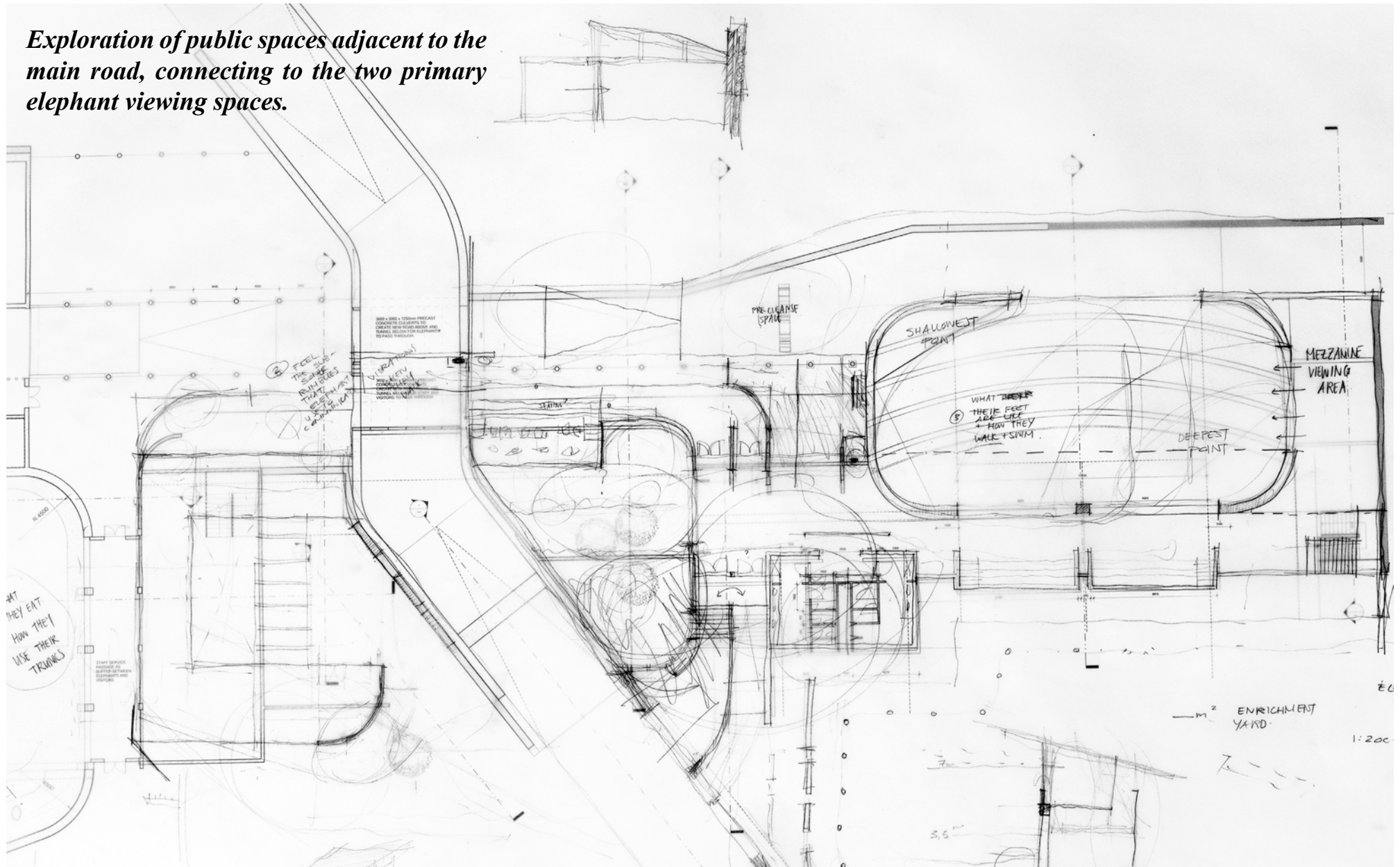


Figure 7.10 Ground plan exploration (Author, 2016).

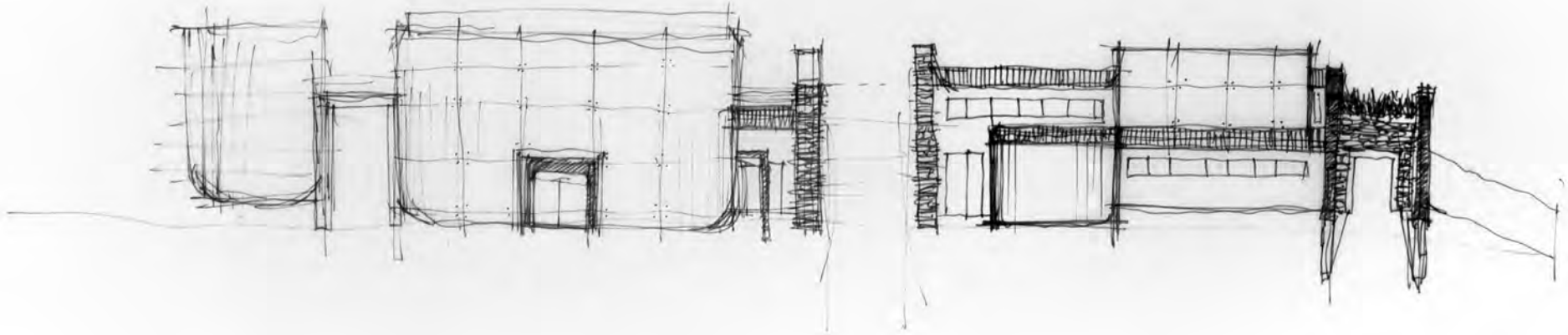
*Digital translation of conceptual design  
development drawings.*



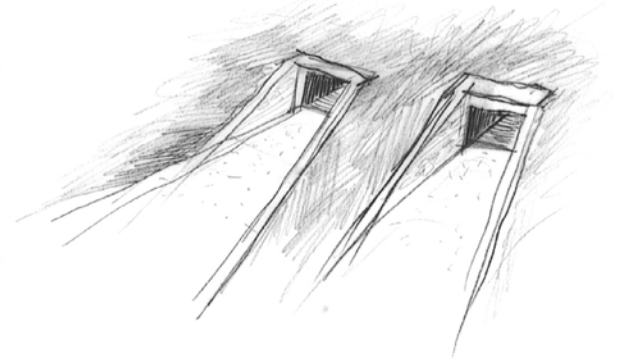
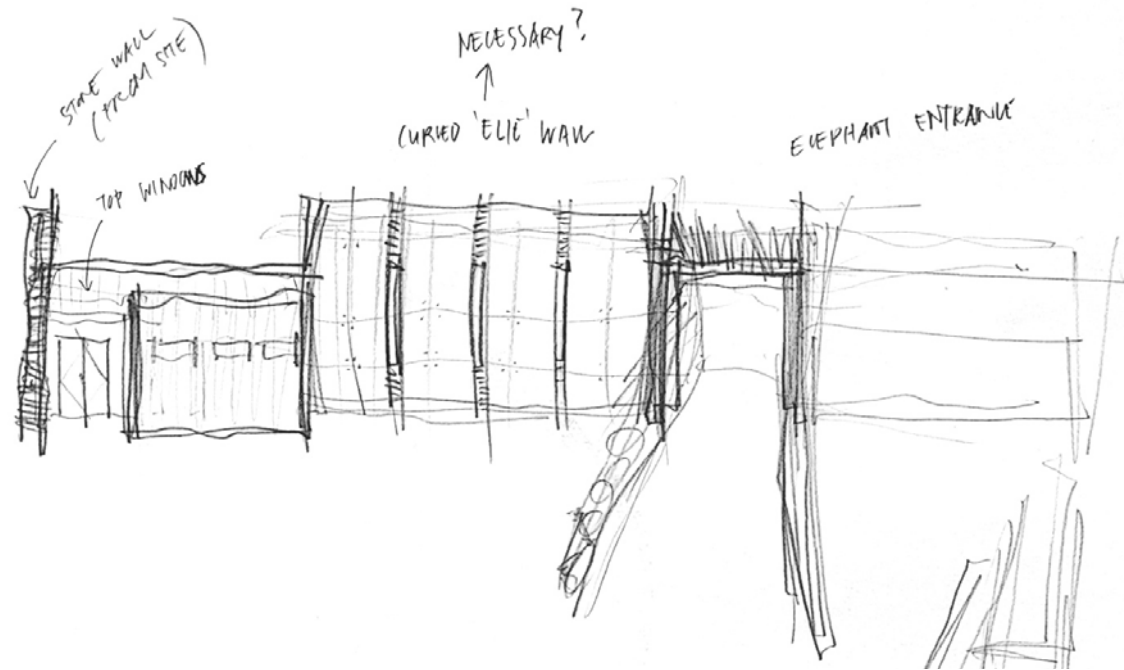




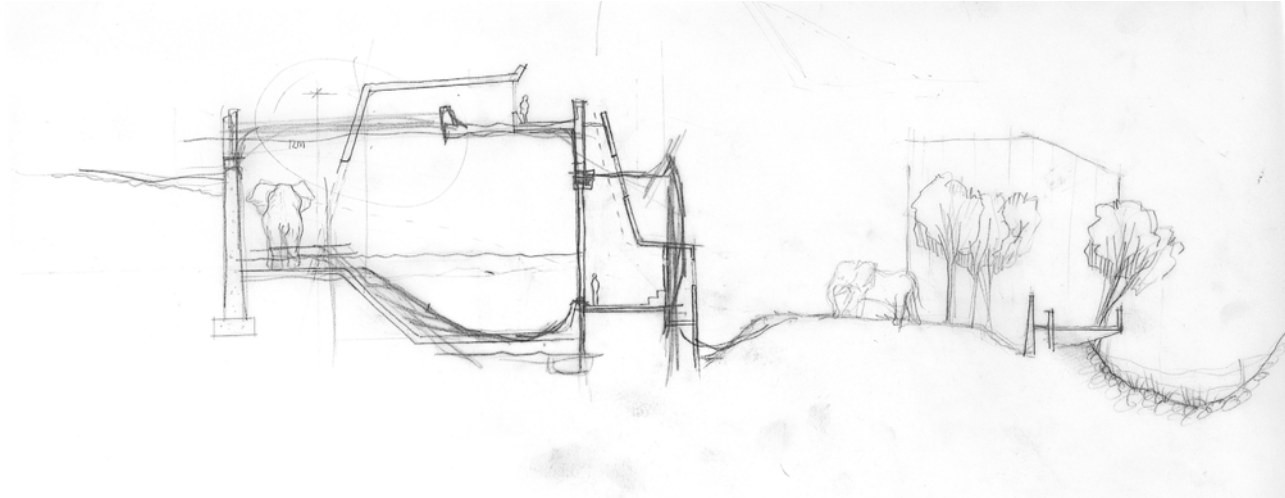
## Design iterations Elevation



*Figure 7.12 - 7.14 Elevation exploration (Author, 2016).*



## Design iterations Section



### Section exploration - curved concrete wall

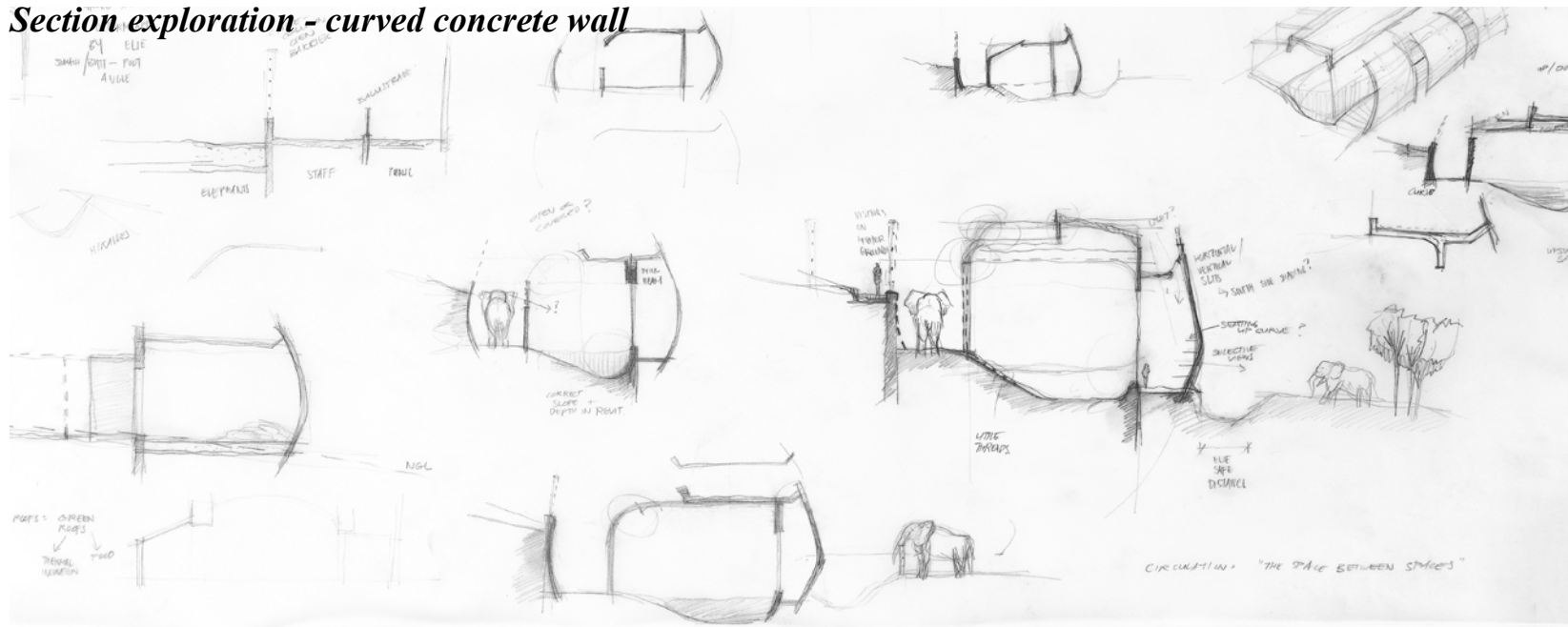
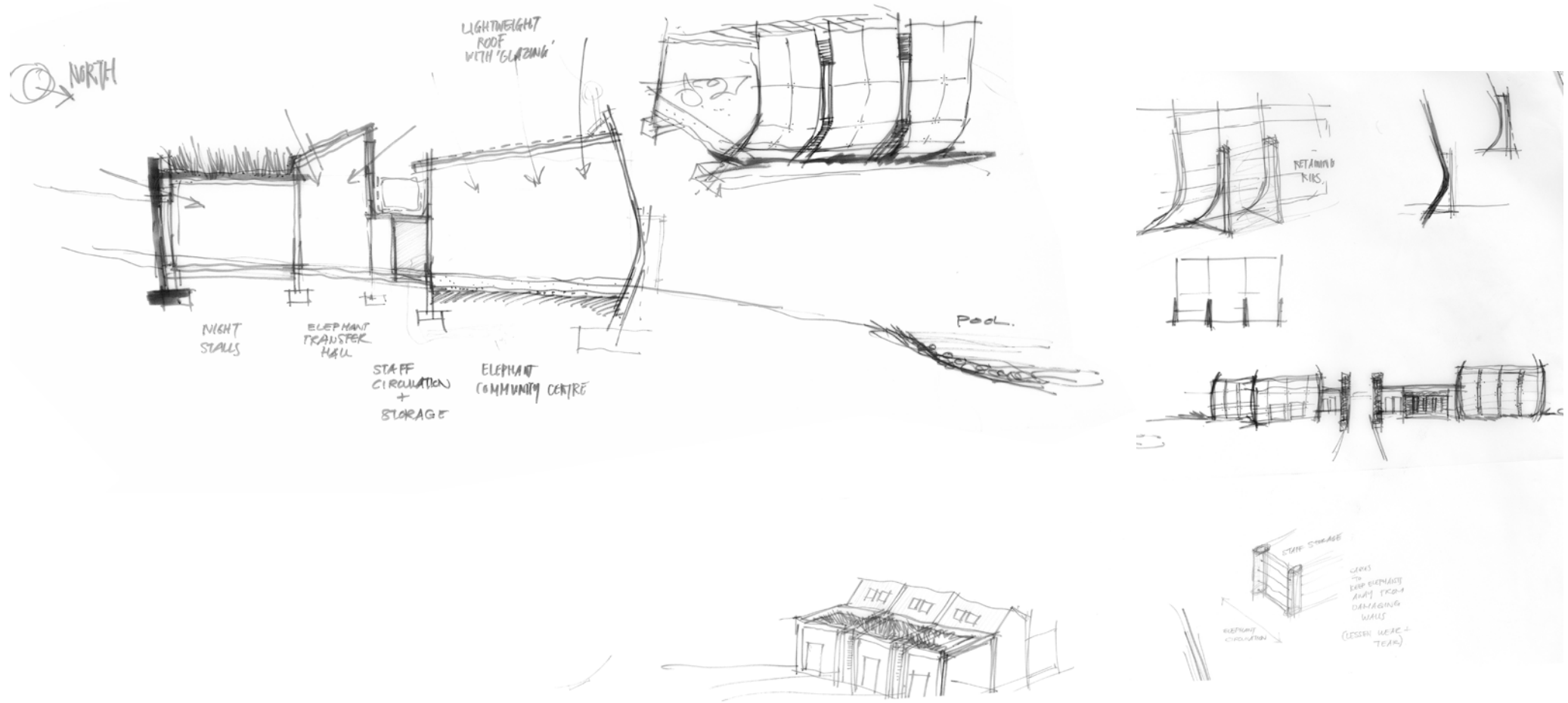


Figure 7.15 - 7.18 Section exploration (Author, 2016).



*Secondary Sections exploration -  
focusing on public interaction*

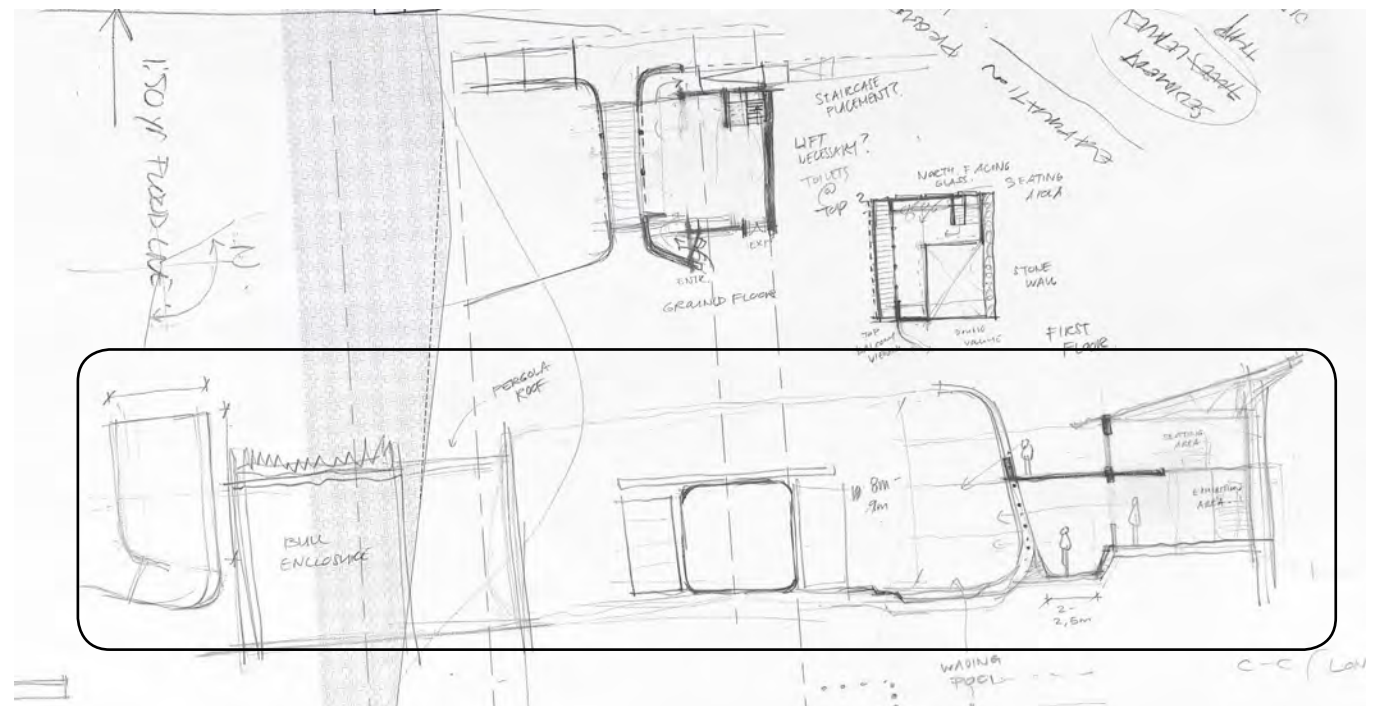
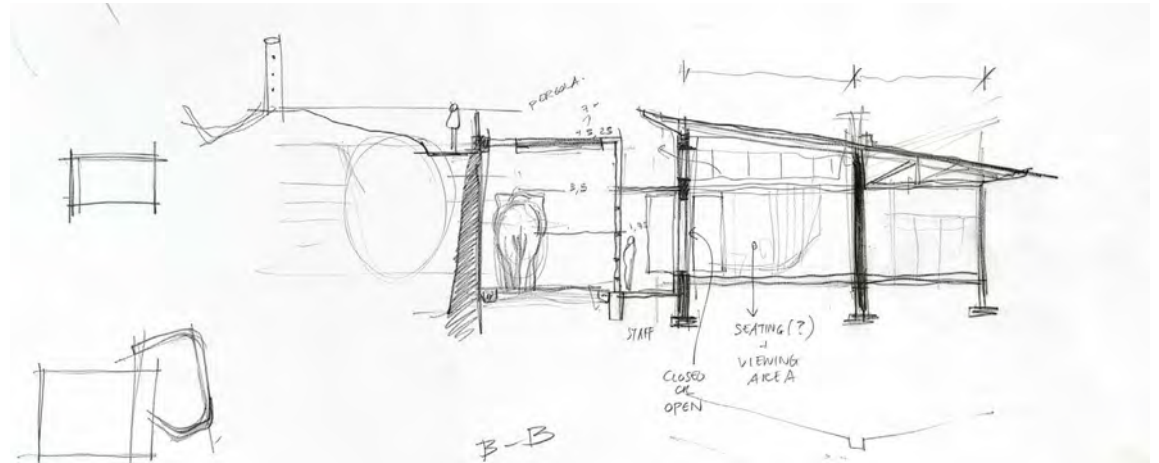


Figure 7.19 - 7.20 Section exploration (Author, 2016).

*First digital drawing produced allowing for further exploration and resolution*

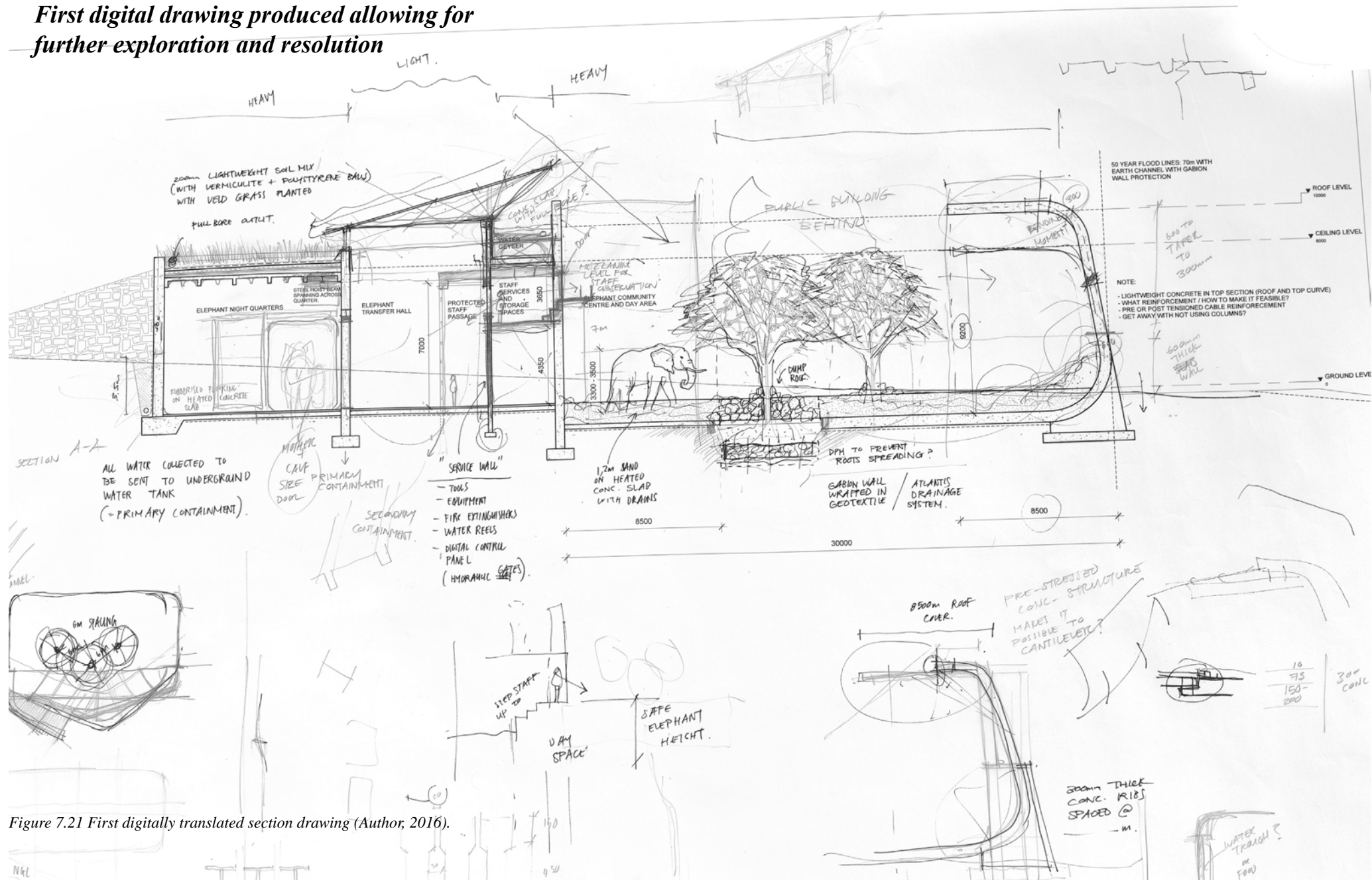
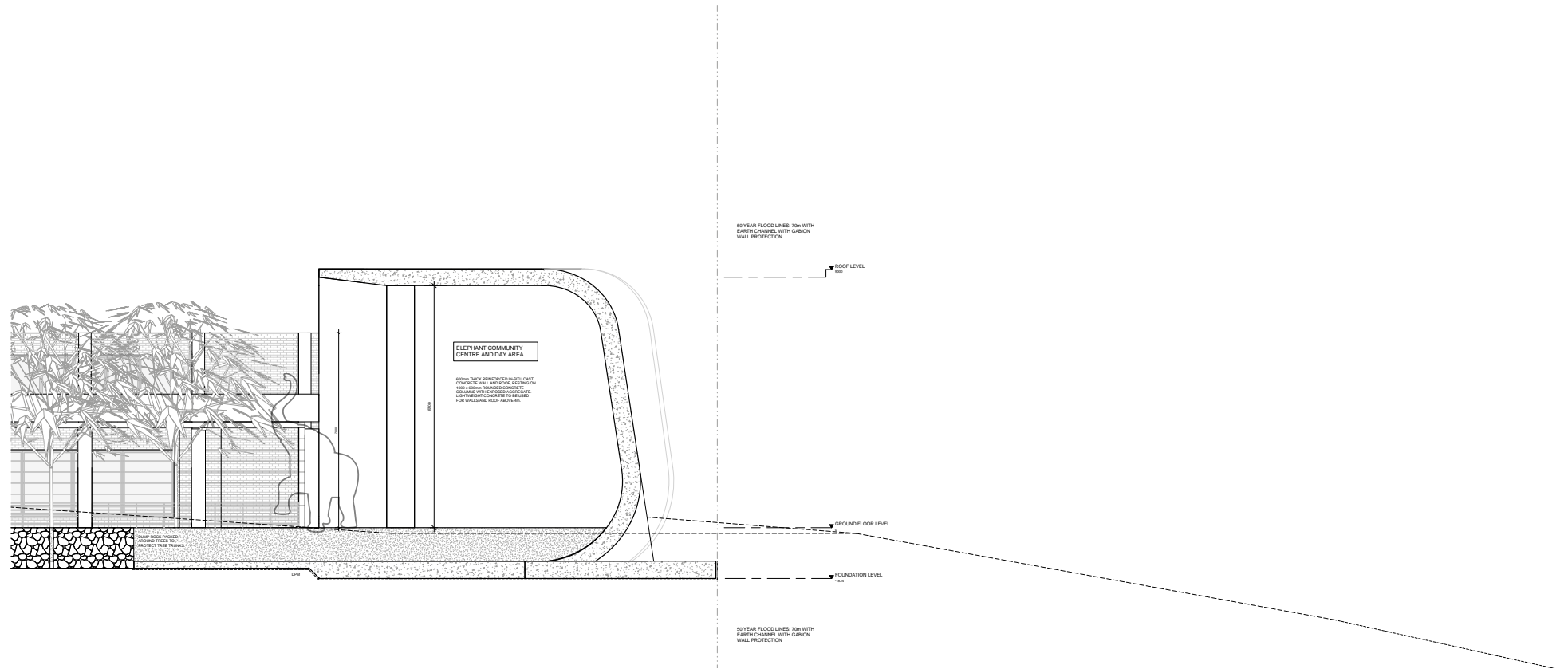


Figure 7.21 First digitally translated section drawing (Author, 2016).







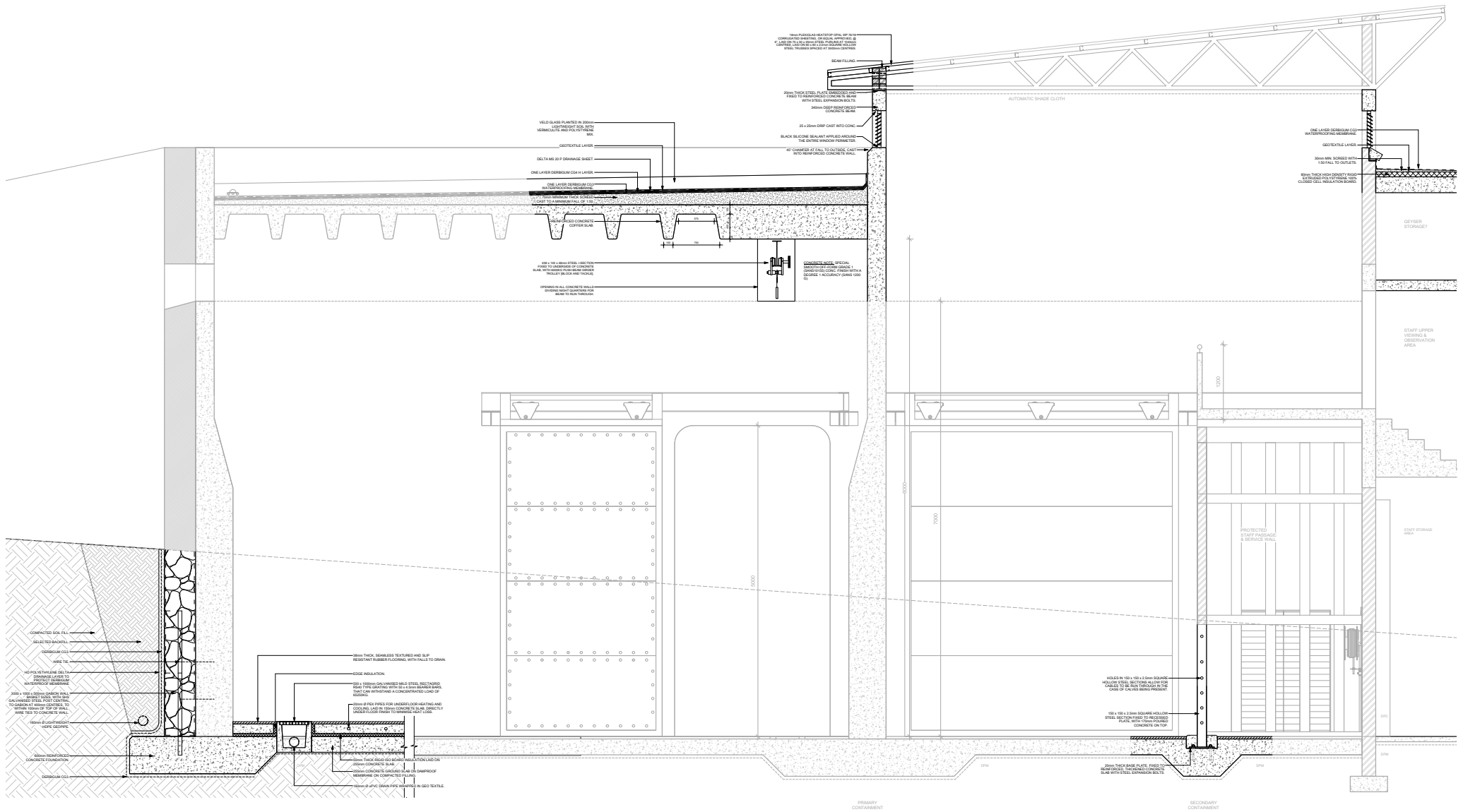


Figure 7.23 Detail Section as it was in mid-October (Author, 2016).



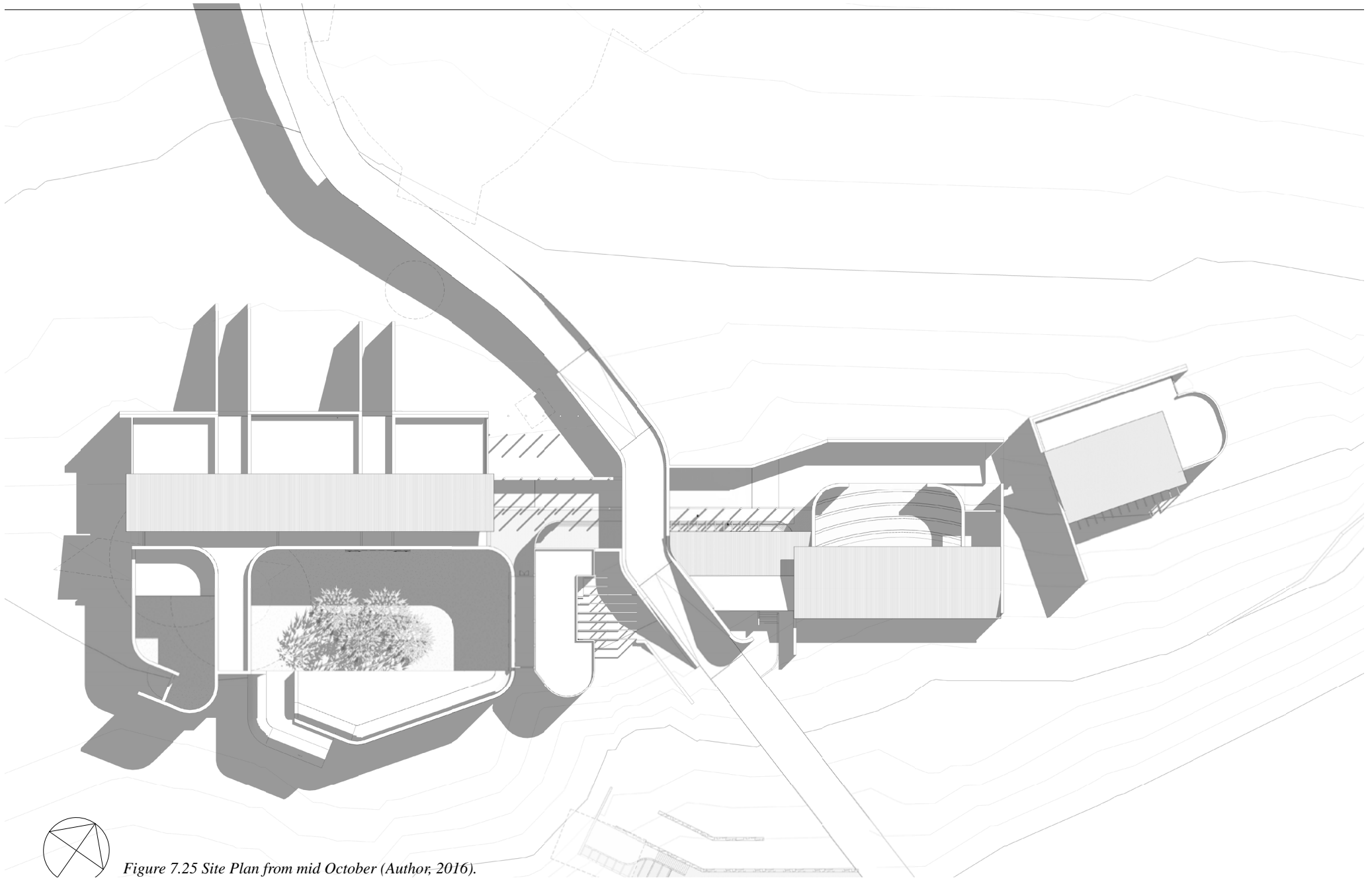


Figure 7.25 Site Plan from mid October (Author, 2016).

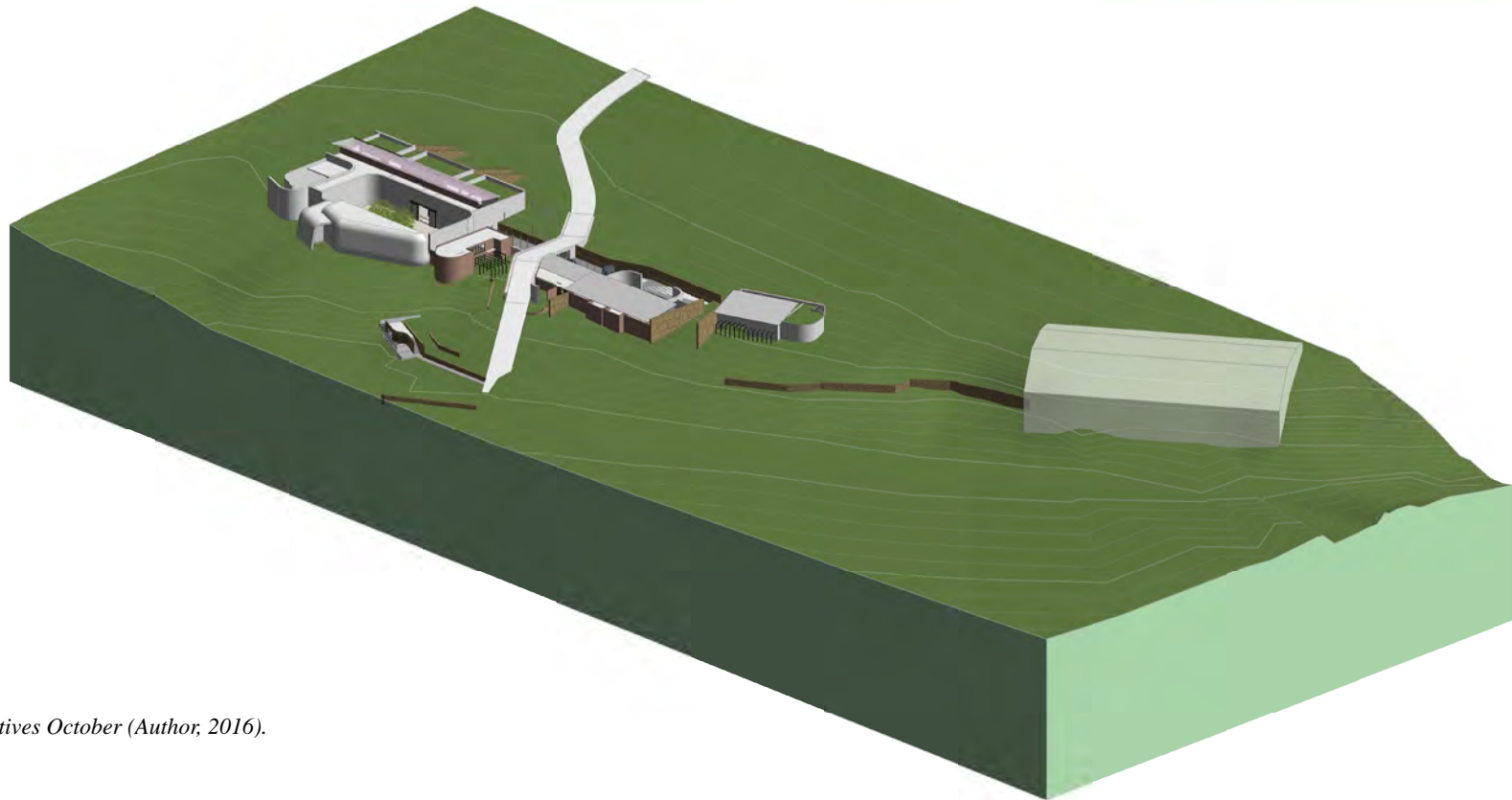
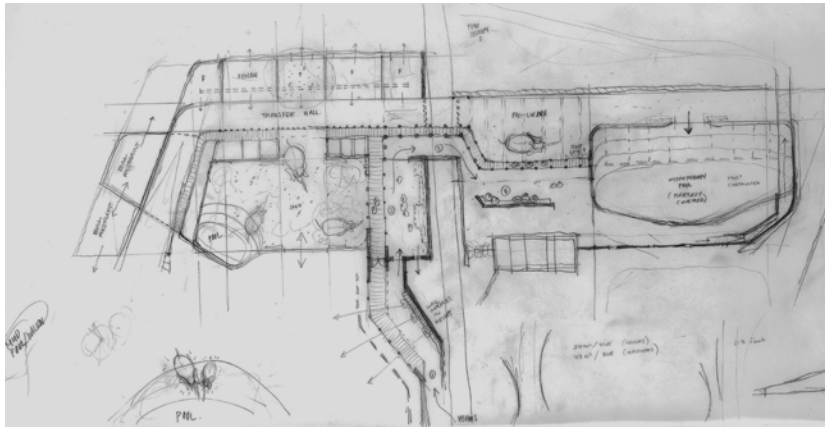
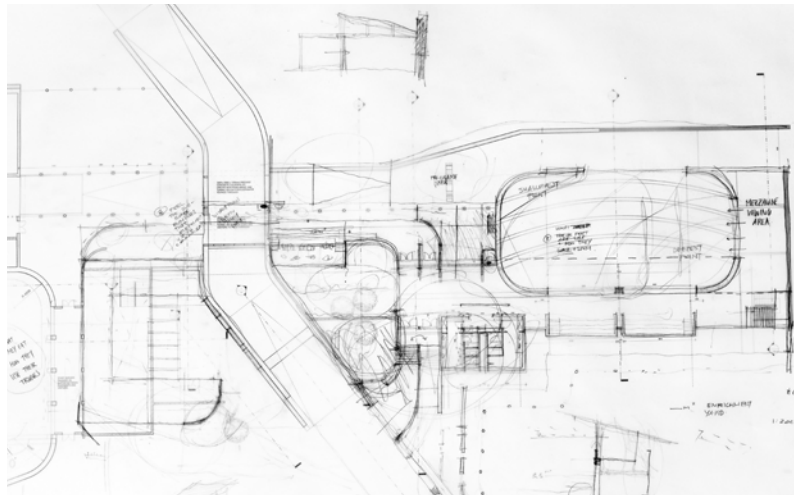


Figure 7.26 Site perspectives October (Author, 2016).

# PROCESS WORK | ITERATIONS



*Ground plan exploration - as linear process for elephant rehabilitation*



*Exploration of public spaces adjacent to the main road, connecting to the two primary elephant viewing spaces.*

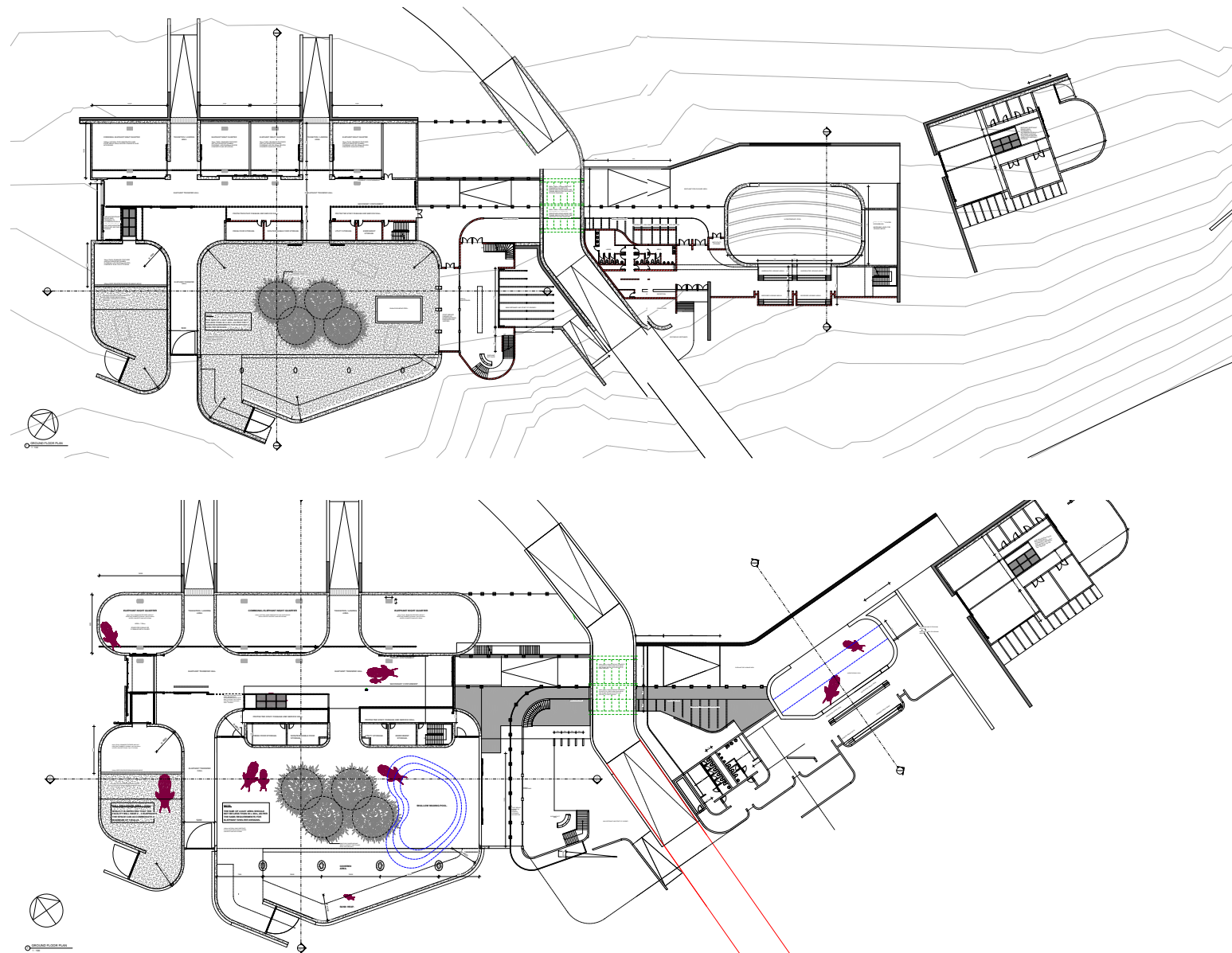


## *Orientation*

*The orientation of the plan changed from facing True North, to allow the building to be integrated harmoniously into the landscape and follow the natural slope.*

*This change also allowed the large, monolithic, concrete feature wall of the main enclosure to be more visible for visitors from street view.*

## DIGITAL TRANSLATION OF DESIGN DEVELOPMENT DRAWINGS



### Orientation

*To ensure effective heat gain for the water in the hydrotherapy pool, and to minimise heat loss, the hydrotherapy pool as well as the clinic were orientated to face true North. The buildings resulted in being integrated into the landscape more effectively.*

### Services integration

*The support staff areas were redesigned to be centrally located in the main elephant building to effectively service all immediate spaces. The ERD was integrated into the staff protected passage with the service wall positioned behind, to aid in treating and examining elephants on a daily basis.*

Figure 7.30 & 7.31 Final plan iterations (Author, 2016).





# 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 be 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).*

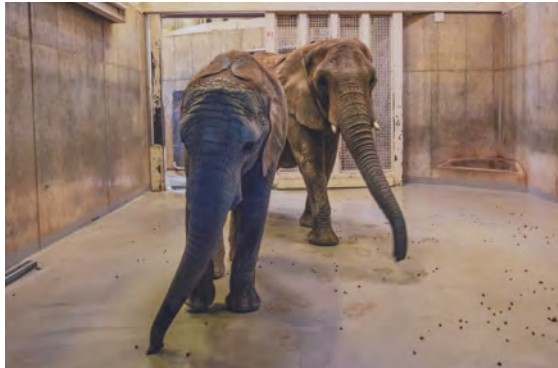
*Figure 8.2 & 8.3 Right above and below: 'MnD Floors' Equine and Zoo range rubber flooring shown in the Giraffe and Elephant barn at the Hogle Zoo, Utah.*

## *Rubber Flooring Night Quarters*

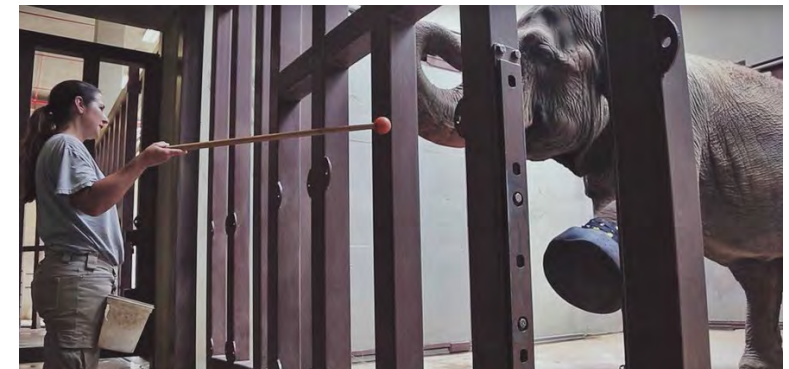
Rubber flooring is utilised in the sleeping areas to alleviate the possible discomfort caused by concrete floors. Since elephants in captivity are prone to foot pathologies and arthritis, rubber flooring is a suitable alternative and shock-absorbent substrate proven to have positive impacts on their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

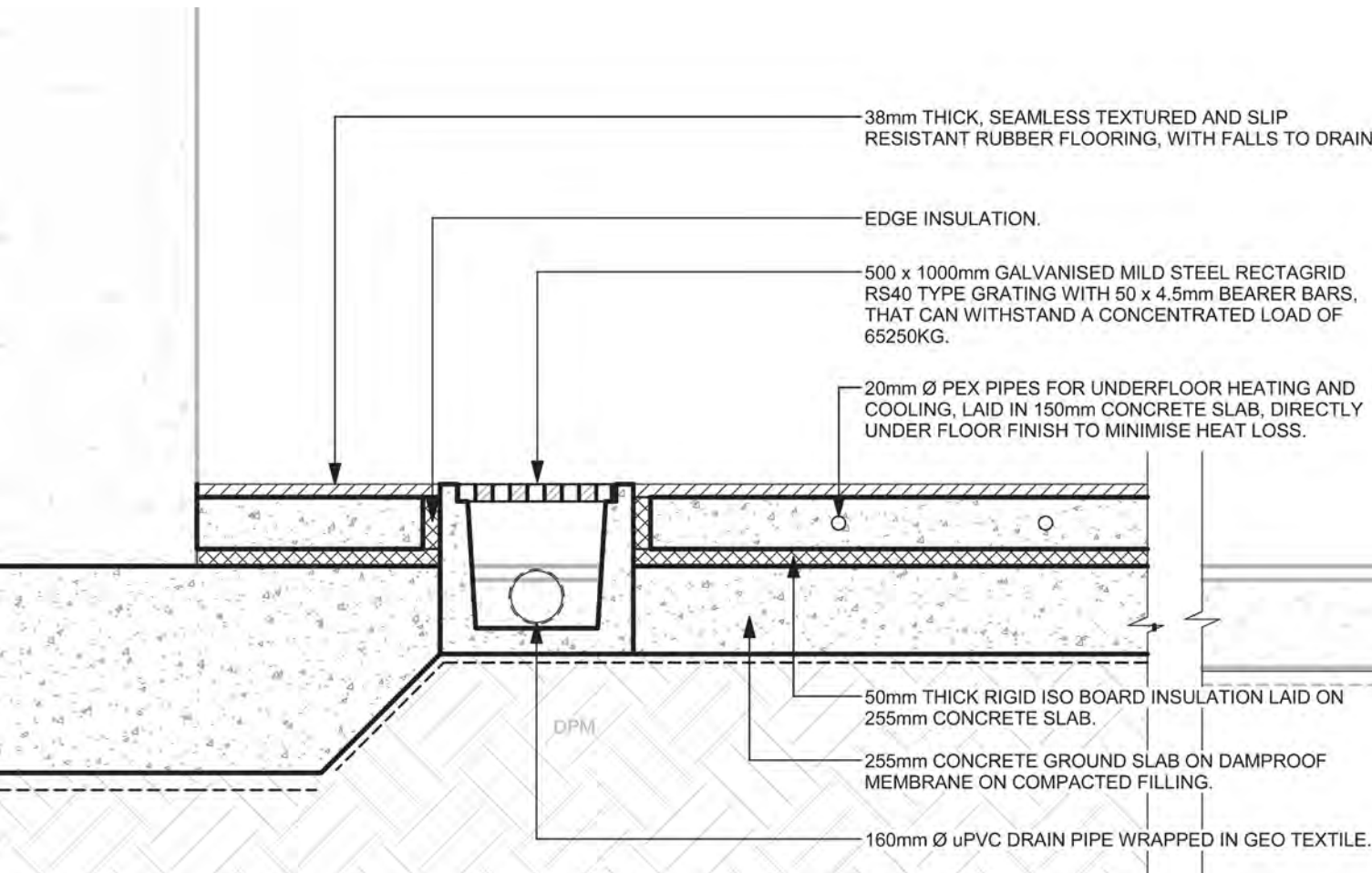


Figure 8. 7 Block and tackle running along steel beam used to raise elephants in emergencies, at the Smithsonian Zoo (Author, 2016).

# Green Roof Detail

1 : 20

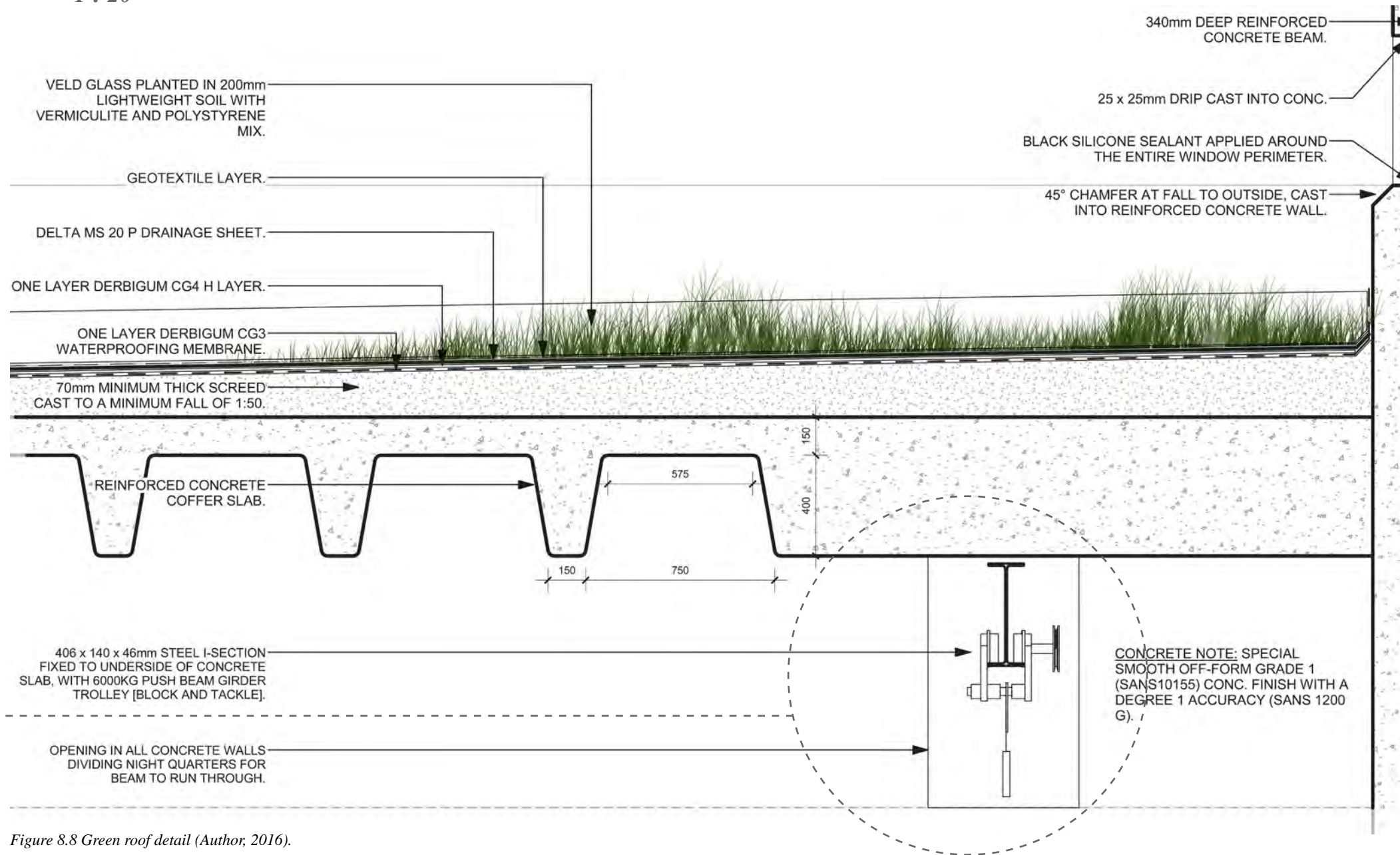


Figure 8.8 Green roof detail (Author, 2016).

## *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

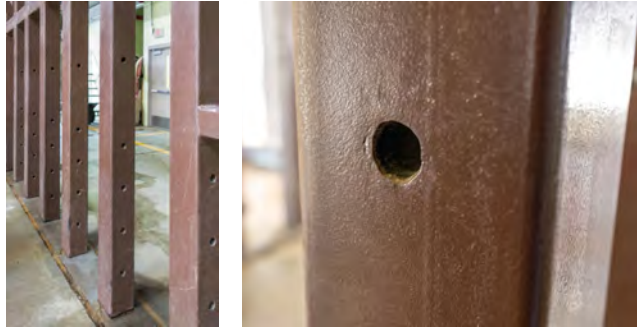


Figure 8.9 Left above: Circular steel members positioned diagonally, at the Elephant House in the Copenhagen Zoo. Figure 8.10 Left below: Circular steel members at the elephant enclosure at the Melbourne Zoo.

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).

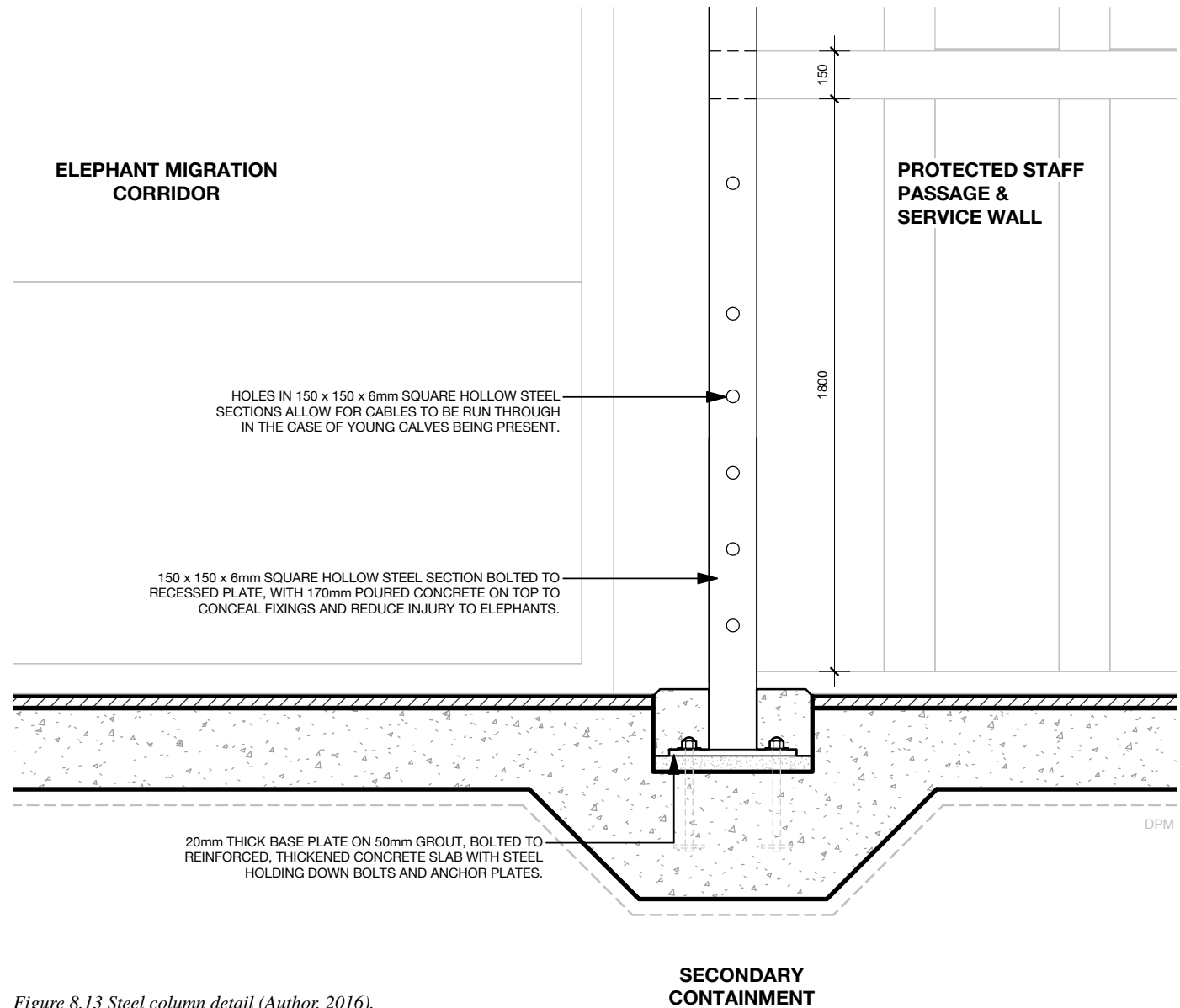
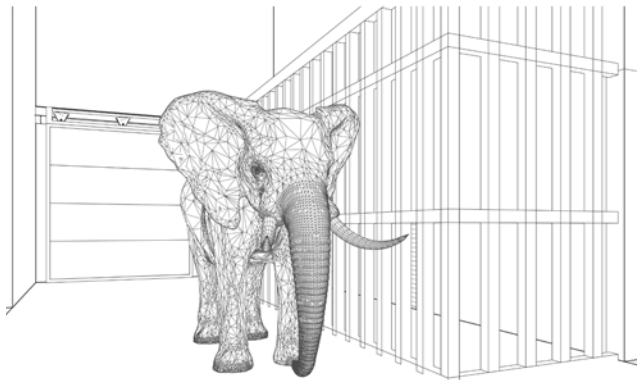


Figure 8.13 Steel column detail (Author, 2016).

## *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



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

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.

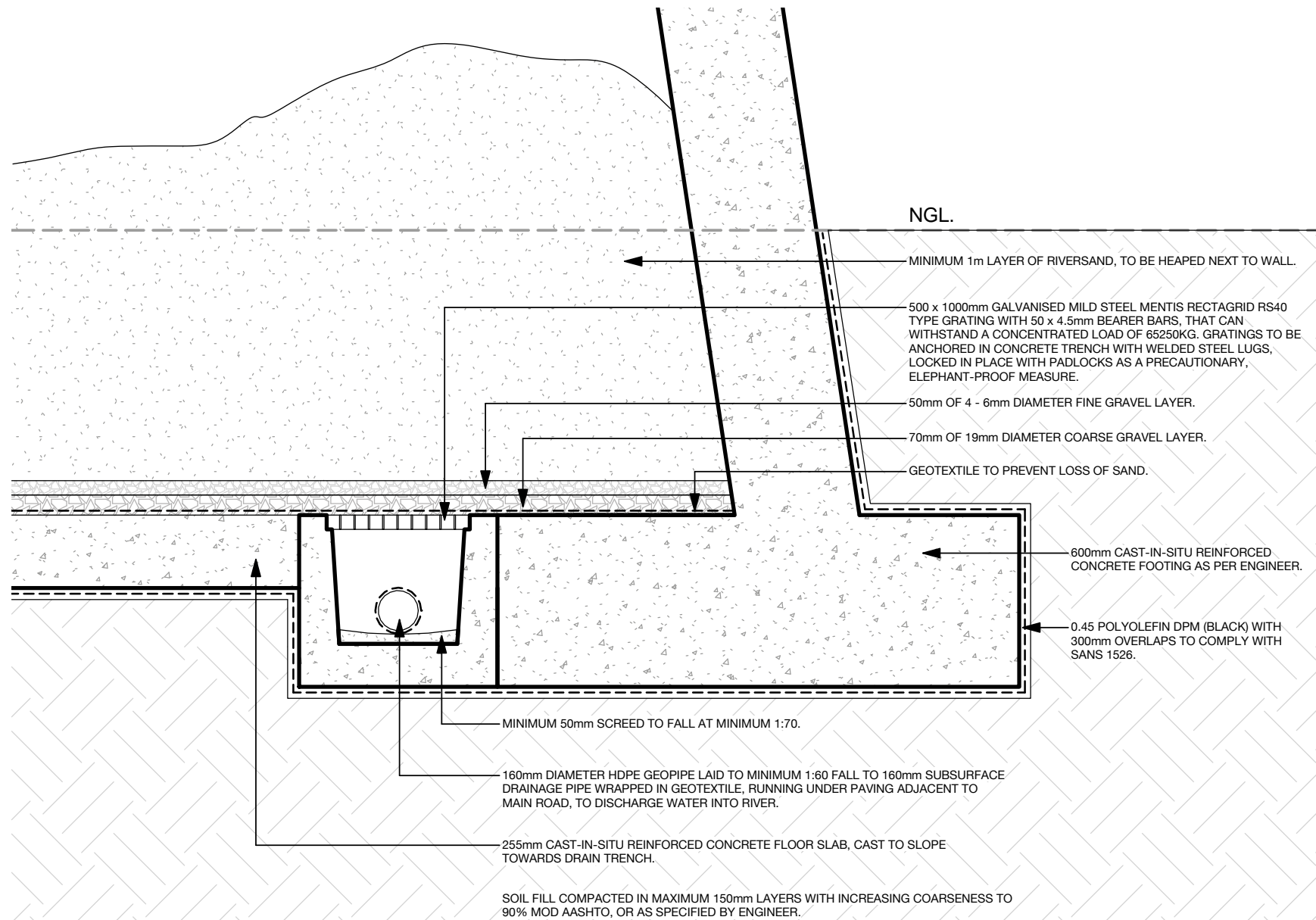


Figure 8.15 Detail of drain in Day Area

## *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.

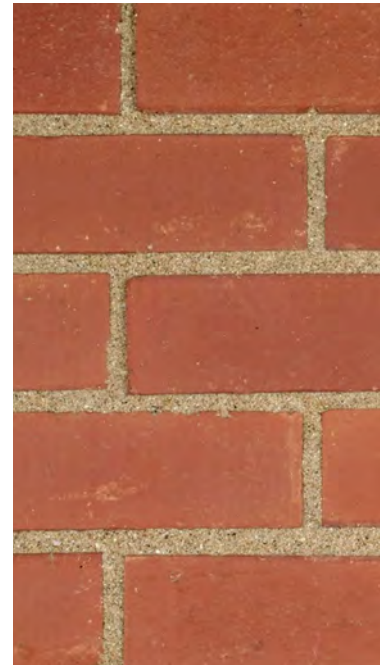
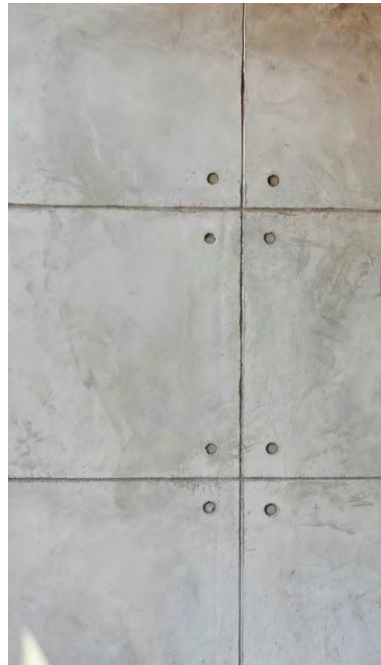
Air inlets to supply fresh air would be needed outside on ground level, preferably positioned in the shade to draw in the coolest and cleanest possible air that is free from dust. These inlets are connected to geothermal pipes running under the building that then feed clean, fresh air into each storage 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, was 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.

<i>Material</i>	<i>Density</i> (Kg/m <sup>3</sup> )	<i>Specific heat</i> (kJ/kg.K)	<i>Volumetric heat capacity</i> <i>Thermal mass (kJ/m<sup>3</sup>.K)</i>
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

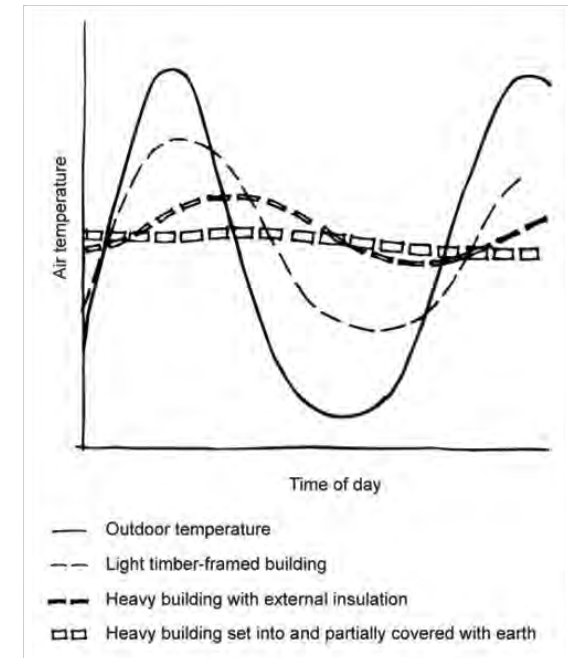


Figure 8.17 Table 1:

Figure 8.18 Table 2:

Figure 8.19 Top right:

<i>Time lag figures for various materials</i>	
<i>Material thickness (mm)</i>	<i>Time lag (hours)</i>
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

## 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*

$$[6 \text{ Elephants} \times 50\text{kg per day}] + [2 \text{ Rhinos} \times 23\text{kg}]$$

$$= 346\text{kg of manure per day}$$

$$= 126\,290\text{kg per year}$$

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

*Therefore:*

$$346\text{kg manure} = 11\,418\text{L Biogas}$$

$$346\text{kg manure} = 6\,920\text{L Methane}$$

1m<sup>3</sup> 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

$$4,182\text{kJ/kg.K} = 1,1616667\text{Wh/L.}^\circ\text{C}$$

$$1,1616 \times 183\text{kL} = 212,6\text{kWh/}^\circ\text{C} = 68,508\text{kWh}$$

@ 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

$$[87,4 / 100] \times 20,1\text{kW} = 17,5\text{kW of Electricity}$$

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

$$[32,4 / 33,7] \times 6,59\text{kW} = 6,34\text{kW of Electricity}$$



## Energy produced used to heat pool results

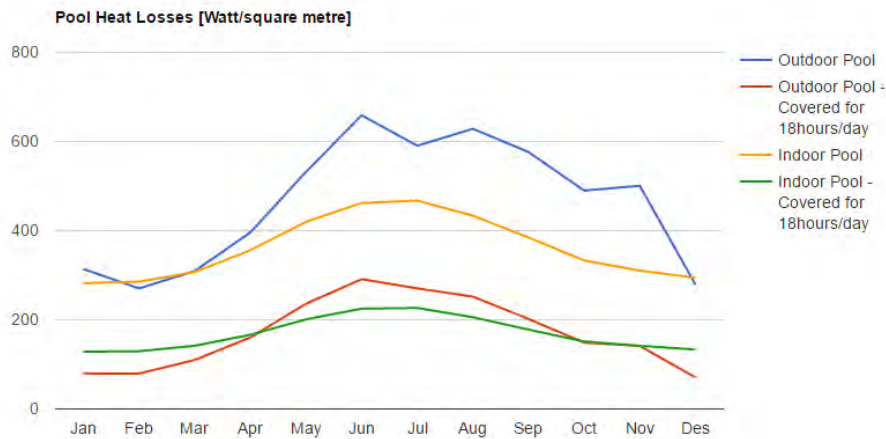
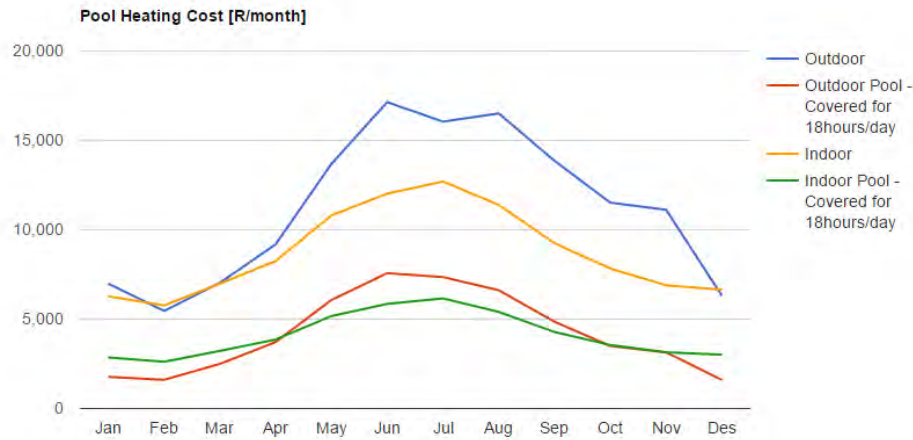


Figure 8.17 Test results

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 <sup>2</sup> ]	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			

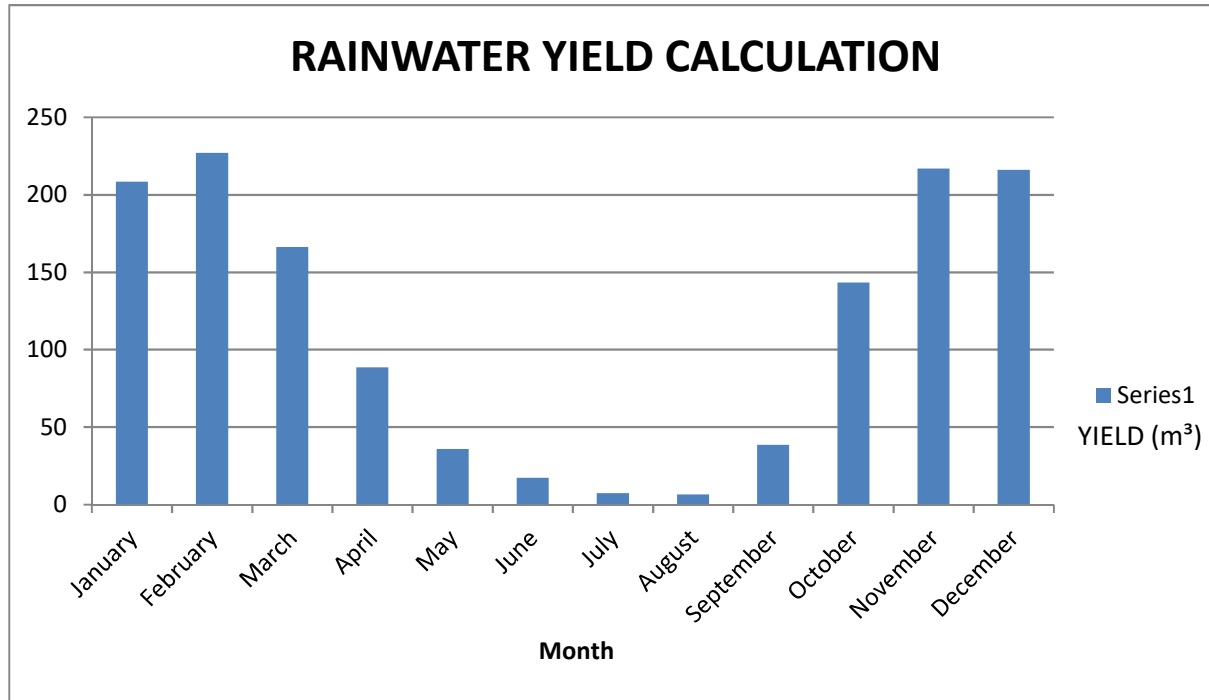
PROPERTY	OUTDOOR POOL	OUTDOOR POOL COVERED FOR 18H/DAY	INDOOR POOL	INDOOR POOL COVERED FOR 18H/DAY
Max Heat Loss [W/m <sup>2</sup> ]	500.7	141.5	310.3	141.7
Heat Pump Size [kW]	114.6	32.4	71.0	31.9
Heat Pump Model Requirement	Enerflow EIP500MTC model.	Enerflow EIP15MT3 model.	Enerflow EIP330MTC model.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

## Calculations

### *Precipitation in Pretoria*

Month	Temperature (°C)			Percepitation		
	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.



## Calculations

### Rainwater harvesting

RAINWATER									
Month	Ave. monthly precipitation, P (mm)	Area of catchment roof 1 (m <sup>2</sup> ) - GREEN ROOF [NIGHT QUARTERS]	Runoff coefficient	Yield (m <sup>3</sup> )	Area of catchment roof 2 (m <sup>2</sup> ) - PLEXIGLAS ROOF [MIGRATION CORRIDOR]	Runoff coefficient	Yield (m <sup>3</sup> )	Area of catchment roof 3 (m <sup>2</sup> ) - 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.

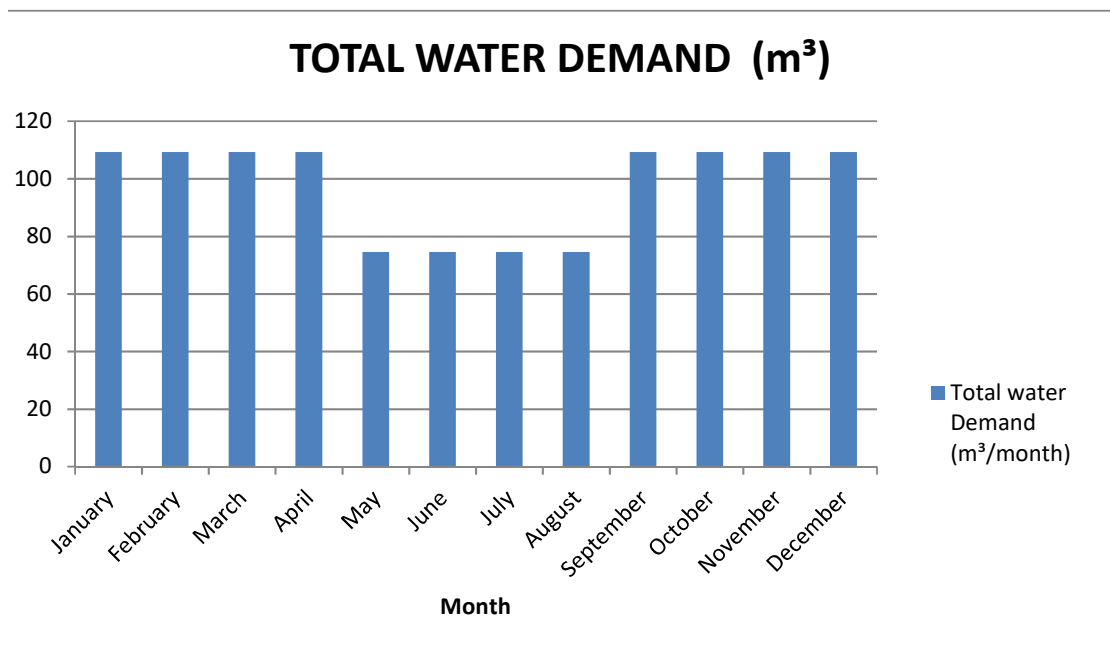
**R YIELD CALCULATION**

Yield (m <sup>3</sup> )	Area of catchment roof 4 (m <sup>2</sup> ) - CONCRETE ROOF [PUBLIC 1]	Runoff coefficient	Yield (m <sup>3</sup> )	Area of catchment roof 5 (m <sup>2</sup> ) CONCRETE ROOF [PUBLIC 2]	Runoff coefficient	Yield (m <sup>3</sup> )	Area of catchment roof 6 (m <sup>2</sup> ) CONCRETE ROOF [CLINIC]	Runoff coefficient	Yield (m <sup>3</sup> )	Area of catchment roof 7 (m <sup>2</sup> ) GREEN ROOF [CLINIC]	Runoff coefficient	Yield (m <sup>3</sup> )	Yield (m <sup>3</sup> ) 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
February		6	200	1200
March		6	200	1200
April		6	200	1200
May		6	200	1200
June		6	200	1200
July		6	200	1200
August		6	200	1200
September		6	200	1200
October		6	200	1200
November		6	200	1200
December		6	200	1200

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

TOTAL WATER DEMAND CALCULATION						
Month	Staff Demand (m <sup>3</sup> /month)	Visitors Demand (m <sup>3</sup> /month)	Elephant Drink Demand (m <sup>3</sup> /month)	Elephant Washing Demand (m <sup>3</sup> /month)	Evap Losses	Total water Demand (m <sup>3</sup> /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 (m <sup>3</sup> )	Demand (m <sup>3</sup> )	Monthly balance	Vol. water in tank (m <sup>3</sup> )	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

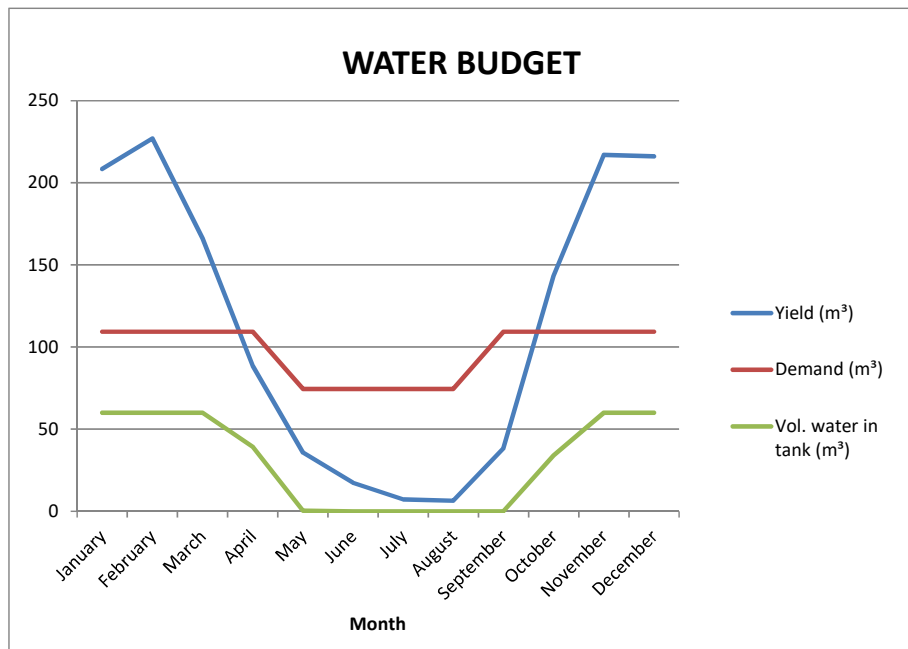
TANK SIZE (m<sup>3</sup>) SAFETY FACTOR FINAL TANK m<sup>3</sup>  
 60 1,333333333 80

Tank Size Selected  
 60

Saving of  
 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 m<sup>2</sup> (No fixed seats)
- C1: Exhibition hall  
1 person per 10m<sup>2</sup>

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:

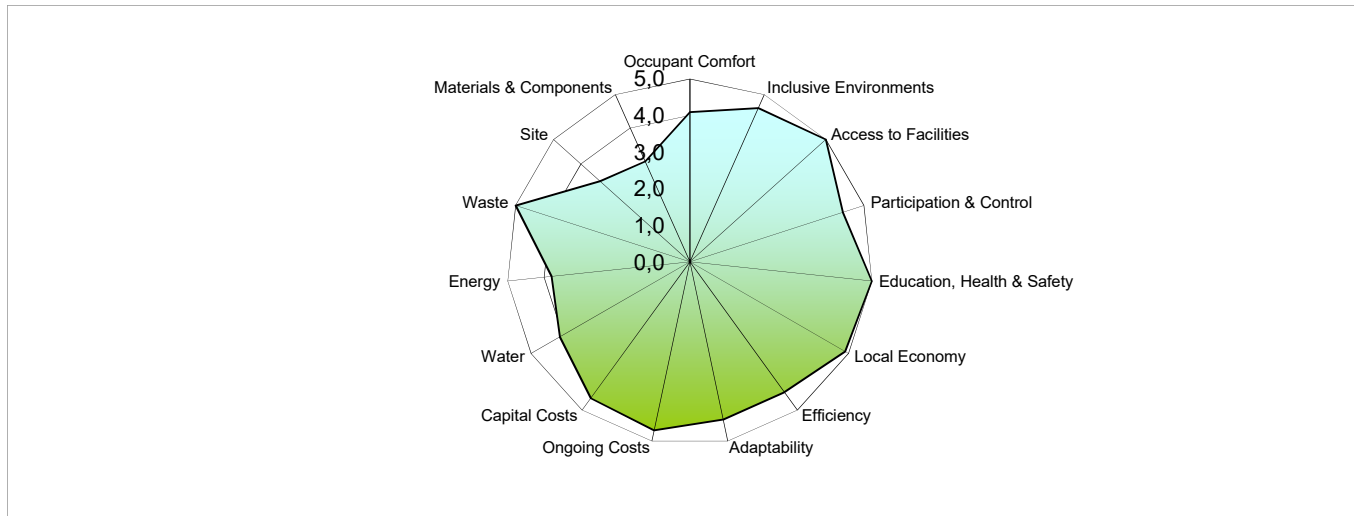
- 5 Water closets
- 3 Wash hand basins

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**

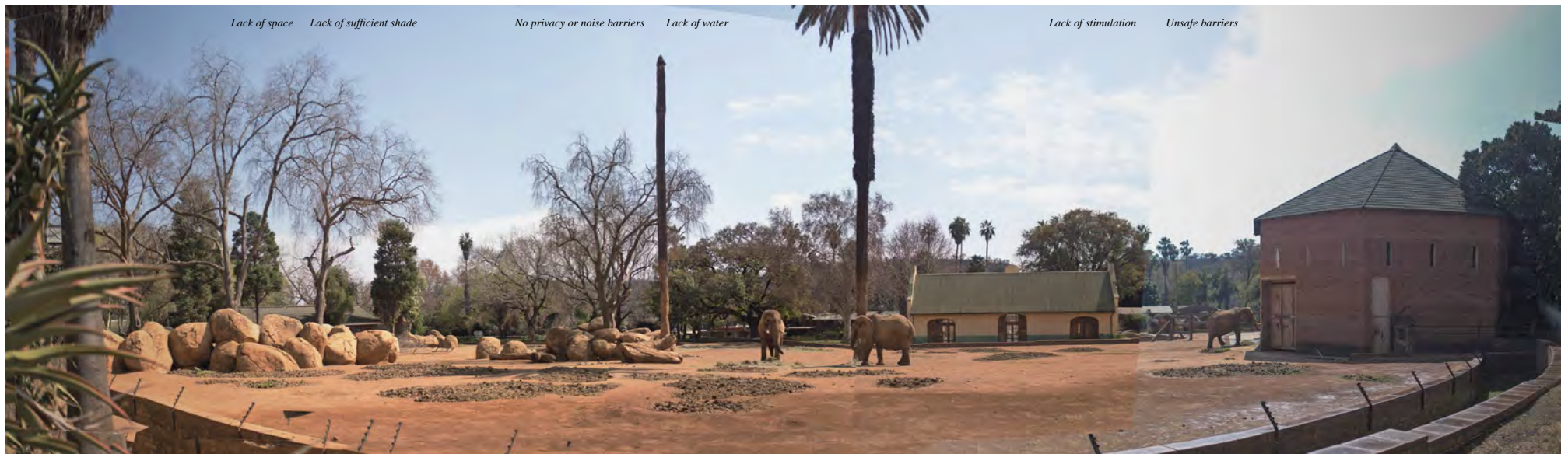


## THE GARDEN OF CAPTIVES

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CREATING A PLACE OF SANCTUARY, FOR OUR GENTLE GIANTS

# EXISTING ELEPHANT ENCLOSURE





# PRECEDENT SMITHSONIAN NATIONAL ZOO

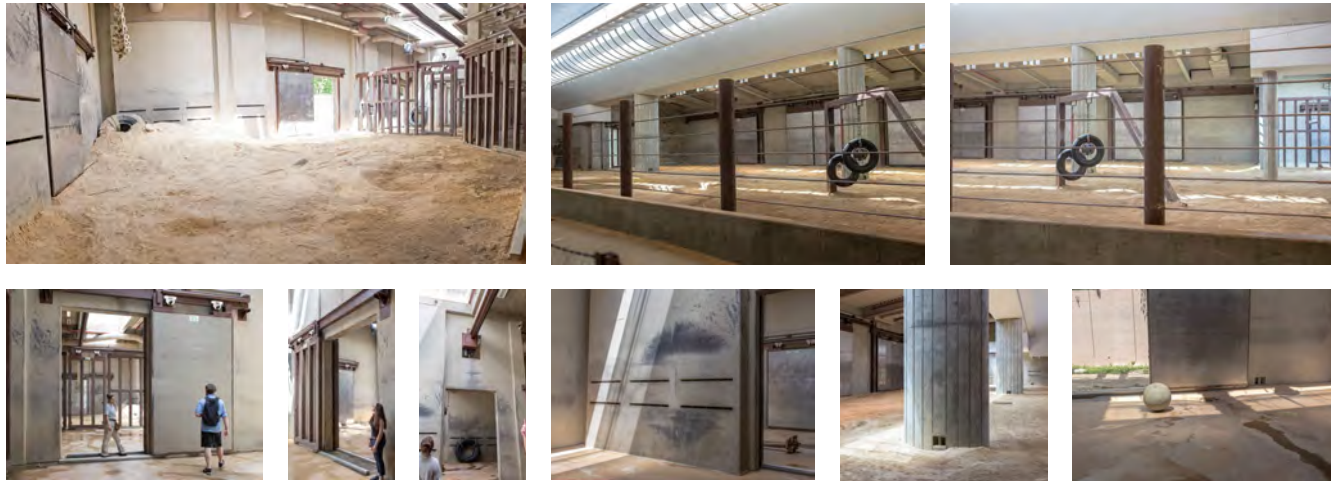
*Architects: pja architects + landscape architects*

*Location: Washington D.C., United States*

*Area: 8 943 m<sup>2</sup>*

*Project completion year: 2012*

*Client: Smithsonian National Zoo*



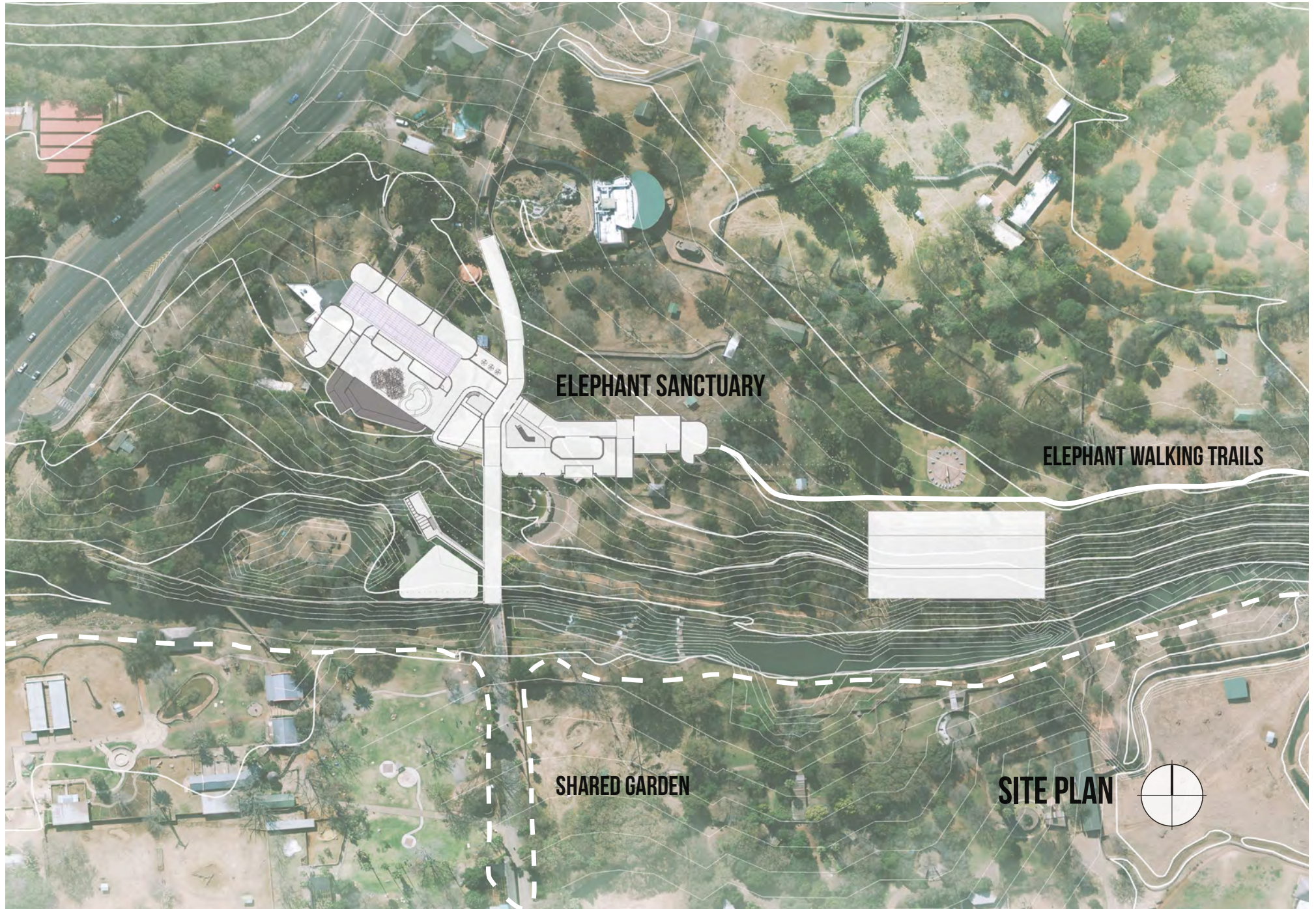
# SITE NATIONAL ZOOLOGICAL GARDENS

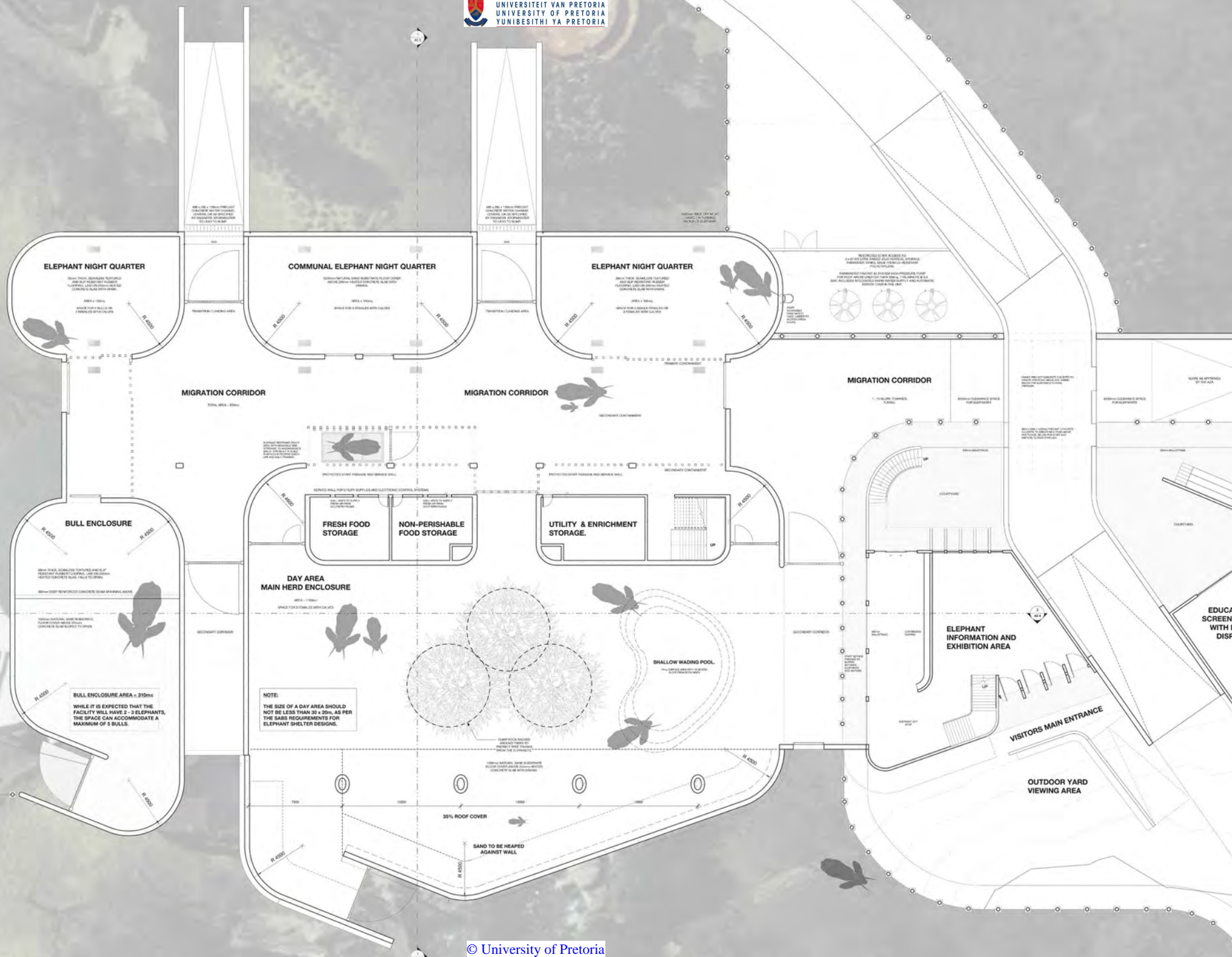
NEW PROPOSED SITE



EXISTING ELEPHANT ENCLOSURE









**ELEPHANT CLINIC**

3000 TYPICAL STAIRS FOR STAIRWAYS  
AND ALL STAIRWAYS AND STAIRS  
CONCRETE SLAB WITH STAIRS  
CONCRETE SLAB WITH STAIRS

CONCRETE SLAB WITH STAIRS  
CONCRETE SLAB WITH STAIRS  
CONCRETE SLAB WITH STAIRS  
CONCRETE SLAB WITH STAIRS

**ANTHROPOLOGICAL ISOLATION AREA**

**MIGRATION CORRIDOR**

**PRIVATE STAFF GARDEN AND YARD VIEWING AREA**

**ELEPHANT PRE-CLEANSE SHOWER DEMONSTRATION AREA**

**HYDROTHERAPY POOL**

**VISITORS ENTRANCE TO HYDROTHERAPY VIEWING**

**EXHIBITION AREA  
DIGITAL DISPLAYS**

**GROUND FLOOR PLAN 1:100**







100 YEAR FLOOD LINE'S 75m WITH  
 1.5M CHANNELED, WITH GARDEN  
 WALL PROTECTION

ROOF LEVEL  
 9000

**ELEPHANT DAY AREA**

400mm THICK PERIMETER IN SITU CAST CONCRETE  
 WALL AND ROOF PERIMETER ON 100mm  
 POLYSTYRENE INSULATION. ALL EXPOSED  
 REINFORCEMENT SHALL BE CORROSION RESISTANT  
 AND SHALL BE PROTECTED BY AN ANTI-CORROSION  
 COATING. ALL REINFORCEMENT SHALL BE  
 USED AS SCHEDULED POSTS FOR THE ELEMENTS

GROUND FLOOR  
 LEVEL

NGL

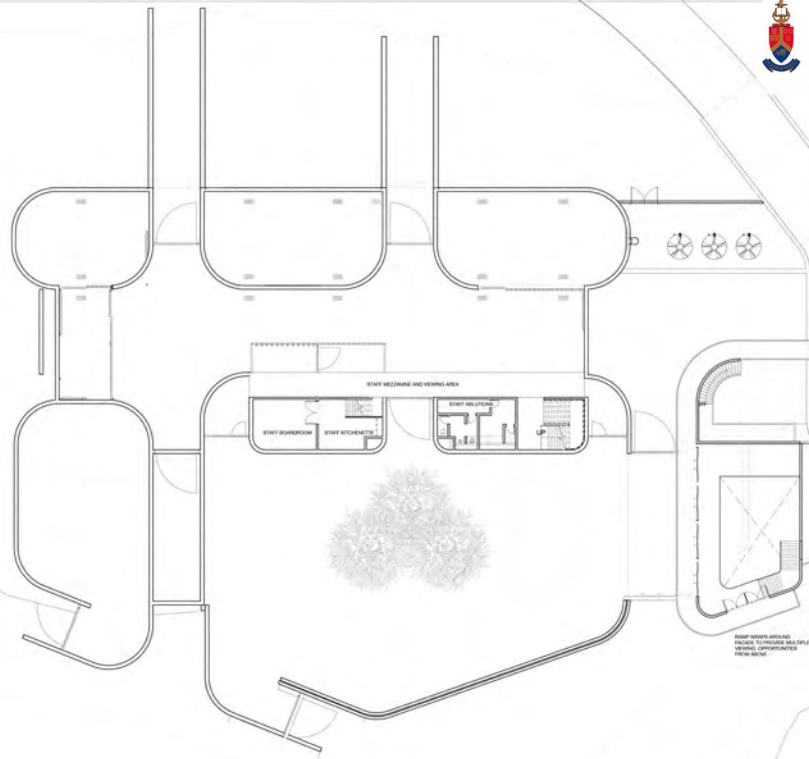
FOUNDATION LEVEL  
 8100

100mm THICK  
 POLYSTYRENE  
 INSULATION  
 ON ROOF  
 PERIMETER

100mm THICK  
 POLYSTYRENE  
 INSULATION  
 ON ROOF  
 PERIMETER

**DETAIL F : DAY AREA DRAIN**

**SECTION A-A 1:50**



**FIRST FLOOR PLAN 1 : 200**



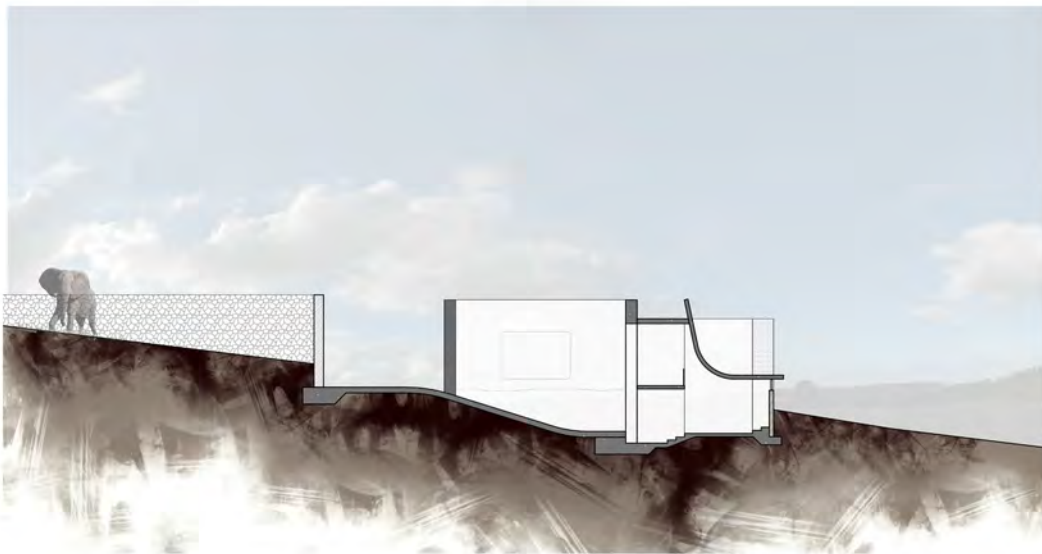
**LOWER GROUND FLOOR PLAN 1 : 200**







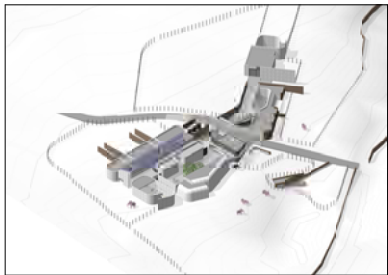
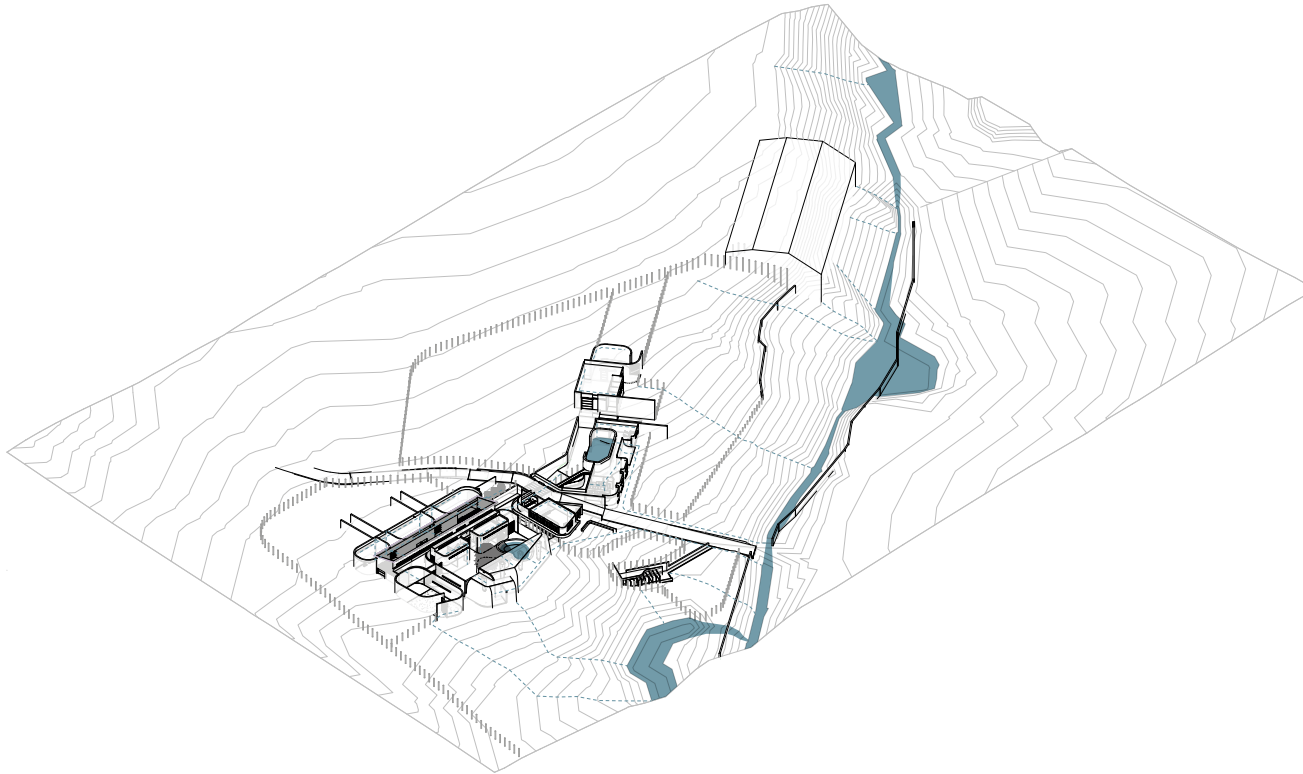
**SECTION B-B 1: 100**



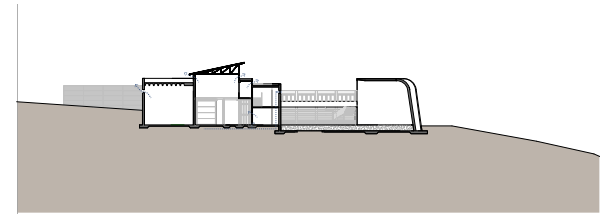
**SECTION C-C 1: 100**

# ENVIRONMENTAL STRATEGIES

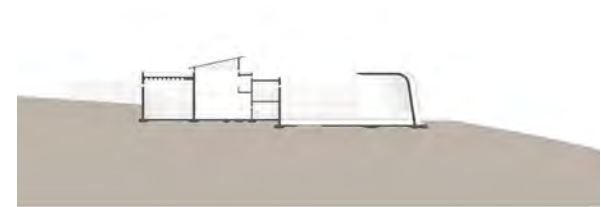
## WATER STRATEGY



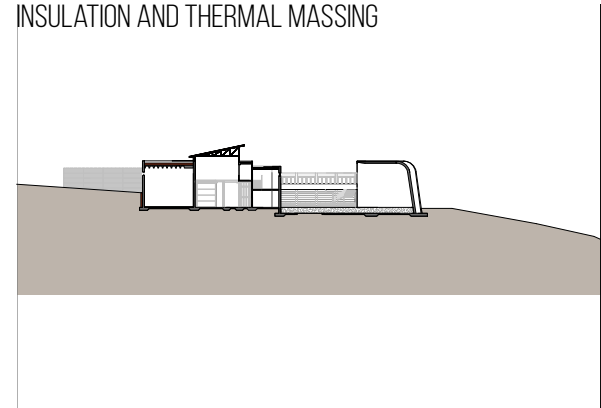
## VENTILATION



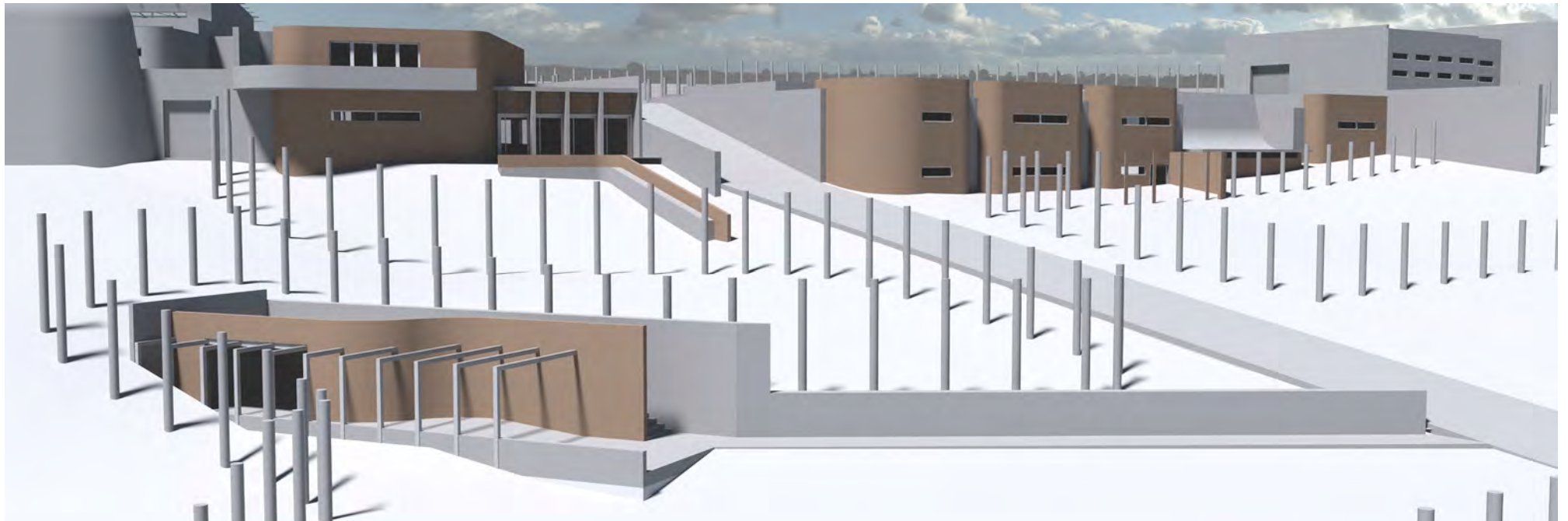
## NATURAL DAYLIGHTING



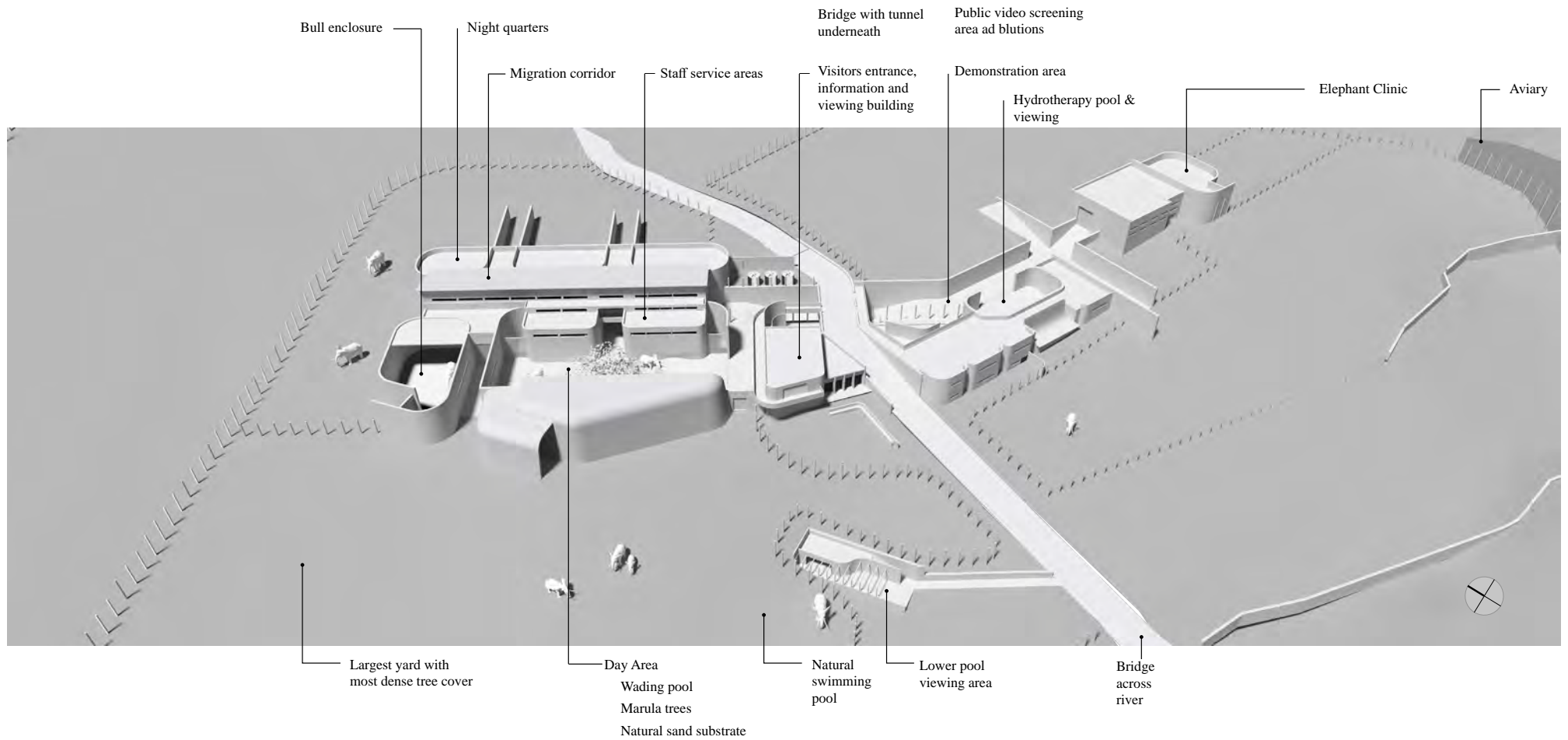
## INSULATION AND THERMAL MASSING



## SOUTH FACADE AND PUBLIC ENTRANCE



# AERIAL PERSPECTIVE

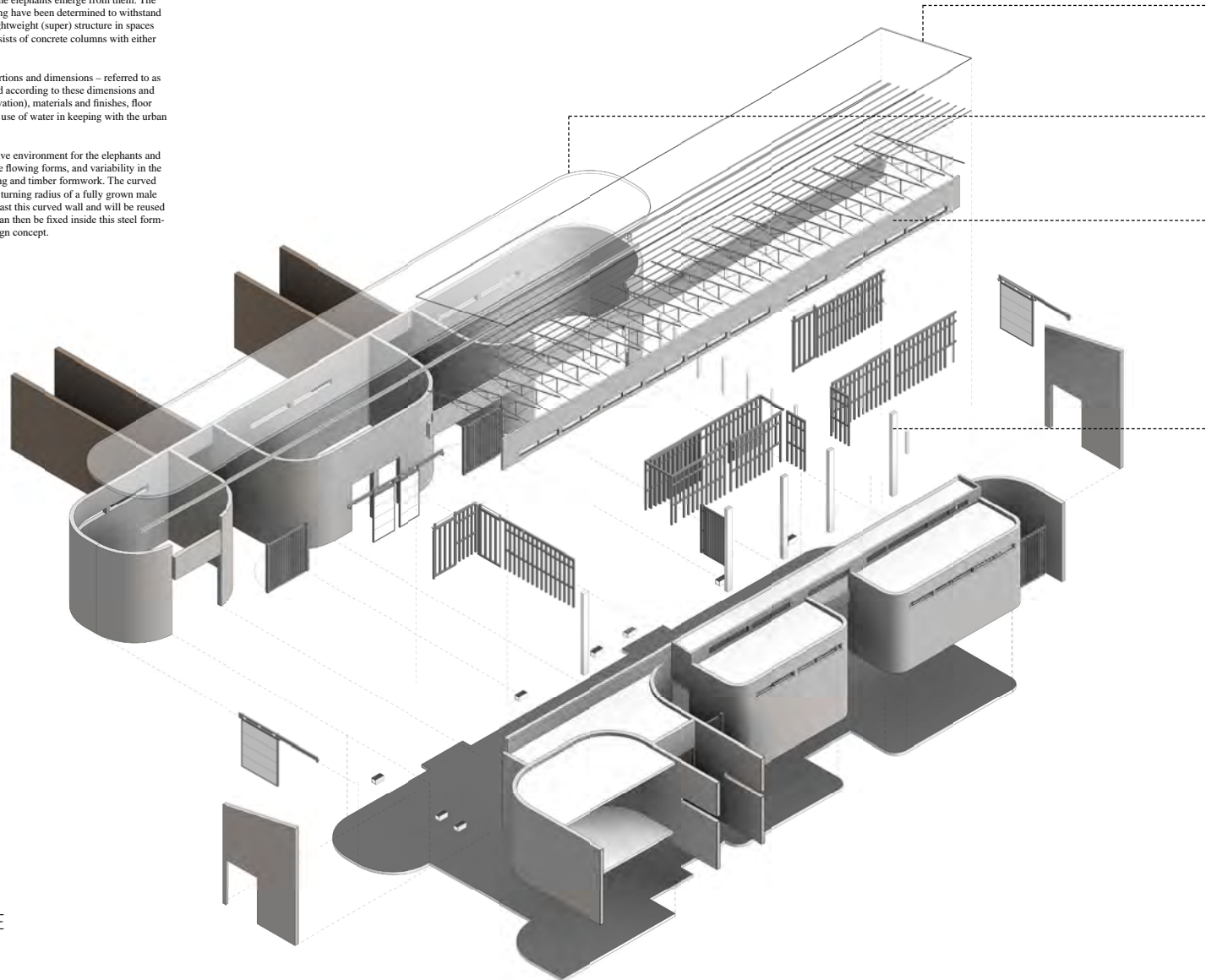


# STRUCTURAL AND TECTONIC INTENTIONS

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.



## ROOF STRUCTURE

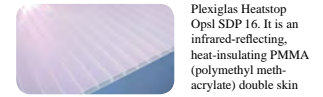
- Plexiglas roof sheeting
- Galvanised steel lipped channels
- Galvanised steel tube trusses
- Reinforced concrete beams
- Reinforced concrete columns

## PRIMARY CONTAINMENT STRUCTURE

- Reinforced concrete walls

## SECONDARY CONTAINMENT STRUCTURE

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



Plexiglas Heatstop Opal 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



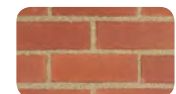
Thick plywood-shuttered cast in situ concrete walls



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



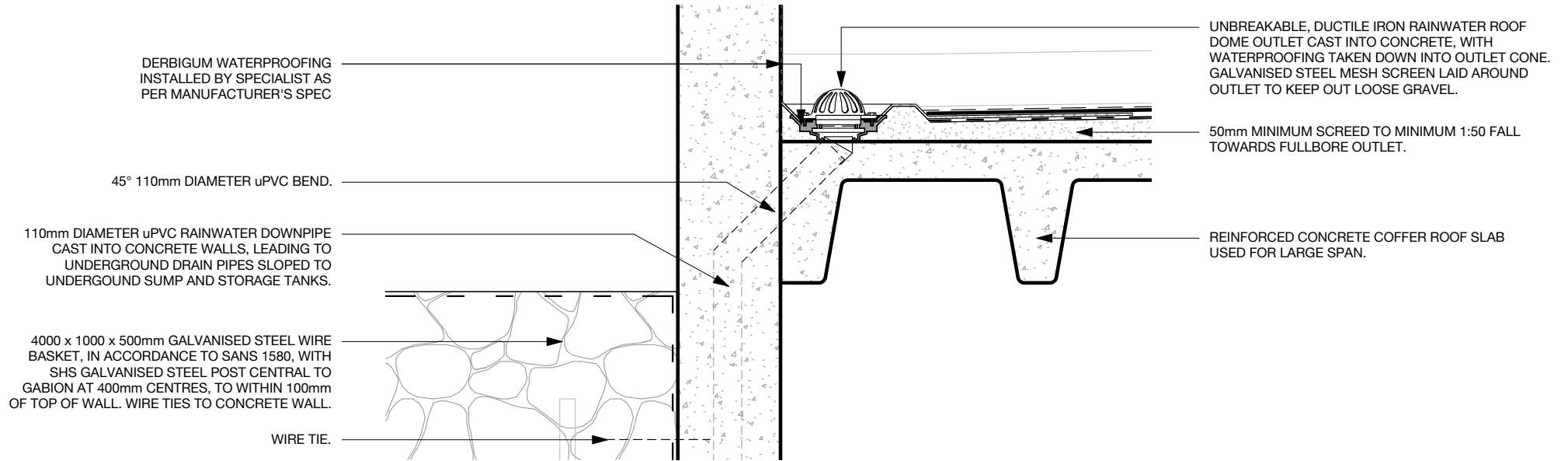
Rubber flooring



Power floated concrete screed

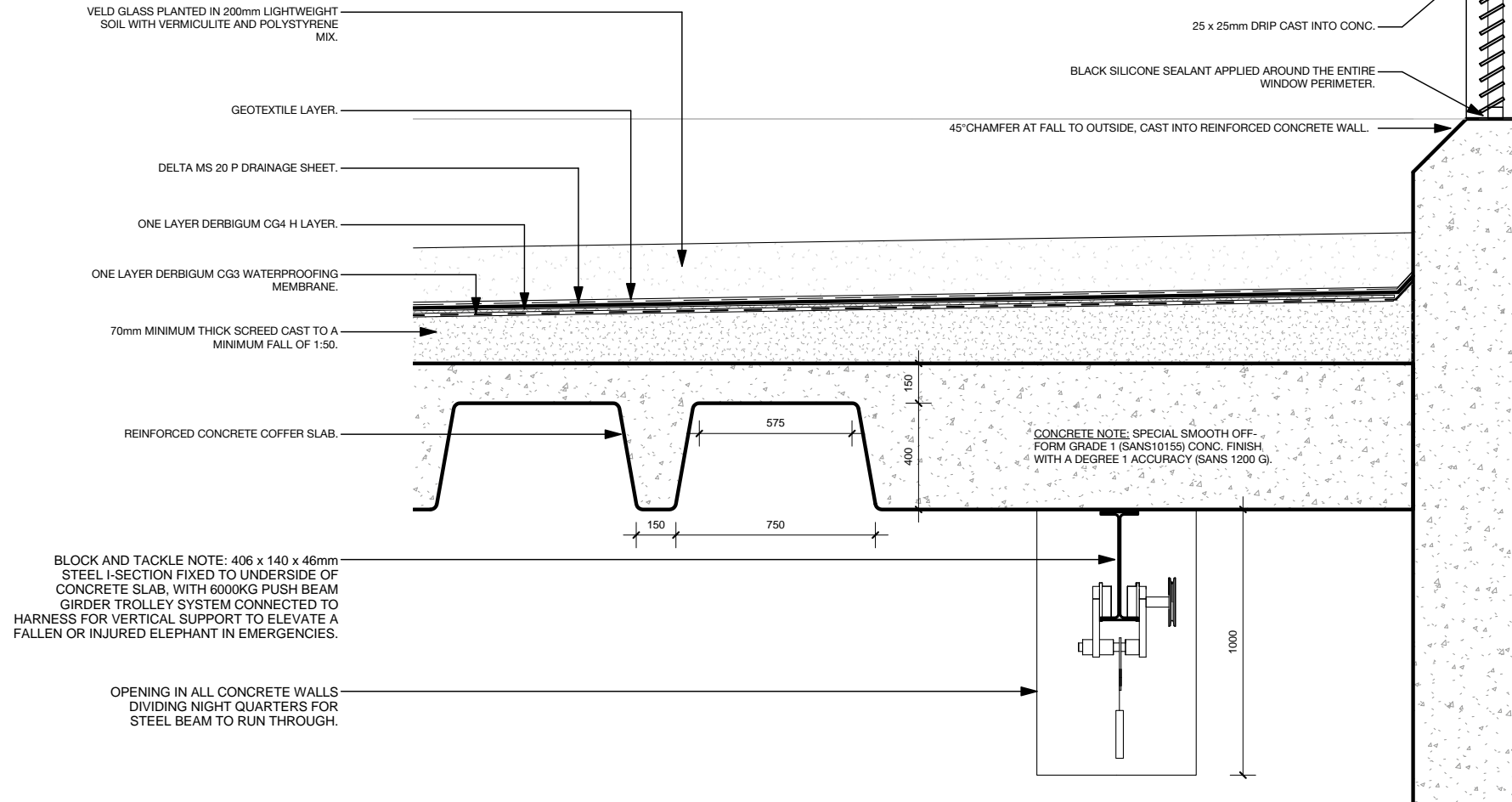
# DETAIL RESOLUTION

## DETAIL A : FLAT ROOF RAINWATER OUTLET TO DOWNPIPE



# DETAIL B : CONCRETE ROOF EAVE

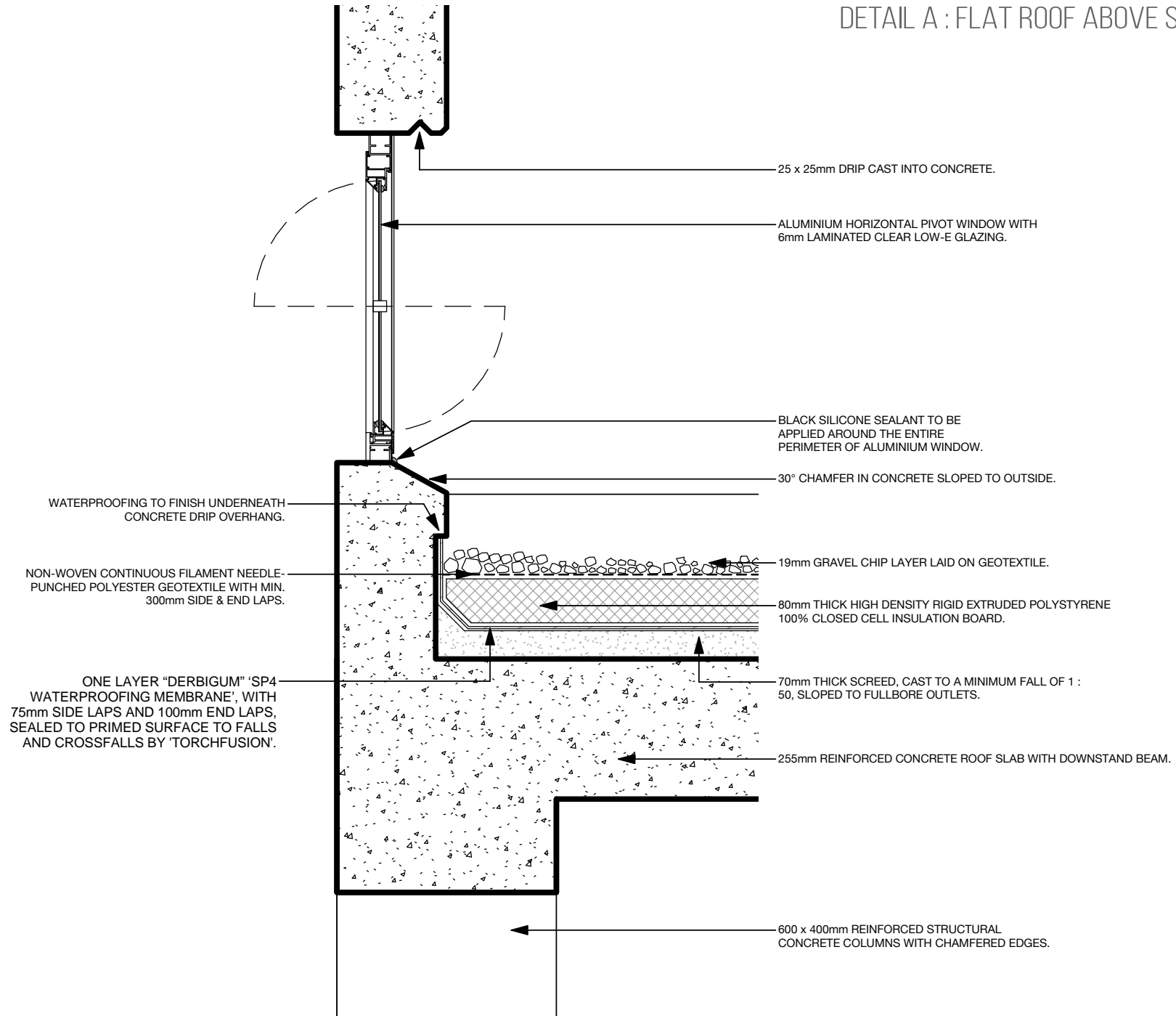
16mm PLEXIGLAS HEATSTOP OPAL SDP 16/980 REFLECTING, HEAT-INSULATING AND WEATHER RESISTANT DOUBLE SKIN OF IMPACT-MODIFIED ACRYLIC (PMMA) SHEETING, OR EQUAL APPROVED, @ 6°, LAID ON 75 x 50 x 20mm STEEL PURLINS AT 1200mm CENTRES, LAID ON 60 x 60 x 2.5mm SQUARE HOLLOW STEEL TRUSSES SPACED AT 3500mm CENTRES.



(Detail not to scale).

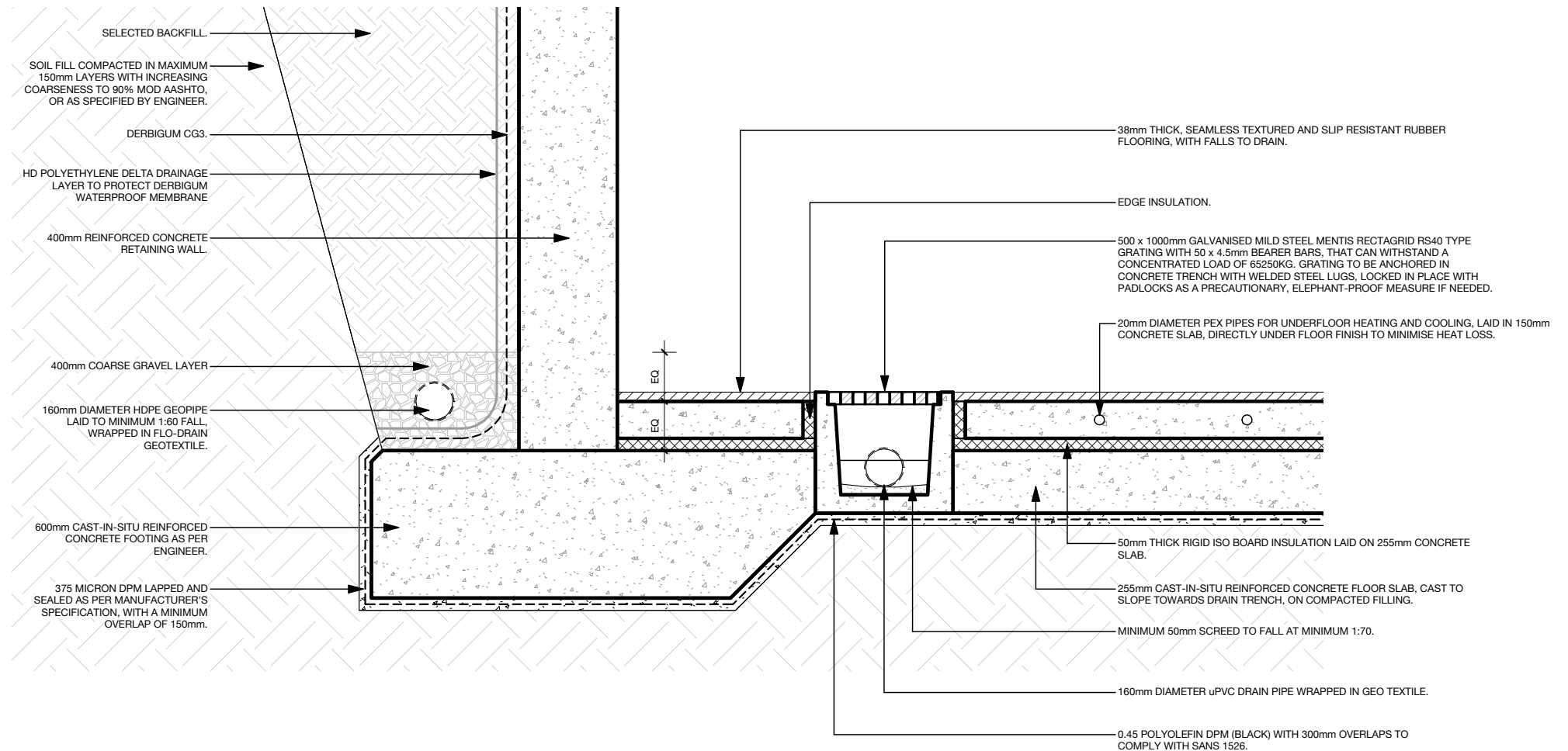
DETAIL A : FLAT ROOF ABOVE STAFF MEZZANINE LEVEL

1 : 10





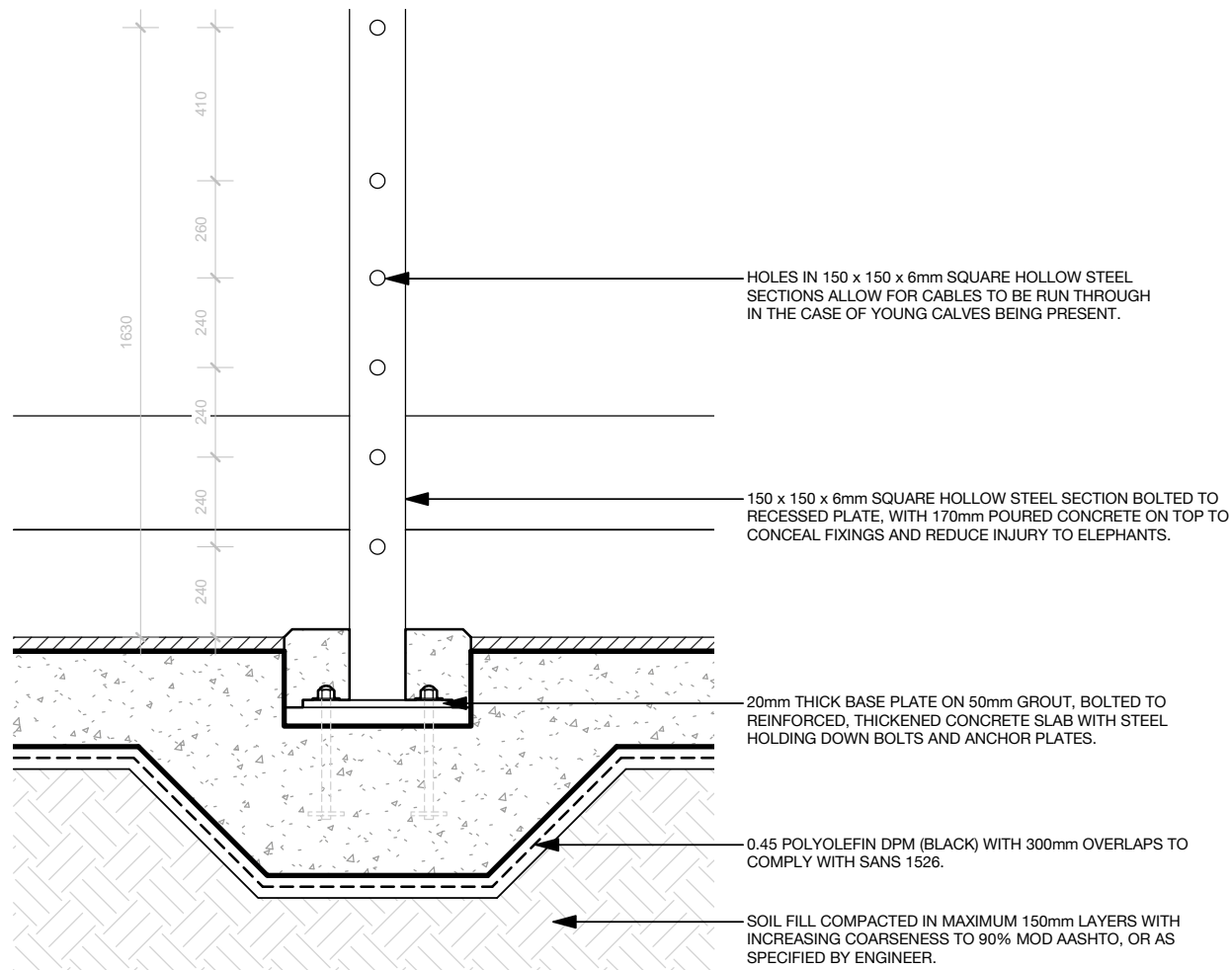
## DETAIL D : RUBBER FLOORING WITH DRAIN



(Detail not to scale).

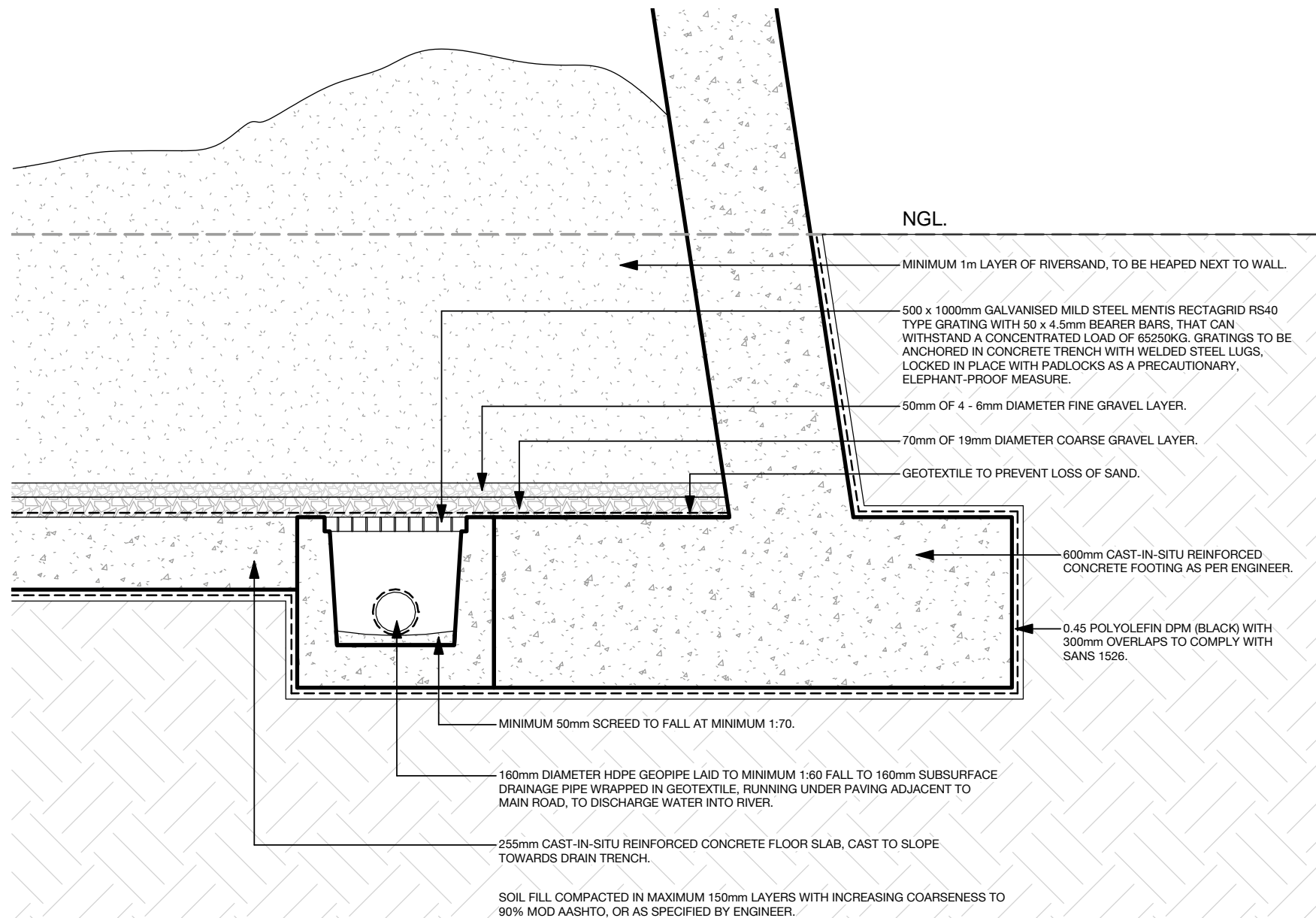
# DETAIL E : HOLLOW STEEL SECTION BARRIER

1:20

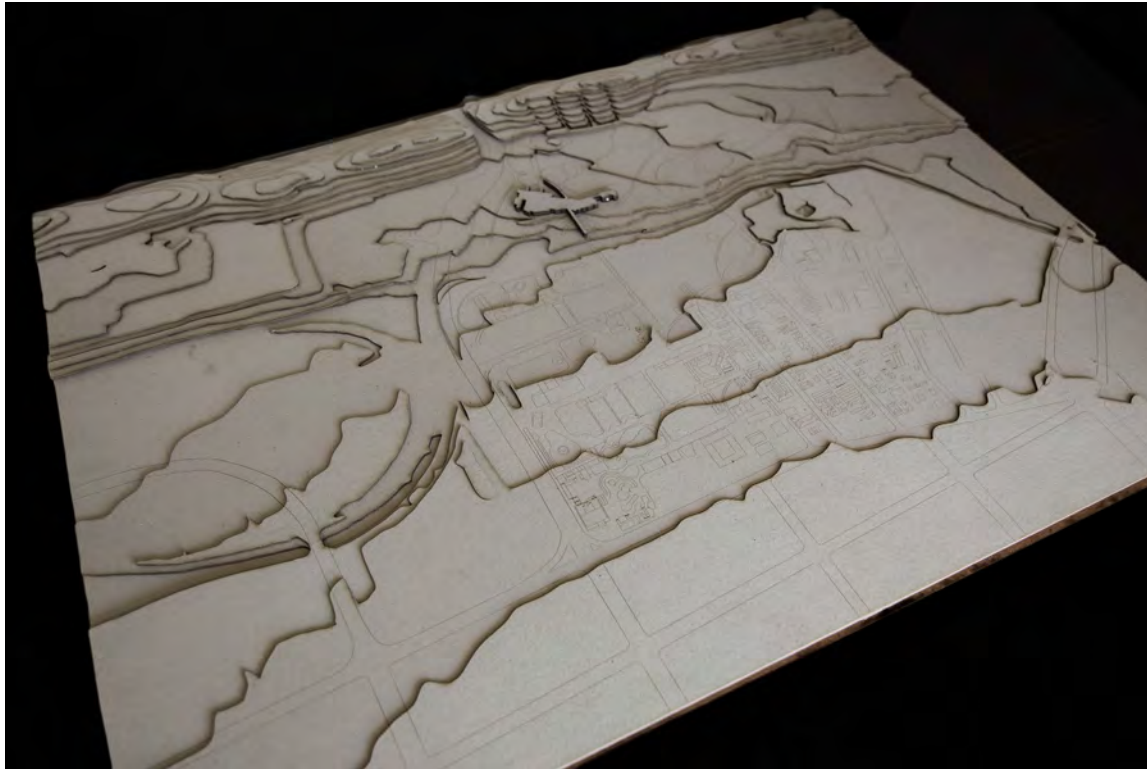


# DETAIL F : DAY AREA FLOOR DRAIN

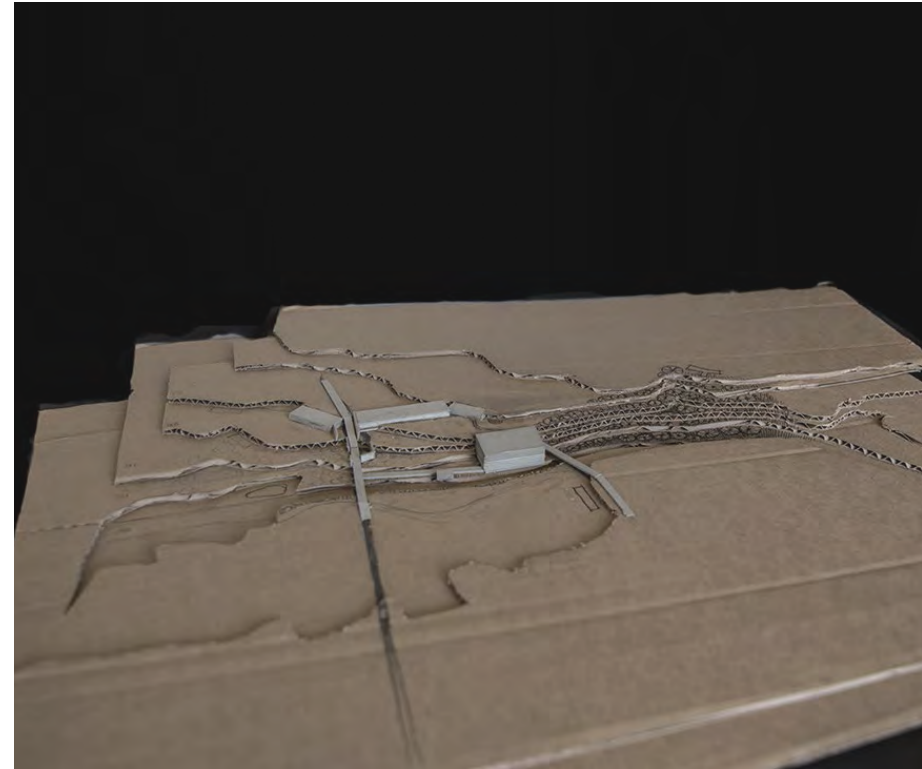
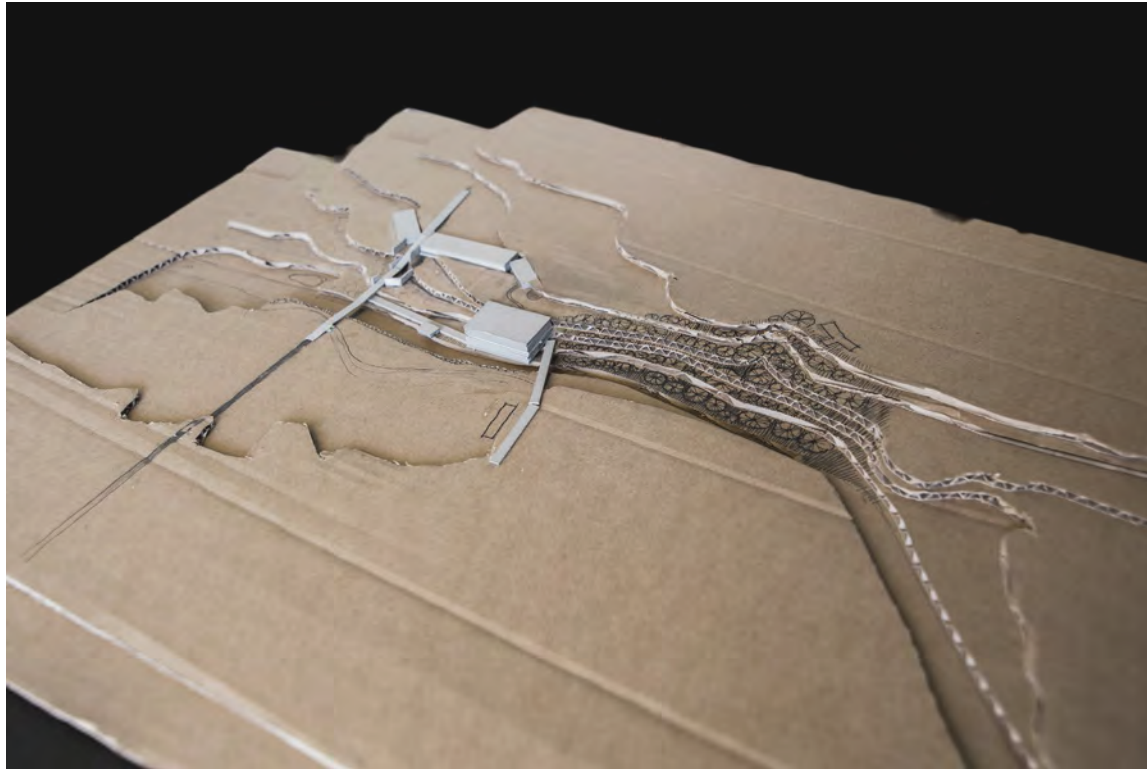
1:20



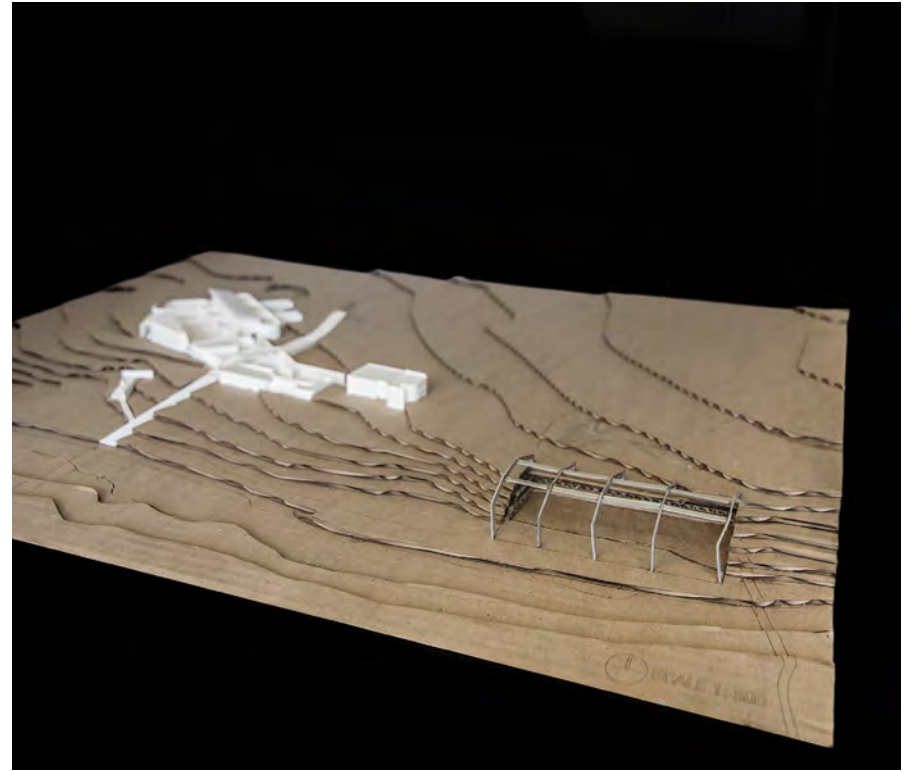
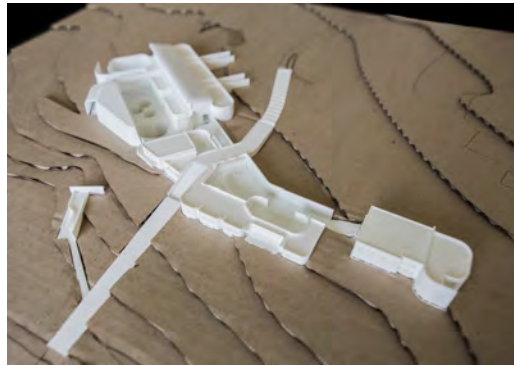
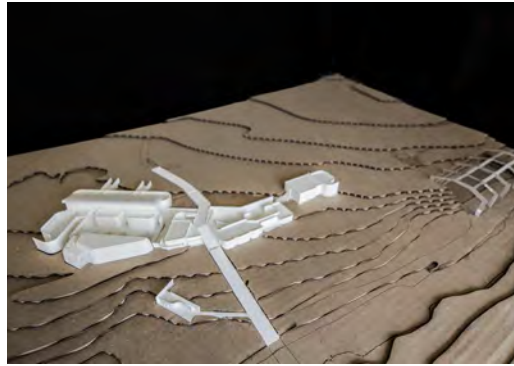
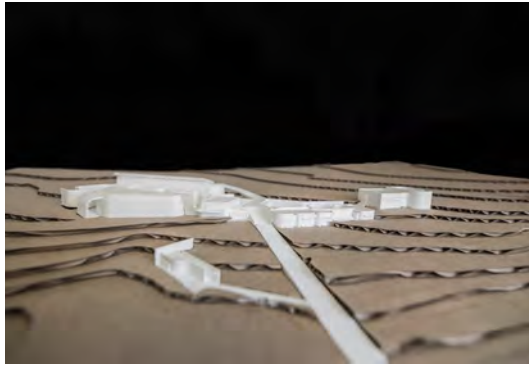
# 1:2000 SITE MODEL



# 1:2000 CONCEPT MODEL



# 1:500 FINAL MODEL



# 1:25 SECTION DETAIL MODEL



# FINAL EXAM PRESENTATION







## 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.

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# Appendix A

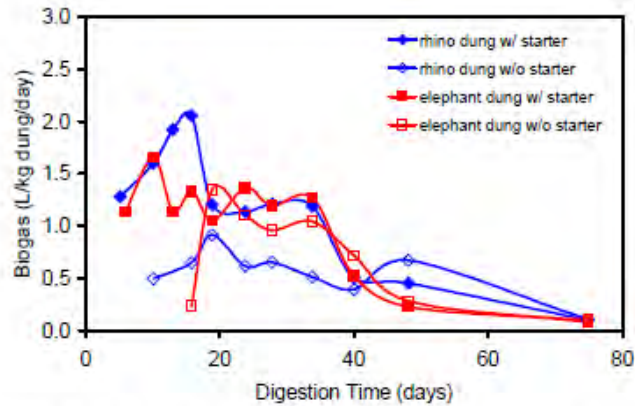


Fig. 7. Biogas production rate for digesters with or without starters.

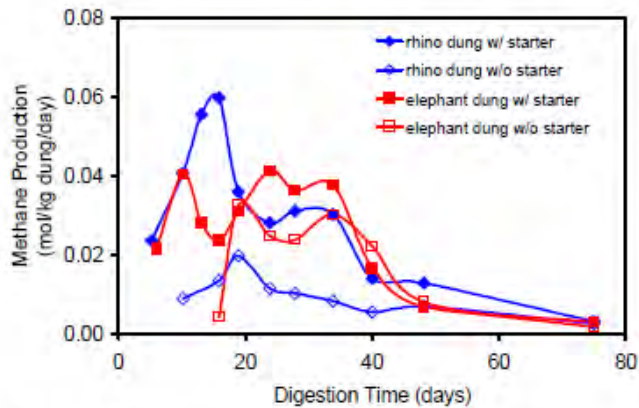


Fig. 8. Methane production rate for digesters with or without starters.

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.<sup>3</sup> The yield of methane on TVS of 0.2 L CH<sub>4</sub>/g TVS follows well those reported by Gunaseelan for average grasses in his review article.<sup>3</sup> 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 <sub>STP</sub> ) <sup>a</sup>	CH <sub>4</sub> (L <sub>STP</sub> )	Yields		
					(L biogas/g dung)	(L CH <sub>4</sub> /g dung)	(L CH <sub>4</sub> /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

<sup>a</sup>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.<sup>5</sup> 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.<sup>6</sup> 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.

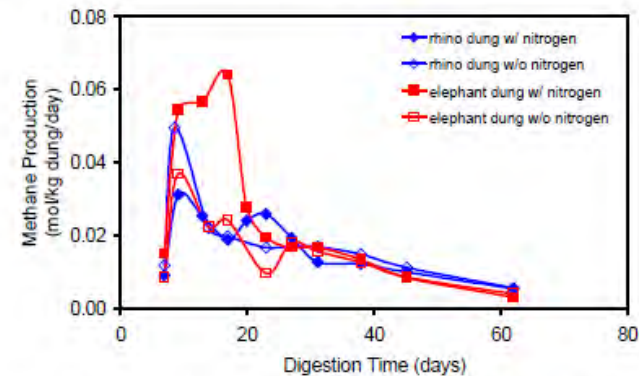


Fig. 9. Biogas production in second set of digesters incubated at 37°C.

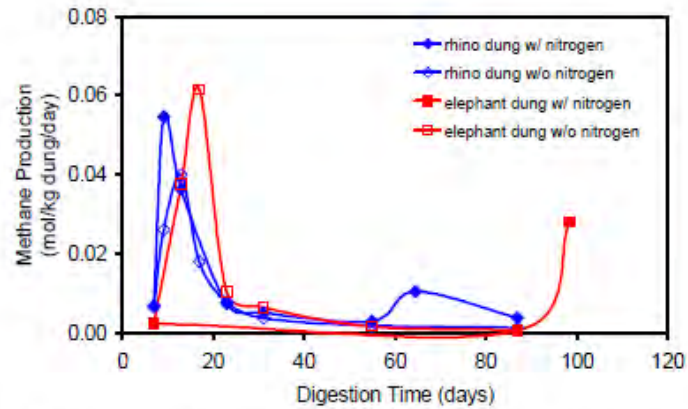


Fig. 10. Methane production in the second set of digesters incubated at 50°C.

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 <sub>STP</sub> ) <sup>a</sup>	CH <sub>4</sub> (L <sub>STP</sub> )	Yields		
					(L biogas/g dung)	(L CH <sub>4</sub> /g dung)	(L CH <sub>4</sub> /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 <sup>b</sup>	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

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



# GROUNDWATER HARVEST POTENTIAL OF THE REPUBLIC OF SOUTH AFRICA

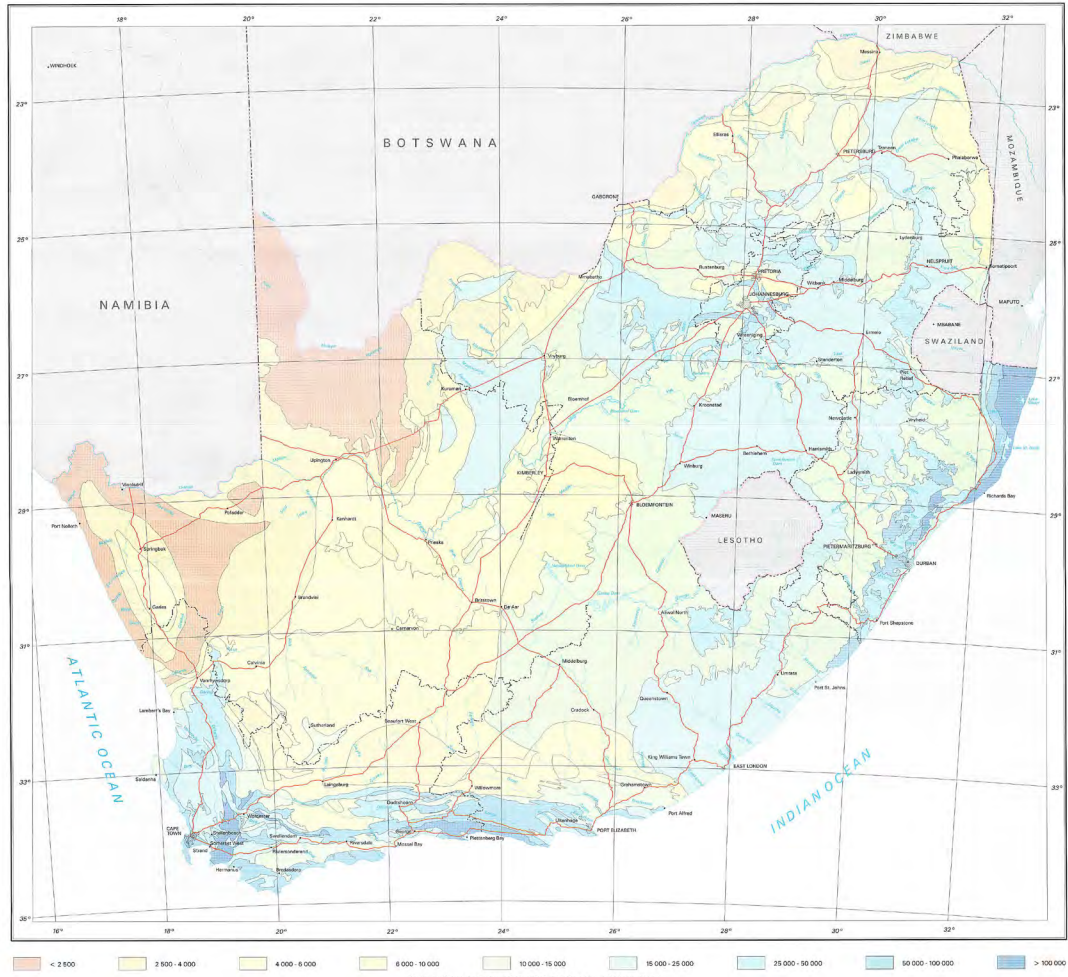
Map Authors - Alan Seymour and Paul Seaward  
Cartography and GIS Support - Elneth Louw

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 dataset, and conventional statistical procedures. 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.



**HARVEST POTENTIAL**  
Harvest Potential is the maximum volume of groundwater that may be abstracted for a given abstraction rate, under the following assumptions: 1. The aquifer is homogeneous and isotropic. 2. The aquifer is unconfined. 3. The aquifer is infinite in extent. 4. The aquifer is homogeneous and isotropic. 5. The aquifer is unconfined. 6. The aquifer is infinite in extent.

**HARVEST POTENTIAL VERSUS EXPLOITATION POTENTIAL**  
When socio-economic factors are incorporated into the Harvest Potential Assessment, the resulting Harvest Potential is the maximum volume of groundwater that may be abstracted for a given abstraction rate, under the following assumptions: 1. The aquifer is homogeneous and isotropic. 2. The aquifer is unconfined. 3. The aquifer is infinite in extent. 4. The aquifer is homogeneous and isotropic. 5. The aquifer is unconfined. 6. The aquifer is infinite in extent.

**METHODOLOGY**  
This country was divided into regions for each region the most abundant recharge and the groundwater storage potential to be estimated. The regions were defined by their hydrological characteristics. The regions were defined by their hydrological characteristics. The regions were defined by their hydrological characteristics.

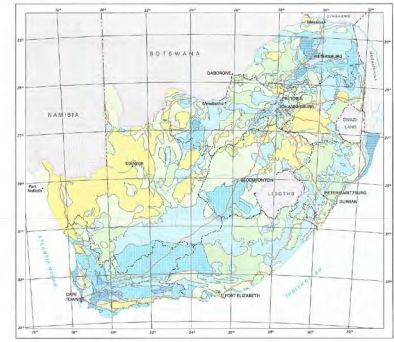
**ACKNOWLEDGEMENTS**  
The authors would like to thank the following individuals and organizations for their assistance in the preparation of this map: 1. The Directorate: Geohydrology. 2. The Department of Water Affairs and Forestry. 3. The Department of Environmental Affairs. 4. The Department of Agriculture, Forestry and Fisheries. 5. The Department of Transport, Logistics and Infrastructure. 6. The Department of Health, Social Services and Child Protection. 7. The Department of Education, Sport and Recreation. 8. The Department of Energy, Environmental Affairs and Planning. 9. The Department of Trade and Industry. 10. The Department of Public Works and Infrastructure. 11. The Department of Rural Development and Human Settlements. 12. The Department of Small Business Development. 13. The Department of Tourism, Creative Industries and Cultural Heritage. 14. The Department of Labour. 15. The Department of Basic Education. 16. The Department of Higher Education and Training. 17. The Department of International Relations and Cooperation. 18. The Department of Information and Communications Technology. 19. The Department of Justice, Constitutional Development and Law. 20. The Department of Public Safety and Security. 21. The Department of Defence and Armaments Production. 22. The Department of Transport, Logistics and Infrastructure. 23. The Department of Health, Social Services and Child Protection. 24. The Department of Education, Sport and Recreation. 25. The Department of Energy, Environmental Affairs and Planning. 26. The Department of Trade and Industry. 27. The Department of Public Works and Infrastructure. 28. The Department of Rural Development and Human Settlements. 29. The Department of Small Business Development. 30. The Department of Tourism, Creative Industries and Cultural Heritage. 31. The Department of Labour. 32. The Department of Basic Education. 33. The Department of Higher Education and Training. 34. The Department of International Relations and Cooperation. 35. The Department of Information and Communications Technology. 36. The Department of Justice, Constitutional Development and Law. 37. The Department of Public Safety and Security. 38. The Department of Defence and Armaments Production.



## FACTORS RESTRICTING HARVEST POTENTIAL

- Volume of average annual recharge
- Variability of annual recharge
- Volume of effective storage

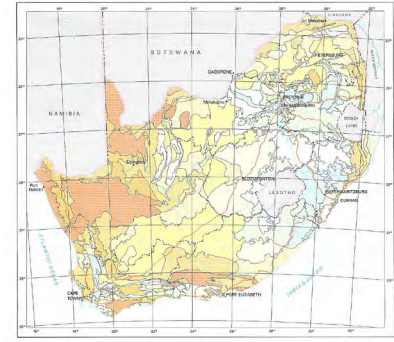
**FACTORS RESTRICTING HARVEST POTENTIAL**  
1. Volume of average annual recharge. In this case the size of the aquifer considerably exceeds the annual recharge volume in that abstraction or harvesting at the average annual recharge rate does not cause a problem. There are some areas where the storage is so extensive that the recharge that even if the aquifer were harvested to twice the annual recharge, would still never deplete the aquifer. The Harvest Potential of Coastal primary aquifers is restricted by mean annual recharge.  
2. Variability of annual recharge. When variability of annual recharge is the limiting factor mean years will have negligible recharge and the number of years between major recharge episodes will vary considerably. In an area with very variable annual recharge is coupled with limited storage then the Harvest Potential is limited by the storage capacity to bridge droughts. Karoo aquifers in the arid western part of the country operate below this pattern.  
3. Volume of effective storage. Recharge occurs regularly most years but cannot all be abstracted; the aquifer increases its storage. The limiting factor is how much groundwater can be stored during the wet season to bridge abstraction during the dry season. Most of the aquifers in the arid western part of the country with the high and more regular recharge fall into this Harvest Potential case where volume of effective storage is a limiting factor.



## AVERAGE BOREHOLE YIELD

- < 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 1992. Geographical areas with low yields are not necessarily a problem. There are some areas where the average yield may not be representative of the average yield for the entire aquifer. The average production borehole yield is controlled by the transmissivity of the aquifer.  
Average production borehole yields influence costs and therefore Exploitation Potential. Low yields require more production boreholes are needed and therefore costs are higher, and exploitation potential is low.  
However, so many other factors also influence Exploitation Potential besides average borehole yields. For example, it may be that 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.



## GROUNDWATER QUALITY

- < 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, via borehole yields, does not determine the Harvest Potential but does affect the Exploitation Potential. Higher Harvest Potential areas are usually groundwater quality suitable for drinking, irrespective of quality. However, if this water is unfit for drinking consumption, it is unsuitable to distribute, then its Exploitation Potential becomes zero.

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

National GIS maps used to compile the National Groundwater Harvest Potential Map include the following:  
1. Bureau of Statistics (Groundwater Resources of South Africa 1995)  
2. Department of Water Affairs and Forestry (Groundwater Resources of South Africa 1995)  
3. Department of Water Affairs and Forestry (Groundwater Resources of South Africa 1995)  
4. Department of Water Affairs and Forestry (Groundwater Resources of South Africa 1995)  
5. Department of Water Affairs and Forestry (Groundwater Resources of South Africa 1995)  
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Author: Alan Seymour and Paul Seaward  
Editor: Elneth Louw  
Cartographer: Elneth Louw  
Date: 1995



## The welfare status 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).



**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
<b>GAUTENG</b>										
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			
<b>Johannesburg Zoo</b>										
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	
<b>Plumari/Askari Lodge</b>										
Plumari/Askari Lodge	Damara	1997	17	M	Elephants for Africa Forever (EFAF)		X			Jun 2015
	Nzeve	1996	18	M	EFAF		X			
<b>KZN</b>										
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	

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

No	Facility	Province	No of elephant	Sex ratio M:F
<b>Captive elephants</b>				
1	Pretoria Zoo /NZG	Gauteng	3	1.2
2	Johannesburg Zoo	Gauteng	2	1.1
<b>Captive/Managed elephants</b>				
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
<b>Managed elephants</b>				
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	Indatu 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
		<b>Total</b>	<b>126</b>	<b>60.66</b>

