



# Designing of Enclosures For Indian Zoos 2014

S.K. Patnaik

B.S. Bonal

S.K. Rustagi

Dr. A.K. Malhotra

L. Dung Dung

*Enclosure drawings by:  
Ashish Kumar Parida*

*Art work by:  
Raj Kumar Behera*



Central Zoo Authority & Civil Construction Unit  
Ministry of Environment, Forests & Climate Change  
Government of India





### Important Note

Though all efforts have been made in this book to provide guidance for all types of exhibits; while executing them in the zoos, they may vary depending on topography, area available, climate and other on site considerations. These designs should be treated as basic reference. Further endeavour should be made to make all designs immersion type. The designs of enclosures for conservation breeding and rescue centre are different from these exhibits. Hence, the designs of all enclosures of endangered species for the entire country and for all exhibits of North East India (except for the exotic species) should be got approved by the Central Zoo Authority before taking up their construction. The drawings given in this book are conceptual designs and the structural details will vary depending on site conditions and materials used, in order to achieve structural stability.







## Acknowledgement

The project titled "Designing of Enclosures for Indian Zoos" was taken up with a view to provide required designs for display of wild animals in captivity which will ensure their well being, while providing excellent visitors experience and nature education. The funds and technical support were provided by the Central Zoo Authority. I am grateful to Shri B.S. Bonal, Member Secretary, Central Zoo Authority for providing financial and technical support.

I am also thankful to Shri B.N. Malhotra, former Chief Engineer and Shri Manoj Kumar, former Executive Engineer of CCU for taking initiative for preparation and start of this project.

After taking over as Chief Engineer (CCU) in March 2014, a team of zoo professionals, engineers, architects and artist was formed. I express my sincere gratitude to Shri S.K.Patnaik, Member, Central Zoo Authority and Dr. A.K. Malhotra, Ex-Curator (Education), National Zoological Park, New Delhi and Shri L. Dung Dung, Superintending Engineer, Shri Raj Kumar, Executive Engineer, Shri V.K. Daroch, Executive Engineer, Shri B.P. Meena, Assistant Engineer and Ms. Asima Mondal, JE, CCU for their active involvement in the project. I sincerely express my gratitude to all the members of CZA's expert group on Zoo design for their valuable suggestions.

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**S.K. Rustagi,**  
Chief Engineer (CCU)





## Preface

There exist about two hundred facilities keeping wild animals in captivity at present in the country. These were established at different times, beginning from the middle of last century to the present, hence their objectives reflect the philosophy prevalent at the time of their establishment. In the absence of any accepted norms or standards for the zoos in the country, the quality and performance of management of captive animals differ widely from institute to institute. This has been felt by the members of the CZA's Expert Group on Zoo Designing while scrutinizing designs of zoo enclosures. The designs of enclosures vary drastically for animals even of same species from zoo to zoo. In order to remove this anomaly, the Central Zoo Authority decided to have a comprehensive publication which can present the basic standard of designs where the animals can exhibit their natural behaviour while ensuring their and visitors safety besides providing pleasant visitors experience. This task was assigned to Civil Construction Unit M/o Environment, Forests & Climate Change for bringing out this publication.

A group of experts was formed by Civil Construction Unit that included zoo professionals, engineers, architects and artist for this purpose.

The expert group held a number of meetings to finalize the contents and the plans of designs.

The publication includes principles of enclosures designing and to make the layman understand about the components of an enclosure, a labelled diagram has been presented. It will help the readers to understand different terminology used in the text.

The book has laid emphasis to develop immersion exhibits instead of stereo typed ones. The enclosures here are so designed that it may resemble its natural habitat and the visitors are placed in a similar landscape where he or she feels like being part of animal's habitat.

Besides the above chapter, barriers for zoo animals, environment enrichment, signage, waste management, drainage and power supply systems have also been described in details for readers.

As regards designs of enclosures, the animals have been divided into twenty five groups. These groups include all types of animals which are being exhibited in zoos in India. The parameters on paddock, cell, kraal, moat, keepers' gallery, chain link fence specifications and standoff barrier have also been provided.

Therefore, it is felt this publication will provide much needed guidance in designing of zoo enclosures for the zoo operators, who can adopt them to suit their own conditions.



**B. S. Bonal**

Member Secretary  
Central Zoo Authority  
New Delhi





प्रकाश जावडेकर  
Prakash Javadekar



राज्य मंत्री  
सूचना एवं प्रसारण (स्वतंत्र प्रभार)  
पर्यावरण वन और जलवायु परिवर्तन  
(स्वतंत्र प्रभार) और  
संसदीय कार्य  
भारत सरकार

Minister of State  
Information & Broadcasting (Independent Charge)  
Environment, Forest & Climate Change  
(Independent Charge) and  
Parliamentary Affairs  
Government of India

## Foreword

The increasing urbanization and development have created enormous pressure on our natural resources. The government of India took initiative to conserve wildlife by establishing a net work of 515 wild life sanctuaries, 105 national parks and 192 zoological parks in the country, but still a number of species are disappearing from their wild habitat. It is felt that zoos may have to serve as the last bastion for some of the threatened and endangered species.

In a span of two centuries of modern zoo history, the zoos in India evolved from early menageries to the present day biological parks. After the establishment of Central Zoo Authority in 1992, efforts were made to improve the conditions of zoos in India. The Central Zoo Authority has been bringing out publications and conducting seminars and workshop to improve the standard of existing zoos.

Central Zoo Authority felt that designing of enclosures on modern lines is a nagging problem. There is acute shortage of professionals in the country to design enclosures.

The Expert Group on Zoo Designing of Central Zoo Authority which reviews the design proposals found it difficult to scrutinize them because they did not follow any particular design elements, though minimum standards had been prescribed. The comprehensive publication titled - 'Designing of Enclosures for Indian Zoos' brought out by Central Zoo Authority through Civil Construction Unit of this ministry for enclosures of different species will be useful to the zoo directors, engineers, architects and consultants engaged in preparing enclosure designs.

It is hoped that this book will be the basic reference material required for designing display of wild animals in captivity which will ensure their well being, excellent visitors' experience and nature education.

I congratulate Central Zoo Authority, Civil Construction Unit and all the experts involved for their hard work in bringing out this publication.

  
(Prakash Javadekar)





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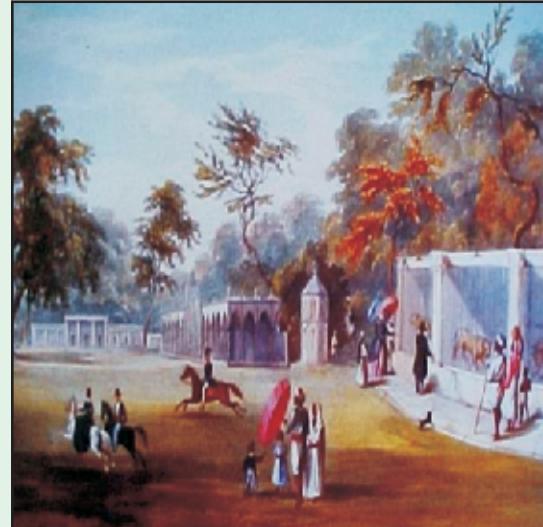


# 1. Introduction

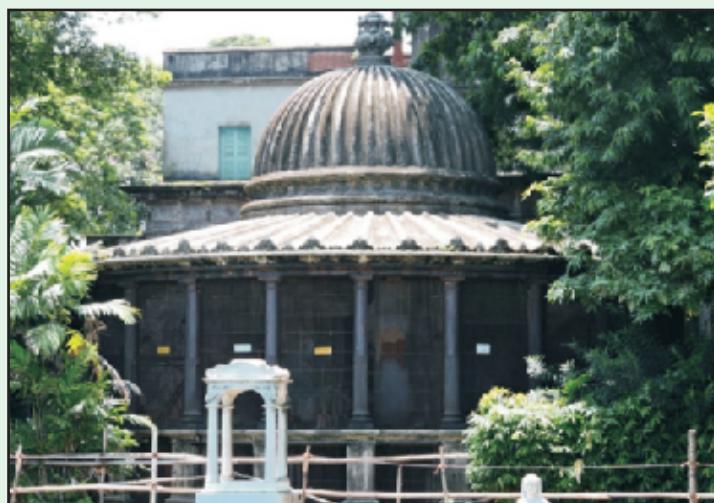
Though private zoos of Maharajas and Rajas in India operated since long as private collections for their own entertainment and entertainment of their guests; modern zoos in India started with Barrackpore Zoo in the outskirts of Kolkata in around 1800 AD even before the establishment of London Zoo. The honor of initiator of modern zoo movement in India goes to Lord Arthur Wellesley, the then Governor General of India, on whose instance this small zoo was set up to study the natural history of India and South East Asia. In a span of almost two hundred years of zoo movement in India, zoos have evolved from early 'menageries' with dingy small barred cages with heavy structural elements, iron bars and stone or cemented floors where the animals did not have any freedom or to exhibit any of their natural behaviour, to the present day 'biological parks'. This metamorphosis has been brought about by the historical, social, scientific and cultural environment prevalent during successive epochs. Animals have always been an integral part of the Indian ethos, hence, at any period of time; zoos reflected the perceptions of the people towards these institutions.

The early zoos reflect our limited knowledge about the biology of animals during that period. There was no concept of any theme or system for arrangement of cages.

Most of such zoos were established during later half of the nineteenth century. The animal collections remained similar to that of a menagerie. The objective was to present exotic animals in somewhat spacious cages. The construction of cages, though, remained similar but there was an attempt to better understand the biological needs of animals. Bear pits were replaced by square or rectangular cages with thick iron bars on three sides while on the fourth side had the feeding chambers or night quarters. Cages for large carnivore, rectangular or square were in two parts. The outer area, where lions or tigers were kept during daytime provided space for some semblance of exercise and in most cases the floor was not paved and heavy iron-bars about five to six meters in height with horizontal elements of iron flats at one third and two third heights of the bars enclosed the outer area. At the top, the iron bars, with their ends shaped like spear, were bent inwards in a loop so as to prevent



1900<sup>s</sup>



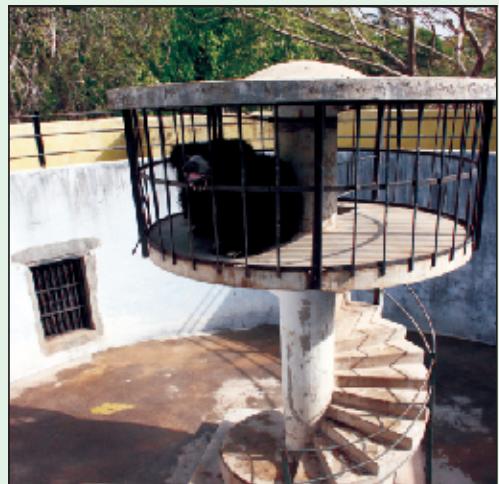
(Marble Palace Zoo, Kolkata)

the animals from jumping out. On the backside were retiring chambers enclosed by solid walls with slits at the top of the back wall to provide ventilation.

Carl Hagenbeck of Hamburg, Germany was the progenitor to use reinforced concrete to design artificial rocks, mounds and moats in his zoo in 1907.

The innovations of Hagenbeck style of zoo architecture and enclosure design can be enumerated as follows: -

1. Use of dry moats or water channels as barriers.
2. Use of artificial rockwork.
3. Overlapping vistas and panoramas.
4. Large open-air exhibits.
5. Display of groups of animals in their social formation.
6. Mixed herbivore exhibits.
7. Large monkey islands.
8. Large space and diverse terrain to accommodate social hierarchy.
9. Zoogeographic organizational concept of exhibits instead of taxonomic arrangement.
10. 'Mega Zoo' concept for planned development



1970<sup>s</sup>

Zoos have been making extensive use of these designs since then. Galvanized steel, stainless steel, or plastic coated chain link wire mesh have been extensively used as barriers. Uses of glass, fiberglass and polycarbonate sheets as barriers in aviaries, reptile exhibits and dioramas have added new dimensions to the display methods for smaller animals and reptiles.

The modern zoos in India started in fifties of the last century after Indian independence. Modern zoo like National Zoological Park, New Delhi was designed by Carl Hegenbeck. Nehru Zoological Park, Hyderabad, Nandankanan Biological Park, Bhubaneshwar, Kanpur Zoo, Arignar Anna Zoological Park, Chennai, M.C. Zoological Park, Chhatbir, Punjab and Indira Gandhi Zoological Park, Vishakhapatnam etc followed design of Delhi zoo. They incorporated moats as a barrier in some of their enclosures which give them a natural look and much larger spaces for animals housed there in. Today, India has 192 large, medium, small and mini zoos including mobile circuses. Many enclosures still lack the basic amenities required for the animals housed therein to exhibit their natural behaviour and ensure their safety and safety of the visitors and keepers.

Another noteworthy exhibitory to be mentioned is the 'Safari Parks' developed in Europe during late 1960's. In India, the first 'Lion Safari' was constructed at the Nehru Zoological Park, Hyderabad by its first curator Mr. Pushp Kumar in 1975. This was followed by a 'Tiger Safari' and a 'Bear Safari' at the same zoo. Several other zoos in the country viz., Nandankanan Biological Park, Bhubaneswar; M.C. Zoological Park, Chhatbir (Chandigarh), Renuka zoo, Renuka, Himachal



Pradesh; Bannerghatta National Park, Karnataka have established safari parks for different species as appendages to the zoos. There are about 15 safari parks in various zoos and national parks. The visitors are taken around in vehicles inside the safari parks where they can observe animals roaming freely from very close quarters. In most of the carnivore safari parks, the animals are taken inside the cells during night. During the initial period, the safari parks were very popular but with passage of time their popularity has declined in some parks due to stereotype docile behavior of the animals on display.

After the establishment of Central Zoo Authority in 1992, efforts were made to improve the conditions of all the zoos and many zoos, which have no scope of improvement and were reluctant to improve, have been shut down. It is endeavour of the Central Zoo Authority to see that all the zoos are brought to the international standard and have enclosures for different species or animals where they can exhibit their natural behaviour, though in a zoo situation, space as much as they enjoy in their wild habitat cannot normally be provided. All the zoos have been asked to prepare long term Master Plan for their planned development in a phased manner. Many of them have already complied with this and others are in the process of completing their master plans. Once completed, they shall comply with the latest guidelines of the CZA.

But a nagging problem remains in designing of the enclosures on the modern lines. There is acute dearth of professionals in the country to prepare enclosure designs for different species for so many zoos in the country. Hence, the zoos opt to prepare enclosure designs by forest subordinates or civil engineers who have hardly any experience in managing zoological parks on the scientific lines. The Zoo Expert Committee of Zoo Designing of the Central Zoo Authority which reviews these proposals pertaining to designs from different zoos finds it very difficult to scrutinize them because they do not follow any particular standard, though some minimum standards have been prescribed by the Central Zoo Authority, which the zoos have to follow while preparing the designs. Hence, it was felt that a comprehensive publication should be brought out for designing of enclosures of different species housed in the Indian zoos so that the zoo directors, engineers, architects and consultants who are engaged for preparing the enclosure designs in future, will make use of them and adopt them to suit to their zoo area, topography, climatic situation and other local features including vegetation and aspect in case of hills, so that the animals in the zoos can be exhibited in enclosures which allows them to exhibit the natural trait while ensuring their safety, safety of visitors, safety of keepers and zoo staff and ensure facility for ease of treatment of ailing animals in future. Civil Construction Unit, Ministry of Environment, Forests and Climate Change was assigned the job of finalizing the publication by Central Zoo Authority.

The Civil Construction Unit approached Shri S K Patnaik, Member, Central Zoo Authority and Dr. A K Malhotra, Ex-Curator (Ed), National Zoological Park, New Delhi, the expert, in the field for active participation in finalizing the document. Accordingly, a committee was formed which consulted the existing designs of different enclosures of prominent zoos of the country, referred to latest literature available on zoos in India and abroad and consulted different zoo personnel to bring out this publication which has attempted to provide principles of designing, characteristic features of enclosures, its different elements, designs for enclosures of different class of species normally housed in Indian zoos, their barrier requirement, enrichment, signage, standoff barriers and the write up on immersion exhibits; which are likely to become characteristic of the modern zoos of twenty first century. Some references have also been included for referring to them by the zoo designers.



## 2. Principles of Enclosure Designing

While conceptual designing of enclosures for most animals kept in Indian Zoos have been provided in this book, the situations like topography, availability of space, climate, aspect of hilly terrain, financial outlay, visitation and vegetation etc play their role in exact designing of any animal enclosure. Hence there will be variation in shape, size, barrier, placement in master layout plan, and other elements of designing shall also vary depending on site conditions. Hence some basic principles should be borne in mind while designing an enclosure at a particular site. They are:

- 1) Topography:** If the enclosure is to be located on flat ground and there is no other constraint of space and funds, one standard design can be adopted. But in sloping landscape, the following aspects have to be taken into consideration.
  - a) Natural waterway: Any natural water way should be completely avoided while placing an animal enclosure.
  - b) Advantage of the slope should be taken and for the purpose the detailed contour map has to be made use of and while designing the enclosure the contours should be clearly shown in the plan for proper appreciation.
  - c) Care should be taken to see that the animal in the enclosure is placed higher than the visitor or at least at the same level, so that the viewer does not see the animal placed down below.
  - d) Advantage of the topography should be taken while designing an enclosure to avoid unnecessary concrete/masonry work.
  - e) In a hilly topography, particularly in the Himalayan zoos, the aspect should be of prime consideration and the enclosures should be planned in such a way that, it gets maximum possible sun light and preferably gets advantage of the morning sun. The predominant wind direction should also be kept in mind.
- 2) Shape, size and orientation:** The shape, size and orientation of the enclosure shall be largely dependent on the species to be housed, its habit, habitat and size. The enclosure should be so designed that, while the animal can exhibit its natural behavior in it, the visitor can see it without much effort.
- 3) Designing:** While designing the enclosure care should be taken to see that geometrical shapes like rectangles, squares and other shapes with sharp corners are avoided and natural curvilinear shapes are adopted and concrete and masonry structures are suitably camouflaged with boulders, vegetation or ferrocement structures.
- 4) Enrichments:** Environmental enrichment is a very important for any animal enclosure and provides much needed activity for the captive animals who can exhibit their natural behaviour through them. These artefacts should be of natural material like logs, vines, poles, boulders, hollow trees and vegetation etc and not artificial steel, concrete or plastic structures.



- 5) **Vegetation:** As far as feasible, no natural vegetation should be destroyed or damaged for constructing an enclosure. If unavoidable, effort should be made to minimize such losses by suitable realignment. Trees should be maintained in a paddock, which will serve as enrichment. Natural vegetation can also serve as screening between the enclosures and between the main visitor circulation and the viewing area.
- 6) **Viewing area:** Efforts should be made to see that the enclosure is not directly viewed from the main visitor path. Hence the viewing area should be screened through appropriate vegetation, natural or planted or any other topographical features like mounds, boulders etc.
- 7) **Placement of enclosures:** Enclosures should not be placed opposite to one another on either side of main visitor path, which will involve unnecessary movement to both sides and create confusion, due to which the viewers shall loose focus on any particular species.
- 8) **Use of natural or artificial features:** Advantage of existing natural features like boulders, precipices, old walls, depression, and trenches should be taken of while planning any exhibit and they can be used as barrier, water pool, enrichment etc in order to reduce unnecessary earth work or artificial structures.
- 9) **Minimum disturbance of the site:** If feasible, there should be minimum possible disturbance to the site involving removal or import of earth/boulders and use of cement, cement concrete, steel or other artificial constructions. Wherever artificial constructions are unavoidable, they should be suitably camouflaged through appropriate vegetation, topographical features and their suitable placement away from direct viewing. Suitable painting or use of boulders etc can also help in this effort.
- 10) **Disposal of solid or liquid wastes:** All enclosures should have arrangement for smooth removal of solid and liquid wastes and their appropriate disposal including recycling.
- 11) **Use of energy saving or renewable energy:** Arrangement should be in place for minimize use of power by switching to low energy consuming equipments like LED and use of non-conventional energy like solar and wind energy etc.
- 12) **Rain water harvesting:** While water use should be minimized in all enclosures by using suitable devices. Rain water harvesting may be adopted to supplement or to minimize total water requirement.
- 13) **Viewing:** The viewing area, barriers and hedges should be so planned that the visitors including small children get unhindered view of the animals and their paddock with all its features. In case the viewing through chain link fence, the colour of chain link fence should be dull black. It will aid in clear viewing the animal.

The viewing area should be planned depending on the daily visitation to the zoo, so that unmanageable population is avoided at any point of time.

Where there is rampart vandalism, glass barrier should be avoided.
- 14) **Signage:** Well designed signage with adequate biological and ecological information in appropriate colour scheme with durable material should be placed at prominent locations near the visitor area of all enclosures.
- 15) **Screening:** All adjacent enclosures should be screened from each other by suitable

vegetation or other measures, so that neither of animals get distracted by the others in adjacent enclosures and the visitors. The visitors are also not distracted by the animals in other enclosures.

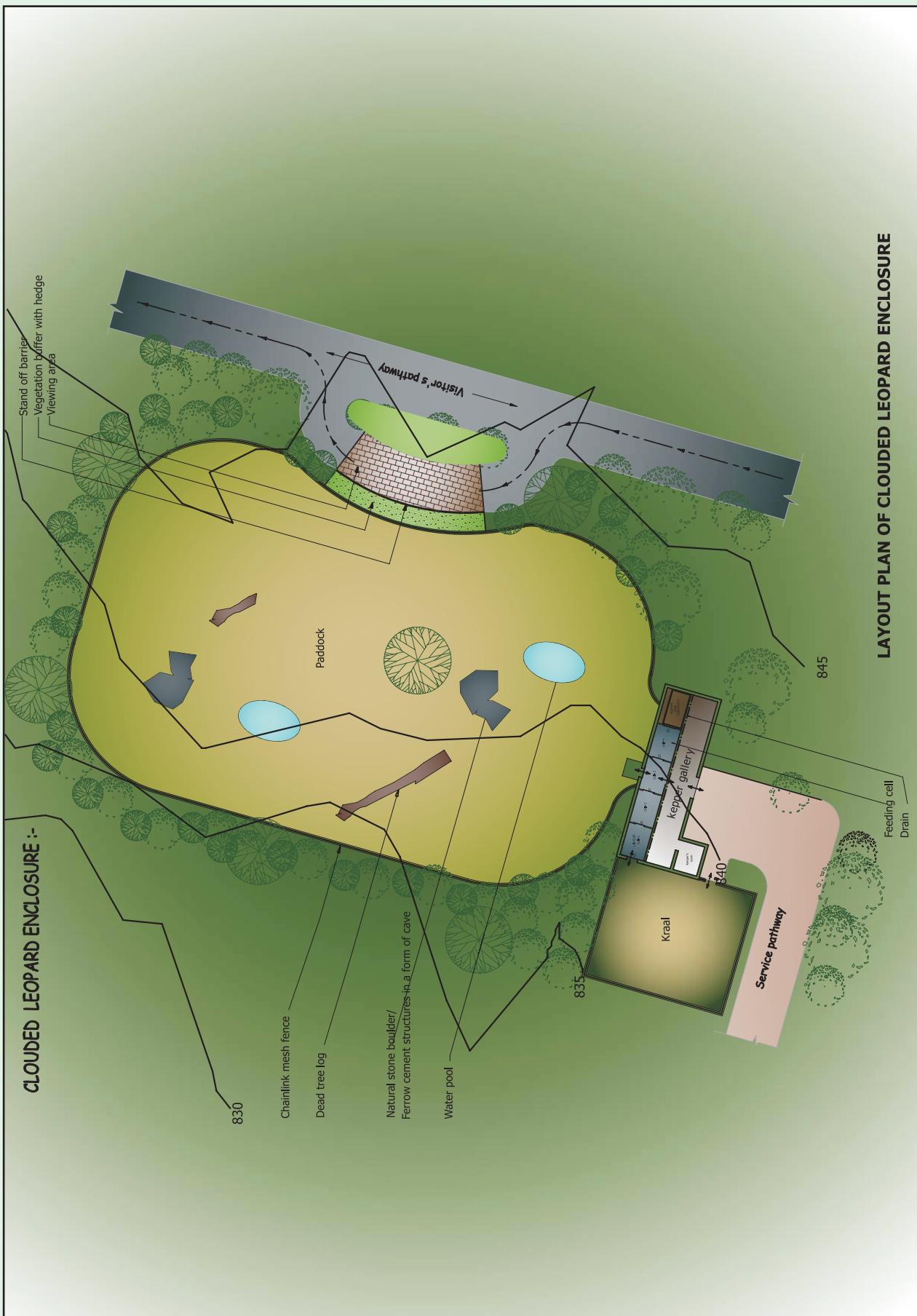
- 16) Placement of enclosures:** Enclosures of predator animals or birds should be placed away from those of prey animals and suitably screened to prevent getting smell, view and hear calls/roars of each other.

Many of the above aspects have been elaborated elsewhere in appropriate chapter of the book, which should be referred to.

While submitting enclosure designs for any species to CZA for approval, an approved layout plan indicating position of the proposed enclosure should be submitted for appreciating its location with respect to other adjacent or neighboring exhibits, roads, paths and other structures. Drawings explaining this are given in pages to follow :

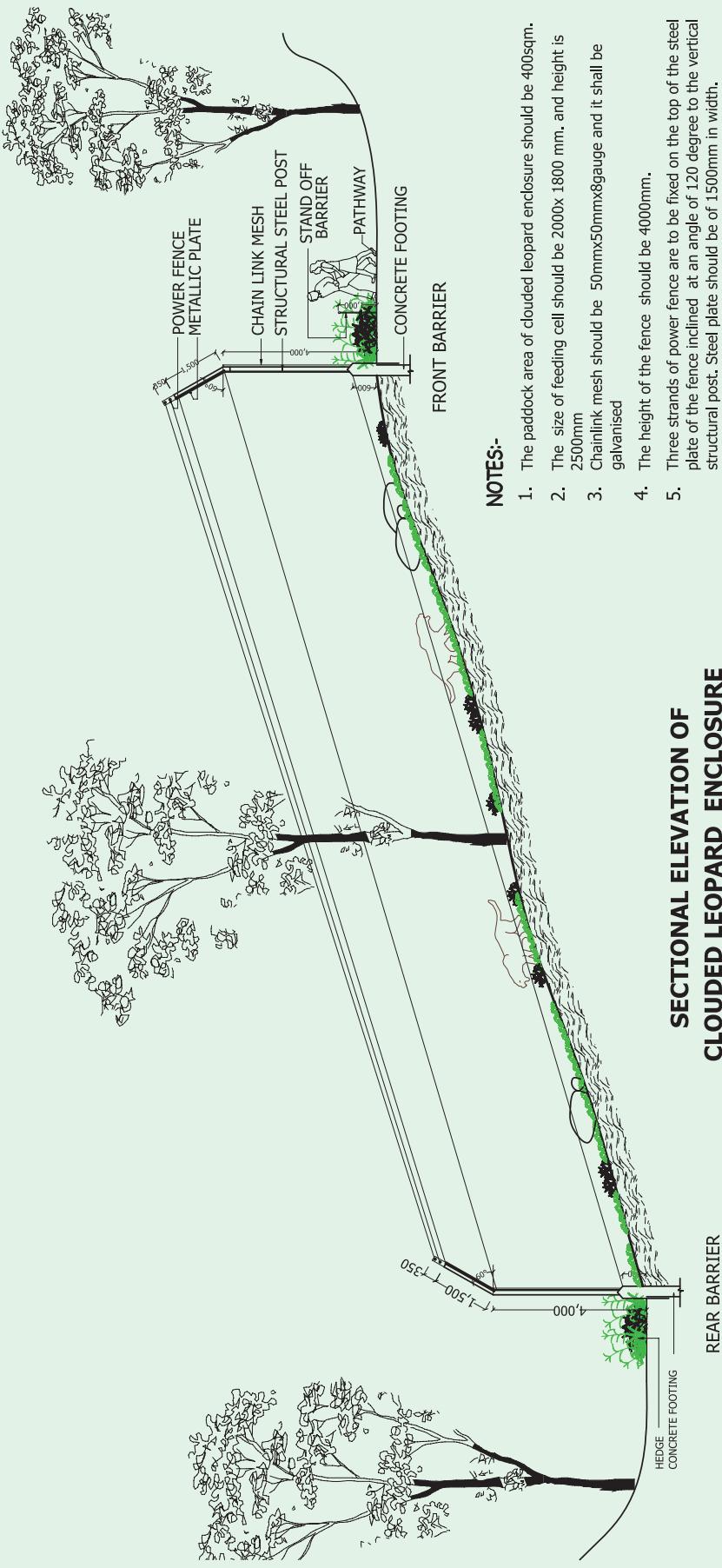








## CLOUDED LEOPARD ENCLOSURE :-

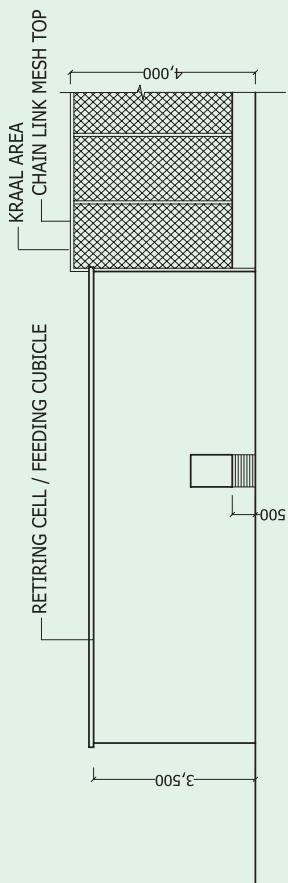


### NOTES:-

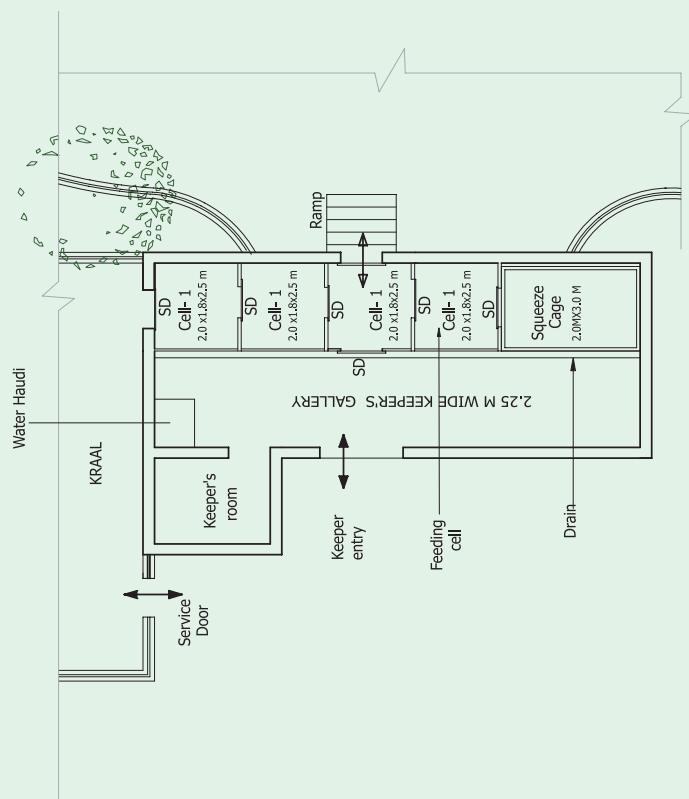
1. The paddock area of clouded leopard enclosure should be 400sqm.
2. The size of feeding cell should be 2000x 1800 mm, and height is 2500mm
3. Chainlink mesh should be 50mmx50mmx8gauge and it shall be galvanised
4. The height of the fence should be 4000mm.
5. Three strands of power fence are to be fixed on the top of the steel plate of the fence inclined at an angle of 120 degree to the vertical structural post. Steel plate should be of 1500mm in width.
6. Chainlink mesh is to be placed on the inner side of the structural post. The mesh is to be embedded with the masonry base which shall be sloped bothway to prevent accumulation of water and urine.
7. Wooden logs, natural stone boulders,trees & shrubs should be placed inside the enclosure for enrichment.
8. No trees or branch of the tree should be within 8000mm from the inner side of fence.
9. Entry gate to the keeper gallery should be 1800 mm wide and 2000mm high.
10. Size of kraal should be 90sq.mt, and top covered.
11. Size of sliding door in cell should be 750mm high and 750mm width.
12. Plinth of the cell should be at a height of 500mm, from the immediate ground level
13. Size of upsliding door in cell should be 900 mm high and 750mm width.

## SECTIONAL ELEVATION OF CLOUDED LEOPARD ENCLOSURE

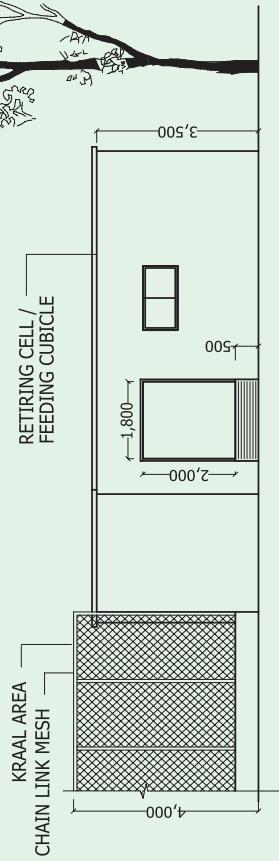
**CLOUDED LEOPARD ENCLOSURE :-**



**ELEVATION  
( FROM PADDOCK )**  
RETIRING CELL / FEEDING CUBICLE



**ELEVATION  
( FROM KEEPER'S ENTRY )**  
RETIRING CELL / FEEDING CUBICLE





### 3. Characteristics of Animal Enclosures

The general principle of enclosure design is to provide as much possible freedom to animal as in its own habitat. Design should address the safety of animals, animal handlers as well as visitors. The enclosure should have the following characteristics:-

- 1) **Adequate display area (Paddock):** Each enclosure should have adequate space to meet the animal's biological requirements, movement, walking, climbing, jumping, digging and running. There are animals which show aggression in behavior and fight for territory, mate and food. The large area with topographical variations and screening etc are some of the solutions which provide scope for the weaker animal to escape and save itself from aggression of other animals. This also provides chance for the secretive animals to escape from direct interaction with visitors.
- 2) **Adequate number of cells:** It is always better to have 1-2 cells more than the number of animals. It helps in cleaning and management operation. The animal gets adequate space for its movement when sliding door is opened between two cells. While quite often the cells will be surrounded by pucca wall and steel bars, in case of ungulates wherever feasible wooden partition along with wooden doors and windows will be quite good. This will be good for extreme climatic conditions and preventing injuries due to infighting.
- 3) **Safety of animals:** All holding areas should be designed without any sharp projections or corners that may hurt an animal. Masonry edges should be rounded off and steel and wood joinery embedded and hidden. In other words, there should not be any protrusions which may injure the animal.
- 4) **Safety of zoo keepers:** All holding areas for aggressive/dangerous animals must have vestibules with double doors, safe zones, feeding and watering slots to allow remote operation. Old enclosures that do not have these features should be modified.
- 5) **Visitor safety:** Zoning off service areas from the public automatically adds to visitor safety. Guard rail of appropriate strength (safety barrier/stand off barrier) should be such that only vertical bars are used or at least horizontal bars are not used so that people cannot climb over the barrier. Chain link mesh is an economical option. The distance of guard rail from moat wall for ferocious animal should be 1.5 metre. The area between the moat wall and guard rail should be planted with thorny hedge in all carnivores. This is especially required at areas with dangerous animals. Of course the main barrier should be so designed that the animals housed therein cannot escape in to the visitors' area. The top of barrier wall should be sloped inwards to prevent visitors from sitting on it.
- 6) **Signage:** A few zoos in India have good signages of any kind with good warning signs. It is time for all zoos to take human life and nature education seriously and invest in signage systems that include comprehensive warning signages. Long-lasting materials that can be used include aluminum and aluminum-composites, powder-coated steel/aluminum and acrylic.

- 7) **Escape proofing:** It must be ensured that the enclosure is safe and secure. The vulnerable points for escape of animals are moats, chain link fence and vertical bars etc. The size of moat or barrier should be such that animal can not jump over. The height and specification of chain link fence be such that it prevents animal escape. The broken and loose fence should be repaired immediately. The masonry work should be checked and repaired regularly. The gap between vertical bars of cells should not be such that it provides space for escape.
- 8) **Provision of kraal:** The kraal is an important component of an ideal exhibit. It is used for isolation, treatment and rearing of young ones. It also provides shade and sun to the isolated animal. It can be with top open or closed depending on the animal housed
- 9) **Ease of treatment:** Each night house should have a squeeze cage particularly for carnivores that aids in proper handling of animal while administering medicine or in minor surgery etc.
- 10) **Enrichment of enclosures:** Each enclosure should be provided with habitat and behavioral enrichment as per requirement of the species housed. They should merge with the landscape, look natural and natural materials like logs, boulders, bamboos vines etc should be preferred.
- 11) **Water supply and drainage system:** Each enclosure should have a haudi (surface storage tank) for adequate storage of water. There should be regular supply of drinking water. A provision of drain for the draining of washing and urine must be made. The drain should be regularly cleaned.
- 12) **Power supply:** Each enclosure should have adequate power points so that electrical gadgets could be used as per requirement. But, the fixtures should be adequately protected to prevent any accident due to their tampering by animals.
- 13) **Ventilation and sun:** The night house should have adequate ventilation for fresh air to pass. Some provision should be made for the direct sun light to fall in the night house except in case of nocturnal animal house.
- 14) **Keepers' room:** A small room with built in shelves or racks should be provided so as to store implements and equipments etc besides a wash basin/sink for cleaning.
- 15) **Preventive maintenance:** To avoid any accident in zoos, preventive maintenance should be planned at a fixed frequency which should include monitoring and maintenance / repair of deteriorated elements of zoos.





## 4. Elements of Enclosures

**Front barrier:** This is a barrier which separates the exhibition area of the enclosure or paddock from the visitors' viewing area. While this barrier separates the viewers from the animals housed in the enclosure, it also ensures safety of both and at the same time does not obstruct or hinder the clear viewing of the animal and the landscape.

**Rear or side barrier:** This barrier is meant to keep the animal safe from any intruder, human and non-human (including feral animals). This may or may not visually obstruct and the material used shall depend on the habit of the animal housed there. It is meant to keep the animals safe and to prevent escape.

**Standoff barrier (SoB):** This is a type of low height barrier that is meant to keep the viewers away from approaching the front barrier and to prevent any proximity to the animal, when it approaches the front barrier. This also prevents unauthorized feeding, teasing, molesting of animals and prevent intrusion into the enclosure by children. The distance between the moat wall and stand off barrier should be 1.5 metre in case of all carnivores. The area between these two should be planted with thorny hedge.

**Hedge:** A low green hedge is normally placed between SoB and the front barrier to prevent people from venturing beyond the SoB to approach the front barrier and provides aesthetic appeal to the enclosure and is an essential requirement.

**Keepers' gallery:** It is a space provided for the 'Animal Keepers' in the night shelter of the animals for their movement while providing service to the animals who come for feeding and resting in to the night shelter. This gallery provides them protection from sun, rain and wind etc.

**Feeding cubicle:** Feeding cubicles are small rooms provided to individual (non-herd) animals, outside the 'paddock' where the animal is provided food, water etc. It is also used for resting at night.

**Paddock/display area:** This is the main area, often reasonably large in size, where the animal spends most of its display time where visitors can view them with ease.

**Kraal:** This is a large enough area, often open from the top or covered with wire mesh etc. in case of climbing animals, where an animal can be kept isolated from the animals on display. This area provides space for injured animals, mothers with cubs or aggressive ones, which cannot be released to the paddock with other animals.

**Feeding kraal:** This type of kraal is covered with wire mesh/nylon net. Here the herbivores/flightless birds can be fed with ease away from visitors, while keeping the feed safe from intrusion by feral animals and birds. These feral animals and birds often take away feed or contaminate them and may also injure the animals concerned.

**Environment enrichment:** In zoo conditions the animals/birds are removed from their natural habitat and brought to a limited space. In order to allow them as much freedom of displaying their natural behaviour as possible, different artefacts like vegetation, logs, dead branches, caves, pools, wallow ponds, sand, vines, nest boxes, rock/wood crevices, tunnels, appropriate substrates, undulations and rocks are provided inside the paddock and feeding cubicles for

removing monotony and boredom, providing exercise and activities. This is called environmental enrichment.

**Squeeze cage:** This is an adjustable cage, which is used for restraining animals, particularly carnivores and bears, for ease of treatment of animals. This is usually kept fixed in the night shelter, often attached to one of the feeding cubicles, where one of the sides of the cage remains fixed while the other is moved through mechanical means, to restrain the animal into a small space, where it cannot move, while it is physically examined and treated.

**Rodent proofing:** Rats often borrow into the animal enclosures and take away the feed supplied to animals and sometime injure birds and small animals. They may also spread disease. It is essential to make them rodent proof. To do this, usually R.C.C. bottom is provided below a earthen substrate of sufficient depth. Besides arrangements are made so that the rodents cannot get in from outside through the wire mesh barrier or doors etc.

**Snake proofing:** Snakes are also a menace and have to be kept away from the enclosures, particularly of birds. This is achieved by suitable arrangement in the plinth and use of appropriate opening of wire mesh.

**Water supply:** Potable water is essential for all animals housed in enclosures, besides cleaning water is required for cleaning the floors, feeding platforms, water troughs etc. This is required in the feeding cubicles, paddocks, kraals and keepers' gallery. Arrangement for inflow and outflow should be made for regular refilling and removal of waste water.

#### **Waste disposal arrangement:**

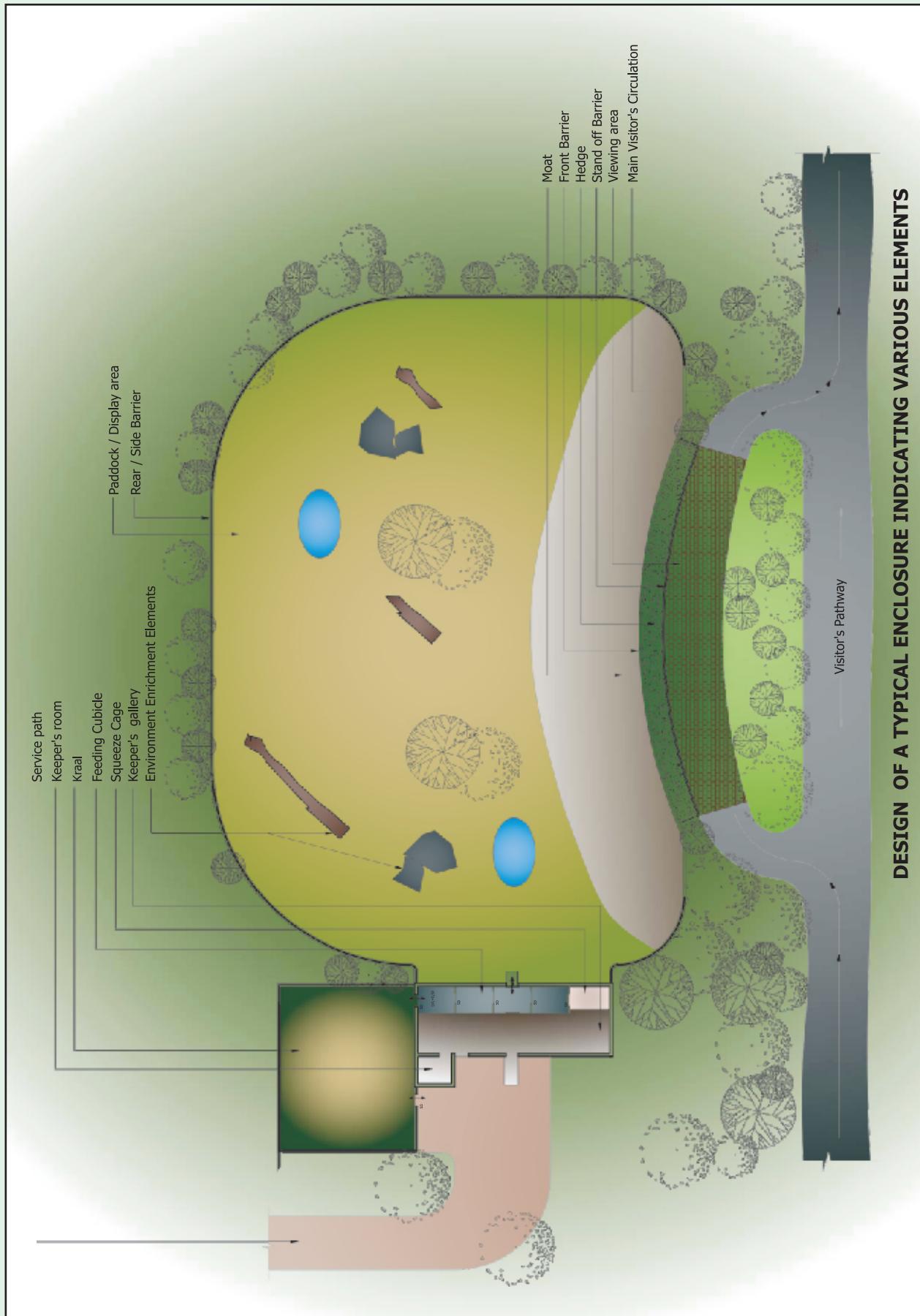
**Solid wastes disposal:** Arrangement should exist for taking away and suitably disposing the solid wastes like feed wastes, bones, faeces etc. away from the enclosure on daily basis.

**Liquid waste disposal:** Arrangement should be available to drain out liquid wastes like waste water after cleaning of enclosures, urine etc. so that it can be drained away and suitably treated before disposal or reuse.

**Power supply:** While the paddocks are usually not illuminated, arrangement of power supply should exist in the night shelters, so that it can be used in case of an emergency. Flood light arrangement may be required, which of course shall be very sparingly used. While doing so, care should be taken to see that the power lines and fixtures etc cannot be touched or tampered with by the animals. Other electrical gadgets will be essential for meeting situations like extreme climatic conditions. Provisions for the same should also be made in order to save energy.

The following labelled enclosure plan gives an illustration of various enclosure elements for proper appreciation while referring to the text.





DESIGN OF A TYPICAL ENCLOSURE INDICATING VARIOUS ELEMENTS

## 5. Immersion Exhibits (Nature Immersing Exhibits/ Enclosures)

Public zoos in different parts of the world started more than two centuries back in the beginning of the 19<sup>th</sup> century or sometimes later. Zoos were almost like circuses which were providing entertainment to the visiting public, who were getting entertained by often interacting with animals by poking, shouting or gesticulating. For this purpose, they were being kept confined to very small spaces secured by strong steel bars or kept in small well like structures. As the time passed, people started becoming more and more concerned about their welfare and started providing more and more spaces to them to facilitate their free movement and to exhibit their natural behaviour, though still being kept behind bars. Subsequent to this, more and more natural surroundings and spaces were provided and thus recreation rather than entertainment which was earlier the motto of the zoological parks came in to vogue.

From the early 20th century, some large zoological parks in the world and in India also started exhibiting some charismatic animals like tigers, lions, chimpanzees and gorillas etc., in large moated enclosures where animals and their surroundings were clearly visible without any artificial barrier and provided large spaces for their movement.

Second half of last century started with creation of quite a few public zoos where the state governments and the union government started setting up new zoos with greater emphasis on conservation education. The zoos like Nehru Zoological Park, Hyderabad, National Zoological Park, New Delhi, Nandan Kanan Zoo, Kanpur Zoo, Arignar Anna Zoological Park, Chennai, MC Zoological Park, Chhatbir, Punjab and Indira Gandhi Zoological Park, Vishakhapatnam came up with Bhubaneshwar very large moated enclosures in next three decades.

After creation of the Central Zoo Authority in 1992, a workshop was held in Hyderabad in December, 1999 where a vision statement "Strategic Vision 2010" was adopted with the following statement.

'Our zoos will have healthy animals in eco-system based naturalistic enclosures supportive to in-situ conservation with competent and contented staff, good educational interpretative facilities, and the support of people and be self sufficient.'

Of course, the term of "Immersion Exhibit" has been used in different parts of the world in zoo designing in last two decades; which means, while the animal exhibited in enclosures which are so designed that it resembles its natural habitat and visitor is placed in such a similar landscape, where he or she feels like being part of the animal's habitat and is not distracted by other artefacts and does not feel that he/she is viewing animal in a closed and artificial environment of the zoo.

It is admitted fact that so far very little efforts have been made in India to create immersion exhibits. Of course, by default the few safaris and walk through aviaries are forms of "immersion exhibits".

Attempts should be made in zoos where the visitor is placed in such a situation where he or she does not hear or see other activities in the zoo and is fully focused on the animal in its habitat

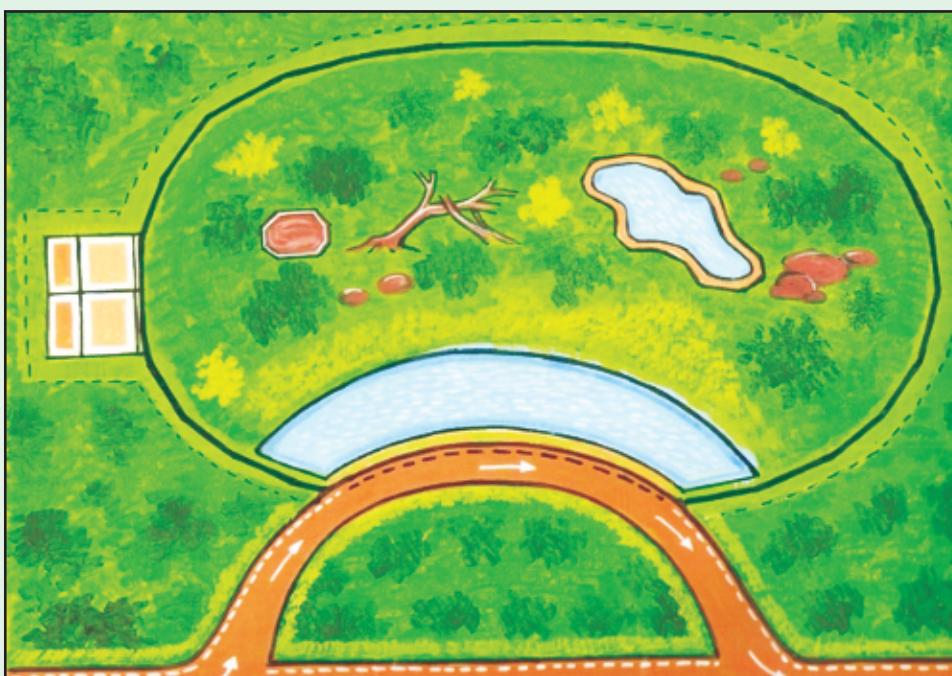


being viewed. While observing its natural behaviour in a properly designed exhibit, aided by well conceived educational tools, the visitor tends to appreciate the ecology of the animal much better than he or she would do in a conventional enclosure. In other words; such an exhibit is intended to show the animals in context of nature, rather than enclosure architecture. Hence, while the architecture is subdued, due prominence is given to the habitat in which the visitor immerses. Even this experience can be further enhanced with sound effects of flowing water, drizzling, sounds of small animals and appropriate lighting etc.

In a design of such exhibit, it is essential that each enclosure including its entire visitor area, whose approach and its surrounding has to be dealt with as an independent entity and should be sealed out not only from other exhibits but also from the main visitors circulation. This can be done through appropriate slopes, boulders and other suitable visual barriers like vegetation for transporting the visitors to the complete world of the animal which is being viewed. The barriers separating visitors from the animal have got to be camouflaged in a way that it does not create any visual obstruction, while both the animals being viewed and the viewing public can remain safe from each other through appropriate design elements.

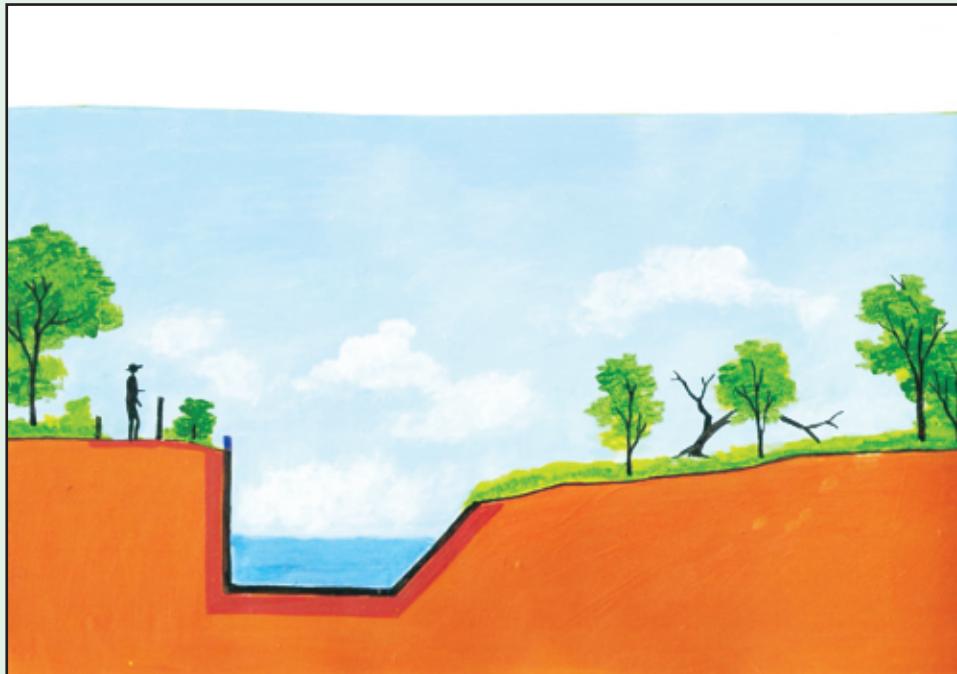
Just by making a design of immersion exhibit, whole purpose for which such an enclosure is being made will not be fully served; unless the enclosure is provided with proper behavioural enrichment that allows the animal to exhibit its natural behaviour as it would exhibit in its own wild habitat.

Several forms of enrichment can be provided, which can include live trees, logs or branches, natural or artificial vines, vegetative groves or bushes, properly designed natural looking water pools, water-falls, flowing water steams, wallow ponds, dust baths, rubbing posts, caves, boulders, cliffs, earth substratum, nesting materials or grass etc. This will depend on the needs of the species housed. Care must be taken that artefacts which are totally artificial like steel play equipments taken from the children parks, automobile tyres, hume pipes, discarded jeep trolleys, concrete structures are avoided.



Picture of an exhibit showing immersion effect

Of course, it is also very much necessary that the barriers should be so designed that they do not create any visual obstruction and merge with the surrounding of the enclosure. Such barriers can be in the form of moats or depressed walls suitably finished to give natural look with water channel, hedges, rocks or boulders, low fence, power fence, glass or piano strings etc. It should be dependent on the habit, size or strength of the animal which is being housed in the enclosure and all efforts should be made to see that the barrier does not visually stand out.



Section of moat of immersion exhibit

Care should also be taken to see that two adjacent enclosures are hidden from each other by using appropriate vegetation or landscape features that enables the animals in them not to be disturbed by each other's behaviour. This also allows the visitors to focus on a particular exhibit not being disturbed by view of the animals in the other exhibits, thereby loosing focus on the animal and its surrounding being viewed.

Care also must be taken to see that the animal houses, the barriers and other artefacts which are placed away from the visitors are also designed in such a way that they do not stand out from the surrounding, due to massive concrete structure, bright colours or prominent placement, thereby distracting the visitors. This can be done through appropriate landscaping, manipulation of vegetation, stone cladding, suitably painting the structures and giving them right texture that merges with the surrounding landscape.

In other words, such an enclosure should be able to create an illusion of a 'protected area' when viewed without any visual or auditory interference by activities in the surrounding landscape occupied by other animals, visitors and their activities or other zoo structures.



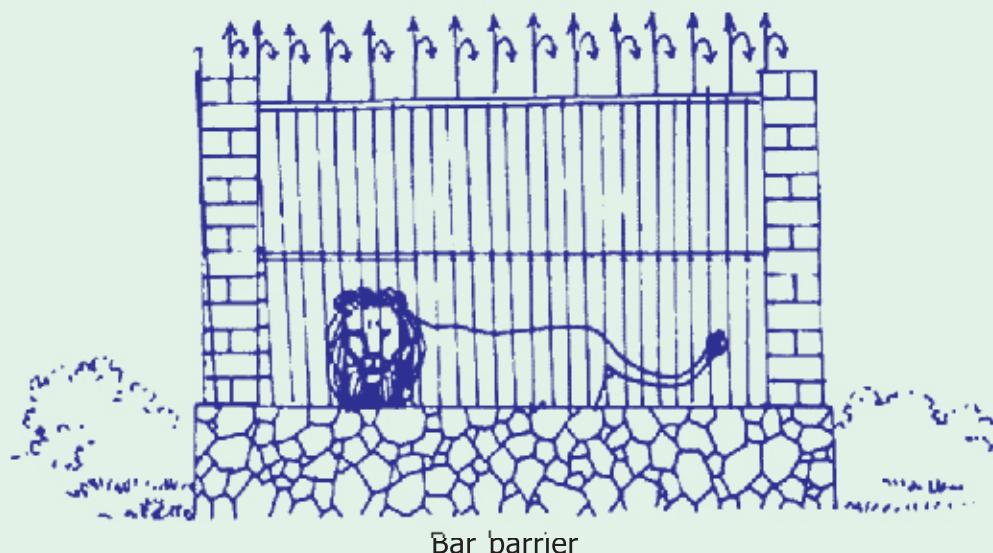


## 6. Barriers for Zoo Animals

In recent times the Indian Zoo Policy has termed barrier as "Enclosure Barrier - means a physical barrier to contain animals within an enclosure". This policy further goes to state "Whenever it is technically feasible, only moats shall be provided as enclosure barrier".

Why this stipulation? Because till very early 20th century almost all zoos kept their large animals behind bars in small cells like in the jails.

It was Carl Hegenbeck, who first attempted to revolutionize enclosure designing by constructing first bar less enclosure in the new zoo at Hamburg Stellinger in Germany in 1907. London zoo followed suit constructing its first moated enclosure in 1913. In 1919 St. Louis zoo also erected its moated enclosure. But it was the Paris zoo, which for the first time incorporated moats in many of its enclosures in the year 1934.



The concept of moated enclosure came to India with the designing of National Zoo, New Delhi which was opened on November 1, 1959. Incidentally Carl Hegenbeck was also one of the advisor for designing of this zoo. Of course very few Indian zoos did construct isolated moated exhibits for some of their charismatic large animals even earlier. In subsequent years Hyderabad, Nandankanan, Kanpur, Vandallur (Chennai), Chhatbir (Punjab) and Visakhapatnam (AP) zoos etc incorporated moats in their exhibit designs. Now many Indian zoos new or old have many moated enclosures as many of them have large spaces available in their zoo premises.

In order to provide near natural habitat to the zoo animals, safaris were thought of, where animals moved freely over several hectares of open land, fenced all around and visitors moved within the safaris in closed vehicles. The first such safari was established in Longleat as late as 1966. Barely a decade after in later part of seventies, Hyderabad zoo constructed its first Lion Safari. This was followed by Nandankanan, Borvilli, Chhatbir, Vandallur and Banerghata (Karnataka) etc.

Whatever may be the type of enclosure or safari all such exhibits need some sort of barrier

to keep the animals safe and the people safe from the animals. Barriers in the animal enclosures in the zoo need to serve many purposes in order to be really good and effective.

The followings are the qualities of a good barrier:

- Safety & security of animal on display
- Safety & security of the visitors
- Safety & security of keepers and other management staff
- Prevent escape of zoo animals
- Ensure proper visibility of animals
- Facility for day-to-day working like cleaning, feeding, observing and treating
- Merging with the enclosure design and surrounding
- Aesthetically appealing
- Reduce stress to the animals

Though moats are generally preferred due to their bar-less appearance, offering full and unobstructed view of the animals to the visitors, they cannot be constructed everywhere due to shortage of space, topography, location, soil conditions and other considerations. There are many types of barriers in use in different parts of the world depending on convenience, topography, animal exhibited, space available and budget. Some of them are listed below:-

Types of Barriers:

- Steel vertical bars
- Horizontal pipes
- Chain link/Welded mesh
- Glass
- Concrete or Stone wall (vertical)
- Natural Cliffs
- Dry/Wet moat
- Hot wires (from mains or solar powered)
- Piano wire
- Shrubbery
- Psychological barrier
- Rubble wall
- Wooden stockade
- Fully covered enclosures



All the above type of barriers use different materials for erecting the barrier, which is also dependent on climate, topography, aesthetic appeal, cost, availability of the material, animal being housed and other factors. The materials generally used are:

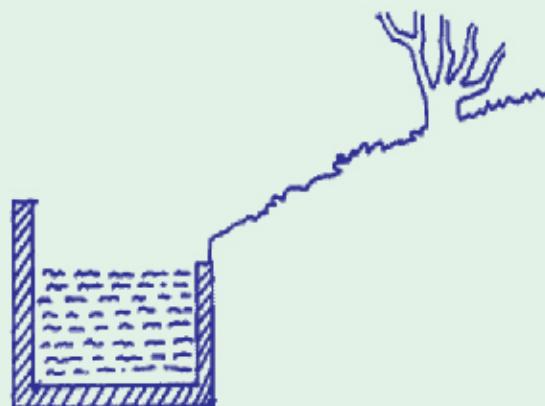
- Cement concrete
- Acrylic/Fiberglass
- Brick & mortar
- Rubble and mortar
- Laterite blocks and mortar
- Chain link mesh and angle iron / rails / welded mesh
- Pipes /angle iron/channels etc

The materials which may include in barrier construction may include:

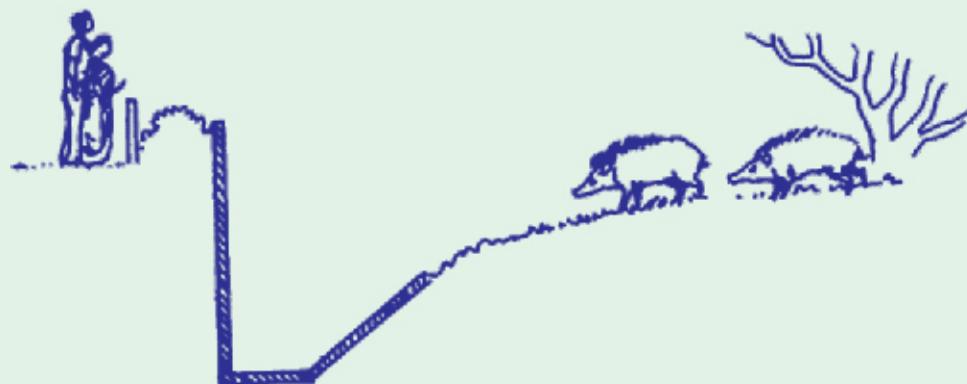
- Mild steel
- Stainless steel
- Wrought iron
- Aluminum
- Nylon nets
- Laminated toughened glass/ordinary glass
- Steel wire
- Wood
- Bamboo
- Cement concrete
- Reinforced cement concrete
- Ferro - cement
- Rubble masonry
- Loose boulders
- Laterite blocks
- Vegetation
- Combination of one or more materials and other suitable materials depending on its availability, cost, site conditions, purpose of use, longevity, animal to be restrained and other considerations. Many more materials may come to the market in years to come. Their use may also be considered depending on their respective suitability.

### 1. Moats as barriers:

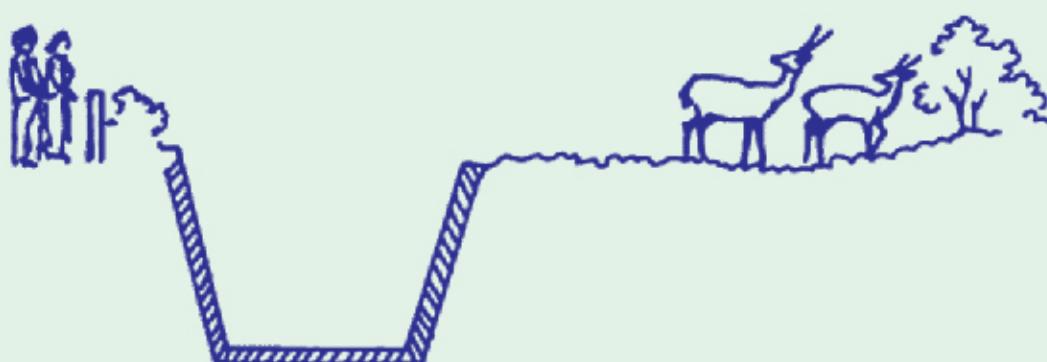
While moats are being advised as good barriers for enclosures in most cases, they have limitations. They can be completely dry or can be filled with water. Dry moats are often preferred as the water requirement for the zoo is drastically reduced and stagnation of water is prevented, thereby reducing water pollution and contamination. But in certain cases water acts as a barrier for animals which are afraid of going into the water even if the depth is very small. The types of moats commonly used are given below:



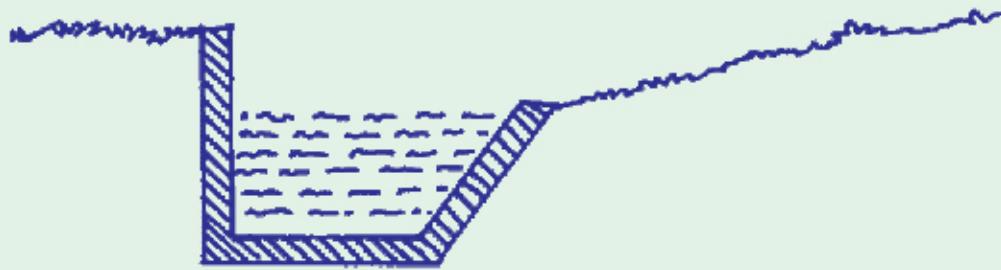
Shallow wet moat



One sided slope dry moat

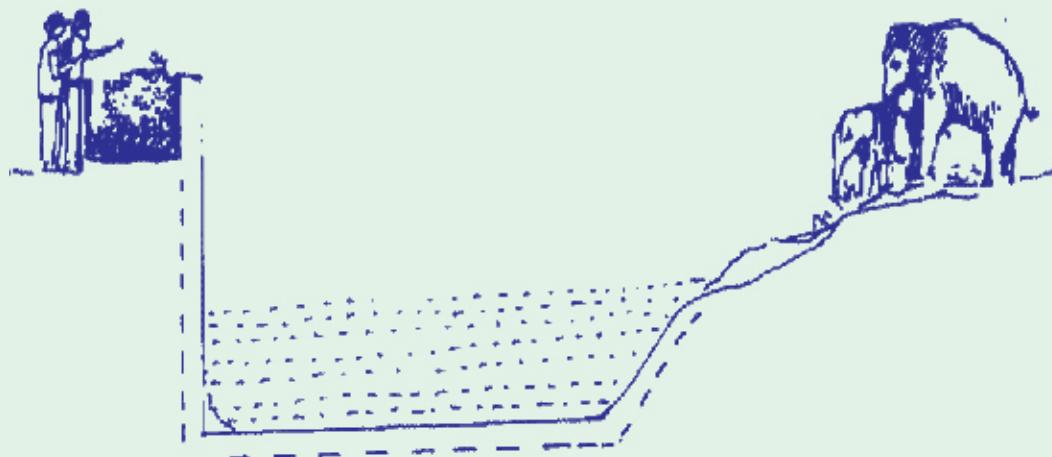


Two sided slope dry moat

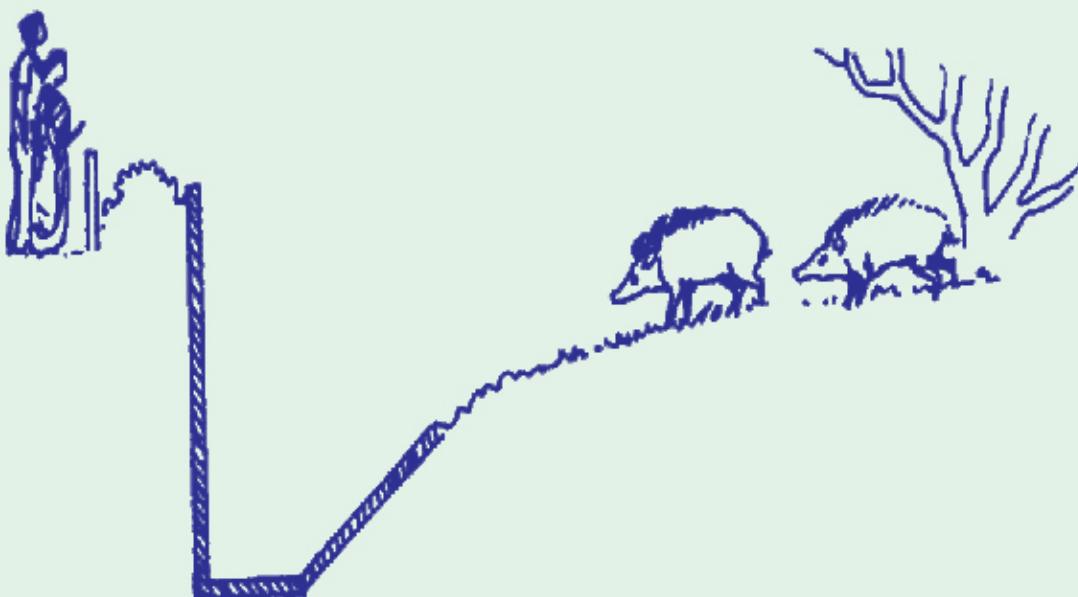


One sided slope wet moat

Used to cover a complete enclosure, where it is difficult to hold an animal through perimeter fence as they can climb. They are also used in inclined fence, where a portion of the fence is erect while upper portion is inclined towards the inner side to prevent a climbing animal to escape.



Stand-off barrier

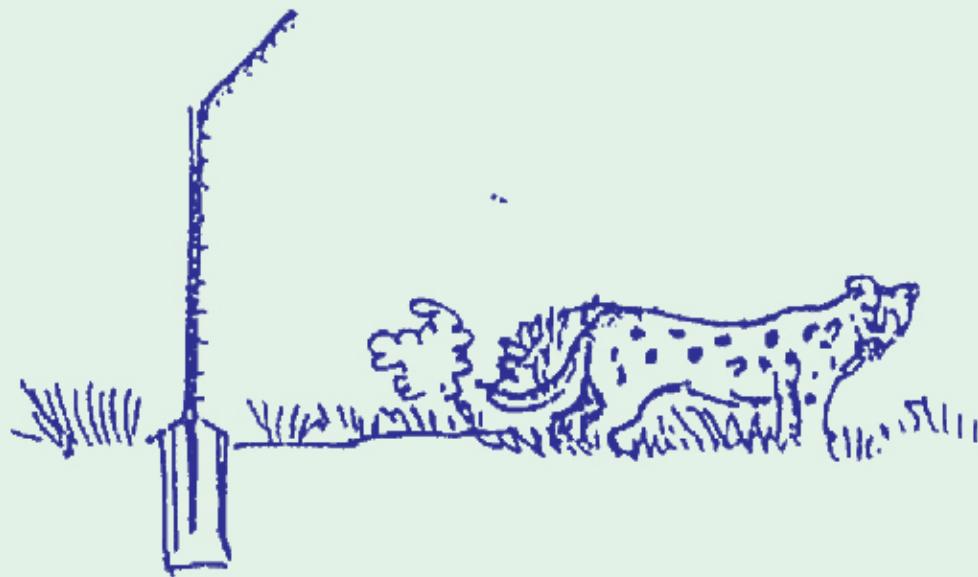


One sided slope dry moat barrier with stand-off barrier

Besides moats there are many other types of barriers which can be effectively and aesthetically used for different purposes. They are described briefly with sketches.

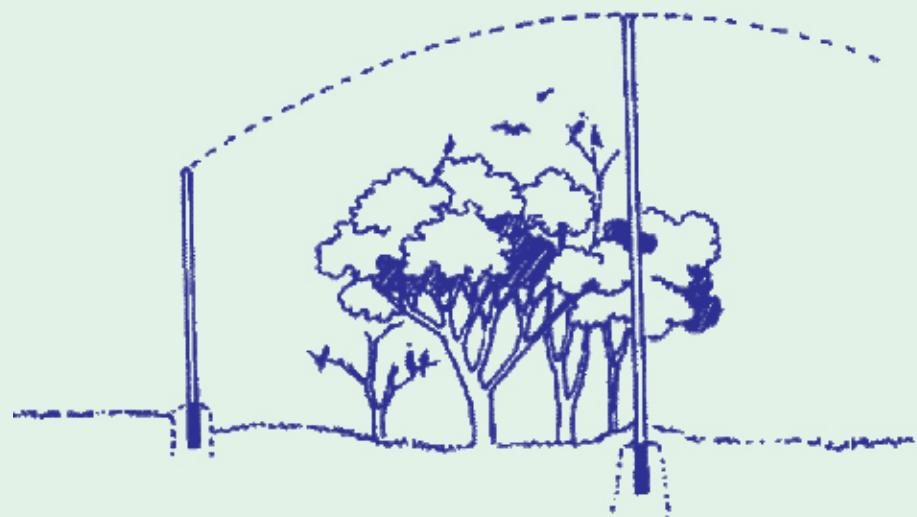
## **2. Chain link wire mesh / Welded wire mesh barrier**

Chain link wire mesh is being increasingly used as barrier in place of bars. They are either used from the viewer side or around safaris.



Vertical Mesh Barrier with Inclination

It is also used to cover a complete enclosure, where it is difficult to hold an animal through perimeter fence as they can climb or fly away. They are also used in inclined fence, where a portion of the fence is erect while upper portion is inclined towards the inner side to prevent a climbing animal to escape. To prevent leopards and jaguars from escaping a steel plate at an angle of 120 degrees to the vertical is also welded to prevent jumping animals to escape. Some monkeys can also be restrained if trees, branches etc can be kept sufficiently away.



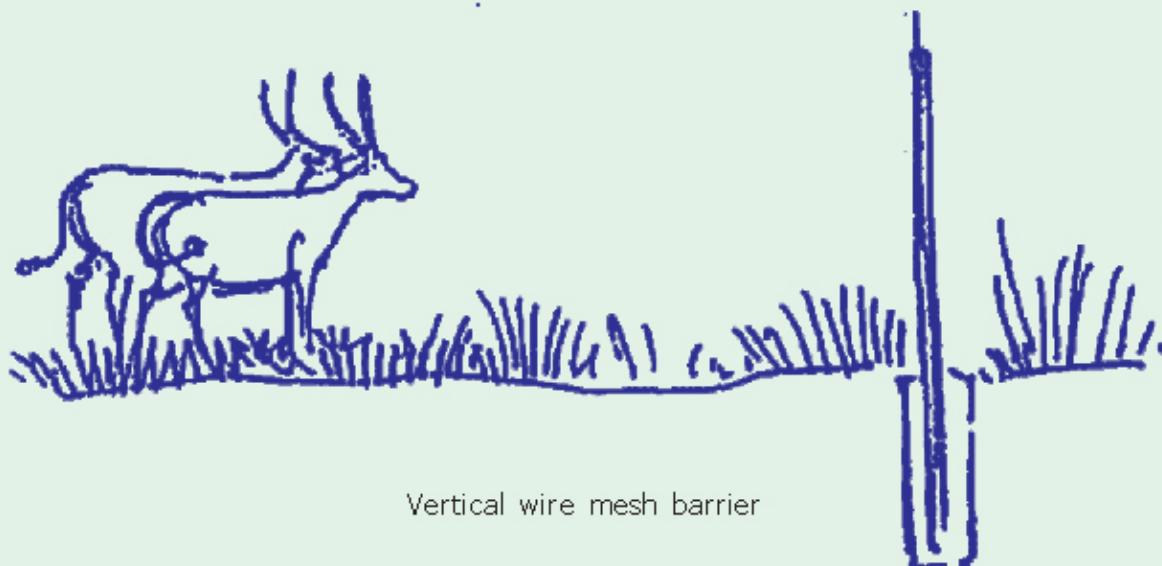
Covered chain link wire mesh barrier



Sometimes smooth steel sheets or other materials are used on the upper portion to prevent escape.



Vertical wire mesh barrier with steel plate at gooseneck portion

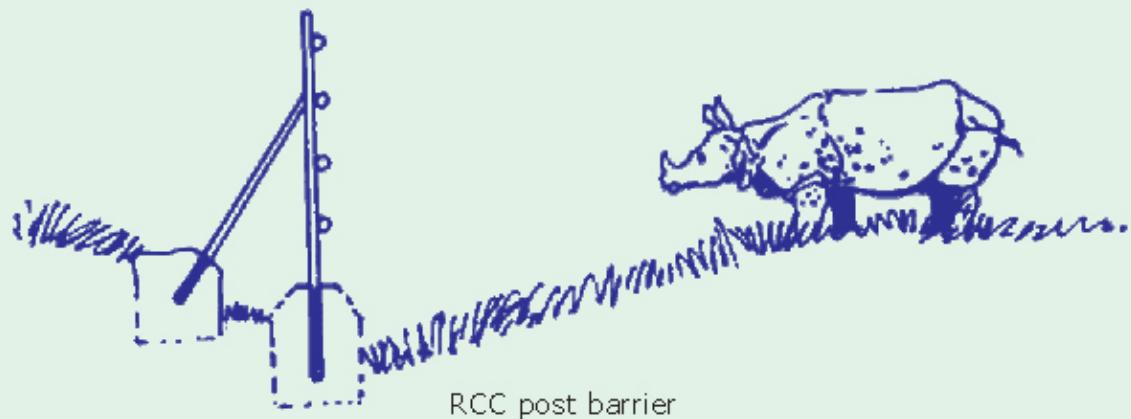


Vertical wire mesh barrier

Welded steel wire mesh is also sometimes used but the chain link mesh is more effective, durable and stronger.

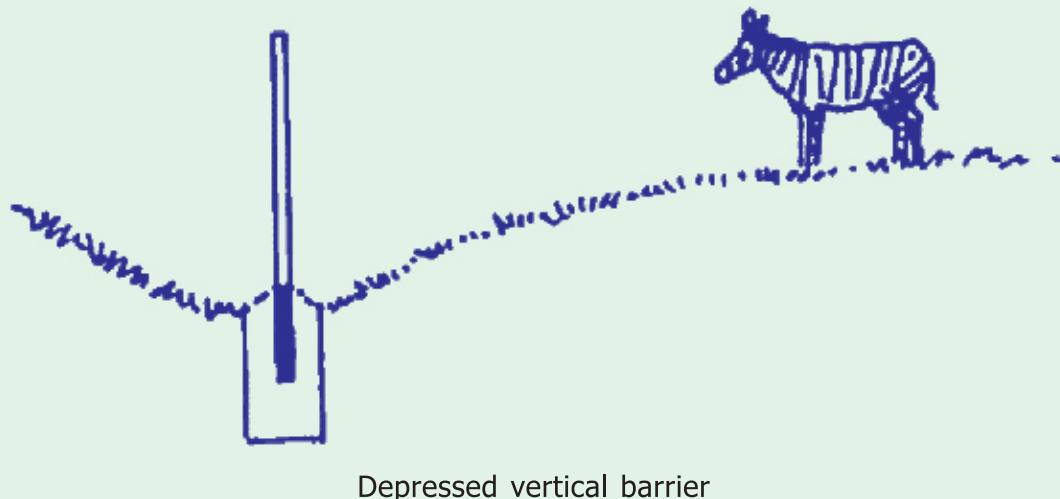
### 3. Reinforced post barrier

Sometimes reinforced post barriers are used to hold strong animals like elephant, rhino or gaur which do not jump. Here the erected posts are held by RCC foundation while they are further supported by struts placed at an angle from outside. The horizontal posts, usually three or more are fixed to the vertical posts on the inner side. The specification of the posts shall depend on the strength and size of the animal.



#### 4. Depressed vertical barrier

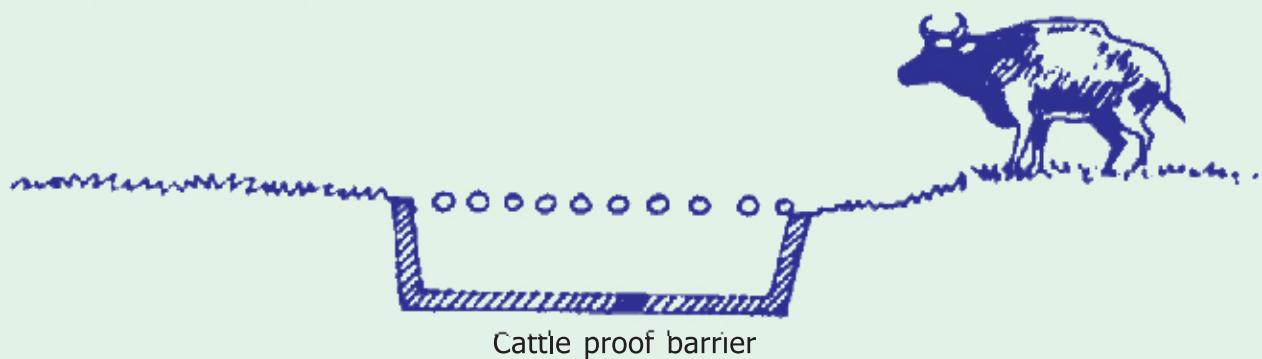
In order to conceal the barrier from the visitor, a depression is created and the vertical barrier of any material is placed within this moat, so that it is not visible to the viewers.



Sometimes this effect is obtained by creating a depression immediately inside the parapet on viewers' side.

#### 5. Cattle-proof fence barrier

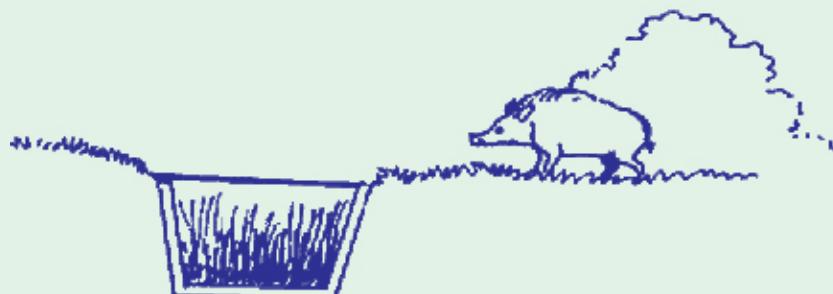
This is used around enclosures of hoofed animals. A shallow moat is created with horizontal pipes which prevent escape of housed animals and the barrier cannot be seen by visitors.





## 6. Horizontal fence barrier

In this type of barrier also a shallow moat is made and a mesh is horizontally placed, held by a frame, so that animals cannot walk away over this without their feet getting trapped. They avoid walking over this fence. This has a good concealed effect also.



Horizontal fence barrier

## 7. Hot-wire barrier

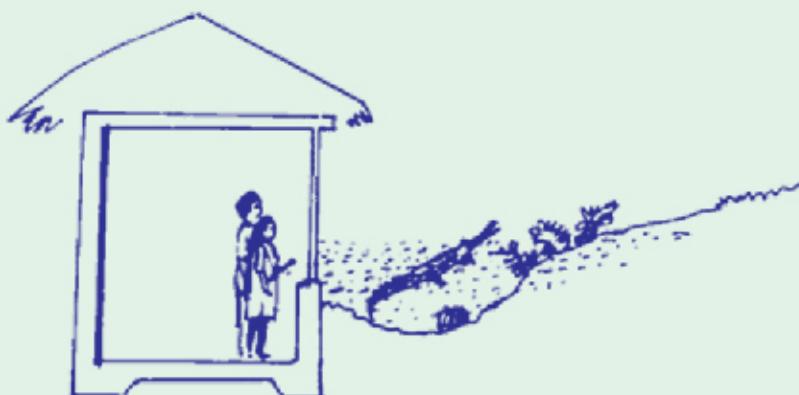
Power fences powered by electricity or solar power are also used to hold the animals quite effectively in many cases. This is quite inexpensive, but the power supply should be uninterrupted and tampering should be prevented. Sometimes warning signals are incorporated in the design, so that an alarm is sounded when the conductor is snapped.



Hot wire barrier

## 8. Glass barrier

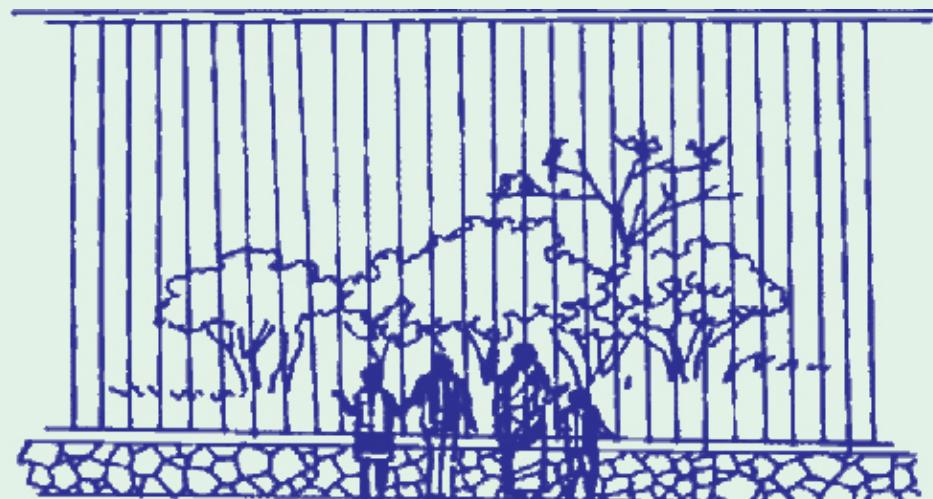
Glass barriers are used with good effect. Now with development of very strong glass, they are even used to hold deep water and also can provide good barrier for even quite strong animals. This is quite effective in indoor exhibits in cold regions. Where there is rampart vandalism, glass barrier should be avoided.



Glass barrier

### 9. Piano-string barrier

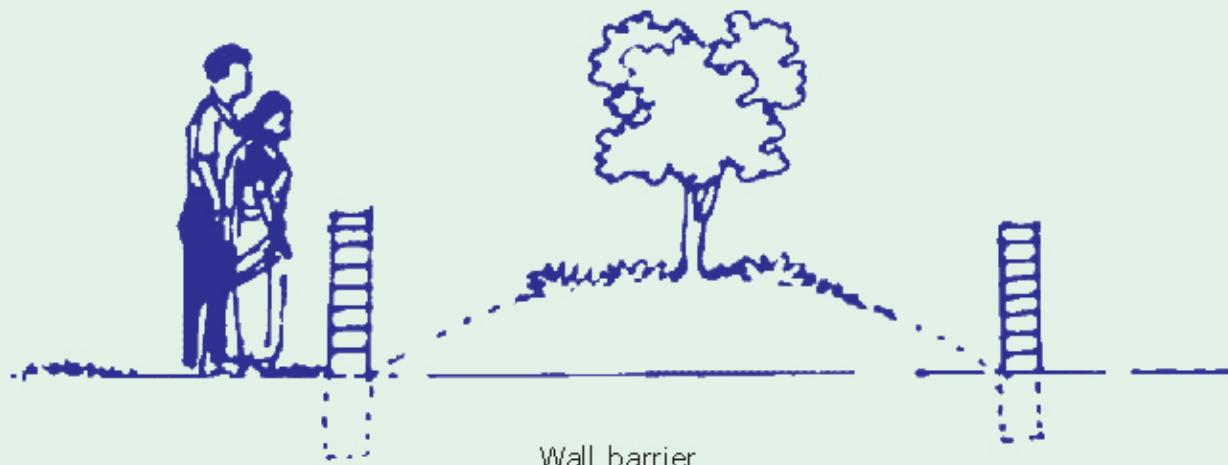
Tensioned vertical wires are also used for holding flying birds, as it does not obstruct the view of the viewers. This is exclusively used for the birds and bats etc.



Piano string barrier

### 10. Wall barrier

Walls of different materials can also hold animals.

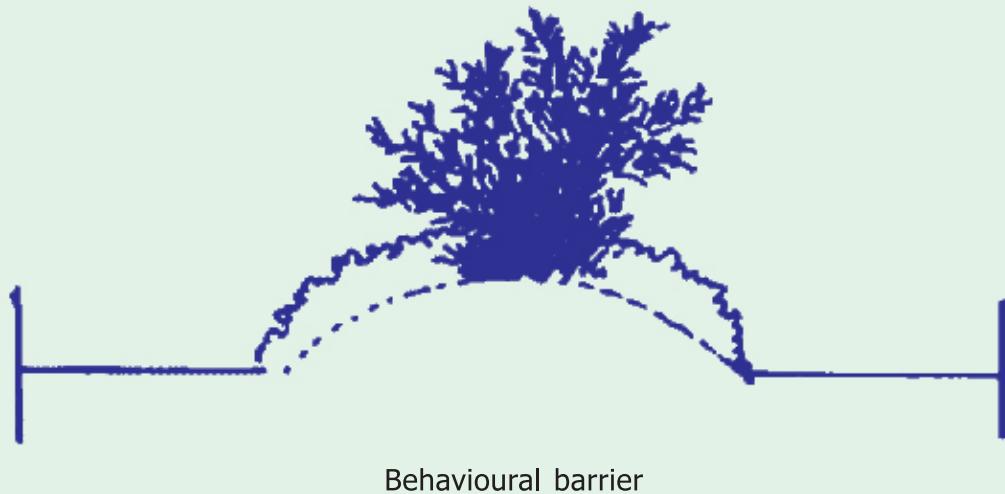


Wall barrier

Even climbing reptiles can be held with smooth inner wall. This can be used as perimeter fence of enclosure also from the viewer's side.

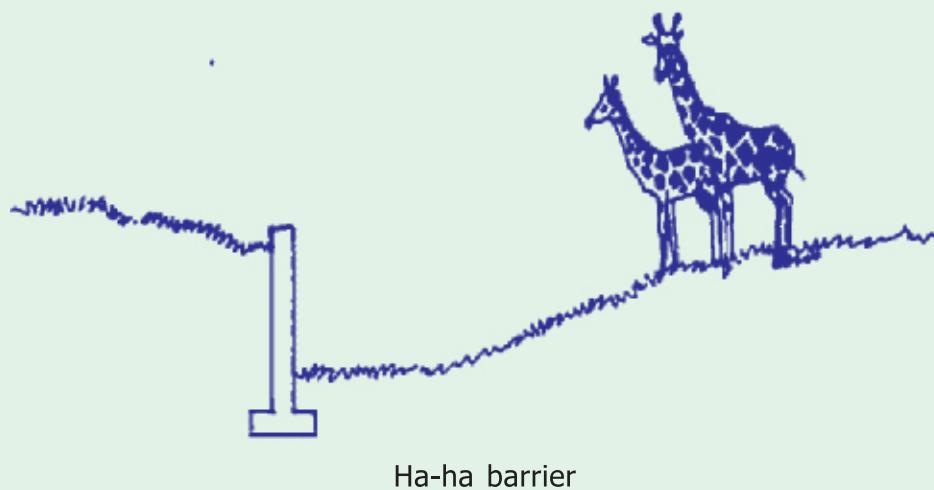
### 11. Behavioural barrier

In this case virtually no barrier is provided, but the animals are provided their food and behavioural needs inside the exhibit, which is surrounded by a dwarf wall or a shallow moat. As the complete need of the species is satisfied inside the exhibit, the animals do not venture out of such exhibits. Very careful planning is needed for such exhibits. Usually small primates are kept in such exhibits with proper conditioning.



#### 12. **Ha-ha barrier**

Here the advantage of the habit (non climbing or jumping) of the animal to be housed is taken. And a low sunken wall is provided. This is quite well concealed from the viewer.

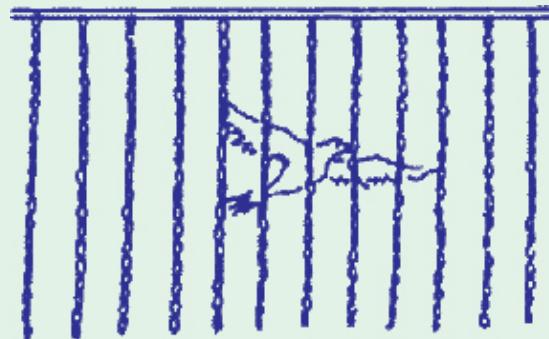


#### 13. **Natural/artificial precipice or depression as a barrier**

Sometimes advantage of natural precipice or depression is taken to confine the animals depending on their habit. Artificial ones can also be created for simulating habitat of the species housed.

#### 14. **Curtain barrier**

Sometimes hanging chains are also used as barrier to confine the birds and bats etc. Their use is limited mostly to entrance of such confined enclosures when the visitors or keepers enter through two parallel curtain barriers. This is used generally in nocturnal animal houses or walk through aviaries. Double gates or revolving gates also meet this requirement.



Curtain barrier

### 15. Vegetation as barrier

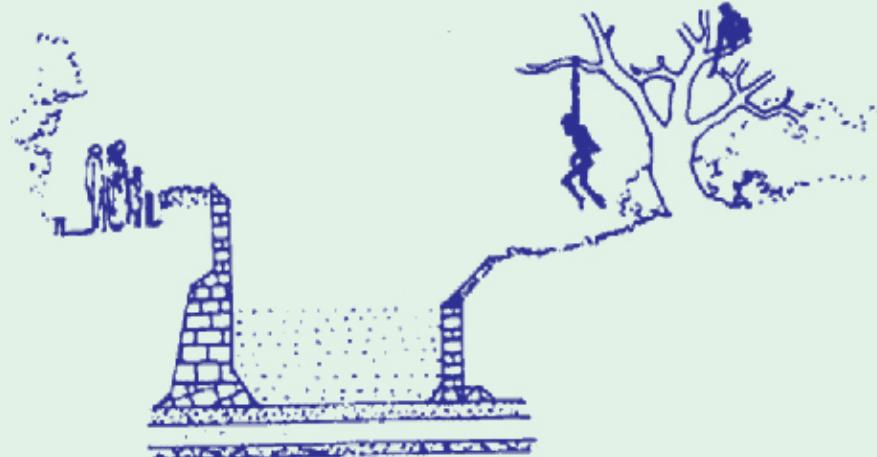
Some animals (small ones) can be confined quite effectively with shrubs properly used as fencing. However, their use is limited.



Vegetation as barrier

### 16. Stand-off barrier (SoB)

Standoff barrier is provided to keep the visitors away from the main front barrier. This is necessary in order to prevent approach of children and others who often interact with the animals and feed them. Sometimes they harass them also and in retaliation ferocious animals attack them. Varieties of materials and specifications can be used as a standoff barrier. Materials like stainless steel bars, steel pipes, horizontal RCC concrete railing, and chain link mesh/welded mesh, bamboo, timber, thick wire, synthetic or natural fibre ropes, metal chains etc are used. They should be spaced apart from the main barrier with intervening space. They should be made with stout material to prevent breakage and there should be no scope of people standing on lower members on the standoff barrier.



Stand-off barrier



According to CZA guide lines the SoB should be 90 cm away from the main barrier to prevent reach of the visitors and it should be 90cms in height to facilitate viewing. However, the distance of standoff barrier from moat wall is recommended as 1.5 metre, in case of carnivores, with thorny hedge in between in view of some incidences which happened earlier where visitors entered inside the paddock. Some zoos place chain link/welded mesh on the moat wall as a SoB. This defeats the very purpose of a moated exhibit and a SoB.



Jaguar exhibit Showing stand off barrier at National Zoological Park ,New Delhi

#### **Types of barriers recommended for different types of animals:**

<b>Animal/bird type</b>	<b>Examples</b>	<b>Front barrier</b>	<b>Rear barrier</b>
Terrestrial species with some jumping & climbing ability	Tiger, Lion	U/Trapezoidal shape dry or wet moats with or without glass viewing, structures at special viewing areas.	U/Trapezoidal shape dry moats or high chain link fences or high/concrete rock walls
Terrestrial climbing, jumping	Leopard/ snow leopard	U/ Trapezoidal shape dry or wet moats with incline/hot wire, with or without glass viewing structures at special viewing areas.	High smooth wall/ chain-link wire mesh fence with inclined steel plate at gooseneck portion.
Terrestrial species / jumping	Jackal, Wolf, Hyena	U/Trapezoidal shape dry moats with or without chain-link wire fences.	U/Trapezoidal shape -dry moats or chain-link wire fences or walls.
Arboreal species / climbing	Himalayan Black Bear, Sloth Bear, other bears.	U-shaped / Trapezoidal shape dry/ wet moats	U-shaped/ Trapezoidal shape dry moats or high smooth walls or overhanging rock walls or high wall or chain-link wire mesh with steel plate at gooseneck portion.

<b>Animal/ bird type</b>	<b>Examples</b>	<b>Front barrier</b>	<b>Rear barrier</b>
Arboreal species/ jumping & climbing	Monkeys, Langurs and apes	U-shaped/Trapezoidal shape dry moats, shallow wet moats, netted aviaries with glass viewing	U-shaped/ Trapezoidal shape dry moats or shallow wet moats, netted aviaries or high wall with overhang or chain-link wire mesh with steel plate at gooseneck portion.
Terrestrial species/ jumping	Blackbuck, Spotted Deer, Barking Deer, Sambar, Nilgai, Flightless bird	Trapezoidal shape dry moats / sunken walls chain-link wire fences or concealed cattle grid in depression	Trapezoidal shape dry moats or chain-link wire fences or rock/ concrete walls
Terrestrial / non-jumping	Gaur, Wild Boar Rhinoceros, Elephant	Trapezoidal shape dry moats/ horizontal bar/concealed depressed barrier. Cattle grid for gaur	Trapezoidal shape dry moats or low walls (clay banks), cattle grids (gaur) / horizontal bar
Aquatic & semi- aquatic species/ non-jumping	Hippopotamus, Crocodiles, Otter, Tortoise, Turtle, Terrapins	Wet moats (exhibit pools)	Low walls with clay banks.
Flying terrestrial aquatic	Flying bird	Chain-link wire mesh with top cover	Chain-link wire mesh with top cover
Crawling and climbing	Snakes and Amphibians	Glass. Chain link mesh for large snakes like python	Walls with top partly covered

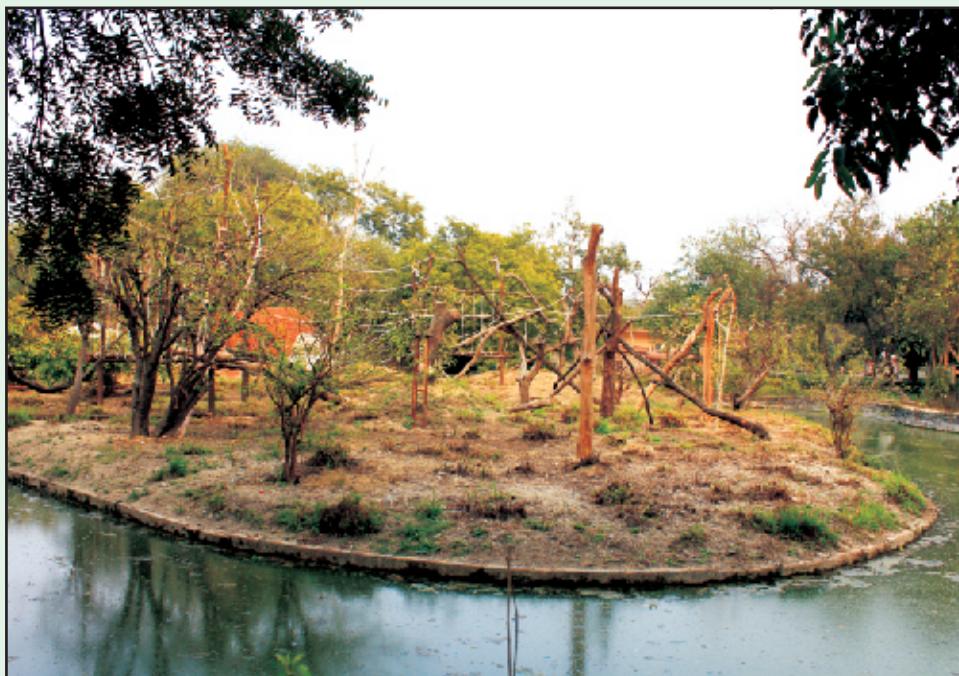




## 7. Environment Enrichment in Animal Enclosures

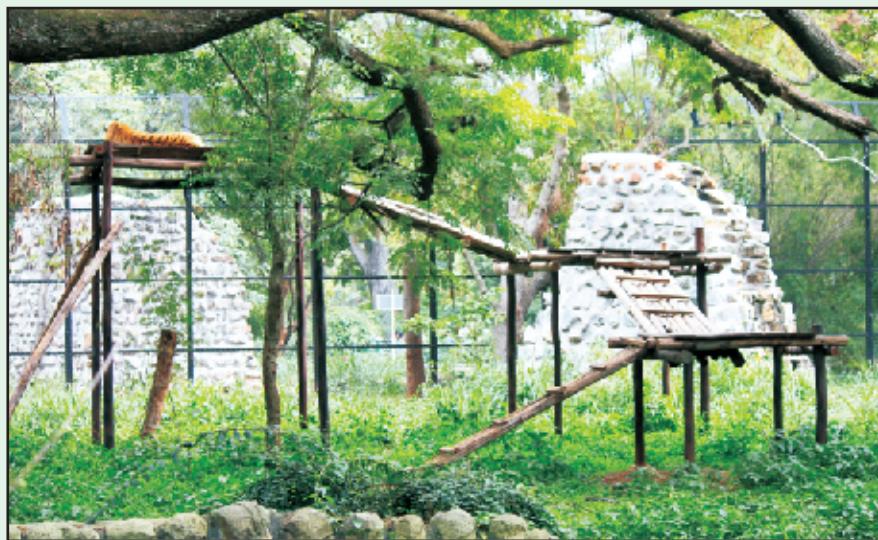
However much we intend to give a large space to any animal exhibit in a zoo condition, it will certainly not be possible to do so. Even if there is possibility to provide large spaces to some smaller animals and birds, it will not be possible to provide them their own natural habitat in captive conditions partly due to want of space, topography, prey base, besides necessity of proper viewing conditions for the visiting public. Sometimes they are brought from far off places to totally alien environments removed from their own habitat conditions including climate. As a result, they cannot exhibit their natural behaviour and tend to behave in peculiar manner often exhibiting stereotyped behaviour, bore dome, swaying, sleeping for long hours, lack of appetite, picking of feathers of mates, rubbing parts of the body and many other behaviour not natural to the species. This affects their well being and health conditions. The visitors also do not like to see animals and birds in such pathetic state.

In order to obviate this, enrichment of enclosures with the right types of artefacts, topography, lighting, vegetation is absolutely essential. Many studies in zoos in different parts of the world have indicated that most such conditions can be remedied through appropriate environmental enrichment of the animal enclosures. These enrichments stimulates natural behaviour like climbing, jumping, scratching, running, rubbing, hiding, sun bathing, wallowing, digging, mating, nesting, acrobatics, playing, swimming and flying etc. and depend on area and topography of the enclosure. This can be best achieved by knowing the behaviour of the animal in the wild and simulating it fully or partially depending on the local conditions.



Lion - tailed Macaque island at National Zoological Park, New Delhi

Good enrichment materials or artefacts are water pools (shallow or deeper), wallow ponds, logs, dead or live trees/branches, vines, both natural and artificial. Live vegetation like shrubs or grasses, hollow logs, nest boxes, caves, ledges, rock crevices, steep slopes, boulders, streams, artificial waterfalls, tunnels or earthen substrates etc. are often used in different zoos. The general topography is also altered to suit the animals' behaviour. Staggering of food presentation, hiding favorite food material, placement of food etc also stimulates activity in animals concerned. Lot of work on this has been done by the Wildlife Institute of India, Dehradun through a project sponsored by the Central Zoo Authority. This can be referred to provide effective enrichment for different species in the zoos.



But care should be taken to see that the material used is safe for the animal concerned, keepers and visitors. They should preferably be natural materials rather than artificial ones made of plastic, concrete or steel. They should not have pointed ends or sharp edges and should not be brittle. Otherwise the animals can be injured or some of them can use them as weapons to attack keepers. They should be permanent or semi permanent in nature obviating the need for frequent replacement.

Activities can also be stimulated by periodically changing the position of different artefacts within the enclosure and placement of food.

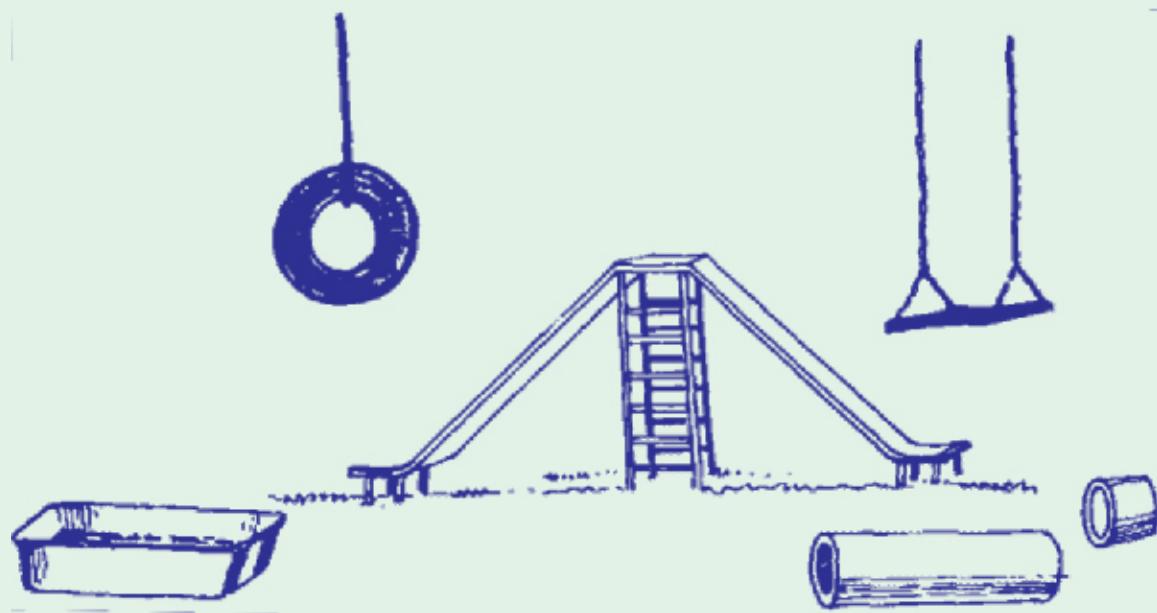
(Three drawings can show some types of good enrichment materials indicated above and those like swings, slides, vehicle, bi-cycle tyre, hume pipes, steel cages which should not be used as enrichment)



(i) Picture of a good enrichment



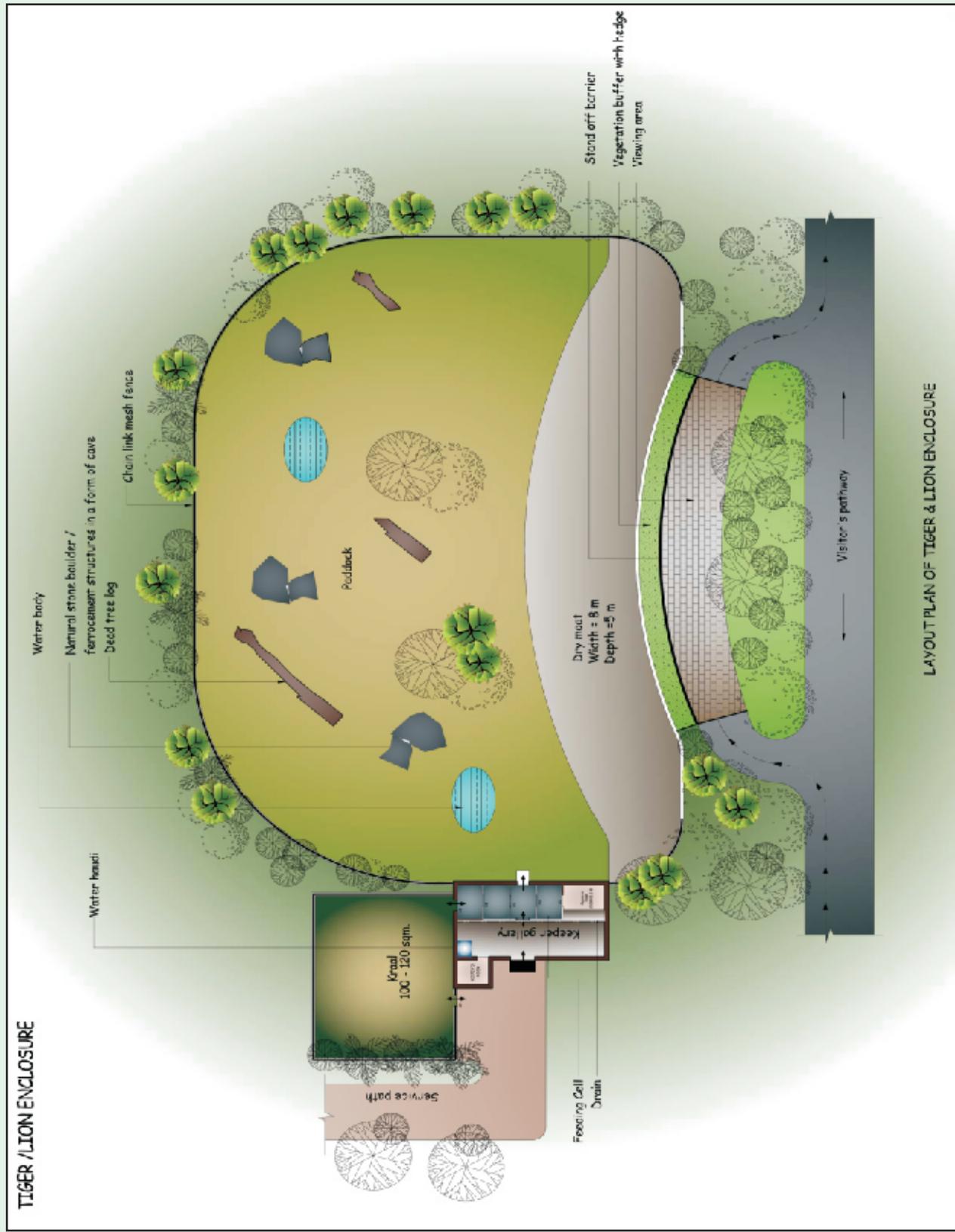
(ii) Picture of a good enrichment



(iii) Picture of a bad enrichment



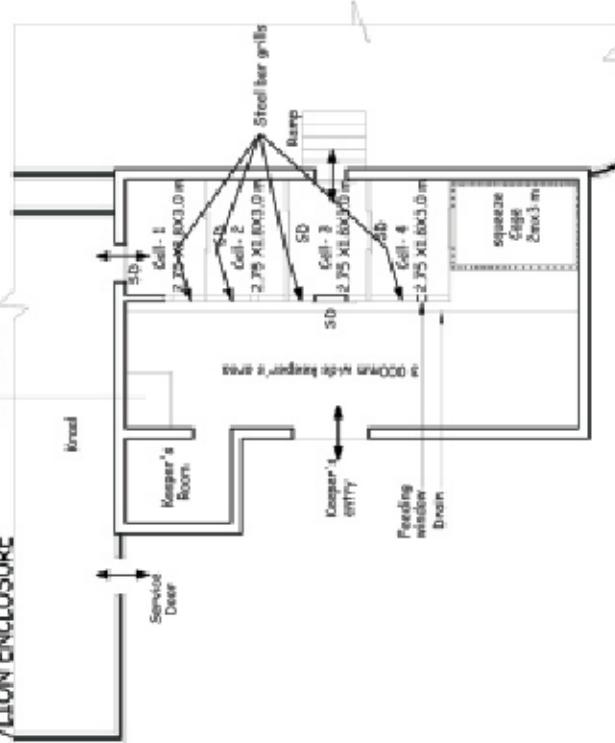
## 8. Design of Enclosures





TIGER / LION ENCLOSURE

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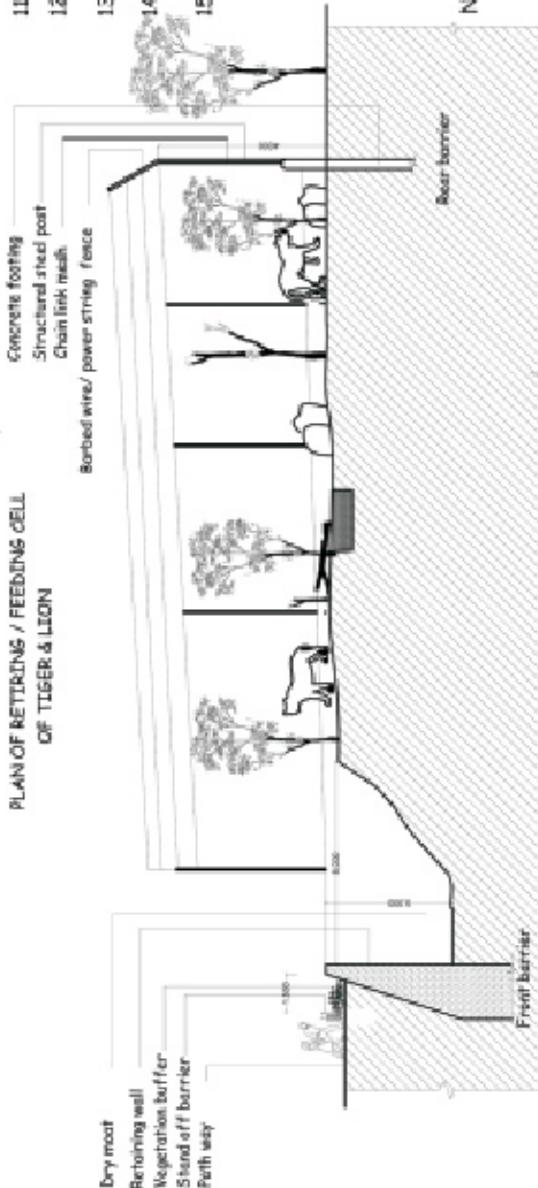


PLAN OF RETIRING / FEEDING CELL  
OF THESE & LION

1. The paddock area of tiger enclosure should be minimum 1000sqm but it can be upto 2000sqm. Kiosk area should be 100 - 120 sqm.
  2. The minimum size of feeding cell should be 2750-3000 mm(l) x1800 mm(w) x3000 mm(h).
  3. Size of sliding door in cell should be of minimum size of 900 mm high and 750 mm wide.
  4. Size of upsliding door in cell should be of minimum size of 900 mm high and 750mm wide.
  5. Keeper's gallery should be of minimum width of 3000mm.
  6. Entry gate to the keeper gallery should be 1800mm wide and 2000mm high.
  7. Chainlink mesh size should be 50mmx50mm & gauge and it should be galvanised. Height should be 5000mm.
  8. Three strings of barbed wire or electric power fence are to be fixed on the top of the fence inclined at an angle of 120 degree to the vertical structural steel post.
  9. Chainlink mesh where ever required is to be placed on the inner side of the structural post. The mesh is to be embedded with the masonry basic which shall be sloped both way to prevent accumulation of water and urine.
  10. Plinth of the cell should be of a height of 500mm.
  11. Size of the feeding window is 2000x2000mm.
  12. A drain should be built parallel to the cells.
  13. A worker house should be built.
  14. Wooden legs, natural stone boulders , trees & shrubs may be placed inside the enclosure for enrichment.
  15. The maximum depth of the enclosure should be maintained between 20m - 25 m to get a closure view of the animal.

20

As per the guidelines of the Central Zoo Authority the minimum sizes  
are as below:-



**SECTIONAL ELEVATION  
OF TIGER & LION ENCLOSURE**

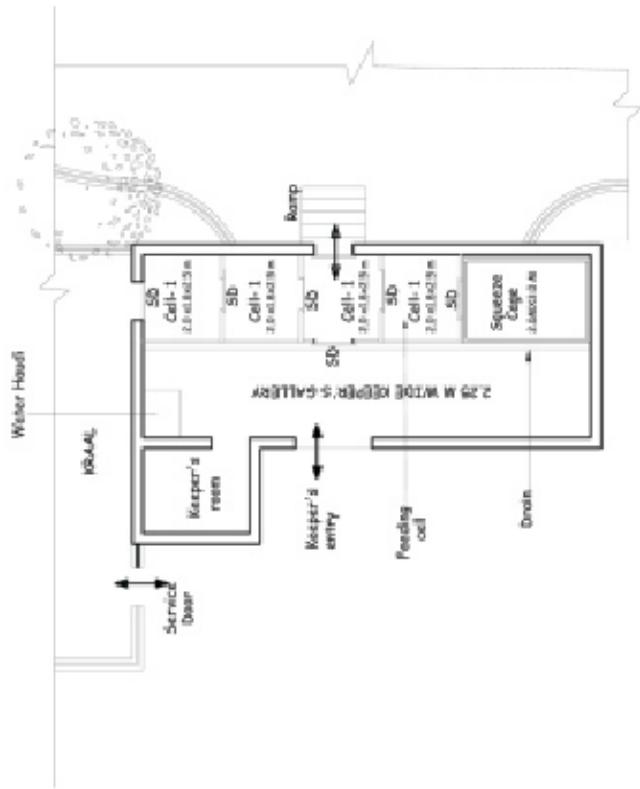
**LEOPARD, CLOUDED LEOPARD & SNOW LEOPARD ENCLOSURE**



LAYOUT PLAN OF LEOPARD, SNOW LEOPARD,  
CLOUDED LEOPARD ENCLOSURE



LEOPARD, CLOUDED LEOPARD & SNOW LEOPARD ENCLOSURE



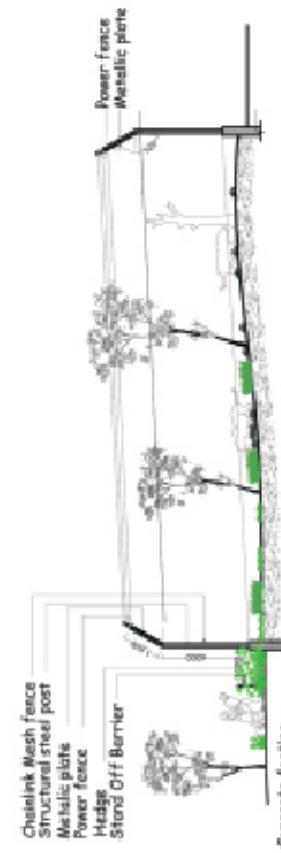
**PLAN OF RETIRING CELL / FEEDING CUBICLE  
OF LEOPARD, SNOW LEOPARD, CLOUDED LEOPARD ENCLOSURE**

- NOTES

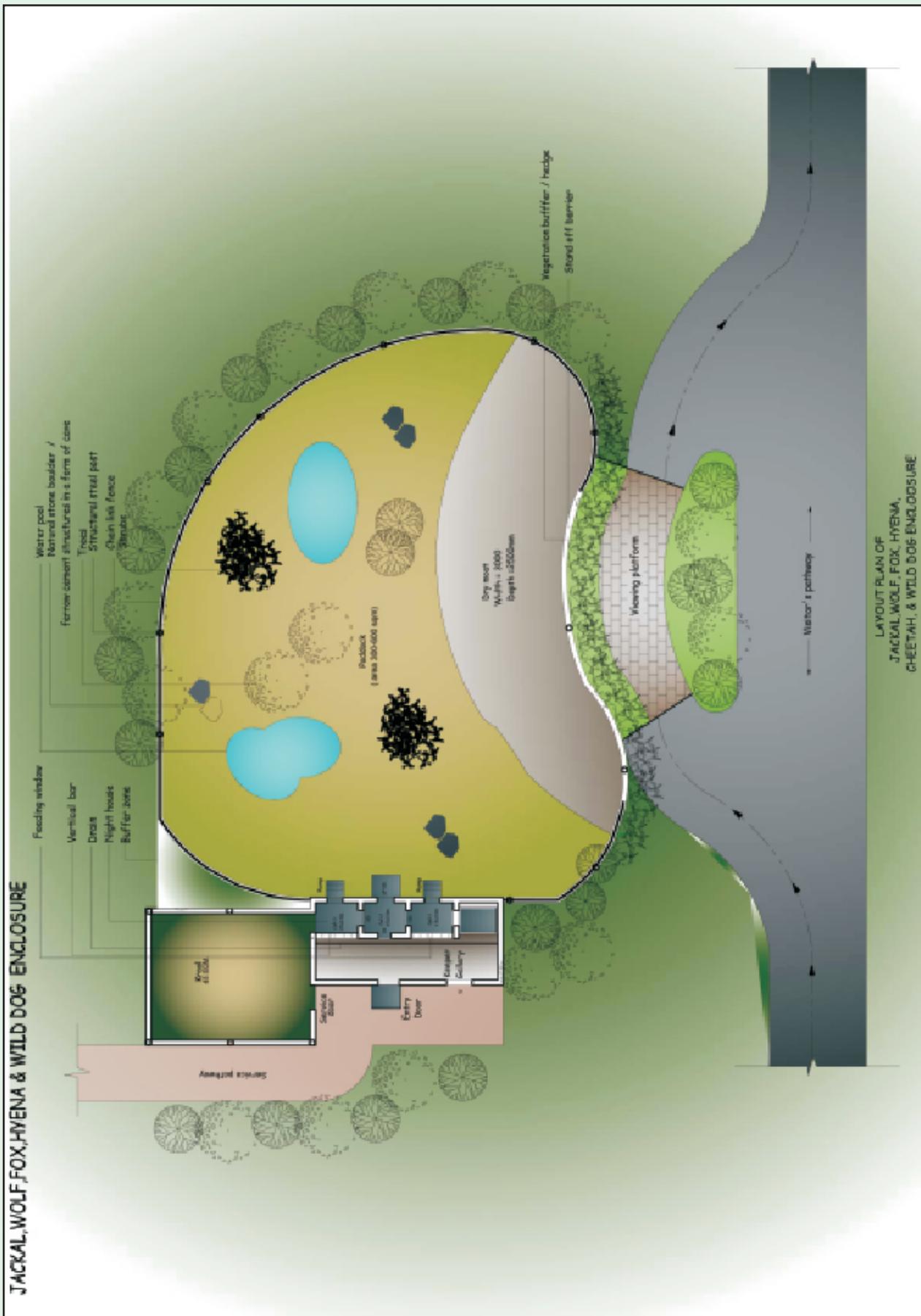
1. The inside & area of leopards enclosure should be 500- 1000sqm. and for clouded leopard it may be 300 - 400 square with top covered.
  2. The minimum size of feeding cell should be 2000x 1500 mm. and height should be 2500mm
  3. Chainlink mesh should be of size of 50mmx50mm gauge and it should be galvanised.
  4. The height of the fence should be 4000mm.
  5. Three strands of power fence are to be fixed on the top of the steel plate of the fence inclined at an angle of 120 degrees to the vertical structural post. Steel plate should be of 150mm in width.
  6. Chainlink mesh where ever required is to be placed on the inner side of the structural post. The mesh is to be embedded with the masonry base which shall be aligned to prevent accumulation of water and wind.
  7. Where ever there is a constraint of space, covered option may be adopted for leopard & snow leopard.
  8. Washed logs, natural stones boulders, trees & shrubs may be placed inside the enclosure for enrichment.
  9. Keeper gallery should be of minimum size of width= 2250 mm.
  10. No trees or branch of the tree should be within 8000mm from the inner side of fence.
  11. Entry gate to the keeper gallery should be 1800 mm wide and 2000mm high.
  12. Size of area should be 90- 100 sq.mt. for leopards (top covered) & for clouded leopard the size may be 40-50 sq.mt (top covered).
  13. Size of sliding door in cell should be of minimum size of 750mm high and 750mm width.
  14. Plinth of the cell should be of a height of 500mm. from the immediate ground level.
  15. Size of upstaging door in cell should be of minimum size of 900 mm high and 750mm wide.

10

**B.** As per the guidelines of the Central Zoo Authority the minimum sizes are as below:-  
Primate area = 5000 sqm  
 $\text{Ferret/otter enclosure} = 1\text{ m} \times 1\text{ m}$   
 $\text{Fox/leopard enclosure} = 1\text{ m} \times 1\text{ m}$   
 $\text{Baboon enclosure} = 2\text{ m} \times 2\text{ m}$   
 $\text{Lion/tiger enclosure} = 2\text{ m} \times 2\text{ m}$



## SECTIONAL ELEVATION





JACKAL, WOLF, FOXHOUND & WILD BOAR ENVELOPES

3

The postdoctoral fellow, Dr. Cho, will continue his research at the University of Guelph, Ontario, Canada. He will be working on the development of a new DCE-MRI technique for the evaluation of breast cancer.

2. Maximum one of following conditions exist or true or false.  
 2500m.  
 3. Size of field should be 40-50 ha.  
 Topographic contour distance & field height  
 width 200m.  
 Distance between should be 200m of which 90% one floor.

4. A corner 5'0" wide should contain minimum 3'2" of earth or earth & rock fill.

5. Slopes should be no steeper than 1 in 10, except where the top of the slope is 10' above the ground level.

6. Banks subject to the danger of collapse should be 10'0" wide and 20'0" high.

7. Corner mesh should be of size 1" x 50mm. Correct run and it should be galvanised.

8. Tree stumps 17' 3" apart should be 10'0" from the top of the fence inclined at an angle of 15° degrees to the vertical straining strand post.

9. Height of the fence should be 20'0" and the individual panels should be open.

10. Chain link mesh should be 1" x 50mm or equivalent or rebar mesh 1" x 1" x 1" x 1" should be used. The mesh should be strained in the assembly base which will be shared by the prevent destruction of an animal enclosure.

11. Driveway entrance 8' 5" in depth should be provided with a single gate or two 7' 0" gates that separate the compound.

12. A set of fire shutter doors provided in the boundary is 8' 5" x 7' 0" each.

13. Height of the entrance barrier should be 9' 0" and it should be 15' 0" maximum from fence.

14. Vegetation less, natural stone boulders, trees & shrubs may be planted beside the enclosure for orientation.

15. In case of corner included, at one right shelter should be provided for novel animals.

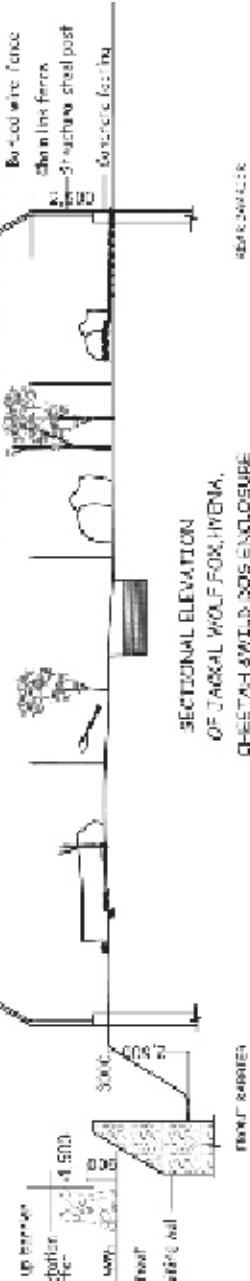
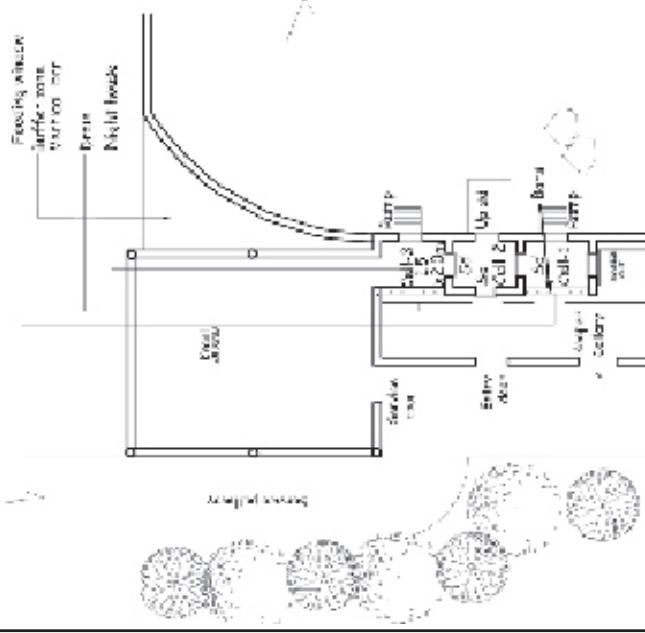
N.B.

As per the guidelines of the Central Zoo Authority for the minimum sizes given as below:

Perimeter fence = 400' 0" m

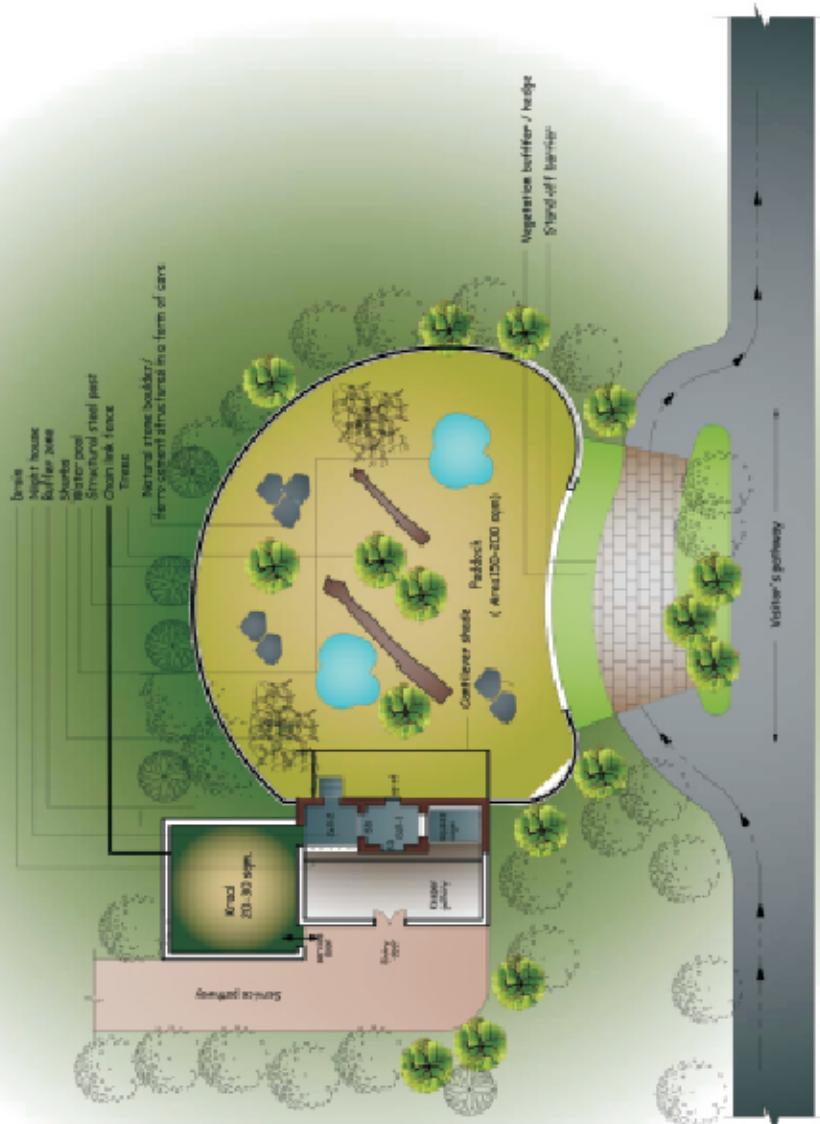
Fencing unit size = 8' 0" h : 2' 0" w width x 12' 0" height = 25' 0"

PLAN OF RETIRING CELL & FERDONS CUBIC Z  
OF JACKAL WOLFPUK HENNA.  
CARTERAN VILLAGE.



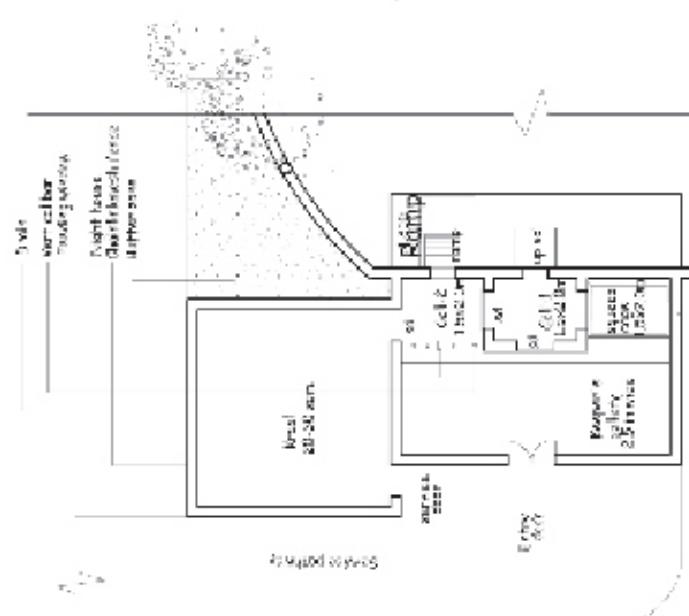
41

**SMALL CATS RATEL & HOG BADGER ENCLOSURE**

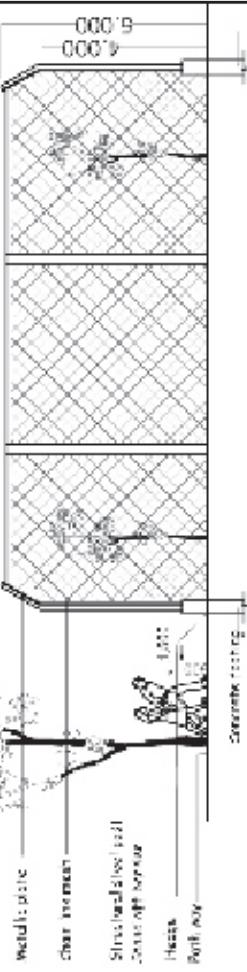




## SMALL CATS RATEL & HOG BADGER ENCLOSURE



PLAN OF BETTERED CELL ENCLOSURES  
OF SMALL CATS, RATEL & HOG BADGER



SECTIONAL ELEVATION  
OF SMALL CATS, RATEL &  
HOG BADGER ENCLOSURE

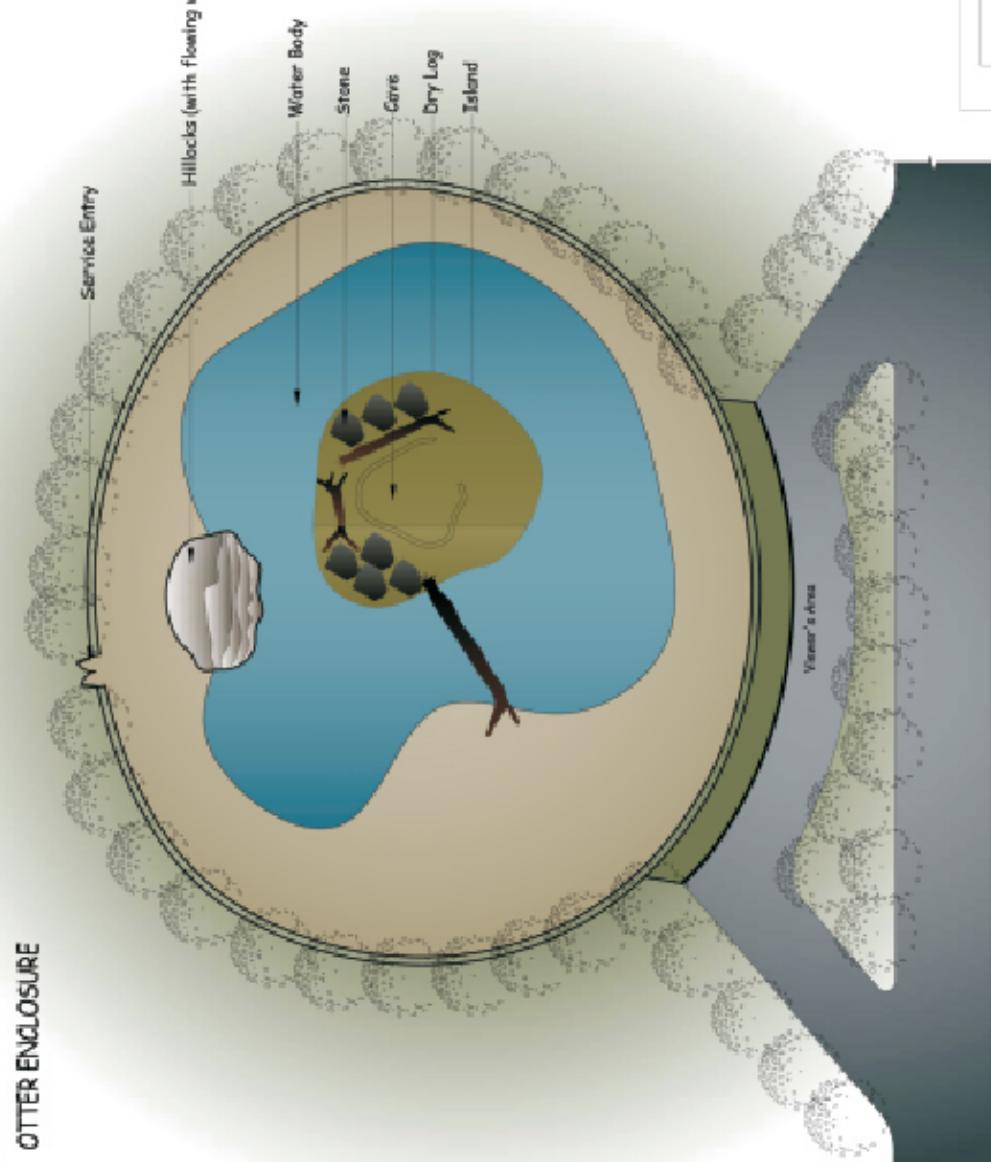
traffic.

1. Padlockable doors should be 1.50-2.00 meters for cats, and 1.80-2.00 meters for the predators - these should be 45 centimeters thick. The hinge and lock parts of the padlockable doors should be 40 centimeters.
2. Cell size should be minimum 200m<sup>2</sup> and maximum 600m<sup>2</sup> per 100.
3. Size of each should be 20x20 m. The appearance of the fence height of this kind should be 2.0-2.5 meters. The distance from the ground should be minimum 1.50-2.00 meters.
4. Fence's stability should be 1.50 meters side by 2.00 meters wide. The floor should be cemented, other less than a tile.
5. Entry walls to the houses should be 0.20 meters thick and 2.00 meters high.
6. Size of a tiles and materials should be used on the floor of 500 mm in a tile, and 500 mm in a brick.
7. Chain-link fence should be made of 25mm diameter wire mesh 1.20m high and should be galvanized. The height of the mesh chain link on each side should be 1.20 meters.
8. Chain-link mesh and metal plates or concrete required one to be placed on the floor and a side of fence structure must be fixed with the necessary bolts which should be stopped software by prevent attachment of other strands.
9. Topping wire covered 100% zinc, same 400-600 gr/m and material TIP must be kept open in the entrance and both ends with 10 cm each and plane to be fixed on the top of the fence indicated in a height of 90 degrees from horizontal to vertical fence plane.
10. Height of the fence will be higher 200 cm and thickness of 100 cm every 10 cm fence.
11. Arrangement water bags (reservoir) in the pens arranged along a height 6.000 meters.
12. Small vertical cut of 1.50 meters height could be arranged in fence.
13. Fencing in size should be 1.50-2.00 meters.

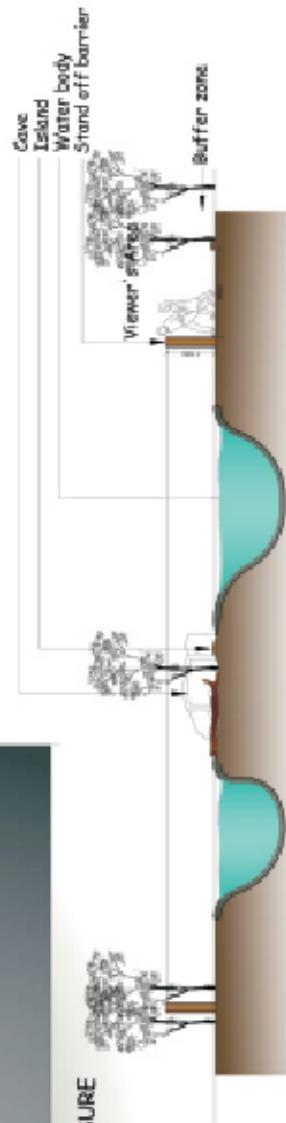
**OTTER ENCLOSURE**

**NOTES:-**

1. Paddock area of otter should be 400 sqm.
2. Cells should not be provided in this enclosure.
3. A gucca pond of 150 - 200 sqm. with an island of 40 sqm. should be provided. The depth of pond should be 1.5m - 2 m.
4. The paddock area should be surrounded with wall of 1.5 m high.
5. Inverted bar inside the paddock on covered wall at a height of 60 cm from ground level should be provided.
6. Service gate of size 1 m. high and 1 m. wide should be provided.
7. Provision for water circulation should be provided.

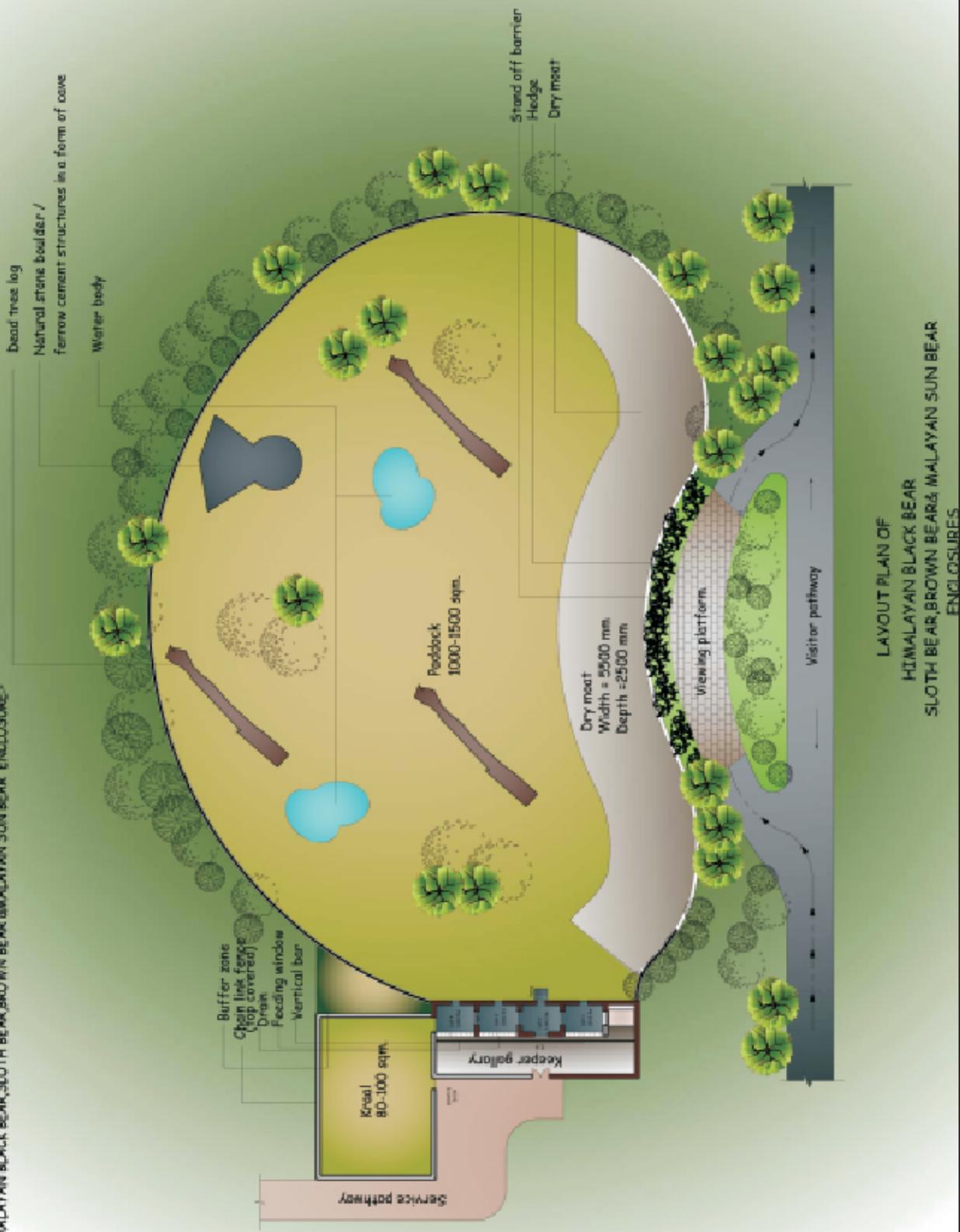


LAYOUT PLAN OF OTTER ENCLOSURE





### HIMALAYAN BLACK BEAR, SLOTH BEAR BROWN BEAR SUN BEAR ENCLOSURE



AYOUT PLAN OF  
HIMALAYAN BLACK BEAR,  
SLOTH BEAR, BROWN BEAR, MALAYAN SUN BEAR  
ENCLOSURES

**NOTES:-**

1. Paddock area should be 1000-1500 sq.m.
2. Cell size should be minimum 2500mm(0.25x0.25m)²x2500mm(h)
3. Size of kroul should be 80-100 sq.m - top cover & the chain link fence height of the kroul should be 2500mm - The service door size should be 1800mm high & 200mm wide.
4. Keeper gallery should be of minimum size of 2500mm wide. The floor should be cemented or with kota stone.
5. Entry gate to the keeper gallery should be 1200mm wide and 2000 mm high.
6. Size of up sliding door in cell should be of minimum 6x28 or 900 mm high and 900 width.
7. Chainlink mesh and steel plates where ever required are to be placed on the inner side of the structural post. This mesh is to be embedded with this missionary base which shall be sloped bothways to prevent accumulation of water and urine.
8. 1 m wide steel plate shall be fixed on the top of the fence inclined in angle 60 degrees to the vertical metal part. Height of the fence should be 4000mm.
9. Height of the standoff barrier should be 900mm & it should be 1500mm away from fence.
10. Area of the water body provided in the paddock is 125sqm & depth is 300mm.
11. Vertical bar of dia (25mmx25mm) should be provided in this cell.
12. Feeding window in cells should be 150mm X 150mm.
13. Dry meat 5500mm wide & 2500 mm deep should be provided. It should be cemented with sump well.
- 14.

**PLAN OF RETENTION CELL / FEEDING CELL  
OF HIMALAYAN BLACK BEAR & MALAYAN SUN BEAR  
SLOTH BEAR, BROWN BEAR & MALAYAN SUN BEAR**

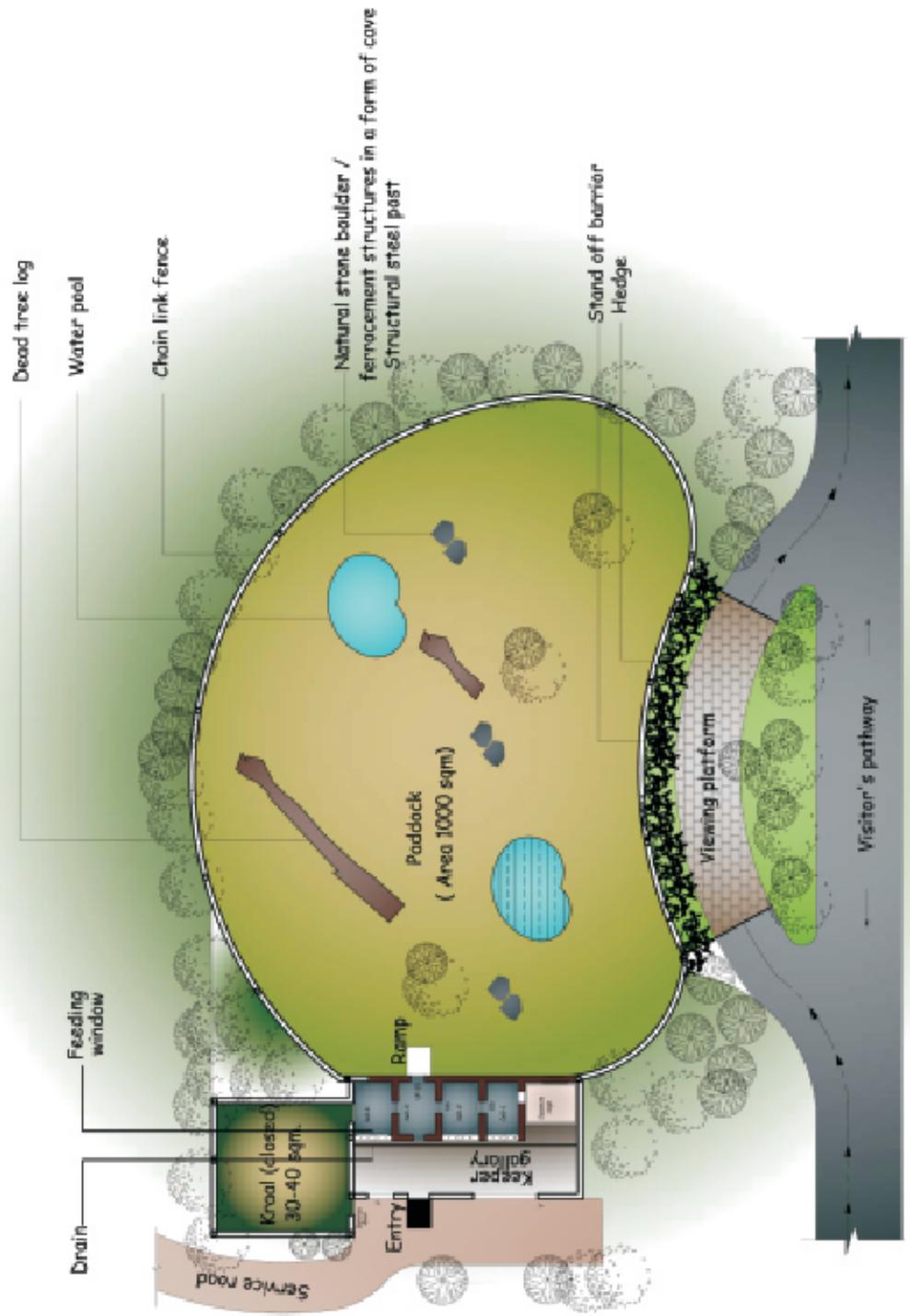
**SECTIONAL ELEVATION  
OF HIMALAYAN BLACK BEAR  
SLOTH BEAR, BROWN BEAR &  
MALAYAN SUN BEAR ENCLoSER**

**N.B.**

As per the guidelines of the Central Zoo Authority the minimum sizes are as below:-

- Paddock area = 1000 Sqm
- Feeding cubicles = length = 2.5 m, width = 1.8m and height = 2.5 m

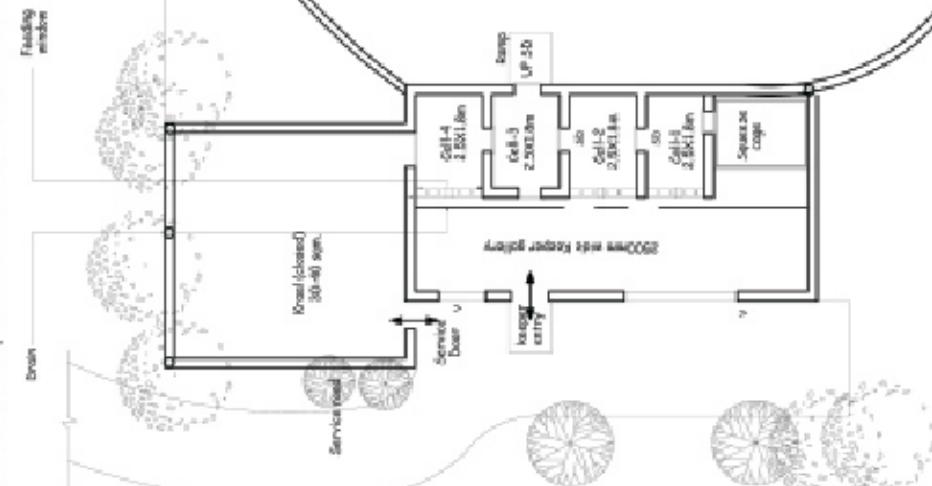
## HOOLOCK GIBBON, CHIMPANZEE & ORANGUTAN ENCLOSURE



AYOUT PLAN OF  
HOOLOCK GIBBON, CHIMPANZEE &  
ORANGUTANS ENCLOSURE



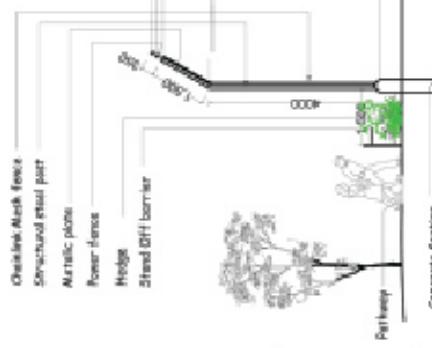
### HOOLOCK GIBBON, CHIMPANZEE & ORANGUTAN ENCLOSURE



PLAN OF RETAINING CELL / FEEDING CUBICLE  
OF HOOLOCK GIBBON, CHIMPANZEE &  
ORANGUTANS

### NOTES:-

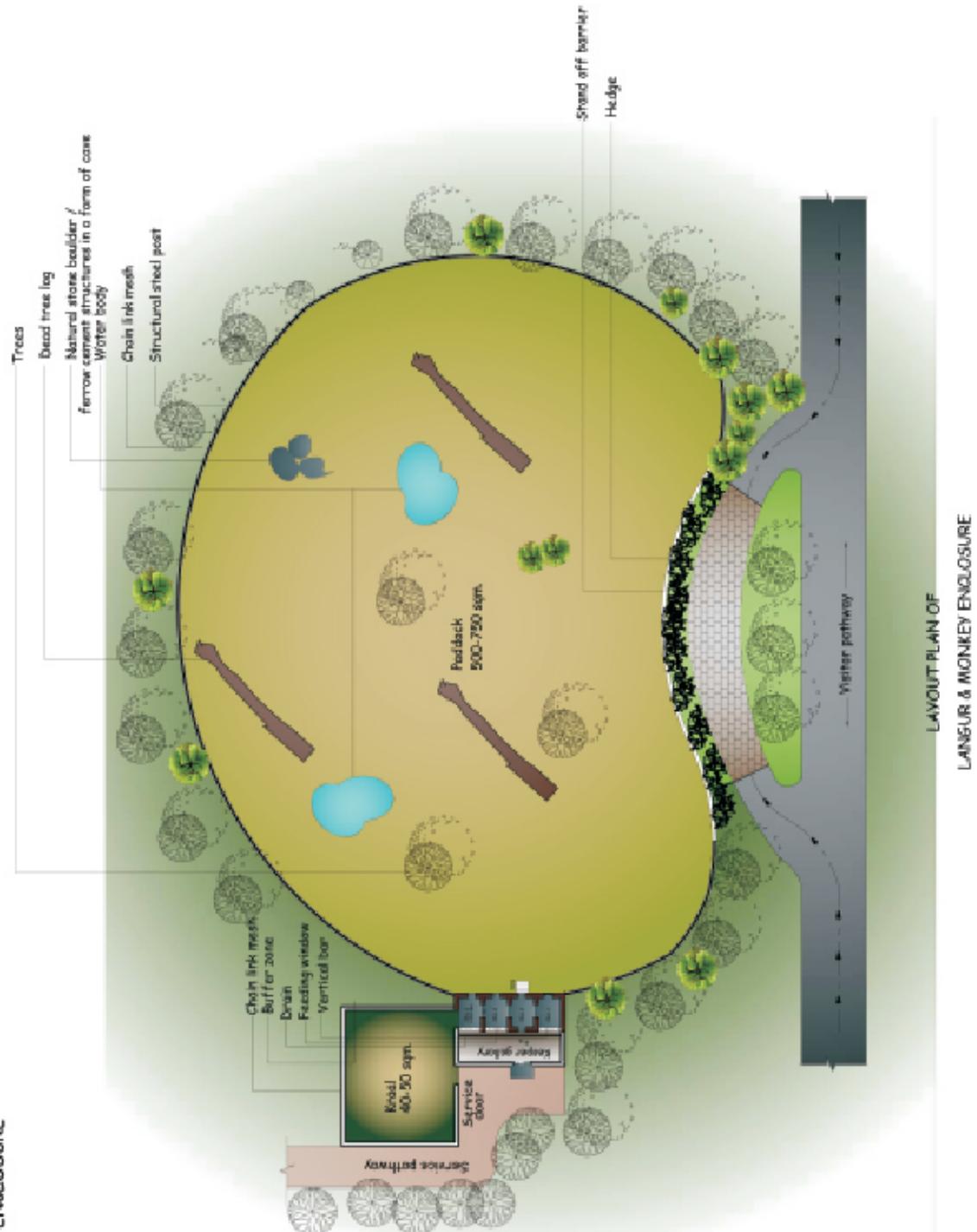
1. The paddock area of hoolock gibbon, chimpanzee & orangutans enclosure should be minimum 1000 sqm -1200sqm.
2. The minimum size of feeding cell should be 2500mm x 1800 mm. & height should be 3000mm.
3. Size of krait should be 30-40 sqm; top should be covered & the height of the fence should be 4000mm.
4. Size of sliding door in cell should be of minimum 3200 x 900mm high and 900mm wide & up slide down 900mm x 750 mm.
5. Keeper gallery should be of minimum size of width- 2500mm, and height 3000mm. Fencing should be cemented kora stone.
6. Entry gate to the keeper gallery should be 1000mm wide and 2000mm high.
7. Chainlink mesh should be of size of 50mmx50mmx0 gauge and it should be galvanised. The height should be from vertical +1.5 mtr inclined instead of 5000mm.
8. 1.5 m wide steel plates should be fixed on the top of the fence inclined and on angle of 60 degree to the worth of structural steel post.
9. In case of dry month 8000mm wide & 5000 mm deep should be provided with in the goddeck area. Dry mort should be placed with dump well.
10. Size of the feeding window should be 150x150mm.
11. Area of the water body provided in the paddock should be 10sqm. with depth of 300mm.
12. Plinth of the cell should be of a height of 40 cm.
13. Strand off barrier height should be 900mm & 1500 mm away from moist soil.
14. Vertical bars used in the cell should be of dia of 25mm & gap between two bars should be 30mm.
15. No tree or branch of the tree should be within 8000mm from the inner side of fence.
16. Wooden logs, natural stone boulders, trees & shrubs may be placed inside the enclosure for enrichment.
17. Tie meter high wall should be constructed on right side facing paddock.

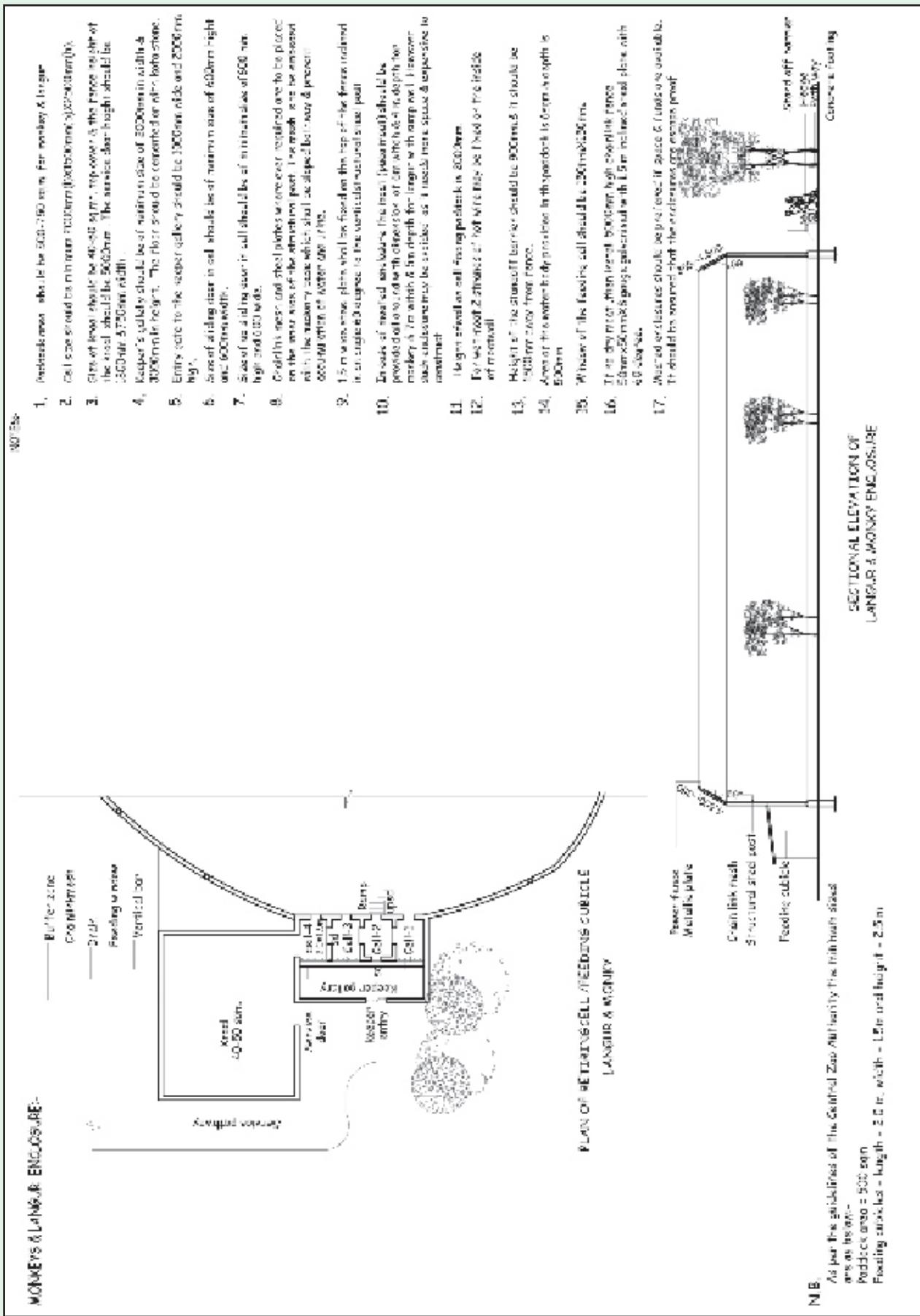


SECTIONAL ELEVATION  
OF HOOLOCK GIBBON, CHIMPANZEE &  
ORANGUTANS ENCL. SUE



## MONKEYS & LANGUR ENCLOSURE



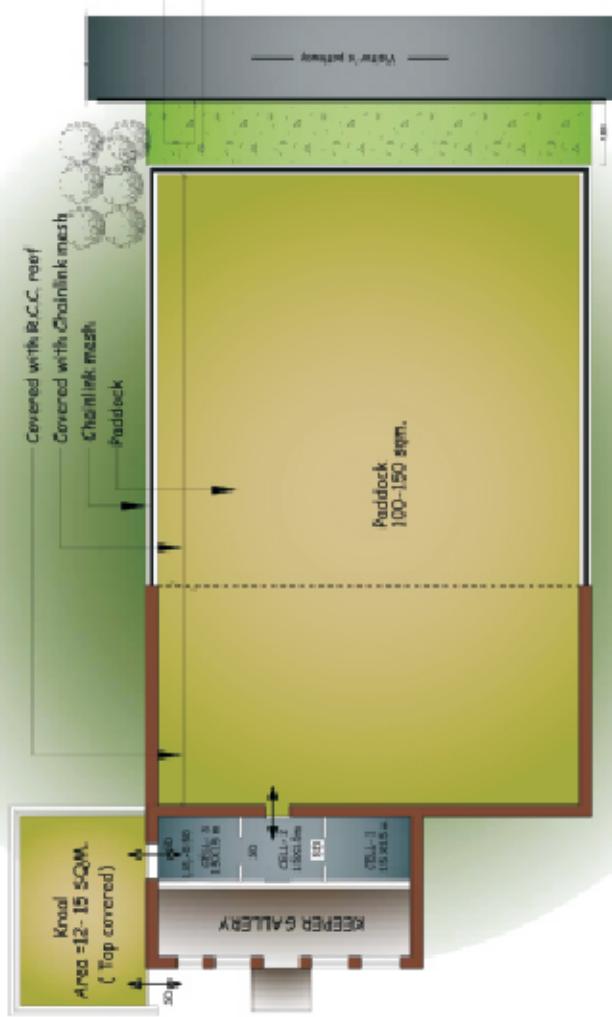




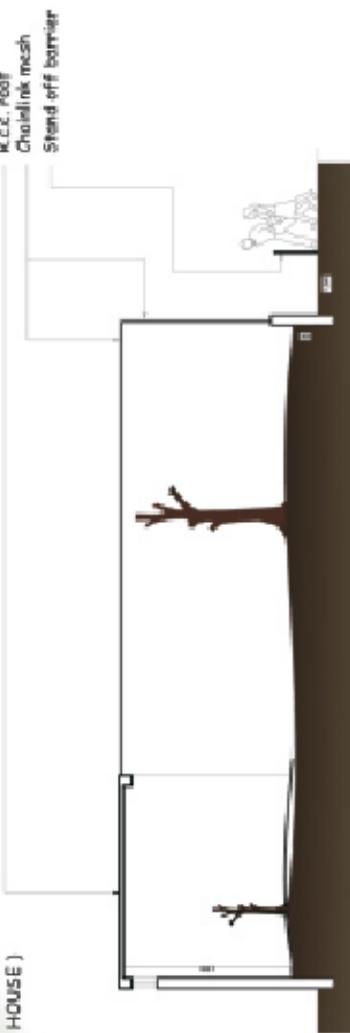
## SLOW LORIS AND SLENDER LORIS

### NOTES:-

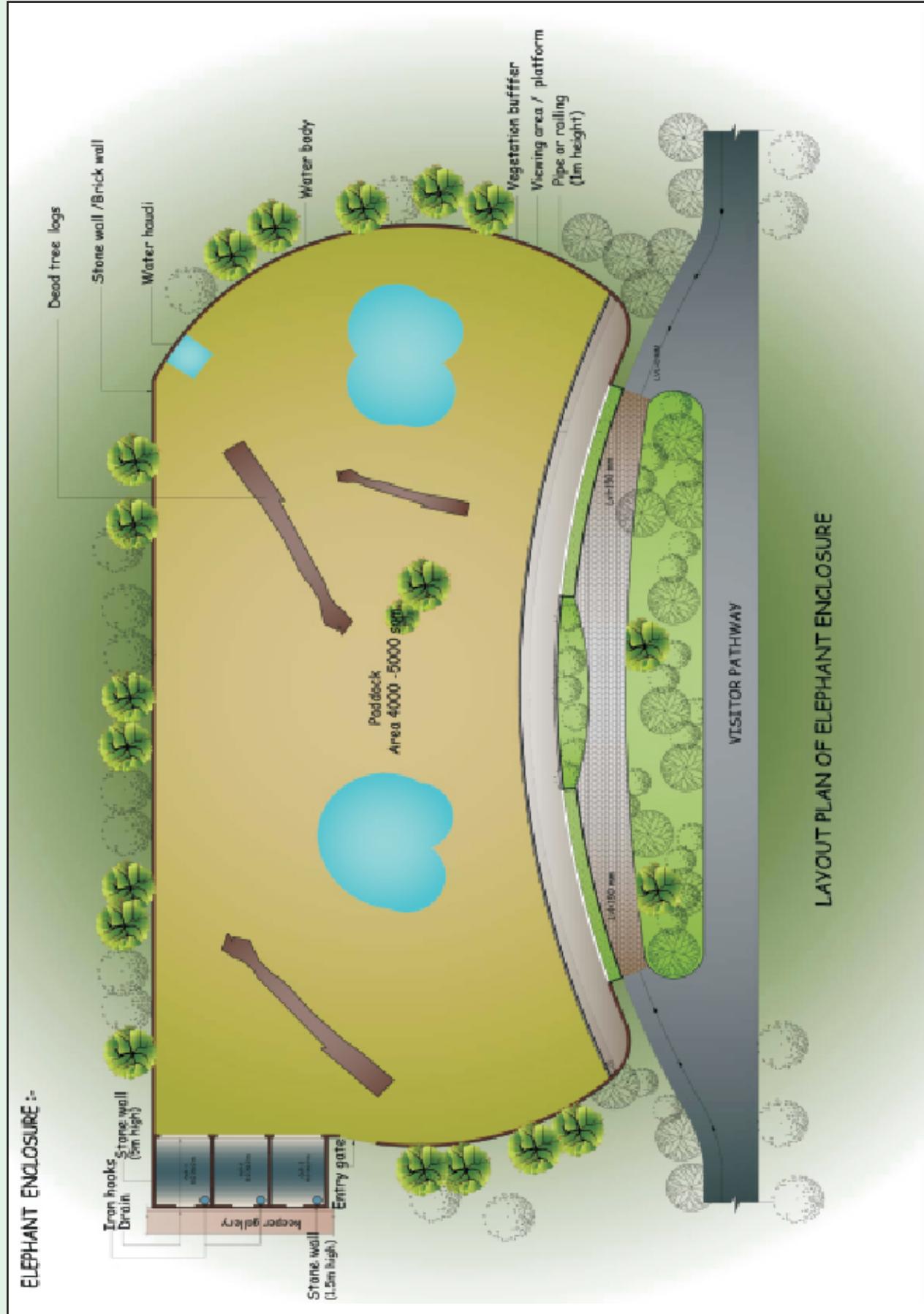
1. Paddock area should be 100-150 sqm.
2. Cell size should be minimum 1500mm(w)X1500mm(l)X2500mm(h).
3. Size of loral should be 12-15 sqm top covered & the fence height of the area should be 3000mm. The service door height should be 1800mm & width should be 750mm.
4. Entry gate to the keeper gallery should be 900mm wide and 2000 mm high.
5. Size of sliding & up sliding door in cell should be of minimum size of 600 mm high and 600mm wide.
6. Floor of keeper's gallery is to be cemented
7. Chainlink mesh should be of 6x6mmx25mm (12 gauge) and it should be galvanised. The height should be 4000mm.
8. Window of the feeding cell should be 150mmX150mm.
9. A porch should be provided from night house towards paddock area to create shade. It should cover at least 1/3rd of the paddock area.
10. The enclosure should be Redhill and sealed pitch.



**LAYOUT PLAN OF ENCLOSURE**  
**SLOW LORIS AND SLENDER LORIS**  
(PREFERABLY TO BE HOUSED IN NOCTURNAL ANIMAL HOUSE )

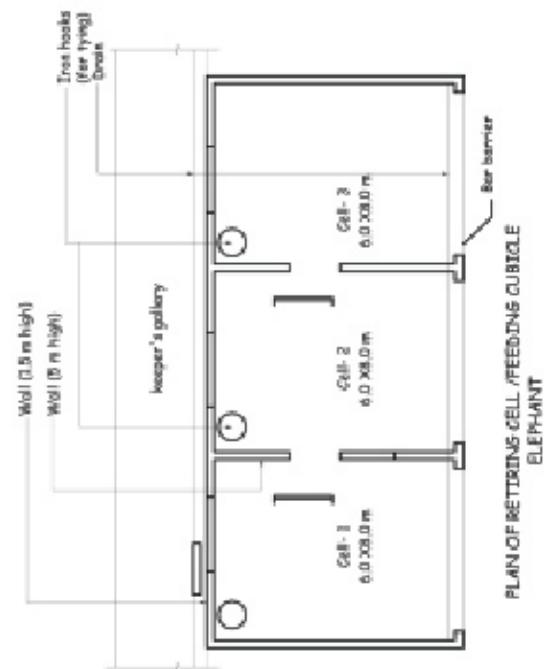


**SECTIONAL ELEVATION OF SLOW LORIS AND SLENDER LORIS**



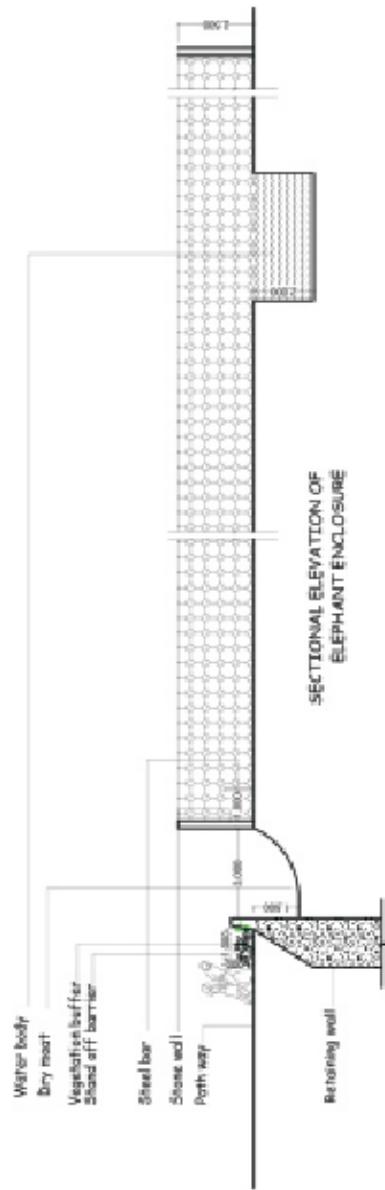


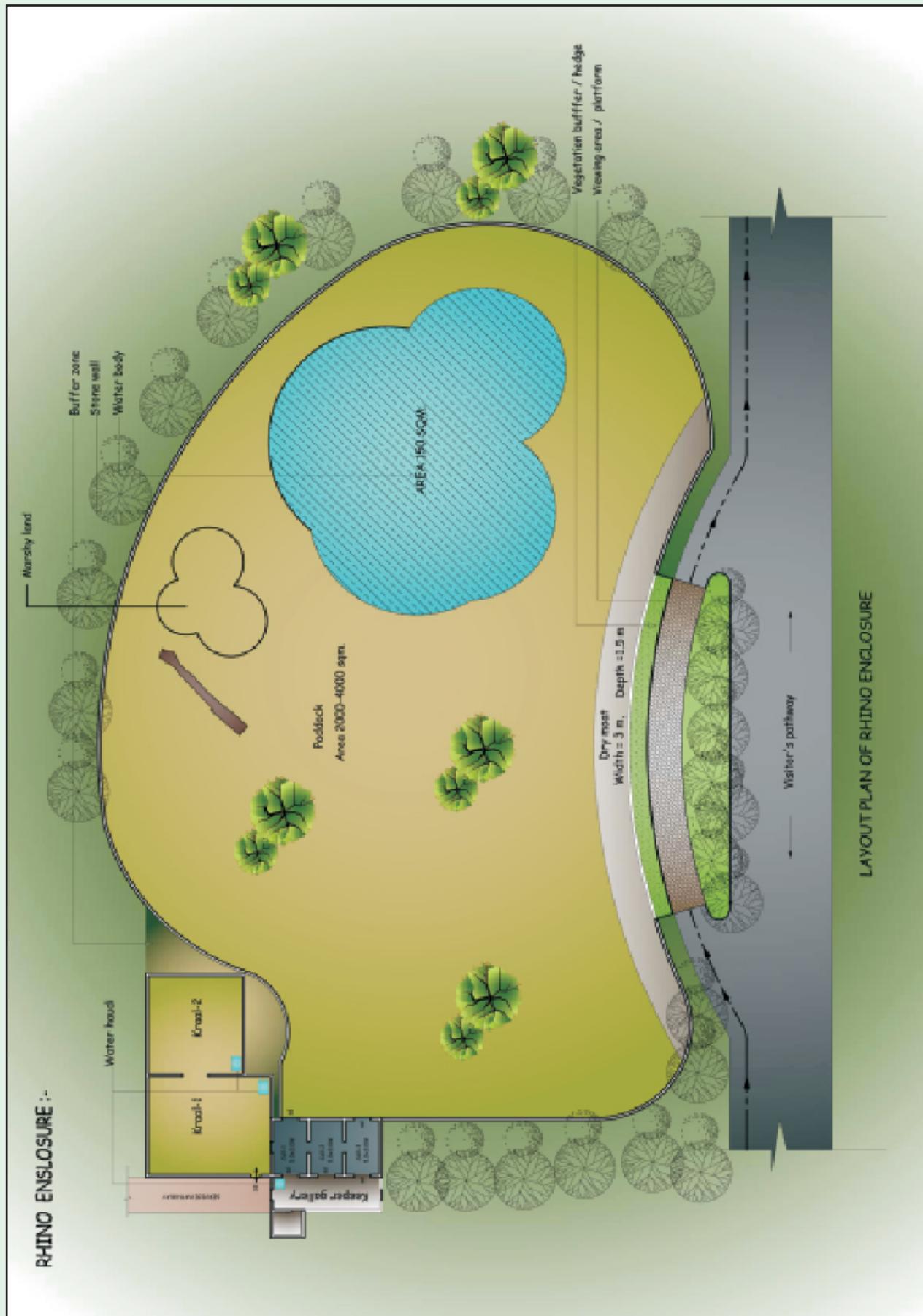
## ELEPHANT ENCLOSURE :-



## NOTES:-

1. The paddock area for elephant enclosure should be minimum 4000-5000 sqm.
2. The minimum size of feeding cell should be 8000mmx6000 mm, and height should be 5500mm and its flooring should be cemented.
3. The size of the dry moat should be 5000mm in width and 1500 mm in depth.
4. Stone wall of the enclosures should be of 2500mm in height. An additional barrier/walling [height +1000mm] should be provided 1000mm away from the moist towards the paddock area.
5. Two nos. of feeding shelves one provided, it should be 30sqm. & height should be 4500mm with in the paddock area.
6. Two pools to be provided one on each side of this enclosure. The area of the pond should be 150-200 sqm and depth of the pond should be 2000mm with provision of in and out of water.
7. Iron locks in the keeper gallery to be provided for chaining to be fixed with r.c.c foundation.
8. Animal entry door (sliding door) should be provided 2000mm width & 4000mm height.
9. The stand off barrier should be 8000mm away from the enclosure and height should be 900mm.



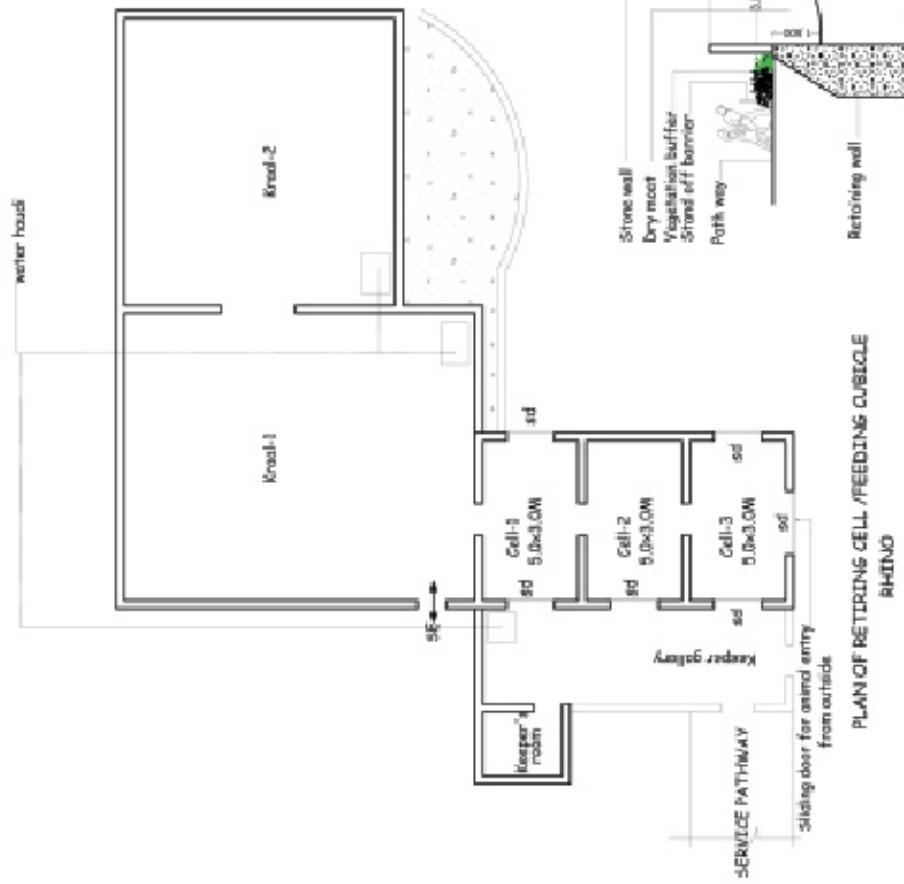




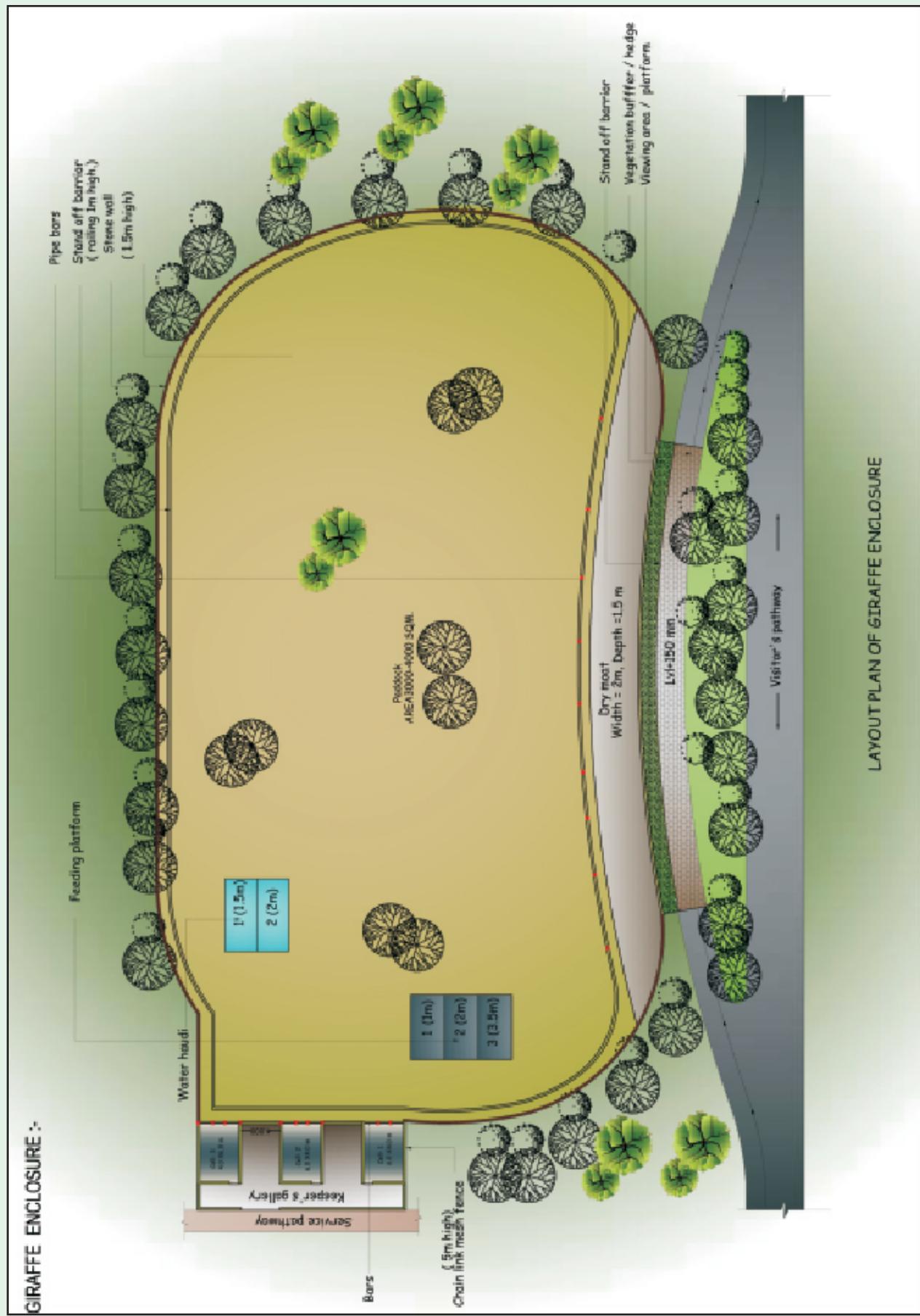
RHINO EMLOSURE

卷之三

1. The paddock area for rhino enclosure should be minimum 2000-4000 sqm.
  2. The minimum size of feeding cell should be 500mm x 3000 mm, and height should be 2500mm and its flooring should be camered ..
  3. The width of the keeper gallery should be 3000mm
  4. Size of sliding door in cell should be of minimum 2000mm high and 1500mm wide.
  5. Entry gate to the keeper gallery should be 1000 mm wide and 2000mm high,
  6. The size of the dry moat should be 3000mm in width and 1500 mm in depth, it should be cameted.
  7. Side barrier should be of brick or stone wall & its height should be 2000 mm.
  8. Water body 150-200sqm should be provided within the paddock area depth of the water body should be 1500 mm.
  9. Size of the leach should be 150-200 sqm. & all sides should be covered with stone wall . Height of the wall is 2000mm..
  10. Service gate should be 900 mm wide & 1800 mm in height
  11. Marshy land of about 1/3rd of paddock area should be provided in one corner.
  12. Hand off barrier of the height of 1.00 mt and 1.00 mt away from the boundary wall should be provided inside the paddock area and hedge should be planted in between.



SECTIONAL ELEVATION OF  
BETHNO END O'SURE

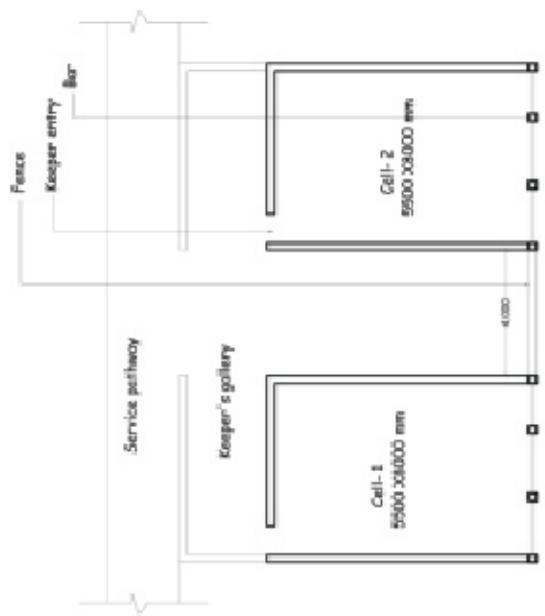




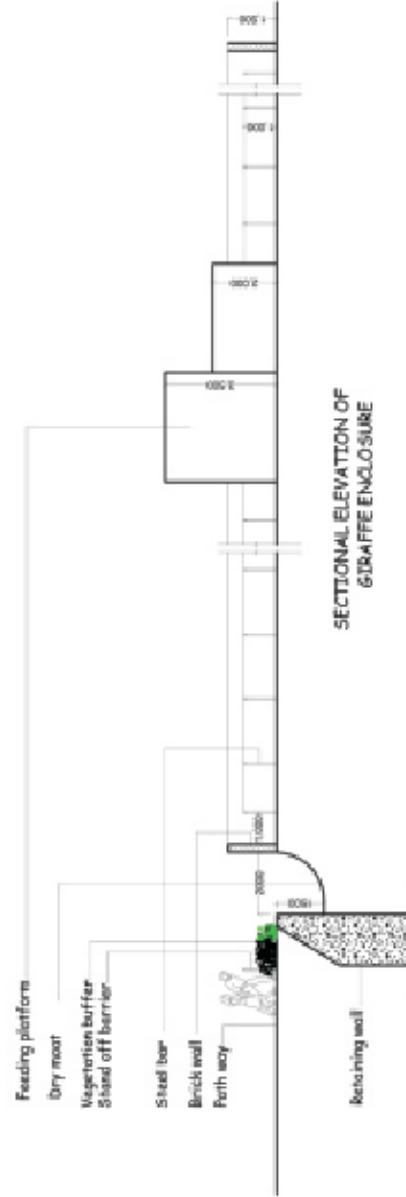
NOTE

- minimum dose - 1000 kg/m<sup>3</sup>

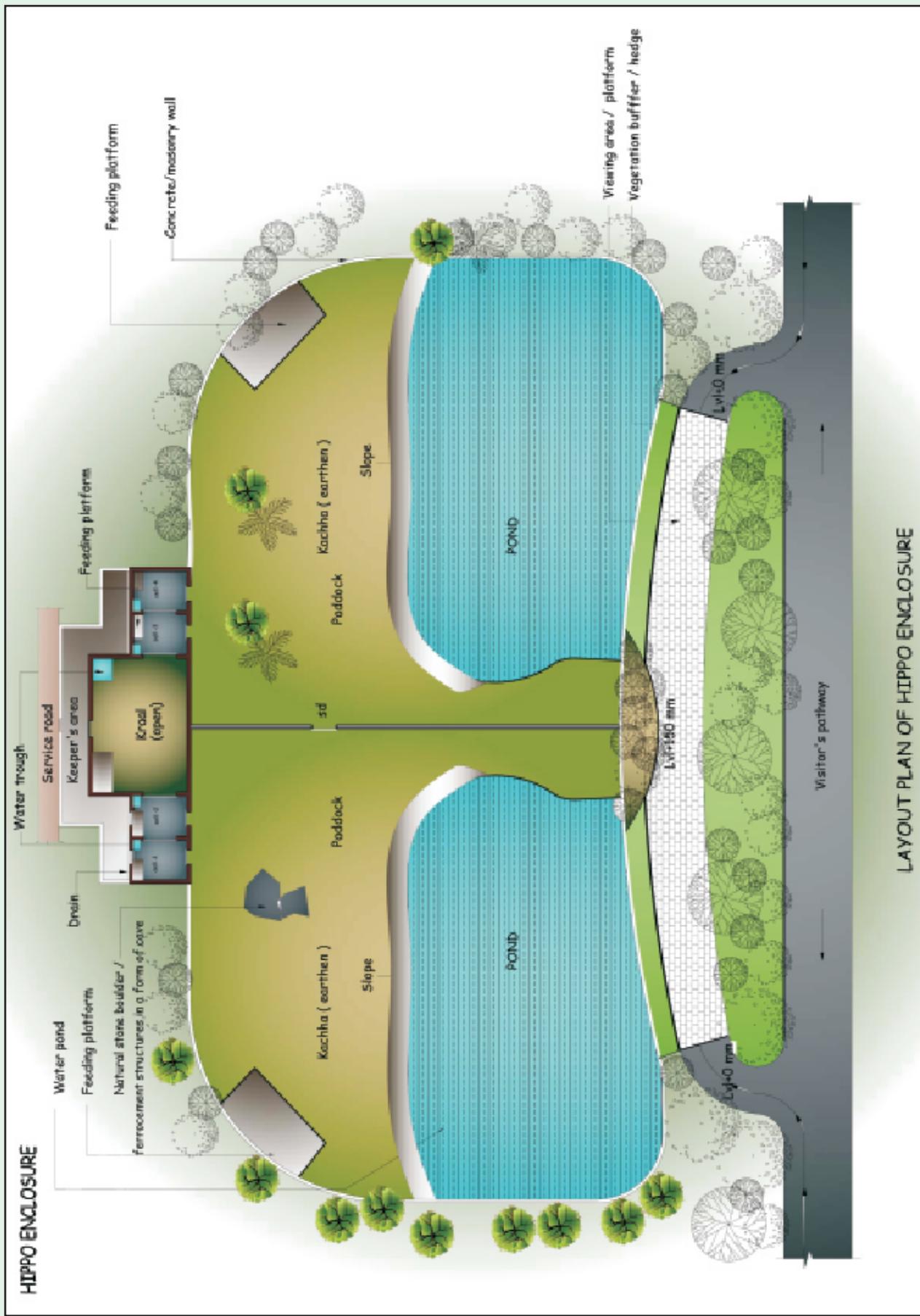
  2. The minimum size of feeding cell should be 8000 mm x 2500 mm, and height should be 6000mm and its flooring should be cemented.
  3. The size of the dry moat should be 2000mm wide and 1500 mm deep.
  4. Stone wall of the enclosure should be of 1500 mm in height, with railing or strand off barrier inside, of height of 1000mm & 1000mm away from stone wall & moist wall.
  5. Three nos. of feeding platforms should be provided with height of 1m, 2m, & 3 m gradually with in the paddock area.
  6. The height of water trough should be 15-2m. Its capacity should be 200 ltrs with provision of inlet and outlets of water.
  7. Animal entry (airtight sliding door) should be provided of 3000 mm wide & 4000 mm in height.
  8. The width of the keeper gate should be 900 mm and height 2000 mm.
  9. The floor of the cell should be cemented.
  10. Strand off barrier should be provided inside the paddock on the inner side at a height of 1 m and 1m away from the moist wall.
  11. Strand off barrier should be provided on visitor side about 1.5 m away from the moist wall and 1 m in height.



**PLAN OF RETIRING CELL / FEEDING CUBICLE  
TRAFFIC**



SECTIONAL ELEVATION OF  
678' EEE FIVE O/S LINE

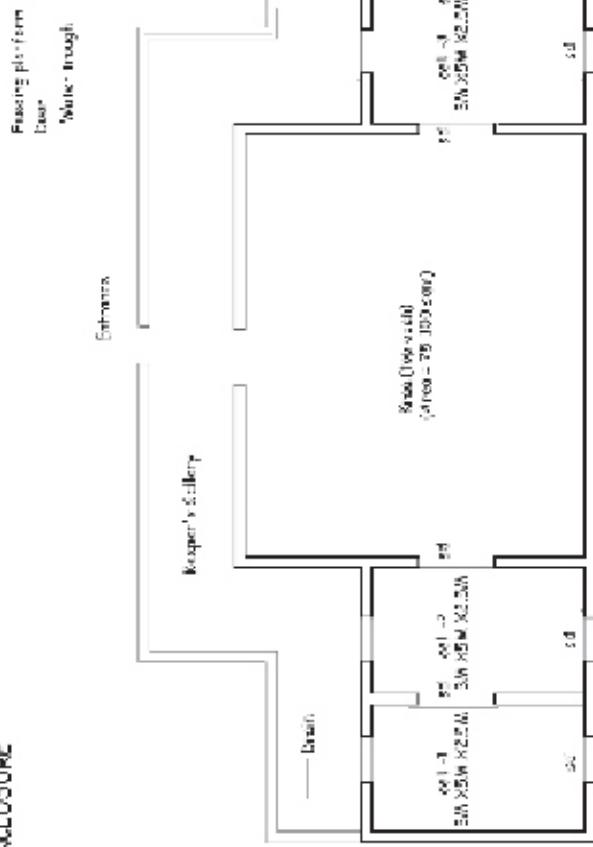




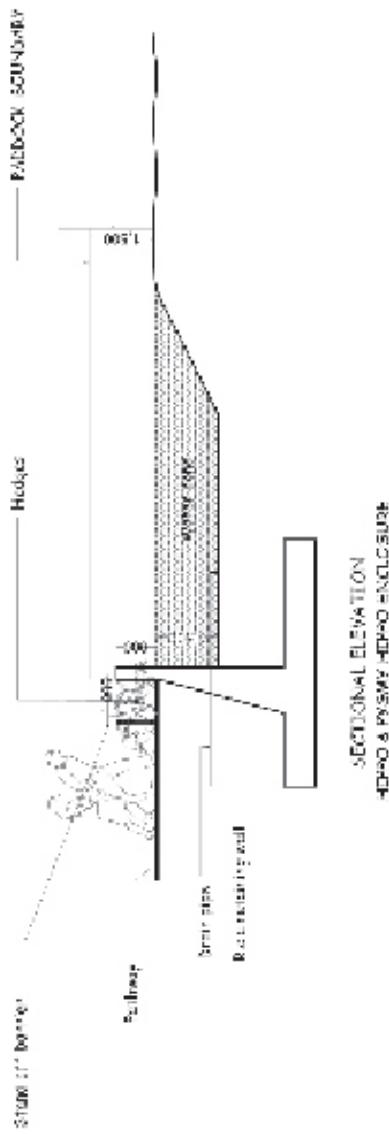
## HIPPO ENCLOSURE

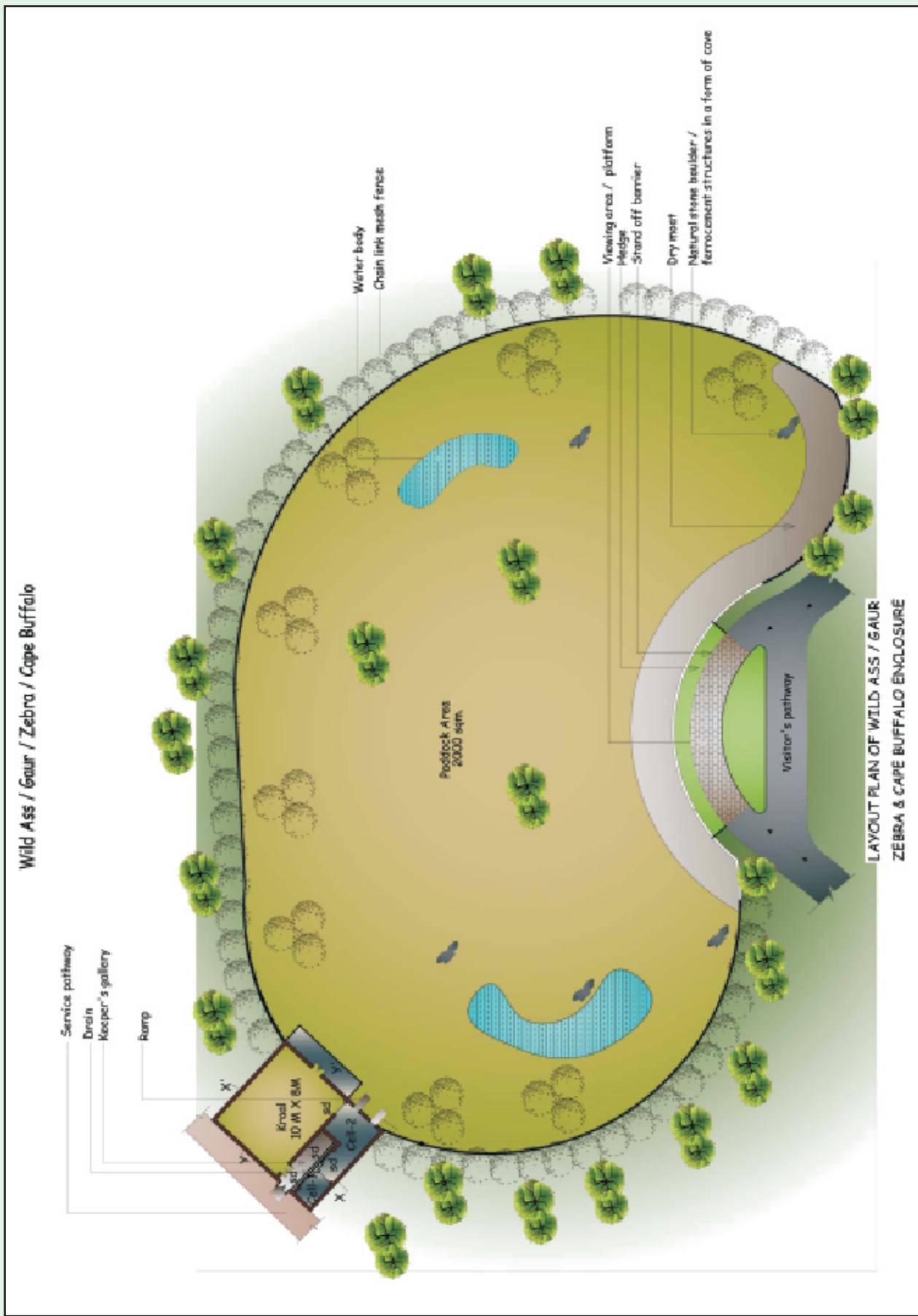
### NOTES:

1. The platform or for hippo enclosure should be minimum 300x300mm.
2. The minimum size of feeding cell should be 500mm x 1000mm, and height should be 300 mm and its feeding should be concealed (no glass).
3. Size of arena should be 75-150 square m and height should be 2000mm, and top mesh.
4. Slope stability sheet in cell should be at minimum slope of 20% and top height 2500mm min.
5. Two ponds to be provided one in each side of the enclosure. The area of the pond should be 100-200 sqm and depth of 1500mm should be 1250mm with a paved base of thick soil of water.
6. Two stand of banyan tree in the 1000mm away front. The enclosure and banyan should be 9000mm.
7. Feeding platform should be provided. Size should be length = 3000mm, width = 1500mm and it should be concrete.
8. Slope wall of the enclosure should be at 3000-mm height.



PLAN OF RETAINING CELL / FEEDING CELL  
HIPPO & BABY HIPPO ENCLOSURE



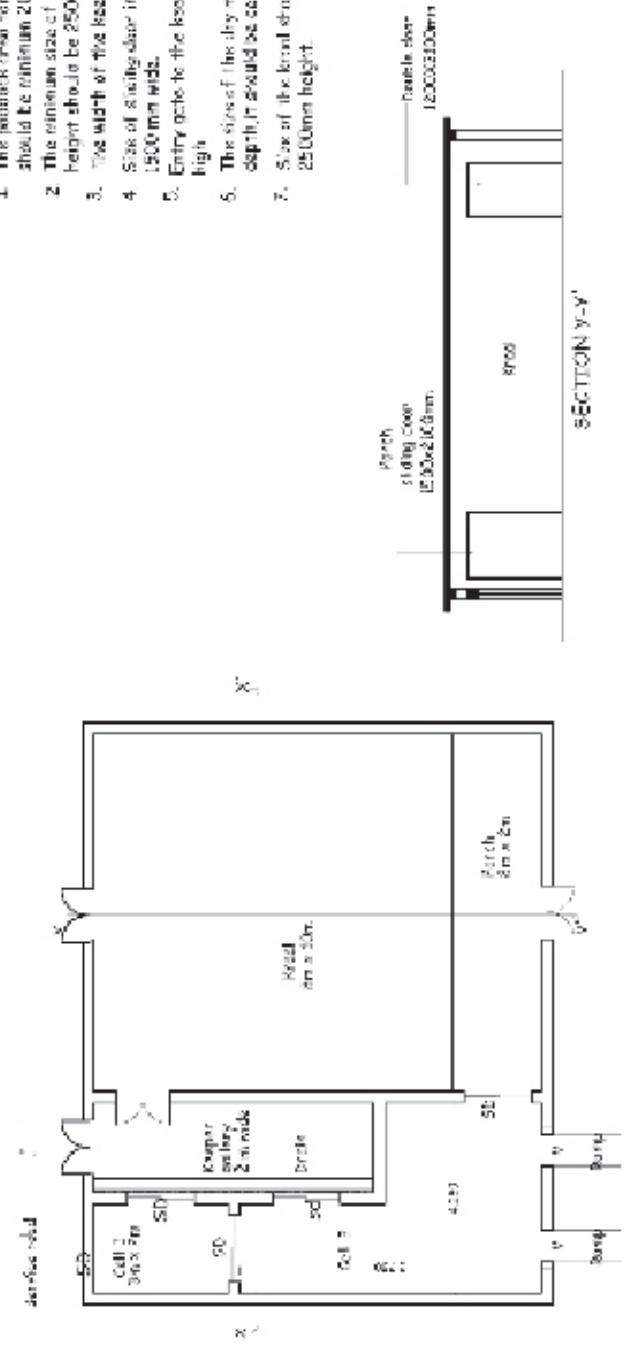




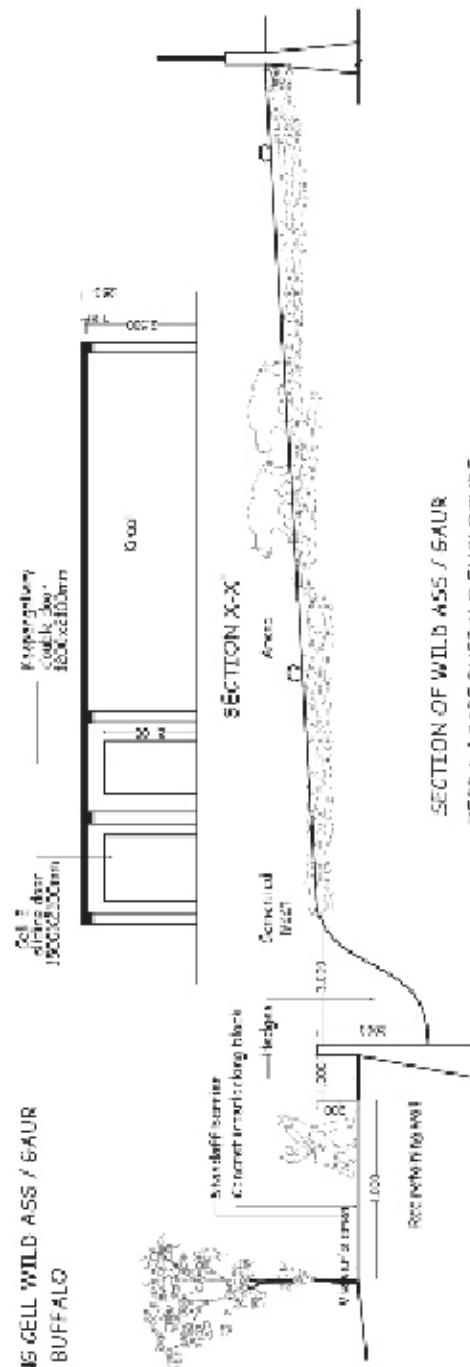
661 f. 2003 / 84982 / JH03 / 455 Ass b/w

NOTES -

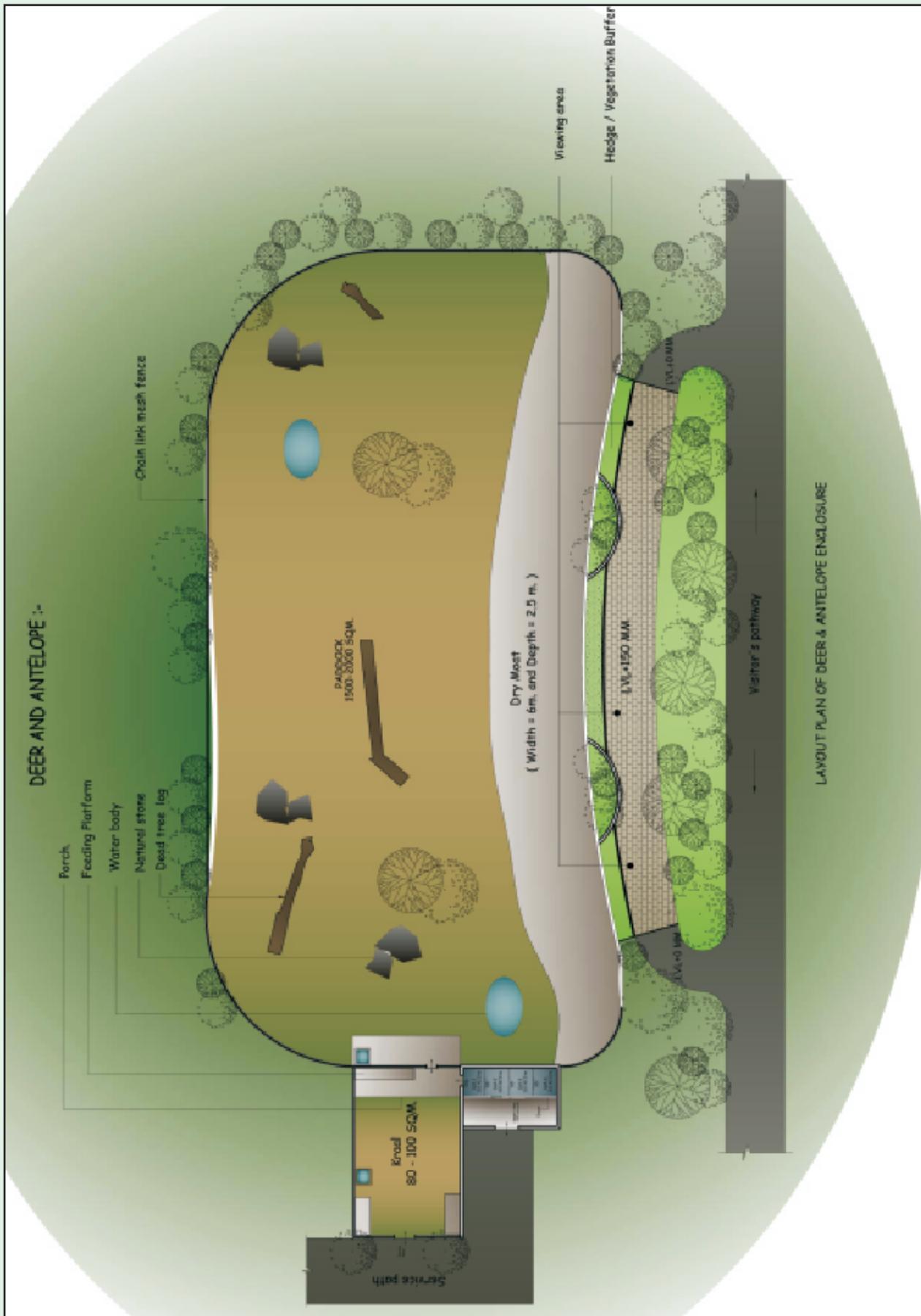
1. The pointed crown for a wild boar, when it comes back to search for food, should be 1500mm (2000mm) high.
  2. The minimum size of feeding coll should be 3000mm x 2000mm, and height should be 2500 mm, and its flooring should be cemented.
  3. The width of the keeper gallery should be 2000mm x 3500mm length.
  4. Size of stables should be 1500mm x 2000mm x 4m high and 1500mm wide.
  5. Entry gate to the keeper gallery should be 1500mm width and 2500mm high.
  6. The size of the dry room should be 3500mm in width, and 2500 mm in depth, it should be cemented with a good wall.
  7. Size of the leach should be 10000 mm in length, 800mm in width & 2500mm height.



PLAN OF RETITTING CELL WILD ASS / GAUR



SECTION OF WILD ASS / GAUR  
ZEBRA / CAPE BUFFALO ENCLOSURE

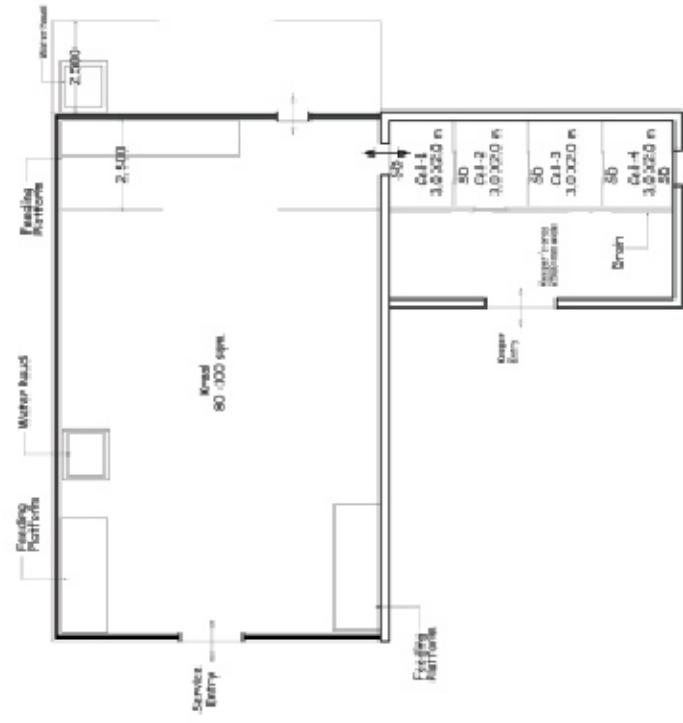




## DEER AND ANTELOPE :-

### NOTES:-

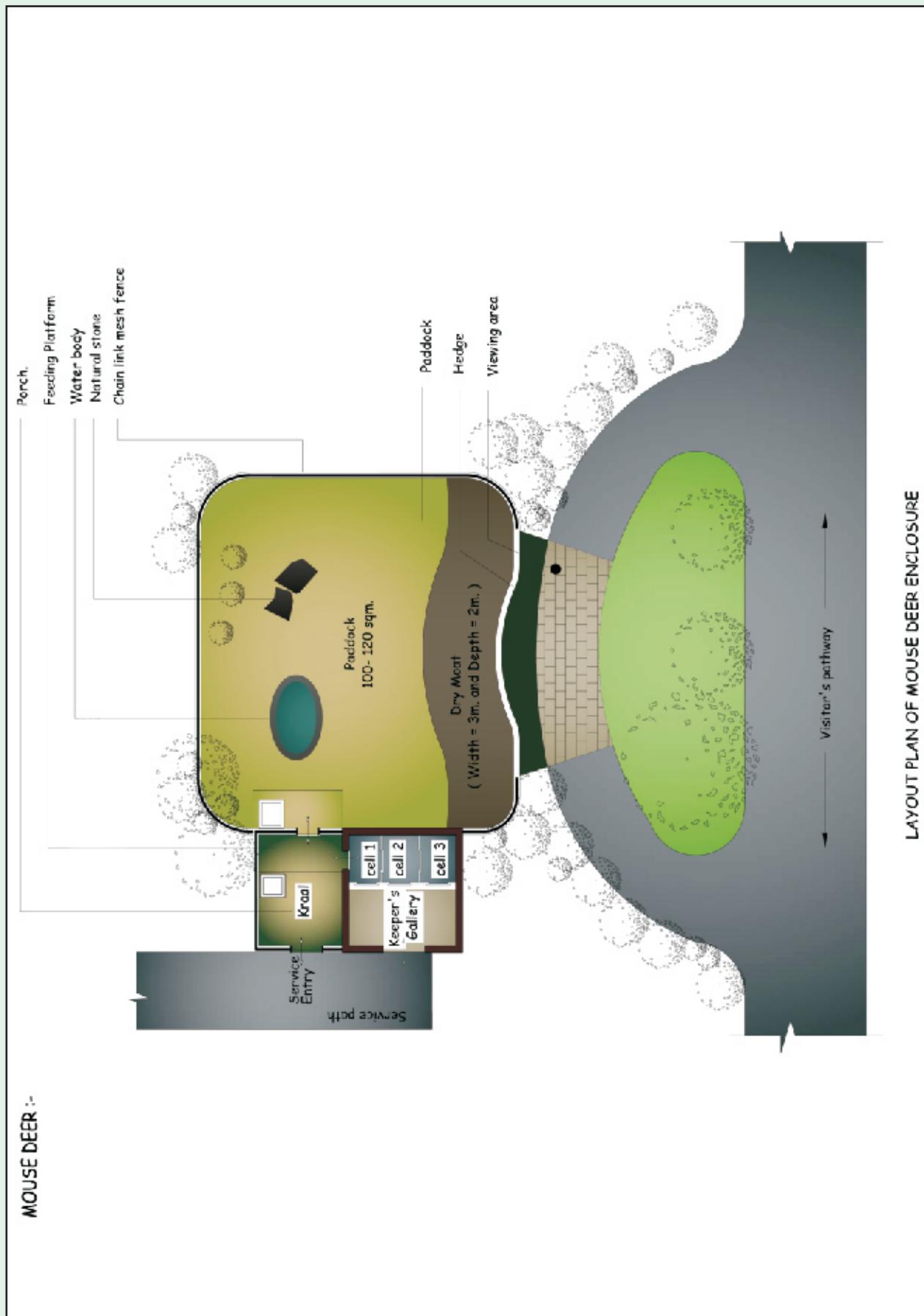
1. The paddock area for deer/ antelope enclosure should be 1900- 2000 sqm.
2. The minimum size of feeding cell should be 3000mmx 2000 mm, and height should be 2500mm and its flooring should be cemented.
3. Keeper gallery should be of minimum size of width= 2500 mm, and flooring should be cemented.
4. Size of sliding door in cell should be of minimum size of 2000 mm high and 1500 mm width.
5. Entry gate to the keeper gallery should be 1.8 mtr wide and 2 mtr height.
6. Size of kraal area = 80- 100 sqm.
7. A porch should be provide to paddock areas as well to the kennel for feeding platforms, and its size should be length = 8000mm, width =2500 mm and height =2500mm
8. The size of the dry moat should be 6000mm wide and 2500 mm in depth.
9. Chainlink mesh fence should be of size of 75mmx75mmx 10 gauge and it should be galvanised. Height of the fence should be 2500mm. Size of the structural angle section should be 50mm x50mm x5mm.
10. The size of the water body in the paddock area should be 12 sqm and depth should be 450mm.
11. Wooden legs, natural stone boulders may be placed inside the enclosure for enrichment.
12. The sliding doors should be made of wood/ timber to avoid injuries in case of ungulates.



PLAN OF RETAINING CELL / FEEDING CIRCLE  
DEER ENCLOSURE



SECTIONAL ELEVATION  
DEER & ANTELOPE ENCLOSURE



LAYOUT PLAN OF MOUSE DEER ENCLOSURE



### MOUSE DEER :-

#### NOTES:-

1. The paddock area for mouse deer should be minimum 100-120 sqm.
2. Cell size should be 1500mm in length, 1000mm in width and 1500mm height.
3. Dry moat of 3000mm wide and 2000mm deep should be provided. The dry moat should be cemented.
4. Height of the fence should be minimum 2500mm and off size of 75mm x 75mm x 10 gauge.
5. Knoll area should be 12 sqm.
6. Sliding door should be 750mm in length and 750mm in width.
7. Porch on paddock side of length of 2000mm, width of 1500mm and 2000mm height be provided.
8. Waterbowl area should be of about 2 sqm. and must be cemented with a depth of 200mm.

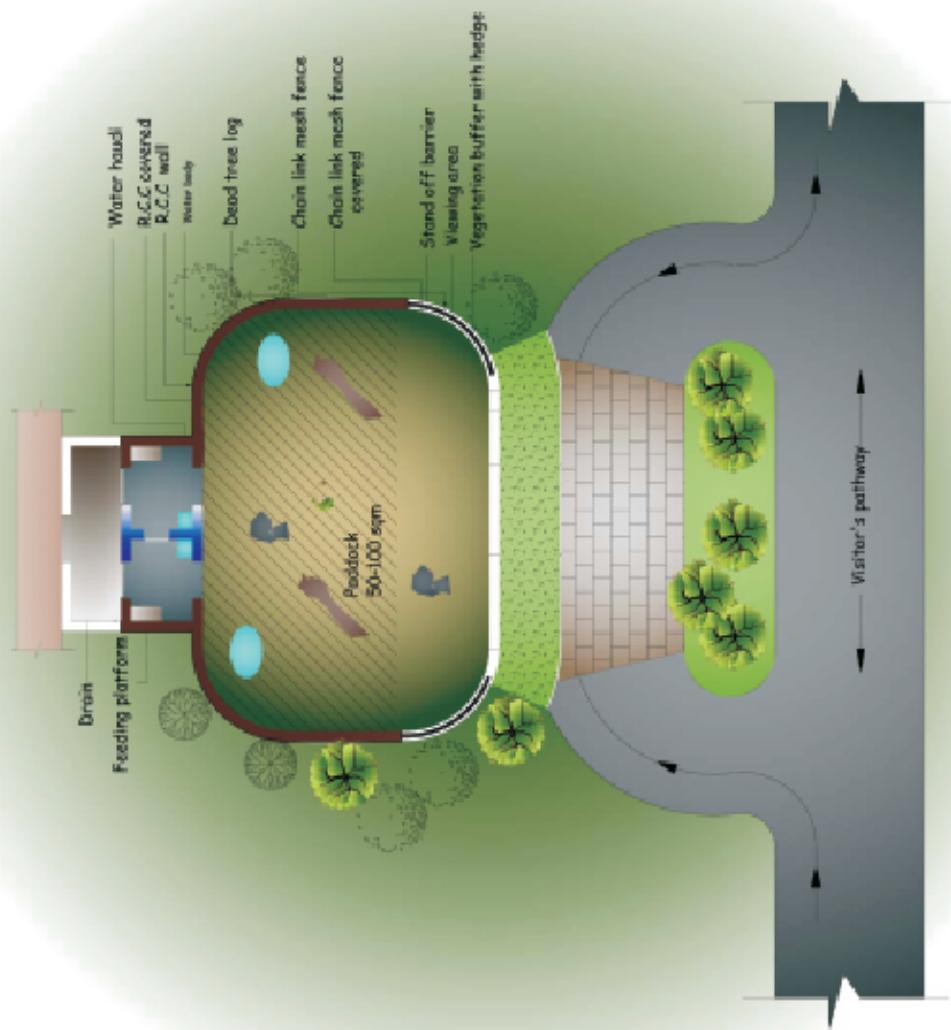


**FEEDING CUBICLES OF MOUSE DEER**



**SECTIONAL ELEVATION**  
( front barrier )

PROCURING ENCLOSURE



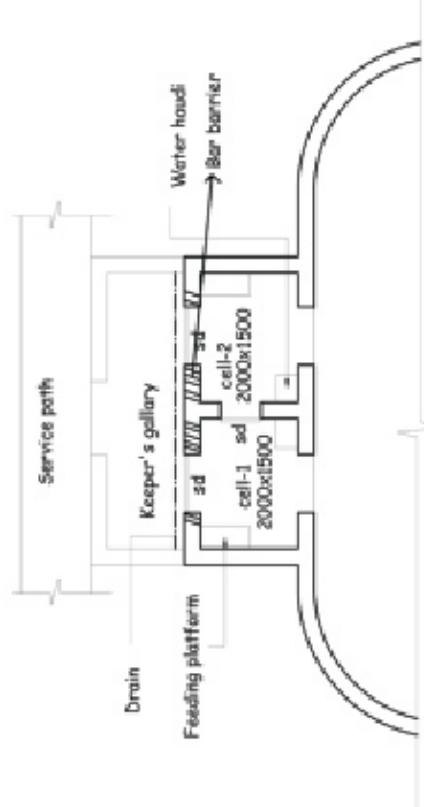
LAYOUT PLAN OF PORCUPINE ENCLOSURE



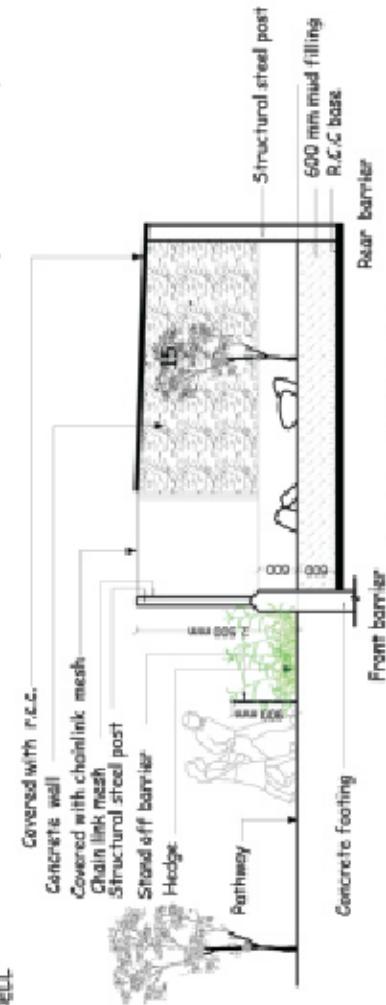
## PORCUPINE ENCLOSURE

### NOTES:-

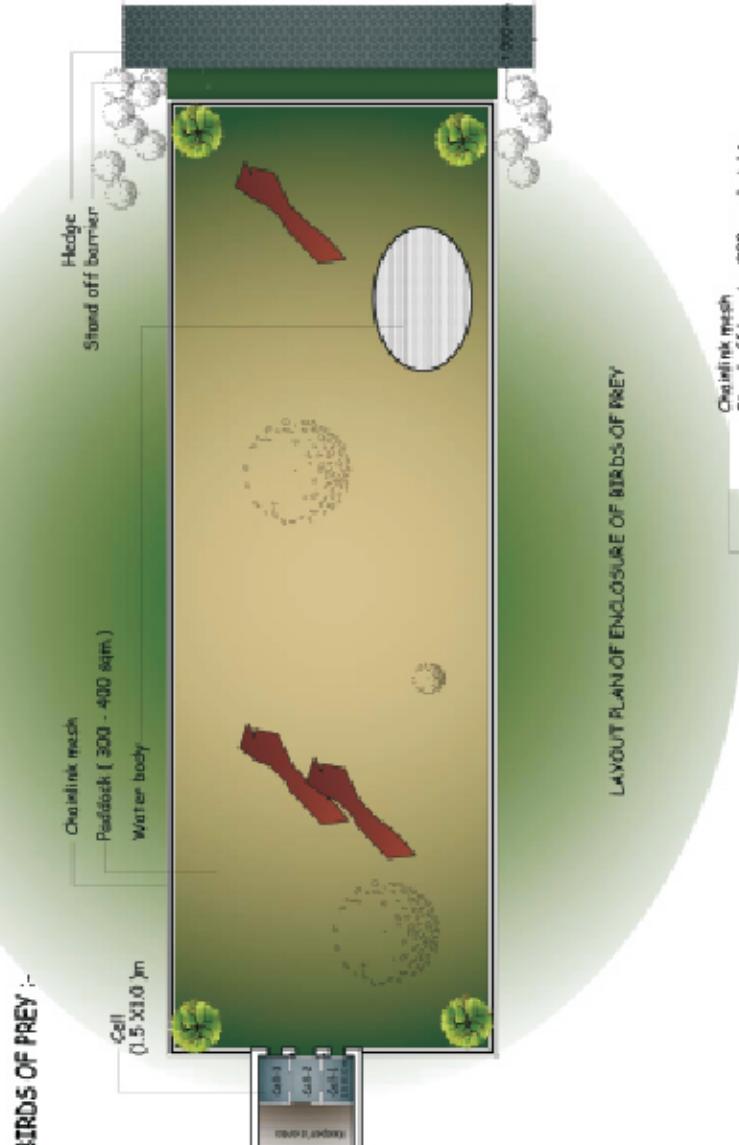
1. The paddock area of porcupine enclosure should be 100-150 sq.mt
2. The minimum size of feeding cell should be 2000mmx1500 mm.
3. Chainlink mesh should 25mmx25mmx12gauge and it should be galvanised
4. The height of the fence should be 2500 mm.
5. As this is a highly volatile natural animal, provided sloped roof with RCC covered or two third of the side areas as covered.
6. Chainlink mesh where ever required is to be placed on the inner side of the structural post.
7. Wooden logs, natural stone boulders, trees & shrubs may be placed inside the enclosure for enrichment.
8. Keeper gallery should be of minimum width of 1200 mm.
9. Size of sliding door in cell should be of minimum size of 1200 High and 900mm width.
10. Plinth of the cell should be set at height of 600mm, from the immediate ground level.
11. Stand off barrier may be made up of concrete.
12. External wall of the cubicle may be cladded with natural cladding stone to achieve a natural looks.
13. In the flooring there should be a R.C.C. bed below the the earthen part and the earthen part should be of 300mm depth.



SECTIONAL ELEVATION  
OF PORCUPINE ENCLOSURE



**BIRDS OF PREY :-**

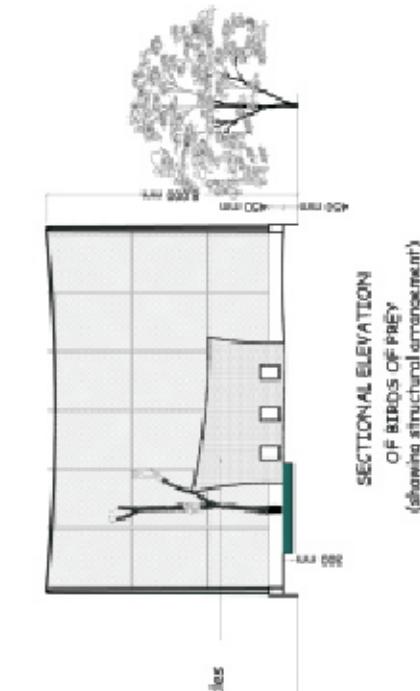


Chainlink mesh  
Padlock ( 300 - 400 sqm )  
Water body  
Cell ( 1.5 x 1.0 m )  
Shed off barrier  
Hedge

**NOTES:-**

- Paddock area for birds of prey should be 300-400 sq.m.
- Cell size should be minimum 1500mm(l)xx1000mm(b)x1000mm(h).
- Chainlink mesh size to be of size of 50mmx50mmx4 mm and it should be galvanised. The height should be 800mm.
- Entry gate to the keeper gallery should be 750mm wide and 1200 mm high.
- Size of sliding door in cell should be of minimum size of 600 mm high and 450mm width.
- Floor of keeper's gallery is to be cemented
- Size of water body should be 10 sqm and depth should be 300mm. The floor of the water body should be puccor cemented

**LAYOUT PLAN OF ENCLOSURE OF BIRDS OF PREY**



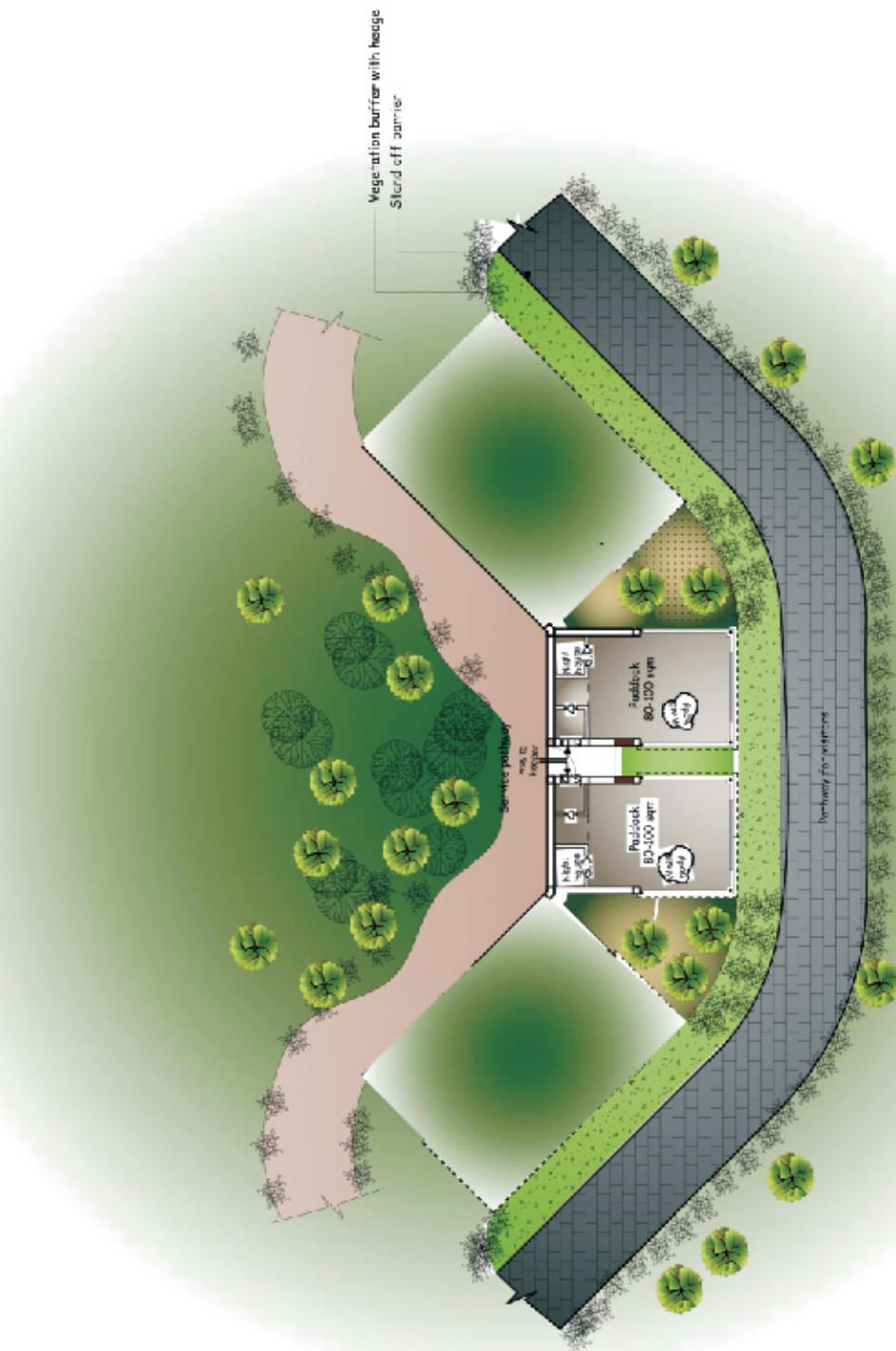
Chainlink mesh  
Shed off barrier 900 mm height  
Feeding cubicles  
1000 mm

**SECTIONAL ELEVATION  
OF BIRDS OF PREY  
(following structural arrangement)**



Chainlink mesh  
Shed off barrier 900 mm height  
Feeding cubicles  
1000 mm

**SECTIONAL ELEVATION  
OF BIRDS OF PREY  
(following structural arrangement)**

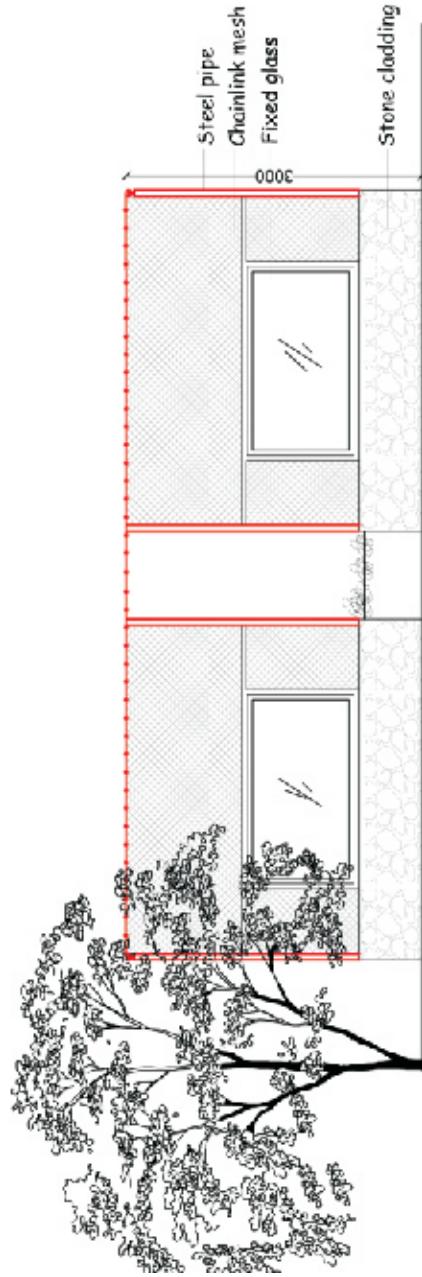


LAYOUT PLAN OF BIRDS(PARROT, MACAW AND PHEASANTS ETC)

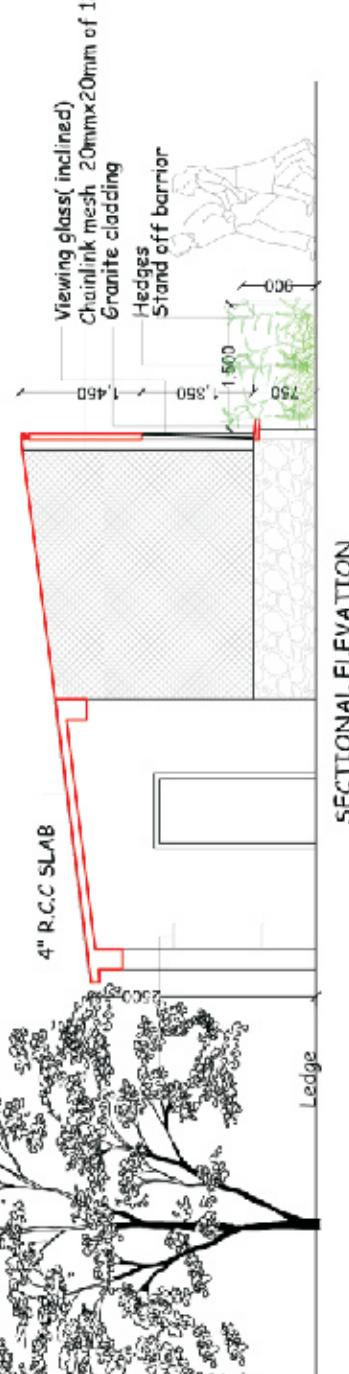
BIRDS ENCLOSURE (PARAKEET, MACAW AND PHEASANTS)

NOTES-

1. Paddock area should be 80x100 sqm.
2. Cell size L=1.20m, W=1.20m, H=1.30m
3. Sliding door size: W=45cm, H=45 cm
4. Porch L=5.00 m, W=1.50 m, H=1.30 m
5. Keeper entry door into paddock W=60 cm, H=1.60m
6. Chain link fence size 25 mmX25 mmX2.5 mm and 30 mm covered on all sides.
7. The floor of cell upto porch should be cemented and rest of the area should be kucha.
8. The height of chain link fencing should be 6.00 m and in case of pheasants it is 3.00 m.
9. The wire - body of size of 2-3 sqm should be provided.
10. Viewing should be either through glass or chain link.
11. Distance between chainlink/Toughened glass and stand off barrier should be 1.00m and height of stand off barrier 90 cm.



FRONT ELEVATION



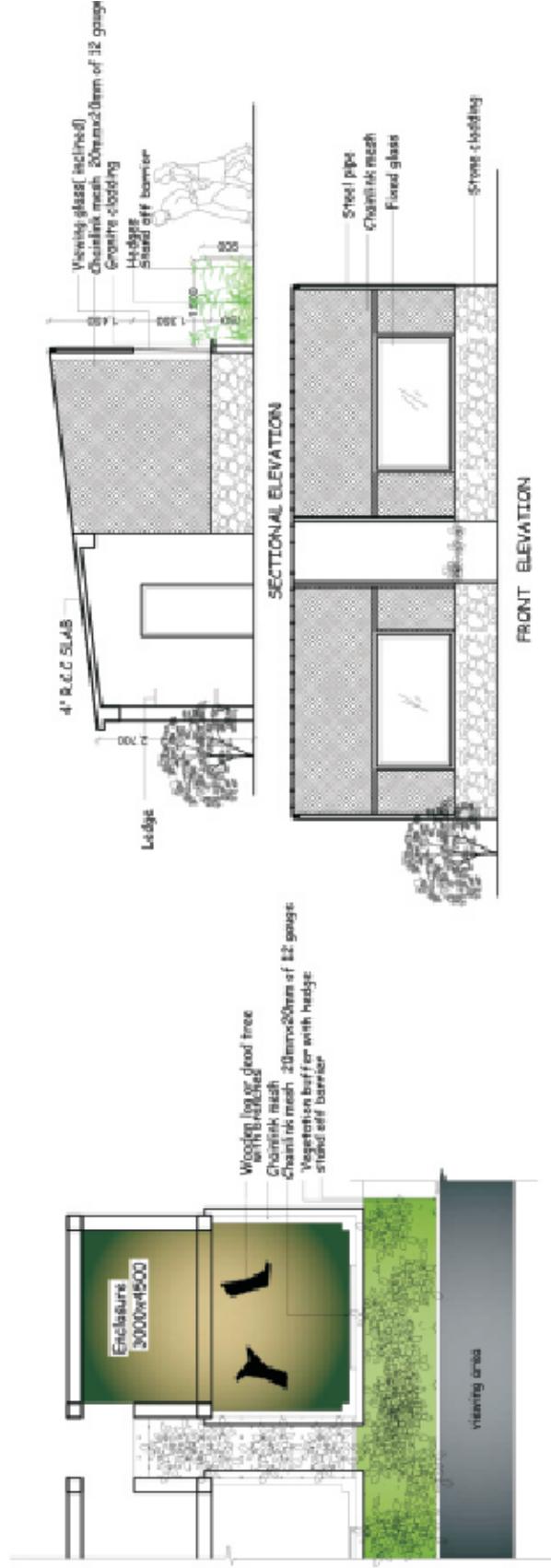
SECTIONAL ELEVATION

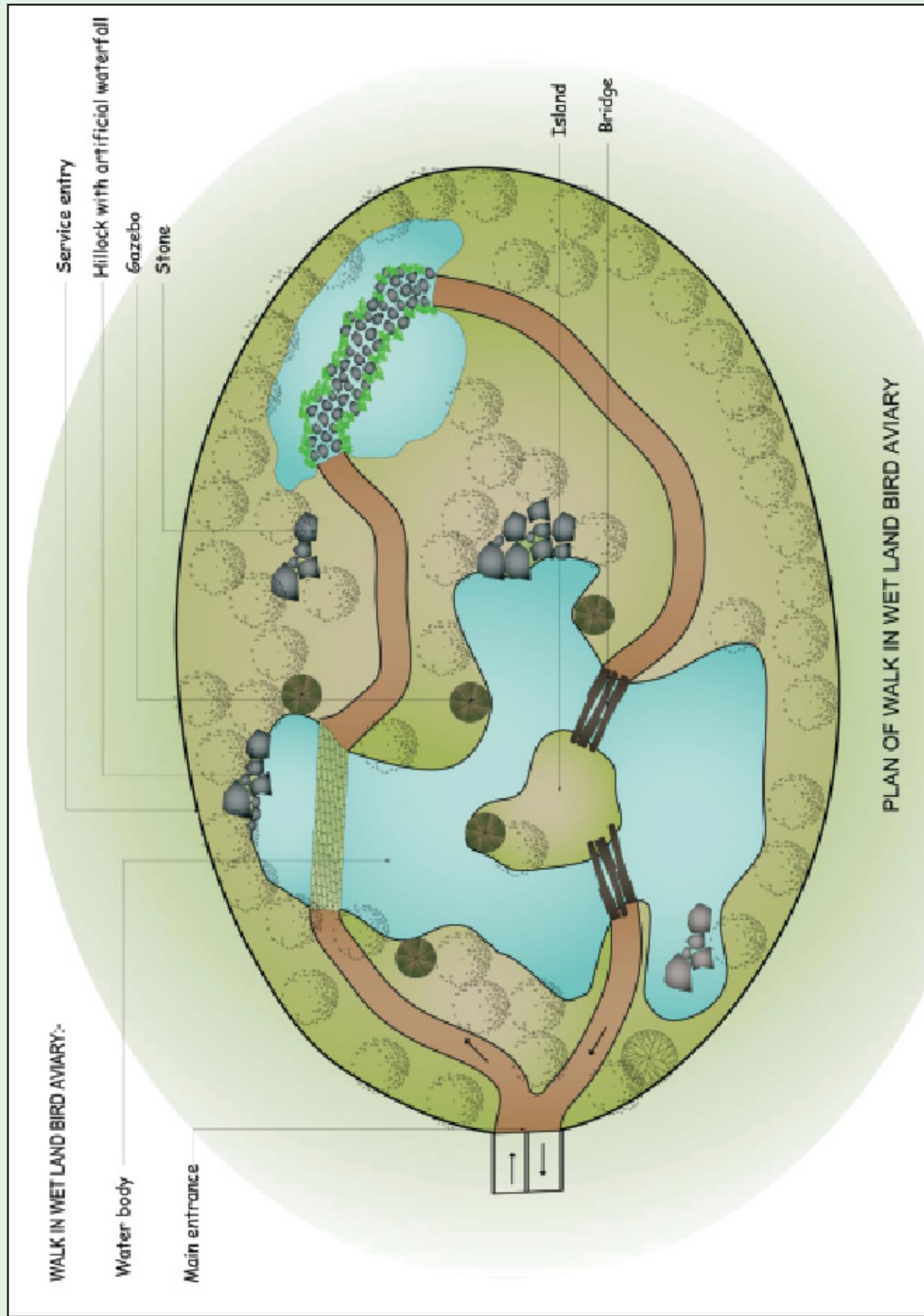


#### ENCLOSURE FOR SMALL BIRDS MUNIA, FINCHES AND BUDGERIGARS

#### NOTES:-

1. The display area of enclosure should be 10-15 sqmt
2. Chainlink mesh should 20mmx20mm 2-gauge and it should be galvanised
3. Chainlink mesh wherever required is to be placed on the inner side of the structural part.
4. Wooden logs, trees may be placed inside the enclosure for enrichment.
5. Plinth of the cell should be at a height of 600mm, from the immediate ground level
6. In the flooring there should be a R.C.C. bed below this the earthen point and the arthen part should be of 300mm depth.



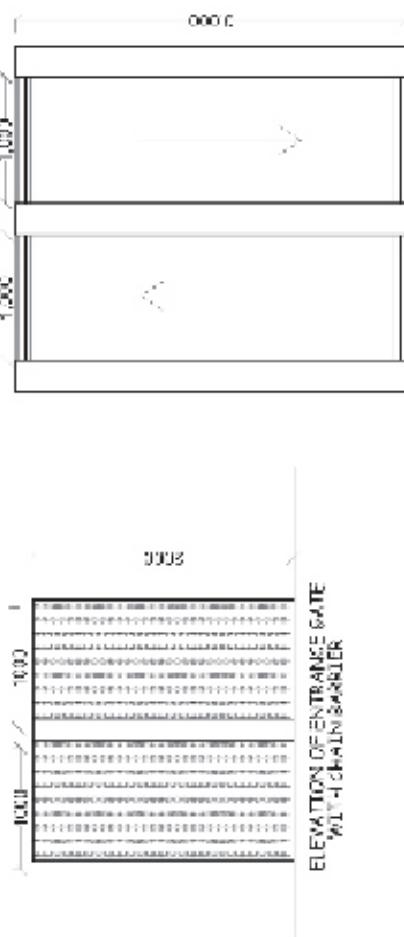




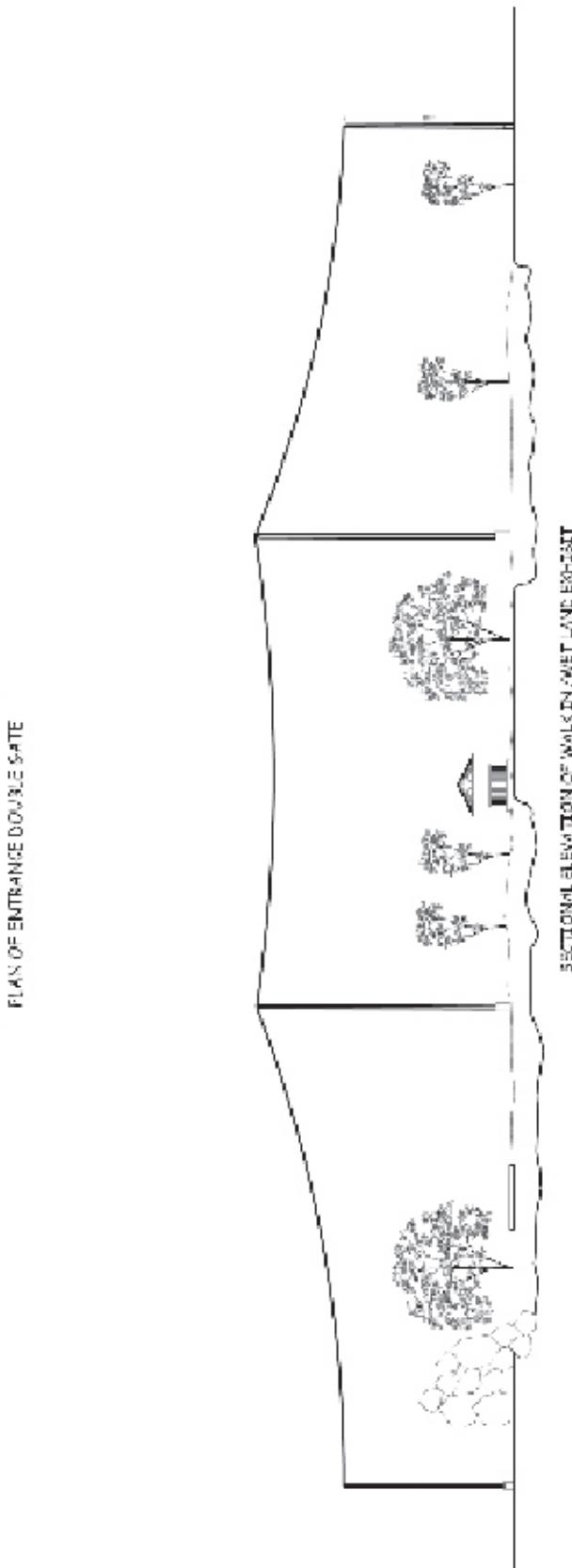
### WALK IN WETLAND BIRD AWARY-

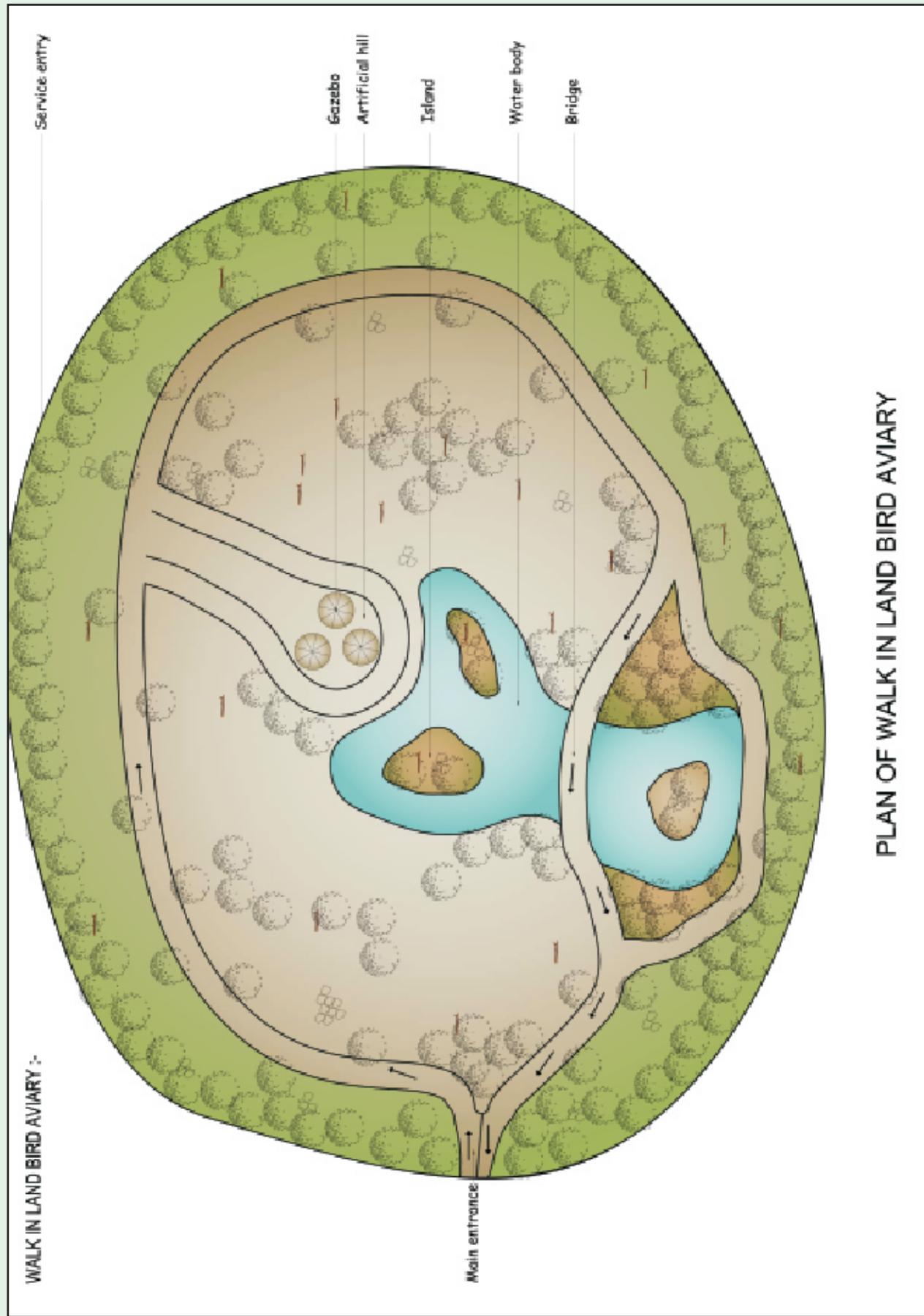
#### NOTES:-

1. Paved area for first bird exhibit in ground line 40'x15' - \$10,000.00 per ft.
2. Chain link fence should cover the paddock and all sides of area 50mm x 50mm x 10 gauge with top covered.
3. The height of over body in the paddock may vary from 15' 6" to 18' 6".
4. Enclosed path with under pass of 10'x10' x 12' and height 12' mt.
5. Double gate at the entrance with partition and sliding doors should be provided.
6. One service cum emergency gate of height of 18' mt. and width of 3 ft. should be provided.
7. Centre height of the safety ground be 8-12 mt depending upon the topography. The height of side chain link fence may be 3-4 mt.



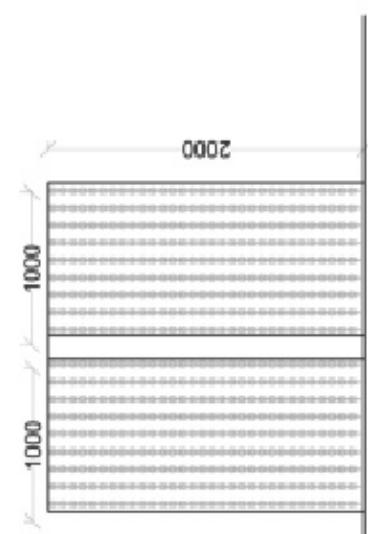
PLAN OF ENTRANCE DOUBLE GATE







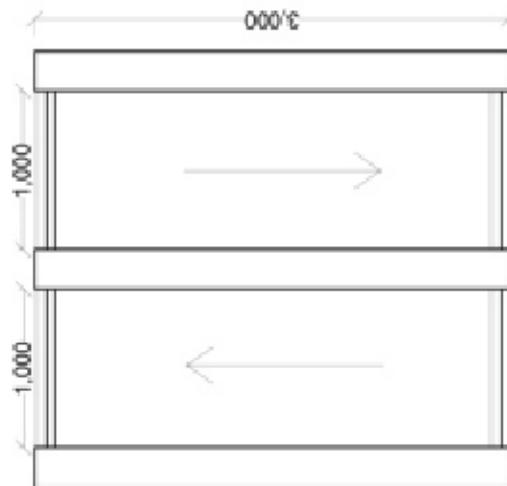
### WALK IN LAND BIRD AVIARY



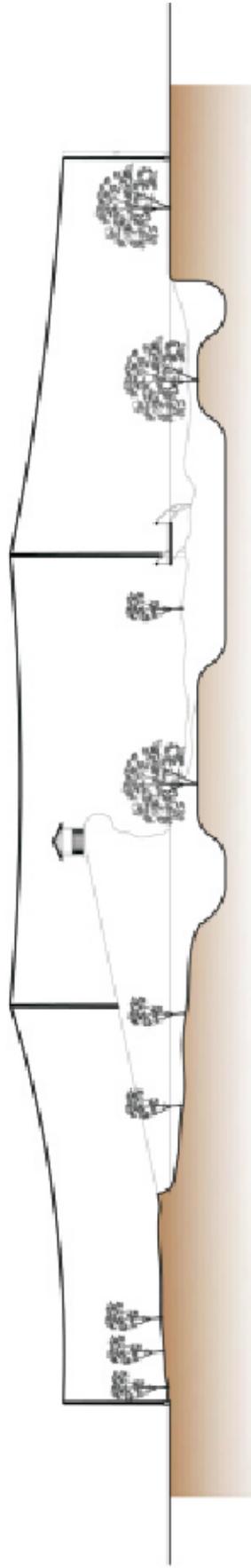
ELEVATION OF ENTRANCE GATE  
WITH CHAIN BARRIER

### NOTES

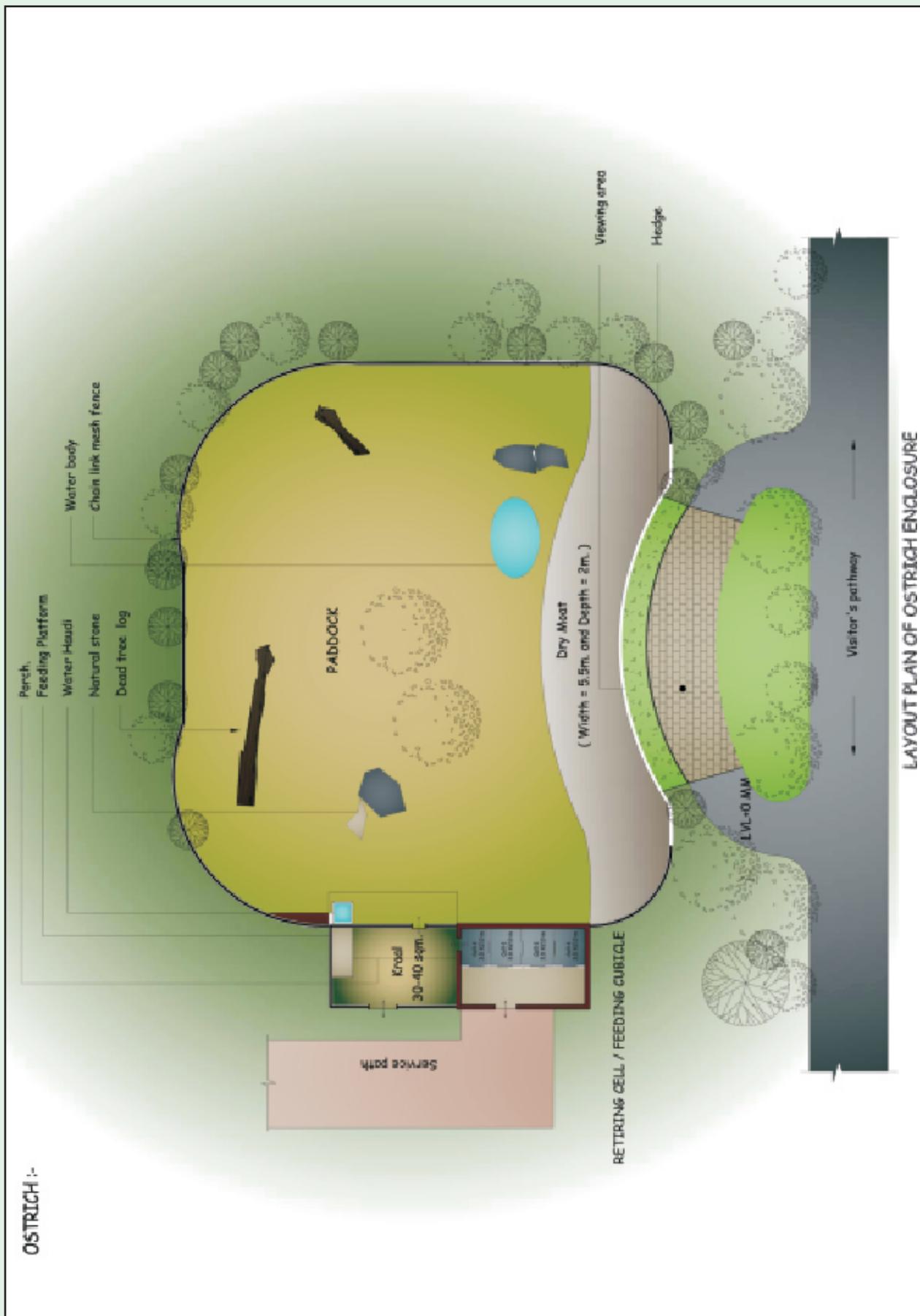
1. Paddock area for walk in aviary should be minimum of 2 hectare.
2. It should be covered on all sides and on top with chain link mesh of 50 mm x 50 mm x 10 gauge.
3. Visitor's path should be pucca and should be 1.5 mtr. in width.
4. The center height of fence should be 8-12 mtr depending upon topography. The height of side chain link fence may be 3-4 mtr.
5. Double gate at the entrance with partition and sliding doors should be provided.



PLAN OF ENTRANCE DOUBLE GATE

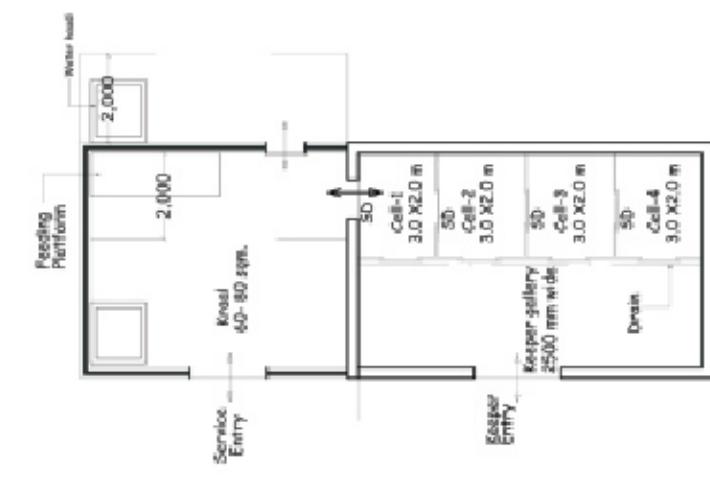


SECTIONAL ELEVATION OF WALK IN LAND BIRD AVIARY

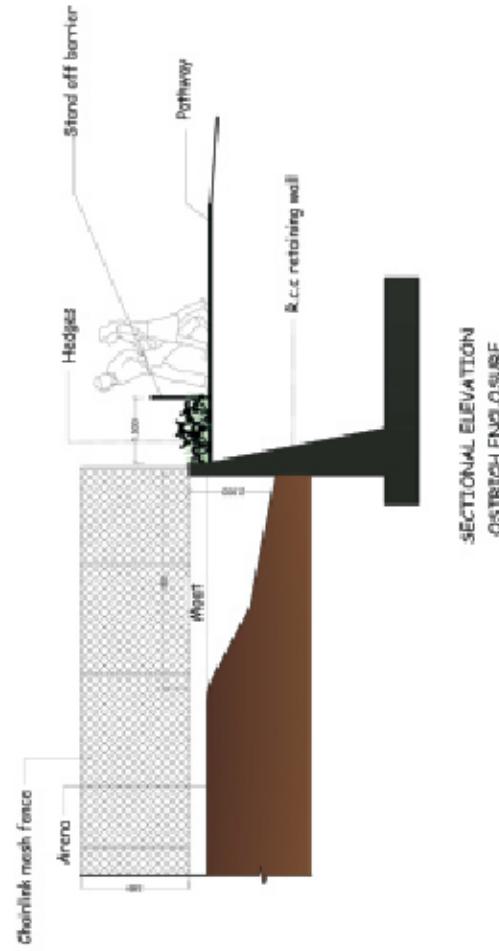


## OSTRICH :-

### NOTES:-



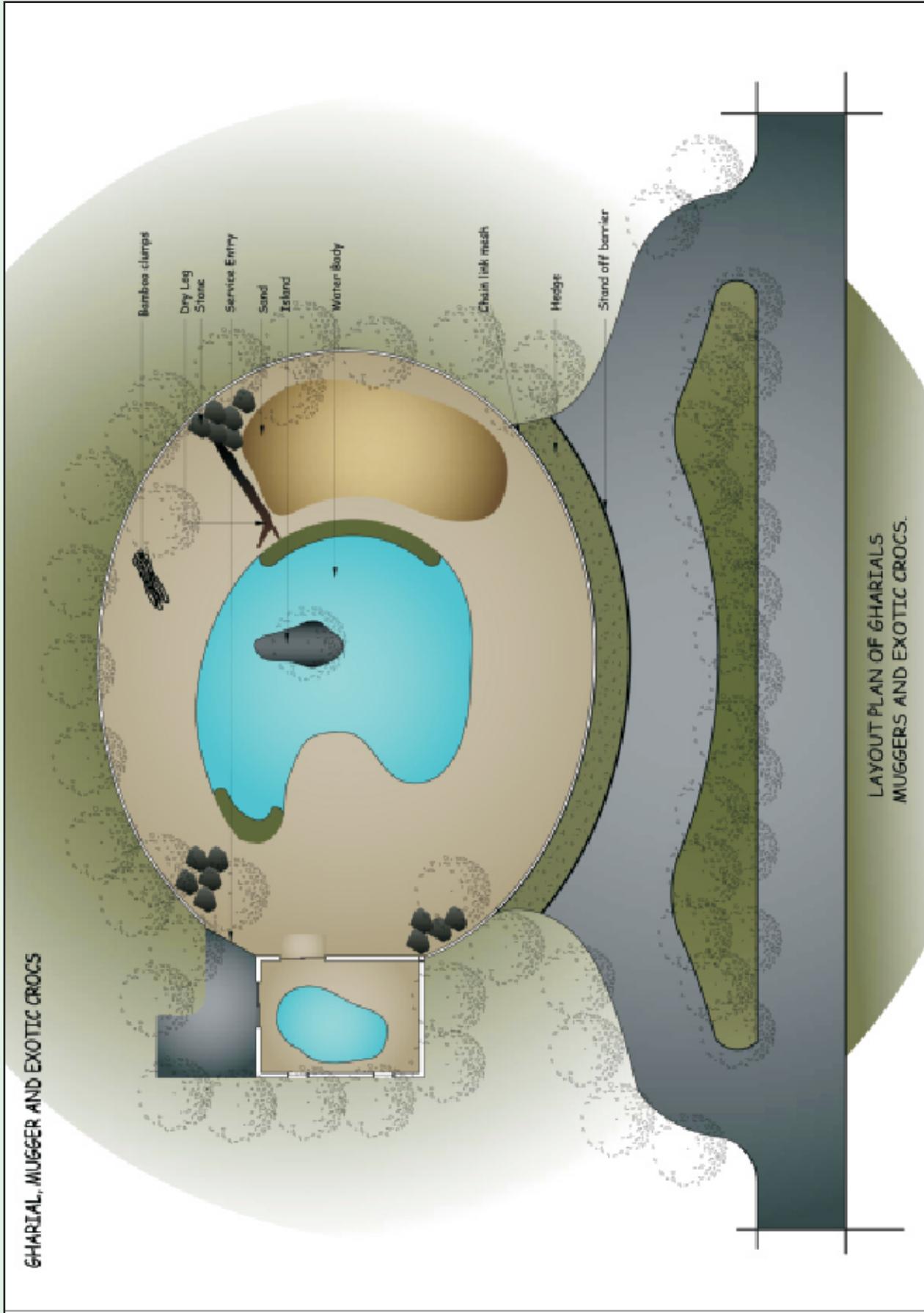
PLAN OF RETIRING CELL / FEEDING CUBICLE  
OSTRICH ENCLOSURE



SECTIONAL ELEVATION  
OSTRICH ENCLOSURE



**GHARIAL, MUGGER AND EXOTIC CROCS**

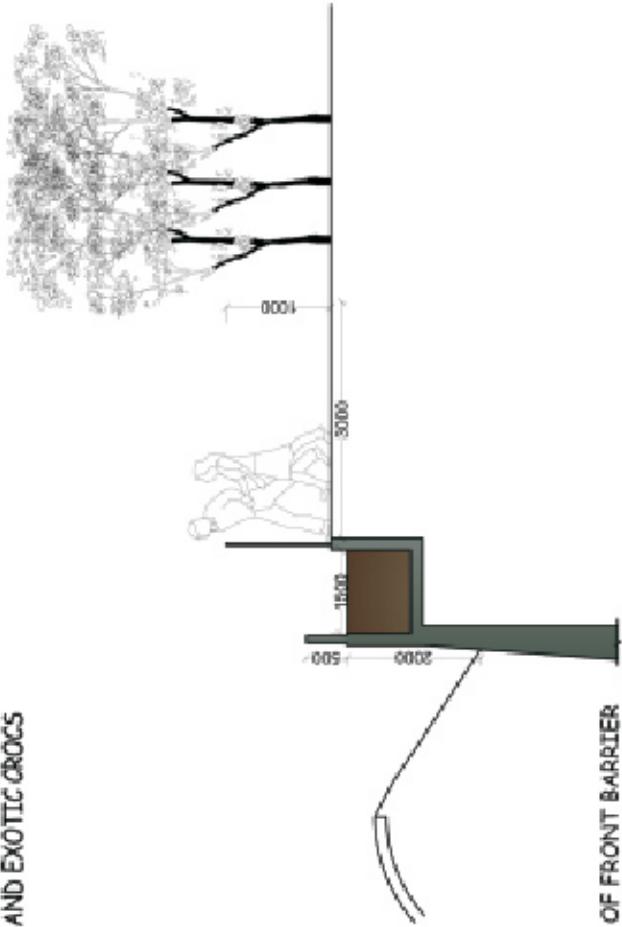




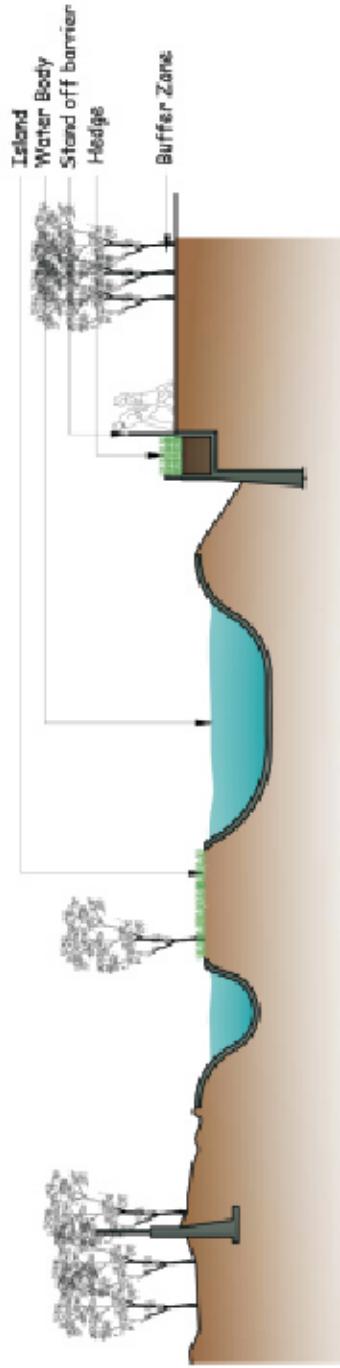
## GHARIAL, MUGGER AND EXOTIC CROCS

### NOTES:-

1. Paddock area for crocodile should be 500 - 600 sq. mtr.
2. Waterbody should be piston area and 150-200 sqmt depth of the water body should be 2000mm, one elongated island within water body of about 1 sqmt should be provided.
3. Side walls should be made of bricks or stones and the height should be minimum 1500mm.
4. Viewing side should be covered with chain link fence of 2000mm high and of size 75mm x 75mm x 10 gauge.
5. Stand off barrier should be 1000mm high and 1500mm away from the chainlink fence.
6. All areas should be hosed with sand mix and the paddock must be provided with sturdy trees.
7. Entry gate to the paddock should be 2000mm wide and 1000mm high.
8. The area of holding pen should be 10sq mtr and its height should be 3mtr, it should be covered on all sides with chain link fence. There should be a service gate in the holding pen.



**DETAIL OF FRONT BARRIER  
OF GHARIAL, MUGGERS AND EXOTIC CROCS.**



**SECTION OF GHARIAL'S,  
MUGGERS AND EXOTIC CROCS.**

**REPTILE HOUSE :-**

**NOTES:-**

- Cell size: python - 80 sqm. and snake - 40 sqm.
- 1/3rd area of cell should be covered with chain link mesh 25mm x 25mm x 10 gauge and 2/3rd of the cell should be covered with concrete slab.
- Viewing side of the enclosure should be of toughened glass inclined at an angle so that the top portion should be outward and the bottom portion should be inward to avoid the reflection from the viewer side.
- Screen off barrier should be 1 m. away from the toughened glass and 90 cm in height.
- Visitor's path should be covered with mesh.
- Water body in the cell should be as per CZA norms.
- Exhaust windows should be provided.
- Floors must be lucite in all cells with the provision of water outlet.
- The height of the wall of the enclosures should be minimum of 3000mm.

Roof covered with charcoal mesh

Brick slabs

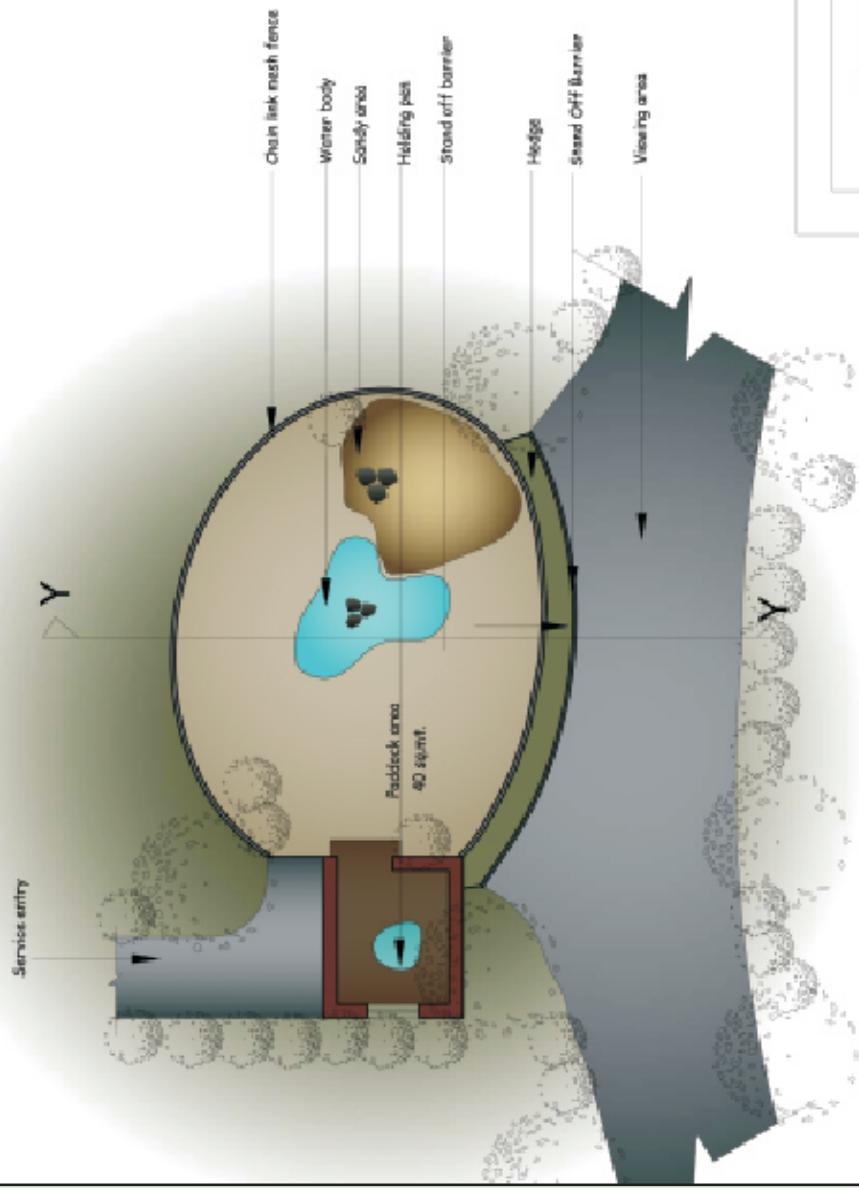
**SECTIONAL ELEVATION**



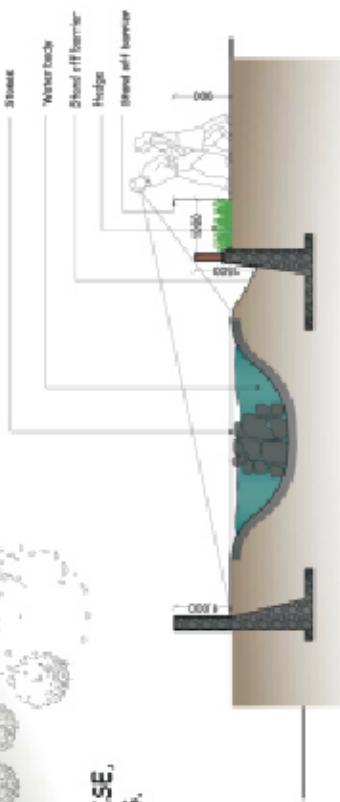
## TORTOISE, TURTLE AND TERRAPINS

### NOTES:-

1. The paddock area:- Tortoises 40-50 sq.mtr, turtle= 80 sq.mtr. terrapin= 80-100 sq.mtr.
2. its height should be 2.25 mtr. covered on all sides with chain link mesh fence of size of 50mm x 50mm x 12 gauge.
3. Water body should be 4 sq. mt. and cemented with a depth of 1 mtr.
4. The enclosure should be bounded by brick wall all around upto a height of 1 mtr.
5. Entry gate to the paddock should be 1 mtr. high and 1 mtr. wide.
6. Viewing side should have chain link fence of 1.5 mtr. High.
7. Stand off barrier should be 1000 mm away from the fence and 900 mm in height.



AYOUT PLAN OF TORTOISE,  
TURTLES AND TERRAPINS.

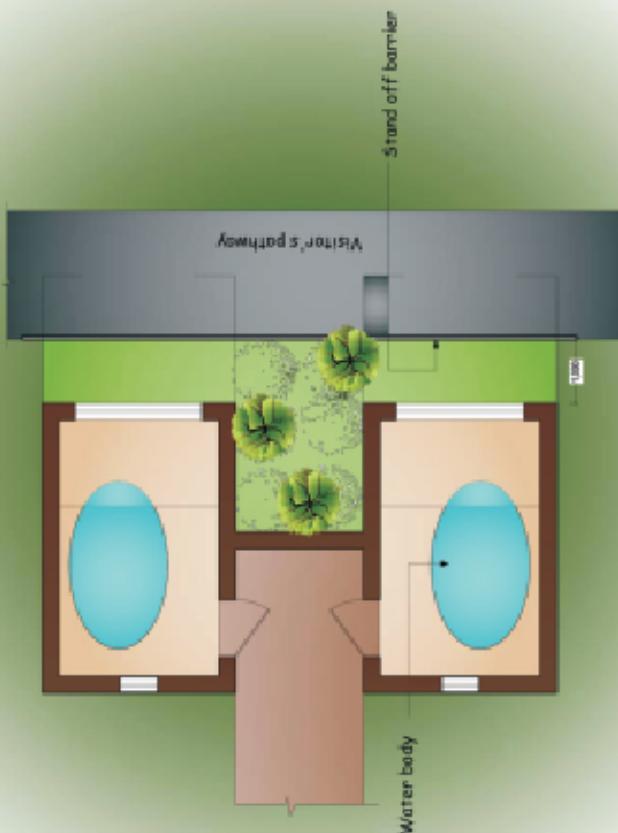


SECTIONAL ELEVATION OF  
TORTOISE, TURTLE AND TERRAPINS

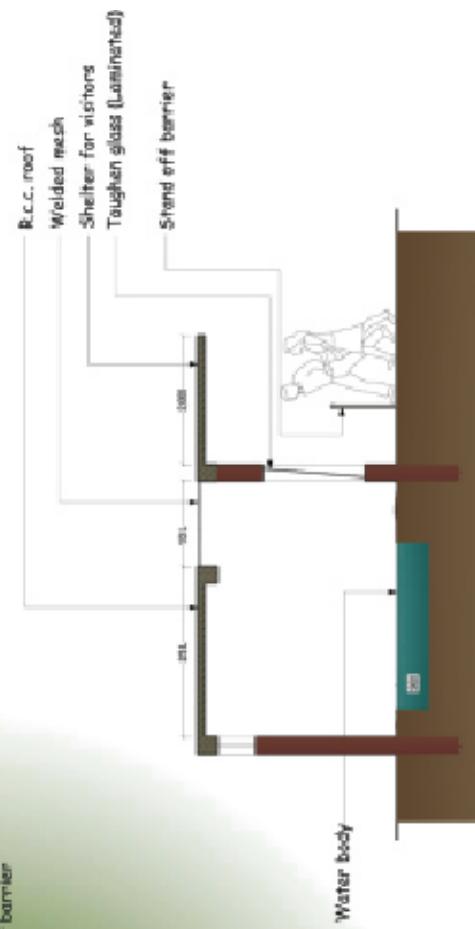
### FROGS AND TOADS :-

#### NOTES:-

1. The paddock area of the frog enclosure should be 10 sqm.
2. Waterbody should be 4 sqm, and it should be cemented with a depth of 500 mm.
3. 1/3rd on the front end should be covered with welded mesh of size (10x10) mm.
4. Height of the cell should be 3000 mm.
5. Entry gate of the cell should be of height 1000mm and width 900mm.
6. Viewing side of the enclosure should be of toughened glass, and it should be placed at an angle so that the top portion should be outward and the bottom should be inward to prevent the reflection from viewer side.
7. The stand off barriers should be 900mm high and it should be 1000mm away from the viewing side of enclosure.
8. All areas should be smooth and the water body should be plated.
9. Shelter for visitors should be covered by a roof of 2000mm width.



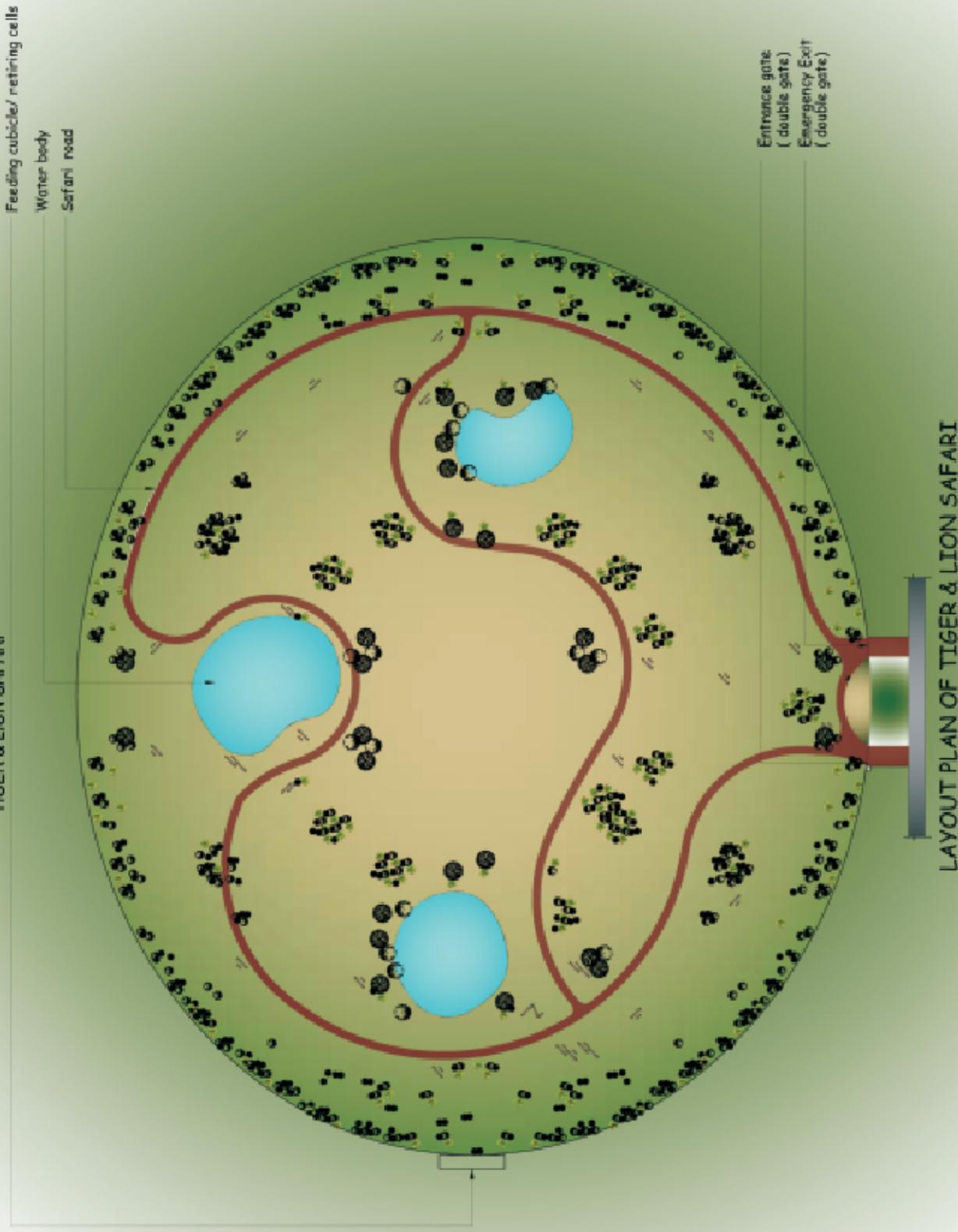
**AYOUT PLAN  
( FROGS AND TOADS )**



**SECTIONAL ELEVATION  
( FROGS AND TOADS )**



## TIGER & LION SAFARI



LAYOUT PLAN OF TIGER & LION SAFARI

TIGER & LION SAFARI

Kradal - 2  
80 - 100 sq.m.

Kronal - 2  
80 - 100 sqm.

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ELEVATION OF ENTRANCE GATE

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**PLAN OF RETIRING / FEEDING CELL  
OF TIGER & LION SAFARI**

## DOUBLE DOOR ENTRANCE



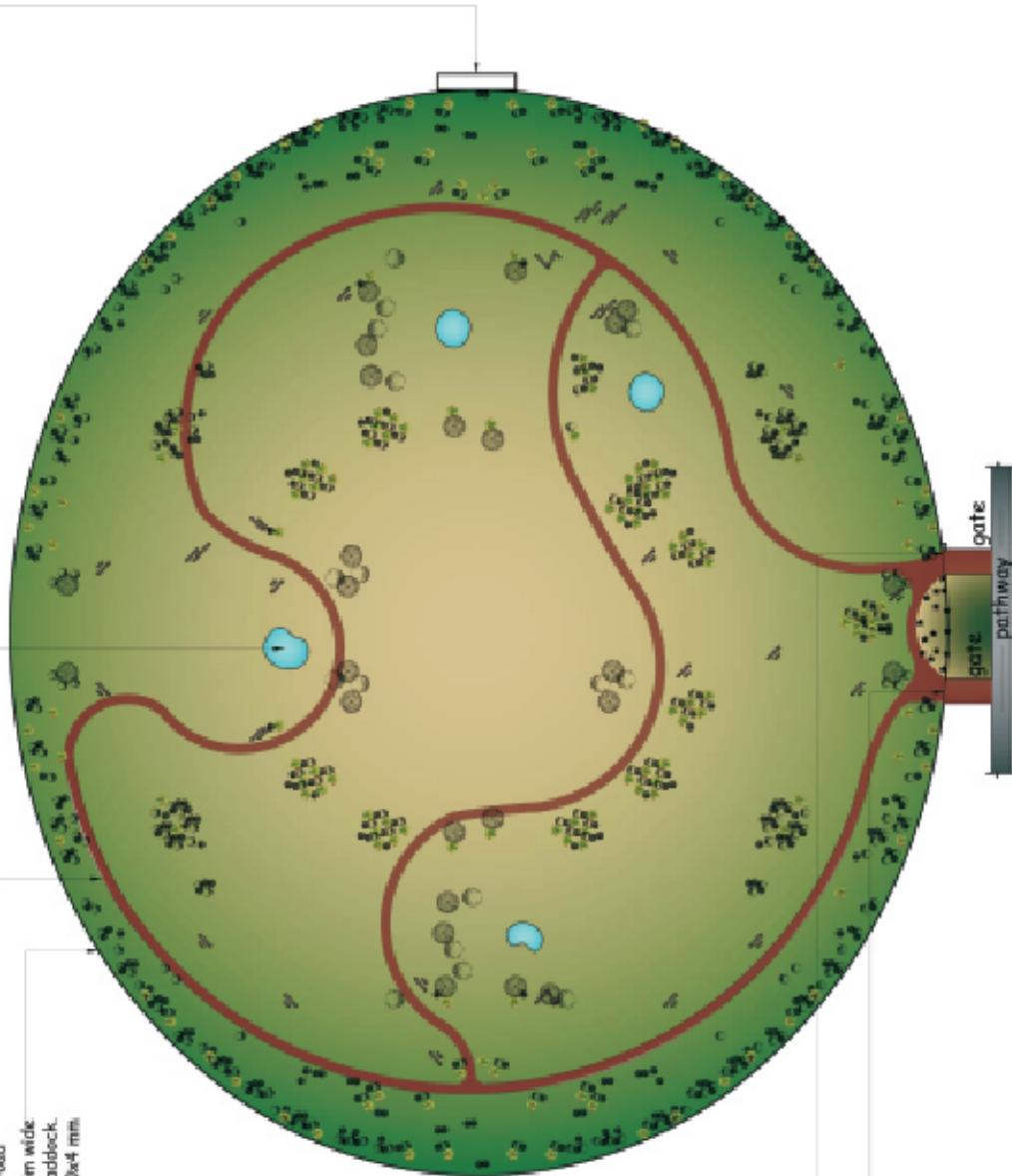
## BEAR SAFARI

Feeding cubicles/ resting cells

Water body

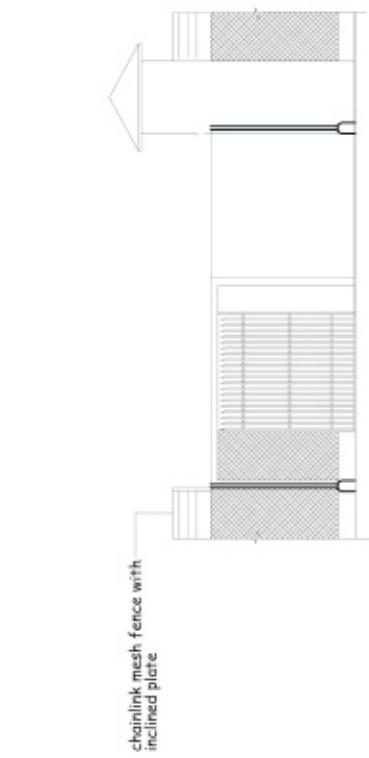
Safari road

Chain link fence: should be of height of 4 mt. with 1.5m wide street plate inclined in an angle 60 degree towards polder. Size of chain link mesh should be -50x50x4 mm.

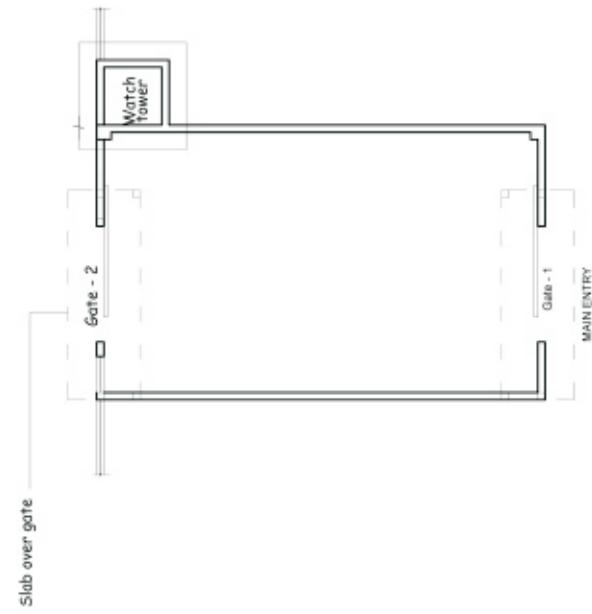


AYOUT PLAN OF BEAR SAFARI

### BEAR SAFARI



### ELEVATION OF ENTRANCE GATE

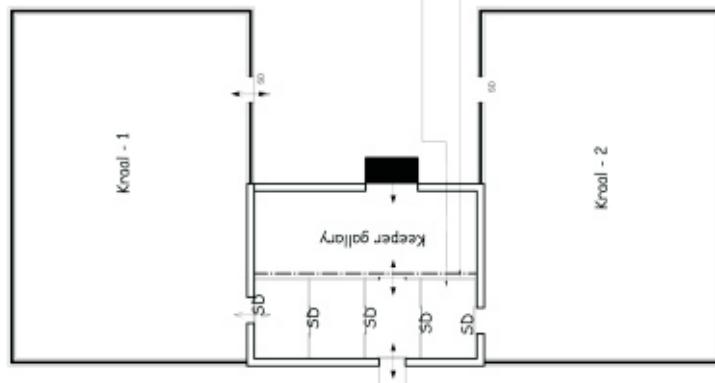


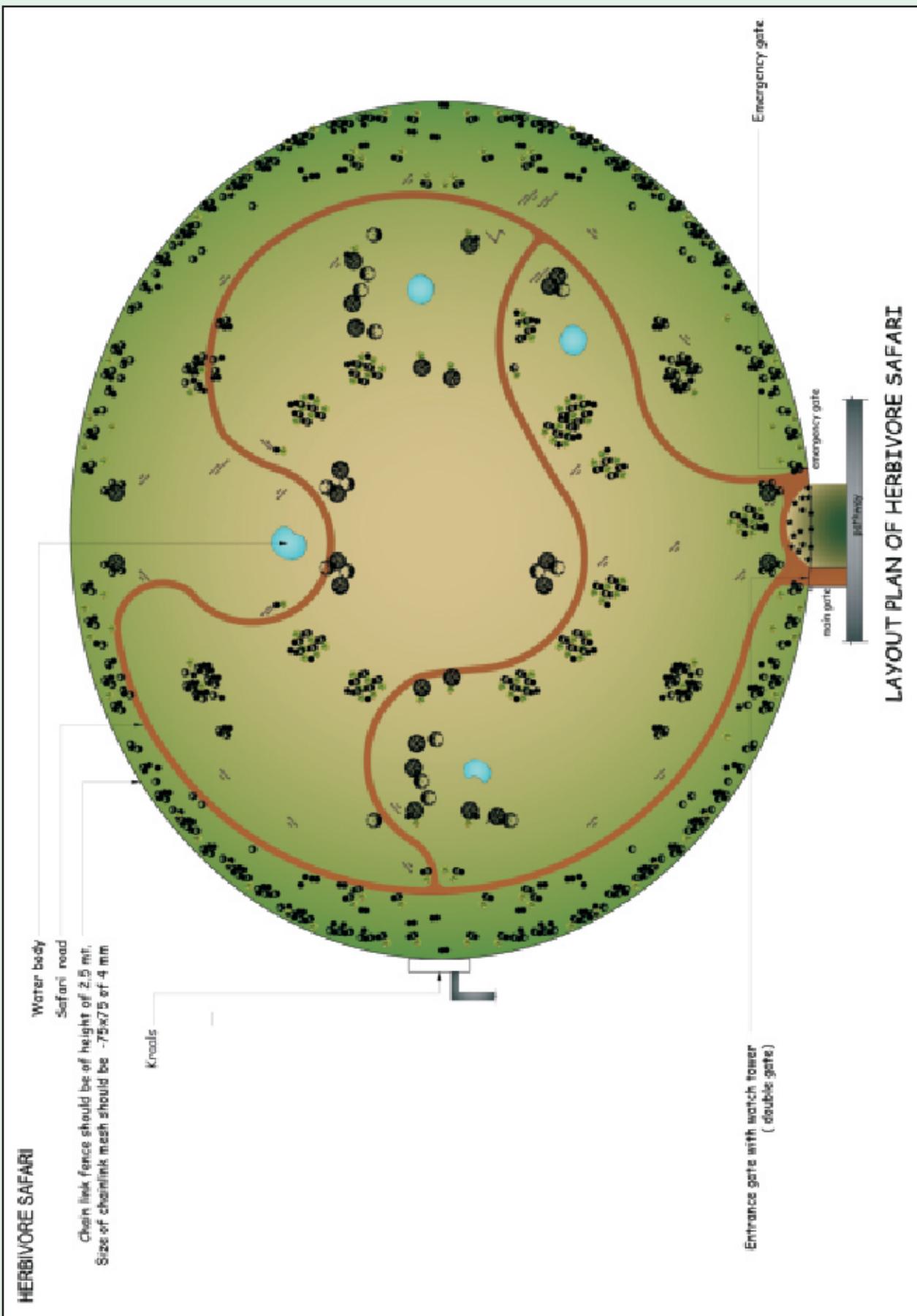
DOUBLE DOOR ENTRANCE

PLAN OF RETIRRING / FEEDING CELL  
OF BEAR SAFARI

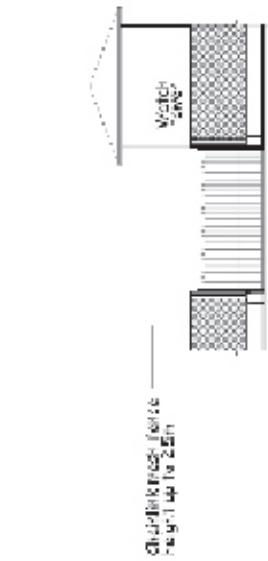
### NOTES:-

1. Paddock area should be 20 hecter
2. Cell size should be  $2.75\text{m(L)} \times 1.80\text{m(W)} \times 3(\text{H})$  mt.
3. Kral size should be 80-100 sqm each.
4. Chain link fence should be of height of 4 mt. with 1.5m wide steel plate inclined at an angle 60 degree towards paddock. Size of chainlink mesh should be of 50mmx50mm of 8 gauge.
5. Entry gate of safari should be double gate as per the size of a safari bus.
6. There should be a double door emergency gate.
7. Safari road should be pucca.
8. 3 to 4 nos. of water body should be provided. The area of the water body should be 6- 10 sqm and 500mm in depth and it should be pucca.
9. The area between two gates should be covered with chainlink mesh
10. A provision of keeper room should be made under the watch tower.
11. Dimension of night house should be as per Bear enclosure.

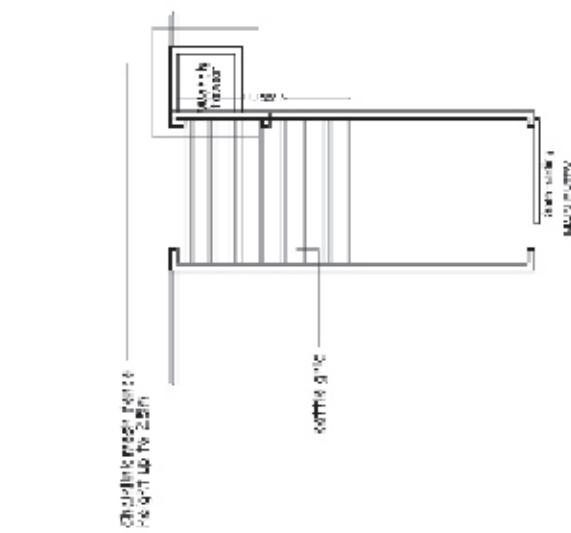




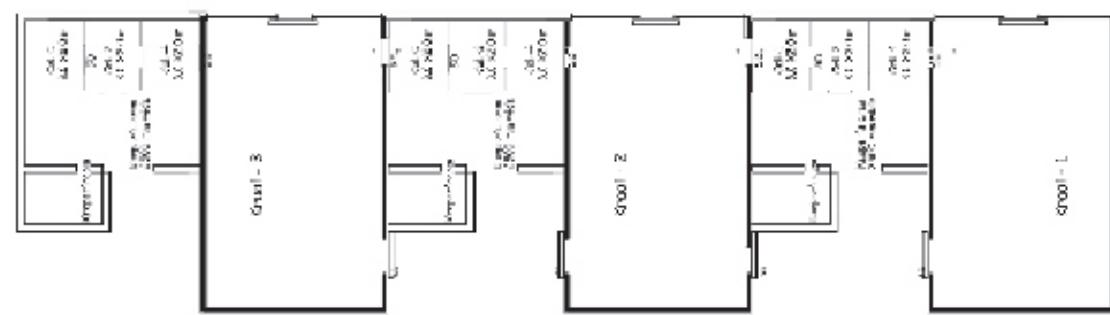
### HERBIVORE SAFARI :-



### ELEVATION OF ENTRANCE GATE



### ENTRANCE & GATE LAYOUT



PLAN OF RETIRING CELL  
OF HERBIVORE SAFARI

### NOTES:-

1. Field track area should be 30% of total.
2. Kerel's zone should be 40 - 50 sq m each separated with 2 height of 4met.
3. Chain link fence should be of height of 2.5 m.  
Size of chain link fence should be -75mmx75mm or 2.5 mm.
4. Entry gate of safari should be suitable gate fit for the stored & secured land.
5. There should be an emergency gate.
6. Safari road should be paved.
7. 3 to 4 feet of buffer body should be provided. The area of the inner body should be 6 - 10 sq m and 50 cm in depth which is spanned by path way.
8. Calli log should be provided in the enclosure gate.
9. The no. of keeper's access right no. 2 will depend upon the no. of species in the safari.



## 9. Signage in Animal Enclosures

The 'National Zoo Policy, 1998' states that "Attractive and effective signage methods and interactive displays to explain activities of various species to visitors, published education material and audio-visual devices are proven methods for driving home the conservation message. Besides signage, the zoo shall also use guided tours, talks by knowledgeable persons and audio-visual shows for effectively communicating the message for conservation to the visitors."

Normally a lay person or a child, who visits any zoo, just looks at a collection of wild animals which he or she does not normally see in his or her surrounding and goes back without knowing anything about the animals, their habit, habitats, physiology or ecology.

In most zoos signage contains a picture of the animal displayed, its common name and scientific name. Some others go on to provide their distribution, reproductive biology and their status in the wild. Of course, some zoos have attempted to provide very elaborate information on their habit, habitat, and classification, distribution worldwide including their various sub-species and food requirement and ecology. Hence their content varies from barest minimum to too elaborate, printed in very small fonts. The former types virtually does not provide any nature education while the elaborate ones are not usually read as the visitors do not have time for the same and the font is too small and often difficult to read.

The sizes, colour and colour schemes, material used and contents all vary widely from zoo to zoo. Even, the signage in the same zoo often differs in shape, size, material used and text. Some zoos use only one language like their local language, Hindi or English.

The signage location in respect to the enclosure is also different. Some place them inside the enclosures which are rather unreadable by the visitors; some others place them in a cluster. In other cases a single signage provides information on all the species displayed in a cluster of enclosures. Except for some zoos, the signages are not attractive to the visitors and are not placed at a right place and height to make an impact on the visitors. It at times seems to be quite confusing. This happens due to non-availability of funds, want of expertise or lack of proper guideline for a proper signage.

Hence the enclosures should be so designed and contents so provided that the zoo visit becomes more effective as the visitors take back some information while having a pleasant recreational experience.

While making and placing a signage the following aspects may be kept in mind.

### 1. Design and layout

The overall appearance of signages can have a significant impact on their appearance and readability. The more legible the signage becomes, the greater chances of its being read.

**Some design features to be kept in mind for effective signages include:**

- The signages should be of sufficient size to be read from a comfortable viewing distance.

- Cramming too much into a signage should be avoided. Space between the various design elements (titles, text, and illustration) will make it easier to read and have greater visual impact.
- There should be approximately 10 words on each line, and between 40-65 characters (including spaces).
- The text should be broken into paragraphs using headings and subheadings.
- Information should be presented in layers.
- Use of capital letters except for short titles should be avoided as it is difficult to read long texts in capitals.
- A uniform style (font size, typeface) should be used throughout the text. Underlining words and use bold or italics may be done only for special emphasis.
- Simple and clear font such as Helvetica, Arial, Optima or Times may be used. More than two or three different fonts should not be used per sign.
- Letters spaced too closely together or too far apart are difficult to read.
- Font size should be big enough to read at a distance of one or two metres. The smallest readable font size is 18 points. A font size of 22 points is easier on the eye even from a 2 metres distance.
- The type should contrast clearly with the background e.g. dark type on light background or white text on dark backgrounds.

**Note:** Red on green and green on red should be avoided as colour blind people will not be able to distinguish.

An example of possible layering with text

Level	Content	Text type	Font size
1	Title	Very big and bold	48 points
2	Subheadings	Big and bold	36 points
3	Body text	Medium	22 points
4	Picture captions	Small	18 points

The most effective signs communicate to their audience through clear, concise and legible messages.

## 2. Pictures

Use of symbol is effective to communicate basic facilities as well as warning or danger. These are especially useful where the audience may either be illiterate, or do not know a particular language.

Signs are more attractive if they include visual elements (diagrams, maps, icons etc.) that relate to the content of the messages.



### 3. Positioning the signages

The first rule of attracting visitor attention is to ensure that signages are placed where they will be seen. To do this, one needs to have some idea about the visitor movement in the zoo. Visitors are most likely to stop at signages displayed that are close to the centre of their line of vision.

Signages should be placed within easy viewing distance not across the moat, or at one end of a very large enclosure, so that the information can be related to the exhibit being viewed.

It is important also to consider whether the space around the signage is open or large enough to accommodate the volume of visitors at a given time, or will it lead to crowding?

The height of the signages is also an aspect to be considered. Several researchers have suggested that the best option is to have the centre of the signage at adult eye height. But others feel that this does not consider the large numbers of children that visit zoos. About 80 cm above the ground is a good height. One attractive option that considers both is to place signages at a lower height but to angle them upwards.

As a general rule, signages should be mounted at right angles to one's line of visitation.

Some other issues that may be considered:

- Available lighting (sunlight and artificial lighting)
- Glare and reflection on the signage
- Position of sunlight it is difficult to read signages with bright sunlight behind them.
- Appropriate colours to be used for the available light conditions.

### 4. Types of signage

The important consideration in choosing the type of signage is to go for the purpose of the signage, and the resources available (budget, technology, materials and expertise). Interpretive signs can be made of a range of different materials and designs. Simple inexpensive signs can be made of paper or cardboard which has been laminated with plastic to make it waterproof. Signs made of more durable materials such as wood, metal or enamel is generally more costly and complex to fabricate.

Temporary signage is useful for announcements such as a new arrival in the zoo, an animal's birthday, an event (a painting competition or film show). It can also be used for seasonal displays (flowering of a tree, butterflies around certain plants, arrival of some migratory birds etc.) For this a laminated paper/cardboard sign is useful. One option is to have a set of frame stands with a removable sign face made and kept ready for use as and when required.

Alternately the laminated signs can be pasted/hung up or pinned at the required placed as well as near the entrance to inform visitors about the events.

Permanent signs are made to last several years and can be used for directional and facility signs, as well as animal enclosures.

## 5. Child-friendly display

Many displays are too high or too complex for children. Some design elements that help:

- Displaying some items or texts at 'child-friendly' heights or on the lower half of a large board with more visuals and simple text.
- Providing a viewing platform for children to stand on, with suitable safety precautions.
- Cutting 'peep holes' in front of some exhibits at various levels to allow viewing by children of different heights.
- Incorporating display boxes on the floor (especially to display simple maps, models of ground dwelling creatures etc.)

<b>Temporary Signages</b>	<b>Permanent Signages</b>
Used for: seasonal displays, new developments (work in progress), visitor management, testing new signages ideas.	Used for: features of general/historic interest, year-round displays, permanent collections.
<b>Materials</b> A signage frame made of metal or wood. A signage face made of paper or cardboard which has been laminated with plastic. The text and images may be done by hand or on a computer.	<b>Materials</b> A signage frame may be made of metal or wood and plinth constructed of cement concrete or stone masonry. A signage face made of baked enamel, vinyl, plastic or aluminum. The text and images may be hand-painted, silk-screened or computer-generated, depending on the technique used.
<b>Installation</b> Easy to move the signages frame with one or two painted legs which can simply be pushed into the ground (if it is not too hard or rocky).	<b>Installation</b> Depends on the design. Signage posts are typically concreted into the ground.
<b>Advantages</b> <ul style="list-style-type: none"> <li>• Flexible (easy to change)</li> <li>• Inexpensive to produce</li> <li>• Allows you to be responsive (e.g. to events, current environmental issues or commonly asked questions)</li> </ul>	<b>Advantages</b> Long-lasting (low maintenance)
<b>Disadvantages</b> <ul style="list-style-type: none"> <li>• Need regular replacement (high maintenance)</li> </ul>	<b>Disadvantages</b> <ul style="list-style-type: none"> <li>• Plant displays may die or change (so the signages become obsolete)</li> <li>• Inflexible (not easy to change)</li> <li>• More costly to produce</li> </ul>



## 6. Materials and Techniques

The range of materials and techniques for fabricating signages is constantly expanding. Choice of material is often based on the kind of 'look' that needs to be achieved. There are several other factors which need also to be considered also. Some of these are:

The content: How detailed, how much text, graphics and type of graphic, colours

The location: Outdoor (blending with surroundings and weather considerations).

Indoor: Lighting conditions

Susceptibility to vandalism and amount of handling (e.g. an interactive sign)

Maintenance: Is regular upkeep and maintenance possible? (Are there financial and human resources available for this cleaning & repairing?)

Project lifespan: How long are the signs expected to last? (Sometimes the displays may change, or the visitors may like to see something new).

Availability of resources: The budget available (both for fabrication as well as maintenance), the designing facilities, the technology available.

It is worthwhile to explore local resources in terms of painters, illustrators etc who can contribute in this respect.

Along with the signage, it is equally important to plan the base of the signage, material to be used, the cost, and setting them up. Regardless of the material chosen, on-going maintenance and upkeep (cleaning etc.) is vital if signages are to remain effective.

## 7. Maintenance

Signage can be affected by time and weathering, accidental damage, or vandalism.

Poorly maintained signages are not only difficult to read, but also send a negative message to visitors. Regular preventive maintenance is essential to ensure the quality of the zoo communication.

The zoo management needs to have a system in place for regular inspection of signs, upkeep and repair. This is cheaper than replacement of badly damaged signages. Funding for this purpose needs to be built into the budget for signage development and fabrication.

## 8. Some materials and techniques

Type	Characteristics
<b>Anodized aluminum</b>	Hard anodized aluminum plate. Only black and white printing possible. Long-lasting, weather-proof and excellent for outdoor use. Minimum life span 10 years.
<b>Vitreous enamel with screen print</b>	Screen printing on vitreous enamel plate. Only two or three flat colour printing possible. Resistant to extreme temperature changes, high humidity, oil and most chemicals. Minimum life span 5 years

Wood, wood composite, concrete with fibre glass coating, laminated paper, laminated card board or hand painted steel sheet can also be used depending on different considerations mentioned earlier.

(The Zoo Education Master Plan may be referred to for further details on designing of signage of zoos.)

Every enclosure should have any one signage on the animal displayed while warning signs and zoo ethics can be provided at appropriate places. Based on the above text some appropriate signage should be adopted for the zoo, as it plays a very important role in nature education in any zoo, as without this a visit to a zoo remains incomplete.



Signage at National Zoological Park, New Delhi



# 10. Waste Management

Solid waste of enclosures includes left over food, fecal matter and bones etc. This waste should be collected in a trough / trolley and be disposed off in a dustbin away from the visitors and secured from the entry of any predators and birds. The solid waste so collected must be removed from the dustbin through municipal corporation or outsourced agency preferably daily to prevent smell and spread of disease. The dustbin must be cleaned and sprayed with disinfectants regularly. This waste can be used for preparation of manure.

The solid waste should be disposed in appropriate manner considering bio-security risk of the product to prevent contamination to species and individual such as :-

- (a) Composting
- (b) Autoclaving
- (c) Chemical sterilization
- (d) Radiation sterilization
- (e) Incineration

The liquid waste primarily constitutes the urine and washing of animal enclosures in the zoo. This waste should be washed and drained off to the septic tank through the drains so constructed in the zoo. The liquid waste can also be put into the municipal sewers through the drains and / or sewers. Where it is found necessary and economical, the liquid waste can be re-used by purifying it through the sewage treatment plants (STP).

Non bio-degradable wastes like polythene should not be allowed in the vicinity of an enclosure. But, when they accidentally come to an enclosure, there should be arrangement in place for its immediate pick up and sending for recycling.



# 11. Drainage System

The drainage planning is essential for channelizing the rain/storm/snow water to desired uses of disposal. The rain and snow melting requiring channelizing of water known as drainage. The design of drainage system depends upon topography of the area, volume of rain fall and snow fall of the particular region. The drainage may be in the form of open channel or covered drains or pipes. In zoos, open drain system can be adopted. Periodic cleaning is required before rainy season to maintain effective drainage. The drainage system should be so designed that entry of water in moat is controlled to prevent flooding and ingress of contamination of the catchment. The drainage plan can be integrated with the rain harvesting system also. In case of natural steep slope the channel should be constructed using cascade or water cushion or energy dissipation basin. The low lying zoo area may need channelized collection of run-off and pumping from the detention basins. The drains can be open kucha drain, brick lined open drain, pucca or stone pitched lining depending on economy and to prevent erosion. The kucha and stone / brick lined without mortar drains helps in ground recharge. The drains should be engineered and designed for efficiency of conveying the runoff effectively without causing flooding of the area.

## 2. Rain water harvesting

The rain water harvesting and conservation is the activity of direct collection of rain water. The rain water can be stored for direct use or can be re-charged into ground water. The main goal is to minimize flow of rain water through drains/nallah to river and to make use of the same. It is known that ground water level is depleting and going down and down in the last decade.



(1) Rain water harvesting system at Mysore Zoo



The rain harvesting in the form of ponds has been done by human civilisation for ages. The ground water in natural form is also a rain harvesting in which the water percolate through soil and stores in aquifers and used in some lakes, ponds, wells and springs. In the areas with less rainfall, the rain water can be used to recharge ground water which improves ground water table. In case of zoo, the rain water collected in shape of pond can be very useful to fulfill demand of water supply after treatment. The ponds, check dams and lakes can be created which help in ground recharge. The roof top rain harvesting can be done by channelizing the water into soak pit or through tube wells. In case of soak pit type recharge the surface run off from pavement can be used for ground recharge after passing through settlement tank.



(2) Rain water harvesting system at Mysore Zoo



## 12. Power Supply

Adequate power supply should be maintained in each enclosure. Necessary points to run fans, coolers and heaters should be provided at appropriate locations. These are necessary to counter the climatic effects particularly in case of carnivores and young ones. It should be ensured that no animal should come in contact with any electric gadget / wire. Provision for tube light / LED should also be made at appropriate locations. There are options available for optical day light system requiring no electricity and such light can be used in the areas where activity is during day time such as toilets, display area etc. Wherever feasible solar power should be used for lighting and heating etc. and earth tubes for cooling in order to save energy.





## 13. Recommended Reading

Central for Environment Education (2008) Zoo Authority, New Delhi	Master Education Plan for Indian Zoos Central
Central Zoo Authority Publication (2008)	Ex-situ wild life conservation and zoos in India
Central Zoo Authority Publication (2012)	Guidelines on minimum dimensions of enclosures for housing exotic animals of different species.
Central Zoo Authority Publication (2006)	Master planning of zoos Proceeding of training programme on master planning of zoos for directors & managers of zoos in India.(WII & Nandankanan Zoological Park)
Central Zoo Authority Publication(2013)	Zoo Designing And Landscape Architecture' Proceedings of the Workshop organized by the School of Planning and Architecture.
Coe, Jon (2009)	Collaborative Enrichment Key note address in 9th international conference on environment enrichment, Torquay, U.K.
Desai, J.H (1994)	Standards / Guidelines for Indian zoos Wild life Institute of India, Dehradun
Desai, J.H (2000)	Zoos of India Central Zoo Authority, New Delhi
Govt. of Australia (2011)	National Zoo Bio-Security Manual
Govt. of India Publication (1973)	Report of the expert committee on zoos Indian Board for Wildlife Dept. of Agriculture, Ministry of Agriculture, New Delhi
Govt. of India Publication (1986)	History of National Zoological Park, New Delhi Ministry of Environment & forest, New Delhi
Indian Zoo Directors' Association	Indian Zoo Year Book (Volume 1 to 5)

Kishor Brij (2001)	Principles of standards for barrier design - A paper presented in zoo directors training programme conducted by S.P.A., New Delhi
Kishor Brij (2008)	Barrier Designs for Zoos, Central Zoo Authority, New Delhi.
Malhotra, A.K. & Jigyasa Turkar (1999)	Project - A synopsis of book of zoo enclosures
Pal, Adit (2004)	Zoo Design and Animal Welfare, Zoos print Vol. XIX No. I
Patnaik S.K. (2000)	Designing barriers for zoo animals - A paper presented in zoo directors training programme conducted by S.P.A., New Delhi
Qasim Syed R.	Waste Water Treatment Planning, Design and Operation
Ramachandra T.V. & Shruthi Bachamanda (2007)	Environmental Audit of Municipal Solid Waste Management Internal Journal Environmental Technology and Management Volume 7 Nos. 3/4
School of Planning and Architecture (200)	Compiled Reference Material on Zoo Planning Design and Landscape Architecture
Tiwari G.N. & Ghosal M.K.	Renewable Energy Resources - Basic Principle and Applications

