TECHNICAL INVESTIGATION

5. Baseline criteria

5.1 Principles

The design principles behind the Ethnobotanic Research Centre (EBRC) are based on limiting the pressures placed on one of South Africa's ecological resources; medicinal plants. This positive regional impact should however not be contradicted with EBRC generating a negative large scale impact.

To begin to limit the ecological pressures generated through the built environment, the following criteria set in the Sustainable Building Assessment Tool (SBAT) are to be met. Not all of the criteria listed in the SBAT are mentioned in this thesis as they are management issues that only come into effect once the construction process is finished.

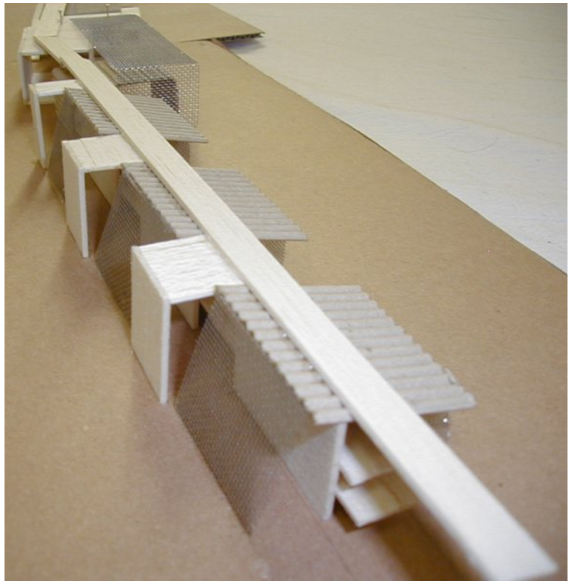
5.2 Occupant Comfort

-Ventilation

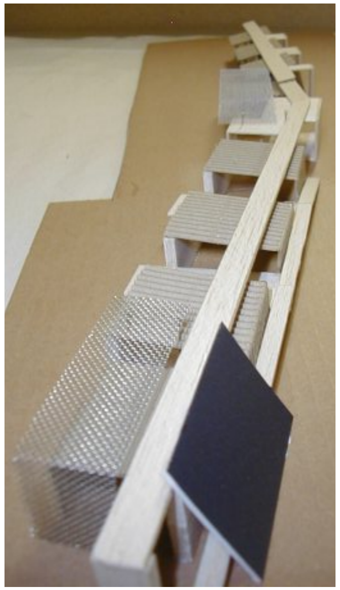
The EBRC is to be ventilated through natural means; the areas that require mechanical ventilation are the physiology labs, chemical store, cold room, kitchens and bathrooms. The chemical store is connected to a separate ventilation system to prevent the spread of chemicals. The physiology labs and cold room need desired temperatures to remain constant and are therefore on a separate HVAC system so temperatures can be controlled accurately.

None of the inhabited spaces in the EBRC exceed a depth of 10metres, which allows for natural cross-ventilation that will occur through fully opening doors and windows. Although Pretoria has very low wind speeds, weather screens will be needed so that windows and doors will never have to be

5.1 Northen perspective [concept model 01]



5.2 Southern perspective [concept model 01]



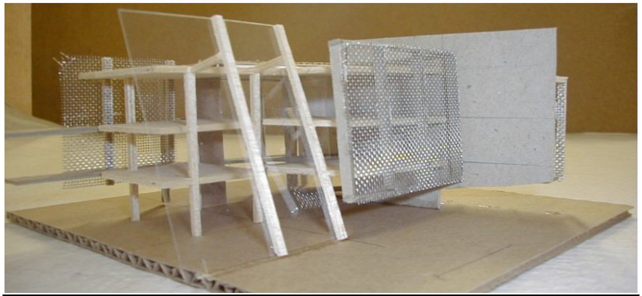
5.3 Perspective [concept model 02]

closed if not wanted. The laboratories are backed by the terrariums, so cross-ventilation will need to be induced through stacks. There is a mechanical backup water cooled system.

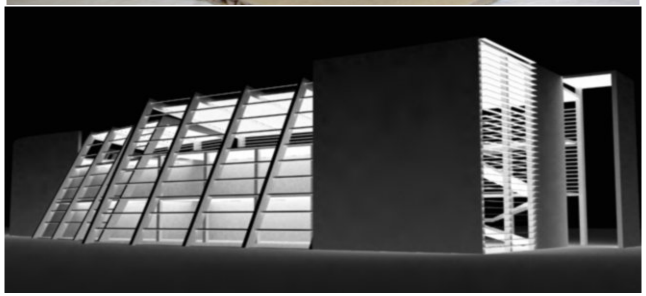
-Thermal comfort

The terrariums serve as a double-glazing system to the laboratories, so maximum natural lighting is provided through the terrariums but because their climates are controlled, high temperatures are not transmitted into the labs. Plant screens enclose the southern façade, creating a cooler outdoor environment in summer and reducing the need to cool the interior. In winter these prevent any cold winds that might occur from penetrating the building.

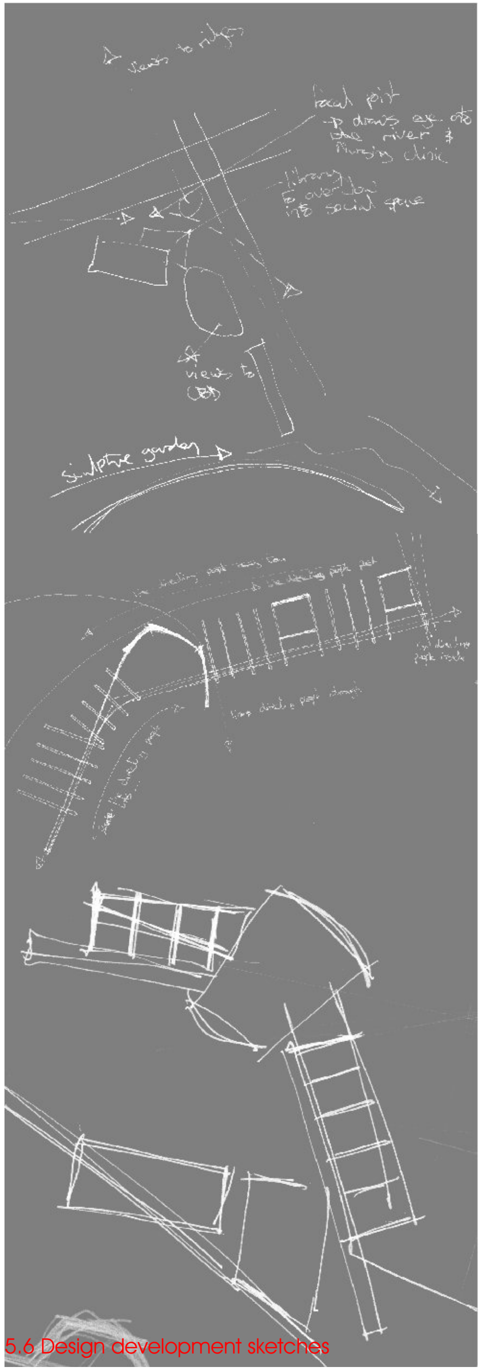
Roof gardens are utilised throughout the EBRC, which help to regulate internal temperatures through insulation and shading. While 60% of the solar radiation is absorbed



5.4 Perspective of first office set [conceptual model 04]

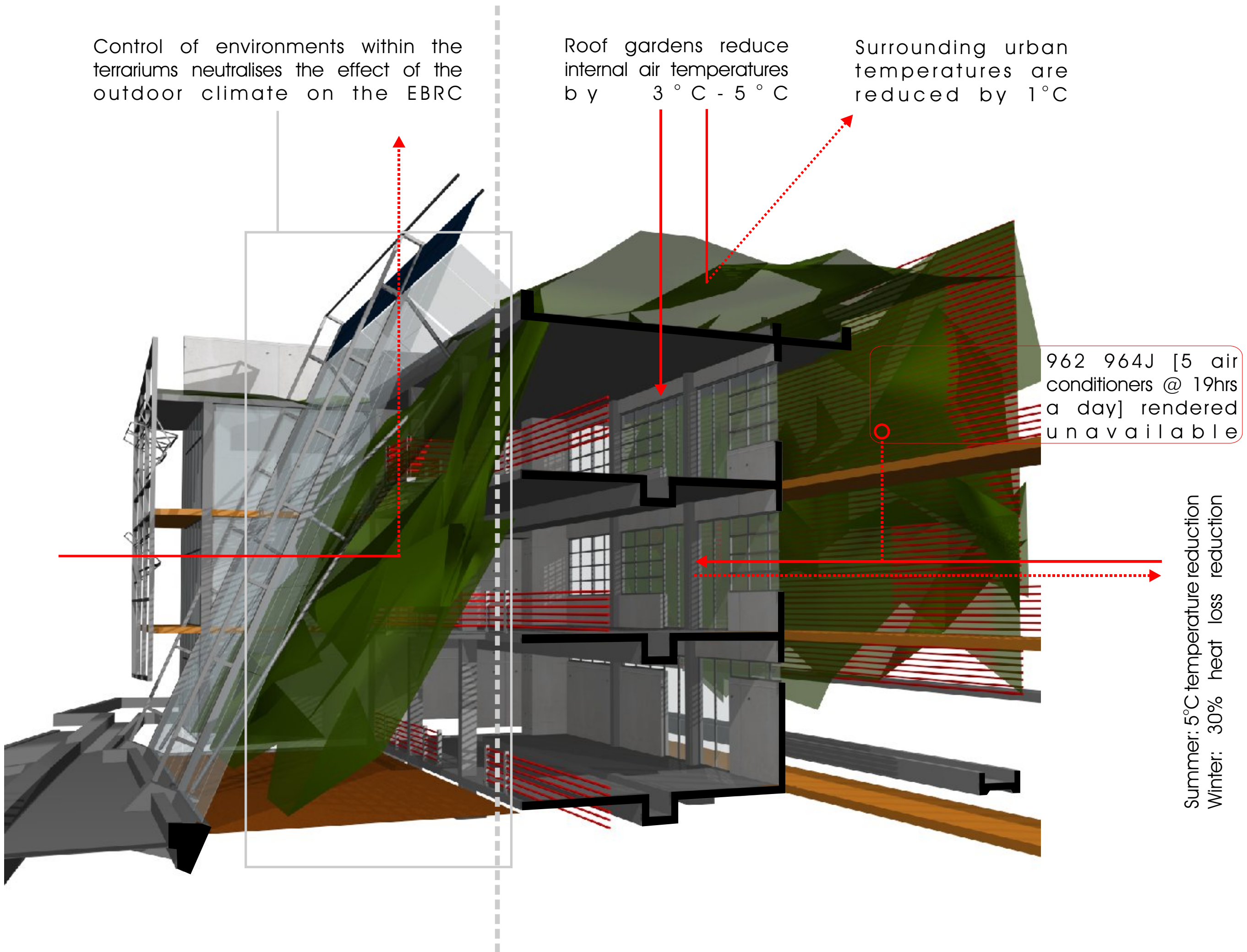


5.5 Conceptual *3D Max* model of first office set



5.6 Design development sketches

5.7 Sectional perspective of final *3D Max* model showing microclimate control



AMALGAM:

MICROCLIMATE CONTROL

through evapotranspiration, exact figures of temperature control are hard to calculate because (Ong B. Lim G, 2002, p3):

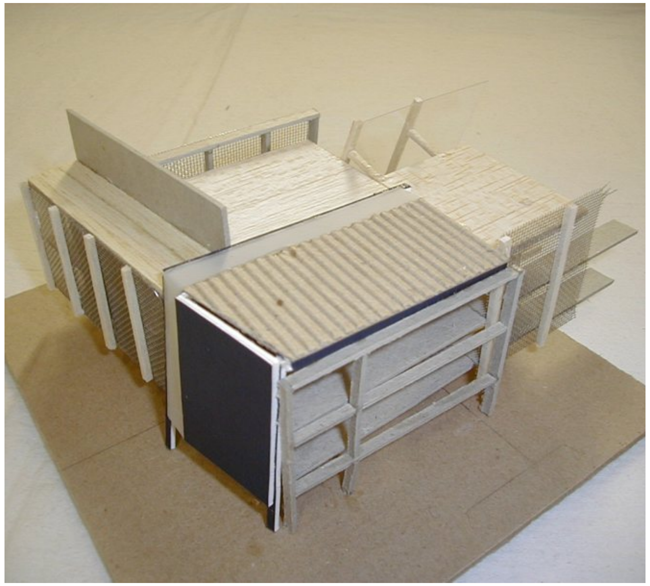
>The soil the plants grow in is not always of consistent density.
>There are usually variable amounts of water in the soil.
>There is a continuous change in root development and soil penetration within the soil.
>There is a continuous change in plant mass and leaf surface area during growth.

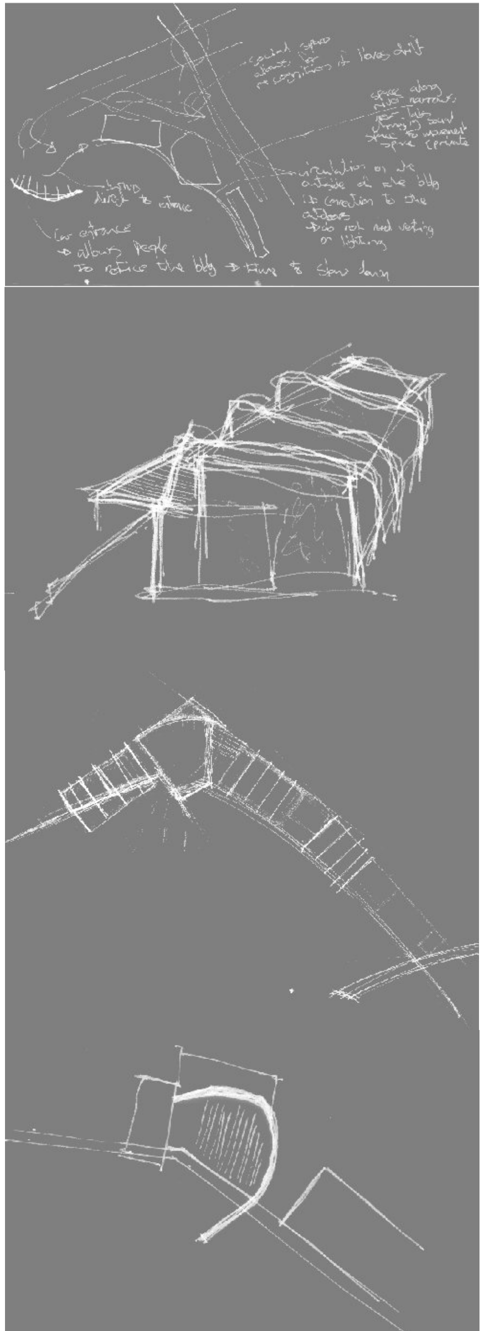
To duplicate the effect of the planted roof, the roof will have to be heavily insulated, shaded and the roof surface aerated. The impact of the plant roofs reduce the internal air temperature by 3°C-5°C and the surrounding urban temperatures by about 1°C (Ong B. Lim G, 2002, p16).

-Lighting

Glare causes high occupant discomfort and occurs when a

5.8 Perspective of entrance [conceptual model 04]





5.9 Design development sketches

bright source is viewed from an area in relative darkness. A room of 3m high and 6m depths should achieve a daylight factor of 1.5-2% at the back of the room to eliminate glare. This is achieved through a 20% glazing to wall ratio (Daniels, 1998, p72).

-Views

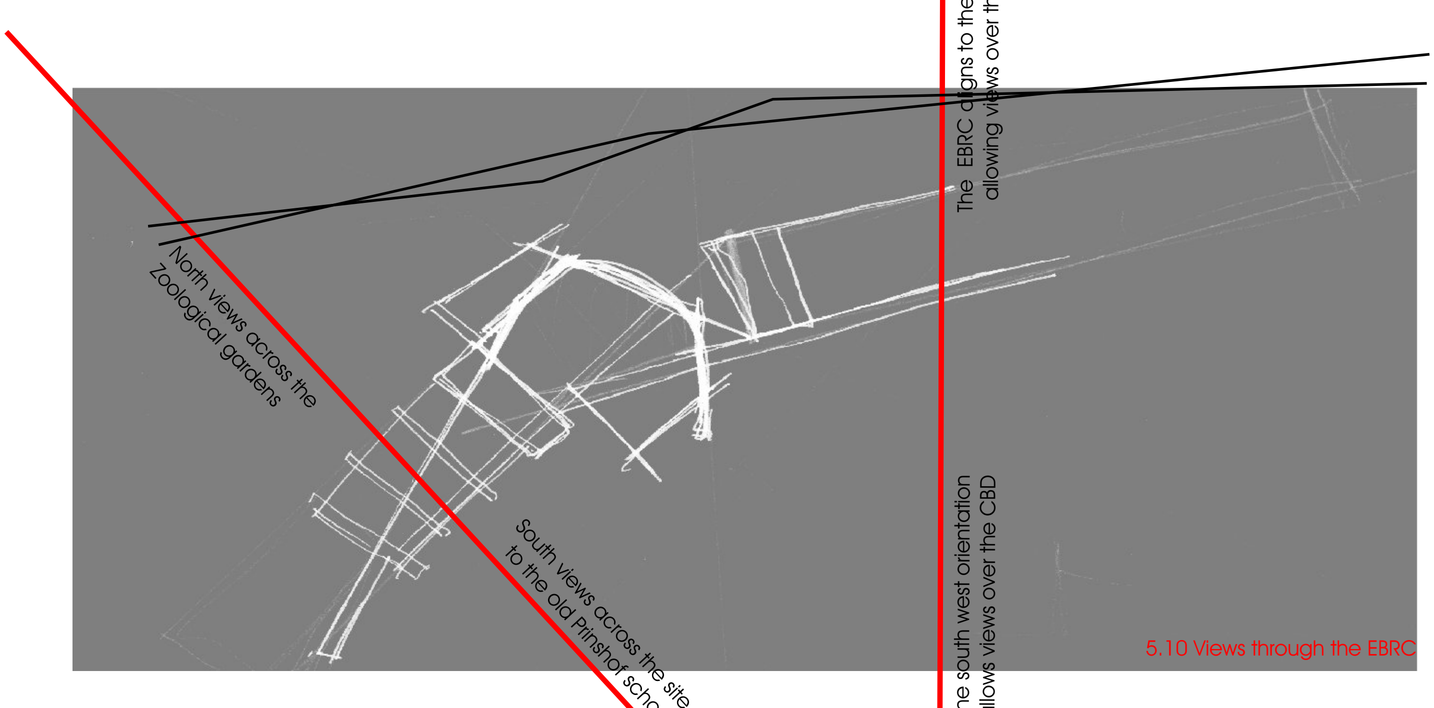
The north / south orientation of the EBRC allows for uninterrupted views up the Apies River and across the Zoological Gardens to the Witwatersberg Range to the north. Views of the CBD skyline are to the south. With part of the EBRC being turned to the river, views eastward through the terrariums of the river and Nursing College are achieved. This orientation provides views in the opposite direction of the old Prinshof School building. The library and café with its outdoor seating space are directly orientated to face the bridge over the Apies River.

-Noise

The only areas of the EBRC susceptible to traffic noise are the laboratories in the western end of the EBRC; however the connected terrarium acts as double-glazing, reducing the traffic noise to below 65dbA. Facilities that are infrequently used, such as the cold room, dark room and physiology labs are placed here.

-Indoor / Outdoor connection

The terrariums create a strong visual connection between the internal and external environments and blur the boundary between the two. Physical connections between the indoors and outdoors are made by having all the ground floor facilities opening and directly accessible to the outside.



5.10 Views through the EBRC

All of the movement through the EBRC takes place outdoors along covered walkways on the southern side of the building, which are enclosed with plant screens.

5.3 Inclusive Environments

-Transport

An informal taxi terminus is located directly across from the EBRC over Dr Savage Street and is proposed in the ARUDF to be converted into a formal public transport terminus. The ARUDF also proposes a bus/taxi stop to the south on Struben Street.

Pedestrian movement is encouraged along the length of the site and between the EBRC and the MRC with safe, well-lit and easily identifiable routes.

-Circulation

The maximum height of the EBRC is 3 stories, so mechanical vertical circulation is unnecessary. A ramp is located at the entrance to the building and two stairwells provides vertical circulation in the middle and at the eastern end of the building. All horizontal movement is located outdoors, preventing the need for any artificial lighting or ventilation. These walkways are weather protected by a number of plant screens.

-Furniture & Fittings

All mechanical equipment is to be located against external walls so that the heat released by the machinery can be transferred through the wall to the outside.

5.11 Proximity of other facilities to the EBRC

5.4 Access to Facilities

-Childcare

The close proximity of the childcare facilities in the Femina Clinic omits the need for facilities in the EBRC.

-Banking

Secure banking facilities are located at the Sancardia shopping mall about 400m away.

-Retail

There are no retail facilities within the EBRC but the ARUDF proposes facilities within the transport terminus across Dr Savage Street.

-Communications

All tenants of the EBRC will have access to Internet facilities in the main library. Major postal services are offered at the main post-office at Church Square, which is located about 1km from the EBRC.
1km from the EBRC.

5.5 Participation & Control

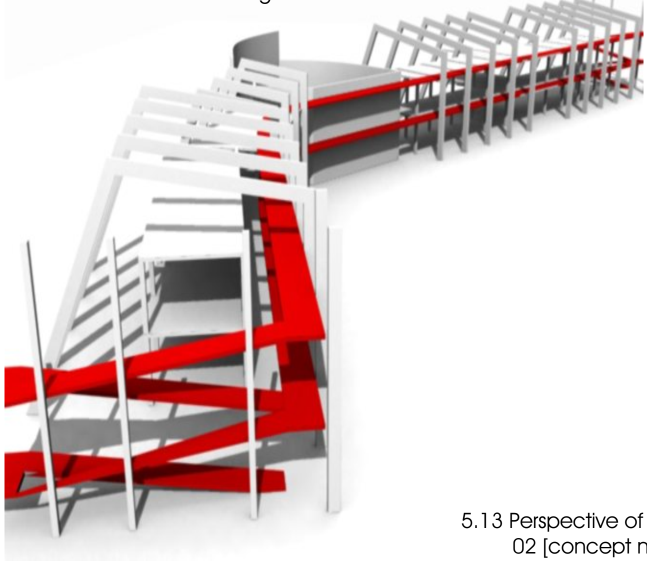
-Environmental control

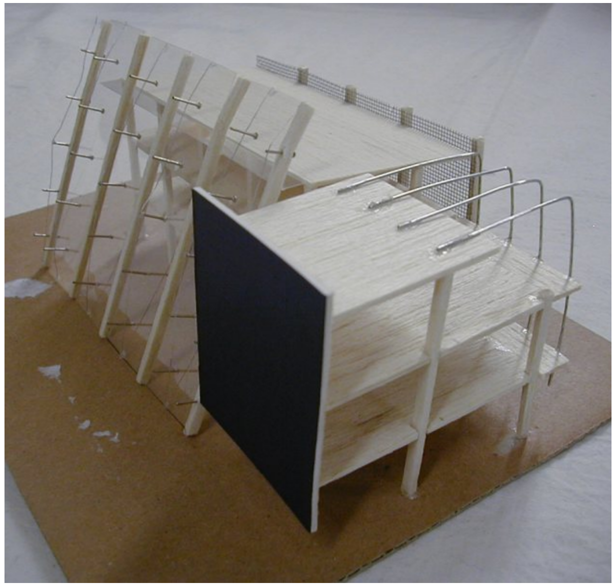
Opening windows and adjustable screens will give occupants a certain amount of control over ventilation and lighting. Task lighting will give occupants control over their immediate space but ambient lighting will be sensor activated at night, which can achieve energy savings between 25-50% (Vishal G. Bansal N, 1999, p81).

-Social spaces

Semi-private space overflows from the cafeteria, with public space adjacent to that along the river. Semi-public spaces overflow from the facilities on the ground floor onto the

5.12 Conceptual 3D Max model indicating horizontal movement through the EBRC





5.13 Perspective of office set 02 [concept model 03] campus gardens.

-Toilets

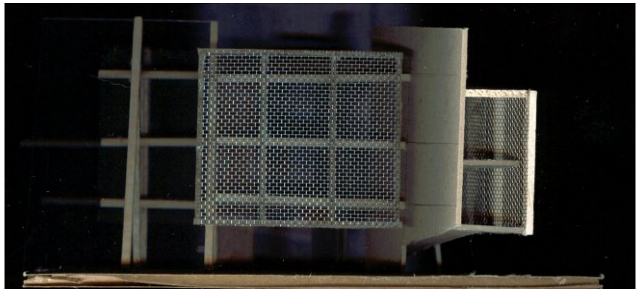
Toilets are located on each floor in the middle of the building, located together.

-Local community

The EBRC is based around awareness of cultures and knowledge transfer so that the community in general is encouraged through the centre. The areas that are physically inaccessible to the public remain visually open so that people are still aware of the activities.

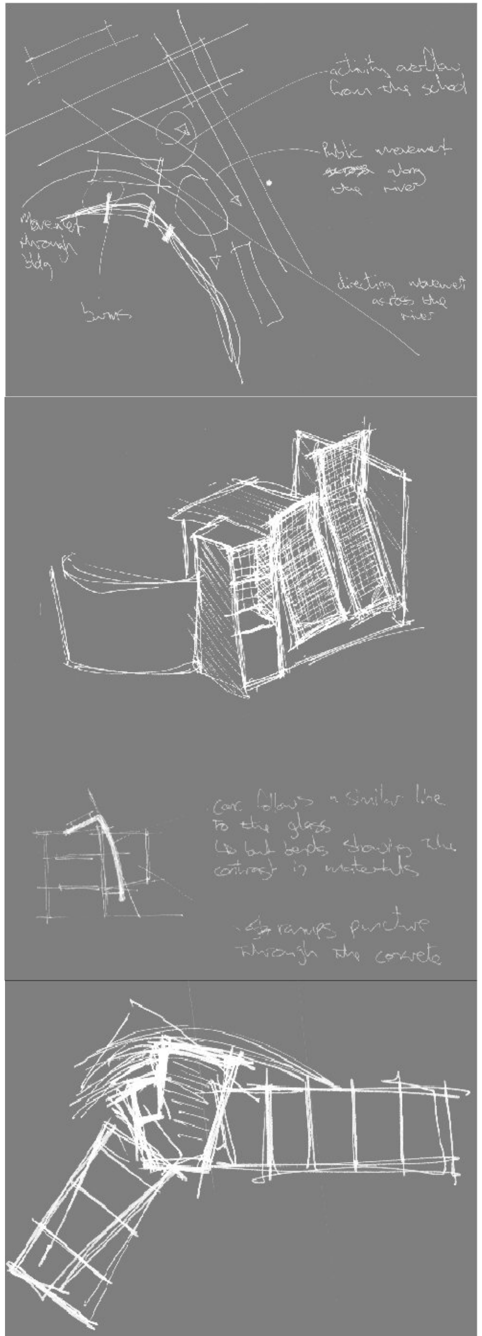
The auditorium is open for public use and the terrariums are open for public viewing. The medicinal plants grown on the site are open to supervised/informed public harvesting.

5.6 Education, Health & Safety



5.14 Elevation of office set 01[concept model 04]

5.15 Southern facade of the auditorium [concept model 04]



5.16 Design development sketches

-Education

Public tours and exhibitions through the EBRC will provide information on medicinal plants, their medical properties, curing properties, parts used, current research findings, etc. A strong emphasis will be made on the origins of use, i.e. the communities that used them, spiritual associations, ceremonies etc.

-Indoor air quality

When the CO_2 content in a room reaches 0,1%, it is considered to be of bad quality. With air intake being from the outside and avoiding the use of re-circulated air, the CO_2 levels can be maintained below 0,1% (Daniels, 1998, p93).

-Exercise & recreation

Large green open spaces that already exist will be retained allowing occupants to utilize.

5.7 Local Economy

-Local contractors

Contractors and workforce based within the Pretoria region will be employed unless expertise from further afield is needed.

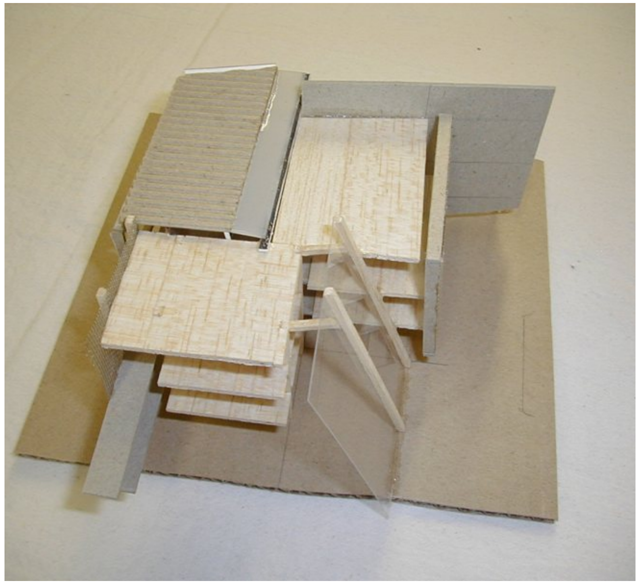
All materials and components are to be sourced within 200km of the site, although certain machinery for the laboratories will have to be obtained from specialised suppliers.

5.8 Efficiency of Use

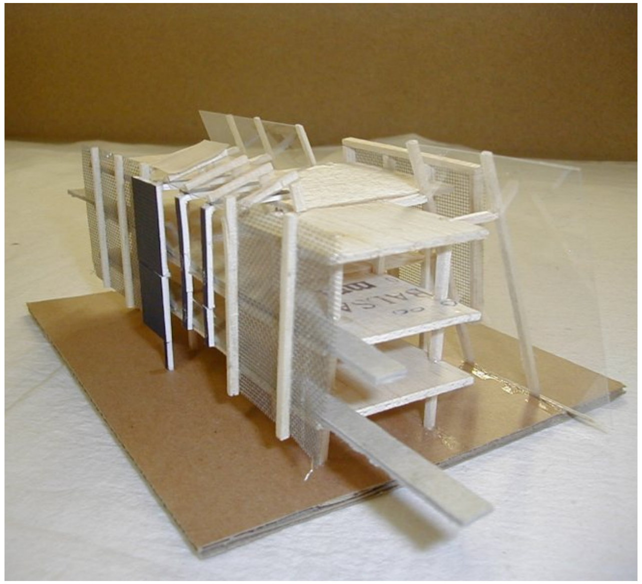
-Occupancy schedule

By integrating the research and general laboratories, use

5.17 Entrance and office set 01 [concept model 04]



5.18 Office set 02 [concept model 04]



thereof will occur after regular working hours and on weekends, creating a possible occupation of more than 50 hours a week.

The library and auditorium too are shared for maximum occupancy and minimum material use.

-Management of space

The offices are the only non-shared working spaces, but are open plan, minimizing the area used and materials needed.

Utilisation of facilities such as the isolated laboratories and waste disposal at the MRC prevents the need for construction of these in the EBRC.

-Disruption & downtime

Photovoltaic panels are used for electricity generation and can serve as backup during power cuts.

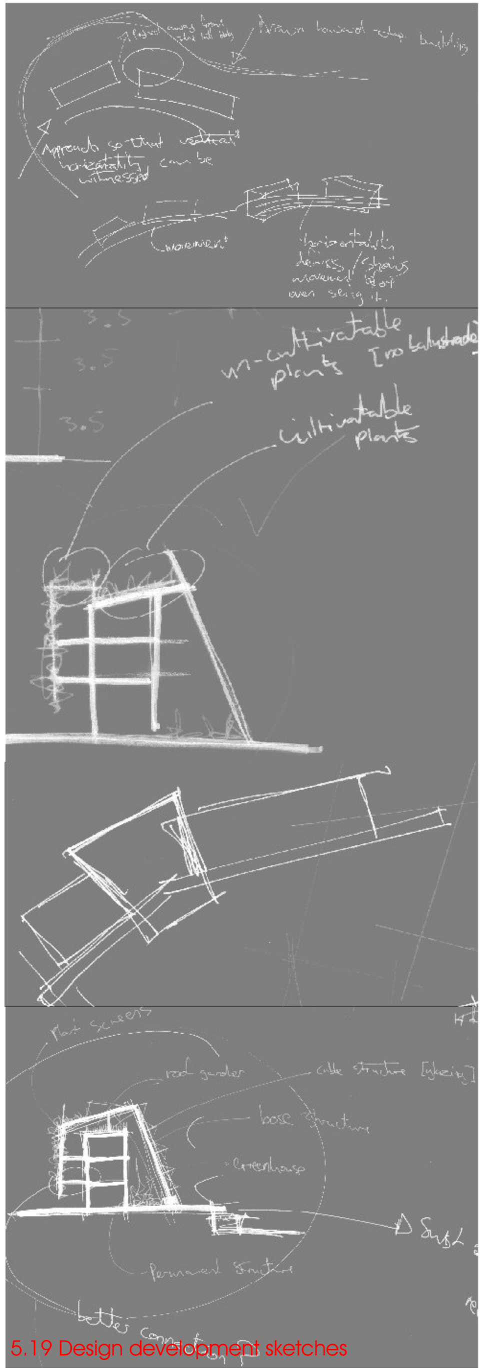
5.9 Adaptability & Flexibility

-Internal partitions

In the Research component the internal partitioning will mostly be of glass, allowing for maximum flexibility, hygiene and natural lighting.

-Structure

The structure is based around a concrete column and slab system on a 5x7m grid. This structure is permanent but allows for flexibility through the infill panels. The terrariums are less flexible in terms of function, but are constructed of an easily dismantled glass and steel structure.



5.19 Design development sketches

-Service spaces

Services run through a series of vertical and horizontal ducts, accompanied by dropped ceilings.

5.10 Capital Costs

-Use of existing

Facilities at the MRC will be shared by the EBRC and vice versa.

-Shared cost

The cost of the EBRC is shared between 4 parties, the MRC, University of Pretoria and the Department of Arts and Culture and Science and Technology. This obviously decreases the individual cost but could create problems with ownership in the future.

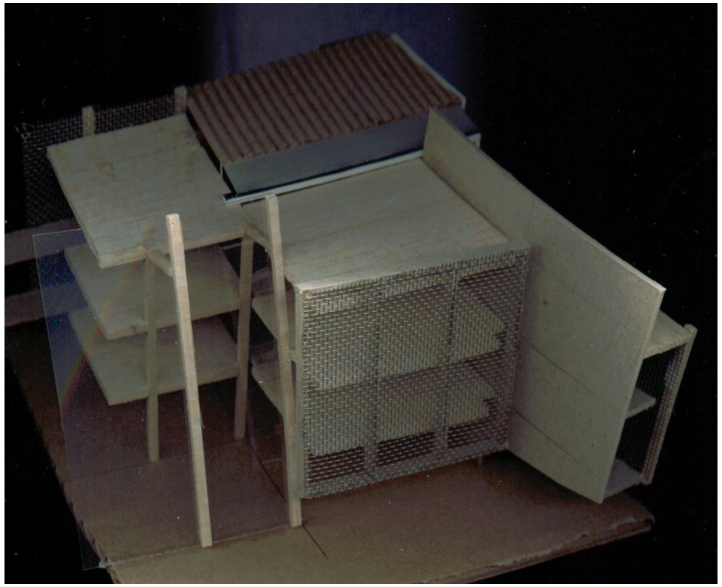
5.11 Water

-Rainwater

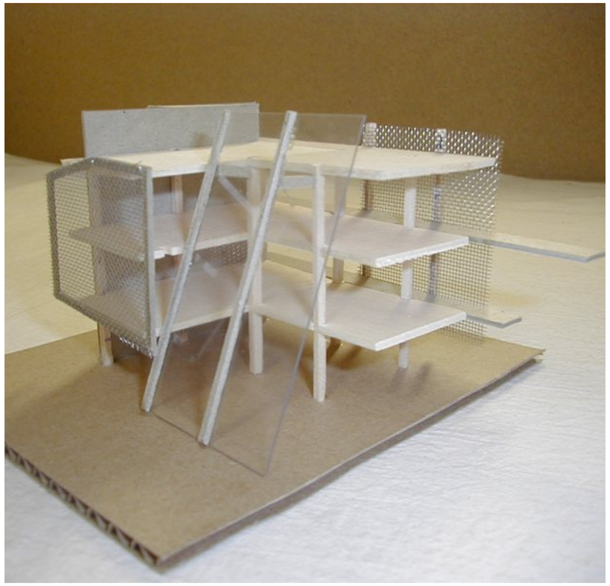
The relatively high amount of vegetation throughout the project requires large amounts of irrigation, it is therefore important to collect as much rainwater as possible. Throughout the site, 8 528kl of water can be collected annually from the roofs of existing buildings alone. This rainwater would otherwise be drained off the site, whereas there is a possibility of collecting that water and releasing it when needed for irrigation. The annual amount of rainwater that can be collected as runoff from the roof gardens is indeterminable as many factors influence this, namely:

>Amount of rainfall in one shower
>Amount of water retained in the soil
>Dryness of the soil
>Amount of vegetation

5.20 South east perspective of ramps [concept model 04]



5.21 Perspective of office set 03 [concept model 04]



Any excess rainwater from the roofs, walkways and landscaping will be directed into the wetland and gray water system, recycled and used for irrigation.

Total amount of collected rainwater:

=collection area x annual rainfall
=1 2183m^2 x 700mm/year
=8 528m^3 / year
=8 528kl / year

Size of rainwater storage A
=collection area x highest months rainfall
=5 112m^2 x 136mm for January
=659m^3

Size of rainwater storage B
=collection area x highest months rainfall
=5 367m^2 x 136mm for January
=729m^3

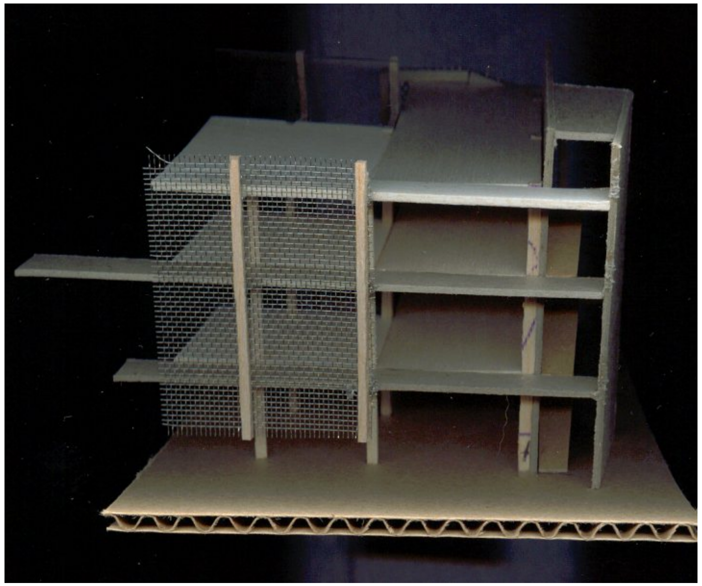
Size of rainwater storage C
=collection area x highest months rainfall
=1 700m^2 x 136mm for January
=231m^3

-Gray water

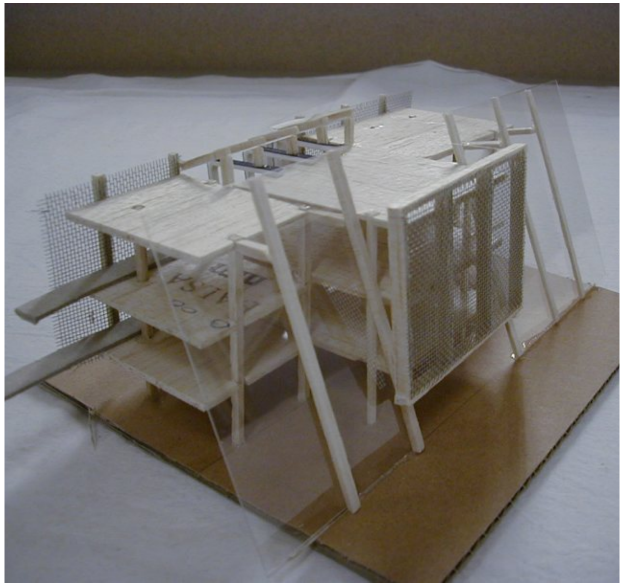
Water from the wash basins will be directed into the wetland, but it is important that organic soaps are always used as a high concentration of soap can kill the aquatic plants. Water from the kitchen will pass through a fat and grease trap before being fed into the wetland. If not, the grease will prevent the water from being aerated and the plants will suffocate. Runoff water from the terrariums and cultivated areas can be directly put into the wetland to get rid of any fertilizers.

The aquatic medicinal plants that are cultivated for research purposes will be grown in the last sections of the wetland system so that they are grown in relatively clean water.

5.22 Southern facade of office set 03 [concept model 04]



5.23 Perspective of office set 03 [concept model 04]



Water consumption:

20l cold water x 137 people per day
=2 740 l/day
and

3l hot water x 137 people per day
=411 l/day

Total water use
=3 151 l/day
=1 150kl/year

The size of the wetland will need to be:

3 151l/day for 7 days (for absorption)
3,15m^3 x 7
=22.05m^3 liquid volume
(this is only 25% of the space, 75% is needed for aggregate and roots)
=22.05m^3 x 4
=88.2m^3
(A depth of 600mm is the maximum depth for absorption, but the depth will be inconsistent for different plant varieties, so an average depth of 300mm will be assumed)
V= A x D
A= 88.2/0,3
A= 294m^2

This is the minimum size of the wetland as an area is needed for aquatic plant propagation.

-Runoff

Impermeable surfaces are limited to walkways and social spaces on the eastern side of the EBRC. Permeable paving is used for parking, this allowing for water to filter back into the water table, which has already dropped due to interference (see appendix C).

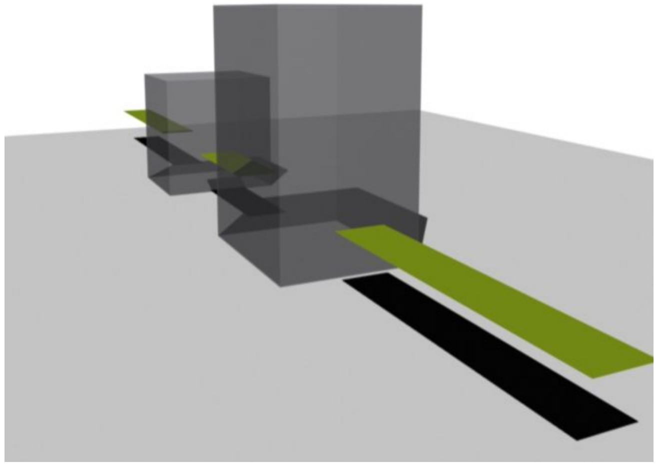
-Planting

Indigenous medicinal plants will be used for soft landscaping as much as possible, reducing the amount of water needed for irrigation.

The water needed for irrigation is:
20mm water per week per m^2
=0.02m / week / 14 000m^2
=280m^{3}/ week
= 14 560kl / year

9 678kl of this amount can be used from the wetland while 8 528kl can be used from collected rainwater. This leaves an excess of 3 646kl that can be used in the toilets or returned to the Apies River depending on the season.

5.24 The footprint is replaced by being elevated onto the building. The biodiversity link is broken, however does allow for some species interaction



5.12 Energy

-Environmental control

By pulling the biophysical environment into the interior of he EBRC, internal cooling can largely be increased. Through transpiration, one large tree can eliminate 962 964J of energy. The mechanical equivalent would be 5 average room air conditioners running for 19 hours a day (Lorch, 1998, p136). The difference being that air conditioners only transfer heat from the interior to the exterior, thus raising the urban heat island, whereas plants render the heat unavailable.

-Appliances & fittings

15W fluorescent light bulbs are used instead of regular 75W light bulbs. The lux provided is the same but the fluorescent bulbs produce 60W less heat energy (Aal, 2002, p7).

Throughout the EBRC, reduced flow-rate taps are used which contain a spray nozzle that reduces the water flow rate by 70% (Edwards, 1999, p123).

6l-flushing toilets are used instead of the regular 7.5l toilets.

-Energy sources, Renewable energy

25m^2 of Photovoltaic panels are incorporated into the terrarium facades.

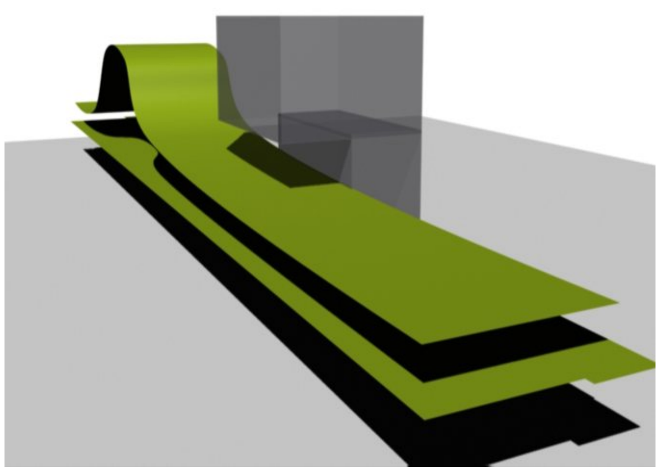
5.13 Waste

-Organic waste

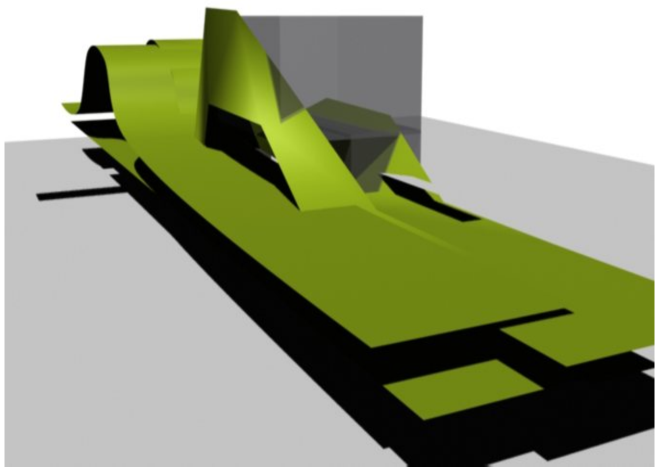
Organic waste from the building as well as biomass left over from research and cultivated plants will be collected on site and used as compost for the plants grown at the EBRC.

-Inorganic waste

5.25 The existing biophysical footprint will be disrupted by the building



5.26 By not limiting this to roof gardens, there is an opportunity for different plant species and further microclimate adjustment



Inorganic waste will be sorted on site at the source through the use of recycling bins.

-Toxic waste

Contaminated and chemical waste produced through research is to be delivered to the MRC (to maximise the efficiency of waste disposal).

5.14 Site

-Brownfield site

Although the EBRC is not built on a Brownfield site, it takes up 4 223m² of cultivated lawns that require high-energy inputs and contain few biophysical ecosystems. The EBRC will contribute at least 10 000m² of indigenous shrubs and trees that would otherwise not have existed on this site.

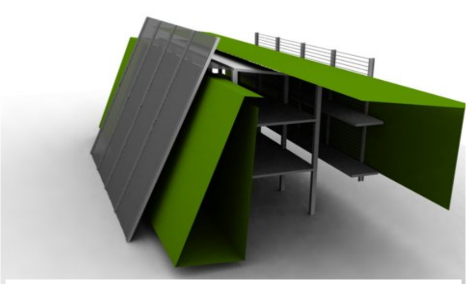
-Ecosystems

Roof gardens replace the biophysical footprint now occupied by the EBRC and attempt to continue the existing biodiversity link along the river. This allows for some extent of species interaction and migration. The main function of the roof gardens is to serve as a venue for plant propagation of medicinal plants for research. By placing these plants on the roof they are protected from accidental damage from passers-by.

-Landscape inputs

Most of the landscaping is biophysical, limiting the need for fertilizers, pesticides etc. These species also produce about 20 times as much oxygen as a cultivated lawn.

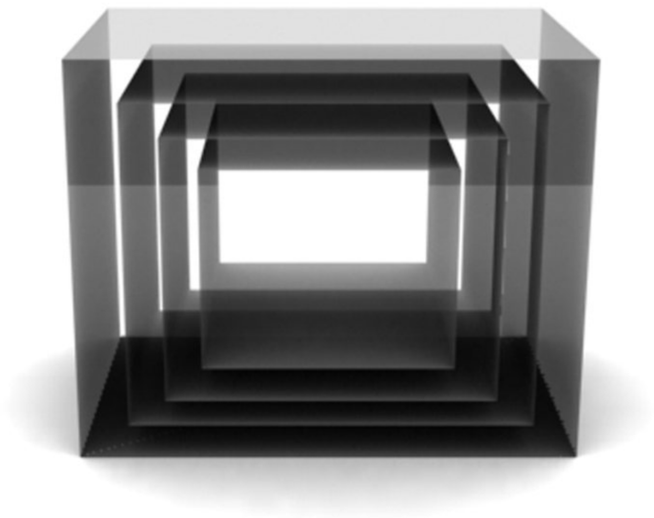
Vegetation on and around the building can improve the microclimate surrounding the EBRC reducing the need for climate control within the building. Façade planting will



5.27 Conceptual *Max model* of terrariums

5.28 Conceptual *Max model* of plant screens and roof gardens

5.29 The building is to made-up of a series of independent layers



reduce temperatures in summer by as much as 5°C as warm air that passes through the plants is cooled through evapotranspiration before it enters the building. This works by; cooling the air within the plant canopy which gets transferred to the building, cooling the surrounding air temperature and cooling the plant surface lowering the radiant temperature.

In winter the planted façade can reduce heat loss up to 30% by forming an insulating layer of air trapped within the overlapping leaves (Lorch, 1998, p135).

5.15 Materials & Components

-Material / Component Sources

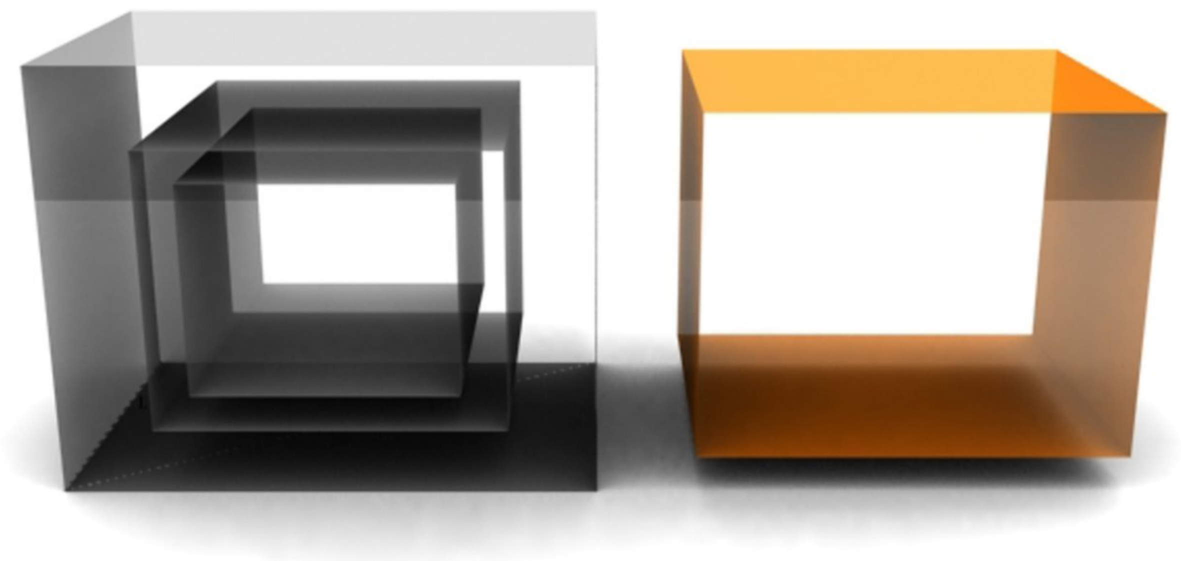
The EBRC is designed for the direct re-use, or 'assembly for disassembly' concept. The principles behind this are (Berge, 2000, p12):

>Separate layers:
The building is made up of layers such as the site, structure, skin, services etc. If the layers need to be renewed, because of their nature, renewal will occur at different periods during the building's life cycle. Each layer is independent from the others allowing for replacement of that layer only.

>Disassembly within each layer:
Components of each layer need to be 'loosely' connected and replaceable. This allows for easy removal and recycling of worn components instead of replacing the entire layer or even building.

>Monomaterial components:
Different materials decay at different rates; when a component consists of more than one material this can lead to premature replacement of that component

5.30 This allows for renovation or removal of that layer only



because one of its materials is worn out. Re-use also becomes difficult, as it is hard to check the quality of composite or laminated materials. It is therefore important that monomaterials are used.

-Steel

Steel is one of the main structural components. It is also used for shading devices, hand railing etc.

Steel generates relatively high waste numbers during production at 601g/kg and 5% of that needing to be taken to special dumps (Berge, 2000, p36). Iron used in the manufacture steel is found near the earth's surface and is extracted through open quarries, which results in large ecological scars and disruption of ecosystems (Berge, 2000, p75).

Steel is protected through zinc coating and galvanizing, both of which are considered as serious environmental polluters. Steel can however be galvanized through an almost pollution free process by electrifying steel which is immersed in sea water, the natural magnesium and calcium forms the protective 'galvanizing' (Berge, 2000, p77). Steel does have a high recycleability value:

>Re-use:
Steel members can easily be disassembled and re-used

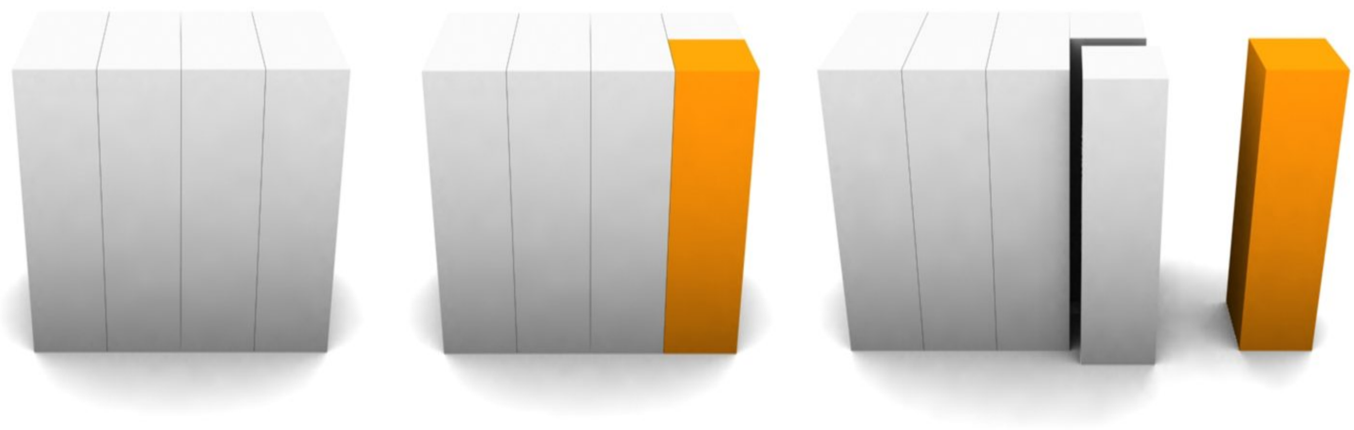
>Recycling:
Steel can be melted-down and remoulded into other components

>Energy recovery:
Steel has no energy generating qualities.

-Concrete

During production fired clay bricks generate 87g/kg of waste and have an embodied energy of 6kJ/Kg, while concrete

5.31 Disassembly within each layer allows for the repair of damaged components without having to replace the entire layer



generates only 32g/kg of waste but has a higher embodied energy of 13kJ/kG. Concrete is used instead of brick on the basis of waste.

>Re-use:
Re-use of in-situ concrete is almost impossible, especially if it is reinforced with steel. Pre-cast members can be reused and are very durable, but larger components become very heavy and need machinery to be moved.

>Recycling:
As with bricks, concrete can only be broken-down into a state used for aggregate.

>Energy recovery:
Concrete has no energy generating qualities but can be used as a heat store.

-Other

Asphalt is used instead of bitumen for waterproofing, as they have an energy consumption of 3MJ/kg and 11MJ/kg respectively (Berge, 2000, p143).

Wool insulation is a renewable resource with a very high thermal capacity at 1.8Kj/kgK. Lower quality wool, which would otherwise be wasted, is to be sourced (Berge, 2000, p299).

5.32 Perspective of terrariums and the labs behind [concept model 04]

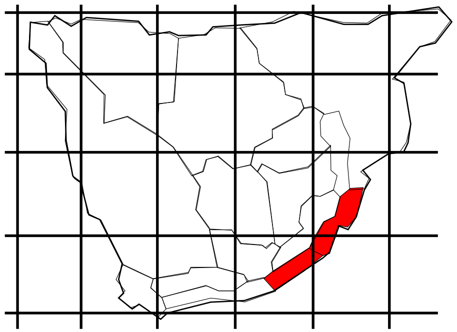
6.1 Climatic Zones

There are three terrariums in the EBRC, each containing two similar climatic zones of the nine zones found within South Africa. These terrariums allow for plant propagation, and therefore experimentation on medicinal plants from around the entire country. Because each climatic zone is different, the 'internal' façade that separates the terrariums from the laboratories will need to be resolved accordingly. Best practice construction technologies from those regions will emerge as appropriate solutions, but it is important to maintain large openings for natural day lighting.

The first terrarium simulates the South-East Coast and Sub-tropical climatic zones. Within these zones temperatures are constantly high and are often 5°C above the comfort zone. Relative humidity can reach 70% and will cause discomfort. The daily temperature range is small at 9°C; this makes temperature control through thermal mass ineffective. For effective temperature control into the laboratories, the façade needs to be of low mass and high insulation. There should be no opening windows so as to avoid the high humidity levels. As with all the terrariums, this terrarium should face north for maximum solar transmittance. However it could face slightly west so that it receives the last solar transmittance of the day, as warm temperatures need to be maintained through the night. For this reason thermal screens will be needed.

6.01 *Acorus calamus*

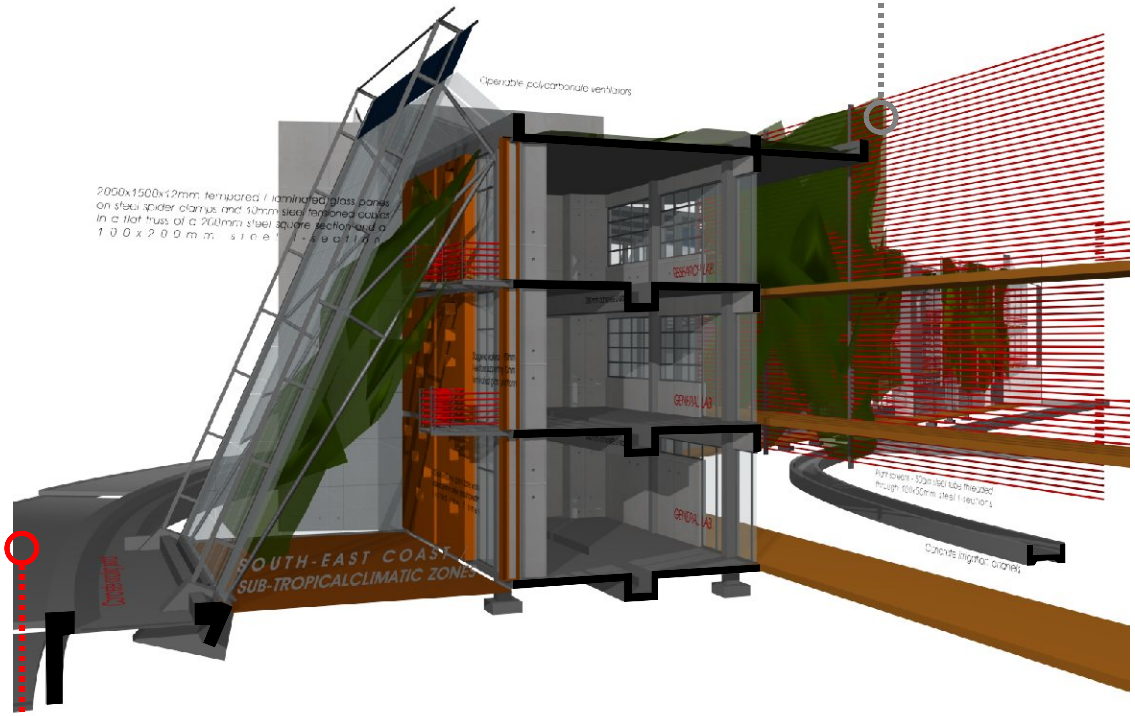
6.02 *Berula erecta*



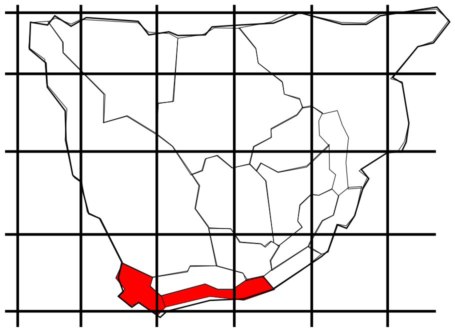
6.03 South-East Coast and Sub-Tropical climatic zone

6.04 *Stangeria eriopus*

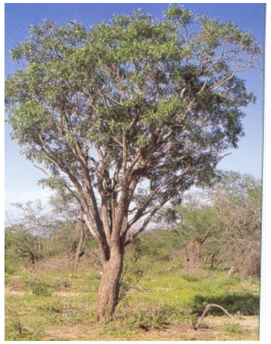
6.05 *Rauvolfia caffra*



6.06 Sectional perspective of final *3D Max* model showing
the South-East Coast and Sub-Tropical terrarium

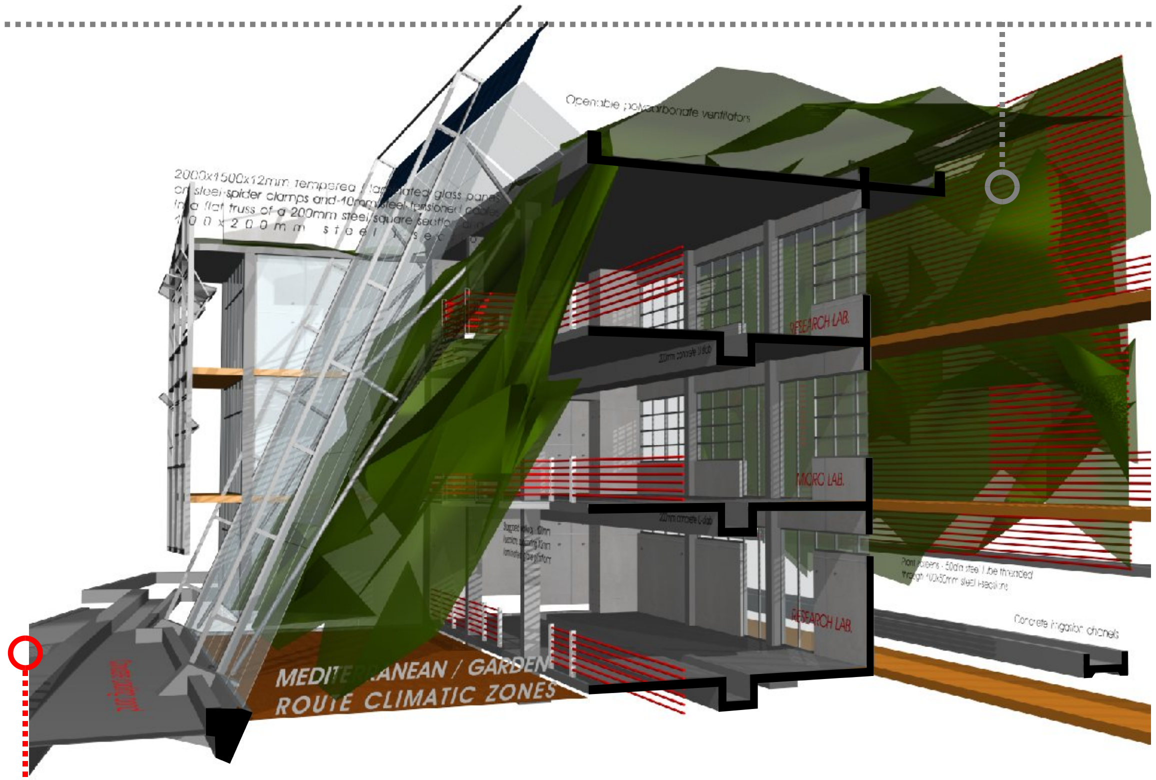


6.07 Mediterranean and Garden Route climatic zones

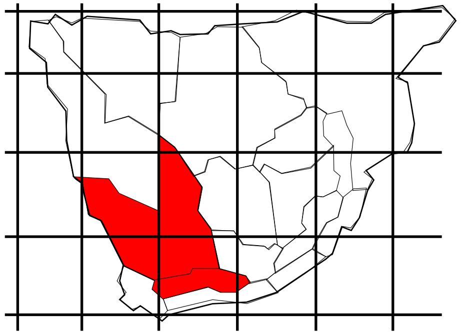


6.08 *Ptaeroxylon obliquum*

6.09 *Rapanea*



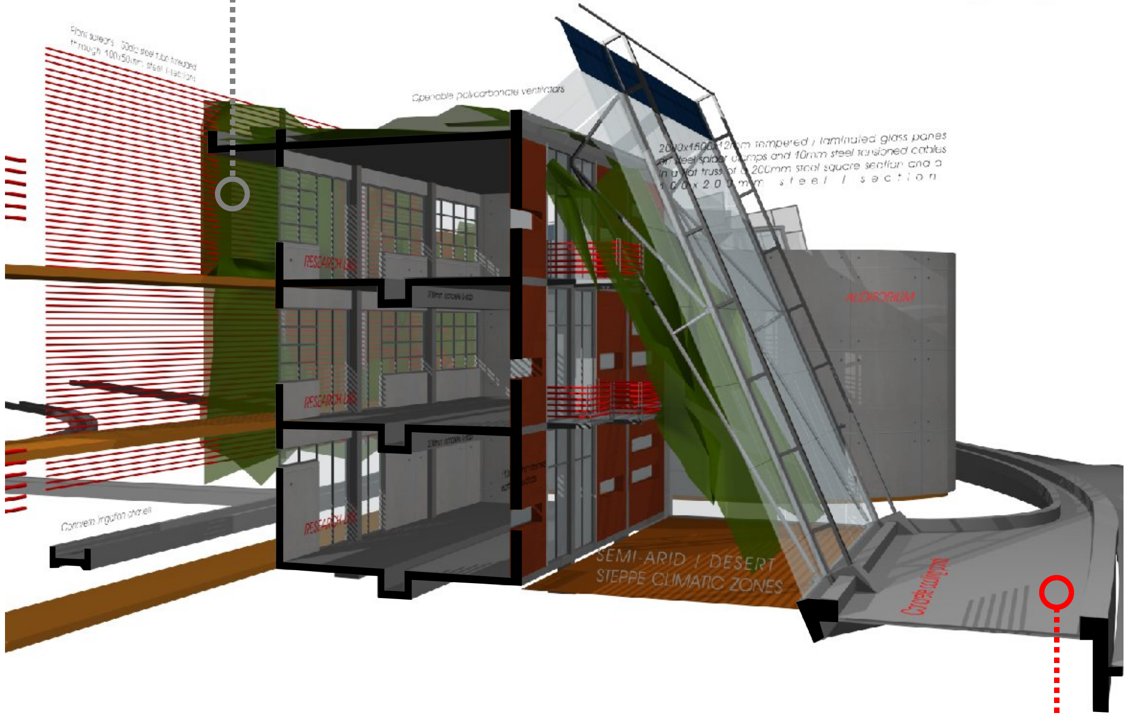
6.10 Sectional perspective of final *3D Max model* showing
the Mediterranean and Garden Route terrarium



6.11 Semi-Arid and Desert Steppe climatic zones

6.12 *Viscum capense*

6.13 *Aspalathus linearis*



6.14 Sectional perspective of final *3D Max model* showing the Semi-Arid and Desert Steppe terrarium

The second terrarium simulates the Semi-Arid and Desert Steppe climatic zones. These zones have very high average temperatures with large temperature swings of over 18°C. The summer day temperatures can extend above the comfort zone by 8°C and winter night temperatures below by 20°C, so thermal screens will not be necessary. The average monthly humidity level is around 55%, which falls within the comfort zone, this allows for opening windows between the terrariums and laboratories. The large diurnal swing means that high mass construction will effectively contribute to thermal damping. Moisture penetration is not an issue due to the low amount of precipitation and humidity.

The third terrarium simulates the Mediterranean and Garden route climatic zones. The average relative humidity of the Mediterranean zone is 54% and 62% for the Garden Route zone. For this terrarium the humidity levels will be allowed to fluctuate between the two, but not exceeding the comfort zone. The day temperatures are moderate and remain within the comfort zone, while night winter temperatures can fall 14°C below the comfort zone. However if a thermal screen is periodically used when needed (if the laboratories are inhabited at night) then there is no need for any façade between the terrarium and laboratories. High mass construction could be used for thermal damping, but a more desirable environment is created with no construction at all.

Note needs to be taken of the possibility of the climatic

6.15 *Dioscorea dregeana* 6.16 *Bowiea volubilis*

zones within the terrariums changing if research required a different zone. The façade between the terrariums and laboratories should therefore be constructed of cheap, easily dismantled materials.

6.2 Landscaping

The plants on and around the EBRC and especially those within the terrariums are grown for research purposes, so the species of plant will depend on the research being done. The following are therefore just examples of the types of plants that may occur.

In the Mediteranean and Garden Route terrarium: *Rapanea melanophloeos* (Cape beech), *Ptaeroxylon obliquum* (Sneezewood)

In the Semi-Arid and Desert Steppe terrarium: *Aspalathus linearis* (Rooibos), *Viscum capense* (Cape mistletoe)

In the South-east Coast and Sub-tropical terrarium: *Rauvolfia caffra* (Quinine tree), *Stangeria eriopus* (Stangeria)

Climbing plants: *Bowiea volubilis* (Climbing potato), *Dioscorea dregeana* (Wild yam), *Centella asiatica* (Pennywort)

The plants in the wetland, especially those in the top portions of the wetland are grown to cleanse the water, so they would not necessarily, but could be medicinal. In the lower ponds, where aquatic medicinal plants would specifically be grown, the following could be used: *Typha capensis* (Bulrush), *Berula erecta* (Water parsnip), *Acorus calamus* (Sweet-flag).