Technical refinement 6

6.1 Introduction

The refinement of the design to make Pretoria Works a productive landscape is based on the development of its phenomenological spatial qualities of water. These qualities guide the investigation of water-treating and water-harvesting systems, plant strategies, the natural swimming pool design, construction material choice and the aquaponics production system to be applied to the site.

6.2 Water treating and water harvesting systems

The design makes use of treated industrial waste water that requires tertiary treatment before it can be used for agriculture, aquaponics and/or human recreational activities. During the industry's downtime, the emphasis of the design is on harvesting rain water, water from the natural stream coming from the ridge and water from the nine boreholes on-site. The constructed wetlands utilise phytoremediation for treating heavy metals of industrial effluents before the water can be used.

The international firm, Integral Climate Change Solutions (ICCS 2018), participated in a project at the Official Visitor Centre of the Cradle of Humankind World Heritage Site to design and construct a wetland to filter and cleanse the site's waste water (see figure 6.2). The cleansed water is released into a dam – attracting a variety of bird- and wildlife to the surroundings – and is then used for irrigation (Maggs 2011). The plant strategy for the constructed wetland makes use of a variety of reeds. The most common being *Phragmites australis*, which grows naturally in many parts of South Africa's wetlands (SALGA 2016:27) This plant species is also used at the Cradle of Humankind because it is fast-growing and can tolerate and clean heavy metals from metal-contaminated sites (Rai 2009:717). For these reasons, this particular plant has been considered for the wetland at Pretoria Works.

Apart from the treated industrial waste water, the proposed design needs to also cater for the harvesting of rain water through the use of retention dams. The evaporation of these dams can be reduced by making use of a Water Evaporation Prevention (WEP) System (a modular floating surface cover). This system is designed and manufactured in South Africa, with its main aim to reduce the effect of water evaporation in a cost-effective manner (The Southern Cape Landowners Initiative [SCLI] 2018). These dams will fill the construction wetlands that form part of a catchment area (see figures 6.3-6.5).

It is important to remain cognisant of the possibility that storm water run-off from hard surfaces (e.g. parking lots and walkways) can collect floating debris. This necessitates the use of a trash trap to remove the floating debris, as well as an oil and grease trap to remove contaminants that are lighter than water before the water flows into an additional constructed wetland for future use.

Appendix A contains a calculation for the total rain water harvest gained through the sedimentation dams that form part of a catchment area.

Fig 6.2 The constructed wetland at the Cradle of Humankind (Maggs 2011)

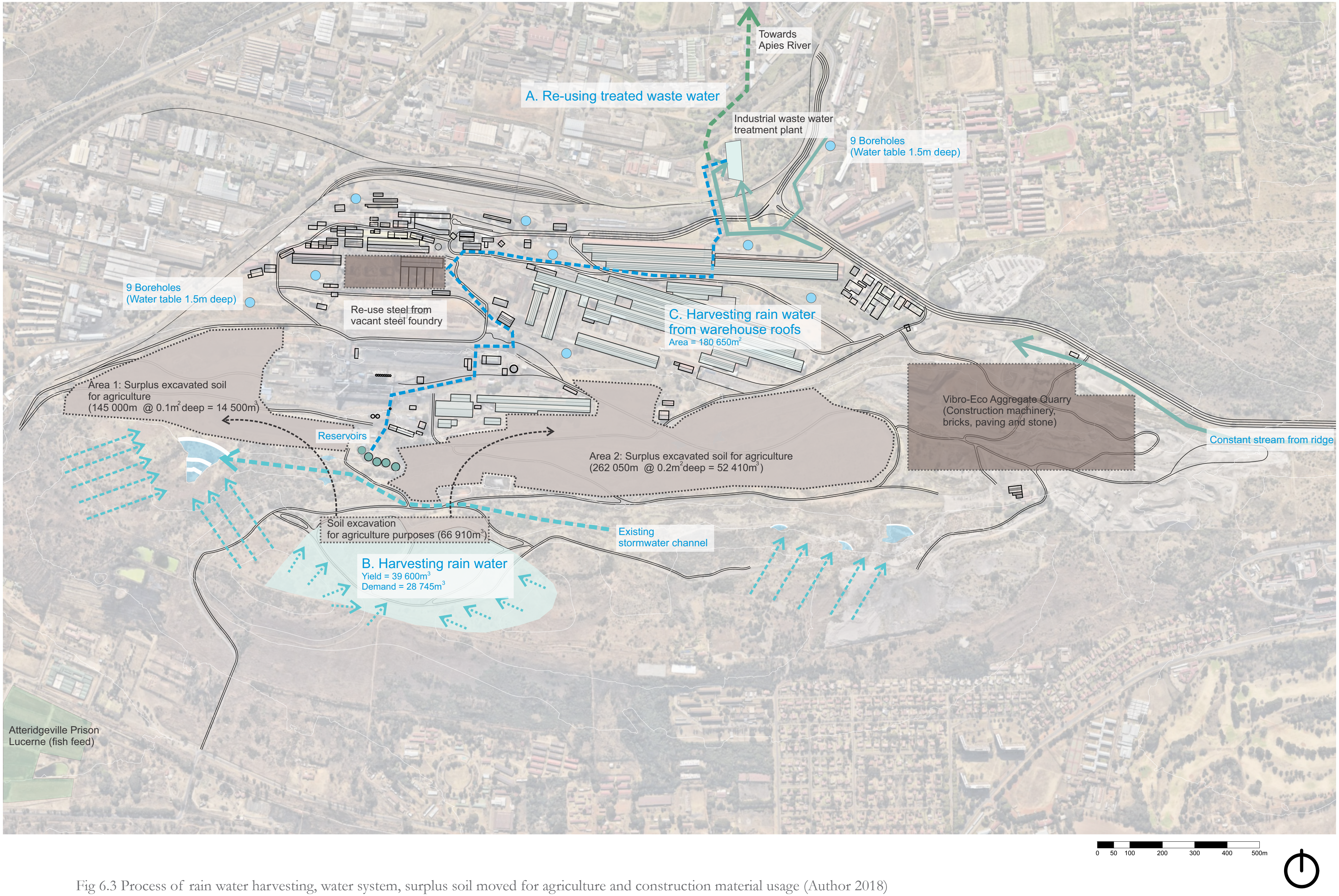


Fig 6.3 Process of rain water harvesting, water system, surplus soil moved for agriculture and construction material usage (Author 2018)

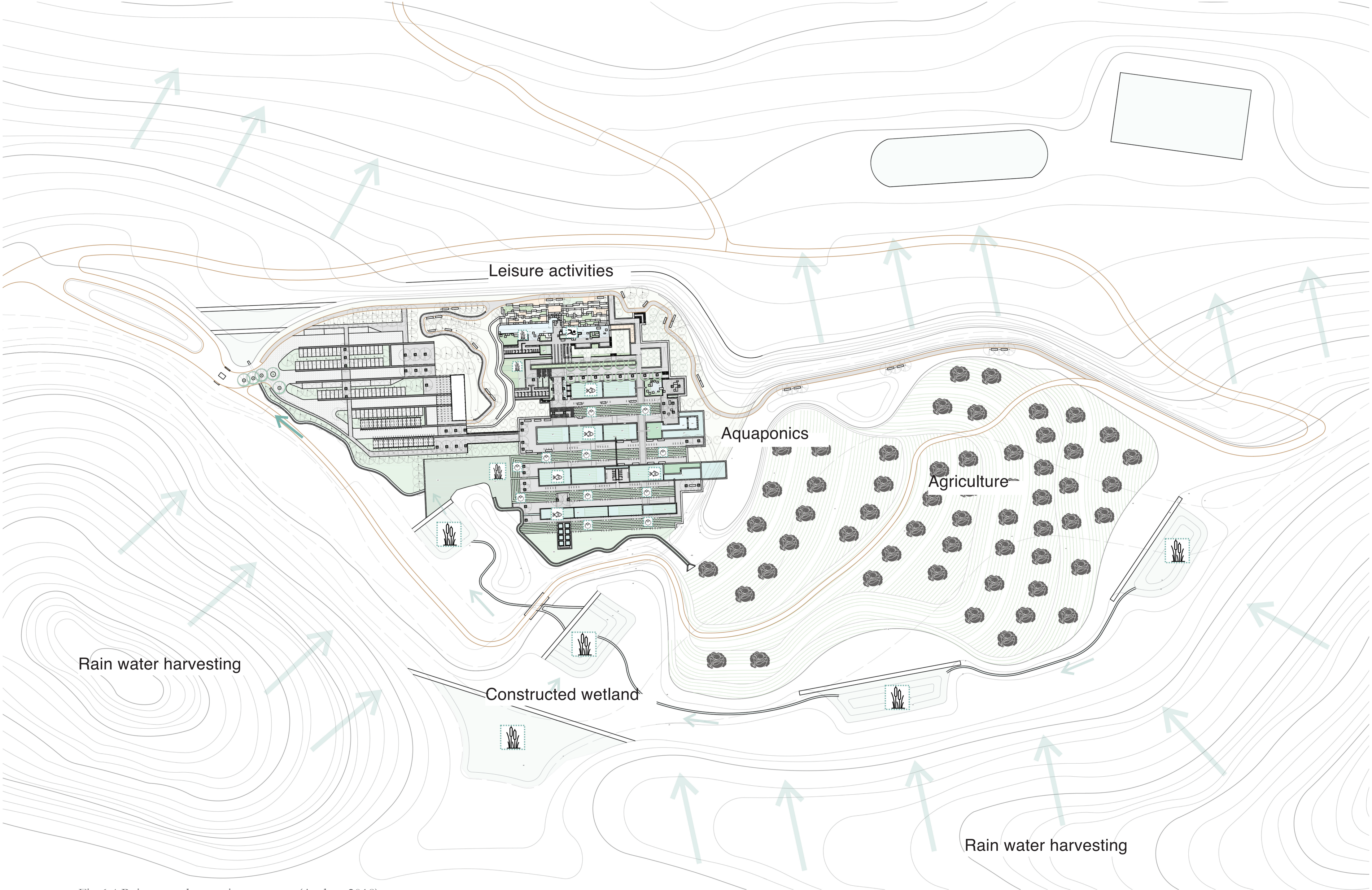


Fig 6.4 Rain water harvesting strategy (Author 2018)

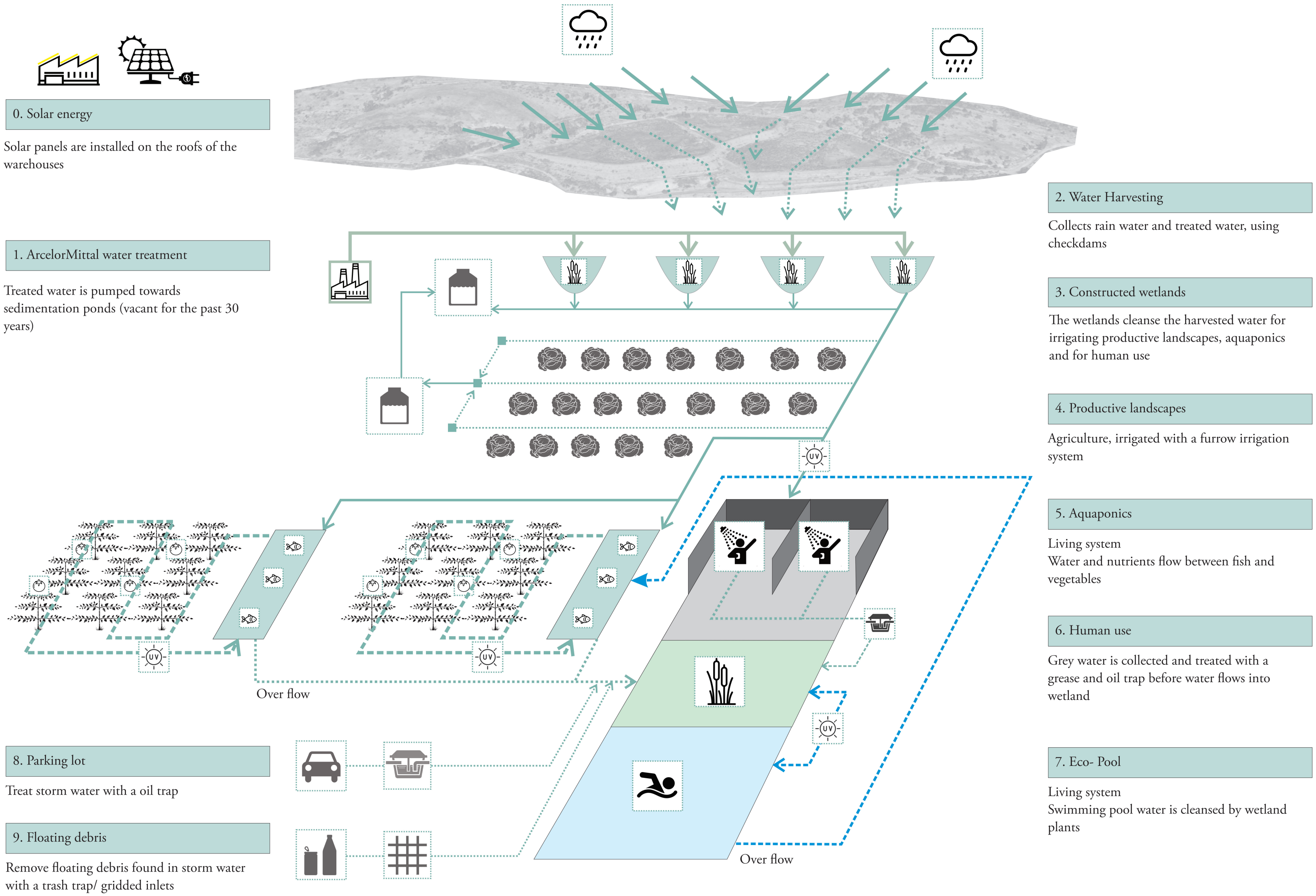
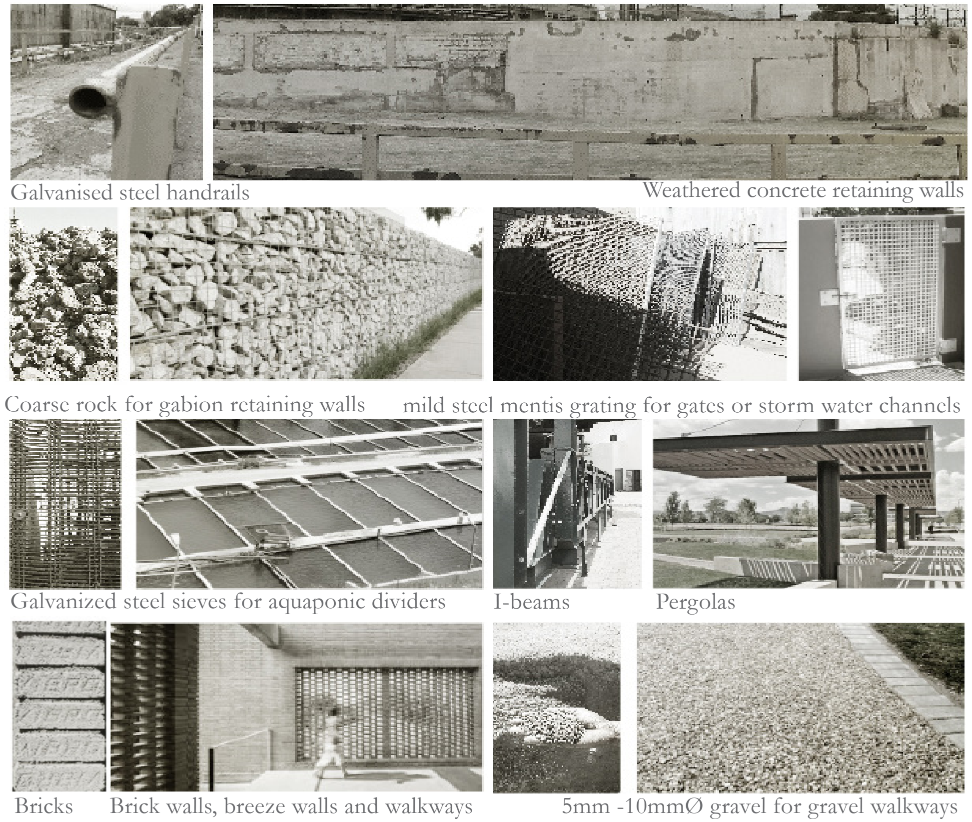


Fig 6.5 Water system (Author 2018)

Existing material palette at Pretoria Works

6.6

Proposed material for the design



6.7

Fig 6.6 Pretoria Works material palette (Author 2018)
Fig 6.7 Proposed material palette (Author 2018)

6.3 Construction material selection

Pretoria Works consists of materials that express an industrial aesthetic; the materials are robust and durable and can withstand deterioration from the industrial processes that take place at the site (see figures 6.6 and 6.7). Therefore, the existing site material can be repurposed for the purposes of the proposed project. These materials consist of pre-manufactured components that can be rapidly assembled. The industrial materials, such as the steel beams found at the vacant steel foundry, are structurally stable and can be used for pergola structures, outdoor light poles and outdoor furniture.

The adjacent quarry, managed by Vibro Eco Aggregate, already rehabilitates Pretoria Works' dumped waste (e.g. tar and blast furnace slag aggregate) for which an estimated 10-15 years are needed to rehabilitate the slag into aggregate. Vibro Eco Aggregate also rehabilitates Pretoria Works' sand and finer sand for brick-making. A study into the potential use of blast furnace slag aggregate as construction material has been conducted in order to test the material's comprehensive strength. The results indicate that blast furnace slag aggregate is a durable product and, when added, increases the strength of concrete (Kim & Park 2016:9-10). The bigger slag rocks can be used to fill the gabion steel baskets for the creation of retaining walls, whereupon certain types of vegetation (e.g. *Portulacaria afra, Senecio barbenoticus, Aristida junciformis*, etc.) could successfully grow.

6.3.1 Precedent study

The bricks used at the Kolumba museum in Cologne, Germany, influenced the material choice and size to construct the walls for the aquaponic system (see figures 6.8 and 6.9). This museum's grey brick façade integrates with the ruin of the church, without redusing the value of the existing stone walls. Pieter Zumthor the museum's architect, chose specific grey bricks (Cilento 2010) that almost disappears from the floor plane towards the sky plane.

The proposed design for Pretoria Works aquaponics system doesn't make use of existing brick walls. However, the significance of using thinner grey bricks influenced the design of integrating the floor plane with the walls that almost disappear into the sky plane.

6.8

6.9

Fig 6.8 and Fig 6.9 Kolumba museum (Cilento 2010)

6.3.2 Precedent study

The gabion baskets that are used at the Iqualada cemetery near Barcelona, Spain, has influenced considerations regarding the materials to be used to construct the retaining walls for the design. The retaining walls at the Iqualada site make use of materials like local rocks and steel rods, which eventually show signs of aging (Kroll 2011). The materials used for the retaining walls camouflage with the rough landscape of the surrounding hills. The earthy tones of the materials increase the aesthetic value of the cemetery, creating an impression that the design has long been part of the natural site (Kroll 2011; see figures 6.10-6.13.

Similarly, the gabion retaining wall for the proposed design site, particularly where it is situated at the natural public swimming pool, can host a variety of vegetation at its foot, sides and top. This retaining wall is divided into a few terraces to maximise the exposure of plants to sunlight throughout the year. The selection of plants has been influenced by a theoretical study (Author 2018) of solar energy and the allocation of suitable indigenous vegetation (see figures 6.15 - 6.17).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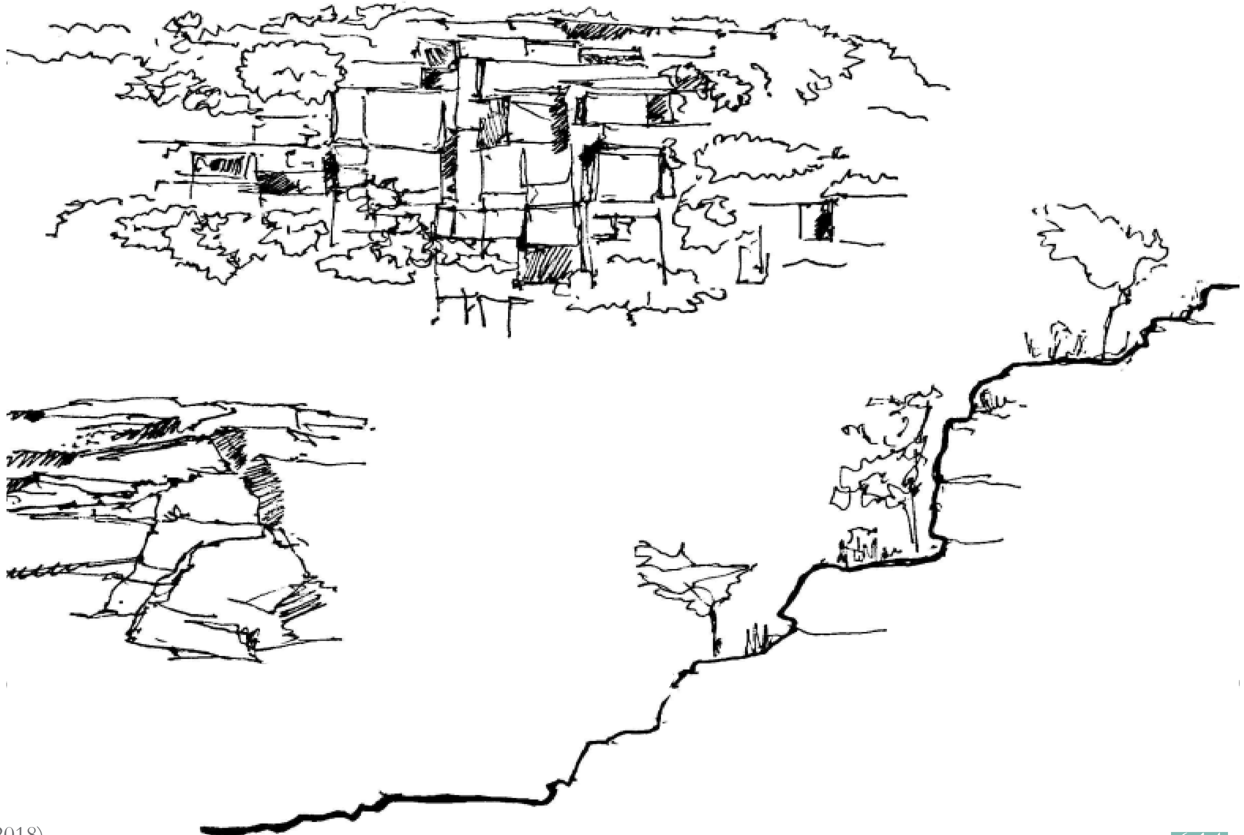
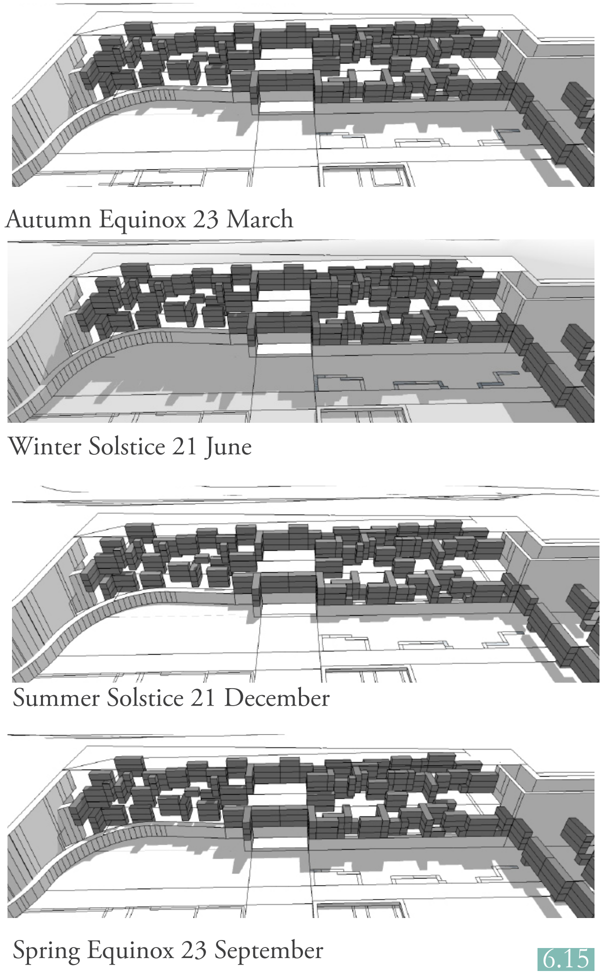

6.14

Fig 6.10-Fig 6.13 Iqualada cemetry (Kroll 2011)
Fig 6.14 Envisaged retaining wall for the proposed design (Author 2018)



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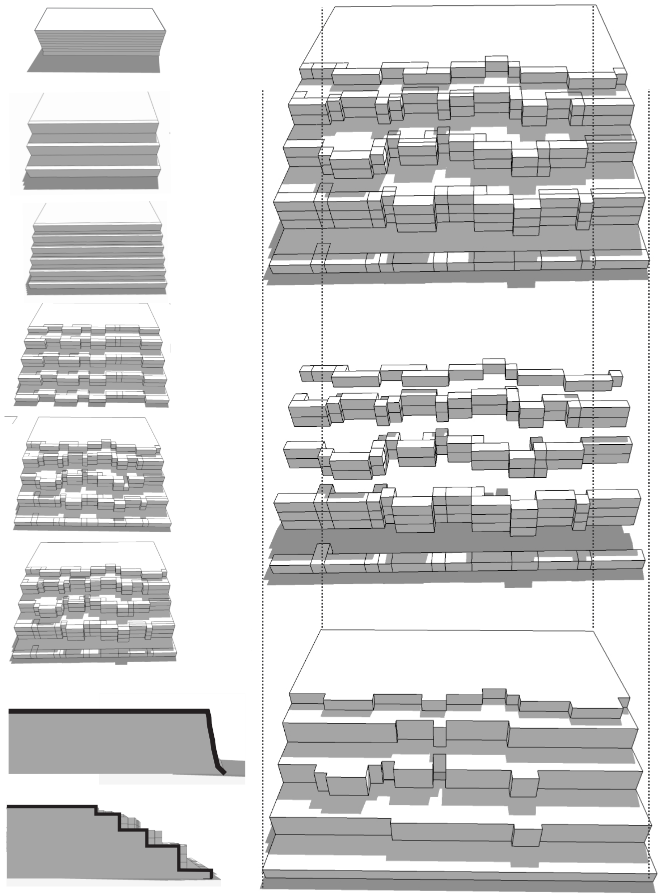

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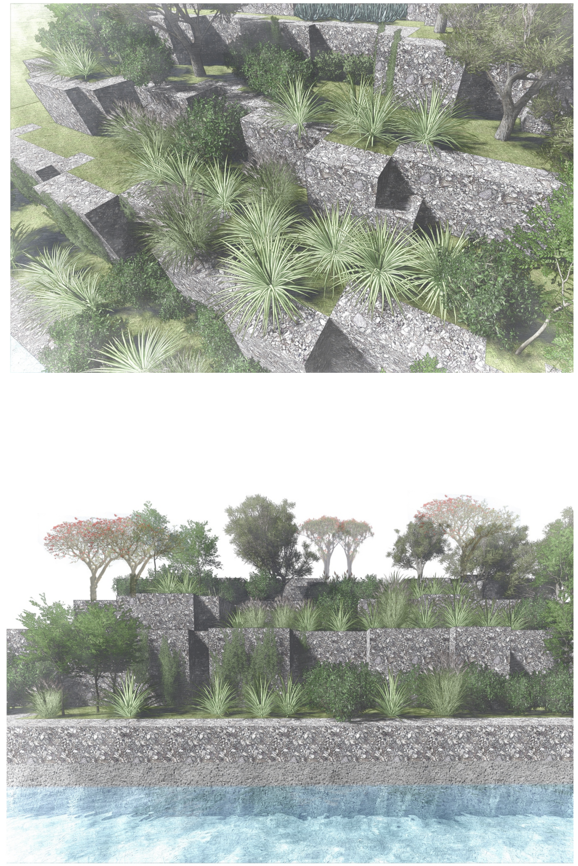


6.17

Fig 6.15 Solar study (Author 2018)
Fig 6.16 Man-made ridge development (Author 2018)
Fig 6.17 Proposed planting for man-made ridge (Author 2018)

6.4 Plant strategy

A variety of indigenous plants that contribute to the phenomenological spatial qualities of water have been selected for the design. These are discussed in more detail in the next subsection. It should be noted that the trees, aloes and veld grass that have been selected are also found in the Gauteng Shale Mountain Bushveld Vegetation Area (Mucina & Rutherford 2011:466). Apart from these, other indigenous plants, such as certain shrubs and groundcovers, have been selected to contribute to space creation. These spaces consist of floor surfaces planted with grass or groundcovers that meet adjacent water spaces (i.e. the edge meeting the pool), as well as enclosed walls in the form of plant screens (line), together with a ceiling plane that consists of spreading tree canopies, climbers on a pergola and a filtered open sky (points) (Robinson 2011:45) (see figures 6.18-6.23)

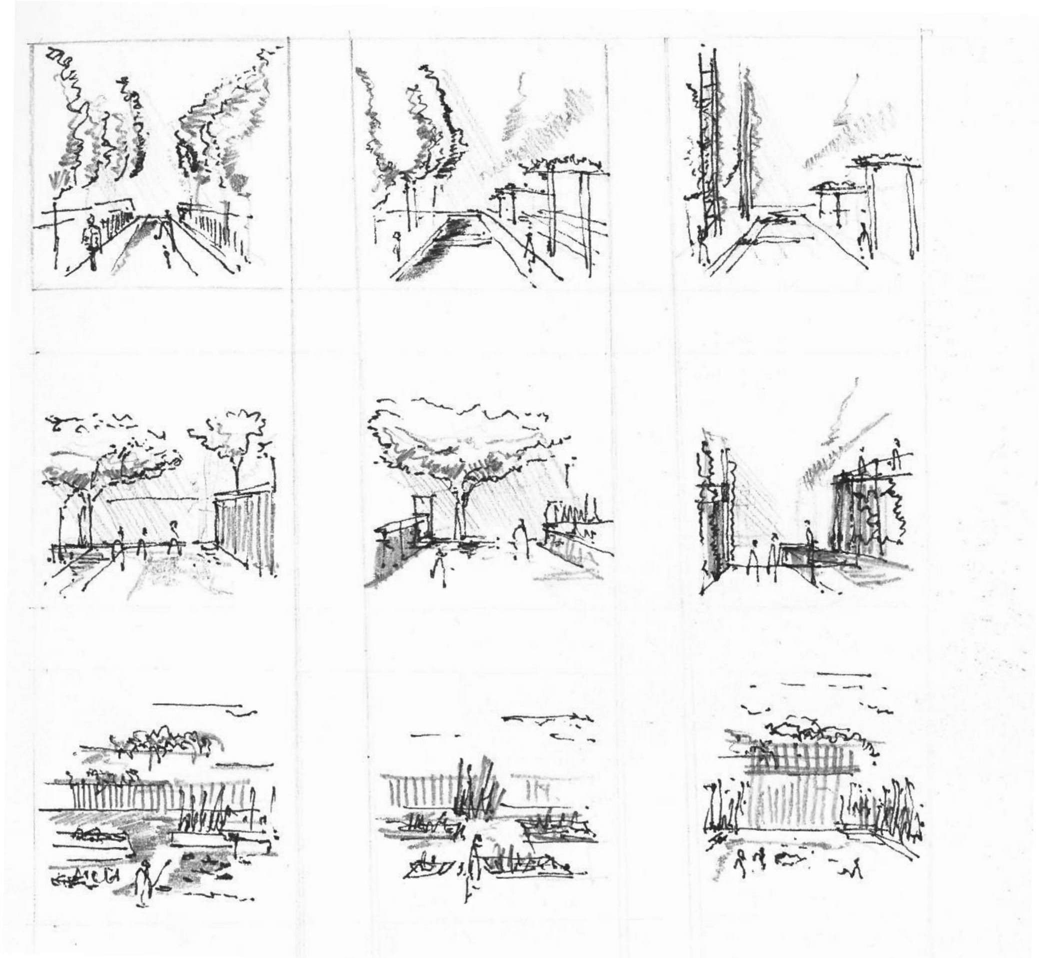


Fig 6.18 Conceptual plants strategy (Author 2018)

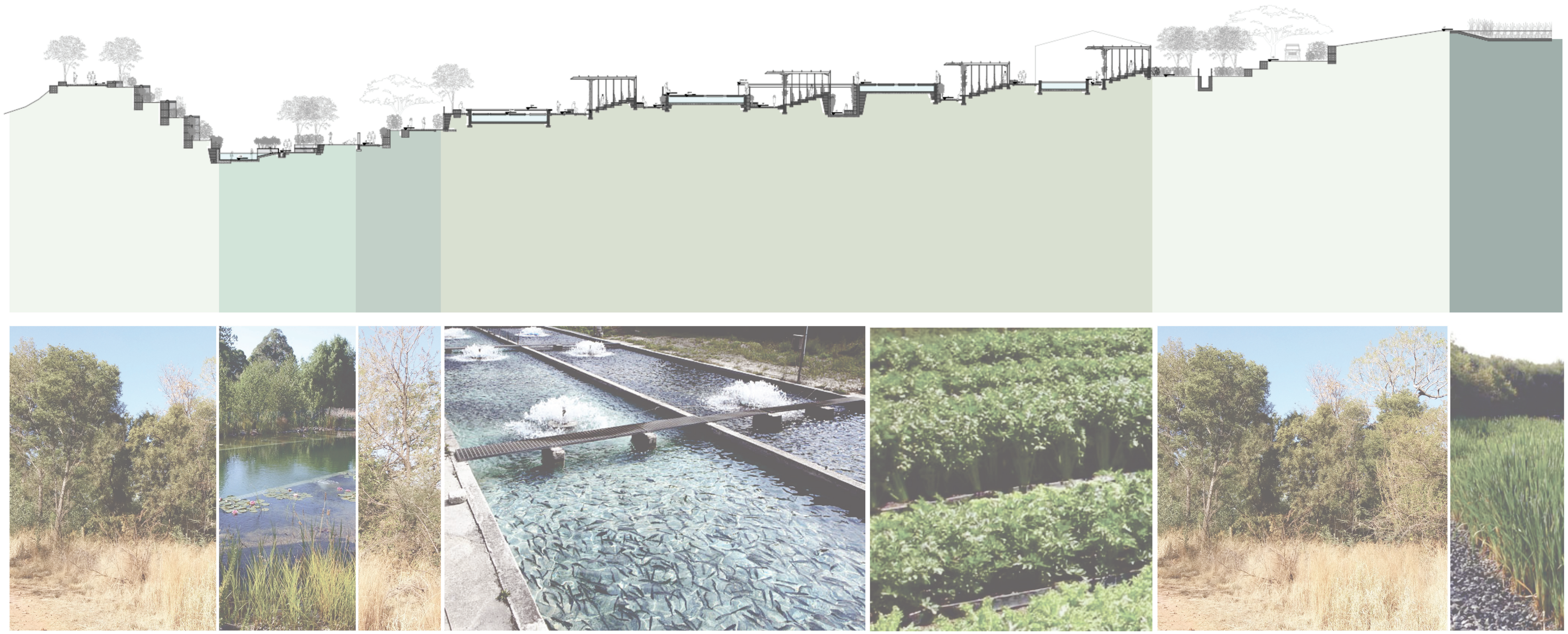


Fig 6.19 Section A--A: planting strategy (Author 2018)

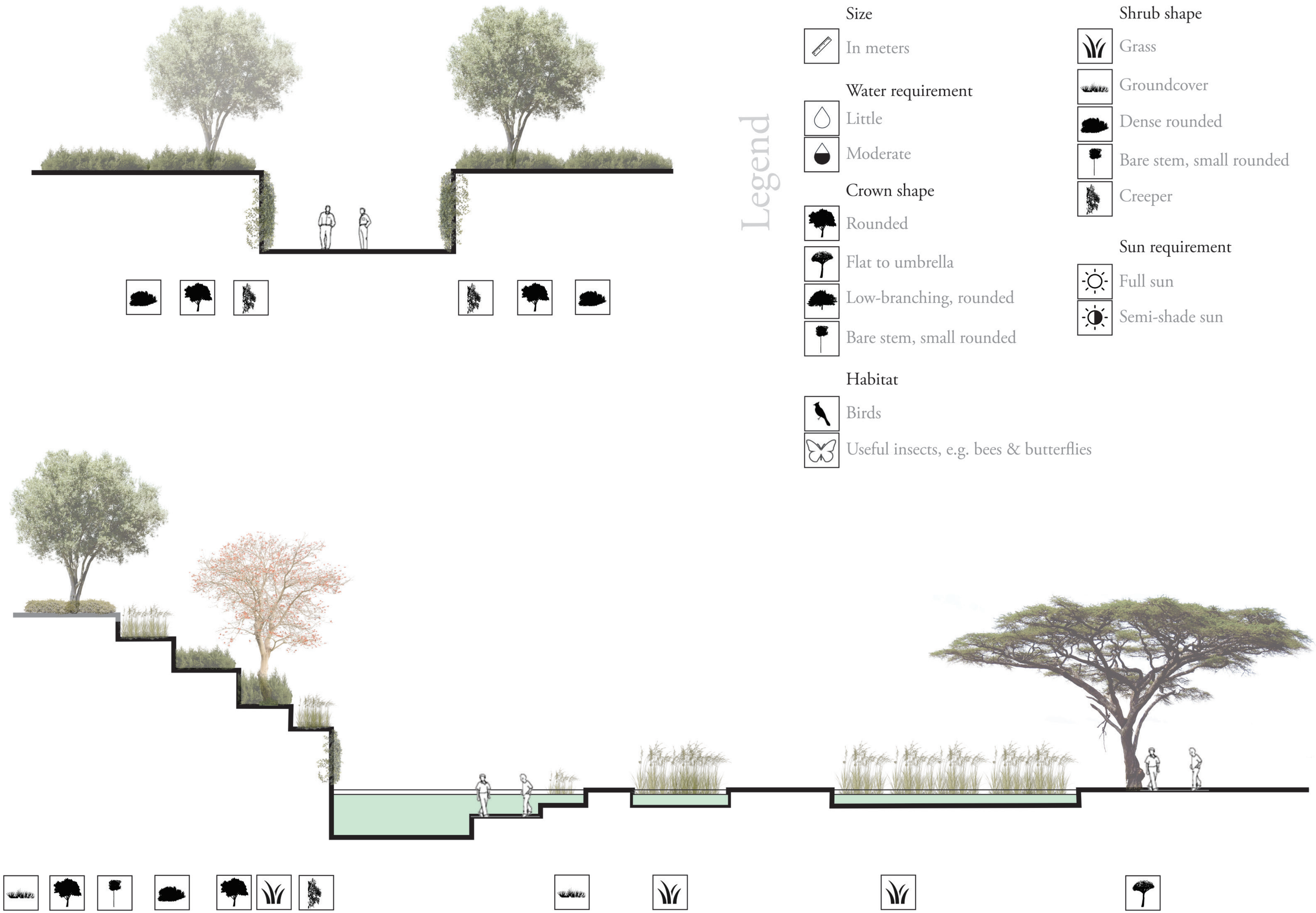


Fig 6.20 Spatial planting strategy (Author 2018)

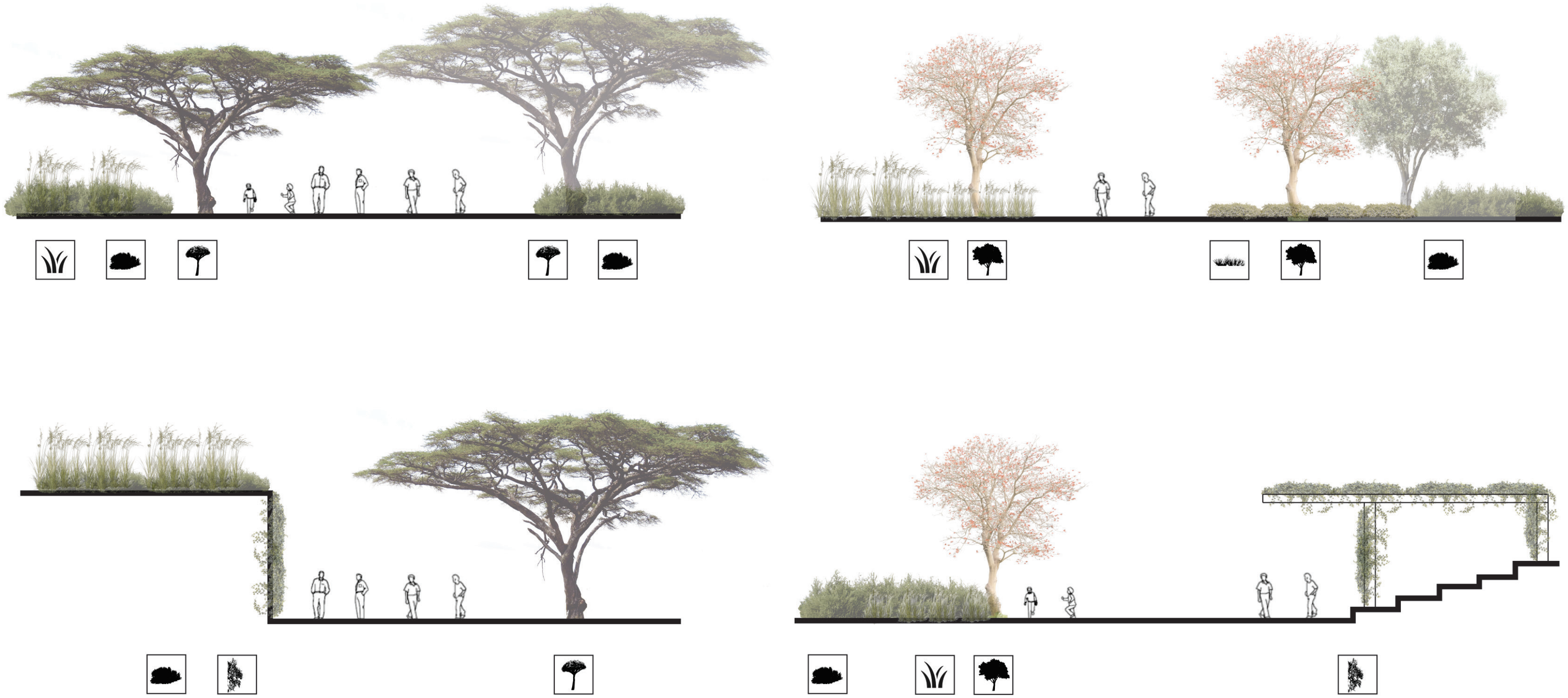


Fig 6.21 Spatial planting strategy (Author 2018)

10-12m

Vachilia tortilis

4-7m

Bolusanthus speciosus

4-7m

Erythrina lysistemon

5-8m

Vachilia karoo

4-8m

Dombeya rotundifolia

4-9m

Celtis africana

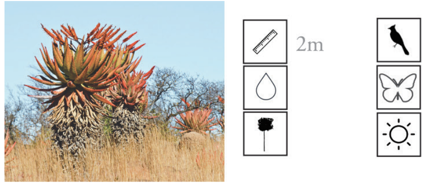
2-3m

Cussonia spicata

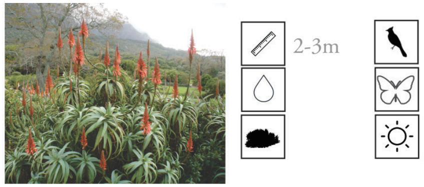
9-12m

Olea europaea subsp. africana

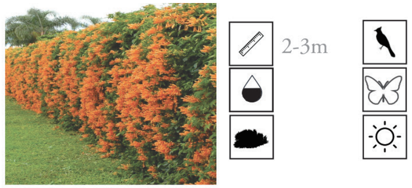
Fig 6.22 Proposed trees (Author 2018)



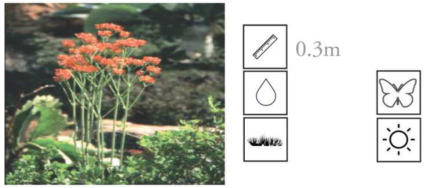
Aloe marlothii



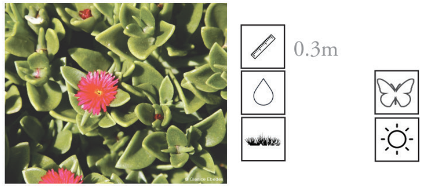
Aloe arborescens



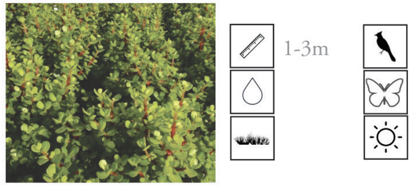
Tecoma capensis



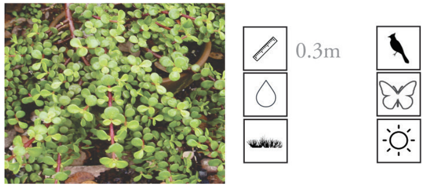
Kalanchoe rotundifolia



Aptenia cordifolia



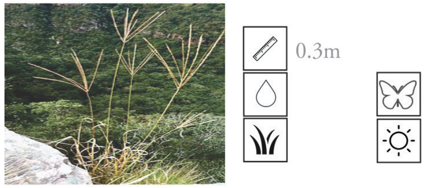
Portulacaria afra



Portulacaria afra 'nana'

Senecio barbenoticus

Aristida junciformis

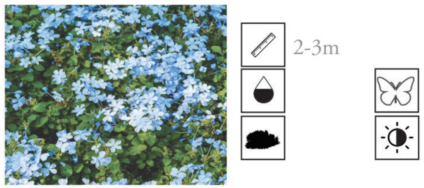


Digitaria eriantha

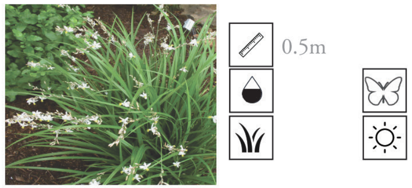
Eragrostis curvula

Hyparrhenia hirta

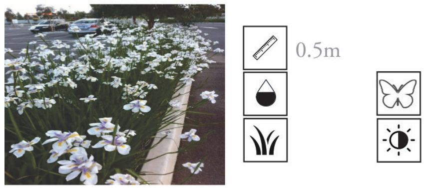
Carissa macrocarpa



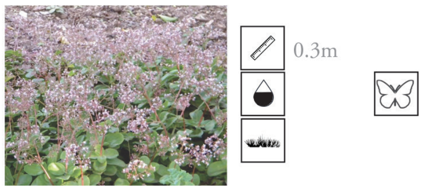
Plumbago auriculata



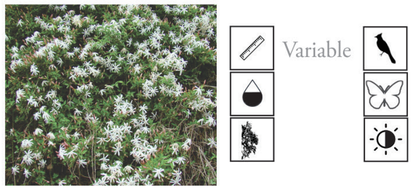
Chlorophytum saundersiae



Dietes grandiflora



Crassula multicava



Jasminum multipartitum

Fig 6.23 Proposed plants (Author 2018)

6.5 Natural swimming pool

A natural swimming pool system does not make use of pressure pumps or filtration systems to remove algae, as occurs with conventional pools (Pavlis 2017:137). Although, this nature system does still require small pumps to circulate water continuously through a bio-filter or 'regeneration area' (Pavlis 2017:141). The bio-filter cleanses the water by making use of wetland plants, which break down the waste found in the water and absorb it through their roots (Pavlis 2017:138). The size of the bio-filter covers 30%-50% of the water volume compared to the swimming pool area. Natural swimming pools can also be used as public pools (Pavlis 2017:139). In such cases, companies like Aqua Design can install the natural pools. These natural pools often report with better water quality than municipal drinking water when their water quality is analysed (Aqua Design 2018). An ultraviolet water treatment system can also be integrated with the design in order to remove any hazardous contaminants that could be part of the water.

The case study of the natural public swimming pool of S-Park (see figures 6.24-6.26) near Sarleinsbach in Austria, designed by BIOTOP, has been investigated for reference in this design. This case study was awarded the Upper Austrian Environmental Protection Prize in 1999. South Africa, which is a developing country, can look into this case study for inspiration. Some details of this case study are as follows:

Swimming area: 1100 m²
Regeneration area: 1350 m²
Total area: 2450 m²

S-Park's natural public swimming pool has a community facility, which includes changing rooms, showers and toilets. This public pool offers user-friendly access around it by means of wooden decks that separate the toddler's (with a pool depth of 0.3 metres) from the adult's section (with a pool depth of 1.2 metres) (Petrich 2018). The pool has a pebble beach entry that creates an anti-slip surface, as well as smooth-surfaced rocks that serve as seating. The public pool also provides surrounding grass areas (approximately 1100 m² in size) where visitors can relax (Petrich 2018).

The proposed design's natural swimming pool to bio-filter ratio is shown in figure 6.27.

Natural swimming pool plant species that have been selected for the proposed design site are:
Miscanthus junceus, Cyperus alternifolius, Cyperus papyrus 'little giant', Schoenoplectus corymbosus, Berula erecta, Nymphae nouchali, Cotula coronopifolia, Vallisneria aethiopica, Juncus glaucus, and *Juncus oxycarpus.*

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6.26

Fig 6.24-Fig 6.26 S-Park natural public swimming pool (Petrich 2018)

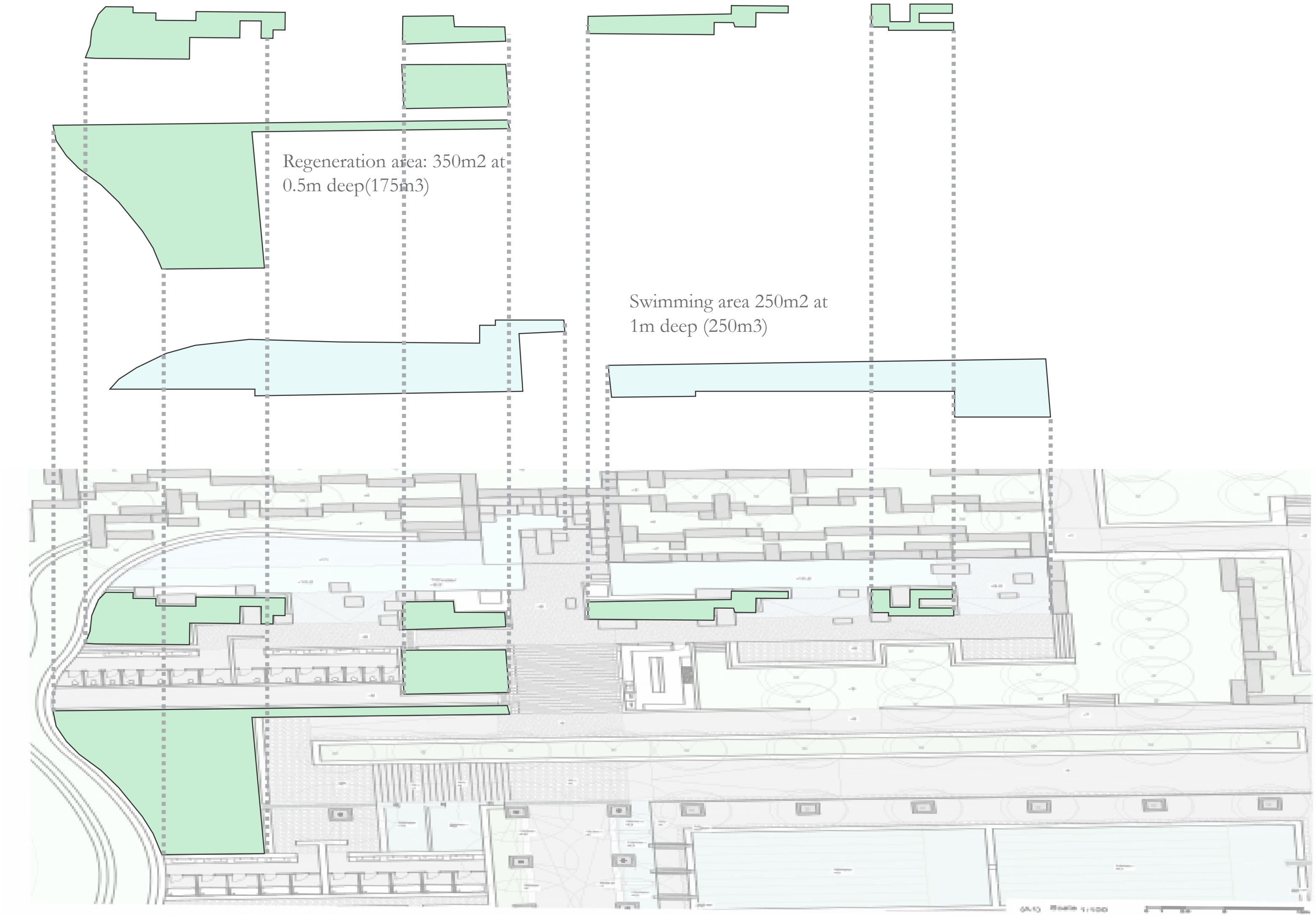


Fig 6.27 Pretoria Works public natural swimming pool ratio to regeneration area (Author 2018)

2-3m

Miscanthus junceus

1-2m

Cyperus alternifolius

0.5-1m

Cyperus papyrus 'little giant'

0.5m

Schoenoplectus corymbosus

1m

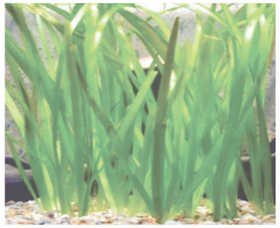
Berula erecta

0.2m

Nymphae capensis

0.2m

Cotula coronopifolia



0.3m

Vallisneria aethiopica

0.7m

Juncus glaucus

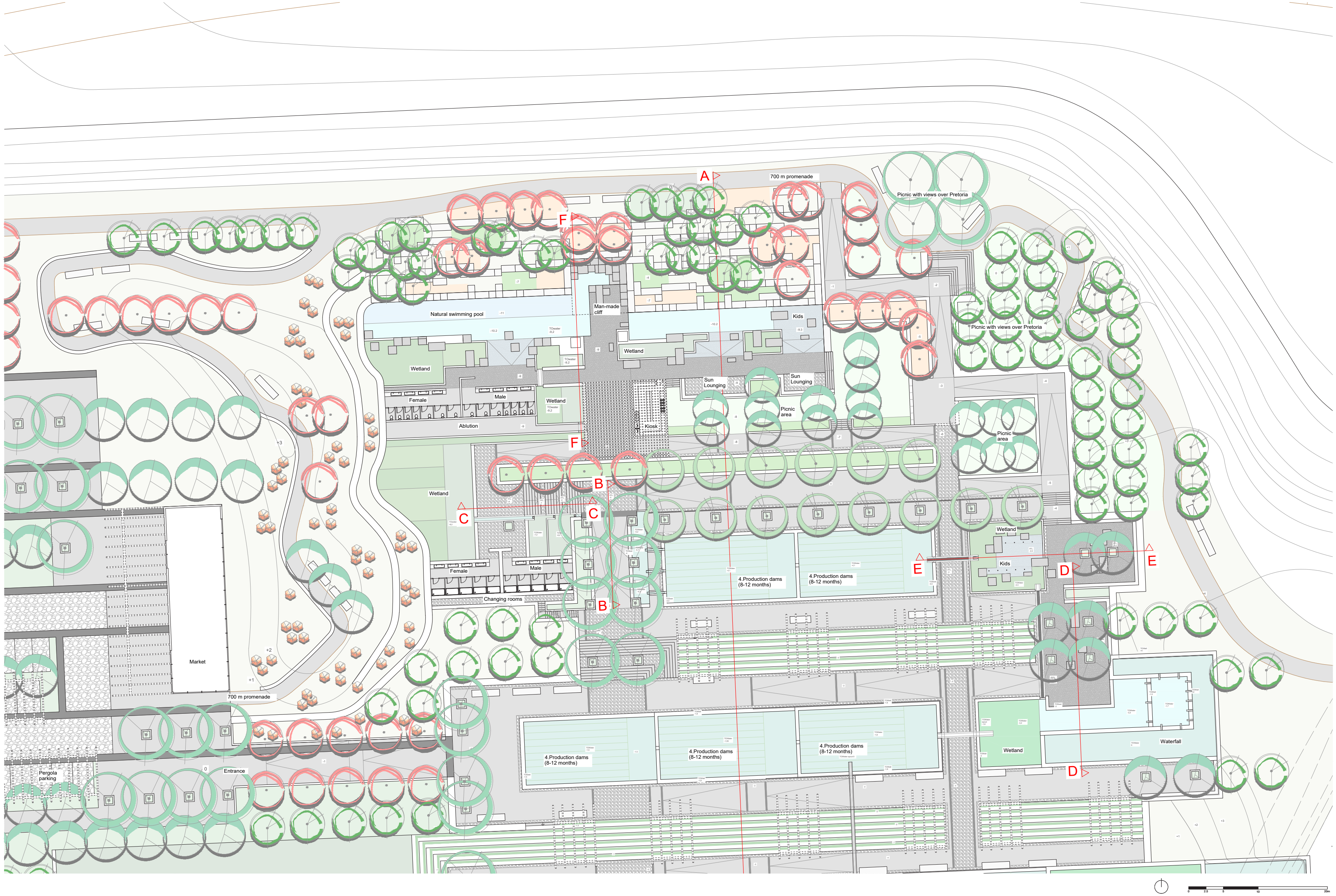
0.5m

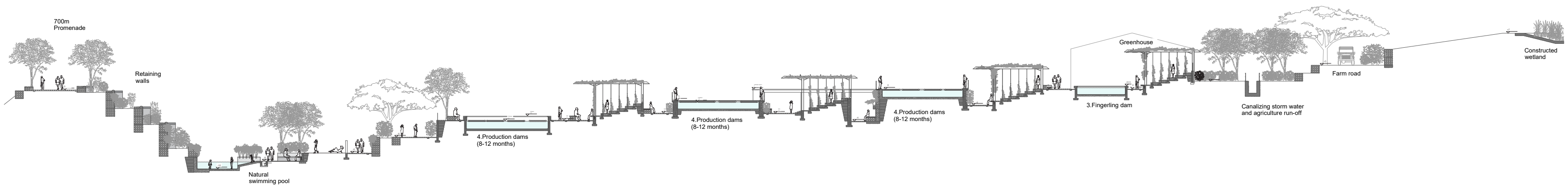
Juncus oxycarpus

0.3m

Aponogeton distachyos

Fig 6.28 Proposed wetland plants (Author 2018)





Section A--A

LEGEND

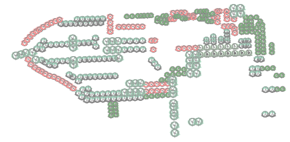
TREES

- Vachilia tortilis
- Celtis africana
- Erytrhina lysistemon
- Harpephyllum caffrum
  Olea europaea subsp. africana
- Tree mix:
  Bolusanthus speciosus
  Cussonia spicata
  Dombeya rotundifolia
  Erytrhina lysistemon
  Seasia leptodictya
  Vachilia karoo

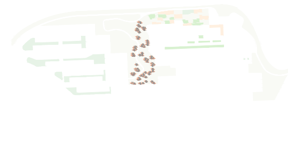
SHRUBS & GROUNDCOVERS

- Aloe mix:
  Aloe arborescens
  Aloe marlothii
- Shrub mix:
  Carissa macrocarpa
  Plumbago auriculata
  Portulacara afra
  Tecoma capensis
- Groundcover mix:
  Aptenia codifolia
  Kalanchoe rotundifolia
  Chlorophytum saundersiae
  Crassula multicava
  Porulacaria afra 'nana'
  Senecio barbetonicus
- Dactyloctenium australe
- Veld grass mix:
  Aristida juncifromis
  Digitaria eriantha
  Eragrostis curvula
  Hyparrhenia hirta
- Wetland Marginal plant mix:
  Berula erecta
  Cyperus alternifolius
  Cyperus papyrus 'little giant'
  Miscanthus junceus
- Wetland Marginal plant mix 2:
  Juncus glaucus
  Juncus oxycarpus
  Schoenoplectus corumbosus
- Wetland Floating plant mix:
  Apongeton distachyos
  Nymphae capensis
  Cotula coronipholia
- Vegetable mix:
  Lima beans (creeper)
  African eggplant (creeper)
  Tomatoes (creeper)
  Pumpkin (creeper)
  Lettuce
  Spinach
  Cabbage

  Herb mix:
  Basil
  Thyme
  Mint
  Rosemary
  Lavendula spp.



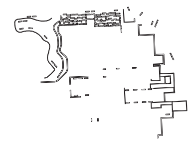
Trees



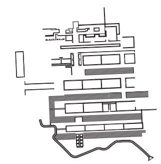
Shrubs and groundcovers

Wetland plant mix

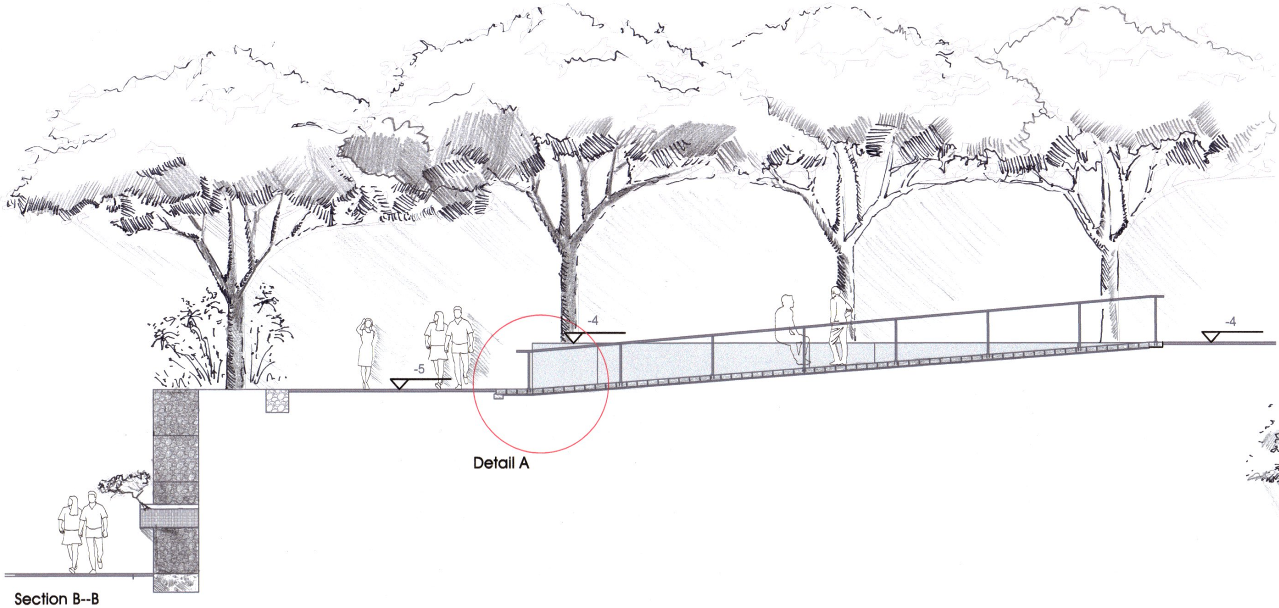
Vegetables and Herbs mix



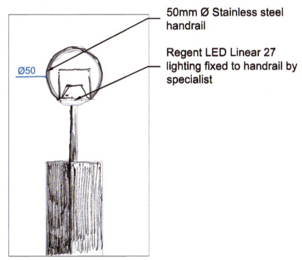
Gabion walls



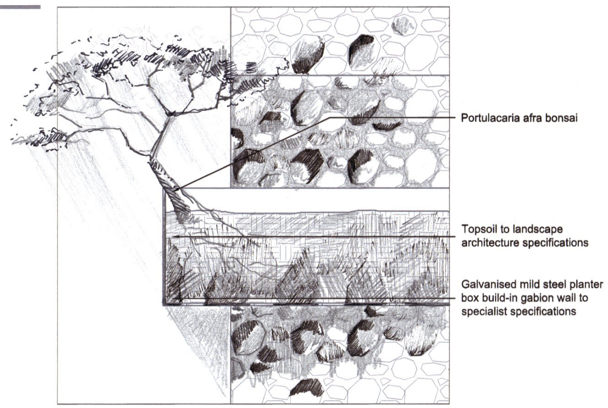
Brick and concrete walls



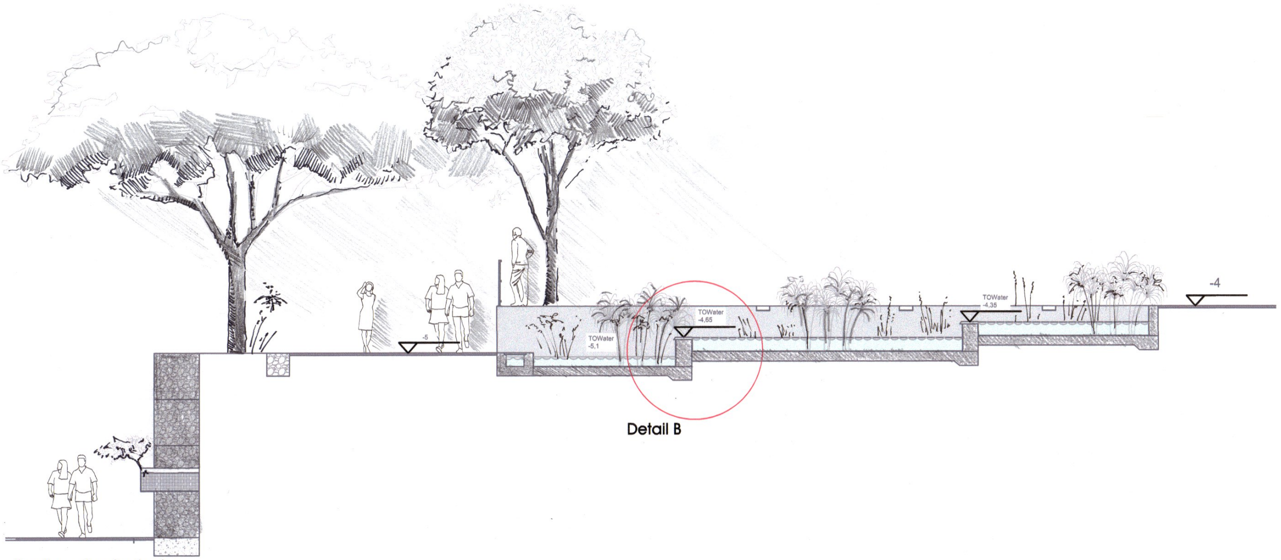
Section B--B
Scale 1:50



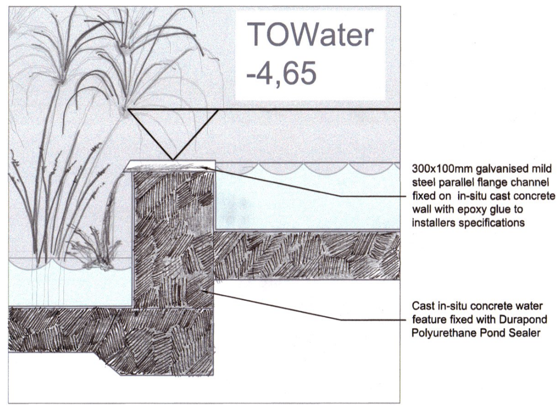
Handrail detail
Scale 1:2



Detail A
Scale 1:10

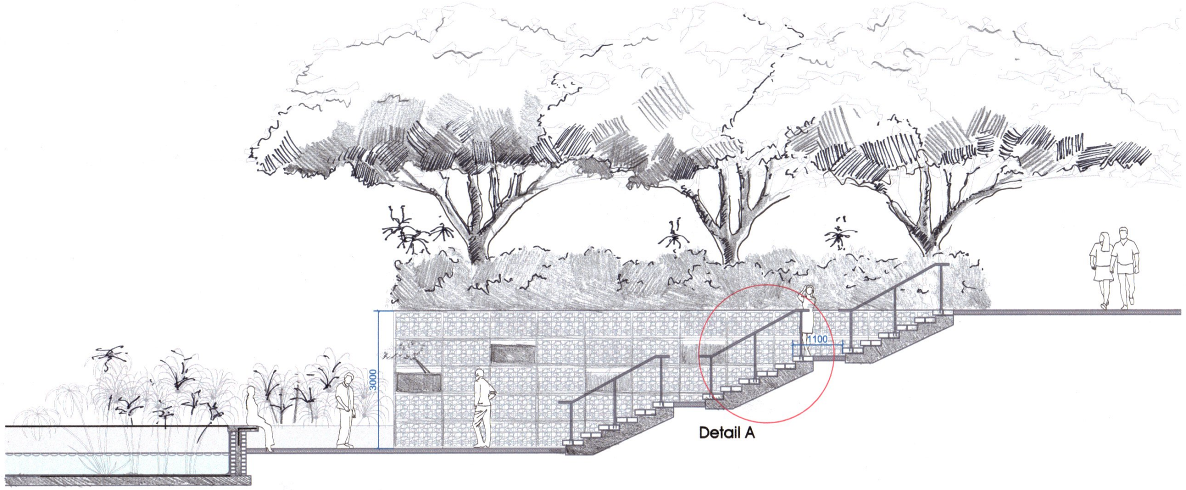


Section of water feature
Scale 1:50

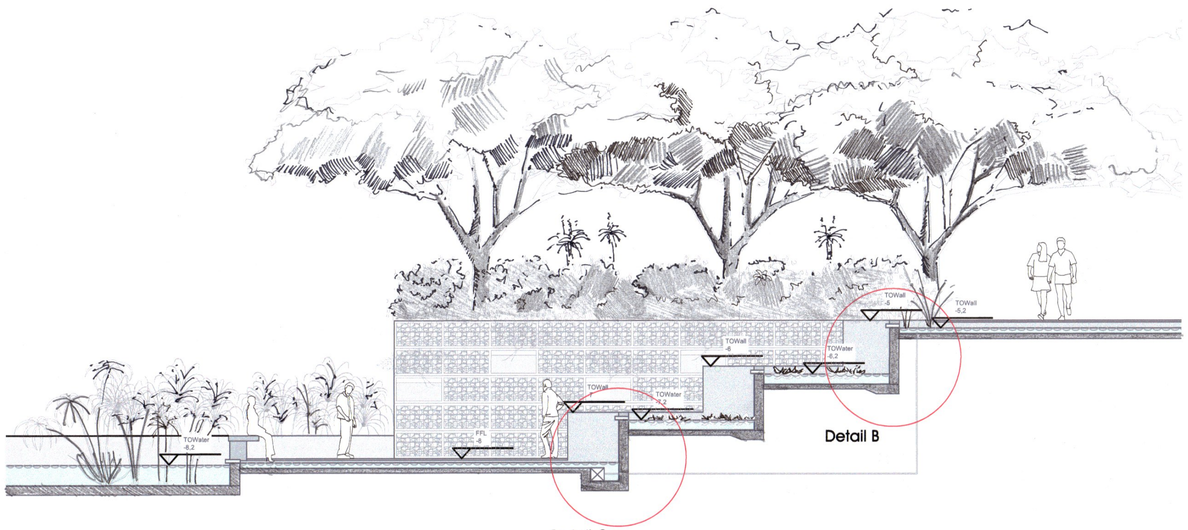


Detail B
Scale 1:10

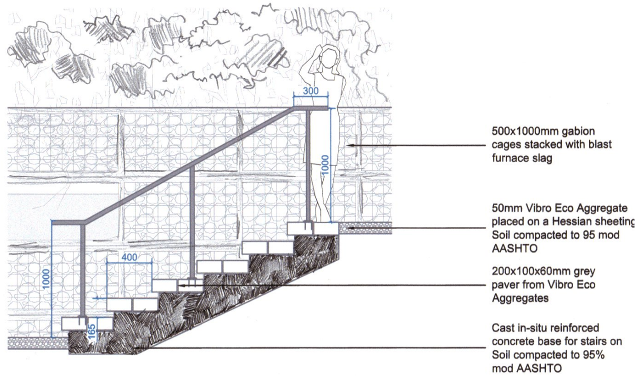
Fig 6.29 Opposite page: Landscape Sketch Plan (Author 2018)
Fig 6.30 Section B--B (Author 2018)



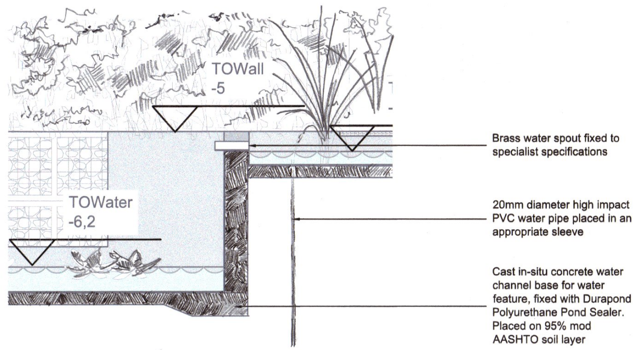
Section C--C
Scale 1:50



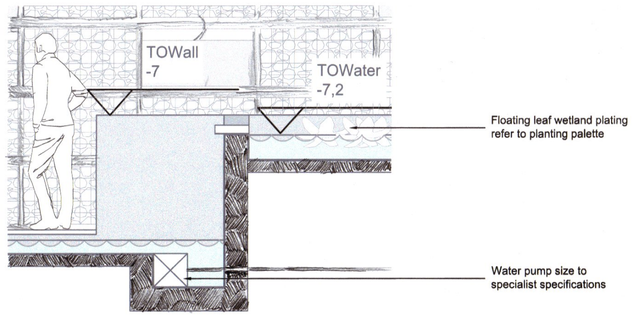
Section of water feature
Scale 1:50



Detail A
Scale 1:20

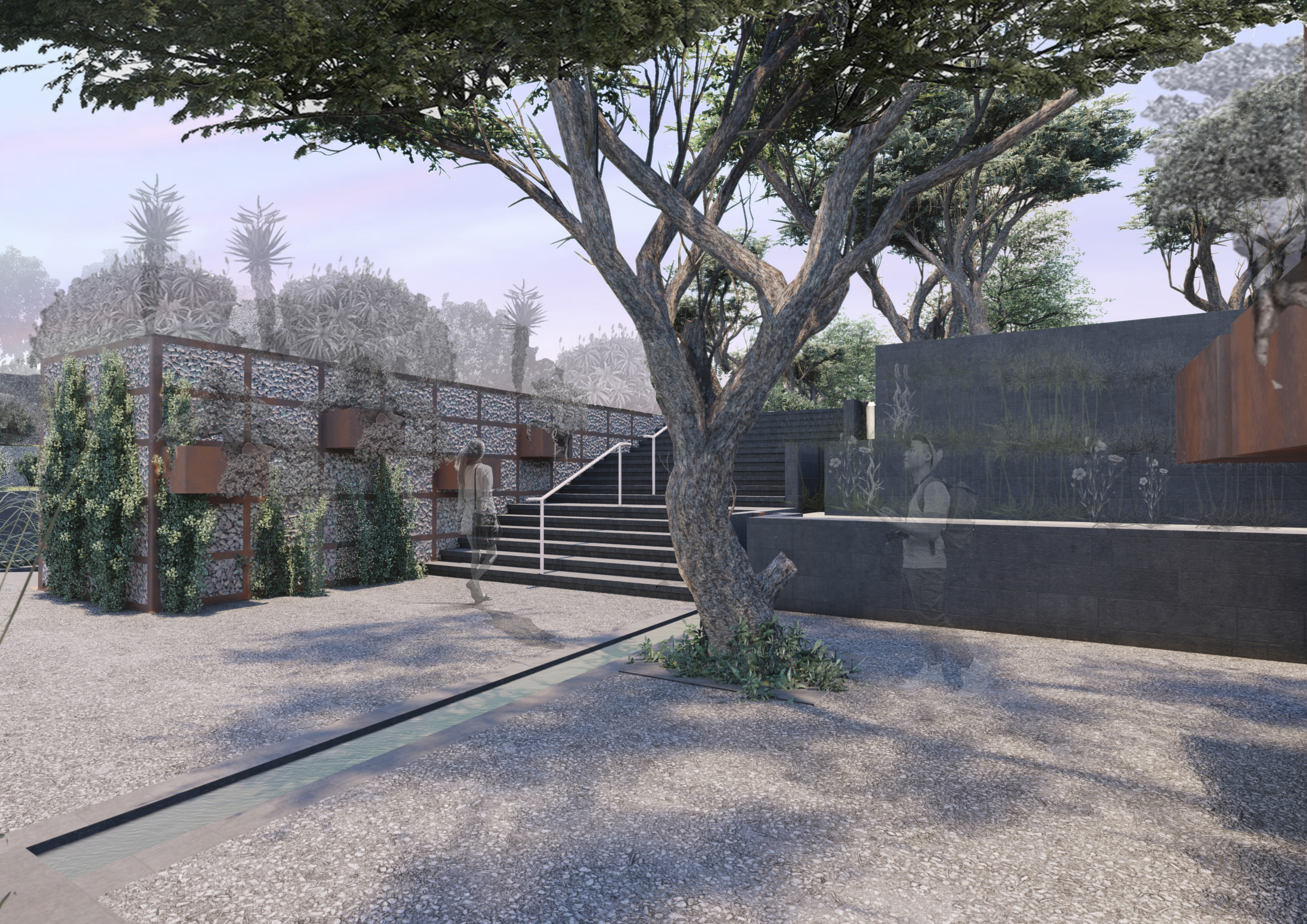


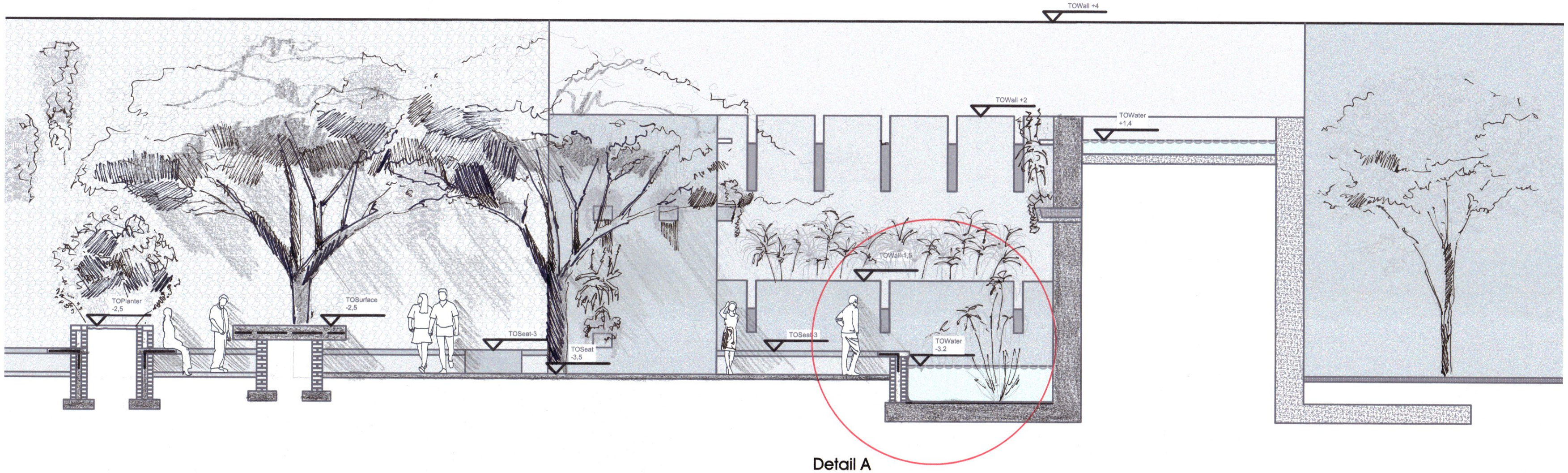
Detail B
Scale 1:20



Detail C
Scale 1:20

Fig 6.31 Section C--C (Author 2018)
Fig 6.32 Opposite page: Perspective of the water feature (Author 2018)





Section D--D
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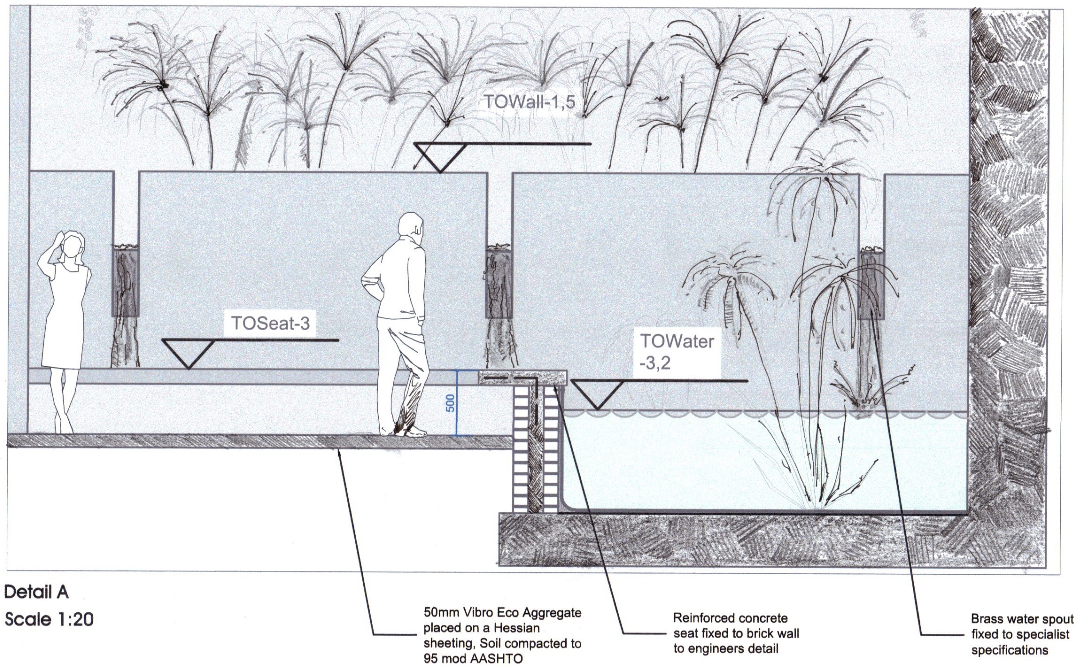


Detail A
Scale 1:20

Fig 6.33 Section D--D (Author 2018)
Fig 6.34 Opposite page: Perspective of the waterfall (Author 2018)

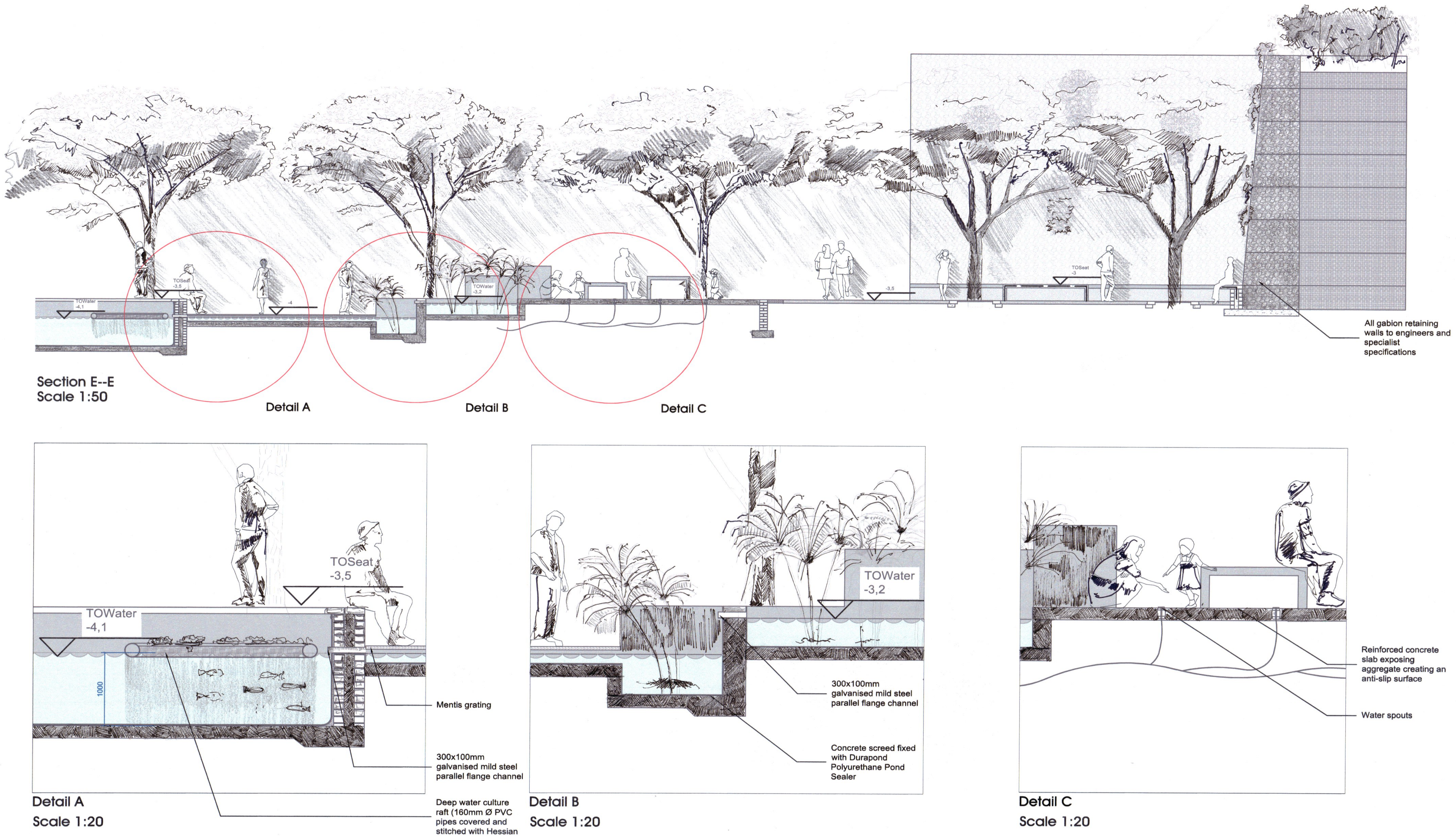
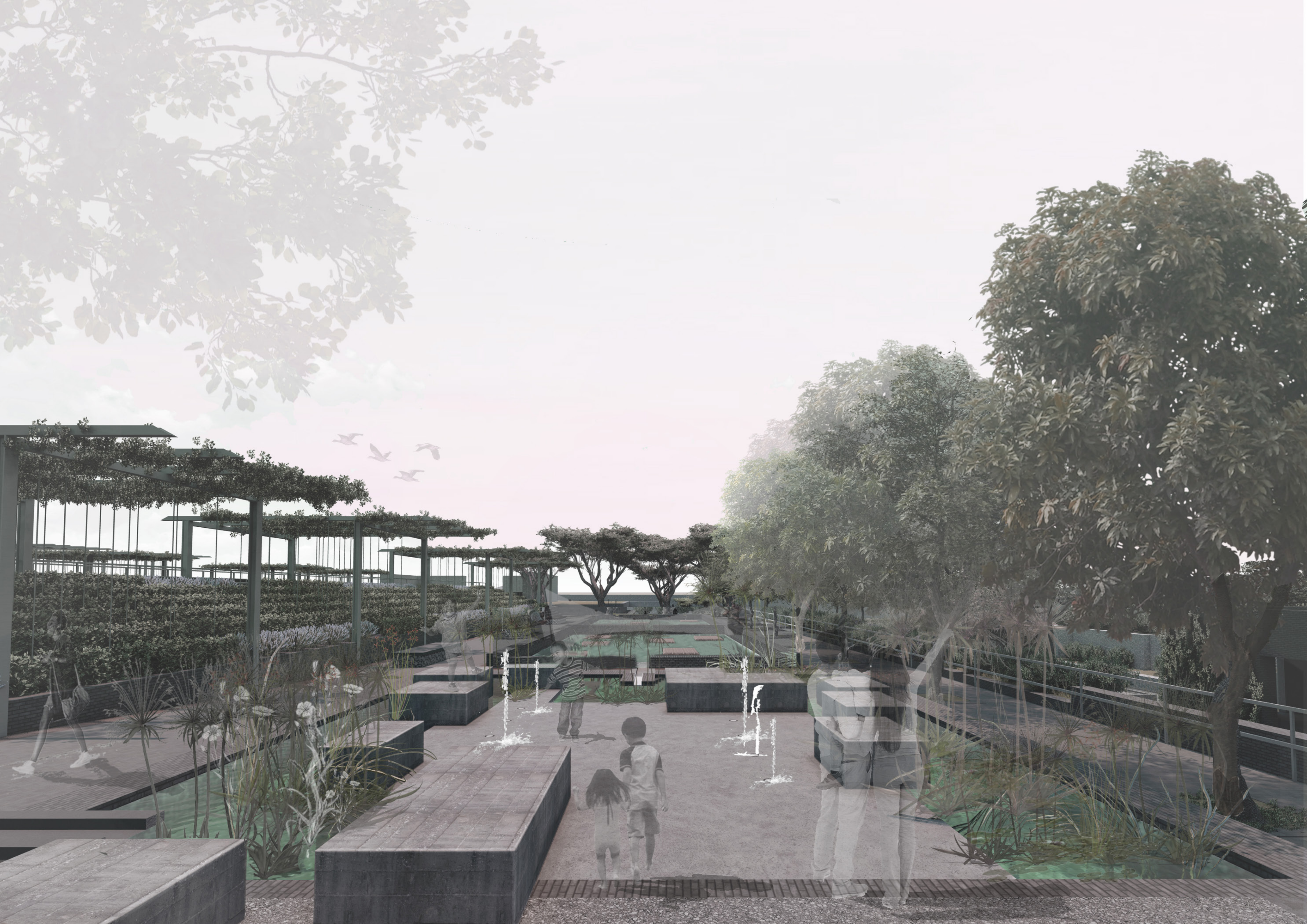
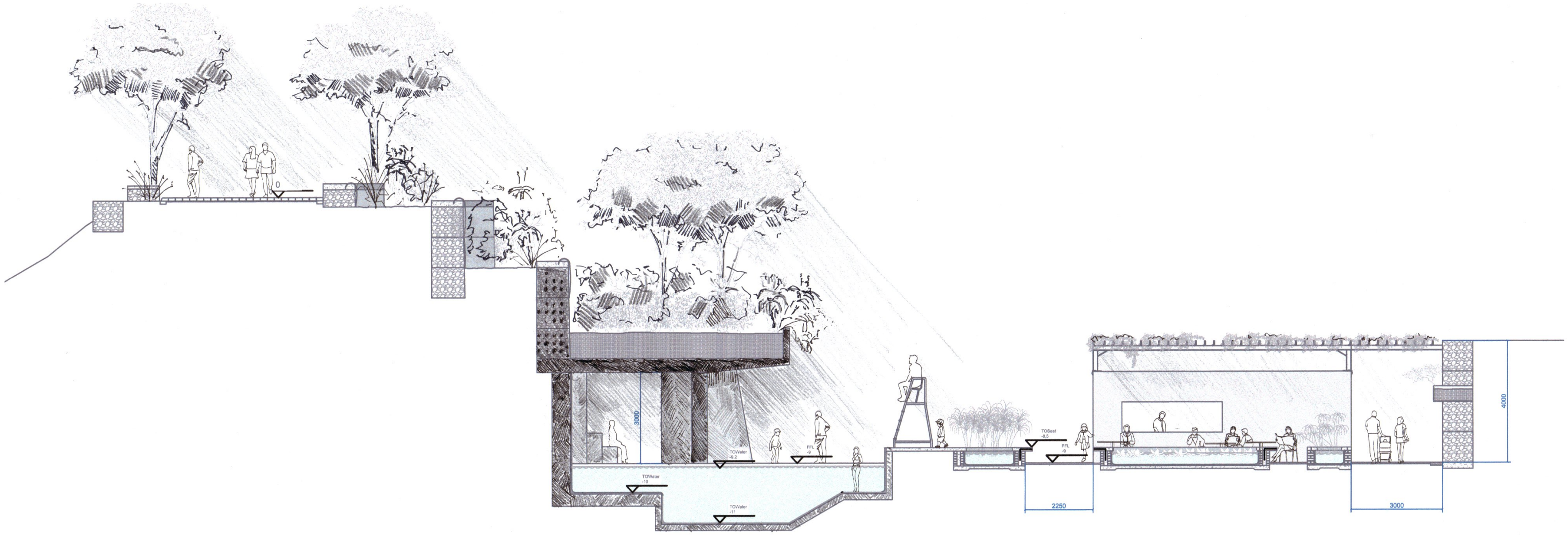


Fig 6.35 Section E--E (Author 2018)
Fig 6.36 Opposite page: Perspective of the kids water feature (Author 2018)





Section F--F
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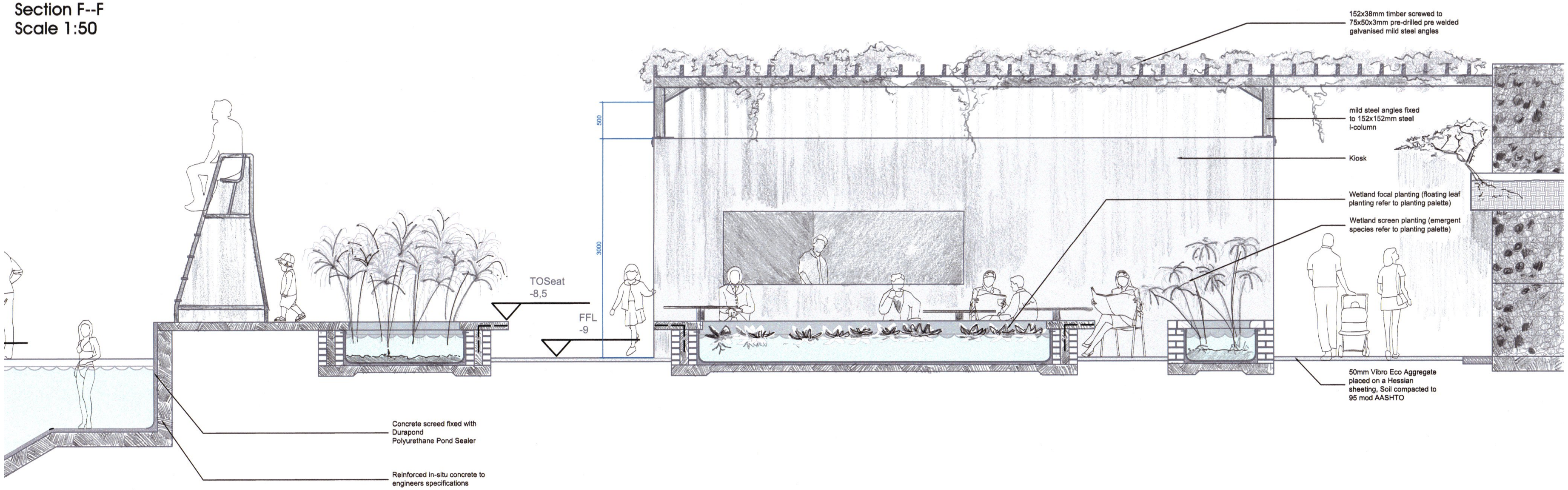
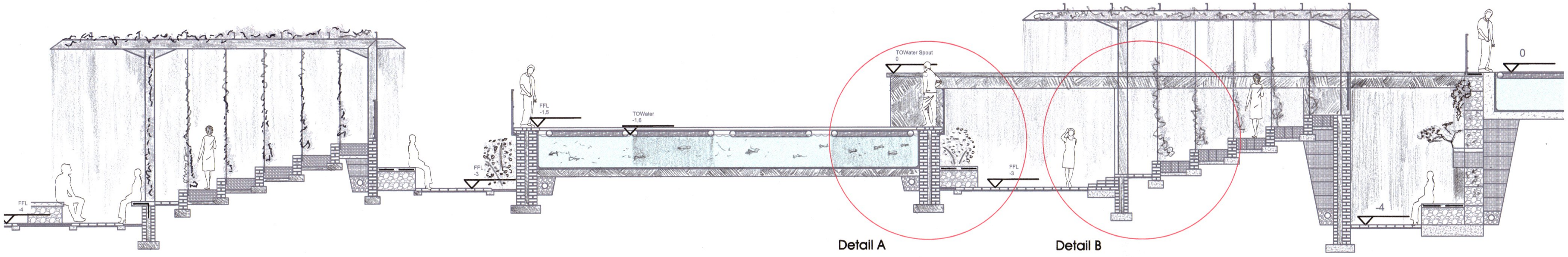
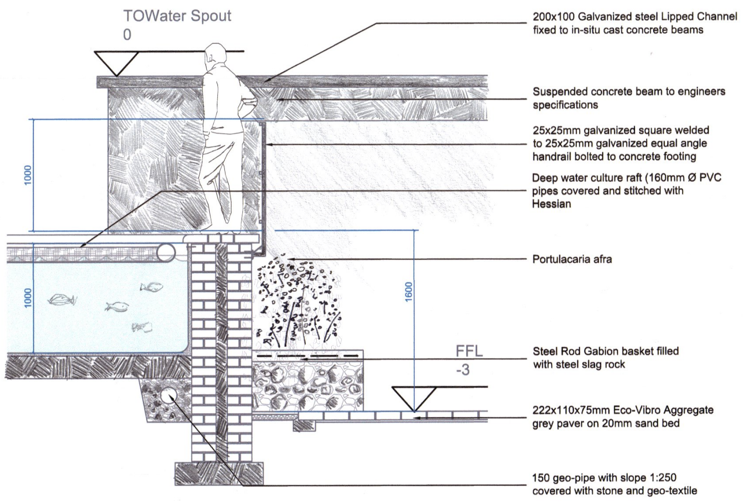


Detail
Scale 1:20

Fig 6.37 Section F--F (Author 2018)
Fig 6.38 Opposite page: Perspective of the natural public pool (Author 2018)



Section A--A
Scale 1:50



Detail A
Scale 1:20

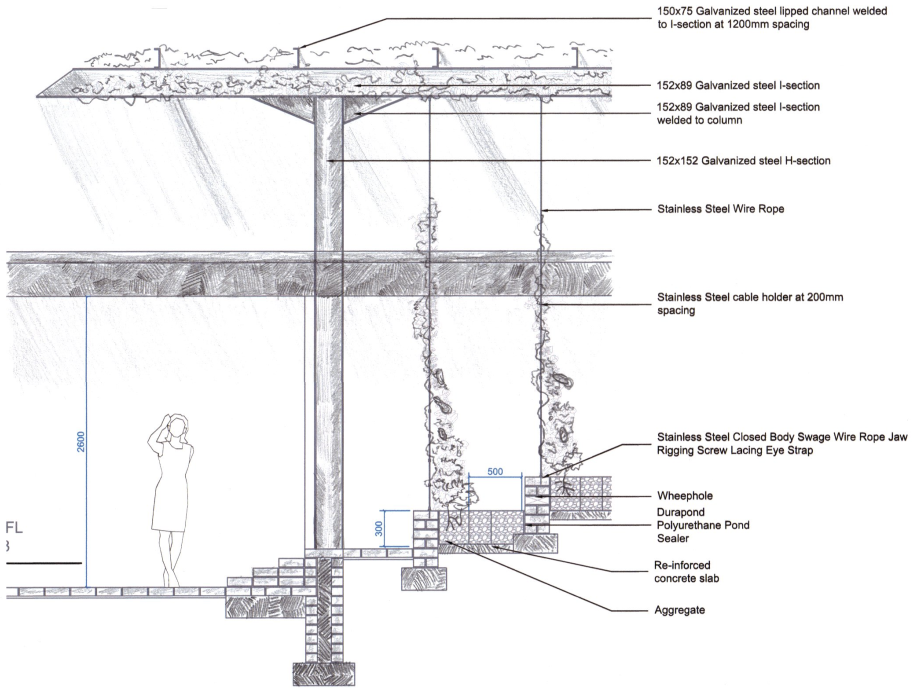
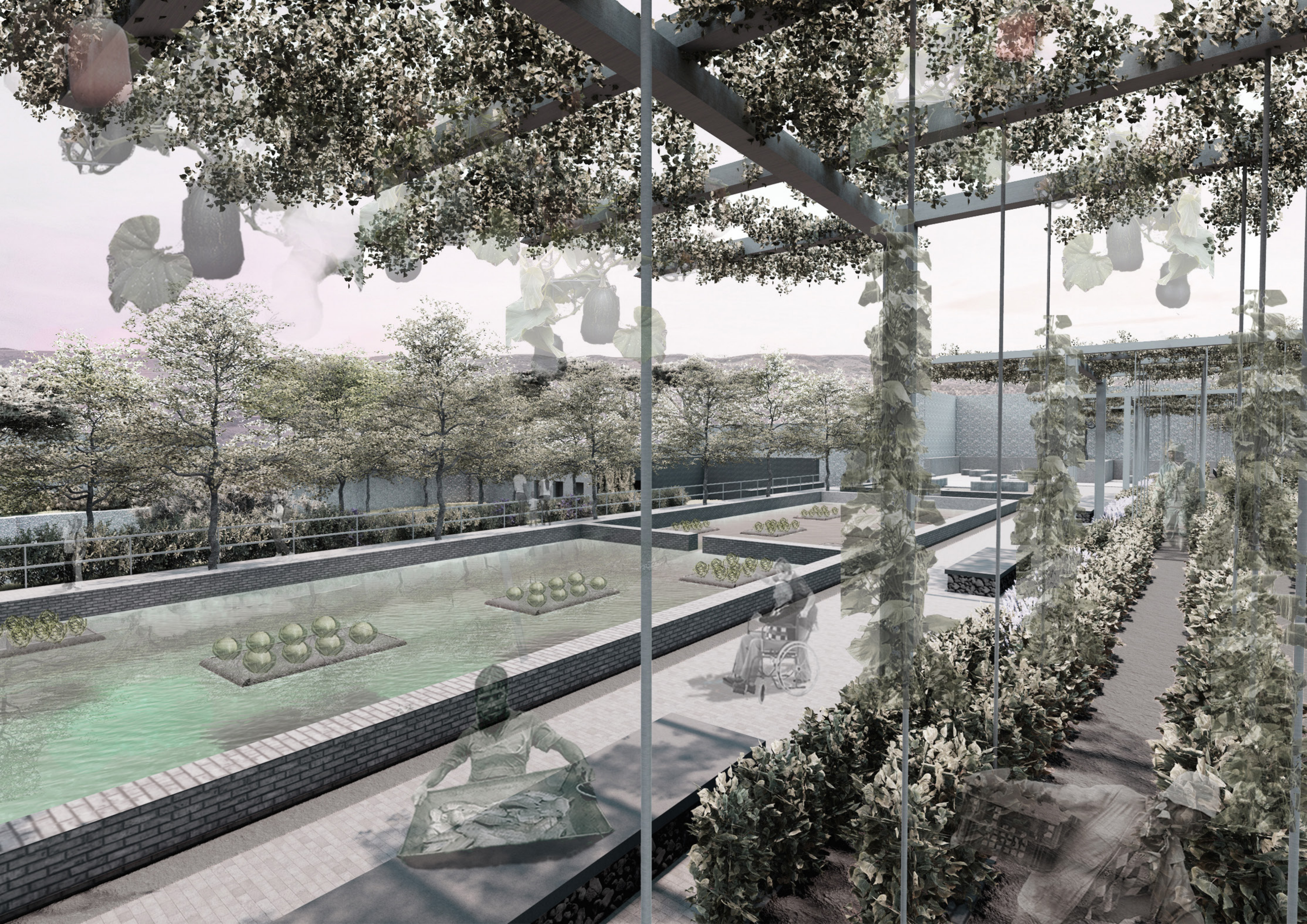


Fig 6.39 Section A--A: aquaponic system (Author 2018)
Fig 6.40 Opposite page: Perspective of the aquaponic system (Author 2018)



6.6 The aquaponics system

The aquaponics system makes use of fish and plants that work together in a closed-loop cycle. As noted previously, the fish species chosen for this design are the red breast tilapia (*Tilapia rendalli*) and the Mozambique tilapia (*Orecohcromis mossambicus*). Tilapia have been chosen because this species can tolerate external natural elements, normally grows in high densities, grows significantly in the region's natural rivers and dams and has a big market value.

6.6.1 The growing process of tilapia

Tilapia can spawn from as young as four months (± 40 grams) every six to seven weeks throughout the year (Pieterse & Viljoen 1994:3). There are various methods that can be used to control spontaneous spawning from a young age, such as making use of predators to control the numbers of small fish (fingerlings), separating the genders or making use of hormone treatment (Pieterse & Viljoen 1994:3-5). For this design, the chosen method for controlling spontaneous spawning is to manage the gender relationship of the fingerlings through hormone treatment (i.e. 90% male and 10% female).

Tilapia farming requires hatching dams wherein a screen is placed between the deep and shallow sides in order to separate the spawning fish (i.e. one male and three females in a 6 m x 6 m spawning space) from the fingerlings (in a 14 m x 6 m space). By making use of this process, 6 000 - 8 000 fingerlings could be harvested in a period of three months. From there, the fingerlings need to be moved towards the growing tanks where hormone treatment happens. The fingerlings stay at the growing tanks for six weeks before they are moved to the growing dams (20 m x 6 m x 1 m deep). The fingerlings stay in these dams until they are transported to the production dams just after the winter (Pieterse & Viljoen 1994:6) (see figure 6.41). Mr Henk Stander from the Aquaculture Division Department of Animal Sciences, the University of Stellenbosch confirmed that production dams need to be shallow and rectangular, each with a size of 200 metres², where an average of 45 kilograms fish/m³ can grow (personal communication, 25 May 2018).The water temperature can be increased in the winter months by using solar-heating.

For an analysis of the aquaponics ratio between fish farms and grow beds, see Appendix E.

6.6.2 Aquaponics plant selection

The plants chosen for the aquaponics grow beds to be used at the ABT and DWC, as discussed in Chapter 3, are the same as some of the vegetables and herbs that already grow in a close proximity to the site. The plants that have been selected are vegetables and herbs, such as lima beans, African eggplant, tomatoes, eggplant, pumpkin, lettuce, spinach, cabbage, basil, thyme, mint, rosemary and lavendula spp.

Some of the vegetables grown in the gardens at the aforementioned Babylonstoren make use of trellising to grow vertically. Vertical gardening is an old gardening technique that makes use of bottom-up and top-down support by means of trellises (Fell 2011:1). Trellises can be made with galvanised steel cables that are fixed at the bottom of the planter and to an overhang support, such as a pergola. This technique improves the production of the crop by exposing the crop to adequate sunlight, which improves fruit growth (Fell 2011:1-2). Trellises can improve air circulation, which can benefit plant growth, save growing space, requires less effort for spraying pests and lessens diseases because problem areas are easily spotted (Fell 2011:1-2). For the proposed design, the use of trellising for vegetables to grow vertically is suggested for the ABT grow beds.

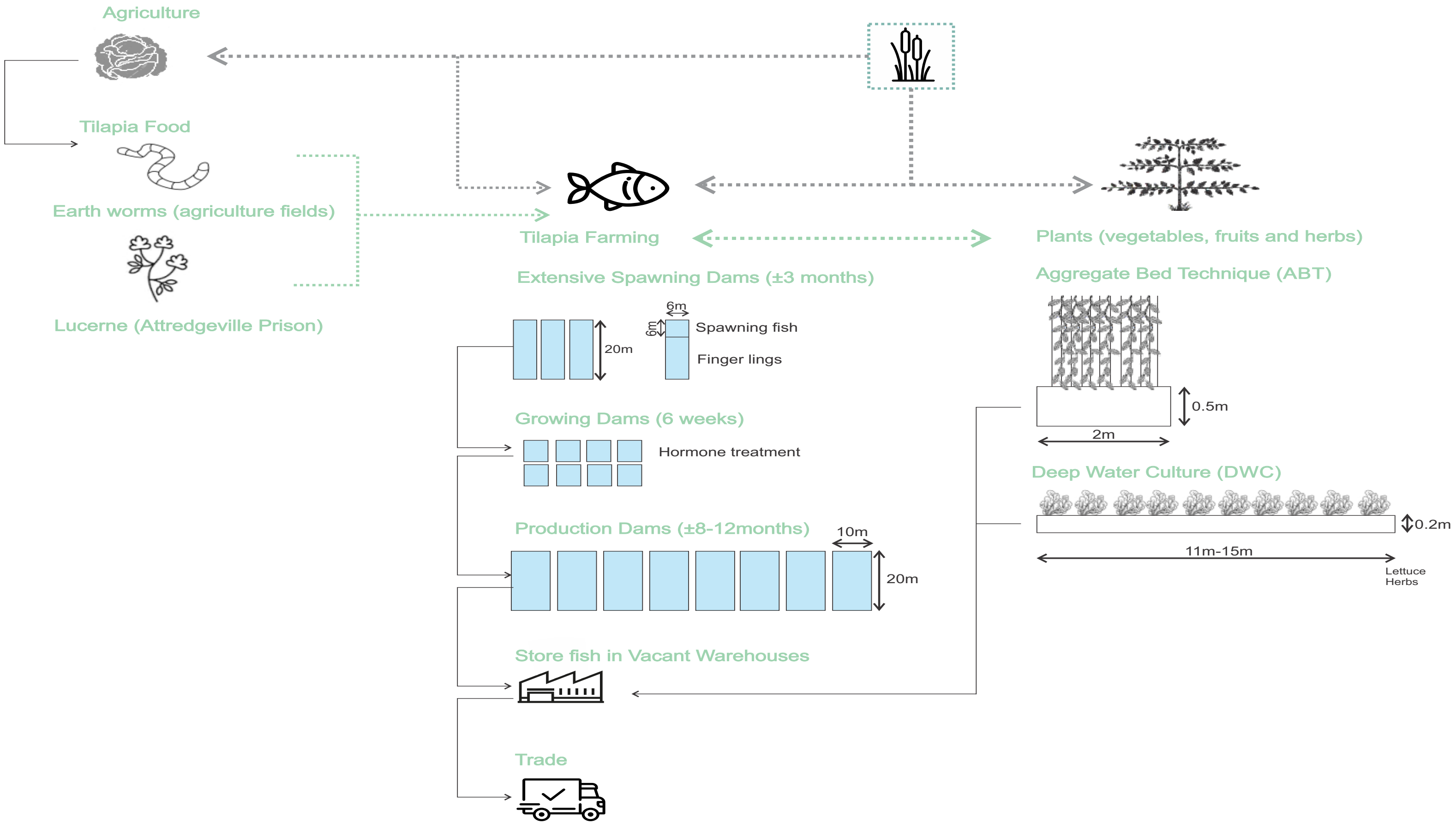


Fig 6.41 Proposed aquaponic system (Author 2018)

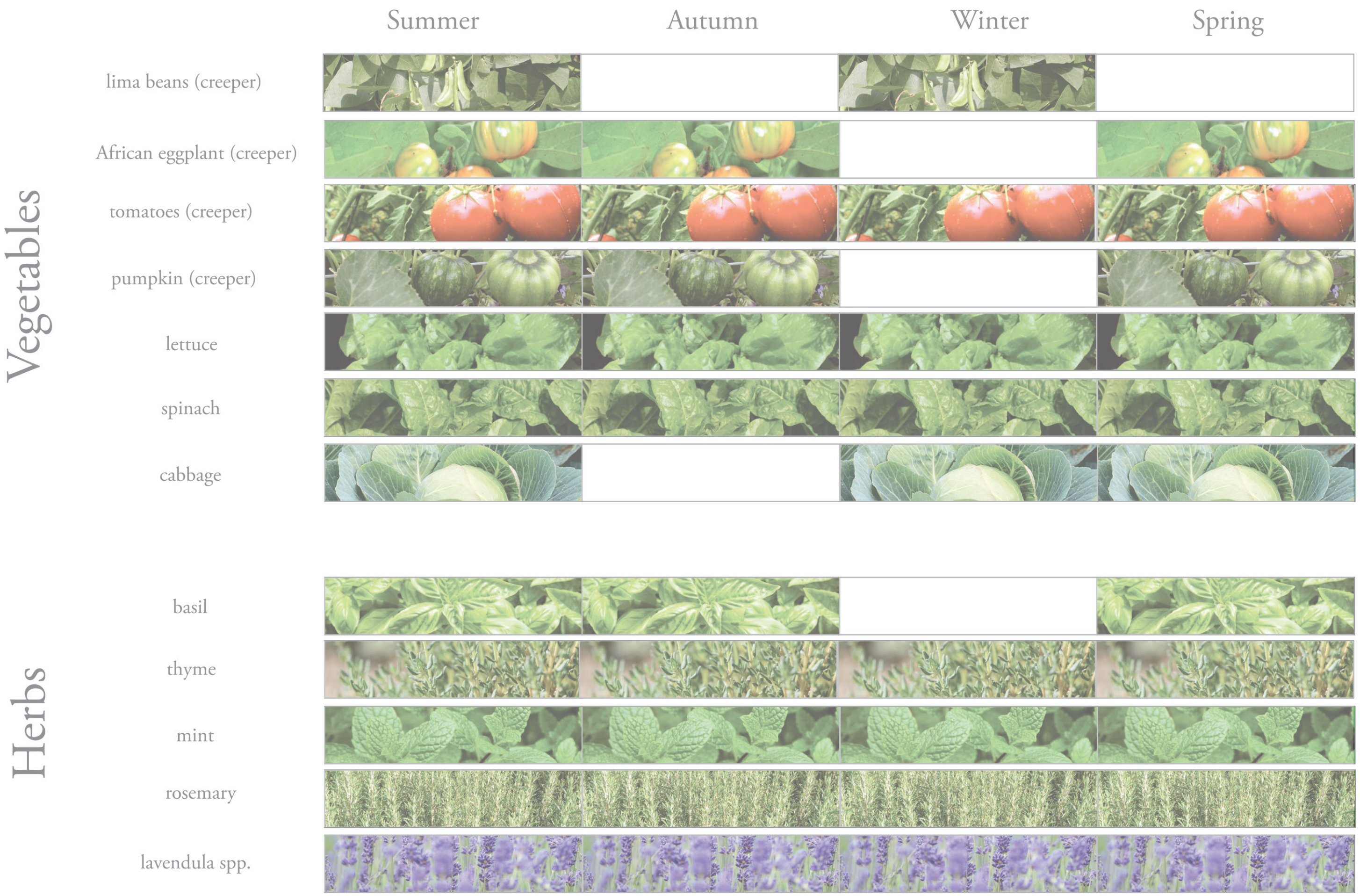


Fig 6.42 Plants proposed for the aquaponics system (Author 2018)

6.7 Conclusion

This chapter has demonstrated how the technical approach for making Pretoria Works a productive landscape is based on the development of its phenomenological spatial qualities of water. These qualities not only guide the investigation into water-treating and water-harvesting systems, plant strategies, the natural swimming pool design, the choice of construction material and the aquaponics production system, but also the decisions to be made about each field. Throughout this dissertation, the emphasis has been on treating industrial waste water before it can be used for agriculture, aquaponics and/or human recreational activities. The proposed design also caters for the harvesting of rain water through the use of retention dams that will fill the construction wetlands.

When confronted with decisions about plants, shrubs, groundcovers and veld grass, their indigenous belonging was evident. This understanding of their indigenous belonging has contributed towards increasing the phenomenological spatial qualities of Pretoria Works.

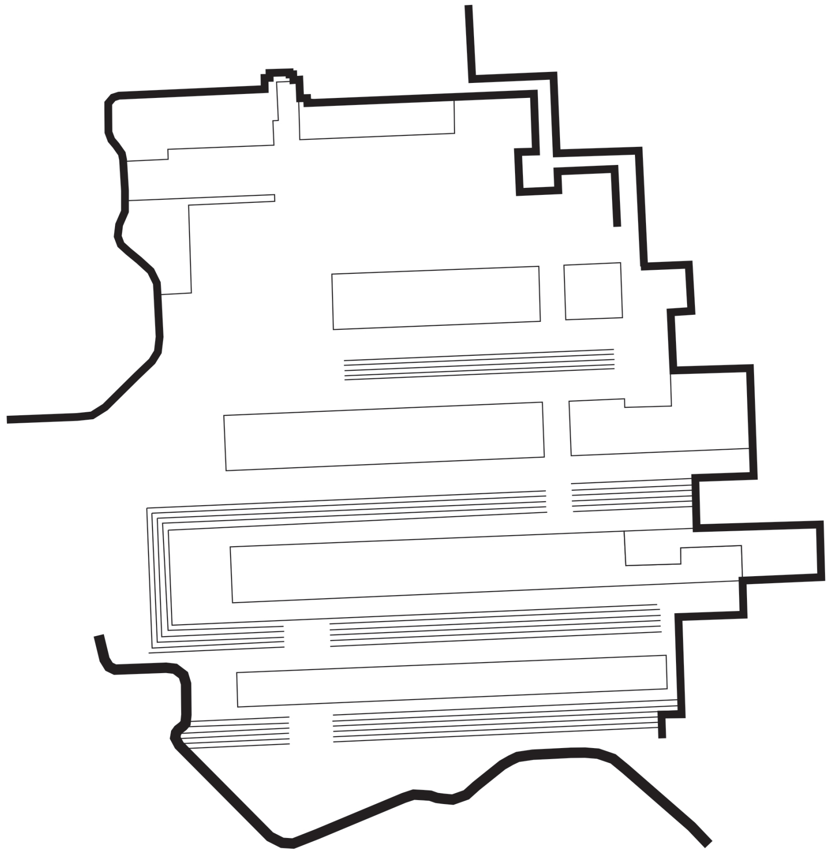


Fig 6.43 Parti diagram of design (Author 2018)

Fig 7.1 Author observing Pretoria Works quarry (Author 2018)