# Conclusion 7

## 7.1 Reflections

A regenerative design was used to create an adaptable social programme to transform Pretoria Works, the industrial waste landscape, into a productive landscape. In so doing, the author has argued that the well-being of the site's surrounding community may be improved. This approach addressed the problem statement of the dissertation, which is that Pretoria Works can be described as a semi-post-industrial site due to the shutdown of its main industrial activity of steel production. The shutdown led to thousands being added to the overall unemployment rate in Pretoria West.

The use of water for food production emerged as a central focus of the dissertation; particularly in relation to the harvesting of rain water and the treatment of industrial waste water through the technology of phytoremediation. This latter technology makes use of constructed wetlands, which forms part of a green network in order to remove heavy metals found in industrial effluents before the water is discharged for agriculture, aquaponics and/or human recreational activities. The aquaponics system offers job opportunities for producing both vegetables and fish through a sustainable ecosystem. Such employment opportunities could significantly improve the well-being of the site's surrounding community.

It was emphasised that to value water as resource, individuals need to become emotionally attached to water. This suggests that water should not be considered only as a resource for production, but also as a phenomenon that resonates with humans' deepest longings, fears and hopes. A phenomenological perspective of water is gained when people are exposed to its appearance, which can be subjectively described. The experience of water is spatially characterised as one of four aspects in architecture: a point, a line, a pool and an edge. An understanding of these aspects led to a design of an aquaponics system, which uses waterfalls (i.e. points that represent gathering) placed at the end of an aquaponics system (i.e. a line that acts as the source of power). A natural swimming pool (i.e. a pool that refers to a place of culture and reflection) within the landscape allows swimmers to immerse themselves into the water and forget about the everyday rush of the city. These pool spaces are integrated with pathways (i.e. an edge that presents a place of restrictions and imagination) towards a promenade that makes use of the existing sedimentation walls. This edge creates spatial experiences for the local public and tourists that could improve the well-being of the people in the community.

## 7.2 Lessons learned

The technology of phytoremediation was considered to replace the existing industrial waste water treatment of Pretoria Works. However, secondary research revealed that the industrial waste water treatment cannot be replaced by phytoremediation, and phytoremediation could only be a tertiary treatment to industrial waste water.

## 7.3 Future research

The technology of phytoremediation and plant choices to treat industrial waste water should be further researched. Hybrid plants can potentially be nursed to treat industrial waste water effectively, and replace an entire industrial waste water treatment plant with a sustainable, cost-effective approach.

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# Appendix A

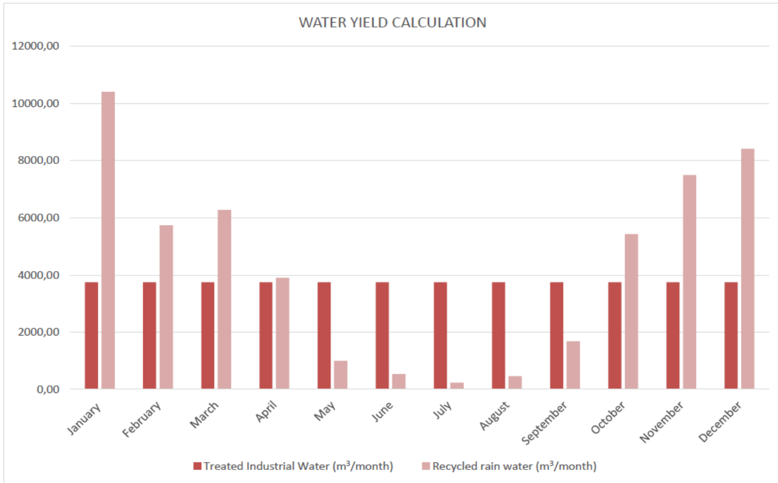
| TREATED WATER | |
|---|---|
| Available | Total yield ($m^3$/month) |
| 20% of total treated water (approximately 15 000$m^3$) | 0 |
| TOTAL | 0 |

| AREA CALCULATION (Mountain, veldgrass) | | | |
|---|---|---|---|
| | | Runoff Coefficient | |
| Catchment | Area, A ($m^2$) | C | C (weighted) |
| Mountain (veldgrass) | 145000 | 0,35 | 0,35 |
| TOTAL | 145000 | | 0,35 |

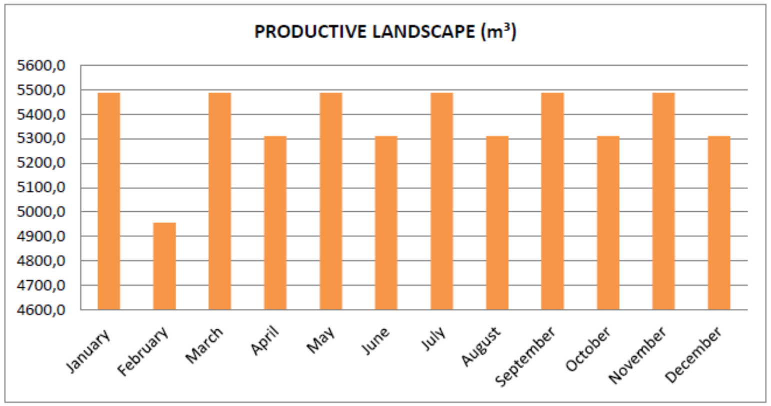
| AREA CALCULATION (Parking) | | | |
|---|---|---|---|
| | | Runoff Coefficient | |
| Catchment | Area, A ($m^2$) | C | C (weighted) |
| Paving | 900 | 0,9 | 0,13 |
| Gravel | 5300 | 0,65 | 0,56 |
| TOTAL | 6200 | | 0,69 |

| AREA CALCULATION (Walkways) | | | |
|---|---|---|---|
| | | Runoff Coefficient | |
| Catchment | Area, A ($m^2$) | C | C (weighted) |
| Paving | 20650 | 0,9 | 0,90 |
| TOTAL | 20650 | | 0,90 |

| WATER YIELD CALCULATION | | | | |
|---|---|---|---|---|
| Month | Ave. rainfall, P (m) | Treated Industrial Water ($m^3$/month) | Recycled rain water ($m^3$/month) | Total yield ($m^3$/month) |
| January | 0,136 | 0,00 | 10008,24 | 10008,24 |
| February | 0,075 | 0,00 | 4125,375 | 4125,38 |
| March | 0,082 | 0,00 | 4510,41 | 4510,41 |
| April | 0,051 | 0,00 | 2805,255 | 2805,26 |
| May | 0,013 | 0,00 | 715,065 | 715,07 |
| June | 0,007 | 0,00 | 385,035 | 385,04 |
| July | 0,003 | 0,00 | 165,015 | 165,02 |
| August | 0,006 | 0,00 | 330,03 | 330,03 |
| September | 0,022 | 0,00 | 1210,11 | 1210,11 |
| October | 0,071 | 0,00 | 3905,355 | 3905,36 |
| November | 0,098 | 0,00 | 5390,49 | 5390,49 |
| December | 0,11 | 0,00 | 6050,55 | 6050,55 |
| | | | | |
| ANNUAL AVE. | 0,674 | 0,00 | 37073,37 | 37073,37 |
| | | | ANNUAL TOTAL | 37073,37 |




| AGRICULTURE | | | | |
|---|---|---|---|---|
| Month | Area ($m^2$) | Irr. depth / week ($m^3$) | Irr. depth / month ($m^3$) | Irrigation demand ($m^3$/month) |
| January | 20000 | 0,025 | 0,11 | 2214,29 |
| February | 20000 | 0,025 | 0,10 | 2000,00 |
| March | 20000 | 0,025 | 0,11 | 2214,29 |
| April | 20000 | 0,025 | 0,11 | 2142,86 |
| May | 20000 | 0,025 | 0,11 | 2214,29 |
| June | 20000 | 0,025 | 0,11 | 2142,86 |
| July | 20000 | 0,025 | 0,11 | 2214,29 |
| August | 20000 | 0,025 | 0,11 | 2142,86 |
| September | 20000 | 0,025 | 0,11 | 2214,29 |
| October | 20000 | 0,025 | 0,11 | 2142,86 |
| November | 20000 | 0,025 | 0,11 | 2214,29 |
| December | 20000 | 0,025 | 0,11 | 2142,86 |
| | | | ANNUAL TOTAL | 26000,00 |




| FISH FARM DEMAND | | | | |
|---|---|---|---|---|
| Month | Area ($m^2$) | Evaporation week ($m^3$) | Evaporation/ month ($m^3$) | Evaporation demand ($m^3$/month) |
| January | 700 | 0,01 | 0,04 | 31,00 |
| February | 700 | 0,01 | 0,04 | 28,00 |
| March | 700 | 0,01 | 0,04 | 31,00 |
| April | 700 | 0,01 | 0,04 | 30,00 |
| May | 700 | 0,01 | 0,04 | 31,00 |
| June | 700 | 0,01 | 0,04 | 30,00 |
| July | 700 | 0,01 | 0,04 | 31,00 |
| August | 700 | 0,01 | 0,04 | 30,00 |
| September | 700 | 0,01 | 0,04 | 31,00 |
| October | 700 | 0,01 | 0,04 | 30,00 |
| November | 700 | 0,01 | 0,04 | 31,00 |
| December | 700 | 0,01 | 0,04 | 30,00 |
| | | | ANNUAL TOTAL | 364,00 |

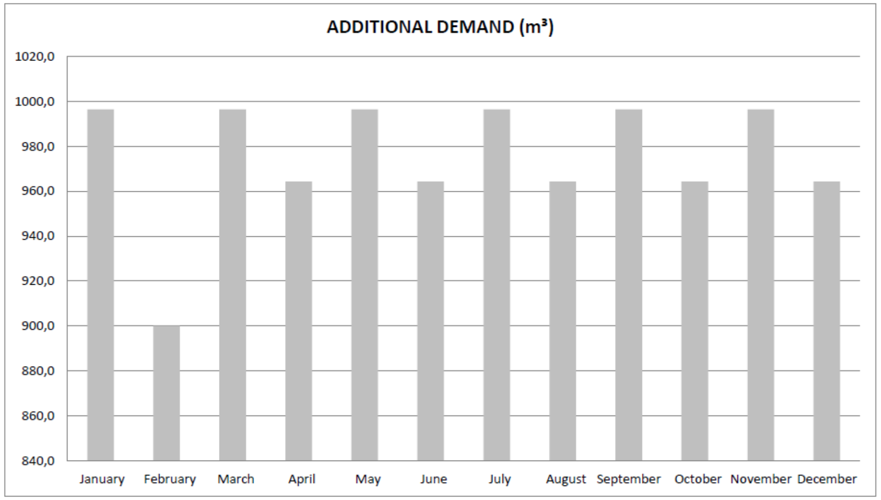
| PRODUCTIVE LANDSCAPE DEMAND | |
|---|---|
| Month | Total demand ($m^3$/month) |
| January | 2245,3 |
| February | 2028,0 |
| March | 2245,3 |
| April | 2172,9 |
| May | 2245,3 |
| June | 2172,9 |
| July | 2245,3 |
| August | 2172,9 |
| September | 2245,3 |
| October | 2172,9 |
| November | 2245,3 |
| December | 2172,9 |
| TOTAL | 364,0 |

| PEOPLE WASHING DEMAND | | | |
|---|---|---|---|
| Month | People | Entity demand / day (l) | Alt demand (m³/month) |
| January | 300 | 8 | 74,4 |
| February | 300 | 8 | 67,2 |
| March | 300 | 8 | 74,4 |
| April | 300 | 8 | 72 |
| May | 300 | 8 | 74,4 |
| June | 300 | 8 | 72 |
| July | 300 | 8 | 74,4 |
| August | 300 | 8 | 72 |
| September | 300 | 8 | 74,4 |
| October | 300 | 8 | 72 |
| November | 300 | 8 | 74,4 |
| December | 300 | 8 | 72 |
| | | ANNUAL TOTAL | 873,6 |

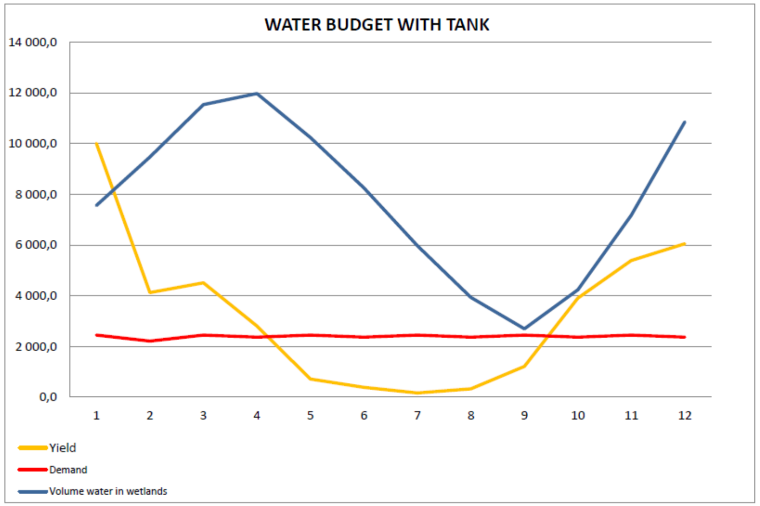
| ECO -POOL DEMAND | | | | |
|---|---|---|---|---|
| Month | Area (m²) | Evaporation week (m³) | Evaporation/ month (m³) | Evaporation demand (m³/month) |
| January | 480 | 0,05 | 0,22 | 106,29 |
| February | 480 | 0,05 | 0,20 | 96,00 |
| March | 480 | 0,05 | 0,22 | 106,29 |
| April | 480 | 0,05 | 0,21 | 102,86 |
| May | 480 | 0,05 | 0,22 | 106,29 |
| June | 480 | 0,05 | 0,21 | 102,86 |
| July | 480 | 0,05 | 0,22 | 106,29 |
| August | 480 | 0,05 | 0,21 | 102,86 |
| September | 480 | 0,05 | 0,22 | 106,29 |
| October | 480 | 0,05 | 0,21 | 102,86 |
| November | 480 | 0,05 | 0,22 | 106,29 |
| December | 480 | 0,05 | 0,21 | 102,86 |
| | | | ANNUAL TOTAL | 1248,00 |

| ADDITIONAL DEMAND | |
|---|---|
| Month | Total demand (m³/month) |
| January | 202,8 |
| February | 183,2 |
| March | 202,8 |
| April | 196,3 |
| May | 202,8 |
| June | 196,3 |
| July | 202,8 |
| August | 196,3 |
| September | 202,8 |
| October | 196,3 |
| November | 202,8 |
| December | 196,3 |
| ANNUAL TOTAL | 2381,6 |

| FOCAL LANDSCAPE IRRIGATION DEMAND | | | | |
|---|---|---|---|---|
| Month | Area (m²) | Irr. depth / week (m³) | Irr. depth / month (m³) | Irrigation demand (m³/month) |
| January | 200 | 0,025 | 0,11 | 22,14 |
| February | 200 | 0,025 | 0,10 | 20,00 |
| March | 200 | 0,025 | 0,11 | 22,14 |
| April | 200 | 0,025 | 0,11 | 21,43 |
| May | 200 | 0,025 | 0,11 | 22,14 |
| June | 200 | 0,025 | 0,11 | 21,43 |
| July | 200 | 0,025 | 0,11 | 22,14 |
| August | 200 | 0,025 | 0,11 | 21,43 |
| September | 200 | 0,025 | 0,11 | 22,14 |
| October | 200 | 0,025 | 0,11 | 21,43 |
| November | 200 | 0,025 | 0,11 | 22,14 |
| December | 200 | 0,025 | 0,11 | 21,43 |
| | | | ANNUAL TOTAL | 260,00 |




| PRIMARY YIELD AND DEMAND UTILIZING A WATER TANK | | | | |
|---|---|---|---|---|
| Month | Yield (m³) | Demand (m³) | Monthly balance | Vol. water in wetland (m³) |
| January | 10 008,2 | 2 448,1 | 7 560,1 | 7 560,1 |
| February | 4 125,4 | 2 211,2 | 1 914,2 | 9 474,3 |
| March | 4 510,4 | 2 448,1 | 2 062,3 | 11 536,6 |
| April | 2 805,3 | 2 369,1 | 436,1 | 11 972,7 |
| May | 715,1 | 2 448,1 | -1 733,0 | 10 239,7 |
| June | 385,0 | 2 369,1 | -1 984,1 | 8 255,6 |
| July | 165,0 | 2 448,1 | -2 283,1 | 5 972,5 |
| August | 330,0 | 2 369,1 | -2 039,1 | 3 933,3 |
| September | 1 210,1 | 2 448,1 | -1 238,0 | 2 695,3 |
| October | 3 905,4 | 2 369,1 | 1 536,2 | 4 231,5 |
| November | 5 390,5 | 2 448,1 | 2 942,4 | 7 173,9 |
| December | 6 050,6 | 2 369,1 | 3 681,4 | 10 855,3 |
| AVERAGE | 39 600,9 | 28 745,6 | 10855,33 | 7 825,1 |
| | | | Safety factor | 1,5 |
| | | | Needed | 11737,609 |
| | | | Tank Size | 11738 |



## Appendix B

### Waste water contaminants commonly produced from steel and iron industry plants

Studies indicate that iron and steel industries produce waste water that may contain cyanide, sulphate, phenol, dust, heavy metal, coal ash, slags and iron ore particles (Jørgensen 2008). The human health effect of each contaminant is briefly indicated in the following subsections. Waste water contaminants

*Cyanide*

Low concentrations of cyanide have been found in some foods and occasionally in drinking-water, which is well below health concerns. These occurrences have mostly been documented in developing countries (World Health Organization [WHO] 2011:342-343). However, high concentrations of cyanide can sometimes occur in surface water (canalising rivers) due to industrial effluent. Exposure to high concentrations of cyanide is extremely dangerous as the cyanide can cause water to become toxic (WHO 2011:342-343).

*Sulphate*

The highest levels of sulphate usually occur in natural sources, such as groundwater, and can also be found through discharged industrial waste water. No health-based guidelines have been proposed for sulphate in water, because sulphate is one of the major components in drinking water, air and food. However, it is recommended to notify health authorities when sulphate exceeds general qualities (in excess of 500 mg/l) (WHO 2011:419).

*Phenol*

The by-products of phenol are 2-chlorophenol; 2,4-dichlorophenol; 2,4,6-trichlorophenol ;l and Phenyl phenol. The usual amounts of phenol present in water is of low-toxicity status and is unlikely to represent any hazard to human health (WHO 2011:410).

*Dust*

Coal mines are some of the most common places where dust which can be hazardous to human health can occur. The lag-time between dust being exposed and its effects (e.g. lung-disease) is approximately 10 years. The term ‘pneumoconiosis’ refers to a group of lung diseases caused by inhaling coal dust (Knott, 2014).

*Heavy metals*

Mining industries are some of the main causes for humans being exposed to heavy metals, due to industrial waste water discharge. This effluent can pose serious threats to human health and water quality when it flows into rivers, lakes and reservoirs (Rai, 2009).

*Coal ash*

Coal ash can be released into the environment through coal transportation, utilisation, and waste disposal. This ash can be introduced to the environment by the leaching of coal, which can affect the quality of the soil, air, surface water and ground water (Chen, 2014, p. 739).

*Slags*

Slags form part of metallic and non-metallic components. Most metallic-component slags contain toxic elements. These elements can marginally leach from the slag when it comes in contact with water and can contribute to environmental hazards by exposing heavy metals making (Reuter 2004:354). Non-metallic components are not soluble in water and can be crushed and made fine for sand, cement and brick making (Reuter 2004:354). Pretoria Works’ adjacent quarry is an example of sand, cement and bricks being made by re-using non-metallic components.

*Iron*

Iron is found naturally in fresh water sources, and is one of the most abundant metals in the earth’s crust. There is a possibility that iron may be present in drinking-water, which could affect its taste and appearance, but it is not considered to be a health hazard (WHO 2011:381-382).

## Appendix C

### Strengths, weaknesses, opportunities and threats manifested in Region Three

Pretoria Works is located on the south-west ridge five kilometres off the Pretoria CBD at the crossing of Roger Dyason and Frikkie Meyer Road. It is situated within the core of Pretoria West's industrial hub. The site forms part of Region Three of the bigger Tshwane framework (COT 2017:38-39). For this project and its relevance thereto, the site can be described through analysing its strengths and weaknesses, and by identifying the opportunities it creates and threats that must be acknowledged and addressed within its composition.

### Strengths

- When looking at the metropolitan area, Region Three is centrally located and accessible from all directions.
- The region holds a significant portion of higher-, middle- and lower-class job opportunities in the metro.
- This region includes the educational heartland of Pretoria; containing all three Tshwane universities, namely The University of Pretoria, UNISA, and The Tshwane University of Technology.
- The region has a variety of landmarks and buildings with historic value, which can and does attract tourists and presents opportunities for new initiatives.
- The region is strategically important because it includes the CBD, and there is good transport links between the region and the CBD.
- The region has good road and rail infrastructure, further facilitating north-south and east-west transport links.
- The area has good industrial infrastructure, including Pretoria Works that can be re-used, as per this project.

### Weakness

- The closing of ISCOR's steel production plant has led to a decline in job security.
- This increased the poverty levels in the west of Pretoria.
- The Pretoria East and West links within the region are not continuous, which has led to the underdevelopment of the western areas of the city.

### Opportunities

- The opportunity exists to introduce new and improved tourism attractions in the CBD, and capitalising on the existing tourist attractions.
- ISCOR's infrastructure could be investigated as a development opportunity for the area.
- There is also an opportunity to increase the density and provision of more job opportunities at the stations located on or in close proximity of the Pretoria Ring Rail Stations, where Cordelfos station adjacent to Pretoria Works forms part of this stations.

### Threats

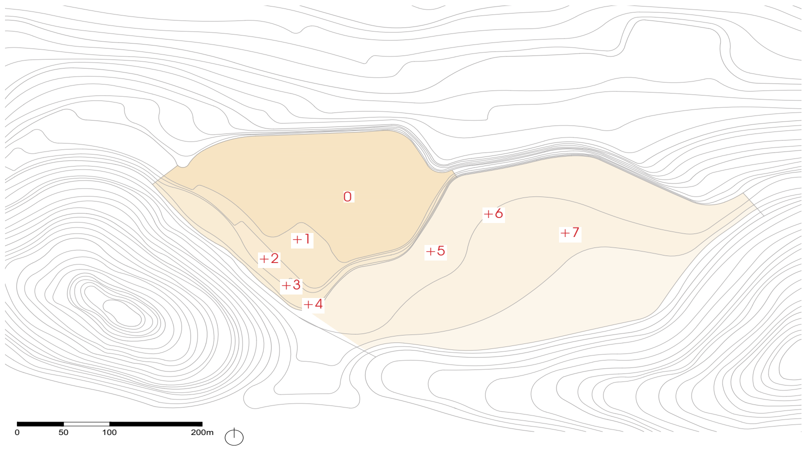
- Parts of the region are under threat due its location in relation to the CBD and the Ring Rail stations that have neglected re-development opportunities for public transport. Strong planning guidance in these instances will be required.

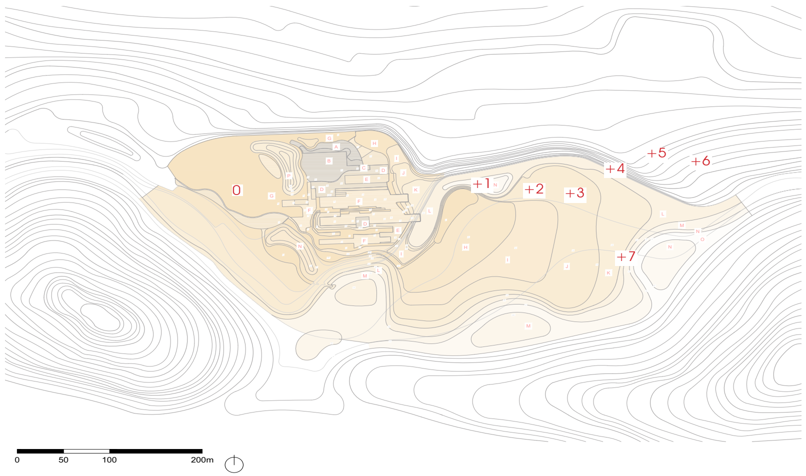
# Appendix D

| SOIL EXCAVATION (LOWEST DAM) | | | | | | |
|---|---|---|---|---|---|---|
| A. Area (m²) | B. Area (m²) | C. Area (m²) | D. Area (m²) | E. Area (m²) | F. Area (m²) | G. Area (m²) |
| 1 000 | 1 750 | 70 | 1 470 | 1 860 | 6 510 | 0 |
| 6m Excavated (m³) | 5m Excavated (m³) | 4m Excavated (m³) | 3m Excavated (m³) | 2m Excavated (m³) | 1m Excavated (m³) | Ground Floor |
| 6 000 | 8 750 | 280 | 4 410 | 3 720 | 6 510 | 0 |
| TOTAL SOIL (m³) | 29 670 | | | | | |

| SOIL EXCAVATION AND FULLING (HIGHEST DAM) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| H. Area (m²) | I. Area (m²) | J. Area (m²) | K. Area (m²) | L. Area (m²) | M. Area (m²) | N. Area (m²) | O. Area (m²) | P. Area (m²) |
| 8 000 | 8 400 | 13 600 | 8 540 | 0 | 9950 | 6570 | 2920 | 5680 |
| 4m Excavated (m³) | 3m Excavated (m³) | 2m Excavated (m³) | 1m Excavated (m³) | Ground Floor | 1m Full (m³) | 2m Full (m³) | 3m Full (m³) | 4m Full (m³) |
| 32 000 | 25 200 | 27 200 | 8 540 | 0 | -9950 | -14270 | -8760 | -22720 |
| TOTAL SOIL (m³) | 37 240 | | | | | | | |
| TOTAL SOIL (m³) | 66 910 | | | | | | | |

| USING EXCAVATED SOIL FOR AGRICULTURE | |
|---|---|
| Agriculture (1) | Agriculture(2) |
| Area (m²) | Area (m²) |
| 145 000 | 262 050 |
| 0.1m deep(m³) | 0.2m deep(m³) |
| 14500 | 52 410 |
| TOTAL SOIL (m³) | 66 910 |



# Appendix E

| TILAPIA FARM REQUIREMENTS FOR PRETORIA WORKS IS DETERMINDED BY SURPLUS RAIN WATER CALCULATIONS | |
|---|---|
| People per day | ± 500 |
| Fish sold per day, 800g per fish | 250 (2 fillets per fish), |
| Fish sold per week, 800g per fish | 1750 fish |
| Fish required per year (50 weeks) | 87500 fish / 70 000kg/$m^3$ |
| Fish harvested in (1$m^3$/45kg/ 10-12 months, Fry 1$m^3$/25kg | 57 fish / 45kg/$m^3$ |
| Production dams (200$m^2$ @1m deep = 200$m^3$ / 10-12 months) | 11250 fish (9000kg/$m^3$) |
| Aquaponic - Fish tanks (3mØ @ 1m deep =7$m^3$/10-12 months) | 315kg/7$m^3$ (394 fish) |
| Production fish ponds required (200$m^3$) | 8 (1600$m^3$) |
| Spawining dams (20m x 6m=120$m^2$ @ 1m deep) | 4 (480$m^3$) |
| Aquaponic - Fish tanks (3mØ @ 1m high =7$m^3$/6 weeks growing section, cleaned by bio-filter) | 8 |
| Deep Water Culture (DWC) 4 fish tanks (1 tank = 7$m^3$= 28$m^3$) /2 Vegetable rafts tanks (15 m x 1m x 0,3m)=200$m^3$/28=7x 2 (vegetable rafts tanks) | 14 Rafts/Production dam |
| Aggregate Bed Technique (ABT) 4 fish tanks (1 tank = 7$m^3$ = 28$m^3$) /16 Growbeds (2mx1mx0,3m)200$m^3$/ 28=7x 16 (growbeds) | 112 Growbeds |
| Combination of Rafts and Growbeds per Production Dam | 10 Rafts with 50 growbeds |

Fig 7.2 Final examination (Author 2018)

Fig 7.3 Final examination (Author 2018)