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RE-MINING
JOHANNESBURG
Urban redevelopment through the treatment of
acid mine drainage

By

DIRK ANDRÉ COETSER

A dissertation submitted as partial fulfilment for the
MASTERS DEGREE IN TECHNOLOGY
in
Architectural Technology (Professional)
in the
Faculty of Art, Design and Architecture
at the
University of Johannesburg

Supervisor: Alexander Opper
Co-Supervisor: Heinrich Kammeýer

2012
AFFIDAVIT: MASTER’S AND DOCTORAL STUDENTS

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DECLARATION

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Figure 1: Restored mining headgear on Main Street, Johannesburg, 2012. Photograph by John Saaiman.
This book is dedicated to my father to whom I owe my life, to my amazing mother and two beautiful sisters. Thank you to Nicola Botes for her loving support, selfless care and for being my biggest inspiration. To my architecture flatmates John Saaiman and Karabo Mokaba, thank you for a special year.

I also want to thank my mentors Alexander Opper and Heinrich Kammeýer for their valuable input.

Lastly, I want to thank the Department of Architecture at the University of Johannesburg for building this masters course and for the knowledge it provided me.
"The fall of Jozi

Egoli shines from the gold mine
From its belly mouth poisoning its skin
The caged beast of toxic acid mine water
is rising from abandoned cavities

The Randlords are gone
The legacy a concrete grid
and the slow acidic seep eroding its future.

Jozi, blessed but cursed by gold"

From the film:

*Ho Wa Ha Jozi* (Lembethe & Ramotsoela 2011)
Abstract

Re-mining Johannesburg

Urban redevelopment through the treatment of acid mine drainage

The architectural intervention proposes an urban redevelopment along the mining belt of the city of Johannesburg through the treatment of acid mine drainage.

The design research includes a network of selected sites located along the Johannesburg mining belt to address the problem of acid mine drainage, as well as to provide solutions for future urban environments.

The main solutions to eradicate the acid mine water problem are infrastructural, which in most cases is associated with inhumane environments. A design question addressing the marriage between harsh infrastructure and humane environments is therefore dealt with in an attempt to create a self-sustaining architecture in which infrastructure can have an integrative urban function for the future.

The dissertation aims to achieve a design intervention that will thread the traces of a mining century into this contemporary African city, through an architecture that will grow into the future of the ever-changing and continuously emergent Johannesburg.
infrastructure + humane environment = self-sustaining architecture

Figure 2: Acid Mine Drainage purification plant in Western Johannesburg: Inhumane environment.
Abstract collage

Appropriated by-products in use.

"New" water based humane environment.

Figure 3: Abstract collage
AMD purification plant.
Hypothesis: Can urban infrastructure become humane environments?

1. Mining void currently filling with AMD

2. Old shafts form link between the invisible underworld and the earth’s surface.

3. Red line: purified water
   Black line: by-products from the purification process

4. AMD purification plant.
   Hypothesis: Can urban infrastructure become humane environments?
World water day 2012

"There needs to be a collective effort by all South Africans to find a long-term solution to Acid Mine Drainage.

In central Johannesburg, some of the sodium-rich water eventually makes its way into the Vaal river. The river can only tolerate the current sodium levels until 2014. It will cost R900m to R1 billion to deal with the short-term solution."

Water Affairs Minister, Edna Molewa (IOL Business, 2012:[sp])
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Glossary

Four terms are essential to the reading of this document:

Decanting:
Acid mine water draining through the earth’s surface.

Acid Mine Drainage (AMD):
Water with an acidic nature escaping from the mining void.

Headgear:
Mining structure above surface.

Tailings:
Also known as mine dumps.
The introduction contains an overview of the purpose of this dissertation and a brief description on how this will be achieved.

2.1 Introduction

2.2 Aims

2.3 Methodology
Introduction

2.1 INTRODUCTION
The city of Johannesburg was born from mining, built on mining and is now facing post-mining trauma - AMD.

With the main solutions to eradicate AMD being infrastructural, the optimal sites to solve the acid mine water problem are located within the urban fabric along the Johannesburg mining belt. The contemporary city has grown into an environment for insurgent practice to evolve in. There are plenty of empty infrastructural pockets within the urban fabric which have become redundant. The infrastructure designed for the current acid mine water problem in this dissertation is also explored: how infrastructure can have an integrative urban function for the future.

2.2 AIMS
The aim of this dissertation is to further knowledge through design and quantitative research that is unique to Johannesburg. The topic, site, literature and final design intervention are all derived from the primary source - Johannesburg.

A tribute to Johannesburg (the mining legacy) is the main subject to be addressed. This is to be achieved architecturally by creating an “archaeology” of the future through the manifestation of relevant architecture.

2.3 METHODOLOGY
The methodology used maintains a balance between qualitative and quantitative research. Existing quantitative research on acid mine water is researched and extracted, while the chosen sites and design include qualitative research methods. Knowledge on the topic is furthered by devising a new architectural response to the acid mine water crisis that also attempts to tie the multiple layers and challenges of Johannesburg together.
Figure 3: Rotated photograph of acidic water on a re-mined mine dump, Johannesburg, 2012.
The historical overview provides the background information essential to the understanding of the AMD crisis. The information about the city of Johannesburg is categorised under the following sub-headings:

3.1 The mining history

3.2 The water history

3.3 Randjeslaagte triangle
Preface

The city of Johannesburg originated as a mining town, developed into the apartheid city and has now become a contemporary African metropolis. Originally, the city was planned and laid out to accommodate temporary mining activities only (as in the case of diamond mining in Kimberley), but the city continued to evolve into the metropolis of Johannesburg.

The city was originally grounded in its mining genesis (fig. 7, page 26) which posed many complexities. These developed into more complex matters which this research document aims to tie together. The history of mining in Johannesburg runs deep - so to speak - it was the reason for the inception of this mining town and could potentially also mean the downfall of the city.

Figure 6: Original mine opening within contemporary Johannesburg.
Figure 7: Sketched map of Johannesburg (the oldest trace of the city), 1886, (Image courtesy of Museum Africa).
The history of Johannesburg is filled with signs of reckless mining with no sense of traceable rehabilitation (fig. 8&9). This is a pattern of negligence that originates from the first mining camps and still prevails.

Witwatersrand Goldfields was proclaimed by Mining Commissioner, Captain Carl von Brandis, on the 20th of September, 1886.

Randjeslaagte became the public diggings on the 4th of October, 1886. When Randjeslaagte became a residential development, the de-proclamation of diggings inside the habitable area was neglected. The Randjeslaagte Syndicate continued to mine in the middle of the new village and found gold between Bree and Pritchard Streets (Meiring, 1986:15). This is almost as illogical as the current state of mining in Johannesburg where informal settlements are often placed on or near radioactive mine tailings. Mine dumps in the Central Business District (CBD) are currently being re-mined, releasing more pollution into the environment.

The original mining camps in Johannesburg still carry their names and geographical locations in the city. Marshall’s Town and Ferreira’s dorp were only incorporated into Johannesburg in late 1887 and 1888 (Meiring, 1986:16). Marshall’s Town was established in September 1887, named after Herbert Marshall and laid out by a draughtsman named Simmonds (Manoim, 2003). A great majority of street names in the Johannesburg CBD are derived from the original mining town and its pioneers. There are reports that the current government is starting the process of renaming these to the names of their political pioneers. These occurrences are ephemeral links to insurgent practices of contemporary cities that Bremner (2010) refers to as the blurring of historic events.
3.1 The mining history

...Johannesburg is filled with traces of reckless mining...
3.2 The supply of water in early Johannesburg

Johannesburg has always encountered problems with either the supply of water or the quality thereof. Whilst most major cities originated near water sources, Johannesburg, however, originated purely around the discovery of gold (Manoim, 2003). From its inception, the city of Johannesburg has had polluted drinking water obtained from the Fordsburg Dip (Meiring, 1986:17). In 1895 Johannesburg experienced a drought at the time. The Johannesburg Waterworks Company only provided drinking water for an hour in the morning and an hour in the evening and cooking had to be done in soda water (Meiring, 1986:24).

Figure 10: Acid mine water in the west of Johannesburg, 2012.
From its inception, the city of Johannesburg had polluted drinking water...
(Meiring, 1986:17)
3.3 Randjeslaagte triangle

Leftover land

The Randjeslaagte triangle (fig.11) on which the CBD of Johannesburg is located was formed due to “Uitvalgrond” a result of insufficient land surveying. These slivers of land were left unclaimed and therefore classified as “Uitvalgrond”. Rissik discovered the Randjeslaagte “Uitvalgrond” and identified it as a piece of land that could be occupied for living and could not be mined because it was inhospitable and stony. Despite this, mining was still being done in the area in 36 claims (Meiring, 1986:17).
The government of the late 1800's did not plan on the mining sector of Johannesburg being a success. Therefore, they commissioned Josias Eduard de Villiers to survey Randjeslaa- with small dense corners for optimal licence values to generate the maximum income out of the mining town while it lasted (Meiring, 1986, p. 15) (Garner, 2011). This formed the very footprint and dysfunctional grid (fig.10) on which the Johannesburg CBD operates today. The city, only planned to generate initial wealth, and was not expected to become a successful, flourishing metropolis. Johannesburg is in many ways still regarded as an economic node, not just by South- African citizens but also by many other African nations.

"DNA"
The initial triangle as a constant trace

**Figure 12:** Randjeslaagte triangle as a constant trace.
Acid Mine Drainage (AMD)

In the following chapter the current situation of AMD is discussed in detail.

4.1 Cause

4.2 Effects

4.3 Western region case study

4.4 Current status

4.5 Current treatment options

4.6 Selected treatment option
Introduction

The Acid Mine Drainage (AMD) problem originated at the beginning of mining in Johannesburg. It developed from deep shaft mining, shallow diggings, the discovery of cyanide and all the proceeding technologies, by-products and the continual gold rush.

There are many factual reports on the issue of AMD in the Johannesburg region, as well as plenty of uninformed publications. Reference is made to three sources to create triangulation where possible to substantiate facts from which a personal stance is formed. The three main reputable sources which are well known in the current field of AMD in Johannesburg are Prof. Frank Winde (conducted the latest report for the inner city banks in 2011), Prof. Terrance McCarthy (conducted most of the 2010 reports) and Mariette Lieferink (activist with extensive knowledge of both government and scientific reports).

Figure 13: Acidic mine water with the city of Johannesburg in the background. The billboard image of a miner on a building is facing towards the potential crisis. Johannesburg, 2012.
Reference is made to three sources to create triangulation within the AMD research.
Figure 14: Visible mining pollution highlighted across the mining belt.
Visible mining pollution (surface)
Figure 15: Invisible mining pollution highlighted across the mining belt.
Invisible mining pollution (sub-surface)

City of Johannesburg

Potential site

40 kilometres
4.1 Cause

The Witwatersrand mining basin holds the biggest gold and uranium reefs in the world. Waste from Goldmines in South Africa results in the largest source of pollution in the country (fig. 14 & 15) (Liefferink, 2012).

Initial mining in Johannesburg occurred through shallow trenches. The excavated matter was crushed with stamp mills and the rock was purified to extract gold by using mercury to clean off the rock. The shallow trenches were then replaced by inclined shafts which again became a problem when the miners started extracting ore deeper than 30 meters because the deep rock absorbed the mercury and did not release the gold. This became a financial crises as gold recovery rates dropped in 1889 and shares became near worthless. The solution to this challenge was already found in 1887 by two men from Glasgow when experimenting with cyanide. They discovered that a weak solution of potassium cyanide dissolved the gold out of the pyrites and that the gold particles cling to zinc shavings that are easy to refine. This discovery led to a big boom in the gold industry of Johannesburg as gold was now extracted from tailings that were regarded worthless before. (Meiring, 1986, 23)

The first destructive by-products of mining in Johannesburg can be traced back to the first gold diggings in the area.

Figure 16: Johannesburg cyanide works (Cachucho, 2012, [sp]).
...destructive by-products of mining in Johannesburg can be traced back to the first gold diggings in the area.
Under normal soil conditions (related to the Witwatersrand) 5% of rain water contributes to groundwater contained in the earth soils and 10% of the rain water is collected by the earth and ends up in streams that flow to the ocean. The rest of the water evaporates into the atmosphere to form clouds. The water filters into the earth and fills the natural voids formed between earth matter (cracks and fractures) (fig. 14). The voids fill up to a certain level which is called the water table. This water and the enclosing matter are called aquifers (McCarthy, 2010:15).

Figure 17: Sub-surface conditions without mining.
4.1 Cause

Subsurface conditions in the absence of mining activity
Mining creates more voids in the earth. Natural water-bearing voids are intersected in some instances leading to natural water flowing into the mine workings. In some cases, concrete pumped at a very high pressure can close these openings. Slow-flowing water can be channelled and pumped to the surface into ponds called sumps (McCarthy, 2010: 15). The 2010 high rainfall figures created a temporary increase of 37.5% to the rising rate of the water table (Winde, 2011).

Figure 18: Sub-surface conditions with mining.
4.1 Cause

Subsurface conditions in the presence of mining activity

natural underground water spills into the mining voids
4.1 Cause

The surface disturbances caused by mining processes along the Johannesburg reefs were narrow and the inflow of rainwater was controlled. The natural voids could still accommodate the rainwater inflow and mine voids where kept relatively dry. As the voids grew, they were pumped to ensure an air-filled environment. This is a balance which was once well maintained, but has now been disturbed (McCarthy, 2010:15).

Mines were closed in the 1950’s along the gold reef (as there were new opportunities) which meant that slowly, each of them also stopped pumping their respective voids. The responsibility was carried over to the remaining operational mines. The last standing mine connected to the continuous void was East Rand Propriety Mines (ERPM). The mine pumped the whole void by its own force from the eastern point of the mining void. The water level in the east was kept constant at 1200 meter by pumping 40 million litres of water per day from under ground. The massive pumping force kept the water level on the western side at a level of 500 meter below surface. In 2008 ERPM stopped pumping water. From water level measurements taken at Crown Mines shaft no. 14 at Gold Reef City, it was ascertained that the level is rising at 15 meter per month according to the 2010 reports. (McCarthy, 2010:17) (Winde, 2011) (Liefferink, 2012).

43500 tons of gold has been mined from the area south of central Johannesburg (Wilson & Anhaeusser, 1998). This has resulted in a large void beneath the surface of the earth near the city area. The mining houses were attracted to deeper opportunities, which left many voids vacant and un-rehabilitated (Heath, 2009:1).

Figure 19: Mining belt diagram indicating the location where the last pumping station was located.
...this has resulted in a large void beneath the surface of the earth near the city area. The mining houses were attracted to deeper opportunities, which left many voids vacant and un-rehabilitated...

(Heath, 2009:1)
4.2 Effects

Effects cycle

Fig. 20: Effects cycle of Acid Mine Drainage
...Chronic exposure to AMD will cause impairment of cognitive functions, skin legions, cancers and neural foetus development which leads to mental retardation...

(Lieferink, 2012)
4.2 Effects

Fool's gold (iron pyrite) which is found in mined rock reacts with oxygenated water to form sulphuric acid. Many other minerals from the earth also dissolve in water. Water being drained from mines is sulphuric, acidic, toxic and corrosive (McCarthy, 2010:19) (Liefferink, 2012). Iron pyrite is the biggest catalyst for AMD (Liefferink, 2012).

The mining residue which presents itself as mine sand or mine dust contains high volumes of uranium and cadmium (Winde, 2011) (Liefferink, 2012) which are both human carcinogens. The yellow brown containments found in the soils are traces of iron pyrite. There are 270 mine dumps in the Gauteng region which contain 6 billion tons of iron pyrite tailings. Historically, many dumps where planned on dolomite and sinkhole areas in order for water to drain faster into the earth. According to recent studies many areas in the Gauteng region have already been classified as high risk radioactive zones. The Department of Mineral Resources found that in the Johannesburg CBD area there are increased levels of radioactivity due to mine dumps used for construction (Liefferink, 2012). As uranium decay, it forms other products like radon gas which is highly radioactive and increases the risk of lung cancer (Liefferink, 2012) (Winde, 2011). Uranium is also one of the most deadly metals on earth as it is not only radioactive but also toxic. This toxicity not only cause kidney disease and kidney failure, but also gene-toxicity which is trans-generational (Liefferink, 2012).

Figure 21: People washing themselves and drinking water contaminated with AMD (Reinders, 2012:[sp])
4.2 Effects

The mining belt is scattered with multiple shafts as a result of 100 years of mining. Shafts are the main potential risk areas for radon leakages as they are directly connected to the void. Radon is odourless and colourless. The lowest lying decanting point in the connected void is the Cinderella shaft in the east of Johannesburg. The most accurate date predicted for decanting from this shaft is mid September 2013 (Liefferink, 2012) (Winde, 2011). Decanting points will have a water flow of 30-40 million litres per day (Winde, 2011) (McCarthy, 2010).

Chronic exposure to AMD will cause impairment of cognitive functions, skin lesions, cancers and neural fetes development which leads to mental retardation. If ingested, uranium stays in the bone marrow, posing a threat to future generations (Fig. 22) (Liefferink, 2012).

Mine residue leakages into natural water sources affect places as far as Potchefstroom 100 kilometres south-west from Johannesburg). There are records stating that annually 800 kilograms of uranium flow into the Potchefstroom reservoir via a spruit (fig. 23) from Mogale City (Liefferink, 2012). The possibility exists that contaminated water might flow into the Vaal river system which will deem the water unsafe for use (Liefferink, 2012) (Winde, 2011). The remaining tailings create a great threat to the AMD crisis as it creates ingress of water into the void and expose the Pyrite to oxygen rich air and water. The re-mining of tailings near Nasrec is one of the hazardous examples (as these tailings are located near void openings) which means that water flows directly into the void. This adds 10-15 million litres per day to the void (Winde, 2011) (Liefferink, 2012).
Figure 23: Pumping of AMD into natural water sources 2012. (Refer to Fig. 10)
4.2 Effects

The opening of tailings also introduces more dust into the air. There are residents of Gauteng who believe it is healthy to eat the mine tailings for nutritional values, especially women and children. Some also use it as a cure for acne and call it their chocolate (fig. 24). There are various radioactive pathways: inhalation of radioactive dust and ingestion (Liefferink, 2012).

Figure 24: Abstraction of radioactive "chocolate".
Figure 25: Re-mining process of mine dumps allowing more water into the mining void, Johannesburg, 2012.
4.2 Effects

Social effect

"The Water Services Act sets a minimum quantity of potable water of 25 litres of water per person per day, or 6000 litres per household per month. The Act also says a household's nearest water supply should be no further than 200m away. People must also not go more than seven consecutive days in a month without access to water."
(Mail & Guardian, 2012: [sp])

Figure 26: Residents of Selobela in Carolina are protesting over acid mine drainage water in their water supply that they have to drink, eat and use to wash with (Dlangamandla, 2012:[sp]).
4.3 Western region case study

The western basin is a possible prelude to what threatens to happen in the central basin (city of Johannesburg) in the near future. It is therefore important to refer to what has happened in the western basin and what is happening currently. The design proposal will propose generic applications on all four basins to act as catalysts towards the resolution of the AMD problem.

This basin (western) (fig. 27) is one of the first critical areas experiencing problems with AMD. This area is predominantly residential with small CBD areas. There are also multiple informal settlements in the Western basin area. Many of these informal settlements are situated on tailing dams which have harsh health implications, as the inhabitants of these settlements grow their crops from the contaminated soil and water (refer to fig. 19). They also inhale the dust from the tailings on a daily basis and the livestock drink and graze from the tailings. It becomes a vicious cycle of contamination. Skin defects have been reported from the inhabitants of the informal settlements. International researchers claim that South Africa is the only country where residential areas are placed directly next to tailing dams (fig. 23). The Cradle of Humankind (International Heritage Site) is also in danger due to AMD from the Witwatersrand basin. The western basin already started to decant in 2002 (Liefferink, 2012).

Figure 27: Mining belt diagram indicating the western region.
...South Africa is the only country where residential areas are placed directly next to tailing dams...

(Liefferink, 2012)

Figures 28-30: Aerial photographs of mining pollution located near human settlements.
4.3 Western region case study

Figure 31: Collage of what activities the Robertson Dam used to accommodate.

Figure 32: Robertson dam documented March 2012 as a radioactive zone.
The Robertson Dam was previously mainly used for recreational purposes and used to house a wide range of activities (fig. 31). It has now been declared a radioactive dam due to AMD (fig. 32) resulting in a neglected and unused space. The uranium levels in this dam are 40,000 times higher than in natural water (Lief-ferink, 2012).
4.3 Western region case study

Ghost towns are formed because of insufficient planning. Amberfield residential development (fig. 31) in Mogale city is closed off and has never been occupied due to a late environmental impact assessment. The development is worth R265 000 000, but is situated on radioactive soil and in close proximity to tailings (Liefferink, 2012). This, however, is ironic compared to the informal settlements built on tailings and other established residential suburbs built as close to tailings as Amberfield but have not been evacuated.

Gold One has made an attempt at a purification plant (fig. 27) in the western basin. The water is mixed with lime which creates slurry which drops to the bottom. The cleaner water is then discharged into a lake, but the sulphide levels in the solution are still too high. This is the cheapest solution to AMD purification (Liefferink, 2012).

Figure 33: Abandoned Amberfield development, Johannesburg, 2012.

4.4 Current status

In 2011 the entire basin merged into one void (Liefferink, 2012) (Winde, 2011). This decreased the amount of rising water from 0.55 meters per day to 0.37 meter per day per day, which resulted in the decanting date being postponed from 2012 to 2013 (Winde, 2011).

The potential volume of AMD in the Witwatersrand is about 350 million litres per day. This is 10% of potable water supplied by Randwater in Gauteng per day. The AMD water has a PH-value of 2 (Liefferink, 2012) (Winde, 2011).

The state cabinet allocated R225 000 000 in 2011 to deal with the potential decanting, which was increased to R 400 000 000 (Winde, 2011). The new decanting date is mid-September 2013 as mentioned previously (Liefferink, 2012) (Winde, 2011).
Figure 34: Gold One purification plant documented, March, 2012.
4.5 Current treatment options

The National Science and Technology Forum (NSTF) and South African Agency for Science and Technology Advancement (SAASTA) held a conference and workshop in July 2011 which was attended by all the critical thinkers on the AMD crisis (including the three main sources on AMD used in this document). The main topics of discussion were possible solutions and research that has been done related to the AMD crisis in South-Africa. The treatment options discussed at this Critical Thinkers Forum are the most recent and technologically advanced examples on the topic. From AMD, resulting from coal mining in Mpumalanga, 35 million liters of drinking water is already being produced per day through the process of desalination (Zvinowanda & Maree, 2011:29).

4.5.1 Reverse Osmosis

Reverse osmosis produces low dissolved solids water which has a poor taste and produces brine as a by-product. The process is energy intensive and cannot discharge radioactivity efficiently. Few job opportunities are created in this particular process. (Bewsey, 2011:6)

4.5.2 Precipitation processes

Precipitation produces water of a moderate quality with low value by-products. Although the process is more energy efficient than reverse osmosis, it cannot discharge radioactivity efficiently and. Sodium and chloride levels can also not be cleared. The plant erection, space required and the running costs are extensive. There are more opportunities for job creation in this process. (Bewsey, 2011:7)

4.5.3 Traditional Ion exchange

This process produces water of good quality and disposes radioactivity effectively. Although more waste is created, some are useful products like Gypsum. (Bewsey, 2011:8)

4.5.4 Trailblazer KNEW Ion Exchange

Water of good quality is produced through this process which also disposes of radioactivity effectively. The by-product produce are commercially viable. Potassium nitrate, ammonium sulphate, paper grade dolomite and electronic grade sodium chloride are produced. The operational costs are low and there are opportunities for job creation. (Bewsey, 2011:9)
4.5.5 Hybrid-ICE plant & Eutectic Freeze Crystallization

The main by-product of the hybrid ice process is sulphur. Africa is the biggest importer of sulphur. South-Africa consumed 1 080 000 tons of sulphur in 2002 of which 700 000 tons were imported. The high consumption of sulphur in South Africa is because of the production of fertilizer. There is also a global demand for sulphur. This technology freezes brine from mining, which separates the water from its by-products. (Zvinowanda & Maree, 2011:40)

The Eutectic freeze Crystallization process works on the same principals as the Hybrid Ice plant. The brine is frozen which separates water from its contaminants due to the variations in freezing temperatures. These two processes are more cost effective than evaporation ponds. (Lewis, 2011)

4.5.6 Algae pond systems

The algae pond system uses natural algae which separates irons out of water and produces bio fuel as a by-product. Large algae ponds are needed where UV rays can catalyze the process. CO2 is one of the few elements used by the system that is eventually released back into the environment as a cleaner CO2 emission. Fertilizers are also produced from the process. (Cowan, 2011:10)
4.6 Selected treatment plant: Trailblazer KNEW Ion Exchange

The selection of a treatment plant was made on performance, environmental impact and feasibility. More than one source was found on the selected treatment option. The products of the process are silt, purified water, salt, dolomite, pot nitrate, pure ammonium sulphate and gypsum (Bewsey, 2011). One of the biggest advantages are the feasibility studies of the process which can turn an intervention into a feasible business (either private sector or government or Public Private Partnership). The extracted by-products can be utilized for many other architectural applications as a response to the process outcomes.

It is being described that the acid mine water can be mined and its by-products extracted through the process of ion-exchange. BHP Bileton & Anglo Coal purify acid mine drainage and sell potable water already. Through this approach the AMD problem can go from being a major problem to being an asset to the city of Johannesburg. (Turton, 2011)

### Feasibility tables

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<tr>
<th>Water fee (R/m³)</th>
<th>INCOME from products</th>
<th>184</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>INCOME from water fee</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL INCOME</strong></td>
<td><strong>198</strong></td>
</tr>
<tr>
<td>Raw materials</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overheads</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL EXPENSES</strong></td>
<td></td>
<td><strong>188</strong></td>
</tr>
<tr>
<td><strong>OVERALL PROFIT</strong></td>
<td></td>
<td><strong>10</strong></td>
</tr>
</tbody>
</table>

Table 1: Profit (Bewsey, 2011:17)

<table>
<thead>
<tr>
<th></th>
<th>R'million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ion exchange plant</td>
<td>121</td>
</tr>
<tr>
<td>Raw material storage</td>
<td>12</td>
</tr>
<tr>
<td>Regeneration storage</td>
<td>7</td>
</tr>
<tr>
<td>Chemical conversion plant</td>
<td>35</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>175</strong></td>
</tr>
</tbody>
</table>

Sales : capex ratio 1.05

Table 2: Sales (Bewsey, 2011:16)
2 Sub-plant diagrams

Figure 35: Potassium Nitrate Process (Bewsey, 2011:17)

Figure 36: Ammonium sulphate purification (Bewsey, 2011:17)
4.6 Selected treatment plant: Trailblazer KNEW Ion Exchange

Figure 37: Ionex flow diagram (Bewsey, 2011:17)
CATEX COLUMN

HEAVY METAL NITRATES

MIXED CATION NITRATES

AMMONIUM SULFATE/CHLORIDE

ANEX COLUMN

SILT
Site

The surface of Johannesburg is “un-layered” and the site explored through:

5.1 Mapping

5.2 Site Essay

5.3 Site diagrams
“It is possible to compile a detailed risk map by combining information on the old mine workings (most of which were accurately surveyed), surface topography and the plans of buildings and other sub-surface structures in the risk zone. However, such a compilation has not previously been undertaken so at present we can only define the risk zone in fairly general terms”

(McCarthy, 2010:20)
Abstract: Detailed risk map

The statement by McCarthy (page 76) validates the mapping process and has in itself created a holistic image of the AMD crisis. The mapping of the city done for the purpose of this dissertation undertakes this challenge of **overlaying all possible maps** that can be sourced relating to the AMD crisis in an attempt to further existing knowledge and also to produce new knowledge. From the emergent composite map **potential sites for the intervention will be identified**, chosen and argued for, rather than choosing a site and post-rationalizing it. In this case, the most relevant information was also sourced and overlaid. Documents, maps, aerials, and service layout maps have been sourced from government departments, mining thesis documents, geologists and archives.

The mine openings that have been created over the years have increasingly become lost in the city (Heath, 2009) (Winde, 2011) due to changes in land-use, shifting responsibilities, lost records, mine closures and the lack of a system that records these openings. New structures built over, on top of or next to these very often hide the openings which make it almost impossible to trace these (Heath, 2009:16). Therefore, the openings that are still visible and possible to locate prove to be very valuable, as they offer very rare traces of openings into the drainage void.
Figure 39: Exploded axonometric of the risk map
5.1 Mapping

Topography: original grassland (1870)
scale 1:25 000

Mining reefs and geography which dictated the Randjeslaagte triangle.

Figure 40: Johannesburg contour map (City of Johannesburg) [64]
5.1 Mapping

1896 Mining town
scale 1:25 000

Mining boom town from which poor quality water was already extracted from the Fordsburg Dip.

Figure 41: 1896 Map of Johannesburg (Courtesy of Museum Africa)
5.1 Mapping

1936 Mining city
scale 1:25 000

The mining town grew into a city.

Figure 42: 1932 Map of Johannesburg (Probert Encyclopedia, 1993) overlaid on the 1886 map. [68]
5.1 Mapping

21st Century African city
scale 1:25 000

The contemporary city was built on a town which was not meant to only be a mining town.

Figure 43: Contemporary Johannesburg overlaid on the 1886 map.
5.1 Mapping

Main road network
scale 1:25 000

Traces of the Randjeslaagte triangle are clearly visible. Other network systems start to break out of the triangle. The more contemporary motorway system breaks the rigid rules of the original grid.

Figure 44: Contemporary main road networks overlaid on the 1886 map.

[72]
5.1 Mapping

Zoning
scale 1:25 000

When analysing this plan most public spaces still remain in original dimensions more or less. The rules of this city were set by the Randlords. These were guided by mining, not by water.

Figure 45: Zoning diagram (City of Johannesburg)
5.1 Mapping

Clean water network
scale 1:25 000

The network enters the city from the south. At this point, it has a vein like quality but changes into a grid where it meets the city.

Figure 46: Clean water network (City of Johannesburg)
5.1 Mapping

Mine plan
scale 1:5000

The invisible is traced in old mining maps. This complex network extends for more than 50 kilometres. It reveals the level of exploitation of the landscape.

Figure 47: Underground plan (Courtesy of Shango)
5.1 Mapping

Typical risk map
scale 1:5000

Figure 48: Typical risk map
5.1 Mapping

Typical risk map

scale 1:25 000

Figure 49: Typical risk map
5.1 Mapping

Decanting map

scale 1:90 000
The points display possible decanting zones across the mining reef. This graphic exposes the seriousness of the crisis and its physical extent. The site investigated in the research is not unique but similar sites are spread over the entire east west axis.

Figure 50: Decanting map
Main road network

Decanting points

Mining pollution

City of Johannesburg site
5.2 Site description

Each mapped decanting point on the mining strip will form part of the bigger site—Johannesburg. This particular idea is explored further in the design section.

The site selected for this dissertation is to be developed further as the pilot project.

The biggest challenge with mining sites are that they are dead (lack of activity). As described in this section it is clear that many activities happen around these sites.

The space around the site consists of smooth space (Bremner, 2010) with a strip of insurgent space underneath the highway as well as an old mine shaft. Taxi owners use the space underneath the M2 motorway as a pause space during the day, partaking in daily rituals of their lives such as playing pool, eating, drinking and cleansing. The other occupants of this space are entrepreneurs who generate income through the washing of taxi’s and the selling of food and drinks. This space has a daily cycle of activities, controlled by the cycles of the city. Most of these taxi drivers are residents from Soweto. They service the Faraday Taxi Rank (west of site) which functions alongside the Mai Mai Muti market.

The open space on the mining site contains traces of animal slaughtering which ties the Muti market and the site together into one system. It is the closest open space to the Mai Mai market where these rituals of animal
slaughter can take place. In most African (South African) cultures, animals are slaughtered for ritualistic purposes. The seepage of blood into the earth is important as it is believed that this pleases the ancestors. Fewer animals are usually slaughtered in urban areas due to spatial constraints. The rituals and activities include eating the liver and pancreas raw, the Zulus empty the contents of the gallbladder onto an honoured person (Mavunga, 2008, 76). People do not just visit the market to buy muti, but also to be healed. The muti is presently used in various ways such as washing, burning, inhaling it, disgorging, enema or steaming (Majola).

There is a strong connection between the rituals and the earth as well as between the use of muti and water. These elements will both be influenced greatly by AMD. The taxi washing area and the cultural insurgent spaces of the pilot site become that which Bremner (2010) refers to as the blurring of original historic events of a place.

There is a ironic relation between the rituals of pouring blood into the earth and the AMD crisis. It is as if the Gods are returning the sacrifice with blood pouring out of the earth in the form of AMD with its red-brown colour. It could be regarded a rejection of our gifts to the Gods, a punishment for the human race as a whole for raping the landscape (fig. 40).
5.3 Site diagram
Design Exploration

This chapter explores writing, drawing and model building as design tools through the following:

6.1 Theoretical discourse as design tool: Post traumatic urbanism
6.2 The Brief
6.3 Design process
Introduction

writing + sketching = solid base for...
Design tools

model building

Figure 57: Building as a tool

design development
6.1 Theoretical discourse:
Post traumatic urbanism

The AMD crisis foresees a traumatic state for the city of Johannesburg. The theoretical approach is devised around this topic of post traumatic urbanism in which utopian vs. dystopian visions, reality and science fiction, resilient cities, rewriting of form and the scripting of a new lived space will be explored. The architectural theory discussed will be used to define the brief.

Whilst “trauma” refers to the space in time right after a perceived image of the future is broken which has not yet been replaced by an image of a new future, “post traumatic” refers to the evidence of the aftermath (Lahoud, 2010:19). Johannesburg is a city with many traces of trauma. Mining is the one of the most visible traumas of the city, but with AMD, the worst is to come. It is a trace of an event that has passed – an ominous scar. For us to be able to productively reintegrate a trauma into our lived space, we need to build a new story and find new evidence to rewrite our lived space (Lahoud, 2010:19). There is a need for a new environment or post-traumatic catalyst to enable the human mind to recreate space from which a new future vision can grow. The AMD crisis will leave (and has already in the west-west rand) a trail of trauma. Thus inhabitants of affected areas will have to recreate their vision of their lived space. Trauma questions lived space and future visions (Lahoud, 2010:19). AMD is in itself trauma, but it is also a post traumatic experience of a century of mining. Our lived experiences and encounters with problematic situations teach us to adapt to our environments. Our personal qualitative experiences prepare us for uncertainties and crisis, whilst from our memories and lived experiences a self-envisioned future is projected (Lahoud, 2010:16).
Architects have the duty to design and visualize envisioned futures. This speaks for architects acting as visionaries for post traumatic environments with the purpose to create new visions for the future with which the traumatized can replace their visions of broken futures. The concept of an imagined future is closely related to utopian ideas about architecture and also to the concept of an unwanted present (Bremner, 2010:39). Trauma is a state of an unwanted present, because it implies no future. This unwanted present needs a manifesto for a new future to break the trauma and enter a post traumatic phase. This is the stage where human nature can start to rebuild a new vision for the future. Architectural design has an obsession with the future, specifically a better future, which makes it utopian by nature (Clear, 2009).

It has become increasingly difficult for architects to predict the future, perhaps because in the past, the utopian architect failed repeatedly in this regard (Clear, 2009). Global warming, poisoning of environments and famine presents a dystopian future rather than a utopian one (Lim & Liu, 2010:10). A dystopian approach illustrates one which is more realistic compared to a utopian approach which aims to save the city from destruction by resolving the problem in its entirety. Some of the most creative work in previous eras of recession and depression has been done by following a dystopian approach. Crisis forces designers to redefine their role in society and offers them new opportunities that get built on their current skill set (Clear, 2009).
6.1 Theoretical discourse: Post traumatic urbanism

In literature, science-fiction offers a valid approach to metaphorical resolution of current issues. Many ideas and issues are explored and envisioned in the fictional realm with some form of a dystopian end that is seemingly more realistic than architectural renders illustrating people who are enjoying a happy, envisioned future. Science fiction depicts a more uncertain future with its own attractions (Clear, 2009). The threat of AMD flooding the streets of Johannesburg (fig.59) or radon gas poisoning the city (fig.58) is a scene one can easily imagine from a science fiction film, rather than in a corporate architectural render. This refers to the utopian proposal the city published for the Top-Star site which is an elusive, uninformed speculation. If an environmental impact study (EIA) needs to be conducted, the findings would be similar to those in the case of the Amberfield development in Mogale city. Catastrophes in the world, such as the events of September 11 of 2001, Tsunamis and many others turn science fiction into reality. This draws once regarded farfetched ideas concerning disaster closer to reality and increasingly validates mappings and concepts of possible disaster.
Figure 58: Radon gas spreading over Johannesburg. A scene that can be associated with science-fiction. Unfortunately it is a reality. (Collage)

Figure 59: Water flooding Johannesburg. (Collage)
These past events are examples of traumatic and post-traumatic urbanism where new futures had to be envisioned by visionaries to be able to create manifestos for a new lived space. Urban trauma is not an invader; it has a sense of place (Benjamin, 2010:24). The urban trauma of September 11, 2001, now defines new places and rewrites the future and current lived space in memory of the event. The urban traumatic design strategies of the apartheid era are one of the main definers of place in contemporary South-Africa, as well as its re-appropriation. The AMD crisis is a soon-to-happen urban traumatic experience which will also need its own trace of place making. “...trauma is the reactivation of an occurrence that in the first instance was simply absorbed or internalized,” (Benjamin, 2010:24). The destructive effects of mining and its by-products in Johannesburg have been evaded for too many years. The creation of sustainable solutions to the problem has not been devised and as a result, the traumatic occurrence is surfacing, literally.

Insurgent uses in cities create new spaces with new identities in existing areas, blurring the history of the original place (Bremner, 2010:40). Cultural activities that have been inserted into pockets of space around the main reef strip blur the history and origins of the city. These insurgent practices trace the continual reinvention of the social environment of contemporary society (Bremner, 2010:41). Johannesburg has become an insurgent city. The place-making effect of traumatic urbanism of the mining legacy is not as evident in the city space as it used to be. There is a need for the city inhabitants to be reminded how they came to inhabit the piece of barren land and why it became such a multi-cultural zone.
Two poles exist in the crisis theory: continuity/repetition (normal rhythms of life) and discontinuity/trauma (broken rhythms) between which the liminal zone of resilience exists. Resilience is the ability to recover. Resilient cities are in a state of instability in which they are able to deal with many traumatic states. This resilience is visible in the slack and redundancy of networks of such cities. Other signs are diversity and distribution that can be spatial, economic, social, or infrastructural. This diversity is also more valuable than centralized efficiency. The resilient city is resistive of computerized information systems, as these cities function on qualitative rather than quantitative domains. (Lahoud, 2010:19)

Post traumatic urbanism of AMD in Johannesburg has very specific needs and issues. There is a visionary aspect to the manifesto in order to create a new vision to be able to re-create a new image for a broken future. Utopian ideas have to be merged with dystopian thoughts, and reality has to become science fiction in order to become real. The post traumatic intervention will have to unravel the mining history that has been blurred by the insurgent city, whilst keeping a trace of its own past. Resilience will be achieved through constant re-definition and the tracing of this process.
6.2 The brief

Abstract
The writing of the brief is devised as a design tool. It is theorized as the DNA of the built aspect of the project. Influences include the research on AMD, post-traumatic theory and a designed accommodation list.

Extracted from theory
The design should address:

- Current trauma of AMD (avoiding environmental poisoning).

- Post-traumatic urbanism of the mining legacy (purifying the water and healing the land).

- Post-traumatic urbanism of the future (healing the scars of the water purifying plant).

- A vision for a new future.

- Place for a new lived space.

- "Un-bluring" the mining legacy in the insurgent city (tracing history).

- Create a rhythm of re-writing a new future.

Main client:

water affairs
Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

Figure 60: Department of water affairs (South Africa, 2012:[sp])

[102]
Extracted from research

The intervention should:

- Address the pollution problem created by the mining legacy.

- Attempt to address the stigma that Johannesburg is a city without water.

- Provide a new pumping facility.

- Provide infrastructure able to handle 40 million litres of water per day.

- Break the trans-generational cycle of the related by-products.

- Create a more humane treatment facility than the one discussed in the case study of the Westrand (page 50).

- Create three sub-plants according to the KNEW process.

- Create storage facilities for by-products of the KNEW process.

- Create input facilities according to the KNEW process.

Accommodation list

Auditorium
Foyer
Museum
3 Laboratories
Laboratories offices
Hotel
Viewing decks
Restaurants
Kitchen
Chamber of AMD
Non-government organization (NGO) office
Mining house office
Government office
Machine space
The design process is a collaboration between sketching and model building. They follow a chronological order as a series of graphics with supplementing texts. Images are categorised as follows:
city of form,
city of memory,
city of landscape,
city of mechanics,
city of water,
city of the future,
city of new urban topography,
city of iconography
and as conclusion
THE CITY
6.3 Design process

Sketch 1: City of form

The Randjeslaagte triangle is one of the strongest originating elements of the city - a form generator that grew out of the mining towns. The sketch illustrates the plan, which can at the same time be read in section. Adding to this, one can also read the traces of the mining tunnels and mine excavations in section, although it was mapped in plan. Thus, the city starts to read as many things. The city grid is regarded a structural grid and a sub-spatial grid whilst boundaries can become boundaries of enclosure or, on a smaller scale, create various spaces. In section the connection between the land and the building is the mining shaft. This is the point at which the city is connected to its origin. One can even go as far as to read the zoning of the inner city in section as the programmatic organization of a building. This triangle is the shape of the city which has been blurred by the contemporary insurgencies. It has become a lost memory of the city of Johannesburg.

Fig. 61: Sketch 1 plan vs. section
6.3 Design process

Model 1: City of form

The model morphs the city into more than one elevation. It is a physical manifestation of sketch nr.1 (fig. 61) Structural strength is felt in the physical form of the shape. The strict Cartesian grid of the city provides a sense of closure to the one facade of the model, while the open facade allows one to read the "organs" of the Randjeslaagte. The duplication of the triangle on all the elevations will allow a building that will read the similar in all its sections (including plan).

Shape that is derived from an environment can be read as a powerful tool to reconstruct memory. The dents, bends and deformation of a shape happened due to past actions (Leyton, 2006:13). In this case shape is read as a device in which the history of a place is stored. Each urban form is a potential storage device for the memory of the place and it origins.

Fig. 65: Model 1 in perspective

[108]
6.3 Design process

Sketch 2: City of Memory

The original structure of the city within the Randjeslaagte triangle follows the narrow constraints of the grid in which there is a sudden change in the urban structure south of the triangle formed by topography and the mining lines. All the nearby shafts are directly linked in this sketch, informing a new grid between the mining infrastructures above the surface of the ground.

Fig. 66: Juxtaposed grid systems
6.3 Design process

Sketch 3: City of Memory

Mining headgear is one of the most apparent symbols of mining. It once marked the landscape of Johannesburg as metaphors of urban acupuncture, indicating nodes of mining activity located across the city and its suburbs. However, as mining was terminated by the mining houses, these structural elements also disappeared from the landscape. The drawing maps the location south of the Randjeslaagte triangle. In section, the highway is read as the ground line with two mining shafts at the particular locations where the headgear once stood. The red containments peering out of the mine void are symbols of a danger which spreads throughout the city. In contrast to the danger, the spread can also be read as a positive element used as a form of a structure that is grown from the by-products of cleansing.

Fig. 67: Layers of memory imposed
6.3 Design process

Sketch 4: City of Landscape

This sketch illustrates a trace of the mining belt, indicating the Randjeslaagte triangle in the middle. It can also be read in elevation, with new landmarks on the locations where shafts are. This trace of the mining legacy is generally lost as most headgears have been demolished over the past few years. These once defined the epoch of Johannesburg. The decanting points are drawn in on plan as possible sites for urban development marked in red. The polluted sites have the potential to become historic sites with functions that can add value to society.
6.3 Design process

Sketch 5: City of Landscape

Three levels of networks exist to which the design is connected; the mining void, the ground plane infrastructure and the wireless communication network. The mining void network is dictated by natural topography, the new infrastructural network is dictated by the existing urban form and infrastructure whilst the airborne communication network is the wireless communication grid dictated by the shortest distance of data travel. These three networks are merged in the main building becoming a metaphor for a data router which translates data languages. The result of these three networks being merged is an urban environment with a humane function which supports the city and its inhabitants.

Fig. 69: Levels of network
6.3 Design process

Sketch 6: City of Form

The Randjeslaagte as a trace of the past is explored by erecting the shape vertically. In this sketch, the two dimensional section explored in sketch nr. 1 is rationalized into a three dimensional shape. The link between the underground world and the surface of the earth is indicated as a dotted shaft. The triangle is placed on top of a shaft opening, celebrating its location. Fractal forms spill out of the structure as a metaphor for the acid and saline state of the contaminants. The by-products of the process can be used in various ways to enhance the humane environment which the fractals start to suggest. The city is visible in the background to establish the link between the plan and elevation of the city that is reversed here as the elevation displays the triangle and the city plan displays only elevation.

Fig. 70: Conceptual merge
6.3 Design process

Sketch 7: City of mechanics

This sketch explores the composition of the different elements of the design into a building. The vertical city is situated on top of a mine shaft whilst the shaft is positioned in a series of conventional dam structures with their channels facing towards the city. The city, with its vertical lines, reads as a grass veld. It illustrates new life on a dead site - an alien in an existing environment. The landscape of Johannesburg used to be only a grass veld, but was invaded by mining structures and towns. This notion is repeated in this drawing where now, the city is the grass veld and the intervention the new generation of Re-mining activity.

Fig. 71: New generation AMD mine
6.3 Design process

Sketch 8: City of water

The human scale is introduced in this sketch. The amount of water that can be purified on a daily basis is large, thus the scale of the storage tanks would also need to be. The building structure itself also needs to reflect the large scale to accommodate the purification process as well as have an impact on the landscape of the city. In this sketch the building is semi-detached from the holding tank. The holding tank isn’t just a water storage facility but a recreational facility as well.

Fig. 72: Introduction of the holding tanks as recreation

[122]
6.3 Design process

Sketch 9: City of mechanics

The pipe structures at the back of the triangle suggest that some of the machine elements are plug-in elements (due to rapid development of technology) that can be replaced by new technologies. The spatial quality of the inside of the water tank is also explored: it is submerged under the water and only revealed as the water level drops.

Fig. 73: Plug-in technology
6.3 Design process

Sketch 10: City of water

The wall of the water storage tank contains functions and can thus be occupied. At this point in the process it only remains a suggestion. The idea of a submerged city inside the holding tank is visible in the sketch, as well as a floating recreational structure for the present. The floating structure is able to follow the water level whether it is rising or dropping.

Fig. 74: Space wall
Michel De Certeau compares walking the city to speaking. In the same way that speaking appropriates language, walking also appropriates the city. This comparison refers to the two concepts of synecdoche and asyndeton. Synecdoche refers to a part representing the whole whilst asyndeton refers to the suppression of linking words in a sentence. Asyndeton refers to modern society where contemporary practice eludes the city into fragments and false fragmented experiences. (Bremner, 2010:30)

The surface of Main Reef road (and the M2 highway) acts as a boundary between the asyndeton and the synecdoche, as the commuters travelling on this road linking the mining belt only experience the city in fast moving images, whereas people occupying the liminal space along this route experience the city in its full force. This route also acts as a geometric memory device which stores the history of the mining legacy.

Fig. 75: Site layer with super imposed intervention
6.3 Design process

**Sketch 12 & 13: City of the future (Phasing)**

The AMD crisis is one that can be solved with constant treatment. The water extracted can eventually be rerouted into the existing city grid and even be redistributed to other regions. The sketch suggests that the storage tanks are designed with the intention of becoming new urban blocks in the future. Once their function as water infrastructure has been served they become mega urban housing infrastructure serving the future city.

The world is becoming more and more urbanized, 50% of people live in cities today, and an estimated 75% of all people will live in cities by 2050 (London School of Economics & DeutscheBank’s Alfred Herrhausen Society, 2007:8). This is a clear indication that architects and planners need to shift methodologies to allow for future expansion and growth.
Fig. 76: Near future water facility

Fig. 77: Far future urban blocks
6.3 Design process

Sketch 14: City of new urban topology

There is a need for a new urban topology for the project. This form needs to be unique to Johannesburg and its mining legacy, but it should also be able to provide for the future environment as a city block. Types are formed from sociological factors and typological diagrams are formed by site specific factors (CM Lee & Jacoby, 2011:19).

Fig. 78: New urban topology experimentation.
6.3 Design process

Sketch 15: City of new urban topology

Most sites in Johannesburg are full of urban life than can be mapped and traced. The proposed sites for this project are mining sites which have become relatively dead sites. The sites sit like voids in the urban vibrancy of Johannesburg, which leave the architect with fewer clues to generate a design intervention. These sketches illustrate found traces on the sites (mining tunnels & topography) and contain the imposed trace of the city grid. The city grid is imposed as a trace of the history of the city, and as an urban metaphor. This grid will be imposed on the recreational aspect of the design. The dimensions of the Johannesburg grid were purely based on the efficiency of generating income. By superimposing the grid on a recreational function, a strong contrast will be formed such as the contrast of the project to the mining legacy.

Fig. 79 - 80: Topology explorations
6.3 Design process

Sketch 16: City of new urban typology

Emerging cities are not growing in the same manner as western cities with manifestos containing organization and centralization (CM Lee & Jacoby, 2011:17). The sketch displays a part of the Randjeslaagte triangle together with a few decanting sites located in close proximity. The topological diagrams of each site are seen in this sketch. This scattering of the topological diagrams break away from the centralized and coherent city grid at the top of the sketch. Peter Carl refers to “typicalities” as those elements that are found in all (CM Lee & Jacoby, 2011:20).

The duplication of the topological diagrams over the different sites contain its typicalities which are found in all the sites, and then its site specific constraints such as site dimension and shape. The geometric shape of each site is also once again a storage device of the history of the site.

Fig. 81: Application of the new topology
6.3 Design process

Sketch 17 & 18: City of the future

Ildefons Cerdá who coined the word “urbanism” referred to it as being the science that manages and regulates the growth of the city through housing and economic activities (CM Lee & Jacoby, 2011, 18). The intervention will address the current challenges around addressing AMD, but it will grow (or reduce) itself into a housing and economic centre for the future (as the AMD crisis is resolved over time). This sketch explored this new form of urbanism that will only be fully revealed as the design evolves over time. The first phase includes the AMD plant and water facilities, whereas the second phase involves the dam voids which have become urban parks, the dam walls which have become city blocks, and the purification plant which have been transformed into a solar power station to provide these new city centres with electricity.

Fig. 82: Near future purification plant
Fig. 83: Far future solar plant
6.3 Design process

Sketch 19 - 21: City of the future

This drawing should be read in section. The way a dam wall presents itself has a psychological effect on the human mind; people prefer the physical appearance of a gravity dam as it looks more stable and reliable (Barratt & Ian, 2011:39). The dam wall will evolve and erode to create habitable space as the water levels drop and the dam walls become buildings. Gravity dam walls have thickness and mass (Barratt & Ian, 2011:39) which will make its choice suitable for a future building.

Fig. 84 - 86: Dam wall evolution

[140]
6.3 Design process

Sketch 22: City of the future

This drawing should be read as a composite drawing. Up to this point in the process, all the elements except the city are all fused in this one sketch. The dam walls are placed in a series which illustrate their evolution. Aldo Rossi referred to buildings being separate from their function and that they evolve over time (CM Lee & Jacoby, 2011:17). This relates to topology of buildings and their functions that are constantly appropriated as in this case of infrastructure being re-appropriated as many things. The connection between the building through an existing shaft and the underworld is traced in the sketch. This is also an elaboration on the link between the three levels of networks mentioned earlier in the design process.

Fig. 87: Composite drawing of process above
6.3 Design process

Sketch 23: City of mechanics

The next step of exploration is a stronger focus onto the building component. The sketch illustrates a coexistence of the building and machine that support each other. The sketch further explores ideas where the machines can provide heat for the building, and the building can control the machine. Control decks, observation areas and laboratories can be created by locating the habitable space and the machine within the same geometry. These two elements of the design are not seen as two different parts but rather as two synchronised dancers.

Fig. 88: Merge between building and machine.
6.3 Design process

Concept model 2: City of Form

The model explodes the machine into more parts rather than just being contained within the building itself. In so doing, the future urban park will contain follies which will provide the large urban voids with a sense of structure. For its current purpose as a recreational water park, these disjointed parts of the machine can be submerged half way into the water. They can heat the water whilst the water can cool the machine. This will create a more comfortable water temperature for people to enjoy. The water recreation park will have an industrial nature that forms part of the langue of Johannesburg and its mining legacy.

Fig. 89: Building & by-product machines within dam walls

[146]
6.3 Design process

Sketch 24: City of iconography

The iconography of the project is very important as it can re-establish the missing mining links in the Johannesburg landscape. This sketch displays a view of the recreational dam looking towards the city. You can see the half submerged machines as well as the main building. The image displays a Johannesburg waterfront, a place-making element which this city has never had before. It's a delirious imposition of a boat in Johannesburg!

Fig. 90: Re-established links in the landscape
6.3 Design process

Sketch 25: City of iconography

The structure of the dam reads as the image of the disappearing mine dumps. The difference between the new icon and the mine dumps are that the new one has the function of providing place and space, whereas mine dumps created landmarks, but invaded space. The triangular shape of the building unlocks the iconography of mining headgear. In this sketch the elevation and plan of the city are clearly read in one view. The very memory of the city (geometry as storage device) is projected in front of the city. This is the beginning of the un-blurring of the hidden histories of the city.

Fig. 91: Iconography

[150]
6.3 Design process

Sketch 26: City of iconography

The part of the machine located in the building is the extraction and water purification part. Out of this process other products are extracted that need further processing which will happen in other parts of the machine. The sketch explores the section-to-plan relationship of the form and the placement of the machine.

Fig. 92: Machine diagram
“draw architecture as though it were already built. In other words, imagine it has already been lived in many times, in many different ways. All that remains now is the ghost of its former incarnations” (Woods, 1997:30)
6.3 Design process

Sketch 27: The city (Phase 1)

This sketch explains the scheme in its near future where it is being used as water storage tank and recreational facility. Parts of the wall will be used as silos for fertilizer extracted from the purification process (as seen on the right) slowly filling as the water is being purified. Other parts of the wall are being used as pure mass for holding water at this stage (as seen on the left of fig. 93). The top strip of the walls will be used as a waterfront where people can escape from a busy city life. On the surface of the water are floating platforms which people can use for walks and as jumping platforms. These will also be used as platforms where people can anchor their sailing boats. The extraction machines are merged into the prismatic building. The fresh water is extracted from this step in the process. The water exits at the top of the building, flowing down the façade. This creates an urban waterfall visible to the city. The other parts of the machine providing the fertilizer are half submerged in the water, heating it, like an industrialized thermal bath. The water is distributed into the city grid from this dam which is continually filled.

Fig. 93: Near future section
6.3 Design process

Sketch 28: The city (Phase 2)

At this later stage, the problem has become more resolved and the process slower. The water levels will keep on dropping as the water is being distributed into the grid and to other existing holding infrastructures. The silos inside the walls are also being filled up with by-products as illustrated on the right. Another by-product of the process is gypsum, which will also be stored in parts of the wall. The other parts of the wall that are exposed will at this stage be occupiable by housing (as seen on the left). The infill will happen informally over time. The gypsum will be used for the infill of the walls. The floating docks will follow the water level, ensuring that the recreational facilities are functioning as long as possible. With the dropping of the water level the other part of the machine is more exposed.

Fig. 94: Future section
6.3 Design process

Sketch 29: The city (Phase 3)

This is a phase of the project in the far future where this city has urbanized even more and the dam walls can now provide for the increased need for housing. The stored fertilizer can now be used to rehabilitate the soil and can be sold for financial gain. The dam voids will be kept as an urban park and the floating docks will be anchored to the ground, functioning as paths for the park. The triangular building is now re-appropriated as a solar power station providing the new urban block with energy. The parts of the AMD machine which will stand in the urban park are traces of the water mining legacy.

Fig. 95: Far future section
6.3 Design process

Structural model 1: the City

The model explores the structural and formal composition. Space and structure are merged into a coherent whole. The shape of the building becomes one of the strongest structural shapes. Cecil Balmond refers to structure becoming more than the usual, where beams and columns replace functions and where structural capacities are carried by unconventional manners (Balmond & Smith, 2002:14). The floors are explored as beams, the walls as columns, and spaces as bracing elements in the

Fig. 96 - 107: Insurgent structural model
6.3 Design process

Concept model: the City (graphic conclusion)

Fig. 108: Image of headgear, the city and new built form
6.3 Design process

Concept model: the City (graphic conclusion)

Fig. 109 & 110: Concept model indicating the building, the dam wall and the connection to the mining void

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6.3 Design process

Near final model (graphic conclusion)

Fig. 111: Structure & Machine [168]
6.3 Design process

Near final model (graphic conclusion)

Fig. 112: Structure, space and machine
6.3 Design process

Fig. 113: Concept model 1

Fig. 114: Concept model 2

Fig. 115: Concept model 3
Fig. 116: Structural model

Fig. 117: Near final model
Design synthesis

The design is explored in further detail through the following:

7.1 Scheme
- 7.1.1 Macro site
- 7.1.2 Micro site
- 7.1.3 Healing the site
- 7.1.4 Near future
- 7.1.5 Future
- 7.1.6 Far future
- 7.1.7 Worst-case scenario

7.2 Building
- 7.2.1 Design thread
- 7.2.2 Components
  - 7.2.3 Zoning
- 7.2.4 Circulation
- 7.2.5 Structure
- 7.2.6 Energy
- 7.2.7 Section
- 7.2.8 Plan
Introduction

7.1 Scheme design

Fig. 118: Scheme
7.2 Building design

Fig. 119: Building
7.1.1 Macro site

Post traumatic urban space

The macro intervention consists of a network of purification stations healing the mining belt. The purification plants are located at the mapped decanting points. Each station mines the acidic void for water containing gold-mining by-products. The landscape is healed over time through the abundance of water and the utilisation of extracted by-products.

Existing road networks connect the purification stations on an urban scale. Each station houses functions specific to its location on the mining belt. The purification plants are further connected via the mining void. As a singular system, the interventions act together to address the trauma. Resilience to mining, including the new intervention, is devised through urban infrastructure left in the landscape.

Fig. 120: Scheme within the context of the mining belt
“If the Department of Water Affairs (DWA) had enough pumps and treatment facilities, it would be able to draw the water down to the environmental critical level”

Marius Keet (water-quality management senior manager at DWA) quoted from (Mining Weekly, 2012:[sp])
7.1.1 Macro site

Post traumatic urban space

Fig. 121: Scheme in context
axonometric

Fig. 122: Location diagram
"In terms of the central basin, the DWA is still waiting for final budget approval for the construction of the treatment plant for the next financial year, adding that the necessary funds for this year have been made available."

Marius Keet (water-quality management senior manager at DWA) quoted from (Mining Weekly, 2012:sp)

Fig. 123: Scheme in context axonometric
Post traumatic urban space

Fig. 124: Scheme in context
7.1.1 Macro site

A new future vision: breaking the urban trauma

(refer to chapter 6.1)
7.1.2 Microsite

Resilient city

The chosen site developed for the purpose of this dissertation includes a purification station and a dam containing purified water.

The mapped sites are all relatively dead sites - deprived of urban life - due to a destructive mining legacy. The new form of urbanism is created through inspiration from the original mining town, the creation of a new future vision (breaking urban trauma) and future housing.

The infrastructure of the dam walls is designed to accommodate future housing. This rhythmic change starts to create a city which can withstand the multiple ripples created by urban trauma and urban growth.

Fig. 125: Locality diagram

Fig. 126: Station in totality
floating docks as urban walkways: trace of the original city grid

dam wall: position determined by the site boundaries

by-product plants: half submerged into the water for heating purposes
7.1.2 Micro site

Intelligent infrastructure

The infrastructure of the scheme is designed to accommodate future adaptations. The dam wall contains multiple concrete slabs which act as structural support against water loads. These slabs also create floor space within the wall mass. The wall contains the storage silo’s that will hold the by-products from the purification process. The silo’s can also become habitable space within the wall once it has completed its lifetime as a silo. The floating docks will follow the water level and finally merge with the earth surface in the form of urban foot paths.

**Fig. 127 - 129: Exploded wall structure axonometrics**
vertical supports, internal circulation and silo

wall surface and base

timber deck from alien timber growing in mine dumps

steel sub-frame

plastic containers

*Fig. 130: Floating dock axonometric*
7.1.3. Healing the site

Post urban trauma

The post traumatic landscape.

Fig. 131: Post traumatic landscape (site)
7.1.3. Healing the site

Architecture as new future vision

The intervention provides a new vision for the future and the present. This breaks urban trauma. This stage is the start of purification and healing of the landscape.

Fig. 132: Intervention in context

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7.1.3. Healing the site

Healing landscape as new future vision

The presence of water and fertilisers as by-products start to heal the micro environments around the sites along the mining belt. Thus, it is not just the intervention itself which creates a new future vision but also the effects of it.

Fig. 133: Landscape in the healing process
7.1.3. Healing the site

Replaced function

The design intervention provides new functions once the landscape is healed. This is designed in order to prevent the cycle of depleted infrastructure traumatizing the urban realm.

Fig. 134: Healed landscape

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7.1.4 Near future (Phase 1)

Fig. 135: New waterfront for Johannesburg
MICRO ENVIRONMENTS CONTAMINATED

-The urban landscape is contaminated, but in the process of purification.
-The social environment is healed through waterfront recreation.

Fig. 137: Wall section indication water level and housing appropriation

Fig. 138: Sectional diagram
7.1.5 Future (Phase 2)

Coexistence between building and purification machine by-product machines: producing fertilizers for far future.

Fig. 139: New waterfront housing Johannesburg
silo's being filled with fertilizer
7.1.5 Future (Phase 2)

MICRO ENVIRONMENTS BEING HEALED

- The urban landscape is being healed by the by-products of purification.
- The social environment is healed through waterfront recreation.

Fig. 141: Wall section indication water level and housing appropriation

Fig. 142: Sectional diagram
X + 37.5%
GLOBAL URBANIZATION

Fig. 140: Urbanization diagram
7.1.6 Far future (Phase 3)

Fig. 143: New urban park and housing
by-product machines:
memory of purification

dam wall now used for housing

solar power:
supports housing
7.1.6 Far future (Phase 3)

The structure can now meet the land as the land has been healed.
7.1.6 Far future (Phase 3)

MICRO ENVIRONMENTS HEALED

-The urban landscape has been healed by the by-products of purification.
-The social environment has also been healed into urban parks supported by mixed housing.

Fig. 146: Wall section indication water level and housing appropriation

Fig. 147: Sectional diagram
GLOBAL URBANIZATION

Fig. 145: Urbanization diagram
7.1.7 Worst case

Fig. 148: Building lifted above contamination
7.1.7 Worst case

MICRO ENVIRONMENTS CONTAMINATED

-the urban landscape is contaminated
-the building provides a safe zone
Fig. 149: Sectional diagram

Fig. 150: Future silo appropriation into a circulation atrium
In the case if the process should not work or when the machine has completed its life-span it can easily be replaced or be removed due to the nature of the assembly of the structure.

Fig. 151: Machine appropriation
7.1.7 Machine depletion
Fig. 152: Diagram indicating the building to be explored further
7.2 Building design

The geometry of the building provides for the elimination of the roof and a southern facade. This allows for less area exposed to heat loss from a colder facade. The roof and northern facade are merged into a singular entity. The building can simply be presented in three elevations (east, west, north), instead of the conventional five elevations.

*Fig. 153: North-east axonometric*

*Fig. 154: South-west axonometric*
service core
positioned to block western sun

western facade
mainly solid to prevent heat gain

SOUTH-WEST AXONOMETRIC
7.2.1 Design thread

Mining headgear is the most evident landmark that mining provides to an urban landscape. Its composition is purely engineered to provide specific functions. The new "acid mine" took inspiration from this design epoch. This also serves the purpose of keeping a historic trace of time and the origin of the city.

The origins of the mining town and its town planning is traced and its DNA extracted. This DNA holds the essence of the existence of Johannesburg.
Fig. 157: Typical section

Fig. 158: Typical plan

[SECTION] vs. [PLAN]
7.2.1 Design thread
7.2.2 Components

Iconography of the city

MASS

Acid mine water purification plant with replaceable components

MACHINE

Mimicking mining headgear

STRUCTURE

Fig. 160: Space axonometric (North-east)

Fig. 161: Machine axonometric

Fig. 162: Structural axonometric
Mix between public & private space

Coexistence

**SPACE**

*Fig. 163: Space axonometric*

**MERGE**

*Fig. 164: Merge between space and machine*
Fig. 165 - 168: Zoning diagrams
Programme extracted from design exploration

View decks

Programme extracted from design exploration

Restaurants

Users: public visitors

Users: all occupants

PUBLIC

PUBLIC
7.2.3 Zoning

Programme extracted from pragmatics

Kitchen

User: chef

Programme extracted from AMD research

Laboratory 1:
by-product management

Users: scientists & office users

PRIVATE

PRIVATE

Fig. 169 - 172: Zoning diagrams
Programme extracted from AMD research

Laboratory 2: machine management
Users: scientists & office users

PRIVATE

Programme extracted from AMD research

Laboratory 3: machine management
Users: scientists & office users

PRIVATE
7.2.3 Zoning

Programme extracted from design exploration

Green-space

User: all occupants

Programme extracted from design exploration

Hotel

Users: visitors to Johannesburg - people learning from the machine (AMD is a global problem)

Fig. 173 - 174: Zoning diagrams

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mix of programme =
- SUSTAINABLE BUILDING
- PASSIVE SURVEILLANCE

Eyes of inhabitants control security

laboratories support the decision makers with real-time information

greenspace supports the building as a whole with breathing space
kitchen directly supports the hotel and restaurants, it also provides the laboratories with meals
hotel supports auditorium for conferences and laboratories as AMD is a global crisis

Fig. 175: Holistic zoning diagram
7.2.4 Circulation

- The public circulation core mimics headgear construction and only connects public levels.
- 2nd fire stair case follows the shape of the building.
- Firemen's lift follows the shape of the building and acts as a visual connection between interior & exterior.
- Lab lift connects the labs to one another as well as to the restaurants.
- Fire and public lift attach to the firemen's lift.
Fig. 176-179: Exploded circulation diagrams
Fig. 180: United circulation diagram
7.2.4 Circulation

Fig. 181: Exploded axonometric indicating public and private circulation

Public vs. private circulation

Fig. 182: Public level

Fig. 183: Private level
7.2.5 Structure

Joists

Girders support the floors & internal walls.

Fig. 184: Joists axonometric

Fig. 185: Ring beam axonometric

Fig. 187-189: Structural influences
Ring beams support joists.

Exterior supports carry ring beams.

Structural system allows for long open spans for insurgent space.
7.2.6: Energy

Heating and cooling systems

evaporative cooling (water sourced from purification process)

Fig. 190: Interior environment indicating the heating and cooling systems
under floor heat exchange system
(heat sourced from purification process)

Fig. 191: Systems linked to purification machine
7.2.6: Energy

Natural light

Western sun shading device

Service core as shading

Wet services core as eastern solar barrier

Viewing decks

Restaurants

Laboratory

summer morning

summer noon

summer afternoon
The viewing decks are not heavily shaded most of the day as a natural experience is desired.

The restaurants receive more direct light than laboratory and office space as occupation is shorter.

The most direct light that the laboratories receive is early morning that heat the space up for the remainder of the day.

Viewing decks

Restaurants

Laboratory

Enhanced natural light in winter

Enhanced natural light in winter
7.2.6: Energy

Wind tunnel

Winter and summer wind rose

Machine as wind breaker

Suction for natural ventilation

Fig. 198: Wind tunnel analysis

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Suction for natural ventilation

Fig. 199: Plan diagram
Clean water will attract natural life.

**Fig. 200: Design section**

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The museum is a public space representing a void. The space has open views toward the post traumatic urban scape. This urban scape was born out of the mining void which is mirrored by the surface line of the earth. The void museum contains nothing within its walls, resembling the effect urban trauma has without the creation of an new future vision through architecture.

The foyer opens up, guiding the viewer's eye towards the machine. The backdrop is the post mining city that is being healed by the machine.

The dam containing purified water can be appropriated in many different ways, providing the city with a mass of water it never had before.

7.2.7 Section
The hotel rooms have different views across the Johannesburg landscape. It ranges from east, north and west. Each room is conceptualized according to its position in the triangle of the building, as if it was a plan of the city.

The green space provides breathing space not just to the building but also to the architectural langue. It breaks the harshness of the machine and serves as reminder that the building has a sole purpose to heal, whether it is environmentally or socially.

The restaurants are located centrally as it is the most shared entity of the building. It offers views towards the city which will result in a variety of vistas for all meals. The restaurants open up towards the green space. This grounds the space and creates a more public environment.

The kitchen has views across the city allowing for more natural light and a humane working environment.

Laboratory 1 & 2 share office space as communication between departments are essential.

The laboratory offices and control rooms have views over the laboratory and the machine.

The briefing zone of the laboratory has views over the purification machine as well as the by-product machines.

Fig. 200: Design section
The NGO and Government department share one space. The two zones are separated by a level difference. It is essential for these two entities to have constant communication as both protect public interest. These two entities are placed above the mining house satellite office. The section is designed so as to provide a communication window overlooking the mining house office space.

The AMD chamber serves the NGO office, government office, and the mining house office. There is a need for a space where these entities can meet. The space is sandwiched between the level where the clean water exits the building and the clean water laboratory. In essence this space is surrounded by clean water. The aim of the discussions taking place in this space will be about cleansing the landscape and relationships between different parties involved.
7.2.8 Plan

Fig. 201 - 206: Axonometric plans

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7.2.8 Plan

Restaurant 2 mezzanine

Restaurant 1 mezzanine

Restaurant 1

Kitchen level

Fig. 207-218: Axonometric plans
7.2.8 Plan

Fig. 220: Axometric plan diagram
Fig. 219: Plan

Entry level
7.2.8 Plan

Fig. 220: Axometric plan diagram
Fig. 221: Plan

Foyer and auditorium
7.2.8 Plan

Fig. 220: Axometric plan diagram
Laboratory 1
Fig. 220: Axometric plan diagram
Fig. 223: Plan

Laboratory 2
7.2.8 Plan
Fig. 224: Plan

Roof plan
Technical innovation

The technical chapter explores the innovation & architectural inspiration for detailing the building

8.1 Learning from the headgear

8.2 Constructing the headgear

8.3 Re-constructing the headgear

8.4 Connections

8.5 Connection lexicon

8.6 Connection & skin

8.7 Axonometric section

8.8 Cross section

8.9 Machine diagram

8.10 Construction drawings
The mining headgear located in Main street Johannesburg for display purposes is a relocated steel structure. The structure was originally used in Rustenburg for platinum mining. After it fulfilled its use there it was dismantled and transported by road to its current location in Johannesburg. The re-erection only took 4 weekends (8 days). Most of the steel was manufactured in South Africa although some elements were produced in Scotland for the re-erection.

This highlights steel as a sustainable material. Inspiration is taken from this construction principle in order to create an architecture that can be easily adapted, relocated and reconfigured in the future. The speed of construction is also crucial as the AMD crisis is a near future concern. Steel is a universal material as indicated above, thus if the South African market doesn’t have the capacity to produce the buildings in time it would be an option to outsource building components (as was done in the construction of the soccer stadiums in 2010).

The mining legacy in Johannesburg is slowly being lost as mining headgear is disappearing from the landscape. This heritage will be restored through the structural detailing of the architectural intervention.
8.1 Learning from the headgear

Fig. 226: Mining headgear detailing. Main street headgear Johannesburg 2012
The structural connections used in detailing mining headgear is engineered for efficiency. The structure is a piece of mining equipment. It has become an urban landmark which can be assembled and disassembled as a result of its construction method. The connection details have an architectural language of a machine-like quality. A representation of the connections will be architecturally detailed within the building. As seen in mining headgear each connection has a unique condition that forms the shape of the components. This idea of prototypical connections lead to a lexicon of connections in this chapter.
8.1 Learning from the headgear

The structural beams, bracing and columns used in mining headgear is purely engineered to withstand loads of mining activity. These elements are a combination of C-channels, I-sections, and tubing. The steel used is hot rolled steel which ensures a durable, strong structure. Where a nominal depth can not be achieved through a singular element due to the availability of steel sizes double C-channel details are used. The durability of these elements (when the correct treatment has been applied) is proven in the few remaining mining headgears in Johannesburg (as seen in fig. 227) which is still located in its original location.
Fig. 227: Mining headgear detailing. Central Rand Gold Crown Shaft Johannesburg 2012
8.2 Constructing the headgear

Fig. 228: Assembly elements

Fig. 229: Placement of connecting elements

Fig. 231: Placement of second gusset plate

Fig. 232: Placement of washers
Fig. 230: Placement of C channels on gusset plate.

Fig. 233: Placement of nuts to complete assembly.
Fig. 234: Connection type A

Fig. 235: Connection type B

Fig. 236: Connection type C
Typical headgear connection details were built as prototypes in order to learn from the process. The most valuable lessons learnt were the purpose of each component in a nut and bolt assembly, the placement of bolt connections (not just for structural design but for ease of construction as well) and the sequence of construction.

8.2 Constructing the headgear
8.3 Re-constructing the headgear

Fig. 238: New prototype connection containing traces of headgear assembly
After the detail models of the headgear details where constructed new connection prototypes where designed to meet the needs of the new building, whilst containing traces of the headgear assembly.
8.3 Re-constructing the headgear

Fig. 239: New prototype connection containing traces of headgear assembly
Fig. 240: New prototype connection containing traces of headgear assembly
8.3 Re-constructing the headgear
8.3 Re-constructing the headgear

Fig. 241: Connection elements
8.4 Connections
8.4 Connections
Experience of the connection details from the interior.

8.4 Connections
Fig. 246: Void museum interior perspective
8.5 Connection lexicon

Fig. 247: Main structure and staircase connection
Fig. 248: Ring beam and screen connection
8.5 Connection lexicon

Fig. 249: Suspension bridge connection detail
Fig. 250: Bracing connection
8.5 Connection lexicon

Fig. 251: Bracing connection
Fig. 252: Main structure and ring beam connection with floor joists
8.5 Connection lexicon

Fig. 253: Main structure and ring beam connection with floor joists
Fig. 254: Main structure and ring beam connection with floor joists
The floors and walls are supported by the custom designed ring beams which are connected to the main structure. The ring beams support open web steel joists. These joists are structurally selected for speed of erection, their light weight as well as long span capabilities. The wall structures are either galvanized wall studs or aluminium mullions.

Fig. 255: Axonometric section (original scale 1: 20)
8.6 Connection & skin

- Double C-channel (200mm X 75mm)
- Column with 50mm spacing
- M40 bolt & double M 40 locknut assembly (chromed)
- Custom ring beam assembly to detail
- 100mm seal
- Double bottom chord
- Double top chord
The steel structure is clad in various materials. The stud walls are clad with fire rated gypsum products and insulated for optimal thermal performance. The glazing system used has a grade of glass and mullions to comply with fire regulations. The floor voids can only be accessed from the accessible floor panels. These are prefabricated fibre cement and steel composite panel. This panel is selected for its durability, fire rating, span, and thermal properties. The floor void contain service reticulation. The ceiling panels fit into the joist profile eliminating a secondary structure. The ceiling panels are to be fixed from above to the joists to prevent floor to floor access.

Fig. 256: Axonometric section (original scale 1: 20)
8.6 Connection & skin

- 3mm channel with 2 coats paint
- 12.5 mm FireStop - fixed to stud with 25mm sharp point screws @ 220mm C/C
- Plastic strip skirting

- 90mm X 40mm glas steel C channel
  - Studs riveted to floor and head tracks @ 600mm C/C
  - (floor track) bolted to ring beam

- Custom ring beam assembly to detail

- 90mm X 40mm glas steel C channel (head track) bolted to ring beam

- 12.5 mm FireStop - fixed to stud with 75mm sharp point screws @ 220mm C/C

- 3mm channel with 2 coats paint

- Evaporative cooling distribution unit fixed with glav rod to open web posts
8.7 Axonometric section

Fig. 257: Axonometric section highlighting the external staircase and load bearing structure (original scale 1:50)
Fig. 258: Axonometric diagram
8.7 Axonometric section

Fig. 257: Axonometric section highlighting internal construction (original scale 1:50)
Fig. 258: Axonometric diagram
8.7 Axonometric section

Fig. 257: Axonometric section highlighting internal structure (original scale 1:50)
Fig. 258: Axonometric diagram
8.7 Axonometric section

Fig. 257: Axonometric section highlighting external skin (original scale 1:50)
Fig. 258: Axonometric diagram
8.7 Axonometric section

Fig. 259: Axonometric section of the stair case (original scale 1:50)

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Fig. 260: Axonometric section of the exterior structure (original scale 1:50)
8.7 Axonometric section

Fig. 261: Axonometric section of the interior (original scale 1:50)
Fig. 262: Axonometric section of the suspension bridge (original scale 1:50)
8.7 Axonometric section
Fig. 263: Axonometric section of the skin (original scale 1:50)
8.8 Section

Fig. 265: Technical section (original scale 1:50)
Fig. 265: Technical section (original scale 1:50)
Fig. 265: Technical section (original scale 1:50)

150mm x 400mm acoustic ceiling panel fitted made up web panel (12m x 5m flat ceiling)
450mm deep x 5mm steel open web panel with 150mm seal, on ring
4mm galv. fixings
120mm x 120mm halogen ceiling light fixtures
30% open area, sheet, 300mm x 300mm

Connection between ring beam and screen sub-frame to M1 steel A
perforated screen sub-frame, 150mm x 30mm steel channel
450mm x 3000mm red oxidised 6.5 painted perforated metal, round hole, galvanised 80x80 15 gauge, mill
300mm x 1200mm stainless Steel, Packed 5% open area, sheet, 3000mm x 300mm
150mm box section, aluminium curtain rail, laser cut glass panels with ANSI Z75.1 & 18mm fixings

Conduit channel (20mm x 75mm) column with 80mm spacing

Passenger lift
300mm x 300mm column with 30mm spacing

120mm x 400mm box section ceiling panel fitted made up web panel (12m x 5m flat ceiling)

Ocistallation connections to detail
Double c-channel 20mm x 75mm column with 30mm spacing
12mm FireProof thickness at 900mm gauge, wall cladding 1200mm at cove and 900mm steel beam on 12mm FireProof Step thickness
450mm deep x 5mm steel open web panel with 150mm seal, on ring
4mm galv. fixings on 1200mm x 600mm steel sheet 300mm x 1200mm current compartment access four panel (120mm x 5m flange)
7 pieces bolted to 450mm open web panel (600mm x 1200mm)

120mm x 120mm halogen ceiling light fixtures
30% open area, sheet, 300mm x 300mm

12mm FireProof thickness at 900mm gauge, wall cladding 1200mm at cove and 900mm steel beam on 12mm FireProof Step thickness

Open web ceiling with concealed 150mm box section ceiling panels (120mm x 5m flat ceiling)
Fig. 265: Technical section (original scale 1:50)

- **Structure & Ring Beam Gusset**: Connection to detail
- **Custom Ring Beam Assembly to Detail**
- **Perforated Metal, Round Hole**: Galvanized (300, 16 gauge, mill finish, 50mm holes, Staggered Pattern, 50% open area, sheet, 3000mm X 3000mm)
- **Perforated Screen Subframe**: 50mm X 50mm steel channel grid (3000mm X 3000mm) red oxidized & painted
- **Perforated Metal, Round Hole**: 50mm holes, (Staggered - Pattern, 50% open area, sheet, 3000mm X 3000mm)
- **Double C-Channel (200mm X 75mm)**: Column with 50mm spacing
- **Connection Between Ring Beam and Screen Subframe to 3D Detail A**
- **Perforated Screen Subframe**: 50mm X 50mm steel channel grid (3000mm X 3000mm) red oxidized & painted
- **Perforated Metal, Round Hole**: Galvanized (300, 16 gauge, mill finish, 50mm holes, Staggered Pattern, 50% open area, sheet, 3000mm X 3000mm)
- **Double C-Channel (200mm X 75mm)**: Column with 50mm spacing
- **120mm Fire Rated Aluminum Curtain System, 8mm Laminated Glass Panels with ANSI 257.1 & 180min Fire Rating**
- **120mm Fire Rated Aluminum Curtain System, 8mm Laminated Glass Panels with ANSI 257.1 & 180min Fire Rating**
- **Structure & Ring Beam Gusset**: Connection to detail
- **Custom Ring Beam Assembly to Detail**
- **Double C-Channel (200mm X 75mm)**: Column with 50mm spacing
- **Steel and Concrete Composite Shaft**
- **120mm Fire Rated Aluminum Curtain System, 8mm Laminated Glass Panels with ANSI 257.1 & 180min Fire Rating**
- **Structure & Ring Beam Gusset**: Connection to detail
- **1200mm X 800mm Non Access Ceiling Panel Filled Inside Open Web Post (120 min Fire Rating)**

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**NGO Office**: 44 m²

**Mining House Office**: 62 m²

**STAR NOTE**: 16 mild steel treads with 25mm chamfered nosing @ 260mm, 17 open risers @ 178mm supported by structural mild steel c-channel stringers

**1100mm High Mild Steel Balustrade**
Fig. 266: Technical section (original scale 1:20)

- 120 mm fire-rated aluminum curtain system, 5mm laminated glass panels with AWS Z71 & 160mm fire rating
- Structure & ring beam gusset connection to detail
- Custom ring beam assembly to detail
- 120 mm fire-rated aluminum curtain system, 5mm laminated glass panels with AWS Z71 & 160mm fire rating

- 4mm glass on 1200mm x 400mm x 400mm webs & 4mm cement composite access floor panel 150mm bearing on 500mm x 500mm 7.5mm steel plate to 60mm gypsum web post @ 1200mm OC
- Structure & ring beam gusset connection to detail
- Custom ring beam assembly to detail
- Connection between ring beam and screen sub-frame to detail A
- 120 mm fire-rated aluminum curtain system, 5mm laminated glass panels with AWS Z71 & 160mm fire rating
Fig. 268: Machine diagram
Fig. 269: Exploded machine diagram
Fig. 270 & 271: Machine elevations
Fig. 272: Space, machine and context
8.10 Construction plans
Fig. 273-279: Technical plans
Conclusion

A short conclusion addressing:

- the dissertation aim
- the self driven process aim
- and the professional aim.
Conclusion:
Meeting the Aims

The aim of the dissertation that is stated in the abstract was met through a number of different methods.

Dissertation aim:

Knowledge about the AMD crisis was furthered through design research. A solution with an architectural approach that is unique and derived from Johannesburg was achieved through an architectural process. The scheme was designed in such a way as to resist redundancy of depleted infrastructure by proposing an archeology of the future.

Aim of self-driven process:

The reading of this dissertation was devised to differ from a normative architectural dissertation. A personal aim was set to use a self driven methodology in the evolution of architectural process, hence the fact that the precedent studies are not placed in the traditional moment of a dissertation. It is evident throughout the document that there is not a consistency of mediums used to conduct process. This inconsistency was executed with a purpose to break with comfort zones within the creative mind. Photography, walking the context, sketching, making, collage and computing were used to present as well as to further design knowledge.
Conclusion: Meeting the Aims

Professional aim:

The professional and academic aim of the dissertation is to prove the efficiency and credibility of a student to enter the professional body as a candidate architect. The methodologies explored in this dissertation display how initial steps into topic research lead into design research (sketching, drawing, theoretical discourse). The architectural technology is designed in such a way that the design research is the strongest influence. This follows a chronology of architectural process from the research idea through to detailing. The mediums used prove the efficiency needed for the contemporary architect to function in a fast moving world. A personal aim was set to push boundaries between hand driven-process (optimal for creativity) and computer-driven process (optimal for efficiency due to the scale of project). Both genres where used when necessary, as illustrated in the dissertation.
Fig. 288: Efficiency in hand driven skills

Fig. 289: Efficiency in innovative technology
Fig. 290: Final urban model indicating mining tunnels, purified water grid, road networks, built context and the design intervention (Photographed by Leon Krije)
Fig. 292: Final 1:200 model (Photographed by Leon Krige)
This chapter illustrates the credibility of the project, rather than serving as direct design inspiration to the proposed project. The precedent studies are discussed as follows:

9.1 Design philosophies

9.2 Local precedents

9.3 International precedents

9.4 Case study

9.5 Inspiration
Precedents

Design philosophy

Local precedent

Case study

Figure 293: Diagram illustrating precedents discussed.
10.1 Local precedents

10.1.1 Millennium Tower

KwaZulu-Natal
Durban
The Bluff
2002
Don Alberts & Partners

Site:
The site is located at the port of Durban.

Brief:
The brief was motivated by increased business across borders entering into the Durban port. The building had to accommodate management for vessel traffic consisting of an operations room, search and rescue room and communication facilities. The brief stated that the building had to be 13 meter in diameter, 27 meters off the ground and have a 360 degree view. The circulation had to be internal and external (Peters, 2009:397).

Design:
The structure is described as a kinetic barometer. The building has a steel cowl that follows the direction of the wind, a mechanically driven spire that oscillates with the ebb and flow of the tides and a large sun dial (the structure itself). The building has a didactic function to the occupants of Durban. Inspiration of the shape was taken from a sugar cane shoot as it is a significant part of the KwaZulu Natal landscape (Peters, 2009:397).

Relevance

The two projects are similar in function because both are unique to their indigenous contexts. Both projects draw inspiration from its economic genesis as well as its major aspect that is listed in the brief. The design of the millennium tower was greatly inspired by the shapes of the local vegetation, as well as local formgiving with regards to function. The combination of different spaces and rooms also serves as an important precedent considering the accommodation of the proposed building. Furthermore, the building and its components react to the environment which relates to the approach of the proposed project adapting and developing into the future.

Figure 294: The building as wind cowl, Durban. (Upfold.peter [sa]).
10.1.2. David Klaaste Multipurpose centre

Karoo
Laingsburg
Bergsig
CS Studio Architects

**Site:**
The site is located adjacent to the N1 driving into Laingsburg - a small town located in the Karoo.

**Brief:**
The brief of the building consisted of a programme to erect community centres in rural areas across the country (Cooke, 2009:245).

**Design:**
The majority of the 80 other centres built (at the time of publication) were mostly utilitarian. The architects challenged this notion and investigated the town to create architecture unique to the specific location. Community participation and abstract model building was a very integral part of the process. The building composition include industrial elements which form part of the Karoo Landscape (Cooke, 2009:245).

**Figure 295:** Concept model of the David Klaaste Multipurpose centre (CS Studio Architects [sa]).
**Figure 296:** Context of the David Klaaste Multipurpose centre (CS Studio Architects [sa]).
**Figure 297:** Landscape elements of the David Klaaste Multipurpose centre (CS Studio Architects [sa]).

**Relevance**
The process of abstraction is evident in the final design of the building which serves as an inspirational element to the proposed design. The architect drew inspiration from the contextual iconography - an approach also taken in the design of the proposed building.
10.2 Case study

Cheonggyechon

South Korea
Seoul
City of Seoul: Municipality of Seoul

The Cheonggyechon used to be a stream flowing through Seoul from East to West. As the city urbanized a concrete deck was constructed over the stream and an express freeway was imposed. These impositions were infrastructural and hid the natural stream entirely from sight. The restoration project proposed to demolish the infrastructure and restore the stream as a humane environment and breathing space for the city of Seoul. The project is the largest of its kind in the Korean history (Lee, 2003:1).

Brief history:
Before the stream was closed off it posed great health risks to the city relating to waste disposal, sewerage and possible flooding. Thus, at that particular time in history, covering the stream was an easy solution to the problems. Construction started in 1937. The stream was fully covered in 1961. This urban tabula rasa resulted in the construction of multiple businesses and tall structures on either side of the concrete slab which was now used as an arterial connection. The traffic increased over this section of Seoul and the elevated freeway (5.4 km long) was constructed between 1967 and 1971 (Lee, 2003:1)

There existed a paradigm towards urban development that focused mainly on infrastructural development for economic growth with the major focus not being the quality of urban life. The city of Seoul identified many problems resulting from the covered stream and its infrastructural impositions such as air pollution, noise pollution and a lack of regional identity, structural and human safety, as well as heritage issues. The city adopted a new paradigm towards urban development with the redevelopment of this strip by proposing to demolish the express way in order to recover the stream. The aims of the project were to recover an ecologically sound environment, restore the functions of the stream, provide the city with an open space and provide the city with a sense of history. The project is described as a milestone as cultural, historic and environmental priorities overshadows development and economic priorities (Lee, 2003:3).

Relevance
In both the proposed project as well as the Cheonggye, infrastructural interventions are turned into humane environments over a period of time. In the case of Cheonggye, the process was accompanied by large project costs as the need for change was unforeseen and not planned. This is a common thread seen in infrastructural design where it is designed solely as infrastructure. The project identifies water pollution and a long process to reintegrate it into the grid as an element of human life. There are many parallels between the covering of the stream and the economic upliftment it provided Seoul with, compared to the mining in Johannesburg and the urban impact it had on the city. The aims of both projects are related in that they seek a more humane environment in a polluted city.
Figure 298: Urban breathing zone of the Cheonggyecheon, Seoul, 2012.

Figure 299: Past express freeway built over the Cheonggyechon (Lee, 2003:2).

Figure 300: Contemporary pedestrian corridor of the Cheonggyechon, Seoul, 2012.
10.3 International precedents

9.3.1. Parc de la Villette “in Johannesburg”

The Parc de la Vilette is not used as a conventional precedent presented in the form of plans, sections and elevations, but rather used as a guide to a mega project.

In some instances, the Parc de la Vilette is not considered a park, but to be one of the largest buildings in the world. Although it is described as a discontinuous building, it has a coherent structure which ties various design aspects, together with the surroundings of the design into one entity. One of the most important characteristics of the park is that it has to be able to change along with its users, differing from the traditional park models. The structure of the park had to contain a large space of unprogrammed place, while still maintaining a coherent structure. The park environment was not designed with a prescribed use of space, but rather to encourage users to activate the space. The site for the park was a semi-industrial area with two existing structures. The design was generated by the superimposition of layers to form unique situations (UME, [sa]).

A reconfiguration of the park was superimposed over the southern edge of the Randjeslaagte triangle. This superimposition created a sense of scale, not just of the park, but also of the mining sites. The meandering paths which Tschumi designed in the Parc de la Vilette were re-conceptualised as a connecting strip along the mining reef. The follies designed by Tschumi were strategically placed to intersect buildings located in Johannesburg. The grid spacing of the follies was left unchanged in order to keep the same sense of scale. The bigger circular elements represent the scale of the mining sites.

This three dimensional modelling exercise was done at an early stage of the project and proved to be a useful exploration in terms of scale.

Figure 301: Parc de La Vilette imposed over the city of Johannesburg.

Figure 302: A reconstruction of Parc de la Vilette in Johannesburg.
9.3.2 Landschaftspark Duisburg Nord

Duisburg Germany
Latz + Partner

The region of Landschaftspark has a rich history of coal mining and steel manufacturing which left a legacy of ecological damage. According to Stilgenbauer (2005:6), what was left behind was “a bizarre landscape of rail beds, smokestacks, slag heaps, polluted soils, industrial ruins and engineered waterways.”

The site falls within a series of sites that was part of the IBA (International Building Exhibitions) Emscherpark initiative to revitalize the post-industrial landscape (Stilgenbauer, 2005:6).

The site used to be a steelworks manufacturing plant before it was bought over and rezoned. The area was explained by the designer as a challenging terrain to work with. Surveying, arranging and unifying the site was the main issue difficult to address due to the scale and industrial nature of the site. The existing structures, however, made it an attractive site. The designer personifies the structures into living animals (Stilgenbauer, 2005:7).

The design team acknowledged the layers left by the industrial era by embracing it in the creation of a new place. The design consists of independent parks systems which also act as a guiding device due to the scale of the site. These different park systems include a railroad park, new footbridges, promenades, a waterpark and vegetation (Stilgenbauer, 2005:7).

Relevance

Landschaftspark is also located in a previously mined and industrial area. The scale of the site relates to the larger site of the proposed project (the whole of Johannesburg) as well as to each macro site individually. The project mainly acts as a precedent for the far future proposal of the proposed project. Similar to Landschaftspark, the machines that will purify the water will be integrated into urban parks.

Figure 303: Existing buildings at Landschaftspark (Wikimedia 2006)

Figure 304: The Landschaftspark (Alexander Franzen, 2011)
10.4 Design philosophy

Metabolism

Metabolism is a term coined by a group of Japanese architects in the 1960’s. The term is based on a philosophy of change and their design philosophy formed around ideas where the city is regarded a constantly growing organism. They designed their own lexicon for architecture which is related to biology rather than structural terms where the term metabolism came from. They refer to change which happens at different rates. Different parts of cities (and buildings) change at different rates, thus they separate these parts of architectural entities to allow for these changes (Kurokawa, 1977:9).

Takara Beautillion Expo 1970.
The geometry of a modular grid system of the design is composed of a steel plate welded to 12 bend steel pipes. The scale of the modular grid size allowed for fast construction with relative low technology needed for assembly. The units within the grid allowed for adaptability of space as well as over all architectural shape (Kurokawa, 1977:01). The more humane scale of the grid spacing allows for quick adaption of insurgent space and the cycles of a city like Johannesburg. The smaller grid starts forming a more organic shape of the mass of the assembly. These different park systems include a railroad park, new foot bridges, promenades, a water park and vegetation fields. (Stilgenbauer, 2005:7)

Relevance
The Metabolists had a strong theoretical approach towards the growth of architecture in relation to the growth of cities. Their built work was still very rigid and whether it totally resembled their theories about architecture is debatable. However, inspiration is drawn from their theoretical thinking about architecture and its rhythms of change.

Figure 305: Modelled structural element as an experiment into Metabolist thinking.
10.5 Inspiration

9.5.1 Bicycle

The essential structure (geometry) and a co-function with mechanical power is executed beautifully in this street bicycle. It illustrates a merge between the essential structural form and the machine, between the human driven and resource driven, between essence and redundancy. There exists a spatial mix within the construct as the machine occupies selected space of the structure whilst avoiding other parts. Both the structure and machine is engineered for optimal performance, both with the same goal in mind: to enhance human life.

Figure 306: Self modified bicycle, Korea, 2012.
10.5 Inspiration

9.5.2 Hong Kong Services

When walking the streets and alleys of Hong Kong, one cannot help but notice the abundance of exposed building services. It is not a hidden element but rather a part of the visual fabric of the city. Most western cities attempt to hide building services, as if the buildings ought to be shy of its inner guts. The ugliness of the naked exposure of the inner working of the buildings in Hong Kong has a beauty to it. The buildings are not trying to hide what they are, or what functions they hide behind their facades. They achieve this not by exposing themselves (transparency in architecture) but by exposing their services. The buildings expose themselves. They do not expose their occupants. Although the streets of Hong Kong are filled with services, you will be surprised to stroll through and ally and struggle to spot a duct.

9.5.3 Dam wall construction

Figure 310: Dam wall construction - The Shasta dam under construction. California, June 1942. Photograph by Russell Lee (Gwarlingo, [sa]).
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