A landscape in transition
Architecture for an extreme climatic condition:
accommodating the informal within a flood-prone area

Design Research Project APG5058S

Submitted in partial fulfilment of the requirements for the degree

Master of Architecture (Professional)

by

John Edwards

September 2009

The copyright of this thesis vests in the author. No quotation from it or information derived from it is to be published without full acknowledgement of the source. The thesis is to be used for private study or non-commercial research purposes only.

Published by the University of Cape Town (UCT) in terms of the non-exclusive license granted to UCT by the author.

University of Cape Town

'a landscape in transition'

ARCHITECTURE

for an extreme climatic condition:

an architectural response to seasonal flooding in Khayelitsha

John Edwards

M. Arch (Prof)

October 2009

DECLARATION

I know the meaning of plagiarism and declare that all the work in this document, apart from the work which is properly acknowledged, is my own.

John Edwards October 2009

Signed:

ACKNOWLEDGEMENTS

I would firstly like to thank UCT's *African Centre for Cities* who hosted Caron von Zeil as part of one of their 'CityLab' workshops. Von Zeil's project *CAMISSA: the place of sweet waters*, inspired a whole new direction for my project. I would also like to thank my supervisors Alta Steenkamp, Jo Noero and Francis Carter who have given me the freedom to express my interests and explore this 'new' terrain, while also subtly guiding and reminding me of the intent and focus of this year's study.

I am also very grateful for all the help given by Patricia Zeig from DiMP and her enthusiasm for my project. I would also like to thank Sue Parnell from the ACC who has been very encouraging towards my field of study and investigation. Thanks also go to Prof. Kevin Winter, Prof. Neil Armitage and Prof. Del Mistro who have listened and offered me guidance while navigating this 'new' terrain.

Lastly, I would also like to thank my family for their support over the past six years and I sincerely appreciate the fact that they were always there for me, supportive and willing to listen.

Figure 1:

House on stilts: prepared for flash floods

CONTENTS

LIST OF FIGURES

All images and drawings by author unless otherwise stated

INTRODUCTION

'a landscape in transition'

'constant change in the relationship between architecture and the landscape'

'this shift demands cross-disciplinary, socially engaged, environmentally aware and inventive projects'

Figure 6: St Mark's Square

(Pearce; 2007; 44)

Figure 5: St Mark's Square Flooded

(Pearce; 2007; 45)

Changing landscapes

The rapid urbanization seen within the City of Cape Town is a dynamic fluid, non-linear process as opposed to being rational, stable or closely predictable. Ecology and systems theory are concepts inherent to the city and its relationship with landscape. Conceptualizing urbanization, human security and disaster risk, especially within Africa, will help unravel the issue at hand. The nature of the problem and the extreme conditions of flooding will also be explored.

There are indications that South Africa's climate is becoming increasingly variable (Napier & Rubin; 2002). Climate change increases the uncertainty faced by vulnerable communities through a widening range of future climate variations and hazards. This is not a hypothetical risk to be addressed several decades into the future, but a real increase in risk that is presently threatening livelihoods. (UNISDR; 2002)

Residents of informal settlements in the Western Cape, as well as elsewhere in South Africa, are the hardest hit by extreme weather conditions and associated flooding. Thousands of households in the province and beyond suffer severe losses in informal dwelling floods and fires. During floods and fires, poor families suffer significant development setbacks. These disasters are also costly for the affected municipalities and provincial departments, and divert resources from other urgently needed services. (Holloway; 2007)

Rapid migration into the province and natural population growth have increased the number of informal settlements across the province. Within Cape Town alone, by 2007, more than 220 separate informal settlements had been identified and mapped. (Holloway; 2007)

There is a radical emerging field of practice in urban and rural renewal that responds to the changing social landscape of the 21st century, which aims to inspire creative and effective responses to contexts of change. This shift demands cross-disciplinary, socially engaged, environmentally aware and inventive projects. These projects offer new methodologies and new perspectives, demonstrating effective and pragmatic ways to tackle problems where current modes of practices often fail to produce any lasting results.

There is also a process of change that is noticeable in the built environment. A state of flux exists in urban centres and rural landscapes where cities shrink, new cities explode, and where issues of urbanization, sustainability and planning have become common. A shift in practice has emerged from and responds to this context of flux and change, with the focus specifically on the built environment as the vessel or catalyst for social, economic and ecological change.

Earth, then and now shows potent visual evidence of our changing world. The book highlights the key issues affecting the world today, environmental change, urbanization, land transformation, the forces of nature, war and conflict, and leisure and culture. The juxtaposition of before and after photographs forces one to look at often-devastating changes. It reinforces what we instinctively know: that climate change is the biggest threat we face. According to Zac Goldsmith from *The Ecologist* it is our job to apply whatever pressure we can for change. (Pearce; 2007; 9)

According to a 2007 survey by the Intergovernmental Panel on Climate Change, we can be almost 100% certain that humans are responsible for the climate change we've seen on the last 50 years. This warming is echoed by various scientific authorities, including the World Meteorological Organization. (Pearce; 2007; 9)

Nature is always on the move, never passive and no one doubts that the world is changing. Thanks in part to the ephemeral nature of many human settlements, nature has demonstrated a remarkable ability to recover. (Pearce; 2007; 12) Evidence shows that nature can recover from the impact of human activity, but she has never experienced anything like the intensity of our current interventions on earth.

Our creativity and inventiveness may have got us into our current environmental mess, but we must hope that they can get us out of it too. And there is evidence that they can. (Pearce; 2007; 15)

Nature is always on the move; never a passive spectator. But even so, humans are implicated not just in obvious things such as draining wetlands, but also in apparently natural changes to the landscape.

Venice, the former capital of a hugely successful merchant empire, is constructed on wooden piles in a lagoon at the head of the Adriatic Sea. But the water all around the city has become its biggest threat. The images on the

previous page shows St Mark's Square, situated at the city's lowest point. During high water, Venice has always been at risk of flooding, but man-made changes to the lagoon, and rising global sea levels, have greatly increased the danger. The lagoon was rarely more than a metre deep and its mud banks absorbed the force of the waves, keeping out high tides. Today, wave surges into the lagoon along shipping channels dredged for cruise ships and other vessels. Many of the mud banks have been eroded. In the past three decades the average high tide in the lagoon has risen by almost half a metre, flooding basements and washing across St Mark's Square around 50 times a year. (Pearce; 2007; 44, 45)

For individuals caught up in the immediate concerns of daily survival, disaster risk management is often not a priority. Poorer people living in settlements such as Bongani TR-Section in Khayelitsha, have a lesser capacity to adapt and are more vulnerable to climate change damages, just as they are more vulnerable to other stresses. They experience the added risks associated with lack of services and land that is often inappropriate for settlement.

On the left one can see images of the changing nature of Khayelitsha, before and after the wetlands were filled in with sand.

For centuries, 'water' cities have been built around the world. These cities have not turned away from the water, but have adopted a functional approach to the idea of water.

These historic 'water' cities serve as a source of insiration for the current task of reconciling water with city

As part of the International Architecture Biennale Rooterdam, the exhibition *'water' cities* established a link between historic waterside cities and waterside cities of the future. The images on the next page are a selection of some of the water cities/ ideas from different periods as shown at the exhibition.

Figure 7: Khayelitsha before the infill

(Brown, Magoba; 2009)

Figure 8: landscape destruction and permanent damage to wetland

Figure 9: Archigram's utopian city, reflecting a technocratic society

Figure 10: MVRDV's 'Floodplain'

Figure 11: competition entry in response to Scotland's changing coast

Figure 12: the floating city, marinas

SITUATION

Critical Image

This image depicts the harsh reality many residents face each winter when the water table rises, forcing many to flee to higher ground, neighbours or family.

However, many choose to continue living in conditions like this because of a lack of resources, assistance or alternatives.

How does one intervene within a sensitive wetland system when the City of Cape Town refuses to relocate residents, and when the very residents themselves refuse to move from the flood prone areas?

How does one stop further development within the wetlands?
What architectural strategies can be developed to improve housing conditions within the water-locked areas?

Figure 3: Critical Image

(Bouchard,. Goncalo, Susienka & Wilson. 2007)

Figure 4: image that sparked my interest in architecture for extreme climates:

'Halley' -British Antarctic Base Camp

(Kronenburg: 2007)

POSITION

Design should be informed by both history, and past and present practices. Analysis of the dynamic social, cultural and natural conditions, values and processes should also inform design processes.

The design intervention will thus be informed by that which already exists. It is a give and take process between recipients and the designer, one which considers the real, the rational and the imaginative.

Ultimately my design intervention will be one which sets up conditions, and is catalytic in enabling and influencing a better relationship between man and landscape. Nature is not static or predictable and social and cultural systems should be considered similarly

The inspiration for this thesis originated/ and was inspired by the figure on the left which shows Halley, the British Antarctic Base Camp. This image triggered ideas of architecture for extreme conditions/ climates.

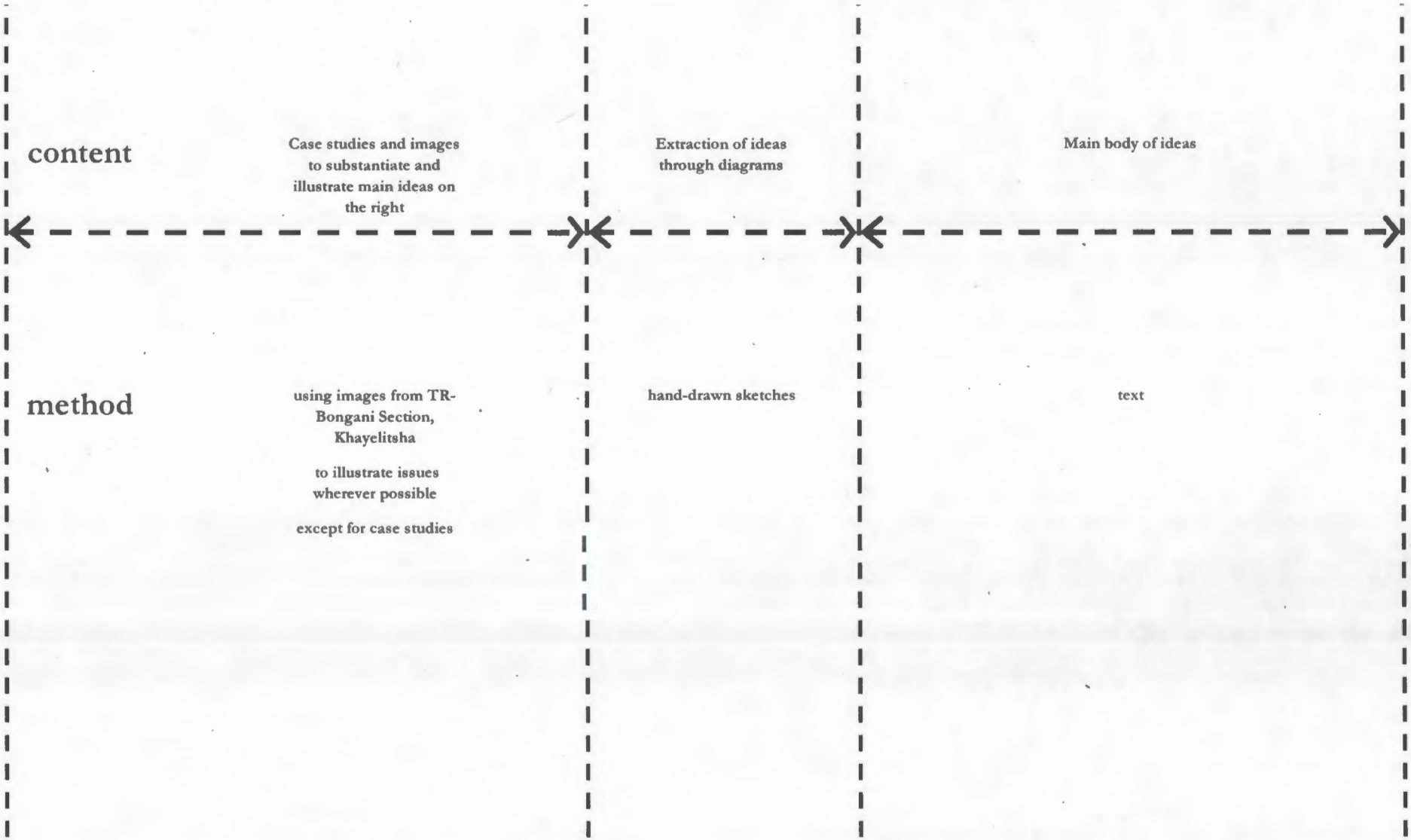
This soon gave way to more local issues. The process took the investigation to the speculative and ever looming danger of predicted sea-level rise and the effect it might have on the built environment.

However, it was felt that the above idea might be too speculative in nature and that a more pressing and existing local extreme condition be sought. It didn't take too long before the investigation narrowed down to the extreme condition of water table rise and the resultant flooding on the Cape Flats.

Still extreme in nature, yet more realistic and threatening, the very open process had led me to a desired and very relevant condition for my thesis topic.

With the above process in mind, the idea of the investigation leading me into certain areas/ fields unknown to me at first should reveal interesting and new insights into the peoblem at hand. By backtracking and re-examining one can narrow the broad field of inquiry and assess all the relevant information along the way.

HOW TO READ THIS DOCUMENT?



ABSTRACT

This thesis investigates an existing extreme climatic condition; the annual water table rise within low lying areas of Khayelitsha, and more specifically TR-Bongani Section which lies along its periphery.

This investigation starts off with an exploration of the notion of 'landscapes in transition', and the constant change in the relationship of architecture with landscape. This hints at the extreme condition of flooding which will be explored later.

This investigation has been divided according to the approach taken towards the site. It consists of three parts which are named according to the scales three different scales of intervention:

Large firstly explores natural infrastructure and investigates the natural system of wetlands 'technology'. Secondly, this chapter deals with the idea of man-made infrastructure. The issue of dealing with the informal is also addressed here. This chapter tries to address this issue by looking at the writing of Dave Dewar and Nabeel Hamdi, in order to gain an understanding of the inherent challenges and opportunities that accompany working within/ with the informal.

This chapter also explores Siting to illustrate the previous parts. **Changing perceptions** investigates changing disaster mitigation strategies/ theories to gain an understanding of the various measures and ideas already in use and how these policies have shaped and impacted on mitigation strategies. The research and Critical Risk Assessments (CRA's) done by UCT' Disaster Mitigation for Sustainable Livelihoods Programme (DiMP) will be discussed and its relevance to my project will also be explained. This chapter serves as broad background to the thesis investigation.

Medium investigates six different approaches to infrastructure provision. Architecture's relationship with other disciplines and the notion of inter-disciplinary work will be explored in *changing relationships*. The first approach looks at Natural processes, the second looks at approaches which are Engineering-orientated, the third looks at Integrated Urban Water Management Approaches, the fourth looks at Architectural approaches, the fifth looks at a Landscape approach and the sixth explores an integrated/ interdisciplinary approach to infrastructural design.

As a result of increased urbanization, a lack of decent service delivery and basic public infrastructure, there is a high incidence of risk/ hazards within informal settlements. **Small:** *Changing attitudes* explores the idea of small 'self-help' mitigation strategies', as seen within the TR-Bongani Section, Khaeylitsha, which will hint at possible clues for intervention at the small dwelling scale.

'propose an architecture that reciprocates, trades & exchanges with its environment, one expanding & contracting, receiving & donating, adapting & adjusting in response to the other'

'a weather-responsive & weather absorbing architecture indicative of a wider agenda: a changeable architecture for changeable conditions'

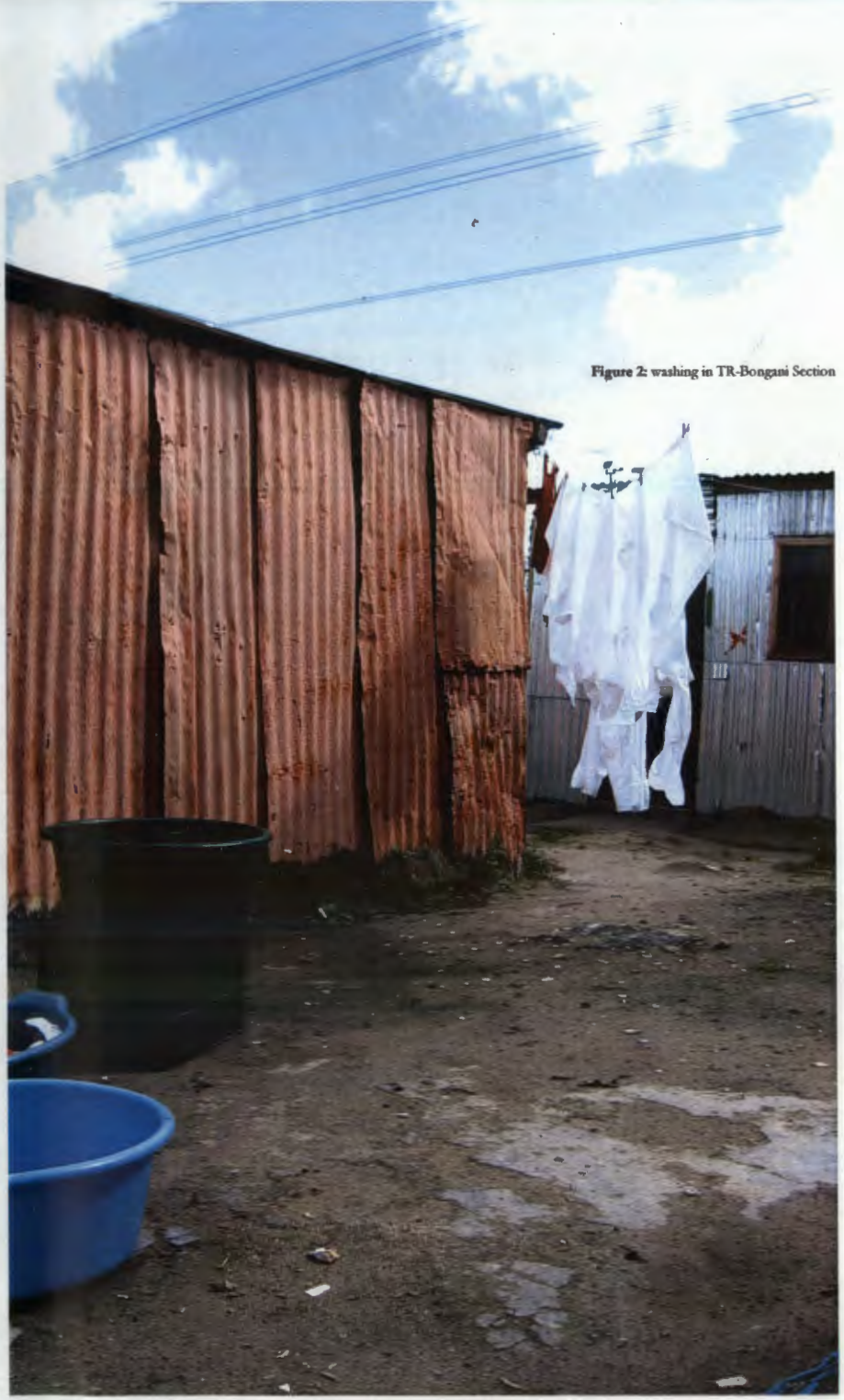


Figure 2: washing in TR-Bongani Section

MOTIVATION

Why this project is unique?

'Architecture for an extreme climatic condition'

Architecture

I started this thesis project by looking at architecture for extreme climates/ conditions. After a rigorous process, which included investigating sea level rise and how this might affect low lying coastline areas in Cape Town, I soon realised that the investigation was far too speculative and that I had to focus my attention on more serious/ relevant and existing extreme climatic conditions within Cape Town.

Description

This thesis therefore investigates an existing extreme climatic condition; the annual water table rise on the Cape Flats and the resultant flooding which occurs.

Almost half the population of Cape Town live in informal settlements, and most of these are located in low lying areas of the Cape Flats. Logic would suggest that people would move to higher and safer ground, but the reality is that socio-economic reasons force people to settle in left-over spaces, which are mostly disaster prone areas, in order to be close to work and transport. Further investigation also surprised me when finding that most shack-dwellers affected do not want to be relocated and that the government have realised (after many previous attempts) that relocation is too costly. This situation therefore created a very interesting 'area of investigation': How does one intervene within a sensitive wetland system when the City of Cape Town refuses to relocate residents, and when the very residents themselves refuse to move from the flood prone areas? And how does one stop further development within the wetlands?

My thesis topic is therefore titled: *'A landscape in transition'- Architecture for an extreme climatic condition: accommodating the informal within a flood-prone area'.*

Why is my project original?

This topic has allowed me to explore other disciplines outside of the field of Architecture. This interdisciplinary research has benefited my project greatly as it has allowed me to challenge the expected. This thesis attempts to explore physical mitigation strategies in response to seasonal flooding and attempts to challenge conventional/ traditional engineering-approaches to stormwater drainage by providing infrastructure related to water-use within informal areas. Practices and customs involving water will be celebrated to create and contribute to meaningful public spaces. This thesis attempts to develop architectural strategies to improve conditions for housing within the water-locked areas. This thesis also attempts to contribute to the improvement of basic living/ dwelling comforts to ensure a reasonable standard of well-being.

The interdisciplinary nature of the project is allowing me to transcend traditional ideas to challenge existing relationships and ways of working to create and engage in meaningful new ideas and methods of working with this challenging problem at hand.

'Process/ technique/ programme'

The water-related infrastructure provided includes various levels of infrastructure delivery, including small slaughterhouses, bathhouses, toilets and water points as well as small service cores. Infrastructure design and its impact/effect on the surroundings are therefore being investigated through design.

Pragmatism

This project/ investigation was initially inspired by the British Antarctic base, but once the scope of investigation was narrowed down, it was fuelled, inspired and driven by the current state of affairs regarding service delivery in our country. Service delivery has, since the inception of this project, become an important issue and cannot be ignored by designers any longer. This project therefore steers away from the romantic as it is very pragmatic in nature.

INITIAL IDEAS

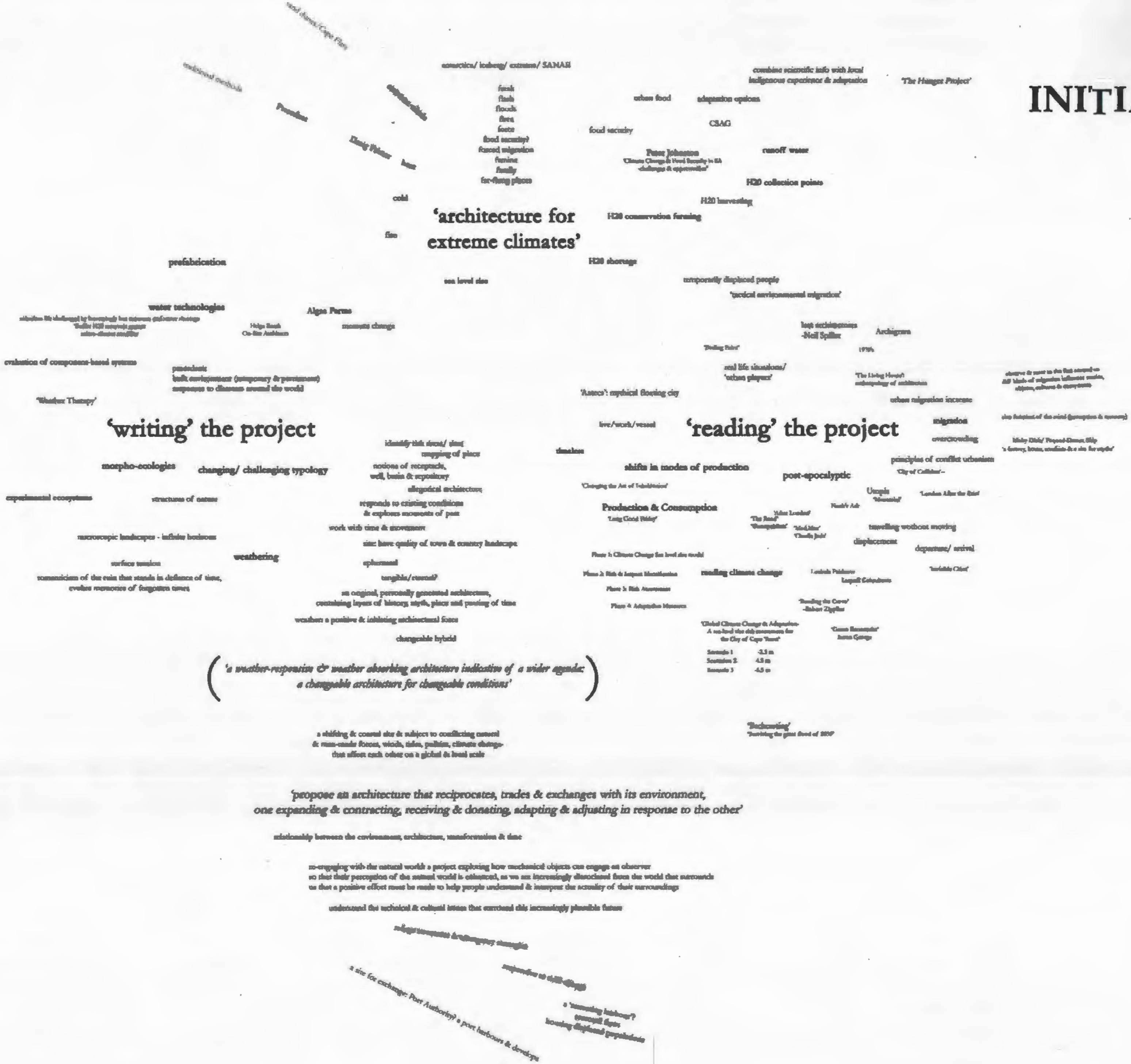


Figure 13: mapping ideas

Design

3 scales of intervention:

1 large: celebrating the use of water within settlements by restructuring and upgrading drainage
urban framework, working from the dwelling up,
& incremental plan of upgrading public spaces associated with water

2 medium: practices and functions associated with the use of water

3 small: specific small scale interventions in mitigating disaster:
flooding platforms for extreme case scenarios where relocation is not an option

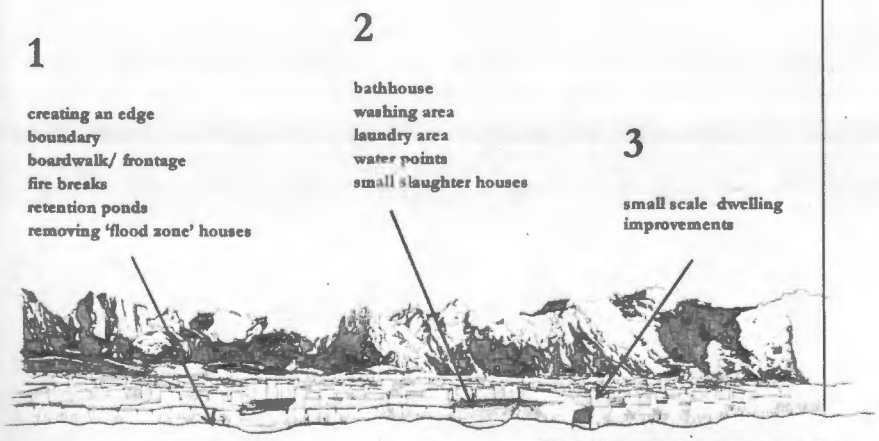


Figure 14: drawing of site showing approach

APPROACH

To the design project and this document

This paper has been divided according to the three different scales of interventions, mimicking the same approach used for the design and approach to the site. These three scales incorporate different streams/ ideas and approaches to upgrading and developing.

Below is an explanation of the approach taken towards design and the different ideas/ approaches at the different scales:

1. **large:**

-understanding the site and the natural wetland system/ considering constructed wetlands to rehabilitate water
-celebrating the use of water within settlements by restructuring and upgrading drainage: celebrate these spaces
-urban framework, working from the dwelling up, and incremental plan of upgrading public spaces associated with water

2. **medium:**

- infrastructure associated with the use of water

3. **small:**

-will reflect on specific small scale interventions at the dwelling scale in mitigating disaster.

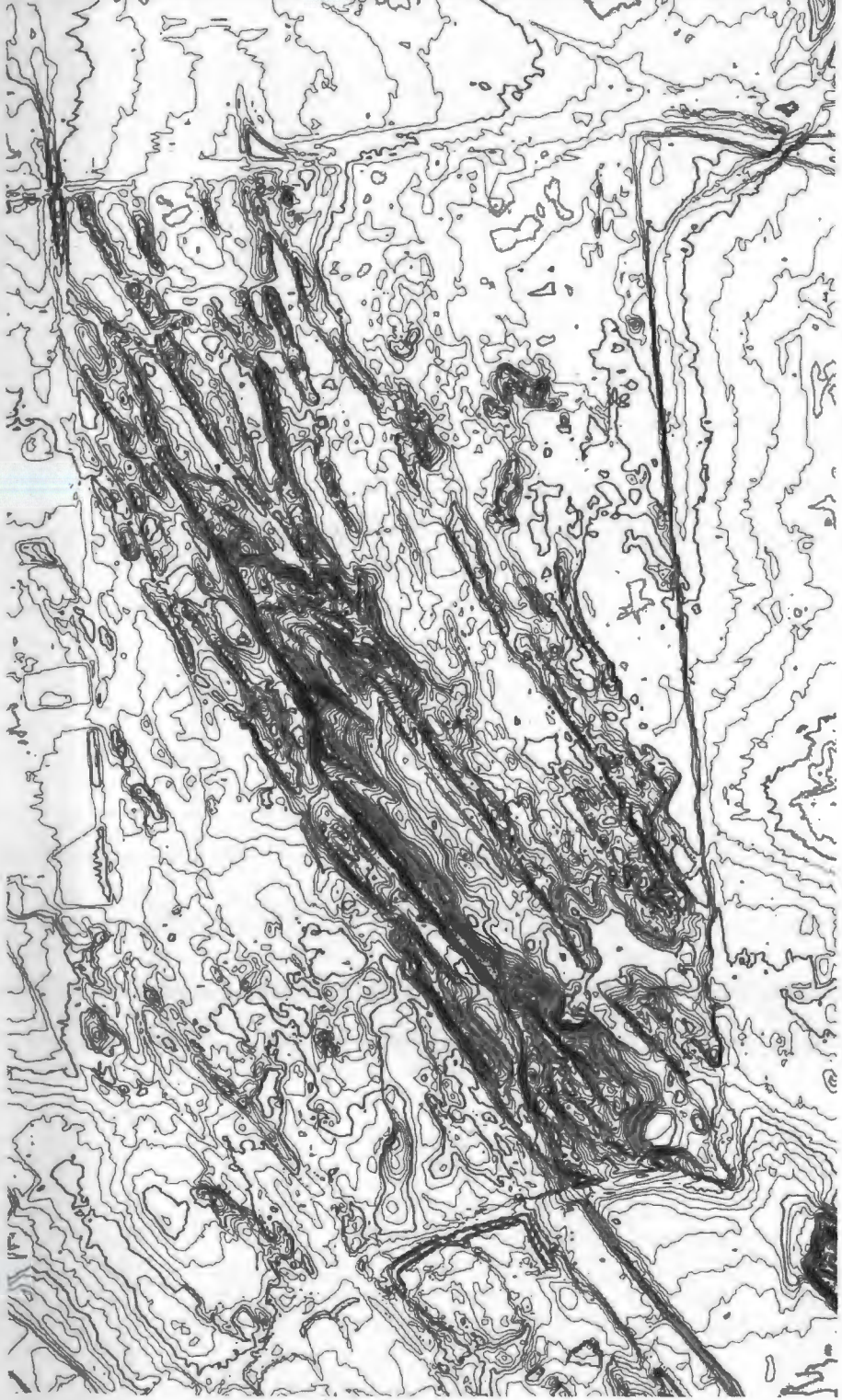


Figure 15: 'the basin'

(GIS mapping Dept UCT)

1. LARGE

Natural infrastructure

Apart from generating development, landscapes could also inform the design of the development and can be seen as operational. Natural treatment systems can inform building design in a way that traditional civic infrastructure doesn't. (Snoonian,; 2001; 131)

Water surrounds us in a network of concealed pipes, is freely available and is disposed of without any difficulty. Most people are usually only confronted with it at various ends of the system; where it comes out of the tap into the sink, the bath or shower. These days it is rare to experience water in the open in our cities, and yet it is increasingly in demand.

Urban design has always been closely linked with water and its use (Dreiseitl, Grau, Ludwig; 2001; 40). This functional relationship can be traced from antiquity through the middle ages to modern times. Water was far more than something that simply had to be supplied and disposed of. It expressed a living relationship between town and its surrounding areas. The way water is handled in towns shows more than the mere technical ingenuity of its citizens, reflecting myth and religion and shows the spiritual constitution of people living in a water culture. This changed fundamentally during and after the industrial revolution, when water and waterways were increasingly brought under control. They were straightened, canalised, built over, buried and filled in, all because this was technically possible.

Water has become one of the key determinants with regards to the future of our world, as we have started to realize that naturally available water supplies are finite and realising that water plays a complex and integral role in the stability of eco-systems.

We are usually only aware of water at a superficial level and only at particular moments. Reduction to simple functions like cleaning, washing and waste disposal reduces the intricate interplay of water with our lives to simplified and imprecise images. (Dreiseitl, Grau, Ludwig; 2001; 42)

Water projects have to address the issue of creating a balance in water management. Retention, purification, evaporation and infiltration must be integral elements in a municipal water programme. (Dreiseitl, Grau, Ludwig; 2001; 40)

Ever since people have organized their surroundings they have had to make water into something they can use, and regulate water management. Water planning is thus one of the oldest driving forces in urban development and gave rise to important engineering constructions at a very early stage in history. But these were always an expression of an attitude as well, of philosophy, myth and religion and were presented aesthetically. Today it is nearly impossible to understand any longer how closely the fields of art, architecture and engineering were linked until the late middle ages: when they formed a unit. An example of this kind of inter-disciplinary work with water is an artist like Leonardo da Vinci.

In the course of history these fields have developed, become more specialized and have moved apart. A real interplay of planning disciplines is rarely found. Architects gravitate towards sites close to water, but rarely address other related water themes and systems. Engineers on the other hand are inclined to find purely technical solutions to questions about water, and often seem to be following a marked urge to convince others and themselves that those solutions are indispensable. (Dreiseitl, Grau & Ludwig; 2001; 43)

But water problems in the city and countryside, which are increasing the world over require holistic strategies and planning. Causes can often be found in the fact that such problems are linked with our social values and customs. Isolated repairs are of limited use only, in terms of both space and time. Integrated planning is essential. (Dreiseitl, Grau, Ludwig; 2001; 43)

Integrated planning approaches include looking at the global and the local issues at play as water always creates a relationship between detail and the whole. Water always stands for exchange and openness as well, reflecting fairness or injustice between human beings. Planning is only successful if the cultural and social needs of the individual users are met and societies are regulated communally, and are expressed correctly. Citizen involvement and participation is crucial. It is important to promote and stimulate people's own creativity, as water is full of

imagination. Planning should allow people the chance to exert their influence and to suggest and agree to open possibilities for play. Another principle includes demonstrating sustainable environmental technologies, meaning that processes for purifying and treating water, for avoiding floods, should not be concealed, but wherever possible be presented openly and creatively. Retaining and managing rainwater in a new area can be integrated into open spaces within the planning process and become part of the architecture. Another principle is admitting multi-functionality as can be seen in nature. Rainwater retention facilities can offer much more than what it is intended for. (Dreiseitl, Grau, Ludwig; 2001; 43)

On the whole, people prefer and have always preferred to establish towns near water, where it could be exploited directly, as a transport medium that promotes trade, as well as contributing to the well-being of the inhabitants. Water can fulfil cultural, architectural and social functions within cities. (Dreiseitl, Grau, Ludwig; 2001; 72)

As globalization proceeds, cities are caught up in world-wide economic competition. If sustainable economic development is to be secured, some rethinking is necessary, water requirements must be made dependent on the water that is available on the spot and in the immediate vicinity-water should ideally not be brought in regardless of the environment and expense. A distinction has to be made between the elemental basic requirement, an additional social requirement and an economic requirement. One should remember the Roman system of water distribution, as it has survived in Nimes. Here the supplies to public wells, commercial operations, baths and private houses were staggered so that water was obtainable in each case only when supplies were adequate. If water was scarce, only the basic public requirement was covered. (Dreiseitl, Grau, Ludwig; 2001; 73)

Water management can only be balanced if social and economic wishes are covered by the quantities of available and renewable water. Water problems must be solved specifically and within the immediate vicinity of every area. Something that works in a certain area, can be inappropriate in another. Realizing this compels us to decentralize responsibility and action. There are many reasons for this: Large supply and disposal systems cost far more than small, autonomous systems. Small units are far less prone to faults and bring small and middle-sized enterprises together to construct and maintain them, and thus reinforce socio-economic structures. Small autonomous systems remain able to function because the people running and using them identify with their system and see it as their property. Water neighbourhoods are also better able to take responsibility for preventative measures. (Dreiseitl, Grau, Ludwig; 2001; 73)

Cape Flats

At one time it was thought that most of the vleis would have been inter-connected on the Cape Flats. It is thought that with the last emergence of the Cape Flats from the sea, changes in topography brought about changes in drainage and that wind-blown sand filled up many of the depressions, isolating the remaining water bodies. One view is that bare stretches of sand once covered the whole of the Cape Flats and that there were continued changes in the size and location of the vleis, as a result of rapidly shifting sand dunes. (Harrison; 1958).

The Cape Flats was artificially stabilized in the early 1900's by the planting of Australian wattles and in the last century urban expansion resulted in the elimination of many of the wetlands that once characterised the Cape Flats. Only the largest systems and some of the smaller, isolated water bodies remain. Without exception, these have been extensively regulated and modified. (Brown, Magoba; 2009; 5)

The present-day arrangement of the rivers and wetlands of the Cape Peninsula and adjacent areas reflects the past and present influences of the area's geology and geomorphology, sea level oscillations and climate change, present-day geomorphological processes such as hydraulic, vegetation and sediment interactions and the human impact such as channel engineering, abstraction of water and sediment, and catchment land use changes. (Brown, Magoba; 2009; 8)

Understanding how best to manage these systems should therefore start with an understanding of their geological history, and the physical constraints imposed by their present-day topography. (Brown, Magoba; 2009; 8)

The two main south draining rivers of the Cape Flats, the Diep River and the Kuils River, were significantly affected by pre-Quarternary and quarternary sea level changes. They created great valleys, which today are buried by the sands on the ocean floor of False Bay and on the Cape flats. Below these sands, cut into the underlying Malmesbury bedrock, are two significant palaeo-valleys that reflect the ancient routes that the proto-Diep River and proto-Kuils River took to the sea. (Brown, Magoba; 2009; 14)

Figure 16: natural infrastructure

South-end of TR-Bongani Section

The gentle-gradient Cape flats-rivers flow over recent Sandveld Group sediments, but roughly follow the courses of the underlying palaeo-valleys of the Diep and Kuils Rivers. The build-up of sediments washed into the area during sea level rises, and the movement of sand and other fine particles along the coast play a significant role in retarding river flow, creating the Cape Flats wetlands. (Brown, Magoba; 2009; 15)

In contrast to rivers, wetlands do not drain the landscape and are areas where water flows slowly or not at all. They therefore accumulate materials like soil particles and organic matter. Because wetlands reduce the rate at which water moves across the landscape, they provide a number of very important services to humans. (Davies & Day, 1998)

They tend to reduce the force of floodwater because they absorb some of the water in their loose, organic, peaty soils. Those wetlands that are areas of reduced gradient also cause the water to spread out across the landscape rather than being channelled trough river courses. Wetland plants such as reeds and sedges, and sometimes trees, further retard the rate at which water flows. Wetlands therefore serve as the most valuable flood-prevention measure. (Brown, Magoba; 2009; 28)

They also tend to cleanse the water passing through them because the reduced flow rates mean that particles (including bacteria) drop out of suspension, and the wetland soils and plants take up nutrients. Thus water leaving a wetland is often of much higher quality from a human perspective than it was when it entered. Wetlands are often constructed as a means of treating poor-quality water. (Brown, Magoba; 2009; 28)

Slowing the movement of water and spreading it laterally allows time for vertical infiltration into the substratum and ultimately into the groundwater. Many wetlands are thus said to aid in groundwater recharge. (Brown, Magoba; 2009; 28)

Cape Town used to be rich in wetlands of various kinds, including extensive seasonally inundated marshes in the rather indefinite lower courses of the Cape Flats Rivers such as the Black, Kuils, Eerste and Lourens. This is evident when looking at erven names on old maps of the Cape Flats, and that almost all of them had the word 'vlei' in the name. Many of these seasonal vleis become inundated in winter as a result of the rise of the water table above the surface of the soil. They form a fairly unusual wetland type that has become extremely rare over the last few decades as a result of housing and commercial development. Many vleis on the Cape Flats are now situated under Khayelitsha. (Brown, Magoba; 2009; 30)

The effects of humans on water chemistry can be profound. Stormwater runoff contains all manner of chemicals, from nutrients to heavy metals and other toxins, as well as bacteria. Stormwater entering the aquatic ecosystem can thus alter the very nature of the water and can ultimately result in the replacement of the natural assemblage of plants and animals with another, more tolerant assemblage. This is one of the reasons (flood abatement being the other) for creating detention ponds, which hold stormwater for long enough for some of the pollutants and sediment particles to settle out. Furthermore, many rivers and vleis now receive water that has been contaminated by human waste from informal settlements and from dysfunctional sewage systems. (Brown, Magoba; 2009; 33)

Rivers with their origins in Malmesbury Group shales or that flow through shales or calcareous sands on the Cape Flats collect nutrients from the surrounding substrates. Fringing reed beds then become the norm. Bulrushes (*Typha capensis*) regularly form dense stands in the marshes fringing the slow-flowing rivers of the cape Flats where finer sediments accumulate. Here they tend to block the waterways such as the Diep and Kuils Rivers, and are often cleared to prevent flooding. (Brown, Magoba; 2009; 39)

Humans have been responsible for many changes to the rivers and wetlands of Cape Town. The early inhabitants of Cape Town settled near rivers because water could be obtained from them and its flood plains provided fertile soils. As the city grew, and the demand for water exceeded the local supply, water was sourced from farther a field and the central role of the city's rivers changed. Instead of being suppliers of water, the use of these rivers in removing unwanted water or wastewater became more important. (Harding and Brown; 2001)

One of the major effects of human activities on the aquatic ecosystems of Cape Town is a modification in the amount of water they receive. Thus, while numerous wetlands have been drained and filled in and lost entirely, many of the remaining once-seasonal vleis have had their characters altered to such an extent by the discharge of treated effluent from waste water treatment works that they are now perennial. (Brown, Magoba; 2009; 98)

The construction of roofs, paths, tarred roads, freeways, pavements and parking lots has greatly reduced the surface area of soils able to absorb water falling as rain, and has increased runoff from the surrounding land, so

that rivers carry more water than before during storms. This is called catchment hardening. The problem has been exacerbated by developments on the low-lying parts of the Cape Flats, forcing the construction of canals to drain what would naturally have been seasonal wetlands, and natural flood attenuation ponds. (Brown, Magoba; 2009; 98)

The engineering of rivers in the area, necessitated by the increased runoff and effluent discharges, has also affected both the aesthetic quality of many river systems and the recreational opportunities offered by them. Increasingly, worldwide, it is being realised that greater environmental, social and economic success can be achieved if urban rivers and wetland fronts are designed with ecological principles in mind. (Brown, Magoba; 2009; 99)

In planning development, the width of the floodplain has to be determined. Within the designated floodplain, permanent structures should be avoided and even agricultural activities limited. However, it is economically impossible to impose restrictions that would cater for very rare storm events as this would exclude large areas of land from development. In practice, development is usually not allowed within the 1-in-20 year floodplain, and only limited development, which excludes housing, and industrial and commercial buildings, is permitted between the 1-in-20 and 1-in-50 year floodlines.

Cape Town's rivers are now carrying a significant amount of water that would not in natural circumstances belong in their catchments. Urbanization has also seen the destruction of many wetlands and vleis that would naturally have absorbed or detained floodwaters. This includes a narrowing, straightening and canalisation of the rivers and an increase in flood peaks and volumes as a result of catchment hardening. Increased runoff augments the effects of spates so that flood peaks may be considerably higher than they would have been under the same weather conditions if the catchment were in its natural state. (Brown, Magoba; 2009; 100)

Large areas of Cape Town are vulnerable to the impacts of flooding. The degree of vulnerability of communities to the impacts of flooding correlates closely with their socio-economic circumstances, with many of Cape Town's poorer suburbs having been constructed in natural floodplains/ wetlands. This construction also resulted in the destruction of many seasonal wetlands. (Brown, Magoba; 2009; 100)

One of the greatest causes of waterlogged conditions on the Cape Flats is the water table, which is usually close to the surface and may rise above ground level after heavy rains and remain that way for long periods. (Brown, Magoba; 2009; 101)

Of the Cape Flats Rivers that are not canalised (lined with concrete), many are 'channelised', meaning their earthen channels have been dug and are maintained by earth-moving equipment. (Brown, Magoba; 2009; 101)

The water quality of rivers in the urban areas of Cape Town is often poor, with effluent discharges into the rivers being one of many factors contributing to the situation. To improve water quality of the rivers, it would be necessary not only to improve the quality of effluent from wastewater treatment works, but also the quality and quantity of stormwater. Furthermore, the loss of riparian vegetation reduces the ability of rivers to purify water through natural processes, which contributes to the overall problem. (Brown, Magoba; 2009; 102)

Various rivers within Cape Town are directly affected by effluent from wastewater treatment (WWT) works. The Kuils river receives effluent from the Bellville, Kuils River, Scottsdene, Zandvliet, Mfuleni and SA Infantry Battalion WWT works.

Other sources of faecal contamination, such as runoff from informal toilet areas, also affect many other rivers in the area. The discharge of treated effluent to vlei areas is also of environmental concern, since it usually results in the formation of permanent systems of the type unknown under natural conditions. (Brown, Magoba; 2009; 102)

In nature, water purification is brought about by biological processes, and minor pollution in a moving body of water is dealt with in this way. Wastewater received at a WWT works consists of faecal matter diluted by considerable quantities of kitchen water, bathwater and laundry water. Industrial effluent may also be part of the total load in works serving industrial areas. Pathogenic organisms, of which E. coli are the best known, are destroyed in the treatment process, solids are settled out in the form of sludge, and the remaining liquid effluent, after further modification, is discharged into a convenient watercourse.

In the normal course of business, the quality of the discharge from WWT works must meet certain basic standards before leaving the works. If met, these standards ensure that effluent is not dangerous to the health of humans and animals, but it may still contain significant quantities of soluble slats, mainly nitrates and phosphates.

Overloading and malfunctions occur, however, and incompletely treated or untreated effluent can and does get discharged into the rivers.

Urban stormwater is also discharged into rivers and canals. This may contain pathogens, oils, litter and other dirt. The quality is particularly bad after a long period of dry weather, when the first flash flood washes concentrated pollutants into the stormwater system. Occasional overflows from the foul sewers, also find their way into the stormwater reticulation. (Brown, Magoba; 2009; 103)

The Kuils River was historically seasonal, draining a vast area of sand dunes, and recharging the Cape Flats aquifer before ever reaching the sea. Draining a catchment of some 240 square kilometres, the river never reached the sea, but emptied into a system of pools, or 'kuils', which are now occupied by the township of Khayelitsha. (Brown, Magoba; 2009; 257)

The Kuils River in its original state flowed through a flattish sandy valley from its source until it reached the Cape Flats proper, where it meandered through a series of 'kuils'. As the demand for formal housing in Cape Town escalated in the early 1980's, the Kuils River valley was identified for low-cost development. The extensive townships of Mfuleni, Kleinvlei, Blue Downs and Delft were built on relatively high ground but inevitably some informal development sprang up in the floodplain. More significantly, the floodplain itself was widened considerably by the change in runoff that occurred as development hardened the surfaces in the upper catchment. New industrial areas were also established, while the growth in towns like Bellville, Brackenfell and Kuilsriver led to the construction of new and larger wastewater treatment works. As these new areas were built, the vastly increased runoff and the outflow from the wastewater treatment works added further to the problems of a stream that was never intended to be the important urban waterway it has become. (Brown, Magoba; 2009; 259)

A permanent connection to the Eerste River formed naturally to cater for the increased flow. Along this route, new wetlands were formed on what had previously been farming land, and new flood threats became apparent in the area known as Zandvliet. (Brown, Magoba; 2009; 259)

By the mid-1980's, the lack of capacity to drain floodwaters away as a result of development in the floodplain had reached a point when flooding became rife. The river regularly overtopped its banks in Kuilsriver and at several other points downstream. The new conditions imposed by the perennial link to the Eerste River resulted in periodic flooding of the Macassar-Zandvliet farming area, the long-established settlement around Sheik Yusuf's tomb, and parts of the newer housing estate of Macassar. Apparently the banks of the lower Eerste River were leveed to prevent back-flow from the Kuils River during periods of high runoff. This however, effectively cut off several of the riparian wetlands, further reducing the flood retention capacity and health of the system. (Brown, Magoba; 2009; 260)

The original Kuils River dune-slack wetlands system was covered with sand in 1988. The area of land now covered by Khayelitsha was once dotted with seasonal and perennial wetlands. Most of these were destroyed when the dunes were bulldozed into the wetlands and the area flattened. Pollution, mainly from large volumes of treated sewage effluent, and an elevated water table have fundamentally changed those wetlands that remained. In reality, the overall extent of the wetlands was little changed, as the water displaced by the infilling had to go somewhere. New, less diverse and less stable, wetlands formed in pockets around the Khayelitsha settlement, for instance, an extensive Typha-dominated reed bed was formed at the junction of the N2 and Baden Powell Drive, and, to this day, rising waters in winter plague the residents, adding to the harsh conditions in the squatter areas. Despite the altered status, these 'new' wetlands still have value as a habitat for aquatic animals, for water purification and for the recharge of the Cape Flats aquifer. (Brown, Magoba; 2009; 263)

Construction of the Driftsands detention Dam in the late 1980's reduced downstream flood peaks and initially saved lower Kuils River from environmentally unfriendly channelisation and canalisation. At first, the wetlands downstream expanded significantly. By about 2000 the encroachment of informal urban development at Mfuleni, Khayelitsha and Macassar into the river floodplain meant that these areas were subjected to increased channel 'maintenance' to prevent flooding of the shacks. The resultant excavation of the channel through the wetlands, combined with frequent burning and high grazing pressures induced large-scale channel erosion. As the bed level dropped in the channel, so the surrounding wetlands drained. Today, the wetlands are a fraction of their former extent. (Brown, Magoba; 2009; 263)

Figure 17: man-made infrastructure

(GIS mapping Dept UCT)

Man-made Infrastructure

Since 1994, the government of South Africa and its housing department has aimed to eliminate informal settlements. However, the housing department could not keep up with the high growth of informal settlements. As a result, local governments have been forced to address the urgent needs of these areas.

The City of Cape Town has undertaken an incremental upgrading plan with subsequent phases. The ESIS (Emergency Servicing of Informal Settlements) project is the first phase. This phase aims at delivering a basic level of services; i.e. water and sanitation on a shared basis, refuse removal, roads, drainage and area lighting. The objective of this phase is to effect an immediate improvement in the lives of citizens with the view to minimizing health and safety risks. The City of Cape Town has recordedvery significant progress and at the end of June 2004, had achieved basic service provision to over 90% of all accessible settlements (Graham; 2001). The subsequent phases entail incremental upgrading of services to national minimum norms and then to full services for those settlements located on land suitable for human habitation. (Drowley, Jember, Kassi & Smith: 2007; 10)

In December 2002 Council approved an integrated Informal Settlements upgrade programme .where infrastructure (predominantly water and sanitation) needs were provided.

A new programme was launched in 2005 to fast track infrastructure delivery to informal settlements

There is a new attitude towards the integration, use and reuse of infrastructure in the creation and sustaining of communities. Infrastructure is the framework that supports more transient and varied activity/ or grid that can be in-filled by social, environmental and economic activities. This is true on a literal level of providing the street and utility grid onto which individual houses or developments attach. Because the provision of basic infrastructure is a fundamental part of shaping a city's plan, to engage citizens of urbanizing settlements (eg. slums and new towns) with this process makes an important statement about their status as active members of the mainstream community, addressing the political and participative issues by proposing not only innovative designs but also new processes for involving the public, reversing in some cases the traditional power balance between deprived communities and the planning process.

This can be as simple as the approach taken in *Barter's Camp*, South Africa, a township where the process of normalizing the community by providing infrastructure took a very sensitive form. In deciding where the new streets should run, the planners walked the site, finding out from residents where the informally agreed boundaries with their neighbours were located, and drawing these on an aerial photograph. The planners then designed the pathways and pegged out the sites based on this working plan, allowing residents a few days to confirm that the pegs were correctly positioned. As a result existing social structures remained intact, contributing to the long-term social stability of the settlement. (Cumberlidge, Musgrave; 2007; 29)

The urbanization of river systems/ basins introduces many changes to the natural behaviour of the system. Roofs, pavements, and roads intercept rainfall and channel it into stormwater systems short-circuiting the natural seepage into the groundwater zone. Groundwater tables fall as a consequence. Stormwater discharges into river systems increase the volume and velocity of water flow causing an increase in bed-scouring and erosion, resulting in downstream siltation and flooding. Countermeasures to stabilise bed and banks often involve the introduction of concrete structures such as weirs and canals, which eventually kills the river biologically. The quality of the water that enters the river also tends to decline, is over enriched with nutrients (impurities are picked off from the road). This results in excessive aquatic plant growth. The decomposition of this mass often releases pungent odours and causes de-oxygenation of the water resulting in the death of aquatic animal life. (Louw, Gasson; 1991; 25)

The solution to these problems lies in stormwater management. This implies the attempt to reduce run-off volumes and velocities by retaining vegetation cover, and by returning stormwater to the groundwater zone from where it can seep slowly into the watercourses. The seepage process is also a self-cleansing one so that the problem of pollution and nutrient enrichment can be reduced. With less erosion and flooding there is less need to canalise the stream or introduce artificial structures. (Louw, Gasson; 1991; 25)

It is thus possible to purify storm water by means of combining natural and chemical processes to supply areas adjacent to the river with potable water for domestic use.

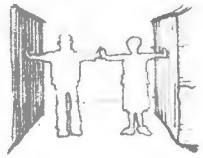


Figure 18: 'blocking' after fire

(Fig 1: www.sdinet.co.za)

The ultimate goal in storm water management in Cape Town to date has been flood prevention. A more ecologically friendly way is the so-called Sustainable Urban Drainage System (SUDS). Termed by the British and now widely used, this system is concerned with protecting, enhancing and replenishing groundwater as well as flood prevention. There are many ways of storm water control practices, some of which naturally reduce pollution before replenishing groundwater.

Stormwater should first flow into a fore-bay. A sediment fore-bay is a small pool (typically about 10% of the volume of the permanent pool). Coarse particles remain trapped in the fore-bay, and maintenance is performed on this smaller pool, eliminating the need to dredge or clean out sediments from the entire wetland. From here it enters the main wetland cell where aquatic plants break down organic pollutants (oils and grease) and use metals and minerals as nutrients for growth. Wetlands also significantly reduce Nitrogen and Phosphorous present in stormwater. Different depths in the main wetland cell are recommended as it promotes plant diversity. In addition, an emergency spillway should be provided to safely convey large flood events. Wetlands should have direct maintenance access to the fore-bay, to allow for relatively routine (five to seven year) sediment cleanouts.

Flood attenuation in highly developed areas, where many of the wetlands and river corridors have already been lost, requires more innovative solutions and more understanding and cooperation from the residents. (Brown, Magoba; 2009; 331)

Kathy Sales, an independent consultant and researcher, says that at the moment we are barely exploring the range of options and alternatives available and basically waiting for the money to be found to continue with business as usual, building high-end infrastructure to link into big bulk schemes, which all needs more money and technical skills than we has available. She also goes on to state that we are not doing enough to explore simpler, more robust technologies, which deliver good wastewater-management solutions, don't need scarce expertise and have a far lower risk of failure. We also should be exploring incremental improvements, starting with the small and moving up from there.

The above sentiment is echoed by Kevin Winter, lecturer and lead researcher in Integrated Urban Water Management at the University of Cape Town. Winter states that the result is that conditions on the ground stay the same while trust between residents and the local authorities continue to deteriorate. He also goes on to say that effective change usually begins with the actors at the level most affected by living circumstances. Success at this level is often recognised when these actors work within a social structure, are prepared to serve in a democratic process, and to persist towards achieving shared or common goals. Winter's research group is dedicated to integrated urban water management and is involved in studying the potential to enlist community-based solutions that focuses attention on understanding the social behaviour and capacity to install low-cost, interim technologies in order to manage grey water problems.

Sales says one can start off with managing run-off by introducing simple channels to lead the water away from places where people live and walk. In settlements that can be upgraded where they are, surely there is more scope for decentralised systems. Sales also states that we focus almost exclusively on big centralized networks but that sometimes it makes sense to explore smaller, self-contained systems that don't need to wait for big costly bulk connections that link into big treatment works that are already over capacity. (Gullion: 2009: 26)

According to Jo Burgess, research manager at the Water Research Commission, one can't easily apply international solutions to grey water treatment in South Africa, such as separating the kitchen water, laundry water and the bath water. Her research has shown that a lot of informal households use water for washing food, then clothes, then people and then the floor, and that by the time it's gone through this process it isn't grey water anymore. Burgess feels strongly that international solutions won't do the trick and that we need to develop a home-grown solution. (Gullion: 2009: 27)

Jay Bhagwan, director of the Water Research Commission states that even though sanitation policy recognises drainage and grey water as part of improved sanitation, the roll-out is just about taps and toilets and that in the context of informal settlements, very little thinking goes into drainage. As the density of the settlements increase, so does the problem of grey water disposal. (Gullion: 2009: 28)

Case study: Slum Networking, India

Slum Networking in India (1987-ongoing) demonstrates how an innovative approach to aspects of development as basic and mundane as sewerage, water supplies and roads can have a major impact on the social and physical renewal of a city. The thinking and approach of this project has huge relevance not only for developing nations but also for Western cities facing problems of infrastructure. (Cumberlidge, Musgrave; 2007; 62)

The Slum Networking concept is based on three principles. The first is that cities have natural drainage patterns and that these can be used as the basis for man-made infrastructure, obviating the need for artificial pumping and deep excavation. Secondly, it treats the slum dwellers as equal to other citizens thereby assimilating the slum dwellers into the mainstream, demanding a financial contribution from them, ensuring that the projects truly meet their needs and that they put pressure, as stakeholders, on the authorities to maintain the system. The third principle is that providing a new physical infrastructure can be a tactic to catalyse wider social and economic change. (Cumberlidge, Musgrave; 2007: 62)

Slum Networking has been developed by the engineer Himanshu Parikh over the last twenty years. It originates from his work in the city of Indore and has been refined and developed since into a sophisticated and sensitive method that is currently being used in cities and villages across India. The projects that have been completed to date have assimilated over one million slum dwellers as full and active citizens and made their slums indistinguishable from normal neighbourhoods. Parikh's design method works with the natural landscape and pattern of development, using the links between topography and the location of drainage channels, slums and public open spaces to create an organic and sustainable framework to support the city.

His observations of the formation of slums and low-income areas revealed that they almost always form near the lowest points of the city, where natural drainage channels occur. By routing new sewerage and water lines just below ground level along these natural paths, they work by gravity rather than requiring pumping stations, as in most western cities. (Cumberlidge, Musgrave: 2007; 64)

By not requiring deep excavation, costs are minimized and the system is easier to maintain. The model also uses a simple but radical design for the new street paving that enables storm water to drain directly into existing waterways rather than into the sewers, conserving water and preventing the sewers overflowing. In almost all cases, careful surveying and subtle re-grading of existing paths and dirt roads means that new routes do not have to be cut through. (Cumberlidge, Musgrave; 2007; 64)

Each family's plot gains a well-built toilet of the same standard as 'normal' houses. Further building works to upgrade the home are undertaken at the households expense. The paved roads are easy to clean and at Monsoon time drain storm water naturally, with the homes raised above the street to prevent flooding. Running water is connected to each house, enabling hygienic cooking and washing with research showing huge improvements in health, leading to better access to education and work.

The concept has also reversed any perception of slums as sapping resources from the city. Indian cities generally have inadequate infrastructure for the city as a whole: sometimes less than five percent of an urban area may have functioning sewerage lines. By over sizing the new drainage lines, it was possible to make the networked 'slum' areas the foundation for providing wealthier areas with functioning infrastructure. (Cumberlidge, Musgrave; 2007; 66)

The development of the Slum Networking approach has shown that although slum dwellers may live in poverty, they can find financial resources and become active financial partners if given the opportunity.

The effects of this radical and equitable approach to the renewal of severely under privileged communities have been extraordinary. Studies showed that after an initial investment of 4000 rupees for the infrastructure installation, each household spent an average of 60 000 rupees on rebuilding their home in a permanent and secure form. Health, education and incomes have improved at faster rates than other programmes targeted at these areas. (Cumberlidge, Musgrave; 2007; 66)

The slum networking process indirectly achieves many other goals. It impacts on the land rights of the slum dwellers as the municipality must codify their legal status before providing infrastructure for these areas. By stopping waste being discharged into the watercourses, it has been possible to make these areas into valuable public green spaces and freshwater reservoirs, as well as uncovering important monuments that historically tended to cluster along watercourses. It also makes slum dwellers into taxpayers for the first time by formally acknowledging them as legal residents, as well as participants in the banking system, radically changing their ability to manage and save money. (Cumberlidge, Musgrave; 2007: 66)

'Small change'

Informal settlements have been recognised as components of the urban landscape in most developing countries for the last fifty years and are characterised by:

1. Lack of basic services
2. Inadequate building structures
3. Overcrowding
4. Unhealthy and hazardous conditions
5. Insecure tenure
6. Poverty and exclusion(UN-Habitat 2005)

How does one accommodate the informal? This thesis will explore this topic by looking at the writing of Dave Dewar and Nabeel Hamdi in order to gain an understanding of the inherent challenges and opportunities that accompany working within/ with the informal. Building on the collective wisdom of people becomes of paramount importance. Hamdi speaks of 'making the ordinary special' and sates that citizenship becomes crucial.

A policy which rewards people, who fail to manage their risk, fosters an environment in which people are either unwilling or unable to manage their risk. The focus of any response should therefore be to communicate and participate with the community, to build understanding around their risks and vulnerabilities, as well as to generate a culture of accountability within the settlement. (Napier, 2002)

The approach to housing delivery thus far has been predominantly about quantity and not quality and focused on delivering specific amounts of houses and not the upgrading of their surrounding environments which should be of greater importance.

Dave Dewar argues that housing does not simply relate to just providing shelter, but that dwelling space should have access to a number of different products which contribute to an improved quality of life. These products are related to the:

-Quality of site

-land- Security of tenure or its lack has a profound impact on satisfaction, psychological health and the degree to which land and housing can be used as an economic asset. (Dewar: 2002: 8)
-Location – access to economic, social, commercial, cultural and recreational opportunity. These significantly impact on cost of living.
-utility services
-Shelter – ventilation, space, safety, privacy, space for positive social interaction.
-Access to an external social and physical environment of high environmental quality. (Dewar; 1997; 25)

From an environmental perspective, the central issue is the quality of the public environment, defined in terms of the quality of social institutions and public space. For the urban poor, who lack adequate personal resources, these external environmental factors are critical in determining their quality of life and in promoting dignity. By definition, the poor are unable to carry out the full range of household activities within private space. In these conditions, the public space operates as urban rooms, accommodating a range of social experiences. In effect, these spaces operate as extensions to the private dwelling units. When these spaces are properly made, the entire environment is dignified, regardless of the quality of the individual units. (Dewar: 2002: 9)

Despite the seriousness of intent to reduce housing backlogs and to tackle the housing problem, severe criticisms have been levelled at housing policy and, particularly, the major emphasis placed on the capital subsidy system. These include:

Local government is increasingly acting as a producer of housing, a somewhat curious reversion to a modified welfare-position. However, most of the subsidy goes towards the provision of serviced land. This leaves very little for the top-structure. In the face of this, the subsidy has a two-edged effect. On the one hand, it fuels a culture of entitlement, which works against self-help practices- a situation which is exacerbated by a lack of institutional support for aided self-help. On the other, there is widespread dissatisfaction with the size and quality of shelter which can be provided. The danger of a culture of entitlement has not escaped the government. (Dewar: 2002: 14)

'Slum Networking demonstrates that the design of infrastructure should be given the same level of attention and innovation as architectural design'

Slum Networking demonstrates that the design of infrastructure should be given the same level of attention and innovation as architectural design. Infrastructure is a common good that is provided to all regardless of income and has a major part to play in ensuring quality of life and communal pride. Too frequently the design of infrastructure discriminates between the well-off and the disadvantaged through quality of service, maintenance and the location of disruptive major works. Slum Networking's participatory approach to the community as stakeholders, its technical innovation and its locally tailored design are exemplary. (Cumberlidge, Musgrave; 2007; 66)

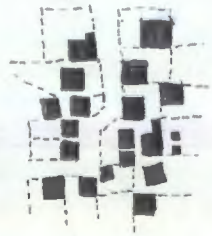
Another example of slum upgrading is found in East Wahdat in Jordan. The New buildings were built on the same sites as the original shacks, ensuring residents did not have to move from their plot as part of a process of legalizing tenure. (Cumberlidge, Musgrave; 2007; 28) In East Wahdat in Jordan, the provision of core service units as the first stage in normalizing a slum community was the first step in providing legal tenure for the residents and gaining recognition as citizens with normal rights. The provision of accessible green spaces has become recognised as a key part of the urban infrastructure.

India also suffers from the legacy of Master plans approaches which have produced spatially unequal and fragmented, segregated cities. India has also experienced the phenomena of slum dwellers who are pushed out from the metropolitan areas as was the case with New Delhi in 1977 where slum dwellers were moved to the unserviced periphery to make way for new infrastructural developments.

The Jawaharlal Nehra National Urban Renewal Programme argues that for cities to realise their full potential and to become effective engines of growth it is necessary that focussed attention be given to the improvement of infrastructure. They have also developed a methodology of 'place neutral language' where the aim is to encourage reforms and fast track planned development of identified cities. The focus is also to be on efficiency in urban infrastructure and service delivery mechanisms, community participation and accountability of ULB's/ parastatal agencies towards citizens.

Figure 19: Slum Networking, India

(Cumberlidge, Musgrave; 2007)



One consequence of this system, was that policy was taking energy out of the housing system as households were sitting back waiting for government to act as opposed to taking responsibility to meet their own shelter requirements. This highlighted the somewhat crazy two-fold position of the state towards the housing policy. On the one hand, in terms of macro-policy rhetoric, the state argued that its role was as a facilitator of housing. On the other, in terms of micro-rhetoric and by actions, it was acting as a supplier of housing. (Dewar: 2002: 15)

The current system entrenches the model of the single housé on the individual plot which, resulting in sprawl, despite the requirements of the Development facilitation Act which calls for more compact and integrated settlements. It is almost impossible to produce walk-up forms of housing under the subsidy system. Further, because of the significance of the price of land in the housing equation, most new development is directed towards cheaper land on the urban periphery, and since the majority of poor households are black, the unsustainable inefficient and inequitable spatial patterns of apartheid are being reinforced and entrenched. (Dewar: 2002: 16)

It can be concluded that it is highly likely that informal settlements will remain a factor of South African life for the foreseeable future. (Dewar: 2002: 19) Politically there is an explicit acceptance of informal housing as a legitimate housing form. Legislatively, the Prevention of Illegal Eviction From and Unlawful Occupation of Land Act (Act 19 of 1998) provides protection from involuntary evictions for all households, regardless of legal forms of tenure or the permanence of structures.

Developmentally, the principal of in-situ upgrading has long been accepted and there are numerous cases of this in the country. There is also considerable conceptual and practical understanding about how upgrading projects of this kind should be approached.

However, there are a number of inherent problems associated with upgrading schemes of this kind:

Firstly, they are essentially reactive: they are public responses to existing settlement patterns. For this reason these settlements often exacerbate problems of spatial fragmentation, inefficiency and inconvenience. Frequently the natural conditions of the sites render them unsuitable for housing purposes. In Cape Town, flooding during winter is common in many of the informal settlements, because of the very high water table. Secondly, in-situ upgrading is a difficult, time-consuming task requiring extensive negotiations with communities. Thirdly, because of the essential participatory processes, the approach is often expensive and energy-sapping. Finally, as Wits-academic Huchzermeyer recognises, all too often understanding of implementation processes has been biased towards the realities of project managers and implementers, rather than towards experiences of organized informal settlement communities. (Dewar: 2002: 20)

An option which has seldom been considered in South Africa is reversing the mindset and working proactively with informal settlement formation processes.

One event which supports this idea is the Grootboom Case. In 1998 a group of informal dweller were evicted from land, and subsequently took the authorities to court, demanding that authorities provide them with acceptable levels of housing and services. The grounds of the demand related to children's constitutional rights to housing. The authorities appealed to the Constitutional Court, which upheld the High Court Hearing which found in favour of the applicants. They ruled that the right of children to housing was an absolute right but that children also had the right to family life. Accordingly, public authorities had the responsibility to assist families with housing until the parents could provide their children with shelter. Materially it required that the authorities should provide 20 communal toilets, 20 communal taps and a sum of money to enable the households to buy materials to waterproof their shacks. (Dewar: 2002: 20)

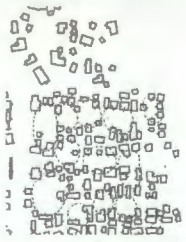
The ruling had two important implications. It emphasized the fact that the innovative socio-economic rights created by the South African Constitution are enforceable by law. It also meant that every local authority should make provision for some form of emergency housing and services which will be at a lower level than that provided through the mainstream housing subsidy system. (Dewar: 2002: 21)

What spatial elements should be publicly provided in informal settlements and what can be best left for people to do themselves?

-Utility services only?
-Full range of elements of public infrastructure
-or a combination of both?

Figure 20: Slum Networking, India
(Cumberlidge, Musgrave; 2007)

Figure 21: Slum Networking, India
(Cumberlidge, Musgrave; 2007)



Dewar puts forward a position which argues that informal settlements cannot be regarded as temporary. History shows that in developing countries, once settlement takes root for any period of time, it effectively becomes permanent (largely because of the risk of growth which soon makes the option of relocation logistically almost impossible). Similarly, the history of the developed world shows that, even in materially advantaged situations, it may take well over a hundred years for informal housing to become formalised, often within the spatial footprint of the original informal settlement. With this in mind, it is sensible to accept informal settlements as a part of the normal, everyday fabric of cities and to accept that the long-term quality of emerging settlements is a central contemporary planning issue. (Dewar: 2002: 25)

Dewar also states that there has been almost no work on the spatial organisation of informal settlements, the processes which underpin those organisational patterns and the implications of these for policy and practice. (Dewar: 2002: 27)

Dewar reaffirms that people are capable of organising land occupation and habitation in a highly efficient manner. All the settlements examined in the case studies by Dewar in '*Accommodating the Informal*' reflect considerable logic and rationality in terms of their organization and according to Dewar four preconditions need to exist for efficiency to be achieved:

The first is acceptance of the fact that people in similar circumstances have equal rights of access to land

The second is that decisions relating to the collective or communal good must take preference over individual self-interest. This was illustrated in all the cases, for example, around the issue of access

The third precondition is that people who benefit from a decision should be responsible for its implementation. A somewhat counter-initiative finding of the study is, in the creation of all the settlements, there was very little collective action.

The fourth precondition is that the amount of land allocated should be related to need (the size of the household, the intention to grow vegetable or keep livestock, the intention to run a spaza shop etc), and not greed. This was also evident in the case studies.

All of the communities reflected a strong sense of community. This spirit is a direct consequence of the processes of settlement formation. Regular public meetings were an integral part of community life. Similarly, the placement of units on the site required discussions and negotiations with neighbours over issues such as air, light, privacy, keeping of pets and livestock etc. Spatial structure also played a significant role in promoting community spirit. Many household activities such as laundry and cooking were commonly conducted in the interstitial spaces, public or private, between neighbours and frequently became communal events. (Dewar: 2002: 98)

All the settlements reflected high and fairly sophisticated levels of social organization. It was also observed that social organizations emerged as a by-product of people getting to know and trust each other through the process of settlement-formation.

In all cases, a very complex system of interstitial spaces between units had developed. The spatial pattern which emerged is far more complex than that which can be designed as seen in the figure on the left of Delft. (Dewar: 2002: 99)

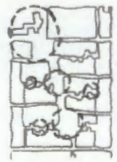
A need for higher order public spaces is evident in all of the settlements studied. The daily functioning of the settlements clearly demonstrates the need for these spaces, for example as gathering or meeting spaces, spaces acting as fire breaks, the need to accommodate livestock, the need for productive spaces, and social spaces to which people can retreat in order to socialise or simply to escape the intensity of daily living at high densities.

A strong legible main circulation system, which opens up all parts of the site to vehicular traffic is also important. In all cases where the main circulation routes were in place prior to occupation, there have been clear and predictable land use responses to them. (Dewar: 2002: 99)

The provision of utility services is of paramount importance in ensuring adequate levels of public health and comfort. The inadequate provision of potable water and sewage disposal, in particular, carries the risk of outbreaks of serious and life-threatening diseases. The frequency of the provision of these services also significantly affects activity patterns and convenience. The distribution of water outlets determines who gets involved in the activity. These water points often become significant gathering or social places. Dewar argues

Figure 23: Slum Networking, India
(Cumberlidge, Musgrave; 2007)

Figure 22: Slum Networking, India
(Cumberlidge, Musgrave; 2007)



for the introduction of bath houses, which double as collective laundry points, as a basic form of infrastructure in informal settlements. (Dewar: 2002: 102)

According to Dewar minimal levels of infrastructure in informal settlements should include:

- Hardened or surfaced main circulation routes
- Larger public spaces
- Collective water points
- Collective toilets
- Bathhouses/ laundries
- Refuse tips at centralized pick-up points

The problem of informal settlements will not disappear within the foreseeable future, because for many households informal settlements represent the cheapest, and often the only and also the best form of entry into the housing market.

Getting ahead of the problem implies accepting informal settlements as one form of mainstream housing delivery, ensuring their rational location, and publicly providing those amenities which do not necessarily result adequately through processes of informal settlement formation. (Dewar: 2002: 105)

There is an emergence of a responsive system of small-scale open spaces which promote social interaction. The open space system is of the utmost importance in determining the quality of life lived in these settlements. A defining characteristic of poverty is that enclosed private dwelling space is small as households cannot carry out all, or even the majority, of household activities within them. Because of this, outdoor spaces associated with the unit, whether public or private, are of paramount importance and are also the primary form of social infrastructure. In informal settlements these spaces are highly responsive to need precisely because they are carefully considered and negotiated by all the households with an interest in the space. (Dewar: 2002: 106)

'It is vital to adopt a spatial, and not merely a functional engineering approach, to the making of these settlements'
- Dave Dewar (Dewar: 2002: 107)

There should be a number of utility services. A network of bulk services (potable water, sewage disposal, electricity, storm water disposal) associated with the major movement spaces should link the higher order spaces, enabling public facilities as well as commercial and small-scale manufacturing activities. A system of bath houses/ collective laundries should be introduced and associated with public spaces and should be made up as pleasant meeting places. Collective public water points should be provided. As a guideline no household should be further than 60 metres from a tap. Collective toilets should also be provided, associated with the taps. (Dewar: 2002: 110)

Incremental growth

Urban settlements are seldom instantly created events: they are continually in the process of becoming and growing. Public structure is central in giving direction to these processes.

The figures on the left represent a conceptual proposal to upgrade the informal section of the settlement of Kliptown in Gauteng. The approach illustrates this principle of creating a system of multi-functional public spaces which give dignity to the settlements as a whole and which accommodate those social and functional needs that cannot be met within the unit or its adjacent spaces. An additional key factor in upgrading is ensuring that those households which are displaced in the public interest be relocated as close as possible to their original site of settlement. (Dewar: 2002: 115)

Case Study: Buenos Aires, Argentina (Pearce; 2007; 86, 87)

Buenos Aires, the capital of Argentina, is one of Latin America's richest and most Europeanized cities, with plenty of upmarket neighbourhoods that would not disgrace Madrid of Milan. But there has always been another side to the city: its poor and crime-ridden shanty towns, or barrios. One of the most notorious has been behind the railway station in the inner city suburb of Retiro. Here, within sight of Buenos Aires, live the city's underclass-the waiters, dog-walkers and production line workers who serve the rich of the city. (Pearce; 2007; 86)

It was only in the 1990's that paved streets and basic services such as regular electricity and clean water arrived behind the railway station. But with the arrival of those services the barrios' residents began to construct a better community. Self-help became the order of the day. Twenty years after the previous photo was taken, photographer Mark Edwards returned to the same spot and found that the new residents were replacing the thin plywood and corrugated iron shacks with a new home of bricks and concrete. An example of development as seen from the ground up. (Pearce; 2007; 87)

Figure 25: Buenos Aires, Inner City

(Pearce; 2007; 87)

Figure 24: Buenos Aires, Inner City

(Pearce; 2007; 87)

Development happens when people, however poor in money, get together, get organised, become sophisticated and go out to scale. (Hamdi: 2004: xvi) Development is the stage you reach when you are secure enough in yourself, individually or collectively, to become interdependent, when 'I' can emerge as 'we' and also when 'we' is inclusive of them. Getting organized is the foundation of all the other developmental goals, the essence of good governance and of sustainable work. It empowers and opens doors.

The point that scientists and Georg Simmel, a contemporary sociologist, is making is that organic systems, in nature and in society, exhibit patterns-recognised in informal cities all over, where problems are solved by drawing on a variety of information from the multitude of small relatively simple and local elements, rather than from some power elite or single brain. There was no prior planning, but there was an effective system of communication that enabled the individuals to act spontaneously and to self-organize in response to need from the bottom up. (Hamdi: 2004: xvii)

Development and emergence differ in at least two significant respects. Firstly development needs designed structures with rules and routines that provide continuity and stability and that offer a shared context of meaning and a shared sense of purpose and justice. The question facing practice, according to Hamdi, is how much structure will be needed before structure itself inhibits personal freedom and gets in the way of process and destroys the very system which it is designed to serve, and becomes self-serving? At what point does it disable the natural process of emergence? According to Capra's *Hidden Connections*, as quoted by Hamdi, skilful practitioners understand the interdependence between design and emergence. They know that in today's turbulent environment, the challenge is to find the right balance between the creativity of emergence and the stability of design. (Hamdi: 2004: xviii)

There is a simple yet challenging premise: intelligent practice builds on the collective wisdom of people and organizations on the ground, those who think locally and act locally, which is then rationalized in ways that make a difference globally. In the language of emergence, it's better to build a densely interconnected system with simple elements and let the more sophisticated behaviour trickle up, as promoted by Johnson in Emergence: the Connected Lives of Ants, Brains, Cities and Software. (Hamdi: 2004: xviii) In this respect, good development practice facilitates emergence, building with what we've got.

Hamdi goes on to say that in order to do something big, one should start with something small and start where it counts. It is about getting it right now and at the same time being tactical and strategic about later. It is not about forecasting, nor about making decisions about the future, but it is about the long range, about being politically connected and grounded and about disturbing the order of things in the interest of change. (Hamdi: 2004: xix)

Emergence and going to scale are complimentary processes, practice is a catalyst to both. (Hamdi: 2004: xix) The philosophy of acting in order to induce others to act, of offering impulses rather than instructions and of cultivating an environment for change from within, starts on the ground and often with small beginnings which have 'emergent' potential. (Hamdi: 2004: xix)

Hamdi states that problem-seeking and problem-solving in these settings demand that we think associatively and holistically. It is here that imagination is as important as knowledge or skill when deciding on professional intervention. Working in the slums of any major city takes imagination to plant the seed of the idea of community around water points, and to craft these creatively, with reason, as centres of community life. It takes imagination to see a standpipe with its intermittent supply of water as a means of generating income, and it takes further imagination, combined with reason, to convince the municipal authorities to seek new partnerships with this. Hamdi goes on to state that in time, we might encourage a new horizontal structure of water management networks which become an integral part of the way cities manage their supply, a new institutional arrangement which everyone recognises as useful and profitable. (Hamdi: 2004: xxi)

In all these ways we recognise in practice the important relationship between top-down planning, with its formal and designed laws and structures, and bottom-up self-organizing collectivism. (Hamdi: 2004: xxii)

In *Small Change* one sees how small beginnings can be carefully crafted into larger programmes, and how emergence can be encouraged and structures designed within the informal. (Hamdi: 2004: xxiii)

Hamdi also states that one can see how practice and practitioners using the power of their authority to empower others, can nurture this process, or sometimes how they can disable it. He also shows how skilful practice can trigger the emergence of novelty and organization; how it can help build an architecture of opportunity for rediscovering community, building networks and stronger organizations, and making money-for communication

and for new partnerships to be explored. In so doing, we enable people to find new ways of doing, thinking and relating in response to everyday problems which one takes for granted. (Hamdi: 2004: xxiv)

Hamdi also argues that mistrust, defensiveness, jargon, abstraction and intellectual competitiveness still dominate academia and that the advancement of belief systems takes precedence over critical thinking. Knowledge is valued more than experience or understanding. Rationality and factual evidence are more rewarded than creativity because they are easier to measure. All these things, according to Hamdi, are anti developmental. (Hamdi: 2004: xxv)

The flood disasters occurring in 2000/ 2001 in Mozambique highlighted the convergence of vulnerable human settlements and natural hazards, creating thousands of homeless and displaced people. Until now, the response has been almost completely reactionary. National and international funded emergency relief is still the predominant reaction to the flooding problems, which is addressing the symptoms and ignoring the causes (Moreno; 2001; 2)

As mentioned earlier, the long-term option taken by the government was to resettle the endangered population, creating unsustainable living conditions in the new areas. In collaboration with MICOA, UN-Habitat conceived an alternative strategy of considering the possibility of living in flood-prone areas and learning how to cope with the risk as this happens in other poor countries with similar characteristics. An example of this is Bangladesh, which borders the Ganges river delta which gets flooded twice a year. The 2000 floods were an exceptional event with an estimated return period of 500 years. Hence, preparedness and mitigation techniques could minimize the negative impacts of moderate flooding on human settlements, avoiding resettlement. (Wamsler; 2006; 109)

Different slum upgrading activities were encouraged, like improving drainage and road conditions, facilitating access to drinking water, maintaining proper sanitation, efficient waste management etc as concrete solutions for reducing the vulnerabilities of floods. Project experiences and consultations concerning slum areas confirmed that the following issues were top priorities in the agenda of most Mozambican Municipalities: poor drainage efficiency; difficult access to safe drinking water; lack of sanitation facilities; inadequate road network and an inefficient waste management.

This positive experience has reinforced the community's will to contribute to improving the living conditions of their own neighbourhoods. Similar to other community-based experiences described by Hamdi, dwellers were enthusiastic about the results obtained, especially because they selected the priority intervention themselves and then executed it. This served to develop a powerful awareness campaign in the neighbourhood for maintaining proper conditions of the drainage systems and access roads. (Wamsler; 2006; 114)

While still supporting policy making at the central level and developing capacity building activities, UN Habitat's intention in Mozambique is to focus on integrated and participatory slum upgrading activities at the local level. The latter represents an adequate solution for reducing vulnerability.

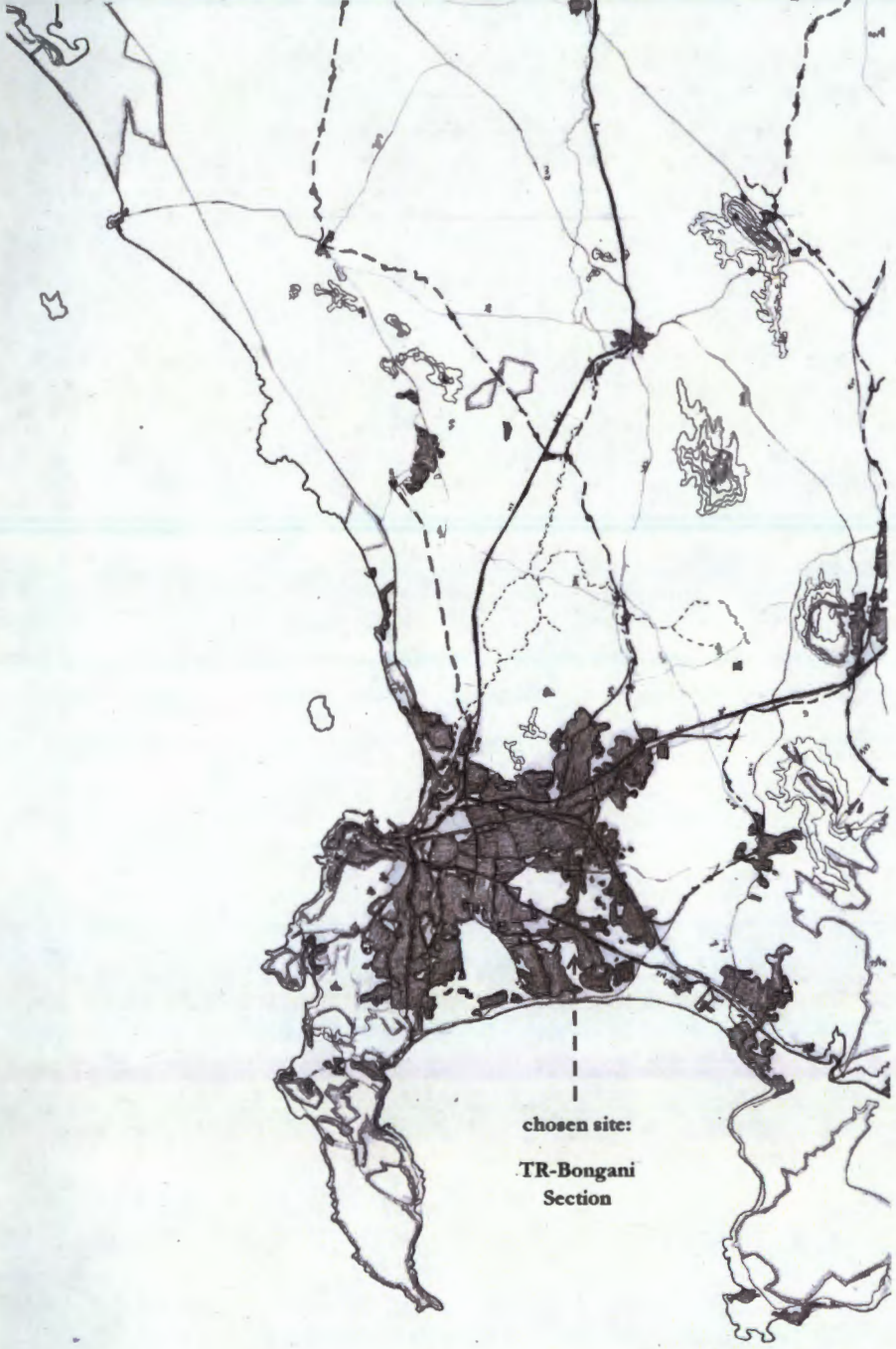


Figure 26: The Cape Metropolitan Area

Showing built infrastructure vs open space

Siting:

high risk areas

(City of Cape Town Informal Settlements flood risk rating survey)

1. Kosovo
   Location: Philippi/ Weltevreden Valley
   no. of dwellings: 4592

2. Bongani TR Section
   Location:Khayelitsha
   no. of dwellings: 2358

3. Barney Molokwana Corner
   Location:Khayelitsha
   no. of dwellings: 4720

4. Masiphumelele Wetlands
   Location:Noordhoek
   no. of dwellings: 1157

5. CT Section
   Location:Khayelitsha
   no. of dwellings: 1416

6. Lotus Park
   Location:Gugulethu
   no. of dwellings: 875

7. Sweet Home
   Location: Philippi
   no. of dwellings: 2217

8. Doornbach
   Location: Table View
   no. of dwellings: 2800

9. Pholile
   Location: Strand
   no. of dwellings: 1250

10. Gqobasi
    Location:Nyanga
    no. of dwellings: 188

11. Kanana
    Location: Gugulethu
    no. of dwellings: 3962

12. QQ Section
    Location:Khayelitsha
    no. of dwellings: 1364

Finding Site

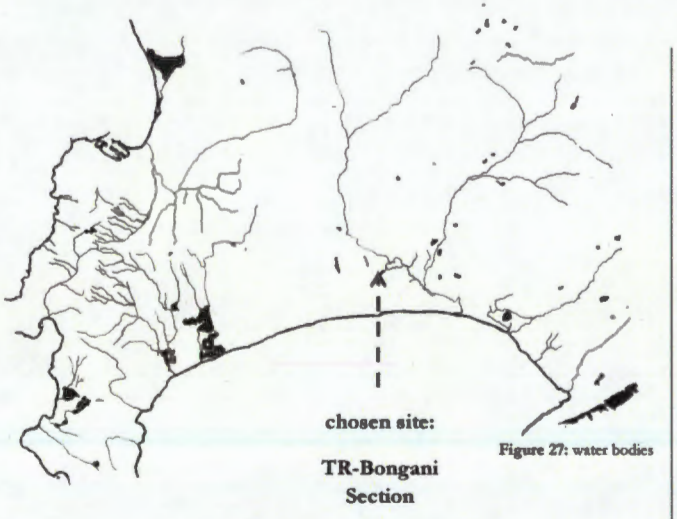


Figure 27: water bodies

Figure 28: built infrastructure

Figure 29: Khayelitsha: flooded areas

Figure 30: Khayelitsha: informal areas

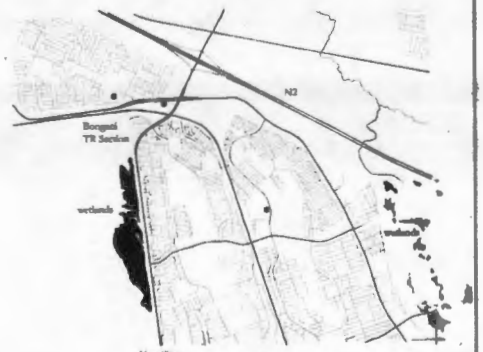


Figure 31: Khayelitsha: water bodies & infrastructure

Locating Site

The drawings on the left were done to identify various flood-prone areas in Khayelitsha before I chose TR-Bongani Section as a site for this thesis investigation

This mapping exercise revealed the interesting site and location of TR-Bongani Section and highlighted its exciting potential.

Figure 32: areas of flooding

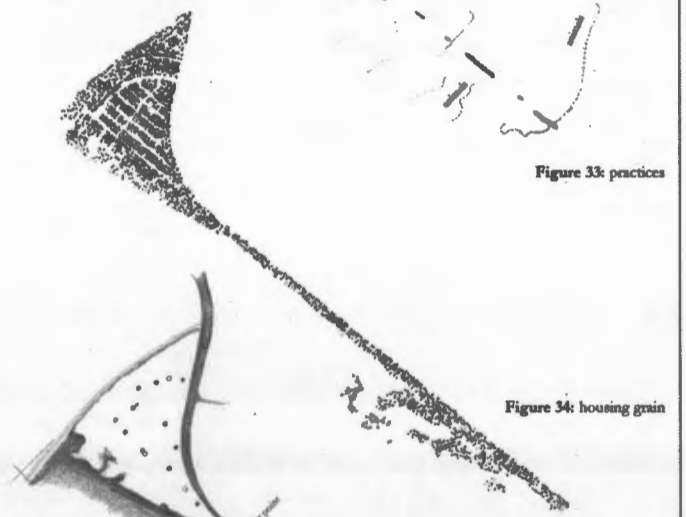


Figure 33: practices

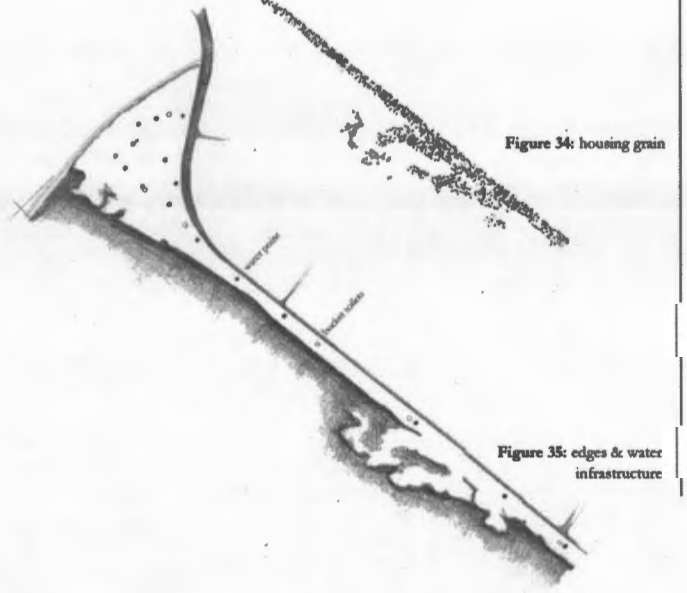


Figure 34: housing grain

Figure 35: edges & water infrastructure

Site layers

After various mapping exercises I extracted the different 'layers' that make up TR-Bongani Section to get an understanding of its different parts and the nature of its edge-like conditions.

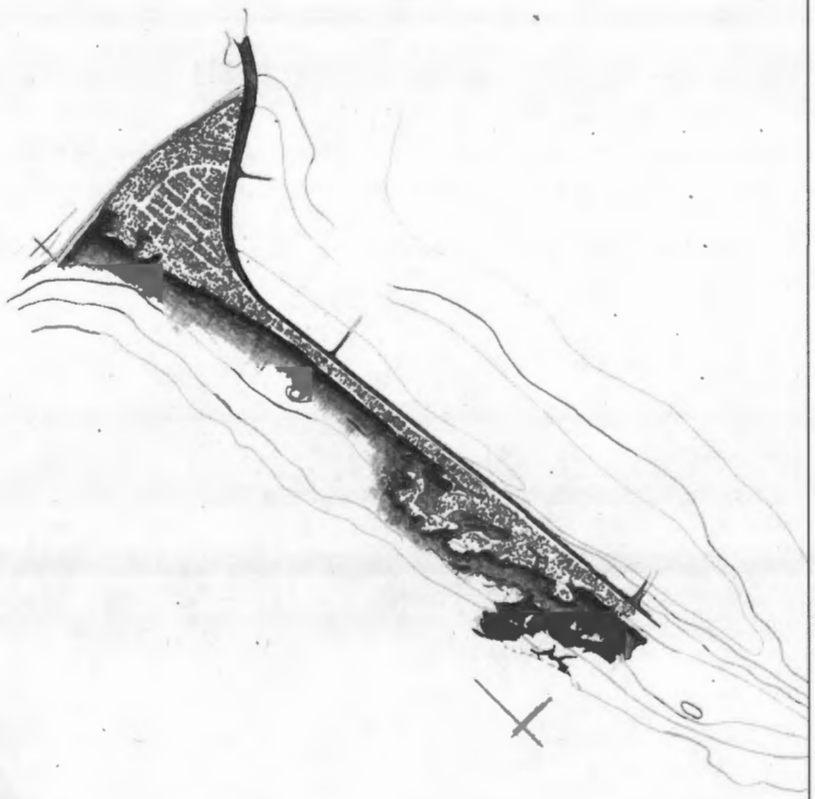


Figure 36: TR-Bongani Section

Figure 37: TR-Bongani Section:

No drainage

Changing perceptions

This chapter investigates changing disaster mitigation strategies/ theories to gain an understanding of the various measures and ideas already in use. A quick look at UN legislation is of critical importance here. Hazards and disasters in African cities, the processes that expose people to hazards and approaches to urban safety will be touched on. By looking at examples from urban Africa options for disaster risk reduction and techniques for urban disaster risk reduction will also be uncovered. The research and Critical Risk Assessments (CRA's) done by UCT' Disaster Mitigation for Sustainable Livelihoods Programme (DiMP) will be discussed and its relevance to my project will also be explained.

Disaster risk reduction is still a relatively new area of knowledge and is slowly developing and undergoing a multifaceted process of institutionalization, especially within the professional discipline and disaster discourse has changed significantly over the last decade. (Wamsler; 2006; 4)

However, while the discourses about disasters seem to have changed, the practical reality and the response of officials and civic organizations too often remains the same, sporadic, passive and reactive. In the shadow of the Asian tsunami in 2004, the United Nations hosted the World Conference on Disaster Reduction in Kobe Hyogo, Japan. The resulting and approved 'Framework for Action' aimed at reducing the human, socio-economic and environmental disaster losses considerably by the year 2015, and urged that the issue of disaster risk in urban panning be addressed by requesting governments to:

'Mainstream disaster risk considerations into planning procedures for major infrastructure projects, including the criteria for design, approval and implementation of such projects and considerations based on social, economic and environmental impact assessments. To develop, upgrade and encourage the use of guidelines and monitoring tools for the reduction of disaster risk in the context of land-use policy and planning. To encourage the revision of existing, or the development of new building codes, standards, rehabilitation and reconstruction practices at the national or local levels.....particularly in informal and marginal human settlements,'..... (Wamsler; 2006; 5)

During the WCDR, developments and changes in risk reduction were showcased. While discussions about risk reduction originated in the context of post-disaster recovery, natural disasters are increasingly recognized as a threat to sustainable development and poverty alleviation. Therefore the issue of mainstreaming risk reduction in the field of development has gained increased importance. (Wamsler; 2006; 5)

During recent years, attention has been increasingly given to the need to mainstream risk reduction in development work in order to reduce the vulnerabilities of poor communities (e.g. UNDP, 2004; UNISDR, 2004). The millennium declaration points towards this need by aiming to achieve a significant improvement in the quality of the lives of slum dwellers. (Wamsler; 2006; 72)

Two of the outcomes of the Second United Nations Conference on Human Settlements 1996, was the identification of good local governance and security of land tenure as the two pillars ensuring sustainable urban development. (UN-Habitat; 1996)

According to the two above mentioned points, an essential complementary action to this should be the establishment of a solid legislation granting security of land tenure. Secure land tenure is necessary for stimulating slum dwellers to invest in improving their housing conditions as well as the surrounding physical environments like drainage, road accessibility etc. (UN-habitat; 2003; 7)

Vanessa Watson echoes the views of Sue Parnell of the African Centre for Cities, stating that a bottoms-up approach, grass roots experience and the reality of the situations at hand should inform and shape existing policies and a compromise needs to be reached in order to achieve sustainable growth within settlements.

Weathering the Storm, a recent publication by DiMP reflects on current international practice in participatory risk assessment. It describes an appoach to risk reduction that actively engages residents of informal settlements, as well as their civil society and government colleagues. This guide has been designed according to the disaster risk profile of the Western Cape and to the cultural and language needs of disaster risk and development practitioners in the province, although many of the issues profiled may apply in other settings. The guide simplifies participatory risk assessment methods so that they can be used for integrated disaster risk management planning at settlement level, or used by a single department to improve flood risk reduction measures.

There are four particularly useful policy and planning documents to guide risk management in informal settlements:

1. South Africa's Disaster Management Act (No. 57 of 2002)

   - provides an integrated and coordinated policy to reduce the risk of and severity of disasters. The Act also provides for emergency preparedness, effective response and post-disaster recovery.

   One of the roles of a municipal disaster management centre is:

   " ..assess and prevent or reduce the risk of disasters, including:

   - development and implementation of appropriate prevention and mitigation methodologies

   - the integration of prevention and mitigation methodologies with development plans, programmes and initiatives; and

2. The National Disaster Management Framework

   -guides the implementation of the Disaster Management Act and provides 'a coherent transparent and inclusive policy on disaster management appropriate for the Republic as a whole'.

   -emphasises 'measures that reduce the vulnerability of disaster-prone areas, communities and households', recognising that efforts to reduce disaster risks should support and add value to developmental initiatives.

   -emphasises the importance of community participation as a non negotiable necessity for effective disaster risk reduction This is explained below.

   - "The community is at the coalface of disaster risk management …

   'All disaster risk reduction planning, the development of projects and programmes and the allocation of responsibilities must be founded on the needs and priorities of communities. Disaster risk reduction is a community-driven process' (NDMF, Section 1.3.2.2)

3. Isidima: The Western Cape Sustainable Human Settlements Strategy

   represents a significant shift in thinking in relation to pressures for housing and urban development in the Western Cape.

   -highlights 'the shift from housing construction to sustainable human settlements;

4. The City of Cape Town Informal Settlements Master Plan.

   -prioritises the provision of essential services and progressive upgrading to city's more than 220 identified informal settlements

Extreme weather events result in considerable hardship for poor families. Many of the risks are the result of unplanned settlements in low-lying or naturally flood-prone areas. Many fire-prone settlements have poor coverage of potable water sources and fire hydrants, or poorly manage those they do have.

Weathering the Storm outlines an assessment approach that is underpinned by a commitment to participatory engagement with communities at-risk and other stakeholders. Although it is not a comprehensive participatory facilitation handbook, the guide calls for respectful developmental process when working in informal settlements with a range of stakeholders.

According to *Weathering the Storm*, there are important ethical guidelines to follow when conducting participatory research in informal settlements. These include:

-Applying the precautionary principle of 'do no harm'.
   -Can raise local development expectations beyond realistic levels, leading to disappointment and can undermine future development action.

-to respect, add value to and build on existing efforts, programmes, initiatives and capabilities. One shouldn't duplicate structures and reinvent projects.

-Ensuring inclusivity, by including less vocal residents, minority language groups, residents who live further away from main tracks and roads and local officials, CBOs and NGOs who may play important 'invisible' roles in the settlement.

-Keeping personal or professional biases under control, including projecting one's own opinion. Informal settlements in the Western Cape are extremely diverse, with different risk conditions and socio-demographic profiles. It is neither ethical nor scientifically robust to project personal opinions in a participatory risk assessment process.

-To be transparent with research findings and view the assessment as a learning opportunity for all participants, rather than as an extractive process. Knowledge generated through a participatory process should be shared among those who generated it and not withheld from them.

The guide describes a community-based approach for reducing disaster risks in informal settlements in the Western Cape. Although the term 'community-based' is used in this guide, it is very clear that informal settlements in the Western Cape are not necessarily communities in which residents share the same values, history, language or culture.

These new/ changing forms of human settlements and suburbs are blurring what one used to separate into 'formal' and 'informal' neighbourhoods. In many low-income formally planned suburbs, there are increasing numbers of informal ('backyard') dwellings and Wendy houses. At the same time, 'in-situ' upgrading in what were originally known as 'informal settlements' is steadily increasing the number of more permanent formal homes and businesses.

An inclusive assessment and planning should be applied in any risk reduction process. This is irrespective of whether 'the community' refers to residents of formal homes and backyard dwellings in a formally-planned suburb or an informal settlement experiencing in-situ upgrading or even a new low-income suburb that is exposed repeatedly to severe weather events and increased run-off. (Holloway; 2008)

In the Western Cape, it is usually poor and marginalised households living in unserviced informal settlements and low-cost housing that are most vulnerable to severe weather events, seasonal flooding and fires. This is especially the case where informal settlements and low-income suburbs are located in risk-prone and ecologically fragile areas, for instance, in wetlands close to Cape Town. The families who live in informal settlements must negotiate many stresses, including lack of a reliable income, poor food security, and the combined threats of fire, flooding, poor health and crime. Their circumstances are made more difficult by limited access to essential services. Most government departments simply cannot keep pace with rapidly growing and often unplanned demands for service provision, including the maintenance and expansion of essential public infrastructure.

Figure 38: TR-Bongani Section:

Little or poor infrastructure

Informal settlements in the Western Cape face many different kinds of risk on a daily basis, including health risks, environmental risks, financial risks and security risks. However, in the case of informal settlements, *disaster risk* specifically means the chance of hardship or loss resulting from the interaction between natural or other hazards and the vulnerable households and communities that are exposed to them. Disaster risk reduction in informal settlements therefore refers to all policies, actions and initiatives that minimise vulnerabilities and disaster risks in informal settlements, including those that incorporate prevention, mitigation and preparedness. Disaster risk reduction is a trans-disciplinary concept that should be applied across municipal and provincial departments. The concept of disaster risk reduction crosses many disciplines, departments and sectors, transgressing the borders of the fields or disciplines involved. Disaster risk reduction can involve structural and engineering interventions (ie improving the strength and resistance of houses, roads and other essential physical infrastructure). Risk reduction can also be non-structural and involve urban planning, education, health and other social vulnerability reduction measures. Environmental interventions are at the forefront of risk reduction– particularly those that protect essential environmental services associated with rivers and wetlands. (Holloway; 2008)

Most disasters are due to a combination of human and natural or other factors, which can, in fact, be reduced. For instance, careful development planning reduces risks by placing low-cost housing in areas safe from riverine or wetland flooding, or by upgrading and maintaining storm-water systems before the onset of heavy rains. While careful urban planning and engineering works can ease exposure to risk for residents of high-risk settlements, social development actions that strengthen community involvement can also reduce risks. The provision of basic services helps to reduce environmental and individual health burdens on poor households and can also reduce fire risks. Similarly, closer cooperation and confidence between settlement residents and local authority representatives can improve municipal service delivery as well as strengthen local responsibility for recurrent risks. Many risks in informal settlements are strongly rooted in social and economic vulnerability, along with unstable sources of employment or livelihood. Employment, education, skills generation and social protection measures that address these pervasive challenges are long-term developmental aspirations that will also reduce social vulnerability in poor neighbourhoods. (Holloway; 2008)

Informal settlements in the Western Cape are diverse, risk reduction efforts will vary from one settlement to another or from one municipality to another, and almost always need to be tailored to local risk conditions and development capacities. Community-based disaster risk management (CBDRM) is an approach that aims to reduce local disaster risks through the application of participatory assessment and planning methods. It is a practical bridging strategy to integrate local development efforts on one hand with strategies that reduce the impact of priority disaster risks on the other. CBDRM aims to reduce vulnerabilities and strengthen people's capacities to manage specific disaster risks, even if it is not possible to address all their day-to-day difficulties.

Community-Based Disaster Risk Management (CBDRM) is a process of developmental disaster risk management in which the residents of communities at risk actively engage in identifying, analysing, managing, monitoring and evaluating disaster risks to reduce their vulnerabilities and enhance their capacities. This approach places people at the heart of disaster risk reduction decision-making and implementation.

An enabling CBDRM process provides a relatively uniform approach that also recognises and can accommodate a diversity of opinions and needs. It allows a wide group of stakeholders, including residents, civil society organisations and local government role players to jointly understand the disaster risk profile in a particular settlement. An inclusive CBDRM process also helps to build consensus on measures that reduce the likelihood of fires, flooding or environmental health risks. One example of this would be when residents and municipal representatives jointly agree that litter is contributing to local flooding and work together to manage the risk. In this example, the residents might agree to use skips and other litter containers rather than dropping refuse in drainage channels or between dwellings. Similarly, the local authority might agree to improve solid waste collection weekly so that litter does not accumulate.

Effective CBDRM requires a shift from teaching to learning. Instead of imparting 'expert' knowledge, the facilitator should assist residents in risk settlements to understand and manage their risks better, with support from external role players such as government departments and non-governmental organisations. Successful facilitators should also be able to provide relevant additional information to support this process.

Participatory risk assessment is one of a range of methodologies that engage communities developmentally and use highly participatory approaches. They all emphasise a bottoms-up approach that aims to empower communities by involving them in defining problems, deciding solutions, implementing activities and evaluating the results of interventions.

Participatory risk assessment is an approach that provides insights into how risks are generated and reduced within a community or settlement. It can be applied in almost any context, urban or rural, and can be carried out within specific sectors or by specific departments. It can also take the form of an integrated process across sectors within one specific settlement or as part of a holistic planning process used by a community-based organisation.

Figure 39: various risks

The integrated risk assessment and planning process involves three phases, with clear activities and outcomes.

1. **preparatory groundwork.**

This is the most important phase in the risk assessment and risk reduction planning process and should take one to two months to complete.

2. **Carrying out a participatory community risk assessment**

A well-conducted participatory risk assessment can help build a shared understanding of local risks and also strengthen cooperation and trust. It uses a wide range of participatory methods.

There are other social science and spatial risk assessment tools that can supplement the participatory activities. These include focus groups, in-depth interviews, surveys and spatial mapping.

There are many different possible arrangements for taking forward the findings of the CRA. One of the most effective is to establish a community-based disaster risk management committee, or to build this into an existing community based structure.

To support good follow-up by all parties concerned, it is important to record the risk assessment process and to make a plan for transparently communicating back to those who participated in the assessment.

3. **Integrated risk management – thinking 'across risks'**

Informal neighbourhoods in the Western Cape face many risks: crime, ill health, flooding, informal dwelling fires and environmental health risks. People in many informal settlements experience flooding, fires and environmental health risks as everyday, chronic risks. These risks can also rapidly upscale into local emergencies, leading to widespread loss of property, temporary displacement and prolonged hardship. For instance, severe storm events that have occurred annually in the Western and Southern Cape since 2003 have seen thousands of low-income residents evacuated from high-risk low-lying areas or sites adjacent to rivers and natural water-courses. Similarly, in the case of informal dwelling fires, from 1995-2005, more than 8 554 informal dwelling fire incidents occurred in Cape Town alone, affecting 40 558 households – around 160 000 people. Most of these incidents resulted in houses being destroyed, along with household property and identity documents, seriously setting back the households affected. Within the province, each of these threats affects thousands of poor families every year. They also create enormous demands on local authorities and humanitarian assistance organisations.

Risks

Many settlements experience both severe fires and urban flooding, sometimes even within the same season. This is because many of the same vulnerability factors increase exposure to these different risks, and lower local capability to manage them. For example, poor levels of environmental health increase the severity of both flooding and fires. Here are some examples of the ways in which vulnerable communities can be exposed to a range of risks:

> Stormwater drains and drainage ditches that are blocked by litter and other household waste can lead to settlement flooding (ponding, and surface runoff) during heavy rains which increases the risk of ill health, especially for children and damaged or destroyed household property.
>
> Solid and liquid waste that dissolves in standing water or run-off during heavy rain can lead to chemicals and irritants being released into the surface run-off and flood water which increases the risk of skin rashes and diarrhoeal , disease (especially in children).
>
> Lack of toilets, especially in heavy rains can lead to human waste that contaminates standing and drinking water which increases the risk of Gastro-intestinal illness and other sicknesses.
>
> Large piles of flammable household waste and litter dumped near to dwellings can lead to an increased fuel load and create fire bridges between dwellings which increase the risk of severe informal dwelling fires, loss of home and property..

These examples show the importance of integrated or 'multi-sectoral' risk management in informal settlements. For instance, although roads and stormwater departments may be primarily responsible for managing flood risks, environmental health workers also play an essential role in flood risk management by providing accessible, dependable solid waste collection and disposal.

The focus of the critical risk assessment conducted in Bongani TR-Section was to establish hazards which affected residents, with particular focus on the local businesses in the settlement. The vulnerabilities that drive the risk for these particular disasters were also studied, and the coping mechanisms of the people and the local

Figure 40: existing water point

businesses were noted. Participatory methods were used to gain an understanding of the perceptions and local knowledge of the local disaster context.

The risks identified as priorities were fires, flooding and environmental health. The factors driving vulnerability include the general state of poverty, unemployment, overcrowding, poorly built housing structures, lack of service provision (toilet facilities, water provision and emergency services), and the situation of the settlement on marginal land, in this case a wetland. The areas most at risk tended to be the lowest lying areas and these areas were particularly vulnerable to flooding due to the lack of proper drainage. The high-risk situation is worsened by other factors such as the lack of services and inadequate infrastructure. Poor sanitation, the lack of drainage, and the damp living conditions, a product of living on a wetland, trigger health risks, (Drowley, Jember, Kassi & Smith: 2007; 2)

2. MEDIUM

Different Approaches: Changing relationships

There has been a significant shift identified within the profession in the past few years: that of the professional operating outside their normal area of practice. There is a new openness to the value of partnership and collaboration within and between practitioners, community groups, agencies, private and public sector organizations. Practitioners should be encouraged to move outside and beyond their own disciplines to work in a broader, 'more strategic and critical role'. (Cumberlidge, Musgrave; 2007; 15)

The case studies presented below are projects that cross over related fields of architecture, urban design, community development, landscape architecture and art, and maps an emerging geography of repair and regeneration that engages physical, social and economic scenarios. (Cumberlidge, Musgrave; 2007; 15)

These projects stand apart from the typical top-down planning that characterized the twentieth century's culture of planning. In contrast, the practitioners seek to break down boundaries between professional and amateur, expert and citizen. Rather than targeting singular objectives, their work focuses on processes that produce multiple benefits, aiming to develop new subjectivities and attitudes as well as physical platforms for community development.

A second key theme within these case studies, arising from the recognition of regeneration as a continuous process of change, has been the idea of the unfinished. (Cumberlidge, Musgrave; 2007; 18)It seems that a prerequisite for success understood by this new practice is that planning and architecture must leave space open for opportunity. This openness should allow for both irrationality in the process and community appropriation of the spaces as development takes place. Temporary and longer time-limited programmes have an important role to play in this, as seen in slum networking in India, where providing the highest quality of infrastructure in a highly participative but financially economic way creates the space for residents to build for themselves. (Cumberlidge, Musgrave; 2007; 18)

Infrastructure is the essential framework for every community, be it hard infrastructure, social infrastructure or environmental infrastructure. The provision of infrastructure, its maintenance and upgrading is conventionally viewed as a problem for engineers that requires a fixed best value solution derived from rational calculation and linear processes that draw on accepted norms. Fast-paced change has meant the desertion of unused infrastructure rather than its adaptation or reuse. Replacement too often results in new structures that cut through the surrounding urban fabric or landscape with no regard for particularities of place, severing communities and resulting in massive environmental damage. (Cumberlidge, Musgrave; 2007; 26)

The provision of basic infrastructure and services does not need to remain the 'expertise' of the engineer. Artists' and practitioners are increasingly using infrastructure as a tool in the production of creative solutions. The projects all challenge the notion of mono-functional neutral infrastructure and instead push the boundaries, making the infrastructure work on many levels that are social, cultural and physical. Infrastructure has a symbolic and cultural value and acts as the physical frameworks that support communities and should contribute to the parallel network of social relationships and active citizenship. (Cumberlidge, Musgrave; 2007; 32)

Figure 41: 'play pump' water infrastructure
(Cumberlidge, Musgrave; 2007)

Case Study: Plankenbrug River

The artificial wetland along the Plankenbrug River below Kayamandi was planted in December 2003. It was designed to filter pollution from the settlement. This is because the Plankenbrug River was identified as the primary source of pollution entering the Eerste River. Very high levels of faecal coliforms in the Plankenbrug River are an ongoing health hazard, particularly during low-flow conditions, despite numerous attempts to remedy the situation, for instance, by constructing artificial wetlands to filter the water. (Brown, Magoba; 2009; 279)

Figure 42: Natural System Approach-artificial wetland

(Brown, Magoba; 2009; 279)

Case Study: Lower Silvermine River Flood Alleviation Scheme

Land which served as floodplain around the lower reaches of the Silvermine River in Fish Hoek regularly flooded as a result of the river's gradual degradation, mainly by invasion of alien trees. It was feared that Fish Hoek would not be able to handle a 1-in-50 year flood, as this would result in floodwaters running along Main Road into the centre of Fish Hoek, inundating large areas of the town. (Brown, Magoba; 2009; 235)

The environmental and drainage divisions of the South Peninsula Municipality, which came into existence in 1997, decided to do something about the situation, and Julia Wood and Martin Thompson were instrumental in evoking some action. The resultant engineering works, which were subjected to extensive impact studies, included redefining the floodplain with gabion structures and earth berms, creating stilling basins to attenuate floodwaters, and filling some adjacent properties to prevent their flooding and make them available for development (Brown, Magoba; 2009; 237)

The project significantly upgraded the aesthetic and recreational potential of the area, turning the riverine area from an eyesore to a far more secure attraction. There was extensive planting of indigenous wetland vegetation and creation of walkways, which now provide a pleasing gateway to the valley.

The Flood Alleviation Scheme illustrates the change in focus and method of engineering interventions over time, with 'soft' ecologically-friendly treatments becoming far more prevalent than in the past, closing the gap between engineers and ecologists. (Brown, Magoba; 2009; 238)

Figure 43: flood alleviation

(Brown, Magoba; 2009)

1. Natural System's Approach

In *Natural Infrastructure* in the previous chapter, the idea of water and landscape as a natural system and technology was explored. The Cape Flats and its hydrology was looked at in detail to gain an insight into the complex nature of the site. The water system was therefore introduced as a 'natural technology'/ existing infrastructure, capable of cleaning or rehabilitating water.

Apart from generating development, landscapes could also inform the design of the development and can be seen as operational. Natural treatment systems can inform building design in a way that traditional civic infrastructure can't. (Snoonian,; 2001; 131)

Wetlands are among the most effective practices for removing stormwater pollutants. Research studies have estimated the effectiveness of wetlands and proven that they are more effective than any other practice at removing nitrate and bacteria.

There is considerable variability in the effectiveness of different types of wetlands, for best results a combination of shallow, deep and gravel based wetlands (where pollutants are removed through biological activity on the surface of the rocks, as well as by pollutant uptake of the plants) are recommended.

Natural drainage paths are nature's own means of disposal and, if properly exploited, also the ideal routes for the man-made urban infrastructure of sewerage, storm drainage, water supply and roads. (Gans &Weisz; 2004)

Case Study: Xochimilco Park, Mexico, 1989-1993

Xochimilco Park is an example of a major open-space project serving a mega city. Its programme and design are based on a multidimensional understanding of the city's needs, the local history and context, and a radical ecological agenda on a scale that has a genuine impact on the city. (Cumberlidge, Musgrave; 2007; 56)

The ground level of the city has sunk by 9 metres during the twentieth century due to the depletion of the natural aquifers. Water resources and adequate stormwater drainage and absorption have become a critical problem due to the rapid urbanization, the drainage of almost all major lakes and watercourses and the lack of adequate infrastructure. (Cumberlidge, Musgrave; 2007; 56)

The park, based around Lake Huetzalin, occupies one of only two areas where examples of the pre-Hispanic technique of 'floating' gardens remain. These gardens, called Chinampas, are a form of agriculture unique to Mexico and are constructed using Willow trees to anchor artificial islands of reeds and organic matter to the base of the lake. This system allows raised ground to be created without destroying the fundamental water resource and enables the environment to both absorb and conserve water. Although a UNESCO World Heritage Site prior to the building of the park, urban encroachment, pollution, silting, and underground aquifer depletion had severely affected the environment. (Cumberlidge, Musgrave; 2007; 58)

The creation of the park was a large-scale ecological restoration project including historic restoration, new environmental business and cultural projects. By restoring the Chinapas, agriculture has been reintroduced to the city, enabling amore sustainable economy and food supply to the local areas as well as providing an important 'green lung' for the city, and recreation and education facilities.

The design was guided by hydraulic strategies: water was pumped back into the aquifer to stabilize the site, large reservoirs were created to retain storm water, polluted water was processed at treatment plants, and treated water was discharged back into the lake to regulate the water levels in the canals.

Sophisticated water management is built into design features and also serves an important function in regulating water levels. (Cumberlidge, Musgrave; 2007; 61)

Figure 44: Xochimilco Park, Mexico
(Cumberlidge, Musgrave; 2007)

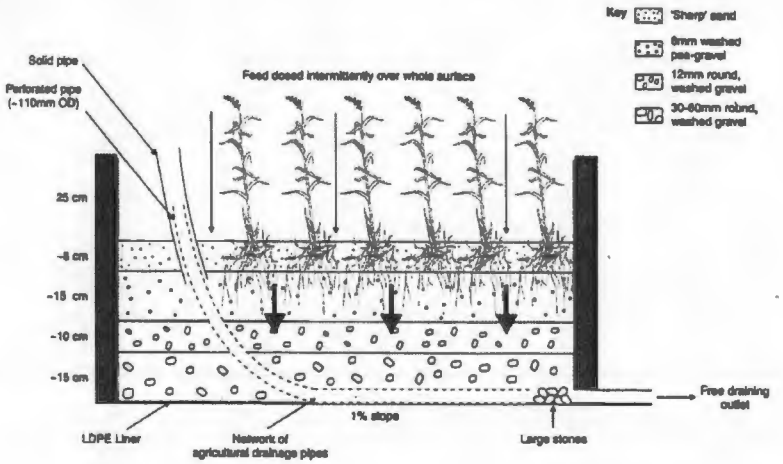


Figure 45: vertical flow reed bed system

(Grobicki: 2002)

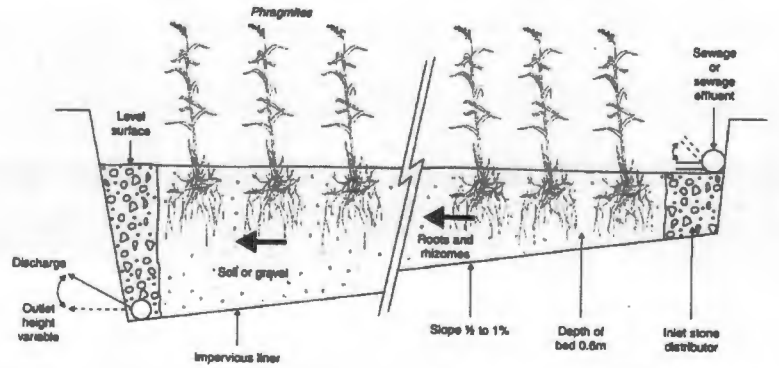


Figure 46: horizontal flow reed bed system

(Grobicki: 2002)

Efficiency of constructed wetlands

From a practical point of view, constructed wetlands offer better opportunities for wastewater treatment than natural wetlands, since they can be designed for optimal removal of BOD, COD and nutrients with simultaneous control over the hydrological and vegetative components of the wetland. Constructed wetlands have been used successfully foo treating domestic wastewater, agricultural wastewater and industrial wastewater. (Grobicki: 2002: A38)

In general, constructed wetlands can be designed to remove more than 90% BOD, COD, suspended solids and bacteriological pollution from the through-flowing wastewater. (Verhoeven and Meuleman, 1999).

There are two main types of constructed wetlands:

1. Vertical Flow Reed Bed Systems (VFRBs)

VFRBs can process a high load of wastewater, but can only be used intermittently. The liquid floods the surface and then percolates downwards and out. The bed then drains completely, allowing air to refill the bed. The next batch of liquid traps these air spaces, thus oxygenating the water. This in turn increases the efficiency of the bed. More than one VFRB bed is necessary so that one bed can drain free while another is in use. VFRBs are less good at removing suspended solids than soluble loading, and therefore in most cases need to be followed by a HFRB as part of a multi-stage treatment system.

Horizontal Flow Reed Beds (HFRB's)

HFRBs process a lower load of wastewater, but are good at removing suspended solids. The liquid flows through the bed horizontally, beneath the surface of the gravel. Because the wastewater fills all the spaces between the gravel. HFRBs are generally oxygen limited and consequently less efficient than VFRBs. They can however be used continuously, so only one is required and they are simpler to operate.

How do they work?

Firstly, the wastewater passes through a settling tank (or septic tank) to remove any solid material. Then it flows into the reed beds for cleansing. Organic material and fine particles are removed from the water as they are filtered out by the soil.

From here, micro-organisms (fungi and bacteria) which develop in the planted soil are responsible for most of the treatment. The root and rhizome systems of the reeds bring air into the soil immediately surrounding them, providing ideal growth conditioned for aerobic bacteria, which form very high populations on the plant roots and rhizomes. Further away from the roots, the environment is anaerobic. Thus there is a mosaic of treatment spheres, allowing the reed bed to act as a self-contained aerobic/ anaerobic digester. This facilitates the impressive ability of reed beds to remove complex and refractory pollutants and reduce them to environmentally neutral outputs. The majority of treatment is by soil microbes, but certain contaminants (such as heavy metals, sulphur and phosphorus) are removed via soil processes. (Grobicki: 2002: A40)

The plants are also extremely important in the functioning of the reed bed. As well as providing oxygen and taking up certain nutrients from the water, the plants ensure that water can continually flow through the soil. (Grobicki: 2002: A41)

Case Study: Cultivation of plants in restored urban wetlands for income for income generation in local communities: Abbot Grobicki WRC Report No. 1054/1/02, August 2002

Wetlands in urban environments are under great pressure due to competition for land resulting from poverty, inadequate infrastructure and services and particularly a lack of housing. An important function of urban catchment management is to preserve and restore urban wetlands where possible. However, under South African conditions, the pressing needs of people for jobs and housing often take precedence over environmental consideration.

Urban wetland conservation and restoration would be encouraged if wetlands could be turned into sustainable economic assets, by the cultivation of economically valuable plants in wetlands. As a result of these considerations the water research commission initiated a project on the cultivation of aquatic plants in restored urban wetlands for income generation in local communities. (Grobicki: 2002: 1)

The guidelines developed differentiate between three types of wetlands, and the use to which a wetland may be put will depend on the type of wetland, and the prevailing legislation and local authority regulations:

Altered wetlands: The guidelines and new green database deal mostly with plants that can be cultivated in already altered and degraded wetlands, where planting will enhance the ecological and hydrological functioning of the wetland

Pristine wetlands: it is recommended that pristine wetlands be used non-invasively or with minimal invasion (eg. for recreation)

Constructed wetlands: this type of wetland can be constructed at a wastewater or stormwater discharge point, in order to prevent the release of nutrients and other pollutants into the environment. Constructed wetlands have shown to be an efficient and economical means of purifying wastewater or stormwater, while at the same time displaying ecological and hydrological functionality within a stormwater system. (Grobicki: 2002: iii)

Constructed wetlands have been used extensively for water purification and growing economically important aquatic plants. The site chosen need only be near a source of water or wastewater. Common plant species that act as bio-filters are *Phragmites spp.*, *Typha spp.* and *Scirpus spp.* and these have all been used for wastewater purification (Verhoeven et al., 1999). These reed species have a high biomass production rate of 1-4 kg/ year dry mass per m sq of stand (Gessner, 2001). *Phragmites spp.* in particular have a high nutrient loading capacity. Hence constructed wetlands are often referred to as reedbeds. (Grobicki: 2002: A38)

2. Engineering Approach

changing infrastructure

Ultimately one of the aims of this thesis is also to try and challenge the stereotypical engineering-based approach of the City towards mitigation and stormwater treatment. The need for inter-disciplinary work and investigation is also recommended.

The existing disaster mitigation strategies being used by the City of Cape Town, the drainage and stormwater and purely engineering orientated approaches to the problem at hand will be considered, and how these can be re-adapted and incorporated within the public realm to raise awareness around the use of water. This is effectively the point where the project takes on a more architectural nature as it is here where uses and customs associated with the process of water is celebrated and highlighted. Case studies where purely engineering approaches have been challenged, will be explored.

Perhaps the most important impact of urbanization has been the increase in runoff, as a result of two main factors. Firstly, water for domestic and industrial purposes is now sourced from outside Cape Town, but it still needs to be disposed of in Cape Town. Much of this water finds its way into the rivers and wetlands, turning formally seasonal vleis into perennial ones, and reducing their ability to absorb peak floodwaters. Secondly, the hardening of the catchments by buildings, roads and other non-permeable surfaces has increased peak stormwater runoff during rainstorms way beyond natural levels.

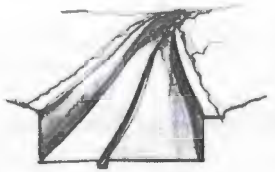
Figure 47: engineering approach
(Brown, Magoba; 2009)

Figure 48: engineering approach
(Brown, Magoba; 2009)

The combination of a loss of floodplains and wetlands, the more perennial nature of the remaining systems, and the vastly increased stormwater runoff meant that the remaining systems were unable to transport or attenuate floodwaters, and flooding in Cape Town became common. In order to reduce the flood risks, rivers and wetlands were channelised or canalised, at great expense, to improve the efficiency with which water is transported to the sea. In many instances, these engineering solutions created other problems, with their associated costs, such as transferring the flood risk to downstream areas, and reducing the ability of aquatic systems to render services such as water treatment. (Brown, Magoba; 2009; 308)

Infilling, channelisation and canalisation have also had a profound effect on the aesthetic and amenity value of river systems, with knock-on social and economic costs. Apart from being unattractive, canalised systems pose a threat for people and animals. Polluted systems also pose a risk to human health. (Brown, Magoba; 2009; 308)

Some rivers have been canalised to enable them to transport floodwaters as efficiently as possible, with little or no thought given to the environment, while others have been protected, by setting back property boundaries, acquiring adjacent open space and registering servitudes. The latter approach has given rise to a greater amenity value, better flood protection and healthier, more biologically diverse river systems. (Brown, Magoba; 2009; 325)



The absolute width of buffers could vary depending on ecological, hydraulic and social criteria. The important issues are that, once determined, the required river reserves would be locked in to future developments in an area and the general trend would be towards sustainable river systems. (Brown, Magoba; 2009; 325)

The same holds true for urban wetlands. As is the case with rivers, these areas buffer the system against the urban environment surrounding them. For both rivers and wetlands, it is worth bearing in mind that while these areas appear suited to pedestrian or other access and picnic and recreational activity, these reduce the ecological benefits of buffers. Hence, buffer zones should be designed carefully to optimize the benefits to all the residents of an area, human and otherwise. (Brown, Magoba; 2009; 326)

Kevin Winter stated that stormwater channels facilitated the movement of run-off into streams and removed ground water from streets. Infrastructure in urban areas, such as buildings, homes, driveways and roads, made the disposal of rain- water swift and easy.

Director of the city council's Roads and Storm water department, Henry du Plessis, said informal settlements were prone to flooding because of their location. "Settlements *are situated lower than river banks and by its (the river's) nature, in stormy weather it would overflow*," he said. Du Plessis said that those were areas with a high water retention table, where water came up from the ground and rainwater flowing downwards caused floods.

Case Study: Langvlei Canal, Retreat, 2000

In 2000, the South Peninsula Administration (SPM) initiated a phased upgrading of the canal environment of Langvlei Canal in retreat.

Phase 1 of the project was part of a SPM Mayoral project, which allowed ward councillors to determine priority needs within their own wards, and focused on a section of the canal adjacent to under-utilized public open space, close to a number of schools. The first phase saw a leveling of banks, construction of footpaths and lighting to increase use and enjoyment and safety of the river corridor.

Phase 2 of the project involved the breaking open of a small section of the canal, and the establishment of a small wetland adjacent to the canal, and educational initiatives to promote the use of open space as classrooms. A later project saw a larger section of the sand River Canal being broken open and the diversion of the low flow into the adjacent wetland.

These projects were ground breaking and showed what could be achieved. The resultant wetlands require fairly intense maintenance, however, which is not always a priority in current City budgets. (Brown, Magoba; 2009; 211)

Figure 49: engineering approach challenged
(Brown, Magoba; 2009)

Case Study: The Moddergat River

The area where the Moddergat River now flows used to be a large swamp and wetland that drained into the Lourens River. About a hundred years ago, Cecil John Rhodes bought land in the area and had a channel dug to drain the swamp into the Eerste River. This artificial channel now forms the lower section of the Moddergat River.

The residential areas of Firgrove and Macassar, and farming areas between the N2 and R102 roads, are prone to flooding by the Moddergat River, largely as a result of draining of the wetlands, manipulation of the floodplain and riverbanks and construction of the channel. A flood-alleviation/ restoration project, initiated in 2000, involved the modification of the lower section of the Moddergat River as well as the modification of some of the bridges crossing it so as to reduce damage to the residential areas next to the river. A soft treatment, with a low-flow channel lined with loose boulders and macro-channel capacity designed to accommodate the estimated 1-in-50 year flood volume, was used. Much of South Africa's worst erosion occurs along riverbanks and anti-erosion measures were introduced to protect the banks where necessary. The residents of the area requested that re-vegetation exclude trees and large shrubs as these would potentially provide hiding places for socially unwanted lawless elements.

The upgrade has proved to be of immense amenity value, with children playing on the grassed base, adults walking along the riverbank and families picnicking and braaing on the upper bank looking down onto the river and the high-flow channel. (Brown, Magobs; 2009; 281)

Figure 50: engineering approach challenged
(Brown, Magobs; 2009)

The department has a Winter Readiness Programme in place where construction staff are deployed to clean dirt in gutters and gulleys that has been accumulating during summer. This procedure, aimed at preventing large-scale flooding, starts in March and ends in August each year. *"Teams are on stand-by during the winter period to act quickly,"* said Du Plessis. He added that, for the duration of heavy downpours, stormwater pipes "*can only accommodate so much water*". The size of pipes throughout the city varies from 300mm to 2.5 metres in diameter, said Du Plessis. He said that major piping systems like the Black River and Liesbeeck River Parkways had been designed to deal with more extreme conditions.

"Only once every 100 years could their banks overflow and cause floods," said Du Plessis. The city's Disaster Risk Management spokesman Johan Minnie said the city also had a "major storms flooding plan" in place, aimed at preventing flooding.

The Catchment, Stormwater & River Management (CSRM) department is responsible for the entire metropolitan area of Cape Town. This contains over three million people including those in the informal settlements. Over the past few years, flood risk has increased and with that, the residents in the settlements have become angry and in some cases, even erupted in protests. Past efforts have been made to address the flood risk but mainly by other organisations in the form of educational materials. Attempts to decrease the flood risks have not been wholly successful and the City is seeking more options. Although the CSRM division of the City is responsible for creation of infrastructure, they are limited as to what they can accomplish in the settlements. There is a lack of space available for construction. Moving residents to other areas also presents a problem because there is a lack of available land. Also, for the City to install significant stormwater infrastructure in the informal areas would create the perception that the City supports this unlawful occupancy. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 10)

Currently, city workers and contractors are continuing to remove this debris in the City's drainage system which contains a series of 6 035 km of pipes and culverts, 1 200 km of rivers, 140 km of open channels and canals, and 680 detention ponds. As of 2007, the Solid Waste department has supplied over 1 700 cubic metres of clean sand and 1 500 cubic metres of rubble to fill low spots and raise floor levels in the 70 affected settlements, all in an effort to manage flood risk. In the year 2007 alone, before the onset of winter, the City spent R76 million on the cleaning of the catchment infrastructure. Though the City of Cape Town has made extensive efforts in theses aspects of stormwater management, these measures have proven to he insufficient, as demonstrated by the extreme flooding events in Cape Town in the winter of 2007. Flood risk management depends on the allocation of efforts in not only stormwater management but in other areas, as well. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 14)

Despite the efforts of the City, the countless impacts of flooding in the informal settlements are still very much apparent. The existing stormwater infrastructure in these affected areas is often ill-maintained, which exacerbates the problem. The flooding has left many areas of the informal settlements uninhabitable for various reasons including health risks and physical dangers. There has not yet been a thorough assessment of the habitability of the affected areas. Although many of them are hazardous, many residents continue to live there, not only because they lack the economic means to move elsewhere but also because they are largely unaware of the dangers associated with flooding. Previous efforts have not been entirely successful in minimising the impact of flooding at the household and community levels (Wood, 2007). In other words, there was a lack of involvement by and collaboration with the residents of the informal settlements about flood risk management. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 1)

These recent events have prompted an emphasis that has moved away from physical control and engineering construction (structural measures) towards reducing human vulnerability through non-structural approaches (Smith, 1992). In accordance with this movement, the City of Cape Town is now moving from a reactive to proactive approach for handling the flooding. In May 2007, the *Catchment, Stormwater & River Management Department* (CSRM) established objectives to improve existing conditions in the settlements. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 1)

While most of these townships do not have formal catchment systems, there is a basic level of service provided by the City, which includes retention ponds around the area, drains around paved roadways, and formal trenches. However, in many cases, these basic services are ineffective due to consistent blockages. There are three main types of blockages which are common to these systems: silt accumulation, man-made blockages, and rubbish build up. Silt accumulation can be attributed to the grey water, which accumulates within the trenches. Residents dispose of wash water and toilet contents in these areas, resulting in large amounts of grey water. Man-made blockages are also frequent within settlement areas. The City places pipes through locations in the affected areas

to transport the water to retention ponds, and many times residents block these pipes with various materials so that they can settle in those areas. This results in the pooling of water and consequent flooding during the winter months. Rubbish blockages are perhaps the most debilitating to the catchment system. The lack of skips or improper location of skips (rubbish collection bins) within these areas results in residents disposing of their rubbish in retention ponds, trenches, and streets. This trash subsequently ends up in the drains and causes blockages. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 4)

> *'We need a drainage system - we need all the basic services. We don't even have a sewerage system. We are using the bucket system'* --TR-Bongani Section resident (Prince, 2007).

Currently, the flooding is worsened by the lack of integration between City departments. The flooding extends beyond the scope of the CSRM department. Trash build up in existing infrastructure, poor placement and design of standpipes also intensify the flooding problem, which are responsibilities of the Solid Waste and Water Demand departments respectively. The Disaster Risk Management department is responsible for communication and awareness materials to be distributed within the settlements. The CSRM, however is responsible for making recommendations to Disaster Risk Management based on what they feel the key issues are concerning flooding. Without the proper communication and cooperation between the departments, the City will only be wasting resources. (Bouchard,. Goncalo, Susienka & Wilson. 2007: 10)

Case Study: Cheonggyecheon River, Seoul
(Pearce; 2007; 108, 109)

Historically, the Cheonggyecheon River was a shallow, wide seasonal stream that formed the divide between the rich in the north and the poor in the south of the City of Seoul. As Seoul grew, the Cheonggyecheon River became little more than a sewer. The river was eventually turned into a road (and the river was encased in a drain underlying it) and later into an elevated 6-lane highway.

But in 2002, with ecological restoration being the main theme around the world, the mayor of Seoul proposed a plan to restore the river, tear down the motorway and create an 8 kilometre long, 800 metre wide 400 hectare park through the city where the river once flowed. The vision was to create a focal point of historical significance and aesthetic appeal.

A city university interviewed thousands of the city's residents about what they thought were important in the city. Most listed environment and water. The electorate approved the restoration. River flow was restored from groundwater sources and 22 new bridges were built. The removal of the motorway had expected and unexpected effects. Traffic jams elsewhere in the city did not increase dramatically, many gave up cars and the city was forced to improve its bus service. Summer temperatures near the river were 3.6 degrees lower than those recorded near the motorway, as the river acted as a natural air conditioner. (Brown, Magobe; 2009; 345)

Figure 51: Cheonggyecheon River, Seoul-after
(Pearce; 2007; 108)

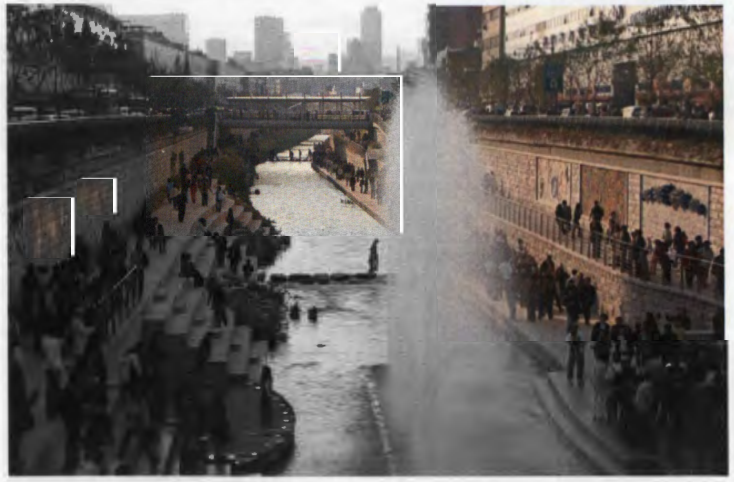


Figure 52: Imazamu-Yethu, Hout Bay:

Local in-situ council improvements to informal area

Case Study: Hangberg, Hout Bay (City of Cape Town Municipality)

Hangberg is situated in Hout Bay. The settlement comprises a mix of low income housing, flats and informal dwellings. The steep slopes of the settlement pose huge challenges to service delivery. Since the late 1990's the number of informal dwellings have grown to over 300, but most residents have overcome the challenge of building and living on these steep, sandy slopes, with many shacks being built to above-average standards. There are a number of two-storey dwellings, many of which are constructed from new corrugated sheeting, brick, wood and sometimes mountain rock.

In 2004 the City of Cape Town installed 37 waterborne communal toilets connected to a network of shallow sewerage pipes. Since then nearly 40% of the dwellings have pirated these facilities to install their own water and sanitation services in their shacks. Surveys revealed that over 85% of householders installed these services in their shacks with the help of neighbours, friends or from the experience that they had gained from their respective workplaces or from watching similar installations that were undertaken by other residents.

Surveys also indicated that there were relatively high levels of social capital and capacity in this settlement. Social capital is also likely to have been strengthened by family and neighbourhood relationships contributing to a network of support that has grown over time – the average length of time that people have spent living in Hangberg, whether in the formal or informal part of the settlement, amounts to 28 years. Such relationships provide the network of support that is built over time to enable the development of skills necessary for implementing water and sanitation services to the household.

In 2006 the Hangberg Civic Project committee was formed by a group of elected residents for the purposes of championing efforts toward the *in situ* upgrade of the settlement. This civic committee together with the services of an NGO (the Development Action Group) proved central in the process of achieving cooperation with the local authority. As a result, the City mayor has taken a special interest in the development of this settlement and has met on several occasions with the civic committee and has included local authority officials responsible for implementing relevant services and for securing land tenure. Social capital has therefore been drawn from within the settlement and also from outside the community in the form of services of the NGO, the mayor and local authority officials.

The civic project committee residents are presently in a far better position to install and manage services. Social capital can be construed as the missing link that separates Hangberg from the other settlements examined by Winter and his UCT students.

It highlights the fact that service delivery in the context of informal settlements is dependent on the social capital as a significant means of securing the co-operation of the local authority and elected councillors that might ultimately lead to securing land and services. As an aside, plans to continue the upgrading process in Hangberg have been boosted recently by a R1.2 million ($130 000 US) grant from the City to increase the number of communal toilets and channel all wastewater (including grey water) into the sewer. The civic committee are concerned about the extent of the pollution resulting from grey water in the stormwater system entering the ocean and want to see improvements in the control and management of wastewater in general.

The intention to engage in participatory action research, collaborative in design, action and reflexive revision, has been realised with only very limited success by this project in the case of the first two settlements discussed. The fieldwork team failed to find local institutional structures with which to run workshops and establish rapport.

In the case of Hangberg, outsiders (the research team and through them the project funders) have driven the process rather than allowed local people to do so. Some key findings have emanated from the research to date:

3. Integrated Urban Water Management Approach

While many South African urban shack settlements have been supplied in recent years with standpipes from which residents are able to draw varying quantities of potable water, they still have inadequate or no provision of sanitation and drainage. In the absence of suitable conveyance systems for the disposal of the grey water that is generated, residents in these predominantly high-density settlements resort to disposing of wastewater on the ground near their dwellings. Such wastewater runoffs often merge with other effluent flows, potentially threatening public and environmental health.

This study by UCT students adopted an Adaptive Decision-Making Process (ADMP) approach in collaboration with residents form various areas to implement a range of low-cost technologies as interim solutions to reduce these negative impacts until such time that formal services can be provided.

They argue that effective community-level solutions for wastewater management depend on the establishment of partnerships and trust amongst all stakeholders

This project emanates from a directed research initiative by the South African Water Research Commission (WRC) to build knowledge and competency in stormwater and sanitation. The study (WRC Project K5/1524, "*Understanding the use and disposal of greywater in the non-sewered areas in South Africa*"), was completed in March 2007, and identified the need for a longer-term study of peoples' behaviour and practices, in which communities without on-site waterborne sanitation could be given opportunities to consider a variety of options in dealing with grey water issues (Carden et al., 2007).

The main focus of the research project was to understand and develop appropriate social and material technologies for grey water management in non-sewered areas (those areas without on-site waterborne sanitation), in order to understand and mitigate the health and environmental impacts of existing grey water management practices.

The project sought to work with all stakeholders to reach decisions about the usefulness and acceptability of the technologies involved.
The following specific objectives were formulated:

-To identify (a) social challenges to effective grey water management and
(b) reasons that previous initiatives to manage grey water had proved unsustainable;
-To identify locally appropriate means
(a) to overcome social obstacles hindering effective and sustainable grey water management practices;
(b) to enable local people to implement and maintain appropriate management systems;
-To identify (a) specific environmental impacts of ineffective grey water management practices and
(b) ways of mitigating those impacts;
-To establish links between grey water quality in informal settlements (especially relating to the chemicals used in detergent products) and the potential for reuse;
-To trial social and environmental interventions in a small sample of informal settlements;
-To develop (a) educational material about grey water management options and techniques for residents of settlements and
(b) 'best practice' guidelines for grey water management in such settlements.

The first step in the process of achieving these objectives was to assess grey water disposal practices in a sample of urban shack settlements in South Africa's Western Cape Province. The goal was to help them to firstly install such technologies, and then to assist them in understanding how to install and manage others of the same kind.

Introduction of grey water management technologies

Six grey water management options were considered by the research team, and those that seemed most appropriate and viable in a particular context were then presented by the fieldworkers to interested individuals and/or small groups in the settlements. The options were:

1. a "drum filter" – described in more detail below;
2. a shallow crate and trench soakaway – also described in more detail below;
3. Improvements to the informal drainage system by channelling wastewater down the sides of access routes through the settlement, and reinforcing channels with cement slurry to prevent erosion;
4. An improved communal tapstand and washing area design;
5. Trench gardening for non-edible crops, e.g. ornamental f lowers for the market;
6. A wetland filter. Only the first and second options have actually been used thus far by the fieldwork team in the two settlements.

-A combination of the development of social capital and the facilitation of an NGO has proven central to progress toward securing land and the co-operation and interest of the local authorities in Hangberg.

-Security of land tenure is one of the complex factors associated with the general state of South Africa's informal settlements that undermines the motivation of individuals to engage in self-help projects, as seen in Waterworks and Langrug.

-There is inadequate communication between residents and local authority structures

-Increasing distrust between residents, elected political councillors and local authorities is a recipe that characterises the failure to implement sustainable services.

-Prospects for sustainable service delivery in informal settlements are reliant on the development of human capacity and effective governance.

Figure 53: Hangberg, Hout Bay

(www.andrewsteen.info)

The drum filter

Building on the contacts established earlier, the fieldworkers found a small number of local householders in each settlement who were willing to allow a portion of the land around their shacks to be converted into small grey water soak-aways. In Waterworks, the first three of these involved the installation of drum filters which the research team thought might be useful in a dense settlement where there is limited space between houses, and where sandy porous soils can be used to drain away water that has passed through a simple filter. Through the intervention of members of a local street committee, a public space between shacks was identified for installation of one drum filter, while a couple of individual residents also volunteered space in their yards to install them there.

The drum filter comprises a 300 litre plastic bin (the type commonly used for storing domestic refuse) that is sunk into the ground so that its lip is only a few centimetres above the ground. The bottom third of the drum is filled with coarse sand whilst a third is filled with small stones and a third is left as empty space. The sides of the lower portion of the drum and its base are perforated so that filtered water can drain into the surrounding soil, while on one side a larger hole is cut and a short length of PVC piping inserted to direct water to a small bucket for water quality testing. The bin lid is turned upside down to form an inverted cone with very small holes drilled into it to allow drainage into the bin whilst excluding gross solids. The small diameter of those holes is intended to limit smells from decomposing organics and the potential for flies and mosquitoes to breed within the bin.

In the instances where the project team experimented with this technology, the inverted lid was covered with a sheet of woven nylon cloth, locally known as 'shade-cloth', also intended to trap solids / sludge and prevent them from entering the drum. The idea is that once grey water pours into the drum, it filters through the stones and coarse sand, which also provide temporary storage, and then passes into the ground below. The short length of PVC piping is there to direct some of that filtered water into a small sealed bucket under the ground so that water samples can be drawn from it, via a single vertical pipe to the surface, for testing purposes.

Shallow crate and trench soak-away

This technology is best suited to settlements where there is sufficient space between houses, for example, in a corridor where at least 4 x 1 metres of space is available. The soakaway is constructed using an upturned plastic milk crate over a trench approximately 3.5m long x 1m wide x 1m deep. The trench is filled with small stones (25mm diameter) and covered with infill from the hole. Reeds, ornamental flowers or rooted crops such as fruit trees or vegetables may be planted over the soakaway to aid in nutrient removal and promote evapo-transpiration. The grate-like opening to the soakaway, the upturned bottom of the crate, is covered with shade-cloth to prevent food matter entering. The cloth is held down on all four sides by stones placed flush with the surrounding ground level and secured to the crate with wire or cable ties. The polyethylene lining on top and bottom of the trench reflects an attempt to reduce the impact of the poorest quality grey water on the groundwater, although the water, once filtered, does seep into the surrounding ground. The lining is also intended to act as a geo-membrane and to prevent contamination of the filtration stones by the surrounding soils, thereby reducing the risk of blockages.

Where there is inadequate evapo-transpiration (e.g. during the winter months where precipitation generally exceeds evaporation), such a stone-filled trench isexpected to provide storage for roughly two weeks of grey water generated by residents of a typical dwelling in an infoemal settlement, prior to its filtration out of the end of the soakaway and into the surrounding substrate. The research team anticipated at least five limitations to the model that would require further evaluation and modification:

-Clogging of the porous shade-cloth material by grease and fats;
-Too rapid pouring of grey water into the grate-like entrance of the soakaway, causing spillages;
-Plants being unable to grow in the high nutrient, alkaline conditions created by the grey water content;
-Space between shacks being too limited for this type of technology;
-Filling up / overflowing of trenches.

Study: Integrated Urban Water Management for Maxaquene A Informal Settlement, Maputo

-UCT Department of Civil Engineering, CIV 436 D Thesis no18

Prepared by Sheila de Carvalho, prepared for Neil Armitage

Objectives: -appraisal of services in Maputo, focussing on peri-urban areas

-propose 4 levels of service delivery catering for upgrades in water supply, sanitation and drainage

-introduce the concept of efficient resource management through waste reuse and recycling initiatives

Services: house connections 11.7%

Yard/ neighbours tap 54.4 %

Public standpipes 32%

Informal waste collection

Informal drainage system

Proposals:

level of service 1: full household water supply

Water borne sanitation & separate drainage system

Level of service 2: yard taps and on-site urine diversion composting toilets

Level of service 3: communal water supply and on-site pour-flush toilets (ablution blocks)

Level of service 4: upgrade current facilities through repair and management of the existing 12 standpipes and on-site vip facilities

Recommendations:

incorporate social, economic, political and environmental factors as well as technical considerations into development projects

Encourage community participation during projects and promote community based management organizations

Support and sponsor health programmes, training, skills development and capacity building initiatives

Create strong links between community organizations, govt sectors and private institutions

Define and consolidate the role of govt and strengthen inter-sectional partnerships

Case Study 1: Caracas *Slum-Upgrading Project* (CAMEBA) outside of Caracas

It was conceptualised by the Ministry of Urban Development and intended to identify contiguous settlement areas for consolidation through the application of a government sponsored Sectorial Plan comprising guidelines for neighbourhoods scale renewal. CAMEBA entertained three primary development goals: to provide infrastructure upgrade to the barrios (technical), to support local institutional development (social), to establish a loan fund for financing home improvements (economic).

The project was initiated in the late 1990's and their stance proposed a shift from the generic state sponsored 'slum-clearance' approach to the informal that has been practiced all over the world, towards a 'bottom-up', people-centred one. Not withstanding the fact that the cost of resettling entire communities is higher than the in situ upgrading of them, the concomitant loss of communality that inevitably accompanies relocation has proven far more costly in human social terms, with adverse affects for civil society. The Urban Pilot Project has now become an integrated component of the citywide initiative and is demonstrative of the success of bringing informal settlements into the larger order of Caracas. (Low: 2009)

Comprising a number of individual built projects, the common element lies in the conception of a vertical access system. Forming a basis for all design interventions this approach understands the favelas from the point of the ordinary citizen negotiating a relatively steep and unmade public terrain; managing the flows of people, of services and maximising density (vertical stacking) for collective buildings. (Low: 2009) This has been realised primarily through the careful renewal and upgrade of a number of existing interior pedestrian systems that organise the settlement. Connecting the upper with the lower reaches of this barrio, their redesign addresses the number of topographic conditions that have negatively impacted on human comfort. The problems of difficult access to individual dwellings, combined with the severe problem of rainwater run-off, and those of light and the absence of collective social space, have been creatively addressed though the joining of infrastructure with culture. According to Low, the street traditionally provides a primary armature for social interaction. Therefore in a disordered settlement of high density the pressure on the public outdoor is intense. When it is unmade it is subjected to extreme demands to perform on multiple levels and in the absence of formal construction it rapidly becomes eroded and constrains all movement and social interaction. Collective life becomes confined to the private.

Working on the ground and within the community afforded the means for a careful urban renewal, resulting in this urban-architecture and has realised a synthesis of engineering with architectural work. Consequently, not only has it become easier for people to gain pedestrian access within their barrio, but more impressively, these renewal insertions have afforded new opportunity for chance encounters between neighbours, for overlapping movement routes and generally encouraging social interaction. (Low: 2009)

The constraint of budget enforced the utilization of a limited formal palette. However, its in situ application lends credence to the demands for a stripped down but essential architecture whose form is derived directly from creatively interpreting user need. The casting of simple concrete platforms, steps, retaining walls and a water channel have evolved an integrated membrane capable of serving community on multiple and integrated ways. The side drainage channels functionally separate waste from people whilst simultaneously stabilising the stair elements and preventing erosion.

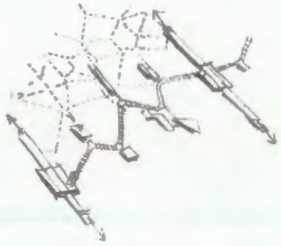


Figure 54: public stairway

(Low: 2009)

4. Architectural Approach

Architectural Case Studies

Urban Pilot Project:	'The vertical access system', San Miguel de la Vega, Caracas, Venezuela, 1998-2001
Architects:	Architects and Planners: Matias & Mateo Pinto (D'Lacoste) architecture studio
Clients:	CONAVI (National Housing Authority) in CAMEBA partnership with the World Bank and the PDVSA (National Oil Company)

Informal settlement residents, living below the 'baseline' are predominantly excluded from development and seldom capable of adapting and extending their socio-economic situation and are caught in a system that displays insufficient empathy for those who do not possess the means to engage formally. (Low: 2008)

These settlements comprise of high density, low-rise and disorderly sprawled development. Characteristically comprised of only private residential fabric, any economic or industrial activity is predominantly home-based. Limited in every aspect, the resultant communities have no land title, little supportive infrastructure, access to education, health, employment, and urban services.

An example of innovation is evident in the upgrade of informal settlements in Caracas, Venezuela, where design ingenuity of architects has enabled an alliance between local government, international aid and the private sector in successfully realising a viable and sustainable approach to addressing this type of problem. (Low: 2008)

Low states that the work of Mateo and Matias Pinto D'Lacoste represents a rare strain of architecture and that their Caracas Atelier has rightfully privileged the pre-existent as the primary basis for intervening in poor communities.

There is clear evidence of a precise reading of site in their work: site as both a material and phenomological construct. The interventions are measured and modest but are never at the expense of the architectural project as a formal investigation. The works are highly charged with an urban-architectural potency, transcending the conventionally accepted divide between centres and their periphery.

According to Low they have managed to place developmental work on par with, and possibly above that of the conventionally accepted projects that occur within developed contexts.

Their approach is highly speculative and explores different scales, hovering between the urban and the architectural and is firmly grounded through its considered response to inherited pre-existent human conditions on the ground. Low states that the effect of this is highly generative and transformative, producing an architecture of sustainable promise. (Low: 2008)

The areas of intervention lies within the favelas, which is frequently on steeply sloping land. The residual space, produced by leftover space between dwellings that are required to perform as both social and technical infrastructure, has been identified as a site of critical intervention, providing the greatest potential for transformation within limited means.

Unlike formal projects where local capacity in the form of skills and community structures pre-exist, urban performance, in contexts such as these, is heavily reliant on additional inputs. Low states that design strategies that reinforce community and the associated development of local capacity necessary for sustaining the everyday life of such interventions are necessary. In environments qualified by predominantly private structures, public infrastructure and amenity can add a new dimension to neighbourhoods and interrupt the accepted malfunctioning of communities. This frequently establishes new instability through a significant interference in a fragile body and architects/ designers are often required to work well beyond the conventional bounds of their training.

This approach is exemplified in the implementation of a number of projects in the areas surrounding Caracas. Four such interventions demonstrate a range of unconventional architectural and urban responses to the problem of immigration that is predominant in Latin America. These interventions are examples of an approach to design that may be described as architecturally urban, address ing the predominant absence of public infrastructure that is necessary for and supportive of community and civil society.

Case Study 2: 'Casa Comunal', the La Vega Community Centre.

Similar creativity has been applied in the design and implementation through a carefully measured intervention this project merges into the landscape. Housing a major sports court on its upper level, the building is supported by two levels of practice areas and gathering/ meeting rooms below.

Together with the ancillary service and ablutions, this ambitious accommodation of new community functions has been remarkably integrated into the surrounding landscape. Despite its scale, the designers have applied a series of landscape techniques to tame what could have been a major intrusion in a fragile settlement. The predominant use of pre-fabricated lightweight components gives a feeling of both social and physical transparency; between functional parts, as well as between the inside and outside of the building in its barrio landscape. The steel framed structure foresees the use of local semi skilled labour from within the barrios. Enabling both local economic advantage and the fostering of communal spirit it contributed to a sense of pride that assists in fostering sustainability through enhancing local ownership and belonging. These strategic design decisions contribute significantly in affording qualities of reintegration that begin to signify an identity for barrio upgrade within these contexts, and thereby contribute in establishing a new basis for thinking through the multiple role of design in informal settlement upgrade. (Low: 2009)

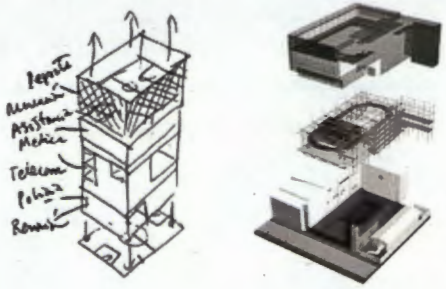
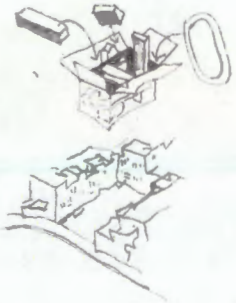


Figure 55: vertical gym

(Low: 2009)

Figure 56: vertical gym

(www.mp-arts.com)



Case Study 3: 'La Ladera Block housing Solution'

The third intervention addresses the construction of an extended landscape designed to accommodate the specific needs of barrio communities by responding to the growing pressure on local settlement practice. Translating a reading of the complex occupational patterns that pre-exist within the barrios, the designers have produced a re-configured ground plane. Building upon their conceptual understanding of the barrio as vertical access system, the new inhabitants are presented with a thickened or extended ground plane. This has been established through the design of an innovative 3-D structure that is capable of accommodating and ordering these complex occupational patterns. Resting in a simple sectional strategy, a series of platforms, supported on a steel frame, begin to describe a system of spaces whose potential lays in their capacity for multiple infill. Mediating specificity with indeterminacy, the outcome was intended to produce a living organism that, as the designers have described it, approximates a reality that hovers between both the barrio and the rationality of the tower in the park.

The strategic balance between freedom and constraint in the designed structure seems to set up opportunity for multiple opportunities to meet the multiple and emerging needs of families dwelling in the barrio. There is sufficient generic space, well connected to the outdoor, that affords opportunity for new and future uses. This projects an open framework, capable of interpretation and therefore of accommodating and building a local community culture, whilst adhering to the principles of the favelas. This 'La Ladera Block housing Solution' project designed by the Pinto's collapses the developed/ developing world divide, reinforcing the value of a people/ practice centred, as opposed to a predominantly formalist delivery approach, to interpreting the project of entry level housing. (Low: 2009)

Consistently designed within a collaborative mode, these projects represent the successful outcome of constructive cooperation between complimentary parties. The result of creativity, rather than functional technocracy, has been in qualitative decision making whereby community and environmental benefits are privileged above those of political, bureaucratic, legislative or individual need. (Low: 2009) The challenge of these projects is in the application of imagination; an architectural imagination that proposes an altered form of agency. Operating from the ground this form of practice demands greater investigation and support in attending to the problem of human sustainability in a globalising world. (Low: 2009)

Case Study: Nelson Mandela Museum, Qunu, Eastern Cape

The Nelson Mandela Museum, spread across three sites in South Africa, takes a lateral dispersed approach to creating a museum that makes the strategic thinking of Western institutions pale in comparison. It is a radical interpretation of a polycentric programme, that in each of the three sites provides social infrastructure opportunities for rural communities, for example a water pump at Mvezo and sporting activities at Qunu. This is not a conventional take on how and where to house a collection of artefacts, but rather a re-envisioning of a memorial as an active ongoing contributor to the community. In response to the urgent need to provide basic infrastructure to remote communities, this dispersed museum also includes communal facilities such a simple structures to create shaded meeting points, and water standpipes and washing places to bring clean water to the community.

Rural areas are the sites not only for innovative planning but for a new level of entrepreneurship and invention. We have already seen the play-pump, an example of how a design-led, simple innovation can play a huge part in addressing pressing issues. The entrepreneurship of the play-pump creates practical yet playful physical infrastructure tailored to the off-grid needs of rural communities in a way that also meets needs for community gathering spaces and the dissemination of vital health information. Boundaries are blurring areas where urban, suburban and rural disintegrate are ever increasing. (Cumberlidge, Musgrave; 2007)

Figure 57: museum as water infrastructure
(Cumberidge, Musgrave; 2007)

Case Study: Platform Making, Imazamu-Yethu, Hout Bay

This is the first in a series of 'platforms' that will be erected in the informal area of Imazamu-Yethu on the outskirts of Hout Bay. Conceptualized by Chilean-born architect Luis Mira, the project was developed and built by the community involved and assisted by a small number of students.

Initiated by Mira and developed as part of a first-year design studio at the University of Cape Town, this project is the first of many 'platform' prototypes. The idea is that more will be built in the same area and that these will serve as research work for Mira.

This 'platform' was completed in September 2009 and was designed to improve the existing site which only had one tap and one surface area for washing laundry. The design now offers and presents various different ways of using the washing area, as can be seen in the following images.

Figure 58: Imazamu-Yethu, new washing platform

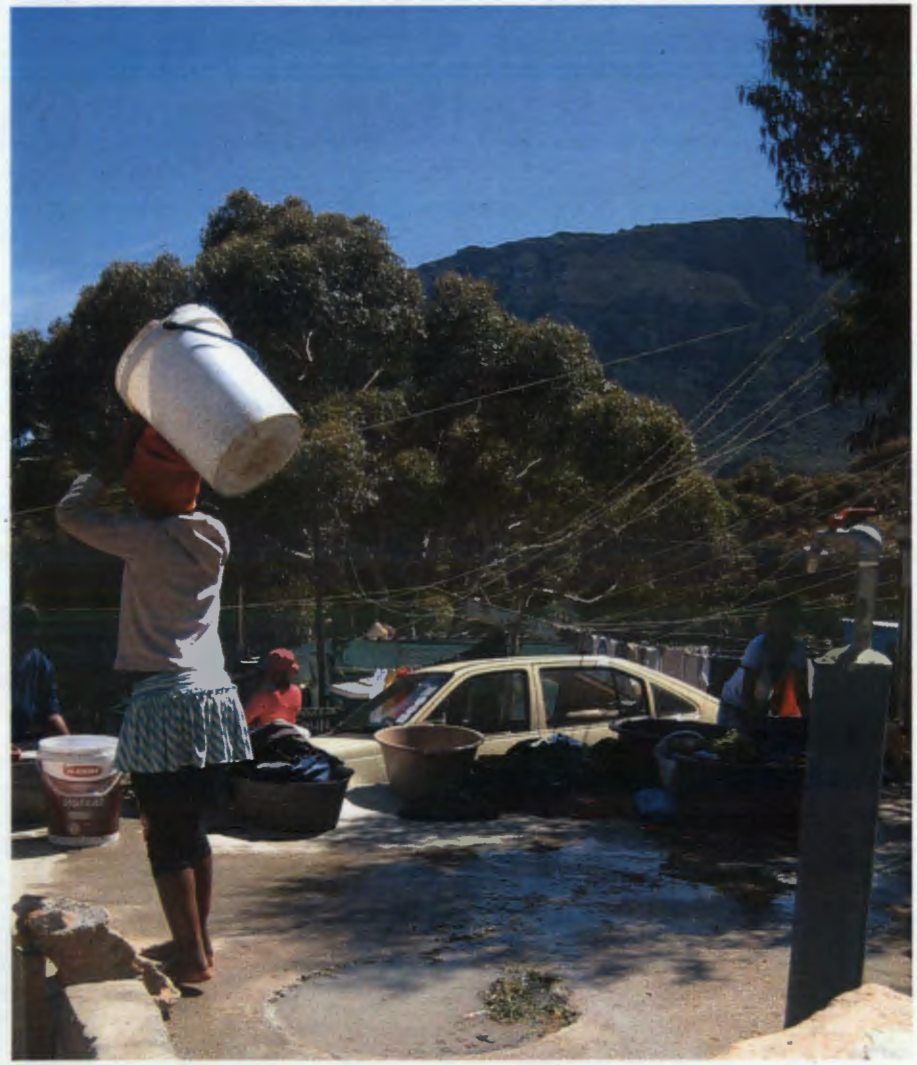


Figure 59: Imazamu-Yethu, new washing platform

Figure 60: Imazamu-Yethu, new washing platform

Figure 61: Imazamu-Yethu, new washing platform

Figure 62: Imazamu-Yethu, new washing platform

-next page

Case Study: Diepsloot Environmental Masterplan

The work displayed in this project is a pilot project for a new model of landscape architectural and urban design practice within informal settlements or slums. The work is under-pinned by extensive theoretical research into current capacity development theories. The process can be described as a fusion of capacity development and landscape architectural practice. (Tyrrell: 2009)

The site is Diepsloot, an urban slum in South Africa. It is located 24km to the north of Johannesburg's city centre. It began as a temporary transit camp and became an area with land allocated for permanent development by the poor. It is currently home to roughly 160 000 people, over half of whom are unemployed.

This project investigates informal components of the community through participatory GPS mapping, establishes a broad landscape vision that represents consensus between individual, organisational and institutional levels, and creates context specific platforms for small physical projects that can act as catalysts for achieving these visions. Due to the vast scale of the challenges here, the design seeks to work at three project scales simultaneously in order to create potentials for interventions that are greater than the sum of their parts.

The focus in the work displayed here is on understanding a complex system through investigative mapping. The proposal works on the premise that once the informal components of the settlement are better understood, they can be mapped in the same way as formal components. Landscape interventions then serve to link formal and informal systems together rather than to replace the informal with a top down design response. (Tyrrell: 2009)

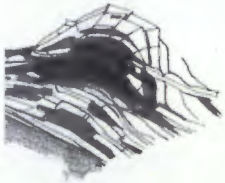


Figure 63: Diepsloot

(http://www.flickr.com/photos/8824022@N04/542089390/)

5. Landscape Approach

Globally, approximately one third of the urban population live in informal settlements, amounting to more than one billion slum dwellers.

The impact of slums on humanity and the environment have become so severe that they can no longer be ignored by city building professionals. In cases of war or a country's collapse, informal populations can often outnumber those living in the formal sectors of the city. If the design disciplines are to claim relevance in addressing the challenges of building a more humane and environmentally balanced planet, there must be greater creative effort in the creation of working methods that engage not only with the 'sustainability ' of the developed urban world but also with the urban slums of the developing world.

Design disciplines are not newcomers to the capacity development realm, but it is only in recent times that there has been a re-emergence of a physical emphasis in development interventions. The failures of past physical development interventions such as mass housing and top down strategic plans have opened the door for a new way of thinking about design, a process of designing with rather than for the urban poor.

It is in this context that, according to Mark Tyrrell, landscape architecture and urban design must lead the charge. The major development challenges lie in the uplifting of whole communities rather than just a few individuals and a new focus on community space and environmental infrastructure is key to this uplift.

Key to this is the relationship between infrastructure development and the landscape/ environment.

Case Study: Alexandria Canal: The Biological Plug

The Biological Plug project proposes a long term strategy for the remediation of Alexandra Canal. In doing so, it generates a number of significant by products that become the building blocks for further environmental and recreational upgrades. It is a design that translates a complex environmental process into an educational and recreational project with an iconic physical design.

The "biological plug" is designed as an element which cleans the canal by a progressive and shifting damming of the polluted waterway. The "biological plug" is a landmass of approximately one hectare located between two transverse weirs in the canal. The fill between the weirs is sediment from the canal floor excavated directly upstream of the plug. The land level of the plug will be set so major storm events can wash over into the canal down stream. Within the "Biological Plug" the contaminated sediment is treated by the use of phytoremeditsion. A process which sees plant material used to extract toxins and heavy metals.

The stormwater trapped behind the Plug is treated and scrubbed using sedge beds and effective micro organism (EM) technology. This technology originating from Japan uses a culture of 80 species of bacteria to carry out both aerobic and anaerobic breakdown of contaminants. The technology is being used in agriculture and wastewater treatment in Japan and lately in Australia.

Once treated the sediments are removed from the plug and used in the construction of new parks in the adjacent brick pits. The plug then moves downstream to treat fresh sediment. It is envisaged that the plug would move every 5 years. At each location the following benefits are achieved.

-a large garden is created providing the means to cross the canal
-a reserve of clean fresh water is created a crossing of the canal is made possible
-remediation is made visible and can be incorporated into education programs
-sediment from the canal is cleaned and then used in the construction of the parks
-important research into phytoremediation can be carried out in a controlled environment.

Water contained may also be diverted to a wetland established in Sydney Park.

Further detailed investigations will be needed to determine contamination in sediments, appropriate plant material, effectiveness of EM on the stormwater and sediment contaminants and whether there are other emerging technologies that may be useful in this situation for decontamination.

It will take 30 to 50 years for the "Plug" to move the entire length of the canal. During this time, upstream water management measures will be implemented to ensure that clean water is delivered to the canal. At the completion of remediation, a large store of fresh water, suitable for variety of uses, is held within the canal.

Figure 64: 'The Biological Plug'

Competition entry

(http://www.architectureaustralia.com.au/unlandscaped/resources/entries/2009/006.pdf)

Case Study: Community/ Private Partnership

Jonathan Timm, communications manager at Mvula Trust, explains that they took a very simple approach at Makause near Germiston. Their intervention was simple; improving a standpipe by building a soak-away. They were testing a people-centred approach that could be replicated at low-cost. The tap was built on top of an old dump, and they were dealing with leachate, not grey water. They dug below the rubbish, lined the sides of the pit with bricks that were salvaged from the dump to build a retaining wall, lined the pit with stone and sand, filled the pit with rocks, poured a little concrete pad around the standpipe, set up a soak-away leading into the pit and surfaced it with grass. The area around the standpipe was cleaned and landscaped. It was the local residents who came up with the most sensible design in the end, one that spoke to the unique characteristics of that standpipe. (Gullion: 2009: 28) While many big infrastructure projects require long planning periods, Mvula trust has shown that sometimes even the smallest effort can have a significant impact.

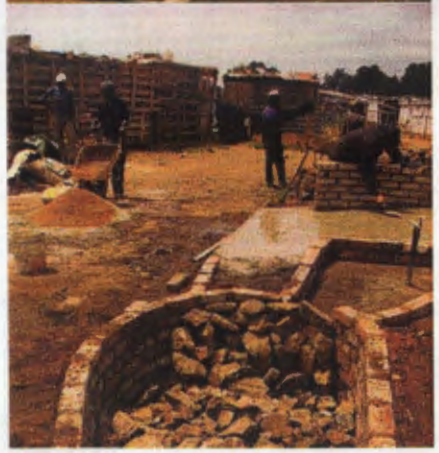
Mvula Trust enlisted the assistance of general Moyo of the Makause Community Leaders Forum, and together the two came up with a plan to build a small soakaway at one of the standpipes in the informal settlement.

Winter states that the institutional system continues to fail people living in these circumstances and therefore his research group recognised interim solutions were urgently required to minimise the risk. (Gullion: 2009: 29)

Consequently, changing the way planners and engineers think about how grey water impacts on the lives of people and the technologies residents are required to use in informal settlements, is perhaps the first step to developing appropriate solutions. Winter stresses that to achieve this, it is important there is a clear understanding of the social dynamics within a settlement and the behaviour of end users. Therefore, solutions begin with a social understanding before designing the technologies. (Gullion: 2009: 29)

Figure 65: community action
(Gullion; 2009)

Figure 66: community action
(Gullion; 2009)



6. Integrated/ interdisciplinary approach

Ultimately one of the aims of this thesis is also to try and challenge the stereotypical engineering-based approach of the City towards mitigation and stormwater treatment. The need for inter-disciplinary work and investigation is also recommended and has been highlighted in many of the previous chapters.

The case studies referred to below showcase examples of interdisciplinary methods for renewal that emphasize citizen involvement. Critical to all of them is that they evolve strategies for change from the ground up.

This can also be seen in the approach of the projects in Caracas, as described earlier in this paper.

Case Study: Lourens River Flood Alleviation Project

Examples of the benefits of a multi-discipline approach could be seen in the Lourens River Flood Alleviation Project, where ecologists examined each cross-section along the length of the river in the field. They outlined ecological and geo-morphological concerns and made suggestion for softening the impacts at each river reach. The eventual designs incorporated many of the suggestions proposed by the ecologists to soften the blow, including:

-multi-stage channels, set according to ecological flow zones, where appropriate,

-a policy of non-disturbance of the river bed and low-flow channel form (including in-stream morphology such as rifle-pool sequences)

-uneven river margins

-establishing slopes of at least 1:2, where possible

-re-vegetation with indigenous riparian plant species

-major earth works focused on outside bends, thereby maintaining sinuosity

-establishment of a nursery to propagate indigenous plants for the rehabilitation process

The project illustrated that it is possible to incorporate ecological principles and social considerations into major urban river works, even where engineering considerations must take preference, to the benefit of all the residents. There is even an economic upside, with the cost-benefits analysis showing us that money spent on softening has a far higher return than money spent on hard engineering. (Brown, Magoba; 2009; 336)

The figures on the left show ways in which typical engineering drainage systems can become more spatial and on the next page one can see this approach taken even further where the idea of the floodplain is also incorporated into the design of the space.

Figure 67: multi-discipline approach
(Brown, Magoba; 2009; 336)

Case Study: Ala Plastica, Argentina, 1995-ongoing

The work of artists collective Ala Plastica in Agentina may be visible only on a micro-scale but it incorporates an impressive bioregional vision focusing on major strategic work with local communities as well as direct actions and built interventions. This study demonstrates how a group of independent practitioners can be effective communicators between communities and authorities at high level. Through their advocacy, networking and live projects, the group has linked together organization from UNESCO to small community groups to realize creative social and environmental projects in the delta of the Rio de la Plata. (Cumberlidge, Musgrave; 2007: 94)

The Rio de la Plata estuary forms the final stage of a water system of the Paran/ Plata basin. Ala Plastica is a cross-disciplinary collective that links ecological, social and cultural programmes. The bioregional initiative grew out of a field project on degraded natural reedbeds, aiming to revive this naturally occurring ecosystem which filtered sewage and other impurities from the water. (Cumberlidge, Musgrave; 2007; 96)

The current major project under the Bioregional Initiative is Project AA, which addresses the effects of flooding on the vulnerable communities of the region. The group has built emergency lodges for flood-prone communities, which act as community centres and ecological research stations. They have also constructed embankments and other protection for school buildings.

Figure 68: Ala Plastica

(Cumberlidge, Musgrave; 2007)

Figure 69: Project AA

(Cumberlidge, Musgrave; 2007)

Multi-disciplinary approach
I have approached the African Centre for Cities' CityLab, after deciding to engage with one of their thematic projects: Floods and the City, which relates directly to the central issue of this thesis. Engaging with their 'brief' will allow me to make use of the incredible source of inter-disciplinary knowledge on our campus in trying to tackle the issue of flooding.

What is the CityLab?
The CityLab is a set of projects run by the African Centre for Cities that aim to enrich our understanding of the challenges of integrated human settlement, using practical issues generated by the experiences of greater Cape Town. The main idea of the CityLab is to draw from the considerable urban expertise of full-time UCT academics and senior graduate students based in departments. They hope to draw UCT students into greater contact with other researchers and practitioners, and hope to revive the debate on how to realise a more integrated human settlement.

What is the CityLab planning?
The most important area of work of the CityLab is the ongoing research of urban specialists at UCT. They hope to present a series of thematic and case based research projects focused on Cape Town that will enrich and extend existing research already taking place.

The CityLab wishes for one to bring one's own work to the attention of practitioners and other scholars at UCT working on applied issues or the same geographical space through a process that will include monthly seminars on a dedicated topic /field excursions and eventually a joint book publication. The idea is that one would continne to publish in one's own disciplinary journals, but that one could publish the work in other forms of popular distribution. The CityLab will ensure that the knowledge generated is brought to the attention of the relevant policy makers. In some cases they will work directly with practitioners and there may be new opportunities to follow implementation schemes.

The CityLab has planned four collective thematic projects in order to achieve its applied research objectives. Each project group would meet monthly, and will run for about a year, culminating in a public dissemination programme and an academic book or special issue journal.

1. **CityLab Thematic project 1: FLOODS and the CITY.**
Both the City and the PGWC have expressed considerable interest in exploring this problem afresh and they are keen to draw from any sound scientific inputs one can muster as they address one of the most pressing issues in informal settlement management in Cape Town and they will have staff directly involved in this theme.

They want to draw in specialist work on issues that inform how floods are understood in Cape Town, and are trying to find the relevant people at UCT who are working on topics that relate to and would inform better urban flood management such as river catchments, geological structure, infrastructure resilience, architecture for flood prone housing, the watertable, wetlands, land use cover change, land use management, insurance, finance, appropriate construction, flood related disease, the lived experience of flooding, floods and biodiversity, climate change, disaster risk strategies, pollution and flooding etc.

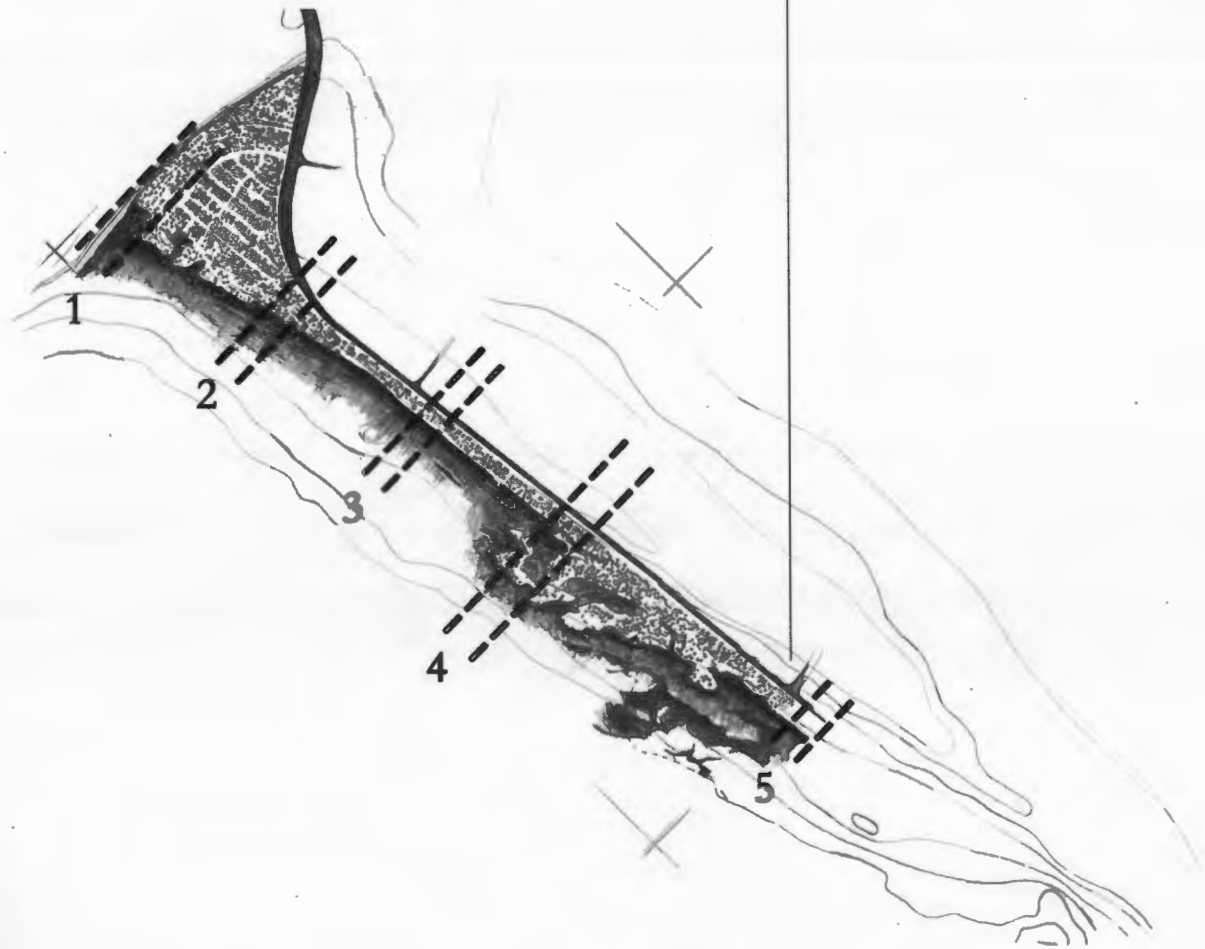
The idea is for specialists to present substantive research findings. The learning will occur through exposure to each other and to the everyday challenges of residents.

2. **CityLab Thematic project 2: HEALTHY CITY**
A suggestion was made that the CityLab explores greater Cape Town from a healthy cities perspective. This is broadly the idea that the burden of disease can be dramatically reduced by non-biomedical interventions such as improved air quality, the relationship between diseases like TB and the built environment, crime reduction, urban health and climate change, better land use planning that enables walking, investment in water quality enhancement, improved traffic safety, safer environments for children etc. Students from the medical school are keen to work with engineers, planners, architects, sociologists, anthropologists etc.

3. **CityLab Area based project 1: CENTRAL CITY**
The City, Province and Cape Town partnership are all ACC partners, while the ACC also has a major commitment to the issue of cultural regeneration. The central city area is thus an obvious starting point for the area based work and they are looking for people at UCT who are working in areas such as land restitution, landscape and meaning, land and culture, CIDs, infill development, gentrification, tourism, alternative design, land regulation reform, land value issues.

4. **CityLab Area based project 2: PHILIPPI**
Academics across the university are engaged in primary research in the highly contested environment of Philippi where many of the substantive challenges of integrated human settlement emerge. Using a case based methodology and an interdisciplinary dialogue the hope is to foster an understanding of complex problems. Work currently being done in the area is focussing on pollution, food security, housing delivery and climate change adaptation in Philippi.

Figure 70: site & areas of intervention



DESIGN

INITIAL STRATEGY

The initial strategy was derived from the mapping exercise during which the worst-hit flooded areas were identified.

The idea was then to develop 5 different levels/ scales of infrastructure. These would then be located close or next to these initial highlighted areas.

These 5 interventions were thus site-based but were to serve as precedent/ prototypes for similar conditions/ interventions on the site. These interventions were thus strategically placed to assist and tackle the issue of flooding by using various principles and strategies.

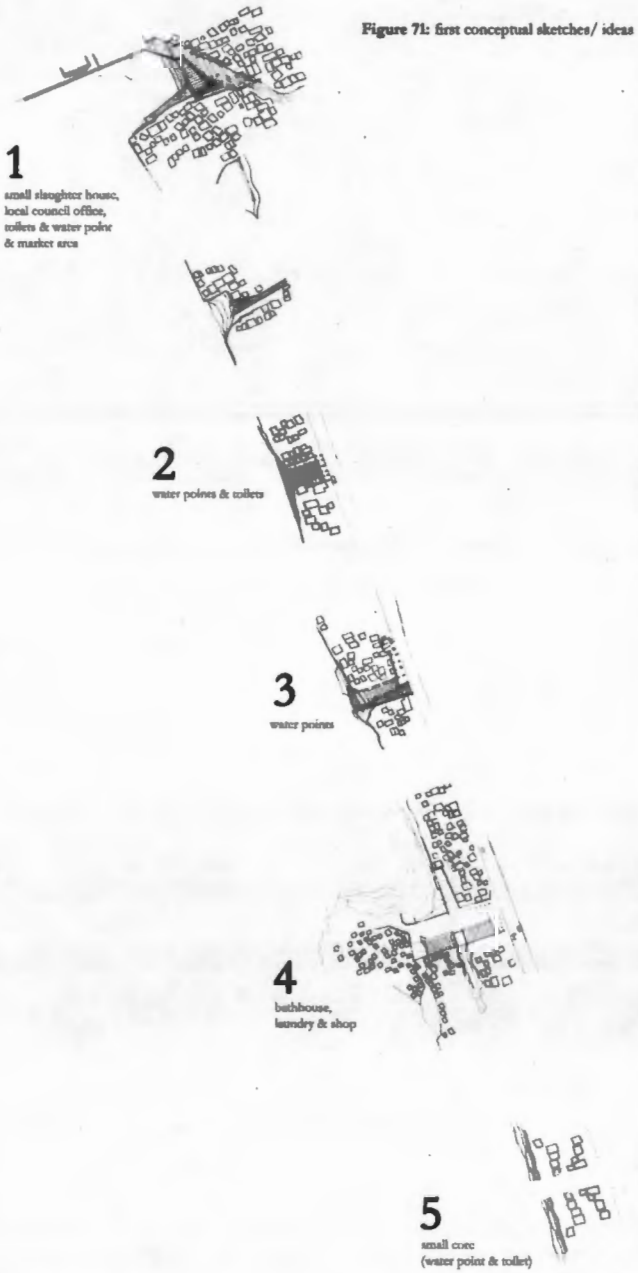


Figure 71: first conceptual sketches/ ideas

INITIAL INTERVENTIONS

The sketches on the left are the first concept sketches of the 5 proposed areas of intervention and examples of the different levels of infrastructure provided on site.

Figure 72: process: intervention 1:

model

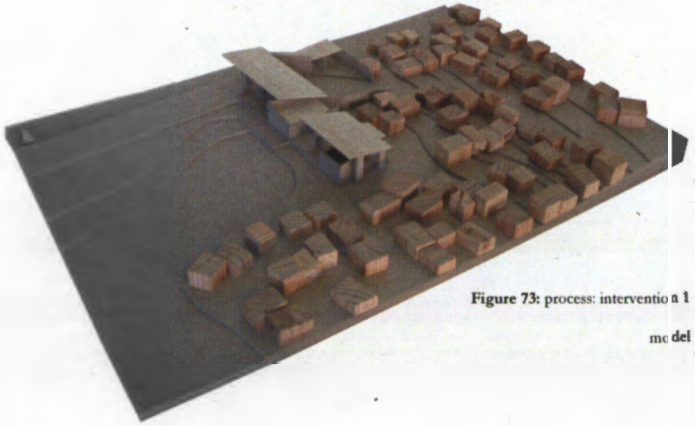


Figure 73: process: intervention 1

model

INTERVENTION 1

-level of provision: 4

-programme:

-small slaughterhouse

-local council office-

-toilets

-laundry

- a retention dam/ playing field as well as a 'reservoir'/ water storage space under the new square as a forecourt to the busy station

This intervention was to address the issue of flooding right next to the station

Strategies:

edge condition
retention dam
water retention pond under square
retention pond/ playfield
constructed wetland
build on/ next to flood prone area
to prevent people from building there

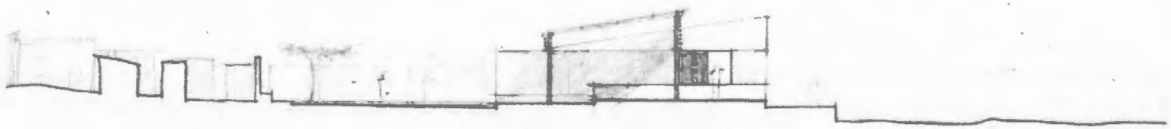


Figure 74: process: intervention 1:

conceptual sectional elevation

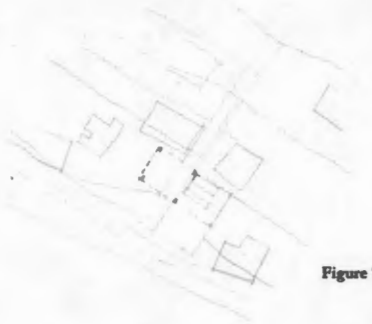


Figure 75: process: intervention 2:

conceptual plan

Figure 76: process: intervention 2:

conceptual elevation

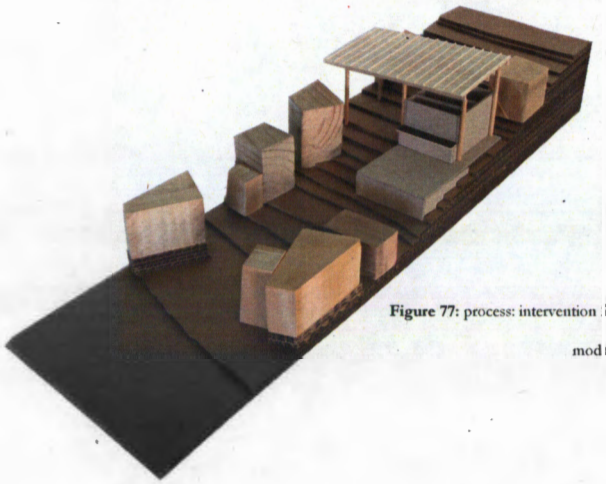


Figure 77: process: intervention 2:

model

Figure 78: process: intervention 2:

conceptual sectional elevation

INTERVENTION 2

-level of provision: 2

-programme:

-water points

-toilets

This intervention was to be located on the edge of the settlement on an existing movement route which also doubled as a water channel

Strategies:

-central/ link
-storage for water when flooding occurs
-raised area
-soakaway

Figure 79: process: intervention 2

-diagrammatic representation

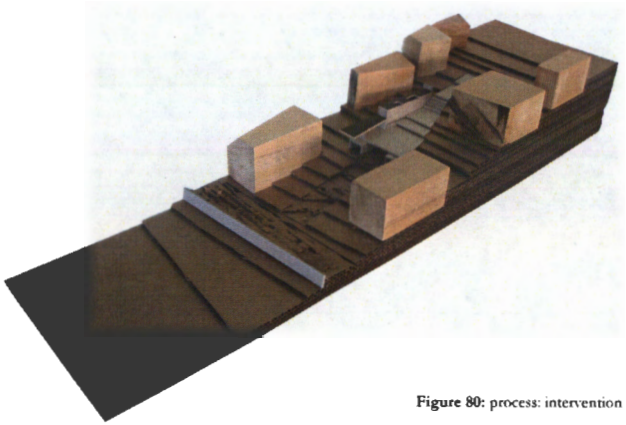


Figure 80: process: intervention 3: model

INTERVENTION 3

-level of provision: 1

-programme:

-water points

-washing platform

Strategies:

-central/ sponge
-storage for water
-channels for drainage
-soakaway
-filters
-constructed wetland

Figure 81: process: intervention 4:

plan

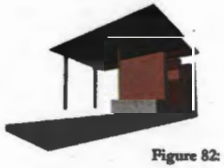
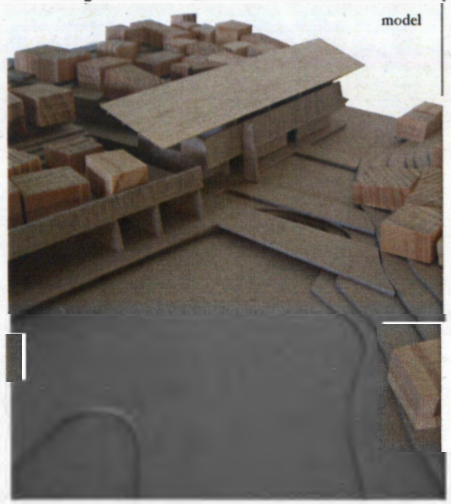


Figure 82: process: intervention 4:

idea

Figure 83: process: intervention 4:

model



INTERVENTION 4

Level of provision: 3

-programme

-bathhouse

-shop

-strategies

-link/ 'pier'
-access/ drainage-filters
-retention dam
-constructed wetland

Figure 84: process: intervention 4:

conceptual sectional

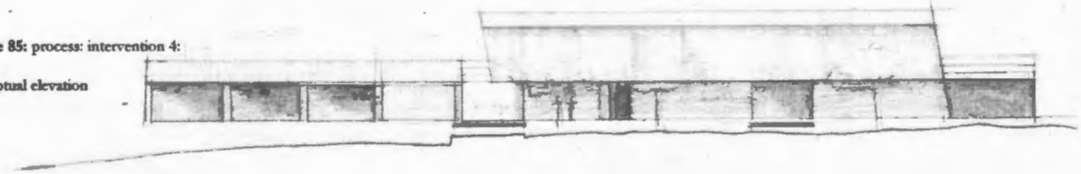


Figure 85: process: intervention 4:

conceptual elevation

INTERVENTION 5

Level of provision: 3

-programme

-core

-water point

-toilet

-Strategies:

-access/ walkway
-ie dual infrastructure
-prepared land
-on-site services
-platforms for building
-dictated by placement of cores

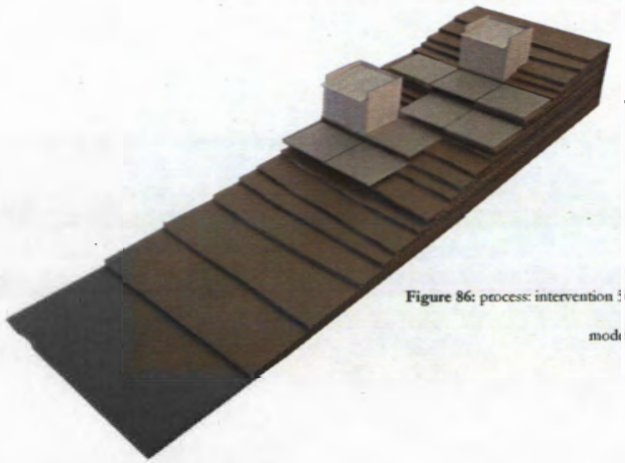


Figure 86: process: intervention 5: model

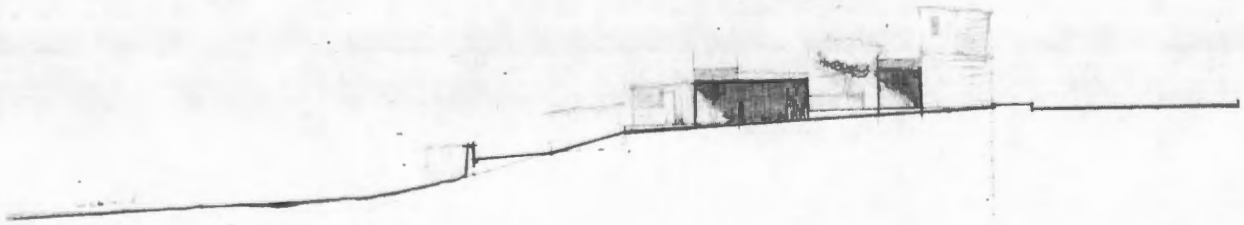


Figure 87: process: intervention 5: model

NEW STRATEGY: *'the element'*

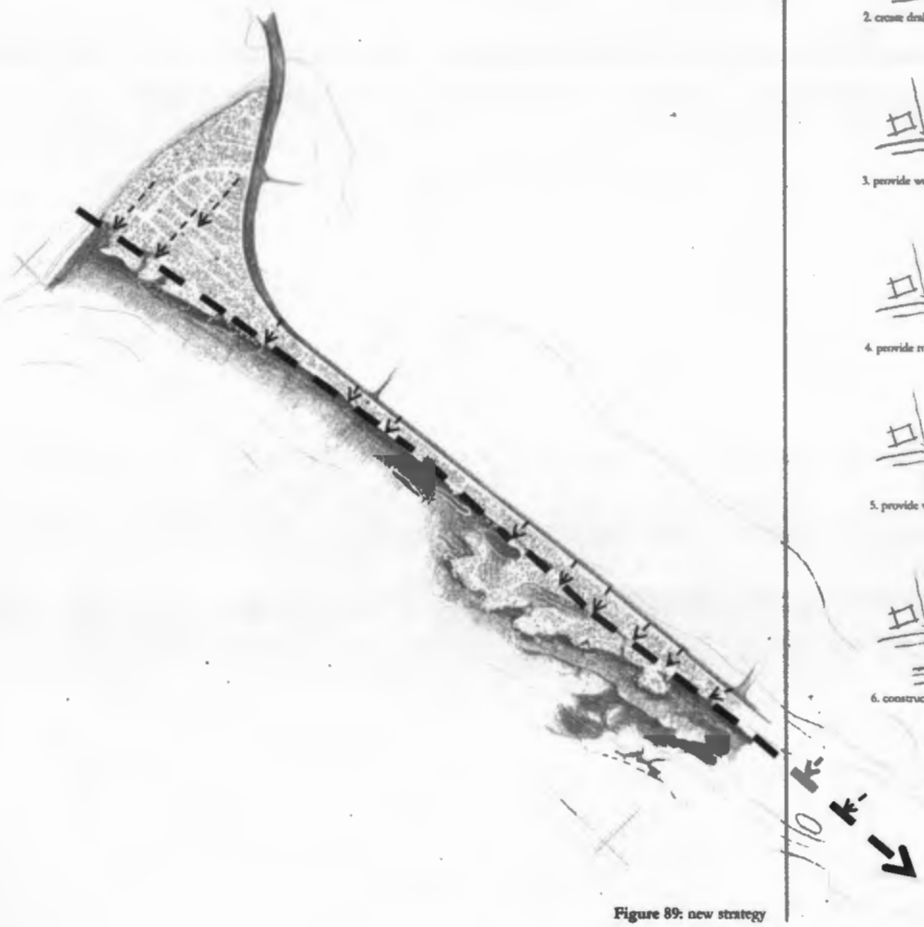


Figure 89: new strategy

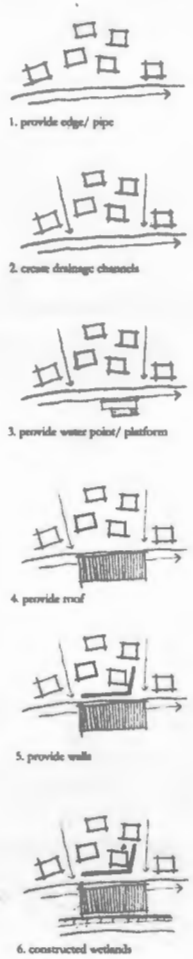


Figure 88: from top to bottom:

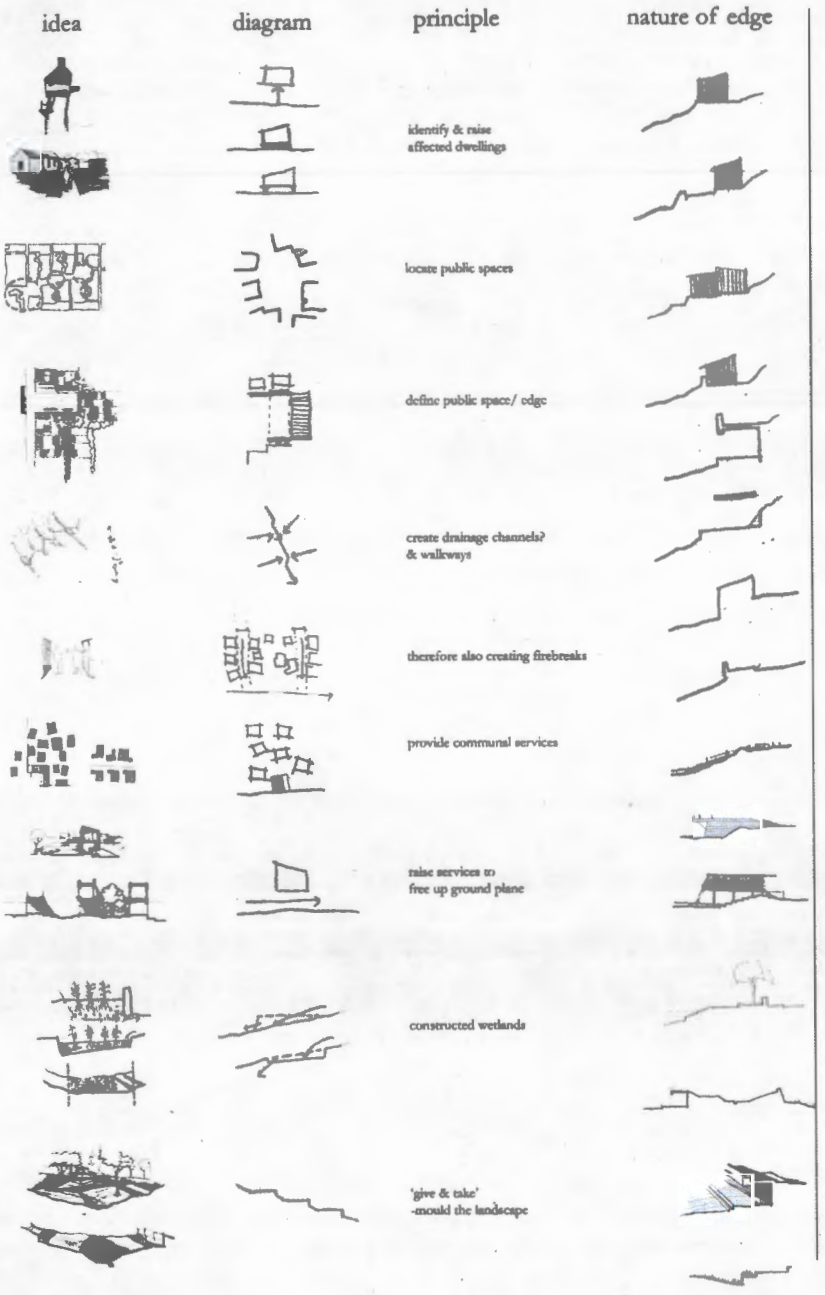
incremental upgrading process

The new strategy is multi-faceted in nature. It makes use of the slope of the site and in essence tries to deal with the water at all levels: flooding, sewerage, surface water etc.

The element would span the entire 2, 5 km of the site and would form an edge to the wetland. At certain points this 'edge/ element' provides different points of use. This element would provide various services (including water related infrastructure) at different points and would allow for different usages.

Essentially it makes use of the slope of the site ,channels away sewerage, provides adequate drainage, provides water, water storage in case of flooding, platforms to build on/ against and provides.

'Defining an edge of opportunity'



MAIN IDEAS/ DESIGN PRINCIPLES

The diagrams on the left show the main/ essential ideas of this project.

Figure 90: all drawings:

main ideas/ principles

EDGE CONDITION

These diagrams explore the edge condition and determined the 'edge/element' and the dwellings affected by flooding

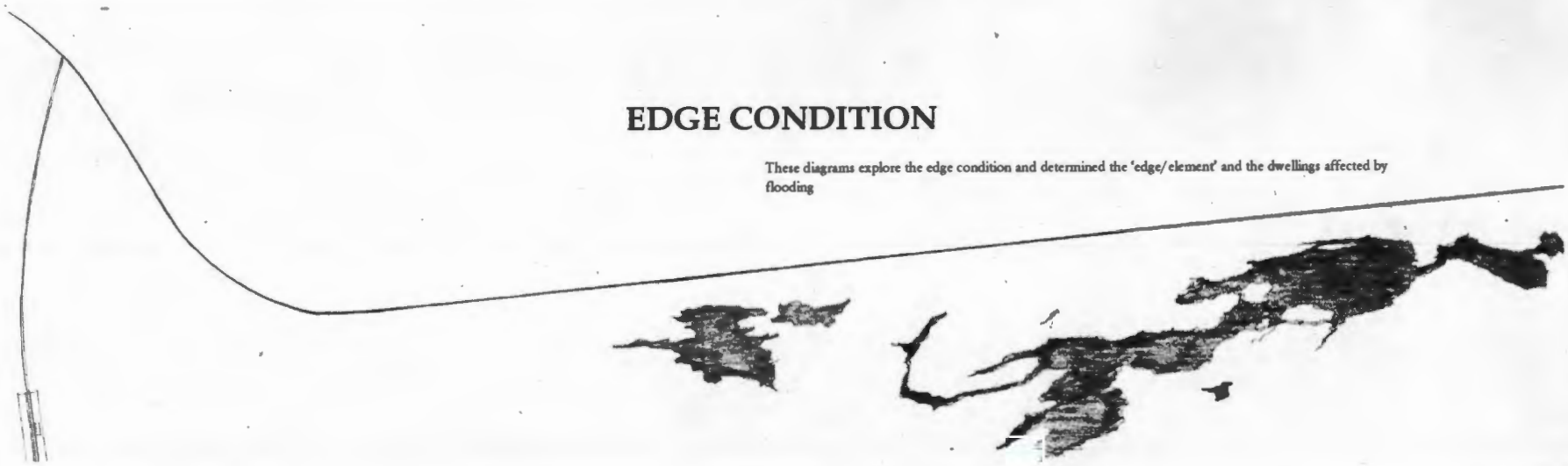


Figure 91: edge of permanent water bodies

Figure 92: edge between man-made & nature

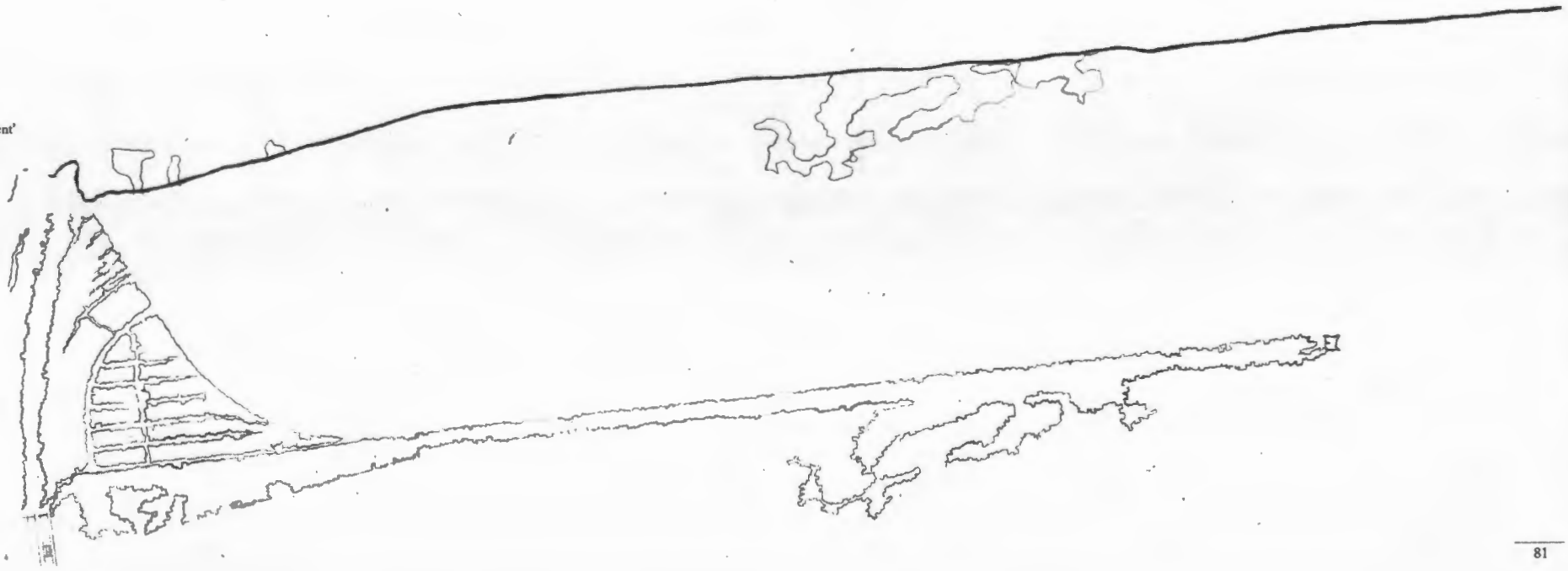


Figure 93: the edge/ 'element'

Figure 94: edge of the settlement

ELEMENT STRATEGY

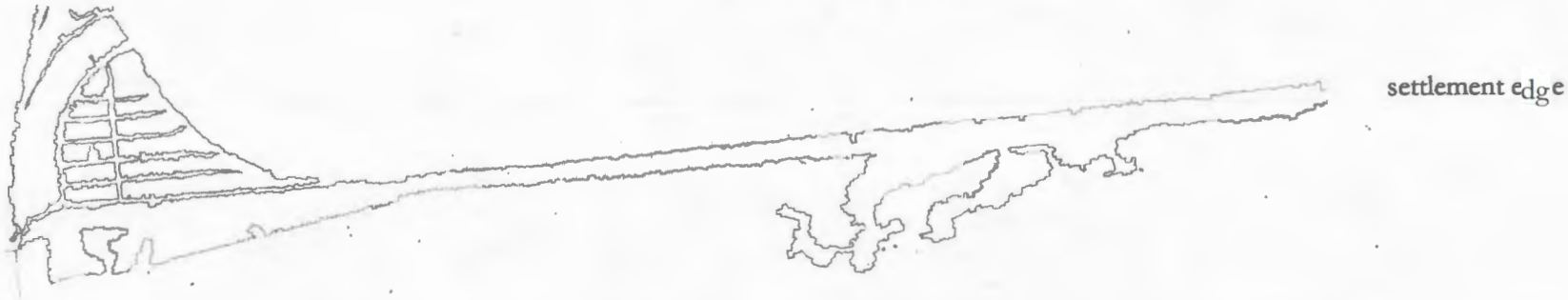


Figure 95: settlement edge

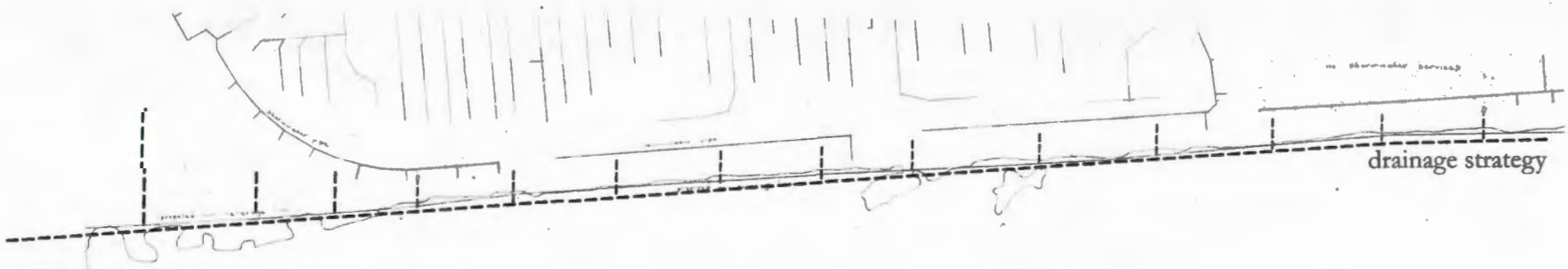


Figure 96: drainage strategy

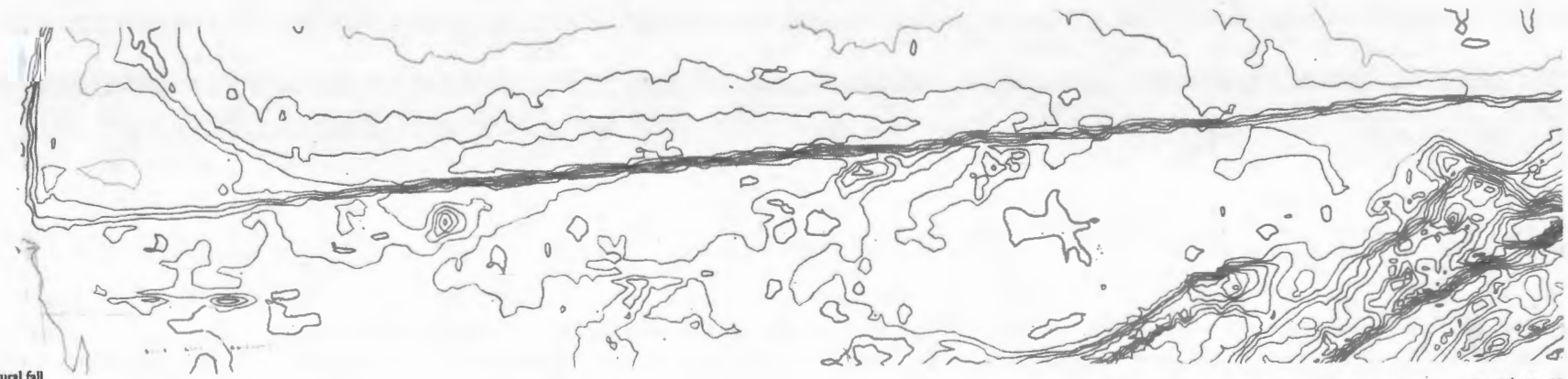


Figure 97: contours: natural fall

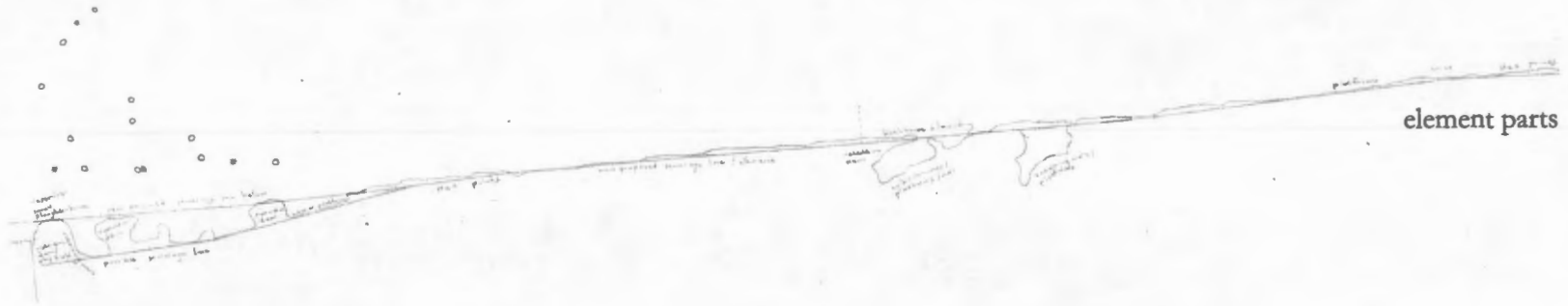


Figure 98: element parts

Figure 99: element

Figure 100: no-build zone

Figure 101: dwellings affected

BASIC CONCEPT DIAGRAM: *'the edge/ element'*

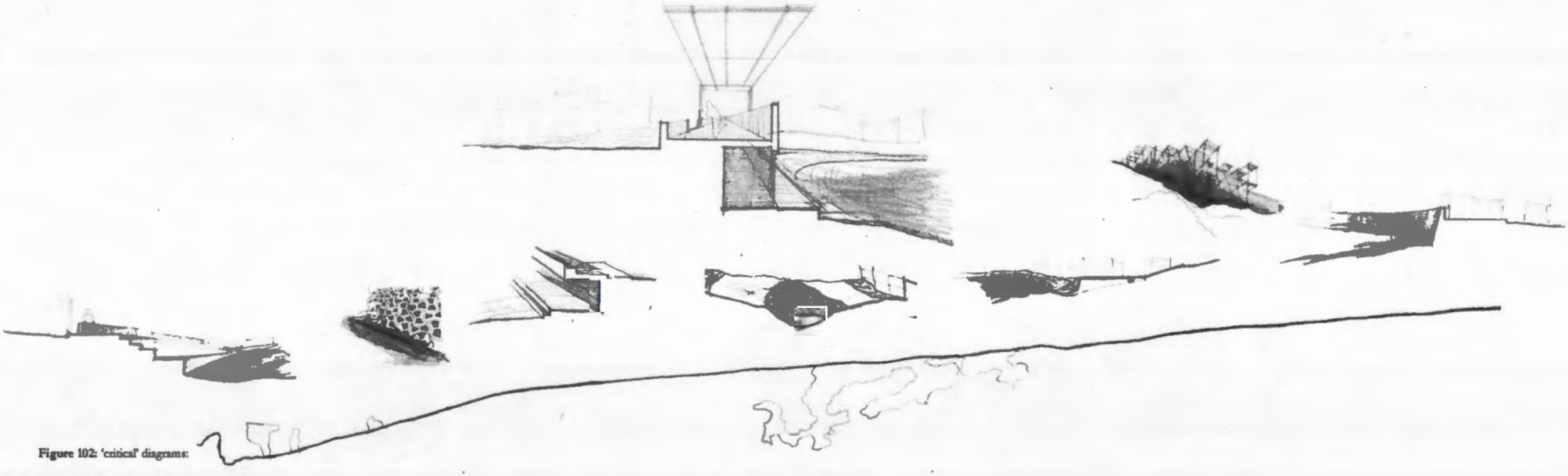


Figure 102: 'critical' diagrams:

Possible scenarios for edge condition

'In real terms, floods are good. Cyclones are good

They play a good role ecologically

What makes them disasters are vulnerable people."

-Ms Paula Zucula, head of the National Disaster Management Institute, Mozambique. (Brown, Magoba; 2009; 31)

Figure 103: houses on stilts on water
(SDI. 2009. p5)

Figure 104: shack on stilts

(Kronenburg: 2007)

3. SMALL

Changing attitudes

As a result of increased urbanization, a lack of decent service delivery and basic public infrastructure, there is a high incidence of risk/ hazards within informal settlements. Various individuals within informal settlements in the City of Cape Town, and also within the TR-Bongani Section have demonstrated small 'self-help' mitigation strategies'. These are being explored as strategies and ideas, which combined with various other initiatives and strategies, could begin to help build disaster resilient communities. Knowledge can be gained by looking at the everyday challenges of residents and implementations within the area.

Relocation, in order to avoid hazardous areas, is seen as a measure to and suggested as a solution to disaster risk, but there are serious problems associated with this. Relocation to less hazardous areas is highly effective in reducing physical risks, but overlooks the centrality of livelihood security to vulnerable people and the intensity of the socio-economic pressures that drive them to occupy hazardous land (Twigg; 2004). In the case of TR-Bongani Section, the City of Cape Town's Disaster Management Official said that they had several meetings with the councillor and other concerned parties in the area regarding relocation but found that people didn't want to be removed. The official also indicated that because of the continued increase of people to the city, alternative space for relocation was also very limited.

According to Twigg, relocation schemes often/ mostly tend to involve sites on the edges of cities where land may be readily available, but jobs and many other facilities not. For this reason relocation is often resisted by vulnerable groups and is often very costly.

Due to functioning of land and property markets, and an inability of land-use planning to cope with rapid population growth, migrants to areas frequently locate and settle in hazard-prone areas.

TR-Bongani Section is an example. Hazard-prone locations are often preferred by the poor as a way of reducing everyday risks by gaining greater accessibility to urban services and employment, even though natural hazard risk may be increased (UNISDR; 2002).

People in hazard prone areas have acquired considerable knowledge and technical expertise for managing risk. Knowledge of how vulnerable people respond to a threat is essential in informing/ influencing outside interventions. People have, out of necessity, devised their own methods for protecting themselves and their livelihoods. These methods are based on their own skills and resources, as well as experiences. Their knowledge systems, skills and technologies are usually referred to as indigenous knowledge. (Drowley, Jember, Kassi & Smith: 2007; 36)

Due to the knowledge and skill differences, some people cope better than others in mitigation measures. Some households have constructed their floors from cement to raise the floor level in order to protect their belongings from seepage. Informal drainage routes have also been observed in some households. But these drainage routes cause water to stand in other areas of households since there is no other area to drain the waste water to. (Drowley, Jember, Kassi & Smith: 2007; 36)

Reliable supplies of clean water and adequate sanitation and sewerage systems are essential to reduce water-related infections. Low-cost technologies for putting up stand-pipes and building toilets and drains have long been available, and, with full community participation, extensive water and sanitation systems can be installed. (Twigg; 2004)

The importance of making facilities disaster resistant is sometimes overlooked, but this too is relatively simple in technical terms. For example, water pipes and pumps can be raised above anticipated water levels, toilets can be positioned where they are less likely to be flooded, drains and sewers can be designed to cope with large volumes of water, and regularly-spaced manholes can give easy access to drains and sewers it they need to be unblocked. (Twigg; 2004)

Perhaps it is also time to accept that parts of the Cape Flats are always going to flood in winter, and to plan accordingly. This situation is not unique and one can look to other parts of the world for clues, where this is also the case. For instance, in some places with a lot of water and seasonal flooding, people live in houses on stilts.

Figure 105: mitigation: shack on stilts **(Bouchard,. Goncalo, Susienka & Wilson. 2007)**

Figure 106: mitigation: shack on crates **(Bouchard,. Goncalo, Susienka & Wilson. 2007)**

Figure 107: mitigation: shack on foundations **(Bouchard,. Goncalo, Susienka & Wilson. 2007)**

Figure 108: mitigation: day-care raised from the ground

Figure 109: mitigation: layers of sheeting on floor

(Witten; 2007) Living areas are kept high and dry and building on stilts does not displace flood water nor does it harden the catchment in the same way as conventional buildings. (Brown, Magoba; 2009; 330)

As demonstrated in examples from various corners of the world, including the TR-Bongani Section in Khayelitsha, a small number of local residents have started demonstrating 'self-help' mitigation strategies. **Small** explores these examples and the organizational strategies and physical mitigation strategies employed in contributing to effective disaster mitigation strategies.

The United States Federal Emergency management Administration distinguishes five basic approaches to flood-proofing, a means to protecting individual structures from the effects of flooding:

-Relocation
-Elevation-raising the building above the flood level, either on piles or on a mound
-Flood walls
-Dry flood-proofing-making the building watertight
-Wet flood-proofing-allowing the basement and ground floor to flood while keeping the habitable portion of the building above flood level. (Miller: 1997: 53)

The recent flooding caused by heavy rainfall, particularly in informal settlements, has been aggravated by littering and dumping, according to city officials, and this has prompted a scientist to suggest houses be built on stilts.

Dr Kevin Winter, an environmental science researcher at the University of Cape Town, said: "Littering certainly obstructs the flow of water preventing it from being drained naturally."

Winter said water was supposed to be drained slowly but hardened surfaces like roads and buildings upset the natural flow of water through land, into river systems and eventually to oceans. The fact that informal settlements were built on wetland areas made it "extremely difficult" to construct houses there, said Winter.
He suggested that authorities improve river maintenance and avoid building in wetland areas but acknowledged that alternative land was scarce.

"Maybe people need to raise their homes and build on pillars or stilts like in Malaysia," –Kevin Winter.

One of the primary causes of the increased flood risk in the informal settlements is the inadequate building practices used by the residents. Because their deficient structures were erected in unsuitable locations, the flood risk is further elevated. There are relatively simple and inexpensive building techniques that can reduce the flood risk. If the City of Cape Town were to communicate a set of structural guidelines to the residents in the areas prone to flooding, the residents would be more aware of their ability to minimise flood risk at the household level.

As a precautionary measure for flooding, many residents build up near the base of their homes using sand, which is sometimes provided by the City (Bouchard,. Goncalo, Susienka & Wilson. 2007: 60)

The use of pallets in Lotus River to prevent seepage can be seen on the image on the left. Concrete flooring in Lotus River to reduce seepage was also observed. Another common mitigation strategy employed is the use of stilts, as seen in Marcus Garvey. (Bouchard,. Goncalo, Susienka & Wilson. 2007)

Figure 110: mitigation: cement around edge of shack

Figure 111: mitigation: layers of material to keep out water

Figure 112: mitigation: raised area around shack

Figure 113: post flood:

Cleaning up

Figure 114: mitigation: raised floor/ house on stilts

Figure 115: mitigation: level/ hard surface at entrance to shack

Figure 116: mitigation: layers of flooring

Figure 117: mitigation?:

Sand packed around edge of shack to channel water

Case Study
Table : Prototype Flood Risk Index
Phola Park
Philippi

	Houses indexed:	122		
risk	**Total houses:**	1375		
	Percent total:	8.87		
		Total Count	**Percentage**	**Weight of risk**
roofs	Pitched	58	0.475	0.0
	Flat	-47	0.385	1.0 roof risk
	bowl	-17	0.138	0.0
floors	-Above	-10	0.082	0.0
	-Level	-59	0.084	0.09 flood risk
	-below	-53	0.434	0.27
typography	-highest 3rd	-190	0.138	0.0
	middle 3rd	-800	0.582	0.14 highest risk
	-lowest 3rd/ valley	-385	0.28	0.27
bodies of water	-Not present	X	0.0 desired level	0.0
	-Bordering	X	1.0	0.14
	-Within	X	0.0	0.27
rubbish removal	-Daily-weekly	X	1.0	0.15
	-weekly-monthly	X	0.0	0.07
	-monthly	X	0.0	0.0

(Bouchard, Goncalo, Susienka & Wilson, 2007: 62)

Table : Comparison of structural techniques to reduce seepage

Method	**Difficulty**	**Estimated cost**	**Pros**	**Cons**
Pallets	Easy	-None to low	Cheap Readily available Can be handmade Simple to set up Easily repaired	Open floor (see page) -Rotting -Low stability Low strength
Sand/concrete bags	-Easy/medium	Low	-Cheap Provides foundation -Mobile -Easy repair -Minimal building materials	-Does not prevent seepage -Stability decreases With height
Concrete	-Medium	-Low to medium (50 kg @ R47,90)	-Long life -Foundation Sturdy -Prevents seepage	-Pooling may occur -Not easily repaired -Cold (no insulation) - May be difficult to pour -Not mobile
Stilts	-Difficult	Probably costly	-Raise house to desired level -Area for storage	-Requires some level of engineering -Lumber not readily available -Low stability if constructed improperly

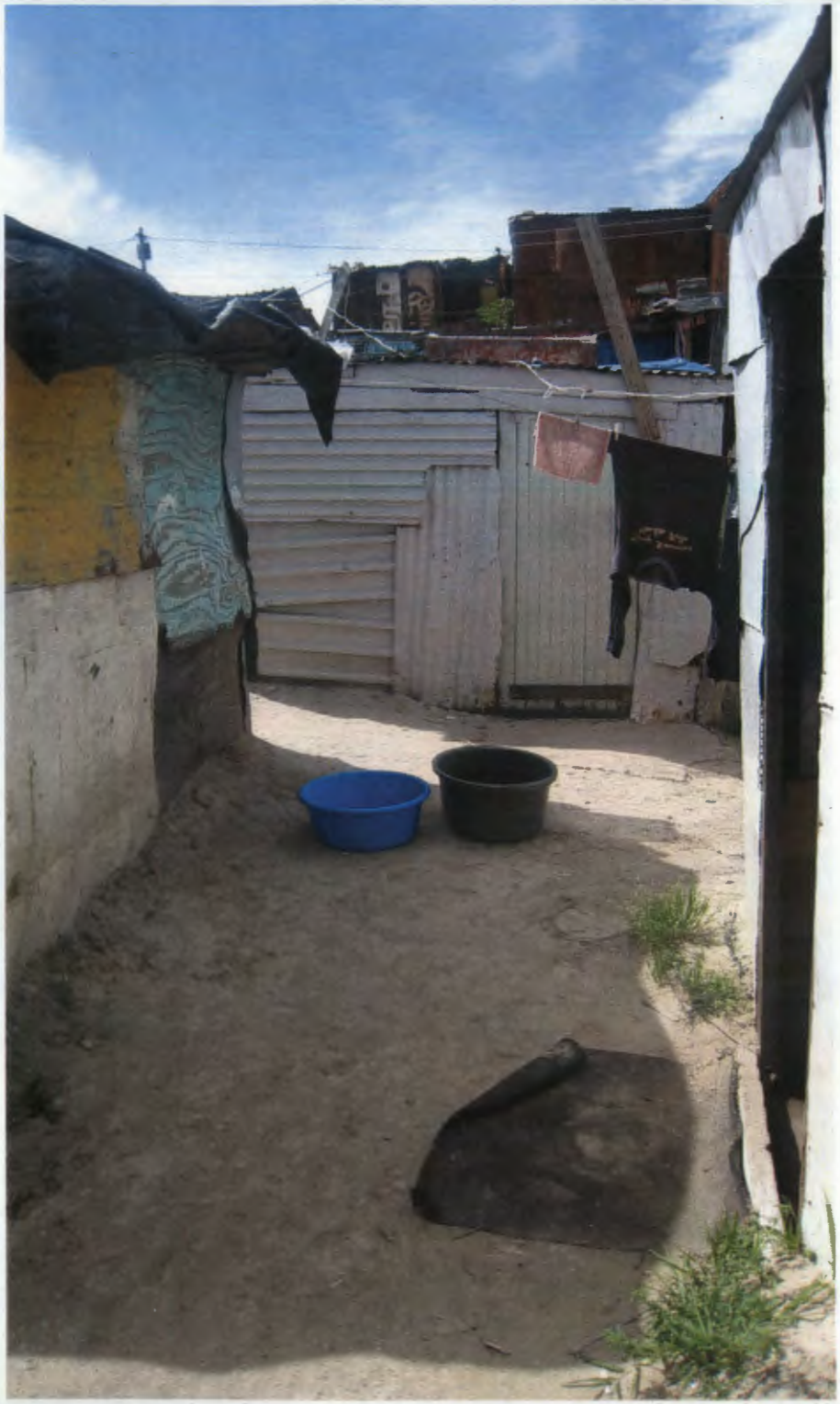


Figure 118: washing

CONCLUSION

This investigation has explored, in essence, the notion of changing landscapes and the need for inter-disciplinary work in order to deal with the changing environment around us.

The investigation followed the same approach as the design: according to the 3 different scales of intervention

Large explored infrastructure, from the natural and the man-made, to mitigation policies, as perceptions around the new weather changes have also shaped new policy and have directed the emphasis from relief to more effective disaster mitigation strategies. Theories dealing with the informal were also looked at, in order to contextualise the project within the 'larger' picture. This was mirrored in the search for a suitable site.

Developing within the informal areas will pose many challenges, but by looking at the work of Dewar and Hamdi it became clear that one would have to work from the bottom up, with the community but also using maximum creativity in providing basic infrastructure/ minimal interventions in creating positive, meaningful public space.

Six different approaches to water infrastructure provision were explored in **Medium**. The first approach looked at Natural processes, showing the effectiveness of natural systems in dealing with water. The second was an Engineering-orientated approach and highlighted how these could be challenged in a more spatial in order to create more meaningful public space. The third looked at Integrated Urban Water Management Approaches which highlighted the need for small-scale, integrated approaches when dealing with water infrastructure within the informal. The fourth looked at Architectural approaches and how the architect can use his creativity in the smallest way to achieve maximum results. The fifth approach explores the work done by Landscape Architects and reveals the idea of locating and working within the 'larger system'. The sixth approach was an integrated/ interdisciplinary approach to infrastructural design, once again stressing the need for interdisciplinary work.

These different approaches influenced the formation of a new, suitable approach towards the site which is also inter-disciplinary in nature and which is pragmatic and makes use of in-situ upgrading in order to avoid the relocation of the affected people on site. This 'edge/ element' would cater for a variety of different uses while providing much-needed water infrastructure and also providing platforms for people to dwell on dry ground.

People are entitled to close-access to water and toilets, but most importantly the right to dwell on level and dry ground.

Small explored the small 'self-help' physical mitigation strategies observed in informal areas around Cape Town and more specifically TR-Section in Khayelitsha, hinting at possible areas for intervention in my thesis exploration.

This paper has aided the investigation into an existing extreme climatic condition; the annual water table rise within low lying areas of Khayelitsha, and more specifically TR-Bongani Section which lies along its periphery.

Figure 119: view from site towards Table Mountain

REFERENCES

Books

1. Aysan, Yasemin and Davis, Ian. *Disasters and the Small dwelling: Perspectives for the UN IDNDR.* James & James Science Publishers. London. 1992
2. *Bartlett School of Architecture, Summer Show Catalogue.* UCL. London. 2007.
3. Bateman, GH. *A bibliography of low-cost water technologies.* Intermediate Technology. London. 1974.
4. Cumberlidge, Clare. Musgrave, Lucy. *Design and Landscape for People.* Thames and Hudson. New York. 2007.
5. Davies, B.R. and Day, J.A. *Vabishing Waters.* UCT Press. Cape Town. 1998.
6. Davis, Ian. *Shelter after disaster.* Oxford Polytechnic Press. Oxford. 1978.
7. *Design for the other 90%.* Smithsonian Institution. New York. 2007.
8. Dewar, David. Todeschini, Fabio. *Rethinking Urban Transport After Modernism: Lessons from South Africa.* Ashgate Publishing. 2004.
9. Dreiseitl, Herbert. Grau, Dieter. Ludwig, Karl HC. *Waterscapes: Planning. Building and designing with water.* Birkhauser. Basel. 2001.
10. Haferburg Christoph. Ossenbrügge, Jürgen. *Ambiguous Restructurings of Post-Apartheid Cape Town: The Spatial Form.* LIT Verlag. Berlin. 2003.
11. Hall, Martin. Murray, Noëleen. Shepherd, Nick.. *Desire Lines : space, memory and identity in the post-apartheid city.* Routledge. London. 2007
12. Hamdi, Nabeel. *Small Change- About the Art of practice and limits of planning cities.* Earthscan. London. 2004.

    Harding, W.R. Brown, C.A. *Cape Metropolitan Area: River Maintenance Manual.* Report to Cape Metropolitan
13. Holloway, Ailsa. *Weathering the Storm.* DiMP, UCT. Cape Town. 2008
14. Huchzermeyer, Marie. *Unlawful Occupation: Informal Settlements and Urban Policy in South Africa and Brazil.* Africa World Press. 2004.
15. Judin, Hilton. Vladislavic, Ivan. *Blank_ Architecture, apartheid and after.* NAi Publishers. Rotterdam. 1998.
16. *Khayalitsha, new home,old story.* Surplus Peoples Project. Cape Town. 1983
17. Khan, Firoz. Thring, Peta. *Housing Policy and Practice in Post-Apartheid South Africa.* Heinemann. Cape Town. 2003
18. Kidokoro, T. Okata, J. Shima, N. *Vulnerable Cities: Realities, Innovations and Strategies.* Springer. Tokyo. 2009.
19. Kronenburg, Robert. *Flexible: Architecture that responds to change.* Laurence King. London. 2007.
20. Kronenburg, Robert. *Transportable Environments.* E&FN Spon. London. 1998.
21. Key, David. *Structures to Withstand Disaster.* Thomas Telford. London. 1995.
22. Mc Garry, Michael. Polprasert, Chongrak. Rybczynski, Witold. *Low-cost technology Options for Sanitation.* International Development Research Centre and the World Bank. Ottawa. 1978.

Figure 120: opposite view:

Looking east towards the edge

23. Miller, John. B. *Floods: People at Risk, strategies for prevention.* United Nations. New York. 1997.

24. Napier, M. Informal *Settlement integration, the environment and sustainable livelihoods in sub-Saharan Africa, programme for Sustainable Human Settlements.* Council for Scientific and Industrial Research 9CSIR). South Africa. 2002.

25. *Nelson, KD. Design and Construction of small Earth Dams.* Inkata. Melbourne. 1996

26. Pearce, Fred. *Earth: Then & Now.* Mitchell Beazley. London. 2007.

27. Pelling, Mark. Wisner, Ben. *Disaster Risk Reduction: Cases from Urban Africa.* Earthscan. London. 2009.

28. Silverman M, Manoim I & Ludman B. *Harrismith, Intabazwe: urban change in a South African town,* University on the Witwaterstrand, Johannesburg, 2007.

29. Simone, Abdou Maliq. Abouhani, Abdelghani. *Urban Africa : changing contours of survival in the city.* London; New York : Zed Books in association with CODESRIA, Dakar, Senegal ; New York : Distributed exclusively in the United States by Palgrave Macmillan. CODESRIA, Dakar, Senegal 2005.

30. Simone, Abdou Maliq. *Urban Processes and change in Africa.* 1998

31. Sinclair, Cameron. *Design Likes you give a damn.* Thames & Hudson. London. 2006.

32. Smith, David M. *The Apartheid City and Beyond: Urbanization and social change in South Africa.* Routledge. London. 1995.

33. Tilman, Harm. *Integration or Fragmentation: The Housing Generator Competition for South African Cities.* NAi Publishers. Rotterdam. 1997.

Talks & Forums

1. *Fire & Flooding in Informal Settlements: Action Now* hosted by the Community Organization Resource Centre, African Security & Justice programme and Ikhayalami. Gugulethu Comprehensive School. 21 May 2009.

2. Mahaderia, Darshini. Faculty of Public Policy & Planning CEPT University, Ahmedabad. 'Challenges of Urbanization in India' presented at the University of Cape Town on the 7th of May 2009.

Reports

1. Bouchard, Bethany. Goncalo, Ashley. Susienka, Michael. Wilson, Kevin. *Improving Flood Risk Management in Informal Settlements of Cape Town.* WPI. Worcester. 2007.
2. Boshoff S, Southworth B, Walker N & Daniels C, Planning for the City of Cape Town: An argument for the long-term special development of Cape Town (Draft document for discussion), City of Cape Town.
3. Gasson, Barrie. Louw, Piet in consultation with OvP Associates. *Constantia-Tokai Valley Conservation Study.* The Constantia Valley Local Council. Cape Town. April 1991

4. Pilon, Paul J. *Guidelines for reducing Flood Losses.* United Nations. 2002.

5. Brown, Cate. Magoba, Rembu. *Rivers and wetlands of Cape Town.* Water Research Commission. Cape Town. 2009.

6. Moreno, E.L. *Slum Upgrading and Vulnerability Reduction in Flood Prone Cities in Mozambique (Maputo, Chokwe, Tete and Quelimane),* unpublished. UN-Habitat project proposal submission to the Cities Alliance. 2001.

7. UN-Habitat. *Habitat Agenda, Second united Nations Conference on Human Settlements.* United Nations Human Settlement Programme, Istanbul Turkey. 1996.

Figure 121: looking South

8. UN-Habitat. *Hand Book on best practices, Security of Tenure and Access to Land-Implementation of the Habitat Agenda*, United Nations Human Settlement Programme, Nairobi, Kenya. 2003 (b).

9. UNISDR. *Living with Risk- Focus on Disaster Risk Reduction: A Global review of disaster reduction initiative.* Geneva. 2002.

10. UN-HABITAT. *The Challenge of slums, Global report on human settlements 2003*, UN-HABITAT. Earthscan. London. 2003.

Unpublished manuscripts

1. Harrison, A.C. *Contribution to the hydrobiology of the Western Cape Province. Part 2: The ecology of some still waters.* Unpublished manuscript. Zoology Department, University of Cape Town. 1958.

Newspaper articles

1. Witten, J. *Cape floods: houses on stilts could help.* Cape Argus. 1 August 2007. p.6.

Journals

1. Connisbee, Molly. *Thinkpiece.* Itch. Volume 1: Issue 2. Bell Roberts. Cape Town.
2. Gans, Deborah & Weisz, Claire. *AD, Extreme Sites: the 'Greening' of Brownfield.* Wiley Academy. Vol 74 No2. March/ April 2004.
3. Gullion, Sheelah. *Shades of Grey*, published in *Water: Sewage & Effluent.* Vol 29 no1. January 2009. p.26-29.
4. Segal, Rafi. Verbakel, Els. *Cities of Dispersal.* Architectural Design. Volume 78: Issue 1. Wiley. 2008. 2008.
5. Snoonian, D. *Drain it right: Wetlands for Managing Runoff in Architectural Record.* August 2001. p. 127 – 132.
6. Tyrrell, Mark. *Landscape. Unlandscaped 2009.* No 123. August 2009. p.18.
7. Wamsler, Christine. *Open House International: Managing Urban Disasters.* Vol 31 no.1. March 2006. Urban International Press. Great Britain. 2006.
8. Watson, Vanessa. *Planning under political transition-lessons from Cape Town's Metropolitan Planning Forum.* International Planning Studies. 3:3. p335-350.

Essays

1. Barac, Matthew. *Transit Spaces: Picturing Urban Change.* 2006.

1. Barac, Matthew. Le Fevre, Simone. Southwood, David. *From Township to Town: Urban Change in Victoria Mxenge.* 2004.
2. Mammon, M. *Moving Towards a Design Approach to Low-income Housing in Urban CapeTown:* The case of Joe Slovo Park (2005).

Websites

1. http://www.architectureaustralia.com.au/unlandscaped/
2. www.sdinet.co.za

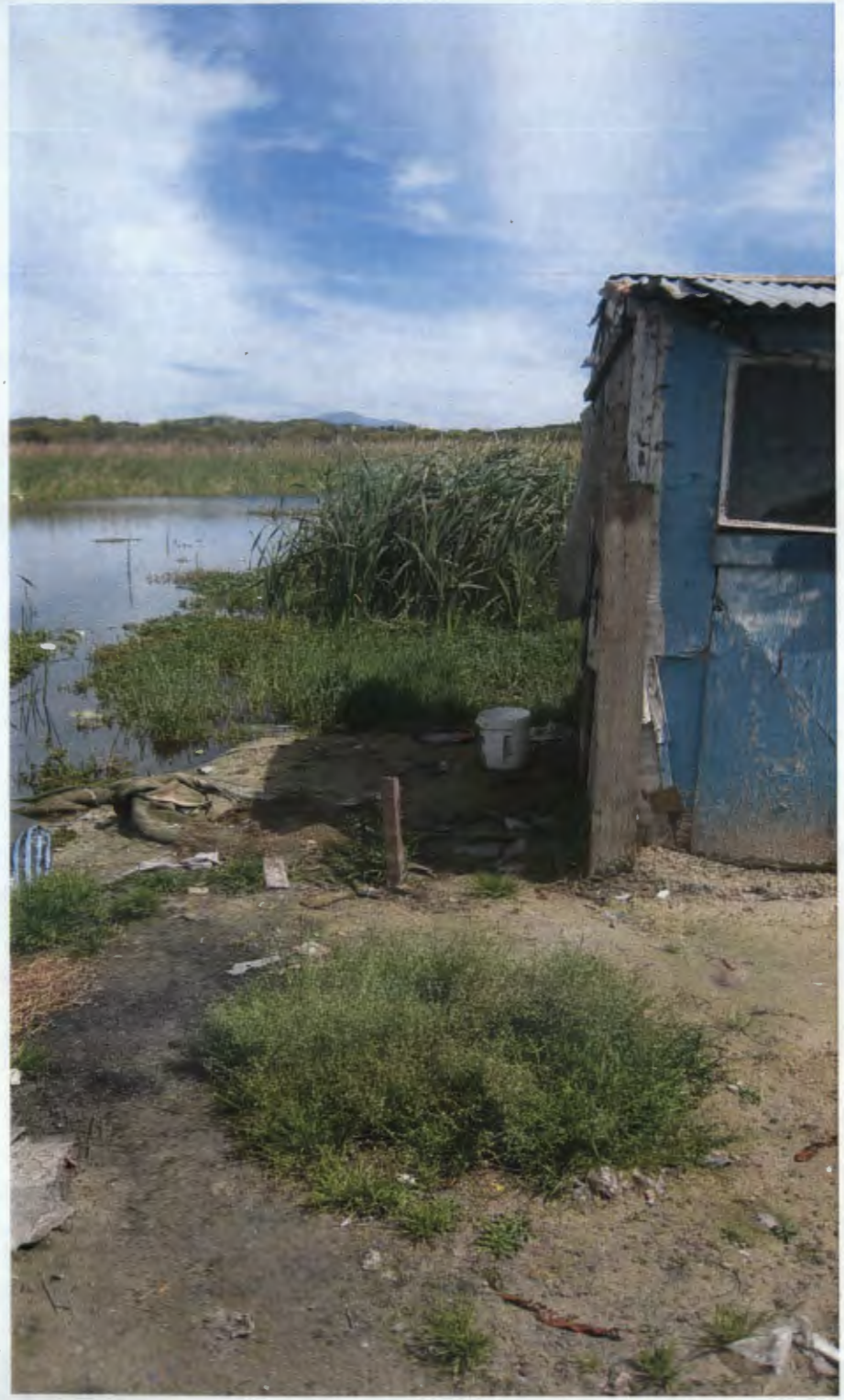


Figure 122: abandoned shack in wetland

APPENDIX

Glossary

abstraction: taking water out of a river, wetland or water body

anthropogenic: caused by humans

aquifer: underground layers of permeable or fractured rock, or unconsolidated materials (gravel, sand, silt, or clay) that hold water or permit appreciable water movement through them.

box culvert: covered canal

buffer zone: an area that reduces the impact of one area on another. River and wetland buffer zones refer to the protection of the riparian zone of rivers and wetlands, at the interface between land and the aquatic ecosystem, which under natural circumstances would be colonised by indigenous riparian plants. These zones are important parts of these systems because they stabilize riverbanks, supply food and shelter for many aquatic and terrestrial animals, and provide shade that it important in regulating water and land temperatures. In cities, the compelling reasons for river buffer zones is that they provide flood storage capacity and attenuate floodwaters. Healthy vegetation along riverbanks also acts as a buffer, protecting the river from sediments, fertilizers and pesticides moving downhill from the surrounding land. Narrow, poorly vegetated riparian zones leave the river vulnerable to pollution and other disturbances. (Brown, Magoba; 2009; 326)

canalisation: make into an artificial waterway

catchment: area of land that collects rainwater into a river or wetland, also known as a watershed or basin

channel: a narrow deep waterway connecting two large bodies of water

chemical assisted sedimentation:

Wet detention ponds can be chemically treated with aluminium sulphate, ferric chloride, aluminium chloride etc. This method is more expensive but can significantly reduce or eliminate bacteria.

community participation

Community or popular participation can be broadly understood as the involvement of people in making decisions about the design and implementation of processes, programmes and projects which affect them.

R Slocum et al (eds). Power, Process and Participation: Tools for change, *London: IntermediateTechnology Publications, 1995.*

cumecs: cubic metres per second-the measurement of the amount of water passing a point in the river at a particular point

detention facility: a structure that temporarily stores excess stormwater for a period of time. The outlet of the structure is designed to release the stored water into downstream watercourse at a rate less than the flow rate into the facility during storm events.

DiMP: The Disaster Mitigation for Sustainable Livelihoods Programme is based at the University of Cape Town.

Figure 123: flood-mitigation

dry detention ponds: These can be seen in and around Cape Town. They are constructed to reduce peak runoff rates with little consideration given to runoff quality improvement. Their mainpurpose is flood control. These ponds only contain water for short periods and can thus function as part of parking lots, sports fields etc but with monitored pollutant removal ranging from insignificant to quite poor. They can be very effective when used in conjunction with other practices such as a wet detention pond. Dry ponds function far better when planted with grass, which can reduce pollutants if water is able to stand for 3 days or more.

dune-slack wetlands: wetlands in the valleys between sand dunes

eustatic: global changes in the sea level due to water mass added (or removed from) the oceans

eutrophication: an increase in concentration of available plant nutrients in river water is an almost inevitable consequence of human presence. It comes from runoff from farms and gardens, from wastewater treatment works and septic tanks, or simply from untreated human or animal waste. The consequences of eutrophication are that plants grow better, faster and often become larger, clogging river channels and hampering the passage of floodwaters. (Brown, Magoba; 2009; 104)

flood attenuation: methods to lessen the effects of flooding

'housing mobility': the process by which an individual who migrates towards the city and squats on an available piece of land secures tenure and upgrades the dwelling/ land and sells to buy within another area and thereby moving out of the initial state of dwelling.

hydraulics: the science that establishes the behaviour of fluid in a pipe, canal, or natural watercourse. In general, the amount and speed of flow depends on the size of the conduit, the slope in a river or canal or pressure in a pipe, the roughness of the material and the sinuosity of the river, canal or pipeline.

hydrology: the science that determines how rainfall will flow across the landscape. In general, the quantity of flow depends on the intensity and duration of rainfall, the area, shape and slope of the catchment, and the nature of the ground and/ or vegetation on which the rain falls.

inundation: the rising of a body of water and its overflowing onto normally dry land

retention facility: a structure that retains runoff indefinitely should the capacity of the structure be sufficient to contain such runoff. Excess flow into the structure will be discharged via a spillway.

riparian zone: the interface between land and a flowing surface water body

roof storage: These behave like dry ponds as permanent untreated standing water is not desirable. The advantage is that very few particles are found in roof runoff as well as fewer pollutants. This is also a way of reducing runoff. It would especially make a big difference in densely built up areas. This water source could then be used for flushing toilets which attributes to 19% of domestic water consumption per day.

transitional zone: In Cape Town, the standard definition of the transitional zone has been expanded to include the wetland transitional zone. This is a low-gradient mixed-bed alluvial zone with trickle flow through wetland vegetation. Many of the rivers of the Cape Flats are in the wetland transitional zone and, in the past, probably comprised a complex array of terminal channels and wetland systems. (Brown, Magoba; 2009; 27)

wet detention ponds: (these include reed beds and wetlands) can remove up to 90% of heavy metals (due to oil on roads) in storm water and also promote biodiversity. They also offer significant flood protection.