August 2004 Severe Storm

Post Flood Assessment

Prepared for Directorate of Transport, Roads and Stormwater, City of Cape Town

Prepared by The Disaster Mitigation for Sustainable Livelihoods Programme (DiMP)
University of Cape Town
May 2005

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Executive Summary

Background

On the morning of Thursday the 5th of August 2004 a severe storm event moved over the City of Cape Town Metropole. It was followed by a second storm that resulted in widespread and serious flooding in a number of areas that included both formal suburbs and informal settlements. The rain also resulted in significant tributaries in the Salt River catchment bursting their banks.

Quantifiable, direct losses incurred as a result of the event exceeded R6.5 million. This includes the relief provided to affected households, losses by the private sector as well as government departments.

The Transport, Roads and Stormwater Directorate in the City of Cape Town took initiative to finance research that recorded the August 2004 severe storm event. This will provide important baseline information.

Specialists in climate research, flood hydrology, environmental analysis, social-risk assessment and disaster impact analysis comprised the multidisciplinary team. The report is intended to show the relationship between the physical hazard process and social vulnerability. Furthermore, the role of institutions in the dissemination of early warning and response is investigated.

Conclusions

The August 2004 flood was a **severe storm event** that was followed by less significant storm. **Significant rainfall** was recorded over Pinelands and Athlone that approached the 1 in 100 year return period over 2-3 hour duration of the event. This resulted in **significant flooding** in many areas.

An **early warning** in the form of a forecast was disseminated to various institutions. However, there were key organisations that did not receive the warning. This resulted in an **uneven level of preparedness** across institutions.

The **dissemination of the early warning to the general public** was not robust enough. This did not enable communities to prepare for the event. It was found however that residents in the selected field sites were unaware of the measures to be taken should a warning be issued. This left communities vulnerable, especially those particularly at risk to flooding.

Fieldwork was conducted in formal as well as informal areas. These included Pinelands, Athlone, Bonteheuwel, Lwandle, Quobasi and Masiphumelele. This afforded the research team to investigate the impacts across different income groups. It was found that the experiences of residents in low-income formal areas and informal settlements were similar. **Socio-economic conditions** were found to exacerbate the impact of the flooding.

The flood had a detrimental **effect on small business** in both formal and informal areas. In certain cases businesses were forced to close down as a result of stock that had been stored in the dwelling being damaged. This highlights the long-term impact on livelihoods of residents in these areas. There is however no method of determining the potential impact on local livelihoods.

The impact of the flood on **the health of informal settlement residents** is of concern. There is evidence that there is a relationship and warrants further study.

Approximately R 4.3 million in **quantitative losses** was recorded. The private insurers carried the bulk of this cost. The impact to the City of Cape Town is included in this amount in terms of the overtime staff costs incurred. This does not however include those who do shift work, as these costs are not recorded.

Recommendations

Strengthen capacity to disseminate early warning and prepare for impending weather event

- Formalisation of the early warning system. This would include an effective means of disseminating early warnings to institutions and at risk communities.
- Revisit the tone, format and content of information received in the warning. The message should include a measure of the possible severity of the event.
- Build an awareness of the weather and how it interacts with the surrounding environment amongst at risk populations.

Strengthen the capabilities of institutions to respond to events

- Conduct a robust risk assessment to determine the communities at risk of flooding. This would assist in more rapid identification of affected areas.
- Consolidate information generated by the risk assessment as well as other available information and incorporate it into GIS.
- Educate people around their rights regarding response to, and relief from, flooding events.
- Improve weather-monitoring capacities. This would include monitoring at a community level.

Improve the understanding of impacts to communities

- Further investigation should be conducted into the relationship between health and the impact of flooding.

Strengthen the ability of at risk communities to cope and recover

- Investigate opportunities to support local livelihoods, such as small businesses, in low income and informal areas.

Acknowledgements

This case-study required the assistance of many individuals and organisations in the City of Cape Town Metropole. The team would like to thank the Transport, Roads and Stormwater Directorate in the City of Cape Town for providing the funding and support necessary to complete this research. A particular thanks is due to Barry Wood from Catchment, Stormwater and River Management.

We especially appreciate the continued support from the departments of Disaster Management and Housing in the City of Cape Town.

We are grateful for the assistance of the organisations listed for their support in collecting data related to climatology and quantitative impact. These include the South African Weather Services, in particular Keith Moir, the South African Insurance Association, Golden Arrow and Metrorail. Many thanks also to those departments and relief agencies who attended the workshops that were held by the team.

Finally, our deepest thanks to the communities of Pinelands, Athlone, Bonteheuwel, Lwandle, Quabasi and Masiphumelele, and to the individuals who participated in the field research.

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Part I Background, Conceptual Framework and Methodology

1.1 Introduction and Context

The August 2004 severe storm event that triggered widespread damage and hardship across much of the City of Cape Town provides an important case-study for South Africa. It clearly underlines the interplay between extreme weather and conditions of environmental, infrastructural and social vulnerability. Part I of this consolidated report provides the general and institutional context for the study, as well as an overview of the research methods used.

Section 1.1 gives a brief overview of the endangering weather system and its impacts.
Section 1.2 introduces the conceptual framework for the study and key terms.
Section 1.3 clarifies the geographic extent of the case study.
Section 1.4 describes the overall research approach and methods used.
Section 1.5 states ethical considerations that are reflected in the report.
Section 1.6 outlines the study's limitations.
Section 1.7 presents the overall structure of the report.

1.1.1 The extreme weather system and its consequences

On the morning of Thursday the 5th of August a severe storm event resulted in widespread and serious flooding in Maitland, Woodstock, Pinelands, Athlone, Bonteheuwel, Nyanga / Guguletu and Somerset West areas. The event produced peak intensities for durations exceeding 3 hours which approached the 1 in 100 year return statistical maximum within a very confined geographic area on the Cape Flats. Rains over the Cape Town Metropole region also resulted in significant tributaries in the Salt River catchment bursting their banks.

Persistent rains over the period 5 August to 9 August 2004, generated by two cold fronts which passed through the area, resulted in significant flooding in many informal settlements across the cape Flats. Quantifiable, direct losses incurred as a result of the event exceeded R6.5 million, while at the same time generating numerous indirect impacts and causing a significant amount of human misery and suffering.

1.1.2 General overview of areas that reported significant disaster impacts

The August 2004 severe storm event triggered serious impacts and losses were experienced across much of the City of Cape Town Metropole. A Joint Operations Centre (JOC) was called into being as a result of the event which generated impacts on a significant geographic scale, the extent of which is represented in figure 1.1.2.1.

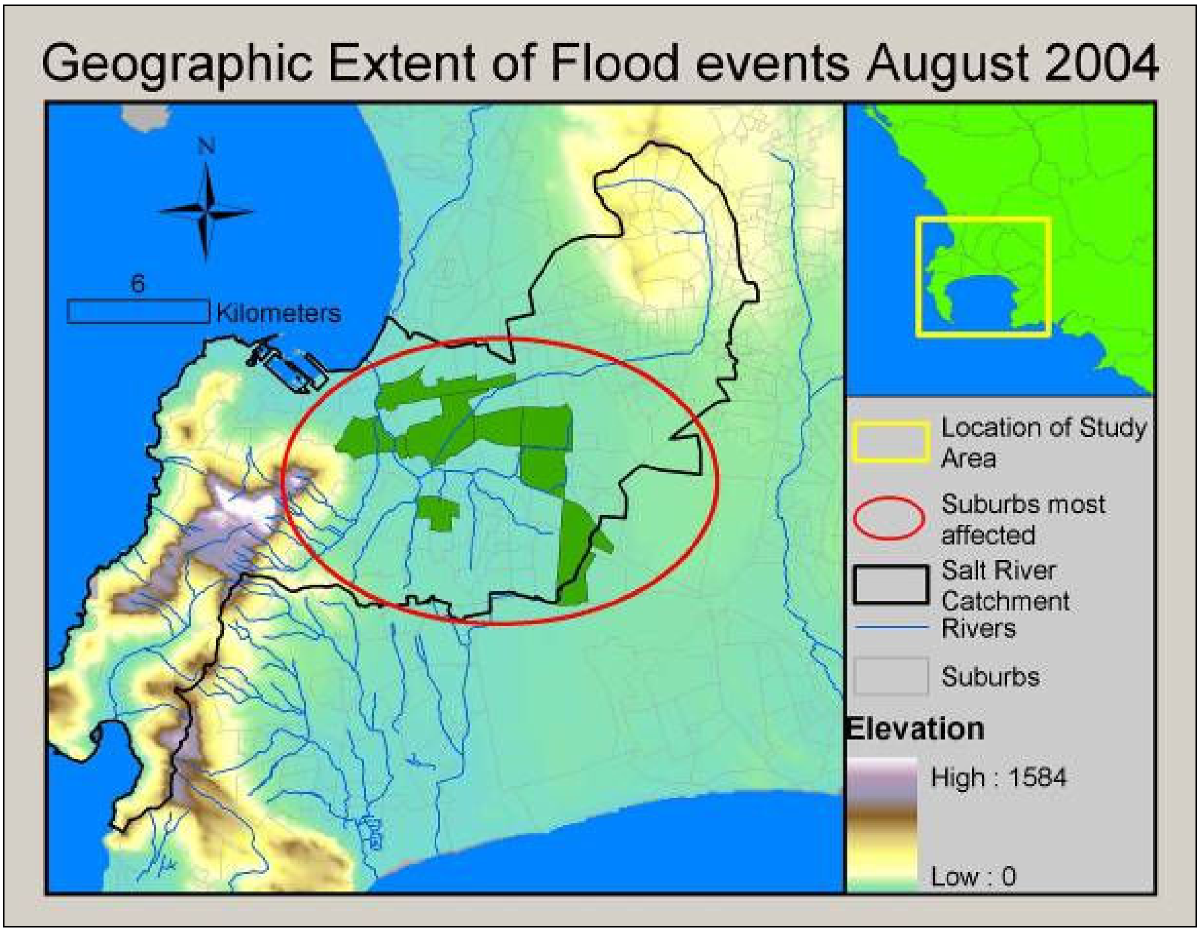

Figure 1.1.2.1: Geographic areas affected by the August 2004 severe storm event

In the context of the August 2004 severe storm event, the wet winter season was considered to be culminating with below average rainfall. The lack of rain throughout the season is expected to have left drainage systems blocked with debris.

1.1.3 Legal Context of the Assessment

The Disaster Management Act was promulgated in 2003 and enacted in March 2004. It is progressive legislation in that it focuses heavily on prevention and mitigation activities that reduce the risk of vulnerable communities to disasters. The proposed National Disaster Management Framework reinforces this by calling for a process of ongoing risk assessment. This entails monitoring small-, medium- and large-scale events, which are those that are not formally declared. This will help determine the levels of risk in the Metropole for a particular hazard as well as the vulnerable communities.

The August 2004 Severe Storm Event has provided an ideal opportunity to identify communities vulnerable to flooding in an urban context. This would also contribute to the City's overall risk assessment.

1.1.4 Institutional arrangements for the research and terms of reference

This case–study was supported by a City of Cape Town department concerned about the interplay between community/household vulnerability and institutional supports that avert or reduce unnecessary disaster loss. The Transport, Roads and Stormwater Directorate supported this research that would deliver a comprehensive disaster event report containing:

- A description and analysis of weather conditions that triggered the flooding.
- An overview of the catchment, river-flow, land-use and run-off characteristics that may have exacerbated the event.
- A description and chronology of the event and measures taken, including rescue, emergency relief, security and communication.
- A description of the impact on people.
- A determination of infrastructure/property damaged and destroyed, disruptions to telecommunication, electricity, road and other lifeline services.
- The response and relief impacts in costs and supplies.

1.2 Conceptual Framework for this Study

In the past, severe weather events such as the cut-off low in March 2003 that was declared a national disaster and its consequences would have been understood as a 'natural disaster', or 'Act of God'. However, international best practice now views disasters as an interplay between natural or other threats *and* conditions of socio-economic, environmental or infrastructural vulnerability. A disaster only occurs when a *vulnerable* household, community, city, province, business, ecosystem or physical structure is subjected to a *shock or stress* which it *cannot withstand* or from which it *cannot recover*[7] *without external assistance.*

Normally, a 'hazard' is viewed as an external phenomenon *with potential to cause harm*, while vulnerability refers to the *internal characteristics* of the household, community or area that increase the likelihood of loss. In this context, it is no longer appropriate to state that a storm 'caused' the flooding, but rather to state that the storm 'triggered' the resultant flooding.

In this conceptualisation, any specific level of *disaster risk* faced by a household, community or area is shaped by *both* hazard and vulnerability conditions, and can be broadly understood as the probability of losses which a household, community or municipality cannot resist, or recover from, without external assistance.

With respect to the August 2004 severe storm event, the *hazard* is understood as the weather system, characterised by heavy rains, over a small area, for a reasonably short period of time. It also involved the ensuing four days of relatively light rainfall that fell between the 5th and the 9th of August.

With respect to this research report, vulnerability is viewed as those characteristics likely to increase the probability of loss with respect to low lying areas, canal and river systems, urban

[7] Here the concept of recovery needs to be differentiated from that of coping. Recovery is to return to a state of well being and general security similar to that which existed before the shock or stress was experienced. Coping on the other hand involves short-term responses to manage the immediate event. Such responses may heighten individuals and communities level of vulnerability and hence livelihood insecurity.

livelihoods, physical infrastructure and critical services, as well as human well-being and health status.

The research presented below seeks to identify those risk conditions that increased the likelihood of loss, as well as the household/community responses and institutional mechanisms that reduced the severity of the impacts associated with the weather event.

1.3 Geographic Focus for the Study

1.3.1 General scale and scope of research

The geographic scale of the event is often hard to define, as it tends to coincide more with environmentally defined areas than administratively defined ones. Even trying to define the area environmentally is problematic as the event rarely affects all areas uniformly. Rather marginal lands would be affected while ‘safe land’ which separates this marginal land may be entirely unaffected. Impacts in the informal settlements are indicative of this. The geographical extent of the August 2004 severe storm event was attained by examining Disaster Management and Transport, Roads and Stormwater’s records of affected areas. See Part III for more detail on why this may prove problematic.

The scale of the severe storm event on August 5 2004, which accompanied the first cold front, was relatively small. It was a rather localised event that resulted in significant impacts in Nyanga, Guguletu, Athlone, Bonteheuwel, Langa, Pinelands, Observatory, Maitland, and Woodstock. The centre of this storm was situated over the general Athlone area, where rainfall intensities were highest

The second cold front brought more widespread less intense longer duration rainfall to the area. This resulted in soils becoming saturated and flooding in numerous informal settlements. Settlements across the Cape Town Metropole were flooded as a result of these rainfall events. Flooding occurred as far south as the South Peninsula local administration, as far east as the Helderberg local administration and as far north as the Blaauwberg and Tygerberg local administrations.

Thus the geographical extent of the flooding was not that wide spread. It must however be noted that flooding is not the only impact associated with severe storm events. Intense rainfall has the ability to contribute significantly to levels of human misery and suffering, especially so in the case of people living in informal structures in both formal and informal areas.

1.4 Methods Used

The multidisciplinary nature of this study demanded the identification of a skilled team with capacity to work across disciplines as well as give in-depth attention to their respective professional fields.

It also called for the use of a wide range of data-collecting, consolidating and analytic instruments and processes.

1.4.1 Defining the technical requirements of the research team

Disaster risk nomenclature would classify the August 2004 severe storm event and its impacts as a 'hydrometerological disaster'. This automatically underlined the need for skilled capabilities in analysing the triggering *climate conditions*, as well as technical skills in evaluating the event's *flood hydrology and* relevant urban activities that may have exacerbated its impacts. In addition, the capturing of the institutional dimensions of the incident, including measures taken in advance to reduce the likelihood of negative impacts, required skilled technical input on *disaster management*. With respect to determining the extent of impacts, including human and infrastructural, it was essential to have capabilities in household and *social vulnerability* assessment, as well as research capabilities to identify, *record and consolidate losses* across multiple sectors and administrative jurisdictions.

Recognising these complementary dimensions resulted in the identification of a skilled team to implement the research. This team comprised climate analysis researchers, a environmental impact specialist and social vulnerability research and disaster loss consolidation teams. The team was supported extensively by Catchment, Stormwater and River Management from the City of Cape Town.

The Disaster Mitigation for Sustainable Livelihoods Programme at UCT acted as secretariat for the research.

1.4.2 Streamlining data collection and analysis

There were several early methodological priorities. These involved determining a uniform geographic scope for the study, as well as processes that allowed subject specialists to focus on their specific areas, as well as provide interdisciplinary feedback to other team members.

a) Defining the geographic scope

Newspaper reports and the early visualisation of the weather system's extent, combined with feedback from Catchment, Stormwater and River Management guided decisions with respect to the scope of the research. The team agreed to limit the scope of the study to the City of Cape Town Metropole.

b) Defining fieldwork requirements

The research team gave priority to fieldwork to ensure accuracy of its results. More than 40 person-days of field research took place for four of the team members who collected information related to the land-use, flood hydrology, institutional arrangements and social risk dimensions of the extreme weather event.

Prior to each team's field travel, sector-specific resource people were identified in the suburb or informal settlements to be visited, meetings scheduled and data collection instruments developed. All fieldwork was completed by 18 March 2005.

c) Developing an iterative research method

The research demanded an iterative research method. This involved constant reviewing of newspaper and government reports, climate analysis findings and feedback from specific sectors to identify potential gaps in information gathering.

d) Ensuring research consultation

Two consultations were conducted, which involved all team members. The first was conducted on 18th August 2004 immediately after the event to the scope of the research. A consultative meeting with the team member as well as various stakeholders took place on 3 November 2004. These stakeholders included departments from the City of Cape Town, Provincial Disaster Management, relief organisations and South African Weather Services (SAWS).

There were many subsequent team meetings that provided an opportunity for all team members to present their preliminary findings and ensure that any research gaps were identified.

A consultation meeting was held in February 2005 with relevant institutions. This meeting was to discuss the institutional response and early warning for the event. Stakeholders ranged from city officials, provincial departments as well as relief organisations.

1.5 Ethical Considerations

In order to ensure confidentiality of information provided by a wide range of resource, people and institutions; individuals consulted in the course of this study will not be referred to by name, but rather by official designation or as representatives of specific organisations.

As there is a lack of a central agency for information consolidation, there were numerous conflicting figures surrounding losses, numbers of people affected and resultant relief payments. This study has consulted numerous individuals in order to determine which would be the most reliable sources for certain types of information as well as verifying figures wherever possible in an attempt to ensure the greatest degree of accuracy.

On a similar note the qualitative, interview, data used in this study was not without its problems. This is due largely to the fact that flooding is seen to be an issue of adequate service, and infrastructure, provision. Given that interviews took place in informal and, in some cases, impoverished formal residential areas, issues around service provision and equity are highly contentious. Due to this it is recognised that both residents and field professionals are liable to tell half-truths as the former try to encourage service provision in their areas, and the latter attempt to justify problems of flooding. This problem is furthered as many field professionals interpret discussions around flooding as a finger pointing exercise where other departments are trying to lay blame.

Given the issues of various ‘truths’ every effort has been made to ensure that this document provides an accurate representation of the events that occurred during and as a result of the August 2004 severe storm event(s).

1.6 Limitations of Research

Although every attempt has been made to accurately capture the events surrounding the August 2004 severe storm event, it was impossible to consult with all those involved. It is clear that in the areas affected, many ‘ordinary citizens’ evacuated school children, ran soup kitchens, and provided help to neighbours as well as those in need. Unfortunately, it has not been possible to contact everyone directly involved and for this reason a case study approach has been used in the research.

Similarly, although the research was directed at areas in which flooding was considered to be highly problematic, it is clear to all members of the research team that significant, if not comparable, impacts were felt in other areas of the City of Cape Town and its surrounds. Unfortunately, time and resource constraints prevented an in-depth review of all the affected areas. In order to deal with this the study report has attempted to speak generically about flooding in informal as well as formal areas based on information gained through site-specific fieldwork.

The fieldwork in this study was also limited to some extent by the willingness of local institutions to cooperate and attend meetings. There was also the problem that interviews took place during the day, while many people were at work. This may have resulted in the research being skewed so that unemployed individuals (and in many instances women) were privileged in the interview process. In this case every effort was made to attain information about the role of the breadwinner in the household.

The fieldwork posed another significant challenge, that of having to use facilitators and translators while working in the informal residential areas. Fieldwork in such conditions always involves some loss of both content and context during the interview process. Obviously any interview methodology is reliant on the fact that the researcher has a degree of faith in the person being interviewed. Problems arose around this due to conflicting information from the institutional and household interviews (see part IV for a more detailed methodology). It is thought however that such conflict may be a result of misinformation on the part of both parties.

A significant limitation to the accuracy of the research was access to current demographic and income statistics for the areas studied. Informal settlements represent dynamic areas in which hard, reliable statistics are, by their very formal nature, hard to come by. Therefore, there was a lack of recent baseline socio-economic data that would have particularly informed the social risk assessment for the city as a whole. Data problems were also apparent regarding weather data. Not all stations had continuous data sets therefore averages calculated may exclude valuable variability. To minimise these effects the researcher only used long record stations with at least 15 years worth of data to construct average. In keeping with world standards it would be best to only use records over 30 years, however this would have resulted in a very poor data sample. It would also be advisable to reconstruct the frequency/duration intensity plots (which were constructed in 1992) so that they include the most recent decade.

A major constraints to the implementation of the research was the consistently uneven management of incident recording/tracking documentation, along with lack of streamlined processes for recording impacts/losses. In the absence of a clear and streamlined recording system, both with respect to incident management, as well as with respect to tracking loss, all members of the research team spent considerable effort attempting to ‘recreate’ the incident. This especially applied to reproducing the institutional links that either enabled or constrained an effective response. This may have resulted in unintended misinterpretation of the information collected.

Finally a significant constraint to the research was the fact that the research was only commissioned about two months after the event had taken place. This resulted in some of the fieldwork only taking place about six months after the event. This obviously limits the fieldwork as the event was so long ago that people struggled to recall the event accurately as well as to provide suitable statistics for the event.

1.7 Structure of this Report

This report is structured in the following way:

Part I introduces the *background, conceptual framework and methods* used in this research.
Part II provides an overview of the *'biophysical' aspects of the disaster event*, specifically the meteorology, flood hydrology and environmental conditions that contributed to its severity. This section also includes information on Cape Town's historical climatology and flood record.
Part III addresses the d*issemination* of the early warning of the disaster incident.
Part IV the *institutional arrangements* around and emergency responses to the disaster incident
Part V examines *patterns of social vulnerability* as well as the losses and associated impacts of the event.
Part VI examines flood mitigation and development strategies for the City of Cape Town Metropole.
Part VII presents the conclusions and recommendations.

Grey boxes of information provide examples from the field that highlight certain concepts which have been discussed in the report.

At the end of each part a summary box of that section is included. It contains a summary and recommendations of the chapter.

Accompanying appendices provide examples of *data collecting instruments* and summary tables, as well as a list of people contacted.

Part II The August 2004 Severe Storm Event: Extreme Weather[8], Flood Hydrology[9] and Environmental Analysis[10]

2.1 Introduction

At the beginning of August 2004 a series of two cold fronts resulted in flooding in both formal and informal settlements in many parts of the Cape Town Metropole. A detailed analysis of biophysical and historic data will be covered within this Chapter as follows:

Section 2.2 provides a context for flood events from historic records and analysis of climatological station data, with consideration of how these may change in the future.

Section 2.3 describes and characterises the August 2005 storm event in terms of rainfall intensity and geographic distribution.

Section 2.4 details the flood hydrology of the weather event, with emphasis on the impact to the stormwater system. It includes an environmental analysis.

2.2 Historical Climatology and Flood History in the Cape Town Metropole

2.2.1 Historical records of flooding

Records of flooding were collected from selected news clippings dating as far back as 1899[11]. Photographs show central parts of the city streets submerged by 3m of muddy water. The most significant storm, from these early records, occurred on 23 June 1904, when 62.5mm fell within an hour. A picture of this event is shown in Figure 2.2.1.1. A full list of all storms resulting in flooding events has been compiled in Appendix 1. This represents flooding incidents that were driven by heavy rains.

From the records collected it appears that flooding generally resulted in roads and property being flooded as well as the subsequent discomfort of cold, wet weather. Mudslides have been known to occur on the mountainside. Also the Cape Flats is generally under water, due to the high water table in this area. Economically, retailer’s merchandise is damaged and many commuters are left stranded as public transport networks are often disrupted.

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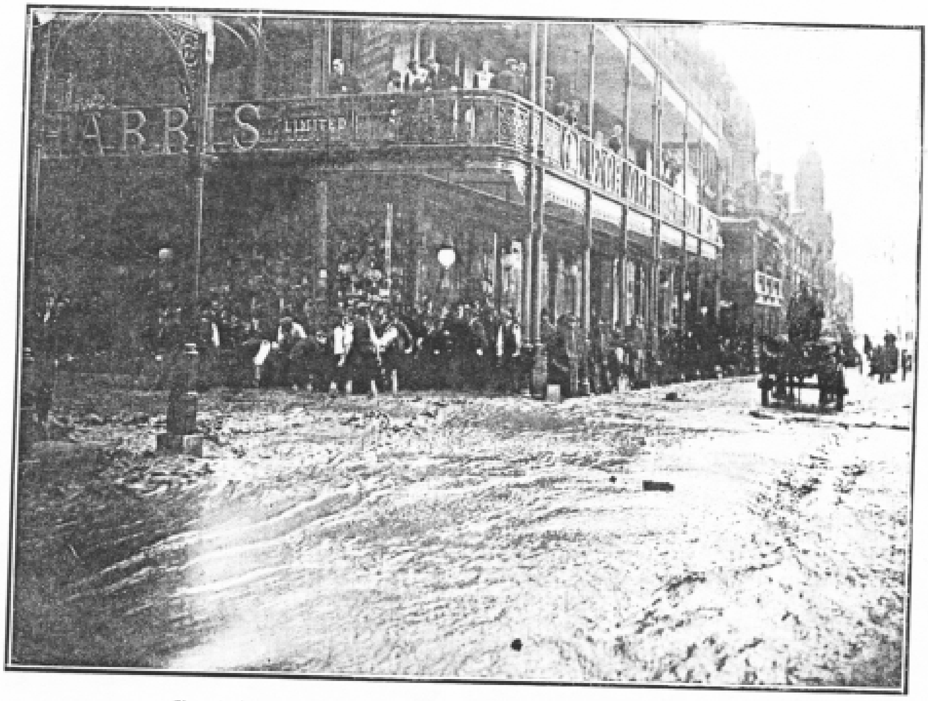

Shop Assistants damming out the water from Cleghorn & Harris' Premises.

Figure 2.2.1.1: Image from 1904 flood in Cape Town

2.2.2 Future considerations

Historical flood records serve as an important basis for the development of flood management policy. However, global warming is changing what is viewed as present day climatology. Global average temperature will rise. Regional responses to that increase will be complex. These responses have been determined using Global Circulation Models (GCMs) that replicate the complex interactions between all components of the earth system by solving mathematical equations that describe these interactions. Over Southern Africa mean temperature is projected to rise by a few degrees. Changes in patterns of rainfall are less straightforward, especially for the summer season, where models are often in disagreement (Giorgi *et al*, 2001)

Luckily, as the Western Cape is a winter rainfall area, it is with greater certainty that slight decreases in annual rainfall should be expected (Hewitson and Crane, 2005). The effect of a decrease in rainfall on runoff has been shown to be amplified in certain areas (Schulze, 2000). New (1998) gave an overview of Western Cape water resource responses to projected changes, indicating the likelihood of water supply shortages within the next 50 years. Expected changes in runoff have also been modelled over southern Africa. Hudson and Jones (2003) showed that changes in extreme flow (induced by heavy rains) were predicted to increase. Variations in seasonality and intensity of rainfall are issues still under scrutiny.

It is expected that there will be an increase in the occurrence of extreme weather events under climate change (IPCC, 2001)[12]. As the global average temperature rises, increased evaporation is expected. This is likely to drive more intense storm systems. Increased flooding will put additional pressure onto the stormwater infrastructure. It is therefore important to assess the current coping capacity of the system by compiling flood risk assessments. This document should act as a guideline on how to structure such a post flood assessment.

Future changes in the intensity and frequency of storm events also need to be addressed. Climate change will alter the thresholds of expected climate, for example the likelihood of a 100-year flood might be increased to a 50-year probability. These changes need to be factored in when developing new infrastructure and upgrading existing systems and should be further researched.

2.2.3 Historical climatology

The Western Cape is a winter rainfall area, receiving most of its rains from May to August. Rainfall has a high degree of spatial variability, meaning that different stations within the city may have substantial differences in received rains on a daily time scale.

The City of Cape Town Metropole has a number of rainfall monitoring stations with records longer than 10 years. These stations were used to draw up long-term averages of monthly precipitation. As not all stations have equal periodicity, some discrepancies may exist (for example the Athlone station has a record only from 1935–1987).

Lower annual rainfall characterises the northern and eastern stations, with highest intensity rainfall occurring at stations along the eastern side of the Table mountain chain. This is the direct result of the mountain encouraging greater uplift, resulting in increased rainfall in these areas. This is known as the orographic effect. This can be seen in Figure 2.2.3.1 below, where it can be seen that Wynberg and Cecilia forest have the highest winter rainfall and Tygerberg and Maastricht farm the lowest. This information is then plotted geographically in Figure 2.2.3.2, in which the differences between mountainous and plains stations can be seen quite distinctly.

However this relation is not quite so simple, as the orographic effect cannot account for all differences. The mountainous area also sets up a mountain wave downwind of the slope, where the air oscillates up and down, creating areas of uplift downwind. The amplitude of the wave and the direction of the wind that induces it will also play a part and can therefore affect different areas depending on those conditions prevailing.

Comparison of the data plotted for Groenvlei (Hanover Park) with Athlone, to the north and Southfield, to the south, demonstrates probable downwind mountain wave effects. Groenvlei appears situated further from the mountain range than both Athlone and Southfield and yet the Groenvlei July rain (108mm) is significantly higher than Athlone (84mm) and Southfield (82mm) respectively.

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[12] This is a result of shifting mean conditions, which subsequently increases the frequency of outlier events.

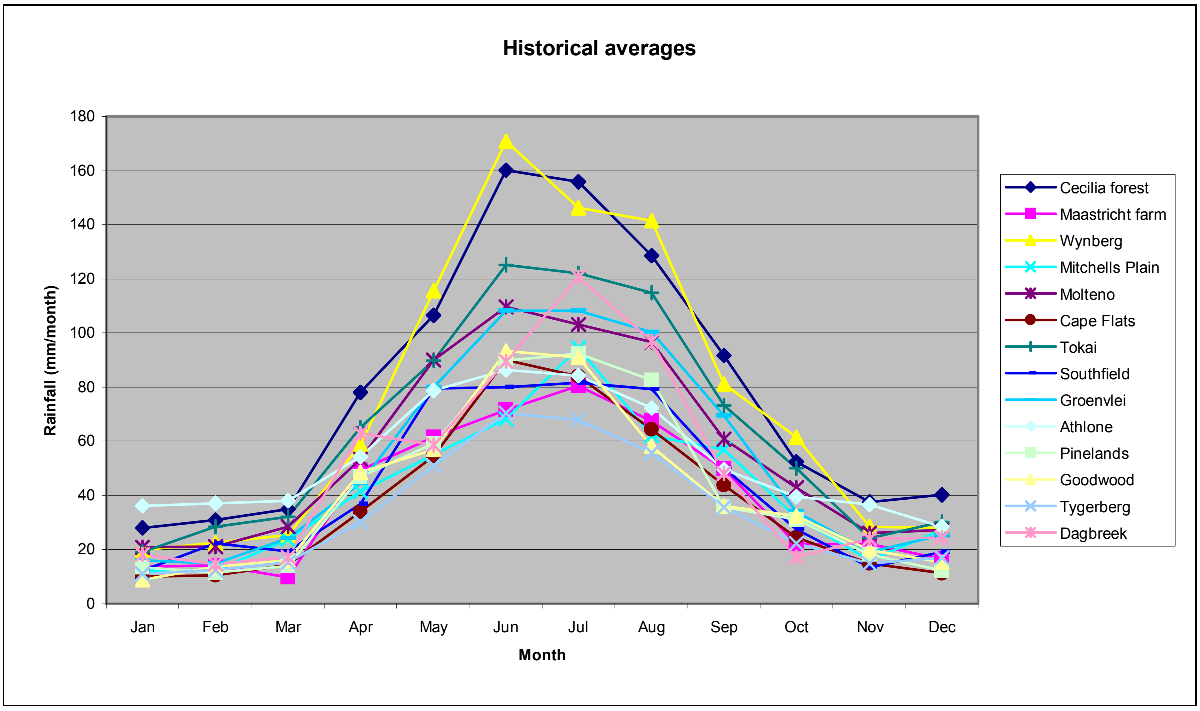


Figure 2.2.3.1: comparison of average monthly rainfall distribution for stations with records exceeding 15 years

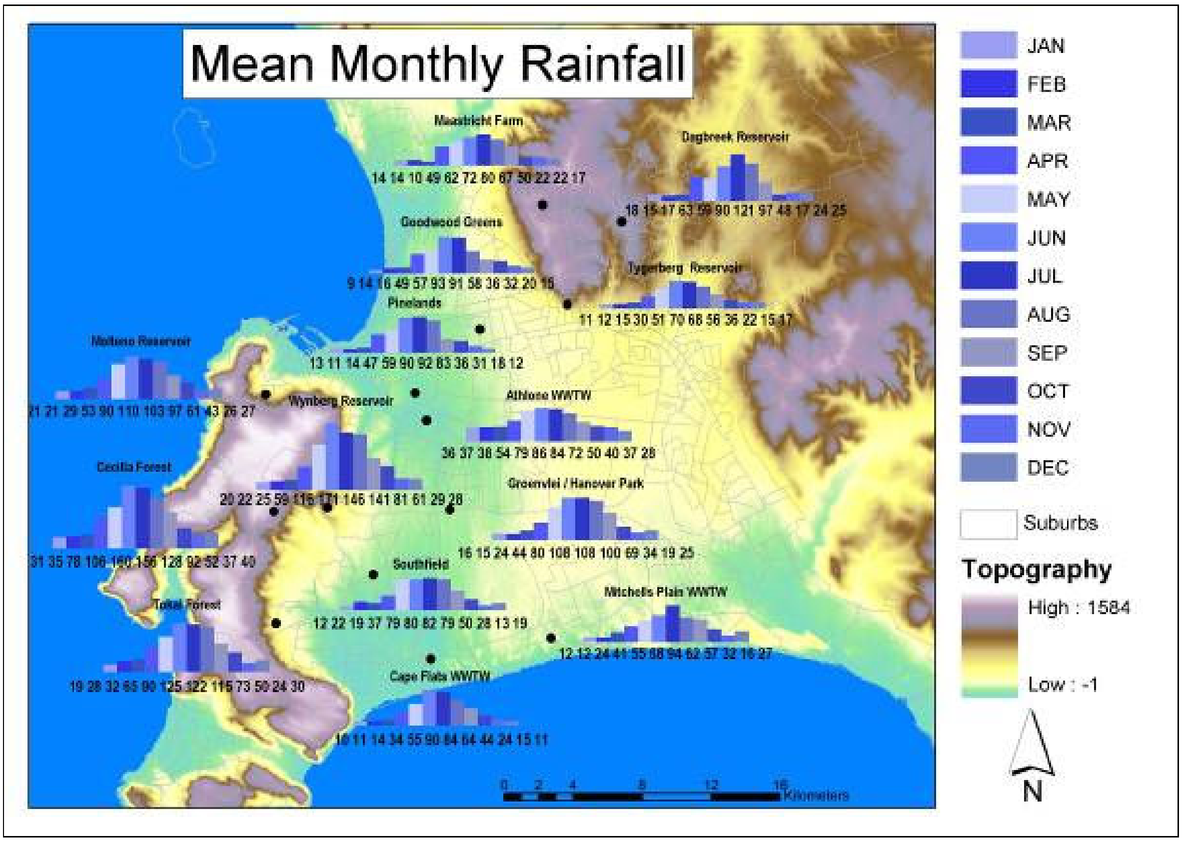


Figure 2.2.3.2: Map view of average rainfall distribution for stations with records exceeding 15 years

2.2.4 Seasonal variations of longer records

From an analysis of the four stations (Figure 2.2.4.1) with longer records, there appears to be a distinct lag of one month in the maximum monthly rainfall between the first and second half of the record. Monthly maximum rainfall appears to have shifted from June to July and there is a sharper decline in rainfall (across all four stations) in the months after July. Although the average annual totals have not changed significantly, seasonality and perhaps intensity could be altered. April seems to show a slight increase in average rainfall, giving a bipolar rainfall regime with peaks in April and July.

As there were only four stations with sufficiently long records – this analysis was still tentative. There is a 20-year cyclical pattern in South African rainfall so we would need to examine at least 50 year records to be sure that this signal was not skewing the results. The 150 year record of rainfall data from the S A Astronomical Observatory was then obtained in which 30 year time slices were analysed. Figure 2.2.4.1 shows that although April rainfall seemed to be higher it is in fact in between the other five time slices and would therefore seem to indicate a normal rainfall pattern.

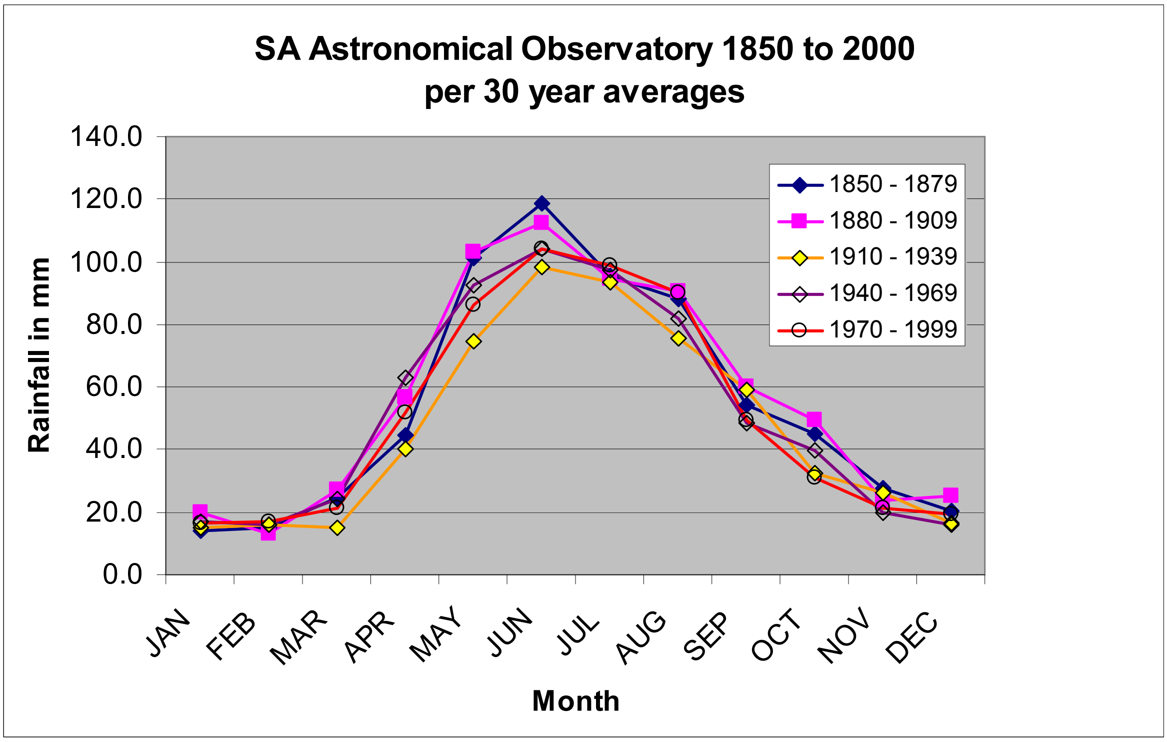


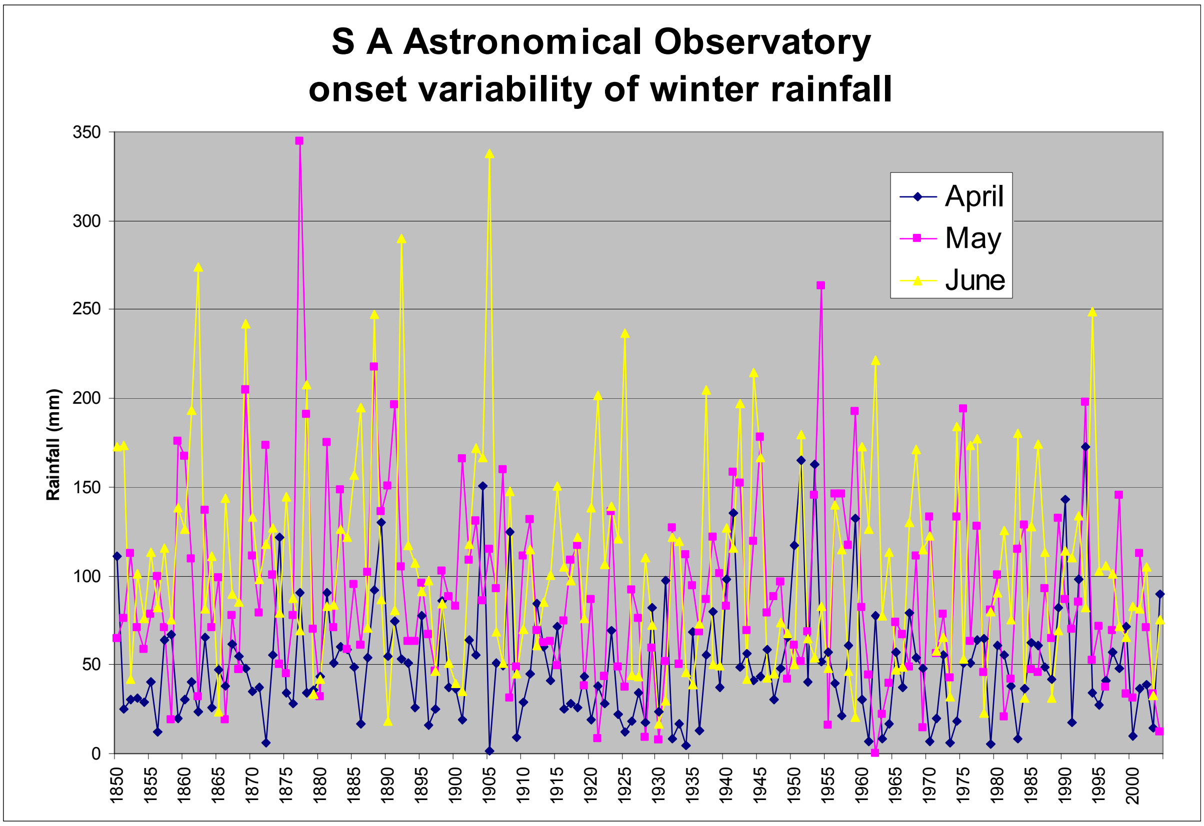
Figure 2.2.4.1: Historical time slices from the Astronomical Observatory record

Some other points of interest:

- winter rainfall (May and June) is during the earliest slots (1850 – 1879 and 1880 – 1909) well exceeds more recent time slices, indicating that the winter peak rains are less.
- winter rainfall was during the 1910 to 1939 slot was very much lower, therefore our present drought may not be unique.

- August rains seem to have little fluctuation in totals although the months of onset and early winter rains show considerably greater spread.

In figure 2.2.4.2 the months of onset (April, May June) are compared. The S A Astronomical Observatory data seems to support that “heavy rains in April generally correspond with lower June rainfall and visa versa.”



<u>Figure 2.2.4.2</u>: Annual differences in winter rainfall by month

The early onset of winter rain has been an all too familiar pattern during the last few years in our winter rainfall region, with dire consequences to our water supply. The pattern has been that

- Good early (April) rain episodes have been associated with significant cut-off Low pressure activity in our area.
- Cut-off Low pressure systems cannot exist without large “blocking” High pressure systems in oceans way to the south of our country.
- The same blocking Highs have tended to persist into June – blocking the normal track of winter rain bearing frontal systems onto Cape Town.

The intensity of rains falling may also be changing. By looking at the wet and dry spell frequency (i.e. number of days with rain and the number of days until next rains), it would be possible to determine whether there are significant fluctuations in the intensity of rain falling. If the intensity were to increase, one would expect that current stormwater systems might become stressed. Longer dry spells could also result in increased blockages of inlets etc, which accumulate litter and leaves when it is not raining.

2.2.5 2004 Flood regime

Three flooding events were deemed to be significant as they caused major flood damage (Source: City of Cape Town).

16 April: Widespread evenly distributed rainfall with sharp downpours during the early morning resulted in many incidents of localised roadway flooding and traffic disruption across the metropolitan area. Properties and buildings were flooded in the Mitchells Plain, Goodwood, Kuils River and Mfuleni primarily due to capacity limitations and blockages. Informal settlements in Philippi, Guguletu and Khayelitsha experienced minor flooding. In general the minor drainage systems coped satisfactorily.

23 July: Heavy rainfalls were recorded over the Southern Suburbs. Exceptionally high intensities in the Fish Hoek and Noordhoek areas resulted in damage to private properties and traffic disruptions. In Wallacedene, a main pipeline blocked resulting in the flooding of a number of dwellings. In general, both the minor and major systems (longer durations) coped satisfactorily.

5-9 August: This significant rainfall event, resulted in widespread and serious flooding in Maitland, Woodstock, Pinelands, Athlone, Bonteheuwel, Nyanga / Guguletu and Somerset West areas. Peak intensities for durations exceeding 3 hours, approached the 1 in 100 year return statistical maximum within a very confined geographic areas on the Cape Flats. Significant tributaries in the eastern portion of the Salt River catchment (Athlone) burst their banks.

Of these storms the August flood was particularly severe as the intensity of rain over the 3-4 hour durations exceeded the 100-year return period in some areas. This is the event that will be focused on in this study.

2.3 The August 2004 Severe Storm Event: Meteorological Report[13]

2.3.1 Synoptic overview

Two large cold fronts hit the Cape successively causing wide spread damage within the city of Cape Town. The South African Weather Service (SAWS) did not forecast the first storm and therefore a low level of preparedness resulted in many delays in response. This was exacerbated by the blockages in the stormwater infrastructure, as there had been very little rain in the previous weeks. SAWS then sent early warnings for an even larger cold front to follow. Due to the large amounts of standing water already causing problems – informal drainage systems failed to cope with the second rainfall event.

[13] Acknowledgements to Keith Moir, SAWS

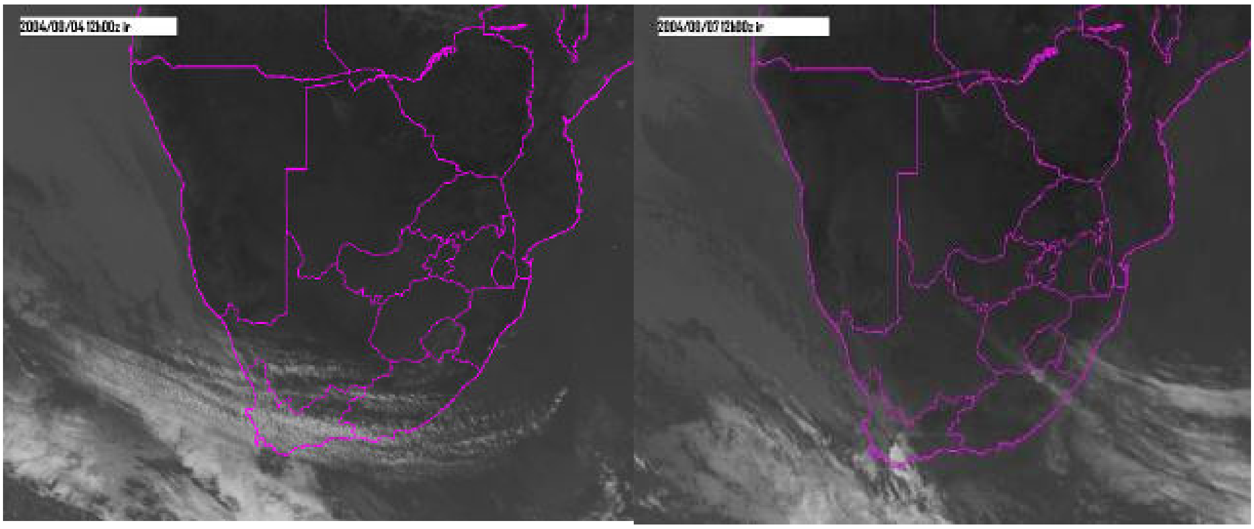


Figure 2.3.1.1: Satellite image from 4 August and 7 August, in which both of the storms can be seen developing

By looking at the synoptic chart from the 4th August in Figure 2.3.1.2, it illustrates a “family” of frontal waves (lows) extending from Marion Island area in the southeast to a Low positioned well to the northwest. Systems such as these (composed of a number of waves) are generally mature in development and thus **slow moving**.

There is a long “fetch” behind the system, which would indicate **very cold** “post frontal” air (i.e. being fetched from a location very far south of Cape Town) the forecast of the 3rd August warns specifically of “Very Cold conditions are expected to set in over the Western high ground areas of the Western and Northern Cape Provinces….”

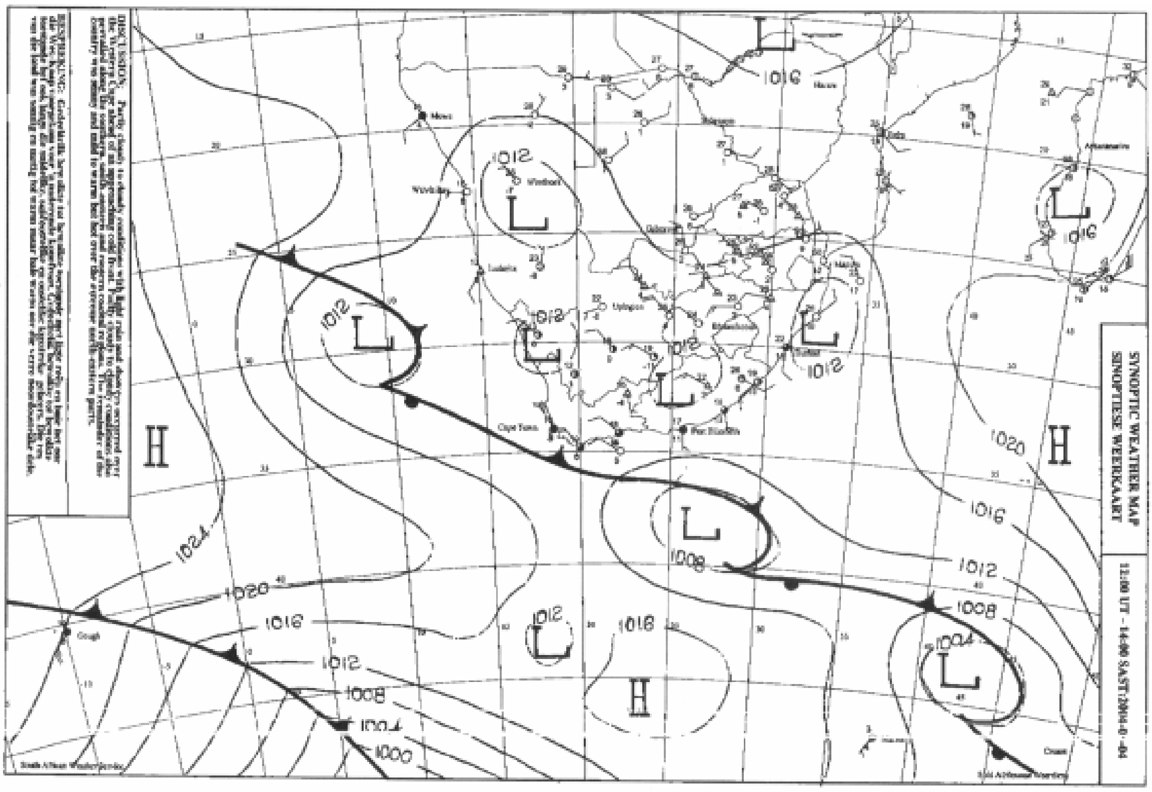


Figure 2.3.1.2: Synoptic Chart for 4 August 2004

2.3.2 Daily rainfall

An overview of the rainfall associated with the event makes a logical start for analysis, as most of the impacts of this storm were flood related. On the 4th, 5th and 7th there are stations with a daily total exceeding 50 mm rain. It would be expected that most of these high total stations would be on the mountain slopes where orographic forcing increases rainfall. However, at Pinelands we see an unexpected peak on the 5th August, which exceeds that of the Newlands station (generally the highest rainfall is recorded at this station in storms). Pinelands' August monthly average is 83mm, therefore this single day constituted 2/3 of the average monthly total. The reason for this high total can be sought in one or a combination of the following factors:

- Mountain wave uplift either over, or down wind, of the mountain was such that Pinelands was particular favoured under the particular wind regime at the time – west or south-westerly as opposed to north-westerly on the 4th and 7th August.
- The intense post frontal cold air of the 5th August is normally highly unstable which favours the development of large Cumulus or Cumulonimbus cloud cells. The increased vertical development in cells such as these does lead to intense rainfall rates.
- Cumulus development is always dependent on some "trigger" which in this case was probably provided by the mountain wave uplift
- The maturity of the system would indicate slow movement, which, in turn, could have led to the combination of favourable factors being in situ over Pinelands for a considerable period.

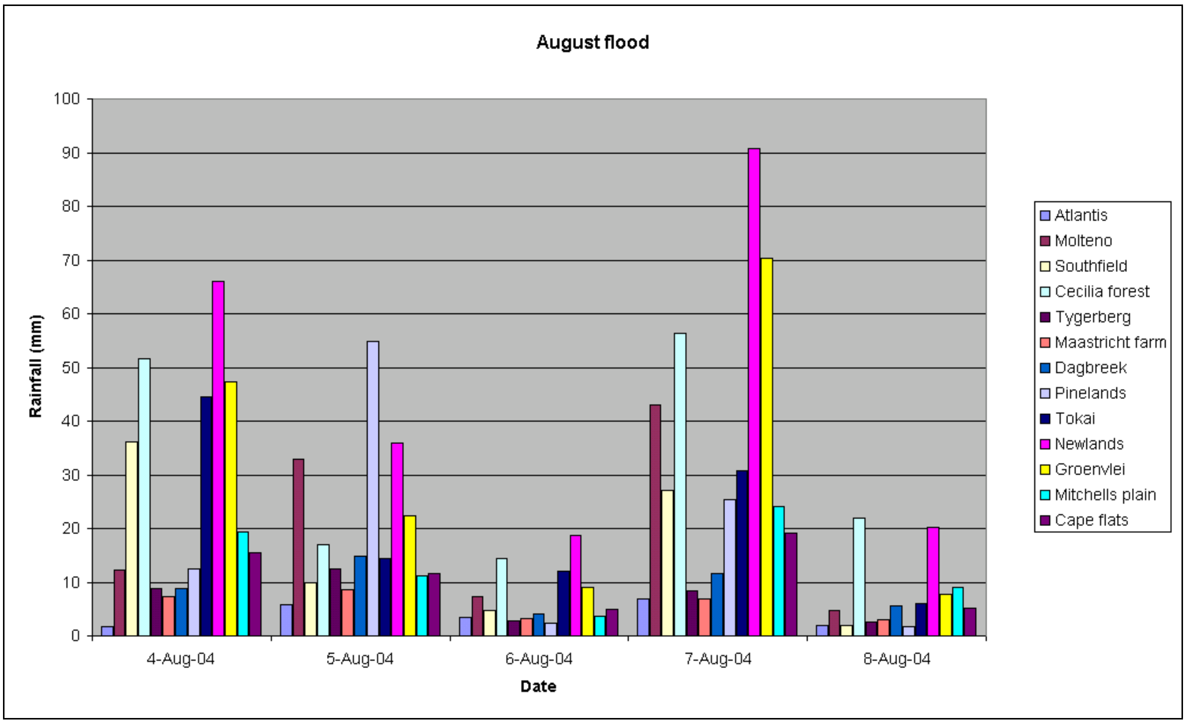


Figure 2.3.2.1: Station rainfall totals over the duration of the two rainfall events

During the second, more intense event, rainfall was highest in Newlands, as one would expect. This second cold front seems to conform to the normal distribution of rain over the peninsula with heaviest rains in mountainous areas. The groundwater table rose and so caused problems as the new rains on the 7th could not be absorbed.

Daily station totals from the City's orthographic/rainfall stations were used in conjunction with SAWS data to compile a GIS layer of rainfall. Various attribute data was attached to individual stations. This included, daily rainfall totals for the August event, as well as flood-return periods. Station data alone, was not sufficient to suitably analyse the spatial patterns of both the return periods and the total daily rainfall. Interpolation procedures were used to convert the point station data to surfaces. Interpolation was performed using ArcMap 8.3 and the Geostatistical Analyst extension.

Various Interpolation methods were tested. The Radial Basis Function (RBF) was found to produce smooth surfaces with the least amount of error. RBFs are a form of artificial neural network. The technique is an exact interpolator that does not alter the original point values. Figure 2.3.2.2 are the surfaces created by the RBF interpolator.

Isohyets connect stations of equal rainfall. These maps are very useful in visualising where rains fell over the duration of the event. Figure 2.3.2.1 above shows daily rainfall totals. By comparing rains from the 4th, 5th and 7th it can be seen that the spatial extent of the effects are rather different. One thing to bear in mind when looking at the 4th and 5th is that the event occurred overnight which is why there is a distinct spatial shift in intensity from west to east as this is the result of the storms progression in an easterly direction. On the 7th rains are more intense over the Table mountain district and the southern suburbs.

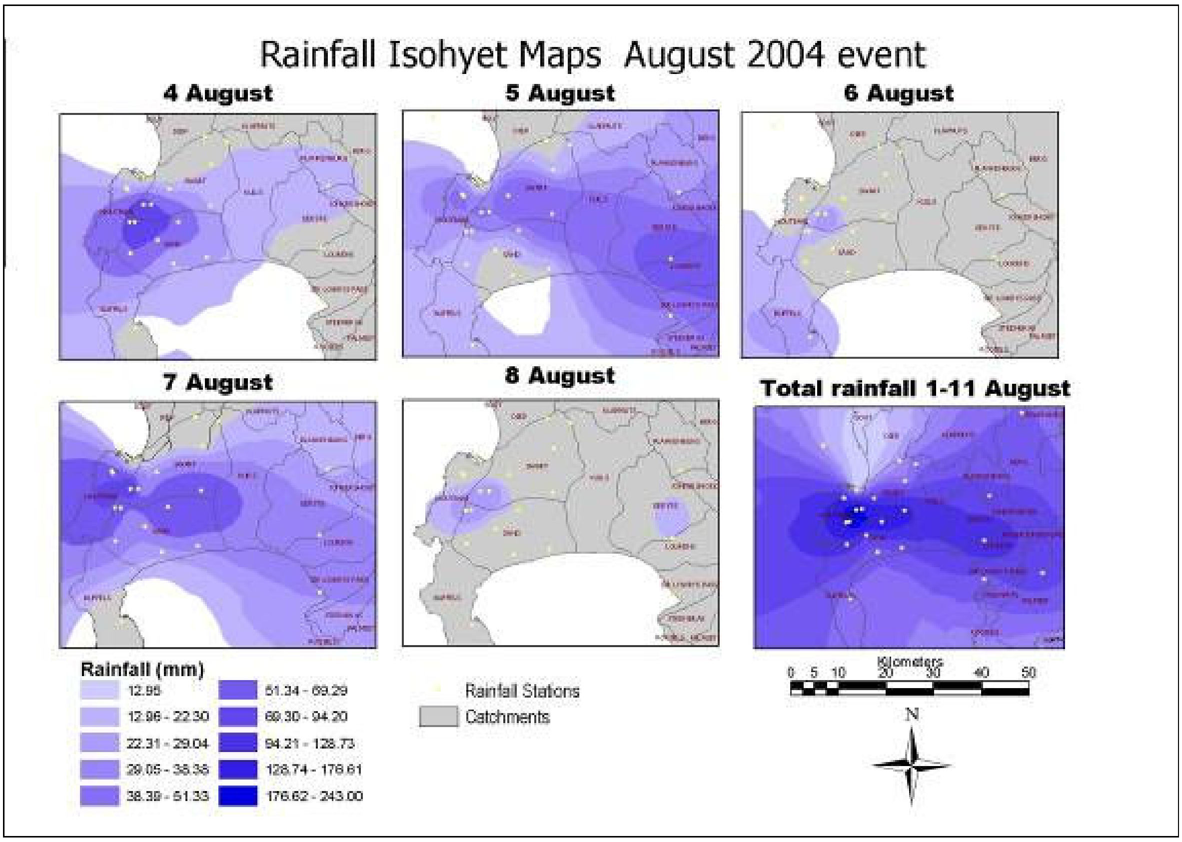


Figure 2.3.2.2: Map of daily rainfall from stations interpolated

2.3.3 Winds and Temperature

Cold temperatures accompanied the intense rainfall, although minimum temperature never dropped below 8°C, the daily average was a cool 14°C. Wind speeds were high at Cape Point, however other areas experienced only moderately strong winds. There has been speculation as to the dual nature of Cape storms. Generally they are either very windy or very wet. A normal sequence of events during the passage of a well developed winter cold front system is that:

- Wind from North or Northwest strengthens during the 24hour period prior to fronts arrival, often reaching gale force – during this period rainfall is limited to "orographic" falls near the mountain.
- Wind starts to moderate significantly as the frontal zone moves over the Peninsula and may or may not "back" into the west or southwest. Rainfall becomes more general spreading over the winter rainfall area, dependent on the intensity of the storm system. Generally in the post frontal sector strong winds are not significant.

Table 2.3.3.1: Station values of temperature and winds for the 5th August

5-Aug	Simonstad	Strand	Elgin farm	Hermanus	Molteno res	CT portnet	CTWO	Paarl	Geelbek
Max temp	10.9	13.6	14.4	13	12.9	13.2	12	12	14.5
Min temp	8.9	10.6	8.5	9.8	10.3	11.2	9.7	9	7.5
Wind dir 8.00am	20	360	310	0	60	***	350	320	350
Wind speed 8.00am	14.2	6.4	5.7	0	2.2	***	6.8	1.6	7.2

In Figure 2.3.3.1, the colour indicates the amount of moisture being carried and the arrows are vectors of wind direction (the longer the vector, the stronger the winds). Most of the winds come from the northwest along a very defined frontal barrier. As the storm passes, there is a switch to a west wind. This pattern of winds has been noted to play an important role in other high intensity rainfall events, including those in 2001 (Lennard, unpublished). Therefore, it may be valuable to look out for these types of wind fields in advance of severe floods.

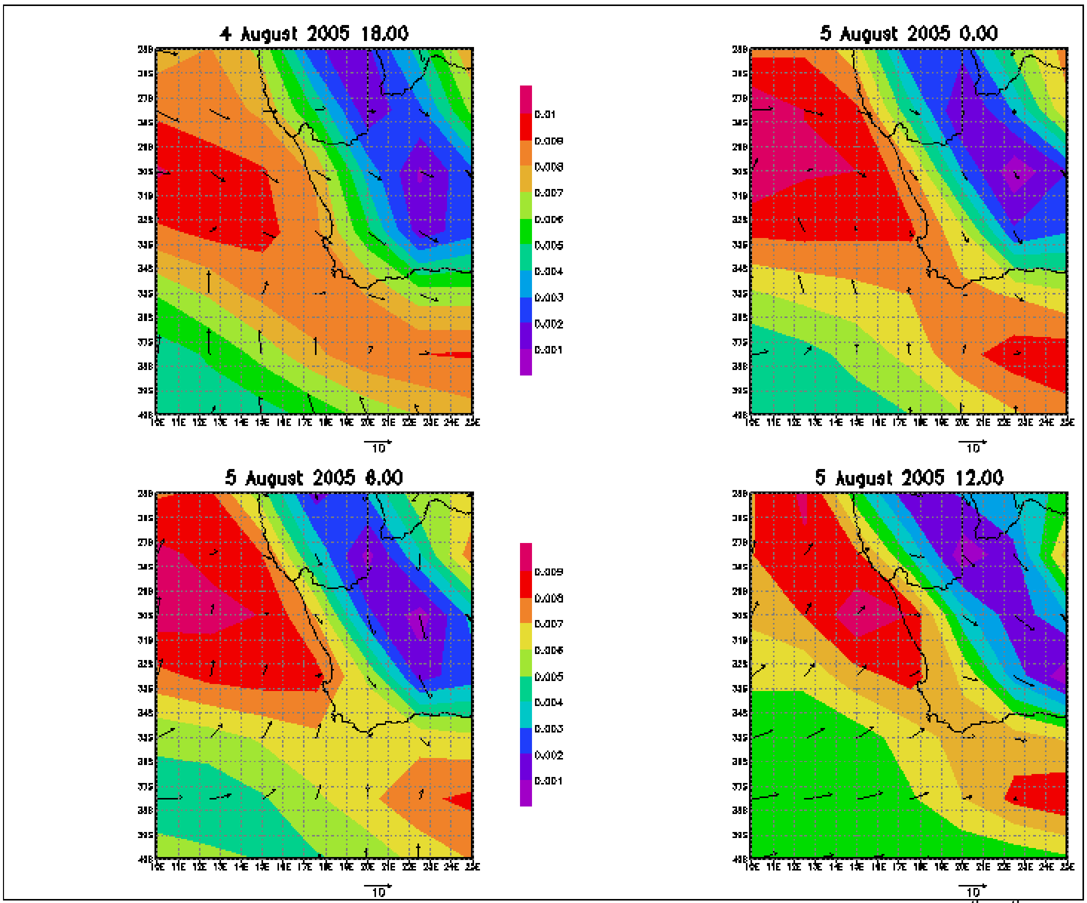


Figure 2.3.3.1: Moisture transport from the evening of the 4th-5th August 2004.

2.4 Flood Hydrology and Environmental Analysis

Human activities, particularly those related to urban development, modify the natural hydrological regime of drainage catchments. The hardening of surfaces and artificial canalisation of water results in increased surface runoff volumes and peak flow rates. Stormwater management systems are required to manage and mitigate these impacts within the constraints of community resources and technical practicality.

The following section provides an overview of stormwater management practice in Cape Town, and document the hydrological response of the system to the meteorological event of August 2004.

2.4.1 Cape Town's Stormwater Management System

Cape Town's stormwater management system comprises an extensive network of underground pipes and surface features such as rivers, canals and ponds as follows:

- 1200 km Rivers and streams (of which 300km are maintained annually)
- A vast and presently indeterminate network of informal or private channels and ponds
- 5500 km of Underground Pipes and Culverts
- 650 Detention and Retention Ponds
- 150 000 Gullies and Intakes

2.4.2 Stormwater Design Philosophy

One of the primary objectives of stormwater system planning and design is to limit risk to generally acceptable levels in a manner that does not prejudice downstream communities or users. Modern stormwater system design incorporates both a minor and major system. The minor system, which caters for the more frequent rainfall events, to limit inconvenience to pedestrian and vehicular traffic, generally comprises underground pipe reticulation with intakes located along roadways. During major rainfall events the roadway then acts as a conveyor of water once the minor or underground system reaches capacity. Typical components of the major system are roadways, watercourses, canals, stormwater ponds and large underground culverts. Stormwater ponds temporarily store overland flows and release water back into the underground system once capacity becomes available.

Systems are sized using various numerical methods that consider the physical catchment characteristics and apply a probabilistic range of storm intensities to calculate the anticipated runoff for various return periods. The return period is defined as the average interval between storm events and is the reciprocal of the annual probability of occurrence. The minor system is typically designed to cope with runoff events of between 2 and 5 year return periods, while the major system must cope with events up to and possibly exceeding 100 year return.

Many of the older areas of Cape Town were not designed on this basis, with obvious inherent deficiencies in dealing with extreme rainfall events.

2.4.3 Flood Mechanisms

Flooding may be defined as;

"A temporary rise in water level or the overflow of water onto land not normally covered by water that results in socio-economic disruption, property damage or threatens the safety of the public."

Within the municipal area of Cape Town most flood incidents occur when stormwater runoff flow rates exceed the capacity of the stormwater system. This applies predominantly in the formally developed areas and floodwaters usually recede within hours. However, in informal settlements and other marginal land on the Cape Flats, flooding is often related to a combination of runoff and groundwater ingress, which accumulates inside dwellings (where floors are lower than the surrounding ground) and ground depressions. This is due to the generally high water tables prevalent in the areas. The floodwaters often do not recede for many days or even weeks with significant socio-economic impact on the affected communities.

2.4.4 Flood Vulnerability

Vulnerability of communities to the impacts of flooding correlates closely with their socio-economic circumstances. As such, a large proportion of Cape Town's population, particularly on the Cape Flats, may be considered vulnerable to the impacts of flooding.

2.4.5 Runoff

Land use and development are important factors to take into consideration when addressing runoff. For example, runoff is greater in the CBD and industrial areas to runoff in residential areas due to the hardening of the surface area (Pers. Comm. Barry Wood). Hardening of the surface area is caused by the construction of roofs, paths, pavements, tarred roads and parking lots and prevents water from being intercepted in the soil by plants, as occurs in residential areas that have natural vegetation cover. Hardening of the surface area in the CBD and industrial areas affects the hydrological behaviour of water as the soil is not able to absorb water falling as rain. The increased runoff augments the effects of spates so that flood return periods may be shorter than they would be if the catchment were in its natural state.

From an ecological perspective, hardening of the catchment also results in a reduction of water quality as it results in increased runoff of stormwater directly into the river, mainly after dry periods when pathogens, oil and atmospheric deposition have collected on the roads and other surfaces (Day, 1995; Davies and Day, 1998).

2.4.6 Land Use

There is mixed land use in the Salt River Catchment Area, which includes residential as well as industrial use. Less densely populated residential areas include Welgemoed and Newlands, whereas more highly urbanised areas include Athlone, Bonteheuwel and Joe Slovo. Epping, Ndabeni and Paarden Eiland are industrial areas located in the catchment. The catchment area also includes the Kirstenbosch Botanical Gardens and the Tygerberg Nature Reserve (City of Cape Town, 2004).

The 5 August 2004 rainfall event, resulted in widespread and serious flooding in the Nyanga, Guguletu, Athlone, Bonteheuwel, Langa, Pinelands, Observatory, Maitland, and Woodstock areas. Peak rainfall intensities for storm durations exceeding 3 hours, approached the 1 in 100 year return statistical maximum within a very confined geographic area, centred over the general Athlone area

2.4.7 Environmental Analysis

Historically, the area surrounding the confluence of the Liesbeek and Black Rivers was part of a large wetland system that extended from Table Bay to False Bay (refer to Figure 2.5.2) (The Environmental Partnership, 2001). Paarden Eiland once consisted of mudflats, islands and estuarine wetlands, which formed a delta at the Salt River, the Black River and the Diep River mouths. The Liesbeek, Salt and Diep Rivers were likely to have been perennial rivers, while the Black River and most of its tributaries most likely seasonal (Day, 1995). Wetland reclamation, which began in the 1940s, along with the construction of major roads and the alteration of drainage lines, have resulted in a modified natural environment (The Environmental Partnership, 2001). The Black River, once seasonal, is now perennial which is mainly as a result of the effluent it receives from the Athlone Waste Water Treatment Works (WWTW) and is almost completely canalised from its confluence with the Liesbeek River to where it meets the sea (Day, 1995).

There are significant flood risks which exist along many of the tributaries in the Salt River Catchment and floodlines along some of the major watercourses have been determined (City of Cape Town, 2004).

Flooding is normally a result of blocked gullies and pipes. In Cape Town the river systems are generally small with small catchment areas and as a result the rivers respond very quickly (Pers. Comm. Barry Wood). The rainfall on the 5 August 2004 was very concentrated and thus the flood event was very localised. During this event peak intensities approached the 1:100 year return period (City of Cape Town, 2004). The flood resulted in many of the canals and rivers bursting their banks as the capacity of the canals were exceeded. For example, the high intensities of water in the Liesbeek and Black Rivers resulted in a bottleneck which caused the Salt River Canal to burst its banks. This flooding occurred as predicted in a study conducted by Ninham Shand (2004) which described possible flooding due to overflow from the Black and Liesbeek River channels as a result of the limited capacity of the Salt River Canal. In the past, excess water would pond in the Salt River Marsh and thus flooding was often prevented. However, due to the modification of the river courses, water is confined to canals in many cases and in the event of excess water, the canal bursts its banks and flooding results as in the case of the Salt River Canal in August 2004 (see Figure 2.4.7.1 below). For more images on the event refer to Appendix 5.

Figure 2.4.7.1: Salt River over-bank flow at Black River Parkway

The August flood was concentrated over the central Cape Flats areas of Langa, Pinelands, Athlone, Guguletu and Bonteheuwel. Those rivers that were affected in the flood event were the Kalksteenfontein, Blomvlei and Vygekraal Rivers. For storms in excess of two hours duration, the average concentration time for these water courses, rainfall intensities were in excess of the 1 in 20-year statistical maximums. The rainfall intensities decreased sharply away from the affected areas.

Statements in the newspapers following the flood event described the cause to be due to the early service maintenance of the river systems in the Salt River Catchment together with the late arrival of winter rains. Although this may have exacerbated the flood, it was not the cause of the flood. The flood was the result of the level of water in the Salt River rising very quickly over a short period of time which back flooded up the Liesbeek River causing the river to burst its banks (Pers. Comm. Barry Wood).

Table 2.4.7.1: Tidal information at Table Bay on 5 August 2004

Tide	Time	Sea Level
Low Tide	00:22	-0.465m below mean sea level
High Tide	06:20	0.645m above mean sea level
Low Tide	12:20	-0.425m below mean sea level
High Tide	18:44	0.775m above mean sea level

There was also speculation as to whether the flooding occurred as a result of the high tide in Table Bay. The peak water level in the Salt River Canal occurred at approximately 11:00 on 5 August 2004. At this time the sea level was –0.3m and close to low tide (refer to Table 2.4.7.1). On 5 August tidal fluctuations were greater than 'normal' due to spring tide on the 1st August 2004. It is therefore apparent from the tide information displayed in Table 2.4.7.1 that the flooding did not coincide with high tide in Table Bay (Pers. Comm. Colin Wittemore).

2.4.8 August 2004 Flood Affected Areas

The primary impact of the flooding was experienced along the tributaries of the Salt River, which drains into Table Bay at Paarden Eiland. The catchment measures approximately 215 km2 in extent and includes Tygerberg Hill and Panorama in the north, Parow and Bonteheuwel in the east, Lansdowne and Bishopscourt in the south and Woodstock in the west The main tributaries include the Liesbeek, Black, Kromboom, Blomvlei, Vygekraal, Jakkalsvlei and Elsieskraal rivers as indicated in Figure 2.4.8.1 below. Peak outflow from the catchment is estimated at 210m3/s with a return period of 50 years (viz. 2% probability of occurance in any year). For some background information on the Salt River catchment refer to appendix 6.

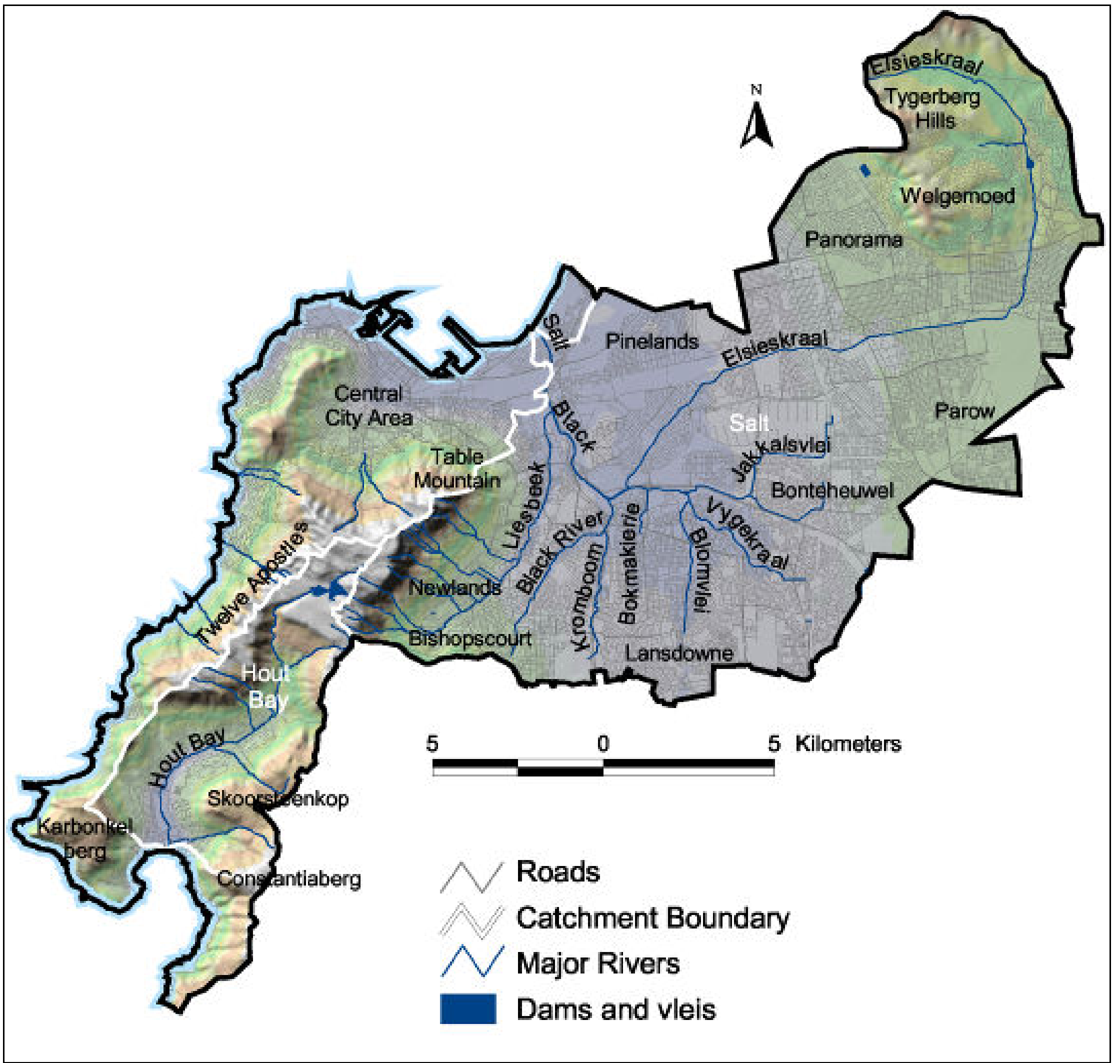


Figure 2.4.8.1: Salt River Catchment and Major Tributaries spatially located in the Metropole

The Salt River catchment is substantially developed under a full spectrum of uses including residential (incl. informal), commercial, industrial and institutional. This development has largely taken place over the past fifty years. As a result, large components of the stormwater management infrastructure have been designed according to outdated standards. Development has also been permitted in inappropriate areas requiring considerable expenditure on flood alleviation works to rectify in certain isolated areas.

2.4.9 Rainfall Intensity

Storms can also be characterised by the amount of rainfall that falls over a given length of time. From this the storm intensity is determined. The larger the quantity of rain falling over this period, the more intense the storm is considered. To undertake this sort of analysis, data with high temporal resolution is required. The Transport, Roads and Stormwater Directorate have roughly 30 stations across the metropole area that records rainfall of five minute intervals.

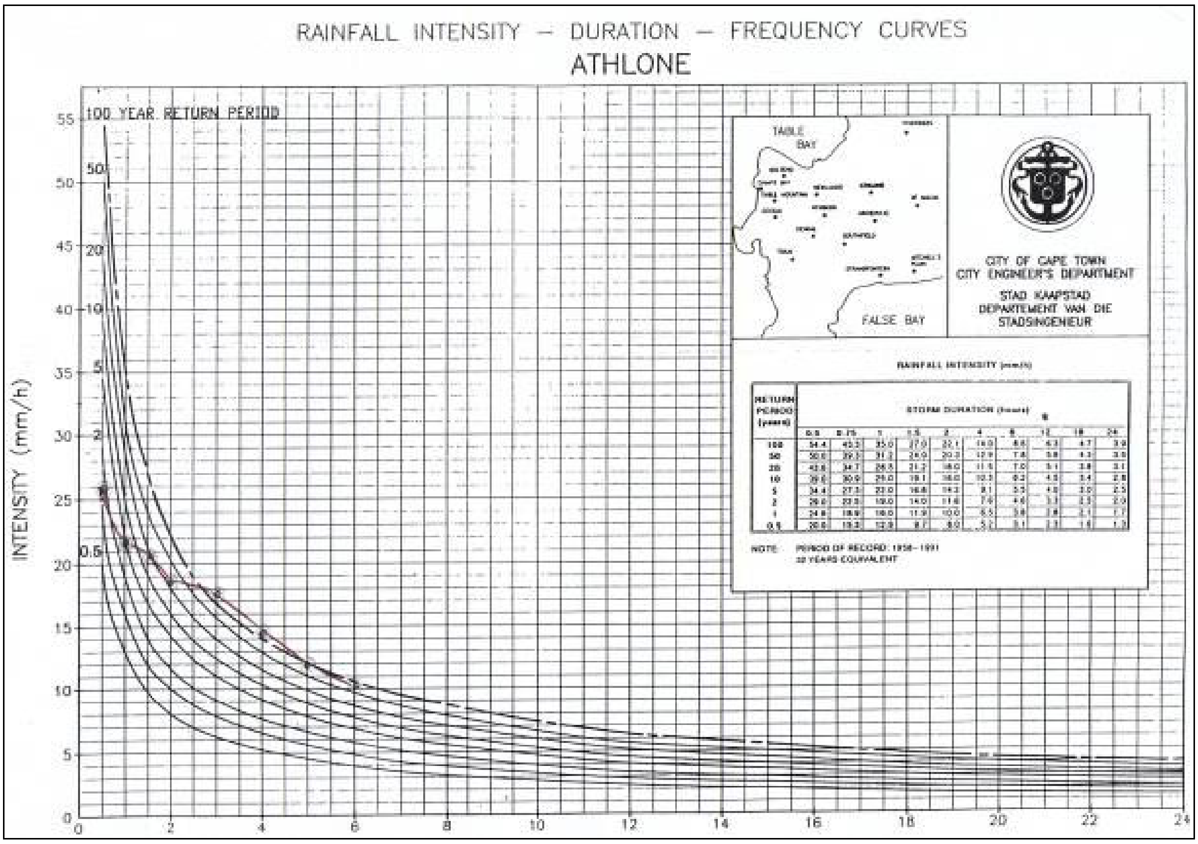


Figure 2.4.9.1: The intensity-duration-frequency curve for the Pinelands /Athlone area on 4th and 5th August

Return periods are calculated by plotting maximum values for a few key time intervals (30 min to 5 hours) for a specific rainfall event (a table of these values is in Appendix 3). These values are then read against intensity-duration-frequency curves, which relate to individual areas/stations long-term rainfall patterns. An example of a curve for pinelands during the event is provided in Figure 2.4.9.1 above. For this event most of the stations fell below the design curves meaning that they are expected to occur on an annual basis. For certain stations, including Pineland, the event curve was above the 100-year flood line for the 3-5 hour duration for the storm in question. When a storm has high intensity over longer periods, the system usually reaches capacity and flooding occurs. Shorter duration heavy rain events are much easier to deal with.

For this event, rainfall intensities at most of the stations were below the one year return (normal expected). For certain stations however, including Pinelands, Athlone and Cape Town International, the intensities exceeded the 50 year return for durations of 3-5 hours, as illustrated in figure 2.4.8.2 below.

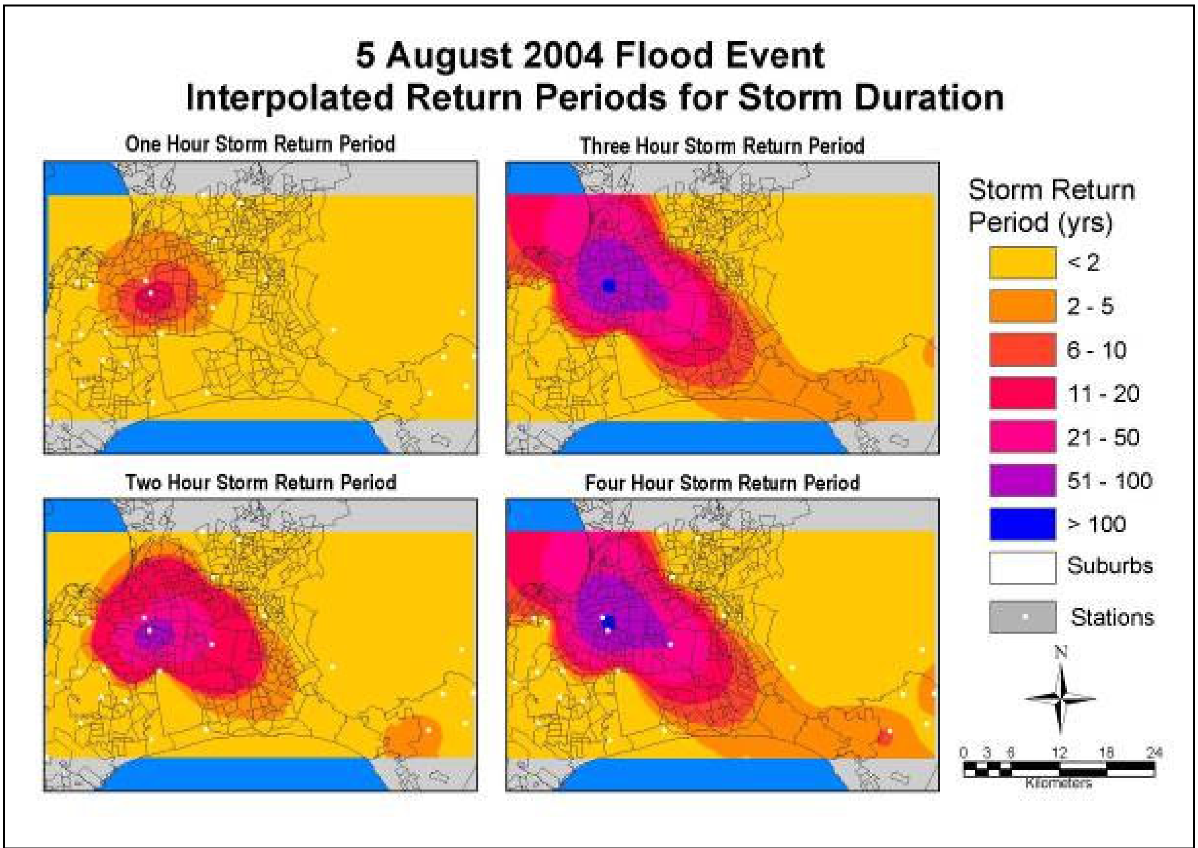


Figure 2.4.9.2: 4th&5th August flood return period intensity for 1-5 hour durations

Rains on 7th and 8th August did not match the previous event in terms of intensity. Although more rain fell in the second event at many stations, the intensity never surpassed the 20-year return period. This is explained by continued or persistent light rainfall as compared to the short, heavier rains experienced on the 4th and 5th. The second event resulted in significant increase in groundwater levels and many informal areas on the low-lying Cape Flats were adversely affected.

Table 2.4.9.1: Recorded Precipitation and Calculated Storm Return Periods (5 August 2004)

Rain Gauge Location	Return Period for Specific Storm Duration					Total Rainfall (00H00 to 24H00)
	30 min	1 hr	2 hr	3 hr	4 hr	
Cape Town International Airport	--	2	>20	50	50	58 mm
Athlone WWTW	2	50	100	>100	>100	67 mm
Pinelands	1	5	>20	100	100	62 mm
Hanover Park	< 0.5	< 0.5	0.5	0.5	0.5	48 mm
Gardens	0.5	2	2	5	5	--
Newlands	0.5	0.5	0.5	0.5	0.5	78 mm
Tygerberg Hill	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	17 mm
Kuils River	1	1	1	1	1	23 mm

Rainfall intensities were high for storm durations exceeding two hours as indicated in Table 2.4.9.1 above. This resulted in significant tributaries in the eastern portion of the Salt River catchment bursting their banks as these major drainage systems have times of concentration exceeding two hours. Floodwaters were however contained within the adjacent floodplain areas reserved for such flood flows. Major detention ponds on the Blomvlei and Vygekraal Rivers filled with water in accordance with their design parameters. No major incidents of flooding were attributable to the capacity of minor underground systems as the storm duration was in excess of one to two hours. These systems are particularly sensitive to high intensity, short duration storms.

Approximately 100 informal dwellings in Gxa-Gxa informal settlement in Guguletu were flooded when the stormwater pond within which they were located filled with water. Water levels in the pond remained high for a number of hours due to a blockage on the downstream stormwater system. A large number of dwellings and streets were flooded in Bonteheuwel and Pinelands due to back-flooding from the Jakkalsvlei and Black Rivers respectively as well as localised pipe and intake blockages. Only nominal flows were observed in the Elsieskraal canal through Pinelands as the northern suburbs experienced comparatively little rainfall.

A sporting facility and associated car park in Observatory was inundated due to reverse flow up the Liesbeek River from the Salt River. Initial claims that this resulted from exceptional tides in Table Bay proved unfounded. Factories in Beach Road Maitland were inundated due to over-bank flow from the Salt River under the Black River Parkway flyover. Major traffic disruptions during the afternoon peak occurred due to flooding of the N1 freeway under the Koeberg Road Bridge, due to a blocked intake. In general the informal settlements were only marginally affected by the 5 August rainfall event.

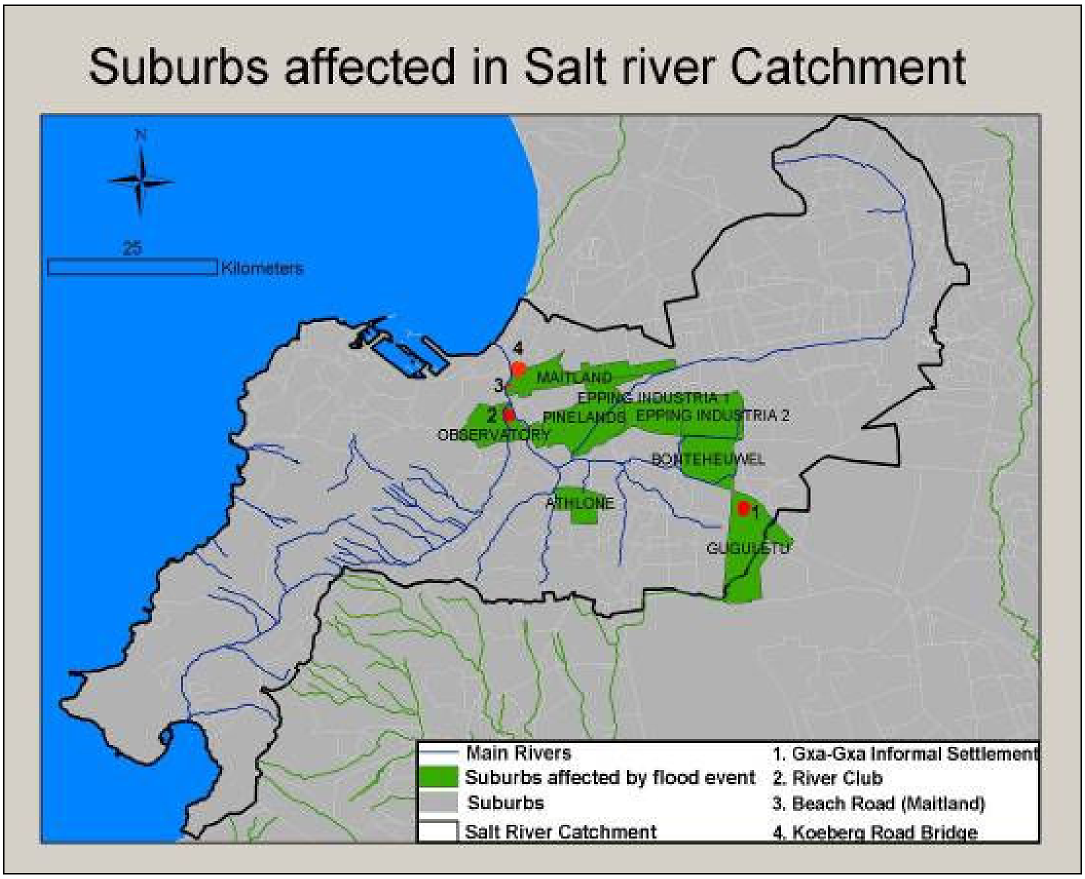


Figure 2.4.9.3: Map of flooded locations

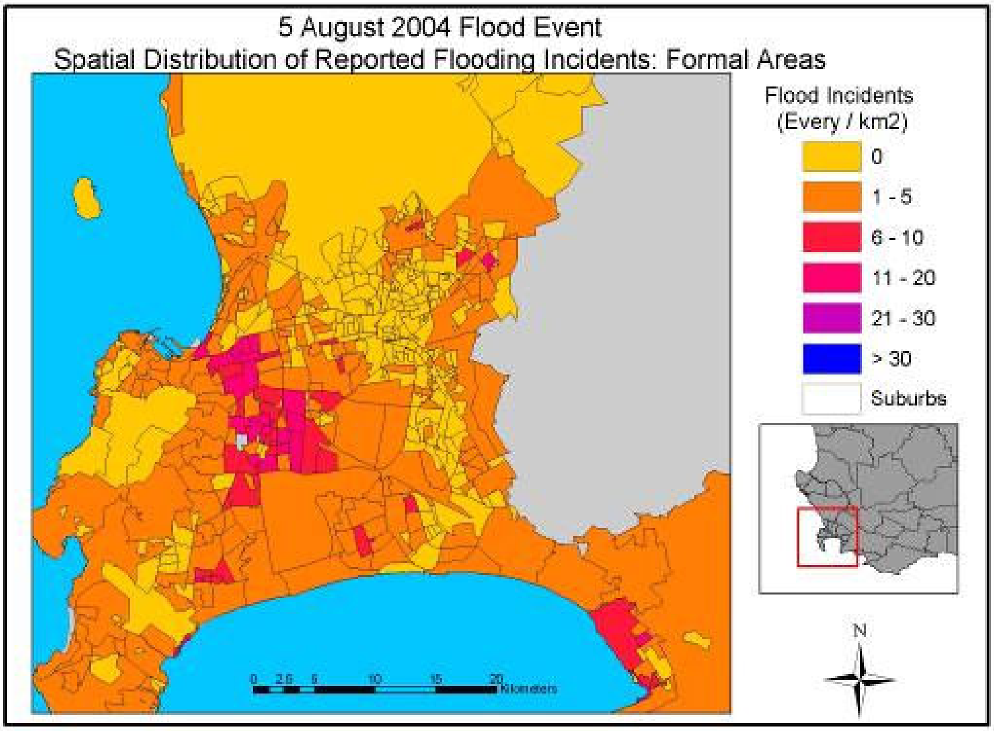


Figure 2.4.9.4: Spatial Distribution of Flood Incidents per Suburb

By contrast, the rainfall on 9 August 2004, although not significant from a hydrological viewpoint, resulted in significant flooding in most of the informal settlements across the municipal area. The worst affected settlements were located in Kraaifontein, Langa, Guguletu/Nyanga, Khayelitsha and Somerset West areas. Approximately 20 000 persons were displaced and required assistance from social services.

On 5 August, a total of approximately 500 road flooding and 100 property flooding incidents were reported. Distribution of these incidents correlates with the storm centroid as depicted in Figure 2.4.6.4 below. In addition a total of 4500 informal dwellings were affected over the period 5 to 9 August.

In Summary

- Rains on the 4th and 5th August were the result of a mature frontal system passing over the Cape, preceded by gail force winds and followed by severe cold.
- Rain fell most heavily over the Pinelands/Athlone area were the intensity approached the 100 year return period over the 2-3 hour duration of the event.
- Many residential areas were flooded in the area.
- On the 7th and 8th August a second front brought more rain. This caused flooding problems in many areas where the water table was still high - such as the Cape Flats.
- Although the second storm was not particularly significant meterologically it did cause suffering in many communities.
- The August flood was concentrated over Langa, Pinelands, Athlone, Guguletu and Bonteheuwel.
- Kalksteenfontein, Blomvlei and Vygiekrall rivers affected.
- The sea tide did not affect flooding.

Part III Early Warning and Preparedness

3.1 Introduction

Early warning systems are seen as a powerful means for effectively reducing risk of, and impacts from, severe weather events. In the context of urban environments in developing countries, such as South Africa, specific constraints exist which serve to limit the effectiveness and implementation of an early warning system. This section of the report examines the current means for disseminating the early warning/weather forecast to both field professionals and the general public.

An early warning system is defined as "the provision of timely and effective information, through identified institutions, that allow individuals at risk of a disaster, to take action to avoid or reduce their risk and prepare for an effective response" (ISDR, 2002 pg 338). The system essentially comprised of three parts:

i. Forecast and prediction of the event;
ii. Processing and dissemination of the warning;
iii. Appropriate response to the warning.

As having an early warning system in place comprises part of a preparedness strategy and since early warning systems serve to allow field professionals to prepare for a response, this section also looks at institutional level and on the ground responses, in both formal and informal areas, to the severe storm event. The section also includes recommendations, which the researchers feel could strengthen the early warning system as well as the response mechanisms, thus reducing the impacts of future severe weather events.

Part III is structured in the following way:

Section 3.2 discusses the general methodology used to obtain the information on the early warning

Section 3.3 discusses the early warning and what the formalised paths are for its dissemination to institutions

Section 3.4 discusses dissemination and preparedness of communities

Section 3.5 discusses recommendations for both the early warning and response procedure

3.1 Methodology

Information on the early warning system used for the August 2004 event was obtained through the institutional and household interviews which were conducted in the field (see part V for a more detailed methodology). Meetings and focus group interviews were also held with numerous persons from different levels of Disaster Management. Other individuals and institutions concerned with early warning were also consulted.

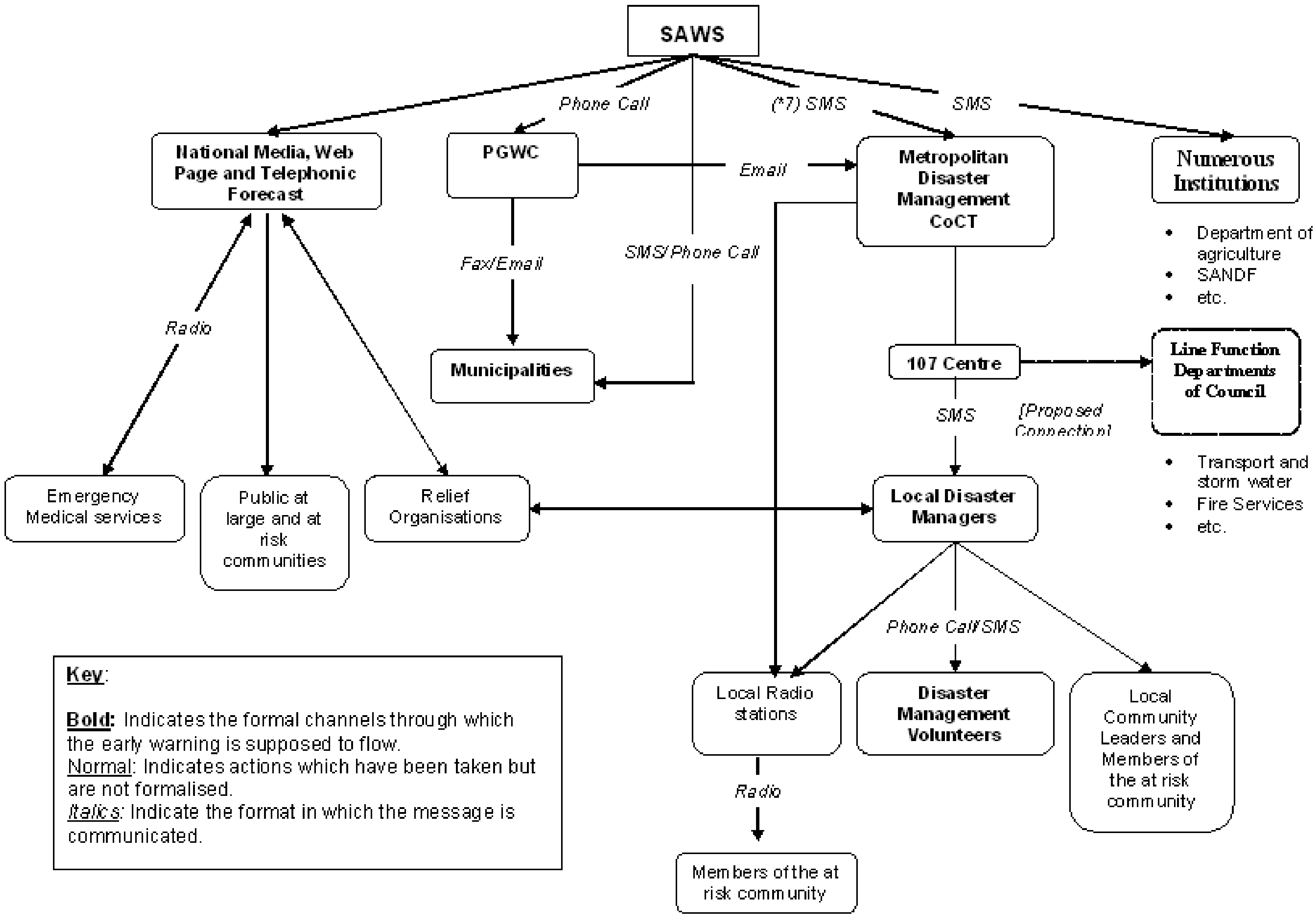


Figure 3.1.1: Organogram of the early warning procedure

3.3 Dissemination and Institutional Preparedness

The formalised aspects of the early warning for the Western Cape do not make up an early warning system; rather what they represent is a forecast, which allows for the preparation for an institutional response. The reason for this differentiation is that the current 'early warning' makes very little formalised provision for actions by the general public, which would reduce the extent or severity of flooding. Rather it simply assists in gearing up institutional response to the impending flooding.

The procedure for the dissemination of an early warning is outlined in Figure 3.1.1. An explanation of the organogram follows:

a) The South African Weather Service (SAWS) produce and disseminate severe weather warnings. Forecasters determine the probability of the onset of the severe weather system and attempt to determine what impacts this will have in terms of rainfall, winds, ocean swells etc. These warnings are given out by the Pretoria head office and from the local Weather Office (DiMP 2004).

b) This warning is then disseminated to the public via the national media and through a telephonic forecast. It is also available on the Internet. In addition to this SAWS makes a phone call to both the Provincial Government of the Western Cape (PGWC) and Disaster Management at the municipal level informing them of the warning. Finally, SAWS have a list of people and institutions to whom they send a SMS (short message service). This 'SMS list' contains numerous institutions including Disaster Management for The City of Cape Town.

c) Upon receiving the phone call from SAWS the PGWC send either a fax or an email to Disaster Managers in the District Municipalities and the City of Cape Town (henceforth to be referred to as The City). Thus the Disaster Managers in The City receive the warning from two sources – one from SAWS and one from PGWC. It is important to note that there is no confirmation of receipt of this communication from either the district municipalities or The City's disaster managers.

d) The email sent to Disaster Management by SAWS is prefixed with *7 this automatically disseminates the warning via the Emergency 107 centre. This centre sends an SMS to Local Disaster Managers (See appendix 4 for a list of persons contacted). This warning is the same in terms of content and format, as the one disseminated by SAWS. Disaster Management for The City may also contact local radio stations to assist with the dissemination of the warning to the general public. Disaster management for The City perform no task in the dissemination of the warning other than relaying the SMS to their local disaster managers, and possibly broadcasting the forecast on local radio stations. There are, however, plans to use the 107 Centre as a strategic point from which to disseminate the warning to line function departments.

e) Upon receiving the warning local disaster managers contact their volunteers.

There is no formal procedure other than the one described above regarding early warning. Thus it is apparent that this formalised procedure serves only to prepare institutions for a response to flooding.

The contact list used by SAWS to SMS a warning was compiled by individuals or organisations requesting to receive the information. This could be problematic in that there may be institutions that should receive a warning but have not been identified.

There also appears to be a problem around the maintenance of accurate cell phone numbers for individuals on the SAWS' SMS list. This resulted in such major institutions as Emergency Medical Services and Transport, Roads and Stormwater reporting that they had been left off the SMS list for the August 2004 severe storm event. However SAWS confirmed that individuals from these departments are on the SMS list.

Emergency Medical Services currently relies on actively listening to the public media or observing the intensity of rainfall on their windscreens as a means for preparing for a response. Relief organisations also rely on the public media to hear about severe storm events, they then actively contact Disaster Management in order to enquire about the expected severity of the event and what relief may be required.

On a whole the current early warning procedure represents a preparation for an institutional response. However, it is limited even in this regard, as it does not enable preparation across all institutions.

3.4 Dissemination and Preparedness by Communities

The current early warning procedure does not undertake any formal measure by which to inform communities on the ground of the forecast. It also fails to prescribe any sort of response by communities to that warning. The use of the public media in disseminating early warnings to at risk communities is often problematic in that it requires access to such media. This is particularly so with regards to flooding in informal settlements. Winter rainfall in areas such as Masiphumelele, Lwandle and Gqobasi was reported to damage informal electricity connections. This means that even those people who have the necessary equipment to access the public media may not be able to do so at times of the year when flooding is likely.

Fieldwork in the selected informal settlements found that the reliance on informal communication networks to disseminate information based on the forecast might be problematic. This is so for two reasons. Firstly not much is known about the information networks in informal settlements, thus it is not certain that the message is reaching everybody (it does not appear to). Secondly, informal settlement dwellers from all three field sites claimed to have little faith in the forecasting ability of their contemporaries and thus did not take the warning seriously enough to act upon it. They also communicated feelings of helplessness in the face of an impending flood, not knowing how to respond. Some capacity needs to be built amongst the informal settlement dwellers so that they know what responses would be appropriate should they receive the warning for a severe storm event.

There are numerous other constraints to the production of an early warning for flooding. Firstly the forecast is usually heavily loaded with jargon (technically difficult to understand terminology). Thus the forecast is difficult to access for people who are not climatologically inclined. This becomes a major problem when a warning is disseminated in the same or a very similar format as the forecast that was received. The second problem with the forecast is that weather forecasting is a complex science; this is especially so as regards the Cape Peninsula, which displays highly dynamic, and spatially varied weather patterns. Thus, formalising the procedure of communicating a warning with at risk communities is complicated, as unrealised warnings may serve to desensitise populations to the dangers of flooding, resulting in an increase in risk increasing behaviour.

3.5 Recommendations

The early warning process needs to be formalised in its dissemination, and prescriptive in its responses on the part of both affected and intermediary parties. The list of parties to be notified of the warning also needs to be well informed. In order to deal with problems of jargon in the forecast it is suggested that more strategic use is made of 107 Centre. This Centre could serve as point of contact between the field professionals and SAWS. The forecast, once received by the centre, could be interpreted, operationalised and then disseminated. This process could be professional/department specific, as different persons need the forecast for different reasons. Such procedures need to be discussed prior to a severe storm event and incorporated into Disaster Managements Standard Operating Procedures (SOP's). This would make the forecast both more useful and more accessible.

It was found through consultation that municipal officials found terminology around the geographic location of high-risk areas to be somewhat problematic as there were unspecific time frames for the onset and duration of the event. Information that was found to be most valued in a forecast was specific spatial information. Numerical values in the forecasts were very well received and were considered as being very useful; in fact they were vital to some field professionals. Notably information about the sea swell was found to be a good, and well received, indicator of the severity of a forecast storm event.

There were a number of requests that investigation be undertaken into the feasibility of including the following type of information in a forecast:

a) Information about the expected duration of the event,
b) Explicit mention about the chance of flooding in a storm event,
c) Updated forecasting which showed the progress of a storm event.
d) A level of warning severity was also requested.

The tone of the current SMS often fails to differentiate it from a weather forecast one might hear on the TV or radio. Thus a change in tone to indicate some measure of urgency, or the inclusion of some hydrological modelling to generate a flood-warning index would be most useful. It is realised that much of the detail sought in weather forecasting is unavailable given the difficulties inherent in weather prediction, however the recommendation is that where possible the details mentioned in this report are made incorporated where and whenever possible.

The problem of a formalised means for communicating the forecast with at risk communities, and generating a prescribed response for these communities, in light of the fact that warnings may not be realised, is a complex one. It is felt that a formalised procedure for informing institutions involved in response and relief of potential flooding would not prove problematic as such institutions would be sympathetic to the complexities of weather prediction and thus not mind that not all warnings issued would be realised. Thus it is imperative that such a procedure be put in place.

As regards communities at risk there was a great deal of concern about the consequences of warnings not being realised. For this reason it was felt that it may in fact be better to build a general cognisance and understanding of the weather and how it interacts with other environmental factors to generate flooding in an area. Thus programmes may look more at education around awareness and preparedness for flooding. Such cognisance could be built through partnerships between at risk communities and the broader surrounding communities. Examples of such partnerships appear is illustrated below in BOX 1.

At the moment there does not appear to be any sort of system that could be understood as a formalised early warning system, even at the institutional level. This is concerning as such a system provides a simple, yet, powerful tool for reducing the losses and impacts attributed to flooding. For this reason it is imperative that a formalised system for conveying an early warning be established at an institutional level, and that appropriate educational and developmental initiatives be taken at the level of the affected communities.

BOX 1

Risk reduction in informal settlements – the responsibility of the broader community

Due to Masiphumelele's close proximity to both work opportunities and to the affluent suburbs of Noordhoek, Kommetjie and Fish Hoek. It produces two interesting cases where simple partnerships between the informal community and the broader community could serve to reduce flood impacts as well as having other positive knock on effects.

Firstly partnerships with the surrounding private sector are easily justifiable as such private organisations serve to gain tremendously from the cheap labour that is available to them due to their close proximity to an informal settlement, thus they should take some responsibility in ensuring that the lives of their employees meet acceptable standards of dignity during times of flooding. Many of Masiphmuelele's inhabitants are involved in occupations in which they require a uniform. In the event of a flood such uniforms are often not useable for the period of inundation or become ruined entirely. In such instances, were large employers to put in place change rooms and then store their employees uniforms on site, loss of work time and the cost of replacing uniforms could be removed as an impact on informal settlement dwellers livelihoods. Such change rooms would also be very useful areas in which to display flood awareness posters etc. they may also prove to be places in which general attention can be drawn to the weather by posting items such as weather forecasts. Postings in such places may also generate some discussion as to how to respond to the impending weather.

The close proximity of both the affluent surrounding areas and Masiphumelele to a vlei means that both areas have a vested interest in the vlei. This point of common interest can be used to draw on the resources of the more affluent areas as well as help integrate the community of Masiphumelele into the broader community, through educational campaigns around the vlei. Such campaigns serve to educate the communities about the interactions between the weather and the surrounding environment while at the same time encouraging the surrounding communities to keep their environment ecologically sustainable.

In Summary

- Current early warning system represents more of a preparation for a response than it does an early warning
- To convert the forecast to an early warning will take collaboration between SAWS and other departments – SAWS should not be solely responsible for disseminating the early warning
- Disaster management needs to become more pivotal in disseminating and operationalising the forecast – effectively transforming it into an early warning
- Contact with SAWS after the dissemination of the severe weather warning may substantially strengthen the usefulness of the warning
- Use of the SMS system requires rigid maintenance of professional contact details
- Capacity needs to be built at numerous levels in order to facilitate peoples ability to make use of a forecast
- Education and general cognisance of the weather may be the best way for reducing impacts to informal settlement dwellers

Recommendations:

- Formalisation of the warning system
- Change the tone, format and type if information received in the warning
- Build an awareness of the weather and how it interacts with the surrounding environment amongst at risk populations

Part IV Emergency Response and Institutional Arrangements

There are two main components to the emergency response procedure. The first takes place at an *institutional level* while the second takes place *on the ground*. The response at the institutional level is common to both formal and informal areas while the practitioners on the ground respond slightly differently in formal and informal areas.

This section looks at institutional level and on the ground responses, in both formal and informal areas, to the severe storm event. The section also includes recommendations, which the researchers feel could strengthen the early warning system as well as the response mechanisms, thus reducing the impacts of future severe weather events.

Part IV is structured in the following way:

Section 4.1 discusses the methodology used to obtain the information on the response to the event

Section 4.2 discusses the institutional response

Section 4.3 discusses the on-the-ground response for informal and formal areas

Section 4.4 discusses recommendations

4.1 Methodology

As with information relating to the early warning system, the response procedures was obtained through the institutional and household interviews. Meetings were held with various government departments as well as relief organisations. A workshop was held in February 2005 with these organisations to help determine the institutional response to the August 2004 event. The "Corporate risk reduction programme and contingency planning for possible flooding in informal settlement areas: winter 2004" (Disaster Management, City of Cape Town 2004) document was consulted in this regard.

A note on figure 4.3.1, the map on relief provided to informal settlements. This data was taken from Disaster Management and indicates the households to whom Disaster Management have records of providing relief after the August 2004 severe storm event. The data was analysed at the suburb level, as this was the finest detail at which all the informal settlements could be examined[14].

[14] One informal settlement – described as Koeberg Bridge (under N7) – could not be identified as an informal settlement in the GIS database. Thus it has been left off the map, this is not thought to be too consequential for the overall analysis as it only makes up 10 affected households. However small scale impacts can not be overlooked as the rights of affected individuals still need be upheld.

4.2 The Institutional Response

The institutional response to flooding, or imminent flooding, is for the Emergency Control Center (ECC) Management Team to convene in the Joint Operations Center (JOC) at The City Disaster Management offices. Such action can only be undertaken in accordance with the following and is illustrated in Figure 4.2.1:

i. Where the size or seriousness of the emergency seems beyond the capability of a service or requires the assembly of the Flood Disaster Relief Team, the Metropolitan Operations Centre can be requested to activate the ECC and Flood Disaster Relief Team (FDRT),
ii. Where the director of Emergency Services is of the opinion that it is necessary to activate the ECC in order to effectively manage an emergency which has occurred or is likely to occur, the ECC must be activated,
iii. The activating service shall via the Metropolitan Operations Centre contact the local Disaster Management duty officer who shall immediately arrange to notify the identified members of the ECC Management Team and FDRT,
iv. The Disaster Management duty officer shall request the members to meet at the ECC.
v. The ECC will evaluate the situation and advise the City Manager regarding the situation and/or the declaration of a disaster, as well as the continued activation or standing-down of the ECC.
vi. The ECC Management team in accordance with the principles and guidelines contained in the City of Cape Town Multi Disciplinary Incident Management Plan (MIMP) will manage all incidents.

Such a procedure was enacted in response to the August severe storm event. The work undertaken in the JOC has been praised, but some limitations have been identified. The primary limitation was that the Geographic Information Systems (GIS) database used "went down", and so did the network that was running this database. This caused problems in undertaking even relatively simple tasks such as accessing the Internet. This is clearly not satisfactory; however plans are in place to upgrade the JOC's capacity for incident management through the implementation of the GEMC3 system. There are also plans to increase the amount, and accessibility, of information being sent to the JOC.

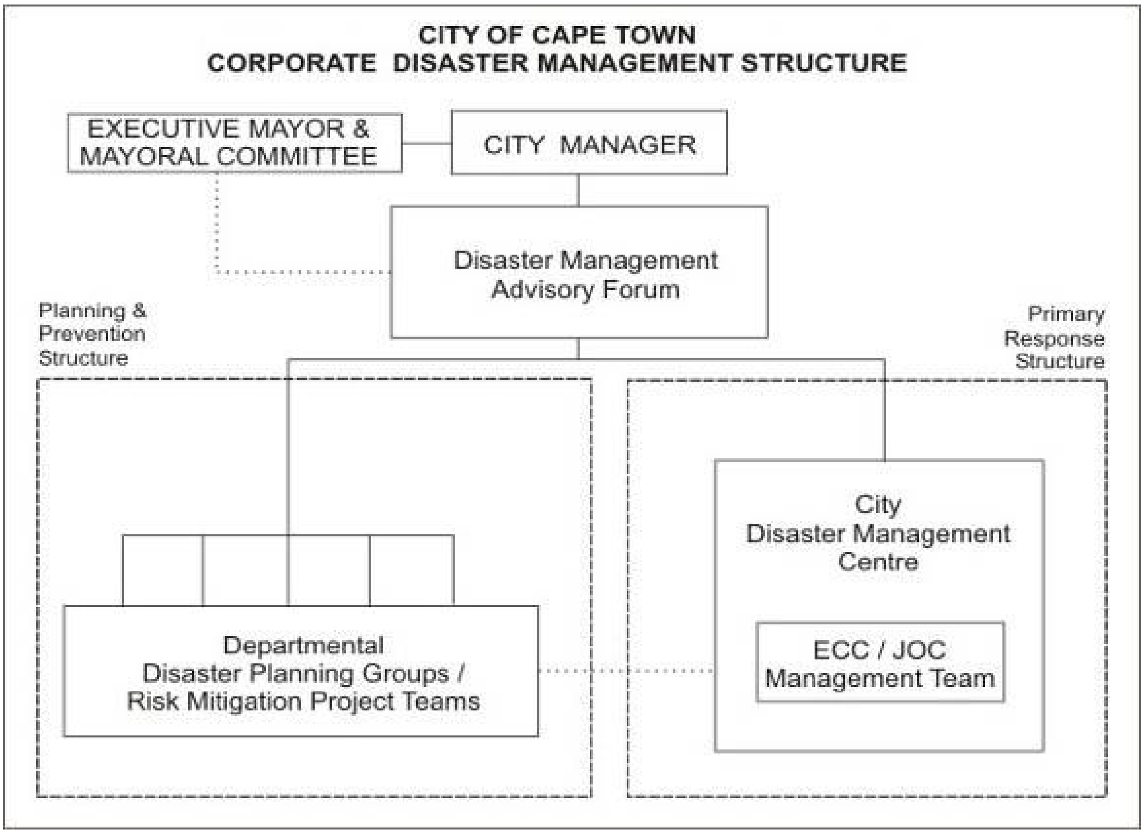


Figure 4.2.1 Organogram of the institutional level response to a flood event -*Taken from the 'Corporate Risk Reduction Programme and Contingency Planning for Possible Flooding in Informal Settlement Areas: Winter 2004'*

4.3 The On-The-Ground Response

In order to enable a response to a flooded area the area must first be identified as flooded. Thus the on-the-ground response procedure comprises of two parts the identification of flooded areas and the response to those areas.

4.3.1 Informal Areas

The on-the-ground procedure in informal settlements is characterised by a large amount of freedom and flexibility on the part of the Disaster Management Coordinators. This is both an understandable and necessary characteristic of a procedure which is enacted in response to a highly dynamic event which inherently requires flexible responses. The fieldwork revealed the following sorts of procedures.

a) Identification of flooded areas

Local Disaster Management and Housing were usually the first formal departments to be informed of flooding in an area. Once either of these departments is notified , they usually contact the other. The pathways by which either Disaster Management or Housing hear about flooding in an area are via members of the affected community or through local ward councillors. Another means of identifying areas that had been affected was reliant on the local field professional's knowledge of the area. Members of both Disaster Management and Housing from all three informal settlement field sites stated that they would often, after heavy rainfalls, drive through the settlements and areas where they thought flooding was likely to occur.

Once a report of flooding was received Disaster Management conduct an on-site assessment to determine whether or not an area could in fact be considered flooded. This process is complicated by the fact that the current definition of what constitutes a flood is problematic. The definition for flooding in informal settlements used in 2004 is as follows:

> "Areas of extensive ponding of flood water which has resulted in water covering floors and areas around dwellings for an extended period of time (more than 48 hrs). This excludes situations where floors are submerged due to having been dug in below natural ground level."
> "Corporate risk reduction programme and contingency planning for possible flooding in informal settlements: winter 2004"[15]

Before one can undertake a critical examination of this definition of flooding some context around the definition is required. This definition was written exclusively for flooding in informal areas which is characterized by a rise in level of the water table to a point where it interacts with the surface and results in a type of flooding which can best be described as 'flooding from below'. The definition was also created in an attempt to prevent individuals claiming they had been significantly flooded when in fact they had not, as well as to provide field professionals with some guidelines as to what they should classify as a flood.

The definition however proves to be problematic for a number of reasons. The most fundamental of which is that the situation is still open to a vast amount of interpretation and this limits its practicality. It is quite obvious that a person who has had their house inundated with water should not be required to live in such conditions for 48 hours before being provided with any type of relief. Thus the Disaster Management Coordinator (DMC) is required to determine whether or not the water is likely to remain in an individual's house for 48 hours given the current water levels. Such a judgment would require some reasonably intimate knowledge of the hydrology of the area; this is a capacity that is thought to be lacking in the majority of Disaster Management Coordinators.

The large degree of interpretability of the definition also means that there will be significant discrepancies in the conditions under which people are classified as flooded and thus entitled to relief. The definition was also thought by participants at a workshop to be problematic due to the fact that legal interpretations of such a definition would very likely be extremely complex. It is recommended, given that the health impacts (see part V) and associated level of human misery during flooding is significant, the definition of flooding should take on a slightly more human perspective.

[15] This definition has since been revised in 2005

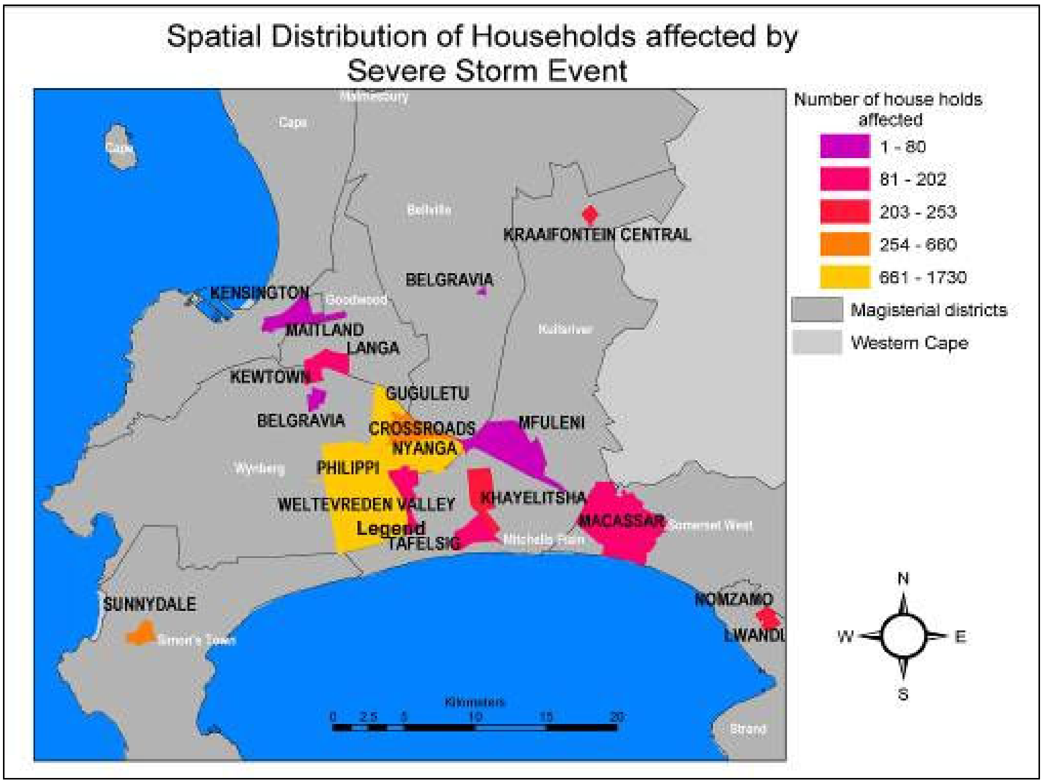


Figure 4.3.1: Map showing the distribution of households that were identified as 'affected', and thus responded to, after the August 2004 severe storm event.

Thus the process for identifying areas which require a response is inherently very informal. There is currently no robust means for ensuring that affected areas receive the response they are entitled to. Furthermore, the apparent lack of uniformity in identifying affected areas appears to be related to the fact that professionals working in different areas have different relationships with the affected communities. It also relates to limited staff available to effectively identify affected areas.

b) Responses to identified areas

The common procedure following the classification of an area as flooded, defined as above, is for Disaster Management to call the engineers at Development Support or Transport, Roads and Stormwater. These engineers then to determine whether there are any structural measures can be taken to facilitate drainage of the area.

While they assess what can be done, Disaster Management opens the halls from which relief will be provided. They then, along with Housing, move through the settlement or area and register all those people whom they deem to be flood affected. In some instances where flooding is as a result of rain entering the dwelling through the roof and not ground seepage, dwellers are provided with poles, plastic sheeting and nails so that they are able to waterproof their dwellings.

In some areas the process of registering affected individuals is conducted with the help of local committee members. It was thought that this increases the validity of the process as such individuals are likely to possess knowledge about the owner of the dwelling and the number of people residing in the dwelling. It was also thought that local participation lent some measure of community ownership to the process.

There are instances where this process has proved problematic. Such instances occur when councillors have gone through the settlement and registered people as flooded without the consent of Disaster Management and without knowledge of the flooding definition. This has proved to be a problem when Disaster Mangers have arrived in the same area and concluded that it was not in fact flooded. In such instances Disaster Managers have experienced aggression from both the local ward councillor and the local inhabitants as expectations of entitlements to flood relief have been generated.

With the affected parties now identified and the halls now open, Disaster Management decides how best to provide relief in the area. Relief takes the form of hot meals in the halls, as well as the provision of food parcels, flood kits and blankets. The type of relief provided is dependant on the manner in which people have been affected. In some instances people find it most beneficial to receive a food parcel as this serves to replace foodstuffs which were lost in the flood. It also provides them with some asset, which can be used to ensure that they gain access to a family members' or friends' dwelling for the time that their own dwelling is uninhabitable. While in other instances flood victims find it more useful to have access to hot meals in the halls.

The decision as to whether or not people attend the halls is often determined by the extent of the flooding. In cases where the entire settlement is flooded most peoples entire social support networks are affected and people have little choice but to attend the halls. The halls appear to be viewed as a last resort and are most heavily attended by women and children. This indicates the greater degree of vulnerability apparent in these groups. A common community response strategy is for one member of the household, usually the male head (this can take the form of an eldest son, husband, boyfriend etc.) to remain behind in the dwelling to look after people's belongings. It must also be noted that not all households possess this male head. In such instances it is common for no one to remain behind in the dwelling.

During the period for which relief is being provided, the flood area is assessed every day by Disaster Management so as to approximate how many meals need to be provided by the relief agency that is operating out of the halls. In some instances there appears to be a lack of communication between Disaster Management and the operating relief agency (see section 5.4for more on this point). The flooded area is also assessed every three days by Social Services to determine whether or not the halls be kept open. When the halls are to be closed people are provided with a day or two's warning that the closure of the halls is imminent. It is acceptable practice that in some instances individuals are provided with a food parcel upon leaving the halls. This is so as to help them cope with the return to their dwellings in which food stocks are likely to have been ruined.

The first stage in the response procedure, the identification of areas that have been affected by flooding, seems to be problematic. Concern arises as the fieldwork highlighted that there were areas that were not assessed that should have been classified as flooded. These areas received no relief during the flood event. This raises the important point that without a formal, systematic means for determining which areas have been affected by flooding, people stand to be left out of the assessment procedure.

The problem is exacerbated, as there is no means by which professionals can identify the areas that have been excluded. Thus even if areas do not receive a response there is no way of knowing that they have not been responded to. There does not appear to be any simple solution to this problem as the process is reliant on the ability of the community to report flooding to the local authorities. Thus a re-examination of the informal communication channels may be in order.

It may also be necessary to evaluate the educational and awareness campaigns being run, in order to check their effectiveness. It is important that practitioners remain cognisant of the fact that this (settlements not being identified) is both an issue and a real possibility. This it is hoped will serve to encourage greater vigilance around which areas have been affected and which areas have not.

4.3.2 Formal areas

The procedure for the on-the-ground response in the formal residential areas is similar to that of the informal areas.

a) Identification of flooded areas

Unsurprisingly the means for identifying flooded formal areas is far more formal than means for identifying flooded informal areas. In the formal areas calls are directed to the 107 Centre via numerous pathways. These range from affected individuals who phone the centre to overloaded depots, who will have been receiving calls from affected persons or been on patrol given the heavy rains. Thus the response in the formal areas is similar to those in the informal areas in that they are reliant on the reporting of flood events in order to enable a suitable response capacity. The response in the formal areas is therefore facilitated by certain factors apparent in formal areas. This includes the abundance of telephone connections, knowledge of rights to a response and knowledge of council's responsibilities.

b) Responses to the flooded areas

If the calls received at the 107 Centre indicate small-scale impacts – i.e. they are small in number or widely distributed in terms of their geographical extent – Disaster Management will simply contact the relevant line function's local depot and refer the problem on to them. In the event of a large number of calls, or a call from an overloaded depot Disaster Management would send out one of its Disaster Management Coordinators to go and assess the area. Such an assessment would then be reported back to the 107 Centre indicating the severity of the event and any relief or response needs that may be specific to that area or situation. Again, once this has happened, the relevant line function depots will be called and informed of the problem in the area.

In the event of significant impacts requiring an emergency response disaster management volunteers would be called into action in order to facilitate rescue, evacuation and relocation activities where, and if, necessary. Again there would be a great deal of reliance upon the relevant line functions to fulfil their role in attending to the problems in any way they deem appropriate.

Fieldwork showed that the line function departments and disaster management battled with available manpower in their ability to respond to flooding in areas. Interviews told of people receiving responses from The City such as "you are not the only ones flooding". Field interviews also told of slow response times, which are thought to be indicative of a lack of manpower.

Communities indicated a general level of dissatisfaction with the response provided by both Disaster Management and the municipal line functions. Due to this communities were found to have to rely heavily on their own resources in order to respond to the flooding. In Athlone local youth were reported to be filling sandbags and distributing them to inundated houses. Such initiatives show how communities managed to cope on their own. Such initiatives if formalised and facilitated show how communities should not only be involved in managing their own risk but also in responding to disaster situations.

It should be noted at this point that there appears to be a disturbing and growing amount of discontent amongst many residents in formal areas. Such discontent is based on the rationale that residents are paying rates and taxes yet municipal services continually focus on areas that do not. This point raises issues of justice, equity and accountability, all of which are highly complex while at the same time being highly emotive and thus of the utmost importance.

All in all, despite community perceptions, Disaster Management's capacity to, and procedure for, responding to flood events seems effective save for the following:

- Problems of flood definition,
- Identification of affected areas
- Lack of manpower.

There still are, however, some constraints to the response procedure. Disaster Management Coordinators state that there is a lack of suitable equipment for them to undertake their required tasks. Complaints from Disaster Managers were around issues of vehicle practicality and safety. The Disaster Management Coordinators vociferously communicated issues of safety. This doesn't appear to be a new issue as the 2004 report states that safety was an issue on the agenda before the severe storm event of August 2004. Lessons learnt, and experienced gained, from previous flood events needs to be taken seriously and acted upon in order to reduce the impacts associated with flooding in the City of Cape Town.

4.4 Recommendations

The problems of identifying which areas have been affected by flooding are likely to persist, as they are reliant on community reporting. However, Catchment, Stormwater and River Management has compiled some maps of flood pone areas, on which they indicate informal residential areas that are built in vlei's or wetlands, that have flooded previously, that are in stormwater ponds, or are within 25m of a watercourse or known floodplain. Such consolidated information obviously proves invaluable in identifying areas that are likely to flood or experience damage in the event of a severe storm event. It is recommended that such analyses be undertaken for all areas in the city. It is further recommended that GIS capabilities be used to aid such mapping.

In attempting to ensure that affected communities report situations of flooding it is thought to be necessary to educate people around the conditions in which they are entitled to relief, especially so as regards flooding – people appeared to be aware that relief was available to fire victims. Fieldwork revealed that many individuals who had been flood affected and who had not received relief reported that they did not know they were entitled to relief and so had not attempted to gain access to any.

In terms of the response, it is thought that by ensuring that Catchment, Stormwater and River Management work more closely with the engineers of Development Support, the responses in the informal areas could be facilitated. This would aid in the identification of infrastructural assistance that could be provided.

Monitoring of the weather event is something that it was thought could significantly aid numerous departments in their ability to respond to an event. The Transport, Roads and Stormwater Directorate currently operates an extensive network of rainfall and flow monitoring stations, at 62 locations across the metropolitan area. Data from 28 of the 62 sites is transmitted at six hourly intervals via a radio telemetry network. A further three sites are downloaded via cellular modems, while the remainder are downloaded manually on a monthly basis. Archived data is utilised for storm analysis and hydrological design purposes.

Upgrading of the radio telemetry system for flood-monitoring purposes is considered feasible. This is provided technological difficulties relating to bandwidth on the radio network can be overcome. Access to raw data can be provided to the Disaster Management Centre via standard corporate network connections. This would allow for real time monitoring of the weather system and would aid in flood area identification as well as making emergency services more efficient. Such technologies already exist for other applications and appear to be relatively simple to implement.

In Summary

- Identification of the informal areas requiring assistance is problematic and underreporting in these areas is apparent
- The current definition of flooding of households in informal dwellings is problematic
- There needs to be proper communication between Disaster Management Coordinators and relief agencies operating in an affected area
- A lack of available manpower is limiting the city's capacity to effectively respond to disaster situations
- The is an alarming growth in the level of discontent with services from people living in the formal areas
- GIS mapping of at risk areas would help in the identification of affected areas
- The use of a near real time weather monitoring network would be useful in aiding response and appears to be feasible.

Recommendations:

- Consolidate information about flood prone areas and incorporate it into GIS
- Educate people around their rights regarding response to, and relief from, flooding events
- Closer collaboration between Transport Roads and Stormwater, and Development Support in responding to flooding
- Improve weather monitoring capacities

Part V Impact Analysis: Residential, Environmental, Government and Private Sector Impacts

Post event impact analysis is seen as critical to disaster management as it motivates whether or not further research should be prioritised and also highlights which aspects of the event need to be examined more closely. The impacts of the August 2004 sever storm event varied substantially and were often difficult to assess and collate. This is mainly because many of the impacts are exceptionally difficult to quantify (see below), this is especially so in the informal areas.

This section of the report examines the impacts and insurance costs in formal residential areas, including those costs incurred by government and the private sector. It then goes on to examine the impacts in informal residential areas as well as discussing the costs of providing relief to those affected by the flood event. The section concludes with some of the recommendations the authors feel could serve to reduce the impacts of future severe storm events.

Part V is structured in the following way:

Section 5.1 Discusses the general methodologies used to obtain both quantifiable and non-quantifiable impacts.

Section 5.2 Asses the impacts and insurance costs in form residential areas including the private sector and government

Section 5.3 Assesses the impacts in informal residential areas

Section 5.4 Discusses the relief costs of the flood event

Section 5.5 Is a brief study and discussion of the Health impacts of the August 2004 severe storm event on children under the age of five in informal settlements

Section 5.6 Discusses some recommendation that could serve to reduce the impacts of future flood events

5.1 General Methodology

5.1.1 Methodology for quantifiable losses and impacts

Quantifiable losses associated with the severe storm event included damage to infrastructure and staff costs incurred by The City. Various organisations were approached for information. These included the provincial and metro spheres of government, as well as the private sector. Using a combination of meetings and telephonic interviews, the damage to infrastructure and property information was collected.

The estimated staff costs focussed only on overtime. This meant that those who work shifts are not included. This information was collected using a template. This was faxed to the different organisations to complete.

The government departments approached included the following:

- Disaster Management (Provincial and Local Spheres)
- Medical Emergency Services (Provincial Sphere)
- Education (Provincial Sphere)
- Electricity (Local Sphere)
- Fire Services (Local Sphere)
- Health (Local Sphere)
- Housing (Local Sphere)
- Social Services (Provincial Sphere)
- Traffic (Local Sphere)
- Transport, Roads and Stormwater (Local Sphere)
- Water and Sanitation (Local Sphere)
- Solid Waste Removal (Local Sphere)

Other organisations include:
- Golden Arrow
- Metrorail
- River Club
- South African Insurance Association (this would only include insurance claims from the insurers who are affiliated with this association)

Relief costs for the August 2004 severe storm event were taken as those costs incurred in providing relief to the affected communities. According to the “Corporate risk reduction programme and contingency planning for possible flooding in informal settlement areas: winter 2004” relief operations are to be carried out by local non-government and community based organisations (NGO and CBO). The department of social services would also subsidise such organisations for all the relief costs they incur, thus costs to the relief organisations represent a cost to government. The Department of Housing also provides flood kits under certain conditions of flooding. These costs are borne by government. The figures for all these costs were obtained through telephonic contact with the organisations and departments responsible for the provision of different types of relief.

5.1.2 Methodology for the selection of field sites

Field sites were chosen from both formal as well as informal areas. With over 170 informal settlements in the City of Cape Town from which to only select three case study sites, the DiMP team had to apply a number of methodologies. These included:

- Review of Disaster Management records for relief assistance provided to flood affected informal settlements.
- Calculation of the rate of households affected/1000 dwellings using Disaster Management relief data. Using a rate of households affected as opposed to the number of households affected would give a clearer indication of the overall percentage of affected households per settlement.
- Review of historical flood information from the Transport, Roads and Stormwater Directorate.
- Consultative meeting with Disaster Management, Development Support, Informal Housing and Catchment, Stormwater and River Management to select 10 informal settlements. The following criteria were applied: high percentage of households/ settlement requiring assistance and a history of past flooding
- Prioritization of the ten selected informal settlements according to the Servicing Informal Settlements Programme. Development Support who is coordinating the

Servicing Informal Settlements Programme has ranked each informal settlement in terms of priority areas for service upgrading. Each settlement was ranked according to whether the settlement was a short term (6 months), medium term (6 – 18 months) or long term (<18 months) priority for Development Support.

- A table including the relief data, rates/ 1000 households affected, historical flood information and the Development Support prioritization was sent via email to selected City of Cape Town departments from which they were requested to select three sites.
- Masiphumelele and Qgobasi informal settlements received the highest votes.

Lwandle informal settlement, in exception was included following this process by Stormwater, Roads and Drainage who had identified the settlement as a problem area in terms of flooding.

In the formal areas Athlone and Pinelands were selected because the severe storm was a 1 in 100 year storm event in those areas. Bonteheuwel was selected as it was found from records to have been affected. These choices gave an opportunity to investigate the impact across income groups.

5.1.3 Methodology for non-quantifiable impacts and losses

The process for collecting data on non-quantifiable impacts and losses was undertaken using numerous semi-structured interviews conducted in six residential areas across the city of Cape Town. These six areas then comprised of three formal areas and three informal areas. Initially it was hoped to conduct fifteen household interviews, and one workshop with key stakeholders in each of the six areas, however logistical problems resulted in this being possible for only four of the six areas. The chosen areas, and methodologies for each area, follow in the table below:

Table 5.1.3.1: Field areas chosen

Type of Area	**Area**	**No of Workshops**	**No of Household Interviews**
Formal	Athlone	0	5
	Bonteheuwel	1	15
	Pinelands	1	0
Informal	Gqobasi	1	15
	Lwandle	1	15
	Masiphumelele	1	15
		5	**65**

In each case the workshop was conducted prior to the household interviews and involved addressing relevant stakeholders on numerous issues around flooding. The workshop also served to identify areas in the respective settlements which had been most severely affected by the August 2004 severe storm event and resultant flooding. Local community members acted as facilitators and translators in the household interviews in the informal settlements, these persons were arranged by the local ward councillor in the area.

5.2 Environmental Impacts and Exacerbating Factors

In terms of the environmental impact of the flood on the 5 August 2005, there has been no significant environmental damage reported to date. The area that flooded returned to its original state once the water level had subsided and no impact to the natural environment was reported. However, it must be noted that monitoring of the flood was only carried out 3-4 months after the event so if there was an impact to the natural environment immediately after the event, it was not necessarily noted.

There were some socio-environmental problems that furthered the impact of the flooding in the informal settlements. The main contributor was the accumulation of waste in informal drainage channels. Dumping was reported to clog drains (see figure 5.2.1) while sewage created high nutrient counts, in informal channels, encouraging vegetation growth and inhibiting drainage (see figure 5.2.2).

Informal settlements in sandy areas mentioned problems of sand being washed into drains which served to block up the system.

Figure 5.2.1: A blocked drain in Lwandle. This drain is situated in a stormwater pond, which is known to fill up and flood the surrounding houses. The amount of waste in the water is also suspected to generate health impacts.

Environmental conditions that serve to exacerbate flooding in informal and formal settlements cannot be separated from their prevailing social conditions as they both influence and affect one another. For example sand is often abundant in informal settlements (such as Masiphumelele) as residents battle to grow vegetation on sidewalks due to the high volumes of pedestrian traffic and the occurrence of livestock (such as goats), which eat any available vegetation, pulling it out by the roots. Thus we need to see that social processes and environmental conditions are closely linked in the ways in which they serve to exacerbate flooding.

Socio-environmental conditions exacerbated flooding in some formalised areas as well. For example a couple in Athlone had built a wall that channelled water into their backyard without allowing for its release. Such building exacerbated localised flooding in this area. The flooding was only alleviated by the removal of the bottom block of the vibracrete wall, which was damming the water. Once this had been done the flooding subsided.

Figure 5.2.2: An overgrown informal drainage canal in Qgobasi. Damp conditions, in a stormwater pond, and high nutrient counts, generated by waste from the informal settlements, result in rapid vegetation growth as seen above. Such growth occurs in the dry summer period rendering such canals ineffective in the rainy season

5.3 An Assessment of the Impacts in Formal Areas

Delineating the impacts of the August severe storm event into their impacts in formal areas and their impacts in informal areas may be misleading. This is due to the fact that housing in Cape Town cannot be divided along such lines. It may in fact be more useful to conceptualise the housing situation on a kind of continuum, with informal shacks on the one end and serviced estates or office blocks on the other. Issues such as backyard shack dwellers in formal areas are a prime example of the difficulties involved in such a separation. They also show the simplistic nature of dividing flood impacts into formal and informal areas. Despite this however, there are distinct differences between the informal shack and formal estate and for this reason this study has divided the continuum along the line of formal versus informal.

Given the above statement it should not be surprising that many of the impacts experienced in the formal low income areas were very similar to those experienced in informal settlements. The main differences between flooding in formal and informal areas is that flooding tends to occur more frequently, more extensively and for a greater duration in informal areas than it does in formal areas. This is largely due to the drainage which has been put in place in the formalised areas. However, should a flood event be of a magnitude great enough to result in household flooding, low-income formal areas stand to sustain significant impacts.

Furthermore, it must be noted that in the older parts of Cape Town the major drainage system – which makes use of the road system to drain an area – is not sufficient due to outdated building regulations. Flooding is more likely to occur in these areas should heavy rains be experienced. Such was the case in Athlone, however in this instance socio-environmental conditions had also exacerbated the flooding (see above).

5.3.1 Quantifiable direct and indirect costs to government and the private sector

Insurance costs in the formal areas are a good indicator of the flood impacts experienced by both the private sector and the state. However, it must be noted (as is mentioned above) that insurance figures are only an indicator of impacts. They are not a transparent and absolute measure of the impacts experienced by formal institutions. This is so for a number of reasons.

Firstly, not all formal institutions (comprising of both the private sector and the state) are insured. Lower income housing areas, such as Bonteheuwel, have a large number of uninsured households, thus they will not be accounted for in insurance costs. The calculation of flood impacts in such areas is far more complex as it involves an understanding of the local livelihoods strategies being employed.

Secondly the figures mentioned in table 4.3.1.1 represent only some of the direct costs incurred by formal institutions. Other indirect costs are significant and take the form of excessive stress on professionals and residents affected by the flood. Indirect costs also include the overall costs to the economy such as loss of workdays through a lack of transportation.

Table 5.3.1.1: Quantifiable recorded costs of the August 2004 severe storm event

Organisation	Description	Cost
Private Insurance	Private Claims	2,474,030.00
Single recreational facility	Insurance Claim	1,500,000.00
Metrorail	105 trains delayed	8,400.00
	13 trains cancelled	19,500.00
	Staff cost	5,610.00
TOTAL DAMAGE		*4,007,540.00*
Disaster Management (City)	Staff Cost	228,680.00
Transport, Roads and Stormwater (City)	Staff Cost	70,000.00
TOTAL STAFF COSTS		*298,680.00*
TOTAL COST		**4,306,220.00**

Table 5.3.1.1 shows the exact insurance figures for damages to formal institutions. Insurance claims made up the bulk of the economic damages; this was followed by an insurance claim made by a single recreational facility. This is also illustrated by Figures 5.3.1.1 and 5.3.1.2. As can be seen, the insurance costs constitute 92% of the recorded impacts.

The costs of delayed and cancelled trains represents a figure determined by Metrorail. This figure is a direct cost which they incur. The staff cost is also a cost incurred by Metrorail. The staff costs indicated for Disaster Management and Catchment, Stormwater and River Management are overtime costs. These costs would be borne by government.

It is also important to note that the government bears numerous other costs which are incurred during the relief and recovery stages of the event. Such costs include subsidising relief organisations the provision of flood relief kits, and possibly an increase in the number of people attending state funded clinics. Such costs are examined later in this section.

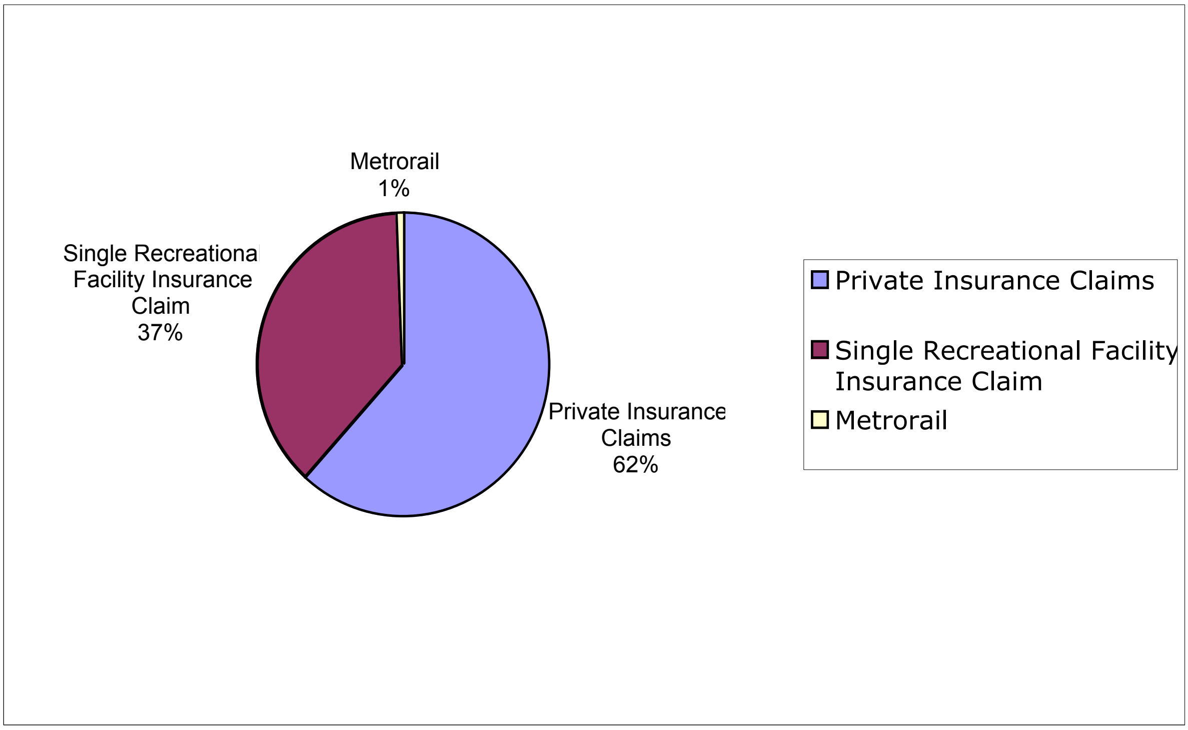


Figure 5.3.1.1: Recorded Impacts Costs, excluding those to the City of Cape Town

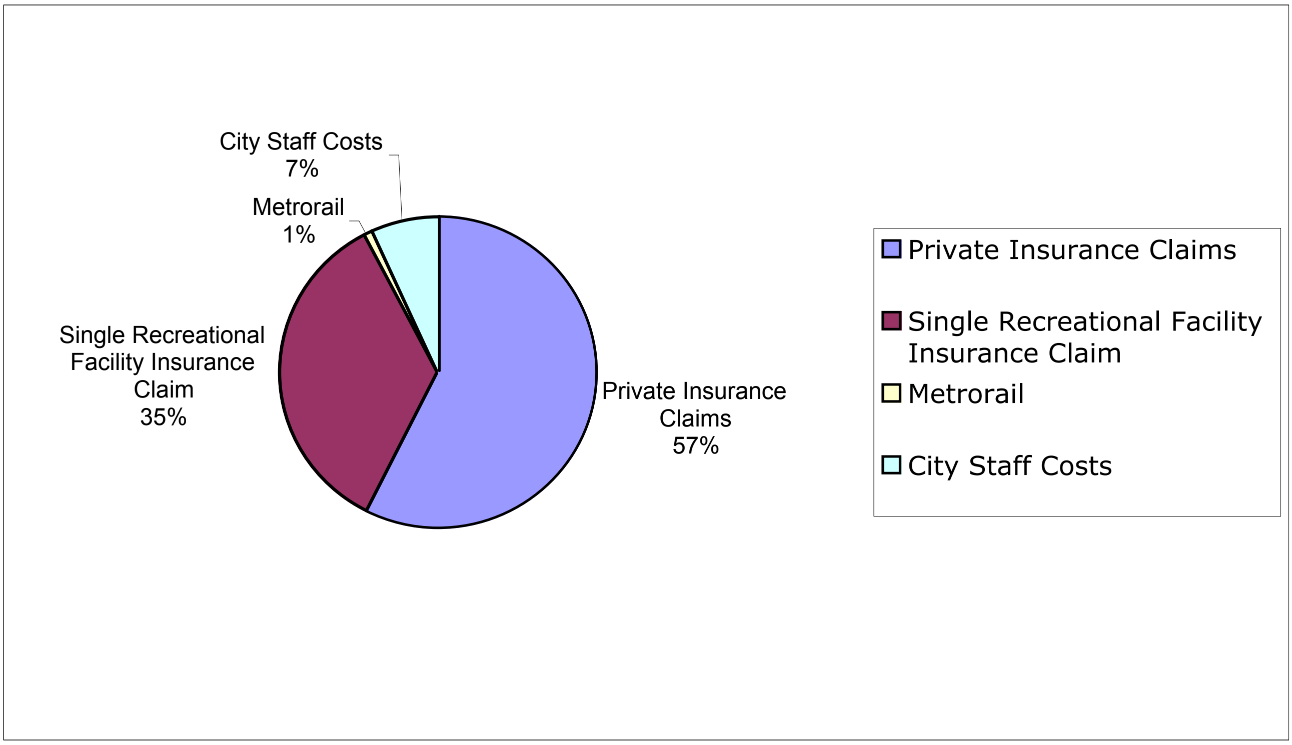


Figure 5.3.1.2: Recorded Impacts Costs, including those to the City of Cape Town

It should be noted at that many of the bodies working in a response capacity, such as Emergency Medical Services and the Fire Services, have their staff work in shifts. It appears as if there is no process to capture the overtime put in by professionals working in these departments. Such overtime is not compensated for by the employer nor claimed by the employees.

Finally a Golden Arrow bus was reported to have broken down as a result of flooding caused by the August 2004 severe storm event, however no cost was determined for this incident. Such instances are indicative of the indirect impacts and costs associated with the severe storm event.

Despite the limitations of such an impact analysis the total cost still amounts to a significant figure at R 4.3 million. When taking into account under-reporting, unpaid work and lack of data, the amount is probably closer to R5 million. This shows the imperative for mitigation strategies that could be used to reduce the frequency, impact and/or severity of such flooding events. This is not a new finding and The World Bank along with the U.S. Geological Survey calculated that global economic losses from natural disasters could be reduced by $280 billion if just one seventh of that amount had been invested in preparedness and mitigation efforts (Abramovitz 2001). Such lessons need to be taken to heart as they represent a possibly significant saving to the economy.

5.3.2 Losses and associated impacts in formal residential areas

Impacts in the formal areas, as in the informal areas, are predominantly not around loss of life. Rather the impacts which are of greatest concern are those pertaining to the loss of household assets. As impact and loss are so intimately related to one another the analysis for the formal area examines them as one. This is unlike the informal areas where the impacts of flooding are not limited only to the loss of household assets.

Losses experienced in low-income formal areas are often uninsured and of a great magnitude as people have, until this point, been able to sustain a lifestyle that has allowed for the accumulation of a large number of assets. The most common losses involve furniture, and electrical appliances such as fridges, freezers, microwaves etc. Low-income residents expressed concerns that they were uninsured and thus it would be unlikely that they would easily be able to re-accumulate the assets lost as a result of the flooding.

Another significant impact of the flooding in formal residential areas relates to the fact that many people work from home. In such cases flooding can damage the stock in retail businesses, while in a service enterprise it serves to prohibit trade. Such losses of potential work and stock can have significant impacts on the lives of affected individuals, as livelihood strategies are often reliant on expected incomes.

The major concern around the financial impacts of flooding is that they may serve to force people into ‘chronic poverty’, from which they are unable to escape. Such people can shift from being economically prosperous individuals to being an economic burden on the surrounding society as a result of the flood. Investigation needs to be undertaken to identify these individuals or households to ensure that such circumstances do not arise.

Other impacts of the flood included missing school and work. Children had to miss school as their uniforms were ruined by the floodwaters. Some individuals missed work as they were unable to get there or due to the fact that their customers were unable to get to them in the case of people who work from home.

The inundation caused by the floods resulted in people having to live in cold and wet conditions often for a significant amount of time. This resulted in sleep deprivation and general discomfort. Although the water only remained in houses for a fairly brief period, the floors were reported to stay wet for up to a month. In certain houses the walls also absorbed moisture and remained damp for some time.

Low income housing in formal areas experienced the flooding of sewage systems. This obviously poses a health problem as well as one of human dignity. Apparently this is a persistent problem as the water level in toilets in Bonteheuwel has been observed to rise and fall depending on the rain falling outside.

Flood events also carry a significant emotional burden. There is a large amount of distress associated with the losses experienced. This is especially so for individuals who are possibly going to be forced into chronic poverty. The loss of pets in the flood was also found to result in significant emotional stress. Finally the flood generated a noticeable degree of anger amongst the residents as they often felt like they had been sidelined somewhat in the formal response to flooding (see section 3.3.2 for more on this point)

5.4 An Assessment of the Impacts and Relief Costs in Informal Residential Areas

The quantification of impacts in informal settlements is a difficult and often fruitless task. It is difficult as many of the impacts are not quantifiable. Human suffering, stress and misery are not things upon which one can put a price or even a value. The quantification of the impacts is further complicated by the fact that the quantification process, which is often only in terms of economic impacts, is not compatible with the processes and conditions apparent in informal settlements. For example what are the *economic impacts* for a classically unemployed individual who is unable to look for work, as he has to stay at home to look after the belongings in his house? Another example is if a person looses a bag of maize meal in a flood and the food is valued at R10 for a bag. This would be considered a fairly minor economic loss, however with no knowledge of the process through which someone has had to go to procure that food, we have no understanding of the impact of its loss. Often such losses have dramatic impacts in terms of how people are forced to cope with, and recover from shocks, while at the same time inducing a significant amount of stress.

The nature of flooding in informal residential areas in the Cape Peninsula and its surrounds is largely around ponding. This is as a result of soil saturation in which the often permanently high, ground water table interacts with the surface Therefore there is little damage to the formalised infrastructure in these areas. As infrastructural damage may be the only way to quantify impact, there is very little quantitative data to come out of this section on impacts in informal settlements. Rather this report has taken a far more qualitative approach were the impacts are discussed in terms of the stresses, pressures and concerns felt by informal settlement dwellers. An understanding of these emotions provided with the context in which they are occurring appears to be the most powerful way of understanding the plight of informal settlement dwellers in the face of flood induced impacts.

5.4.1 Damage to Infrastructure

There were no reports of damage to formal infrastructure in the informal settlements. This is due mainly to the nature of the flooding in these areas as discussed in the previous paragraph. The impact to informal infrastructure was perceived by the communities to be of far greater consequence. Such impacts included damage to furniture and dwellings. This was as a result of both inundation and other climatic conditions such as wind and rain that were perceived to accompany flooding. Rain was considered a hazard as it served to short out informal electrical connections and damage electrical household appliances. Wind was considered to be a far greater hazard in that it could blow the roofs off structures and even cause entire structures to collapse. Wind was then seen to result in further hazards as it had the potential to result in harm as people were hit by flying material.

Figure 5.4.1.1: Women and children in Masiphumelele, note the water apparent in the vlei. Dwellings are situated less than 10m from this spot. This photo was taken during February 2004 when the Western Cape was in a drought. This gives some indication of the height of the water table even in the dry season in many of the informal settlements

5.4.2 Social Impacts

When discussing the impacts of flood events it is important to note that flooding in informal settlements on the Cape Peninsula and its surrounds is unlikely to result in any great loss of life. The impacts of flooding are more around human misery and suffering. This does not serve to reduce the imperative to confront the problems experienced by flood victims, as flooding impacts become the concern of human dignity and acceptable standards of living.

The flood impact that appears to be most prominent in the minds of informal settlement dwellers is that of personal health. The fieldwork across all three sites revealed health as the primary concern in the event of a flood. Reports of a rash were common to virtually every household interviewed across all three settlements. The rash is reported to affect individuals of all ages and occur all over people's bodies. In one case in Masiphumelele it was shown to leave what appeared to be permanent scarring. Some individuals referred to this rash as chicken pox, but it is thought that this is a misdiagnosis on the part of the flood victim. It is hypothesised that this rash is a result of extended contact with floodwaters, which are likely to be contaminated with faecal matter and large amounts of leachate, as a result of the large amount of waste that is apparent throughout informal settlements. The rash appeared to affect almost everyone who was forced to live in inundated conditions.

Other health impacts that were common to almost all the households across the three settlements included reports of flu and fever. One individual in Lwandle described the problem as a type of "steam in the air" which upon being inhaled served to make him sick. Numerous other individuals reported symptoms of respiratory infections such as coughing. Other health problems reported in the area include diarrhoea and a lack of appetite in small children (See section 4.5 for more on this).

The health problems were compounded as many people were unable to attend the clinic due to them having to stay at home and guard their belongings, or being forced to seek further work in order to make up for work missed as a result of the rain. The imperative to find work was also often increased as people had to make enough money to recover from the losses (see below) sustained during the flood. When asked whether people attended the clinic many said that they were unable to, as they could not afford it. This seemed strange, as treatment at the clinic is free. Upon further prompting, people explained that they could not afford the time to get to the clinic. Many people also complained that due to the floodwaters they were unable to get themselves, and in many instances their sick children, to the clinic. The floodwater posed a threat in that there was a concern that such contaminated water might make the already sick children sicker and that in the case of Lwandle people were unable to cross an open channel, which lay between them and the clinic, as there was no suitable crossing point. The floodwaters also served to limit mobility, as people were concerned about standing on broken glass or other sharp objects concealed by the floodwaters.

The point of the exposed channel which acted as a barrier to flood victims is important in that it shows there to be a misconception about flooding on the Cape Flats which is thought to be solely around issues of ponding. In Lwandle the open channel raised fears of drowning in the floodwaters with reports of individuals being washed away in the torrent. Such a channel acts as spatial barrier, preventing people from getting to shops, work, schools and other amenities during the times of the flood. This channel was in fact put in place in order to increase drainage and reduce flooding in the area. The oversight was that there is no suitable crossing point, save for some informal planks placed over two drainage pipes (Fig. 4.4.2.1). Such an open channel as the one observed in Lwandle illustrates how such channels need to be noted, as they act as significant hazards in times of flooding in informal settlements.

Other impacts of the floods were children missing school as a result of damaged books and damaged or soaked uniforms. There were also instances in which children could not attend school, as they were unable or unwilling, to wade through the floodwaters. People often had to miss work for similar reasons except that included in the list of reasons was that individuals had to remain in their dwellings so as to protect their belongings, and make sure that their houses did not sustain excessive damages due to the flooding.

Another reason for people losing out on work time was that many individuals are involved in outdoor labour. Jobs such as tree felling and construction cannot be undertaken in the rain. Since most of these professions have a policy of no work, no pay, missing work can have significant effects on livelihood strategies. At this point it must be mentioned that there were no reports of people losing their jobs as a result of missing work during the floods. Most employers, it would seem, were sympathetic to the plight of the flood victims.

Figure 5.4.2.1:Showing the open trench and the informal crossing point in Lwandle. Note this is described as a torrent in times of flooding and is reported to have the ability to knock people off their feet.

Other impacts of the flood are harder to identify and revolve largely around the labour performed by women in the home. Such labour is important as it is already marginalized in much social analysis. The labour performed, usually by women, in the home is undervalued and is often viewed as being of no significant economic importance. However it has been shown to be vital to the functioning of the economic system as a whole.

During a household flood the chores performed in the home become substantially more arduous. Activities such as cooking and cleaning in a flooded home are exceptionally difficult when there are few dry surfaces in an already cramped space. The amount of available space is often further reduced as the dwelling is crowded with children who can no longer attend school nor play outside. Sickness throughout the household makes caring for the rest of the family significantly more complex as it now involves trips to the clinic (which are often made more complex as flood waters are to be negotiated) and more vigilant child care. All these conditions, as well as others such as longer trips to undertake shopping, then result in further stress and anxiety for the person (whom is often sick themselves) whose role it is to undertake such chores in the home.

5.4.3 Losses

The most common losses in the floods were clothes, groceries, furniture and appliances. Groceries were usually damaged as they got wet and thus were no longer usable. Appliances were often damaged by water entering the dwelling through the roof. Damage was in some cases permanent, while in others it was only temporary. However, as people are often reliant on the working of such appliances the knock on effects could be significant. Where refrigerators have broken people have had food go off. Food stocks can represent a significant investment in the home as buying in bulk is usually cheaper, thus losses of these stocks represent a significant impact. The flood also rendered clothing that was soaked for an extended period of time useless. Damage to furniture included the loss of mattresses, tables, floor mats and insulation materials (usually cardboard).

People, who remained in their homes, commented that they remained there in order to prevent any theft of their goods. Interestingly however when people who had left their homes to go to the halls were questioned about any theft of their belongings, they all reported that nothing had been stolen. The only exception was one instance in which a shabeen owner had had some beer stolen from her while she was away from her home. Thus, people's fear of crime may in fact be worse than crime itself in the settlement (see Box 2).

A significant loss due to flooding was that of informal trading or formal work-from-home stock. People interviewed reported losing beer, textiles and food stocks to the flood. Such losses are significant as they represent not only a physical loss but also constrain income generation in the settlement. Such losses were in some cases reported to have resulted in the collapse of small businesses, as they were no longer viable. This was due to an excessive loss of capital, which was tied up in stock. One individual reported that she was no longer willing to place so much capital in stock as it could easily be lost to future flooding.

BOX 2

Fear of Crime

Many of the flood victims interviewed stated that they remained behind in their dwellings so as to guard their personal belongings. There is no doubt that since such action results in people having to live in inundated dwellings it increases their exposure to conditions which it is hypothesised are detrimental to their health. Such action is interesting in that in instances where people did leave their dwellings and no one remained behind there were very few reports of any theft. In fact the only report of theft came from a shabeen owner who had beer stolen from her. Thus it could be that people's fear of crime may in fact be worse than crime itself.

The 2004 Corporate risk reduction programme and contingency planning for possible flooding in informal settlements states that there is to be policing of "emergency shelters and affected areas". Whether or not this is occurring is unclear, nor was it clear who should be responsible for ensuring that such policing is carried out by the South African Police Service (SAPS) and or the South African National Defence Force (SANDF). The successful policing of an area may in fact be the reason that most people reported very few losses even when forced to leave their dwellings. If this is the case then people need to be assured that their belongings are safe, and that they needn't place their health at risk in order to ensure their safety. This is especially so in the case of HIV and AIDS patients.

In some instances people spoke of fears of losing their entire dwelling, although this did not appear to be a problem in the August flood. The loss of a dwelling is not likely to be the direct result of a flood. Rather it is due to associated weather conditions such as strong winds and driving rain.

5.5 Relief Costs

The organisations involved in the provision of relief for the August 2004 flood event were The South African Red Cross Society, The Mustadafin foundation, The South African National Zakáh Fund (SANZAF), The Salvation Army, Historically Disadvantaged Individuals (HDI), The Lions Foundation, and The Department of Housing in Western Cape. The relief costs are shown in table 5.5.1.

Table 5.5.1: Showing the costs of relief operations for the August floods. Note this is likely to be an underestimate of the total relief costs due to a lack of data on indirect costs.

Organisation	Direct Costs	Indirect Costs	Total Costs
Red Cross	232 000		232 000
Mustadafin	350 000		350 000
SANZAF	220 000		220 000
Salvation Army	184 000	5 952	189 952
HDI	565 878	18 762	584640
Lions	100 000	NA	100 000
Housing (flood kits)	592 214		592 214
Total Relief Cost	2 224 092	24 714	2 268 806

The total cost of relief at approximately R 2.2 million represents a significant amount. It is important to note that this amount does not include all indirect costs. Costs such as gas for cooking and transportation are often not well recorded and thus not sufficiently represented in the above analysis. For this reason such an analysis is likely to be an underestimate of the total costs of the relief operation. Some critical comments can however be made here about state subsidisation of relief and the manner in which relief is provided.

There appears to be a lack of uniformity on the cost of blankets across the organisations. The size of the subsidy provided by Social Services across organisations per relief item appears to differ. This is clearly not sufficient given the large amount of spending involved in relief operations and given the fact that differing costs probably result in differing quality of relief goods. It was found in an interview with Disaster Management for The City that since the August storm event the operating procedures of the relief agencies have been standardised in terms of expenses etc.

Finally there was conflicting information between Disaster Management and Housing on the numbers of flood kits provided. The compilation of this table was undertaken using figures provided by Housing, as they are responsible for the provision of the flood kits.

The entire relief operation appears to be a little haphazard. This is understandable given the nature of the situation in which relief is being provided. However, there appears to be a lack of a uniform formal procedure for the provision of relief.

The fieldwork showed that in certain areas there was a lack of consensus between Disaster Management, relief workers, and relief agency administrators around which individuals were entitled to relief. This is exemplified in the situation of providing hot meals to individuals who are not resident in the halls, but are still flood affected. Both Disaster Management and the administrator from the relief agency stated that people were not to be issued a hot meal unless they were residing in the halls. This is in conflict with relief workers who are providing meals on the ground to people who were not resident in the halls.

There were instances in certain areas where Disaster Management was unaware that the halls had been opened and that there were around 1000 people residing in them. These examples display the lack of organisation and formalisation of the process of relief provision. Either there is a lack of procedure or the professionals working in the field do not follow the procedure. In either case it is quite clear that some measure of uniformity needs to be established in order to ensure that relief agencies operate efficiently and that flood victims receive the relief to which they are entitled. (See section 4on 'Emergency Response and Institutional Arrangements' for more on this)

5.6 Recovery

Recovery strategies were multiple and varied. They included activities such as attending the halls and obtaining blankets or other donations such as clothing. People also relied on support from extended family and friend networks. Support took the form of money, clothes, building materials etc. In certain instances people's employers helped them recover from the flood by offering similar donations.

There was a report of an individual in Lwandle who, due to a lack of alternate options, was forced to obtain a loan from a local moneylender. This was reported to be problematic, as the individual concerned was required to pay back the loan at what she considered to be a very high rate of interest.

In many instances people simply did not recover from the flood event. Ultimately they became more impoverished by the event. In such instances it is quite likely that people's vulnerability to future disasters (not only flooding) was heightened by this event. This is quite evidently a real problem as a failure to assist recovery simply the risk realised by individuals.

5.7 Health Impacts of Flooding in Informal Settlements: A Quantitative Study of Children under 5

An analysis of the health impacts associated with flooding was undertaken for the city of Cape Town. The study made use of both qualitative and quantitative methodologies. During the field interviews affected individuals spoke freely of the perceived health impacts of flooding and living in inundated areas. A regressive analysis of clinic admissions data for the city of Cape Town was also undertaken in an attempt to validate some of the qualitative findings from the field.

5.7.1 Methodology

Quantitative data was sourced from community health clinics (CHC) from across the city of Cape Town. Data on the monthly total number of children under five who presented with symptoms of diarrhoea and lower respiratory tract infections was obtained for the period 01/01/2003 to 01/10/2004. Clinics from the three informal settlements studied in the field were then identified. The admission patterns from these clinics were then compared to the general admission patterns from clinics from the rest of the city. A five-month moving average filter was applied to the citywide data in order to smooth the data and highlight any seasonal signal which may be apparent in the data. This filtered data was then graphed against the cumulative admissions for the selected clinics so that any deviation from this seasonal signal could be identified. Should such a deviation from the seasonal signal exist and show an increase in the number of clinic admissions for the months of August and or September (as there may be some lag), then this should in part validate the quantitative findings from the field.

The selected clinics were:

- Crossroads 1 CHC
- Crossroads 2 CHC
- Masiphumelele CHC
- Ikwezi CHC

While it is appreciated that some individuals in the three field sites may attend other clinics, the above clinics were chosen as they were central to the areas from which reports of health impacts had been received. Thus the impacts attributable to flooding are likely to be most apparent in these areas.

Children under the age of five were chosen for examination as they are thought be less likely to have been exposed to pre-determining factors through such life experiences as historical employment (Truluck, 1993).

A five-month moving average filter was applied to the data as there was concern over how many months' data one could afford to lose to the averaging process. The admission data series only ran until October 2004, therefore to ensure that there was a moving average value for August 2004 one could only make use of a five month moving average filter.

5.7.2 Limitations of the study

The use of a qualitative approach to determining health impacts is particularly problematic. This is especially so when using an interview methodology to attain such data. This is due to the fact that perceptions of illness are often very different to their biomedical concepts (Mull and Mull 2004). Thus people's perceptions of their health may be misconceived due to misunderstandings around causality and diagnosis of diseases. However, given these precautions the fieldwork still revealed some interesting and compelling evidence for the harmful health impacts caused by flooding in informal settlements.

A regressive analysis of health data is often problematic as there are numerous factors that mask the variables the study is attempting to isolate. This is especially so in environment-health relationships. In this instance the clinics that have been examined are admitting people from outside and inside the flooded areas . Thus numerous admissions may mask the signal of impacts attributable to flood conditions. The data is also problematic in that lower respiratory tract infections may include infections which would not be attributable to flood conditions. Another limitation is the temporal extent of the data. It is problematic to define a seasonal cycle if one has less than seven cycles in the available data set. The poor temporal resolution is also problematic as monthly totals are less informative than daily admissions.

5.7.3 Results

<u>5.7.3.1 Qualitative results</u>

Of the 45 field interviews virtually every one revealed a concern about people's health during times of flooding. Such concern usually sat as a priority in people's fears of impending flooding. The most commonly reported impact was that of some type of rash, which occurred all over the individual's body. This rash affected people of all ages and, in some cases, left what appeared to be permanent scaring on the skin.

The second most commonly reported health impact, which is of interest to this study, was that of respiratory tract infections. These included numerous reports of flu, coughing, pneumonia and bronchitis, with accompanying problems of fever. Other reported health problems were diarrhoea and a lack of appetite in small children. However as the limitations to the study states these results are problematic, as informal settlement dwellers have been found to attribute such respiratory tract infections exclusively to conditions of cold and damp weather (Lyun and Tomson 1996; and Hussain and Lobo et al. 1997). At the same time they often judged fast breathing impressionistically and tended to attribute it to fever alone (Mull and Mull 2004).

5.7.3.2 Quantitative results

a) Admissions for lower respiratory tract infections:

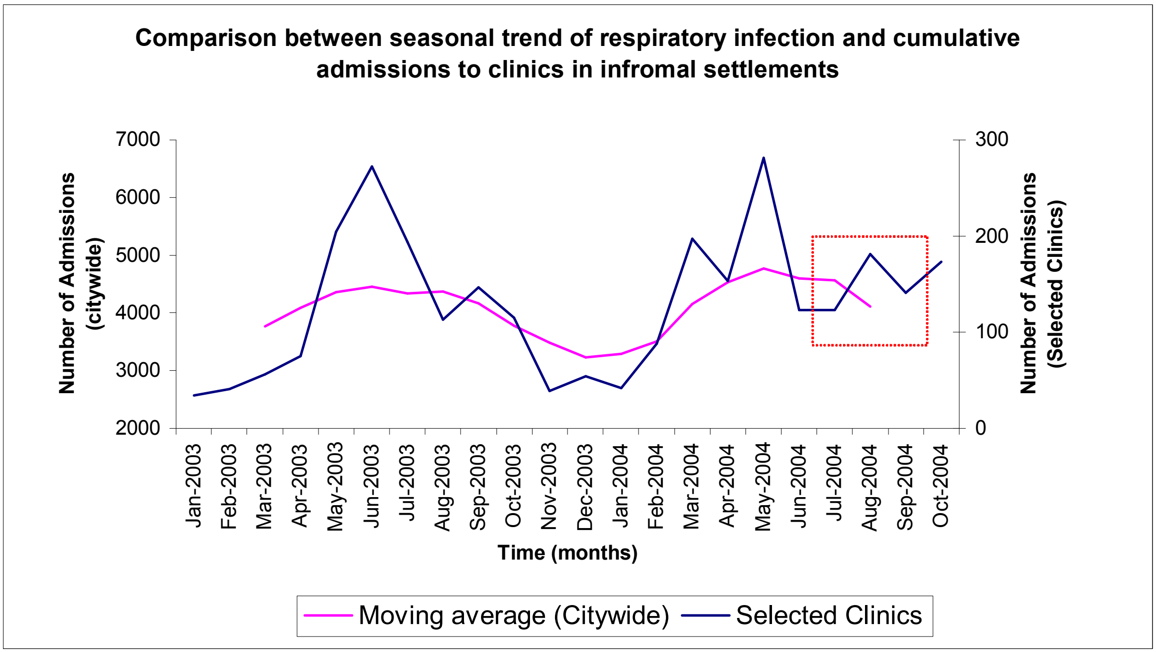


Figure 5.7.3.1: Graph comparing lower respiratory tract infections in selected clinics with the seasonal trend in clinic admissions for the City of Cape Town.

Figure 5.7.3.1 clearly shows what appears to be a seasonal cycle in the admission patterns to CHC's for the City of Cape Town. The seasonal signal is apparent in both the smoothed citywide moving average and the raw data from the selected clinics. Of interest to us is the end of the graph, the boxed section. This part of the graph shows the period July 2004 to September 2004. The graph shows that the citywide seasonal signal is decreasing for the month of August 2004, however the selected clinics show an increase for the month of August, during which the flooding occurred. Thus what this graph is telling us is that the admission pattern in the selected clinics appears to differ from the citywide admissions for the month of August showing an increase instead of a decrease. Thus the relative increase in clinic admissions for the month of August is small because the impact of the event is being masked by the seasonal trend which is driven by all the flood unaffected individuals attending the clinic.

b) Admissions for Intestinal infections:

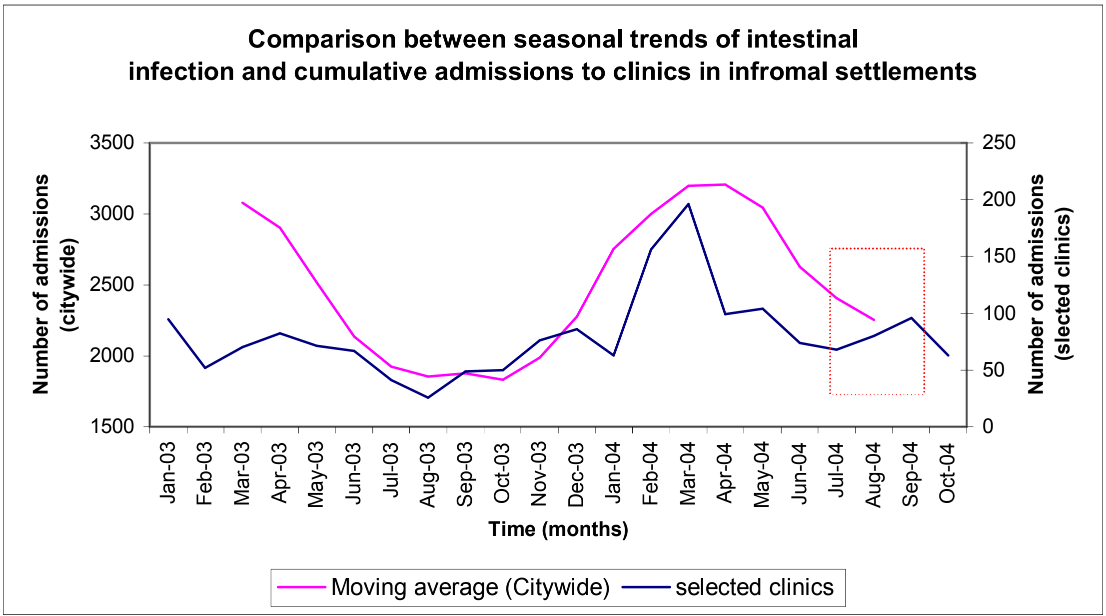


Figure 5.7.3.2: Graph comparing intestinal infections in selected clinics with the seasonal trend in clinic admissions for the City of Cape Town.

Figure 5.7.3.2 shows similar evidence to figure 5.7.3.1 described above, in that a seasonal signal is apparent in both of the data sets. The seasonal cycle in admissions for diarrhoea differs from that of lower respiratory tract infections however, the signal is still apparent. Again the boxed area on the graph is the area of interest to us and again the citywide seasonal average shows admissions to be decreasing, while the raw selected clinic data shows admissions to be increasing for the month of August 2004. Thus the pattern and hence the argument is similar to the one above. The relative increase in admissions for the month of August is not substantial, however this is because the seasonal signal is masking the potential impact of the August 2004 severe storm event.

5.7.4 Conclusions

Given the inherent limitations of both the qualitative and quantitative methods of examination used in this study we can only conclude that the health impacts of flooding have not been fully determined. However, the results from this study drawn from both the qualitative and quantitative data show a compelling argument for further research to be undertaken to determine the health impacts of flooding in informal settlements. This is argument is furthered when we consider that flooding has been shown to be detrimental to the health of informal settlement dwellers in Indonesia, due largely to the poor physical environment in which people find themselves (Santosa and Permukiman 2003). The World Health Organisation (WHO) has also found that in the developing world 21% of children die as a result of diarrhoea, acute respiratory infection, malaria, measles and perinatal conditions. We cannot overlook the importance of respiratory and intestinal health impacts of flooding in informal settlements.

The qualitative data from this study clearly shows that health impacts are a concern of the affected communities. Such concern is worth investigating as it may generate some concrete conclusions, which could shed light on the plight of informal settlement dwellers during times of flooding. Health impacts and/or the stresses associated with a perception of impending impacts are significant under conditions of flooding. For these reasons alone the health impacts associated with flooding in informal settlements are worth investigating. While one need not mention the importance of such research should the perceptions of the impacts of living in standing water be correct. Thus there is an exceptionally strong case for future research into the health impacts of flooding given the evidence revealed by this research.

5.8 Recommendations

The following recommendations are written not with the hope of reducing the extent, frequency or duration of flooding, but rather in the hope that the impacts of flooding can be reduced to some extent.

Firstly it needs to be acknowledged that formal residential areas are not all significantly different from informal residential areas. In fact conditions during flooding in many low-income formal residential areas may be found to be very similar to those conditions apparent in informal settlements during times of flooding. For this reason relief and response operations may need to focus some of their limited manpower on formal residential areas.

It is also strongly recommended that further investigation be conducted into the health impacts associated with flooding in informal settlements. It may, in light of the argument put forward above, be necessary to investigate the health impacts of flooding in low-income formal residential areas as well. Such investigation is imperative as knowledge about this environment health relationship could serve to significantly reduce the amount of human misery and suffering apparent during times of flooding in informal settlements. It is recommended that such research take the form of a prospective study. Although this is obviously more time consuming, it is significantly more reliable due to the fact that retrospective studies are fraught with difficulties surrounding data capture.

The Health department knew little of the health impacts associated with flooding in Cape Town's informal settlements. The current involvement of health departments in flooding extends as far as Environmental Health whose role it is to check the halls to ensure that they are sanitary, and that piped water and sanitation facilities are available, suitable and adequate. Environmental Health also plays a role in educating the community around the dangers associated with stagnant floodwaters. There is currently no involvement by the Personal Health department and it is hoped that this research encourages such participation.

There were significant losses in both formal and informal residential areas during times of flooding, especially as regards trading stock and lack of insurance . Research should be conducted into the feasibility of providing micro finance options or state funded insurance. This would help small and informal businesses cope with and recover from the shock of having large amounts of stock destroyed, or large business contracts lost.

At this point a cautionary note is worth mentioning. Should interventions like micro financing be put in place, one needs to conduct research into what financial options are currently available to informal settlement dwellers. The importance of this is highlighted by the example where an individual had made use of a local moneylender in order to obtain the capital required to survive the stress imposed by the flood event. In this instance the indiscriminate provision of micro-finance may serve to compromise the livelihood strategy of the moneylender. As a general rule it is important that extensive community participation be undertaken before such developmental actions are implemented. This is done to ensure that such actions are embraced by the community and also to help fully understand the impacts such interventions might have on the community. The second rule is to ensure that current interventions compliment existing livelihood strategies that are currently being employed in the settlement.

The final recommendation is that there is some formalised procedure by which the Disaster Management Centre communicates on a regular basis with the other institutions and/or individuals involved in the relief operation so as to ensure coordination of the relief operation and to ensure that those individuals who are entitled to relief receive such assistance.

In Summary

- Socio-environmental conditions do serve to exacerbate impacts
- Flood impacts in low income formal residential areas may be very similar to those in informal settlements
- The quantifiable economic impacts of the flood event were significant
- The uninsured impacts of the flood event were also significant – these were more apparent in the low income formal and informal settlements
- Flood impacts have a detrimental impact on small scale businesses in both formal and informal areas
- There is evidence that informal residential areas suffer significant health impacts as a result of the flooding
- Flooding in informal settlements tends to have a rather minor effect on the formal infrastructure apparent in the areas
- Exposed channels in flood times present a significant hazard in informal settlements and have significant impacts on the lives of informal settlement dwellers
- The role of the women in the home becomes significantly more complex during times of flood
- Floodwaters rain and wind are perceived of as hazards by informal settlement dwellers
- There needs to be some standard devised around the provision of relief and its subsidisation
- Informal settlement dwellers view the halls as a last resort in recovering from floods
- Evidence from a study of the health impacts of the event indicates that further research is needed in this field.

Recommendations:

- Low-income formal areas experience flooding similarly to informal areas. This has implications for the provision of relief.
- Further investigations should be conducted into health impacts.
- Investigate micro lending options for low income and informal areas.
- Establishment of a formalised procedure for the coordination of relief.

BOX 3

Lending to the Poor

(Porter and Sheppard, 1998. A World of Difference: Society, Nature, Development, pp. 526.)

Nurjahan was married at 12, but was abandoned by her husband a year later, 3 months pregnant. She returned to the family that had raised her, working as a cook while raising her son. She was landless, and had never earned more than $37.50 a year until she was offered a loan by the Grameen Bank. Five years after that loan, her annual income is $250; she owns two goats, a pregnant cow, 10 hens, and two thirds of an acre of land (which she purchased for $1000); and she employs two farmhands to assist with the rice harvest.

The Grameen Bank was founded in 1983 by Muhammad Yusuf, professor of economics in the city of Chittagong, Bangladesh, after he met Sophia Katoon, a 22-year old furniture maker working 7 days a week. Sophia looked twice her age and lived in abject poverty, because she had to sell her output to a money lender in return for borrowing money to pay for her inputs. With a loan from Professor Yusuf of a few dollars, within a few months Sophia had increased her income seven times and repaid the loan. Calculating that she was paying money lenders more than 3,000% interest a year, Professor Yusuf founded the Grameen Bank to provide "microcredit" loans to the poorest of the poor. Average loans of a little more than $100 are made without requiring collateral or security from the borrower. The borrower also determines which business activity to use the loan for, and the bank helps make this successful. Rates of interest are only as high as are needed to keep the bank solvent. Borrowers purchase one, and only one share in the bank, together owning 98% of its shares, and receive dividends on any profits made. Today, the Grameen Bank operates in half the villages of Bangladesh, loaning close to $500 million to 1.7 million borrowers. Ninety-four percent of these are women, in part because they are poor, and in part because they have proven to be exceptionally reliable and successful in using the loans to develop successful microenterprises. Ninety-eight percent of all loans have been repaid on time at 20% interest rates, and 54% of borrowers have raised their incomes above the poverty line. Research showing that failure to move out of poverty is correlated with ill-health has recently led the Grameen Bank to seek (in cooperation with the Bangladeshi government) to offer medical services to its borrowers at a cost of $1.25 per family per year, and 2c for each visit to the doctor. The bank's startling success, confounding the principals of banking, has launched imitators and a current fascination with "microcredit" worldwide (Mathews, 1994)

Part VI Flood Mitigation Strategies in the Cape Town Municipal Area

Flood risk is a function of both the natural processes which give rise to rainfall or groundwater fluctuations, drainage system capacity and human behaviour. For reasons of resources and practicality, it is not feasible to completely eliminate flood risk. It can however be managed to acceptable levels through appropriate planning, design, construction, operation and maintenance of stormwater infrastructure as well as proactive development management and disaster planning.

6.1 Strategic Planning and Management Context

Stormwater Management in Cape Town involves both the quantitative and qualitative management of urban runoff in a manner that ensures public health and safety as well as conservation and enhancement of both the built and natural environments. This approach was formalized in 2002 by adoption of a comprehensive five year strategy formulated to guide improvement and enhancement of the service. Strategic outcomes include improved flood risk management and protection of receiving waters from pollution. Performance is this regard is monitored and evaluated by means of key performance indicators. These measure and track the extent and nature of flooding as well as key water quality determinants in both inland and coastal waters. It should be noted that outcomes for the stormwater service are often impacted by other services such as solid waste management.

The current service delivery model comprises centralised strategic planning, monitoring, information management and community outreach support services with decentralised service provision, upgrading and maintenance of stormwater infrastructure and river systems including community/user interaction. This model is however presently under review in sympathy with the corporate transformation processes.

6.2 Capital Development Programme

The capital development programme for stormwater management and flood control may be divided into two broad components, namely; infrastructure provision and upgrading or rehabilitation of existing infrastructure. During the 2003/2004 financial year R48.4m was allocated to stormwater capital projects. Approximately three quarters of this budget related to public housing projects or basic infrastructure provision.

6.3 Preventative Maintenance of Infrastructure

Transport, Roads and Stormwater Directorate are primarily responsible for the maintenance of stormwater systems. Repair and maintenance budgets for the 2003/2004 financial year totalled R49m for both in-house and contract works. In distributing maintenance budgets, various criteria such as infrastructure under management, incident history and socio-economic criteria are considered.

Funding is still considerably less than generally accepted norms based on current replacement values for the infrastructure currently estimated at R10b. This under investment will ultimately result in deterioration of assets and reduced levels of service delivery.

6.3.1 Planning and Development Control

Various policies and guidelines are applied to manage development impacts on the stormwater system and mitigate flood risk for communities in terms of the provisions of Land Use Planning Ordinance (LUPO). These include planning, design and construction standards for new or upgraded infrastructure associated with development. The protection of floodplains also receives high priority due to high inherent flood risk adjacent to major open watercourses. In this regard, the applicable floodplain management guidelines ensure that any development within the 100 year floodplain is appropriate from both flood management and environmental perspectives. Building below the 50 year floodline may only be permitted in exceptional circumstances.

The Transport, Roads and Stormwater Directorate are in the process of promulgating a Bylaw relating to Stormwater Management which will provide a regulatory framework for protection of the stormwater system.

In Summary

- Current service delivery model includes strategic planning, monitoring, information management and community outreach support services.
- Decentralised service provision
- Funding for maintenance of stormwater infrastructure is below accepted norms.
- This will lead to deterioration of assets and reduced levels of service delivery.
- Promulgation of Bylaw in progress to protect stormwater system.

Part VII Conclusions and Recommendations

The August 2004 flood event was as a result of two separate weather events. The first resulted in rainfall with intensities that exceeded the 100-year frequency in certain areas and hence was a significant event. A second storm followed. Although it was not meteorologically significant, its impacts were.

The dissemination of the early warning was not robust enough. The weather forecast was disseminated to certain organisations. These organizations could then prepare for the event. There were however organizations that did not receive the warning such as Emergency Medical Services and Transport, Roads and Stormwater. Furthermore, there was limited information dissemination to the general public and none to vulnerable communities.

Recommendations to improve the early warning system would include:

- The formalisation of the early warning system. This would entail investigating the tone, format and type of information received. It would have to be discussed with key stakeholders as different organisations find different information useful.
- The SAWS forecast should be interpreted into an early warning through collaboration between SAWS and other stakeholders such as Disaster Management.
- Awareness should be raised of the weather systems and how these interact with the physical environment.

The identification of informal settlements and other areas in need of assistance after the event was problematic. This could possibly be remedied by the following:

- A robust risk assessment should be undertaken to determine communities at risk of flooding. This would assist in more rapid identification of affected areas.
- The information from the above mentioned risk assessment should be consolidated and incorporated into GIS.
- Awareness of low income and informal settlement residents should be raised with regards to what kind of response and relief is available.
- There should be a process of identifying people or communities whose livelihood and health have been affected by the flood.

It was found from fieldwork conducted that the flood impacted on small businesses in both formal and informal areas. This was as a result of stock being stored in the dwelling being damaged. In some instances this resulted in the collapse of the small business as so much capital was tied up in stock. Further investigation should be conducted into the feasibility of providing support to the small business owner.

In informal settlement areas children missed school. Those residents who were employed had to miss a work and so lose wages, a result of the ‘no work, no pay’ policy. This had implications for their livelihood.

The impact of the flood on health was a primary concern to informal settlement residents. An investigation into the health impacts using City clinic data indicates a possible relationship between health and flooding. It is suggested that further research be conducted with regard to this.

Furthermore, it was found that the experiences of residents in the low-income areas were similar to those in informal settlement areas, though they did not receive the same response and relief. This is possibly linked to limited City resources.

The recorded quantitative losses amount to approximately R 6.5 million. This includes damages to private property; the relief provided after the event and recorded overtime staff costs for the City of Cape Town. It also includes costs related to transportation services such as the bus and rail services. The costs do not include 'hidden' costs to the City such as the extra time worked by those who do shifts. The quantitative impact cost does not however reflect the suffering and discomfort experienced by residents in low income and informal settlement areas. It was found that the socio-economic conditions in these areas served to exacerbate impacts.

It is expected that the future will bring more frequent extreme weather events as a result of climate change. It is therefore important to ensure that the City is able to respond to these events effectively and put in place mitigation strategies to reduce the vulnerability of at risk residents.

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Appendix 1 SIGNIFICANT FLOOD REGISTER (1989–2004)

Date	Area	Station	(MM) Rain	Period	(Years) Return	Comments
6/08/1899	Cape Town					Photos from the flood. St Georges, Adderly and Waterkant streets under water.
23/06/1904	Cape Town					At 12h15 rain from the west particularly over Table mountain. Clouds lifted and the (worst squall of the day) broke out over the upper part of gardens at 13h00. Large amounts of water flooding through doors. A "muddy wall of water a couple of feet high" rushing down Breda St and into Mill St. During the evening to night several further heavy downpours plus lightning and thunder.
25/06/1904	Cape Town		62.5mm	1 hour	100 yrs (Estimated by S. Carter)	Rain throughout the preceding night (from 21h00). At 9 am rain came from over signal hill in "great sheets" pushed by a north-westerly wind. (Reports of store assistants knee deep in water in Adderly Street)
1924						
6/10/1938		**Muizenberg**	39.6mm			Called a "cloudburst" very localized nature of storm. Vredehoek estate, Camps bay mass of water running in streets carrying boulders. De Waal Drive a river. Water eventually ended up at Woodstock station. Shops, Stores and factories under 3 feet of water.
		Table Mountain	116.5mm			
		Wynberg	95.9mm			
		Molteno	68.5mm			
		Fire Station	111.5mm			
		Newlands	35mm			
16/02/1940	Cape Town	Molteno	36mm	Approx 1hr	20yrs (Estimated by B. Wood)	Caused by "secondary depression". Flash highly localized event. Basements flooded in Adderly Street. Worst since 1924, but not as bad as 1904 when St Georges street was a river of water. Most rain fell within 1 hour between 3am and 4am.
		Newlands	2mm	24hrs		
		Wynberg	19mm	24hrs		
		Muizenberg	25mm	24hrs		
		Woodhead	35mm	24hrs		
		Steenbras	2mm	24hrs		
30/07/1941	All areas	Steenbras	44mm	24hrs		Liesbeek and Black rivers experienced worst flood in 20 years. Malmesbury cut off. Bellville quarries damaged. Main Street of Somerset West and Strand railway station flooded. Areas around
		Woodhead	57mm	24hrs		

		Newlands	51mm	24hrs		Prince George's Drive flooded. Main Road, Rondebosch flooded affecting shops and houses. Other towns affected included Paarl, Franschoek, Ceres and Rawsonville
		Muizenberg	58mm	24hrs		
		Molteno	48mm	24hrs		
		Wynberg	126mm	24hrs		
1/08/1941	Grassy Park, Zeekoevlei					Vast expanses of Cape Flats flooded
12/07/1950	Cape Peninsula	Newlands	170mm	24hrs		
19&20/04/1951	Parrow Platterklip					
18-20/05/1954	All Areas	Newlands	100mm			Worst damage in 10 years. Wettest May on record. Bridge near post office in Hout Bay washed away. Craft sunk in Simonstown harbour. Worcester isolated.
7/10/1954		Newlands	100mm			"First winter storm" Strong winds (68 miles per hr) thunder. Dam levels still low.
8&10/07/54						Hail Storms. 1ft thick in Rondebosch. Flooding on Cape Flats
19/07/1954 and 20/07/1954	All areas	Simonstown	108mm	48hrs		Worst winter in 20 years, 150 000 pounds damage. 50 000 ponds damage in Simonstown. Landfalls at Chapmans Peak, Redhill, Millers Point. Black river 4ft into Raapenberg pumps station area. Houses in Dido Valley flooded to depth of 450mm by mud. 20 Foot waves battered Atlantic seaboard. 40ft breach in Diep River damaging 6 properties.
		Newlands	127mm	48hrs		
		Wyngerg	102mm	48hrs		
		Wynberg	71mm	24hrs		
		Bellville	26mm	24hrs		
		Newlands	60mm	24hrs		
		Steenbras	17mm	24hrs		
		Molteno	22mm	24hrs		
		Wingfield	15mm	24hrs		
17/06/1957		Newlands & Wynberg	40mm	4 hrs	1yr	Rain fell between 2.22 and 6.25pm
		Table mountain	38mm	4 hrs	1 yr	
21/08/1957		Molteno	59mm			
		Newlands	108mm			
12-13/06/1974	Cape Town General	Moteno	81mm	6hrs	15 - 20	Peninsula
		Athlone	40mm	54hrs		
		Kendal	65mm	55hrs		
		Wynberg	86mm	24hrs		
7/07/1975	S. Suburbs	Wynberg	80mm	7hrs	15	Princess Vlei area
		Kendal	55mm	6hrs		
1/06/1976	S. Suburbs	Wynberg	58mm	6hrs	15	S. Suburb

		Kendal	40mm	7hrs		
19-20/08/1977	S.Suburbs	Athlone	168mm	24hrs	20 - 50	3 Arts, Diep River
		Kendal	16mm	1hr		
22-26/06/1983		Newlands	78mm	24hrs	50	**Generally not significant, wind strengths very significant however**
14-18/05/1984	S.Suburbs	Southfield	60mm	3hrs	0	S. Suburbs
		Wynberg	127mm	24hrs		
5/07/1985	S.Suburbs	DF. Malan	61mm	2hrs	20 - 50	N. Suburbs
11/04/1993	Cape Town General	Newlands	71mm			
		Cecilia forest	59mm			
		Stranfontein	58mm			
		Molteno	56mm			
26/05/1997						
23/07/2004	Noordhoek	Noordhoek	48mm	0.7hrs	20	Exceptionally high rainfall intensities in the Fish Hoek and Noordhoek areas resulted in damage to private properties and traffic disruptions
5/08/2004	Athlone / Pinelands	Athlone	106mm	3hrs	100	This significant rainfall event resulted in widespread and serious flooding in Maitland, Woodstock, Pinelands, Athlone, Bonteheuwel, Nyanga / Guguletu and Somerset West areas. Peak intensities for durations exceeding 3 hours, approached the 1 in 100 year return statistical maximum within a very confined geographic areas on the Cape Flats. Significant tributaries in the eastern portion of the Salt River catchment (Athlone) burst their banks.
		Pinelands	97mm	3hrs	100	
		Cape Town International Airport	56mm	3hrs	50	

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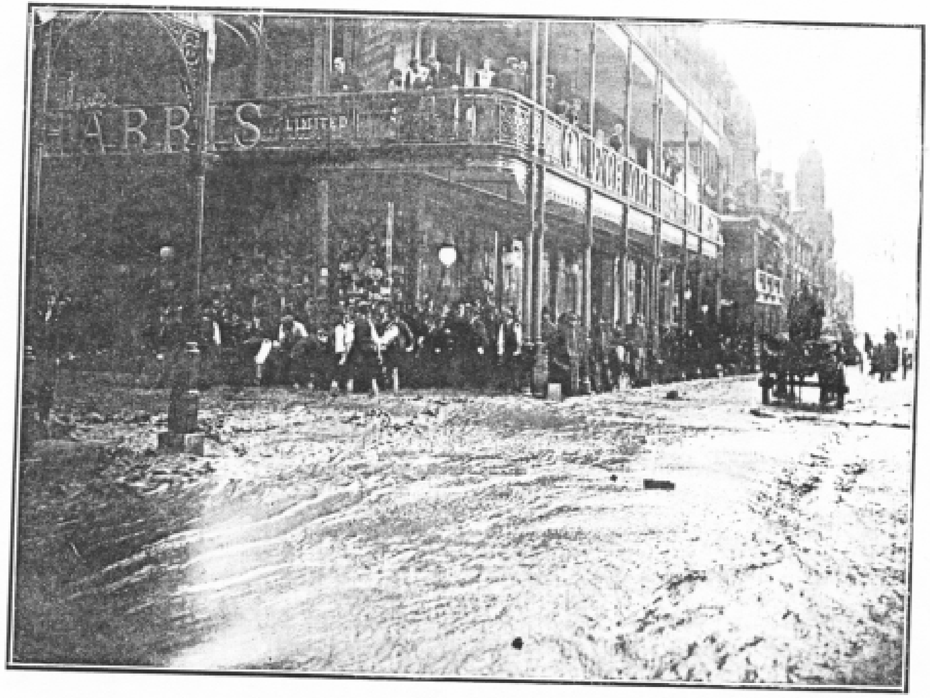
1. Press Clippings obtained from Messrs Ninham Shand Consulting Engineers
2. Gavin Pike, City of Cape Town (1980's)
3. Barry Wood, City of Cape Town
4. African studies Library, University of Cape Town

Appendix 2 PHOTOGRAPHS from 1899 and 1904 respectively

by E. Peters.] BOTTOM OF ADDERLEY STREET.



Shop Assistants damming out the water from Cleghorn & Harris' Premises.

Appendix 3 FLOOD INTENSITY/DURATION CALCULATIONS

August 4th & 5th Rainfall (mm per hour)	5min	10min	15min	30min	60min	90min	120min	180min	240min	300min	360min
CFTP D53	1-2yr	0	0	0	0	0	0	0	0	0	0
MPSW D54	0	0	0	0	0	0	0	0	0	0	0
Devils Peak D55	0.5	0.5	0	0	0.5	0.5-1	0.5-1	0.5-1	0.5	0.5	0
Molteno Reservoir D56	0.5-1yr	0.5-1yr	0.5-1yr	0.5-1yr	1-2yr	1-2yr	2	2-5yr	2-5yr	2-5yr	2-5yr
Maastricht farm D36	0	0	0	0	0	0	0	0	0	0	0
Dagbreek Reservoir D37	0	0	0	0	0	0	0	0	0	0	0
Tygerberg Reservoir D38	0	0	0	0	0	0	0	0	0	0	0
Pinelands D40	2-5yr	2-5yr	2	1	5	10-20yr	20yr	100yr	100yr	50-100yr	50-100yr
Groenvlei D46	0	0	0	0	0	0	0	0	0.5-1yr	0.5-1yr	0.5-1yr
Kendal Road D47	0	0	0	0	0	0	0	0	0	0	0
Southfield Depot D48	0	0	0	0	0	0	0	0	0	0	0
Tokai D51	0	0	0	0	0	0	0	0	0	0	0
Noordhoek D64	0	0	0	0	0	0	0	0	0	0	0
Cecilia forest D222	0	0	0	0	0	0	0	0	0	0	0
Cape Tech	1-2yr	1	0.5-1yr	0.5	1-2yr	2-5yr	5	5-10yr	5-10yr	10yr	10
UCT	1.5	0	0	0	0	0	0	0	0	0	0
Herschel	0	0	0	0	0	0	0	0	0	0	0
COSAT	1-2yr	1	0	0	0	0	1	1-2yr	1-2yr	1-2yr	1-2yr

August 7th & 8th Rainfall (mm per hour)	5min	10min	15min	30min	60min	90min	120min	180min	240min	300min	360min
CFTP D53	0	0	0	0	0	0	0	0	0	0	0
MPSW D54	1	?	0	0	0	0	0	0	0	0	0
Devils Peak D55	10	5-10yr	5	2	2	1	0.5	0	0	0	0.5
Molteno Reservoir D56	2-5yr	2-5yr	2-5yr	1		1-2yr	1	0.5-1yr	0.5-1yr	1-2yr	2
Maastricht farm D36	0	0	0	0	0	0	0	0	0	0	0
Dagbreek Reservoir D37	1-2yr	1-2yr	1	0	0	0	0	0	0	0	0
Tygerberg Reservoir D38	0	0	0	0	0	0	0	0	0	0	0
Pinelands D40	1	0.5-1yr	0.5-1yr	0.5	1	0.5	0	0	0	0	0
Groenvlei D46	2	0.5-1yr	0.5-1yr	0.5	1	2	2-5yr	5-10yr	5-10yr	5-10yr	5-10yr
Kendal Road D47	0.5-1yr	0	0	0	0	0	0	0	0.5	0.5	0.5
Southfield Depot D48	0.5-1yr	0	0	0	0	0	0	0	0	0	0

Tokai D51	0	0	0	0	0	0	0	0	0	0	0
Noordhoek D64	2-5yr	2	1	0.5-1yr	0.5-1yr	0.5-1yr	0	0	0	0	0
Cecilia forest D222	1-2yr	1	0.5-1yr	0	0	0.5	0.5	1	1-2yr	1	1
Cape Tech	1-2yr	0.5	0	0	0	0	0	0	0	0	0
UCT	2yr	1	0.5-1yr	0	0	0	0	0	0	0	0
Herschel	0	0	0	0	0	0	0	0	0	0	0
COSAT	1-2yr	1-2yr	1-2yr	1-2yr	1	1-2yr	1-2yr	1-2yr	2-5yr	2-5yr	2-5yr

0 indicates values falling below the 1:0.5 yr return period

Appendix 4 List of people on the SMS list for early weather warnings August 2004

Weather	Shaun Ross	Technical Supervisor
Weather	J. Minnie	Duty Civil Protection Controller
Weather	Mr W. Wessels	Director : Emergency Services
Weather	Piet Swanepoel	Disaster Management Admin
Weather	Elizabeth Adonis	Disaster Management Admin
Weather	Len Labuscagne	Disaster Management Admin
Weather	Greg Pillay	Disaster Management Admin
Weather	Chris Konings	Disaster Management Admin
Weather	Peter Daniels	Disaster Management Admin
Weather	Andre Aucamp	Disaster Management Admin
Weather	Judy Haumann	Disaster Management Admin
Weather	Enoch Kopele	Disaster Management Admin
Weather	Feziwe Kumalo	Disaster Management Admin
Weather	Austin Leader	Disaster Management Admin
Weather	Lennox Mashazi	Disaster Management Admin
Weather	John Page	Disaster Management Admin
Weather	Charlotte Powell	Disaster Management Admin
Weather	Mark Pluke	Disaster Management Admin
Weather	John Roode	Disaster Management Admin
Weather	Owen Sibeko	Disaster Management Admin
Weather	Wilfred Solomons	Disaster Management Admin
Weather	Johan V/D Westhuizen	Disaster Management Admin
Weather	S Steenkamp	Provincial Administration
Weather	Mr G Laskey	Manager : Disaster Management
Weather	J. Brown	Duty Civil Protection Controller
Weather	F. Schlaphoff	Duty Civil Protection Controller
Weather	Andre Brink	Soc Services
Weather	Clive Jansen	PGWC Soc Services
Weather	Mr S v Rensburg	Koeberg Area Co-ordinator
Weather	Jaco Groenewald	Control Center Supervisor
Weather	John Ellis	Manager

Appendix 5 Flooding Images from the August 2004 severe storm event

Salt River Over-bank flow at Black River Parkway Flyover (Ninham Shand)

Hazel Road, Rylands

Beach Road, Maitland

Bonteheuwel

River Club in Observatory

Gxa-Gxa Informal Settlement, Guguletu

Appendix 6 Overview of the Salt River Catchment

A.6 The Salt River Catchment

The Salt River Catchment Area covers 214 km^2 and comprises the following rivers: Liesbeek, Black, Kromboom, Bokmakierie, Blomvlei, Vygekraal, Jakkalsvlei, Elsieskraal and Salt Rivers. Detail on the Liesbeek and Black Rivers is provided below.

A.6.1 Description of the Liesbeek River

The Liesbeek River is less than 9km long and the majority of the lower section is canalised (refer to Figure 2.5.1). The source of the river is on Table Mountain where the upper catchment is located above the Kirstenbosch Botanical Gardens (Day, 1995). The Vaalkat, Nursery, Skeleton and Window Stream come together to form the Liesbeek River (CMC, 2000). All the upper tributaries of the river run through the Gardens where human disturbance is minimal and the vegetation is largely indigenous (Day, 1995). The Liesbeek River is naturally a perennial river, however abstraction in these upper reaches, in particular from Window and Nursery Streams, has caused the flow to almost cease during the summer months (Day *et al.* 1999).

Other mountain streams which drain the eastern slopes of Table Mountain include the Loeriebos and Fernwood Streams (which drain the portion of Table Mountain between Kirstenbosch and Newlands Forest), Hiddingh and Newlands Streams (which flow through Newlands Forest) and Rhodes Memorial Stream (which drains the north eastern portion of Table Mountain). Most of these streams are fairly pristine in their upper reaches, but are however heavily abstracted and manipulated. With the exception of the Fernwood and Newlands Streams, most of these streams flow through the suburbs as underground culverts (CMC, 2000).

On the lower slopes of the mountain, below the Kirstenbosch Botanical Gardens, is the high-income residential area of Bishops Court consisting of large properties (Day, 1995). In this section, the river is surrounded by alien vegetation. The river channel is deeply incised and infilling of the banks and construction has taken place along the stream channel. There are banks that are 20-30 metres high that have been created along the river and as a result, sedimentation of the downstream environment has caused the loss of the naturally heterogeneous instream habitat (CMC, 2000).

The further downstream the river meanders, the smaller the plot sizes become and therefore the greater the quantity of the catchment is hardened houses, roads, and parking lots. There is very little indigenous vegetation found downstream of the Kirstenbosch Botanical Gardens. From Newlands downstream, large sections of the river are canalised and those short sections of the river that are not canalised are degraded by erosion. In the Mowbray area, there is more open space and major roads. Below Mowbray is the confluence of the Liesbeek and Black Rivers. From the confluence of the two rivers, the river runs through both industrial areas and railway marshalling yards (Day, 1995).

A.6.2 Description of the Black River

Downstream of the Athlone WWTW, several canals draining the Cape Flats join together to form the Black River (refer to Figure 2.5.1) (CMC, 2000). Within this reach, the Black River is essentially a slow flowing, highly polluted system, which has been severely altered from its natural state. Once a seasonal river, the Black River is now perennial owing much of its volume to effluent from Borcherds' Quarry and Athlone WWTW, as well as urban runoff. Although the water quality is still poor, the upgrade of the Athlone WWTW in 1986 improved the water quality significantly from a prior state of critically-severe organic pollution (Day, 1995).

In the vicinity of the Rondebosch Golf Course, the Black River flows in a wide earth canal, which continues alongside the M5 highway until its confluence with the Liesbeek Canal. Efforts have been made in this section to reinstate some of the riparian wetland habitats, and a wetland in the area between the M5 and N2 currently receives stormwater runoff from these highways. Downstream of this point the river flows in a wide concrete canal and is known as the Salt River Canal, an estuarine system of very little ecological value, which empties into Table Bay (CMC, 2000).

Remnants of the wetlands that once covered the Cape Flats within the Salt River Catchment include the Vincent Palotti wetland, the Valkenberg wetlands and the Raapenberg wetlands. Due to extreme canalisation of the Black River, there is very little connection between these wetlands and the river. Nevertheless, they are productive systems and support a relatively rich avifaunal community. From this perspective, the remnant wetlands along the Black River play an important role in the ecology of the Salt River Catchment (Turpie, 1994).