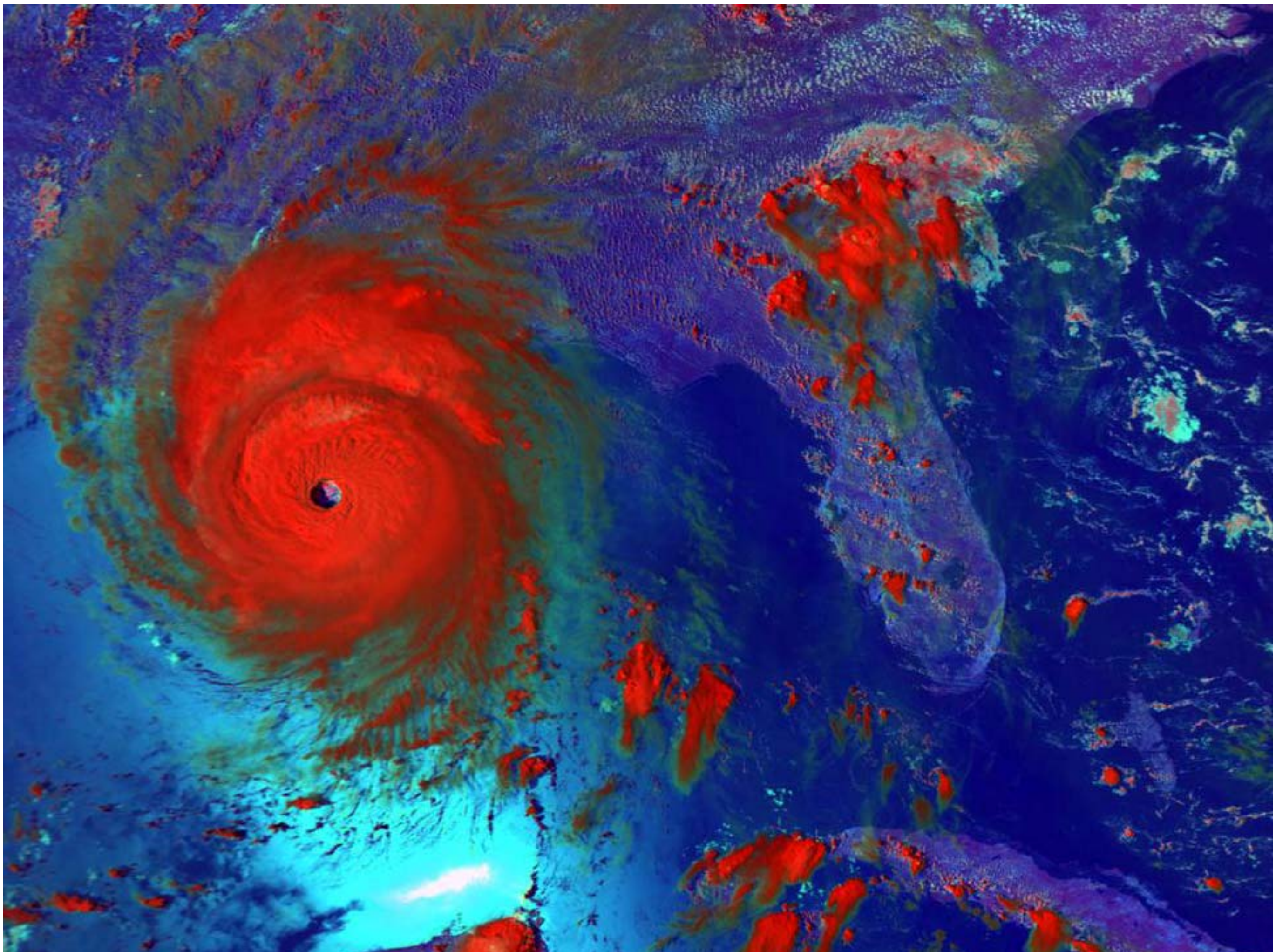
A Framework for Modelling Losses arising from Natural Catastrophes in South Africa

Roger R Grobler



Synopsis

Property insurance covers policyholders against losses arising out of a wide range of occurrences. Premiums are calculated by taking into account estimates of the frequency and the severity of the losses. Estimating the frequency and severity arising from claims caused by natural catastrophes is difficult, due to the relatively low frequency of natural catastrophes, and the unavailability of historical catastrophe claims data. The accumulation of a large number of claims in the geographical area affected by the catastrophe is of particular interest to insurers and reinsurers alike.

This dissertation discusses the fundamental issues underlying the modelling insurance losses from natural catastrophes in South Africa. A suggestion is given of the key parameters that need to be taken into account, and a framework is given for models describing losses arising from floods, hail and tornadoes.

Sinopsis

Eiendom versekering beskerm polishouers teen verliese veroorsaak deur ‘n wye verskeidenheid van moontlike oorsake. Premies word bereken deur die frekwensie en quantum van eise te beraam. Die beraming van die frekwensie en quantum van eise veroorsaak deur natuurlike katastrofes is besonder moeilik, weens onder andere die relatiewe lae frekwensie van natuurlike katastrofes, en die gebrek aan historiese data. Die akkumulasie van eise in ‘n geografiese area getref deur ‘n natuurlike katastrofe is van besondere belang vir beide versekeraars en herversekeraars.

Die verhandeling bespreek die onderliggende beginsels van die modellering van versekeringsverliese veroorsaak deur natuurlike katastrofes in Suid Afrika. Die sleutel parameters word voorgestel, en ‘n raamwerk word gegee vir modelle wat die verliese veroorsaak deur vloede, hael en tornadoes beskryf.

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1. Preamble: The initiative for the research

Following a series of lectures given by Jürgen Graeber and Norbert Künig (of the Hannover Reinsurance Company) at the Insurance and Actuarial Science Department at the University of Pretoria, the idea was aired of a research unit at the university, sponsored by The Hannover Reinsurance Company.

The research unit was established, under sponsorship of both the Hannover Reinsurance Company and The Hollandia Reinsurance Company. The first project that was undertaken by the research unit was the modelling of natural catastrophes in South Africa, specifically from the vantage point of losses incurred by the insurance industry.

The actuarial analysis of short-term (also termed general) insurance risks is relatively new, compared to the more traditional actuarial study areas, such as life insurance and pensions. Actuarial involvement in short-term insurance has increased significantly over the last few years. The annual meeting of the General Insurance Study Group in the UK is currently attended by in excess of 300 delegates.

The research project was headed up by the author of this dissertation. This dissertation contains the findings of the research unit, and is submitted for the purposes of satisfying the requirements of a Magister Commercii degree in Actuarial Science. The bulk of the research was concluded by July 1996.

2. What is a catastrophe?

2.1 Definitions

Catastrophe (non-life): Conflagration, earthquake, windstorm, explosion, and other similar events that result in substantial losses. Catastrophe losses (the whole loss of an insurance company arising out of a single catastrophic event) are usually protected by Excess of Loss treaties in order to limit any one such loss to a specific amount.

- KPMG Glossary of Terms for the insurance industry

Catastrophe (life): Total claims on a long term insurer arising out of a single catastrophic event (e.g. fire, earthquake, storm, explosion or similar event).

- KPMG Glossary of Terms for the insurance industry

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catastrophe n. **1** a great and usu. sudden disaster. **2** the denouement of a drama. **3** a disastrous end; ruin. **4** an event producing a subversion of the order of things.

- The Concise Oxford Dictionary (Ninth Edition)

2.2 Cataclysms

The occurrence of catastrophes in areas inhabited by humans invariably causes loss of life and widespread damage to property. It is not difficult to think of historical catastrophes that disrupted the lives of thousands of people in large areas. The most famous of these catastrophes is arguably Noah's flood. It is also the worst catastrophe (by a long margin…) known to man in as far as loss of life and property damage is concerned. Modern day catastrophes fortunately have less divine intervention (or unfortunately...) and the catastrophes are not quite as severe as the one Noah came to experience.

Archaeologists have unearthed evidence indicating "acts of God" (other than Noah's flood) much more severe than we have experienced in our recent history. Those events were in some cases so extreme that entire species were wiped out (such as the dinosaurs). Ice ages, for example, are said to have frozen great mammoths and sable-tooth tigers "in their tracks" in places like Siberia.

One relatively new theory[1], claims that as recently as 10 000 BC a sudden and cataclysmic shift took place that could best be described as the entire crust of earth moving around the inside of the earth in great, big jerking movements. Continents (Antarctica) were plunged into a new ice age by being moved into the Polar Regions. For around 3 000 years the after effects were still felt on earth as ocean levels fluctuated dramatically, submerging large tracts of lands while other areas were rapidly frozen over. Terrific floods rampaged and earthquakes abounded as the crust settled into its new position. Gigantic tsunamis swept in devastation over coastal

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[1] *"Fingerprints of the Gods" - Graham Hancock. Graham Hancock's theory was published as popular non-fiction. As far as the author is aware, Graham Hancock is not a recognised scientist, nor has his theory been accepted in the scientific community. His theory is included in this dissertation as a description of a potential cataclysm, albeit speculative.*

areas, causing havoc in their wake. Great many myths from numerous cultures (including Noah's story) may pertain to this chaotic era in the earth's history. From these myths and from complex mathematical and time-keeping systems the timing of the "end of the fifth sun" is to be just after the year 2000. More specifically, according to Mayan tradition and hieroglyphs, on 23 December 2013. Mayan tradition indicates that the end of the fifth sun is to occur when the earth will be consumed by fire.

2.3 Modern day catastrophes

There are two main categories in which to place catastrophes:

- Natural catastrophes
- Man-made or man-induced catastrophes

Natural catastrophes are caused by nature’s severe forces, causing widespread havoc if the area struck is populated. Man-made catastrophes are normally less severe. They are caused by man and could theoretically have been prevented if proper care had been taken beforehand. This dissertation focuses on losses caused by natural catastrophes.

The damage caused by catastrophes can also be categorised into several components:

- Loss of life
- Social damage
- Damage to state owned property
- Damage to privately owned property
- Economic loss, due to loss of income and earnings

The first two components cannot, generally speaking, be indemnified due to their nature (you cannot give back a lost life, and one cannot quantify the social loss suffered by any individual or group of people). The next component is the responsibility of society as a whole, and will be borne by society. The last two components can be indemnified by the use of insurance.

3. Scope of this research

The aim of this research is to explain methodologies that can be used to estimate losses caused by future natural catastrophes in South Africa, with the purpose of estimating insured losses in mind.

To attain the above aim the dissertation is broken up into several parts:

- An analysis of historic natural catastrophes occurring in South Africa in terms of their frequency and severity (section 5),
- Development of the exposures to natural catastrophe in terms of insured interest sub-divided into appropriate geographical regions (section 6), and
- Development of models to quantify the effect that future catastrophic events may have on the insured interest in terms of damage caused and subsequent losses to be claimed (sections 7 to 11).

4. The results presented in this dissertation

The subject area of catastrophes and the resulting losses is very wide and diverse. It consists of several disciplines, including actuarial science (which forms the author's background) and natural sciences (notably hydrology, geology and meteorology). The results presented in this dissertation do not attempt in any way to cover all the possible approaches and disciplines that may be utilised in modelling natural catastrophes. The main South African natural catastrophes are covered - Floods, hailstorms, tornadoes and earthquakes. Floods are covered in the most detail. The results presented for flood modelling focus around the expected severity of floods at specific points. As far as the author could establish, the approach of linking calculated Regional Maximum Flood (RMF) parameters to damage caused by historical floods in order to find a predictive flood damage model has not been suggested before.

The methodology suggested for modelling hailstorms and tornadoes is based on mainstream actuarial literature and statistical techniques. Insufficient information was found relating to earthquakes to warrant extensive coverage in this dissertation. The findings of the Swiss Reinsurance Company is included for completeness.

The results presented are intended to form a potential framework for the much more extensive work that needs to be done to model catastrophes sufficiently in order to calculate expected insurance and reinsurance losses.

5. Catastrophes

5.1 Catastrophes in South Africa

South Africa is not known as an area prone to major natural disasters. That does not mean South Africa is exempt from natural catastrophes - natural catastrophes can and do occur. In terms of natural catastrophes the two most prominent occurrences are two extremes: Floods and droughts. There are also isolated incidences of meteorological phenomena, including tropical cyclones, tornadoes and severe thunderstorms. These occurrences may lead to subsequent flooding, as well as structural damage to buildings and loss of life. Other natural catastrophes include veldt and forest fires, locust infestations, very rarely earthquakes and landslides following heavy rainfall[2].

There is speculation as to the occurrence of a climate change. The change can be described as an increase in climatic variability. That means that the occurrence of extreme events may be on the increase[3]. If past events are to be used as an indicator of the possibility of future events, this is a factor of which one must be very aware.

Both the two important natural catastrophes (floods and droughts) affect the insurance industry. The difference between the two is that losses due to droughts were historically supported to a large extent by government funding by means of the

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[2] *National Report of the Republic of South Africa - Prepared for the IDNDR Mid-term Review and the 1994 World Conference on NATURAL DISASTER REDUCTION (p4).*

[3] *Alexander (1994) - p.65*

drought relief fund. There can be no doubt that the greatest catastrophe suffered in South Africa is drought. Droughts affect large areas, depriving humans from their livelihood and causing much distress. Droughts, however, will not be modelled in this study, as they fall outside the scope of the study. The insurance industry does not suffer great losses due to droughts. It may be an area that warrants future research though. Looking at an insurance loss perspective, flooding poses the greater risk, due to the widespread damage caused over a short time span[4].

In Table 1 below a summary is given of some of the most significant meteorological events in South African history, which should be seen as natural catastrophes. Note that all amounts are reflected in 1996 money terms.

[4] *Floods are caused by excessive widespread rainfall. The causes, nature and life cycle of a flood are discussed in 7.*

Date	Region	Event	Detail[5]
September 3, 1853	Eastern Cape	Snow	Hundreds of people froze to death after severe snowstorm.
June 12, 1902	Interior	Snow	Most severe snowstorm in memory over SA. Snow 1.5m deep in East Griqualand where 13 000 sheep froze to death.
February 1, 1936	Settlers	Hailstorm	Devastating hailstorm with hailstones the size of coconuts reported. Ten people killed by hailstones. Several head of cattle also killed. Nine people killed by raging water. 380mm of rain fell in 15 minutes.
November 26, 1948	Roodepoort	Tornado	Worst tornado in known SA history. 700 homes wrecked, 4 people killed. Damage estimated at R150m. Track of 64 km touching down 15 times.
November 17, 1949	Pretoria	Hailstorm	Devastating . Hailstones with a circumference of 23 cm (diameter 7cm). Not a single building without broken windows or broken roofs in Pretoria West. At Iscor 12 000 large windows broken and hundreds of motor cars badly damaged.
January 7, 1958	North-Eastern Transvaal	Cyclone	Flooding of Sand, Letaba and Selati Rivers with large-scale devastation of homes, bridges and crops. Half the black population of Messina's homes washed away.
January 7, 1966	Transvaal Lowveldt	Cyclone	Great damage in Maputo. Heavy rain in Transvaal Lowveldt.

[5] *All figures roughly adjusted to 1996 terms.*

Date	Region	Event	Detail[5]
September 1, 1968	Port Elizabeth	Flooding	Communication links broken, streets demolished, buildings, buses, cars, trees, people and animals washed away. Damage estimated at R400m. Eleven people drowned.
March 4, 1974	Central Interior	Flooding	Millions of rands' damage along Modder and Riet Rivers. At Upington the Orange River flooded 80% of the houses on the island and along the river. Fish River Valley experienced worst flood in 120 years. In Cradock 200 homes were inundated.
February 9, 1977	North-Eastern Regions	Cyclone	Widespread flooding. Ten people drowned at Tshipise near the Kruger National Park.
January 28, 1978	Pretoria	Flooding	Homes, factories and flats flooded. 11 people dead.
January 25, 1981	Laingsburg	Flooding	One of the greatest disasters in SA history. 104 people drowned, 185 homes, old-age home and 23 offices destroyed.
February 1, 1984	North-Eastern Regions	Cyclone	Cyclone Domoina killed more than 200 people in Mozambique, Swaziland, Eastern Transvaal and North-Eastern Natal. Damage to sugar cane fields estimated at R470m. Damages to bridges estimated at R25m. Most rain to fall in one day at one point ever recorded in SA (597mm at St Lucia lake).
November 1, 1985	Pretoria	Hailstorm	Major hailstorm striking Pretoria city centre and surroundings. Damage estimated at R400m. Roofs collapsed, windows of cars,

Date	Region	Event	Detail[5]
			homes and flats knocked out.
September 28, 1987	Natal	Flooding	Described as worst floods in Natal ever. Homes washed away, collapsed or buried in mud. Thousands of kilometres of roads damaged, 14 bridges washed away, all entrance routes to Durban closed. R3 300m damage, 388 deaths and 68 000 homeless.
February 29, 1988	Central Interior	Flooding	One of the greatest flood disasters ever in Free State, Western Transvaal, Northern Cape and Karoo. In Free State 47 bridges destroyed. 1300 homes evacuated in Northern Cape. Thirty magisterial districts declared disaster areas.
March 20, 1990	Welkom	Tornado	Structural damage of R230m. Twenty square km affected.
November 3, 1993	Utrecht	Tornado	Tornado devastated a path of 35 km long and 200m wide. 40 people lost their homes in Glencoe. 7 people killed.
February 2, 1994	Ladysmith	Flooding	Worst flood in 78 years. Damage of R60m. More than a thousand families left homeless.

Table 1: Most significant meteorological events in South African history[6]

As a very broad indication, the frequency of natural catastrophes between 1948 and 1995[7] (according to the events in Table 1) was one every three years. The average

[6] *Caelum 1991 and subsequent updates.*

cost per year in terms of catastrophes was (very roughly) R150m. The average cost per event was roughly R400m (in 1996 money terms)[8].

From Table 1 it can be seen that the natural meteorological catastrophes affecting South Africa are:

- **cyclones,**
- **flooding,**
- **tornadoes, and**
- **hailstorms**.

Two severe events are mentioned where snow was the cause of distress. The losses were not material though, but rather a loss of livestock and human life. Furthermore the two events occurred in 1853 and 1902, a very long time ago.

There is much speculation as to the danger of earthquake. The Swiss Reinsurance Company, in particular, has done some work on the assessment of earthquake exposure. Their findings are included in the section on earthquakes. Since the actual occurrences of earthquakes in South Africa have not caused significant losses the estimates are highly speculative, and therefore for the purposes of this dissertation the findings of the Swiss Reinsurance Company are sufficient.

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[7] *This table does not contain any earthquakes, but only events of meteorological nature.*

[8] *These costs were quoted as total losses, as opposed to insured losses.*

5.1.1 Tropical cyclone

"***Of all the disasters that the weather may inflict on mankind the TROPICAL CYCLONE is undoubtedly the most devastating.***" - Caelum[9]

Probably the worst cyclone in terms of loss of human life hit Bangladesh on 12-13 November 1970. An estimated 300 000 to 500 000 people were drowned. It was not only the worst cyclone ever, but also the worst modern day catastrophe, in terms of fatalities.

On the insurance side the nightmare of all catastrophes was Hurricane Andrew[10]. The losses are estimated at a total of USD 16 billion. That outstrips the second largest catastrophe by over USD 4 billion, and the third largest by over USD 9 billion.[11]

The damage caused by the cyclones is due to winds reaching 33m/s and torrential rainfall. The most rain ever to fall at a single point in South Africa was during Cyclone Domoina, when 597mm was measured in one day at Lake St. Lucia in Natal.

There are a fair number of cyclones originating in the South West Indian Ocean, but hardly any of these ever reach the South African coast. Tropical cyclones are a very real danger though, and the possibility of a higher future frequency due to climatic changes is one that should be kept in mind.

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[9] *Caelum - December 1991*

[10] *Cyclones are also known as hurricanes and typhoons.*

[11] Swiss Re*, Sigma no 2/1996, in terms of 1992 prices*

5.1.2 Flooding

Floods may be caused by various meteorological events, including the dreaded tropical cyclones mentioned above. A flood basically occurs when the earth cannot absorb all the rain that falls, and excess water flows over the land. Flooding is the occurrence causing the largest losses in South Africa.

5.1.3 Tornadoes

One could be surprised to notice the number of tornadoes occurring in South Africa each year. It is an event that enjoys relatively little media coverage, because of the small damage usually involved. The tornadoes that occur typically hit sparsely populated rural areas, damaging crops and the occasional building. Where it does hit a populated area however, the damage may be excessive. The third largest catastrophe in world history in terms of damage was a tornado that hit Japan on 27 September 1991, causing USD 5.7 billion in damages.

5.1.4 Hailstorms

Several regions in South Africa suffer hail on a quite regular basis. It happens very rarely though that the hail causes much damage other than extensive crop damage. Hail has been known, however, to cause widespread damage when hailstones the size of golf balls, tennis balls, and even coconuts have been observed.

5.2 Hazards causing catastrophes

Table 2 summarises the natural hazards affecting South Africa, the historical probability of occurrence, the regions affected and the type of damage caused.

Hazard	Probability of occurrence	Regions affected	Assessment
Tropical cyclones	10 in past 35 years causing severe rainfall, 2 making landfall.	Northern and Eastern Transvaal Northern Natal	Flooding and wind damage
Lightning	10-12/km^2 per year	South Eastern Transvaal Eastern Mountainous Natal	Bush and forest fires
Cloudbursts and wind squalls	16 in past 10 years in Transvaal	Countrywide	Flooding Wind damage
Hail	4-8 days per year at a point in Highveldt	Mainly Highveldt	Hail damage
Tornadoes	Up to 12 a year	Countrywide	Severe wind damage
Cut-off lows	156 cases from 1952-1982 in South Africa 1 out of 5.2 potential flood causing systems per annum causing floods	Southern and Eastern coastal regions	Flooding

Table 2: Natural Hazards affecting South Africa[12]

5.3 Catastrophes to be assessed in this study

The priority of events to be investigated in this study follows the extent of damages caused by each. Earthquakes are not events that have ever caused any catastrophic damage in South Africa. That is not to say that earthquakes do not occur. They do occur and it might be that in the future an earthquake causes major damage. This possibility is fairly remote, however. Any projection made regarding earthquakes will

[12] *Alexander - 1993*

naturally be extremely uncertain. As mentioned earlier, this dissertation will use the findings made and published by the Swiss Reinsurance Company.

The most important natural catastrophe to be assessed is flooding, due to the nature and size of losses involved. On average floods that cause relatively large-scale damage occur once every two years in South Africa[13]. The prediction of expected flood damage over time for a large area is very difficult. Flooding probably has the most facets of all the events under consideration. A great many variables determine the size and eventual damage caused by a flood. These variables have different effects depending on the region in which the flood occurs. The working of a flood is discussed in section 7.

Tornadoes and hail may be two events that are easier to assess. A large number of both events occur each year, making statistical projection based on past events possible. Furthermore the damage caused by a hailstorm or tornado does not depend to such a large extent on the characteristics of the area as it does when assessing flood risk.

Tropical cyclones are a very important risk to examine. The frequency of serious cyclones in South Africa is relatively low (10 in the last 35 years causing severe rainfall, 2 out of the 10 making landfall, 1 of the 2 causing damage[14]). The possibility of a cyclone making landfall over Durban should be considered, as the ensuing losses may be enormous.

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[13] Smith *et al, 1981*

[14] *Cyclone Domoina*

What follows is a more detailed discussion of the catastrophes that should be assessed (earthquake, flooding, including cyclones, tornadoes and hailstorms), as well as a description of the problems inherent to the damage assessment of each.

6. Exposure Database

Part of the scope of this research was to do initial investigations into the exposures of insurers in South Africa.

Exposures in South Africa change significantly over time, and care must be taken in any model to adjust historical data in such a way as to most accurately reflect the situation applicable for the period under investigation.

6.1 What is an exposure database?

An exposure database is the value of properties subdivided by area. The smaller the areas by which the information is subdivided, the more accurate an analysis becomes. To get accurate assessments of the damage that could be caused by various catastrophes one would need exposure databases on

- domestic property,
- commercial and industrial property, and
- commercial and domestic vehicles.

Ideally, one should have the exposures for a particular insurer, to which an actuarial model can be applied. This is the so-called “bottom-up” approach. The converse, i.e. the top-down approach, is when economic exposures are determined. The insured portion for each area should then be applied to the database, which will result in the insured exposures per area. Applying the catastrophe model will give an expected market loss. Applying the insurer’s market share derives the expected loss for a particular insurer.

The bottom-up approach is obviously preferable, but application of the bottom-up approach by a reinsurer is difficult, due to the limited access to such detailed information.

6.2 Residential property in South Africa

In this study an economic exposure database was compiled on residential property. A similar approach can be followed to arrive at commercial property and vehicle databases.

6.2.1 ENPAT

The first step was to obtain a geographical database. The *Geographical Information Systems Lab* of the University of Pretoria compiled the ENPAT[15] database. In this database South Africa is subdivided in 9660 areas, with various types of information associated with these areas. In particular the census (or magisterial) district of each area is known.

6.2.2 Central Statistical Services (CSS)

The CSS compiled information on the number of residential properties in each magisterial district for 1991. There are 361 magisterial districts in South Africa. The information for each district was subdivided as explained below.

[15] ***En****vironmental* ***P****otential* ***At****lases (Department of Environmental Affairs and Tourism)*

Census District	Dwelling Area	Houses (1-3)	Houses (4-5)	Houses (6+)
BELLVILLE	Urban	3903	21105	17524
BELLVILLE	Semi-Urban	1026	692	138
BELLVILLE	Non-Urban	955	416	203

Flats (1-3)	Flats (4-5)	Flats (6+)	Town Houses (1-3)	Town Houses (4-5)
6181	1288	83	1859	2768
24	10	0	3	1
51	7	1	243	52

Town Houses (6+)	Retirement (1-3)	Retirement (4-5)	Retirement (6+)
204	542	103	9
0	0	0	1
1	2	0	1

Table 3: Example of CSS data[16] for Bellville magisterial district

[16] *The results in the tables were obtained by analysing the same electronic data used by the CSS as a source for their reports.*

It was therefore known that in 1991 there were 1859 town houses, with one to three bedrooms, in the urban area of Bellville.

Next, average house prices (1996) were obtained from ABSA bank subdivided by broad region.

ABSA Region	Small Houses	Medium Houses	Large Houses	All Houses
Gauteng	R 135 359	R 179 828	R 245 189	R 174 501
Johannesburg	R 152 468	R 217 364	R 273 866	R 206 319
East Rand	R 119 533	R 158 641	R 219 811	R 155 807
West Rand	R 154 022	R 181 395	R 281 551	R 182 050
Vaal Triangle	R 96 085	R 123 475	R 167 592	R 118 621
Pretoria	R 134 978	R 193 070	R 253 115	R 179 712
Western Cape	R 138 543	R 190 014	R 278 667	R 172 412
Cape Town Metro	R 140 696	R 193 962	R 284 660	R 173 866
Kwazulu/Natal	R 135 661	R 182 211	R 238 759	R 168 328
Durban/Pine Town Metro	R 138 843	R 205 911	R 269 388	R 175 333
Rest of Kwazulu/Natal	R 123 079	R 142 907	R 207 037	R 153 483
Free State	R 97 401	R 136 240	R 203 577	R 140 656
Eastern Cape	R 112 350	R 160 962	R 232 192	R 150 041
PE/Uitenhage/EL Metro	R 110 065	R 164 476	R 249 494	R 151 634
Rest of Eastern Cape	R 125 202	R 147 680	R 172 716	R 143 257
Mpumalanga	R 109 394	R 143 230	R 200 711	R 142 043
North West	R 116 738	R 140 456	R 188 023	R 141 431
Northern Cape	R 96 951	R 133 213	R 171 897	R 127 482
Northern Province	R 118 183	R 176 636	R 289 497	R 137 738
RSA	R 130 026	R 175 650	R 239 463	R 166 296
Rest of Region	R 129 812	R 175 076	R 262 186	R 166 878

Table 4: Average House Prices (ABSA)

The above information was matched with the CSS information by assuming a small house is a one to three bedroom house, a medium house a four to five bedroom house and a large house a six plus bedroom house.

Next a scaling factor was applied to differentiate between urban, semi-urban and non-urban areas. These factors were not investigated thoroughly. However the main aim of the research is to demonstrate a methodology. For commercial application of the database, these parameters should be determined scientifically.

Dwelling Area	Dwelling Area Scale
Urban	1
Semi-Urban	0.75
Non-Urban	0.5

Table 5: Dwelling Area Scales

Similarly a scaling factor was applied to arrive at exposure values for the other dwelling types, i.e. flats, retirement houses and town houses.

Dwelling Type	Dwelling Type Scale
Flat	0.5
House	1
Retirement	0.6
Town House	0.75

Table 6: Dwelling Type Scales

6.2.3 Residential exposure database

The total residential exposure in each ENPAT area is now calculated as follows:

1. Calculate the size (in km^2) for each magisterial district.

2. From 1 the proportion each ENPAT area is of the magisterial district it is in can be calculated.

3. Using the proportion in 2 the number of the various dwellings can be allocated to each ENPAT area.

4. The ABSA house price data is then used (as discussed earlier) to arrive at a total exposure for each ENPAT area.

In this calculation a growth index was applied since the number of dwellings relate to 1991. It was assumed that in urban areas the growth rate was 4% per annum and in other areas 1.5%. Again these assumptions warrant further investigation.

The above process is illustrated below as it would be done in Microsoft Access:

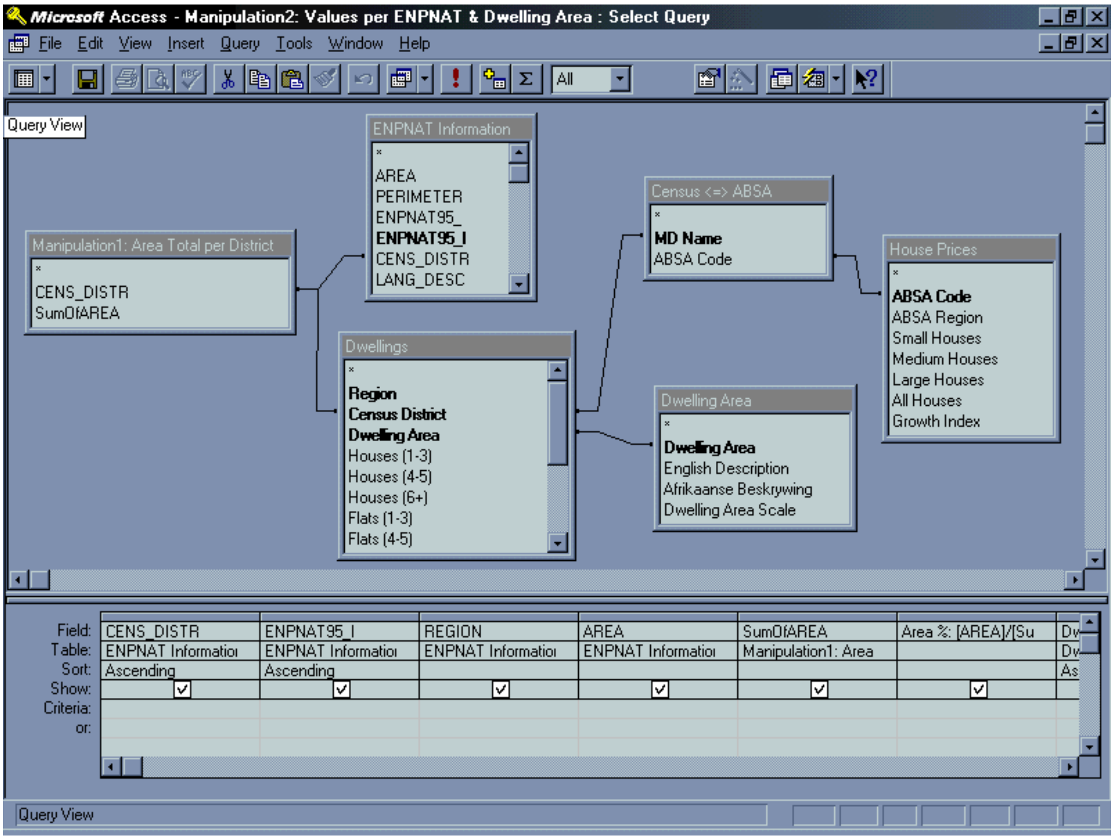

Figure 1: Access Table Relationships for the Exposure Database

Since the exposure per ENPAT area is available, it is now straightforward to produce exposures per census district, ABSA region and province, depending on the requirements of the subsequent analysis. The total economic residential exposure per Province is given below:

PROVINCE	EXPOSURE
GAUTENG	R 208 001 642 291
WESTERN CAPE	R 120 581 900 244
KWAZULU/NATAL	R 103 729 927 799
EASTERN CAPE	R 40 627 705 541
FREE STATE	R 34 854 468 818
NORTHERN PROVINCE	R 30 223 228 455
MPUMALANGA	R 29 377 262 797
NORTH-WEST	R 16 872 607 143
NORTHERN CAPE	R 12 755 117 777
TOTAL	**R 597 023 860 865**

Table 7: Total Economic Residential Exposure per Province

The exposure database is part of a computerised catastrophe model, and any of the parameters mentioned above can be changed. Should certain aspects be investigated in more detail, such results can easily be incorporated into the model.

6.3 Maps

6.3.1 Exposure Density Map of South Africa

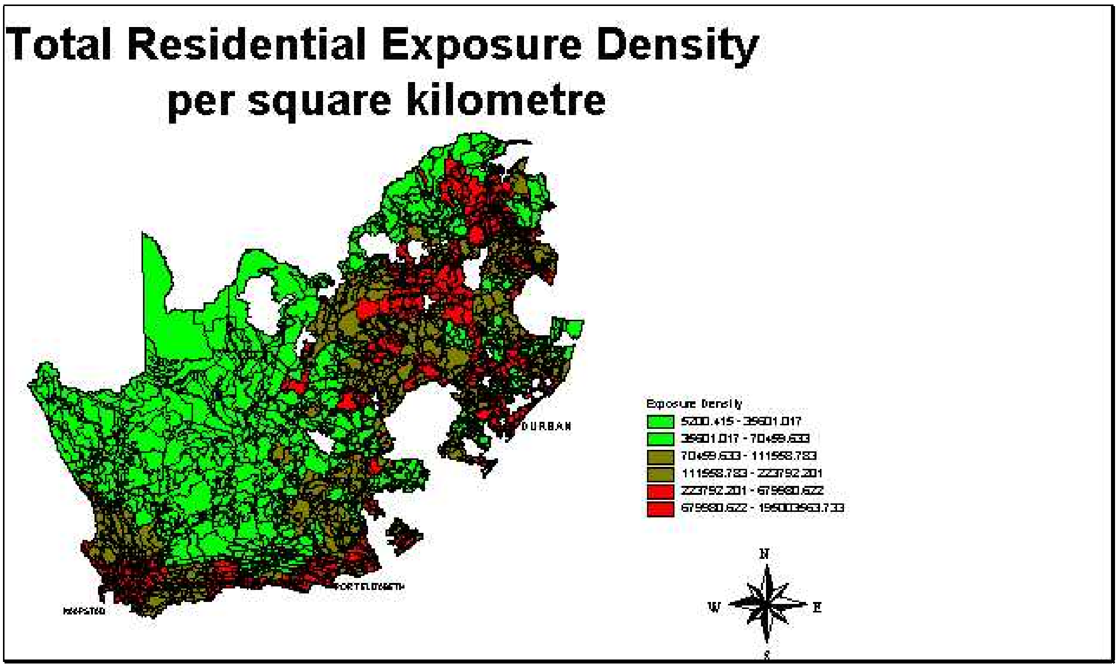

Figure 2: Residential Exposure Density in South Africa

6.3.2 Exposure Density Map of Gauteng and Surroundings

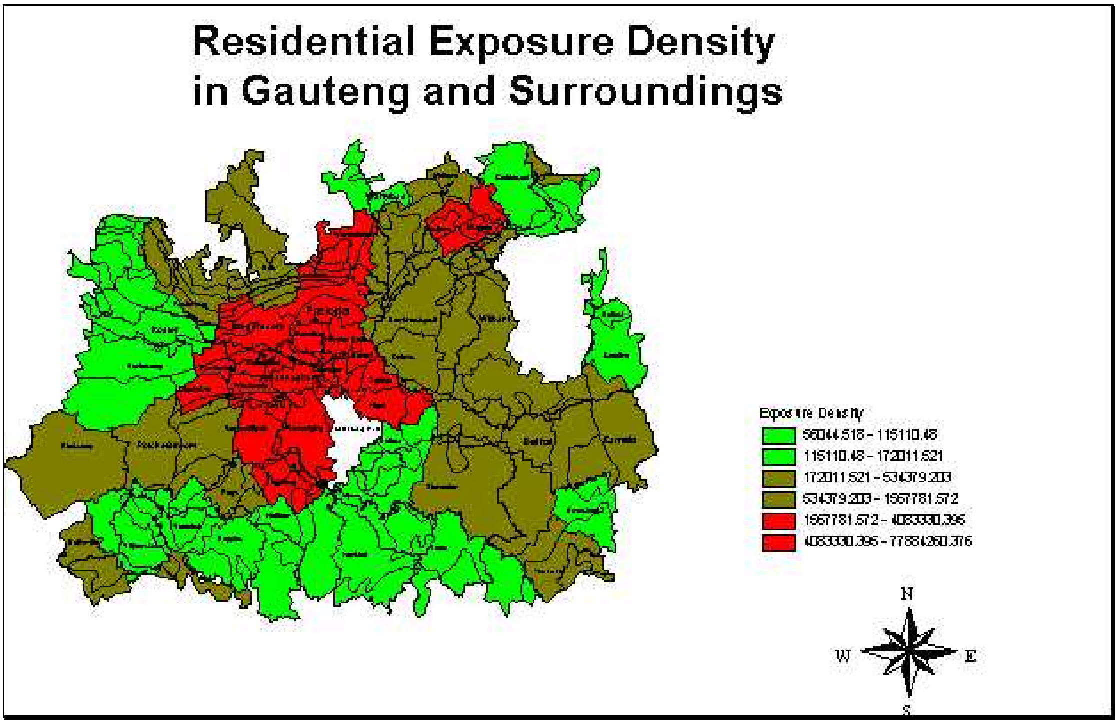

Figure 3: Residential Exposure Density in Gauteng

6.3.3 Exposure Density Map of Cape Town and Surroundings

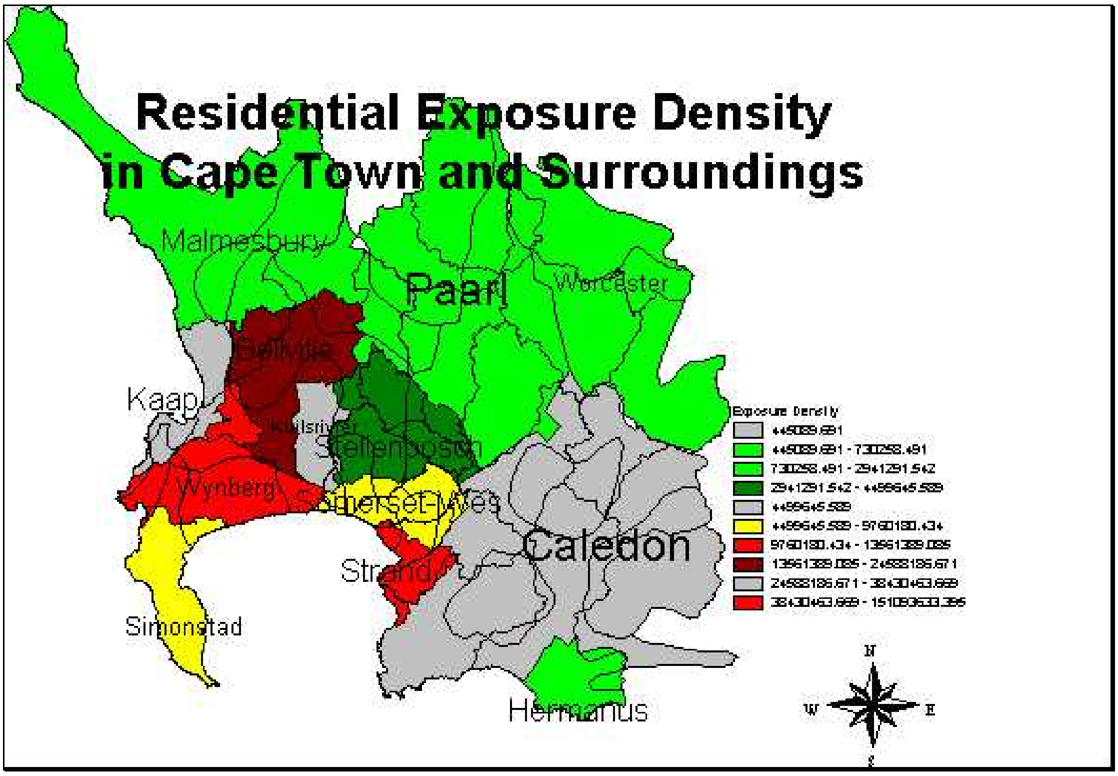

Figure 4: Residential Exposure Density in Cape Town and Surroundings

7. Flooding

7.1 What is a flood?

Alexander (1993) defines a flood as

- a discharge causing damage,
- a discharge overtopping river banks, or
- a discharge exceeding a specified value.

The discharge is most commonly caused by heavy rainfall, but may also be caused on occasion by a dam burst. Typically, a flood can be divided into two broad stages[17], namely a land and a channel phase. The land phase is the first phase when the soil or land covering cannot absorb all the water, and the excess water causes a run-off. This phase rarely causes significant damage. The run-off caused by the land phase flows into or reaches a river, causing an increase in the water level of the river. When the banks of the river are transgressed the flood enters its channel phase, and this is normally when damage occurs. The areas on the bank of the river inundated are called the flood plains. The size of the flood plain will vary depending on the size of the flood, as well as the topography of the area surrounding the river. In Figure 5 the birth of a flood is illustrated, listing the parameters influencing the extent of damage eventually caused by the flood.

[17] Smith*, et al - 1981*

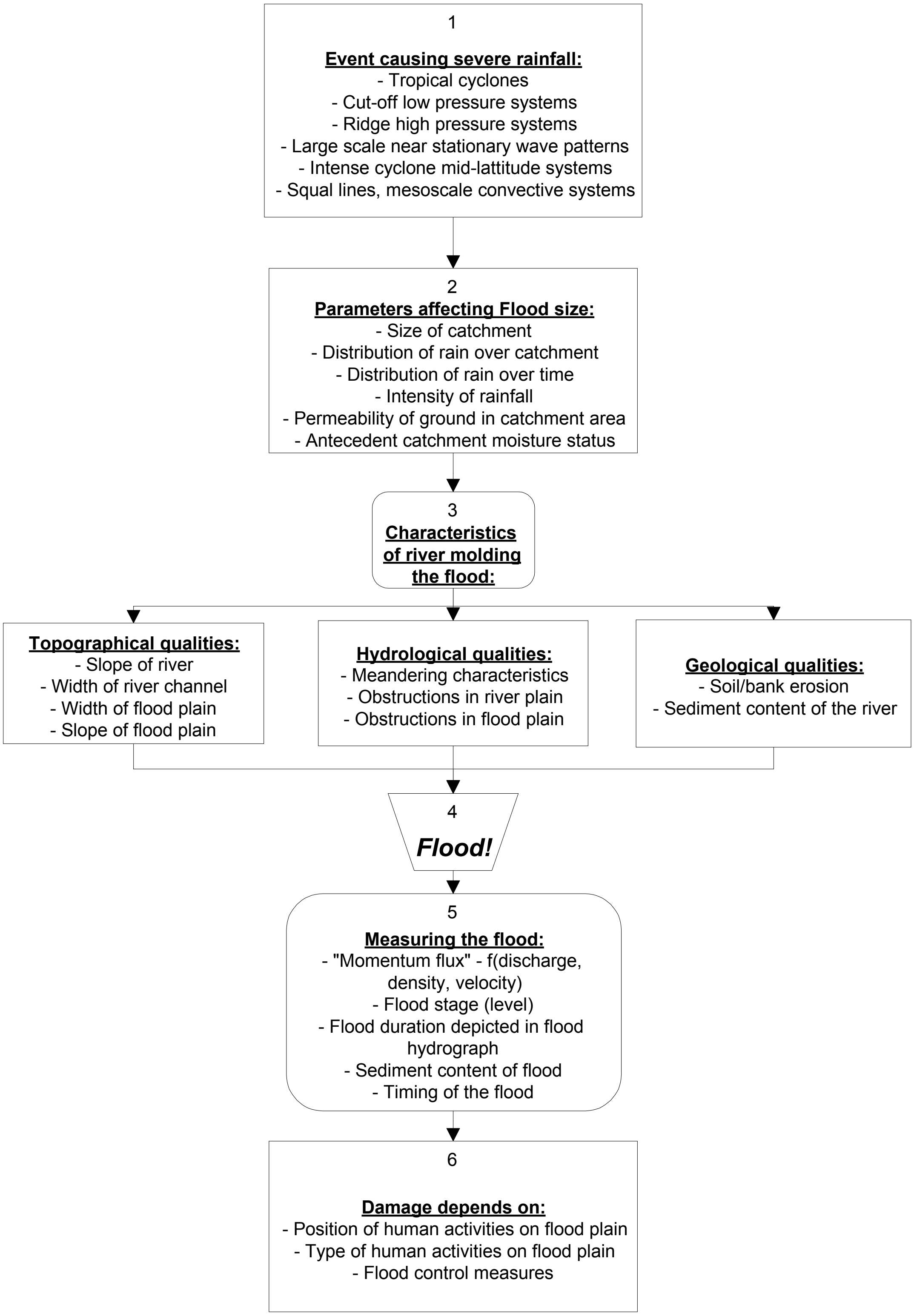

Figure 5: The birth of a flood

7.2 Where does water flow to?

Hydrologists have divided the country into catchment areas. In a catchment area all the water not absorbed by the soil runs off to end up in a common river. For example, if it rains excessively in the Fish River catchment area, the Fish River may experience a flood. The size of the catchment area is a vital parameter in the prediction of a flood's size. The catchment area is also not fixed, but varies from point to point. The size of the catchment area at a specific point is a function of the location of that point relative to the whole catchment area for the particular river. The further one moves downstream, the larger the catchment area becomes, as it picks up cumulatively. In Figure 6 the point of the river at 3 will include the whole of catchment area 1, 2 and most of 3. When the river reaches the ocean, the water flow will include water that came from catchment areas 1, 2, 3 and 4.

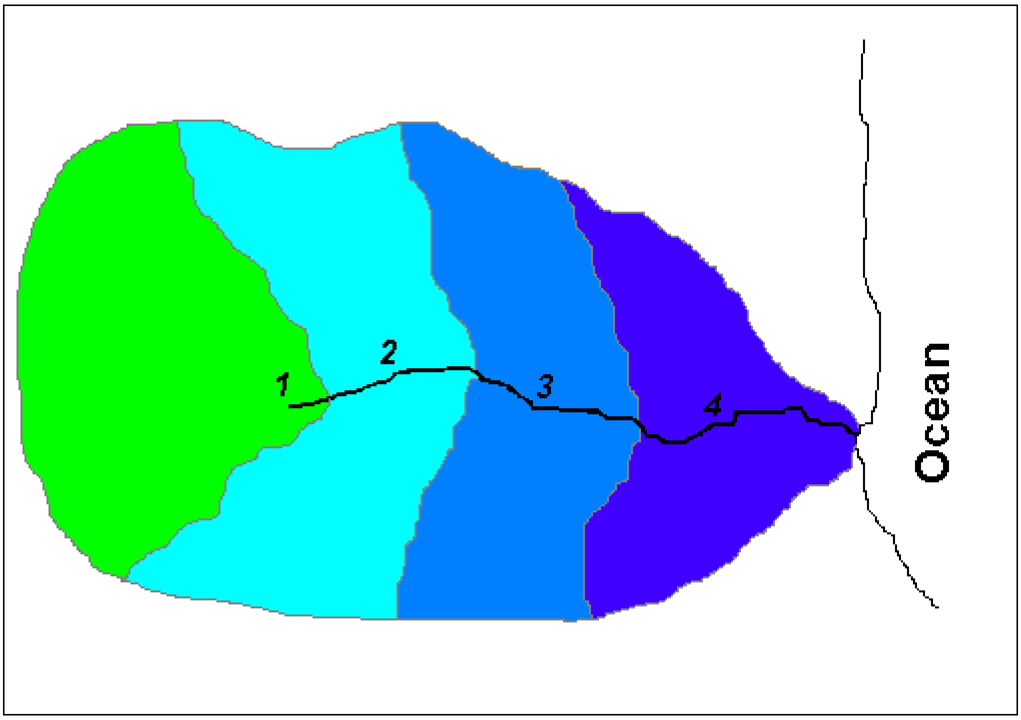

Figure 6: The catchment areas of a river

7.3 How much rain causes a flood?

The size of a flood is a function of several parameters. When considering rainfall the size of the flood will depend on the amount of rain, the intensity of rainfall, and the distribution of the rainfall over time. There is a difference between the intensity of rainfall and the distribution of rainfall over time. The intensity is important because soil cannot absorb vast quantities of water in a short period of time. The water not absorbed will follow gravity, and will eventually end up in a river. The distribution of rainfall over time, on the other hand, affects the capability of the soil to absorb water. The term used is the "antecedent catchment moisture status"[18]. If a lot of rain has fallen during preceding days, the soil will lose some of its ability to absorb water. This characteristic leads to another soil-related characteristic, or parameter. The capability of the soil to absorb water in the first place is called the permeability of the soil. In arid regions, the permeability of the soil is typically low, causing larger run-off than would be expected in semi-arid areas.

Urbanisation has had the effect of reducing permeability of ground cover, or to lessen the absorption ability. Simple examples are roads and parking lots, where the permeability is zero.

7.4 Bursting Banks

Flooding invariably occurs around rivers. The natural run-off for water is towards some river. When heavy rain has fallen, the river rises due to the water reaching it because of the land phase of the flood. If the river transcends its banks, the areas in

[18] *Alexander - 1993*

the floodplains around the river suffer flooding. Here a whole new number of parameters come into play.

The severity of the flood depends a lot on the river from which the flooding originates. It depends on the slope of the river, i.e. the gradient of the water flow. It depends on the width of the river channel. The Apies River in Pretoria was a major cause of floods earlier this century. The municipality channelised the river, causing smoother meandering characteristics and a wider channel. Hence, the risk has been largely contained.

The severity of the flood depends on the characteristics of the area in which the damage occurs, namely the flood plains. A river with steep areas flanking its banks will have very small flood plains. An area with flat areas flanking its banks will have large flood plains (see Figure 7). To illustrate this point, consider the floods of 1988 in the central interior of South Africa. The rain causing the floods was classified as Class 3 only[19] by Alexander (1993), and yet widespread damage was caused. The reason for the disaster is mainly the flat topography of the Free State. When the water rises a very large area risks inundation.

[19] *During the period 1910 to 1989 South Africa has experienced 100 Class 3 rainfalls, 24 Class 4 rainfalls and only 4 Class 5 rainfalls, three of which occurred in the Natal region.*

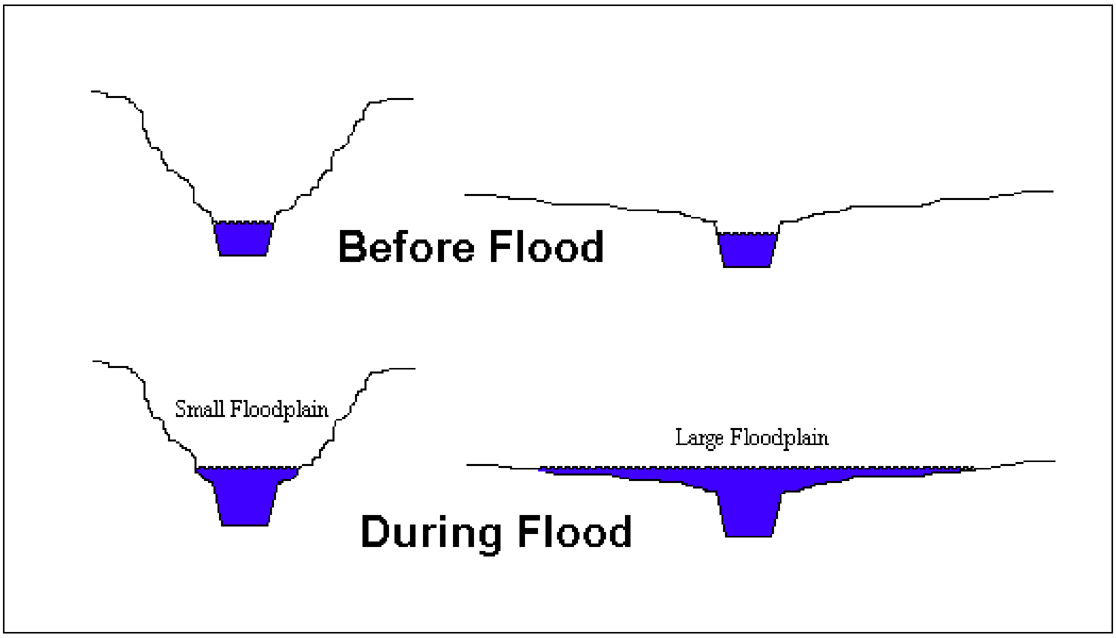

Figure 7: Floodplains depend on the surrounding topography

7.5 How big is a big flood?

The estimation of a flood's size is a fundamental problem one has when considering catastrophes caused by floods. There are several possible approaches, and two considerations have to be borne in mind:

- What is the purpose of the investigation?
- How practical is the chosen approach?

The first consideration is easily fielded: This study considers the losses caused to the insurance industry following a flood. From this perspective it follows naturally that the way in which to estimate the potential size of a flood is by the damage caused in real monetary terms. This approach, however, is not practical:

- An exceptionally large flood in a sparsely populated area may cause very little damage, if any. A relatively small flood in a densely populated area may cause large losses.

- If two factors are kept constant, namely the exposure (property exposed to damage) and the size of the flood measured in some scientific way (volume of water, flood peak, etc.), the amount of damage still depends on quite a few factors. These factors include the saturation level of the ground, the topography of the area surrounding the river and the flood control and warning systems in place.

Quantifying the size of a flood poses a few very complex problems. For purely hydrological purposes, the flood is easily quantified by use of a flood hydrograph in an *ex-post* situation. Projecting the likelihood and size of floods at a particular point is not that simple. The three basic methodologies underlying the estimation of floods are probabilistic, deterministic and empirical methods.

7.5.1 Probabilistic methods

The probabilistic method extrapolates observed flood peaks to obtain probabilities on flood peaks not yet observed. It uses the observed flood peaks over the period over which data is available to estimate probabilities (or return periods) for those floods. The problem with this method is that the period under observation is too short to make any valid conclusions regarding floods with return periods far longer than the period under observation. It may be valid to interpolate, but the curve used when extrapolating is entirely unknown. It is thought that the curve may be of exponential nature, rather than of linear nature, but who is to say?[20]

---

[20] *A discipline that has been developed especially with infrequent (and extreme) events in mind is Extreme Value Theory (EVT). It has been applied to earthquake occurrences, credit risk modelling, and even stock exchange crashes. The mainsteam literature on EVT (such as "Modelling extremal*

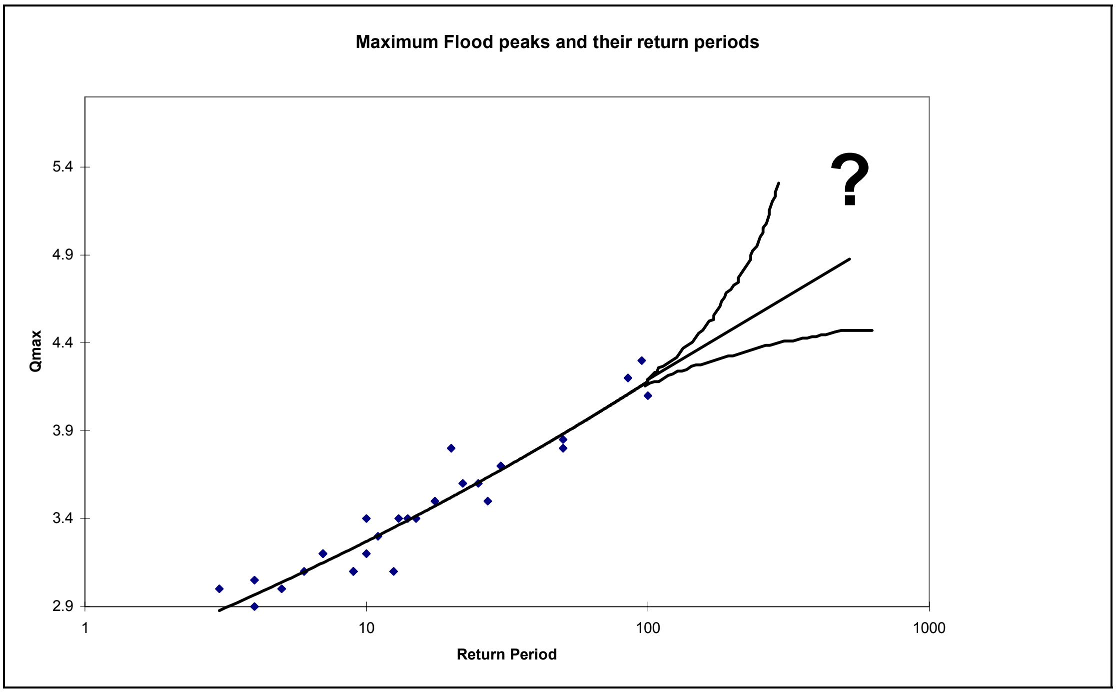

Figure 8: Flood Size and Expected Return Periods

7.5.2 Deterministic methods

The deterministic method is based on a hydrological analysis of the physical factors that play a role in the flood process. The maximum flood peak is equated to the "probable maximum flood" (PMF). From a purely theoretical point of view, this approach is inherently attractive, as it can be applied to any site if the physical factors can be quantified. Unfortunately, the method does not work well. There are too many uncertainties causing the effects of the physical factors to be so uncertain, that the cumulative error may equal the magnitude of the PMF itself[21].

events for insurance and finance." – Embrechts, Klüppelberg and Mikosch 1997) was only published after the completion of this research, and further reference to EVT is therefore not included in this dissertation.

[21] *Kovacs (1988)*

7.5.3 Empirical methods

The approach set out in Kovacs (1988) plots maximum observed flood peaks in hydrologically homogeneous regions against the catchment area. An envelope curve is drawn to include the points considered to be the upper limit of the expected flood peaks. The equation given in Kovacs (1988) is:

$$Q_{\max} = cA_e^{\;x}$$

where Q_{max} is the expected flood peak,

A is the catchment area, and

c and x are regional constants.

This approach is based on work done by two Frenchmen, J. Francou and J.A. Rodier, published in a paper in 1967[22]. The methodology proposed in this dissertation is based on their flood measurement.

7.5.3.1 The Francou-Rodier method of flood peak classification

The maximum flood peak is given in Kovacs (1988), as "…an approximate upper limit of flood peaks at a given site…" The maximum flood peak gives an indication of the extent of a flood at a given site, and does not say much of the probability of such a flood. It may however, be useful if used in conjunction with weather events at a particular site.

[22] *Essai de classification des crues maximales.* Proceedings of the Leningrad Symposium on Floods and their computation, UNESCO, 1967.

It is possible to go into a great amount of technical detail regarding the estimation of maximum flood peaks. The hydrological nature of floods from a technical perspective is not what concerns this research, but the nature and extent of damage caused by these floods. It is inter-linked with the hydrological nature and hence the definitions pertaining to floods as provided by the hydrologists will be used.

The Francou-Rodier coefficient is seemingly the most widely used measure in South Africa of possible flood severity in particular regions. It is based on the empirical approach outlined above. The Francou-Rodier method is said[23] to be suited for the definition of regional maximum flood peak envelope curves. The K-values (Francou-Rodier coefficients) are used in formulae to calculate the Regional Maximum Flood (RMF). By using the RMF (which is the maximum flood empirically observed at a point) one can estimate the frequency and severity of floods in a region or at a point.

The theory underlying the estimation of the coefficient is quite complex and discussed in Kovacs (1988). Kovacs established a catalogue giving the K-values for regions in South Africa, as well as for most of the larger rivers.

[23] *Kovacs -1988*

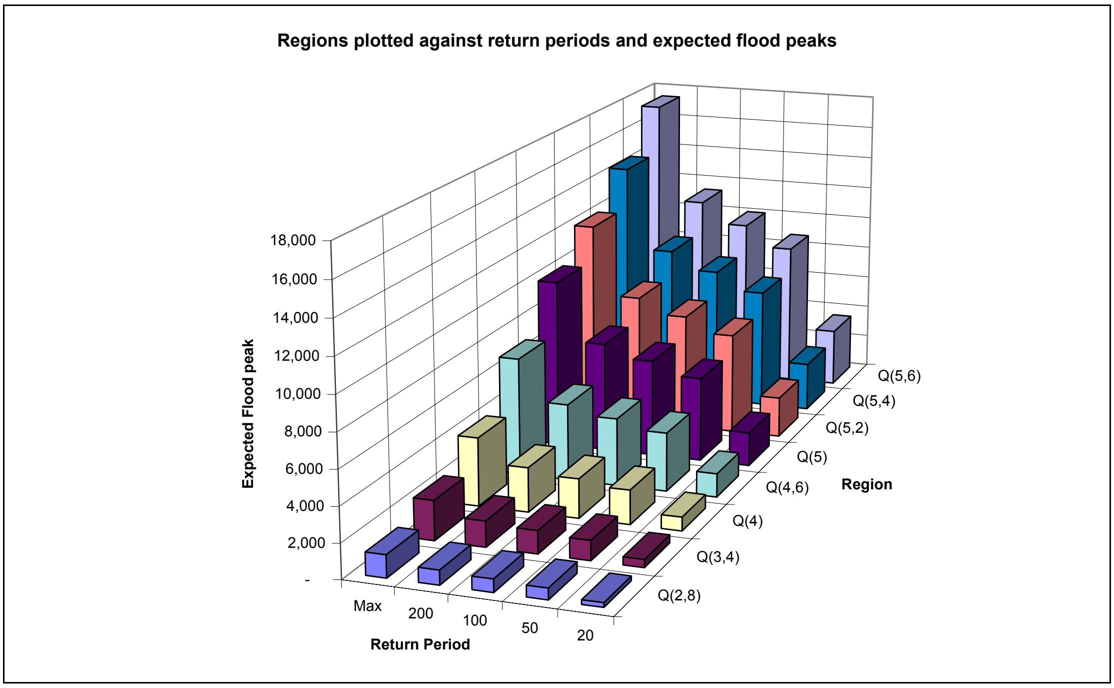

Figure 9[24]: K-values, return periods and expected flood peaks

In Figure 9 the relationship between the K-value of an area, the return period of a flood, and the expected flood peak (measured in cusecs - m^3/s) is given, as would be expected by the relationship Q_{max}/RMF. In Kovacs (1988) this relationship is given as:

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[24] *The catchment area size was taken as 10 000 km^2*

Return Period	Q_{max}/RMF
20	0.20
50	0.50
100	0.575
200	0.65

Table 8: Relationship between return period and Q_{max}/RMF

The RMF is calculated in each instance by reference to the following table of formulae:

Region K-value	RMF (m^3/s)	Area range (km^2)
2.8	$1.74A_e^{0.72}$	500 - 500 000
3.4	$5.25A_e^{0.66}$	300 - 500 000
4	$15.9A_e^{0.60}$	300 - 300 000
4.6	$47.9A_e^{0.54}$	100 - 100 000
5	$100A_e^{0.50}$	100 - 100 000
5.2	$145A_e^{0.48}$	100 - 30 000
5.4	$209A_e^{0.46}$	100 - 20 000
5.6	$302A_e^{0.44}$	100 - 10 000

Table 9: Calculation of RMF for different K-values

The formulae in Table 9 are applied as follows:

- For a specified point, the appropriate K-value is determined from the Kovacs catalogue.

- The K-value determines the formula to be used from Table 9. The formula is applicable for a catchment area falling in the range in the third column in Table 9.
- Example: The RMF for a point with a catchment area of 20 000 km^2 and a K-value of 5 is calculated as follows: RMF = 100 x 20 $000^{0.5}$ = 14 142 m^3/s.

7.6 Exposure in the area

7.6.1 The problems

The problem posed by the exposure in the area affected by the flood is that the damage caused depends on a great number of factors, some of which are difficult to determine. Firstly, the extent and type of damage depends on the location of the property relative to the flood. In the "middle" of the flood, i.e. where the river normally flows the velocity of the water flow can be enormous. Structures subjected to large velocity water flow might be swept away or suffer severe structural damage. Further danger emanates from the fact that structures swept away upstream may cause further damage to structures downstream.

On the banks of the flood however, the flow of water may be close to zero. Damage caused to structures on the banks of the flood will be due to inundation, and will be much less severe than those subjected to high velocity water flow. A further factor comes into play, namely the duration of inundation. If the buildings are inundated briefly to a foot above floor level, the damage will be small. If the buildings are inundated for a long period (a week) the saturation of the floor and foundation may give rise to considerably more damage.

In Figure 10 the damage caused by inundation (above floor level) is given per square meter[25]. The data on which the graph is based bears no relevance to the period of inundation, due to the difficulty of obtaining accurate data in this regard. The damage values are roughly adjusted to 1996 money terms

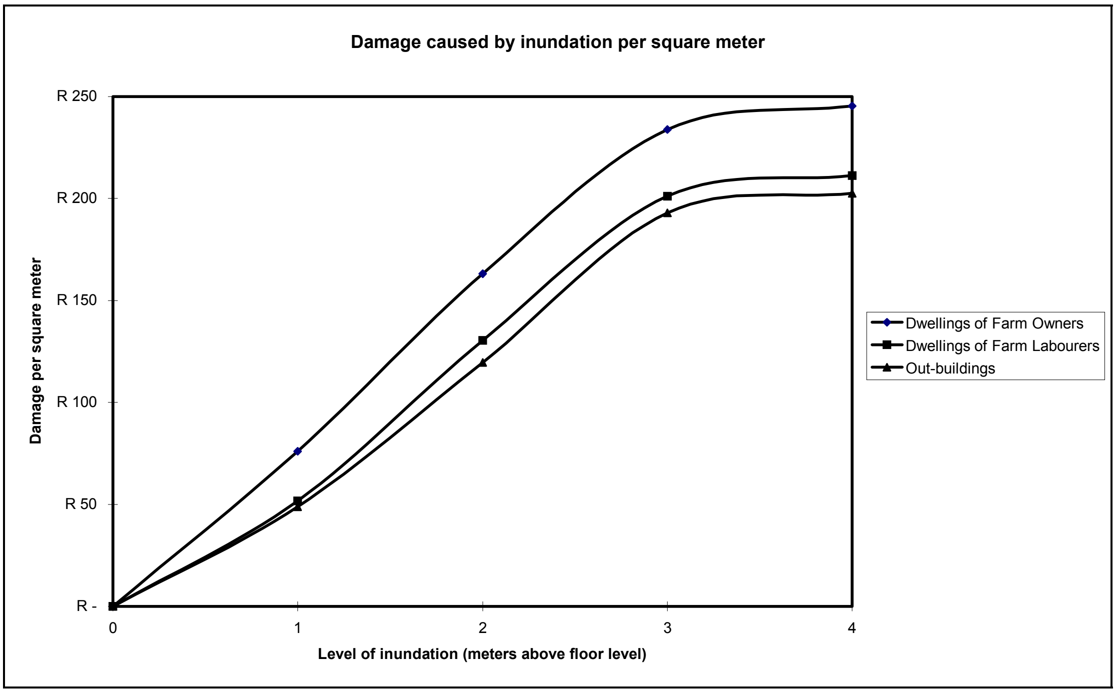

Figure 10: Damage caused by inundation

The next point to consider is the type of structures. "Normal" residential houses may offer little by way of resistance to high velocity water flow. More substantial structures (e.g. buildings with reinforced walls) may resist all but the largest of floods. Furthermore, the nature of adjacent structures will influence the risk a particular structure bears in terms of heavy particles of flotsam striking down its resistance to the high velocity water flow.

[25] Smith *et al, 1981*

In terms of damage to domestic contents, the efficiency of flood warning systems will play a substantial role in the avoidance of such losses.

7.6.2 What data is available?

In recent times, the demographic data available for South Africa has improved dramatically. One can obtain data for all the major metropolitan areas and most of the towns down to street level. The data includes fields like:

- Type and size of house
- Value of house
- Age of structure
- Details of inhabitants
- Type of vehicle used

The data to be used for the purposes of this investigation is not nearly as detailed. Because of the large number of uncertainties surrounding the estimation of damage and the occurrence of catastrophes, it would be senseless to use exposure data down to very fine detail. The data to be used in this investigation are residential units subdivided into magisterial districts. The derivation of the exposure database is discussed in section 6.

7.7 Flood-producing weather systems

A brief summary of the flood producing weather systems follows for completeness sake[26].

7.7.1 Cut-off low and ridging high pressure systems

According to Alexander (1994), most of the well-documented floods in South Africa were caused by cut-off low-pressure systems[27]. The confluence of particular meteorological factors causes widespread rainfall nation-wide. The occurrence contributes a large portion of the country's total annual rainfall. Some well-known historical floods caused by this weather system were:

Port Elizabeth	September 1968
East London	August 1970
Laingsburg	January 1981
Natal	September 1987

Table 10: Well-known historical floods

7.7.2 Large scale, near stationary wave patterns

This weather system mainly causes widespread rainfall over the central interior of South Africa. It occurs in a rather narrow zone, less than 250 km wide, stretching north-westwards from the Eastern Cape across southern Free State to Botswana.

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[26] *Obtained from Alexander (1994).*

[27] *Taljaard (1985)*

7.7.3 Intense cyclone mid-latitude systems

These systems often cause heavy rainfall in the winter rainfall area of the south-western Cape Province and the coastal zone stretching eastwards to Natal. The systems are often accompanied by gale force winds strong enough to cause property damage.

7.7.4 Squall lines, mesoscale convective systems

These systems develop over the interior of South Africa. They are several hundred kilometres long and 50 to 100 kilometres wide. They may cause heavy downpours and cloud bursts. The system itself seldom has the potential to cause extensive flooding, but it may saturate a catchment area to such an extent that conditions conducive to flooding are created.

7.7.5 Tropical cyclones[28]

A full discussion on tropical cyclones follows in section 9.

7.8 Findings of the analysis

From the above discussion it is clear that there are many uncertainties involved when estimating

- events giving rise to flooding,
- the subsequent extent of flooding, and

[28] *Also called "hurricanes" in the North Atlantic and "typhoons" in the Eastern Pacific oceans.*

- the damage caused by the flood.

The severity of the flood can be estimated reasonably satisfactorily by reference to the Regional Maximum Flood. The problem is that it is difficult to relate the flood peak (m^3/s) to the damage caused by the flood. It is true that a portion of the damage is due to structural damage caused by the velocity of water striking the structure. This damage will bear some relevance to the flood peak. A large portion of the damage, however, is caused by inundation. The level of inundation, as well as the period of inundation depends heavily on the topography of the floodplains, as well as the permeability of the soil. These parameters will differ widely from area to area, and the information is not available for South Africa at this point in time. The geographical data available is of two-dimensional nature. The problem can be solved if a team of experienced engineers assesses each and every point in the country, which is obviously impractical. In terms of the estimation of flood damage, this information is crucial, becoming more important as one looks at localised areas.

7.8.1 Approaches

The biggest problem, however, is that South Africa has been fortunate enough not to suffer from too many serious catastrophes this century. Those that did occur have been poorly documented in public sources (mainly newspapers) in terms of actual losses suffered. It is the author's belief that insurance or reinsurance companies may have actual loss data pertaining to specific catastrophes. There are two possible approaches for the assessment of damage: A top down approach, as, to the author's knowledge, is used for the CatMap[29] product, and a bottom up approach.

7.8.1.1 Top down approach

The top down approach is clearly the less desirable of the two approaches. It is based on market losses. It estimates the losses to the economic market following a catastrophe. To get to an individual insurer's loss, the percentage market share of that insurer is applied to the estimated losses.

7.8.1.2 Bottom up approach

The bottom up approach looks at the insurer's book, and assesses catastrophe damage pertaining to that book of business, possibly by assessing individual risks separately, in the case of large fire risks.

7.8.2 Findings

The main problem encountered in the research was the absolute lack of damage data. Scientific journals and publications seem to rely on newspaper reports as to the damage in property and the newspaper reports mostly quote estimates made by reinsurance companies[30]. Whether the spokesperson's comments were based on actual figures or were merely an educated guess made for public relations purposes is

[29] *A software package used to estimate damage caused by catastrophes. Mainly applied to the United States.*

[30] *Munich Reinsurance Company in particular.*

unknown. The fact is that if there is any loss data that can be used, it is in the hands of the insurers and reinsurers.

What is done in the research is to calculate the RMF values for the catchment areas of four rivers in Natal, as well as the flood peaks for various return periods. This is an extremely time-consuming exercise. It is hoped that by explaining the methodology, an assessment can be made as to whether it is worth the while to allocate the resources needed to complete the study for the whole of South Africa. The calculation of the RMF values is explained in section 7.5.3.1.

It is fairly straightforward to use the top down approach and predict losses for catastrophes in particular areas, based on the losses published for the events.

7.8.2.1 Loss estimates based on the 1987 floods

The RMF values for the ENPAT areas falling within the catchment areas of the Mgeni[31], Mlazi, Lovu and Mkomazi rivers in Natal were calculated. A total of 201 ENPAT areas fall within these catchment areas, including the high exposure areas of Durban and Pietermaritzburg. Loss estimates and return period detail were used as given in Ferreira's 1989 thesis *"Die hantering van omgewingsrampe: 'n Gevallestudie van die September 1987-vloede in Natal en Kwazulu"*[32].

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[31] *The Mgeni River flows through Durban and caused widespread damage during the 1987 Natal floods.*

[32] *The handling of catastrophes: A case study of the September 1987-floods in Natal and Kwazulu.*

The total residential damage estimates (in 1987 terms) were calculated from Ferreira's estimates as follows:

		R'million
Total Reported Damage		**1 000.00**
Less:		-341.84
Damage to infrastructure and services in Natal (excluding agriculture and housing)	259.96	
Agricultural losses	81.88	
Damage to housing		*658.16*

Table 11: Damage caused by the September 1987 Natal Floods

It was assumed that the R658 million in damages was all caused in Natal, and by inspection, the assumption seems reasonable. The area of investigation comprises of only a part of Natal, however. The proportional allocation of damage to the area of investigation was done by weighting the ENPAT areas in terms of residential exposure in money terms:

1996 Exposure	**R'million**
Total Residential Exposure in Natal	R 103 000
Total Exposure in area of investigation	R 62 000
1987 Exposure	
Total Residential Exposure in Natal	R 31 673
Total Exposure in area of investigation	R 19 065
Weighted proportional damage in area of investigation	***R 396***

Table 12: Exposures for the area of investigation in Natal

The next step was to allocate the R396 million in damage to the ENPAT areas in the area of investigation. Allocating the damage by using exposure as only weighting (as was done in the first allocation) was deemed unsatisfactory, as areas lying at the lower end of a catchment area are more exposed to flooding than areas higher up[33]. A somewhat arbitrary adjustment was made to the exposure in each area. This was done

[33] *In the first allocation it was assumed that the flood risk in the area under investigation was the same as in the rest of Natal.*

by calculating an RMF-factor and multiplying the exposure by the RMF-factor. The RMF-factor was calculated by taking the RMF for the particular area and dividing it by the average RMF for all the areas under investigation. These adjusted exposure figures were then used as weights for allocating the damage figures.

A parameter of the modelling that is particularly important is the assumed return period of the particular flood. The reason for this will become evident.

Ferreira quotes several different sources giving return periods at several different points in Natal, for the September floods. Detail of the estimations is given below:

Details of estimation	**Return Period Estimated**
Only in 3 of the 27 rivers documented by Kovacs (1988) was the size of the flood in the region of a 1 in 200 year event.	1 in 200 years
Mgeni river at the Midmar Dam (Kovacs)	1:35-year
Mgeni river at the Albert Falls Dam (Kovacs)	1:40-year
Mgeni river at the Nagle Dam (Kovacs)	1:50-year
Mgeni river at the Inanda Dam (Kovacs)	1:120 to 1:150-year
Whole Mgeni river area (Davis & Mcleod 1988)	Less than once in 100 years, may even have been a 1:200 or 1:350-year flood
Mgeni-estuary (Cooper et al. 1988b)	1:120 to 150-year

Table 13: Estimated Return Periods for the Natal Floods at various points

In view of the above information a return period for the whole investigation area of 1:150-years was used. The relationship between the flood peak (Q_{max}) and the area's RMF was discussed in section 7.5.3.1. From this relationship a graph was plotted (Figure 11):

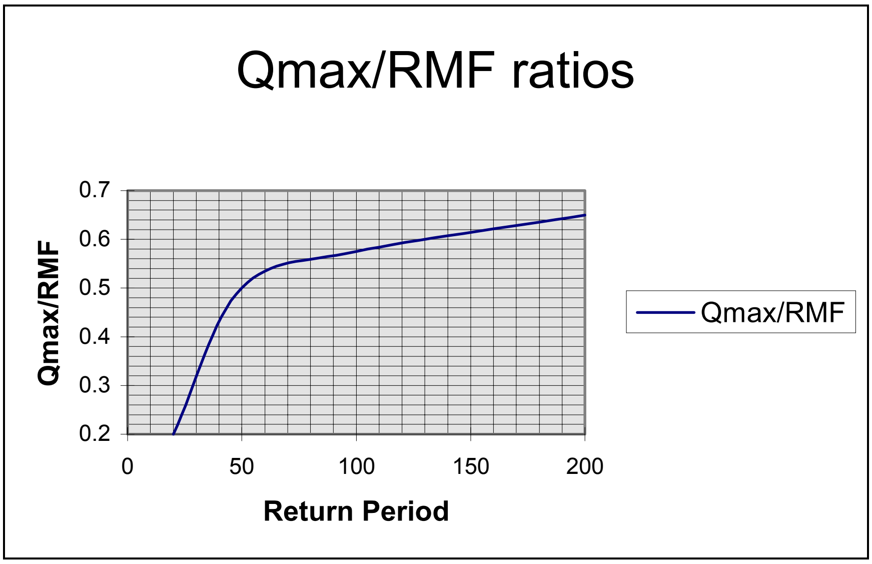

Figure 11: Graph depicting the relationship between return periods and Q_{max}/RMF

From Figure 11 a value of 0.615 is obtained as the relationship between Q_{max} and the relevant area's RMF. From this figure the flood peak for every area can be calculated for the September 1987 Natal floods. An extract of the full calculation is given in Table 14 below (full details of the entire investigation area are given in Appendix A: Flood Damage Assessment):

Census District	Regional Maximum Flood (RMF)	RMF Factor (Ratio to Average)	Flood Peaks			
			20-year return	50-year return	100-year return	200-year return
Durban	9933	2.0399	1987	4967	5711	6456
Inanda	9765	2.0054	1953	4883	5615	6347
Pietermaritzburg	8643	1.7749	1729	4321	4969	5618
Estcourt	1563	0.3209	313	781	898	1016
Umvoti	232	0.0476	46	116	133	151

Census District	Exposure in R'million (1996)	Exposure in R'million (1987)	RMF-factor adjusted exposure	Propor-tionate Damage in R'million	Damage Ratio	
Durban	2 715.23	834.96	1 703.21	26.05	3.120%	
Inanda	1 716.77	527.92	1 058.69	16.19	3.067%	
Pietermaritzburg	1 179.04	362.56	643.51	9.84	2.715%	
Estcourt	0.01	0.00	0.00	0.00	0.491%	
Umvoti	1.41	0.43	0.02	0.00	0.073%	
Totals for entire area:	**61 904.16**	**19 036.02**	**25 903.48**			

Census District	Estimated Flood Peak for Natal Floods	Damage in R'million				
		20-year return	50-year return	100-year return	200-year return	
Durban	6109	8.471	21.178	24.355	27.532	
Inanda	6006	5.266	13.164	15.139	17.113	
Pietermaritzburg	5315	3.201	8.002	9.202	10.402	
Estcourt	961	0.000	0.000	0.000	0.000	
Umvoti	143	0.000	0.000	0.000	0.000	
Totals for entire area:		**128.837**	**322.093**	**370.407**	**418.720**	

Census District	Damage Ratios				Expected Annual Damage Ratio	Expected Damage in 1996 terms (R'million)
	20-year return	50-year return	100-year return	200-year return		
Durban	1.015%	2.536%	2.917%	3.297%	0.147%	3.994
Inanda	0.997%	2.494%	2.868%	3.242%	0.145%	2.483
Pietermaritzburg	0.883%	2.207%	2.538%	2.869%	0.128%	1.509
Estcourt	0.160%	0.399%	0.459%	0.519%	0.023%	0.000
Umvoti	0.024%	0.059%	0.068%	0.077%	0.003%	0.000
Totals for entire area:	**0.677%**	**1.692%**	**1.946%**	**2.200%**	**0.098%**	**60.75**

Table 14: Calculation of Damage Ratios for the selected areas in Natal

After the various flood peaks for the different areas had been calculated for the September 1987 floods, those flood peaks were used as an index for the size of the flood. To obtain damage estimates for different return periods the flood peaks pertaining to those return periods are used to calculate the damage expected from such a flood in a particular area. The expected annual damage is calculated on the assumption that only one of four floods can possibly occur: Either a 1:20-year, 1:50-year, 1:100-year or a 1:200-year flood. The assumption means that any flood can be classified as one of the above. The expected annual damage is given in Table 14 above, as well as in Figure 12 below.

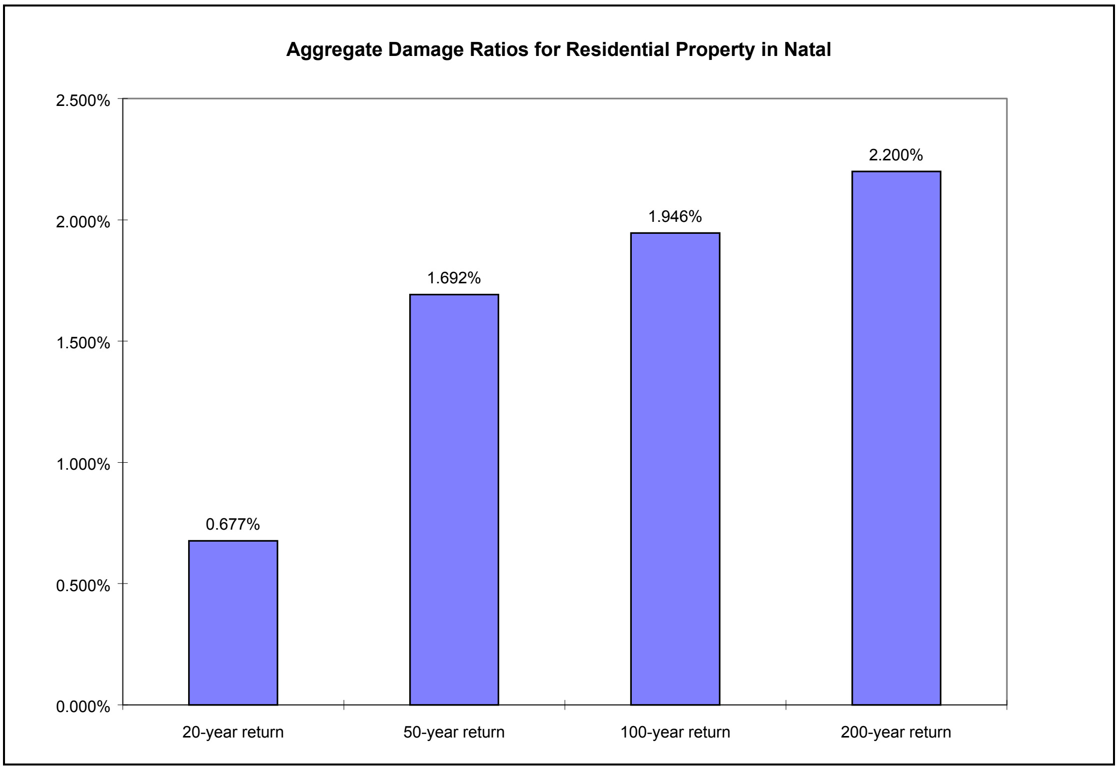

Figure 12: Aggregate Damage Ratios for Residential Property in Natal

7.8.2.2 Using the bottom-up approach

To use the bottom up approach for a particular insurer the insurer must have a reference database, with actual loss data. In other words, what its exposure was at the time of the flood as well as the ensuing losses. It will be surprising if any insurer has accurate data in this regard for the big events, such as the 1987 Natal floods. The next uncertainty introduced into the equation is the estimation of the return period of the event. This return period will then be used to project the expected losses for any one year for a particular event, in a particular period. If more than one reference event is used accuracy can be greatly enhanced.

7.8.3 Further work

The calculation of RMF values for magisterial districts is very time consuming, as it involves several computer packages at once, and a lot of manual data manipulation. It was not seen as productive to calculate RMF values for the entire South Africa prior to the assessment of suitability of the proposed methodology. RMF values for particular regions in Natal were calculated, and if the methodology is seen as useful, the remainder of the country should be done. It is an extensive exercise and is estimated to require around 2000-2500 man-hours. The expertise required to do the exercise is not great, as it is routine data manipulation. The amount of hours, however, does render it an expensive exercise and one might seek a quicker, and less detailed approach.

7.8.4 Map of Area of Flood Investigation

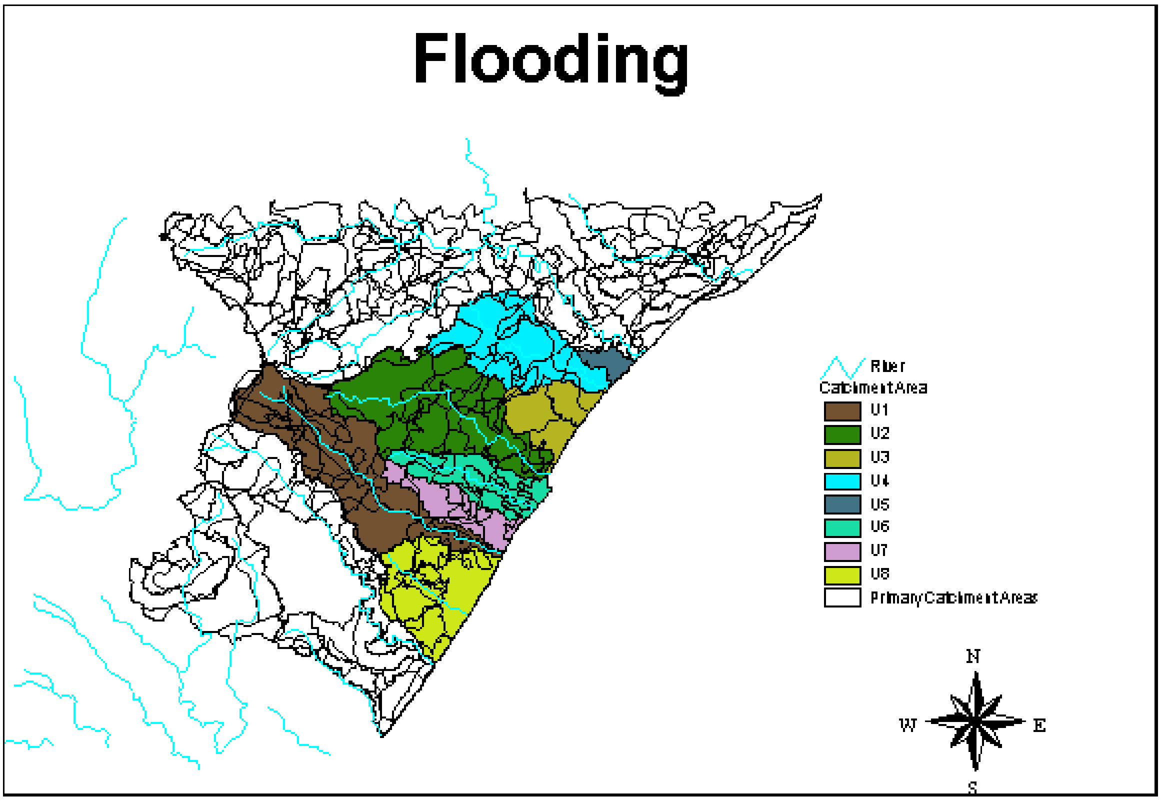

Figure 13: Area Investigated for Flood Damage Assessment

8. Earthquake

In South Africa, a view has developed that the earthquake catastrophe reinsurance rates are (completely) inadequate. The Swiss Reinsurance Company held a catastrophe seminar on 25 July 1996 where several loss scenarios were discussed, in terms of earthquakes.

Since 1960, South Africa has experienced two significant earthquakes. In 1969, an earthquake in Ceres caused damage of more than R200 million in insured damage in today's terms. Welkom experienced a mining induced tremor which completely destroyed a hotel to cause damage in excess of R100 million in today's terms[34]. Clearly, an earthquake risk does exist.

South Africa does not lie on a ridge of a major tectonic plate, and therefore the much publicised danger caused by stress build-up between plates does not affect South Africa as severely as it does California, for example. There are some areas in South Africa that can and do experience earthquakes for other reasons. In Gauteng, the extensive mining activities are conducive to earthquakes. It is still unclear as to what effect the mining activities have in terms of amplifying natural earthquakes. One opinion is that due to mining activity (blasting, for example) several small tremors are caused quite frequently. These tremors do not cause significant damage on their own, and act as a stress reliever to any stress building up beneath the surface. Due to this relieving effect the danger of a major earthquake caused by a sudden natural stress release is reduced.

[34] *Swiss Re.*

The other areas that have experienced several historical earthquakes are Cape Town and the Orange Free State.

According to the latest seismicity results from the Council of Geoscience[35] South Africa can expect earthquakes in Cape Town and Johannesburg of Modified Mercalli Intensities (MMI) VIII and VII respectively, once in every 500 years. The Swiss Reinsurance Company applies a damage ratio of 4% and 20% of Total Sum Insured to MMI VII and VIII respectively. The Swiss Reinsurance Company estimates current insured exposures as follows:

CRESTA Zones 5, 6, 7 (Gauteng)	R520 billion
CRESTA Zone 6 alone	R250 billion
CRESTA Zones 8, 10, 11 (Cape)	R250 billion
CRESTA Zone 8 alone	R100 billion
CRESTA Zones 4, 9 (Natal)	R200 billion

Table 15: Exposures in the various CRESTA Zones

[35] *Swiss Re Natural Catastrophe Seminar, July 1996.*

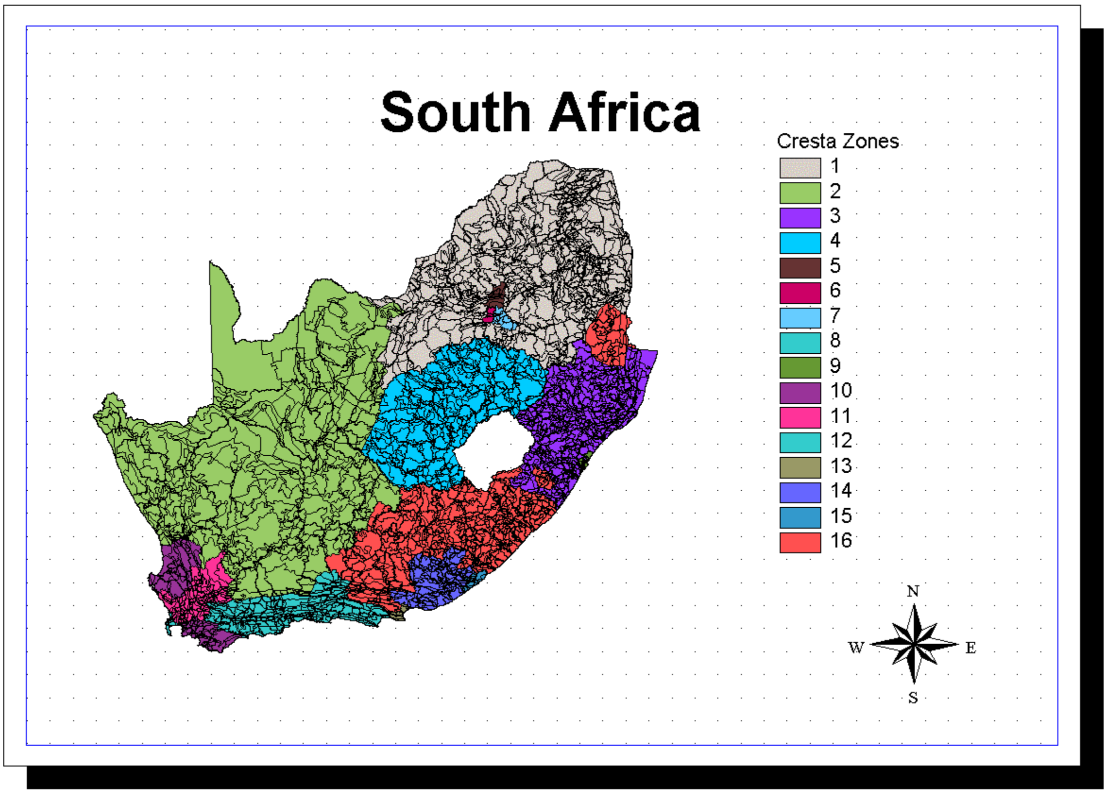

Figure 14: Map of the CRESTA Zones in South Africa

Based on the above exposures the two earthquakes in Cape Town and Johannesburg have damage potentials of between R10 and R50 billion. That equates to expected annual damage of between 0.1 and 0.4 per million.

	Severity of Earthquake expected	Damage Ratio	Exposure	Expected Damage	Expected Annual Damage	Rate (Expected Annual Damage over Insured Exposure)
Cape Town	MMI VIII	20%	R250 billion	R50 billion	R100 million	0.04%
Johannesburg	MMI VII	4%	R250 billion	R10 billion	R20 million	0.008%

Table 16: Calculation of expected annual earthquake damage in Cape Town and Johannesburg

In the author's view, the probability estimates attached to these events can only be highly speculative.

9. Cyclone

9.1 Nature of the storm[37]

Cyclones are the most destructive storms that occur. Heavy downpours of rain, accompanied by winds of more than 33m/s cause severe damage. Cyclones are usually fairly small (100-1 000km in diameter), circular and symmetric, focusing around an eye, which normally has a diameter of less than 50km, and is calm, dry and hot, relative to the surrounding storm. The strongest winds are found just outside the eye along the leading edge of the cyclone.

The major meteorological requirements for the formation of a tropical cyclone are the following:

- Warm sea surface temperatures of at least 26.5ºC, along with a relatively deep ocean mixed layer,
- mean upward motion and high mid-level relative humidity,
- significant levels of cyclonic vorticity in the lower atmosphere, and
- weak vertical wind shear directly over the pre-storm disturbance.

The energy source of cyclones is high sea surface temperatures, along with the deep mixed layer in the ocean, preventing the mixing of colder sub-surface water with the hot surface water. *If temperatures are on the increase globally, the frequency of occurrence of these devastating storms might increase.*

[37] *Alexander - 1993*

9.2 The Indian Ocean Tropical Cyclone[38]

One of the global hot spots for cyclone generation is in the Indian Ocean, over the equator, north-east of Madagascar. Out of every ten cyclones that originate in the south-west Indian Ocean, only four, on average, enter the Mozambique Channel. Even though nine cyclones travel through the channel on average each year, only ten have had an effect on rainfall in South Africa. These ten are listed in Table 17.

Name	*Dates*
A	11-16 February 1956
Astrid	December 1957 / January 1958
Brigette	24 December 1957 - 2 January 1958
Claude	30 January - 1 February 1960
Caroline	30 December 1965 - 5 January 1966
Eugenie	4 - 13 February 1972
Danae	5 - 22 February 1972
Emilie	21-30 January 1976
Domoina	16-31 January 1984
Imboa	11-20 February 1984

Table 17 - Cyclones entering the Mozambique Channel[39]

Of all the cyclones listed above only Domoina (1984) reached South African shores, and caused considerable damage.

Alexander (1993) suggests that cyclones making landfall are usually confined to low-lying regions. This means that high mountains, such as the Drakensberg escarpment, provide an effective barrier against a cyclone. Domoina's path, for example, appears to have been deflected by the Drakensberg, causing the cyclone to move south, parallel with the escarpment.

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[38] *Alexander - 1993*

[39] *Darlow - 1990*

9.3 Damage caused

Again, it is extremely difficult to project damages arising from cyclones in South Africa, mainly due to the low historical frequency and lack of damage figures. Damage caused by cyclones can be broken up into flood related damage, as well as damage caused by the actual storm. The flood damage is considered in the section on flooding, as cyclones are one of the flood producing weather systems. To consider the damage of the storms itself, the actual occurrences of cyclones making landfall over the last 46 years were taken as basis. That shows a frequency of 10 in every 46 years, one of which makes landfall in South Africa.

Under the assumption that a cyclone is diverted by mountain ridges and higher areas, the areas exposed to cyclone damage[40] were taken as low lying coastal areas in the North-Eastern parts of South Africa. Areas "protected" by mountain ridges were not considered. The topographical data used was somewhat limited in that it provided only the height of the highest point in a particular ENPAT district. Somewhat arbitrarily, 900m above sea level was chosen as the cut-off point for cyclone prone areas. From this analysis, 546 ENPAT areas were identified as being exposed to cyclone damage. In the 546 areas, the total residential exposure in 1996 is R73.046 billion.

As mentioned above the frequency used in the analysis was 1 in every 46 years, or 2.17%. The severity figures used were chosen arbitrarily and four different figures are illustrated below:

[40] *Cyclone damage referring to damage done by the storm making landfall, and not flooding caused by cyclones not making landfall.*

Severity per event (as percentage of total residential exposure)	*Expected Annual Damage Ratio*	*Expected Annual Damage in 1996 terms (R'million)*
0.5%	0.0109%	R7.940
1%	0.0217%	R15.880
2%	0.0435%	R31.759
2.5%	0.0543%	R39.699

Table 18: Damage Caused by Cyclones

In the above analysis it is assumed that an area's latitude does not affect its exposure (other than the fact that only areas in the North-Eastern part of the country were chosen). This is not absolutely accurate, since areas lying further south are less exposed than areas in the north. The difference between the areas lying furthest north and south respectively, is less than 800 km, and in that light the assumption was deemed fair.

A list of the 546 areas is given in Appendix B: Cyclone Damage Assessment, with details of the exposure and expected damage in each at a severity per event of 2%.

9.4 Map of Areas Exposed to Cyclone Damage

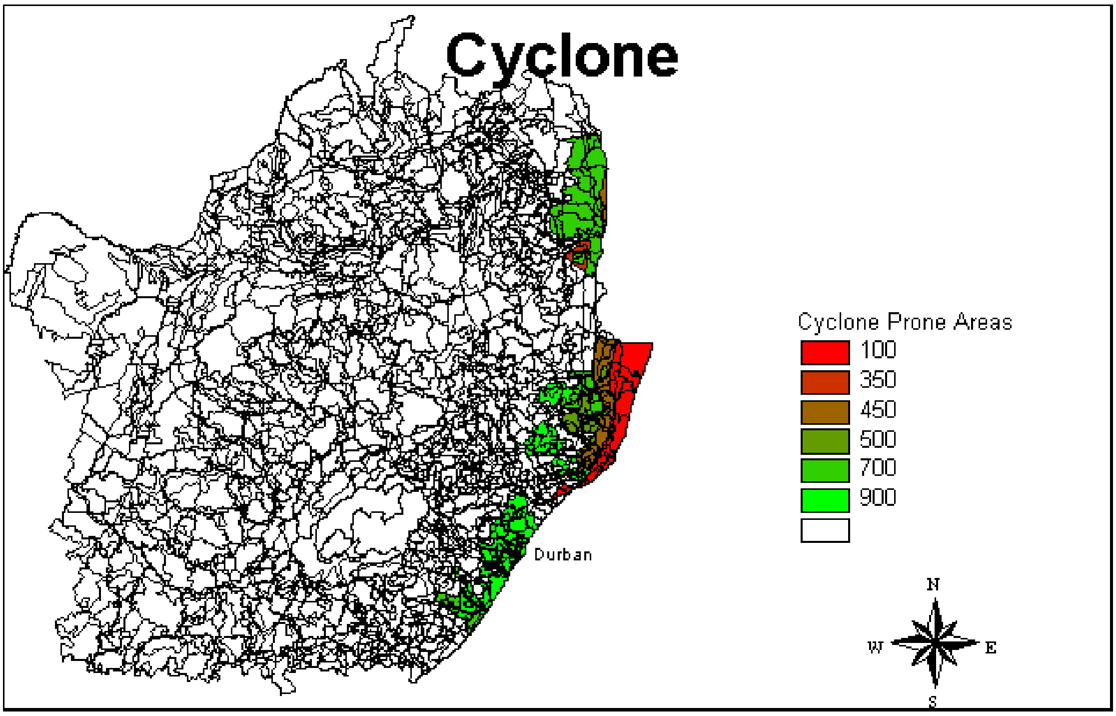

Figure 15: Areas prone to Cyclone Damage[41]

[41] *The legend denotes the height of the highest point in each of the districts.*

10. Tornadoes

10.1 Data Used

Compared to some of the other perils, the historical occurrence data on tornadoes is quite comprehensive. The data was taken from the South African Weather Bureau's publication - Caelum, which documents notable weather events since the 1600's. The events are based on observations made, and therefore may not include tornadoes in sparsely populated areas. The frequency derived from the data was therefore adjusted upwards to take into account tornadoes not documented in Caelum. It was decided to use a frequency of ten tornadoes per annum. As mentioned previously, this parameter can be changed should a more in depth analysis indicate a more appropriate figure.

The damage caused by tornadoes has been extensively researched in the USA[42]. Fujita classified tornadoes according to intensity, from F0 (lowest) to F5 (highest)[43]. The intensity is measured according to maximum wind velocity.

Fujita Classification	Maximum Wind Velocity (mph)	Percent of observed tornadoes in classification
F0	40 - 72	19.9%
F1	73 - 112	44.0%
F2	113 - 157	26.6%
F3	158- 206	7.2%
F4	207 - 260	2.1%
F5	261 - 318	0.2%

Table 19: Fujita Tornado Classifications

The damage caused by a tornado to residential brick structures is given below:

[42] *Wiggens (1976)*

[43] *A F5 tornado is referred to as: "The finger of God".*

		Tornado Intensity					
Damage State	**% Damage**	**F0**	**F1**	**F2**	**F3**	**F4**	**F5**
None	0 - 0.05%	95.9%	44.2%	15.2%	10.3%	8.6%	0%
Light	0.05 - 1.25%	3.2%	17.7%	10.6%	2.8%	2%	1.1%
Moderate	1.25 - 7.5%	0.6%	32%	13.6%	11.3%	2.8%	2.2%
Heavy	7.5 - 65%	0.1%	5%	21.9%	21.1%	12.8%	13.3%
Severe	65 - 100%	0.1%	0.9%	28.1%	23.4%	26.7%	18.7%
Collapse	100%	0.1%	0.2%	10.7%	31%	47.2%	64.7%

Table 20: Damage caused by tornadoes to residential brick structures

In other words, should an F3 tornado strike, in 11.3% of the cases the damage to property will be between 1.25% and 7.5% of the value of the structures.

Using the above information, a simulation model of tornado damage was built. This model can be used to assess other types of catastrophes as well, inter alia hailstorm.

10.2 Simulation of experience

The simulation technique is useful when it is impossible or difficult to calculate the result analytically. The following example is simple enough to calculate the resulting losses analytically. The simulation technique is illustrated for the purposes of developing a more complex model, especially where several risk processes are involved and where interdependencies (especially over time) between events occur. Simulation techniques are also very powerful to rapidly test the impact of various permutations of reinsurance treaties.

A catastrophe simulation model was developed to assess the likely damage caused by tornadoes:

Step 1:

A Poisson process is used to simulate the number of tornadoes occurring each year. As mentioned previously, a frequency of ten tornadoes per annum is used.

Step 2:

It is simulated where these tornadoes take place. Since tornadoes only affect a small area, ENPAT areas were used in the analysis.

Superficial investigation indicated that tornadoes are a countrywide phenomenon. It was thus assumed that each ENPAT area has an equal chance of being struck by a tornado. Obvious improvement to the model will be to produce a list of areas with a measure of the probability of being struck by a tornado. It will be straightforward to incorporate such an improvement in the model, but extensive research will have to be done to ascertain such a measure.

Step 3:

The damage caused by the tornadoes is the next simulation process. First the intensity is simulated, i.e. was the tornado a F1, F2, … or a F5. The following probability distribution function (PDF) was used:

Tornado	Probability	Damage Ratio
F0	19.9%	0.29%
F1	44.0%	4.281%
F2	26.6%	42.489%
F3	7.2%	58.469%
F4	2.1%	74.005%
F5	0.2%	85.052%

Table 21: Probability distribution of tornado intensities

The above PDF means that should a tornado strike, only 0.2% of the time will it be of intensity F5. Using the American experience, 86.375% of the properties in its path will then be destroyed. An assumption regarding the average size of the area a tornado affects must also be made. Again based on the USA data the following values were assumed:

Tornado	Mean Tornado Area (square miles)
F0	0.02
F1	0.27
F2	1.72
F3	8.00
F4	28.36
F5	83.90

Table 22: Area affected by different tornado intensities

The damage caused by each of the simulated tornadoes is then calculated as follows:

$$Damage = d \times \frac{A_1}{A_2} \times E$$

where d = Damage ratio.

A_1 = Average area (km^2) a tornado affects.

A_2 = Area (km^2) of chosen ENPAT area.

E = Total residential exposure in the ENPAT area.

Step 4:

The total damage of all the tornadoes simulated is now calculated.

Step 5:

Steps 1 to 4 is repeated 10 000 times.

Using the 10 000 simulated results the following can be calculated:

- the expected value of the annual damage caused by tornadoes to residential property in South Africa,
- the variance of the annual damage, as well as
- an empirical probability distribution function.

The actual results of the exercise were:

Expected annual damage: R38 639 429 (0.0065% of total exposure)

Standard deviation of the damage: R279 575 678

As is to be expected, the simulations indicated that the results were extremely variable. The histogram showing the PDF is below:

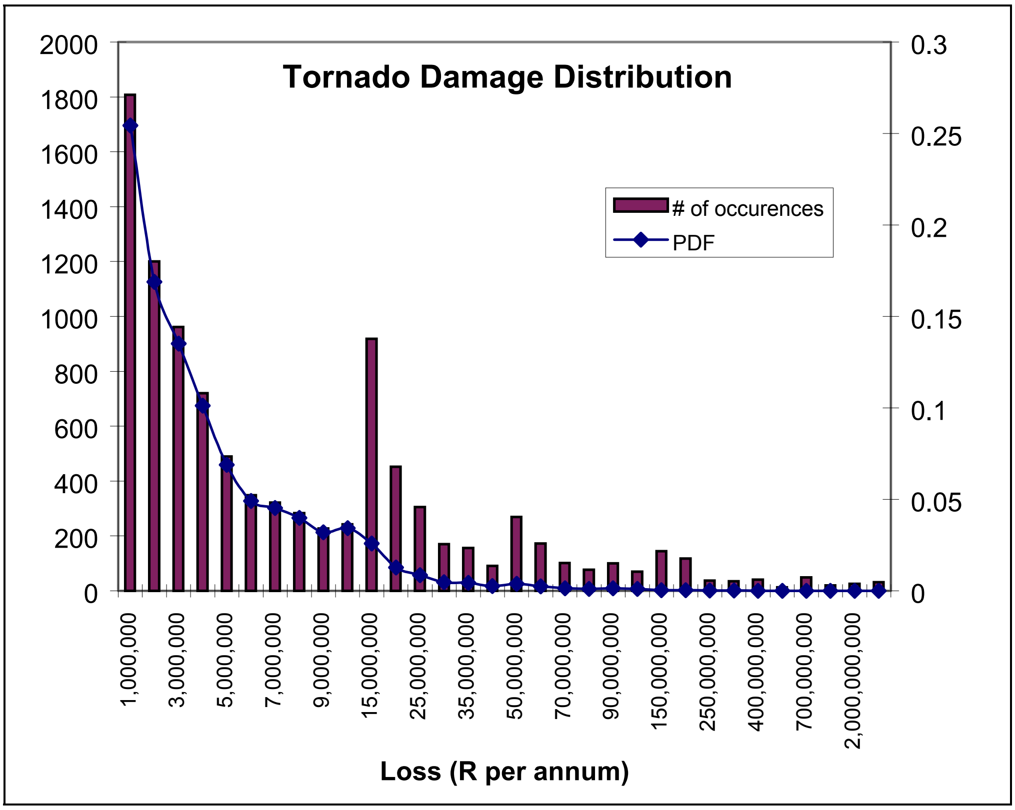

Figure 16: Results of simulation of tornado experience (Probability Distribution Function)

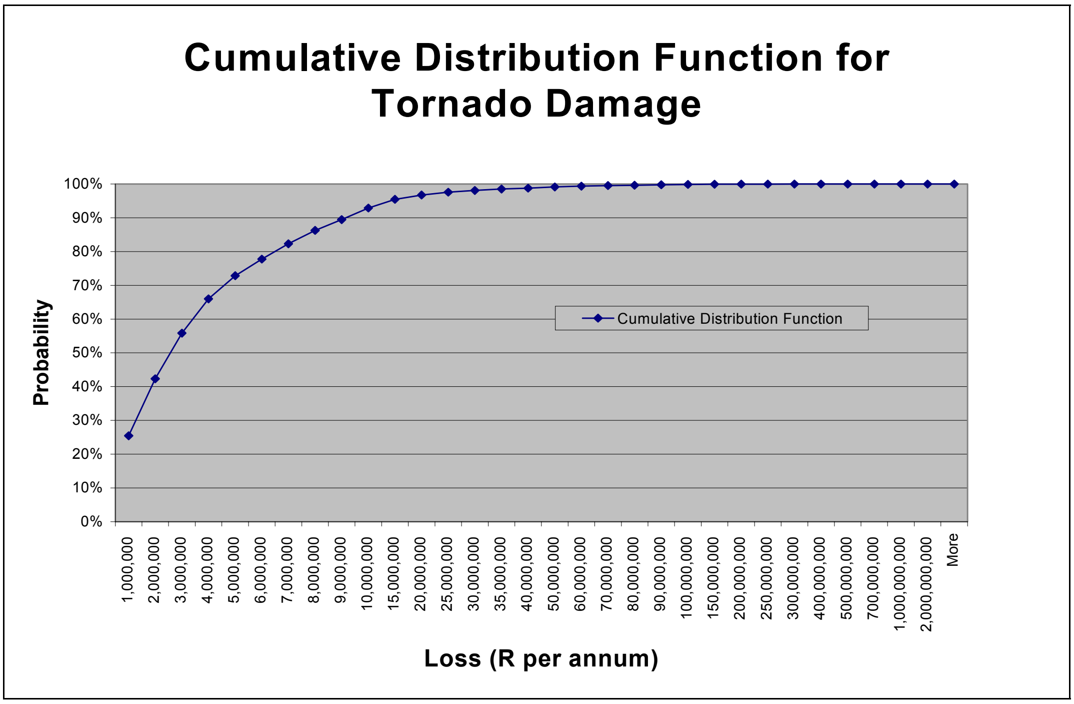

Figure 17: Results of simulation of tornado experience (Cumulative Distribution Function)

From the PDF we can answer questions like: "What is the probability of the annual losses due to tornadoes exceeding R100m?" Using the simulation results in this case the answer is 5.16% (i.e. 516 of the 10 000 simulations produced total annual damage to residential property in excess of R100m). Note that the actual figures quoted here are very likely to be too large, since the American experience used was not appropriately adjusted to reflect the South African situation.

By applying the top-down approach, a reinsurer could use this model to calculate the theoretical premium it ought to charge to cover the particular catastrophe.

11. Hail storms

A similar model as used in the tornado analysis can be applied to assess likely damage caused by hailstorms. The major difference between the two phenomena is that a hailstorm typically affects a much larger area than a tornado. For this reason, the analysis will not be done per ENPAT area but by magisterial district. A list giving the relative likelihood of a hailstorm in each district will be a prerequisite, since some districts are much more prone than others to be affected by hail.

Although the damage caused by hail to residential property can be extensive, damage to vehicles is likely to be much larger. To arrive at meaningful results one will have to compile an exposure database on vehicles (similar to the residential property database, used above).

A further refinement to the hail model will entail simulating the time of day the hailstorm occurs. A fierce hailstorm five o'clock in the afternoon, when traffic flow is dense, will cause much larger losses, than the same storm at three in the morning.

Adding the abovementioned modifications to the model is straightforward. However, getting accurate parameters for the model, will require extensive research regarding hailstorms in South Africa.

12. Completion of the model

This dissertation outlines the methodologies that may be used to assess potential damage caused by catastrophes in South Africa. The findings given are insufficient for rating purposes, and the models need to be completed and possibly put into computer software for purposes of rating catastrophe treaties. If it is believed that the findings can be applied meaningfully to risks in the South African market and/or other markets the model can indeed be completed. However, it will be quite expensive.

13. Conclusion

Doing a catastrophe assessment in an area such as South Africa where the incidence of catastrophes is fairly low, is more difficult than in areas of high incidence, due to the lack of data and previous research. One of the perils that is quite prominent in South Africa is the peril of flood. Assessing potential flood damage was the most difficult and complicated part of the research, and as is indicated in the findings, much work still needs to be done to transform the suggested methodology into an insurance rate-producing model.

It is sincerely hoped that some utility will come from the work done.

14. Acknowledgements

The author would like to express sincere gratitude towards Professor George Marx for the guidance and mentoring throughout the duration of the research. Many hours of his labour went into reviewing, giving input and reviewing again, and again.

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The original idea for the research unit was aired by Mr. Norbert Künig. Thank you.

A final word of thanks to the sponsors of the project, the Hannover Reinsurance Company and The Hollandia Reinsurance Company. Without their commitment the research would probably never have taken place.

15. References

ALEXANDER, W.J.R. (1990*a*). *Flood hydrology for Southern Africa.* UNIVERSITY OF PRETORIA.

ALEXANDER, W.J.R. (1993). *Flood Risk Reduction Measures.* UNIVERSITY OF PRETORIA.

ALEXANDER, W.J.R. (1994). *Disaster Mitigation Proposals for South Africa.* WORLD CONFERENCE ON NATURAL DISASTER REDUCTION, YOKAHAMA, JAPAN, 23-27 MAY 1994.

ARCVIEW 2.0. *Geographical Information System (GIS).* ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE.

CAELUM (1991) & SUBSEQUENT UPDATES. *A History of notable Weather Events in South Africa: 1500-1990.* THE WEATHER BUREAU, DEPARTMENT OF ENVIRONMENT AFFAIRS.

CATMAP. *Basic Course on Probability and Statistics for CATMAP ® Users.* APPLIED INSURANCE RESEARCH, INC.

CATMAP. *Basic Course on Simulation, Model Building and Validation for CATMAP ® Users.* APPLIED INSURANCE RESEARCH, INC.

CLARK, C. (1984). *Flood.* TIME LIFE BOOKS.

CLARK, K.M. (1987). *A Formal Approach to Catastrophe Risk Assessment and Management.* PROCEEDINGS OF THE CASUALTY ACTUARIAL SOCIETY.

DARLOW, T. (1990). *The effects of sea surface temperature on tropical cyclones in the South West Indian Ocean.* PAPER PRESENTED AT THE STUDENT GEOGRAPHY CONFERENCE, UNIVERSITY OF PORT ELIZABETH, OCTOBER 1990.

DICKSON, D.C.M. & WATERS, H.R. (1992). *Risk Models.* DEPARTMENT OF ACTUARIAL MATHEMATICS & STATISTICS, HERRIOT-WATT UNIVERSITY, EDINBURGH.

DU PLESSIS, D.B. & BAIN, S.C. (1987). *Dokumentasie van 1974 - vloede in die Oranje- en Groot-Visrivier.* DEPARTMENT VAN WATERWESE, TEGNIESE VERSLAG 132.

DU PLESSIS, D.B., BURGER, C.E., DUNSMORE, S.J. & RANDALL, L.A. (1989). *Documentation of the February-March 1988 floods in the Orange River basin.* DEPARTMENT OF WATER AFFAIRS, TECHNICAL REPORT 142.

DUNN, P. (1985). *An investigation into tropical cyclones in the South West Indian Ocean.* DEPARTMENT OF WATER AFFAIRS, DIRECTORATE OF HYDROLOGY, FLOOD STUDIES TECHNICAL NOTE 1, PRETORIA.

ENPAT (1995). *Environmental Potential Atlas*. DEPARTMENT OF ENVIRONMENTAL AFFAIRS AND TOURISM, DEVELOPED BY GIS LAB UNIVERSITY OF PRETORIA.

EUROCAT. *EUROCAT ™ 1.0 Technical Documentation.* APPLIED INSURANCE RESEARCH, INC.

FERREIRA, C. E. (1989). *Die Hantering van Omgewingsrampe: 'n Gavallestudie van die September 1987-vloede in Natal en Kwazulu.* UNIVERSITY OF PRETORIA.

FRANCOU, J. & RODIER, J.A. (1967). *Essai de classification des crues maximales.* PROCEEDINGS OF THE LININGRAD SYMPOSIUM ON FLOODS AND THEIR COMPUTATION, UNESCO, 1967.

FREUND (1992). *Mathematical Statistics.* FIFTH EDITION, PRENTICE-HALL INTERNATIONAL EDITIONS.

HANCOCK, G. (1994). *Fingerprints of the Gods.*

IDNDR MID-TERM REVIEW AND THE 1994 WORLD CONFERENCE ON NATURAL DISASTER REDUCTION (1994). *National Report of the Republic of South Africa.*

KPMG. *Glossary of Terms for the insurance industry.*

KOVACS, Z. (1988). *Regional Maximum Flood Peaks in Southern Africa.* DEPARTMENT OF WATER AFFAIRS, TECHNICAL REPORT 137.

SMITH, D.J.G., VILJOEN, M.F. & SPIES, P.H. (1981). *Guidelines for Assessing Flood Damage in South Africa.* WATER RESEARCH COMMISSION.

SWISS REINSURANCE COMPANY, (1994). *Global warming: element of risk.*

SWISS REINSURANCE COMPANY, (1995). *The Great Hanshin Earthquake: Trial, Error, Success.*

SWISS REINSURANCE COMPANY, (1996). *Catastrophe Seminar South Africa.*

SWISS REINSURANCE COMPANY, SIGMA NOS 1995 2/1996, 6/1995,.

TALJAARD, J.J. (1985). *Cut-off lows in the South African region.* TECH. PAPER NO. 14, WEATHER BUREAU.

WIGGENS, J.H. (1976). *Natural Hazards: Tornado, Hurricane, Severe Wind Loss Models.* NATIONAL SCIENCE FOUNDATION, WASHINGTON, DC, DIVISION OF POLICY RESEARCH AND ANALYSIS.

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18. Appendix A: Flood Damage Assessment

			Flood Peaks										Damage in R'million			
CENS_DISTR	Regional Maximum Flood (RMF)	RMF Factor (Ratio to Average)	20-year return	50-year return	100-year return	200-year return	Exposure in R'million (1996)	Exposure in R'million (1987)	RMF-factor adjusted exposure	Propor-tionate Damage in R'million	Damage Ratio	Estimated Flood Peak for Natal Floods	20-year return	50-year return	100-year return	200-year return
Durban	9933	2.0399	1987	4967	5711	6456	2,715.23	834.96	1,703.21	26.049	3.1198%	6108.79509	8.47	21.18	24.36	27.53
Embumbulu	9898	2.0328	1980	4949	5692	6434	220.85	67.91	138.05	2.111	3.1089%	6087.46238	0.69	1.72	1.97	2.23
Pinetown	9894	2.0319	1979	4947	5689	6431	2,902.40	892.51	1,813.53	27.736	3.1077%	6085.00874	9.02	22.55	25.93	29.31
Vulamehlo	9771	2.0067	1954	4886	5618	6351	7.04	2.16	4.34	0.066	3.0690%	6009.29447	0.02	0.05	0.06	0.07
Inanda	9765	2.0054	1953	4883	5615	6347	1,716.77	527.92	1,058.69	16.192	3.0671%	6005.51895	5.27	13.16	15.14	17.11
Umzintu	9736	1.9994	1947	4868	5598	6328	23.51	7.23	14.45	0.221	3.0580%	5987.70124	0.07	0.18	0.21	0.23
Vulamehlo	9717	1.9956	1943	4859	5588	6316	42.55	13.09	26.11	0.399	3.0521%	5976.20523	0.13	0.32	0.37	0.42
Ntuzuma	9695	1.9910	1939	4847	5575	6302	6,055.38	1,862.08	3,707.33	56.701	3.0450%	5962.31622	18.44	46.10	53.01	59.93
Ndwedwe	9629	1.9775	1926	4815	5537	6259	29.36	9.03	17.85	0.273	3.0244%	5921.95373	0.09	0.22	0.26	0.29
Ndwedwe	9557	1.9626	1911	4778	5495	6212	93.33	28.70	56.32	0.861	3.0017%	5877.38524	0.28	0.70	0.81	0.91
Embumbulu	9501	1.9512	1900	4751	5463	6176	79.58	24.47	47.75	0.730	2.9843%	5843.33817	0.24	0.59	0.68	0.77
Richmond (Kwazulu/Natal)	9454	1.9414	1891	4727	5436	6145	40.59	12.48	24.23	0.371	2.9692%	5813.91942	0.12	0.30	0.35	0.39
Camperdown	9322	1.9144	1864	4661	5360	6059	16.74	5.15	9.85	0.151	2.9279%	5733.00883	0.05	0.12	0.14	0.16
Empumalanga	9299	1.9096	1860	4649	5347	6044	1,480.44	455.25	869.34	13.296	2.9206%	5718.67400	4.32	10.81	12.43	14.05
Richmond (Kwazulu/Natal)	9171	1.8833	1834	4585	5273	5961	5.45	1.68	3.16	0.048	2.8804%	5639.90016	0.02	0.04	0.05	0.05
Ixopo	9132	1.8753	1826	4566	5251	5936	46.16	14.19	26.62	0.407	2.8682%	5616.04288	0.13	0.33	0.38	0.43
New Hanover	8958	1.8396	1792	4479	5151	5823	8.19	2.52	4.63	0.071	2.8136%	5509.09090	0.02	0.06	0.07	0.07
Empumalanga	8932	1.8344	1786	4466	5136	5806	309.58	95.20	174.63	2.671	2.8056%	5493.45217	0.87	2.17	2.50	2.82
Ndwedwe	8859	1.8193	1772	4429	5094	5758	21.69	6.67	12.13	0.186	2.7825%	5448.27628	0.06	0.15	0.17	0.20
Camperdown	8800	1.8072	1760	4400	5060	5720	102.11	31.40	56.74	0.868	2.7640%	5411.98881	0.28	0.71	0.81	0.92
Ndwedwe	8647	1.7757	1729	4323	4972	5620	1.40	0.43	0.76	0.012	2.7158%	5317.59760	0.00	0.01	0.01	0.01
Pietermaritzburg	8643	1.7749	1729	4321	4969	5618	1,179.04	362.56	643.51	9.842	2.7145%	5315.19947	3.20	8.00	9.20	10.40
Empumalanga	8508	1.7473	1702	4254	4892	5530	138.66	42.64	74.50	1.139	2.6724%	5232.63305	0.37	0.93	1.07	1.20
New Hanover	8474	1.7402	1695	4237	4872	5508	39.55	12.16	21.16	0.324	2.6615%	5211.26227	0.11	0.26	0.30	0.34
Richmond (Kwazulu/Natal)	8383	1.7216	1677	4192	4820	5449	0.84	0.26	0.44	0.007	2.6331%	5155.67308	0.00	0.01	0.01	0.01
Ixopo	8377	1.7203	1675	4188	4817	5445	0.08	0.03	0.04	0.001	2.6310%	5151.61835	0.00	0.00	0.00	0.00
Vulamehlo	8375	1.7200	1675	4188	4816	5444	0.19	0.06	0.10	0.002	2.6305%	5150.73030	0.00	0.00	0.00	0.00
Embumbulu	8374	1.7197	1675	4187	4815	5443	0.19	0.06	0.10	0.002	2.6302%	5150.02678	0.00	0.00	0.00	0.00
Vulamehlo	8374	1.7197	1675	4187	4815	5443	0.22	0.07	0.11	0.002	2.6301%	5149.94408	0.00	0.00	0.00	0.00
Vulamehlo	8373	1.7194	1675	4186	4814	5442	0.17	0.05	0.09	0.001	2.6297%	5149.14755	0.00	0.00	0.00	0.00
Embumbulu	8372	1.7192	1674	4186	4814	5442	7.27	2.23	3.84	0.059	2.6294%	5148.53072	0.02	0.05	0.05	0.06
Vulamehlo	8367	1.7182	1673	4183	4811	5438	0.18	0.06	0.10	0.001	2.6278%	5145.42210	0.00	0.00	0.00	0.00
Embumbulu	8365	1.7180	1673	4183	4810	5438	0.14	0.04	0.08	0.001	2.6275%	5144.75583	0.00	0.00	0.00	0.00
Vulamehlo	8365	1.7179	1673	4183	4810	5437	1.85	0.57	0.98	0.015	2.6275%	5144.69489	0.00	0.01	0.01	0.02
Richmond (Kwazulu/Natal)	8354	1.7157	1671	4177	4804	5430	17.34	5.33	9.15	0.140	2.6240%	5137.88988	0.05	0.11	0.13	0.15
Empumalanga	8342	1.7131	1668	4171	4796	5422	247.21	76.02	130.23	1.992	2.6200%	5130.07126	0.65	1.62	1.86	2.11
Hlanganani	8216	1.6872	1643	4108	4724	5340	38.72	11.91	20.09	0.307	2.5804%	5052.62627	0.10	0.25	0.29	0.32
Ixopo	8161	1.6759	1632	4080	4692	5305	9.10	2.80	4.69	0.072	2.5632%	5018.90985	0.02	0.06	0.07	0.08
Ixopo	7999	1.6426	1600	3999	4599	5199	0.01	0.00	0.00	0.000	2.5123%	4919.18344	0.00	0.00	0.00	0.00
Ixopo	7999	1.6426	1600	3999	4599	5199	0.27	0.08	0.14	0.002	2.5123%	4919.11399	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	7994	1.6416	1599	3997	4596	5196	0.00	0.00	0.00	0.000	2.5107%	4916.06933	0.00	0.00	0.00	0.00
Ixopo	7994	1.6416	1599	3997	4596	5196	0.18	0.05	0.09	0.001	2.5107%	4916.06424	0.00	0.00	0.00	0.00
Ixopo	7990	1.6409	1598	3995	4594	5194	5.22	1.60	2.63	0.040	2.5097%	4914.08147	0.01	0.03	0.04	0.04
Richmond (Kwazulu/Natal)	7895	1.6214	1579	3948	4540	5132	0.19	0.06	0.09	0.001	2.4799%	4855.69681	0.00	0.00	0.00	0.00
Ixopo	7894	1.6211	1579	3947	4539	5131	0.08	0.02	0.04	0.001	2.4794%	4854.73239	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	7892	1.6208	1578	3946	4538	5130	0.00	0.00	0.00	0.000	2.4789%	4853.86904	0.00	0.00	0.00	0.00
Ixopo	7892	1.6208	1578	3946	4538	5130	0.00	0.00	0.00	0.000	2.4789%	4853.84341	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	7892	1.6208	1578	3946	4538	5130	0.21	0.06	0.10	0.002	2.4789%	4853.83979	0.00	0.00	0.00	0.00
Ixopo	7891	1.6205	1578	3945	4537	5129	1.19	0.37	0.59	0.009	2.4784%	4852.76224	0.00	0.01	0.01	0.01
Ixopo	7869	1.6160	1574	3934	4525	5115	0.09	0.03	0.04	0.001	2.4715%	4839.29492	0.00	0.00	0.00	0.00
Impendle	7867	1.6156	1573	3934	4524	5114	6.78	2.09	3.37	0.052	2.4710%	4838.27867	0.02	0.04	0.05	0.05
New Hanover	6739	1.3840	1348	3370	3875	4381	44.16	13.58	18.79	0.287	2.1168%	4144.69875	0.09	0.23	0.27	0.30
Pietermaritzburg	6610	1.3576	1322	3305	3801	4297	595.17	183.02	248.46	3.800	2.0763%	4065.44588	1.24	3.09	3.55	4.02
New Hanover	6549	1.3449	1310	3274	3766	4257	23.97	7.37	9.91	0.152	2.0569%	4027.56927	0.05	0.12	0.14	0.16
Pietermaritzburg	6477	1.3302	1295	3239	3724	4210	4,116.99	1,266.01	1,683.98	25.755	2.0344%	3983.39129	8.38	20.94	24.08	27.22
Durban	6081	1.2489	1216	3041	3497	3953	1,485.99	456.95	570.68	8.728	1.9101%	3740.03548	2.84	7.10	8.16	9.22
Durban	6044	1.2411	1209	3022	3475	3928	1,742.36	535.79	664.99	10.171	1.8982%	3716.84755	3.31	8.27	9.51	10.75
New Hanover	6027	1.2377	1205	3013	3465	3917	10.93	3.36	4.16	0.064	1.8929%	3706.48058	0.02	0.05	0.06	0.07
Chatsworth	5999	1.2320	1200	3000	3449	3899	2,833.65	871.37	1,073.52	16.419	1.8842%	3689.44089	5.34	13.35	15.35	17.35
New Hanover	5991	1.2303	1198	2996	3445	3894	90.57	27.85	34.27	0.524	1.8817%	3684.50066	0.17	0.43	0.49	0.55
Hlanganani	5949	1.2217	1190	2974	3421	3867	130.69	40.19	49.10	0.751	1.8685%	3658.56965	0.24	0.61	0.70	0.79
Chatsworth	5927	1.2173	1185	2964	3408	3853	2,535.24	779.61	949.00	14.514	1.8618%	3645.39947	4.72	11.80	13.57	15.34
Durban	5863	1.2040	1173	2931	3371	3811	9,157.74	2,816.08	3,390.43	51.854	1.8414%	3605.45977	16.86	42.16	48.48	54.81

			Flood Peaks										Damage in R'million			
CENS_DISTR	Regional Maximum Flood (RMF)	RMF Factor (Ratio to Average)	20-year return	50-year return	100-year return	200-year return	Exposure in R'million (1996)	Exposure in R'million (1987)	RMF-factor adjusted exposure	Propor-tionate Damage in R'million	Damage Ratio	Estimated Flood Peak for Natal Floods	20-year return	50-year return	100-year return	200-year return
Vulindlela	5768	1.1846	1154	2884	3317	3749	3.16	0.97	1.15	0.018	1.8118%	3547.50145	0.01	0.01	0.02	0.02
Impendle	5768	1.1845	1154	2884	3316	3749	0.01	0.00	0.00	0.000	1.8116%	3547.13463	0.00	0.00	0.00	0.00
Ixopo	5767	1.1844	1153	2884	3316	3749	3.39	1.04	1.24	0.019	1.8114%	3546.86147	0.01	0.02	0.02	0.02
Ixopo	5708	1.1722	1142	2854	3282	3710	0.33	0.10	0.12	0.002	1.7928%	3510.30482	0.00	0.00	0.00	0.00
Ixopo	5702	1.1710	1140	2851	3279	3706	0.72	0.22	0.26	0.004	1.7909%	3506.70369	0.00	0.00	0.00	0.00
Hlanganani	5689	1.1684	1138	2845	3271	3698	43.92	13.50	15.78	0.241	1.7869%	3498.91854	0.08	0.20	0.23	0.26
Camperdown	5685	1.1676	1137	2843	3269	3696	1.34	0.41	0.48	0.007	1.7857%	3496.56261	0.00	0.01	0.01	0.01
Pietermaritzburg	5683	1.1671	1137	2842	3268	3694	508.75	156.44	182.59	2.793	1.7850%	3495.21216	0.91	2.27	2.61	2.95
Hlanganani	5626	1.1554	1125	2813	3235	3657	107.16	32.95	38.07	0.582	1.7671%	3460.15831	0.19	0.47	0.54	0.62
Pietermaritzburg	5621	1.1544	1124	2811	3232	3654	328.97	101.16	116.78	1.786	1.7656%	3457.04280	0.58	1.45	1.67	1.89
Pinetown	5615	1.1531	1123	2807	3228	3650	1,239.00	381.00	439.32	6.719	1.7635%	3453.04742	2.19	5.46	6.28	7.10
Lions river	5581	1.1461	1116	2790	3209	3627	3.11	0.96	1.10	0.017	1.7528%	3432.11694	0.01	0.01	0.02	0.02
Lions river	5572	1.1444	1114	2786	3204	3622	73.20	22.51	25.76	0.394	1.7502%	3427.04676	0.13	0.32	0.37	0.42
Embumbulu	5507	1.1309	1101	2754	3167	3580	249.28	76.66	86.69	1.326	1.7297%	3386.81864	0.43	1.08	1.24	1.40
Lions river	5469	1.1232	1094	2735	3145	3555	2.01	0.62	0.69	0.011	1.7178%	3363.54582	0.00	0.01	0.01	0.01
Hlanganani	5464	1.1221	1093	2732	3142	3551	80.69	24.81	27.84	0.426	1.7161%	3360.20041	0.14	0.35	0.40	0.45
Pietermaritzburg	5375	1.1037	1075	2687	3090	3493	146.22	44.96	49.63	0.759	1.6881%	3305.37383	0.25	0.62	0.71	0.80
Vulindlela	5356	1.0999	1071	2678	3080	3481	13.65	4.20	4.62	0.071	1.6822%	3293.76634	0.02	0.06	0.07	0.07
Pietermaritzburg	5353	1.0993	1071	2676	3078	3479	114.15	35.10	38.59	0.590	1.6813%	3292.05018	0.19	0.48	0.55	0.62
Lions river	5342	1.0971	1068	2671	3072	3472	0.05	0.02	0.02	0.000	1.6779%	3285.33903	0.00	0.00	0.00	0.00
Hlanganani	5342	1.0970	1068	2671	3072	3472	38.79	11.93	13.09	0.200	1.6778%	3285.25159	0.07	0.16	0.19	0.21
New Hanover	5338	1.0963	1068	2669	3069	3470	68.81	21.16	23.20	0.355	1.6766%	3282.95233	0.12	0.29	0.33	0.37
Impendle	5282	1.0848	1056	2641	3037	3433	0.90	0.28	0.30	0.005	1.6591%	3248.59430	0.00	0.00	0.00	0.00
Embumbulu	5215	1.0709	1043	2607	2998	3389	420.87	129.42	138.59	2.120	1.6378%	3206.94341	0.69	1.72	1.98	2.24
Pinetown	5215	1.0709	1043	2607	2998	3389	3,153.28	969.66	1,038.38	15.881	1.6378%	3206.94341	5.16	12.91	14.85	16.79
Durban	5215	1.0709	1043	2607	2998	3389	3,476.81	1,069.15	1,144.93	17.511	1.6378%	3206.94341	5.69	14.24	16.37	18.51
Lions river	5213	1.0705	1043	2606	2997	3388	0.20	0.06	0.07	0.001	1.6372%	3205.77041	0.00	0.00	0.00	0.00
Vulindlela	5212	1.0704	1042	2606	2997	3388	0.08	0.03	0.03	0.000	1.6370%	3205.41841	0.00	0.00	0.00	0.00
Hlanganani	5212	1.0704	1042	2606	2997	3388	139.37	42.86	45.87	0.702	1.6370%	3205.40778	0.23	0.57	0.66	0.74
Vulindlela	5075	1.0423	1015	2538	2918	3299	315.04	96.88	100.97	1.544	1.5941%	3121.31823	0.50	1.26	1.44	1.63
Vulindlela	5007	1.0282	1001	2503	2879	3254	1,502.21	461.94	474.95	7.264	1.5725%	3079.03911	2.36	5.91	6.79	7.68
Vulindlela	4988	1.0244	998	2494	2868	3242	6.76	2.08	2.13	0.033	1.5667%	3067.76553	0.01	0.03	0.03	0.03
Vulindlela	4987	1.0241	997	2493	2867	3241	0.15	0.05	0.05	0.001	1.5663%	3066.84829	0.00	0.00	0.00	0.00
Hlanganani	4987	1.0241	997	2493	2867	3241	39.36	12.10	12.39	0.190	1.5663%	3066.82768	0.06	0.15	0.18	0.20
Hlanganani	4921	1.0107	984	2461	2830	3199	88.10	27.09	27.38	0.419	1.5458%	3026.71521	0.14	0.34	0.39	0.44
Embumbulu	4908	1.0080	982	2454	2822	3191	164.88	50.70	51.11	0.782	1.5417%	3018.71050	0.25	0.64	0.73	0.83
Embumbulu	4908	1.0080	982	2454	2822	3191	87.39	26.87	27.09	0.414	1.5417%	3018.71050	0.13	0.34	0.39	0.44
Embumbulu	4908	1.0080	982	2454	2822	3191	96.53	29.69	29.92	0.458	1.5417%	3018.71050	0.15	0.37	0.43	0.48
Pinetown	4781	0.9818	956	2390	2749	3108	438.08	134.71	132.26	2.023	1.5016%	2940.26227	0.66	1.64	1.89	2.14
Impendle	4772	0.9800	954	2386	2744	3102	0.01	0.00	0.00	0.000	1.4988%	2934.76586	0.00	0.00	0.00	0.00
Hlanganani	4771	0.9798	954	2386	2743	3101	0.01	0.00	0.00	0.000	1.4986%	2934.25689	0.00	0.00	0.00	0.00
Impendle	4771	0.9798	954	2386	2743	3101	0.01	0.00	0.00	0.000	1.4986%	2934.24731	0.00	0.00	0.00	0.00
Hlanganani	4770	0.9797	954	2385	2743	3101	0.46	0.14	0.14	0.002	1.4983%	2933.80356	0.00	0.00	0.00	0.00
Hlanganani	4770	0.9795	954	2385	2743	3100	0.73	0.22	0.22	0.003	1.4981%	2933.32007	0.00	0.00	0.00	0.00
Impendle	4768	0.9792	954	2384	2742	3099	0.01	0.00	0.00	0.000	1.4977%	2932.54484	0.00	0.00	0.00	0.00
Impendle	4767	0.9790	953	2384	2741	3099	0.04	0.01	0.01	0.000	1.4974%	2931.91379	0.00	0.00	0.00	0.00
Hlanganani	4764	0.9784	953	2382	2739	3097	0.86	0.27	0.26	0.004	1.4964%	2929.96982	0.00	0.00	0.00	0.00
Impendle	4763	0.9781	953	2381	2739	3096	0.07	0.02	0.02	0.000	1.4959%	2929.05184	0.00	0.00	0.00	0.00
Hlanganani	4756	0.9768	951	2378	2735	3092	37.72	11.60	11.33	0.173	1.4939%	2925.08277	0.06	0.14	0.16	0.18
Umlazi	4735	0.9724	947	2368	2723	3078	206.15	63.39	61.65	0.943	1.4873%	2912.14223	0.31	0.77	0.88	1.00
Umlazi	4733	0.9720	947	2366	2721	3076	5,272.58	1,621.36	1,575.92	24.102	1.4866%	2910.74758	7.84	19.60	22.53	25.47
Impendle	4690	0.9632	938	2345	2697	3049	0.01	0.00	0.00	0.000	1.4732%	2884.59703	0.00	0.00	0.00	0.00
Hlanganani	4689	0.9630	938	2345	2696	3048	0.50	0.15	0.15	0.002	1.4728%	2883.84099	0.00	0.00	0.00	0.00
Polela	4688	0.9628	938	2344	2696	3047	4.98	1.53	1.47	0.023	1.4725%	2883.29753	0.01	0.02	0.02	0.02
Embumbulu	4674	0.9600	935	2337	2688	3038	5.78	1.78	1.71	0.026	1.4682%	2874.80688	0.01	0.02	0.02	0.03
Camperdown	4667	0.9583	933	2333	2683	3033	226.08	69.52	66.63	1.019	1.4657%	2869.90286	0.33	0.83	0.95	1.08
Lions river	4664	0.9577	933	2332	2682	3031	545.54	167.76	160.67	2.457	1.4648%	2868.12736	0.80	2.00	2.30	2.60
Hlanganani	4619	0.9486	924	2310	2656	3002	38.47	11.83	11.22	0.172	1.4508%	2840.81615	0.06	0.14	0.16	0.18
Polela	4550	0.9344	910	2275	2616	2957	2.51	0.77	0.72	0.011	1.4291%	2798.16805	0.00	0.01	0.01	0.01
Hlanganani	4514	0.9270	903	2257	2596	2934	1.65	0.51	0.47	0.007	1.4178%	2776.11100	0.00	0.01	0.01	0.01
Polela	4511	0.9264	902	2255	2594	2932	0.00	0.00	0.00	0.000	1.4168%	2774.25578	0.00	0.00	0.00	0.00
Impendle	4511	0.9264	902	2255	2594	2932	3.92	1.21	1.12	0.017	1.4168%	2774.23346	0.01	0.01	0.02	0.02

CENS_DISTR	Regional Maximum Flood (RMF)	RMF Factor (Ratio to Average)	Flood Peaks: 20-year return	50-year return	100-year return	200-year return	Exposure in R'million (1996)	Exposure in R'million (1987)	RMF-factor adjusted exposure	Proportionate Damage in R'million	Damage Ratio	Estimated Flood Peak for Natal Floods	Damage in R'million: 20-year return	50-year return	100-year return	200-year return
Impendle	4135	0.8492	827	2068	2378	2688	0.28	0.09	0.07	0.001	1.2988%	2543.17712	0.00	0.00	0.00	0.00
Impendle	4107	0.8434	821	2054	2362	2670	0.00	0.00	0.00	0.000	1.2900%	2525.84241	0.00	0.00	0.00	0.00
Hlanganani	4107	0.8434	821	2053	2361	2669	18.08	5.56	4.69	0.072	1.2899%	2525.68571	0.02	0.06	0.07	0.08
Hlanganani	4070	0.8358	814	2035	2340	2645	17.30	5.32	4.45	0.068	1.2783%	2502.99151	0.02	0.06	0.06	0.07
Impendle	4034	0.8285	807	2017	2320	2622	7.29	2.24	1.86	0.028	1.2671%	2481.06488	0.01	0.02	0.03	0.03
Vulindlela	3882	0.7971	776	1941	2232	2523	0.03	0.01	0.01	0.000	1.2191%	2387.13065	0.00	0.00	0.00	0.00
Camperdown	3058	0.6279	612	1529	1758	1987	19.38	5.96	3.74	0.057	0.9604%	1880.45863	0.02	0.05	0.05	0.06
Embumbulu	3058	0.6279	612	1529	1758	1987	47.41	14.58	9.15	0.140	0.9604%	1880.45863	0.05	0.11	0.13	0.15
Empumalanga	3058	0.6279	612	1529	1758	1987	482.48	148.37	93.16	1.425	0.9604%	1880.45863	0.46	1.16	1.33	1.51
Camperdown	2796	0.5743	559	1398	1608	1818	17.27	5.31	3.05	0.047	0.8783%	1719.82931	0.02	0.04	0.04	0.05
Empumalanga	2735	0.5617	547	1367	1573	1778	55.67	17.12	9.61	0.147	0.8590%	1681.98134	0.05	0.12	0.14	0.16
Empumalanga	2702	0.5550	540	1351	1554	1756	3.11	0.96	0.53	0.008	0.8488%	1661.90313	0.00	0.01	0.01	0.01
Camperdown	2700	0.5546	540	1350	1553	1755	32.36	9.95	5.52	0.084	0.8482%	1660.77449	0.03	0.07	0.08	0.09
Richmond (Kwazulu/Natal)	2700	0.5546	540	1350	1553	1755	8.42	2.59	1.44	0.022	0.8482%	1660.77449	0.01	0.02	0.02	0.02
Richmond (Kwazulu/Natal)	2700	0.5546	540	1350	1553	1755	46.77	14.38	7.98	0.122	0.8482%	1660.77449	0.04	0.10	0.11	0.13
Camperdown	2700	0.5546	540	1350	1553	1755	57.10	17.56	9.74	0.149	0.8482%	1660.77449	0.05	0.12	0.14	0.16
Camperdown	2700	0.5546	540	1350	1553	1755	63.59	19.55	10.84	0.166	0.8482%	1660.77449	0.05	0.13	0.16	0.18
Hlanganani	2499	0.5133	500	1250	1437	1625	71.16	21.88	11.23	0.172	0.7850%	1537.04185	0.06	0.14	0.16	0.18
Camperdown	2482	0.5097	496	1241	1427	1613	8.82	2.71	1.38	0.021	0.7796%	1526.46747	0.01	0.02	0.02	0.02
Camperdown	2446	0.5024	489	1223	1407	1590	30.93	9.51	4.78	0.073	0.7684%	1504.55264	0.02	0.06	0.07	0.08
Hlanganani	2339	0.4803	468	1169	1345	1520	2.06	0.63	0.30	0.005	0.7345%	1438.27151	0.00	0.00	0.00	0.00
Hlanganani	2334	0.4793	467	1167	1342	1517	0.76	0.23	0.11	0.002	0.7330%	1435.30777	0.00	0.00	0.00	0.00
Hlanganani	2332	0.4789	466	1166	1341	1516	0.24	0.07	0.04	0.001	0.7325%	1434.20875	0.00	0.00	0.00	0.00
Underberg	2331	0.4788	466	1166	1341	1515	7.54	2.32	1.11	0.017	0.7323%	1433.85981	0.01	0.01	0.02	0.02
Embumbulu	2317	0.4758	463	1158	1332	1506	18.32	5.63	2.68	0.041	0.7277%	1424.84538	0.01	0.03	0.04	0.04
Camperdown	2282	0.4686	456	1141	1312	1483	0.00	0.00	0.00	0.000	0.7166%	1403.22618	0.00	0.00	0.00	0.00
Pietermaritzburg	2282	0.4686	456	1141	1312	1483	739.89	227.52	106.61	1.631	0.7166%	1403.21955	0.53	1.33	1.52	1.72
Lions river	2238	0.4595	448	1119	1287	1454	5.63	1.73	0.80	0.012	0.7028%	1376.08142	0.00	0.01	0.01	0.01
Umvoti	2197	0.4512	439	1099	1263	1428	1.92	0.59	0.27	0.004	0.6901%	1351.15754	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	2170	0.4457	434	1085	1248	1411	3.34	1.03	0.46	0.007	0.6816%	1334.62735	0.00	0.01	0.01	0.01
Impendle	2091	0.4294	418	1046	1202	1359	2.36	0.73	0.31	0.005	0.6568%	1286.04847	0.00	0.00	0.00	0.01
Pietermaritzburg	2025	0.4158	405	1012	1164	1316	0.01	0.00	0.00	0.000	0.6360%	1245.31140	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	2025	0.4158	405	1012	1164	1316	6.73	2.07	0.86	0.013	0.6360%	1245.30864	0.00	0.01	0.01	0.01
Impendle	1888	0.3877	378	944	1085	1227	0.01	0.00	0.00	0.000	0.5929%	1160.89311	0.00	0.00	0.00	0.00
Underberg	1887	0.3875	377	943	1085	1226	2.14	0.66	0.26	0.004	0.5926%	1160.41201	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	1848	0.3795	370	924	1063	1201	15.09	4.64	1.76	0.027	0.5805%	1136.61881	0.01	0.02	0.03	0.03
Underberg	1740	0.3574	348	870	1001	1131	0.40	0.12	0.04	0.001	0.5466%	1070.29569	0.00	0.00	0.00	0.00
Hlanganani	1712	0.3515	342	856	984	1113	12.43	3.82	1.34	0.021	0.5376%	1052.73182	0.01	0.02	0.02	0.02
Hlanganani	1672	0.3433	334	836	961	1087	1.91	0.59	0.20	0.003	0.5250%	1028.06601	0.00	0.00	0.00	0.00
Impendle	1665	0.3420	333	833	958	1083	0.27	0.08	0.03	0.000	0.5231%	1024.21291	0.00	0.00	0.00	0.00
Hlanganani	1620	0.3327	324	810	932	1053	0.02	0.00	0.00	0.000	0.5089%	996.48126	0.00	0.00	0.00	0.00
Impendle	1620	0.3327	324	810	932	1053	0.00	0.00	0.00	0.000	0.5089%	996.44877	0.00	0.00	0.00	0.00
Impendle	1619	0.3326	324	810	931	1053	0.05	0.02	0.01	0.000	0.5086%	995.96099	0.00	0.00	0.00	0.00
Hlanganani	1611	0.3309	322	806	926	1047	5.94	1.83	0.60	0.009	0.5060%	990.79673	0.00	0.01	0.01	0.01
Hlanganani	1591	0.3267	318	795	915	1034	4.91	1.51	0.49	0.008	0.4997%	978.34602	0.00	0.01	0.01	0.01
Impendle	1574	0.3232	315	787	905	1023	0.00	0.00	0.00	0.000	0.4943%	967.92409	0.00	0.00	0.00	0.00
Underberg	1574	0.3232	315	787	905	1023	0.04	0.01	0.00	0.000	0.4943%	967.77841	0.00	0.00	0.00	0.00
Underberg	1571	0.3226	314	785	903	1021	0.00	0.00	0.00	0.000	0.4934%	966.00676	0.00	0.00	0.00	0.00
Underberg	1571	0.3225	314	785	903	1021	0.04	0.01	0.00	0.000	0.4933%	965.92749	0.00	0.00	0.00	0.00
Underberg	1567	0.3219	313	784	901	1019	0.05	0.02	0.01	0.000	0.4923%	963.90266	0.00	0.00	0.00	0.00
Estcourt	1563	0.3209	313	781	898	1016	0.01	0.00	0.00	0.000	0.4908%	960.98668	0.00	0.00	0.00	0.00
Impendle	1562	0.3209	312	781	898	1016	1.18	0.36	0.12	0.002	0.4908%	960.93686	0.00	0.00	0.00	0.00
Richmond (Kwazulu/Natal)	1363	0.2799	273	681	784	886	0.25	0.08	0.02	0.000	0.4281%	838.18653	0.00	0.00	0.00	0.00
Vulindlela	1353	0.2779	271	677	778	880	42.29	13.00	3.61	0.055	0.4251%	832.29805	0.02	0.04	0.05	0.06
Lions river	1340	0.2752	268	670	771	871	0.01	0.00	0.00	0.000	0.4209%	824.10625	0.00	0.00	0.00	0.00
Lions river	1340	0.2752	268	670	770	871	0.00	0.00	0.00	0.000	0.4209%	824.08049	0.00	0.00	0.00	0.00
Hlanganani	1339	0.2749	268	669	770	870	0.66	0.20	0.06	0.001	0.4205%	823.32664	0.00	0.00	0.00	0.00
Underberg	1336	0.2743	267	668	768	868	1.15	0.35	0.10	0.001	0.4195%	821.48247	0.00	0.00	0.00	0.00
Pietermaritzburg	1314	0.2699	263	657	756	854	237.61	73.07	19.72	0.302	0.4128%	808.33804	0.10	0.25	0.28	0.32
Impendle	1224	0.2514	245	612	704	796	0.00	0.00	0.00	0.000	0.3845%	752.84444	0.00	0.00	0.00	0.00
Impendle	1224	0.2513	245	612	704	795	0.01	0.00	0.00	0.000	0.3843%	752.46918	0.00	0.00	0.00	0.00
Underberg	1221	0.2507	244	610	702	793	5.39	1.66	0.42	0.006	0.3834%	750.74466	0.00	0.01	0.01	0.01
Richmond (Kwazulu/Natal)	1164	0.2391	233	582	670	757	6.43	1.98	0.47	0.007	0.3657%	716.08251	0.00	0.01	0.01	0.01

			Flood Peaks										Damage in R'million			
CENS DISTR	Regional Maximum Flood (RMF)	RMF Factor (Ratio to Average)	20-year return	50-year return	100-year return	200-year return	Exposure in R'million (1996)	Exposure in R'million (1987)	RMF-factor adjusted exposure	Propor-tionate Damage in R'million	Damage Ratio	Estimated Flood Peak for Natal Floods	20-year return	50-year return	100-year return	200-year return
Richmond (Kwazulu/Natal)	1164	0.2391	233	582	670	757	12.27	3.77	0.90	0.014	0.3657%	716.08251	0.00	0.01	0.01	0.01
Richmond (Kwazulu/Natal)	1164	0.2391	233	582	670	757	17.54	5.39	1.29	0.020	0.3657%	716.08251	0.01	0.02	0.02	0.02
Hlanganani	1145	0.2352	229	573	658	744	11.18	3.44	0.81	0.012	0.3597%	704.26049	0.00	0.01	0.01	0.01
Lions river	1091	0.2240	218	545	627	709	2.70	0.83	0.19	0.003	0.3425%	670.66932	0.00	0.00	0.00	0.00
Lions river	1066	0.2189	213	533	613	693	1.44	0.44	0.10	0.001	0.3347%	655.39654	0.00	0.00	0.00	0.00
Lions river	1052	0.2161	210	526	605	684	53.10	16.33	3.53	0.054	0.3305%	647.10147	0.02	0.04	0.05	0.06
Underberg	384	0.0788	77	192	221	249	0.42	0.13	0.01	0.000	0.1205%	235.93953	0.00	0.00	0.00	0.00
Umvoti	232	0.0476	46	116	133	151	1.41	0.43	0.02	0.000	0.0728%	142.52429	0.00	0.00	0.00	0.00
Underberg	208	0.0426	42	104	119	135	0.00	0.00	0.00	0.000	0.0652%	127.62334	0.00	0.00	0.00	0.00
Hlanganani	207	0.0426	41	104	119	135	3.90	1.20	0.05	0.001	0.0651%	127.54304	0.00	0.00	0.00	0.00
Vulindlela	15	0.0031	3	8	9	10	0.06	0.02	0.00	0.000	0.0047%	9.23989	0.00	0.00	0.00	0.00
Underberg	12	0.0025	2	6	7	8	0.00	0.00	0.00	0.000	0.0039%	7.58873	0.00	0.00	0.00	0.00
Underberg	5	0.0011	1	3	3	3	0.00	0.00	0.00	0.000	0.0016%	3.21345	0.00	0.00	0.00	0.00
Average:	**4869**					**Totals:**	**61,904.16**	**19,036.02**	**25,903.48**				**128.84**	**322.09**	**370.41**	**418.72**

19. Appendix B: Cyclone Damage Assessment

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Durban	KWAZULU/NATAL	900	9,157.745	228.944	4.977	0.0543%
Inanda	KWAZULU/NATAL	900	7,917.800	197.945	4.303	0.0543%
Ntuzuma	KWAZULU/NATAL	900	6,055.380	151.385	3.291	0.0543%
Umlazi	KWAZULU/NATAL	900	5,272.582	131.815	2.866	0.0543%
Durban	KWAZULU/NATAL	900	3,476.809	86.920	1.890	0.0543%
Pinetown	KWAZULU/NATAL	900	3,153.276	78.832	1.714	0.0543%
Pinetown	KWAZULU/NATAL	900	2,902.401	72.560	1.577	0.0543%
Chatsworth	KWAZULU/NATAL	900	2,833.647	70.841	1.540	0.0543%
Durban	KWAZULU/NATAL	900	2,715.233	67.881	1.476	0.0543%
Chatsworth	KWAZULU/NATAL	900	2,535.235	63.381	1.378	0.0543%
Durban	KWAZULU/NATAL	900	1,742.361	43.559	0.947	0.0543%
Inanda	KWAZULU/NATAL	900	1,716.773	42.919	0.933	0.0543%
Ntuzuma	KWAZULU/NATAL	900	1,492.249	37.306	0.811	0.0543%
Durban	KWAZULU/NATAL	900	1,485.987	37.150	0.808	0.0543%
Empumalanga	KWAZULU/NATAL	900	1,480.437	37.011	0.805	0.0543%
Pinetown	KWAZULU/NATAL	900	1,238.997	30.975	0.673	0.0543%
Pietermaritzburg	KWAZULU/NATAL	900	1,179.038	29.476	0.641	0.0543%
Umzintu	KWAZULU/NATAL	900	1,016.796	25.420	0.553	0.0543%
Nsikazi	EASTERN TRANSVAAL	700	927.704	23.193	0.504	0.0543%
Durban	KWAZULU/NATAL	900	759.313	18.983	0.413	0.0543%
Port Shepstone	KWAZULU/NATAL	900	553.080	13.827	0.301	0.0543%
Lower Tugela	KWAZULU/NATAL	900	484.599	12.115	0.263	0.0543%
Empumalanga	KWAZULU/NATAL	900	482.480	12.062	0.262	0.0543%
Pinetown	KWAZULU/NATAL	900	438.075	10.952	0.238	0.0543%
Embumbulu	KWAZULU/NATAL	900	420.873	10.522	0.229	0.0543%
Port Shepstone	KWAZULU/NATAL	700	397.807	9.945	0.216	0.0543%
Empumalanga	KWAZULU/NATAL	900	309.584	7.740	0.168	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	290.966	7.274	0.158	0.0543%
Embumbulu	KWAZULU/NATAL	900	249.281	6.232	0.135	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	247.839	6.196	0.135	0.0543%
Empumalanga	KWAZULU/NATAL	900	247.212	6.180	0.134	0.0543%
Port Shepstone	KWAZULU/NATAL	700	230.515	5.763	0.125	0.0543%
Camperdown	KWAZULU/NATAL	900	226.085	5.652	0.123	0.0543%
Embumbulu	KWAZULU/NATAL	900	220.853	5.521	0.120	0.0543%
Ezingolweni	KWAZULU/NATAL	700	218.469	5.462	0.119	0.0543%
Ndwedwe	KWAZULU/NATAL	900	215.394	5.385	0.117	0.0543%
Lower Umfolozi	KWAZULU/NATAL	100	213.641	5.341	0.116	0.0543%
Umlazi	KWAZULU/NATAL	900	206.150	5.154	0.112	0.0543%
Port Shepstone	KWAZULU/NATAL	700	205.291	5.132	0.112	0.0543%
Port Shepstone	KWAZULU/NATAL	900	199.084	4.977	0.108	0.0543%
Nkomazi	EASTERN TRANSVAAL	350	191.490	4.787	0.104	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	179.549	4.489	0.098	0.0543%
Lower Umfolozi	KWAZULU/NATAL	100	178.967	4.474	0.097	0.0543%
Mtunzini	KWAZULU/NATAL	100	164.996	4.125	0.090	0.0543%
Embumbulu	KWAZULU/NATAL	900	164.882	4.122	0.090	0.0543%
Ongoye	KWAZULU/NATAL	100	162.168	4.054	0.088	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	154.663	3.867	0.084	0.0543%
Ezingolweni	KWAZULU/NATAL	900	147.601	3.690	0.080	0.0543%
Ongoye	KWAZULU/NATAL	100	140.100	3.502	0.076	0.0543%
Empumalanga	KWAZULU/NATAL	900	138.660	3.467	0.075	0.0543%
Ongoye	KWAZULU/NATAL	900	137.969	3.449	0.075	0.0543%
Port Shepstone	KWAZULU/NATAL	900	134.729	3.368	0.073	0.0543%
Hlabisa	KWAZULU/NATAL	100	132.257	3.306	0.072	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	127.344	3.184	0.069	0.0543%
Witrivier	EASTERN TRANSVAAL	700	119.748	2.994	0.065	0.0543%
Mahlabatini	KWAZULU/NATAL	900	119.643	2.991	0.065	0.0543%
Port Shepstone	KWAZULU/NATAL	900	109.760	2.744	0.060	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	104.828	2.621	0.057	0.0543%
Ezingolweni	KWAZULU/NATAL	700	103.074	2.577	0.056	0.0543%
Camperdown	KWAZULU/NATAL	900	102.109	2.553	0.055	0.0543%
Nkomazi	EASTERN TRANSVAAL	350	99.541	2.489	0.054	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	97.138	2.428	0.053	0.0543%
Embumbulu	KWAZULU/NATAL	900	96.535	2.413	0.052	0.0543%
Ndwedwe	KWAZULU/NATAL	900	93.325	2.333	0.051	0.0543%
Barberton	EASTERN TRANSVAAL	700	93.170	2.329	0.051	0.0543%
Vryheid	KWAZULU/NATAL	900	92.485	2.312	0.050	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Embumbulu	KWAZULU/NATAL	900	87.392	2.185	0.047	0.0543%
Inanda	KWAZULU/NATAL	900	86.433	2.161	0.047	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	82.929	2.073	0.045	0.0543%
Lower Umfolozi	KWAZULU/NATAL	100	81.792	2.045	0.044	0.0543%
Witrivier	EASTERN TRANSVAAL	700	74.332	1.858	0.040	0.0543%
Enseleni	KWAZULU/NATAL	450	71.837	1.796	0.039	0.0543%
Lower Tugela	KWAZULU/NATAL	900	68.172	1.704	0.037	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	66.941	1.674	0.036	0.0543%
Lower Umfolozi	KWAZULU/NATAL	100	64.167	1.604	0.035	0.0543%
Camperdown	KWAZULU/NATAL	900	63.589	1.590	0.035	0.0543%
Enseleni	KWAZULU/NATAL	900	62.097	1.552	0.034	0.0543%
Ongoye	KWAZULU/NATAL	900	60.209	1.505	0.033	0.0543%
Emzumbe	KWAZULU/NATAL	900	60.189	1.505	0.033	0.0543%
New Hanover	KWAZULU/NATAL	900	59.795	1.495	0.032	0.0543%
Hlabisa	KWAZULU/NATAL	450	58.513	1.463	0.032	0.0543%
Empumalanga	KWAZULU/NATAL	900	55.668	1.392	0.030	0.0543%
Emzumbe	KWAZULU/NATAL	900	55.057	1.376	0.030	0.0543%
Port Shepstone	KWAZULU/NATAL	700	54.124	1.353	0.029	0.0543%
Alfred	KWAZULU/NATAL	700	53.836	1.346	0.029	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	53.341	1.334	0.029	0.0543%
Enseleni	KWAZULU/NATAL	100	53.121	1.328	0.029	0.0543%
Port Shepstone	KWAZULU/NATAL	900	52.765	1.319	0.029	0.0543%
Ongoye	KWAZULU/NATAL	900	51.464	1.287	0.028	0.0543%
Ezingolweni	KWAZULU/NATAL	700	51.282	1.282	0.028	0.0543%
Ingwavuma	KWAZULU/NATAL	100	51.124	1.278	0.028	0.0543%
Nongoma	KWAZULU/NATAL	500	50.862	1.272	0.028	0.0543%
Enseleni	KWAZULU/NATAL	450	48.253	1.206	0.026	0.0543%
Enseleni	KWAZULU/NATAL	450	47.485	1.187	0.026	0.0543%
Embumbulu	KWAZULU/NATAL	900	47.412	1.185	0.026	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	46.769	1.169	0.025	0.0543%
Nkomazi	EASTERN TRANSVAAL	350	45.997	1.150	0.025	0.0543%
New Hanover	KWAZULU/NATAL	900	44.156	1.104	0.024	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	41.896	1.047	0.023	0.0543%
New Hanover	KWAZULU/NATAL	900	39.545	0.989	0.021	0.0543%
Ezingolweni	KWAZULU/NATAL	900	38.717	0.968	0.021	0.0543%
Barberton	EASTERN TRANSVAAL	350	38.179	0.954	0.021	0.0543%
Vulamehlo	KWAZULU/NATAL	900	37.789	0.945	0.021	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	37.468	0.937	0.020	0.0543%
Mahlabatini	KWAZULU/NATAL	900	36.819	0.920	0.020	0.0543%
Emzumbe	KWAZULU/NATAL	900	35.464	0.887	0.019	0.0543%
Nongoma	KWAZULU/NATAL	500	35.380	0.885	0.019	0.0543%
Umzintu	KWAZULU/NATAL	900	34.285	0.857	0.019	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	33.675	0.842	0.018	0.0543%
Hlabisa	KWAZULU/NATAL	500	32.706	0.818	0.018	0.0543%
Ezingolweni	KWAZULU/NATAL	900	32.556	0.814	0.018	0.0543%
Camperdown	KWAZULU/NATAL	900	32.363	0.809	0.018	0.0543%
Barberton	EASTERN TRANSVAAL	350	32.361	0.809	0.018	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	31.948	0.799	0.017	0.0543%
Camperdown	KWAZULU/NATAL	900	30.929	0.773	0.017	0.0543%
Pinetown	KWAZULU/NATAL	900	30.047	0.751	0.016	0.0543%
Barberton	EASTERN TRANSVAAL	700	29.858	0.746	0.016	0.0543%
Ndwedwe	KWAZULU/NATAL	900	29.360	0.734	0.016	0.0543%
Port Shepstone	KWAZULU/NATAL	700	29.327	0.733	0.016	0.0543%
Eshowe	KWAZULU/NATAL	900	29.073	0.727	0.016	0.0543%
Ongoye	KWAZULU/NATAL	900	28.548	0.714	0.016	0.0543%
Vryheid	KWAZULU/NATAL	900	27.946	0.699	0.015	0.0543%
Alfred	KWAZULU/NATAL	700	27.101	0.678	0.015	0.0543%
Enseleni	KWAZULU/NATAL	100	26.335	0.658	0.014	0.0543%
Mtunzini	KWAZULU/NATAL	900	26.108	0.653	0.014	0.0543%
Hlabisa	KWAZULU/NATAL	450	25.813	0.645	0.014	0.0543%
Emzumbe	KWAZULU/NATAL	900	25.641	0.641	0.014	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	24.666	0.617	0.013	0.0543%
Witrivier	EASTERN TRANSVAAL	700	24.550	0.614	0.013	0.0543%
Alfred	KWAZULU/NATAL	700	24.449	0.611	0.013	0.0543%
Enseleni	KWAZULU/NATAL	900	24.337	0.608	0.013	0.0543%
Witrivier	EASTERN TRANSVAAL	700	23.737	0.593	0.013	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Mahlabatini	KWAZULU/NATAL	900	23.575	0.589	0.013	0.0543%
Umzintu	KWAZULU/NATAL	900	23.506	0.588	0.013	0.0543%
Nongoma	KWAZULU/NATAL	700	23.047	0.576	0.013	0.0543%
Inkanyezi	KWAZULU/NATAL	900	22.943	0.574	0.012	0.0543%
Port Shepstone	KWAZULU/NATAL	900	22.411	0.560	0.012	0.0543%
Emzumbe	KWAZULU/NATAL	900	22.278	0.557	0.012	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	22.029	0.551	0.012	0.0543%
Hlabisa	KWAZULU/NATAL	100	21.839	0.546	0.012	0.0543%
Ndwedwe	KWAZULU/NATAL	900	21.687	0.542	0.012	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	21.366	0.534	0.012	0.0543%
Nongoma	KWAZULU/NATAL	500	21.133	0.528	0.011	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	21.036	0.526	0.011	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	20.621	0.516	0.011	0.0543%
Vulamehlo	KWAZULU/NATAL	900	20.184	0.505	0.011	0.0543%
Hlabisa	KWAZULU/NATAL	450	19.552	0.489	0.011	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	19.507	0.488	0.011	0.0543%
Camperdown	KWAZULU/NATAL	900	19.379	0.484	0.011	0.0543%
Ezingolweni	KWAZULU/NATAL	900	18.913	0.473	0.010	0.0543%
Umzintu	KWAZULU/NATAL	900	18.830	0.471	0.010	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	18.580	0.464	0.010	0.0543%
Witrivier	EASTERN TRANSVAAL	700	18.476	0.462	0.010	0.0543%
Embumbulu	KWAZULU/NATAL	900	18.320	0.458	0.010	0.0543%
Barberton	EASTERN TRANSVAAL	700	18.131	0.453	0.010	0.0543%
Ongoye	KWAZULU/NATAL	450	17.428	0.436	0.009	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	17.383	0.435	0.009	0.0543%
Camperdown	KWAZULU/NATAL	900	17.268	0.432	0.009	0.0543%
Camperdown	KWAZULU/NATAL	900	16.739	0.418	0.009	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	15.983	0.400	0.009	0.0543%
Hlabisa	KWAZULU/NATAL	100	15.730	0.393	0.009	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	15.090	0.377	0.008	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	14.969	0.374	0.008	0.0543%
Piet Retief	KWAZULU/NATAL	700	14.968	0.374	0.008	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	14.857	0.371	0.008	0.0543%
Hlabisa	KWAZULU/NATAL	450	14.519	0.363	0.008	0.0543%
Vryheid	KWAZULU/NATAL	900	14.135	0.353	0.008	0.0543%
Witrivier	EASTERN TRANSVAAL	700	13.901	0.348	0.008	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	13.690	0.342	0.007	0.0543%
Port Shepstone	KWAZULU/NATAL	700	13.637	0.341	0.007	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	13.519	0.338	0.007	0.0543%
Mtunzini	KWAZULU/NATAL	100	13.284	0.332	0.007	0.0543%
Enseleni	KWAZULU/NATAL	900	13.205	0.330	0.007	0.0543%
Piet Retief	KWAZULU/NATAL	700	13.202	0.330	0.007	0.0543%
Ngotshe	KWAZULU/NATAL	900	12.997	0.325	0.007	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	12.944	0.324	0.007	0.0543%
Ingwavuma	KWAZULU/NATAL	450	12.772	0.319	0.007	0.0543%
Enseleni	KWAZULU/NATAL	450	12.214	0.305	0.007	0.0543%
Hlabisa	KWAZULU/NATAL	100	12.157	0.304	0.007	0.0543%
Mahlabatini	KWAZULU/NATAL	900	12.049	0.301	0.007	0.0543%
Piet Retief	KWAZULU/NATAL	700	11.785	0.295	0.006	0.0543%
Port Shepstone	KWAZULU/NATAL	900	11.521	0.288	0.006	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	11.387	0.285	0.006	0.0543%
New Hanover	KWAZULU/NATAL	900	10.928	0.273	0.006	0.0543%
Nongoma	KWAZULU/NATAL	700	10.283	0.257	0.006	0.0543%
Hlabisa	KWAZULU/NATAL	450	10.117	0.253	0.005	0.0543%
Ongoye	KWAZULU/NATAL	900	10.083	0.252	0.005	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	10.071	0.252	0.005	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	9.671	0.242	0.005	0.0543%
Enseleni	KWAZULU/NATAL	450	9.626	0.241	0.005	0.0543%
Hlabisa	KWAZULU/NATAL	700	9.386	0.235	0.005	0.0543%
Hlabisa	KWAZULU/NATAL	100	9.140	0.228	0.005	0.0543%
Ingwavuma	KWAZULU/NATAL	100	9.111	0.228	0.005	0.0543%
Port Shepstone	KWAZULU/NATAL	700	9.105	0.228	0.005	0.0543%
Enseleni	KWAZULU/NATAL	900	9.076	0.227	0.005	0.0543%
Barberton	EASTERN TRANSVAAL	700	9.063	0.227	0.005	0.0543%
Umzintu	KWAZULU/NATAL	900	9.008	0.225	0.005	0.0543%
Ingwavuma	KWAZULU/NATAL	450	8.914	0.223	0.005	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Camperdown	KWAZULU/NATAL	900	8.824	0.221	0.005	0.0543%
Ndwedwe	KWAZULU/NATAL	900	8.775	0.219	0.005	0.0543%
New Hanover	KWAZULU/NATAL	900	8.652	0.216	0.005	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	8.419	0.210	0.005	0.0543%
Hlabisa	KWAZULU/NATAL	450	8.405	0.210	0.005	0.0543%
New Hanover	KWAZULU/NATAL	900	8.288	0.207	0.005	0.0543%
New Hanover	KWAZULU/NATAL	900	8.192	0.205	0.004	0.0543%
Port Shepstone	KWAZULU/NATAL	700	8.068	0.202	0.004	0.0543%
Ongoye	KWAZULU/NATAL	900	7.877	0.197	0.004	0.0543%
Inkanyezi	KWAZULU/NATAL	100	7.855	0.196	0.004	0.0543%
Umzintu	KWAZULU/NATAL	900	7.632	0.191	0.004	0.0543%
Ngotshe	KWAZULU/NATAL	900	7.600	0.190	0.004	0.0543%
Ndwedwe	KWAZULU/NATAL	900	7.561	0.189	0.004	0.0543%
Nkomazi	EASTERN TRANSVAAL	700	7.447	0.186	0.004	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	7.396	0.185	0.004	0.0543%
Witrivier	EASTERN TRANSVAAL	700	7.356	0.184	0.004	0.0543%
Barberton	EASTERN TRANSVAAL	700	7.353	0.184	0.004	0.0543%
Ingwavuma	KWAZULU/NATAL	450	7.156	0.179	0.004	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	7.144	0.179	0.004	0.0543%
Ingwavuma	KWAZULU/NATAL	450	7.114	0.178	0.004	0.0543%
Vulamehlo	KWAZULU/NATAL	900	7.037	0.176	0.004	0.0543%
Hlabisa	KWAZULU/NATAL	100	6.934	0.173	0.004	0.0543%
Nongoma	KWAZULU/NATAL	700	6.908	0.173	0.004	0.0543%
Hlabisa	KWAZULU/NATAL	500	6.753	0.169	0.004	0.0543%
Enseleni	KWAZULU/NATAL	900	6.729	0.168	0.004	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	6.516	0.163	0.004	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	6.384	0.160	0.003	0.0543%
Hlabisa	KWAZULU/NATAL	500	6.329	0.158	0.003	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	6.185	0.155	0.003	0.0543%
Nongoma	KWAZULU/NATAL	500	5.961	0.149	0.003	0.0543%
Emzumbe	KWAZULU/NATAL	900	5.917	0.148	0.003	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	5.845	0.146	0.003	0.0543%
Embumbulu	KWAZULU/NATAL	900	5.781	0.145	0.003	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	5.775	0.144	0.003	0.0543%
Eshowe	KWAZULU/NATAL	100	5.771	0.144	0.003	0.0543%
Nongoma	KWAZULU/NATAL	700	5.602	0.140	0.003	0.0543%
New Hanover	KWAZULU/NATAL	900	5.574	0.139	0.003	0.0543%
Ixopo	KWAZULU/NATAL	700	5.503	0.138	0.003	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	5.452	0.136	0.003	0.0543%
Barberton	EASTERN TRANSVAAL	350	5.378	0.134	0.003	0.0543%
Port Shepstone	KWAZULU/NATAL	700	5.376	0.134	0.003	0.0543%
Nongoma	KWAZULU/NATAL	500	5.317	0.133	0.003	0.0543%
Hlabisa	KWAZULU/NATAL	700	5.248	0.131	0.003	0.0543%
Witrivier	EASTERN TRANSVAAL	450	5.045	0.126	0.003	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	4.971	0.124	0.003	0.0543%
Hlabisa	KWAZULU/NATAL	500	4.945	0.124	0.003	0.0543%
Piet Retief	KWAZULU/NATAL	450	4.933	0.123	0.003	0.0543%
Ngotshe	KWAZULU/NATAL	700	4.873	0.122	0.003	0.0543%
Hlabisa	KWAZULU/NATAL	450	4.867	0.122	0.003	0.0543%
Witrivier	EASTERN TRANSVAAL	700	4.747	0.119	0.003	0.0543%
Port Shepstone	KWAZULU/NATAL	700	4.682	0.117	0.003	0.0543%
Hlabisa	KWAZULU/NATAL	500	4.594	0.115	0.002	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	4.576	0.114	0.002	0.0543%
Hlabisa	KWAZULU/NATAL	100	4.558	0.114	0.002	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	4.488	0.112	0.002	0.0543%
Ngotshe	KWAZULU/NATAL	900	4.436	0.111	0.002	0.0543%
Mahlabatini	KWAZULU/NATAL	500	4.432	0.111	0.002	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	4.310	0.108	0.002	0.0543%
Vulamehlo	KWAZULU/NATAL	900	4.282	0.107	0.002	0.0543%
Emzumbe	KWAZULU/NATAL	700	4.257	0.106	0.002	0.0543%
Nongoma	KWAZULU/NATAL	900	4.242	0.106	0.002	0.0543%
Nongoma	KWAZULU/NATAL	500	4.130	0.103	0.002	0.0543%
Nongoma	KWAZULU/NATAL	500	3.860	0.097	0.002	0.0543%
Enseleni	KWAZULU/NATAL	900	3.785	0.095	0.002	0.0543%
Ngotshe	KWAZULU/NATAL	900	3.660	0.091	0.002	0.0543%
Ingwavuma	KWAZULU/NATAL	450	3.490	0.087	0.002	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Kwa Mapumulu	KWAZULU/NATAL	900	3.422	0.086	0.002	0.0543%
Barberton	EASTERN TRANSVAAL	700	3.377	0.084	0.002	0.0543%
Hlabisa	KWAZULU/NATAL	700	3.357	0.084	0.002	0.0543%
Enseleni	KWAZULU/NATAL	900	3.352	0.084	0.002	0.0543%
Ngotshe	KWAZULU/NATAL	900	3.346	0.084	0.002	0.0543%
Witrivier	EASTERN TRANSVAAL	700	3.241	0.081	0.002	0.0543%
Ingwavuma	KWAZULU/NATAL	500	3.184	0.080	0.002	0.0543%
Ngotshe	KWAZULU/NATAL	700	3.142	0.079	0.002	0.0543%
Empumalanga	KWAZULU/NATAL	900	3.108	0.078	0.002	0.0543%
Umzintu	KWAZULU/NATAL	900	3.061	0.077	0.002	0.0543%
Hlabisa	KWAZULU/NATAL	500	3.011	0.075	0.002	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	2.952	0.074	0.002	0.0543%
Ngotshe	KWAZULU/NATAL	700	2.882	0.072	0.002	0.0543%
Hlabisa	KWAZULU/NATAL	700	2.771	0.069	0.002	0.0543%
Nongoma	KWAZULU/NATAL	500	2.576	0.064	0.001	0.0543%
Nkandla	KWAZULU/NATAL	900	2.496	0.062	0.001	0.0543%
Mahlabatini	KWAZULU/NATAL	500	2.485	0.062	0.001	0.0543%
Ngotshe	KWAZULU/NATAL	900	2.459	0.061	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	500	2.443	0.061	0.001	0.0543%
Umzintu	KWAZULU/NATAL	900	2.442	0.061	0.001	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	2.342	0.059	0.001	0.0543%
Ingwavuma	KWAZULU/NATAL	450	2.327	0.058	0.001	0.0543%
Ngotshe	KWAZULU/NATAL	700	2.228	0.056	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	500	2.139	0.053	0.001	0.0543%
Barberton	EASTERN TRANSVAAL	700	2.112	0.053	0.001	0.0543%
Babanango	KWAZULU/NATAL	900	2.106	0.053	0.001	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	2.080	0.052	0.001	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	2.052	0.051	0.001	0.0543%
Nongoma	KWAZULU/NATAL	500	2.022	0.051	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	500	2.004	0.050	0.001	0.0543%
Umzintu	KWAZULU/NATAL	900	1.990	0.050	0.001	0.0543%
Nongoma	KWAZULU/NATAL	700	1.988	0.050	0.001	0.0543%
Ngotshe	KWAZULU/NATAL	700	1.971	0.049	0.001	0.0543%
Babanango	KWAZULU/NATAL	900	1.954	0.049	0.001	0.0543%
Eshowe	KWAZULU/NATAL	100	1.949	0.049	0.001	0.0543%
Vulamehlo	KWAZULU/NATAL	900	1.917	0.048	0.001	0.0543%
Ngotshe	KWAZULU/NATAL	700	1.908	0.048	0.001	0.0543%
Vulamehlo	KWAZULU/NATAL	900	1.851	0.046	0.001	0.0543%
Enseleni	KWAZULU/NATAL	500	1.797	0.045	0.001	0.0543%
Ixopo	KWAZULU/NATAL	900	1.781	0.045	0.001	0.0543%
Alfred	KWAZULU/NATAL	700	1.751	0.044	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	450	1.696	0.042	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	450	1.636	0.041	0.001	0.0543%
Witrivier	EASTERN TRANSVAAL	700	1.590	0.040	0.001	0.0543%
Ngotshe	KWAZULU/NATAL	700	1.576	0.039	0.001	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	1.571	0.039	0.001	0.0543%
Enseleni	KWAZULU/NATAL	900	1.477	0.037	0.001	0.0543%
Babanango	KWAZULU/NATAL	900	1.453	0.036	0.001	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	1.432	0.036	0.001	0.0543%
Ndwedwe	KWAZULU/NATAL	900	1.398	0.035	0.001	0.0543%
Witrivier	EASTERN TRANSVAAL	450	1.371	0.034	0.001	0.0543%
Ezingolweni	KWAZULU/NATAL	900	1.360	0.034	0.001	0.0543%
Camperdown	KWAZULU/NATAL	900	1.345	0.034	0.001	0.0543%
Barberton	EASTERN TRANSVAAL	350	1.341	0.034	0.001	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	1.237	0.031	0.001	0.0543%
Nongoma	KWAZULU/NATAL	500	1.221	0.031	0.001	0.0543%
Ndwedwe	KWAZULU/NATAL	900	1.195	0.030	0.001	0.0543%
Barberton	EASTERN TRANSVAAL	700	1.175	0.029	0.001	0.0543%
Ndwedwe	KWAZULU/NATAL	900	1.079	0.027	0.001	0.0543%
Umzintu	KWAZULU/NATAL	900	1.074	0.027	0.001	0.0543%
Hlabisa	KWAZULU/NATAL	450	0.932	0.023	0.001	0.0543%
New Hanover	KWAZULU/NATAL	900	0.924	0.023	0.001	0.0543%
Port Shepstone	KWAZULU/NATAL	700	0.918	0.023	0.000	0.0543%
Mtunzini	KWAZULU/NATAL	100	0.846	0.021	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.838	0.021	0.000	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	0.836	0.021	0.000	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Nongoma	KWAZULU/NATAL	700	0.822	0.021	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.821	0.021	0.000	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	0.766	0.019	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.757	0.019	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.718	0.018	0.000	0.0543%
Pinetown	KWAZULU/NATAL	900	0.699	0.017	0.000	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	0.674	0.017	0.000	0.0543%
Nongoma	KWAZULU/NATAL	900	0.636	0.016	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.608	0.015	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.563	0.014	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	450	0.540	0.013	0.000	0.0543%
Ezingolweni	KWAZULU/NATAL	900	0.533	0.013	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.523	0.013	0.000	0.0543%
Nkomazi	EASTERN TRANSVAAL	350	0.512	0.013	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.489	0.012	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.477	0.012	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.431	0.011	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.408	0.010	0.000	0.0543%
New Hanover	KWAZULU/NATAL	900	0.405	0.010	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.403	0.010	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.395	0.010	0.000	0.0543%
Nsikazi	EASTERN TRANSVAAL	700	0.388	0.010	0.000	0.0543%
Port Shepstone	KWAZULU/NATAL	700	0.387	0.010	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.373	0.009	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.359	0.009	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.348	0.009	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.346	0.009	0.000	0.0543%
Umzintu	KWAZULU/NATAL	900	0.345	0.009	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.343	0.009	0.000	0.0543%
Ongoye	KWAZULU/NATAL	900	0.331	0.008	0.000	0.0543%
Camperdown	KWAZULU/NATAL	900	0.329	0.008	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	450	0.308	0.008	0.000	0.0543%
Ongoye	KWAZULU/NATAL	100	0.308	0.008	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.302	0.008	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.291	0.007	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.266	0.007	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.265	0.007	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.263	0.007	0.000	0.0543%
Richmond (Kwazulu/Natal)	KWAZULU/NATAL	900	0.248	0.006	0.000	0.0543%
Barberton	EASTERN TRANSVAAL	700	0.245	0.006	0.000	0.0543%
Umvoti	KWAZULU/NATAL	900	0.243	0.006	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.238	0.006	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.233	0.006	0.000	0.0543%
Ongoye	KWAZULU/NATAL	900	0.233	0.006	0.000	0.0543%
Nongoma	KWAZULU/NATAL	700	0.233	0.006	0.000	0.0543%
New Hanover	KWAZULU/NATAL	900	0.231	0.006	0.000	0.0543%
New Hanover	KWAZULU/NATAL	900	0.222	0.006	0.000	0.0543%
Piet Retief	KWAZULU/NATAL	700	0.218	0.005	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.217	0.005	0.000	0.0543%
Enseleni	KWAZULU/NATAL	450	0.216	0.005	0.000	0.0543%
Camperdown	KWAZULU/NATAL	900	0.206	0.005	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.197	0.005	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.192	0.005	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	450	0.185	0.005	0.000	0.0543%
Witrivier	EASTERN TRANSVAAL	700	0.184	0.005	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	0.182	0.005	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.181	0.005	0.000	0.0543%
Port Shepstone	KWAZULU/NATAL	700	0.181	0.005	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.179	0.004	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.168	0.004	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.167	0.004	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.166	0.004	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	100	0.166	0.004	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	450	0.160	0.004	0.000	0.0543%
Enseleni	KWAZULU/NATAL	500	0.156	0.004	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.155	0.004	0.000	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Embumbulu	KWAZULU/NATAL	900	0.151	0.004	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.150	0.004	0.000	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	0.149	0.004	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	0.147	0.004	0.000	0.0543%
Ongoye	KWAZULU/NATAL	450	0.145	0.004	0.000	0.0543%
Lower Tugela	KWAZULU/NATAL	900	0.141	0.004	0.000	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	0.138	0.003	0.000	0.0543%
Port Shepstone	KWAZULU/NATAL	900	0.136	0.003	0.000	0.0543%
Barberton	EASTERN TRANSVAAL	700	0.132	0.003	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.129	0.003	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.127	0.003	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.127	0.003	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.122	0.003	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.120	0.003	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.109	0.003	0.000	0.0543%
Inkanyezi	KWAZULU/NATAL	100	0.107	0.003	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.094	0.002	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.085	0.002	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.085	0.002	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.084	0.002	0.000	0.0543%
Ongoye	KWAZULU/NATAL	900	0.082	0.002	0.000	0.0543%
Lower Tugela	KWAZULU/NATAL	900	0.082	0.002	0.000	0.0543%
Enseleni	KWAZULU/NATAL	450	0.079	0.002	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	500	0.078	0.002	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.076	0.002	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.072	0.002	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	0.072	0.002	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.070	0.002	0.000	0.0543%
Ezingolweni	KWAZULU/NATAL	700	0.065	0.002	0.000	0.0543%
Enseleni	KWAZULU/NATAL	450	0.063	0.002	0.000	0.0543%
Inkanyezi	KWAZULU/NATAL	900	0.060	0.001	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.059	0.001	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.055	0.001	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	700	0.052	0.001	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.050	0.001	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	700	0.047	0.001	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.041	0.001	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	450	0.039	0.001	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	100	0.039	0.001	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.037	0.001	0.000	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	0.036	0.001	0.000	0.0543%
Barberton	EASTERN TRANSVAAL	700	0.034	0.001	0.000	0.0543%
Nongoma	KWAZULU/NATAL	700	0.033	0.001	0.000	0.0543%
Piet Retief	KWAZULU/NATAL	700	0.033	0.001	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.031	0.001	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.030	0.001	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.029	0.001	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	450	0.028	0.001	0.000	0.0543%
Vryheid	KWAZULU/NATAL	900	0.028	0.001	0.000	0.0543%
Embumbulu	KWAZULU/NATAL	900	0.026	0.001	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.026	0.001	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.026	0.001	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.025	0.001	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.022	0.001	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.022	0.001	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.021	0.001	0.000	0.0543%
Ndwedwe	KWAZULU/NATAL	900	0.021	0.001	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.020	0.001	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.020	0.001	0.000	0.0543%
Umzintu	KWAZULU/NATAL	900	0.020	0.001	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	700	0.019	0.000	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	500	0.019	0.000	0.000	0.0543%
Witrivier	EASTERN TRANSVAAL	700	0.019	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.018	0.000	0.000	0.0543%
Lower Tugela	KWAZULU/NATAL	900	0.018	0.000	0.000	0.0543%
Witrivier	EASTERN TRANSVAAL	700	0.016	0.000	0.000	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Vryheid	KWAZULU/NATAL	900	0.016	0.000	0.000	0.0543%
Alfred	KWAZULU/NATAL	700	0.016	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.015	0.000	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.015	0.000	0.000	0.0543%
Alfred	KWAZULU/NATAL	700	0.015	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.015	0.000	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	100	0.014	0.000	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.014	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.013	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.013	0.000	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.013	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	700	0.013	0.000	0.000	0.0543%
Pietermaritzburg	KWAZULU/NATAL	900	0.012	0.000	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.012	0.000	0.000	0.0543%
Ndwedwe	KWAZULU/NATAL	900	0.012	0.000	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.011	0.000	0.000	0.0543%
Lower Tugela	KWAZULU/NATAL	900	0.010	0.000	0.000	0.0543%
Barberton	EASTERN TRANSVAAL	350	0.010	0.000	0.000	0.0543%
Mtunzini	KWAZULU/NATAL	100	0.008	0.000	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.008	0.000	0.000	0.0543%
Ongoye	KWAZULU/NATAL	900	0.008	0.000	0.000	0.0543%
Kwa Mapumulu	KWAZULU/NATAL	900	0.008	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.007	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	700	0.007	0.000	0.000	0.0543%
Ezingolweni	KWAZULU/NATAL	700	0.006	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	900	0.006	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.006	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.006	0.000	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	900	0.005	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.005	0.000	0.000	0.0543%
New Hanover	KWAZULU/NATAL	900	0.004	0.000	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.004	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	450	0.004	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.004	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.004	0.000	0.000	0.0543%
Vulamehlo	KWAZULU/NATAL	900	0.003	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	700	0.003	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.003	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.003	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.003	0.000	0.000	0.0543%
Mahlabatini	KWAZULU/NATAL	900	0.003	0.000	0.000	0.0543%
Ngotshe	KWAZULU/NATAL	450	0.003	0.000	0.000	0.0543%
Camperdown	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Embumbulu	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Enseleni	KWAZULU/NATAL	450	0.002	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.002	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.002	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.002	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
New Hanover	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Enseleni	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.001	0.000	0.000	0.0543%
Nongoma	KWAZULU/NATAL	500	0.001	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Lower Umfolozi	KWAZULU/NATAL	450	0.001	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.001	0.000	0.000	0.0543%
Ndwedwe	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Alfred	KWAZULU/NATAL	700	0.000	0.000	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	450	0.000	0.000	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	450	0.000	0.000	0.000	0.0543%

CENS_DISTR	REGION	HI_POINT	Exposure (R'million)	Expected Damage per event (R'million)	Expected Annual Damage (R'million)	Expected Annual Damage Ratio
Mtonjaneni	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Ubombo (Kwazulu)	KWAZULU/NATAL	450	0.000	0.000	0.000	0.0543%
Emzumbe	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	450	0.000	0.000	0.000	0.0543%
Hlabisa	KWAZULU/NATAL	500	0.000	0.000	0.000	0.0543%
Mtonjaneni	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Ingwavuma	KWAZULU/NATAL	450	0.000	0.000	0.000	0.0543%
Ixopo	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Babanango	KWAZULU/NATAL	900	0.000	0.000	0.000	0.0543%
Totals:			**73,046.627**	**1,826.166**	**39.699**	**0.0543%**